Issued: September 25, 2008

Southwest Climate Outlook

The University of Arizona.
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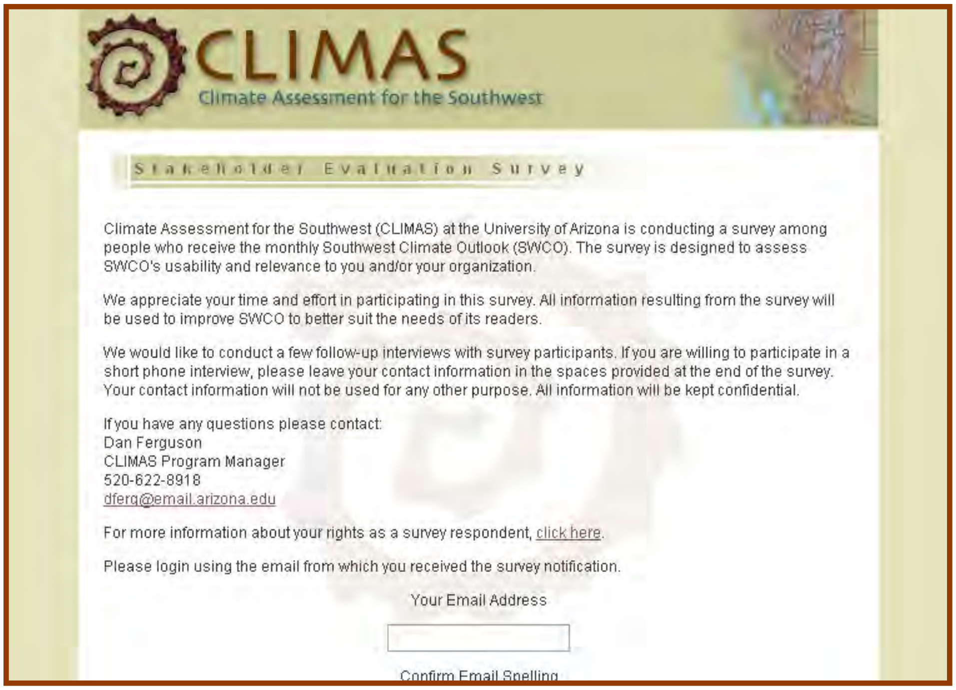
CLIMAS
Climate Assessment for the Southwest

Stakeholder Evaluation Survey

Climate Assessment for the Southwest (CLIMAS) at the University of Arizona is conducting a survey among people who receive the monthly Southwest Climate Outlook (SWCO). The survey is designed to assess SWCO's usability and relevance to you and/or your organization.

We appreciate your time and effort in participating in this survey. All information resulting from the survey will be used to improve SWCO to better suit the needs of its readers.

We would like to conduct a few follow-up interviews with survey participants. If you are willing to participate in a short phone interview, please leave your contact information in the spaces provided at the end of the survey. Your contact information will not be used for any other purpose. All information will be kept confidential.

If you have any questions please contact:
Dan Ferguson
CLIMAS Program Manager
520-622-8918
dferg@email.arizona.edu

For more information about your rights as a survey respondent, click here.

Please login using the email from which you received the survey notification.

Your Email Address

Confirm Email Spelling

Source: http://climas.biocom.arizona.edu/login.cfm

Photo Description: CLIMAS is evaluating the *Southwest Climate Outlook* to ensure that it remains useful and applicable to you. CLIMAS is conducting an online survey. Your participation will be vital to shaping future changes we make to the *Outlook*. To take the survey, please visit: http://climas.biocom.arizona.edu/login.cfm.

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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ENSO

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ENSO-neutral conditions dominate the equatorial Pacific Ocean again this month with near-average sea-surface temperature (SST) observations in the central portion of the basin...

September Climate Summary

Drought – Drought conditions in both Arizona and New Mexico improved, largely the result of continued summer monsoon rains.

Temperature – Temperatures in the past month have been much cooler than average across eastern and southern New Mexico, while most of Arizona has been slightly warmer than average.

Precipitation – Southern areas in Arizona and New Mexico continue to have a wet monsoon season, with rainfall totals measuring as much as 300 percent above average. Northern areas remain relatively dry.

Monsoon – Many areas in southern Arizona and New Mexico received above-average precipitation in the last month. Phoenix has enjoyed almost twice the average amount of rainfall since the onset of the monsoon.

ENSO – ENSO-neutral conditions dominate the equatorial Pacific Ocean again this month, but ocean warming has not disrupted the atmospheric circulation patters from the recent La Niña.

Climate Forecasts – The long-lead forecasts for late 2008 through early 2009 calls for slightly increased chances of below-average precipitation and a slightly increased chance of above-average temperatures for many parts of Arizona and New Mexico.

The Bottom Line – The monsoon season is waning but the impact of a wetter-than-normal summer has improved drought conditions for many areas in Arizona and New Mexico. Currently, soil moisture conditions in most of New Mexico and southern Arizona are adequate for crop needs. Rain is still needed in sections of northern Arizona to alleviate drought conditions.

Improving the *Southwest Climate Outlook*

As many of our readers know, the *Southwest Climate Outlook* provides current, pertinent, and reliable climate information to stakeholders. CLIMAS has been publishing the monthly report since the spring of 2002 to help educate stakeholders and improve communication between those who produce climate-related information and those who use it.

After six years of publication, CLIMAS is evaluating the *Outlook* to ensure that it remains useful and applicable to you. To produce the best product that meets your needs, CLIMAS is conducting an online survey. Your participation will be vital to shaping future changes we make to the *Outlook*. The survey will take only about 10 minutes and will largely consist of multiple choice answers. All information will be kept confidential. The survey will be available on-line until October 31st.

To take the survey, please visit the link below.

Survey link: http://climas.biocom.arizona.edu/login.cfm

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Flash floods in city environments

The good, bad, and sometimes fatal judgements that motorists make

By Zack Guido

The yellow and black signs pop up throughout Tucson every summer: "flood area." They are silent sentinels, warning motorists that a torrent of rain water is surging through a dip in the road or stretch of street, making it dangerous to pass.

Yet, every monsoon season in Tucson and throughout the Southwest sees motorists plow ahead across temporary road rapids, hoping to make it to the other side with nothing more to show for it than wet tires.

Some aren't so lucky; they misjudge the depth of the water and find themselves floating uncontrollably in their vehicles or, worse, are drowned.

Intense rains are common during the monsoon season, and so are flash floods. As of August 28, the National Weather Service in Tucson had issued 83 flash flood warnings for southeast Arizona, prompting many city planners as well as people in charge of broadcasting flash flood warnings to ask why motorists throw caution to the wind—or in this case, to the water. A University of Arizona graduate student Ashley Coles has some answers for them.

Figure 1. This photo was taken on July 28, 2008, several blocks north of Speedway Boulevard on Park Avenue in Tucson. *Source: Ashley Coles.*

Hazardous Roads

Each year in the United States the number of deaths caused by floods is greater than all other weather-related hazards except extreme heat. Higher populations in cities give urban flash floods higher profiles, but rural areas are equally affected.

The Centers for Disease Control reports that more than half of all flood-related drownings occur when vehicles are driven into hazardous flood waters. The next highest percentage occurs when people on foot are swept into swollen and fast flowing waters. In Arizona and New Mexico, 57 people have died since 1995, and hundreds of others have needed swift water rescues, according to news sources.

In the Southwest, flooded roads often occur during the intense and short-lived monsoon storms between June and September. In Tucson, when precipitation at any of the 93 rain gauges incorporated in the Pima County Flood Control District's (Pima Flood District) monitoring network exceeds one inch per hour, the Pima Flood District alerts the Tucson Department of Transportation (T-DOT) of possible dangerous flood conditions. The monitoring data is also retrieved by the National Weather Service (NWS) in Tucson and incorporated into their decision to issue flash flood advisories or warnings.

Despite these warnings, effective communication of flash floods is virtually impossible, said Tony Haffer, meteorologist for the NWS in Phoenix. Over the air waves, Haffer continued, it is difficult to mention the specific locations of flash floods. Alerts often catch motorists off-guard, and they might not reach motorists who are listening to music or people not in vehicles.

On July 26 in Ruidoso, New Mexico, a young man lost his footing and drowned in the raging Rio Ruidoso. A month later, two women were killed in Phoenix in separate incidents when flash floods swamped their cars.

"Water is typically muddy and it's difficult to judge depth. It doesn't take much water to get into trouble," Haffer said.

The main reason for the casualties is that people underestimate the depth of water and as a result misjudge the force of the current. In fact, as little as six inches of flowing water can knock down an adult, and 18 inches is enough water to float most vehicles, including big SUVs.

Warnings are not going to reach everyone. "Thank goodness not many people die. But unfortunately we have a number of motorists who put themselves in danger and also put rescuers at risk," Haffer said.

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Flash floods, continued

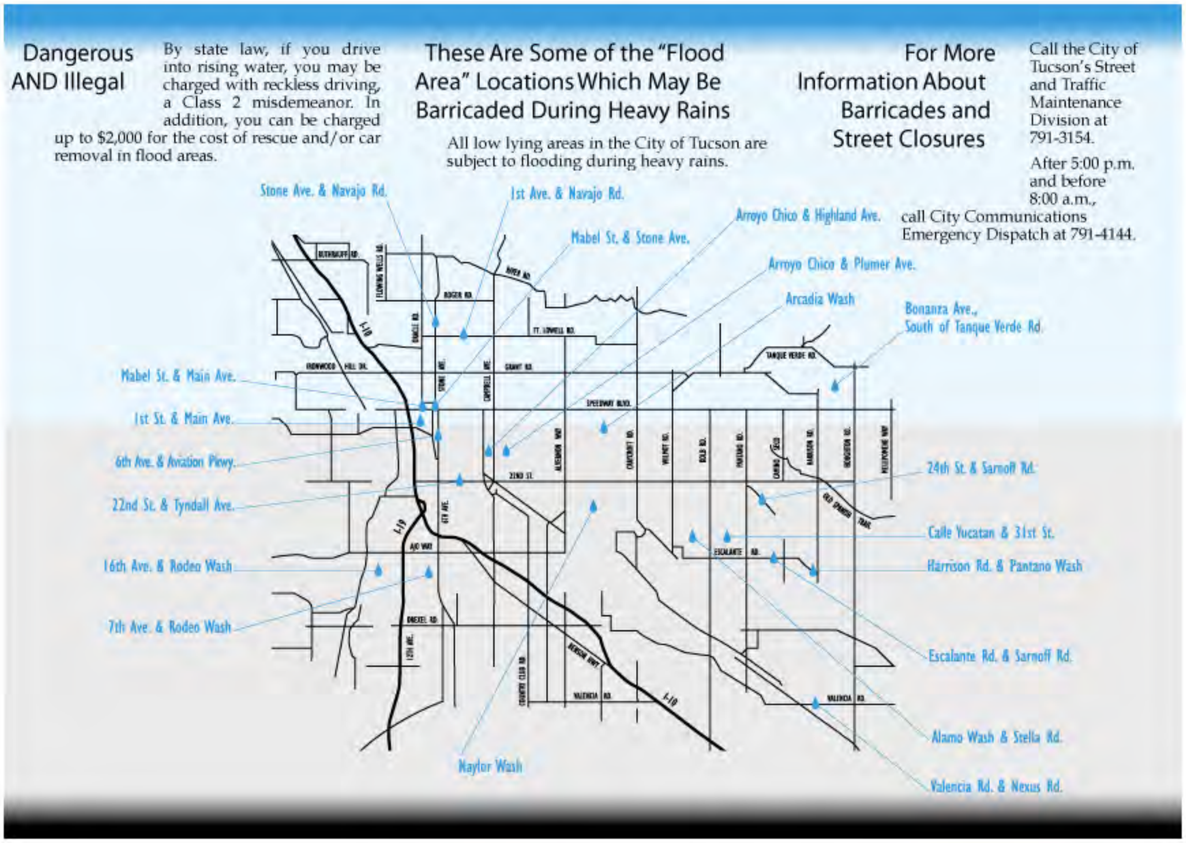

Figure 2. Map of street locations in Tucson that are prone to floods and that may be barricaded during heavy rains. This map does not include all the locations that may be flooded. *Source: This map was produced by the Tucson Department of Transportation for its public outreach campaign, "Operation Splash."*

On August 31, Tucson firefighters rescued two men who were trapped in their truck after their pick-up stalled in deeper-than-expected water and free-wheeled 1,000 feet down Arroyo Chico.

Why roads are flooded

For newcomers to the Southwest, flooded roads in downtown cities undoubtedly seem out of place. Where are the culverts, the bridges, the flood control ditches typical of other places? Even the simultaneous occurrence of rain and flooding is novel.

"Many people are transplants and they come from areas outside the Southwest; it's a whole different animal here," Haffer said. "Deserts are primed for floods because the sun bakes the soils and makes the ground more impermeable."

The hard soils and intense monsoon rains collaborate to immediately cascade water off the landscape into a network of hundreds of natural rills and gullies that focus water into larger channels. Where the city roads overlay these waterways, roads become rivers during heavy rains.

In fact, Haffer said, "engineers and planners designed roads to carry water. When you see water on roads, that is what they were intended to do."

During flash floods in Central Tucson, for example, water flowing in Navajo Wash crosses First Avenue, creating a dangerous pool, before funneling onto Navajo Road. Navajo Road then channels the water past Euclid and Stone avenues, creating two more hazardous intersections, and several more blocks before dumping the water into a cemetery.

It would undoubtedly be safer for motorists if all the water flowed under Tucson, but this would require a New York City-scale subway water system—a bird's eye perspective displays a city built over hundreds of washes. And although some roads perform their double duty well, too many of them flood. T-DOT has identified at least 23 locations where flooding poses a threat to motorists (Figure 1). There simply isn't enough money to dig up the roads and neighborhoods and install large diameter culverts, sometimes for miles.

"The city of Tucson alone has well over $500 million in drainage needs," said Andrew Dinauer, city engineer for T-DOT. "Some years we receive zero dollars for flood control."

The steep rise in building materials in recent years has worsened the budget crunch. The price of concrete, steel, and other materials have nearly doubled in

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Flash floods, continued

the last three to four years. Project budgets approved in the past now only buy half the project. It's becoming cheaper to purchase entire blocks of houses than to install the needed drainage control for specific neighborhoods, Dinauer said.

As a result, city engineers and planners are beginning to rethink drainage control and floodplain management. Out of necessity, they now perceive runoff as a resource rather than a nuisance and are researching adaptation strategies, such as storm water harvesting. Some managers are also contemplating engineering flood control structures for the 500-year storm instead of the 100-year storm to protect against increases in flood magnitude that may result from climate change; with the deficient financial resources, this may be a pipe dream.

No amount of money can change the fact that Tucson and other desert cities are built upon an arroyo-rich landscape. During extreme weather some roads will flood. It ultimately becomes the responsibility of the motorist to use good judgment.

Why people cross flooded roads

At the end of July 2007, Ashley Coles found herself living her research. At the time, she was a second year graduate student in The University of Arizona's Department of Geography. As part of a Climate Assessment for the Southwest-funded project, she was researching the factors that led people to either drive through flooded roads or compelled them not to. On that rainy afternoon, she drove north on Park Avenue and was several blocks from Speedway Boulevard when the road was swallowed by water. Exercising good judgment, Coles pulled her car to the curb. A white sports car driven by a young man, however, passed her and plowed into the road-come-river. The water choked off his engine. Seconds later he emerged from his car, standing in ankle deep water, undoubtedly regretting his decision. Meanwhile, a big-wheeled truck pulled alongside to fashion a tow, while a sedan spun around on the far side (Figure 2).

Had Coles brought her research papers with her, she would have handed the three drivers the same survey questionnaire that she sent to 1,000 residents of Tucson in an attempt to understand the motives of "crossers" and "non-crossers."

Coles crafted the survey in collaboration with risk managers and personnel from agencies such as T-DOT, NWS, and Pima County Regional Flood Control District. Their participation was essential for Coles because "if the results were going to be used, managers needed to be on board from the beginning. I didn't want to hand them a product and then ask if it was useful," she said.

Coles' analyzed the 160 returned surveys and concluded that more people admitted that they had crossed flooded roads without knowing the water depth than did not cross—97 people responded that they had at least once in their life driven across a flooded road, while 63 said they had never crossed.

Coles discovered that the main motive behind "crossers" was the prior successful crossing of another vehicle. She also found that, not surprisingly, the size of the vehicle mattered. Of the respondents with trucks and SUVs, 84 and 73 percent were "crossers," respectively, while only 57 percent of the people in cars had crossed a flooded road.

Coles' effort to reach out to management agencies highlights a growing desire in the academic community to conduct research with practical uses. Coles' research not only gave her a degree, but more importantly it helped risk managers understand why people make bad decisions in spite of many efforts to improve their decisions, including the threat of a fine of up to $2,000 on people who are rescued from a barricaded flooded road and stigmatizing them for breaking the "Stupid Motorists Law."

Perhaps the most important result of Coles' research is the knowledge that warning signs and barricades confuse motorists by not conveying the degree of danger. "The fact that the signs remain in place when the roads are dry or when the flow is 'a trickle' leaves the motorist to assess the hazard based on environmental cues, such as water flowing over the curb level, or perhaps the behavior of other motorists," Coles wrote in her study. "However, as motorists become accustomed to the presence of signs at flood-prone intersections, the lack of a sign creates a false sense of security for those who trust the signs and will not cross when they are present."

Several solutions exist for improving the communication of flood risk: signs that flash only during hazardous conditions, alternative route maps that become common knowledge, and use of new technologies like car-mounted Global Positioning Systems that help illuminate alternative routes. Unfortunately, these solutions are expensive. And since most participants in the survey responded that they seek advice from others during flash floods, perhaps the best solution is continued education so that social networks better protect motorists.

Although there are few casualties of flash floods in the Southwest, most people are affected by them. Looking toward the future, Coles envisions that the impact of flash floods on society will increase. More extreme events may be in store in the future, she said, and the population in the Southwest will continue to grow, increasing the number of people caught on the wrong side of a flooded road. Also, Coles said, as cities expand, additional washes become roads, boosting the number of hazardous areas, while a growing number of impermeable surfaces increases the magnitude of flash floods.

Temperature (through 9/17/08)

Source: High Plains Regional Climate Center

Temperatures since the beginning of the water year on October 1 have averaged between 60 and 75 degrees Fahrenheit along the lower Colorado River and in the lower elevations in Arizona (Figure 1a). Temperatures on the Colorado Plateau and most of northern and central New Mexico have averaged between 45 and 60 degrees F. The highest elevations in northern New Mexico and Arizona averaged between 35 and 45 degrees F. Southern and southeastern New Mexico generally averaged 60 to 65 degrees F.

The water year temperatures have been 0 to 2 degrees below average in the higher elevations in both states, while the lower elevations have had temperatures of 0 to 4 degrees F above average in New Mexico and 0 to 2 degrees above average in Arizona (Figure 1b). The high elevation negative temperature departures were due in part to extensive winter snow cover across the Southwest and the Colorado Rockies.

In the past 30 days, and for much of the summer monsoon, temperatures were 1 to 5 degrees F colder than average across southern and eastern New Mexico (Figures 1c–d). Temperatures in northwestern New Mexico and southern Arizona have been mostly 0 to 2 degrees F below average, while central and northern Arizona have been 0 to 2 degrees F above average. The Yuma area in southwestern Arizona has been very warm and dry, with temperatures of 2 to 3 degrees above average.

Notes:

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

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

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

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

On the Web:

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

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

Figure 1a. Water year '07–'08 (through September 17, 2008) average temperature.

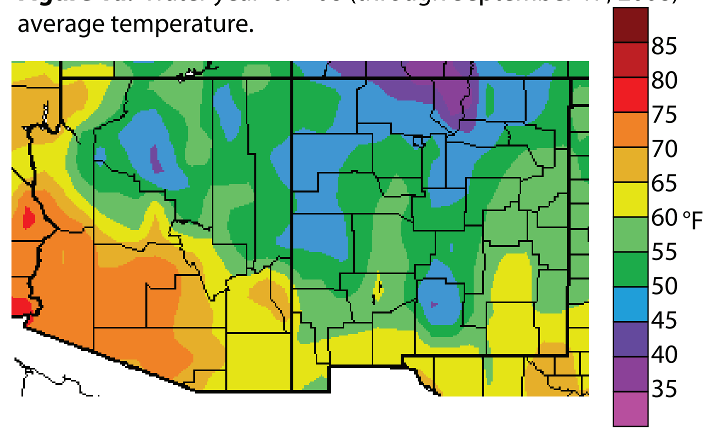


Figure 1b. Water year '07–'08 (through September 17, 2008) departure from average temperature.

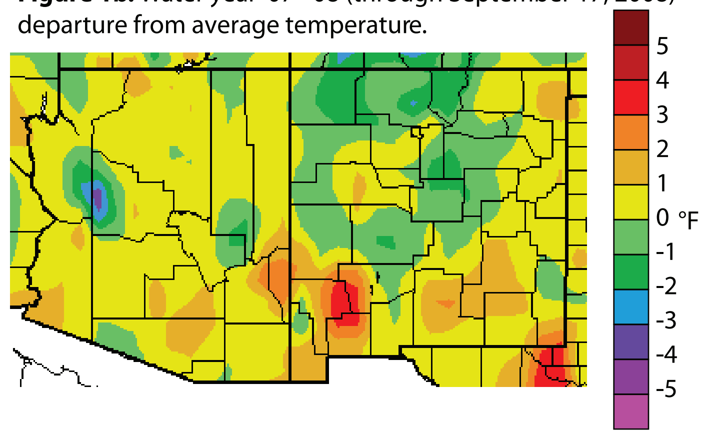


Figure 1c. Previous 30 days (August 19–September 17, 2008) departure from average temperature (interpolated).

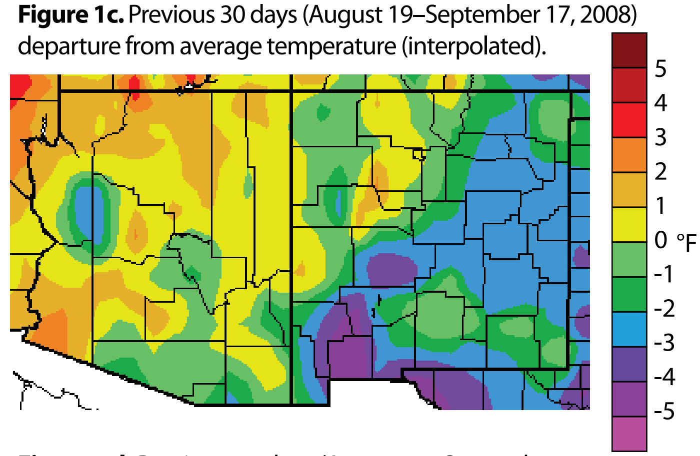
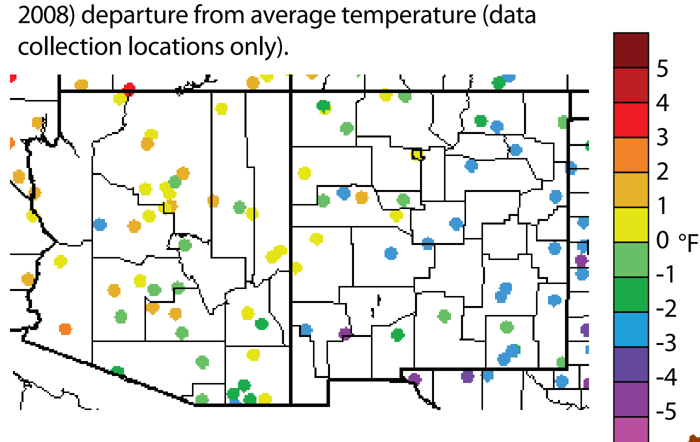


Figure 1d. Previous 30 days (August 19–September 17, 2008) departure from average temperature (data collection locations only).



Precipitation (through 9/17/08)

Source: High Plains Regional Climate Center

Water year precipitation continues to be highly variable across Arizona and New Mexico. Above-average rainfall has occurred in south-central Arizona and New Mexico, largely as a result of the wet monsoon. Above-average rainfall in the highest elevations of eastern Arizona and northern New Mexico has been largely due to the wet winter. The wettest areas have received 130–175 percent of average precipitation (Figures 2a–b). The driest areas—east and west central New Mexico, the Colorado Plateau just above the Mogollon Rim, and southwestern Arizona—have received between 50 and 70 percent of average precipitation. Most areas of both states received 80–100 percent of average precipitation for the water year, with dry winter areas balanced out by a wet summer.

In the past 30 days, central and eastern New Mexico has been very dry with less than 5 to 70 percent of average precipitation (Figures 2c–d). Northern Arizona and central and northwestern New Mexico have had 5–90 percent of average precipitation. The monsoon has been active in southern Arizona and southwestern New Mexico; many parts of those areas have received 150–300 percent of average precipitation. The monsoon rains, however, have consistently missed a few areas of northern Pima and Cochise counties in Arizona.

Both winter and summer have been wet during the current water year; this has helped offset last year, which was very dry.

Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2007, we are in the 2008 water year. The water year is a more hydrologically sound measure of climate and hydrological activity than is the standard calendar year.

Average refers to the arithmetic mean of annual data from 1971–2000. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

The continuous color maps (Figures 2a, 2c) are derived by taking measurements at individual meteorological stations and mathematically interpolating (estimating) values between known data points. Interpolation procedures can cause aberrant values in data-sparse regions.

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

On the Web:

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

For National Climatic Data Center monthly precipitation and drought reports for Arizona, New Mexico, and the Southwest region, visit: http://lwf.ncdc.noaa.gov/oa/climate/research/2003/perspectives.html#monthly

Figure 2a. Water year '07–'08 (through Septmber 17, 2008) percent of average precipitation (interpolated).

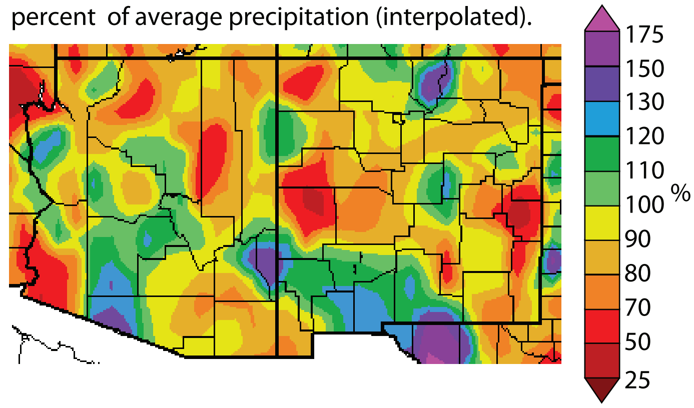


Figure 2b. Water year '07–'08 (through September 17, 2008) percent of average precipitation (data collection locations only).

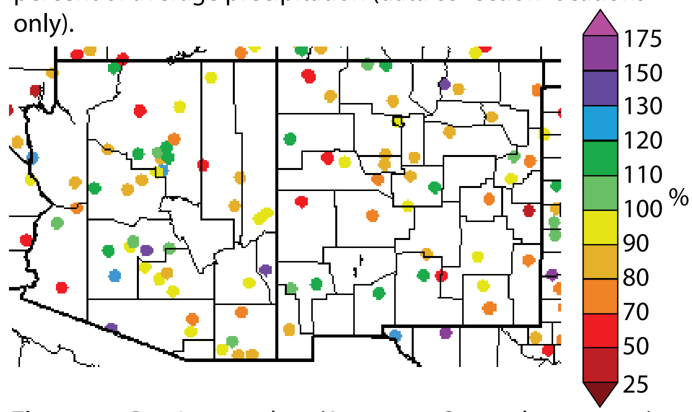


Figure 2c. Previous 30 days (August 19–September 17, 2008) percent of average precipitation (interpolated).

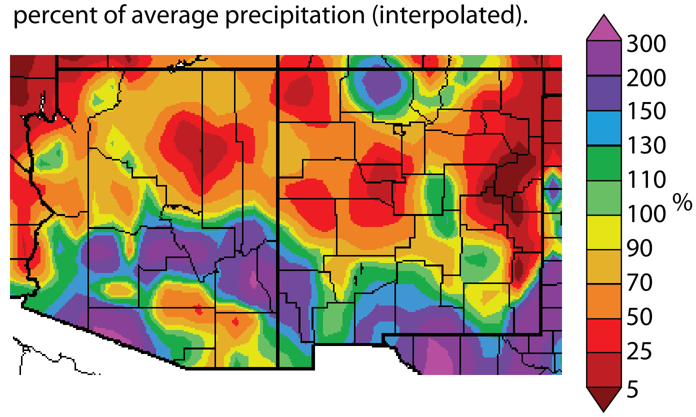
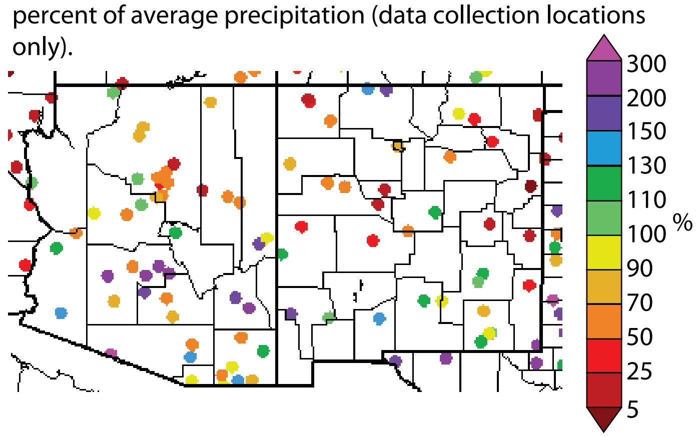


Figure 2d. Previous 30 days (August 19–September 17, 2008) percent of average precipitation (data collection locations only).



U.S. Drought Monitor

(released 9/18/08)

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

Drought severity in both New Mexico and Arizona remained virtually the same this month as the conditions reported in August (Figure 3). Abnormally dry conditions lingered in Arizona's northwest corner and in southeast and northeast New Mexico; more than 83 percent of Arizona and 70 percent of New Mexico are not in drought. Monsoon rains, which have been as much as 300 percent above normal in southern Arizona and New Mexico during the period between August 19 and September 17, have helped many southwestern regions remain below the lowest drought intensity grade.

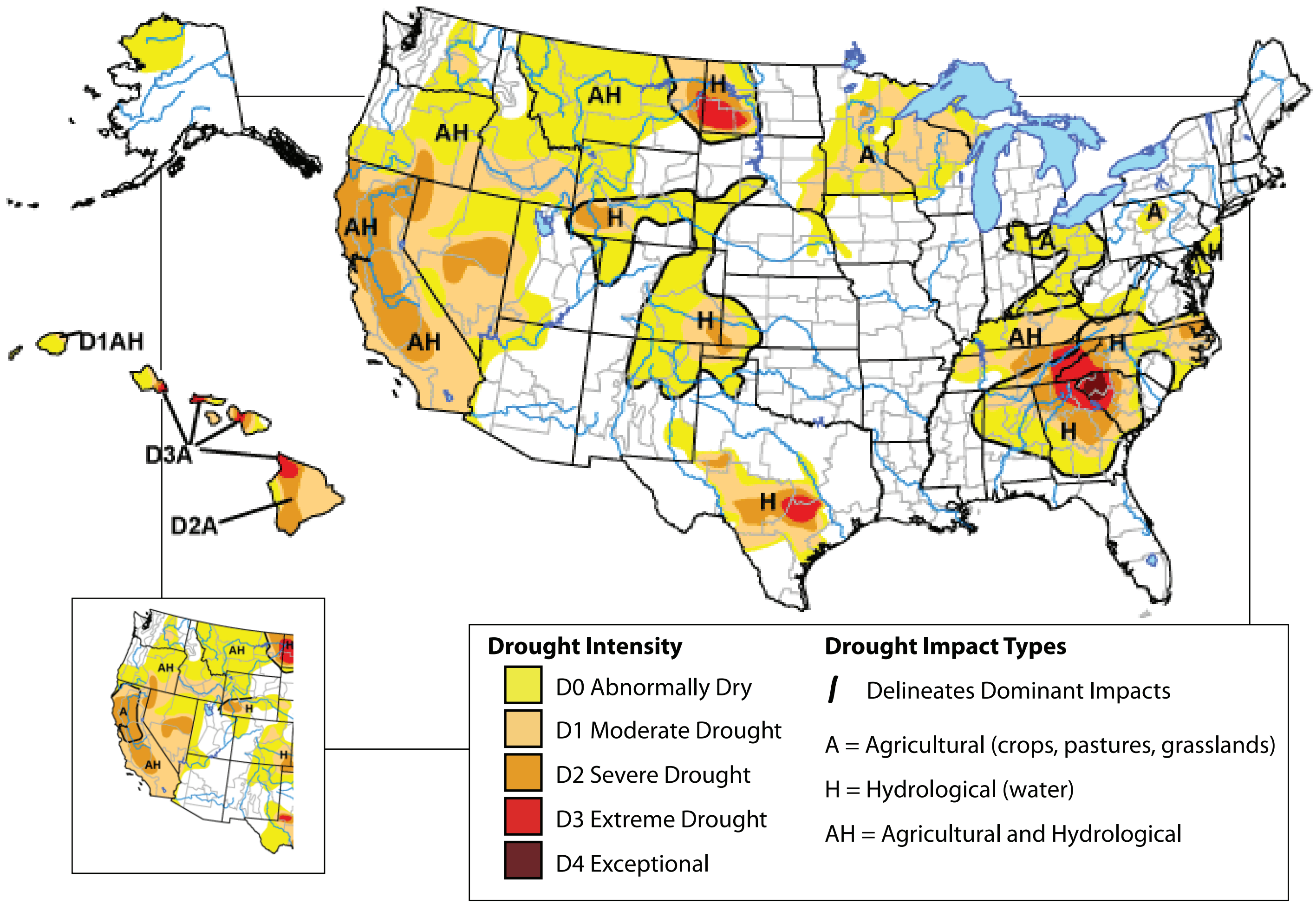
In drought-related news, farmers in Cibola County in New Mexico are now eligible for low-interest emergency loans from the Farm Service Agency (*Las Cruces Sun*, August 29). The agency announced on August 29 that the U.S. Department of Agriculture (USDA) has decided to include the county as a disaster area due to the effects of prolonged drought conditions. The USDA declared 31 other New Mexico counties as disaster areas at the end of July. Although some relief has accompanied the wet conditions of recent months, this designation reflects the cumulative impacts of prolonged drought conditions.

Notes:

The U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The inset (lower left) shows the western United States from the previous month's map.

The U.S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of the several agencies; the author of this monitor is Laura Edwards, WRCC, and Brian Fuchs, NDMC.

Figure 3. Drought Monitor released September 18, 2008 (full size), and August 21, 2008 (inset, lower left).



On the Web:

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

Arizona Drought Status

(data through 7/31/08)

Source: Arizona Department of Water Resources

July was a good month for precipitation across much of Arizona, with above-average precipitation falling in many areas. These wet conditions helped improve short-term drought conditions across much of the state, according to the August Arizona Drought Monitor Report (Figure 4a). Eight watersheds saw improvements, with five moving from abnormally dry status to no drought and three moving from moderate drought to abnormally dry conditions. Most improvements occurred across the east-central and southeastern portions of the state.

So far, 2008 has been a "drought roller coaster," with conditions in Yavapai County shifting from a wet 2007–08 winter season to an unusually dry spring and back to a wet summer monsoon season (*Camp Verde Bugle*, September 18). Tim Skarupa from the Salt River Project noted that short-term conditions look good in the Verde River watershed, where 15 inches already have fallen this year—two inches above average. Tony Haffer, a member of the Governor's Drought Task Force and a meteorologist in the National Weather Service office in Phoenix, noted that even though short-term conditions have improved, long-term drought conditions persist because of numerous dry winters over the past 10 years (Figure 4b). The roller coaster may continue with a slightly increased chance of drier-than-average conditions occurring across parts of Arizona over this upcoming winter season.

Current Arizona drought status information is based on National Weather Service Cooperative Observer data collected through the end of August. Data are not available until the beginning of the next month, causing a one-month lag in drought status calculations presented in the monthly Arizona Drought Monitor Report.

Notes:

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

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

On the Web:

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

Figure 4a. Arizona short-term drought status for August 2008.

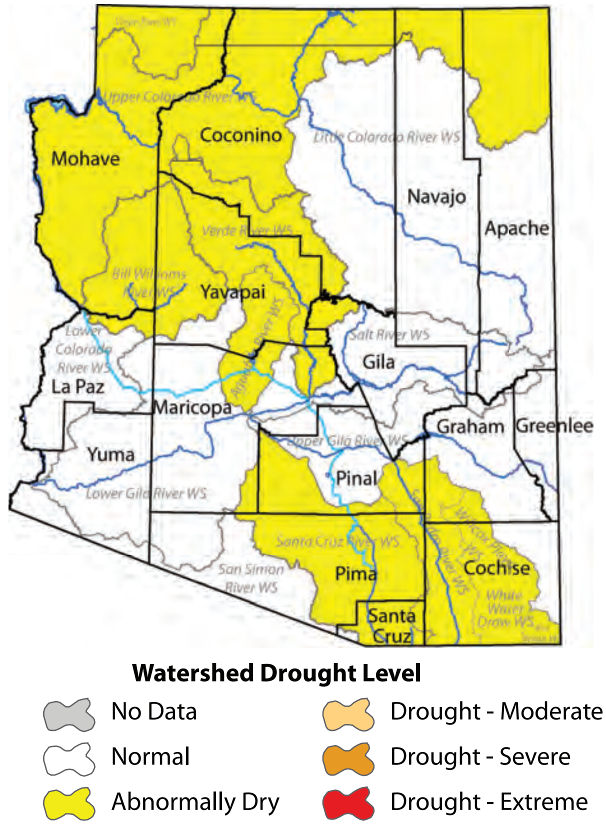
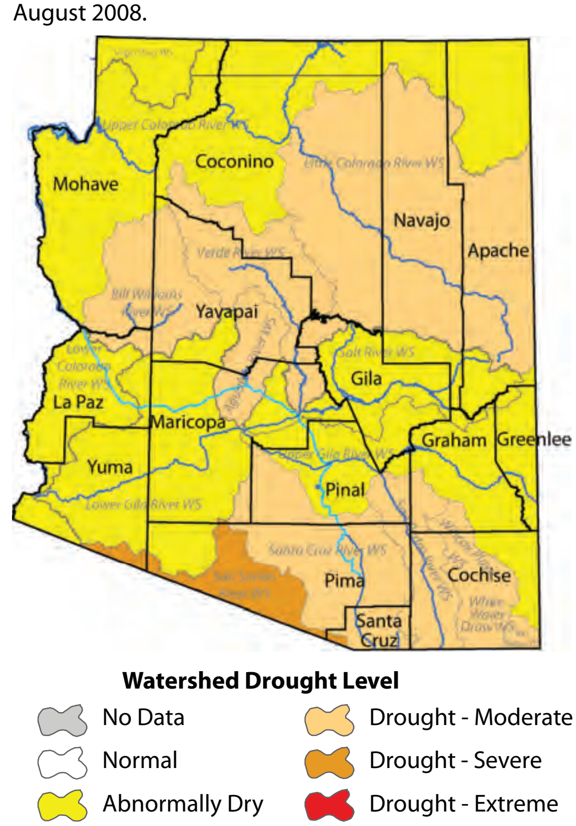


Figure 4b. Arizona long-term drought status for August 2008.



New Mexico Drought Status

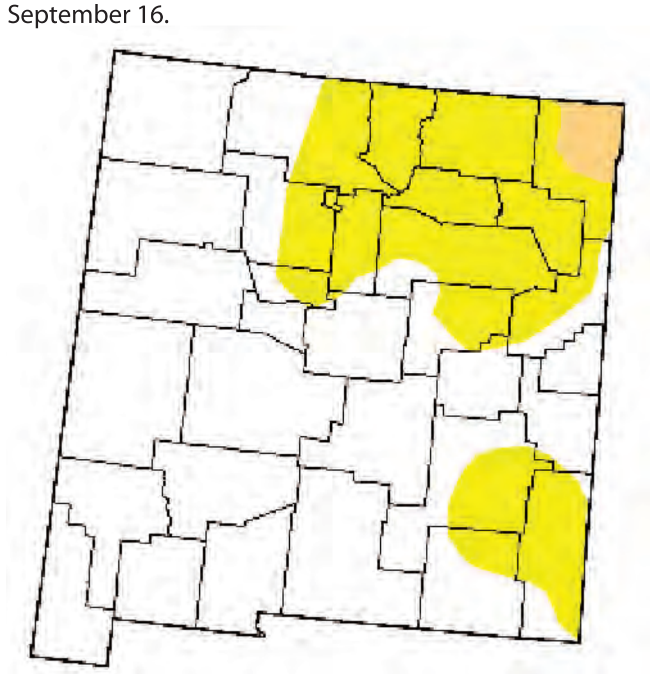
(released 9/18/08)

Source: New Mexico State Drought Monitoring Committee

Drought conditions have continued to improve across portions of extreme northeast and southeast New Mexico, according to the September 16 National Drought Monitor map. In the past month, summer rains helped lift these regions out of severe and moderate drought and into abnormally dry status (Figure 5). Slightly less than 30 percent of the state is designated as abnormally dry and only 1.5 percent is designated as having moderate drought status. This is a dramatic improvement over the past three months. In June, more than 80 percent of the state experienced some level of drought, with more than 50 percent falling into the severe to extreme drought categories. A wet summer monsoon thunderstorm season aided by several tropical storms is responsible for these significant improvements in short-term drought conditions.

Soil moisture conditions reported on September 16 were good, with 64 percent of the state experiencing adequate soil moisture and 9 percent in the surplus category, according to the September 16 USDA Weekly Weather and Crop Bulletin. Range and pasture conditions were also in relatively good shape; 48 percent of the state range areas were classified as having good conditions and 13 percent as having excellent conditions.

Figure 5. New Mexico drought map based on data through September 16.



Drought Intensity

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

Notes:
The New Mexico section of the U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of the several agencies.

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

On the Web:

For the most current drought status map, visit:
http://www.drought.unl.edu/dm/DM_state.htm?NM,W

For the most current Drought Status Reports, visit:
http://www.nmdrought.state.nm.us/MonitoringWorkGroup/wk-monitoring.html

Arizona Reservoir Levels

(through 8/31/08)

Source: National Water and Climate Center

Combined reservoir storage in Lakes Powell and Mead decreased by approximately 300,000 acre-feet during August (Figure 6). Nevertheless, compared with last August, combined volumes in the two lakes have increased by more than 2.0 million acre-feet. According to the U.S. Bureau of Reclamation, reservoir storage in the Colorado River basin above Lake Mead is projected to be about 58 percent of capacity at the end of the water year on September 30. During August, storage in the Salt and Verde River watersheds declined slightly, though levels are substantially higher than they were one year ago.

Arizona water officials are studying the idea of importing desalinated ocean water from the Gulf of California to provide a future "permanent" water supply (*Arizona Republic*, August 31). The effort would be a collaboration between Puerto Peñasco, the Central Arizona Project, and Salt River Project. Officials are studying the cost, energy sources, and environmental issues associated with constructing a desalination plant.

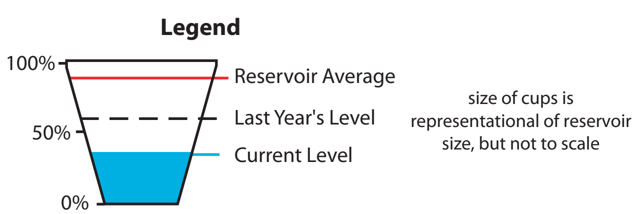
Notes:

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

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

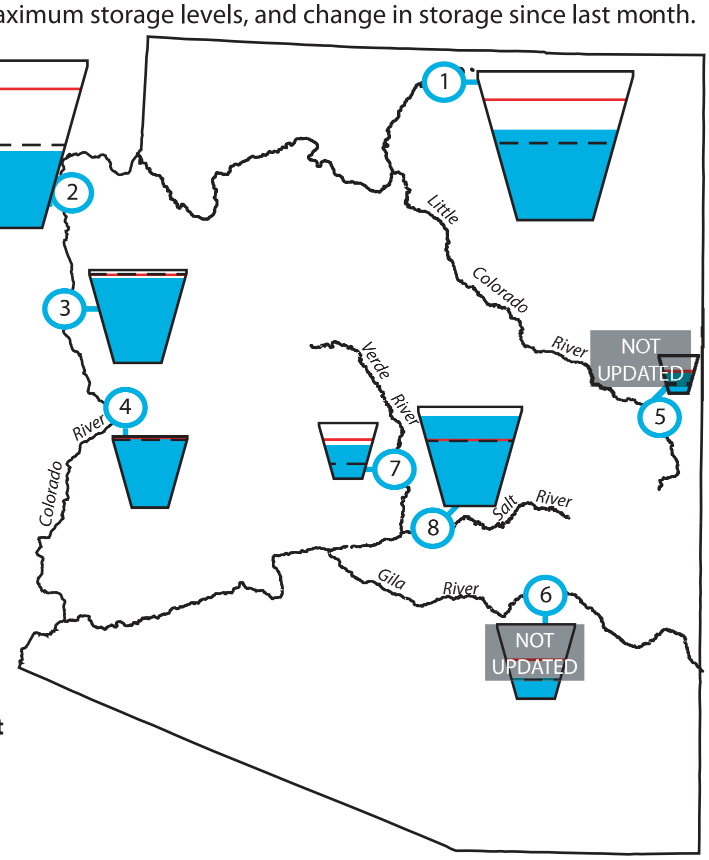
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Dino DeSimone, Dino.DeSimone@az.usda.gov.

Figure 6. Arizona reservoir levels for August 2008 as a percent of capacity. The map also depicts the average level and last year's storage for each reservoir. The table also lists current and maximum storage levels, and change in storage since last month.



Reservoir Name	Capacity Level	Current Storage*	Max Storage*	Change in Storage*
1. Lake Powell	61%	14,803.0	24,322.0	-389.0
2. Lake Mead	46%	11,955.0	26,159.0	65.0
3. Lake Mohave	91%	1,646.0	1,810.0	-19.7
4. Lake Havasu	95%	590.5	619.0	13.1
5. Lyman Reservoir	NOT UPDATED			
6. San Carlos	NOT UPDATED			
7. Verde River System	61%	174.9	287.4	-4.5
8. Salt River System	91%	1,852.5	2,025.8	-49.2

*** 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 8/31/08)

Source: National Water and Climate Center

New Mexico total reservoir storage declined slightly during August (Figure 7). Only Brantley and Conchas reservoirs showed increases during the last month. Despite declines, Heron, Navajo, and El Vado reservoirs were at or above 79 percent of capacity; Elephant Butte reservoir is at 26 percent of capacity, which is 8 percent greater than it was last year at this time.

In water news, ground was broken on the Navajo Nation Municipal Pipeline, part of the Animas-La Plata project authorized under the Colorado Ute Settlement Act of 2000 (*Farmington Daily Times*, September 12). The $60 million federally-funded project is expected to be completed by 2012. The pipeline will provide water to Farmington, Upper Fruitland, San Juan, Hogback, Nenahnezad, and Shiprock, and will strengthen ties between Farmington and the Navajo Nation. Most importantly, the water supplied by the pipeline will provide the Navajo Nation with opportunities for economic development and improved standards of living.

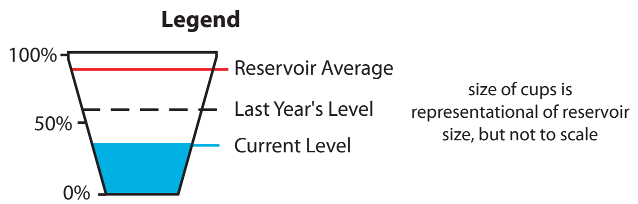
Notes:

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

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

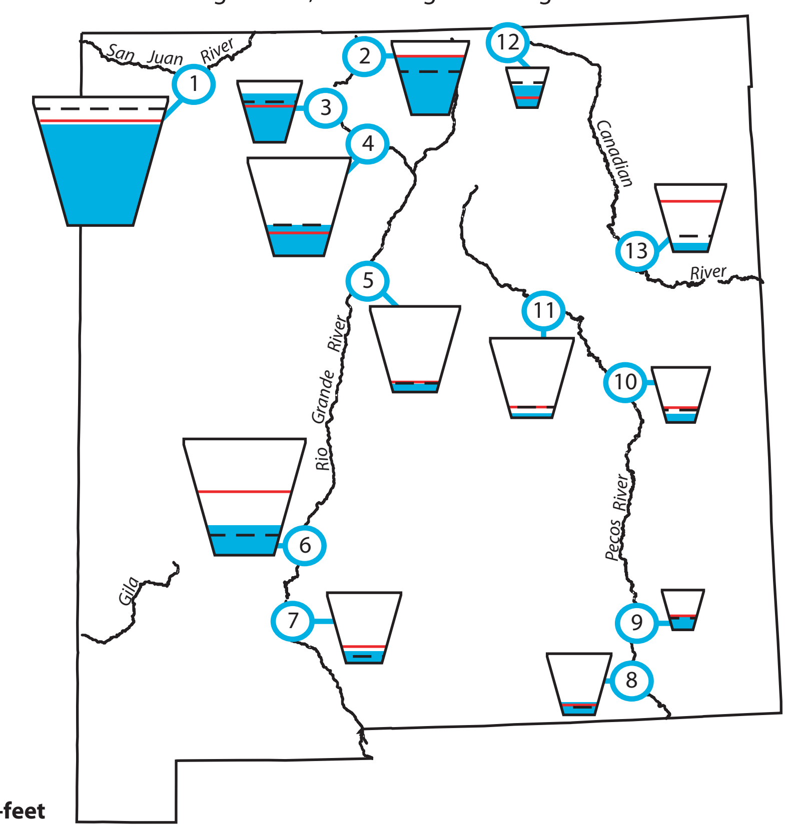
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Richard Armijo, Richard.Armijo@nm.usda.gov.

Figure 7. New Mexico reservoir levels for August 2008 as a percent of capacity. The map also depicts the average level and last year's storage for each reservoir. The table also lists current and maximum storage levels, and change in storage since last month.



Reservoir Name	Capacity Level	Current Storage*	Max Storage*	Change in Storage*
1. Navajo	79%	1,341.0	1,696.0	-27.7
2. Heron	79%	315.6	400.0	-3.7
3. El Vado	80%	156.1	195.0	-21.7
4. Abiquiu	32%	177.2	554.5	-3.3
5. Cochiti	10%	50.6	491.0	-0.3
6. Elephant Butte	26%	575.1	2,195.0	-51.3
7. Caballo	17%	56.9	332.0	-7.4
8. Brantley	21%	30.5	147.5	4.8
9. Lake Avalon	33%	1.3	4.0	-0.2
10. Sumner	16%	15.9	102.0	-2.9
11. Santa Rosa	6%	25.0	438.3	-3.3
12. Costilla	56%	9.0	16.0	-2.1
13. Conchas	13%	33.5	254.2	6.8

*** 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

Monsoon Summary
(through 9/16/2008)

Source: Western Regional Climate Center

The monsoon season is waning. Dew point temperatures are falling and precipitation is becoming more infrequent. The National Weather Service in Tucson writes that typically in September the high altitude winds begin to blow more consistently from the southwest which decreases the moisture delivery into Arizona. As a result, soils begin to dry out and near-surface temperatures begin to cool. The lack of low-level moisture and a more stable atmosphere causes thunderstorm activity to diminish.

A look back on monsoon precipitation reveals that since July 1, precipitation in southern Arizona and most of New Mexico has been above average (Figures 8a–b). In Phoenix, for example, a total of 5.7 inches was measured at Sky Harbor International Airport between June 15 and September 15 nearly three inches more than the historical average. The total rainfall at the airport in Tucson was 5.52 inches, about a half inch below the historical average.

Monsoon precipitation has been variable across the Southwest. While southeast Arizona and southern New Mexico have experienced above-average precipitation, in some areas as much as 300 percent of average, northern areas in both states have mostly received below-average precipitation (Figure 8c). Topography has also created variability. For example, areas above 5,000 feet on Mount Lemmon in Tucson received as much as 19 inches in August, while only 1.7 inches were measured at Tucson International Airport.

Figure 8a. Total precipitation in inches July 1–September 16, 2008.

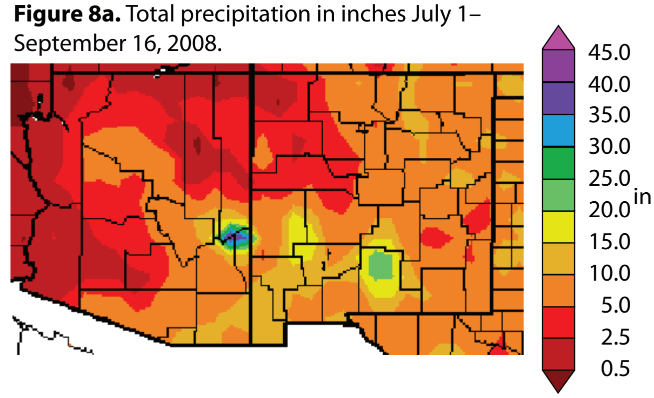


Figure 8b. Departure from average precipitation in inches July 1–September 16, 2008.

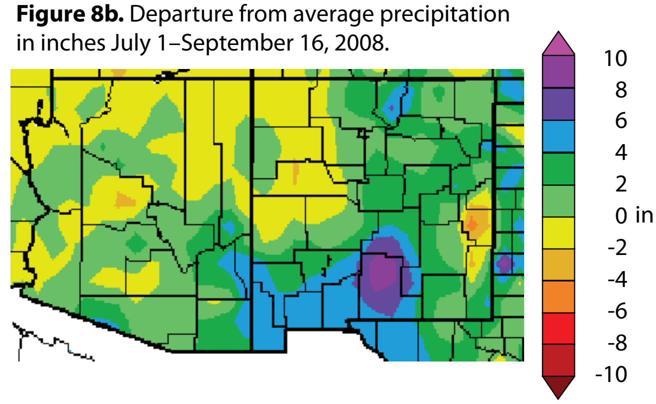
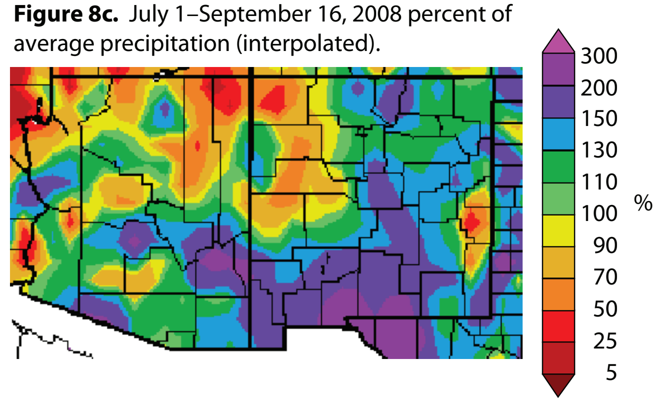


Figure 8c. July 1–September 16, 2008 percent of average precipitation (interpolated).



Notes:

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. Departure from average precipitation is calculated by subtracting the average from the current precipitation.

The continuous color maps (Figures 8a–c) 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 data used to create these maps is provisional and have not yet been subjected to rigorous quality control.

On the Web:

These data are obtained from the National Climatic Data Center:
http://www.hprcc.unl.edu/maps/current/

Temperature Outlook
(October 2008–March 2009)
Source: NOAA Climate Prediction Center (CPC)

The NOAA Climate Prediction Center (CPC) long-lead temperature forecasts for the Southwest show slightly increased chances of above-average temperatures for most of the region into early 2009 (Figures 9a–d). The highest chances of above-average temperatures are during November through January in Arizona and most of New Mexico. The forecasts are based primarily on long-term temperature trends. Atmospheric and ocean conditions in the equatorial Pacific Ocean are leaning toward ENSO-neutral conditions, which means these temperature predictions are not related to the El Niño-Southern Oscillation (ENSO) phenomenon.

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 9a. Long-lead national temperature forecast for October–December 2008.

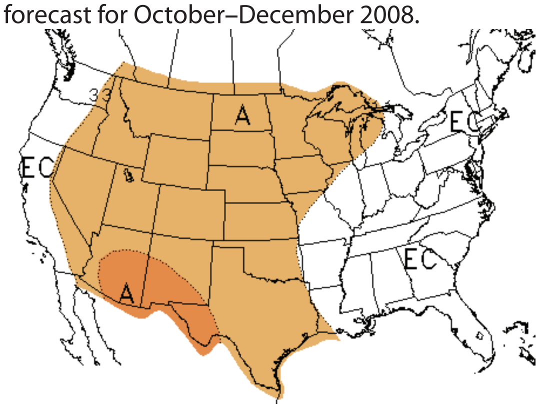


Figure 9b. Long-lead national temperature forecast for November 2008–January 2009.

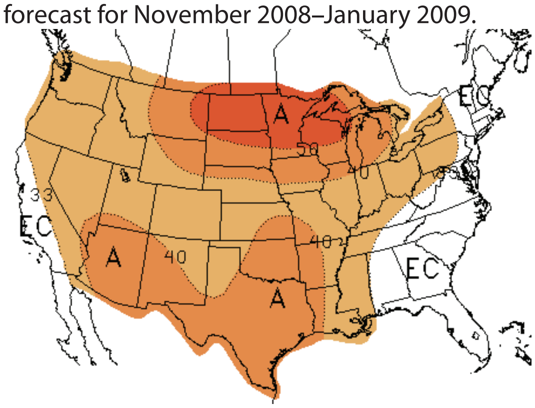


Figure 9c. Long-lead national temperature forecast for December 2008–February 2009.

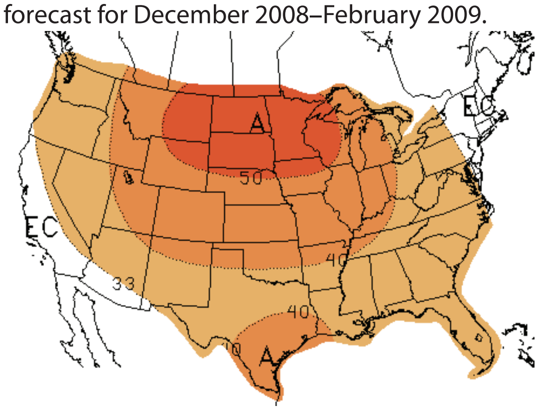
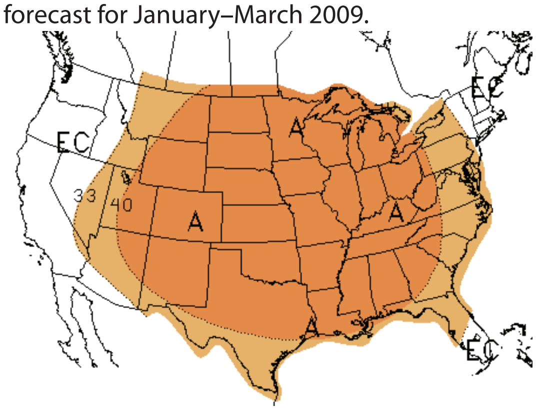


Figure 9d. Long-lead national temperature forecast for January–March 2009.



A= Above

- 50.0–59.9%
- 40.0–49.9%
- 33.3–39.9%

EC= Equal chances. No forecasted anomalies.

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

(October 2008–March 2009)

Source: NOAA Climate Prediction Center (CPC)

The NOAA Climate Prediction Center (CPC) long-lead precipitation forecasts for the Southwest show slightly increased chances of below-average precipitation for the region during the fall and early winter (Figures 10a–d). With the expectation that the atmospheric and ocean conditions in the equatorial Pacific will remain in near-neutral ENSO conditions, the forecasts are based primarily on predictable precipitation trends indicated by the NOAA-CPC consolidation forecast. That forecast combines high-accuracy statistical methods with dynamic model predictions from the NOAA Climate Forecast System model.

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 10a. Long-lead national precipitation forecast for October–December 2008.

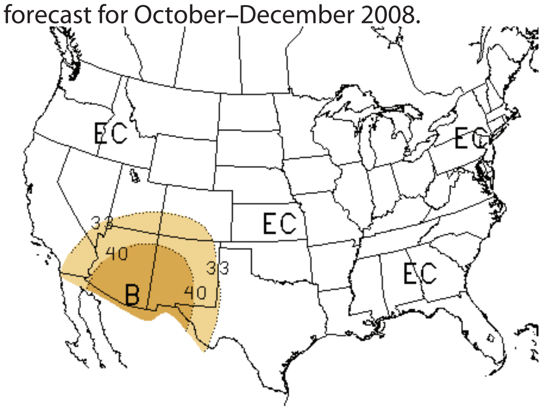
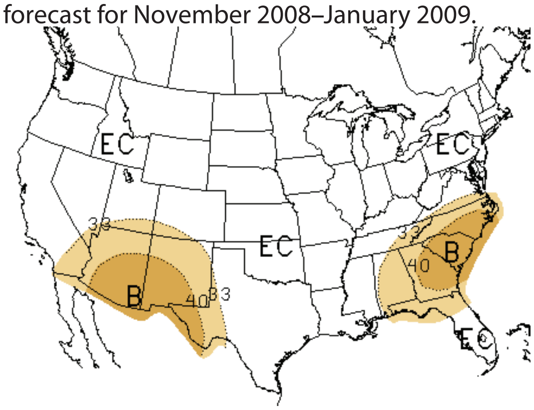


Figure 10b. Long-lead national precipitation forecast for November 2008–January 2009.



B= Below
33.3–39.9%
40.0–49.9%

Figure 10c. Long-lead national precipitation forecast for December 2008–February 2009.

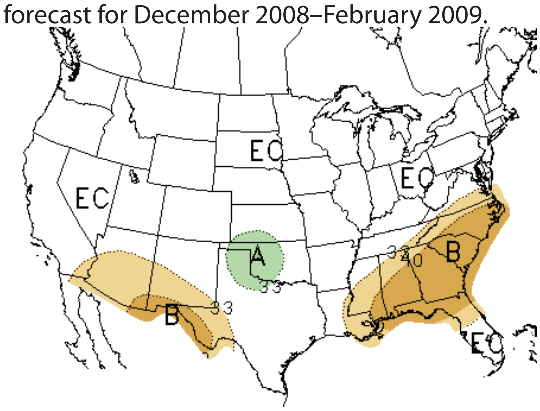
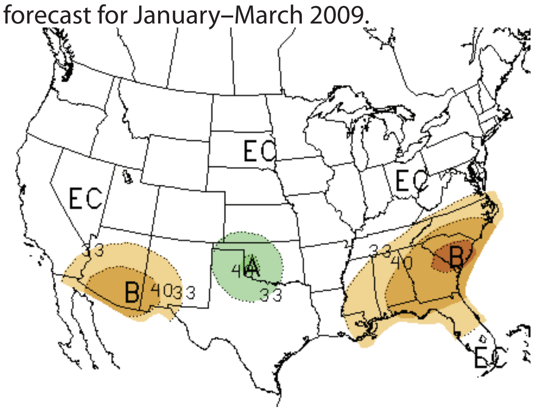


Figure 10d. Long-lead national precipitation forecast for January–March 2009.



A=Above
40.0–49.9%
33.3–39.9%

EC= Equal chances. No forecasted anomalies.

On the Web:

For more information on CPC forecasts, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.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 December 2008)

Source: NOAA Climate Prediction Center (CPC)

Drought conditions are ongoing and will generally persist in Texas, Nevada, California, Hawaii, and parts of the Southeast and the Midwest (Figure 11). Only several small areas in northern California and Texas will experience improvements, while the smaller Hawaiian Islands will develop drought conditions. This outlook is based predominantly on subjective synthesis of recent conditions and two-week and seasonal forecasts. Similar to last month, this month's U.S. Seasonal Drought Outlook through December suggests that both Arizona and New Mexico will generally not experience drought. The above-average summer monsoon precipitation has contributed to this outlook.

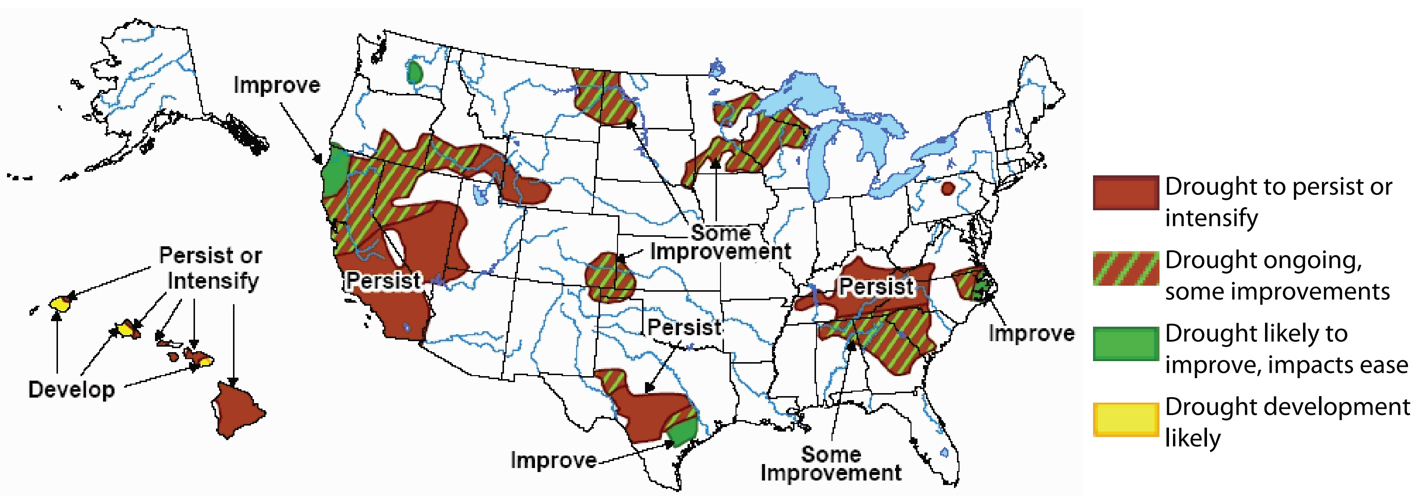
In Texas, rainfall associated with a frontal system and the remnants of Tropical Storm Lowell brought some relief to western Texas, while rainfall associated with Hurricane Ike did the same for eastern Texas (not shown on map). Recent weather forecasts suggest that coastal sections of southeast Texas will receive rainfall; an area of improvement is indicated over southeast coastal Texas. Further inland, short-term forecasts indicate no rain over the area. Medium and longer-range forecasts have near-normal or equal chances over interior Texas, and soil moisture forecasts suggest worsening conditions. For these reasons, the drought area over interior Texas is forecast to persist. The NOAA-Climate Prediction Center (CPC) assigns a moderate confidence for the Texas forecasts.

The West is entering a climatologically dry time of year, and recently only small amounts of precipitation have fallen. Over northern California, precipitation forecasts for an 8- to 14-day window indicate above-normal precipitation. In southern California, however, medium and longer-range forecasts generally show warmer and drier-than-normal conditions. The CPC assigns a moderate confidence for these western forecasts.

Notes:

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

Figure 11. Seasonal drought outlook through December 2008 (released September 18, 2008).



On the Web:

For more information, visit:
http://www.drought.gov/portal/server.pt

El Niño Status and Forecast

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

ENSO-neutral conditions dominate the equatorial Pacific Ocean again this month with near-average sea-surface temperature (SST) observations in the central portion of the basin. Slightly above-average SSTs in the eastern Pacific that developed over the past several months cooled slightly in August, returning to near-average temperatures. The International Research Institute for Climate and Society (IRI) noted that the recent warming in the eastern Pacific did little to disrupt atmospheric circulation patterns from the lingering La Niña event of last winter and spring. This is evident in the continuing positive Southern Oscillation Index (SOI) values, which continue to indicate a weak and lingering La Niña atmospheric response. The August SOI value actually rebounded slightly after dropping over the past several months, but still indicated a near neutral-ENSO state (Figure 12a).

ENSO forecasts made this month by the IRI indicate an even higher probability (greater than 85 percent) of ENSO-neutral conditions continuing through the remainder of 2008 and into early 2009 (Figure 12b). The forecast has a 90 percent confidence that ENSO neutral conditions will continue over the September through November period, with only a 5 percent chance of either La Niña or El Niño conditions forming during this period. The chance of an El Niño increases by late winter (February–April) to 20 percent, edging out the chance of a La Nina event (10 percent), but is still far below the increased chance (70 percent) of ENSO-neutral conditions continuing through spring 2009. ENSO-neutral conditions do little to disrupt atmospheric circulation patterns through the fall and winter seasons and historically do not favor either unusually wet or dry patterns in upcoming months. This limits upcoming seasonal forecasts that rely on strong signals in the Pacific to help guide outlooks.

Notes:

Figure 12a shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through August 2008. 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 and Society (IRI) probabilistic El Niño-Southern Oscillation (ENSO) forecast for overlapping three month seasons. The forecast expresses the probabilities (chances) of the occurrence of three ocean conditions in the ENSO-sensitive Niño 3.4 region, as follows: El Niño, defined as the warmest 25 percent of Niño 3.4 sea-surface temperatures (SSTs) during the three month period in question; La Niña conditions, the coolest 25 percent of Niño 3.4 SSTs; and neutral conditions where SSTs fall within the remaining 50 percent of observations. The IRI probabilistic ENSO forecast is a subjective assessment of current model forecasts of Niño 3.4 SSTs that are made monthly. The forecast takes into account the indications of the individual forecast models (including expert knowledge of model skill), an average of the models, and other factors.

Figure 12a. The standardized values of the Southern Oscillation Index from January 1980–August 2008. 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).

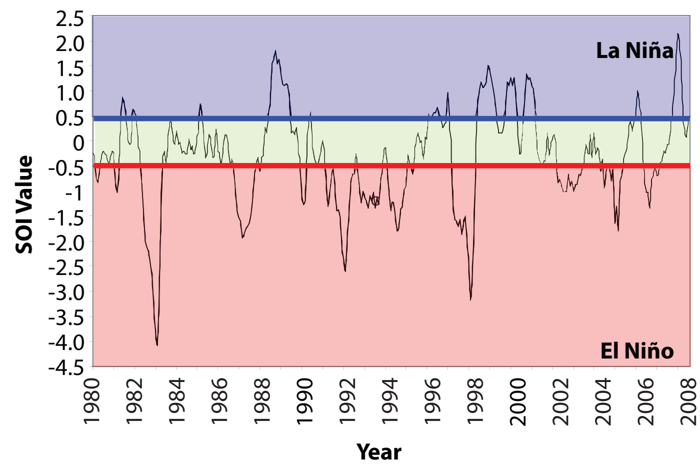
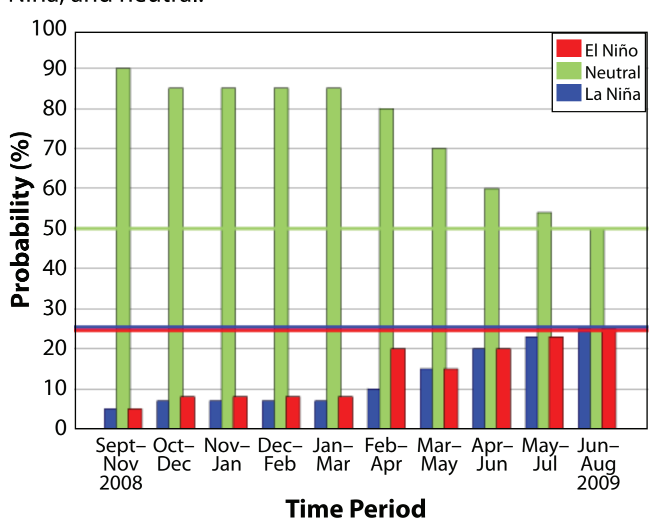


Figure 12b. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released September 18, 2008). Colored lines represent average historical probability of El Niño, La Niña, and neutral.



On the Web:

For a technical discussion of current El Niño conditions, visit:
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

For more information about El Niño and to access graphics similar to the figures on this page, visit:
http://iri.columbia.edu/climate/ENSO/

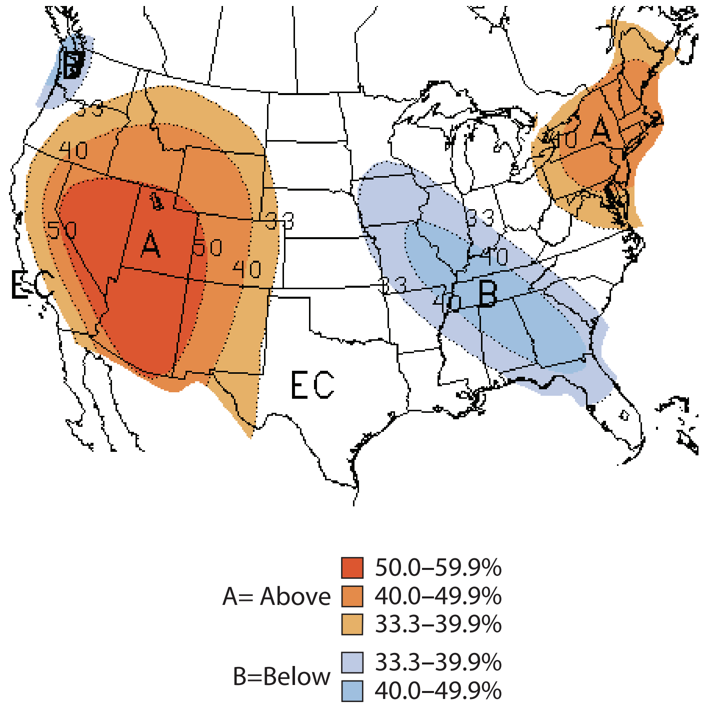
Temperature Verification

(June–August 2008)

Source: NOAA Climate Prediction Center (CPC)

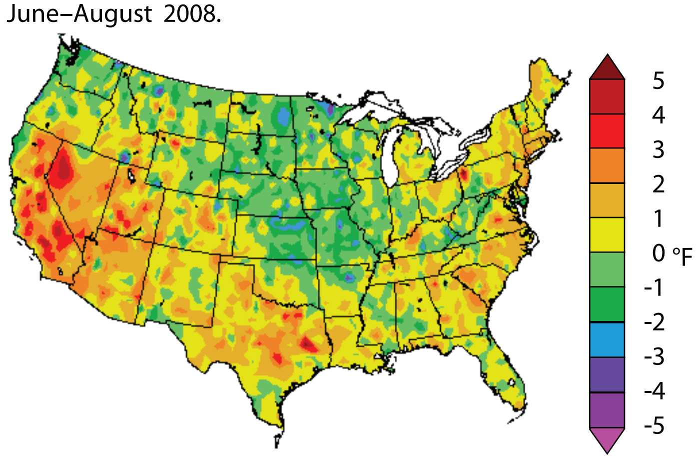
The NOAA-Climate Prediction Center (CPC) seasonal temperature outlook for June–August 2008 predicted increased chances of above-average temperatures for most of the western United States and New England, including fairly high probabilities of above-average temperatures throughout Arizona, Utah, and Nevada. The CPC also predicted a slight chance of below-average temperatures through the eastern Midwest and into the eastern Gulf of Mexico region as well as western Washington (Figure 13a). These predictions were based primarily on long-term temperature trends. The overall observed pattern of temperatures from June through August was fairly consistent with the CPC prediction, with temperatures slightly above average in much of the West and New England and near average along the Washington coast (Figure 13b). The long-lead forecast predicted a moderate chance of below-average temperatures through parts of the South, but the observed record revealed near-average to slightly above-average temperatures for the much of this region.

Figure 13a. Long-lead U.S. temperature forecast for June–August 2008 (issued May 2008).



EC= Equal chances. No forecasted anomalies.

Figure 13b. Average temperature departure (in degrees F) for June–August 2008.



Notes:

Figure 13a shows the NOAA Climate Prediction Center (CPC) temperature outlook for the months June–August 2008. This forecast was made in May 2008.

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

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

Figure 13b shows the observed departure of temperature (degrees F) from the average for the June–August 2008 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.

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
(June–August 2008)
Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (CPC) seasonal precipitation outlook for June–August 2008 predicted equal chances of near-, above-, and below-average precipitation throughout the Southwest (Figure 14a). The outlook also predicted a slightly increased chance of below-average precipitation for much of the northern Rockies and western Plains as well as the Pacific Northwest. The long-lead forecast also called for slightly increased chances of above-average precipitation for most of the Gulf of Mexico. Observed precipitation revealed very dry conditions through most of the California, much of the Pacific Northwest, the northern Rockies, and the western Plains (Figure 14b). Much of the Gulf of Mexico region experienced slightly above-average precipitation. The Southwest also generally experienced above-average precipitation throughout the summer, with many areas exceeding the long-term average. Overall, the observed precipitation pattern in the Great Basin, the Pacific Northwest, the Southeast, and Northeast is close to what the NOAA-CPC outlook predicted.

Figure 14a. Long-lead U.S. precipitation forecast for June–August 2008 (issued May 2008).

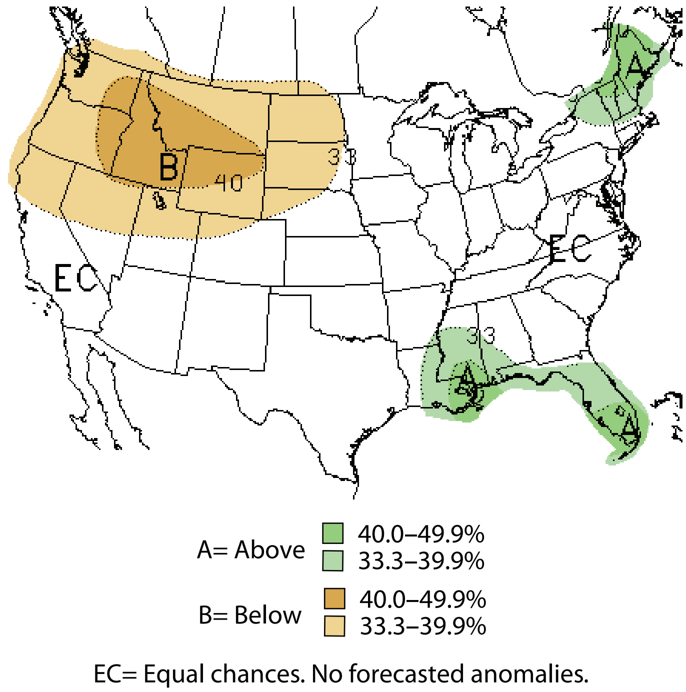
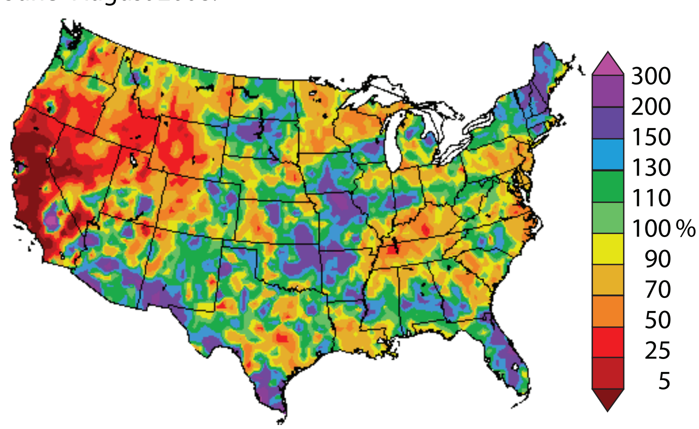


Figure 14b. Percent of average precipitation observed from June–August 2008.



Notes:
Figure 14a shows the NOAA Climate Prediction Center (CPC) precipitation outlook for the months June–August 2008. This forecast was made in May 2008.

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

Figure 14b shows the observed percent of average precipitation for June–August 2008. 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