

Southwest Climate Outlook

THE UNIVERSITY OF ARIZONA.



Photo Credit: Kathy Brierley

Photo Description: This photograph was submitted by Paul Brierley. It pictures a dust storm that blanketed Phoenix, Arizona on July 6, 2006. Paul Brierley wrote, "[This is] a photo that my wife, Kathy Brierley, took before the storm hit Chandler/Gilbert. At this point we were just starting to feel the wind. Just moments before the picture, we watched the dust overtake the San Tan mountains."

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



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June Climate Summary

Drought – Drought continues in the Southwest, with most of the region in severe or extreme drought, and some areas in exceptional drought due to the long-term precipitation deficits.

- Drought conditions are expected to persist or intensify throughout most of the Southwest. Some improvement is expected in western New Mexico and southern Arizona.
- Reservoirs in Arizona and New Mexico have declined since this time last year.

Fire Danger – The long-term moisture deficits and high fuel loadings are producing critically high fire potential, particularly in the higher elevation timber.

Temperature – Since the start of the water year on October 1, 2005, temperatures throughout most of the Southwest have been above average.

Precipitation – The Southwest has been much drier than average since the start of the water year, with many locations experiencing the driest winter and spring on record.

Climate Forecasts – Experts predict increased chances of warmer-than-average temperatures and equal chances of precipitation through December 2006.

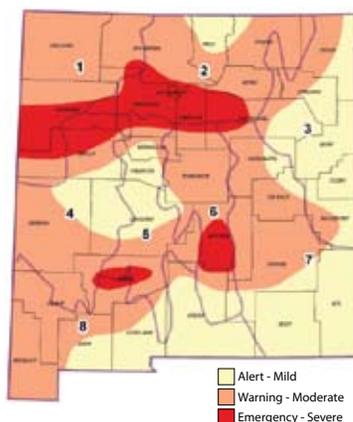
El Niño – ENSO-neutral conditions are expected to continue over at least the next three months.

The Bottom Line – Drought is likely to persist or intensify over most of the Southwest. Hydrological drought continues to affect streamflow and some large reservoir levels, and agricultural drought conditions have persisted throughout the region.

New Mexico Drought Maps

The New Mexico Drought Status page, which you usually find in the “Recent Conditions” section of the *Southwest Climate Outlook* is not included in this month’s issue. The meteorological (short-term) drought map can be found online at the National Weather Service Albuquerque Office’s website: <http://www.srh.noaa.gov/abq>. We will reinstate a newly designed New Mexico Drought Status page next month. We apologize for any inconvenience this may cause.

The New Mexico Drought Monitor Committee is currently reassessing its drought maps, and the *Southwest Climate Outlook* will include these new maps in future issues.



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This work is published by the Climate Assessment for the Southwest (CLIMAS) project and the University of Arizona Cooperative Extension; and is funded by CLIMAS, Institute for the Study of Planet Earth, and the Technology and Research Initiative Fund of the University of Arizona Water Sustainability Program through the SAHRA NSF Science and Technology Center at the University of Arizona.



Hurricane intensity rises with sea surface temps

Some variations linked to warming air temperatures

BY MELANIE LENART

High sea surface temperatures (SSTs) fuel stronger hurricanes.

No one argued about that at a recent workshop on tropical cyclones and climate change held at the International Research Institute for Climate Prediction in New York. The distinguished experts at the March workshop even agreed that Atlantic hurricane seasons are likely to remain active for at least several decades to come.

But what is driving the rise in SSTs so strongly linked to hurricane activity—global warming or natural variability? And how might other factors influence hurricane activity as the world warms? That was up for debate.

The answers have important implications for society. If hurricanes and other tropical cyclones are drawing their extra strength from global warming, then the world can expect to face a century or more of intense hurricanes. For the landlocked Southwest, storms that start out as tropical cyclones can provide welcome rains and the occasional flood.

If the observed increase in hurricane intensity relates only to naturally recurring fluctuations, residents along the South and East coasts menaced by Atlantic hurricanes could expect a reprieve within a few decades. The East Pacific hurricane seasons that moisten the Southwest, meanwhile, could slow down in the near future, based on previous experience. A busier-than-average Atlantic season often means a calmer-than-usual East Pacific season, which many attribute to the influence of El Niño.

The power behind North Atlantic and North Pacific seasonal hurricanes combined has more than doubled since about the mid-1970s, as shown by re-

search by Kerry Emanuel of the Massachusetts Institute of Technology (*Nature*, August 4, 2005). Reliable records go back to the 1940s. The power dissipation index (PDI) he used tallies tropical cyclones of any strength and includes their size and life span when considering how much energy they contained.

SSTs explained about 88 percent of the variability in Atlantic seasonal hurricane energy since 1970 when compared in multi-year trends, Emanuel noted during the workshop. As ocean temperatures rise, so does hurricane intensity (Figure 1).

Ocean temperatures have been rising around the world, most notably since the mid-1990s, as documented by Sydney Levitus and colleagues at the National Oceanographic Data Center (*Science*, March 24, 2000). The scientific community agrees that rising temperatures in the ocean and air relate to global warming from society's use of fossil fuels like coal, oil, and gas.

Emanuel showed evidence that Atlantic SSTs generally move in synch with northern hemisphere air temperatures when considered at the decadal scale (Figure 2). His results challenge the existence of the Atlantic Multidecadal Oscillation, a mode of natural variability in SSTs that was originally proposed by Michael Mann, Emanuel's co-author in the new study (*Eos*, June 13, 2006).

"I would submit to you that there's just no plain evidence now that you have an oscillation," Emanuel said. "There just isn't evidence in nature, as opposed to models, for this."

These findings imply that Atlantic SST will continue to increase with warming air temperatures, strengthening hurricanes at least to some degree as it does. Northern hemisphere temperatures are projected to rise by another 3 to 10

degrees Fahrenheit (F) throughout the twenty-first century.

Those arguing that natural variability, not global warming, is driving SST increases and other factors that influence hurricane strength include Christopher Landsea of the Hurricane Research Division. His paper with lead author Stanley Goldenberg, Alberto Mestas-Nuñez, and William Gray maintains that hurricane activity reflects a pattern of ups and downs that stay in place for decades at a time (*Science*, July 20, 2001).

"With Kerry's very interesting results today, I don't know if I'd say it's a cycle or not, but there is multi-decadal variability," Landsea said at the workshop, referring to Emanuel's work pairing air temperature with SST (Figure 2).

Landsea and Emanuel have been facing off on whether the increase in intense hurricanes stems from natural variability or global warming in a variety of venues, including a May media briefing and the pages of scientific journals (e.g., *Nature*, December 22, 2005).

Landsea argues that researchers have gotten better at detecting hurricanes in recent years, making it challenging to compare recent tallies with earlier ones. Even the Atlantic dataset, considered the world's best from about the mid-1940s, contains potential wind speed biases, he said. Meanwhile, he has little faith in the data used to assess global increases in cyclone strength, such as that used in the analysis by Peter Webster of the Georgia Institute of Technology and several colleagues that made headlines in 2005.

Webster and the others compared cyclone records derived from satellite images for six ocean basins around the world for 1975 through 2004. They found the number of intense storms

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Hurricanes, continued

had increased by 57 percent when they compared the second half of the record to the first half (*Science*, September 16, 2005). For these purposes, intense hurricanes refer to Category 4 and 5 cyclones, which have sustained wind speeds above 130 miles per hour.

SST had increased during the second half of the record as well, the authors noted. Their analysis of the East Pacific basin showed the number of intense hurricanes jumped from 36 in the first period (1975–1989) to 49 in the second period (1990–2004), even though the total number of hurricanes remained about the same for the two time frames.

The satellite measurements use factors such as eye definition and apparent cloud height to estimate cyclonic wind speeds. Landsea suggested the data may contain flaws because the measurements come from a variety of people who made their assessments during the year in question. Since the earlier time period, satellite coverage, hurricane recognition, and technology all have improved. The researcher said when he and a colleague applied modern detection techniques to satellite images from the earlier period for the Indian Ocean, they found several intense hurricanes that had not been included in the dataset used by Webster and others.

Webster, in turn, pointed to a recent reanalysis of the South Indian Ocean—the region where data presented the most problems—which reached similar results as their 2005 paper. The random errors canceled each other out in the end, he said, leading to the result that the Indian Ocean has seen an increase in intense hurricanes like the other five basins.

Other researchers are finding similar results from an independent data set that does not involve satellite images, Webster added. He pointed to a paper published earlier this month by Ryan Srivier and

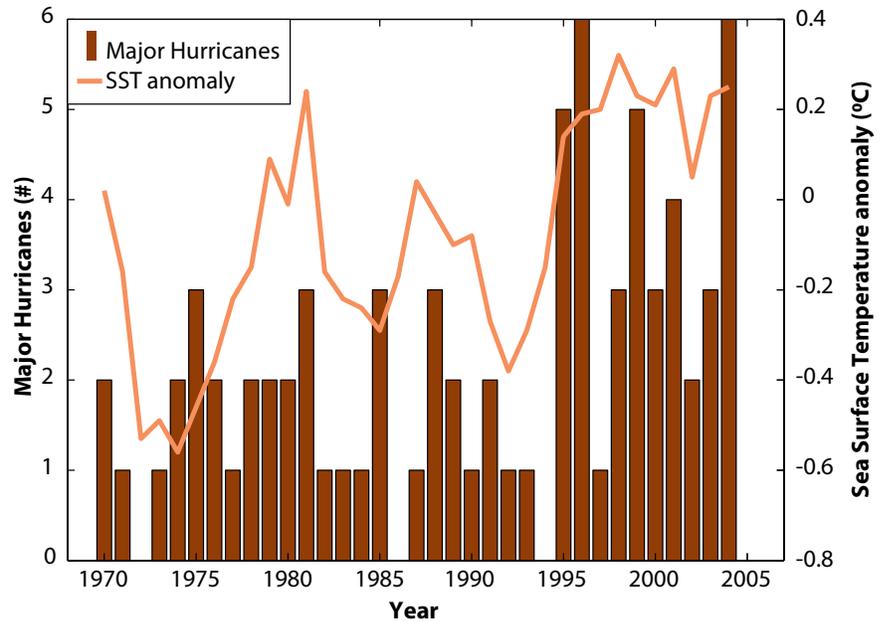


Figure 1. The number of major hurricanes a year in the northern Atlantic (bars) tends to reflect sea surface temperatures (SSTs) fluctuations (line). Major hurricanes have sustained winds above 110 miles per hour. Data courtesy of Christopher Landsea of the National Hurricane Center.

Matthew Huber of Purdue University (*Geophysical Research Letters*, June 2006).

The researchers used data for 1958–2001 developed by a European weather forecasting center to calculate the power dissipated by hurricanes and other tropical cyclones around the world. When comparing the pre-1979 data to the later part of the record, they found the overall PDI had increased by about a quarter. The Purdue researchers' results for the globe looked almost identical to Emanuel's results, even though they used a different approach to average out annual variability, and they considered the world rather than just the northern Atlantic and Pacific. The results also support Webster's results, as the authors note.

A global assessment using hurricane tracking data found only a small increase in intense hurricanes when splitting the last 20 years of data into two halves for comparison (*Geophysical Research Letters*, May 2006). By this assessment, global activity peaked between 1992 and 1998, a time frame that was split by the comparison of 1986–1995 to 1996–2005.

Researchers on both sides of the argument are puzzled by the extent of the apparent hurricane response to a relatively minor rise in SST. SSTs have risen by only about half a degree F on average globally, and slightly less than 1 degree F in the Atlantic region where hurricanes tend to develop.

Yet the average annual number of major hurricanes per year in the Atlantic more than doubled when comparing the 1995–2004 to the period 1971–1994, based on data from Landsea (Figure 1).

During the earlier time frame, Atlantic SSTs averaged below 83 degrees F during the peak hurricane season (August–October) in all but three years. Since 1995, Atlantic seasonal mean SST has averaged above 83 degrees—but the difference between the two averages represents only about 1 degree F.

“The sensitivity is a lot more than we would have predicted,” Emanuel said, referring to his Atlantic research that showed a similar jump in intense hurricanes. The combined measure of

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Hurricanes, continued

hurricane power increased roughly four times more than his earlier models had projected it would based on the seasonal SST rise, he indicated. While his model suggested a 5 percent increase in peak winds with a 1 degree Celsius (C) warming, his analysis showed a 10 percent in peak winds with little more than half a degree C warming.

Emanuel suggested that the lack of major volcanic activity since Mount Pinatubo's eruption in 1991 could be affecting relevant dynamics of the upper atmosphere as well as SSTs. Volcanic eruptions can temper the warming for a year or so when their explosions spew aerosol particles up into the stratosphere. Pollution involving sulfate aerosols can have a similar temporary cooling effect. In fact, he suspects aerosols from pollution and volcanoes may have been behind the Atlantic's calm phase from the mid-1970s through the mid-1990s.

Vertical wind shear also has an important influence on individual storms, Emanuel noted, even though it doesn't show up as important in "smoothed" data in which values for several consecutive years are averaged together. Wind shear occurs when high-level winds move much faster or in a different direction than those at the surface. Hurricanes tend to form and persist more frequently in situations of low vertical wind shear.

Landsea agreed wind shear wielded an important influence on individual storms. "Most of the time, hurricanes are like people. They don't live up to anywhere near their potential. And most of the time it's because of wind shear," he said.

At the seasonal scale, vertical wind shear tends to decrease as SSTs increase, as Goldenberg and Landsea and their co-authors note in their 2001 paper.

Scientists have long known that SSTs must reach about 80 degrees F before

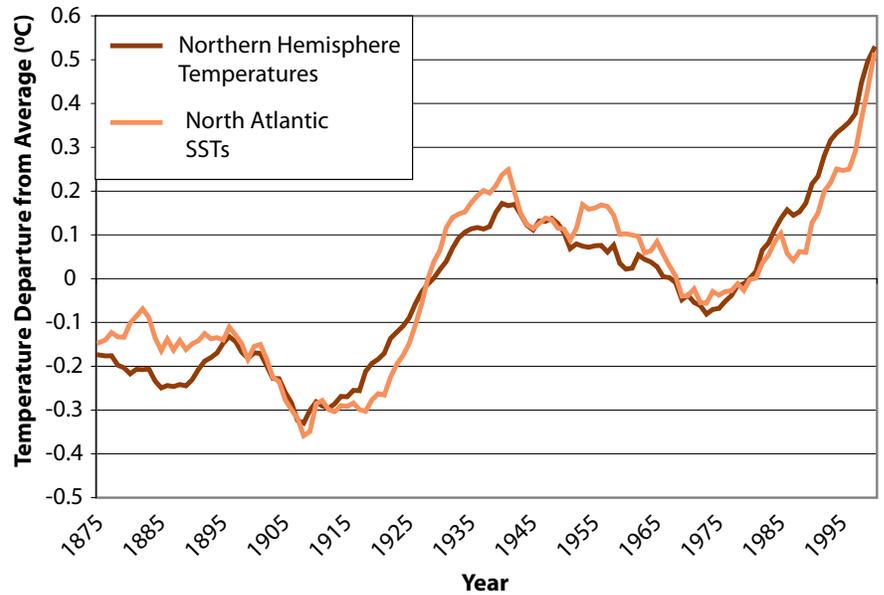


Figure 2. North Atlantic sea surface temperatures (SSTs) tend to closely match northern hemisphere air temperatures when both are smoothed at the decadal scale. In both cases, temperature values cover the peak hurricane season of August-October. Data courtesy of Kerry Emanuel of the Massachusetts Institute of Technology.

hurricanes can form. In the current climate, this temperature seems to serve as a general threshold for tropical convection—the process behind hurricanes, monsoons, and even many thunderstorms.

For instance, David Mitchell's research on the North America's monsoon system has found Arizona's summer monsoon rains won't begin until its moisture source, the Gulf of California, reaches close to 80 degrees Fahrenheit at the surface (*Journal of Climate*, September 1, 2002). Similarly, Chidong Zhang's research links this temperature threshold to the tropical convection behind many thunderstorms (*Journal of Climate*, October 1993).

What's more, Mitchell has found that the Gulf's SST must top 84 degrees to trigger the heavy rains that mark a strong monsoon in Arizona. Increases beyond that temperature don't have as dramatic of an impact, he indicated.

If a similar threshold applied to hurricane activity, that could help explain the sudden jump in intense Atlantic hurricanes from a relatively small change in temperature (Figure 1).

A threshold scenario would imply some good news: It could mean society is not necessarily facing a doubling in intense hurricane numbers for every rise of 1 degree Fahrenheit. On the other hand, it could imply that intense hurricanes will continue to thrive unless ocean basins drop below the threshold temperature.

In a warming world, even the threshold temperature for spawning hurricanes can shift. The SST needed to launch tropical convection rises with global air temperature, Emanuel said. This further complicates the issue.

Given the impact of hurricanes on society, this topic will continue to generate debate until the scientists involved reconcile their results with their models and each other. But it's worth remembering that nobody is predicting a decrease in Atlantic hurricane activity anytime soon.

Melanie Lenart is a postdoctoral research associate with the Climate Assessment for the Southwest (CLIMAS). The SWCO feature article archive can be accessed at the following link: <http://www.ispe.arizona.edu/climas/forecasts/swarticles.html>



Temperature (through 6/14/06)

Source: High Plains Regional Climate Center

Relentless above-average temperatures have continued to prevail across the Southwest. Since the start of the water year on October 1, 2005, temperatures across most of the region have been 0–4 degrees Fahrenheit above average (Figures 1a–b). Average temperatures have ranged from the upper 60s F in southwest Arizona to the lower 30s F in north-central New Mexico. Over the last 30 days temperatures have been much warmer than average, ranging from 2–8 degrees F above average over most of Arizona, and from 4–8 degrees above average over most of New Mexico (Figures 1c–d). The highest departures from average have been in eastern New Mexico and in a small area in southeastern Arizona. Most of southwestern Arizona has been warmer than average by 2–4 degrees F, and some small areas in far northwestern Arizona and in far southwestern New Mexico have been cooler than average by 0–4 degrees F. According to the National Weather Service, May 2006 was the sixth warmest May on record for Tucson, and in Albuquerque only one early morning temperature was below average all month. Nationally, May 2006 was the fifth warmest May on record for the period 1895 to the present.

Notes:

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

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

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

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

On the Web:

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

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

Figure 1a. Water year '05–'06 (through June 14, 2006) average temperature.

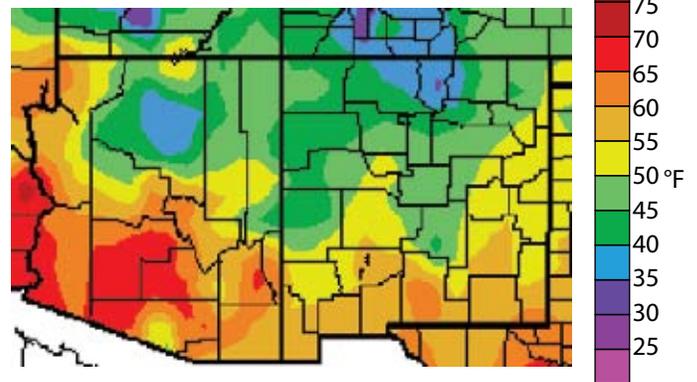


Figure 1b. Water year '05–'06 (through June 14, 2006) departure from average temperature.

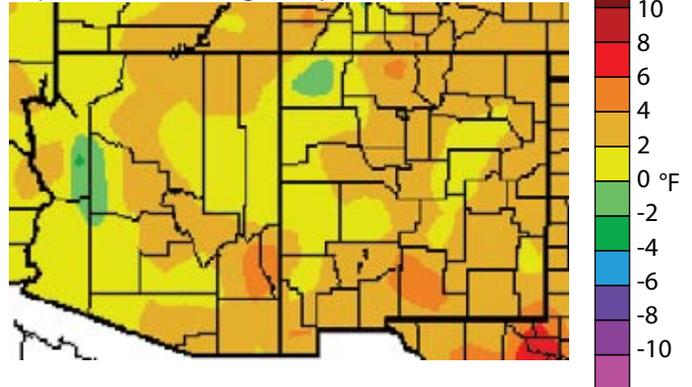


Figure 1c. Previous 30 days (May 16–June 14, 2006) departure from average temperature (interpolated).

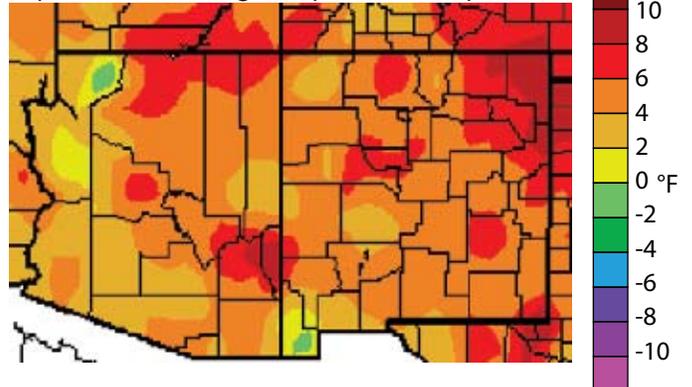
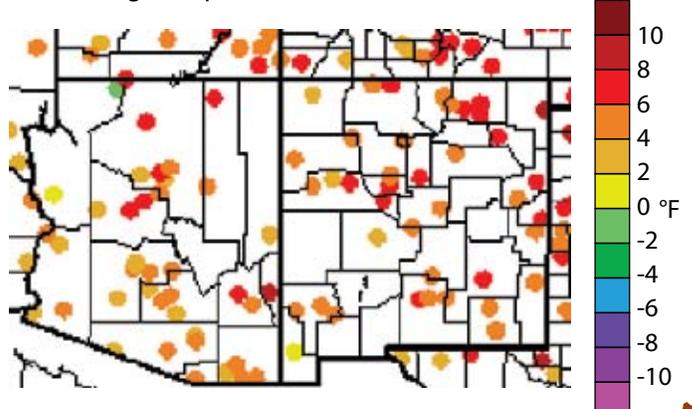


Figure 1d. Previous 30 days (May 16–June 14, 2006) departure from average temperature (data collection locations only).



Precipitation (through 6/14/06)

Source: High Plains Regional Climate Center

Despite some rain in early June, precipitation across the region remains far below average since the start of the water year on October 1, 2005, (Figures 2a–b). Precipitation has been less than 50 percent of average for most of the Southwest, and portions of the area have been below 25 percent of average. In Tucson, the period September 1–May 31 ranks as the driest combined fall, winter, and spring on record. In New Mexico, May marked the seventh consecutive excessively dry month for the state. Seventeen localities around the state, including Albuquerque, Ruidoso, Animas, and Raton, reported the period of November through May as the driest on record. Precipitation for the last 30 days also has been well below average, with most of the Southwest receiving less than 50 percent of average (Figures 2c–d). As the result of some unusual rainstorms in early June, a portion of southern Arizona and southwestern New Mexico received above-average rainfall, along with some other smaller scattered areas in the region. Statewide precipitation averages in May were well below average in both Arizona and New Mexico. In New Mexico, the statewide average was only 36 percent of the long-term average.

Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2005, we are in the 2006 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 '05–'06 through June 14, 2006 percent of average precipitation (interpolated).

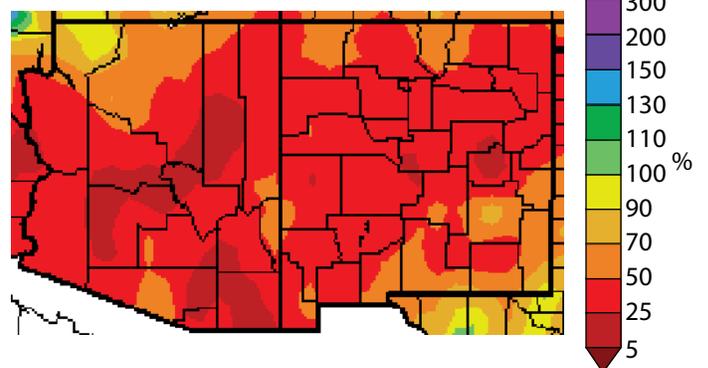


Figure 2b. Water year '05–'06 through June 14, 2006 percent of average precipitation (data collection locations only).

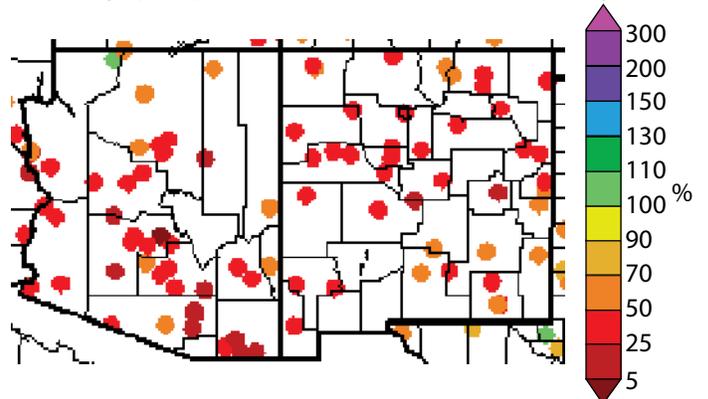


Figure 2c. Previous 30 days (May 16–June 14, 2006) percent of average precipitation (interpolated).

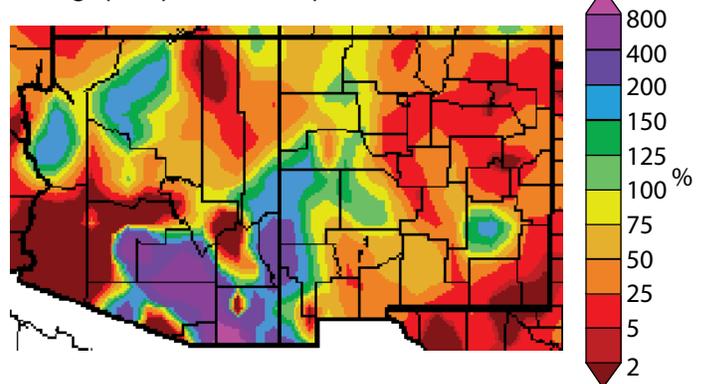
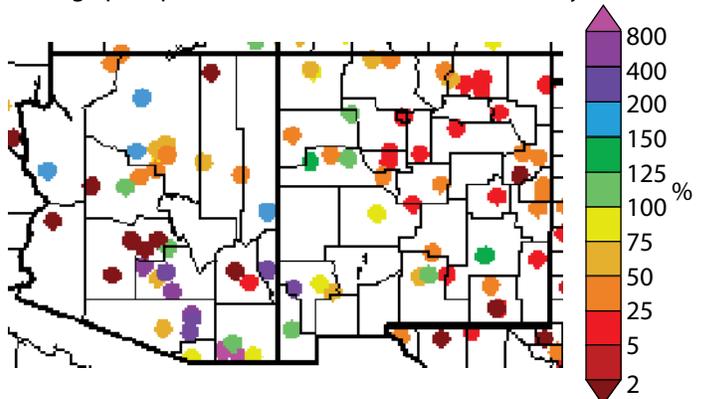


Figure 2d. Previous 30 days (May 16–June 14, 2006) percent of average precipitation (data collection locations only).



U.S. Drought Monitor

(released 6/15/06)

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

Drought conditions in the Southwest have continued to worsen. Severe drought has expanded northward in New Mexico to the Colorado border, and moderate or severe drought now holds sway over the previously drought-free southeastern corner of New Mexico (Figure 3). Exceptional drought conditions persist in parts of southeastern Arizona and southwestern New Mexico, and extreme drought conditions continue in a band stretching from central and southern Arizona across New Mexico into the Texas and Oklahoma panhandles. Many areas in Arizona and New Mexico have set record low precipitation amounts for the water year to date (see Figure 2a–d). Despite some occasional precipitation received in the spring and early June, not

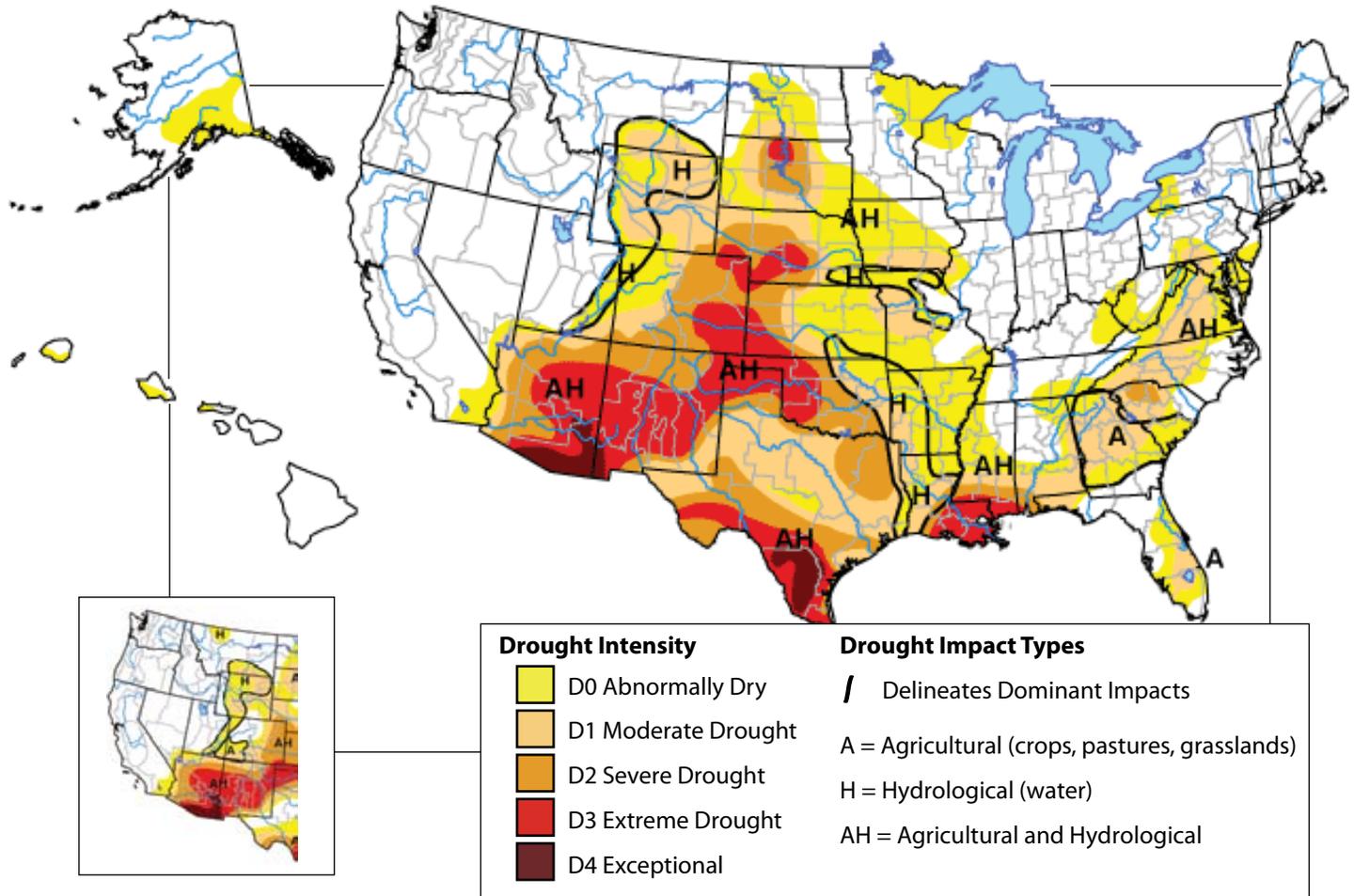
enough has fallen to overcome the long-term rain and snow deficits. The entire Southwest is now experiencing some level of drought due to the extremely low precipitation received during the winter and spring. The region is considered to be in agricultural drought, with impacts on crops, pastures, and grasslands, and is also being impacted by hydrologic drought, which leads to decreased river discharges and declining water levels in lakes and groundwater aquifers.

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 Rich Tinker CPC/NOAA.

Figure 3. Drought Monitor released June 15, 2006 (full size) and May 18, 2006 (inset, lower left).



On the Web:

The best way to monitor drought trends is to pay a weekly visit to the U.S. Drought Monitor website: <http://www.drought.unl.edu/dm/monitor.html>



Arizona Drought Status (through 5/31/06)

Source: Arizona Department of Water Resources

Short-term drought conditions continue to be severe throughout most of the state (Figure 4a). Extreme drought still exists in the Agua Fria River watershed in central Arizona, and across much of southern Arizona. Since the start of the water year on October 1, 2005, precipitation has been much below average over virtually the entire state (see Figures 2a–b). The long-term drought situation ranges from abnormally dry to extreme over most of the state, due to the exceptionally dry winter coupled with the previous long-term moisture deficit (Figure 4b). Virtually all of the state is in some level of drought or abnormal dryness, except for some areas in the southwestern parts of the state in Yuma and La Paz Counties near the Colorado River. Abnormally dry conditions exist in most of the western half of the state, and all along the northern border with Utah. Most of the eastern half of the state is in severe long-term drought status, including Whitewater Draw in far southeastern Arizona, which was in moderate status last month. The Santa Cruz River Basin in southern Arizona remains in extreme drought, while the Verde River basin in central Arizona is in moderate long-term drought status.

Soil moisture conditions continue to deteriorate in the state, with 83 percent of the pasture and range land rated in “poor” to “very poor” condition, up by 7 percentage points from last month. This time one year ago only 26 percent of the pasture and range land was in “poor” to “very poor” condition.

Notes:

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

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

On the Web:
 For the most current Arizona drought status maps, visit:
http://www.azwater.gov/dwr/Content/Hot_Topics/Agency-Wide/Drought_Planning/

Figure 4a. Arizona short term drought status for May 2006.

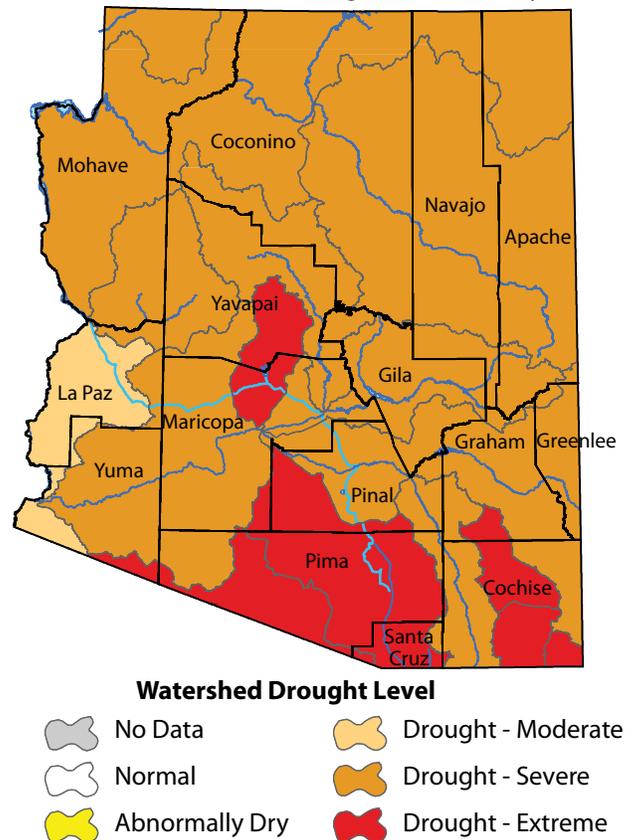
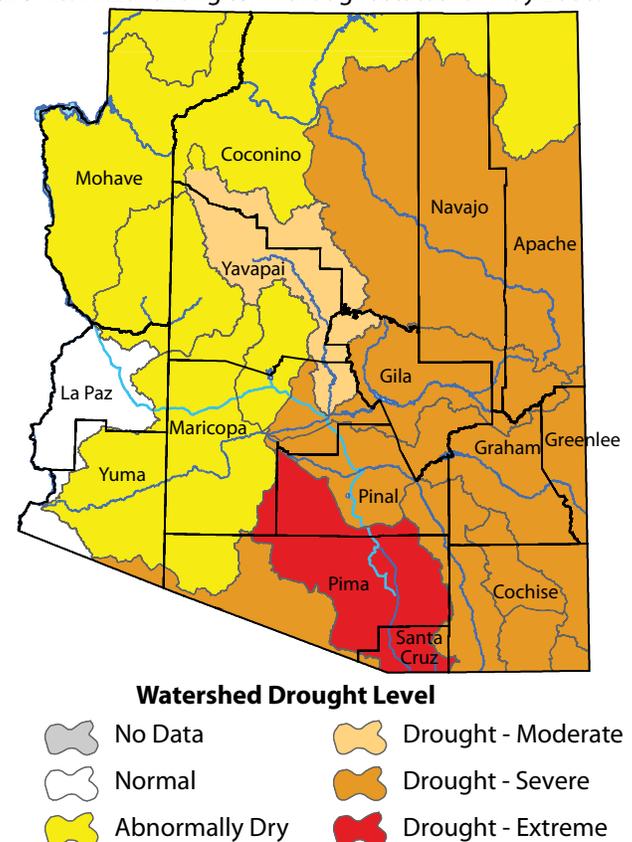


Figure 4b. Arizona long term drought status for May 2006.



Arizona Reservoir Levels (through 5/31/06)

Source: National Water and Climate Center

Arizona's total in-state reservoir storage continued to decline over the last month, by about 4 percent of capacity. The total storage on the Colorado River rose by about 1 percent of capacity as the result of spring snowmelt and runoff from the upper Colorado. The Salt River system and San Carlos reservoir on the Gila River both declined by 4 percent, while Lyman Lake fell by about 6 percent of capacity (Figure 5). Storage on the Verde River system remained constant at 45 percent. On the Colorado River, Lake Havasu rose by less than 1 percent, while Lake Mohave rose by 1.5 percent. Of the two largest reservoirs, Lake Mead fell by 1.9 percent of capacity, while Lake Powell rose by about 4 percent. The total storage on the Colorado River rose by 1.3 percent of capacity, while the combined in-state and Colorado River storage rose by 1 percent.

Within Arizona, storage on the three largest reservoirs has continued to decline since this time last year as the result of the ongoing severe drought conditions. The Salt River system has declined by 18 percent of capacity since a year ago, but remains at about 11 percent above the long-term average level. Storage on the Verde River system is currently at about 64 percent of average. The San Carlos reservoir now holds

just over a quarter of the amount of water it did a year ago, having declined by about 35 percent of capacity to only 12 percent, or about 23 percent of average. Storage in Lake Powell has increased by 7 percent of capacity since this time last year, but total storage on the Colorado River is at only about two-thirds of average due to long-term precipitation deficits in the Upper Colorado River Basin.

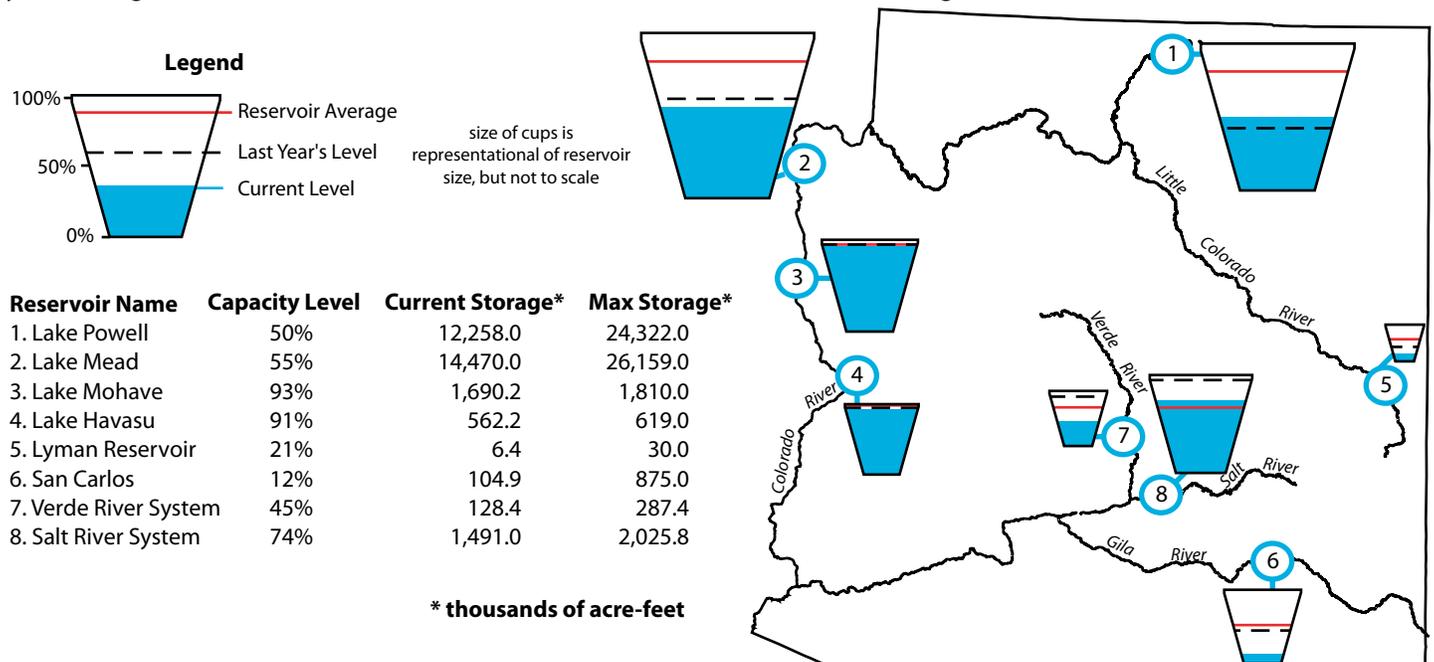
Notes:

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

The table details more exactly the current capacity level (listed as a percent of maximum storage). Current and maximum storage levels are given in thousands of acre-feet for each reservoir.

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 May 2006 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.



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 5/31/06)

Source: National Water and Climate Center

Most reservoirs in New Mexico declined somewhat since last month, although some increased in storage (Figure 6). The total storage of 13 reservoirs declined by 0.5 percent of capacity. On the San Juan River, Navajo Reservoir rose by about 3 percent of capacity. Like last month, the largest increases were on the Rio Grande, where Caballo and Heron rose by 5 and 6 percent, respectively. Also on the Rio Grande, Costilla declined by 5 percent, Elephant Butte and El Vado fell by 4 percent and 3 percent, respectively, and Abiquiu fell by 2 percent. Cochiti held steady at 10 percent. On the Pecos River, Brantley fell by 9 percent and Sumner and Santa Rosa fell slightly by 2 percent and 1 percent, respectively. Lake Avalon held steady at 25 percent of capacity. Conchas on the Canadian River declined by 7 percent.

The continuing moisture deficits in New Mexico have largely depleted the surplus water produced by the abundant moisture and snowpack received during the wet winter and spring of 2004–2005. Overall storage in New Mexico is now slightly less than it was a year ago, having declined by about 4 percent of capacity since the end of May 2005. Total storage statewide is now at about 90 percent of the level it was this time last year. The current reservoir storage is 70 percent

of the long-term average, compared to 77 percent a year ago. Storage in most of the systems near the Colorado border is above average or near average, including Navajo, Abiquiu, and Costilla reservoirs. In the east, storage in Santa Rosa is still near average. All other major storage systems in central and southern New Mexico remain well below average, including Elephant Butte, the largest reservoir in the state, which currently is at only 15 percent of capacity or 23 percent of average.

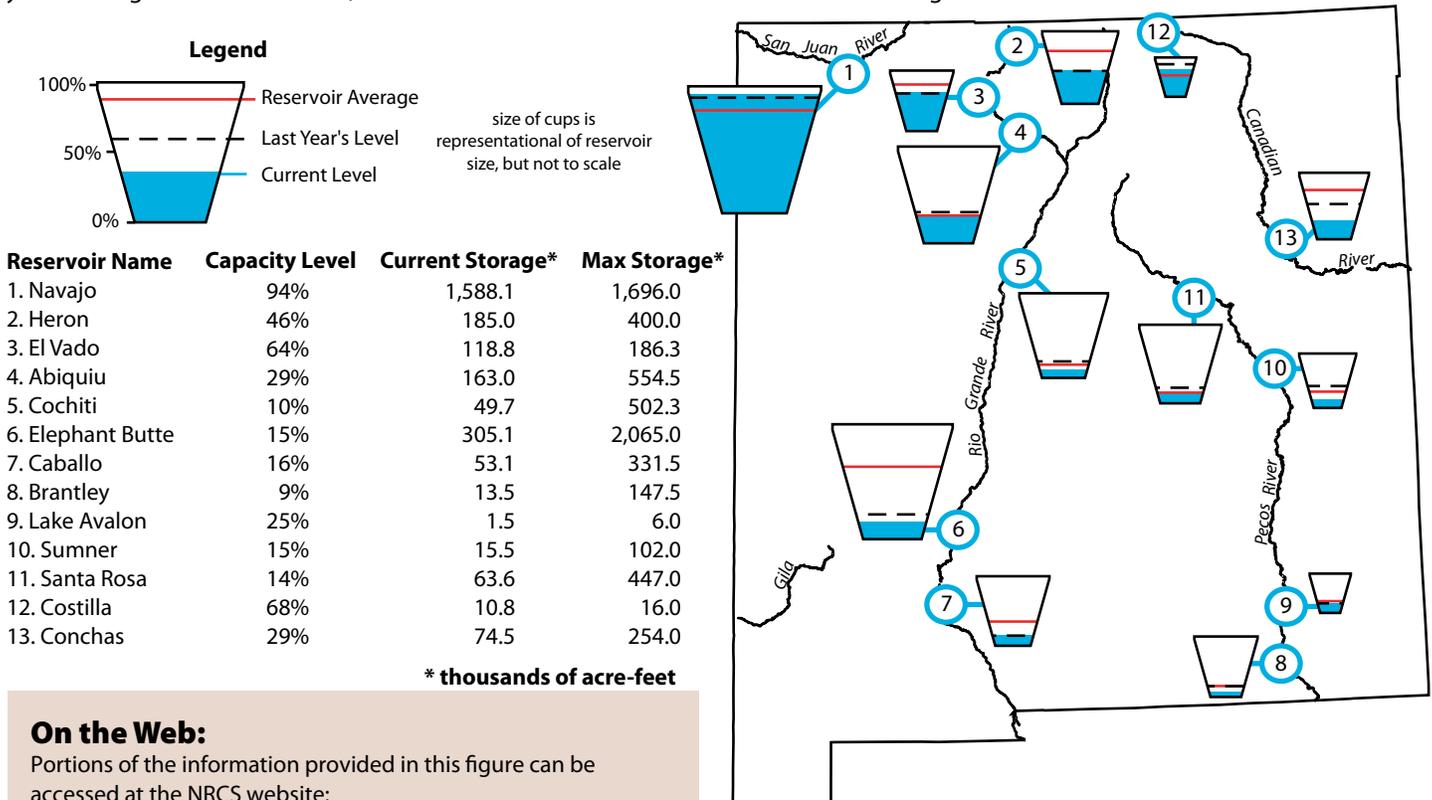
Notes:

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

The table details more exactly the current capacity level (listed as a percent of maximum storage). Current and maximum storage levels are given in thousands of acre-feet for each reservoir.

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 May 2006 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.



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 Fire Summary (updated 6/15/06)

Source: Southwest Coordination Center

As of June 13, the Southwest Coordination Center (SWCC) reports that 2,347 fires have burned 421,337 acres of land so far this year in Arizona and New Mexico (Figure 7a). About 72 percent of the fires were caused by humans. The rest were lightning-caused fires, accounting for about one-third of the acreage. This is more than twice the average number of fires by the end of June, and nearly five times the average acreage by this time of year. Well over half of these fires occurred in New Mexico, accounting for 93 percent of the acreage burned. The numbers above do not include prescribed fires, which are set to prevent larger fire potential or for ecosystem health, nor wildland fire use, in which natural fires are allowed to burn as long as they pose no threats. Agencies have reported 139 prescribed fires burning 73,358 acres, and 20 wildland fire use fires burning 15,046 acres to date, according to SWCC.

A total of 96 large fires (greater than 100 acres) have accounted for about three-quarters of the acreage so far this year (Figure 7b–c). Arizona has had 29 large fires compared to 67 in New Mexico. Nine of those fires—eight of them in New Mexico—have been larger than 10,000 acres and have accounted for 245,852 acres, or about 58 percent of the total acreage burned so far this season. The largest fire to date in Arizona was the Black Mountain Complex fire near Kingman, which burned 12,637 acres.

Notes:

The fires discussed here have been reported by federal, state, or tribal agencies during 2006. The figures include information both for current fires and for fires that have been suppressed. Figure 7a shows a table of year-to-date fire information for Arizona and New Mexico. Prescribed burns are not included in these numbers. Figures 7b and 7c indicate the approximate locations of past and present “large” wildland fires and prescribed burns in Arizona and in New Mexico. A “large” fire is defined as a blaze covering 100 acres or more in timber or 300 acres or more in grass or brush. The name of each fire is provided next to the symbol.

On the Web:

These data are obtained from the Southwest Area Wildland Fire Operations website:

http://gacc.nifc.gov/swcc/predictive/intelligence/daily/ytd_daily_state.htm

http://gacc.nifc.gov/swcc/predictive/intelligence/situation/swa_fire.htm

Figure 7a. Year-to-date fire information for Arizona and New Mexico as of June 13, 2006.

State	Human Caused Fires	Human caused acres	Lightning caused fires	Lightning caused acres	Total Fires	Total Acres
AZ	909	20,460	243	9,221	1,152	29,681
NM	776	257,831	419	133,825	1,195	391,656
Total	1,685	278,291	662	143,046	2,347	421,337

Figure 7b. Arizona large fire incidents as of June 15, 2006.



Figure 7c. New Mexico large fire incidents as of June 15, 2006.



Temperature Outlook

(July–December 2006)

Source: NOAA Climate Prediction Center (CPC)

The NOAA-CPC temperature outlook calls for above-average temperatures for the Southwest through November 2006 (Figures 8a–c). Except for a narrow strip along the California coast, the July–September outlook indicates increased chances of warmer-than-average temperatures throughout the entire West, extending eastward through much of the Midwest and including Florida, and New England. The area with highest probabilities for above above-average temperatures is centered over Arizona and southwestern New Mexico, with greater than 50 percent chances extending over Nevada, Utah, Colorado, New Mexico, and West Texas. As the outlook period progresses through summer into fall, those chances contract into the Southwest. No areas of cooler-than-average temperatures are included in the outlook through December (Figure 8d).

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 July–September 2006.

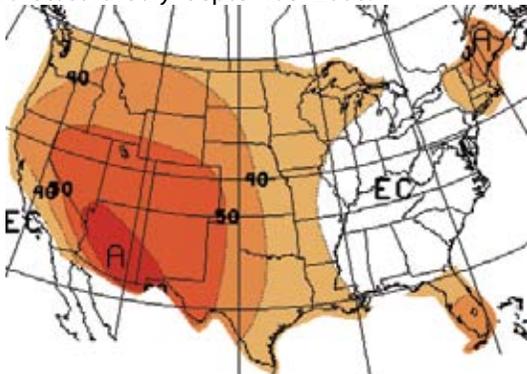


Figure 8c. Long-lead national temperature forecast for September–November 2006.

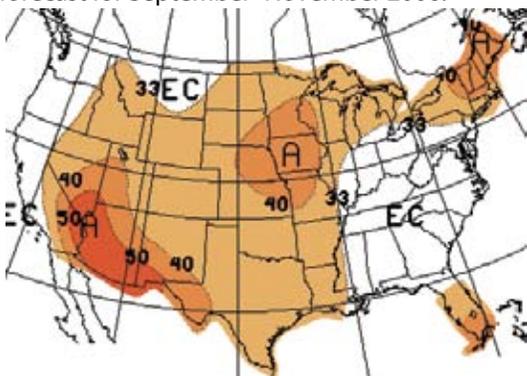


Figure 8b. Long-lead national temperature forecast for August–October 2006.

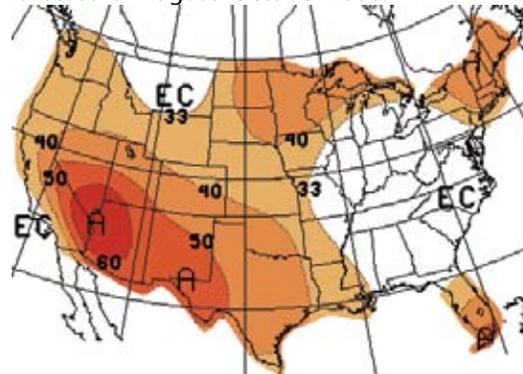
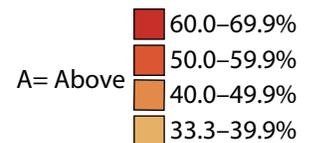
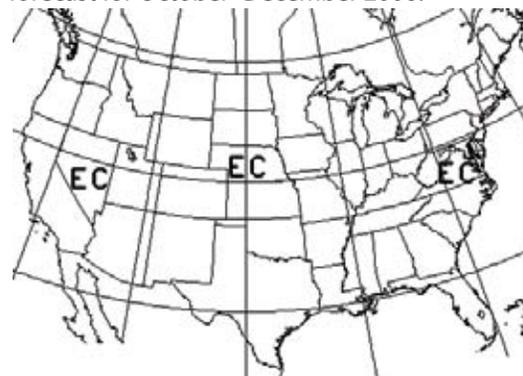


Figure 8d. Long-lead national temperature forecast for October–December 2006.



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

(July–December 2006)

Source: NOAA Climate Prediction Center (CPC)

Long-lead precipitation outlooks from the NOAA-CPC for July through September call for equal chances of below-average, average, or above-average precipitation for almost all of the Southwest except for the southeastern corner of New Mexico, where below-average precipitation is indicated (Figure 9a). The anomaly of below-average precipitation is centered in West Texas and extends into southwestern Oklahoma and southeastern New Mexico. Summer precipitation forecasts are difficult to make for the Southwest during ENSO-neutral conditions because of the lack of a statistical connection with the North American Monsoon System. Elsewhere, the outlook calls for below-average precipitation in northern California and part of the Northwest through October, and for increased chances for wetter-than-average conditions in Florida and the southern Atlantic Seaboard states through October, persisting into November in Florida (Figures 9b–c).

Figure 9a. Long-lead national precipitation forecast for July–September 2006.

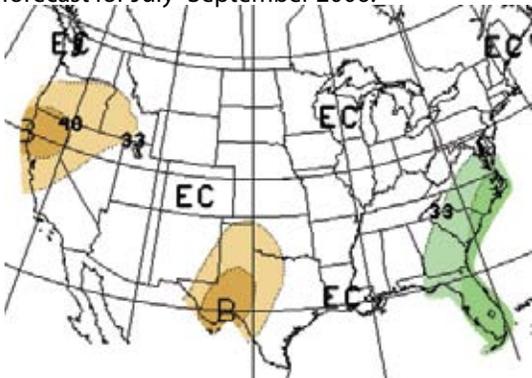


Figure 9c. Long-lead national precipitation forecast for September–November 2006.

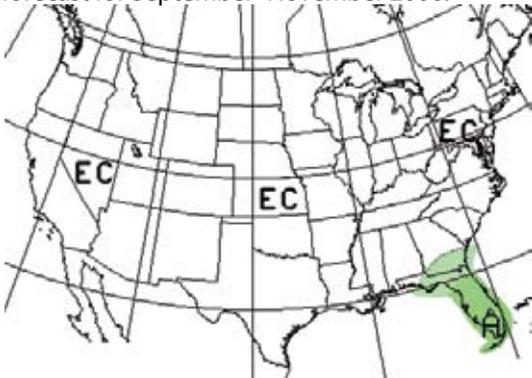


Figure 9b. Long-lead national precipitation forecast for August–October 2006.

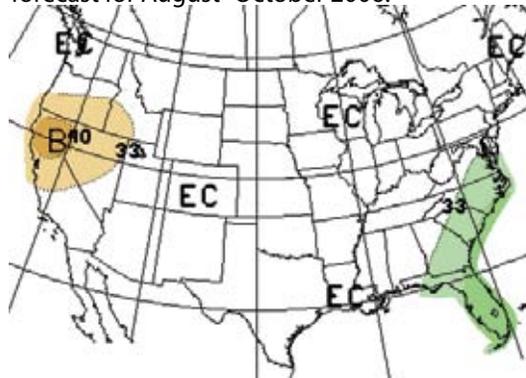


Figure 9d. Long-lead national precipitation forecast for October–December 2006.



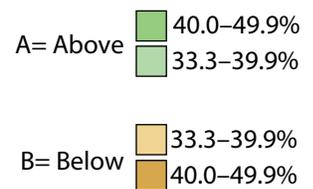
Notes:

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.



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 September 2006)

Source: NOAA Climate Prediction Center (CPC)

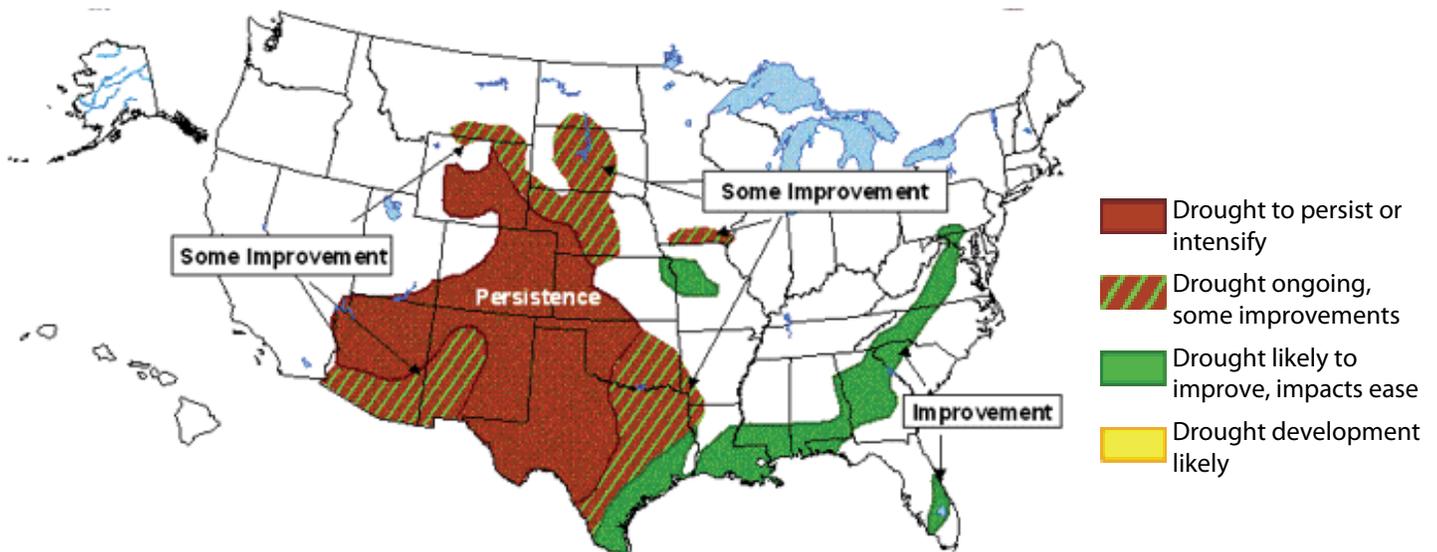
The U.S. drought outlook through September 2006 calls for drought conditions to persist throughout nearly all of Arizona and New Mexico, and from central and southern Texas northward through most of Oklahoma, southern and eastern Colorado, western Kansas and Nebraska, and into much of Wyoming and South Dakota (Figure 10). Some improvement is expected in the ongoing drought areas across southern Arizona and southwestern and central New Mexico, contingent upon adequate rains during the summer monsoon thunderstorm season. Some improvement in ongoing drought areas is also expected in east Texas and eastern Oklahoma, parts of far southwestern Arkansas and northwestern Louisiana, southern Iowa, central and western Nebraska, central South Dakota, northeastern Wyoming, and southeastern Montana. Elsewhere, improvement in drought conditions is expected in a band extending along the Gulf Coast from far southern Texas to northern Florida and continuing northward along the Appalachians to southern Pennsylvania. Improvement is also expected in southern Florida, northwestern Missouri, and far northeastern Kansas.

No long-term drought relief is in sight for the Southwest because of the virtual absence of winter precipitation this last season in the region, even though some temporary relief came from some springtime storms. The early summer is characteristically very dry in Arizona and New Mexico, and we are unlikely to see any significant precipitation before the monsoon season. Ongoing drought conditions have contributed greatly to elevated fire risks across the Southwest during the spring and early summer. The Southwest Coordination Center reports that the fire danger through June is higher than average across nearly all of the Southwest, reaching critical levels in the higher elevation timber country stretching from central Arizona along the Mogollon Rim into central New Mexico, and in the mountains in northern New Mexico and the Sacramento Mountains in the southeastern part of the state. June is the month in which the most fires occur on average in the Southwest, and the abundance of dry fuels across the region points to a very active fire season this year.

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 September 2006 (release date June 15, 2006).



On the Web:

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



Wildland Fire Outlook

Sources: National Interagency Coordination Center, Southwest Coordination Center

Above-average significant fire potential is expected across most of the Southwest through June into early July (Figure 11a). Fuel loadings are above average in much of the region, and the ongoing severe drought has caused the abundant fuels in many areas to be at or near critical moisture levels (Figure 11b). The danger is particularly high in the middle to higher elevation timber fuel types. The areas of critically high fire potential correspond roughly to the higher country in the Southwest, stretching from central Arizona along the Mogolon Rim into central New Mexico, and in the mountains of northern and southeastern New Mexico. Thunderstorms and dry lightning could have a major impact on increased ignitions and immediate fire spread as moisture begins to enter the region prior to the monsoon season. The above-average temperature outlook, combined with the generally insignificant rainfall to be expected in June in the Southwest, points to a high probability of the continuation of a very active to critical fire season until the onset of the monsoon rains in July. Fire potential in eastern New Mexico should begin to decrease soon as moisture gradually increases from the east.

Figure 11a. National wildland fire potential for fires greater than 100 acres (valid June 1–30, 2006).

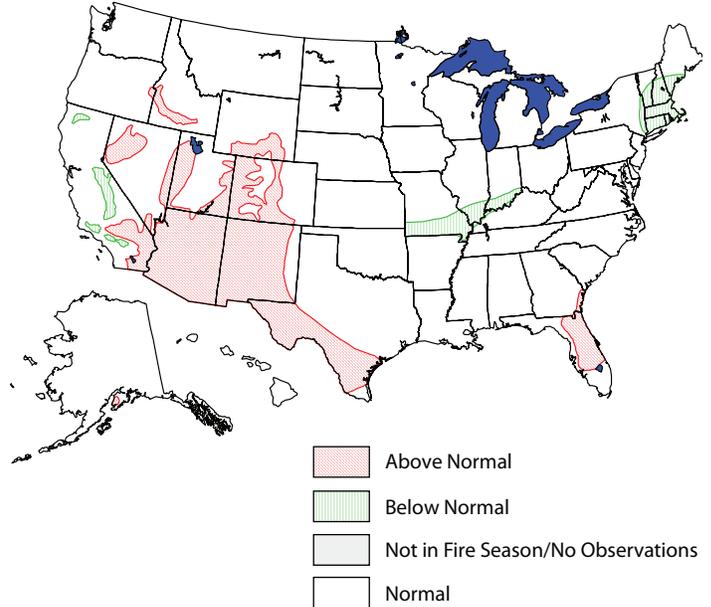


Figure 11b. Current fine fuel condition and live fuel moisture status in the Southwest.

Current Fine Fuels					
Grass Stage	Green	Cured	X		
New Growth	Sparse	Normal	X	Above Normal	

Live Fuel Moisture	
	Percent of Average
Ponderosa Pine	95
Douglas Fir	99
Piñon	91
Juniper	76
Sagebrush	150
1000-hour dead fuel moisture	10
Average 1000-hour fuel moisture for this time of year	8–14

Notes:

The National Interagency Coordination Center at the National Interagency Fire Center produces monthly wildland fire outlooks. The forecasts (Figure 11a) consider climate forecasts and surface-fuels conditions in order to assess fire potential for fires greater than 100 acres. They are subjective assessments, based on synthesis of regional fire danger outlooks.

The Southwest Area Wildland Fire Operations produces monthly fuel conditions and outlooks. Fuels are any live or dead vegetation that are capable of burning during a fire. Fuels are assigned rates for the length of time necessary to dry. Small, thin vegetation, such as grasses and weeds, are 1-hour and 10-hour fuels, while 1000-hour fuels are large-diameter trees. The top portion of Figure 11b indicates the current condition and amount of growth of fine (small) fuels. The lower section of the figure shows the moisture level of various live fuels as percent of average conditions.

On the Web:

National Wildland Fire Outlook web page:
<http://www.nifc.gov/news/nicc.html>

Southwest Area Wildland Fire Operations (SWCC) web page:
<http://www.fs.fed.us/r3/fire/>



El Niño Status and Forecast

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

ENSO-neutral conditions are expected to prevail over the next three months, consistent with the decrease of the Southern Oscillation Index to the value of 0.5 (Figure 12a). During May, sea surface temperatures were near average at most locations in the central and eastern equatorial Pacific Ocean in all of the Niño regions. During the month, above-average precipitation was observed over portions of Indonesia and extreme northeastern Australia, while below-average precipitation occurred over most of the equatorial Pacific. Low-level and upper-level winds over the tropical Pacific were near average during the month. Beginning in February, the basin-wide upper-level ocean heat content increased, and since early April positive anomalies have been observed. Collectively, these atmospheric and oceanic features indicate ENSO-neutral conditions, according to the NOAA-CPC. Most of the climate models predict ENSO-neutral conditions in the tropical Pacific through the end of 2006, but the spread of the forecasts among different ENSO models (not shown), from weak La Niña to weak El Niño, indicate considerable uncertainty in the outlooks for the latter half of the year. The

Notes:

Figure 12a shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through May 2006. The SOI measures the atmospheric response to SST changes across the Pacific Ocean Basin. The SOI is strongly associated with climate effects in the Southwest. Values greater than 0.5 represent La Niña conditions, which are frequently associated with dry winters and sometimes with wet summers. Values less than -0.5 represent El Niño conditions, which are often associated with wet winters.

Figure 12b 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.

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/>

probabilistic forecast issued by the IRI is in agreement with CPC, predicting an 80 percent chance of ENSO-neutral conditions during the next three months, and lower but still above-average chances for ENSO-neutral conditions for the foreseeable future.

Historically, ENSO-neutral conditions do not provide any strong climate predictive information for summer precipitation for the Southwest. The NOAA-CPC outlook for precipitation in the Southwest is for equal chances of below-average, average, or above-average precipitation in virtually the entire region for the next six months.

Figure 12a. The standardized values of the Southern Oscillation Index from January 1980–May 2006. La Niña/El Niño occurs when values are greater than 0.5 (blue) or less than -0.5 (red) respectively. Values between these thresholds are relatively neutral (green).

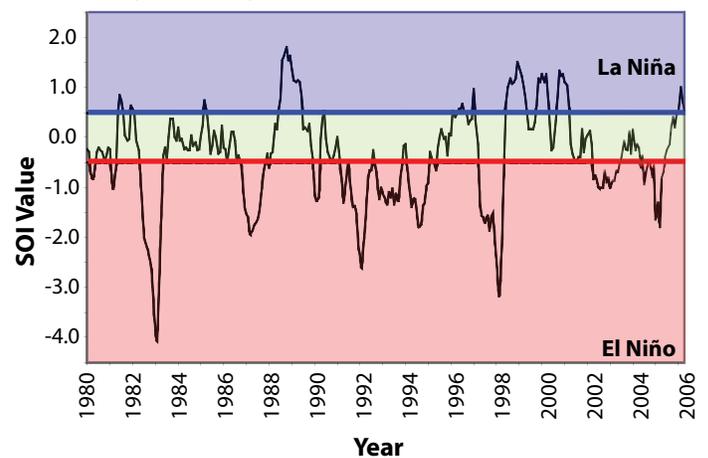
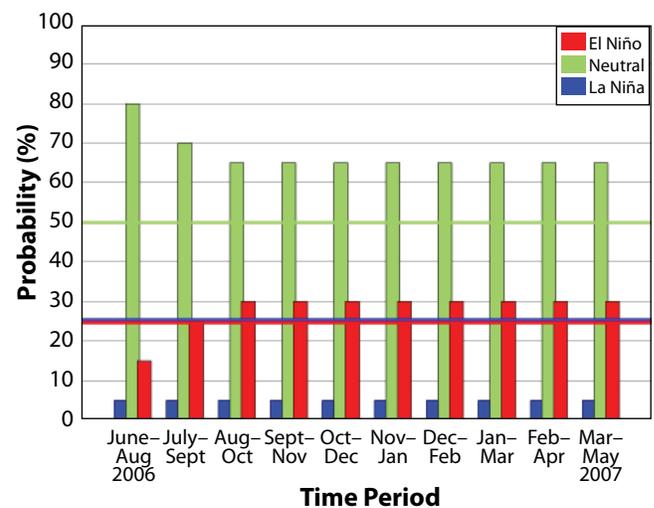


Figure 12b. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released June 15, 2006). Colored lines represent average historical probability of El Niño, La Niña, and neutral.



Temperature Verification

(March–May 2006)

Source: NOAA Climate Prediction Center (CPC)

The long-range outlook for March–May 2006 from the NOAA-CPC predicted above-average temperatures across the southern tier of states from California to Alabama. The areas of highest probability were over the Southwest, from southern and central Arizona to southwestern and central New Mexico (Figure 13a). In the north, cooler-than-average temperatures were forecast from western Washington to northwestern Minnesota. Observed temperatures across most of the central states were 0–6 degrees Fahrenheit above average, with the warmest anomalies over Texas (Figure 13b). The far western states ranged from 0–4 degrees F below average, while the East was generally 0–2 degrees F below average. The outlook performed well in predicting the above-average temperatures from central Arizona across New Mexico and Texas into Alabama, but poorly in predicting above-average temperatures from western Arizona to the West Coast, where cooler-than-average temperatures prevailed. The results were mixed in the north, where cooler-than-average temperatures prevailed as forecast in the Northwest, but above-average temperatures occurred from Montana to Minnesota.

Notes:

Figure 13a shows the NOAA Climate Prediction Center (CPC) temperature outlook for the months March–May 2006. This forecast was made in February 2006.

The outlook predicts the likelihood (chance) of above-average, average, and below-average temperature, but not the magnitude of such variation. The numbers on the maps do not refer to degrees of temperature.

Using past climate as a guide to average conditions and dividing the past record into 3 categories, there is a 33.3 percent chance of above-average, a 33.3 percent chance of average, and a 33.3 percent chance of below-average temperature. Thus, using the NOAA CPC likelihood forecast, in areas with light brown shading there is a 33.3–39.9 percent chance of above-average, a 33.3 percent chance of average, and a 26.7–33.3 percent chance of below-average precipitation. Equal Chances (EC) indicates areas where reliability (i.e., the skill) of the forecast is poor and no prediction is offered.

Figure 13b shows the observed departure of temperature (degrees F) from the average for the March–May 2006 period. Care should be exercised when comparing the forecast (probability) map with the observed temperature maps. The temperature departures do not represent probability classes as in the forecast maps, so they are not strictly comparable. They do provide us with some idea of how well the forecast performed. In all of the figures on this page, the term average refers to the 1971–2000 average. This practice is standard in the field of climatology.

Figure 13a. Long-lead U.S. temperature forecast for March–May 2006 (issued February 2006).

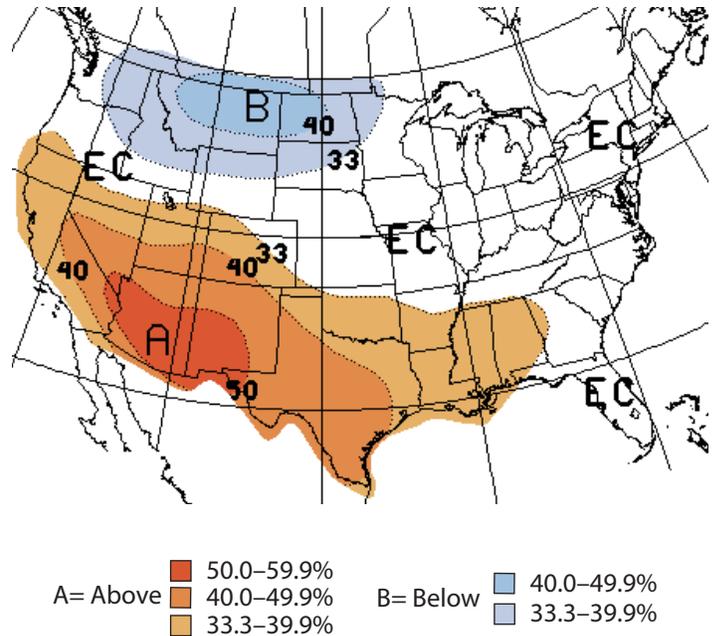
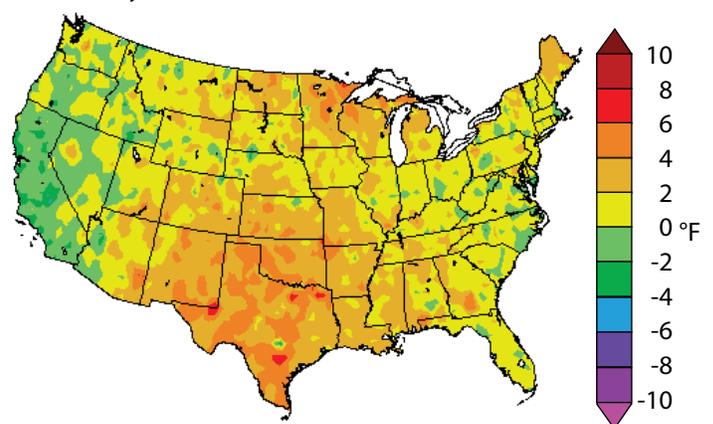


Figure 13b. Average temperature departure (in degrees F) for March–May 2006.



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

(March–May 2006)

Source: NOAA Climate Prediction Center (CPC)

The long-range outlook from the NOAA-CPC for March–May has resulted in a near bulls-eye verification for the second month in a row. The outlook called for increased chances for below-average precipitation in a large anomaly extending from southern California across the Southwest into southern Texas and north to Nebraska, with the highest probabilities over central Arizona (Figure 14a). Below-average precipitation was also forecast in another area including Florida and the far Southeast. An area of above-average precipitation was predicted in the Northeast and Midwest, from Indiana to Michigan and western New York. Observed precipitation matched the forecast well in the Southwest and surrounding regions, where below-average precipitation occurred almost everywhere except for some parts of southern and northwestern Arizona, southern California, and central Texas (Figure 14b). Results were also good in the Southeast, where below-average precipitation prevailed as predicted, and the observed above-average precipitation centered over Indiana and Michigan was a fairly good match for the predicted wetter-than-average anomaly there.

Figure 14a. Long-lead U.S. precipitation forecast for March–May 2006 (issued February 2006).

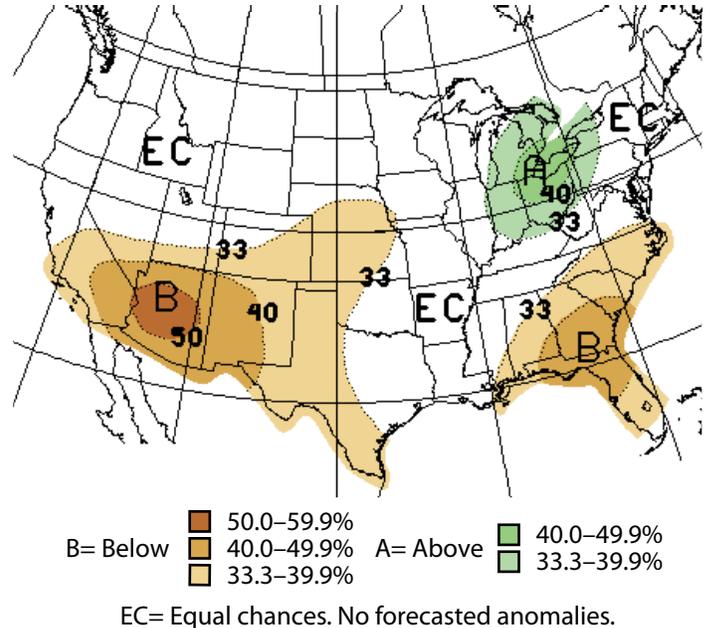
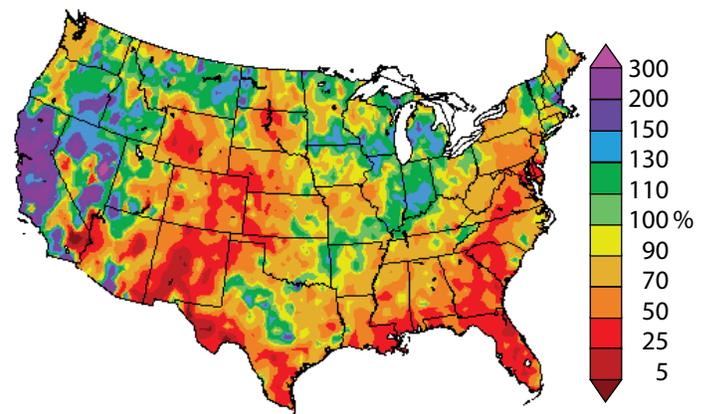


Figure 14b. Percent of average precipitation observed from March–May 2006.



Notes:

Figure 14a shows the NOAA Climate Prediction Center (CPC) precipitation outlook for the months March–May. This forecast was made in February 2006.

The outlook predicts the likelihood (chance) of above-average, average, and below-average precipitation, but not the magnitude of such variation. The numbers on the maps do not refer to inches of precipitation. Using past climate as a guide to average conditions and dividing the past record into 3 categories, there is a 33.3 percent chance of above-average, a 33.3 percent chance of average, and a 33.3 percent chance of below-average precipitation. Thus, using the NOAA CPC likelihood forecast, in areas with light brown shading there is a 33.3–39.9 percent chance of above-average, a 33.3 percent chance of average, and a 26.7–33.3 percent chance of below-average precipitation. Equal Chances (EC) indicates areas where reliability (i.e., the skill) of the forecast is poor and no prediction is offered.

Figure 14b shows the observed percent of average precipitation for March–May. Care should be exercised when comparing the forecast (probability) map with the observed precipitation maps. The observed precipitation amounts do not represent probability classes as in the forecast maps, so they are not strictly comparable, but they do provide us with some idea of how well the forecast performed.

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

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

