Issued: December 21, 2004

CLIMAS
Southwest Climate Outlook

December 2004 Climate Summary

Hydrological Drought – Hydrological drought continues in Arizona and much of New Mexico.

- Storage in many reservoirs held nearly steady or increased slightly this month.
- Northeastern and central Arizona and northwestern New Mexico remain in extreme drought, while conditions in northwestern Arizona improved slightly.

Precipitation – Western Arizona and eastern New Mexico have received from 400–800 percent of average precipitation during the water year. Snowpack is also above average in many Southwest river basins.

Temperature – Water year temperatures are near average in the Southwest. The past 30 days have been cooler than average.

Climate Forecasts – Long-lead forecasts call for increased chances of above-average temperatures in Arizona and western New Mexico for the next 6 months. Increased chances of wetter-than-average conditions are predicted through May 2005.

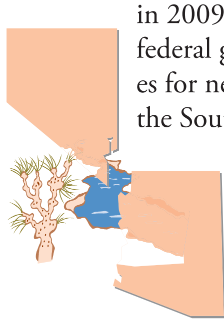
El Niño – Sea surface temperatures in the tropical Pacific Ocean remain indicative of a weak El Niño, which is expected to continue until May 2005.

The Bottom Line – The Southwest is expected to see limited improvement in drought conditions through early 2005, although reservoir levels are forecasted to remain low.

The climate products in this packet are available on the web:
http://www.ispe.arizona.edu/climas/forecasts/swoutlook.html

Water Rights

On December 16, final approval came on a deal between Arizona and Nevada in which Nevada may buy up to 1.25 million acre-feet of Arizona's allotment of Colorado River water at a total cost of $330 million over many years (*San Francisco Gate*, December 16). The money, which will be paid in a $100 million payment in 2005 and ten $23 million installments beginning in 2009, will come from bond revenue, federal grant money, connections charges for new customers, and a fund from the Southern Nevada Water Authority (*Las Vegas Review-Journal*, December 10). Nevada will also support Arizona's effort to protect Central Arizona Project's water allotment (*Arizona Republic*, December 3).



For more information on water rights see page 9…

In this issue:

The Southwest Climate Outlook is jointly published each month by the Climate Assessment for the Southwest project and the University of Arizona Cooperative Extension.

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The University of Arizona

The future Colorado River: Will it deliver?

Rising temperatures will put stress on both supply and demand

BY MELANIE LENART

Climate change could further humble the mighty Colorado, already bowed by the ongoing drought and shrunken by a growing population of Arizona users.

Currently, the Colorado River meets about two-fifths of Arizona's water needs, with groundwater providing another two-fifths and other rivers supplying most of the remaining demand. But the potential for rising temperatures to decrease the amount of water supplied by the Colorado while simultaneously increasing overall water demand has spread ripples of concern among those who monitor and model the Colorado and other Arizona water sources.

Much of Arizona's Colorado water flows through an open canal system known as the Central Arizona Project (CAP), which delivers river water to Phoenix, Tucson, and other cities, explained Katharine Jacobs during a December press briefing on warming and water supply that was organized by two University of Arizona groups: the Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) and the Climate Assessment for the Southwest (CLIMAS).

"In the context of Assured Water Supply determinations, the Arizona Department of Water Resources uses an assumption that the CAP is a reliable supply," said Jacobs, who worked for the ADWR for more than 20 years before joining the UA faculty last year. Under the Assured Water Supply determinations that apply to new subdivisions in central Arizona metropolitan areas, developers must show on paper that there's enough water to support their proposed subdivisions for 100 years.

The current drought already is challenging that assumption, as CAP water users would be the first to have their water supply reduced if a shortage were declared in the Lower Basin states of Arizona, Nevada, and California. The ongoing warming of the atmosphere adds to the uncertainty of the Southwest's water future, Jacobs explained.

"The big issue is whether we can store enough water to offset longer drought periods than we previously anticipated," she said.

Reservoir storage in Lake Powell and Lake Mead totaled about 23 million acre-feet as of Dec. 15, although only about three-fourths of what remains is accessible. In addition, Arizona has "banked" about 2 million acre-feet of Colorado water via groundwater recharge and other programs since 1996, said Timothy Henley, manager of the Arizona Water Banking Authority.

Reconstructions of past droughts based on tree-ring records indicate that two rivers supplying Phoenix with water, the Colorado and the Salt, can be in drought simultaneously, as CLIMAS Project Manager Gregg Garfin noted during the briefing, showing preliminary results of an analysis by Katherine Hirschboeck and David Meko of the University of Arizona Laboratory of Tree-Ring Research. The final results of the study are expected to be released publicly in early 2005 by the Salt River Project.

Governor Janet Napolitano also sees a connection between warming temperatures and regional water supplies and noted her concern in an aside following a Water Listening Session in Tucson last week.

"I'm concerned about climate change in a lot of different ways. I think the drought is certainly an outgrowth of climate change," the governor said, adding that she believed national legislation was needed to address the problem. Nationally, the bipartisan "Climate Stewardship Act," cosponsored by Arizona Senator John McCain, calls for reduced emissions of carbon dioxide and other greenhouse gases that trap heat at the surface.

Greenhouse warming is expected to bump up the average annual temperature in the Southwest by about 3 to 4 degrees Fahrenheit over the next 45 years, according to an analysis by Martin Hoerling, Jon Eisheid, and Gary Bates of the National Oceanic and Atmospheric Administration (NOAA) that involved averaging four different global climate models.

The link between greenhouse gases and temperature is fairly predictable. Long-term temperature fluctuations tend to go up and down with atmospheric carbon dioxide levels in time, and temperature projections for the future mirror the growing accumulation of carbon dioxide and other greenhouse gases in the atmosphere.

The relationship between temperature increases and precipitation is less certain. While some climate models predict an increase in precipitation for the Southwest, others predict a decrease or a lack of change. However, most predict a greater proportion of rain compared to snow as spring arrives earlier in the year and fall lingers later. The decline in snow days could affect overall streamflow, as the Colorado River depends upon spring snowmelt for much of its annual volume (Figure 1).

But even if precipitation rates remained the same—or increased only somewhat—the projected change in temperature alone would impact water supplies, Jacobs noted at the briefing. An increase

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Colorado River, continued

in annual temperature by 4 degrees Fahrenheit, as predicted by the NOAA analysis, could translate into a 5 percent or more increase in evaporation rates, based on calculations by Paul Brown of the UA's Arizona Meteorological Network, she pointed out.

Evaporation from streams and reservoirs consumed about 113 billion gallons (0.35 million acre-feet) in the Lower Basin from Hoover Dam on down during 2002, not counting the CAP system, based on figures in a U.S. Bureau of Reclamation report. A 5 percent increase would boost the amount lost to evaporation by another 5.6 billion gallons annually, enough water to theoretically support 70,000 southwestern residents. (There are about 326,000 gallons in each acre-foot of water, enough to support an average family of four for a year.)

Evaporation occurring before the water reaches the Colorado riverbed may prove even more important as climate warms. Evidence indicates the temperature increases will make the river more sensitive to changes in timing and amount of snow and rain, mainly by affecting the rate of water flowing from overland soils to streams, known as runoff.

Basically, drier soils tend to absorb more of the water inching toward streams, much as a dry sponge captures more moisture than a wet one.

For instance, a hydrological model developed by University of Washington researchers to represent the years 2010 to 2098 found allocations to the Lower Basin states could fall short one-fourth of the time in their climate change scenario. They paired the projected increasing temperatures with fluctuating precipitation rates that averaged about 4 percent lower than the norm for 1950 to 1999. This slight decline in precipitation yielded a 16 percent reduction in runoff.

The University of Washington model did not simulate a potential increase of rain-on-snow events, on the other hand. These events can cause floods that help fill reservoirs, although reservoir gains from these events tend to mean losses in groundwater recharge. At any rate, the sensitivity of the system should concern water managers, the authors note in their *Climatic Change* paper (March, 2004).

"The bottom line implication of the paper is that the system is in a very fragile equilibrium. Very small changes in precipitation are able to reduce the runoff so the system is no longer in equilibrium," explained Professor Dennis Lettenmaier, one of the five researchers who designed and tested the model.

Runoff tends to decline at a faster rate than precipitation decreases, in reality as well as in their model. For instance, the mere 1 percent decrease in precipitation in the Colorado River Basin during 1995 that they cite in their paper translated into a roughly 7 percent drop in basin-wide streamflow that year, based on U.S. Bureau of Reclamation data.

Meanwhile, warming temperatures are likely to increase demand for water by both agricultural and urban users, as Jacobs and SAHRA colleague Gary Woodard noted during the briefing. Agriculture accounts for about 70 percent of Arizona's water use and 80 percent of the state's Colorado River use. Applying the 80 percent ratio to Arizona's annual allocation of 2.8 million acre-feet would make this about 730 billion gallons.

Of this, about 400 billion gallons of water a year evaporate from croplands, judging from USBR data for 2002. The 5 percent increase in evaporation rates that could accompany a 4-degree-Fahrenheit temperature increase, then, could consume roughly 20 billion additional gallons.

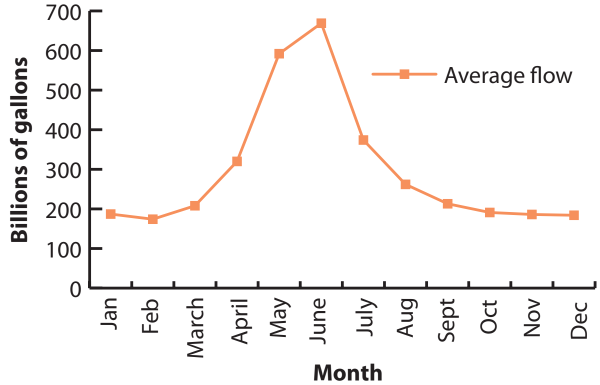


Figure 1. Values for average monthly flow of the Colorado River, above, are based on U.S. Bureau of Reclamation monthly reconstructions for 1922–2003, using actual measurements of streamflow at Lee's Ferry, Arizona, coupled with reports of withdrawals by Upper Basin users. Most of the Colorado's volume comes during spring and summer, as snow melts on the Rocky Mountain peaks that provide the bulk of the river's volume. This makes the river sensitive to changes in snow cover.

At the same time, higher temperatures will stretch out the growing season, as spring comes earlier and fall stays later. This can lead to increased water demand for urban landscaping, Woodard said. Although the higher carbon dioxide levels actually improve the water efficiency of plants, the potential water savings from this factor may well be lost to the longer growing season, he said.

Higher evaporation rates will boost water demand among pool owners as well. Further, higher temperatures will increase the demand for electrical power, which consumes water through cooling towers, Woodard noted. Cooling towers become less efficient with warmer temperatures, he added.

The future Colorado River could be stretched thin for other reasons in addition to rising temperatures, including policy changes and growing population. At this point, Arizona is using all of its annual allocation (Figure 2), although some of it goes for groundwater recharge programs.

continued on page 4

Colorado River, continued

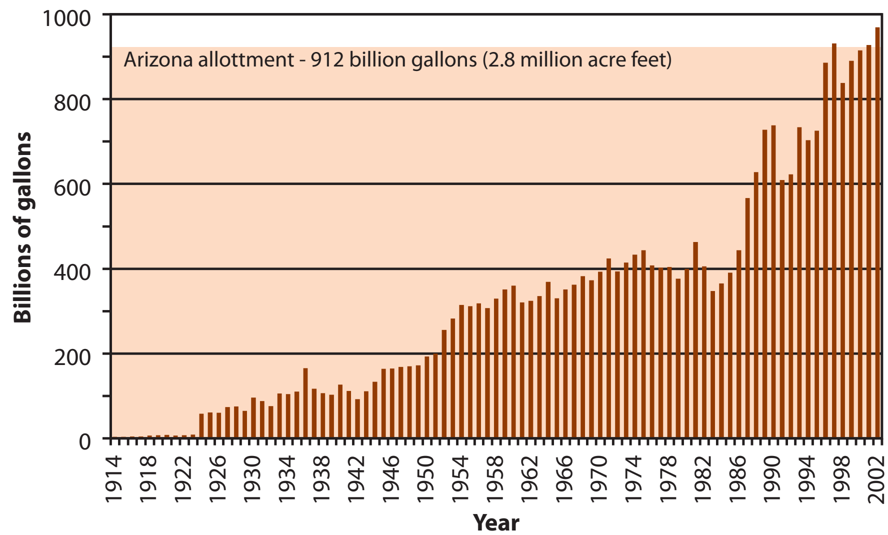


Figure 2. The proportion that Arizona uses of its 2.8-million-acre-feet Colorado River allocation has climbed in recent years. In years of declared surplus, it can even exceed the allocation. Some of the increase in use since 1996, however, relates to "banked" Colorado water as part of an Arizona program to recharge groundwater. Source: U.S. Bureau of Reclamation data.

Tribal needs will be a source of demand in years to come. This increase will expand as officials from many sides negotiate and litigate to implement a policy that has technically been on the books for decades: carrying out the promise to share Colorado River water with the American Indians living on Arizona's many reservations.

By some accounts, the annual amount of Colorado water owed to the various tribes surpasses the 2.8 million acre-feet allocated to the entire state. By all accounts, tribal rights to a share of the Colorado can only increase in years to come. Legal wrangling continues while some reservation residents continue to haul water to their homes.

When groundwater is factored in, most of the increasing demand for water in the future seems likely to come from population growth as developers build new subdivisions around the state.

"We anticipate that the Arizona population will continue to grow at the rate it has in the last decade," the governor told those attending the Water Listening Session in Tucson. A repeat of the last decade's 37 percent increase would grow the state population to about 8 million people by 2014, up from 5.8 million in 2004, according to statistics from the Arizona Department of Economic Security.

Although public officials tend to talk about population growth as though it's unavoidable, some area residents aim to slow the pace to a "managed growth."

For instance, 6 of the 17 people who addressed the governor during the listening session cited concerns that nearby developments were threatening local groundwater stores, and most of these comments received a hearty round of applause from the 100-plus people in attendance. Conservation of water and riparian areas was the only theme that received more commentary, with nine people weighing in, not counting those who pointed accusing fingers at golf courses. A few tackled both conservation and population growth.

"Existing people have to reduce their existing use in order to allow other people to come in," said area resident Tricia Gerrodette, who likened living amid the limited resources in the desert to being on a lifeboat. "At some point, if you allow too many people on that lifeboat, everyone will die."

Humans have the advantage of being able to walk, drive, or fly away from a region with dwindling water resources, but many other species are less fortunate. The ongoing climate change could prove fatal for some native riparian species, especially when coupled with the continuing diversion of water out of the river and into cities and croplands.

For human residents of the Southwest, the likely outcome of future shortages is an increase in the cost of water as the regional bidding for a scarce resource becomes more competitive.

As Robert Glennon, a UA law professor and the author of "Water Follies" noted, planners of a resort near the Grand Canyon would have been willing to shell out $20,000 to buy and transport each acre-foot of delivered surface water. (The deal fell through following a Sierra Club lawsuit.) That's quite an increase from the $15 an acre-foot typically paid by an Arizona farmer, he pointed out.

"This development offers a clear vision of what lies ahead. Water is worth a lot more money than people have realized," he wrote in his 2002 book. "Even though water is a scarce commodity, most Americans have not yet faced the conditions that economists call scarcity, which occurs when people alter their consumption patterns in response to price increases."

Southwesterners can expect the era of cheap water to end in the next decade or so, given the guaranteed increase in demand and the likely decrease in supply facing the growing number of users of the Colorado River in Arizona.

Melanie Lenart is a postdoctoral research associate with CLIMAS. For more on the connection between climate change and western drought, see the December 2003 feature article at http://www.ispe.arizona.edu/climas/forecasts/articles/climatechange_Dec2003.pdf.

Temperature (through 12/15/04)

Sources: Western Regional Climate Center, High Plains Regional Climate Center

Water year average temperatures through December 15 range from the mid-30's (degrees Fahrenheit) in northern New Mexico and Arizona to the mid-70's in southwestern Arizona (Figure 1b). Most areas have near average conditions, except for Arizona's far north, where temperatures are up to 3 degrees below average (Figure 1a). Focusing on the past 30 days, much of the Southwest is within 2 degrees of the average temperature. A portion of west-central Arizona is up to 4–6 degrees cooler than average, while a swath from west-central to south-central Arizona and small areas in southwestern and north-central New Mexico are 2–4 degrees cooler than average for this time frame (Figure 1c–d).

In November Albuquerque was 0.3 degrees warmer than average and during December is 0.7 degrees warmer [Albuquerque National Weather Service (NWS)]. Statewide, New Mexico was slightly cooler than average for November. In Arizona Tucson, Flagstaff, and Phoenix ranged from 1.7 to 2.5 degrees below average (Tucson NWS, Flagstaff NWS, and Phoenix NWS). Both Tucson and Phoenix are reporting slightly above-average temperatures, while Douglas is 1.6 degrees below average through mid-December.

Figure 1a. Water year '04–'05 (through December 15, 2004) departure from average temperature.

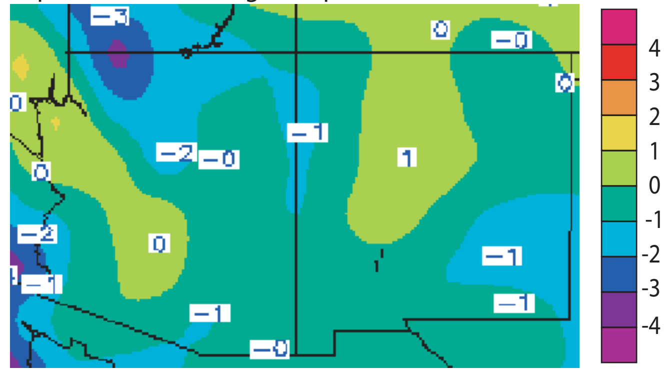


Figure 1b. Water year '04–'05 (through December 15, 2004) average temperature.

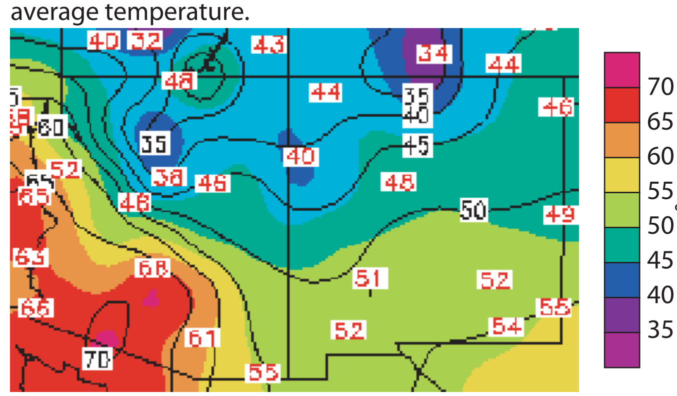


Figure 1c. Previous 30 days (November 16–December 15, 2004) departure from average temperature (interpolated).

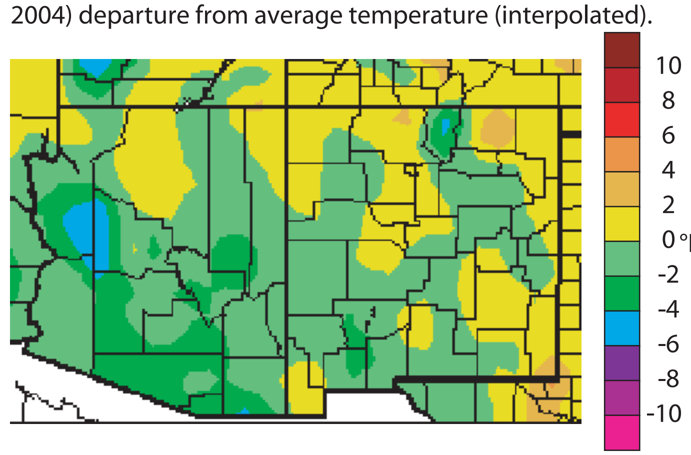
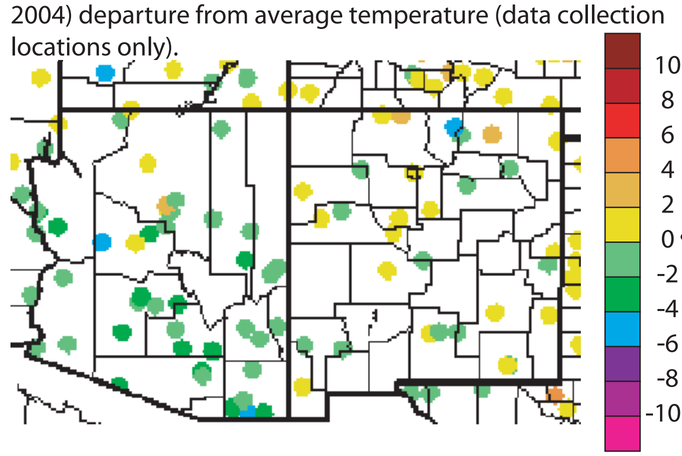


Figure 1d. Previous 30 days (November 16–December 15, 2004) departure from average temperature (data collection locations only).



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.

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

On the Web:

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

Precipitation (through 12/15/04)

Source: High Plains Regional Climate Center

Western Arizona and parts of eastern New Mexico have received from 200 to 800 percent of average precipitation since October 1 (Figures 2a–b). Other areas of eastern Arizona and western New Mexico are drier than average, as low as 25–50 percent of average. The past 30 days show a slightly different pattern (Figure 2c–d). In addition to western Arizona and eastern New Mexico, central and far southwestern New Mexico also received above-average precipitation. In far northeastern Arizona and northwestern New Mexico, where extreme drought persists (see page 7), drier-than-average conditions continue.

A late November storm led to reduced water release at Davis Dam (Laughlin, Nevada). Increased flow into Lake Havasu from the Bill Williams River meant that less release from Davis Dam was necessary to maintain levels at Lake Havasu (*Imperial Valley Press*, November 29). Release was also reduced at Parker Dam (Parker, Arizona), because heavy precipitation translated to lower water orders in southern Arizona and California (*Needles Desert Star*, December 1). The same storm prompted increased water release at Alamo Dam (west-central Arizona) as heavy rains led to a rapid rise in inflow. Sky Harbor International Airport in Phoenix, received 0.72 inches of rain from December 4–6, which is only 0.20 inches below the average for the entire month (*Arizona Republic*, December 7).

Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2004 we are in the 2005 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/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

Figure 2a. Water year '04–'05 through December 15, 2004 percent of average precipitation (interpolated).

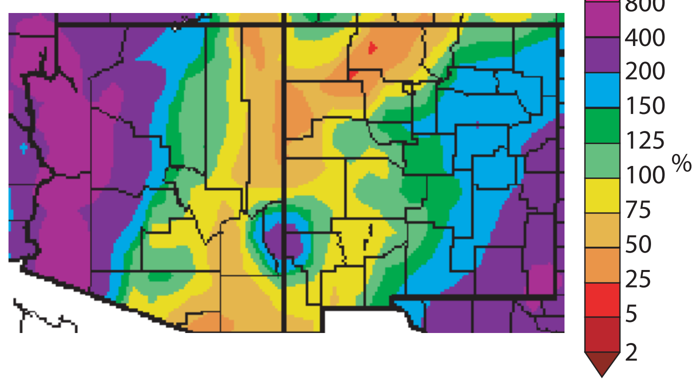


Figure 2b. Water year '04–'05 through December 15, 2004 percent of average precipitation (data collection locations only).

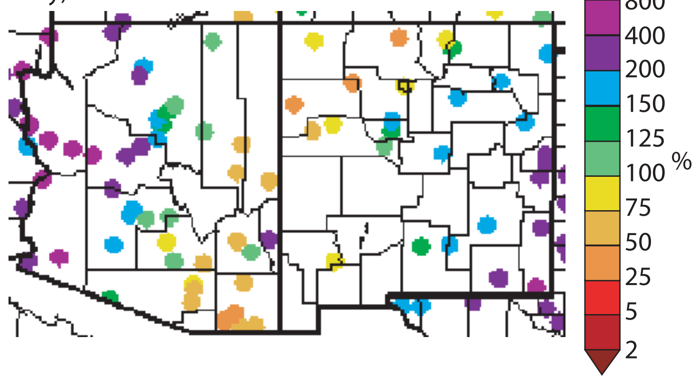


Figure 2c. Previous 30 days (November 16–December 15, 2004) percent of average precipitation (interpolated).

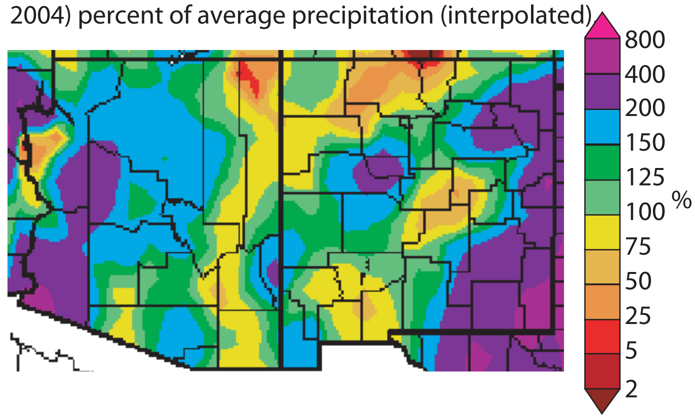
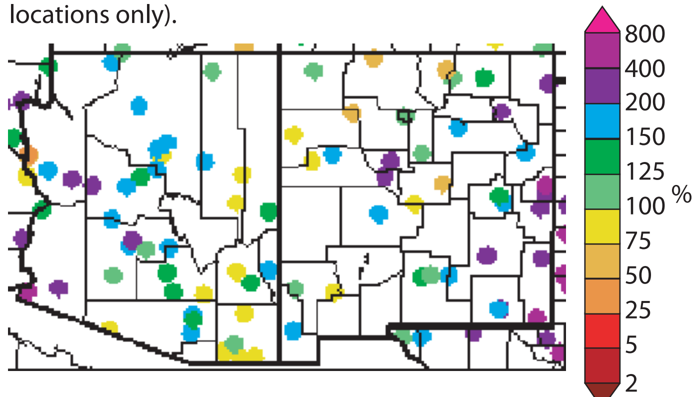


Figure 2d. Previous 30 days (November 16–December 15, 2004) percent of average precipitation (data collection locations only).



U.S. Drought Monitor

(released 12/16/04)

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

There has been very little change in Southwest drought status since mid-November (Figure 3). In Arizona, drought status increased in a small region near the South Rim of the Grand Canyon, which is now in the extreme category. Drought status decreased north of Lake Mead and along the lower Colorado River in southeastern California, changing from severe to moderate.

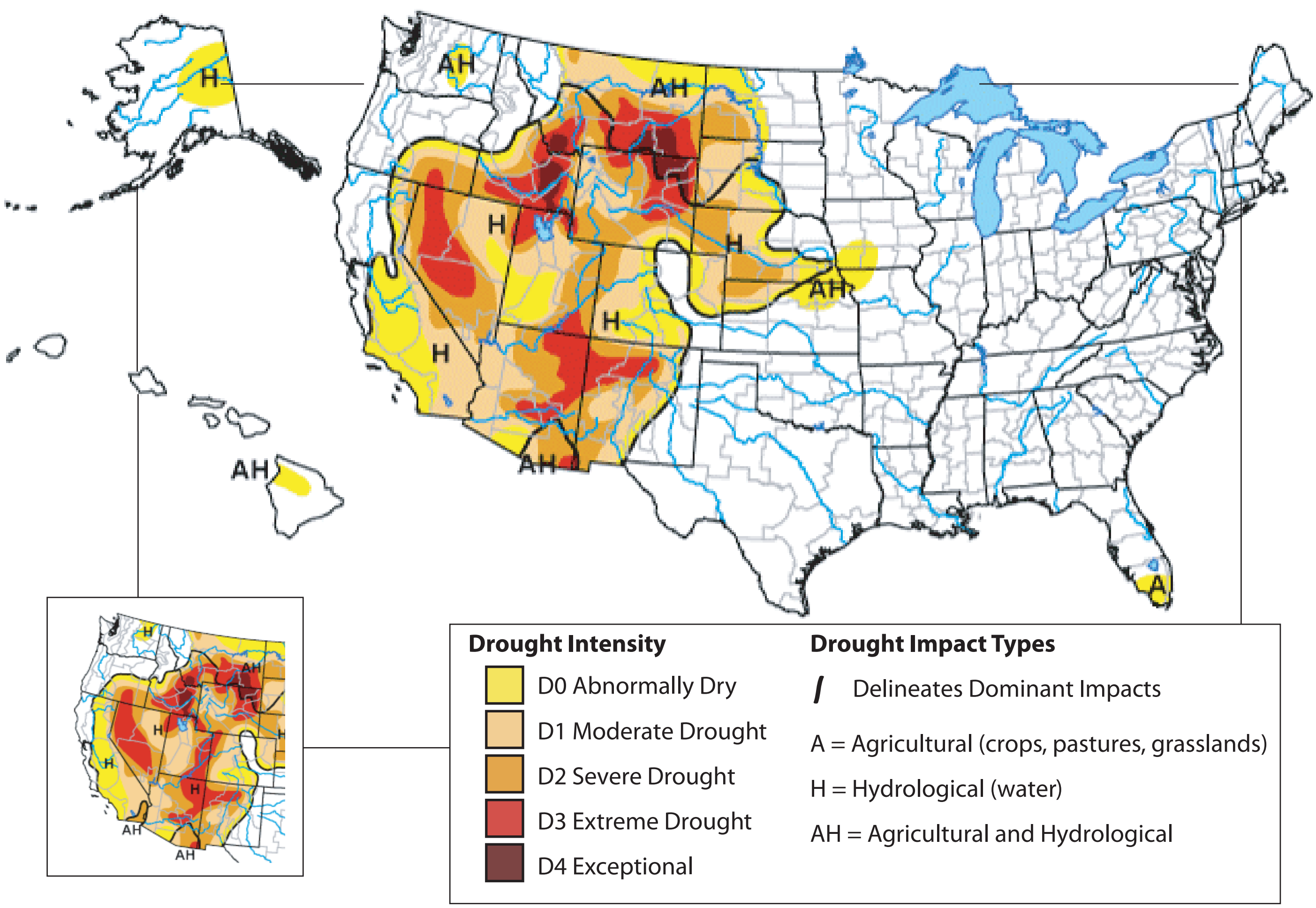
Plans continue to develop for the "virtual water university" proposed by Arizona Governor Janet Napolitano. According to the *ASU Web Devil* (November 29), the three state universities will work together to study and develop strategies to deal with drought in Arizona. ASU will focus on water-use patterns in urban areas, UA will concentrate on water resources, and NAU will study watersheds. In December Napolitano presented the plans throughout the state. The Western Governors Association met in December to discuss the drought, and in a letter to Congress, requested provisions for the National Drought Preparedness Act (*Billings Gazette*, December 7). This would create the National Integrated Drought Information System and would establish a National Drought Council.

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 David Miskus JAWF/CPC/NOAA.

Figure 3. Drought Monitor released December 16, 2004 (full size) and November 18, 2004 (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

New Mexico Drought Status
(through 12/9/04)

Source: New Mexico Natural Resources Conservation Service

Very little change has taken place in the short-term drought status in New Mexico since late October. Eastern New Mexico ranges from normal to advisory levels, with more severe conditions in the central and western parts of the state (Figure 4a). Emergency status persists in northwestern and south-central New Mexico. Hydrological drought remains the same as in late October. Many river basins are in emergency status in the long-term, except for the Pecos River Basin, which is in alert status (Figure 4b).

In early December New Mexico Governor Bill Richardson announced the 25 recipients of grants from the Water Innovation Fund, a state fund that provided a total of $10 million to projects to fight drought by recycling or conserving water (KRQE, November 30, and *U.S. Water News*, December 2004). Some of the recipients include New Mexico Tech for its proposal to produce and install water sensors to reduce irrigation (*El Defensor Chieftain*, December 4), the town of Cloudcroft for its project to reclaim wastewater and make it potable, and the Fastditch company for its installation and monitoring of a new liner for irrigation canals (KRQE-TV, November 30). According to the *U.S. Water News* (December 2004), Governor Richardson estimates the savings at 32 billion gallons of water per year. Richardson also acted as a lead governor at the Western Governors Association meeting in early December (*Billings Gazette*, December 7).

Notes:

The New Mexico drought status maps are produced monthly by the New Mexico Drought Monitoring Workgroup. When near-normal conditions exist, they are updated quarterly. The maps are based on expert assessment of variables including, but not limited to, precipitation, drought indices, reservoir levels, and streamflow.

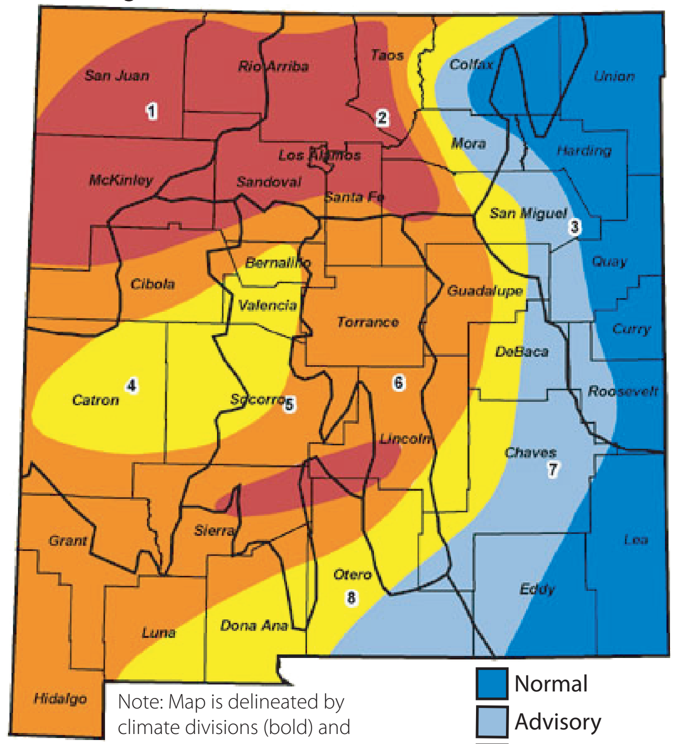
Figure 4a shows short-term or *meteorological* drought conditions. Meteorological drought is defined usually on the basis of the degree of dryness (in comparison to some "normal" or average amount) over a relatively short duration (e.g., months). Figure 4b refers to long-term drought, sometimes known as *hydrological* drought. Hydrological drought is associated with the effects of relatively long periods of precipitation shortfalls (e.g., many months to years) on water supplies (i.e., streamflow, reservoir, and lake levels, groundwater). This map is organized by river basins—the white regions are areas where no major river system is found.

On the Web:

For the most current New Mexico drought status map, visit:
http://www.nm.nrcs.usda.gov/snow/drought/drought.html

Information on Arizona drought can be found at:
http://www.water.az.gov/gdtf/

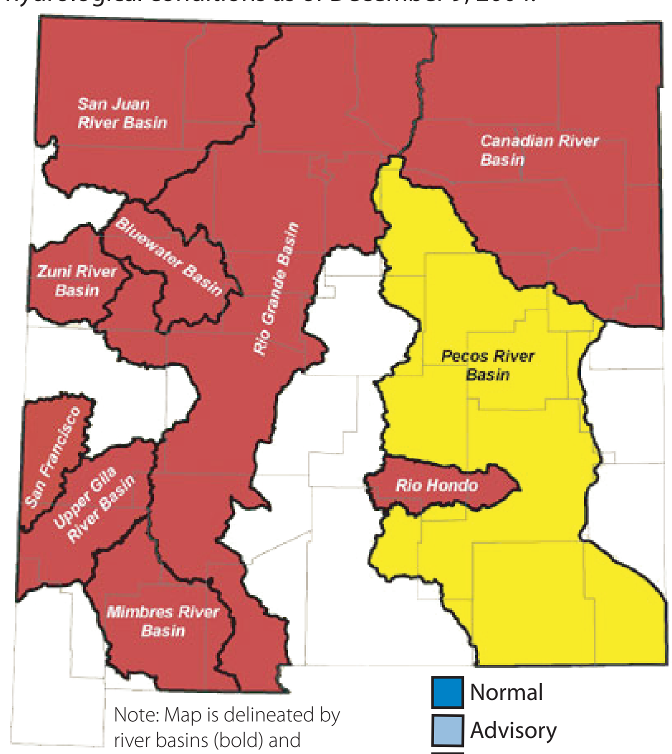
Figure 4a. Short-term drought map based on meteorological conditions as of December 9, 2004.



Note: Map is delineated by climate divisions (bold) and county lines.

Normal
Advisory
Alert
Warning
Emergency

Figure 4b. Long-term drought map based on hydrological conditions as of December 9, 2004.



Note: Map is delineated by river basins (bold) and county lines.

Normal
Advisory
Alert
Warning
Emergency

Arizona Reservoir Levels

(through 11/30/04)

Source: National Water and Climate Center

Most Arizona reservoirs remain well below capacity (Figure 5), although many were holding steady or even making gains through the end of November. Lyman Reservoir and San Carlos Lake are still at less than 10 percent capacity. November was the fourth consecutive month that many lakes remained steady or showed an increase in storage. Only two reservoirs, Lake Powell and Lake Havasu, experienced storage decreases. While Lake Powell's capacity dropped only 1 percent, the current storage is down to approximately 8.9 million acre-feet or 37 percent of capacity. This marks the first time in more than 35 years that the lake has been below 9 million acre-feet and the lowest it has been since May 21, 1969. Show Low Lake remained steady, but the remaining reservoirs showed a storage increase.

The Arizona Water Settlement Act, which the U.S. House of Representatives passed in mid-November, includes a provision for the Gila River Indian Community and the Tohono O'odham Nation to receive 200,000 acre-feet of water from the Central Arizona Project each year (*Payson Roundup*, November 23). In addition, water from the Blue Ridge Reservoir in the Salt River System will be transferred from the Salt River to the U.S. Bureau of Reclamation. Of the 8,000–10,000 acre-feet available annually from the reservoir, 3,000 acre-feet will be sold to Payson, 500 acre-feet to Gila County, and the remainder to the Phoenix Valley (*Payson Roundup*, November 23). Prescott Valley will be implementing increased water rates beginning January 1, 2005 (*U.S. Water News*, December 2004).

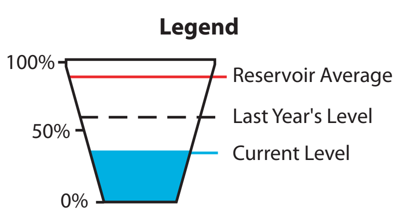
Notes:

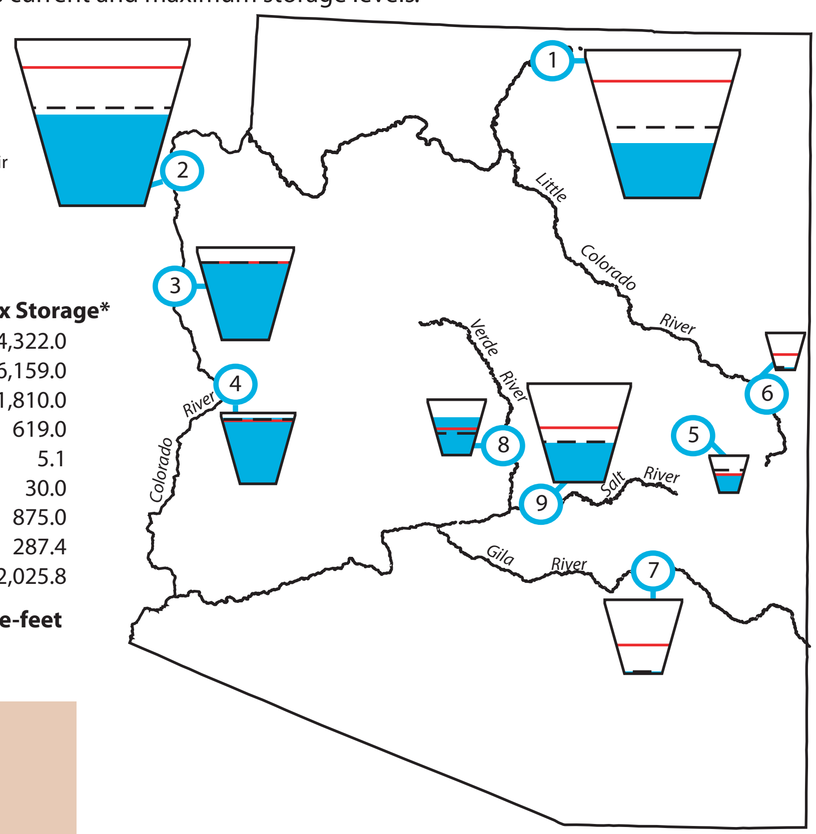
The map gives a representation of current storage levels for reservoirs in Arizona. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total 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 (red line) and the 1971–2000 reservoir average (dotted 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.

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. For additional information, contact Tom Pagano at the National Water Climate Center (tpagano@wcc.nrcs.usda.gov; 503-414-3010) or Larry Martinez, Natural Resource Conservation Service, 3003 N. Central Ave, Suite 800, Phoenix, Arizona 85012-2945; 602-280-8841; Larry.Martinez@az.usda.gov).

Figure 5. Arizona reservoir levels for November 2004 as a percent of capacity, the map also depicts the average level and last year's storage for each reservoir, while the table also lists current and maximum storage levels.





Reservoir Name	Capacity Level	Current Storage*	Max Storage*
1. Lake Powell	37%	8,889.0	24,322.0
2. Lake Mead	55%	14,367.0	26,159.0
3. Lake Mohave	84%	1,512.2	1,810.0
4. Lake Havasu	93%	575.8	619.0
5. Show Low Lake	47%	2.4	5.1
6. Lyman Reservoir	7%	2.1	30.0
7. San Carlos	3%	21.9	875.0
8. Verde River System	68%	194.7	287.4
9. Salt River System	40%	818.5	2,025.8

*** thousands of acre-feet**

On the Web:

Portions of the information provided in this figure can be accessed at the NRCS website:
http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html

New Mexico Reservoir Levels

(through 11/30/04)

Source: National Water and Climate Center

Unlike Arizona, New Mexico reservoirs did not fare as well in November, although fewer than half of them experienced a decrease (Figure 6). The reduction was small in most cases, however, Brantley Lake storage dropped by 8 percent of capacity or approximately 12,000 acre-feet. Navajo Reservoir is the only lake at greater than 30 percent capacity. Among the reservoirs with increased storage, Lake Sumner and Costilla Reservoir had the highest rates of increase (adding 4 percent and 3 percent of capacity, respectively). The Natural Resources Conservation Service (NRCS) reports that only Abiquiu and Brantley lakes are higher than their average capacities, while over half are below 50 percent of their average capacities. Compared to November 2003 levels, 9 of the 13 reservoirs are higher, some significantly so. For example, Brantley Lake is 7.5 times higher than it was last year, and Santa Rosa is about 6 times higher than last year (NRCS).

Challenges to plans to buy land and the associated water rights along the Pecos River have been dismissed by New Mexico State District Judge David Bonem (KLTV, December 1). Once the plan is implemented, the state must meet its required water deliveries to Texas or else the federal government may annex management of the river. Elsewhere, Mayhill residents recently met with officials to discuss the dropping water levels in their wells and springs and how the state is working to help the town (*Alamogordo News*, December 13). In what Otero County Commissioner and Cloudcroft administrator Michael Nivision terms a "moral obligation," Mayhill has been helping Cloudcroft with their low water supplies by allowing it to haul water from Mayhill's wells, just as Cloudcroft has done in the past for its neighbors.

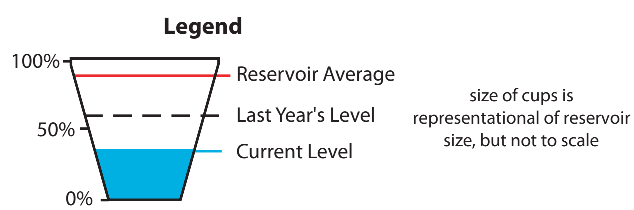
Notes:

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 (red line) and the 1971–2000 reservoir average (dotted 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.

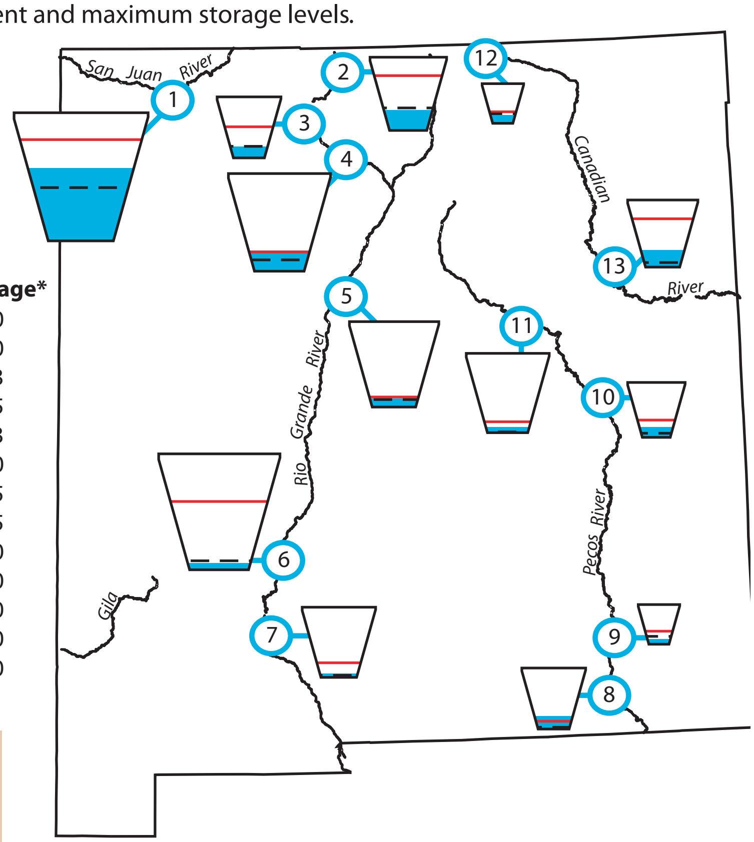
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service. For additional information, contact Tom Pagano at the National Water Climate Center (tpagano@wcc.nrcs.usda.gov; 503-414-3010) or Dan Murray, NRCS, USDA, 6200 Jefferson NE, Albuquerque, NM 87109; 505-761-4436; Dan.Murray@nm.usda.gov).

Figure 6. New Mexico reservoir levels for November 2004 as a percent of capacity, the map also depicts the average level and last year's storage for each reservoir, while the table also lists current and maximum storage levels.



Reservoir Name	Capacity Level	Current Storage*	Max Storage*
1. Navajo	57%	970.2	1,696.0
2. Heron	28%	110.9	400.0
3. El Vado	19%	36.0	186.3
4. Abiquiu	21%	114.1	554.5
5. Cochiti	10%	49.1	502.3
6. Elephant Butte	6%	128.0	2,065.0
7. Caballo	6%	21.0	331.5
8. Brantley	21%	30.3	147.5
9. Lake Avalon	13%	0.8	6.0
10. Sumner	19%	19.4	102.0
11. Santa Rosa	7%	30.1	447.0
12. Costilla	21%	3.3	16.0
13. Conchas	25%	63.2	254.0

*** thousands of acre-feet**



On the Web:

Portions of the information provided in this figure can be accessed at the NRCS website:
http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html

Southwest Snowpack

(updated 12/16/04)

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

Southwest snowpack has increased since mid-November due to some autumn storm systems. Only the SNOTEL sites in the Salt River Basin were not reporting any snow as of December 16 (Figure 7). Many areas were reporting greater than average snow-water content (SWC). Both the Mimbres River Basin in southwestern New Mexico and the Verde River Basin in central Arizona registered greater than 200 percent of average SWC. To the north, southern Utah basins were reporting near to slightly above-average SWC, and southern Colorado SNOTEL sites ranged from 90–125 percent of average. Snow in Utah and Colorado basins is important, because these states contain headwaters and tributaries of the Colorado River. Greater-than-average snowpack during the winter and early spring in the upper Colorado River basin translates into benefits for both the upper and lower Colorado River states.

Snow reports from one winter-like storm system ranged from 1 inch in eastern New Mexico to 18 inches at Westner Springs, which is just west of Las Vegas, NM [Albuquerque National Weather Service (NWS)]. Snowfall caused Santa Fe public school officials to cancel classes on November 24 (*Santa Fe New Mexican*, November 24). Another less powerful late November storm that hit New Mexico brought 1 inch of snow in several areas to 10 inches in the southern San Juan Mountains. During the first weekend of December, Flagstaff received 7 inches of snow (*Arizona Republic*, December 7), while totals in New Mexico ranged from a dusting to 7 inches near Quemado (Albuquerque NWS).

Figure 7. Average snow water content (SWC) in percent of average for available monitoring sites as of December 16, 2004.

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 7 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.

On the Web:

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

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

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

Temperature Outlook
(January–June 2005)
Source: NOAA Climate Prediction Center

The long-lead temperature forecasts from the NOAA-Climate Prediction Center (CPC) show increased chances of above-average temperatures for much of the western United States through June 2005 (Figures 8a–d). The highest probabilities are consistently in western Arizona, southeastern California, and southern Nevada. New Mexico has increased chances of warmer-than-average conditions in the western half of the state, and increased chances of cooler-than-average temperatures or no forecasted anomalies elsewhere. Increased chances of below-average temperatures are confined mainly to the Gulf Coast states and Southeast through April (Figures 8a–b) and to the central United States from March–June (Figure 8c–d). While forecasts from the International Research Institute for Climate Prediction (not shown) also indicate increased chances of above-average temperatures in the Southwest, the probabilities are slightly lower.

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 the reliability (i.e., 'skill') of the forecast is poor; 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 8a. Long-lead national temperature forecast for January–March 2005.

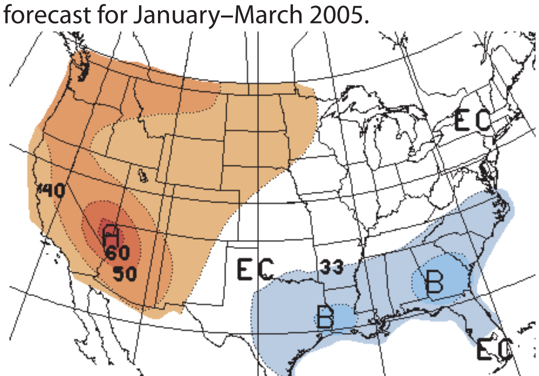


Figure 8b. Long-lead national temperature forecast for February–April 2005.

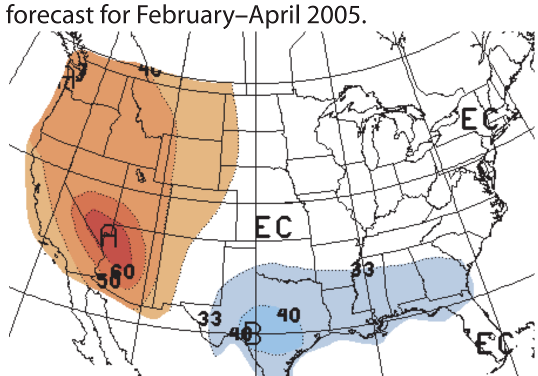


Figure 8c. Long-lead national temperature forecast for March–May 2005.

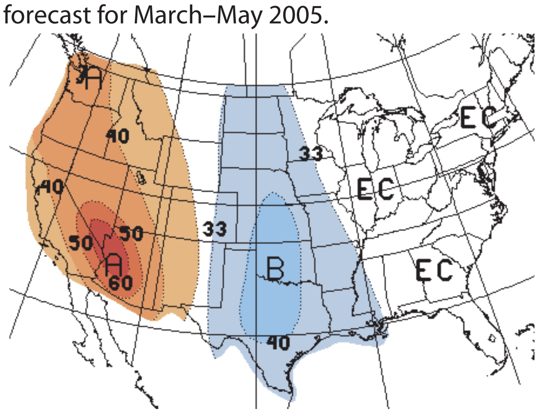
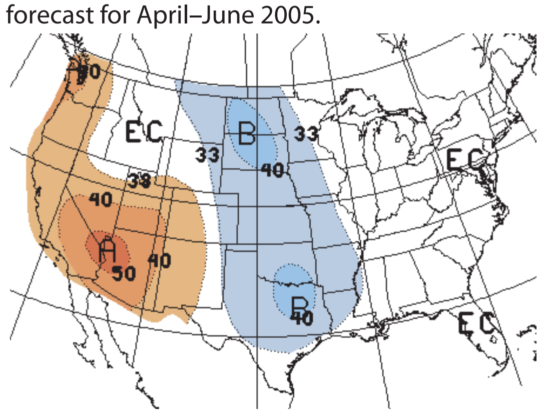


Figure 8d. Long-lead national temperature forecast for April–June 2005.



A= Above
- 60.0–69.9%
- 50.0–59.9%
- 40.0–49.9%
- 33.3–39.9%

B= Below
- 33.3–39.9%
- 40.0–49.9%

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.html
(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

(January–June 2005)

Source: NOAA Climate Prediction Center

The long-lead precipitation forecasts from the NOAA-CPC predict increased chances of above-average precipitation through April for most of the southern tier of the United States and increased chances of below-average precipitation in the Northwest and from the mid-Mississippi Valley to New England (Figures 9a-b). From March–May (Figure 9c), increased chances of wetter-than-average conditions are forecasted only for the Southwest and parts of California, Nevada, and Texas. The predictions do not have any forecasted anomalies during April–June 2005 (Figure 9d). Southeastern Arizona, southern New Mexico, and extreme western Texas have the highest probabilities through the first three periods. The main conflict between the CPC forecasts and those from IRI (not shown) is for January–March. International Research Institute for Climate Prediction excludes northern New Mexico from increased chances of above-average precipitation.

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 the reliability (i.e., 'skill') of the forecast is poor; 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 precipitation forecast for January–March 2005.

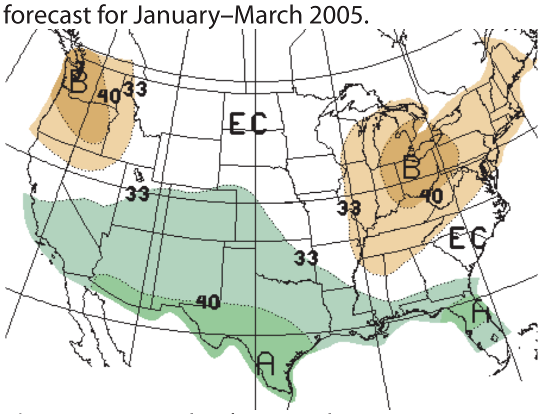


Figure 9b. Long-lead national precipitation forecast for February–April 2005.

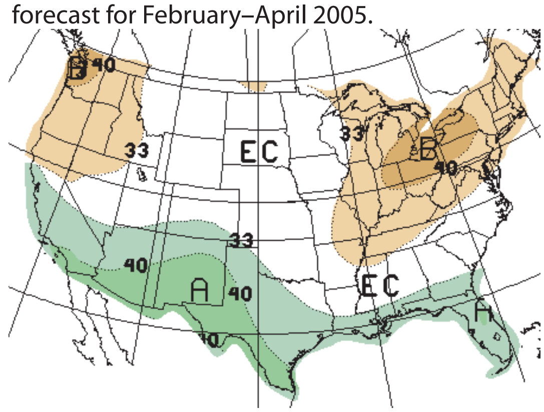


Figure 9c. Long-lead national precipitation forecast for March–May 2005.

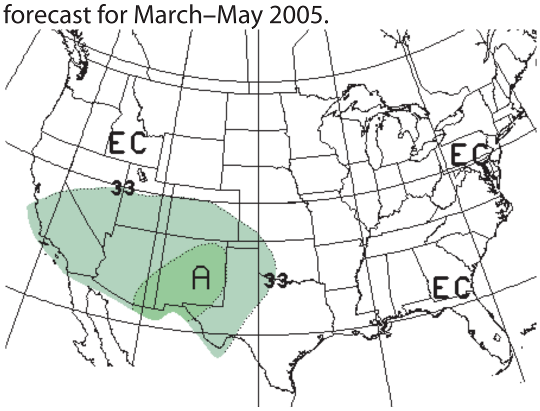
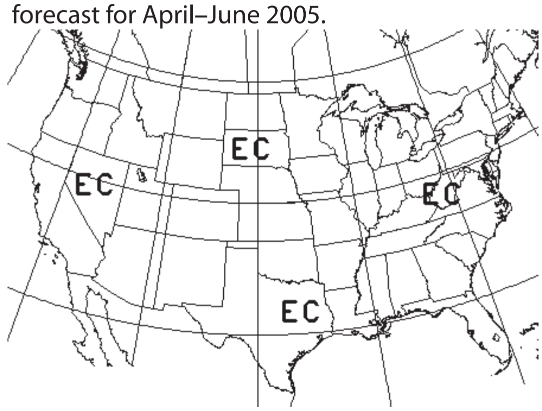


Figure 9d. Long-lead national precipitation forecast for April–June 2005.



A= Above: 40.0–49.9%, 33.3–39.9%

B= Below: 33.3–39.9%, 40.0–49.9%

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.html
(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 March 2005)
Sources: NOAA Climate Prediction Center

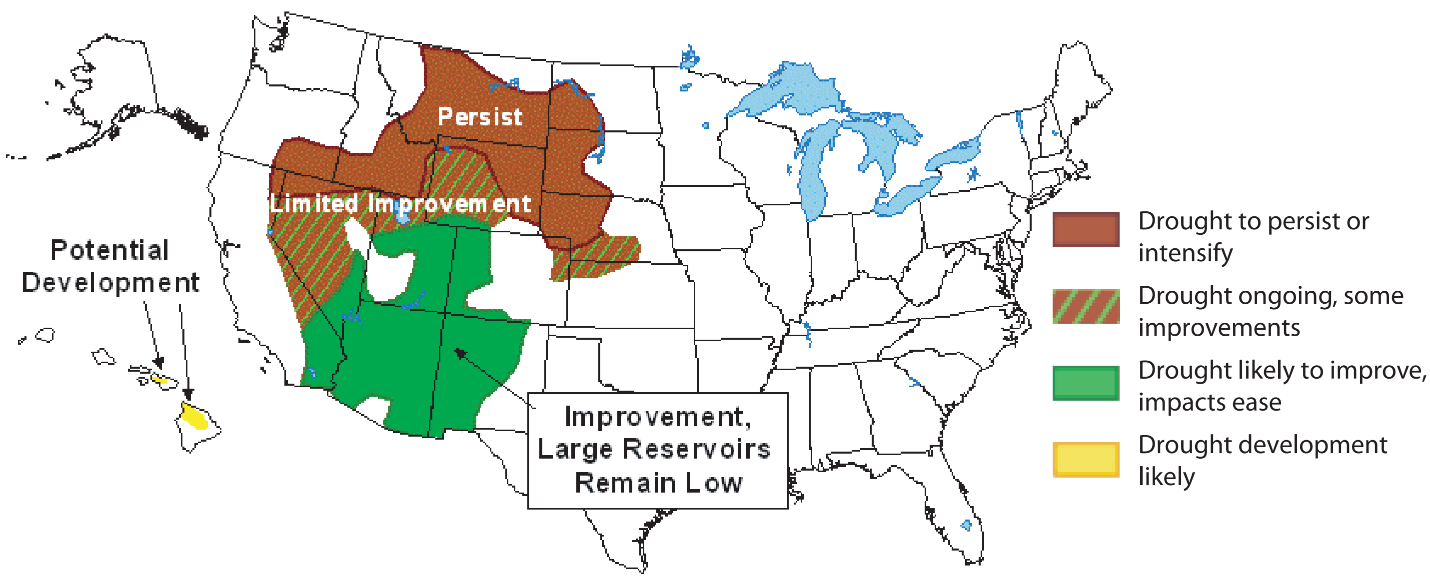
The NOAA-Climate Prediction Center (CPC) forecasts improvement in drought conditions for the Southwest and at least limited improvement for much of the western United States through March 2005 (Figure 10), although experts anticipate that large reservoirs will remain low. The pattern of expected improvement very closely follows the pattern shown on the precipitation outlook for January–March 2005 (page 13). The only area not forecasted to improve is the northern Rocky Mountains and the northwestern Great Plains. The continuing forecast for El Niño, although weak, is important in the predicted reduction in the drought. Experts believe that there is a 75 percent chance that this weak El Niño will exist at least through March (page 15).

While recent precipitation is not sufficient to eliminate impacts of the drought, it has eased them slightly in some locations. Andrew Ellis, Arizona state climatologist, says that any light, steady rain is advantageous (*East Valley Tribune*, December 6). Less intense precipitation means that more water soaks into the ground, which is particularly beneficial when snow begins to melt. As snowmelt occurs, the water will contribute more to runoff and streamflow and eventually to partial recharge of the region's reservoirs. At the recent annual meeting of the Colorado River Water Users Association, David Brandon, a NOAA hydrologist, said that winter and spring snowmelt could result in twice the water (approximately 2.8 million acre-feet) flowing into Lake Powell in the spring compared to last spring (*Santa Fe New Mexican*, December 17). With streamflows in the Colorado River higher than that seen during each of the past five years, even average winter precipitation throughout the Colorado River Basin and the resulting snowmelt and runoff may lead to at least a temporary reprieve from the dry conditions and an increase in reservoir storage. Experts continue to remind the public, however, that several years of above-average precipitation is necessary to see major improvement.

Notes:

The delineated areas in the Seasonal Drought Outlook (Figure 10) are defined subjectively and are based on expert assessment of numerous indicators, including outputs of short- and long-term forecasting models.

Figure 10. Seasonal drought outlook through March 2005 (release date December 16, 2004).



On the Web:

For more information, visit:
http://www.drought.noaa.gov/

El Niño Status and Forecast

Sources: NOAA Climate Prediction Center, International Research Institute for Climate Prediction

The Southern Oscillation Index (SOI) remains indicative of a weak El Niño (Figure 11b). SOI decreased slightly in November, but its inconsistent pattern continues to hamper forecasting any potential strengthening or weakening of El Niño. The probabilistic El Niño-Southern Oscillation forecast from the International Research Institute for Climate Prediction (IRI) indicates that El Niño has the highest probability of dominating conditions (Figure 11a), based on sea surface temperatures in the central tropical Pacific Ocean. IRI predicts an 80 percent chance that it will continue from December 2004–February 2005. Even as late as March–May, forecasts indicate a 65 percent likelihood of persisting El Niño conditions. Beginning in May–July, IRI expects higher probabilities for neutral conditions to dominate the tropical Pacific Ocean. This trend continues through August–October.

Charlie Ester, water resources operations manager with the Salt River Project, believes that the upcoming winter will bring short-term benefits to the drought, due in part to the effects of El Niño (*East Valley Tribune*, December 6). In the same article Arizona state climatologist Andrew Ellis warns that because the current El Niño is weaker than previously forecasted, the precipitation in the next several months is difficult to predict. University of Washington climatologist Nathan Mantua agrees, saying that confidence is fairly low in the precipitation patterns in the United States (*Oregonian*, December 16). The article further states that scientists with the Australian Bureau of Meteorology are hesitant to label the event "El Niño," because they do not see the atmospheric responses that typically follow the ocean's behavior during El Niño.

Figure 11a. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released December 16, 2004). Colored lines represent average historical probability of El Niño, La Niña, and neutral.

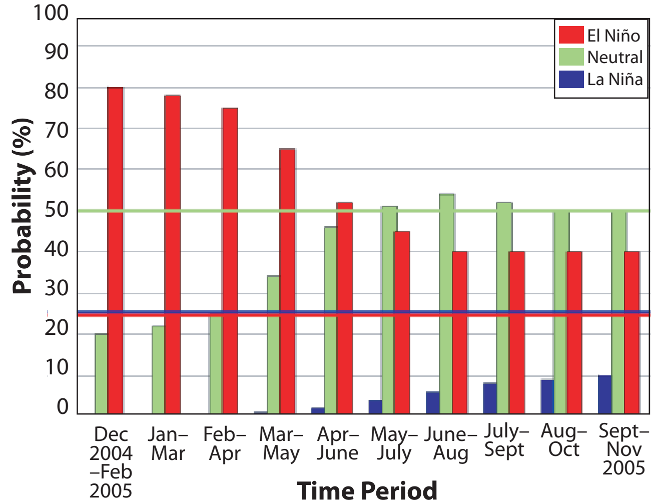
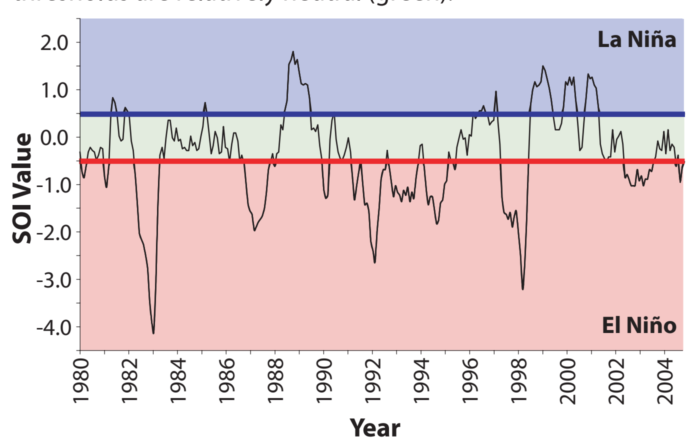


Figure 11b. The standardized values of the Southern Oscillation Index from January 1980–November 2004. La Niña/El Niño occurs when values are greater than 0.5 (blue) or less than -0.5 (red) respectively. Values between these thresholds are relatively neutral (green).



Notes:

Figure 11a shows the International Research Institute for Climate Prediction (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 11b shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through September 2004. 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.

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
(September–November 2004)

Source: NOAA Climate Prediction Center

The NOAA-Climate Prediction Center (CPC) forecast for September–November indicated increased chances of above-average temperatures for most of the Southwest, the coastal Pacific Northwest, and southern Florida (Figure 12a). The rest of the nation had equal chances of experiencing above- or below-average temperatures. In the Southwest, the highest probabilities were indicated from the boot heel of New Mexico to southern Nevada.

The CPC long-lead forecast for the period did not perform favorably in the Southwest. The departure from average temperature map shows that while much of the United States had slightly above-average or higher temperatures, cooler-than-average values occurred in much of the Southwest (Figure 12b). Arizona and New Mexico were mainly below average, although extreme southeastern and southwestern New Mexico was 2–4 degrees Fahrenheit above average. The long-lead forecast performed more favorably in predicting fwarmer-than-average conditions in Florida and the parts of the coastal Pacific Northwest. However, the above-average temperatures from the Gulf Coast to the northern Plains and Great Lakes (up 6–8 degrees) were also troublesome for the models.

Figure 12a. Long-lead U.S. temperature forecast for September–November 2004 (issued August 2004).

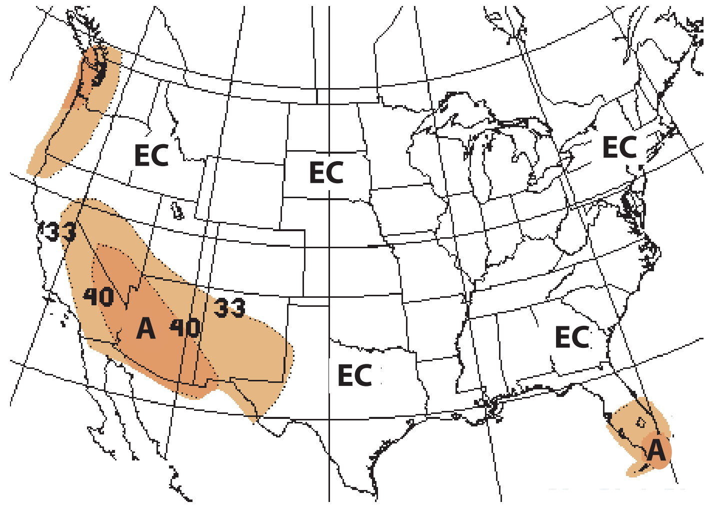
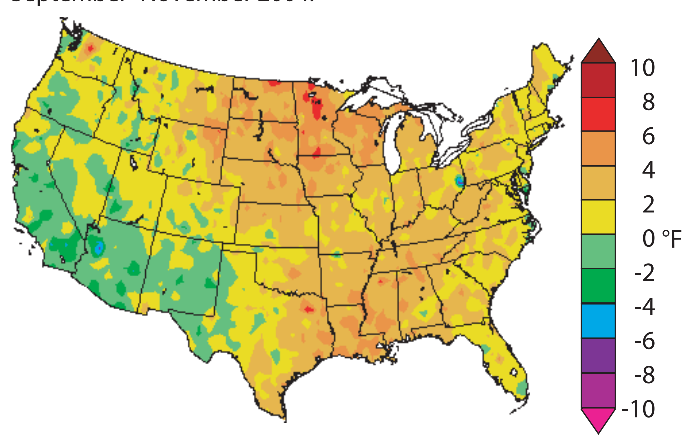


Figure 12b. Average temperature departure (in degrees F) for September–November 2004.



Notes:

Figure 12a shows the NOAA Climate Prediction Center (CPC) temperature outlook for the months September–November 2004. This forecast was made in August 2004.

The September–November 2004 NOAA CPC 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. Care should be exercised when comparing the forecast (probability) map with the observed temperature maps described below.

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 12b shows the observed departure of temperature (°F) from the average for September–November 2004.

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.

On the Web:

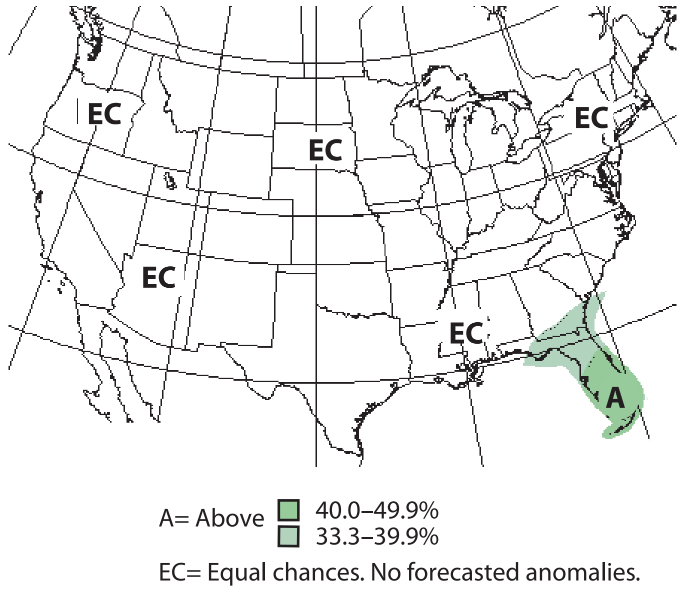
For more information on CPC forecasts, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html

Precipitation Verification
(September–November 2004)

Source: NOAA Climate Prediction Center

The NOAA-CPC precipitation forecasts for September–November indicated increased chances of above-average precipitation only in Florida and extreme southern Georgia (Figure 13a) with the highest probabilities in southern Florida. Judgment was withheld elsewhere. Figure 13b displays the complex pattern of precipitation anomalies across the United States. In the Southwest, eastern New Mexico and western and northern Arizona were much wetter-than-average, with some areas receiving more than 400 percent of average precipitation. Portions of the Plains, Mid-Atlantic states, and southern California and Nevada also received greater than 200 percent of average precipitation. However, only 25–50 percent of average precipitation fell in portions of northwestern New Mexico and south-central Arizona, as well as in Northwest, the Great Lakes region, and northern New England. The CPC long-lead forecast performed well in Florida and southern Georgia, but it did not indicate the extremes in other areas of the United States.

Figure 13a. Long-lead U.S. precipitation forecast for September–November 2004 (issued August 2004).



Notes:

Figure 13a shows the NOAA Climate Prediction Center (CPC) precipitation outlook for the months September–November 2004. This forecast was made in August 2004.

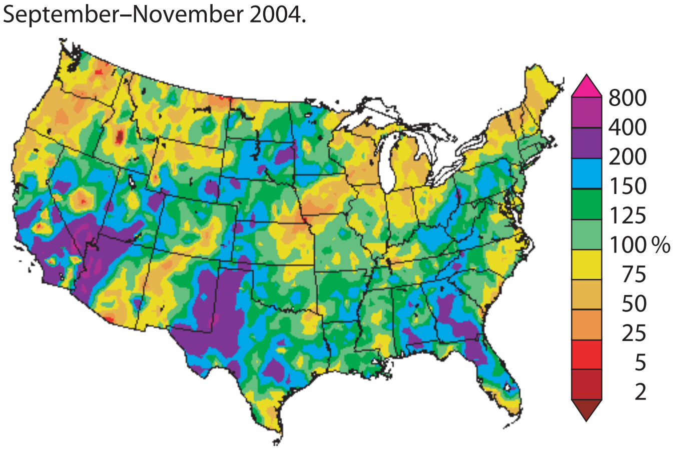
The September–November 2004 NOAA CPC outlook predicts the likelihood (chance) of above-average, average, and below-average precipitation, but not the magnitude of such variation. The numbers on the maps do not refer to inches of precipitation. Care should be exercised when comparing the forecast (probability) map with the observed precipitation maps described below.

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 13b shows the observed percent of average precipitation observed September–November 2004.

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 13b. Percent of average precipitation observed from September–November 2004.



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.html