# CLIMAS

# Southwest Climate Outlook

## Monthly Climate Packet
## November 2003

Climate Assessment for the Southwest
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# Section A

# BACKGROUND

CLIMAS
Southwest Climate Outlook
November 2003
THE UNIVERSITY OF ARIZONA®

# Average winter rains in Arizona could bring drought relief

When the most recent water year ended in September, the state of Arizona was in much better shape than it had been in the previous year. Perhaps surprisingly, a round of normal winter rain and snow could be enough to pull much of the state out of drought, at least in the short term. This represents a dramatic improvement over last year, when there was virtually no chance of the drought ending from winter season precipitation.

This assessment follows from the average state value of -3.3 on the Palmer Drought Severity Index (PDSI). As Figure 1 indicates, six of the seven climate divisions in the state improved compared to the water year ending September 30, 2002. In southeastern Arizona (climate division 7 on Figure 2), conditions remained dire in some places, particularly in Cochise and Graham counties.

In general, 6 to 10 inches of precipitation in the six months from October through March would be enough to pull the state out of drought. The statewide average for the same six-month period is 6.2 inches. Although 46 of the past 108 winter seasons (42 percent) have produced a statewide average of 6 inches or more, only nine winters have yielded statewide precipitation averages of 10 inches or greater.

So the likelihood of a statewide reprieve depends on the precipitation falling in the right place as well as the right time. The approximate amount of rain required by each climate division to escape drought conditions and the probability of this occurring are shown in Table 1, which is based on the Palmer Hydrological Drought Index (PHDI) rather than the PDSI. Both indexes use the same two-layer soil model to assess water balance, but the PHDI is slightly more conservative (1).

Even with the PHDI, the six-month prognosis (October–March) was yielding about a 1-in-5 to almost 1-in-2 chance that drought conditions could end by April in four of the seven climate divisions (Table 1), with odds greater than 1-in-10 for the remaining divisions. Admittedly, these are not great odds, but they are markedly better for most divisions than the three-month prognosis (October-November), as the table indicates. What's more, the three-month prognosis for November–January improved for every region except climate division 6, which had been temporarily freed of the clutches of drought by official standards as of September, at least in the shorter term prognosis.

These probabilities—and the determination of whether a division is in a drought, for that

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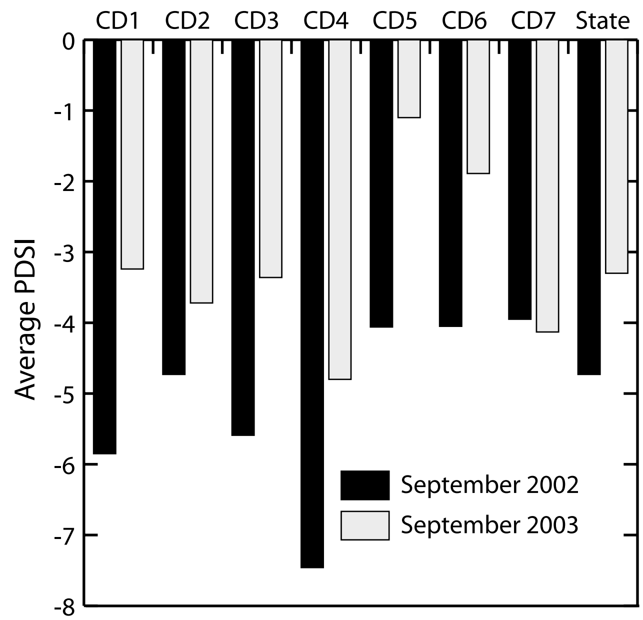


**Figure 1.** Palmer Drought Severity Index by Arizona Climate Division, September 2002 vs. September 2003.

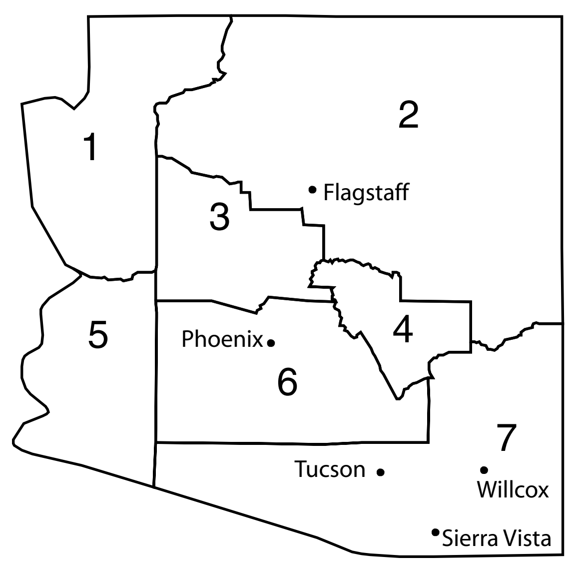


**Figure 2.** Map of Arizona Climate Divisions.

# Winter Rains, continued

matter—are based on average precipitation in that division during the most recent three completed decades, in this case 1971–2000. Following this line of reasoning, Winslow could be in a drought year with 75 mm of rainfall (about 3.1 inches), while Yuma would be enjoying above-average annual rainfall with the same amount.

It's important to note that the probabilities do not consider whether the Southwest climate has moved into a drier climate pattern in general. Some suspect the Pacific Decadal Oscillation (PDO) moved in 1998 into a potentially 20- to 30-year cool phase that would tend to bring drier conditions to Arizona (2), particularly in a swath along the Colorado River from the Grand Canyon through about the Petrified Forest, and in the southeastern part of the state, particularly around Casa Grande and Tucson (3).

Even worse, if a PDO cool phase is coupled with a warm phase of the Atlantic Multidecadal Oscillation (AMO), as some fear, this could result in a double-whammy that could increase the likelihood of a long-term drought in the Southwest (4). The AMO is a pattern of slowly varying sea-surface temperature and associated atmospheric circulation in the North Atlantic Ocean. Recently, researchers have determined that this pattern has effects on precipitation in the continental United States, including the southern Rocky Mountains. For example, an AMO warm phase between 1940–1960 coincided with the 1950s Southwest-Southern Plains drought (5).

The PDO is still fluctuating, and at this point it's unclear whether it will quickly return to a cool phase. Also, the science involving the AMO circulation pattern is still in the relatively early stages.

So there's still hope that drought conditions could end by spring, at least for this year. Last year's winter precipitation helped. By the end of September, water year precipitation values were within about a third of an inch of normal in all divisions, and had even topped normal values in climate divisions 1 and 5, albeit it ever so slightly.

Some February and March storms drizzled rain around the state, a welcome relief from an unusually warm and incredibly dry January. Temperature plays a smaller but sometimes decisive role in drought through its effect on evaporation rates. Despite January's unseasonably warm temperatures, the temperature departure for the water year as a whole was less dramatic than in the previous year. Statewide, average temperature was about 2 degrees Fahrenheit above the 1895–2003 mean for the water year that ended in September, compared to about 2.5 degrees Fahrenheit above the mean for the previous year.

**continued on page 3**

**Table 1.** The columns show the precipitation required to end the current drought in the time period indicated and the odds of receiving the required amount by Arizona climate division. (See Figure 2 for location of divisions.) The odds are based on the percentage of times the division received the requisite amount of precipitation during periods of similar time frames between 1971—2000.

| | **October-March** | | **October-December** | | **November-January** | |
|---|---|---|---|---|---|---|
| Climate Division | Precipitation required to end drought (inches) | Odds of receiving precipitation required to end drought (%) | Precipitation required to end drought (inches) | Odds of receiving precipitation required to end drought (%) | Precipitation required to end drought (inches) | Odds of receiving precipitation required to end drought (%) |
| 1 | 4 to 8 | 15 to 18 | 3 to 6 | 7.5 to 9 | 3 to 6 | 18 to 24 |
| 2 | 8 to 12 | 15 to 18 | 6 to 9 | 6 to 7.5 | 3 to 6 | 12 to 18 |
| 3 | 8 to 12 | 18 to 47 | 6 to 9 | 7.5 to 9 | 3 to 6 | 24 to 30 |
| 4 | 12 to 16 | 18 to 47 | 9 to 12 | 6 to 7.5 | 9 to 12 | 6 to 13 |
| 5 | Trace to 4 | 18 to 47 | Not in drought | | Not in drought | |
| 6 | 4 to 8 | 18 to 47 | Not in drought | | Trace to 3 | 36 to 85 |
| 7 | 8 to 12 | 12 to 15 | 6 to 9 | 3 to 4.5 | 3 to 6 | 12 to 18 |

## Winter Rains, continued

As for the all-important precipitation, one storm centered around February 13 and concentrated around central Arizona dropped about three inches in the Phoenix area, and another storm system spread across Arizona starting around February 25 (6). The latter lingered in some areas, including Winslow, Phoenix, and Tucson, through the first few days of March (6). Mid-March brought more rains to much of the state (7).

By March 25, Arizona's snowpack was near its long-term average in many basins (8). As snow melted, streamflow improved and reservoir levels rose. White-water tour operators welcomed an "ideal" season on the Upper Salt River, after facing a raft-free season the previous year. (9) Storage in six Salt River Project lakes had reached an average of 43percent capacity, compared to 35 percent at that time during the previous year (10). Unlike the Verde and Salt rivers, Colorado River runoff did not approach normal levels, but the basin was expected to yield about two-thirds of its usual runoff compared to little over one-tenth the previous year (11).

If the Colorado River basin were to receive 100 percent of normal snowpack this year, streamflow still would lag behind at about 80 percent of normal, predicted U.S. Bureau of Reclamation hydrologist Chris Cutler (10). Dry soils absorb more moisture before releasing some of it as runoff, which is why it takes longer to rebound from hydrological drought than meteorological drought.

The spring fire season made it clear that last year's winter precipitation had not cleared the hurdles set by the entrenched drought. At the same time, it did succeed in moving the hurdle down a notch or two for the coming winter. A November 12 storm that dropped another half an inch to inch of rain across much of the state (7) lent a hopeful sign that the improvement might continue in the current water year that began October 1.

However, even in the somewhat improbable event that some or all of the state goes back to normal conditions in the coming water year, there would be no guarantee that it wouldn't revert back into drought in the near future. As researchers pointed out during a national drought workshop held in Tucson last week, occasional years of normal or even above-average precipitation can occur even during decades-long entrenched droughts found in historic records, and in prehistoric records developed from tree rings.

But it's a sure bet that, even then, the people suffering through the drought appreciated a year or two of reprieve.

— Melanie Lenart, CLIMAS Research Associate and Andrew Ellis, Arizona State Climatologist

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(1) Keyantash, J., and J. A. Dracup. 2002. The quantification of drought: an evaluation of drought indices. *Bulletin of the American Meteorological Society,* 83(8):1167–1180.

(2) Carter, R. 2002. PDO: Where will the footprints lead? *END Insight Newsletter,* October 2002. Climate Assessment for the Southwest project, University of Arizona. Available at http://www.ispe.arizona.edu/climas/forecasts/articles/PDO_Oct2002.pdf.

(3) Brown, D. P., and A. C. Comrie. 2002. Sub-regional precipitation linkages to SOI and PDO in the Southwest United States. *Atmospheric Science Letters,* 3:94–102.

(4) Gray, S. T., J. L. Betancourt, C. L. Fastie, and S. T. Jackson. 2003. Patterns and sources of multidecadal oscillations in drought-sensitive tree-ring records from the central and southern Rocky Mountains. *Geophysical Research Letters,* 30(6):49-1–49-4.

(5) Enfield, D. B., A. M. Mestas-Nuñez, and P. J. Trimble. 2001. The Atlantic multidecadal oscillation and its relation to rainfall and riverflows in the continental U.S. *Geophysical Research Letters,* 28(10):2077–2080.

(6) S. McKinnon, and C. Miller. 2003. Storm to continue until morning, fill reservoirs. *The Arizona Republic,* Feb. 25, 2003.

(7) Based on daily observed precipitation events for the past 365 days for Winslow, Phoenix, Tucson and Yuma. Information accessible through the National Oceanic and Atmospheric Administration's Climate Prediction Center's interactive website at http://www.cpc.noaa.gov/products/global_monitoring/precipitation/global_precip_accum.html

(8) M. Tobin. 2003. Dwindling snowmelt trouble for thirsty SW. *The Arizona Daily Star,* March 25, 2003.

(9) S. McKinnon. 2003. Rafters frolic, tubers are up a creek. *The Arizona Republic,* April 19, 2003.

(10) S. McKinnon. 2003. Storms boost water supply. *The Arizona Republic,* April 8, 2003.

(11) Associated Press. 2003. Winter rains not enough to end Arizona's drought. *The Arizona Daily Star,* April 9, 2003.

# Monthly Climate Summary - November 2003

## Highlights

**Hydrological Drought –** Hydrological drought continues in the Southwest.

- Most New Mexico river basins remain in emergency drought status.

**Precipitation** – An early November storm brought precipitation to parts of Arizona and New Mexico, including more than 10 inches of snowfall in parts of northern New Mexico. Some areas, such as parts of southern Arizona, have experienced short-term drought recovery. However, drought conditions have intensified in southern New Mexico, in the vicinity of Santa Fe, and along the Arizona-Utah border.

**Temperature** – Temperatures across most of Arizona and New Mexico have been above average during the past month and well above average in southeastern New Mexico.

**Range Conditions –** New Mexico continues to exhibit poor range and pasture conditions (relative to state averages). About 83 percent of New Mexico pasture and rangeland is in poor to very-poor condition.

**Climate Forecasts –** Seasonal forecasts indicate considerably increased probabilities of above-average temperatures across Arizona and most of New Mexico through the winter and early spring months. December 2003–January 2004 precipitation forecasts are ambiguous. However, a consensus of forecasts indicates very slightly increased probabilities of below-average precipitation for western Arizona.

**ENSO –** Due to neutral ENSO conditions, seasonal climate forecasts have a high degree of uncertainty.

## The Bottom Line

Hydrological drought is expected to persist in most of the Southwest through the winter.

- The **most likely scenario** is that above-average temperatures continue throughout the winter and early spring. There is no indication that the Southwest will receive substantial precipitation during the next several months.
- The worst case scenario is that neutral El Niño conditions do not bring even average precipitation to the Southwest. This would result in continued soil moisture and reservoir depletion by the beginning of summer 2004.
- The best case scenario is that El Niño rebounds this winter and spring, and brings above-average precipitation. In Arizona, occasionally a weak-moderate El Niño brings well above-average precipitation, but this has not occurred often in the historical record.



The climate products in this packet are available on the web:

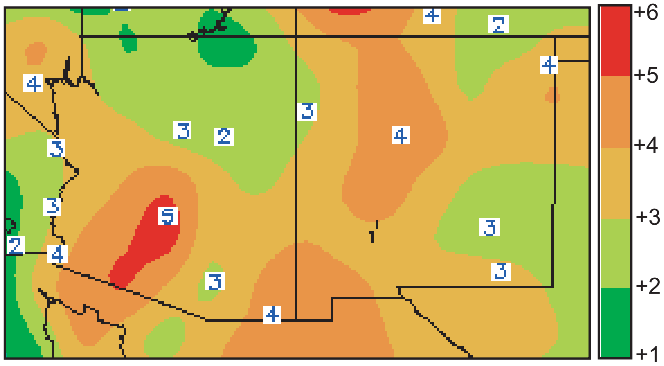
http://www.ispe.arizona.edu/climas/forecasts/swoutlook.html

# Section B

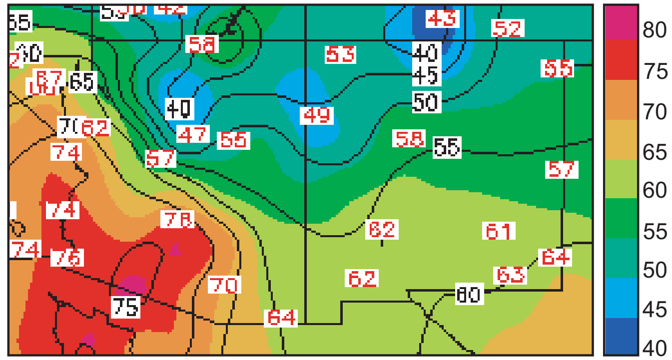
# RECENT CONDITIONS

# 1. Recent Conditions: Temperature (up to 11/19/03) ♦ Sources: WRCC, HPRCC

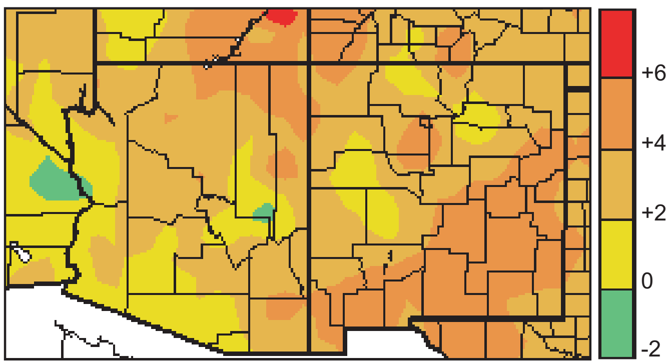
1a. Water year '03-'04 (through 11/19) departure from average temperature (°F).



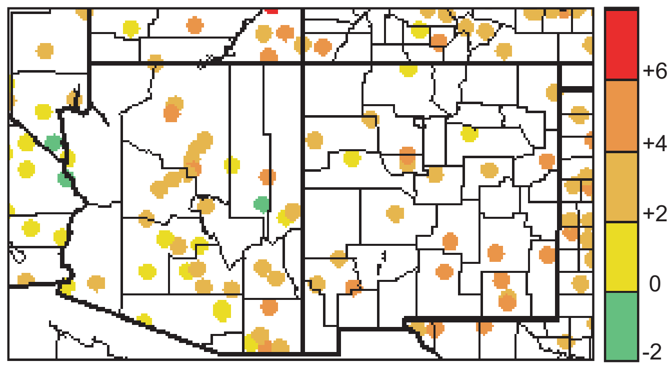

1b. Water year '03-'04 (through 11/19) average temperature (°F).




1c. Previous 30 days (10/21 - 11/19) departure from average temperature (°F, interpolated).




1d. Previous 30 days (10/21 - 11/19) departure from average temperature (°F, data collection locations only).




**Highlights**: The temperatures during the past 30 days (Figure 1c and 1d) have been slightly closer to average than they were during the first three weeks of the water year. Nevertheless, above-average temperature anomalies have continued to persist across Arizona and New Mexico (Figure 1a). Temperatures have been considerably above-average in southeastern New Mexico, where minimum temperatures have been around 6°F above the 1971-2000 average during the past 30 days.

For these and other temperature maps, visit: http://www.wrcc.dri.edu/recent_climate.html and http://www.hprcc.unl.edu/products/current.html

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

**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. Data are in degrees Fahrenheit (°F).

Departure from average temperature is calculated by subtracting current data from the average. The result can be positive or negative.

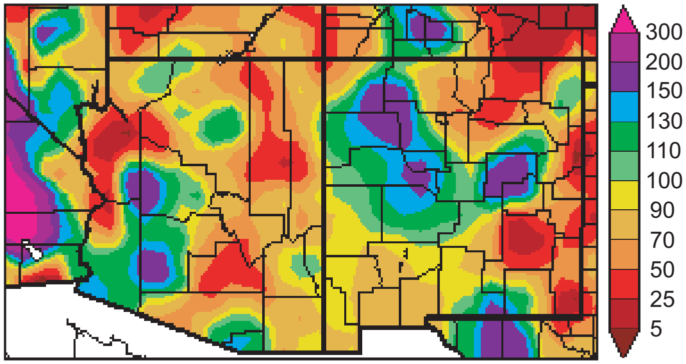
The continuous color maps (Figures 1a, 1b, 1c) are derived by taking measurements at individual meteorological stations and mathematically interpolating (estimating) values between known data points. The blue numbers in Figure 1a, the red numbers in Figure 1b, and the dots in Figure 1d show data values for individual stations.

Note: Interpolation procedures can cause aberrant values in data-sparse regions.

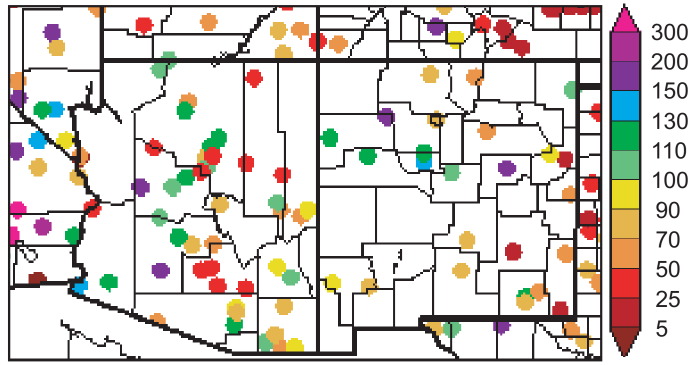
Figures 1c and 1d are experimental products from the High Plains Regional Climate Center (HPRCC).

# 2. Recent Conditions: Precipitation (up to 11/19/03) Source: High Plains Regional Climate Center

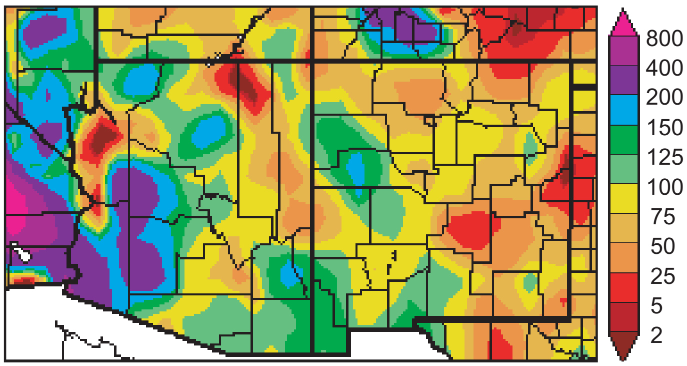
2a. Water year '03-'04 (through 11/19) percent of average precipitation (interpolated).



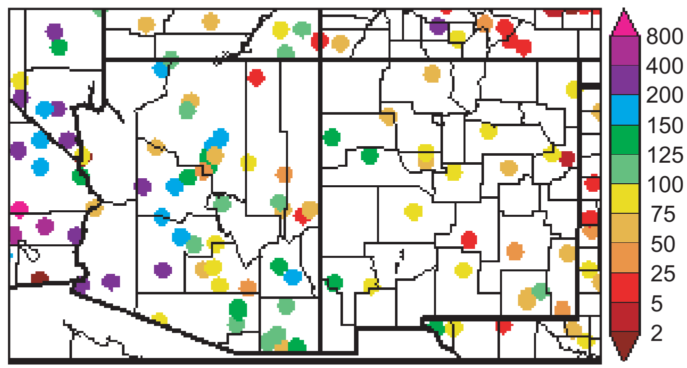

2b. Water year '03-'04 (through 11/19) percent of average precipitation (data collection locations only).




2c. Previous 30 days (10/21 - 11/19) percent of average precipitation (interpolated).




2d. Previous 30 days (10/21 - 11/19) percent of average precipitation (data collection locations only).




**Highlights**: A storm crossed the region on or near November 11-13 and delivered up to an inch of precipitation across parts of Arizona and New Mexico. Western Arizona received significantly above-average precipitation from this storm; the percent of average precipitation for many locations in western Arizona exceeded 200%. However, it is important to note that average precipitation for mid-autumn is less than 0.5 inch for much of southwestern Arizona. Besides the single event, there has been little precipitation in Arizona and New Mexico during the past 30 days. For reasons unclear, some spatial patterns in Figures 2a and 2c (e.g., western Arizona) do not reflect point data patterns in Figures 2b and 2d. Caution should be used when viewing the interpolated figures.

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

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

**Notes:**

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2003 we are in the 2004 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.

Note: Interpolation procedures can cause aberrant values in data-sparse regions.

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

These figures are experimental products from the High Plains Regional Climate Center (HPRCC).

# 3. Annual Precipitation Anomalies and Daily Event Totals Source: NOAA Climate Prediction Center

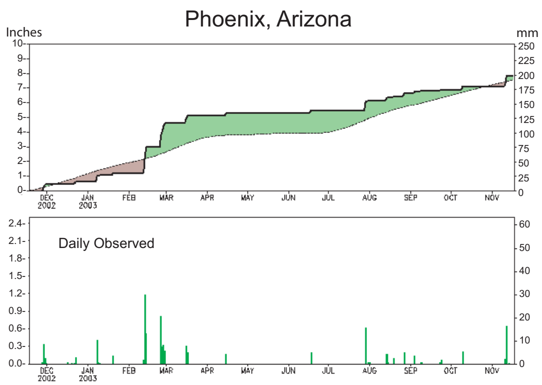
**Notes:** Based on a long-term average (1971-2000) of daily precipitation, these graphs contrast how much precipitation actually has accumulated at each station over the past year (beginning in mid-November 2002) with how much precipitation typically is received.

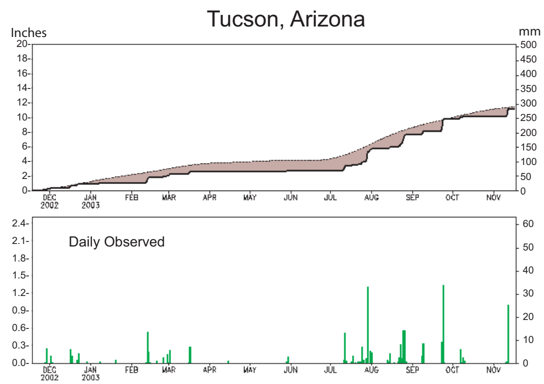
The top of each of the pairs of graphs shows average (dotted line) and actual (solid line) accumulated precipitation (i.e., each day's precipitation total is added to the previous day's total for a 365-day period). If accumulated precipitation is below the long-term average, the region between the long-term average and the actual precipitation is shaded grey, and if accumulated precipitation is above the long-term average, the region between the actual precipitation and the long-term average precipitation is shaded green.

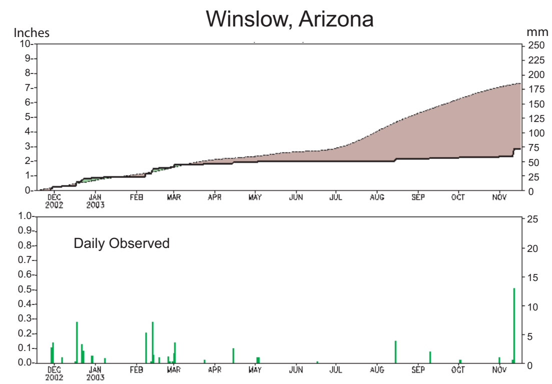
The green bars at the bottom of each of the pairs of graphs show the daily precipitation amounts (in both inches and millimeters) for the past year. Thus, one can get a sense of how frequent and intense individual precipitation events have been at the selected stations.

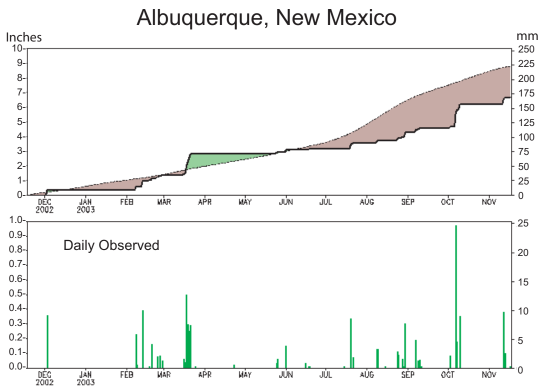
It is important to note that the scales for both the accumulated precipitation and the daily precipitation vary from station to station.

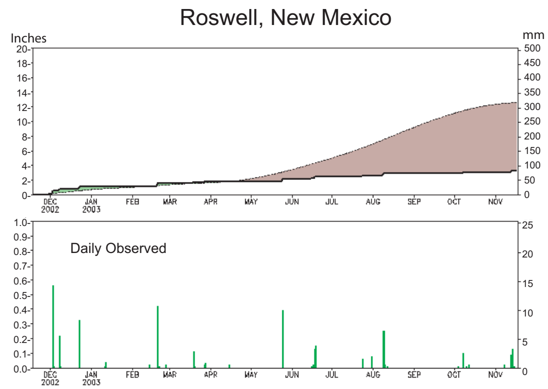
This type of graph is available for several other stations in Arizona and New Mexico as well as for many other places in the world. The graphs are updated daily by NOAA CPC at http://www.cpc.noaa.gov/products/global_monitoring/precipitation/global_precip_accum.html.

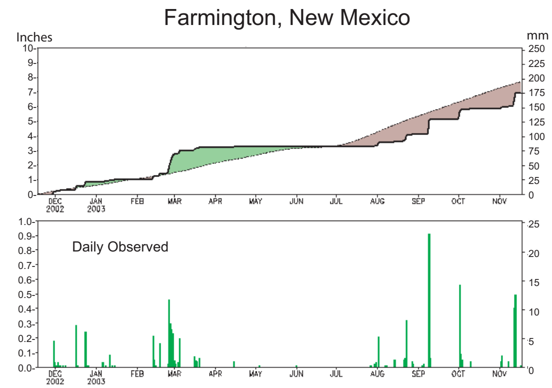


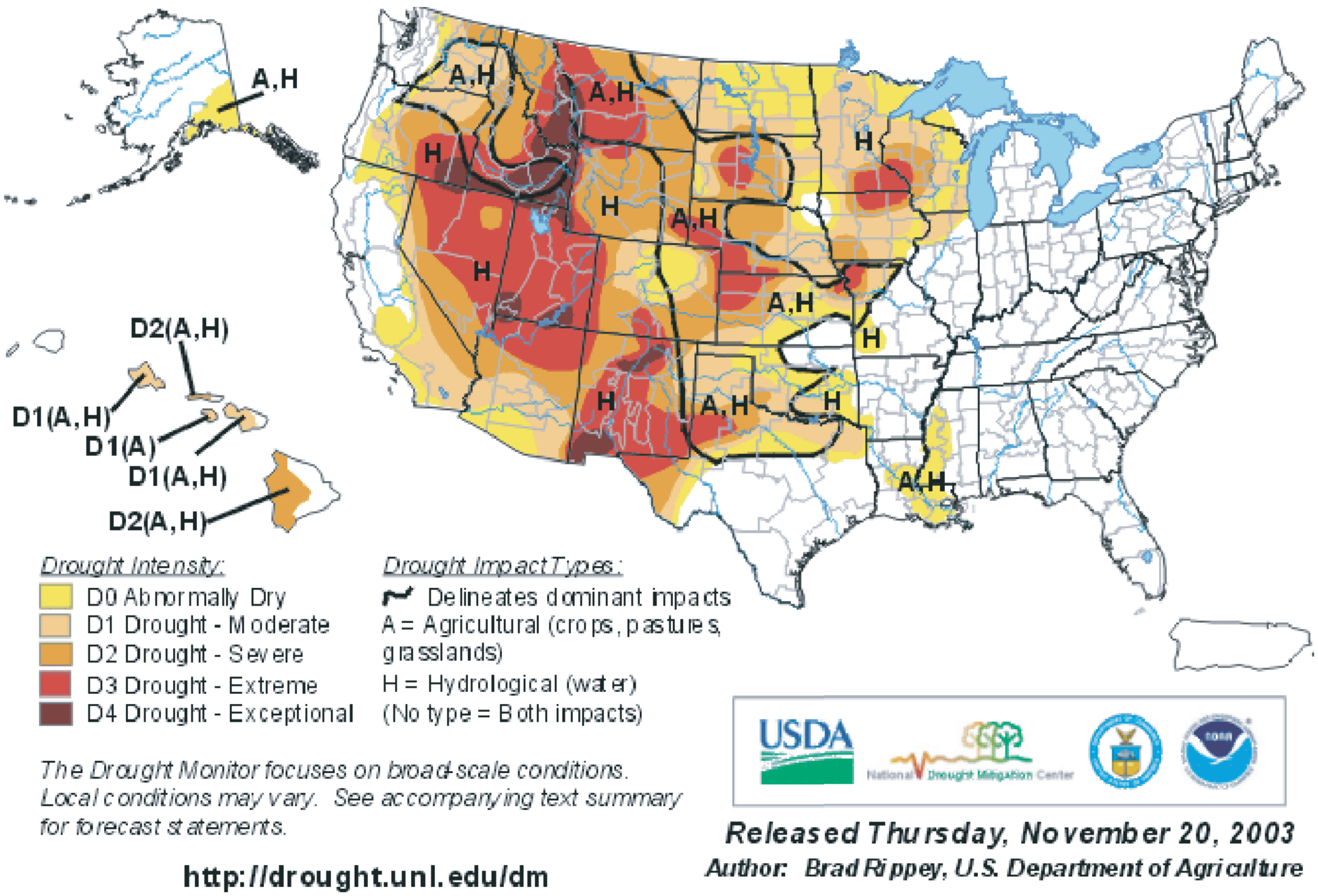



## 4. U.S. Drought Monitor (updated 11/18/03) Source: USDA, NDMC, NOAA




**Notes:**

The U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. This monitor was released on 11/20 and is based on data collected through 11/18.

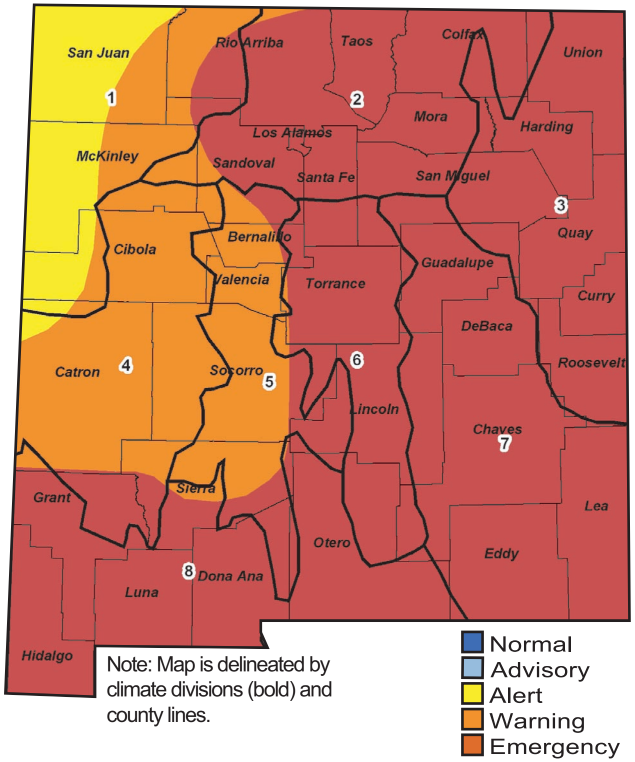
The best way to monitor drought trends is to pay a weekly visit to the U.S. Drought Monitor website (see left and below).

The U.S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) PDSI, soil moisture, stream flow, precipitation, and measures of vegetation stress, as well as reports of drought impacts.

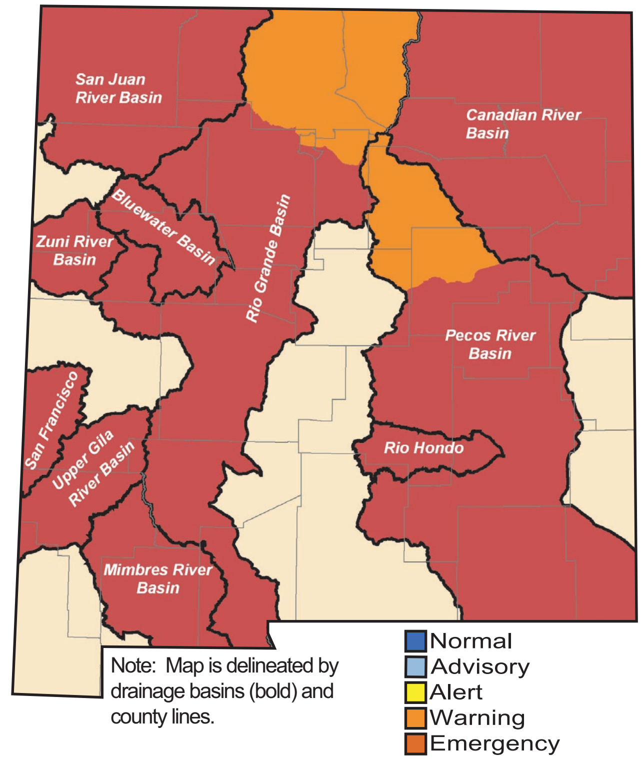
**Highlights**: There was little change in drought status of the southwestern United States as determined by the U.S. Drought Monitor. The changes from last month as shown here were mostly confined to a change in drought conditions from extreme (D3) to exceptional drought status (D4) in two areas of New Mexico: a portion of the Northern Mountains climate division in the Santa Fe area, which received only 70% of average rainfall in October; and much of the Southern Desert climate division around Animas and Truth or Consequences, which received 58% of average precipitation in October. The precipitation information comes from the National Weather Service Albuquerque Forecast Office (http://www.srh.noaa.gov/abq/climate/pcpn2003.htm). Compared to last month's map, the only change in Arizona is a change in drought conditions in Arizona's northeastern-most corner from severe (D2) to extreme drought conditions (D3). The Natural Resources Conservation Service's Nov. 21 weekly report of Snowpack/Drought Monitor Update, however, reported an improvement in drought conditions for parts of the Southwest, (primarily in the vicinity and south of the Mogollon Rim, stretching from central Arizona to western-most New Mexico).

# 5. Drought: Recent Drought Status for New Mexico (updated 11/21/03) ♦ Source: New Mexico NRCS

Meteorological Drought Map
Drought Status as of November 21, 2003



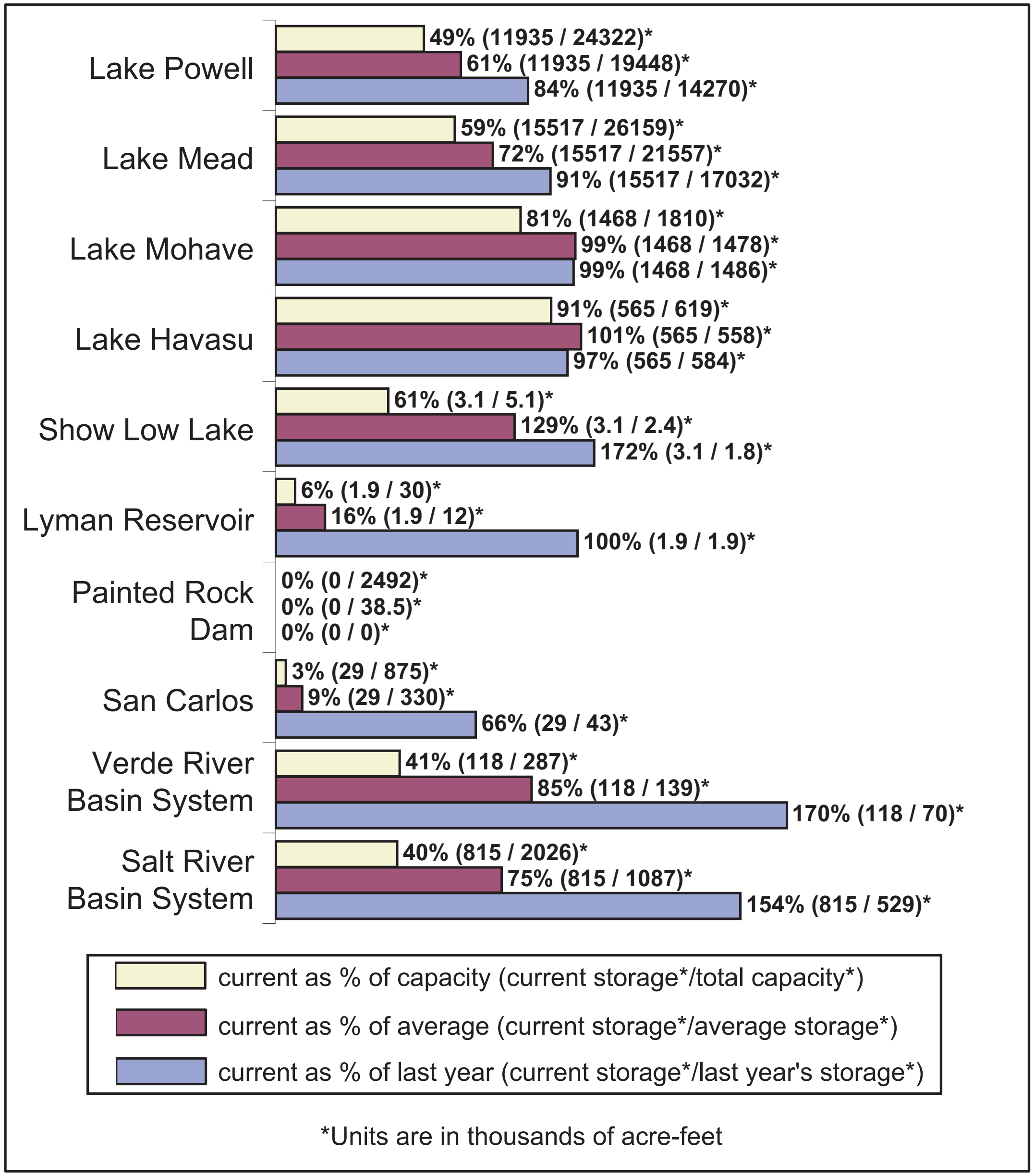

Hydrological Drought Map
Drought Status as of November 21, 2003




**Notes:** Despite relatively high rainfall in October over some of New Mexico, the drought persisted over much of the state and even worsened over its eastern third. For the eastern portion of New Mexico, the average temperature between Oct. 21 and Nov. 19 was generally 2 to 6 degrees Fahrenheit higher than the 1971-2000 average; precipitation during the same time frame was half or less of the 1971-2000 average. October precipitation was above average for three of New Mexico's climate divisions—the Central Valley, Central Highlands, and Southeastern Plains—but remained below average for the remaining five divisions. The lowest October precipitation values (58% of the 30-year average) were measured in the Southern Desert division, which includes Animas and Truth or Consequences. According to the USDA, 83% New Mexico range and pasture land is in poor or very poor condition. Streamflows are below average over most of New Mexico.

The New Mexico maps (http://www.nm.nrcs.usda.gov/snow/drought/drought.html) are currently produced monthly, but when near-normal conditions exist, they are updated quarterly. Information on Arizona drought can be found at: http://www.water.az.gov/gdtf/

## 6. Arizona Reservoir Levels (through the end of October 2003) Source: USDA NRCS



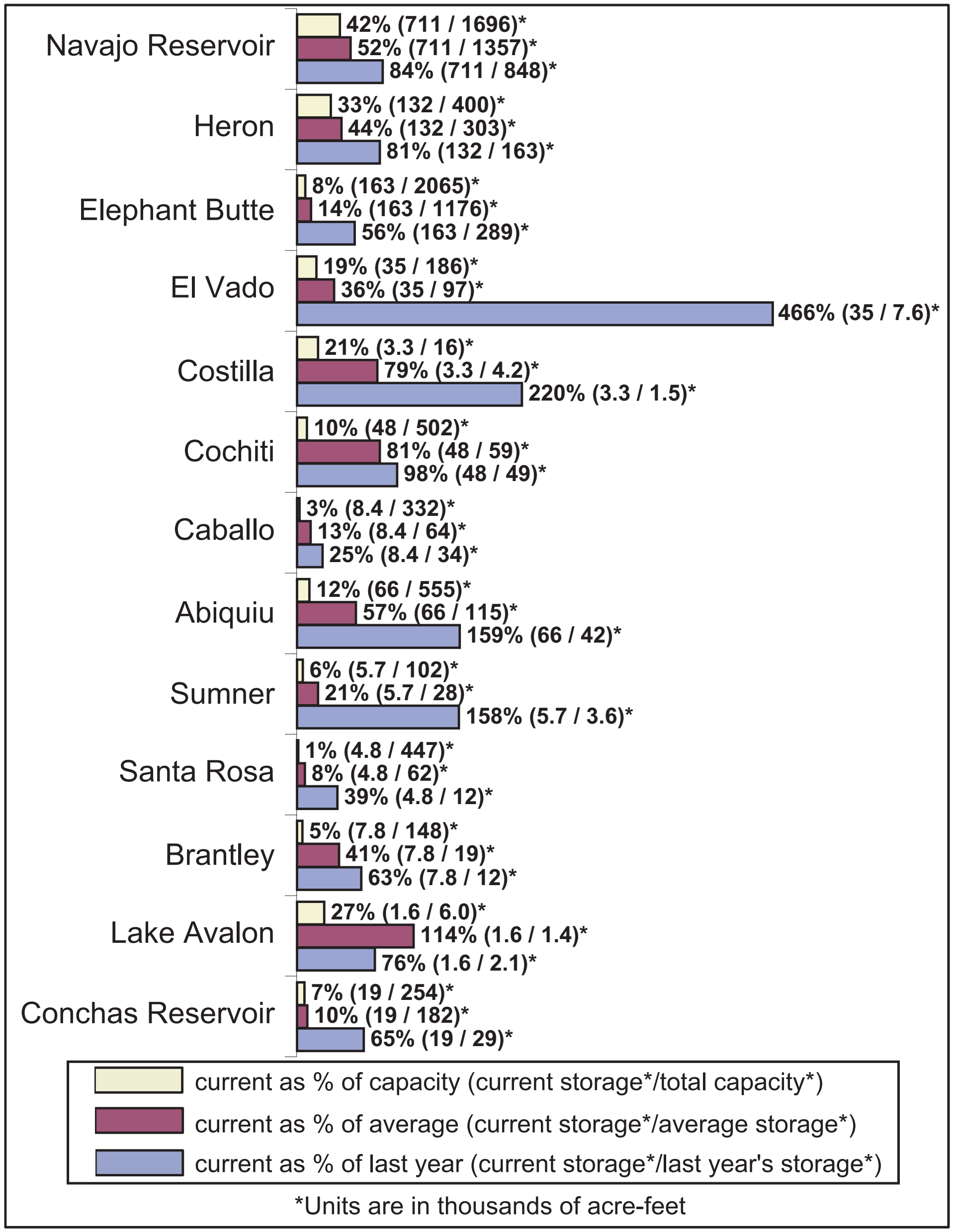

**Notes:** Reservoir reports are updated monthly and are provided by the National Water and Climate Center (NWCC) of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). Portions of the information provided in this figure can be accessed at the NRCS website:
http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html

As of 11/12/03, Arizona's report had been updated through the end of October.

For additional information, contact Tom Pagano of the NWCC-NRCS-USDA (tpagano@wcc.nrcs.usda.gov; 503-414-3010) or Larry Martinez, NRCS, USDA, 3003 N. Central Ave, Suite 800, Phoenix, Arizona 85012-2945; 602-280-8841; Larry.Martinez@az.usda.gov)

**Highlights**: Reservoir levels in Arizona (indicated at left) continued to decline during the month of October. About five of the reservoirs, including the Salt River Basin system, maintained stable levels relative to the previous month, with decreases of less than 1 percent or slight gains. The Verde River Basin system, however, dropped by about 14% compared to its level in the previous month, and several reservoirs along the Colorado River system—Lyman Reservoir, Lake Mohave, and Show Low Lake—dropped by approximately 10% compared to the previous month's levels.

## 7. New Mexico Reservoir Levels (through the end of October 2003) Source: USDA NRCS




**Notes:** Reservoir reports are updated monthly and are provided by the National Water and Climate Center (NWCC) of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). Reports can be accessed at their website:
(http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html).

As of 11/12/03, New Mexico's report had been updated through the end of October.

For additional information, contact Tom Pagano of the NWCC-NRCS-USDA (tpagano@wcc.nrcs.usda.gov; 503-414-3010) or Dan Murray, NRCS, USDA, 6200 Jefferson NE, Albuquerque, NM 87109; 505-761-4436; Dan.Murray@nm.usda.gov)

**Highlights**: Thanks to October precipitation that reached an average of 86% of the 1971-2000 average for New Mexico's eight climate divisions, some reservoirs in the state have begun to rise again.

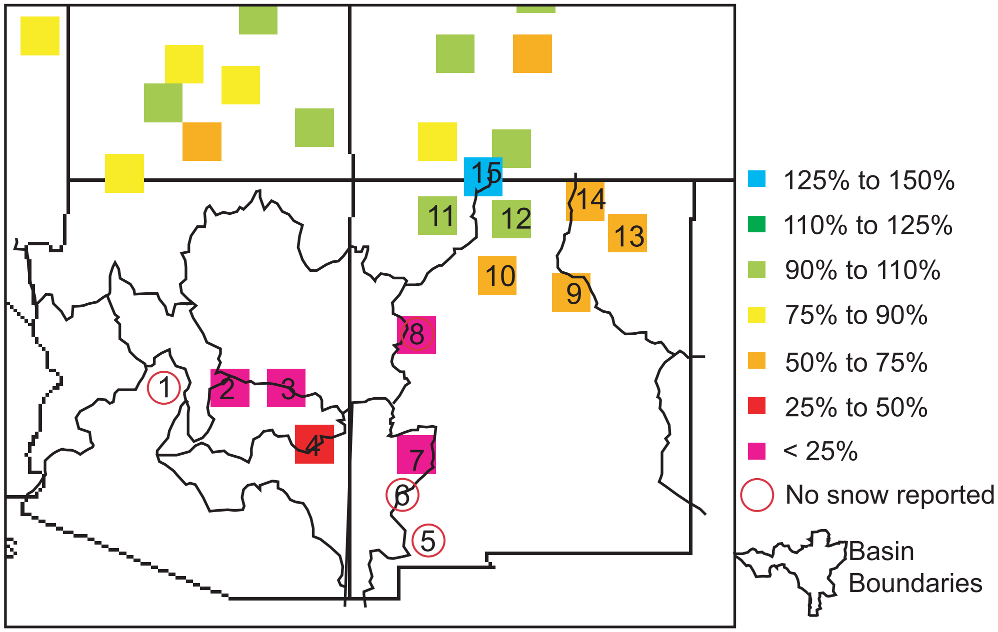
Lake Avalon, Costilla, Brantley, and Conchas reservoirs were among those that saw an increase in water storage by the end of October. However, levels continued to drop through the month in Navajo Reservoir, as well as Heron, El Vado, and Elephant Butte reservoirs.

A normal amount of precipitation this winter would not rescue the Navajo Reservoir, Interstate Stream Commission Director Norman Gaume said. In an Oct. 25 *Albuquerque Journal* story, he warned that there was a "substantial probability" the reservoir could drop of 300,000 acre-feet by July, placing it below a diversion point for the Navajo Irrigation Project.

Similarly, Truth or Consequences officials worried that precipitation patterns like those of the past two years would drain Elephant Butte Reservoir to below 1% of its capacity by next August. This means that southern New Mexico farmers would receive only about 20% of their normal allocation, according to an Oct. 31 *Albuquerque Journal* story.

# 8. Snowpack in the Southwestern United States (updated 11/24/03) Source: USDA NRCS, WRCC

8. Basin average snow water content (SWC) for available monitoring sites as of 11/24/03 (% of average).




**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

**Highlights**: As of November 24, 2003, four SNOTEL sites in three Arizona river basins are reporting measurable snow water content (SWE) values. Percent of average values at individual sites range from 33% to 121% (Snowslide Canyon in the San Francisco Peaks near Flagstaff), but actual SWE amounts are only a few inches. In New Mexico, 37 SNOTEL sites in eight basins are reporting measurable SWE. Percent of average values range from 11% to over 200%. Actual SWE amounts for New Mexico SNOTEL sites are only a few inches, but a handful of sites in the Upper Rio Grande and San Juan River basins are reporting over ten inches of SWE at this time. The Albuquerque National Weather Service office suggests that it would take many more snow-producing storms like the November 12-13 storm (see highlights for Figure 2 in this packet) in order to alleviate the drought.

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

For a numeric version of the SWC map, visit: http://www.wrcc.dri.edu/snotelanom/basinswen.html

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

**Notes:**

The data shown on this page are from snowpack telemetry (SNOTEL) stations grouped according to river basin. These remote stations sample snow, temperature, precipitation, and other parameters at individual sites.

Snow water content (SWC) and snow water equivalent (SWE) are different terms for the *same* parameter.

The SWC in Figure 8 refers to the snow water content found at selected SNOTEL sites in or near each basin compared to the *average* value for those sites on this day. *Average* refers to the arithmetic mean of annual data from 1971-2000. SWC is the amount of water currently in snow. It depends on the density and consistency of the snow. Wet, heavy snow will produce greater SWC than light, powdery snow.

Each box on the map represents a river basin for which SWC data from individual SNOTEL sites have been averaged. Arizona and New Mexico river basins for which SNOTEL SWC estimates are available are numbered in Figure 8. The colors of the boxes correspond to the % of average SWC in the river basins.

The dark lines within state boundaries delineate large river basins in the Southwest.

These data are provisional and subject to revision. They have not been processed for quality assurance. However, they provide the best available land-based estimates during the snow measurement season.

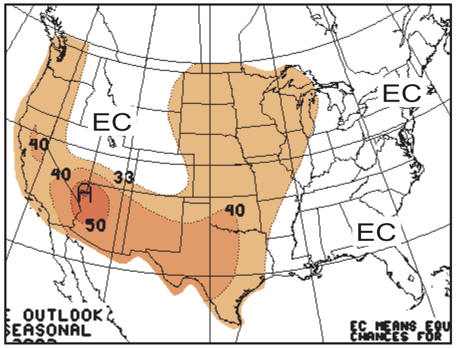
# Section C

# FORECASTS

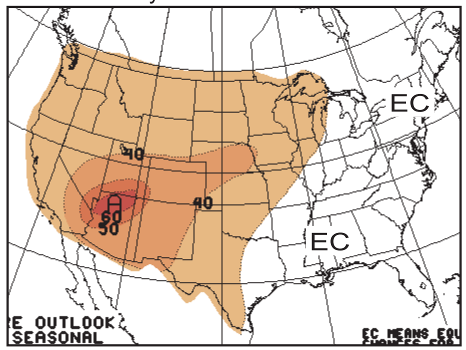
# 9. Temperature: Multi-season Outlooks ♦ Source: NOAA Climate Prediction Center

Overlapping 3-month long-lead temperature forecasts (released 11/20/03).

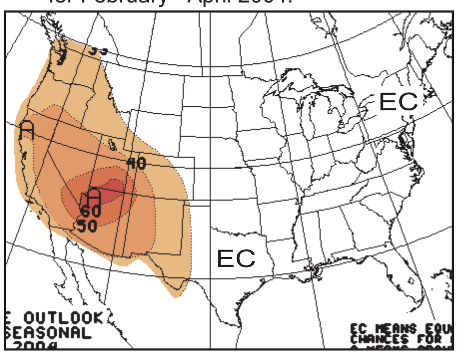
9a. Long-lead national temperature forecast for December 2003 - February 2004.



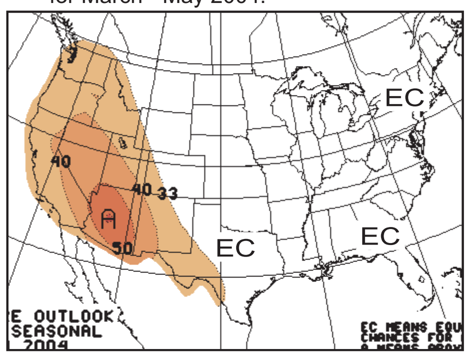

9b. Long-lead national temperature forecast for January - March 2004.




9c. Long-lead national temperature forecast for February - April 2004.




9d. Long-lead national temperature forecast for March - May 2004.




Percent Likelihood of Above and Below Average Temperatures*

- > 60%
- 50% - 59.9%
- 40% - 49.9%
- 33% - 39.9%

A = Above

*EC indicates no forecasted anomalies due to lack of model skill.

**Highlights:** The NOAA-CPC temperature outlooks for December 2003 through May 2004 forecast considerably increased probabilities of above-average temperatures for most of the Southwest (Figures 9a-d). The maximum likelihood of above-average temperatures (greater than 60%, which indicates only a 7% likelihood of below-average temperatures) is centered over northern Arizona for winter and early spring (Figures 9b-c). The CPC predictions are based on the agreement among long-term temperature trends for the region and indications from statistical models. In additon, the predictions indicate very good agreement among dynamical models regarding an atmospheric circulation pattern that favors high pressure (thus, high temperatures and low precipitation) over the West Coast. The International Research Institute for Climate Prediction (IRI) temperature forecasts (not pictured) also indicate significantly increased probabilities of above-average temperature for the southwestern United States, including a 50% likelihood of above-average temperatures centered over northern and western Arizona and during the entire December-May forecast period.

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

**Notes:**

The NOAA CPC (National Oceanic and Atmospheric Administration Climate Prediction Center) 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.

In a situation where there is no forecast skill, one might look at average conditions in order to get an idea of what might happen. Using past climate as a guide to average conditions and dividing the past record into 3 categories, there is a 33.3% chance of above-average, a 33.3% chance of average, and a 33.3% chance of below-average temperature.

Thus, using the NOAA CPC likelihood forecast, in areas with light brown shading there is a 33.3-40.0% chance of above-average, a 33.3% chance of average, and a 26.7-33.3% chance of below-average temperature.

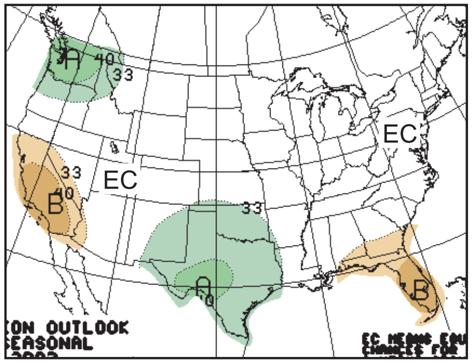
The term average refers to the 1971-2000 average. This practice is standard in the field of climatology.

Equal Chances (EC) indicates areas where reliability (i.e., the ‘skill’) of the forecast is poor and no anomaly prediction is offered.

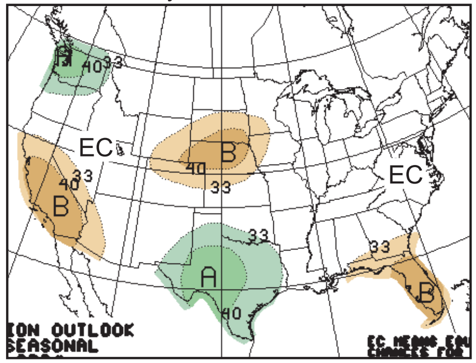
# 10. Precipitation: Multi-season Outlooks ♦ Source: NOAA Climate Prediction Center

Overlapping 3-month long-lead precipitation forcasts (released 11/20/03).

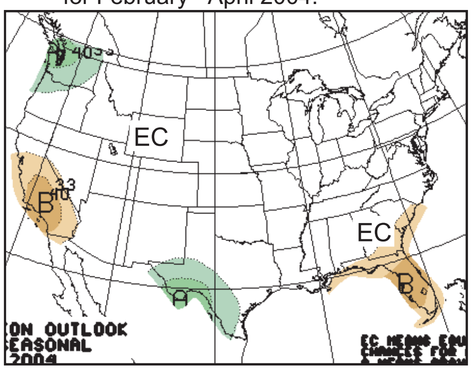
10a. Long-lead U.S. precipitation forecast for December 2003 - February 2004.



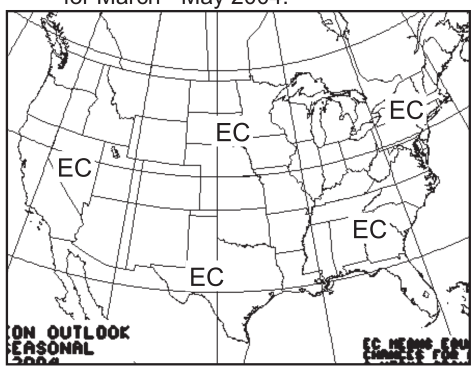

10b. Long-lead U.S. precipitation forecast for January - March 2004.




10c. Long-lead U.S. precipitation forecast for February - April 2004.




10d. Long-lead U.S. precipitation forecast for March - May 2004.




Percent Likelihood of Above or Below Average Precipitation*

> 40%
33% - 40%
A = Above

33% - 40%
> 40%
B = Below

*EC indicates no forecasted anomalies due to lack of model skill.

**Highlights**: NOAA-CPC forecasts for December 2003-March 2004 indicate slightly increased probabilities of below-average precipitation for the most western portions of Arizona, whereas slightly increased probabilities of above-average precipitation are predicted for eastern and southeastern New Mexico (Figures 10a-b). CPC forecasters have reserved judgment regarding precipitation in the Southwest for the late winter and early spring months (Figures 10c-d). These forecasts are based chiefly on insights from statistical and dynamical models. The December 2003-May 2004 IRI precipitation forecasts (not pictured) indicate slightly increased probabilities (40%) of below-average precipitation for the Southwest, covering most of the region for January-April 2004. An experimental forecast from the NOAA-Climate Diagnostic Center (not pictured), calls for a 38-48% likelihood of below-average precipitation across most of northern and eastern New Mexico this winter (January-March 2004). NOAA CPC climate outlooks are released on Thursday, between the 15th and 21st of each month.
For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html
Please note that this website has many graphics and may load slowly on your computer.
For more information about IRI experimental forecasts, visit: http://iri.columbia.edu/climate/forecast/net_asmt/

**Notes:**
The NOAA CPC (National Oceanic and Atmospheric Administration Climate Prediction Center) 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.

In a situation where there is no forecast skill, one might look at *average* conditions in order to get an idea of what might happen. Using past climate as a guide to average conditions and dividing the past record into 3 categories, there is a 33.3% chance of above-average, a 33.3% chance of average, and a 33.3% chance of below-average precipitation.

Thus, using the NOAA CPC likelihood forecast, in areas with light green shading there is a 33.3-40.0% chance of above-average, a 33.3% chance of average, and a 26.7-33.3% chance of below-average precipitation.

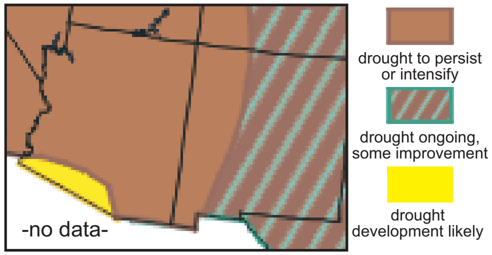
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

Equal Chances (EC) indicates areas where reliability (i.e., the 'skill') of the forecast is poor and no anomaly prediction is offered.

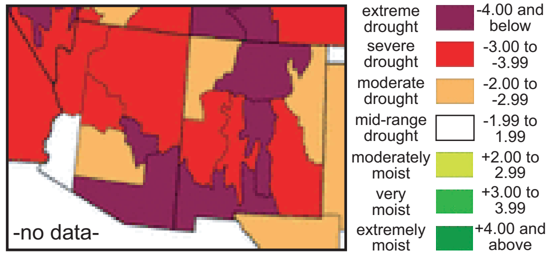
# 11. Drought: Seasonal Drought and PHDI Outlook Maps ♦ Sources: NOAA-CPC, NCDC

**Notes**:
The delineated areas in the Seasonal Drought Outlook (Fig. 11a) are defined subjectively and are based on expert assessment of numerous indicators, including outputs of short- and long-term forecasting models.

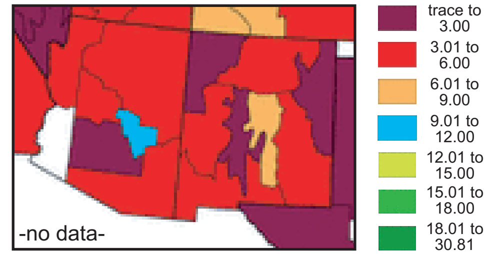
11a. Seasonal drought outlook through February 2004 (accessed 11/20).




11b. October 2003 PHDI conditions (accessed 11/20).



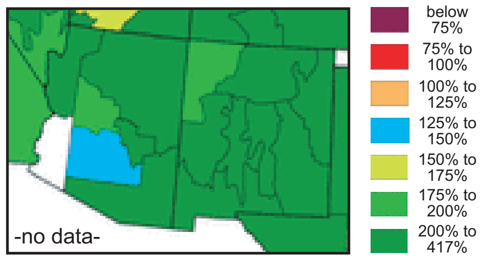

11c. Precipitation (in.) required to end current drought conditions in three months.



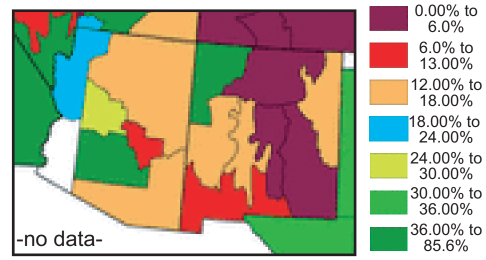

Figures 11b-e are based on the Palmer Hydrological Drought Index (PHDI), which reflects long-term precipitation deficits. PHDI is a measure of reservoir and groundwater level impacts, which take a relatively long time to develop and to recover from drought. Figure 11b shows the current PHDI status for Arizona and New Mexico.

Figure 11c shows the amount of precipitation, in inches, needed over the next three months to change a region's PHDI status to -0.5 or greater—in other words, to end the drought. Regions shown in white have a current PHDI value greater than –2.0 (e.g., in Figure 11b - e, these regions are not in hydrological drought).

11d. Percent of average precipitation required to end current drought conditions in three months.




11e. Probability of receiving precipitation required to end current drought conditions in three months.

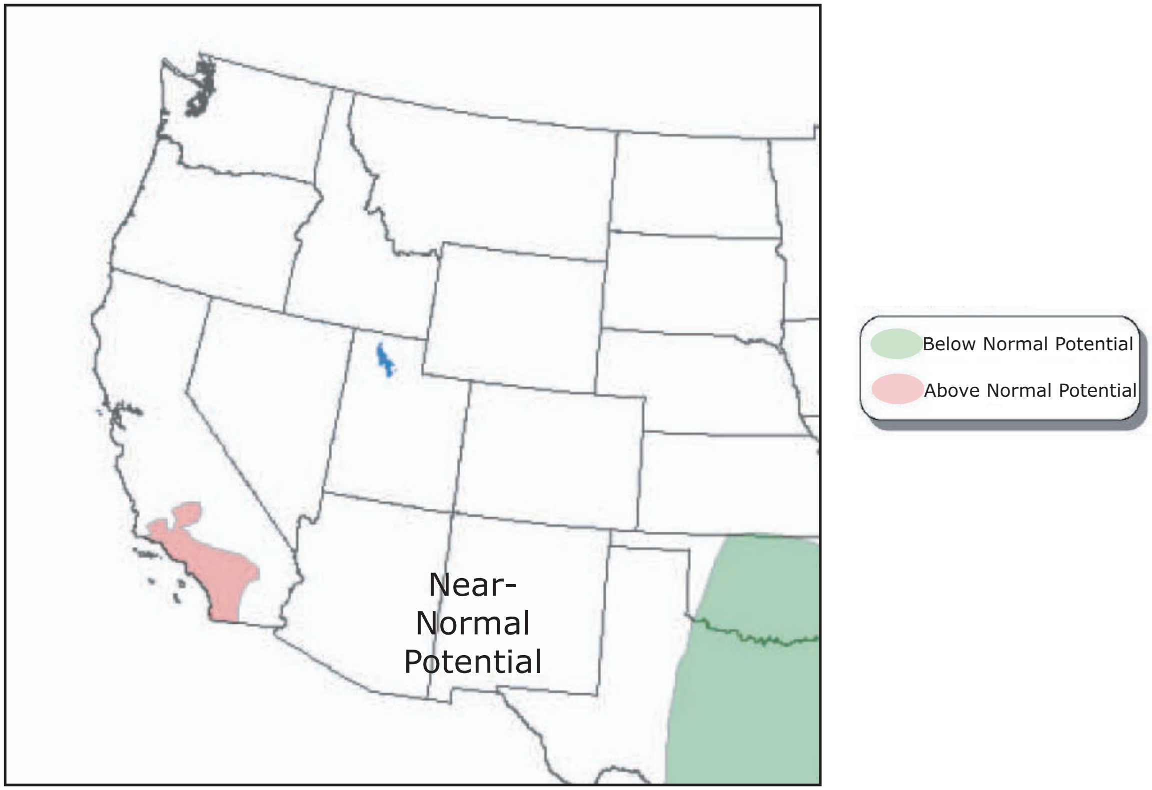



The season in which the precipitation falls greatly influences the amount of precipitation needed to end a drought. For example, during a typically wet season more precipitation may be required to end a drought than during a typically dry season. Also, because soil moisture conditions generally are lower in the dry seasons, the precipitation needed to bring soil conditions back to normal may be less than that required to return soil moisture conditions to normal during a generally wetter season. Figure 11d shows the percent of average precipitation needed to end drought conditions in three months, based on regional precipitation records from 1961–1990. A region that typically experiences extreme precipitation events during the summer, for example, may be more likely to receive enough rain to end a drought than a region that typically is dry during the same season. The seasons with the greatest probability of receiving substantially more precipitation than average are those subject to more extreme precipitation events (such as hurricane-related rainfall), not necessarily those seasons that normally receive the greatest average amounts of precipitation. Figure 11e shows the probability, based on historical precipitation patterns, of regions in Arizona and New Mexico receiving enough precipitation in the next three months to end the drought. Note that these probabilities do not take into account atmospheric and climatic variability (such as El Niño-Southern Oscillation), which also influence seasonal precipitation probabilities.

**Highlights:** Although drought conditions intensified for some parts of northwestern Arizona and northern New Mexico (11b), the probability of pulling out of drought generally improved for much of the Southwest with the advent of some October storms. The improvement is registered in a change of scale for Figure 11e. Last month, six of the seven categories represented values of 9% or below, compared to less than two categories this month.

For more information, visit: http://www.drought.noaa.gov/ —and— http://www.ncdc.noaa.gov/oa/climate/research/drought/drought.html

## 12. National Wildland Fire Outlook ♦ Source: National Interagency Coordination Center



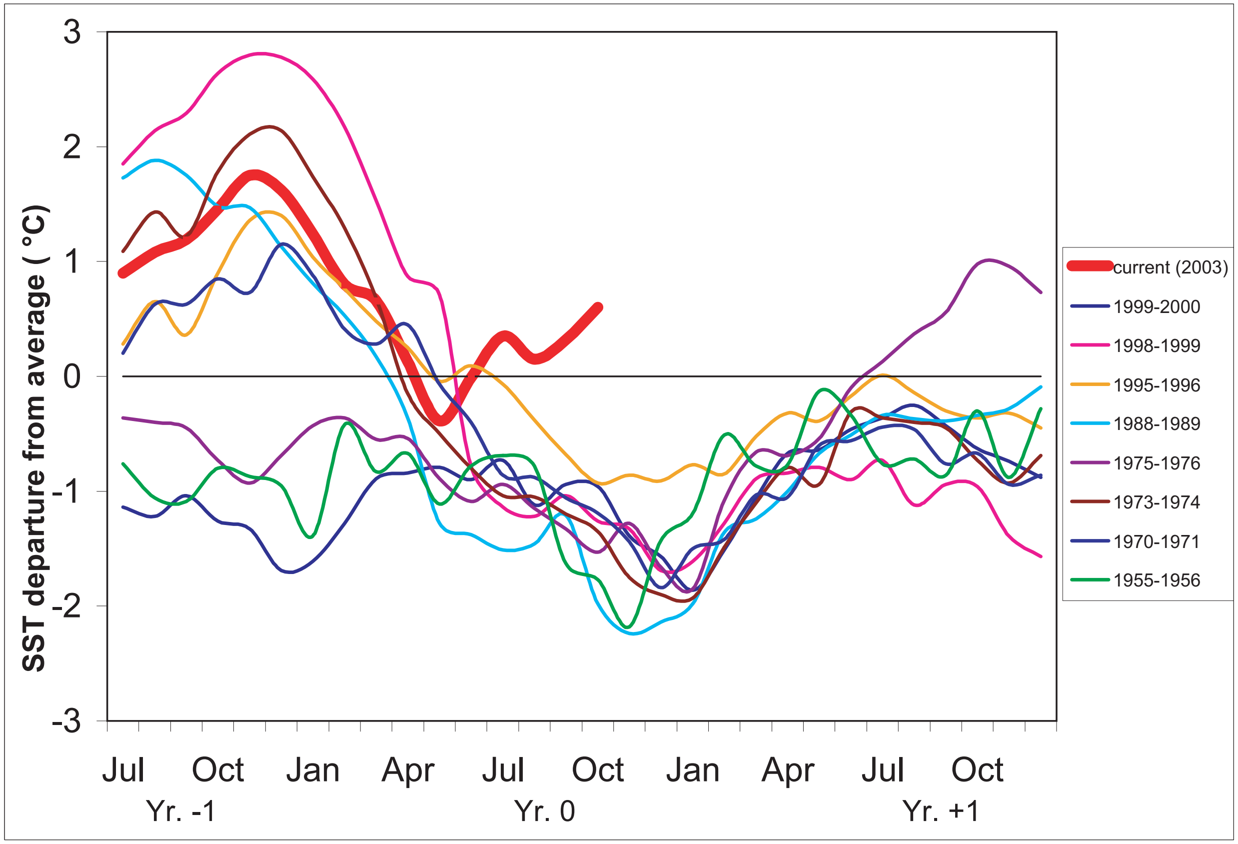

**Notes:** The National Interagency Coordination Center (NICC) at the National Interagency Fire Center (NIFC) produces monthly (Figure 12) wildland fire outlooks. These forecasts consider climate forecasts and surface-fuels conditions in order to assess fire potential. They are subjective assessments, based on synthesis of regional fire danger outlooks.

**Highlights**: The November 1-30, 2003 NICC wildfire outlook is for near-normal fire potential for Arizona and New Mexico. The Southwest Coordination Center (SWCC) forecast (not pictured) indicates normal-to-above-normal fire danger potential for much of our region in an area stretching from northwestern Arizona, southeast to the West Texas-southeastern New Mexico border. The SWCC forecast notes that the elevated fire danger levels "are not expected to be critical enough to support long-term significant large fire activity." As of November 24, 2003, observations of large fuel moisture readings (so-called 1000-hour fuels) for the Southwest (not pictured) indicate relatively low fuel moisture across southern Arizona and most of New Mexico. In addition, as of November 24, 2003, a daily snapshot of the National Fire Danger Rating System (NFDRS) fire danger rating indicates that fire danger in southeastern Arizona and southern New Mexico is high; the NFDRS fire danger rating for southeastern New Mexico (not pictured) is very high. The NFDRS rating for most of Arizona and northern New Mexico is moderate.

For more detailed discussions, visit the National Wildland Fire Outlook web page: http://www.nifc.gov/news/nicc.html
and the Southwest Area Wildland Fire Operations (SWCC) web page: http://www.fs.fed.us/r3/fire/
For an array of climate and fire assessment tools, visit the Desert Research Institute program for Climate, Ecosystem, and Fire Applications (CEFA) web page:
http://cefa.dri.edu/Assessment_Products/assess_index.htm

# 13. Tropical Pacific Sea Surface Temperature Forecast Sources: NOAA-CPC, IRI

13. Current (red) and past La Niña event sea surface temperature anomalies (°C) for the Niño 3.4 monitoring region of the equatorial Pacific ocean.




**Notes:** The graph (Figure 13) shows sea-surface temperature (SST) departures from the long-term average for the Niño 3.4 region in the central-eastern equatorial Pacific Ocean. SSTs in this region are a sensitive indicator of ENSO conditions.

Each line on the graph represents SST departures for previous La Niña events, beginning with the year before the event began (Yr. –1), continuing through the event year (Yr. 0), and into the decay of the event during the subsequent year (Yr. +1).

The most recent SST departures are plotted as a thick red line. The magnitude of the SST departure, its timing during the seasonal cycle, and its exact location in the equatorial Pacific Ocean are some of the factors that determine the degree of impacts experienced in the Southwest.

**Highlights:** Sea-surface temperatures (SSTs) remained slightly above-average for most of the tropical Pacific Ocean. By the end of October, positive SST anomalies were observed in all Niño monitoring regions; however, lower-atmosphere winds and other ENSO indices do not show any significant trends and support forecasts for ENSO-neutral conditions. The International Research Institute for Climate Prediction (IRI) probabilistic forecast shows an 83% chance of neutral, a 15% chance of El Niño, and a 3% chance of La Niña conditions for December 2003-February 2004. A majority of the NOAA-CPC's statistical and coupled model forecasts also indicate near neutral conditions (Niño 3.4 SST anomalies between -0.5°C and +0.5°C) for the remainder of 2003 and early 2004. According to NOAA's Climate Prediction Center, weak El Niño conditions might develop by spring 2004 if persistent enhanced cloudiness and rainfall develops in the vicinity of the International Date Line, accompanied by weaker-than-average low-level easterly winds over the central and western equatorial Pacific.

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 figure above, visit: http://iri.columbia.edu/climate/ENSO/

# 14. Precipitation Verification: August – October 2003 ♦ Source: NOAA Climate Prediction Center

Figure 14a. Long-lead U.S.precipitation forecast for August - October 2003

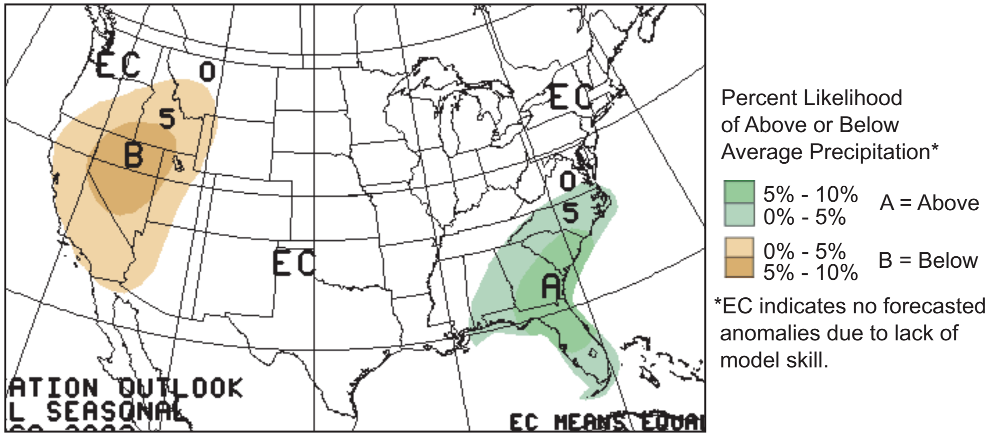



Figure 14b. Observed precipitation for August - October 2003 (inches).

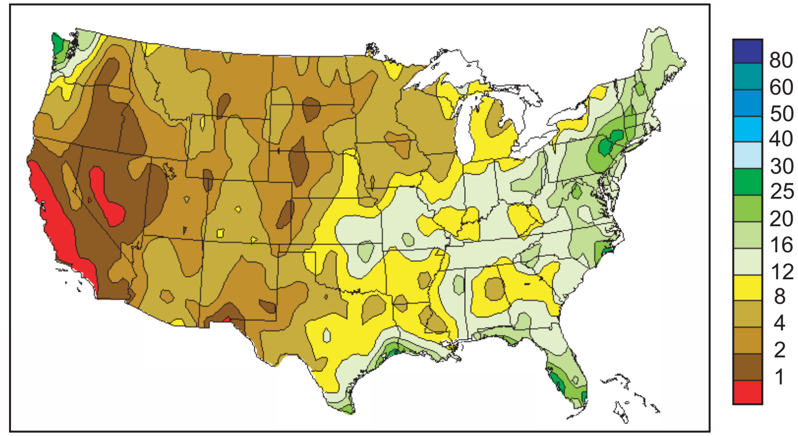
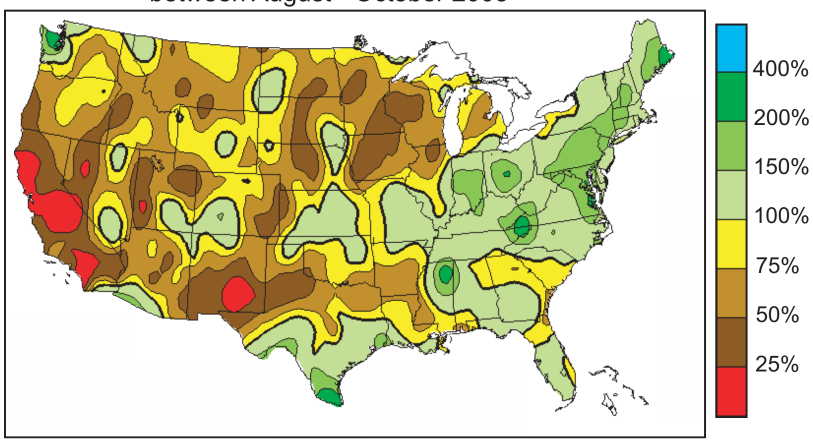



Figure 14c. Percent of average precipitation observed between August - October 2003




**Highlights:** The NOAA-CPC August-October 2003 precipitation outlook forecast slightly increased probabilities of below-average precipitation for western Arizona. Most of Arizona and New Mexico received below-average precipitation during the forecast period. However, southwestern Arizona received above-average precipitation. Overall, the forecast was accurate for most of the two regions for which a forecast was made (i.e., the western and southeastern United States).

**Notes:** Figure 14a shows the NOAA Climate Prediction Center (CPC) precipitation outlook for the months August–October 2003. This forecast was made in July 2003.

The August–October 2003 NOAA CPC outlook predicts the excess likelihood (chance) of above-average, average, and below-average precipitation, but not the magnitude of such variation. The numbers on the forecast map (Figure 14a) 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% chance of above-average, a 33.3% chance of average, and a 33.3% chance of below-average precipitation. Thus, using the NOAA CPC likelihood forecast, in areas with light green shading there is a 33.3-38.3% chance of above-average, a 33.3% chance of average, and a 28.3-33.3% chance of below-average precipitation. Equal Chances (EC) indicates areas where reliability (i.e., the skill) of the forecast is poor and no excess likelihood prediction is offered.

Figure 14b shows the total precipitation observed between August–October 2003 in inches. Figure 14c shows the observed percent of average precipitation for August–October 2003.

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.

# 15. Temperature Verification: August – October 2003 ♦ Source: NOAA Climate Prediction Center

Figure 15a. Long-lead U.S. temperature forecast for August - October 2003

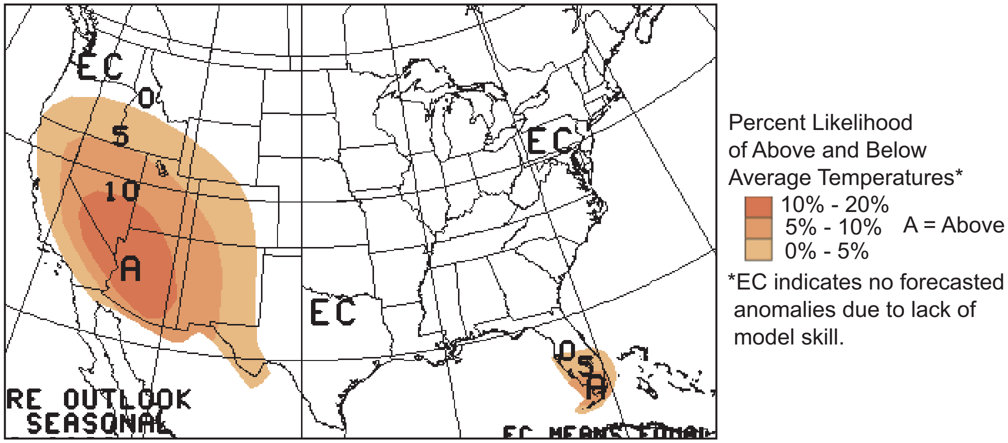



Figure 15b. Average Temperature (in °F) for August - October 2003

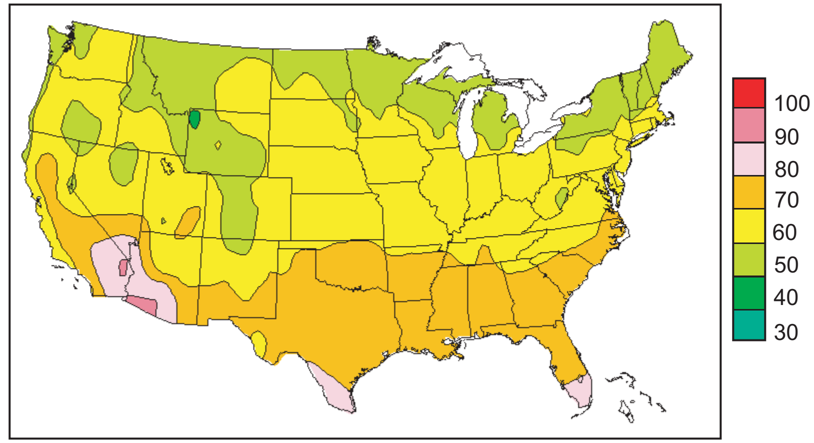
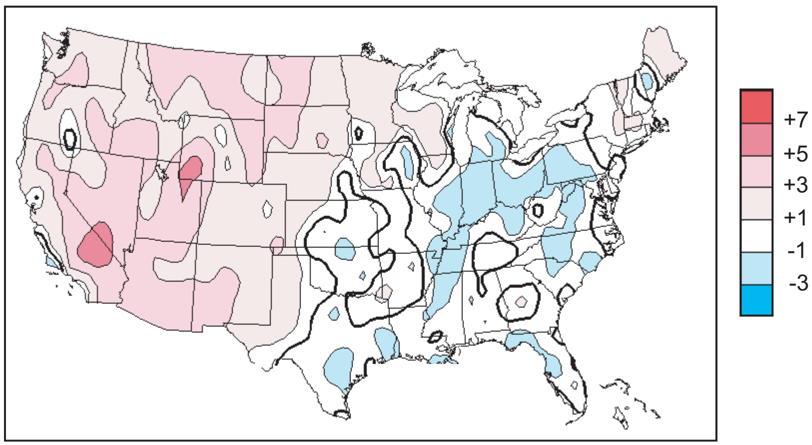



Figure 15c. Average Temperature Departure (in °F) for August - October 2003




**Highlights:** The NOAA-CPC August-October 2003 temperature outlook forecast increased probabilities of above-average temperature for our region, with the greatest probabilities stretching across Arizona. Figure 15c shows that all of our region displayed above-average temperatures during the forecast period. Most of the region with the highest forecast probabilities did experience temperatures 3-5 °F above average. NOAA-CPC forecasts for southern Florida, however, were not accurate.

**Notes:** Figure 15a shows the NOAA Climate Prediction Center (CPC) temperature outlook for the months August–October 2003. This forecast was made in July 2003.

The August–October 2003 NOAA CPC outlook predicts the excess 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 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% chance of above-average, a 33.3% chance of average, and a 33.3% chance of below-average temperature. Thus, using the NOAA CPC likelihood forecast, in areas with light brown shading there is a 33.3-38.3% chance of above-average, a 33.3% chance of average, and a 28.3-33.3% chance of below-average precipitation. Equal Chances (EC) indicates areas where reliability (i.e., the skill) of the forecast is poor and no excess likelihood prediction is offered.

Figure 15b shows the observed average temperature between August–October 2003 (°F). Figure 15c shows the observed departure of temperature (°F) from the average for August–October 2003.

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.