

# Southwest Climate Outlook

THE UNIVERSITY OF ARIZONA  
Arizona's First University.



Source: GiGi Owen

**Photo Description:** The Candelaria Wetland at the Candelaria Farm Preserve in Albuquerque, New Mexico in July 2008. This shallow wetland provides a habitat for waterfowl, shore birds, and wading birds and is managed by the City of Albuquerque.

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The NOAA-Climate Prediction Center (CPC) seasonal temperature outlook for August–October 2008 predicted increased chances of above-average temperatures for much of the western United States...

## November Climate Summary

**Drought** – Short-term drought conditions remained virtually the same as one month ago, with the southern half of Arizona drought free and the northern half of the state abnormally dry. In New Mexico, short-term drought conditions worsened slightly from one month ago.

**Temperature** – Since the beginning of the water year on October 1, temperatures have been 1 to 4 degrees F above average across both states.

**Precipitation** – Most of New Mexico and Arizona have experienced extremely dry conditions since October 1 as a result of strong high pressure systems over the southwestern U.S. that have forced cold fronts to pass to the north.

**ENSO** – The El Niño-Southern Oscillation remained in a neutral phase once again this month, with near-average sea surface temperatures across much of the equatorial Pacific Ocean

**Climate Forecasts** – The long-lead precipitation forecasts show slightly increased chances of below-average precipitation for most of the southern half of the U.S. through March 2009. Long-lead temperature forecasts suggest that there are slightly higher chances of above-average temperatures through February 2009 in New Mexico and eastern Colorado.

**The Bottom Line** – Since the beginning of the water year on October 1, most of Arizona and New Mexico have been warm and dry. The dry conditions are due to strong high pressure systems over the southwestern U.S. that forced the cold fronts to move north. Storms forecasted to move over the Southwest during Thanksgiving week should help moisten the landscape.

## Urban Weather and Climate

The American Meteorological Society's 89th annual meeting, Urban Weather and Climate: Now and the Future will be held at the Phoenix Civic Plaza Convention Center in Phoenix, Arizona on January 11–15, 2009. Numerous specialty sessions, workshops, presentations, and field trips will focus on six cross-cutting urban and climate themes: measurement systems and networks; modeling and forecasting; observations and studies of high-impact weather; geographic influences on urban weather and climate; human and environmental impacts; and implications of climate change and population growth.

A free, special session called WeatherFest will be open to the public on the first day of the conference. This four-hour fair is designed to excite an interest in math, meteorology, and science. WeatherFest will feature about 60 interactive science exhibits, including hands-on experiments, educational information, and career guides. This popular event typically draws more than 2,500 visitors.



For more info: [http://www.ametsoc.org/MEET/annual/...](http://www.ametsoc.org/MEET/annual/)

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# Powering the Southwest with solar and wind

By Zack Guido

Imagine this: cities and towns hum with electric cars that speed down photovoltaic solar-paved roads, organic solar cell paint coats buildings, and sleek wind turbines spin on many roofs. Spongy sidewalks transform the mechanical energy of footsteps into electricity. Algae ponds offer up biofuels, and bobbing wave machines harness the oscillations of the ocean.

Science fiction? It may sound like it today, but a number of entrepreneurs, scientists, and energy officials say some of those clean-energy solutions to powering society aren't as far out as they sound; some have already become reality, particularly those that draw on conventional solar and wind power. These energy sources not only appeal to industrial-scale development, but also to smaller residential and commercial users who view them as good investments and strategies to reduce their carbon footprint.

"There are technical hurdles," said Kevin Koch, owner of Technicians for Sustainability, a Tucson-based company that specializes in installing small solar systems. "But it is conceivable to have most of an individual's power generated in their home."

His company is part of an expansion of businesses in the Southwest that are stimulating and satisfying growth in renewable energy that harnesses the incessant sun and captures the wealth of wind.

## Greenhouse gas emissions

Energy and climate are entwined. Burning coal and natural gas to generate electricity emits greenhouse gases that trap heat in the atmosphere, and hotter temperatures boost the need for more energy.

Since the industrial revolution, humans have been releasing greenhouse gases (GHG) into the atmosphere in increasing quantities. These gases, such as

carbon dioxide and methane, act like a one-way mirror—they allow solar energy to warm the land surface and atmosphere, but block some of the radiation emanating from Earth back to space. Based on physics, the more of these heat trapping gases wafting into the atmosphere, the higher the temperature.

The atmospheric concentrations of the potent GHG carbon dioxide (CO<sub>2</sub>) has wiggled up and down between approximately 180 and 300 parts per million (ppm) for nearly 700,000 years. Samples of CO<sub>2</sub> and other gases that are stand-ins for temperature measurements are preserved in ice and sediment cores. They display a similar pattern: high temperatures are accompanied by high concentrations of CO<sub>2</sub>, and vice versa.

Last year, concentrations of CO<sub>2</sub> hit 385 ppm. This, combined with the ice records and the heat-trapping physics of GHG, provide a granite foundation for the conclusions made in the recently published Intergovernmental Panel on Climate Change (IPCC) report: warming of the climate system is unequivocal and most of the observed increase in global average temperatures since the mid-20th century is very likely (greater than 90 percent) due to the observed increase in human emitted GHGs.

Last year the atmospheric concentrations of CO<sub>2</sub> jumped 2.4 ppm, an increase that surpassed projections made by the IPCC. This leap, which is part of an accelerating GHG atmospheric concentration pattern, forebodes an increasingly warm future—in the past 100 years, global temperatures have increased roughly 1.3 degrees Fahrenheit, with the majority of that warming occurring in the past 30 years. Between 1970–2004, global emissions of GHGs increased by 70 percent, and CO<sub>2</sub> accounted for 77 percent of the total human-produced emissions.

The largest component of human GHG emissions between 1970 and 2004 came from the energy supply sector, and the most carbon intensive form of energy production comes from coal (Figure 1). In the Southwest, most of the electricity is produced by coal-fired power plants.

There are, however, clean alternatives to energy generation, and people are becoming more concerned about the climate altering impacts of burning fossil fuels.

## Solar in the Southwest

Just a few years ago, Koch had three employees helping him install commercial and residential solar systems in Tucson. Now he has 15 and needs more help; he's booked through the end of January.

"It is a real exciting time in the solar industry. Business in the last few years has exploded. We're in a real interesting spot because the foundation has been laid to build a renewable energy society," Koch said. "Solar is not the sole answer, but it is a piece of the puzzle."

In the recent report, "Solar Energy in Southern Arizona," William Harris, the President and CEO of Science Foundation Arizona, builds on Koch's views.

"Arizona is the solar capital of the United States. In fact, with the necessary technology, Arizona has enough sun to provide power for the entire country. We have the opportunity to lead the world in solar technology development in a span of five to ten years and reap enormous benefits: environmental impacts, wealth generation resulting from commercialized technologies, and economic implications for entire regions," Harris said.

The stimulus for this vision may have come in the form of the Emergency Economic Stabilization Act of 2008. If there is a silver lining to the recent economic turmoil, it may be that the

continued on page 4



## Solar and wind, continued

economic bailout plan included needed tax incentives for renewable energy such as solar and wind.

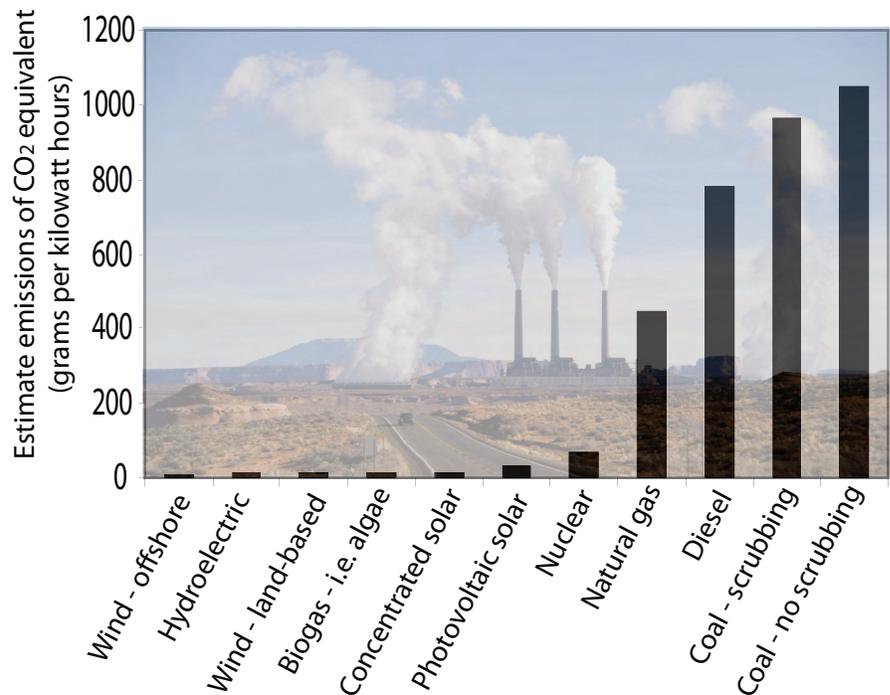
The law extends to 2016 a 30 percent tax credit for homeowners who put solar panels on their roofs. The new plan removes the maximum credit of \$2,000 so that a homeowner installing a \$15,000 system would be able to claim a credit of \$4,500. A tax credit encouraging energy efficiency in existing homes has also been extended for a year. Now, improvements such as a biomass stove or an energy-efficient water heater are eligible for tax rebates. Building contractors working on new homes will also be eligible for a credit of up to \$2,000 by including energy efficient systems for heating and cooling.

These federal incentives can be combined with state tax incentives and local rebates. Tucson Electric Power (TEP), for example, has a mandate to produce 15 percent of its power with renewable energy, said Bruce Plenck, solar energy coordinator for Tucson. TEP's rebate pays \$3 per watt for systems that connect to the grid so that a one-kilowatt residential module would receive a \$3,000 rebate.

Undoubtedly, Koch's business is spurred by the tax breaks for builders and consumers and by the combined forces of increasing energy costs and a growing consciousness that global warming is real and in large part brought on by burning fossil fuels.

"There are very few people I come in contact with that don't have an interest in helping the environment," Koch said, adding that the economic bailout plan also helped. "People can now receive a 7–8 percent return on their solar investment; people are now also motivated by economic concerns."

A three-kilowatt photovoltaic system in Tucson generates enough electricity to



**Figure 1:** Greenhouse gas (GHG) emissions from numerous energy production types. Emission are in CO2 equivalents, which tallies all GHG emitted in the common unit of CO2. Lifecycle emissions include the carbon footprint required in all aspects of the energy production, from resource extraction (i.e. coal mining), to operation, to decommission of the facility. Data obtained from Sovacool, 2008.

meet the needs of the average household. This small residential system can eliminate electricity bills, avoids burning 4,800 pounds of coal that would generate 7,200 pounds of CO<sub>2</sub>, and can save 1,920 gallons of water that are required to cool coal power plant turbines. Solar systems also last an average of 30 years.

Despite a sun that is rarely hidden by clouds, solar energy development in the Southwest has been slow precisely because coal is cheap. The price per kilowatt hour (kWh) of coal-generated electricity in Arizona is around 3 cents; solar electricity nears 20 cents per kWh. As a result, 90 percent of Arizona's electricity comes from coal-fired power plants. Many solar industry economic analysts believe that the cost of solar electricity has to fall to 10 cents per kWh to compete with fossil fuels.

To meet this challenge, the U.S. Department of Energy's (DOE) Solar Energy Technologies Program began stimulat-

ing collaborative public-private partnerships to reduce the cost of solar energy to 7 to 10 cents per kWh by 2015 and to 5 cents by 2020.

And now that the tax incentives for solar energy are guaranteed until 2016, companies can feel safe that solar projects are good investments. The extension of the credits will also stimulate large projects with megawatt capacities. Near Gila Bend in Arizona, for example, construction on a 280-megawatt solar-powered plant is in overdrive, Plenck said. If this power plant were to turn light bulbs on today, he said, it would be the largest solar plant in the world.

### Wind in the Southwest

It's not just solar energy in the Southwest that offers an alternative to fossil fuels. It is also the invisible power of the breeze, which can transform wind into energy—on a relatively small scale—for a house or a building.

continued on page 5



## Solar and wind, continued

“Small wind has been growing so rapidly,” said Andy Cruz, co-founder and vice president for Southwest Wind Power. “We hope to double or triple our business next year.”

Cruz’s business, based in Flagstaff and bent on expanding the market for small-scale wind power, recently developed a wind turbine that can connect to the electric grid. Now, consumers can sell their surplus energy back to the utility companies, overcoming a past impediment to small-scale wind energy use.

To generate enough power to make small-scale wind energy viable, the wind needs to blow at an average 12 miles per hour. Winds that descend from the Rocky Mountains help create an environment suitable for large-scale wind farms and residential units in the Southwest, particularly in New Mexico (Figure 2). New Mexico’s wind energy-generating capacity leaped from one megawatt at the end of 1999 to 496 megawatts at the end of 2007, according to DOE. As a comparison, the average home uses around 1,000 kWh per month; 496 megawatts could supply roughly 50,000 homes with their yearly energy needs.

Arizona, on the other hand, lags behind New Mexico in wind development, primarily because the wind only passes the 12 miles per hour threshold in isolated pockets, such as Flagstaff, near the White Mountains, and on some tribal lands.

Similar to solar, the wind sector will profit from the tax incentives passed in the economic stabilization plan.

“I spent a good portion of my life in Washington meeting with endless offices trying to push this legislation through,” Cruz said. “When tax incentives would expire, the market would collapse.”

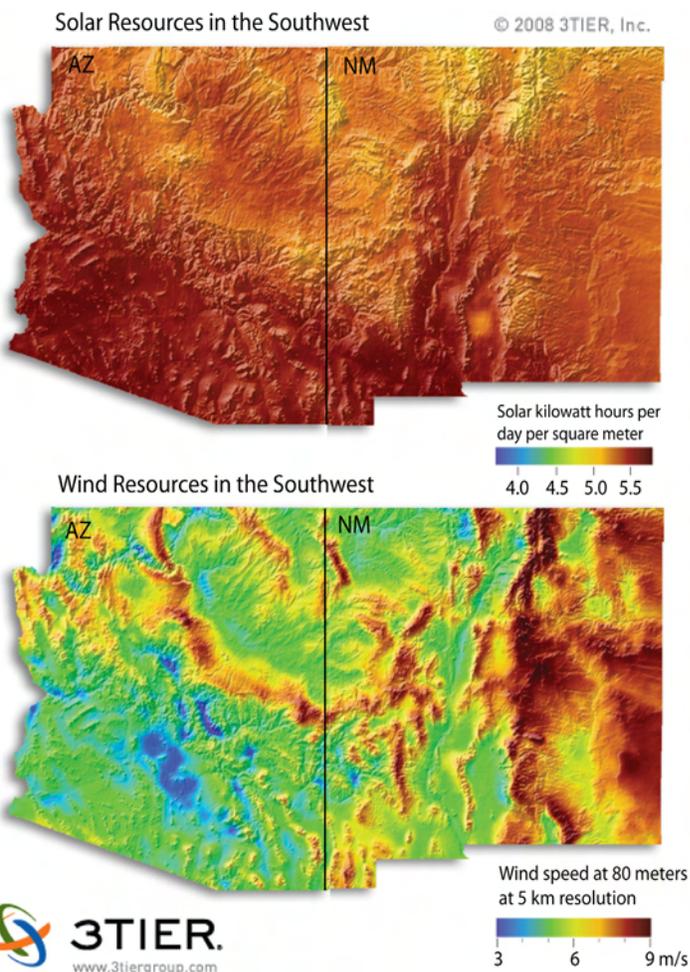
Cruz sees the future role of wind energy much like Koch sees solar: as one critical part of the larger sustainable living picture.

“People don’t buy small wind turbines solely on economics,” Cruz said. “They buy based on energy security, climate change, and hedging that future prices of fossil fuels will go up.”

With a carbon tax on the table and higher transportation costs, it seems likely that the price of coal and natural gas will indeed increase in the future. The economics for wind power, however, seem favorable today, even without increases in the price of fossil fuels. A typical system costs around \$15,000 and last 20 years.

With the federal tax rebate and local rebates offered by utility companies (Arizona Public Service offers approximately \$5,000), wind systems can be installed for around \$8,000. This may sound expensive, but bundling the amount into a 30-year mortgage, which, according to Cruz is a common practice, lowers the installation cost to about \$5 per month. The monthly savings on electricity can be six times that amount.

Wind farms and residential units combined can create energy independence and reduce GHG emissions. A U.S. Department of Energy report concluded that wind can supply 20 percent of U.S. electricity by 2030 and reduce projected CO<sub>2</sub> emissions by 25 percent—the equivalent of taking 140 million cars off the road.



**Figure 2:** The solar resources for the Americas as well as the wind resources over most of the globe, were made accessible to the public by 3 Tier Group, a Seattle-based company that provides assessment and forecasting for solar, wind, and hydroelectric development.

### A look ahead

Recently, prices at the gas pump have thinned wallets. Drought in key regions around the globe has conspired with high transportation costs to drive up food prices. And the concerns for climate change have mounted. In light of these issues, the economy and public policy may be ready for widespread commitment to renewable energies.

Clean energy is everywhere, from gusts of winds to light streaming from the sun. “We can keep waiting and waiting for huge technological advances,” Plenck said, but good options for clean energy are currently available.

Koch elaborated: “Fantastic options.”



## Temperature (through 11/19/08)

Source: High Plains Regional Climate Center

Temperatures since the water year began October 1 have averaged between 50 and 60 degrees F across most of New Mexico and northern Arizona, with higher elevations averaging between 35 and 50 degrees F (Figures 1a–b). The southern and southwestern deserts of Arizona and the lower Colorado River have experienced temperatures between 60 and 75 degrees F. These warm temperatures have been up to 4 degrees F above average for this time of year across both states. A few areas in the northwest mountains and south-central valley of New Mexico have seen temperatures up to 4 degrees F below average. October and November generally have several storm systems that bring cold air and precipitation, including snow at the higher elevations. This year, only three weak cold fronts have moved across Arizona and New Mexico, bringing scattered rain and snow showers. However, between those storm systems, persistent high pressure brought unseasonably warm temperatures to the entire Southwest. During the past 30 days, Arizona and the northern mountains of New Mexico have been 2 to 6 degrees F warmer than average (Figures 1c–d). Central New Mexico has been 0 to 2 degrees F warmer than average, and some high elevation locations in northwestern, southeastern, and south central New Mexico have been up to 4 degrees F colder than 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.

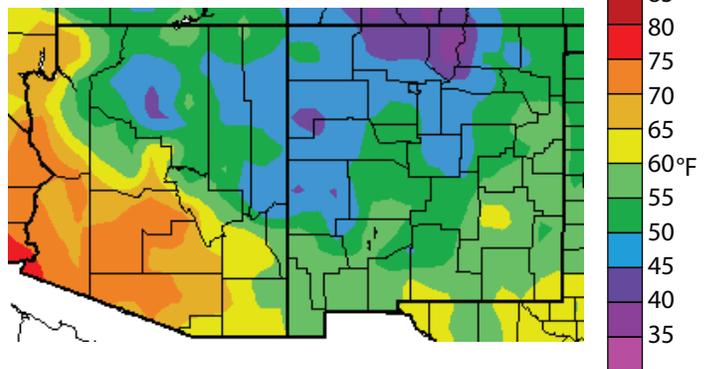
These are experimental products from the High Plains Regional Climate Center.

### On the Web:

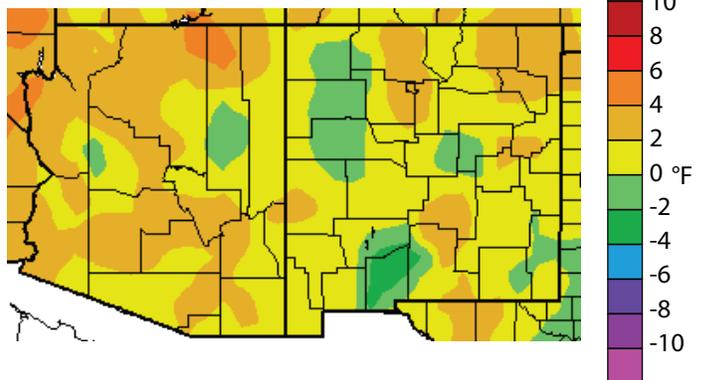
For these and other temperature maps, visit:  
<http://www.hprcc.unl.edu/maps/current/>

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

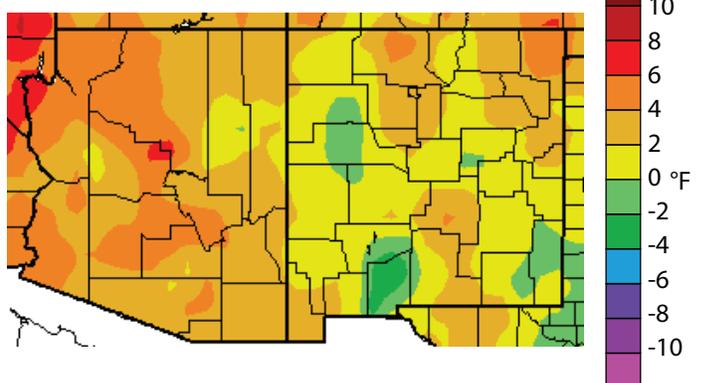
**Figure 1a.** Water year '08–'09 (through November 19, 2008) average temperature.



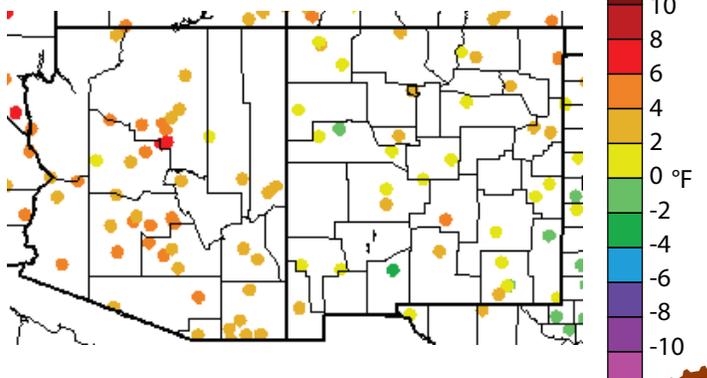
**Figure 1b.** Water year '08–'09 (through November 19, 2008) departure from average temperature.



**Figure 1c.** Previous 30 days (October 21–November 19, 2008) departure from average temperature (interpolated).



**Figure 1d.** Previous 30 days (October 21–November 19, 2008) departure from average temperature (data collection locations only).



## Precipitation (through 11/19/08)

Source: High Plains Regional Climate Center

The new water year continues to be very dry in the Southwest, with the majority of Arizona receiving less than 25 percent of average precipitation (Figures 2a–b). Northwestern and southern New Mexico have also had less than 50 percent of average precipitation. Central New Mexico has received 50 to 100 percent of average precipitation, while eastern New Mexico has received 100 to above 300 percent of average.

The extreme dry conditions in Arizona and western New Mexico are due to strong high pressure systems over the southwestern U.S. that have forced the cold fronts to pass to the north, through Utah and Colorado. The clockwise circulation around the high pressure brought warm, dry air from the Nevada and southern California deserts into Arizona and eastern New Mexico. Wet conditions in eastern New Mexico are the result of heavy precipitation from Tropical Storm Norbert in early October. In the past 30 days, both Arizona and New Mexico have had less than 50 percent of average precipitation, with less than 0.50 inches of precipitation falling in most locations (Figures 2c–d). Only three storm systems passed through the region in the past month, and they were weak systems with little moisture.

### Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2008, we are in the 2009 water year. The water year is a more hydrologically sound measure of climate and hydrological activity than is the standard calendar year.

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

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

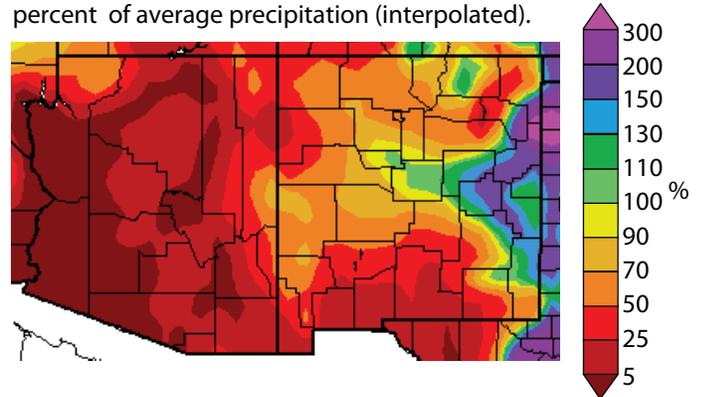
The dots in Figures 2b and 2d show data values for individual meteorological stations.

### On the Web:

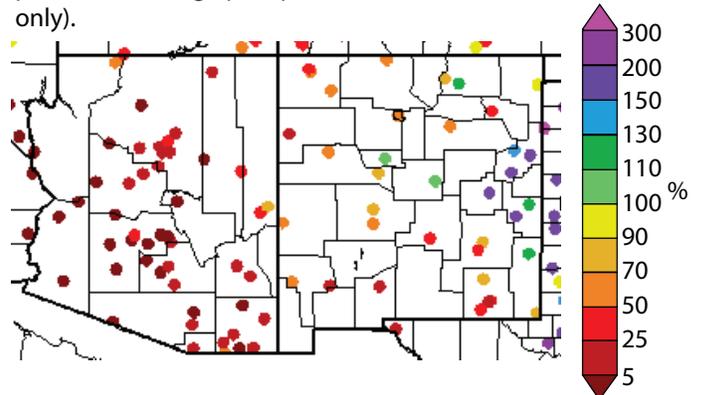
For these and other precipitation maps, visit:  
<http://www.hprcc.unl.edu/maps/current/>

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

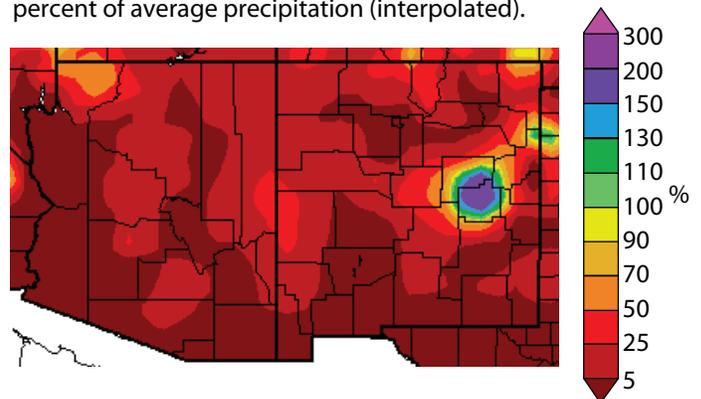
**Figure 2a.** Water year '08-'09 (through November 19, 2008) percent of average precipitation (interpolated).



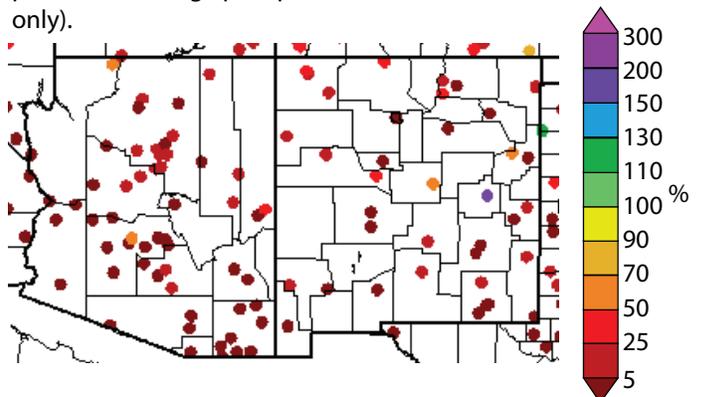
**Figure 2b.** Water year '08-'09 (through November 19, 2008) percent of average precipitation (data collection locations only).



**Figure 2c.** Previous 30 days (October 21–November 19, 2008) percent of average precipitation (interpolated).



**Figure 2d.** Previous 30 days (October 21–November 19, 2008) percent of average precipitation (data collection locations only).



## U.S. Drought Monitor

(released 11/20/08)

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

Drought conditions in Arizona and New Mexico substantially increased in area compared to last month (Figure 3). Almost the entire Colorado Plateau region, an elevated geographic area centered approximately on the Four Corners region, has been designated as abnormally dry. Large parts of northwestern Arizona and small areas near the California border in southwestern Arizona are also classified as abnormally dry. In New Mexico, the north-central portion of the state remains in an abnormally dry status, while the north-eastern corner contains both abnormally dry and moderate drought conditions.

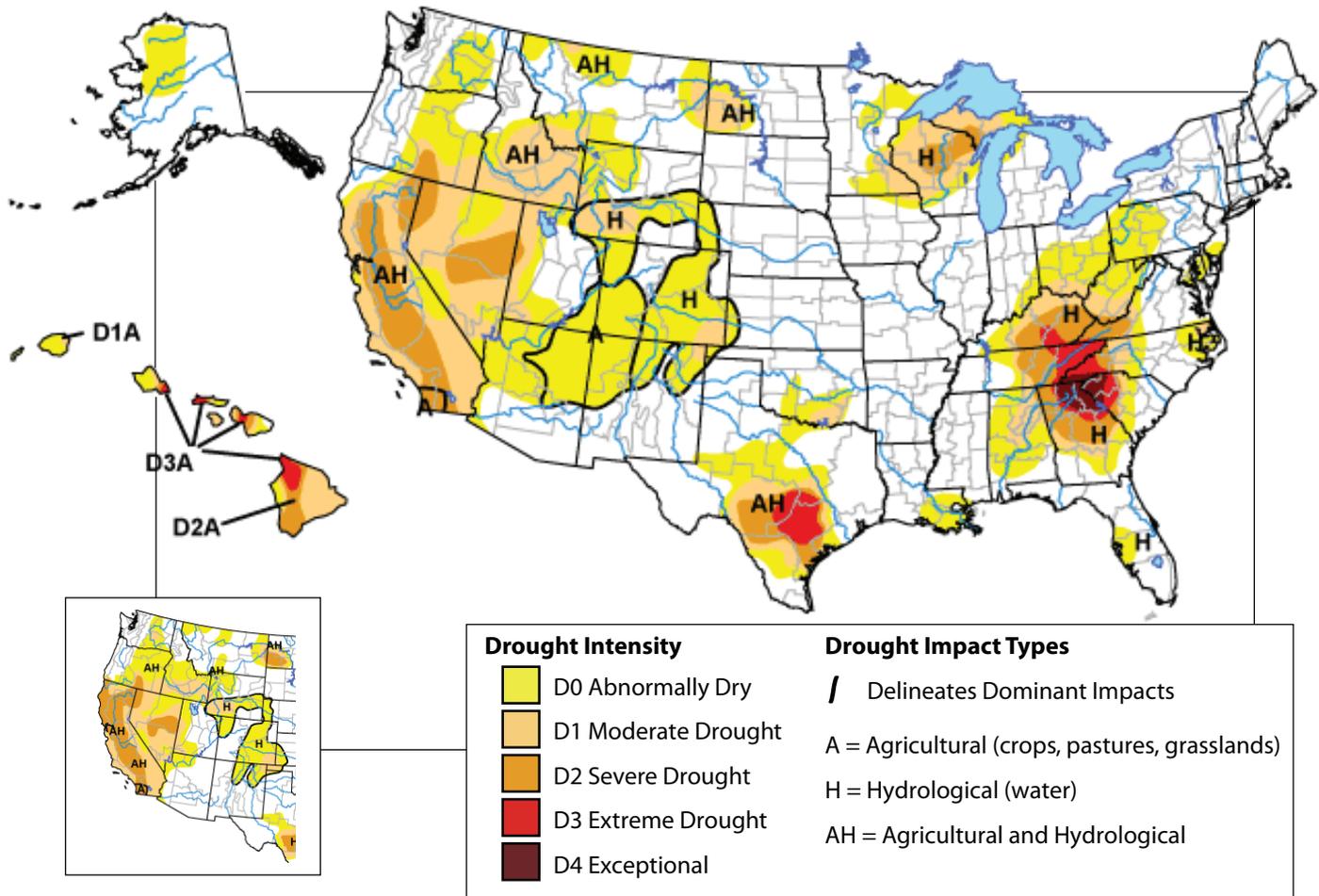
As of November 18, approximately 40 percent of Arizona has no drought status, while 59 percent is abnormally dry. In the past week alone, 26 percent of the state was downgraded from no drought status to abnormally dry. In New Mexico, about 61 percent of the state has no drought status on November 18, down from 81 percent just one week ago; approximately 39 percent is abnormally dry. About 40 percent of the U.S. has abnormally dry conditions or worse.

### 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 Brad Rippey, USDA.

**Figure 3.** Drought Monitor released November 20, 2008 (full size), and October 16, 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 9/30/08)

Source: Arizona Department of Water Resources

Short-term drought conditions in September remained unchanged from August, according to the October Arizona Drought Monitor Report, which lags the actual date by one month. The southern half of Arizona remained drought free, while the Upper Colorado River, Little Colorado River, Bill Williams River, Verde River, and Agua Fria River watersheds all saw abnormally dry conditions due to below-average precipitation at the end of the summer monsoon season and through early fall (Figure 4a).

Long-term drought conditions continue to persist across all of the watersheds in Arizona due to long-term deficits (up to four years) in precipitation (Figure 4b). All watersheds are experiencing at least abnormally dry conditions with several watersheds in southern and north-central Arizona observing moderate drought conditions. The only improvement in long-term drought was observed in the San Simon River watershed, which moved from severe to moderate drought with the October update.

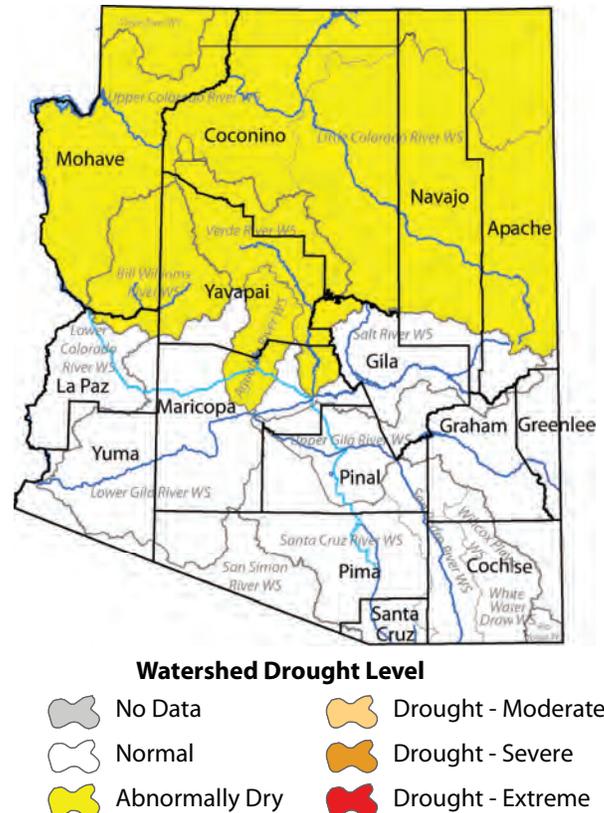
During a recent workshop in Tucson, climate and public health experts discussed recent findings that link climate variability to the incidences of diseases ranging from West Nile virus to dengue fever (*Arizona Daily Star*, November 17). The frequency and intensity of drought has been linked to the occurrences of valley fever infections, especially in the Tucson metropolitan area. This may be due to interactions between dry conditions and the production of dust that can be inhaled, raising the risk of valley fever infections.

### Notes:

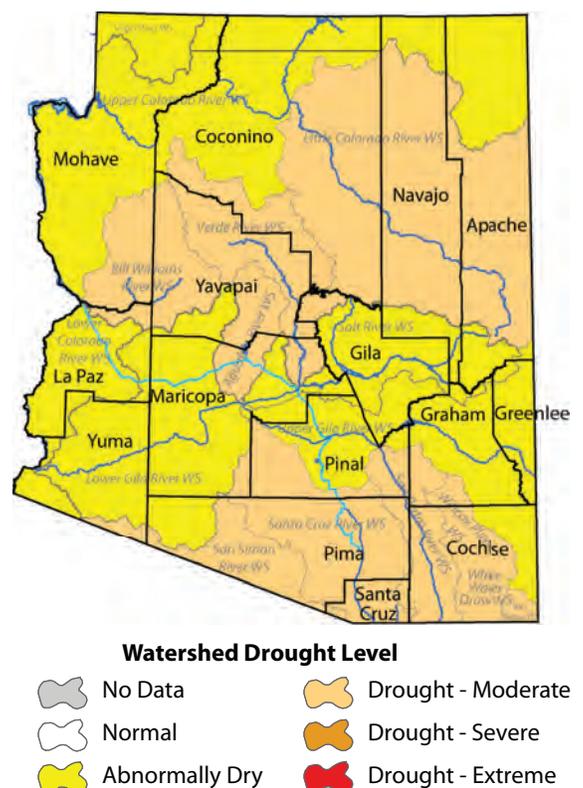
The Arizona drought status maps are produced monthly by the Arizona Drought Preparedness Plan Monitoring Technical Committee. The maps are based on expert assessment of variables including, but not limited to, precipitation, drought indices, reservoir levels, and streamflow.

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).

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



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



### On the Web:

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



## New Mexico Drought Status

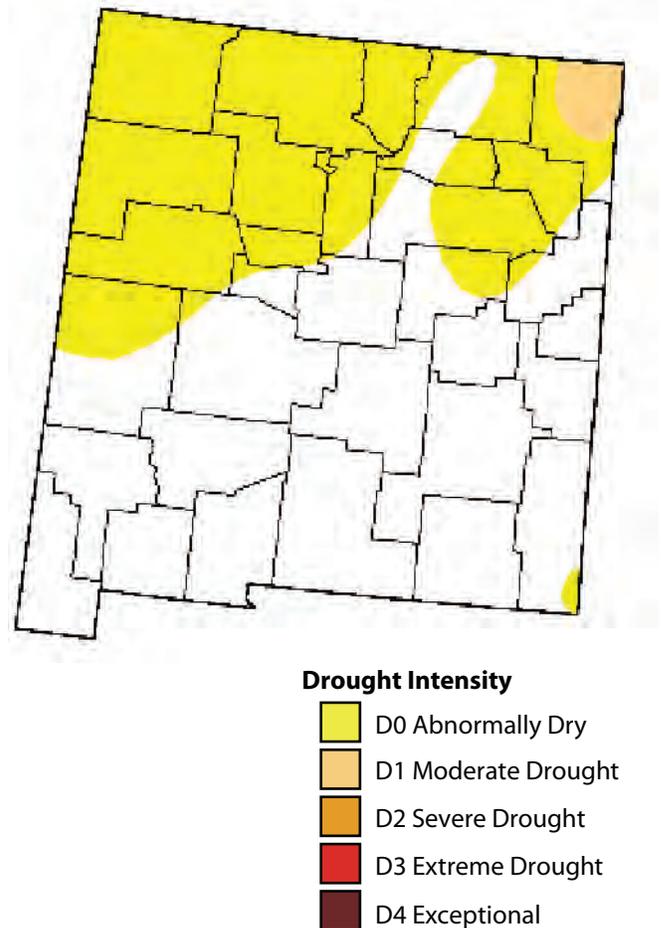
(released 11/20/08)

Source: New Mexico State Drought Monitoring Committee

Drought conditions in New Mexico reported in the November 18 issue of the National Drought Monitor worsened slightly across portions of the state since October 14. Abnormally dry conditions have crept into the northwestern quarter of New Mexico, while abnormally dry and moderate drought covers the extreme northeast corner of the state (Figure 5). Below-average precipitation persisted across northern New Mexico through October and early November, leading to the encroachment of short-term drought conditions. The remainder of the state was drought free due to the lasting effects of above-average summer rainfall.

Drought disaster assistance has been made available to farmers and ranchers in Otero and Eddy counties in southern New Mexico (KOAT News, November 19). Low interest emergency loans are available to producers in these counties who suffered losses stemming from the exceptionally dry conditions that hit the region last winter and spring.

**Figure 5.** New Mexico drought map based on data through November 18.



#### 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](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 10/31/08)

Source: National Water and Climate Center

Combined reservoir storage in Lakes Powell and Mead declined by 137,000 acre-feet during October (Figure 6). Nevertheless, compared with last year, combined levels have risen more than two million acre-feet. During October, storage in the Salt River watershed slightly increased, while storage in the Verde River watershed declined approximately 36 percent, or about 60,000 acre-feet; both watersheds currently have substantially more water than they had one year ago.

In Arizona water news, the San Pedro River, one of the last free-flowing rivers in Arizona, received additional environmental protection on November 12 when 122 acres just north of the U.S. border with Mexico were acquired by the Nature Conservancy, the Arizona Game and Fish Department, and the U.S. Fish and Wildlife Service. This acquisition is critical to protect aquatic and riparian habitat along the river, including several endangered and threatened species such as the southwestern willow flycatcher and Chiricahua leopard frog.

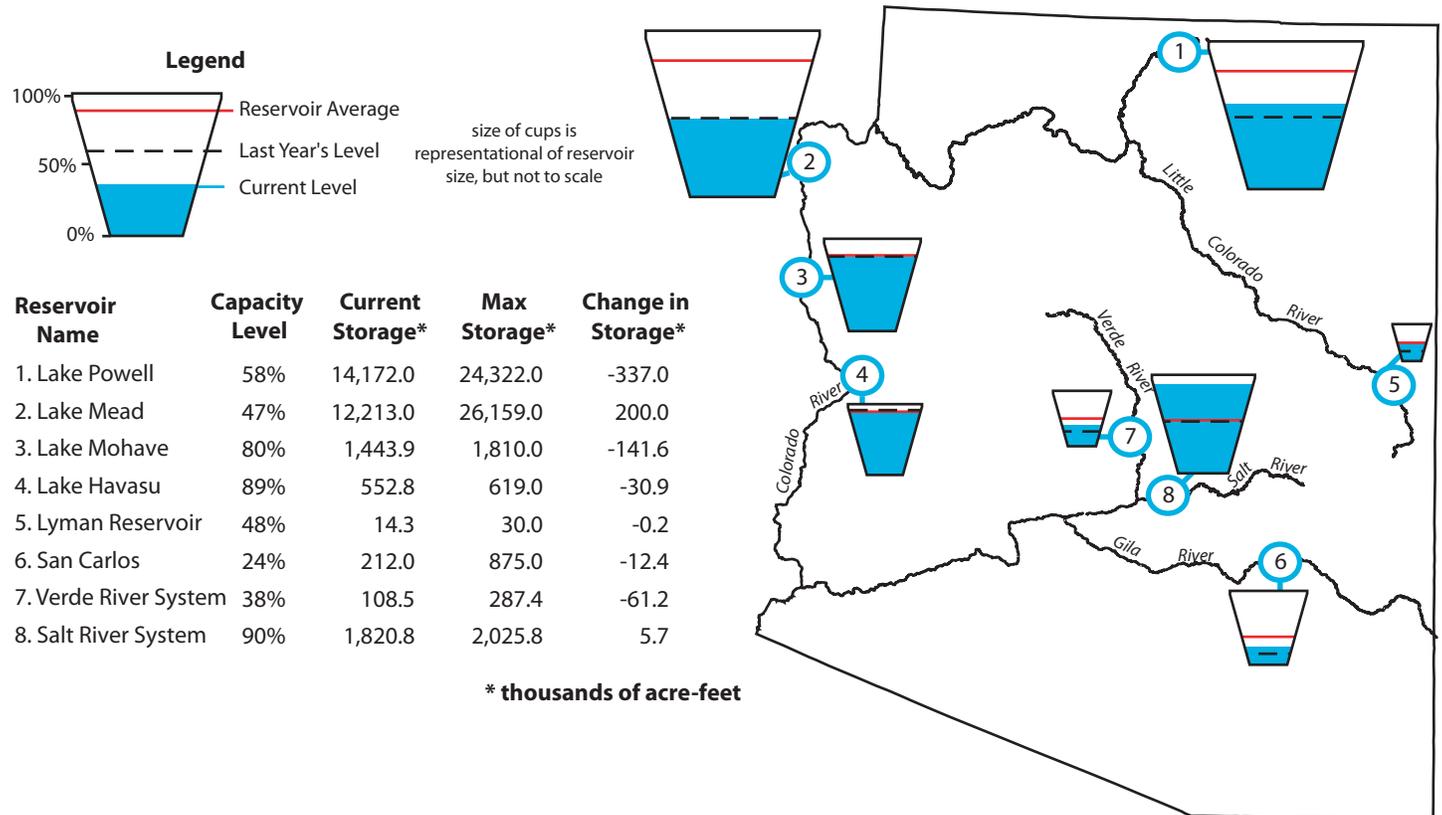
### Notes:

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 October 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.



### 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](http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html)



# New Mexico Reservoir Levels (through 10/31/08)

Source: National Water and Climate Center

The total reservoir storage in New Mexico declined slightly during October (Figure 7). Storage in New Mexico's larger reservoirs, Heron and Navajo, declined during the last month. However, these reservoirs are at more than 70 percent of capacity.

In New Mexico water news, an entrepreneur wants to bring water to Sante Fe from sources approximately 145 miles away, in Fort Sumner. This type of long-distance water pipeline may become more common in the Southwest and other parts of the country as the value of drinking water catches up with the cost of delivering it (*The New Mexican*, November 1).

The Navajo Nation is seeking \$7.3 million from Congress to improve the Navajo Indian Irrigation System. Without this funding, the Navajo Agricultural Products Industry may be unable to farm its current acreage and deliver corn and wheat.

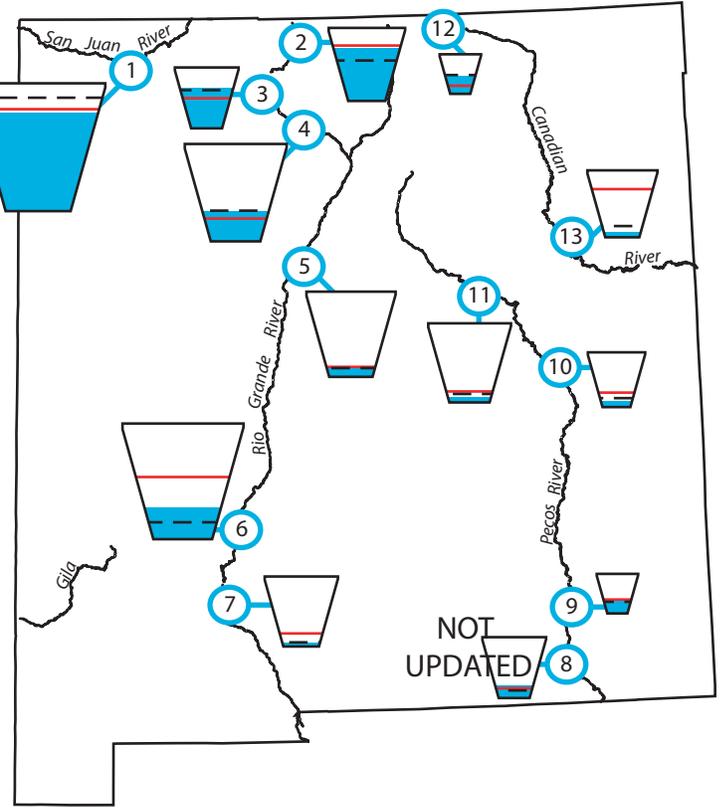
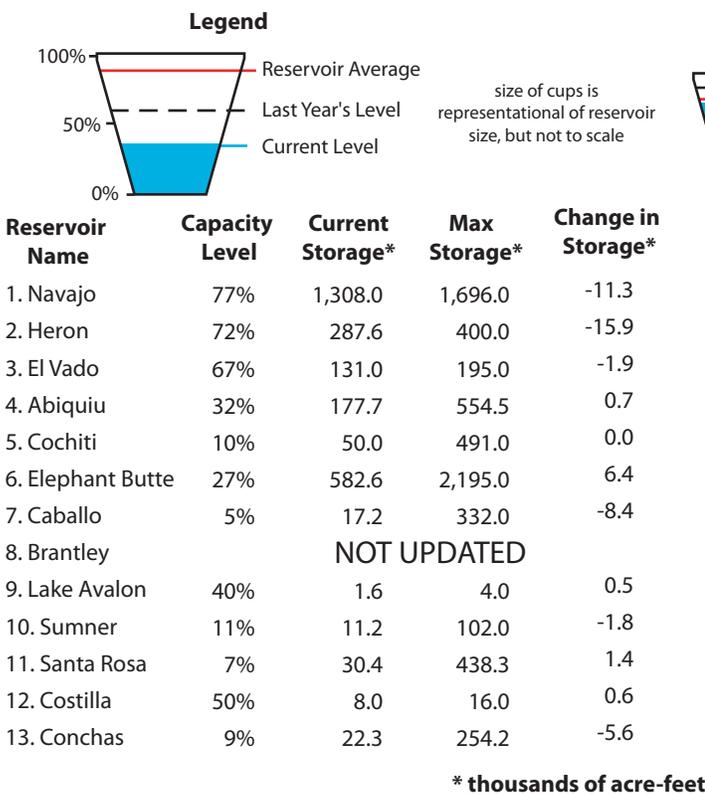
### Notes:

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 October 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.



### 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](http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html)



# Southwest Snowpack

(updated 11/20/08)

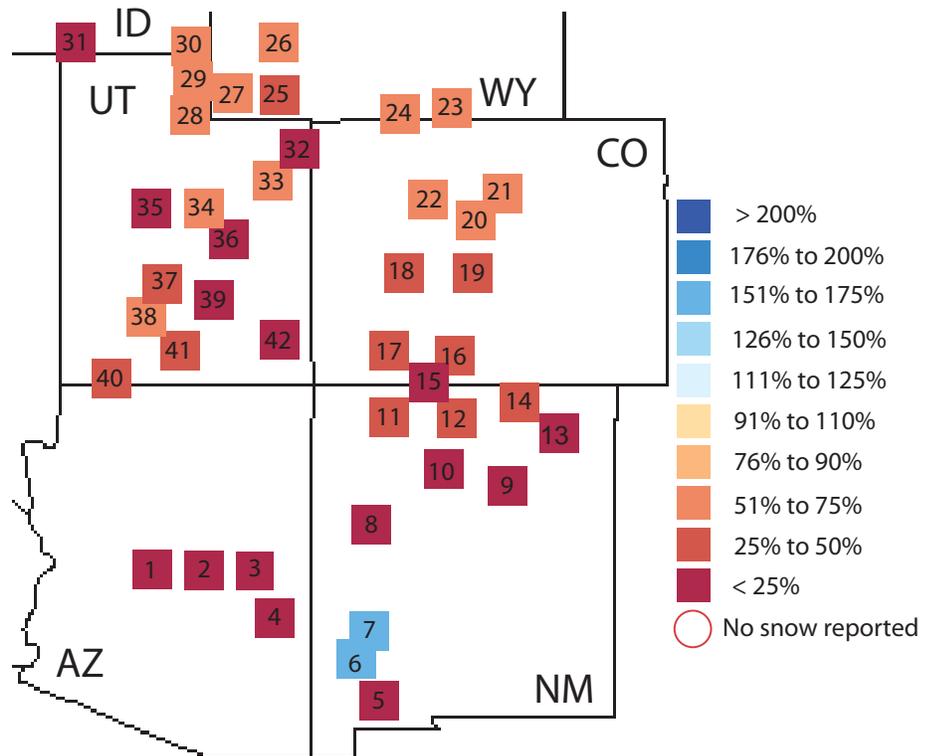
Sources: National Water and Climate Center, Western Regional Climate Center

The early snowpack in Arizona and New Mexico as of November 18 is generally less than 50 percent of the 30-year, 1971–2000 average (Figure 8). According to the National Resource Conservation Service’s SNOTEL monitoring stations, the southern headwaters of the Little Colorado River basin in Arizona has snow water equivalent (SWE) equal to only 18 percent of the historic average. In Arizona and New Mexico, the exception to below-average snowfall is only in the Gila River Basin, where two sites in New Mexico have recorded accumulated SWE of more than 125% percent of the historic average.

The Rocky Mountain states to the north, which supply most of the water in the Colorado River and Rio Grande, have also experienced low early season snowfall. In the headwaters of the Rio Grande in Colorado, the average SWE of 10 SNOTEL measuring stations is 32 percent of average. Similarly, in the Upper Colorado River Basin, the average SWE of the 28 reporting SNOTEL sites is only 18 percent of average.

The National Oceanic and Atmospheric Administration’s winter outlook for December–February calls for a slightly greater chance of warm weather for most of New Mexico and equal chances for warmer or colder weather for Arizona and the Rocky Mountain region. The outlook also suggests that southern Arizona will be slightly drier, while there are equal chances of drier or wetter conditions in the rest of the Rocky Mountain region and New Mexico.

**Figure 8.** Average snow water content (SWC) in percent of average for available monitoring sites as of November 20, 2008.



**Arizona Basins**

- 1 Verde River Basin
- 2 Central Mogollon Rim
- 3 Little Colorado - Southern Headwaters
- 4 Salt River Basin

**New Mexico Basins**

- 5 Mimbres River Basin
- 6 San Francisco River Basin
- 7 Gila River Basin
- 8 Zuni/Bluewater River Basin
- 9 Pecos River
- 10 Jemez River Basin

**Colorado Basins**

- 11 San Miguel, Dolores, Animas, and San Juan River Basins
- 12 Rio Chama River Basin
- 13 Cimarron River Basin
- 14 Sangre de Cristo Mountain Range Basin
- 15 San Juan River Headwaters

**Notes:**

Snowpack telemetry (SNOTEL) sites are automated stations that measure snowpack depth, temperature, precipitation, soil moisture content, and soil saturation. A parameter called snow water content (SWC) or snow water equivalent (SWE) is calculated from this information. SWC refers to the depth of water that would result by melting the snowpack at the SNOTEL site and is important in estimating runoff and streamflow. It depends mainly on the density of the snow. Given two snow samples of the same depth, heavy, wet snow will yield a greater SWC than light, powdery snow.

Figure 8 shows the SWC for selected river basins, based on SNOTEL sites in or near the basins, compared to the 1971–2000 average values. The number of SNOTEL sites varies by basin. Basins with more than one site are represented as an average of the sites. Individual sites do not always report data due to lack of snow or instrument error.

**On the Web:**

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

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

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

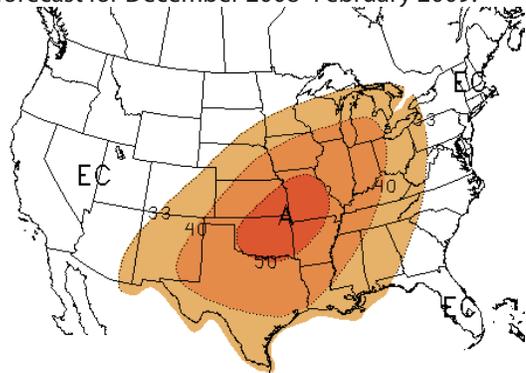


# Temperature Outlook (December 2008–May 2009)

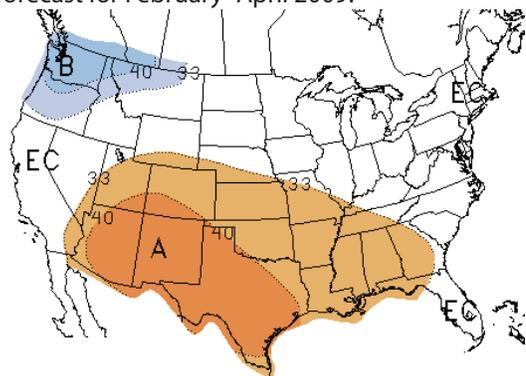
Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (CPC) long-lead temperature forecasts for the continental U.S. and Alaska show equal chances of above-, below, and near-normal temperatures for most of the West through fall; in the Southwest, New Mexico and eastern Colorado show slightly higher chances of above-average temperatures through February 2009 (Figure 9a). The southern Plains also have a fairly high chance of experiencing above-average temperatures during this time. As the forecast proceeds through late winter and into spring (Figures 9b–d), the chances of above-average temperatures increase throughout the West; the forecast has significantly increased chances of much of Arizona seeing warmer-than-average temperatures by late spring. With the El Niño-Southern Oscillation (ENSO) remaining in the neutral phase, these forecasts are based primarily on long-term trends in temperature.

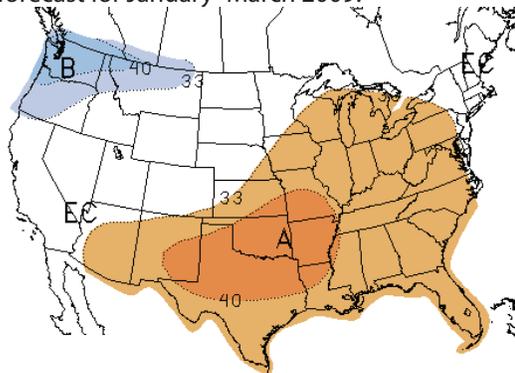
**Figure 9a.** Long-lead national temperature forecast for December 2008–February 2009.



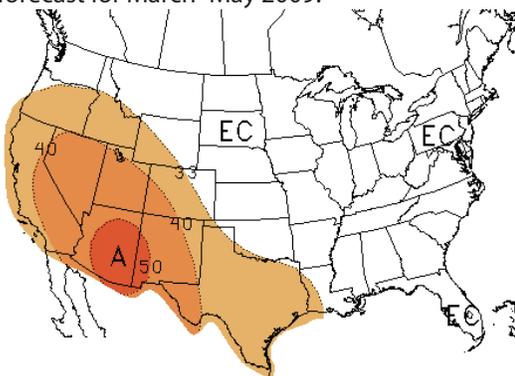
**Figure 9c.** Long-lead national temperature forecast for February–April 2009.



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



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



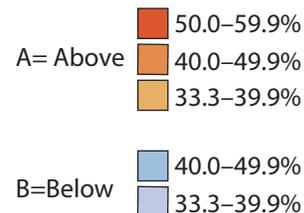
**Notes:**

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.



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](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/](http://iri.columbia.edu/climate/forecast/net_asmt/)



# Precipitation Outlook (December 2008–May 2009)

Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (CPC) long-lead precipitation forecasts show slightly increased chances of below-average precipitation for most of the southern half of the U.S. through March 2009 (Figures 10a–b), with the greatest chances of below-average precipitation in south-central and southeast Arizona. The forecast shifts to equal chances of above-, below-, and near-normal precipitation as spring progresses for most of the U.S., including the Southwest (Figures 10b–d). The Southeast is forecast to see below-average precipitation through May 2009 (Figure 10d). Forecasters expect the atmospheric and ocean situation in the equatorial Pacific to remain near neutral El Niño–Southern Oscillation (ENSO) conditions, which means these forecasts do not rely heavily on ENSO trends.

## Notes:

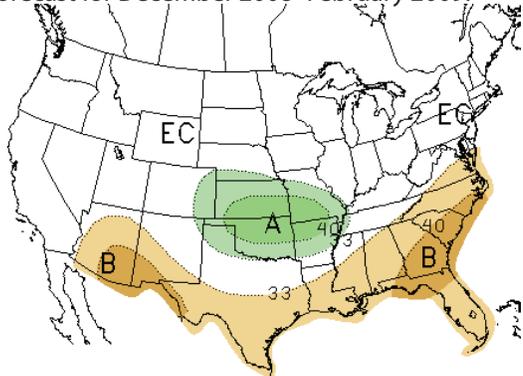
These outlooks predict the likelihood (chance) of above-average, average, and below-average precipitation, but not the magnitude of such variation. The numbers on the maps do not refer to inches of precipitation.

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.

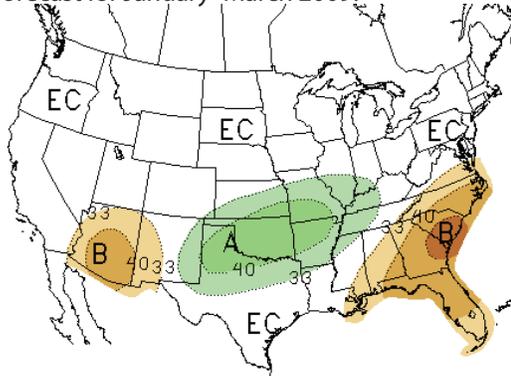
Thus, using the NOAA-CPC precipitation outlook, areas with light green shading display a 33.3–39.9 percent chance of above-average, a 33.3 percent chance of average, and a 26.7–33.3 percent chance of below-average precipitation. A shade darker green indicates a 40.0–50.0 percent chance of above-average, 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.

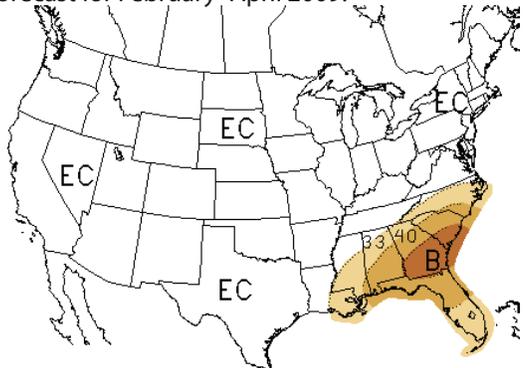
**Figure 10a.** Long-lead national precipitation forecast for December 2008–February 2009.



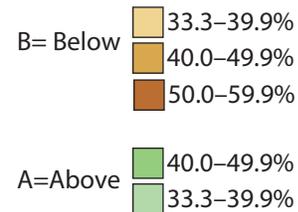
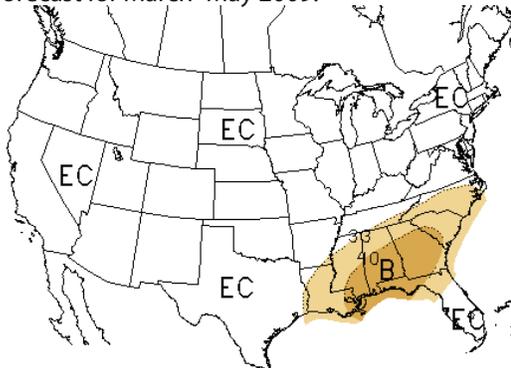
**Figure 10b.** Long-lead national precipitation forecast for January–March 2009.



**Figure 10c.** Long-lead national precipitation forecast for February–April 2009.



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



EC= Equal chances. No forecasted anomalies.

## On the Web:

For more information on CPC forecasts, visit:  
[http://www.cpc.ncep.noaa.gov/products/predictions/multi\\_season/13\\_seasonal\\_outlooks/color/churchill.html](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/](http://iri.columbia.edu/climate/forecast/net_asmt/)



## Seasonal Drought Outlook (through February 2009)

Source: NOAA Climate Prediction Center (CPC)

Drought conditions for November 20 through February 2009 will generally persist in southern Texas, southern California, northern Wisconsin, and parts of the Southeast (Figure 11). Numerous areas in the U.S. will experience improvements in drought conditions, including most of Nevada, central and northern California, Hawaii, and parts of the Southeast. On the other hand, drought development is likely in many regions, including Florida and western Arizona. This outlook is based predominantly on subjective synthesis of recent conditions and two-week and seasonal forecasts.

The forecast for the desert Southwest is difficult. The National Oceanic and Atmospheric Administration's Climate Prediction Center (NOAA-CPC) states that drought may expand eastward into Arizona. This outlook is based primarily on the December–February precipitation forecast and the fact that, though the season is relatively wet in some areas, the region is one of the driest in the country and has been particularly dry in the past several years. Although CPC suggests that the most prudent forecast for this area is drought, this outlook has substantial uncertainty, as several models

suggest that a large storm system may move through the region in late November. If this, or other storms, drop heavy precipitation on the region, the drought situation could markedly and rapidly change. In part because of this uncertainty, CPC assigns low confidence to the forecast that western Arizona will experience drought during the forecasted period.

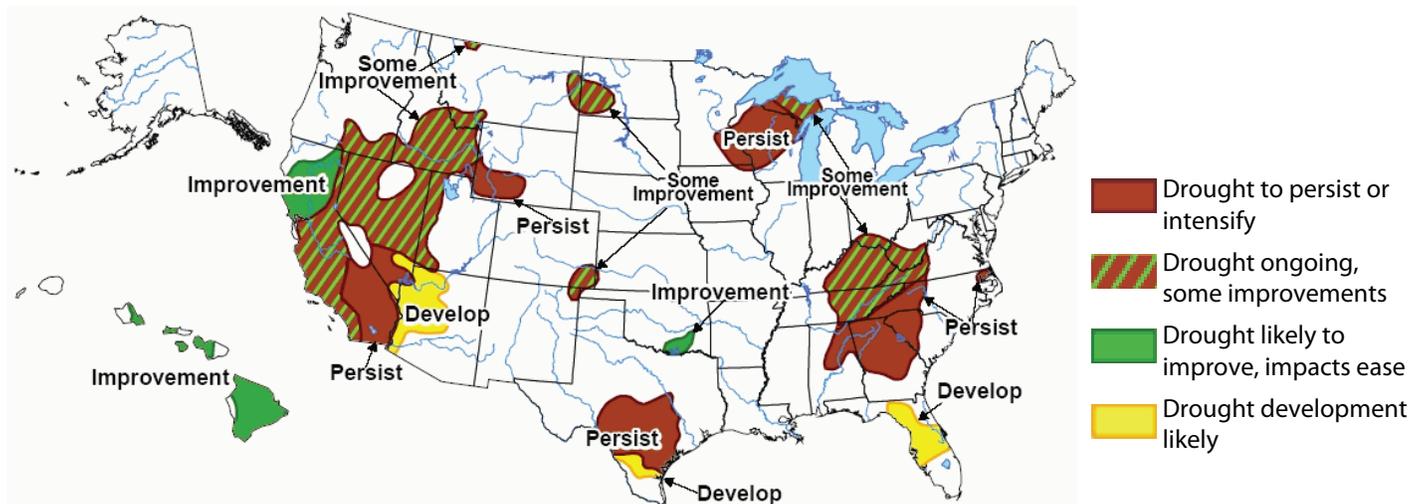
For New Mexico, some improvement is anticipated for the drought area in the state's northeastern corner. The outlook suggests that after a dry end to November this area will experience above-normal precipitation. CPC has high confidence in this forecast.

For northern California, CPC anticipates improvement in drought conditions as a result of a forecasted wetter-than-normal December. Some improvements are expected in central and southwestern California, Nevada, and southern Idaho. In these areas, December–February is a relatively wet and cold time of year, particularly in the higher elevations where snowpacks accumulate and provide a primary source of water for the regions.

### 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 February 2009 (released November 20, 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)

The El Niño-Southern Oscillation (ENSO) remained in its neutral phase once again this month with sea surface temperatures (SSTs) near-average across much of the equatorial Pacific Ocean. The pattern of slightly above-average SSTs in the eastern Pacific that was present last month subsided in intensity over the past 30 days. The International Research Institute for Climate and Society (IRI) reported that there was some discussion about whether or not the above-average SSTs were signaling the beginning of an El Niño event.

The Southern Oscillation Index (SOI; Figure 12a) remained relatively high again this month after falling precipitously during the spring and summer with the end of the 2007–08 La Niña event. In typical ENSO-neutral conditions, the SOI values would be lower than they currently are. The IRI notes that the high SOI values experienced in the past several months may not be indicating a return to La Niña conditions, but may be caused by seasonal variations in atmospheric circulation.

### Notes:

Figure 12a shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through October 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.

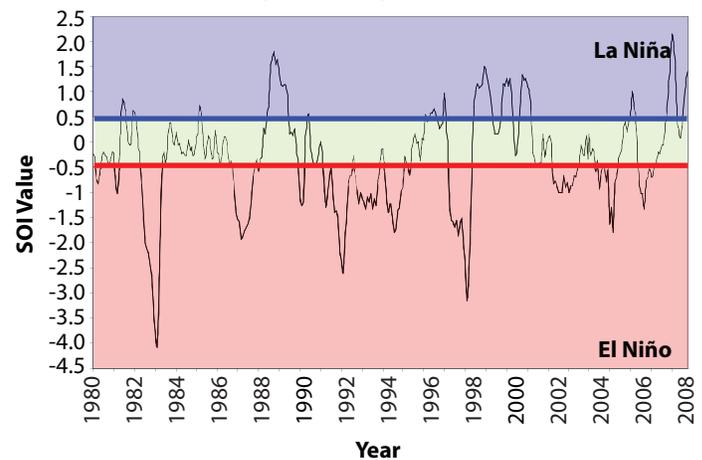
### On the Web:

For a technical discussion of current El Niño conditions, visit: [http://www.cpc.ncep.noaa.gov/products/analysis\\_monitoring/enso\\_advisory/](http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/)

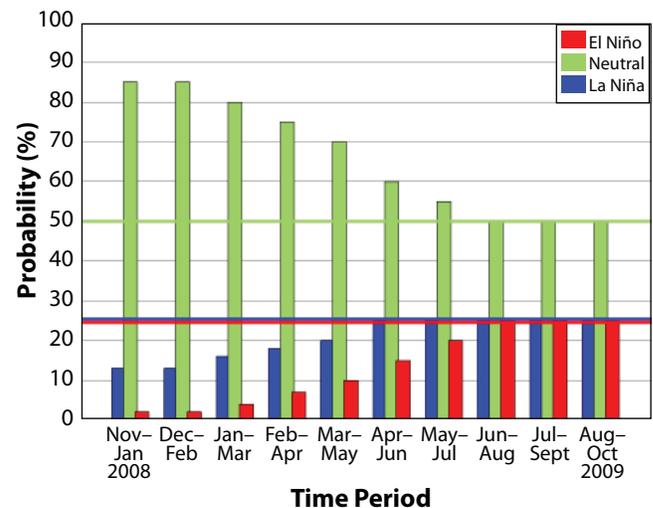
For more information about El Niño and to access graphics similar to the figures on this page, visit: <http://iri.columbia.edu/climate/ENSO/>

The probability of ENSO-neutral conditions continuing through the upcoming winter and spring 2009 seasons remains high at more than 80 percent in the IRI forecast (Figure 12b). The chance of El Niño or La Niña conditions developing over this period remains very low (5 percent and 15 percent respectively). The National Oceanic and Atmospheric Administration's Climate Prediction Center reports that several ENSO models suggest that a La Niña event could develop during the winter season. The current oceanic and atmospheric environment is especially sensitive to the impact of weather events that could produce SSTs and wind patterns that reinforce La Niña or El Niño conditions. Rapid development of La Niña conditions would favor below-average winter precipitation for the Southwest U.S.

**Figure 12a.** The standardized values of the Southern Oscillation Index from January 1980–October 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 November 20, 2008). Colored lines represent average historical probability of El Niño, La Niña, and neutral.



## Temperature Verification (August–October 2008)

Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (CPC) seasonal temperature outlook for August–October 2008 predicted increased chances of above-average temperatures for much of the western United States, including fairly high probabilities of above-average temperatures throughout Arizona and New Mexico and a slight chance of below-average temperatures along the Washington and Oregon coasts (Figure 13a). The forecast also predicted warmer-than-average temperatures in New England. These predictions were based primarily on long-term temperature trends.

The overall observed pattern of temperatures was inconsistent with the CPC prediction in some areas. Temperatures were slightly below average through much of the South and New England. Washington, Oregon, and northern California coasts saw near-average to slightly below-average temperatures (Figure 13b). Arizona, Nevada, and California, however, experienced warmer-than-average temperatures. With the El Niño-Southern Oscillation (ENSO) remaining in the neutral phase, these forecasts, which are based primarily on long-term trends in temperature, were unable to predict the anomalously cool weather.

### Notes:

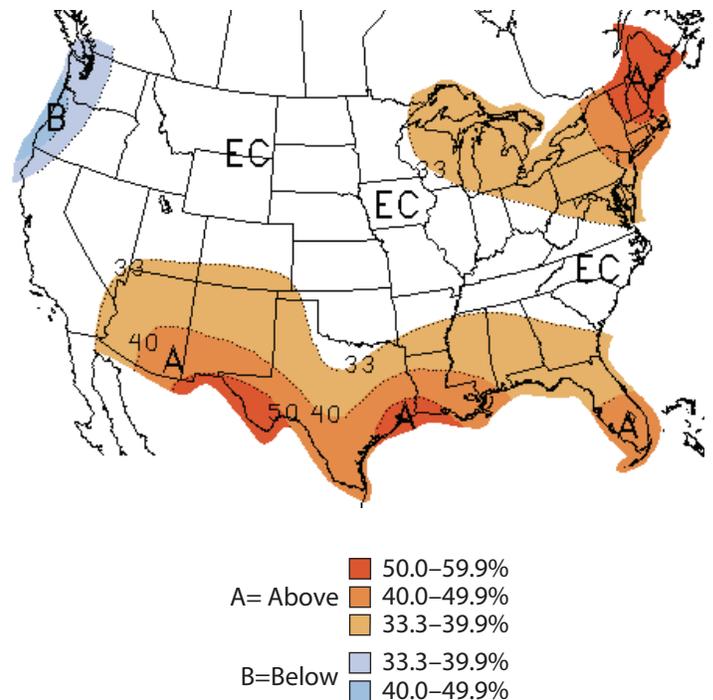
Figure 13a shows the NOAA Climate Prediction Center (CPC) temperature outlook for the months August–October 2008. This forecast was made in July 2008.

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.

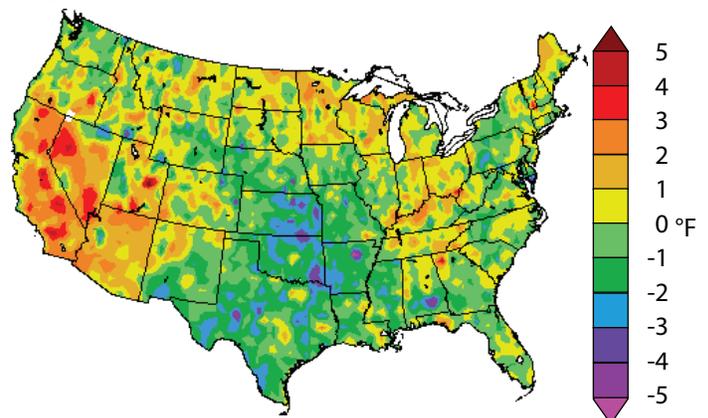
Figure 13b shows the observed departure of temperature (degrees F) from the average for the August–October 2008 period. Care should be exercised when comparing the forecast (probability) map with the observed temperature maps. The temperature departures do not represent probability classes as in the 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.

**Figure 13a.** Long-lead U.S. temperature forecast for August–October 2008 (issued July 2008).



EC= Equal chances. No forecasted anomalies.

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



### 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](http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html)



## Precipitation Verification

(August–October 2008)

Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (CPC) seasonal precipitation outlook for August–October 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 Pacific Northwest and slightly increased chances of above-normal precipitation for most of the Gulf of Mexico and New England.

Observed precipitation revealed very dry conditions through most of California, Nevada, the Pacific Northwest, and the northern Rockies (Figure 14b). Much of the Gulf of Mexico region experienced slightly above-average precipitation, as did most of New England and a substantial portion of the Midwest and southern Plains. The Southwest generally experienced near-average to below-average precipitation throughout the summer, with some areas, particularly the Four Corners region, experiencing far below-average precipitation. Overall, the observed precipitation pattern in the Pacific Northwest, the Gulf Coast, the Midwest, and New England is close to what the NOAA-CPC outlook predicted.

### Notes:

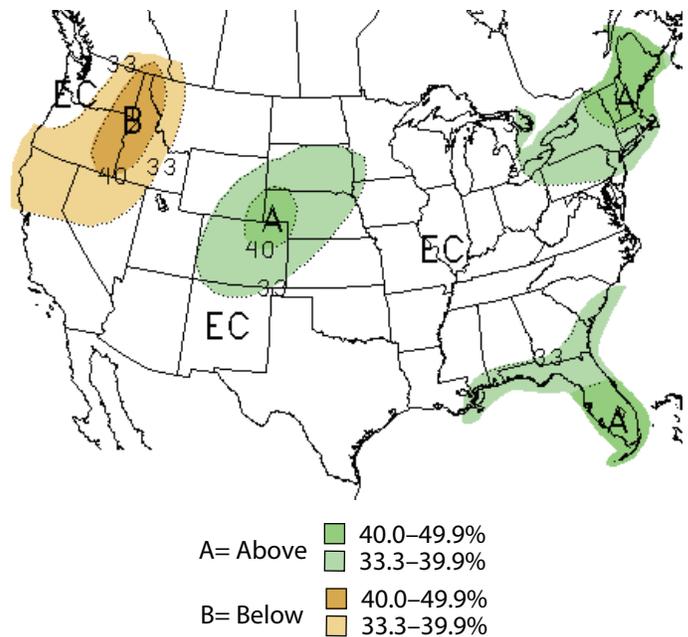
Figure 14a shows the NOAA Climate Prediction Center (CPC) precipitation outlook for the months August–October 2008. This forecast was made in July 2008.

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 August–October 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.

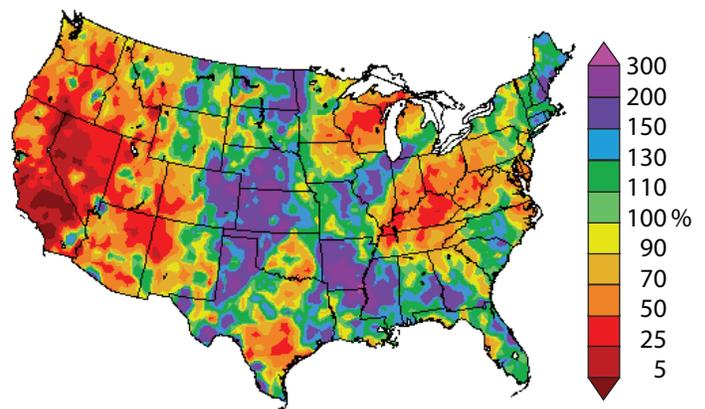
In all of the figures on this page, the term average refers to the 1971–2000 average. This practice is standard in the field of climatology.

**Figure 14a.** Long-lead U.S. precipitation forecast for August–October 2008 (issued July 2008).



EC= Equal chances. No forecasted anomalies.

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



### 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](http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html)

