Institute for the
Study of Planet Earth

THE UNIVERSITY OF
ARIZONA®
TUCSON ARIZONA

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August 20, 2002

Dear Participant,

First of all, thank you very much for returning your completed surveys from last month's packet. Only a month into the project, we are already gaining valuable insight into how our diverse group of project participants is using climate information and forecasts, and what we can do to make this information more accessible and useful. We have also received some more in-depth comments about your weather/climate information needs and reactions to the materials provided. We are working on addressing those comments and integrating them where possible into future packets. Please keep the excellent feedback coming!

This month's information packet contains some updated versions of last month's materials, as well as some new information. The August newsletter highlights the on-going monsoon season, as well as eastern North Pacific tropical storms, whose peak season begins in August and lasts through October. The newsletter should provide you with some useful background information on these phenomena. Your packet contains charts that describe tropical storm formation and past storm tracks, and information based on historical records that show the effect that El Niño conditions have had on the Southwest in the past during this time of year.

We have also included graphics that show the impact of this year's monsoon rains in four locations in northern and southern New Mexico and Arizona. The graphics show that although the monsoon has been quite productive in some areas, such as Tucson, it has barely made an impact on the drought in other areas, such as Albuquerque. Even in areas where the monsoon has been strong, the charts help to visualize how far behind different areas of the Southwest remain with regard to average rainfall amounts, and that the drought persists despite the short-term relief that some areas are receiving. Two additional sheets of information on drought illustrate in greater detail the depth of this dry spell and pinpoint how much rainfall would be required to return to average conditions.

You may encounter some unfamiliar terms in this month's packet as well. We've updated the glossary on the website, at http://www.ispe.arizona.edu/climas/end/. As always, the graphics from this month's packet are posted on the website, along with links referenced in the packet to websites that will provide you with more information on specific topics.

You'll notice a few formatting changes to the packet as well. The table of contents and the survey chart look a little different this month. Instead of using figure numbers, the packet is now organized by page numbers and overall content. We hope that by asking that you respond to topical pages, instead of to each graphic individually, the response process will be simplified and the amount of time required to complete the survey will be reduced. We'd appreciate any comments you have on the new format.

In an effort to comply with University of Arizona human subjects regulations and assure the privacy of your responses, we have assigned each participant a number, which is located on the survey, survey chart, and on each packet. We will be using these numbers as we analyze the data from the surveys.

Thank you for the deluge of new contacts we received in response to the initial survey question asking about others who might be interested in participating in the project. We greatly appreciate your help in expanding the project to others who would benefit from receiving this information. While we would like to include as many participants as possible in the project, our budget limits the number of packets we can afford to send out. Therefore, we are working on setting up a means of viewing the packet contents on-line or through file transfer, which will allow us to expand the project. We will be contacting the new participants whom you suggested about this in the near future.

Finally, in response to requests from some of our participants to know more about others involved in the project, we've included a list of the project participants, along with their contact information. We are planning to hold an end-of-project workshop next summer that we hope everyone will be able to attend, and thus you'll get the chance to meet each other in person. More details on this workshop will be provided in the months to come.

We hope that you enjoy and are informed by this month's packet. As always, feel free to contact us if you have any comments or concerns.

Best regards,

Rebecca H. Carter
Research Associate

Gregg Garfin
Assistant Staff Scientist

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Evaluation – Monthly Information Packet

For: August 2002 Packet Number: 2

Please complete the following questionnaire about the information packet contents.

1. Does the information provided in this packet (check one):

   ___ confirm your assessment of current climate conditions

   ___ contradict your assessment of current climate conditions

   ___ both confirm and contradict your assessment of current climate conditions

2. Was there information missing from this packet that you would like to receive? (please specify)

3. Did you share or discuss any of the information provided with your co-workers?

   (please specify their position)

____ Top management ____ Field operations ____ Public relations/Education

____ Middle management ____ Research/Analysis

____ Other (please specify)____

4. Did any of the information we provided have an influence on your organization?

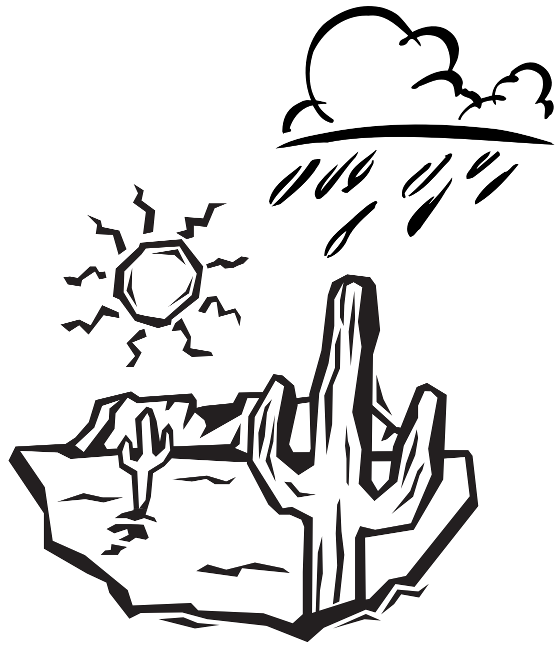
   ____Yes ____No

   If Yes, please specify the information used and how you used it.

5. On the attached chart, please evaluate each of the information products provided in this packet, and whether or not you used that particular item.

Page #	Description	**General Impression?** 1=Useful *(or)* 2=Merely interesting *(or)* 3=Neither	**Adequate Lead Time?** 1 = Yes 2 = No	**Detail?** 1 = Just Right 2 = Too Much 3 = Too Little	**Easy to Understand?** 1 = Easy 2 = Moderate 3 = Difficult	**Graphic Style?** 1 = Good 2 = So-So 3 = Poor	**Action Taken?** 1 = Yes 2 = No	August 2002 **What action? Other comments?**
	Background							
	END InSight Newsletter							
	Executive Summary							
	Recent Conditions							
1	Temperature							
2	Precipitation							
3	U.S. Drought Monitor							
4	Recent Drought Status Designation for New Mexico							
5	Palmer Drought Severity Indices (PDSI)							
6	Arizona Reservior Levels							
7	New Mexico Reservior Levels							
	Forecasts							
8	Monthly and 3-Month Temperature							
9	Multi-season Temperature							
10	Monthly and 3-Month Precipitation							
11	Multi-season Precipitation							
12	PDSI Forecast and U.S. Seasonal Drought Outlook							
13	National Wildland Fire Outlook							
14	U.S. Hazards Assessment							
15	Tropical Pacific SST Forecast and El Niño Forecasts							
	Focus on El Niño, Drought, and Tropical Storms							
16	AZ and NM Typical vs. Actual Accumulated Aug Precip							
17	Precip Required to End or Ameliorate Drought by 12/30/2002							
18	September El Niño Temperature and Precipitation Impacts							
19	Tropical Storms, El Niño, and the Southwest							

END InSight



CLIMAS El Niño-Drought Initiative

Information Packet #2
August 2002

Climate Assessment for the Southwest
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TABLE OF CONTENTS

Section A

BACKGROUND

Executive Summary, August 2002

Summer monsoon conditions have provided much-needed precipitation for the region, despite the majority of the precipitation thus far occurring chiefly in southeastern Arizona and western New Mexico. Monsoon moisture and increased humidity have reduced fire danger for most of the region. However, many of the areas experiencing the most extreme drought, for example northern Arizona and New Mexico, have not received substantial monsoon precipitation. Within areas of extreme drought, range conditions continue to degrade, and many localities have imposed water use restrictions.

Long-term climate outlooks indicate an increased likelihood of above-average temperatures for portions of the region in the coming months. However, increased probabilities of above-average precipitation are not likely to occur until as far off as December. Thus, severe drought will likely continue to grip the Southwest. With the exception of southern New Mexico, forecasts indicate there is less than a 30% chance of drought amelioration during the next 5 months in the region, and less than 10% chance of ending drought conditions entirely.

Forecasters now indicate that the early stages of a weak-to-moderate El Niño event have developed. The El Niño is expected to persist through the remainder of 2002 and into early 2003. Based on instrumental records, the majority of El Niño events have brought greater than average precipitation to Arizona and New Mexico; thus, forecasts show a slight increase in the likelihood of above-average precipitation by the turn of the year. However, Southwest winter precipitation during El Niño years is highly variable, and weak El Niño events during the past 50 years have sometimes resulted in lower than average winter precipitation in our region.

News from the CLIMAS El Niño-Drought Initiative

END InSight

August 2002

THE UNIVERSITY OF ARIZONA

Monsoon brings relief, but not likely to end drought conditions

By Melanie Lenart & Rebecca Carter

Everyone knows that the monsoon can spell relief for parched plants and Southwesterners weary of the sun's incessant glare. But just how likely is it that this year's monsoon will break the current drought that grips much of Arizona and New Mexico?

Not very likely, any way you look at it. Using Tucson as an example, rainfall records from 1895-2001 show that drought occurred in 17 of those years; but in only four was the monsoon sufficient to break the drought, according to Andrew Comrie, a University of Arizona climatologist and geography professor involved in the END Insight Initiative.

Comrie stated that the Tucson area would need 9 to 12 inches of precipitation over the three-month monsoon period to break the current drought, compared to an average of 6 to 7 inches during the season. NOAA has given the likelihood of sufficient rain falling to end the drought only a 2 or 3% chance.

It is far more likely that enough rain will fall to at least ease the current drought situation, if not totally eradicate it. Comrie believes that there is a 15 to 20% chance that enough rain will fall to bring parts of the region out of severe drought (measured at –4 on the Palmer Drought Severity Index) up to –2, or moderate drought conditions. Significant improvements have already been noted in southeastern Arizona and western New Mexico.

Predicting the strength of a monsoon season, however, challenges climatologists because of the many complexities involved. Various researchers have found evidence that summer rainfall correlates to a number of factors, including snowpack and changes over the Pacific Ocean. But climatologists are still working out the details of this intriguing system.

Researchers are also challenged to better forecast which locations will benefit from the monsoon's spotty storms, which can leave some places lush and green from abundant rainfall, while neighboring areas remain dry and brown when the rain misses them. Although some localized areas do seem to recurrently receive higher rainfall amounts, these areas can shift over time. Precisely why this happens is not fully understood; nor can it be forecast with a high degree of certainty.

The term "monsoon" describes the change in wind direction that occurs near the beginning of summer, bringing with it the clouds that played hooky during spring.

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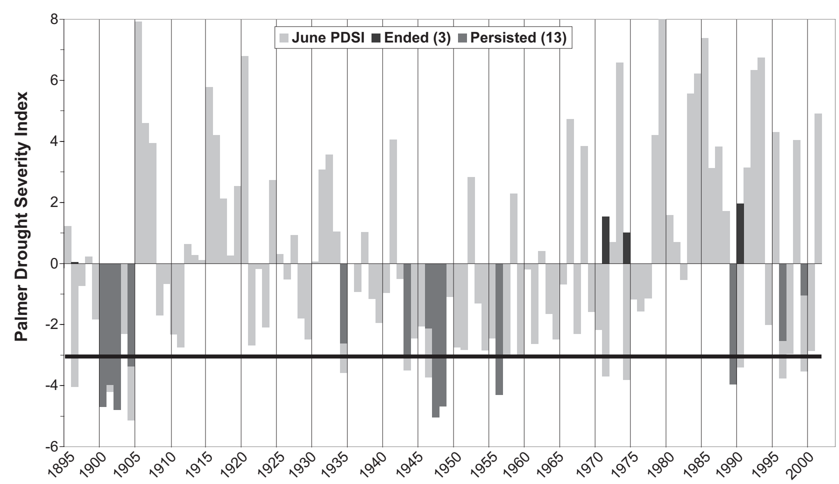

Does the monsoon end drought? Southeastern Arizona experienced 17 years of severe drought from 1895-2001 (indicated by PDSI below -3 for month of June). Monsoon rains ended drought conditions (indicated by PDSI > -0.5 for September) in only four of those years. Source: National Climatic Data Center.

Monsoon, continued

The winds of change tend to bring rain around July 3 to the southern New Mexico and around July 6 to southern Arizona, give or take about two weeks. Monsoon conditions then migrate north over the ensuing week or so.

It's no coincidence that the arrival of the North American monsoon comes on the tail end of the hot, dry spring. As with the much stronger Asian monsoon that graces and sometimes floods India, the change in wind direction is driven by the heating of the land.

Hot air rises off the heated land, causing nearby air to rush in to fill the void. In much the same way a stiflingly hot morning sets the stage for a midday updraft, the seasonally heated land surface draws in the raw material of sea breezes. This coastal air is filled with moisture evaporated from the nearest seas. The Gulfs of Mexico and California fuel the North American monsoon, with some backup from the Pacific Ocean.

According to David Gutzler, a climate researcher at the University of New Mexico in Alburquerque, the strength of the North American monsoon can be related to snowpack on nearby mountaintops. However, the relationship holds better for New Mexico than for Arizona. In an analysis published in the *Journal of Climate* (Volume 13, page 4018), he found that April 1 snowpack at four key Southwestern stations explained about 61% of New Mexico's summer rainfall variation and about 30% of Arizona's summer rainfall variation for the period 1961-1990.

"Our speculation was that if there is a snowpack effect, it seemed plausible that land surface forcing (i.e., heating) might affect New Mexico more than Arizona simply because we're farther from monsoon moisture sources," said Gutzler.

"Snowpack was really low this year in the parts of the Rockies that we've looked at that show this correlation," he pointed out. Similarly, Arizona snowpack was only about 25% of the usual amount.

Although this type of empirical study cannot confirm a cause-effect relationship, he notes that the correlation fits the expectation that snowmelt would temper the heating of the land, thus leading to a weaker monsoon. The reverse also holds, which appears so far to be good news for the Southwest this summer.

However, for reasons that remain mostly unexplained at this point, the dry winter / wet summer relationship falls apart somewhat when other periods are considered, such as 1951-60 and 1991-95. In some cases, snowfall events after April 1 appear to have tipped the scale. Tropical storms can also influence summer rainfall totals in ways that don't necessarily relate to the monsoon itself.

Gutzler and others continue to examine the influence of Pacific Ocean sea surface temperatures on Southwest precipitation. Two factors that come into play are the tropical Pacific Ocean changes that fluctuate year-to-year with the phase of El Niño, and slower changes in the North Pacific Ocean that influence climate on 15-30 year time scales. The 15-30 year variability in the North Pacific seems to have an effect on short-term wintertime atmospheric connections between the Pacific and the North American continent (the so-called "Pacific / North American (PNA) teleconnection," a circulation pattern that plays out in the atmosphere somewhere between 2-4 miles above the earth). Atmospheric variations associated with these long-term changes in the North Pacific Ocean also seem to be connected to multi-year precipitation variations across the Southwest in the 20th century, such as the severe long-term drought in the 1950s.

Gutzler suspects the rather weak correlation he found for El Niño and summer rainfall occurs because El Niño tends to increase winter precipitation in the Southwest. The heavier snowfall then goes on to weaken the monsoon. Similarly, he believes that the positive phase of the PNA teleconnection pattern that heralds wet summers in Arizona again relates to snowfall, because his work with others has correlated a positive PNA index with low snowpack.

If monsoon strength were only dependent on snowfall, the Southwest could be in good shape for the ongoing season. However, a long-term drought would have a tendency to weaken the North American monsoon, albeit spottily. For instance, during the 1950s drought, monsoonal rains were in short supply in Las Cruces, New Mexico, but not in Tucson (*Journal of Climate,* Volume 11, page 3130).

All in all, it seems Southwesterners can hope for some temporary relief from the ongoing drought. At the very least, the monsoon promises to provide cloud cover that will slow the evaporative drain of water from the landscape. At best, it can replenish soil moisture in some local areas, giving vegetation a fighting chance in the potentially dry months to come.

Tropical Storm Impacts on Arizona and New Mexico

By Rebecca Carter

Once the drama that monsoon storms can bring to Arizona and New Mexico subsides toward the end of August, it may seem like time to breathe a sigh of relief and look forward to calmer autumn weather. However, fall can also be a time of dramatic and sometimes dangerous weather, due largely to tropical storms. Actually, tropical storms can feed into monsoonal moisture flows and contribute to copious rainfall totals.

Some of the most severe weather-related events recorded in Arizona have been caused by tropical storms, more than can be attributed to either the monsoon or drought. When the National Weather Service's Phoenix office put together a listing of Arizona's top ten weather / water / climate events for the 20th century, flooding due to tropical storms caused three of the ten most costly weather events in terms of impacts on people, property, and the economy and also was cited in four of the eleven honorable mentions.

The deadliest natural disaster in Arizona's history was a tropical storm that resulted in 23 deaths. According to National Weather Service offices in Arizona, heavy rains were spawned by an influx of moisture from a dying Pacific tropical storm named Norma over Labor Day weekend of 1970. During the 24-hour period from 10 p.m. September 4th to 10 p.m. September 5th, 11.4 inches of rain were measured in the official recording rain gauge at Workman Creek, about 60 miles east-northeast of Phoenix at an elevation of 7,000 feet. Of the 23 lives lost in the flooding, 14 were in campground areas at the headwaters of the Tonto Creek drainage. Most of the deaths occurred as people attempted to leave the campgrounds for home. Some rivers rose 5 to 10 feet per hour, with Sycamore Creek, near Sunflower, experiencing floodwaters that reached 36 feet above the creek bed.

The tropical storms that affect Arizona are often the remains of hurricanes that form in the eastern Pacific Ocean. Although the official hurricane season begins May 15 in the eastern and central Pacific basins, June through October are the most active months for tropical storm formation. Data from 1961-2000 show that the storms peak in frequency in August, with an average of 3.8 storms, while July and September each average 3.7 storms. During a typical hurricane season, 16 named storms form in the eastern Pacific, 9 of which become hurricanes, and 5 of those become major hurricanes.

While most tropical storms fall apart as they make landfall, some do possess enough power to make it into Arizona and eastern New Mexico. In fact, Erik Pytlak of the Tucson National Weather Service Office calculated that Arizona can expect a direct hit from a named tropical storm, including heavy rainfall, every 4.5 years and that a storm will affect the state indirectly every two years. That means that Arizona is more frequently affected by tropical storms than some coastal states such as New Jersey!

Tropical storms that are likely to affect Arizona are those that make landfall along the Pacific coast of Baja California and travel northeasterly into the state, often coming across the border with southern California and most strongly impacting the western portions of Arizona.

New Mexico is less likely to be affected by tropical storms, but may still experience some minor impacts. On rare occasions, tropical storms moving inland from the Gulf of California will cause heavy rains in the southwestern part of the state, according to the Western Regional Climate Center. Interestingly, the eastern and central parts of the state also may be affected by tropical storms, but by those spawned in the Atlantic, rather than in the eastern North Pacific.

Flooding is by far the greatest threat that tropical storms pose to Arizona and New Mexico. However, high winds also can be a danger, although this aspect of tropical storms has been much less studied. Although the lower elevation winds that accompany such storms may dissipate by the time the storm reaches Arizona or New Mexico, these gusts can still be quite well organized at higher altitudes, particularly those over 7,000 feet. Tropical storms in general are likely to cause greater amounts of property damage and other losses as populations grow in the Southwest.

ENSO conditions such as El Niño or La Niña can affect the year-to-year levels of vertical wind shear over both the North Atlantic and eastern North Pacific. During an El Niño, vertical wind shear increases, which suppresses the ability of hurricanes to form. This effect is particularly pronounced in the North Atlantic, where research indicates that during El Niño years the likelihood of hurricanes is de-

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Tropical Storms, continued

creased and during La Niña years the likelihood of Atlantic hurricanes is increased. For example, El Niño-like conditions from 1991 to early 1995 were accompanied by very little Atlantic tropical storm and hurricane activity. However, the La Niña years of 1995 and 1996 showed increased tropical storm activity in the North Atlantic, but reduced the number of storms over the eastern North Pacific.

During strong El Niños, such as 1997-98, the eastern North Pacific recorded close to an average number of storms at 17, but the storms were more intense than usual. Hurricane Linda reached unprecedented sustained winds of 185 mph, and Hurricane Guillermo followed close behind at 162 mph. This was also the year that Hurricane Pauline devastated Acapulco, leaving 232 dead and hundreds of thousands homeless.

El Niño also may affect the usual track of tropical storms: in 1997, Hurricane Nora was one of two storms that tracked well north of their normal area. Although the storm did not follow its expected path and weakened considerably upon landfall, rainfall amounts of three to five inches were recorded in western Arizona. Nora caused a loss to agriculture estimated at several hundred million dollars and left about 12,000 people without electricity in Yuma, according to the NWS Tropical Prediction Center.

The North Atlantic, on the other hand, experienced only seven storms in 1997, compared to its average of 10; of those, three became hurricanes, as opposed to an average of six. This year, NOAA's Climate Prediction Center does not expect the current weak El Niño to have much of an effect on tropical storm activity in the North Atlantic. Similar comprehensive forecasts for the eastern North Pacific are not available, which reflects a long-standing lack of attention to tropical storms in this area.

El Niño and La Niña Impacts on Tropical Storm Activity

	La Niña	La Niña	La Niña
Duration (# days)	6.1 / 5.0	6.5 / 6.0	7.1 / 6.0
# Storms	15.1 / 17.0	15.2 / 16.0	15.6 / 15.0
# Fall Storms	4.5 / 4.0	5.4 / 5.0	6.2 / 6.0

Note: # of years – La Niña = 9; Neither =18; and El Niño = 13, for 1961-1990. Average values are to the left of the slash and median values are to the right of the slash.

Gregg Garfin of the END Initiative has attempted to provide some answers to what this tropical storm season may bring to Arizona and New Mexico. Garfin examined climatological records from 1961-2000 and found that the overall number of tropical storms is not any greater during El Niño years than during other years.

The National Weather Service Tucson office also found no clear link between El Niño and tropical storm impacts in Arizona. Forecasters reviewed tropical storm records from 1965 to the present and found that of the nine direct hits that Arizona has received, three occurred during El Niño events, three happened during La Niña conditions, and three took place during neutral years.

However, Garfin found that the duration of tropical storms during El Niño years is greater than the duration of storms during La Niña years. He also found that the number of *fall* storms (September-November) is greater during El Niño years.

Garfin identified four strong El Niño events, and four weak ones, based on their intensity during the start of the tropical storm season. He found that during strong El Niño events, tropical storms tend to be longer (7.6 days) and stronger, with a slight tendency toward greater than average frequency (16.5). In contrast, during weak El Niños, such as the one currently occurring, Garfin found that tropical storms tend to be shorter than average length (5.6 days), fewer in frequency (10.2), and weaker.

Regardless of whether or not there is a clear El Niño influence on tropical storms, there is no doubt that these weather systems can have major impacts on drought. For example, the remnants of Tropical Storm Olivia brought 3 to 5 inches of rain to southeastern Arizona and southwestern New Mexico around October 11 and 12, 2000, according to the U.S. Drought Monitor archives. This ended abnormally dry conditions in the area that had begun the previous December in parts of the states and provided these areas with a buffer in terms of soil moisture and water supply that some climatologists say protected the area for over a year from widespread drought conditions.

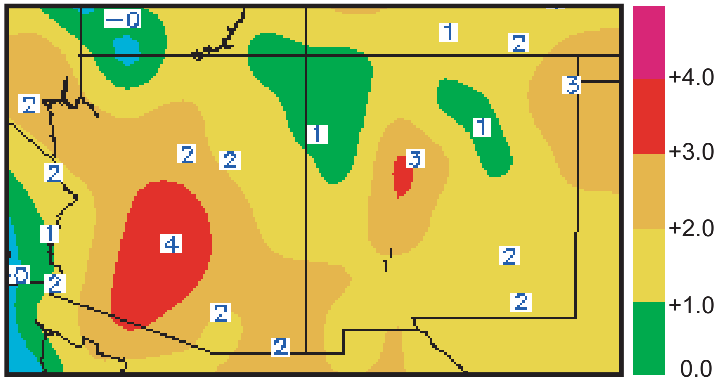
Thus, using the past as a guide to the future, we might reasonably expect that Arizona will see a fairly quiet tropical storm season, despite the presence of an El Niño. However, as you've heard before, no two El Niños are alike—so stay tuned!

Section B

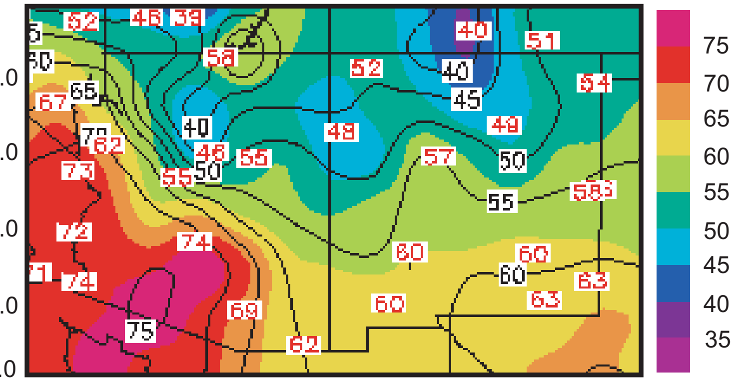
RECENT CONDITIONS

1. Recent Conditions: Temperature (up to 8/14/02) (Source: Western Regional Climate Center)

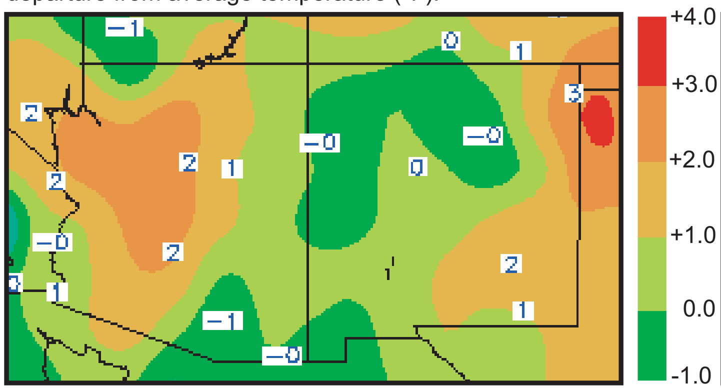
1a. Water year '01-'02 (through 8/14)
departure from average temperature (°F).



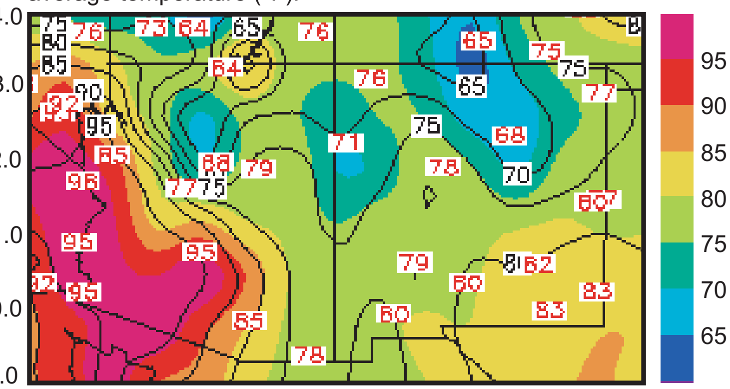
1b. Water year '01-'02 (through 8/14)
average temperature (°F).



1c. Previous 28-days (7/17 - 8/14)
departure from average temperature (°F).



1d. Previous 28-days (7/17 - 8/14)
average temperature (°F).



Notes:

The Water Year begins on October 1 and ends on September 30 of the following year.

'Average' refers to arithmetic mean of annual data from 1971-2000.

The data are in degrees Fahrenheit (°F).

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

These maps are derived by taking measurements at meteorological stations (at airports) and estimating a continuous map surface based on the values of the measurements and a mathematical algorithm. This process of estimation is also called spatial interpolation.

The red and blue numbers shown on the maps represent individual stations. The contour lines and black numbers show average temperatures.

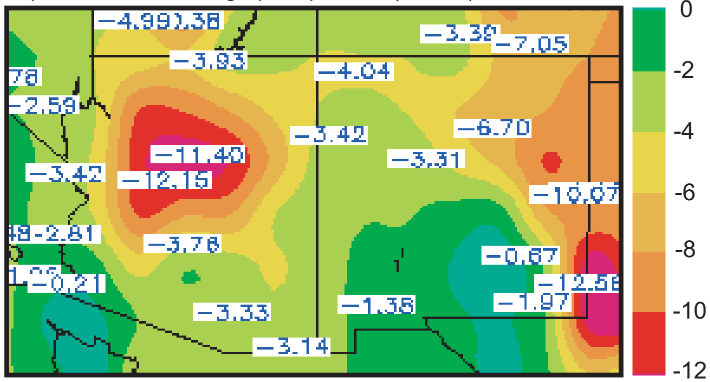
Highlights: Since October 1, 2001, temperatures have been above average throughout our region (Figures 1a-b). Albuquerque, NM, which has an average annual temperature of 57°F, is already at 57°F for the water year, and we still have the remainder of August and September to account for! In the past 28 days, most of our region has recorded near average temperatures, with both slightly above and below temperatures (Figures 1c-d). An active monsoon pattern has produced significant cloud cover and precipitation for southeast Arizona and eastern central New Mexico, contributing to slightly below average temperatures in those areas.

For these and other maps, visit: http://www.wrcc.dri.edu/recent_climate.html

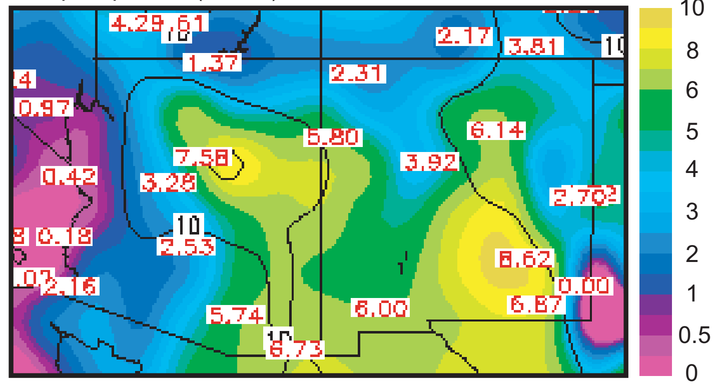
For information on temperature and precipitation trends, visit: http://www.cpc.ncep.noaa.gov/trndtext.htm

2. Recent Conditions: Precipitation (up to 8/14/02) (Source: Western Regional Climate Center)

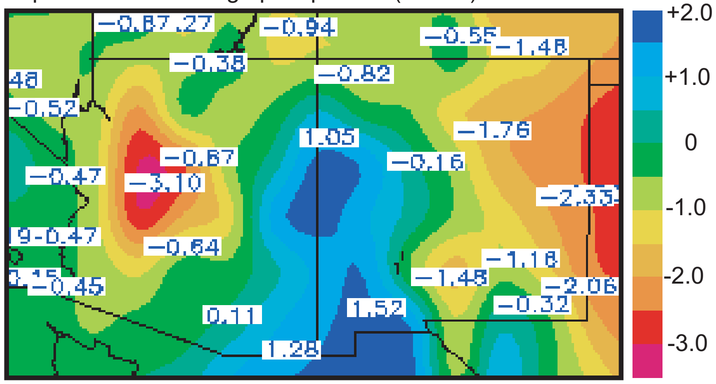
2a. Water year '01-'02 (through 8/14)
departure from average precipitation (inches).



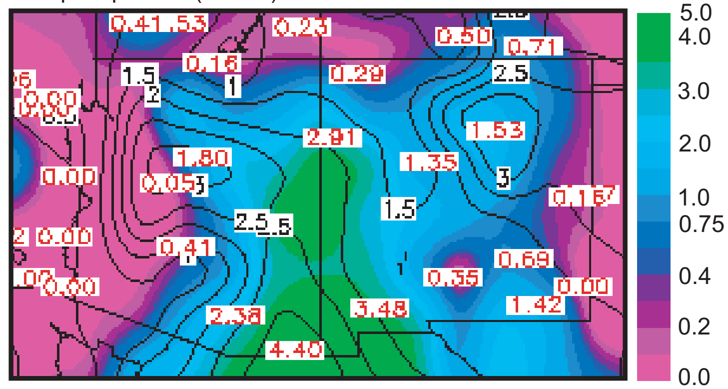
2b. Water year '01-'02 (through 8/14)
total precipitation (inches).



2c. Previous 28-days (7/17 - 8/14)
departure from average precipitation (inches).



2d. Previous 28-days (7/17 - 8/14)
total precipitation (inches).



Notes:

The Water Year begins on October 1 and ends on September 30 of the following year.

'Average' refers to the arithmetic mean of annual data from 1971-2000.

The data are in inches of precipitation. Note: The scale for Figure 2d is non-linear.

Departure from average precipitation is calculated by subtracting current data from the average and can be positive or negative.

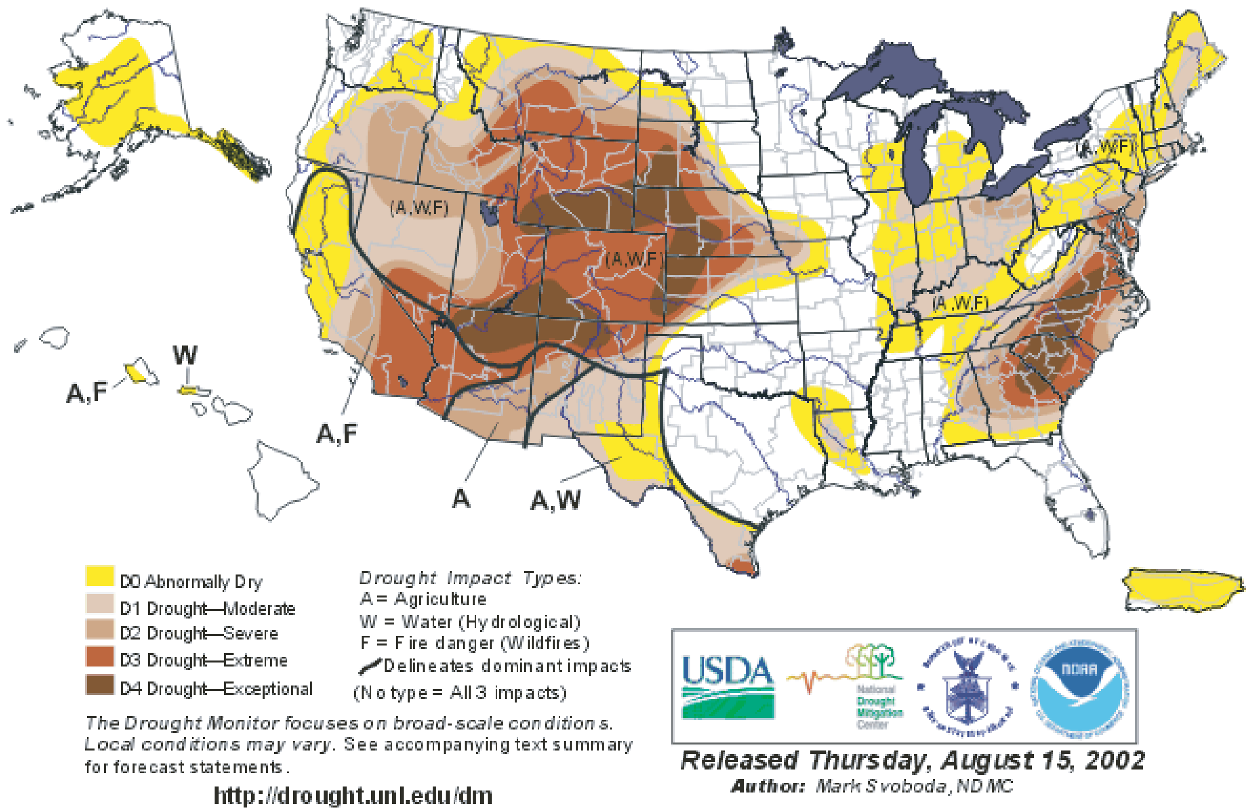
These maps are derived by taking measurements at meteorological stations (at airports) and estimating a continuous map surface based on the values of the measurements and a mathematical algorithm. This process of estimation is also called spatial interpolation.

The red and blue numbers shown on the maps represent individual stations. The contour lines and black numbers show average temperatures.

Highlights: For most of our region, precipitation has been far below average since the beginning of the water year. For example, Flagstaff AZ, which receives about 23" of precipitation each year on average, has a current precipitation deficit of over 11" (Figures 2a-b). During the most recent 28 days (Figures 2c-d), summer rainfall has brought some relief to parts of our region, in particular eastern New Mexico and southwestern Arizona. Central northern Arizona and eastern New Mexico have received far less precipitation in the last 28 days compared to average (Figures 2c-d) and continue to exhibit extremely dry conditions.

For these and other maps, visit: http://www.wrcc.dri.edu/recent_climate.html

3. U.S. Drought Monitor (8/13/02)



Notes:

The U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. This monitor was released on 8/15 and is based on data collected through 8/13 (as indicated in the title).

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

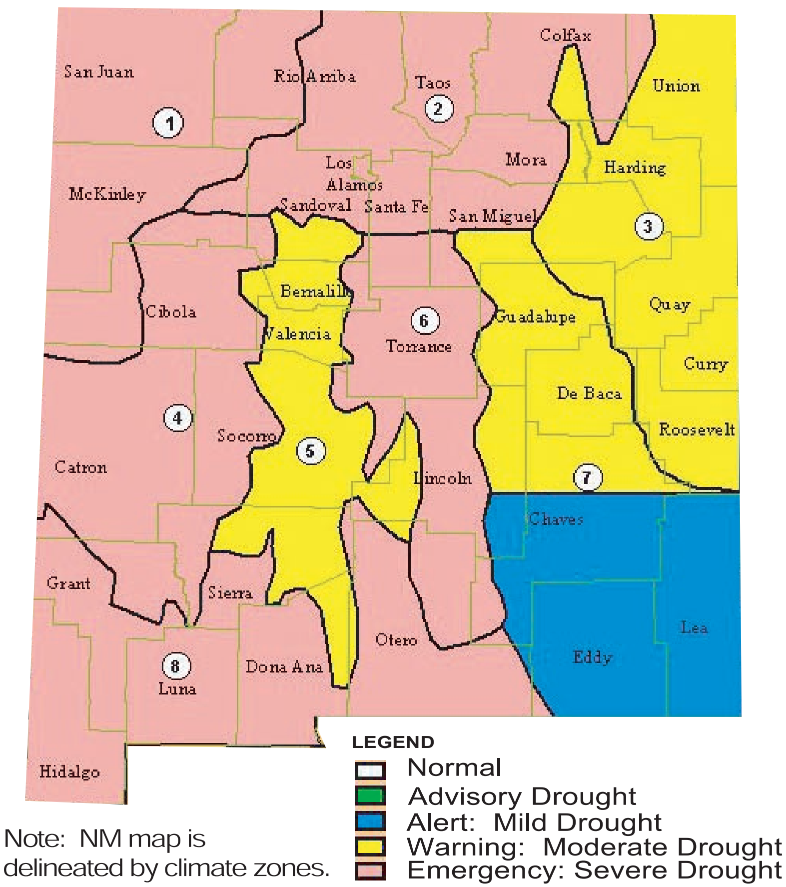
The U.S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) PDSI, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts.

Highlights: Despite an increasing proportion of the United States. experiencing drought conditions, monsoon precipitation in the Southwest has provided relief for southern portions of Arizona and New Mexico, as the drought classifications for these areas has been downgraded over the last month. However, drought relief in southeastern Arizona has been spotty, with excellent rainfall and *green-up* for some localities and below average rainfall and just a hint of green-up within just a few miles. Northern Arizona and much of New Mexico continue to experience exceptional drought (the most extreme Drought Monitor rating) as monsoon conditions have yet to produce significant precipitation in those areas. Range conditions in New Mexico continued to decline, with 71% of rangelands in poor or very poor condition. News and agricultural reports from media sources in Arizona and New Mexico indicate continued drought impacts on reservoirs and lakes, wildlife, power generation, and livestock.

4. Drought: Recent Drought Status Designation for New Mexico

New Mexico Drought Map

Drought Status as of August 8, 2002

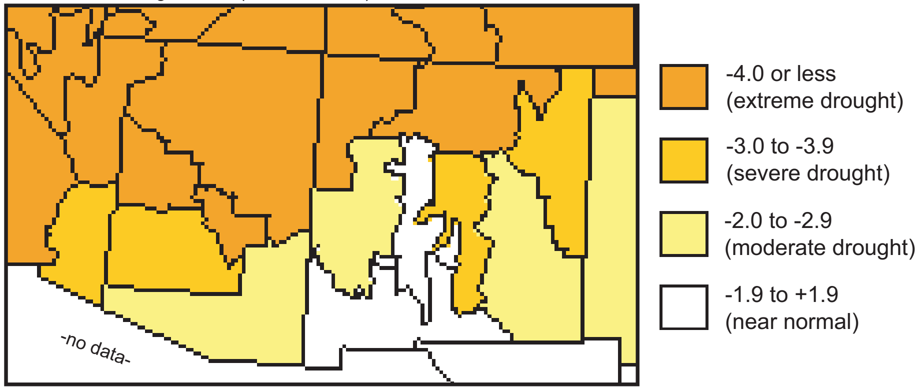


Source: NM Natural Resources Conservation Service (2002)

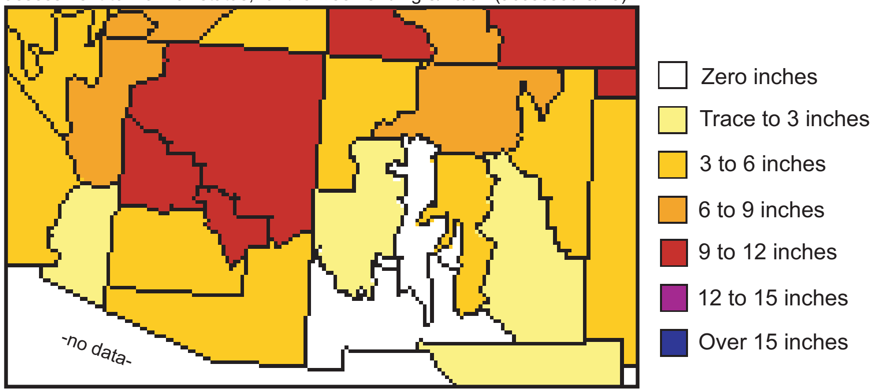
Notes: The New Mexico drought map is produced by the New Mexico Natural Resource Conservation Service (NMNRCS) and was updated on August 8, 2002. We were unable to determine if the Arizona Division of Emergency Management (ADEM) had updated the Arizona drought map from the most recent one obtained (May 31, 2002) and, therefore, the Arizona map was not included. The ADEM map can be obtained by contacting Matt Parks at ADEM at (602) 392-7510. The New Mexico map currently is produced monthly but when near normal conditions exist it is updated quarterly. It can be accessed at the NMNRCS website (http://www.nm.nrcs.usda.gov/snow/Default.htm). The Arizona drought declaration map, a recent product of the ADEM, is not yet produced on a regular basis.

5. PDSI Measures of Recent Conditions (through 8/15/02)
(Source: NOAA Climate Prediction Center)

5a. Current weekly Palmer Drought Severity Index (PDSI), for the week ending 8/10/02 (accessed 8/15).



5b. Precipitation (inches) needed to bring current weekly PDSI assessment to 'normal' status, for the week ending 8/10/02 (accessed 8/15).



Notes:
The PDSI (Palmer Drought Severity Index) attempts to measure the duration and intensity of long-term conditions that underlie drought.

'Normal' on the PDSI scale refers to moisture levels based on long-term climatological expectations.

Arizona and New Mexico are divided into *climate divisions*. Climate data are aggregated and averaged for each division within each state. Note how climate division boundaries stop at state borders.

These maps are issued weekly by the NOAA CPC.

Highlights: Figure 5a shows that recent soil moisture conditions indicate drought for most of our region. Over the last month, PDSI values for southeast Arizona and southwest New Mexico have moved towards more normal levels, but those areas remain dry and subject to improvement, which varies greatly over small regions. PDSI values for northern Arizona and New Mexico remain in the *extreme drought* category (see legend), unchanged from a month ago. Figure 5b shows that most of our region would require an extraordinary amount of precipitation to bring our drought status back to *normal* within one week. Only southwest New Mexico and the Rio Grande valley can be considered near normal for this time of year. Much of northern Arizona would require over 10" of rain in the next week to reach normal PDSI values!

For a more technical description of PDSI, visit: http://www.cpc.noaa.gov/products/analysis_monitoring/cdus/palmer_drought/ppdanote.html

For information on drought termination and amelioration, visit: http://lwf.ncdc.noaa.gov/oa/climate/research/drought/background.html

6. Arizona Reservoir Levels (through end of July 2002) (Source: USDA NRCS)

	Current Storage*	Last Year Storage*	Average Storage*	Basin/ Reservoir Capacity*	Current as % of Capacity	Last Year as % of Capacity	Average as % of Capacity	Current as % of Average	Current as % of Last Year
Salt River Basin System	551	851	1187	2335	24	36	51	46	65
Verde River Basin System	74	156	145	310	24	50	47	51	47
San Francisco - Upper Gila River Basin									
San Carlos	49	142	352	875	6	16	40	14	35
Painted Rock Dam	0	0	34	2492	0	0	1	0	—
Total of 2 Reservoirs	49	142	386	3367	1	4	11	13	35
Little Colorado River Basin									
Lyman Reservoir	2	7	13	30	6	22	45	13	28
Show Low Lake	2	3	3	5	43	65	51	85	67
Total of 2 Reservoirs	4	10	16	35	11	28	46	25	41
Northwestern Arizona									
Lake Havasu	561	576	586	619	91	93	95	96	97
Lake Mohave	1695	1657	1567	1810	94	92	87	108	102
Lake Mead	17343	20245	21647	26159	66	77	83	80	86
Lake Powell	15333	19764	20749	24322	63	81	85	74	78
Total of 4 Reservoirs	34933	42242	44548	52910	66	80	84	78	83

* units are in thousands of acre-feet

Notes: Reservoir reports are updated monthly and are provided by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service. Reports can be accessed at their website (http://www.wcc.nrcs.usda.gov/water/reservoir/resv_rpt.html). Arizona's report was updated through the end of July as of 8/14/02.

Highlights: All basins are below average levels. The Salt and Verde systems are exceedingly low, which has prompted the Salt River Project to reduce water deliveries by one-third next year. In order to promote water conservation, the sandstone water fountain in front of Phoenix City Hall was recently shut down. Northwestern Arizona levels along the Colorado River still are mostly below average. Should drought conditions persist, communities and others reliant on water from these sources may be faced with challenging management decisions.

7. New Mexico Reservoir Levels (through end of July 2002) (Source: USDA NRCS)

	Current Storage*	Last Year Storage*	Average Storage*	Basin/ Reservoir Capacity*	Current as % of Capacity	Last Year as % of Capacity	Average as % of Capacity	Current as % of Average	Current as % of Last Year
Canadian River Basin (Conchas Reservoir)	22	87	186	254	8	34	73	12	25
Pecos River Basin									
Lake Avalon	1	1	1	6	13	20	20	67	67
Brantley	11	16	22	148	7	11	15	49	68
Santa Rosa	1	4	59	447	0	1	13	2	26
Sumner	1	3	27	102	1	3	27	5	50
Total of 4 Reservoirs	14	24	110	703	2	3	16	13	59
Rio Grande Basin									
Abiquiu	90	132	138	555	16	24	25	65	68
Caballo	41	63	103	332	12	19	31	39	65
Cochiti	50	49	65	502	10	10	13	77	102
Costilla	1	7	6	16	7	43	38	18	16
El Vado	23	165	129	186	12	89	69	18	14
Elephant Butte	444	952	1251	2065	22	46	61	36	47
Heron	184	337	320	400	46	84	80	58	55
Total of 7 Reservoirs	833	1705	2012	4056	21	42	50	41	49
San Juan River Basin (Navajo Reservoir)	1007	1457	1412	1696	59	86	83	71	69

*units are in thousands of acre-feet

Notes: Reservoir reports are updated monthly and are provided by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service. Reports can be accessed at their website (http://www.wcc.nrcs.usda.gov/water/reservoir/resv_rpt.html). New Mexico's report was updated through the end of July as of 8/14/02.

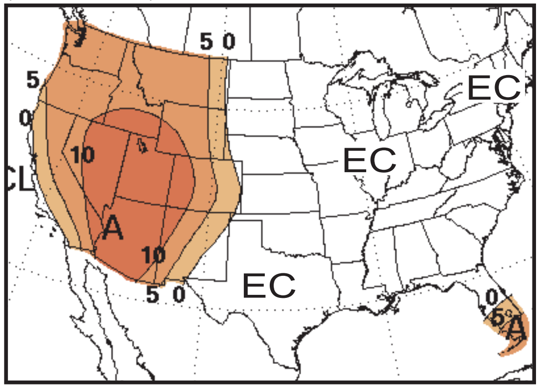
Highlights: All three basins are at very low levels, with roughly two-thirds of average levels for this time of year. The Pecos river basin is surprisingly low. While not representing a significant storage of water, current levels at the four Pecos Basin reservoirs are at only 2% of capacity and only 13% of average for this time of year. On August 8, 2002, the city of Farmington, NM declared a *water advisory* and asked residents to voluntarily curb water use.

Section C

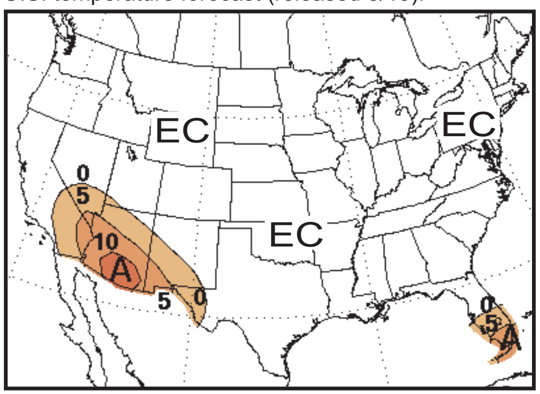
FORECASTS

8. Temperature: Monthly (Sep.) and 3-Month (Sep.-Nov. 2002) Outlooks (Source: NOAA CPC)

8a. September 2002 U.S. temperature forecast (released 8/15).



8b. September - November 2002 U.S. temperature forecast (released 8/15).



Percent Likelihood of Above Average Temperatures*

- 40% - 50%
- 30% - 40%
- 20% - 30%
- 10% - 20%
- 5% - 10%
- 0% - 5%

*EC indicates no forecast due to lack of model skill

Highlights: The CPC temperature outlook for September shows slightly increased probabilities of above average temperatures in our region (especially in Arizona) (Figure 8a). For the next three months (September-November), the outlook indicates increased probabilities of above average temperatures in Arizona and southwestern New Mexico (Figure 8b). For south-central Arizona, the probabilities are as follows: 43.3-53.3% probability of above average, 33.3% probability of average, and 13.3-23.3% probability of below average temperature. These predictions are based chiefly on long-term trends for increased temperature in our region, plus the results of some statistical models. NOAA CPC climate outlooks are released on the Thursday between the 15th and 21st of each month.

For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html
Please note that this website has many graphics and may load slowly on your computer.

Notes:

The NOAA CPC (National Oceanic and Atmospheric Administration Climate Prediction Center) outlooks predict the "excess" likelihood (chance) of above average, average, and below average temperature, but **not** the magnitude of such variation. The numbers on the maps **do not** refer to degrees of temperature.

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

Thus, using the NOAA CPC excess likelihood forecast, in areas with light brown shading (0-5% excess likelihood of above average) there is a 33.3-38.3% chance of above average, a 33.3% chance of average, and a 28.3-33.3% chance of below average temperature.

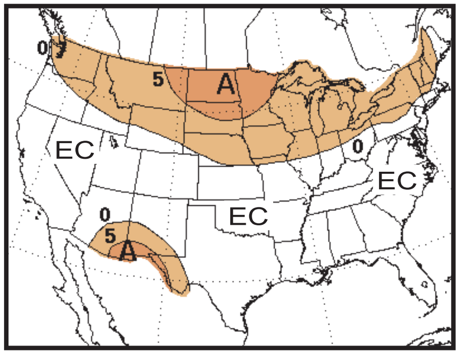
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

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

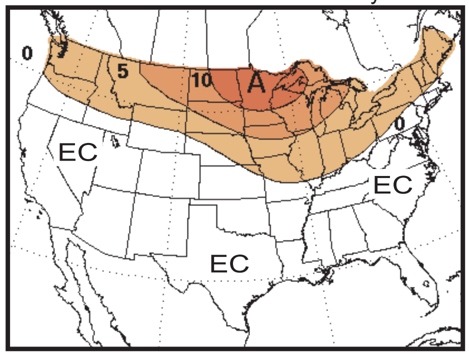
9. Temperature: Multi-season Outlooks (Source: NOAA Climate Prediction Center)

Overlapping 3-month long-lead temperature forecasts (released 8/15/02).

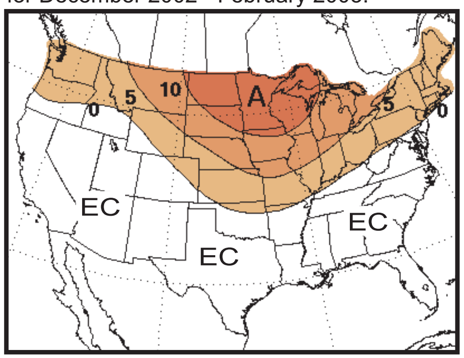
9a. Long-lead national temperature forecast for October - December 2002.



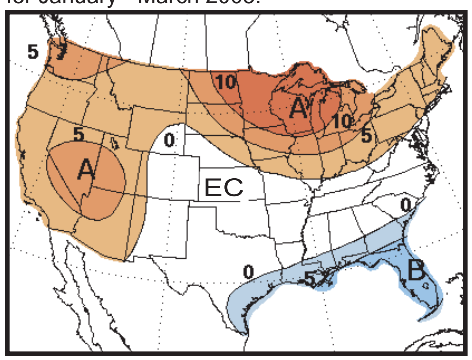
9b. Long-lead national temperature forecast for November 2002 - January 2003.



9c. Long-lead national temperature forecast for December 2002 - February 2003.



9d. Long-lead national temperature forecast for January - March 2003.



Percent Likelihood of Above/ Below Average Temperatures*

10% - 20%
5% - 10%
0% - 5%

0% - 5%
5% - 10%
10% - 20%

*EC indicates no forecast due to lack of model skill

Notes:
The NOAA CPC (National Oceanic and Atmospheric Administration Climate Prediction Center) outlooks predict the "excess" likelihood (chance) of above average, average, and below average temperature, but **not** the magnitude of such variation. The numbers on the maps **do not** refer to degrees of temperature.

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

Thus, using the NOAA CPC excess likelihood forecast, in areas with light brown shading (0-5% excess likelihood of above average) there is a 33.3-38.3% chance of above average, a 33.3% chance of average, and a 28.3-33.3% chance of below average temperature.

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

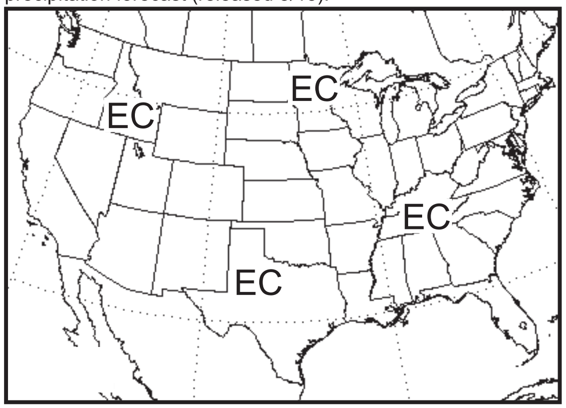
Equal Chances (EC) indicates areas where reliability (i.e., the 'skill') of the forecast is poor and no prediction is offered.

Highlights: The CPC temperature outlooks for October 2002-March 2003 show increased probabilities of above average temperatures in southeastern Arizona and southwestern New Mexico in the fall (October-December) (Figure 9a) and slightly increased probabilities of above average temperatures in Arizona in the winter (January-March 2003) (Figure 9d). No prediction ("Equal Chances") is offered for most of New Mexico during any of the three-month periods and for the region as a whole during November 2002-February 2003 (Figure 9b - c). These predictions are based on a combination of factors, including long-term trends, soil moisture, and moderate El Niño conditions. Long-term trends favor higher probabilities of increased temperatures, but forecasters have balanced this with the tendency for lower than average temperatures in the Southwest during an El Niño event. NOAA CPC climate outlooks are released on the Thursday between the 15th and 21st of each month.

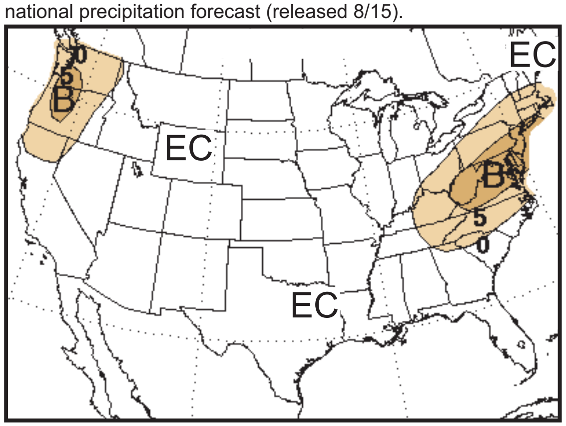
For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html
Please note that this website has many graphics and may load slowly on your computer.

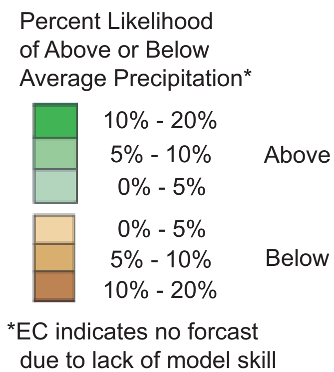
10. Precipitation: Monthly (Sep.) and 3-Month (Sep.-Nov. 2002) Outlooks (Source: NOAA CPC)

10a. September 2002 national precipitation forecast (released 8/15).



10b. September - November 2002 national precipitation forecast (released 8/15).





Highlights: The CPC has reserved judgment (i.e., "Equal Chances") regarding both September and September-November precipitation in Arizona and New Mexico (Figures 10a-b). The lack of forecast certainty during the early fall reflects the complexity of forecasting when many factors must be taken into account. In this case, factors include not only El Niño influences but also tropical storms and shifts in the jet stream track. These forecasts are based on a combination of factors, including the results of statistical models, moderate El Niño conditions, and long-term trends. NOAA CPC climate outlooks are released on the Thursday between the 15th and 21st of each month.

For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html
Please note that this website has many graphics and may load slowly on your computer.

Notes:
The NOAA CPC (National Oceanic and Atmospheric Administration Climate Prediction Center) outlooks predict the "excess" likelihood (chance) of above average, average, and below average precipitation, but **not** the magnitude of such variation. The numbers on the maps **do not** refer to inches of precipitation.

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

Thus, using the NOAA CPC excess likelihood forecast, in areas with light green shading (0-5% excess likelihood of above average) there is a 33.3-38.3% chance of above average, a 33.3% chance of average, and a 28.3-33.3% chance of below average precipitation.

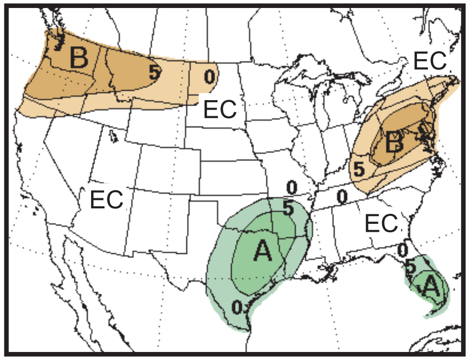
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

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

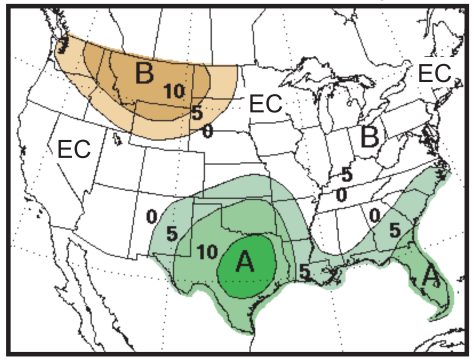
11. Precipitation: Multi-season Outlooks (Source: NOAA Climate Prediction Center)

Overlapping 3-month long-lead precipitation forcasts (released 8/15/02).

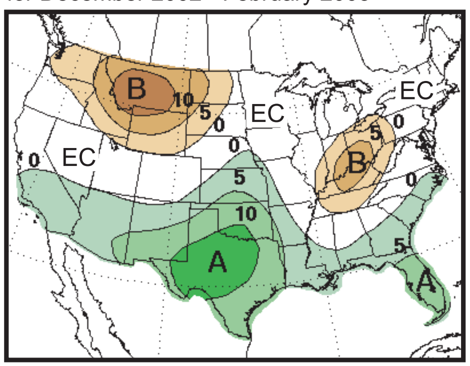
11a. Long-lead national precipitation forecast for October - December 2002.



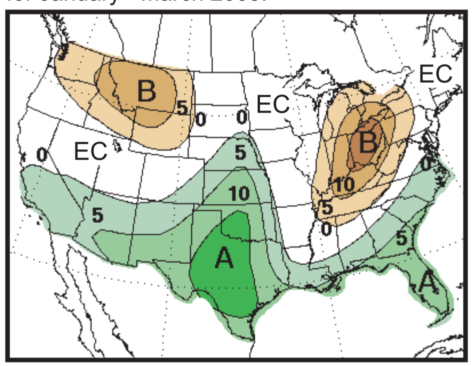
11b. Long-lead national precipitation forecast for November 2002 - January 2003



11c. Long-lead national precipitation forecast for December 2002 - February 2003



11d. Long-lead national precipitation forecast for January - March 2003.



Percent Likelihood of Above or Below Average Precipitation*

Above: 10% - 20%, 5% - 10%, 0% - 5%

Below: 0% - 5%, 5% - 10%, 10% - 20%

*EC indicates no forecast due to lack of model skill

Highlights: No prediction ("Equal Chances") is offered for Arizona and New Mexico for October-December 2002 (Figure 11a). The next three overlapping seasons (November 2002-March 2003) show increased probabilities of above average precipitation in the Southwest (Figures 11b-d). The greatest confidence in these predictions is centered over southern New Mexico. These predictions are based chiefly on the historical tendency for above average precipitation in the Southwest during an El Niño event. However, El Niño-related winter precipitation in the Southwest is highly variable. While many high precipitation winters in the Southwest were during El Niño events, El Niño also has produced below average precipitation in our region. Decision makers are advised to monitor the strength of the El Niño event as it progresses. NOAA CPC climate outlooks are released on the Thursday between the 15th and 21st of each month.
For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html
Please note that this website has many graphics and may load slowly on your computer.

Notes:
The NOAA CPC (National Oceanic and Atmospheric Administration Climate Prediction Center) outlooks predict the "excess" likelihood (chance) of above average, average, and below average precipitation, but **not** the magnitude of such variation. The numbers on the maps **do not** refer to inches of precipitation.

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

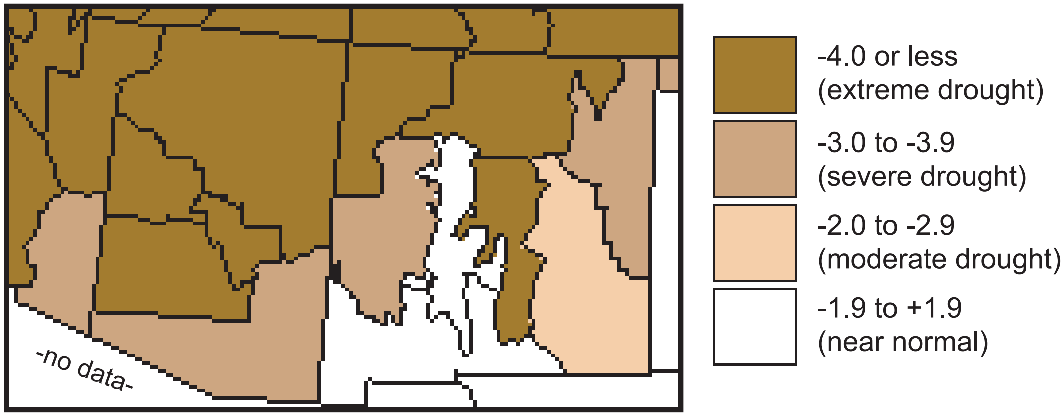
Thus, using the NOAA CPC excess likelihood forecast, in areas with light green shading (0-5% excess likelihood of above average) there is a 33.3-38.3% chance of above average, a 33.3% chance of average, and a 28.3-33.3% chance of below average precipitation.

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

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

12. Drought: PDSI forecast and U.S. Seasonal Drought Outlook (Source: NOAA CPC)

12a. Short-term Palmer Drought Severity Index (PDSI) forecast through 8/17/02 (accessed 8/15).



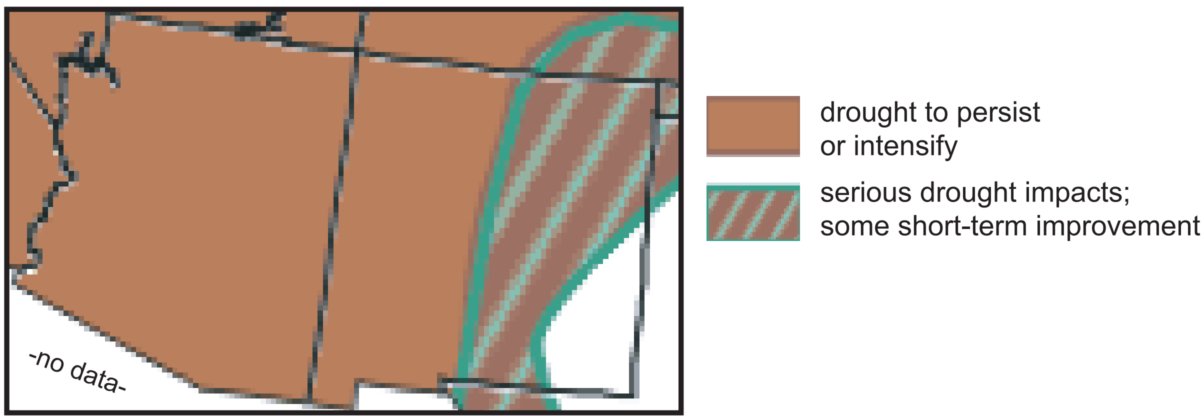
Notes:

The PDSI (Palmer Drought Severity Index) attempts to measure the duration and intensity of the long-term drought.

'Normal' on the PDSI scale is defined as amounts of moisture that reflect long-term climate expectations.

The delineated areas in the Seasonal Drought Outlook are defined subjectively and are based on expert assessment of numerous indicators including outputs of short- and long-term forecast models.

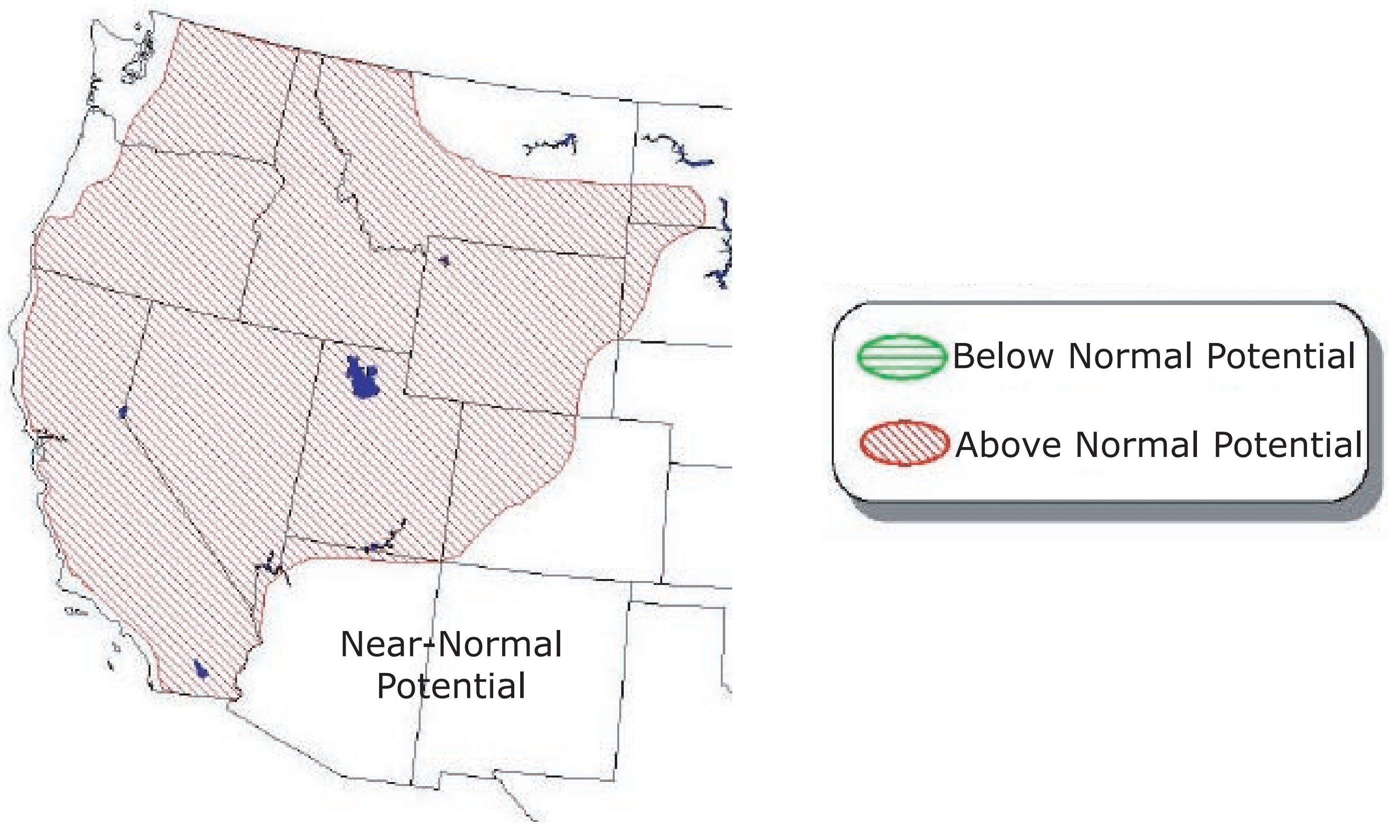
12b. Seasonal drought outlook through November 2002 (released 8/15).



Highlights: The short-term PDSI forecast (Figure 12a) indicates extreme to severe drought conditions for most of Arizona and New Mexico, although southwestern and central New Mexico are at near normal conditions for this time of year. The seasonal drought outlook (Figure 12b) reflects some respite from short-term dryness in eastern New Mexico due to monsoon rainfall. However, drought conditions are forecasted to persist or intensify in most of the Southwest, as the monsoon season comes to an end.

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

13. National Wildland Fire Outlook (valid August 1 – August 31, 2002)
(Source: National Interagency Fire Center)

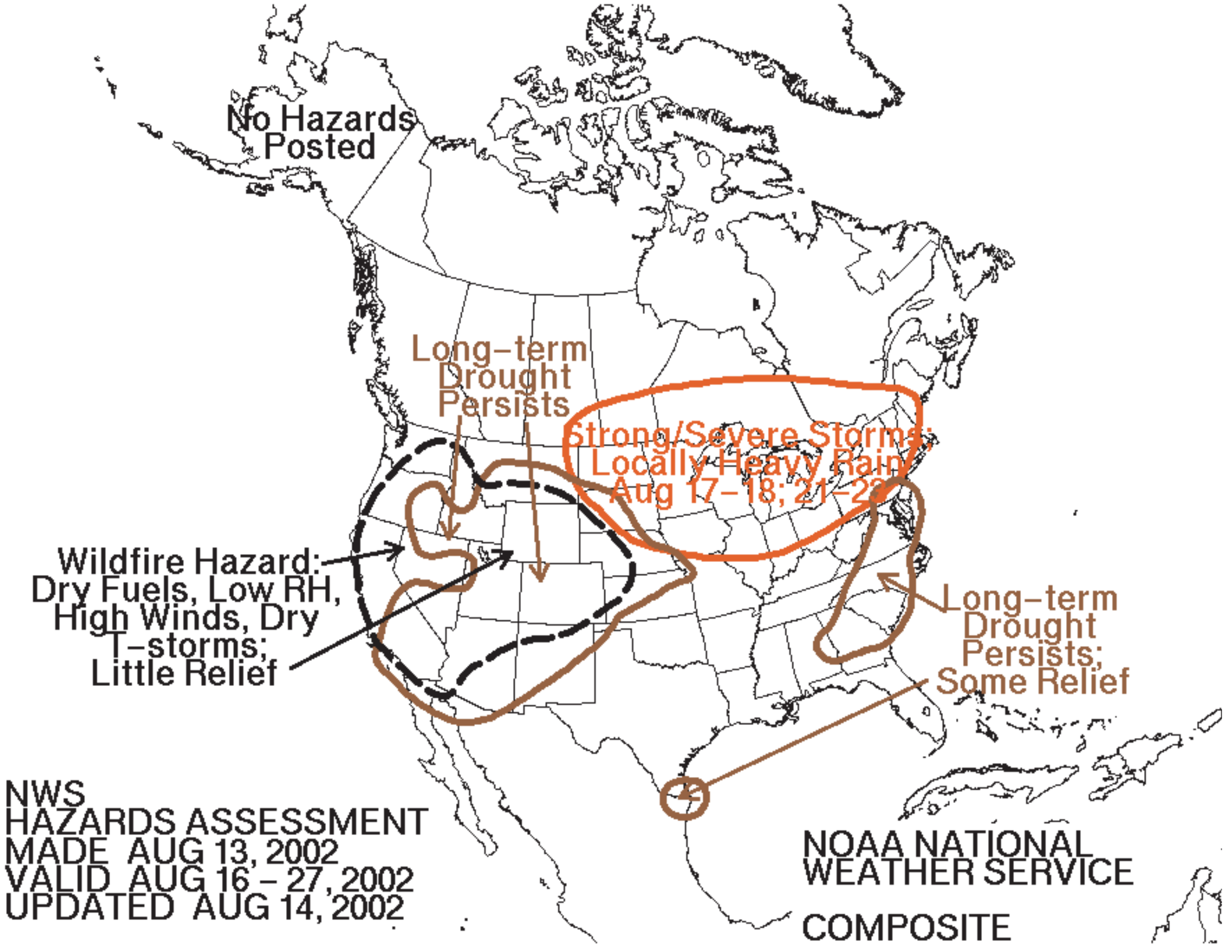


Notes: The National Wildland Fire Outlook (Figure 13) considers climate forecasts and surface fuels conditions to assess fire potentials. It is issued monthly by the National Interagency Fire Center.

Highlights: The high fire danger exhibited in the Southwest during the early summer months has diminished due to summer precipitation and increased humidity. However, regional sources indicate that dry conditions in the northern part of our region might soon cause reinstatement of fire restrictions. To date 941,688 acres have burned on public lands in Arizona and New Mexico.

For more detailed discussions, visit the National Wildland Fire Outlook web page: http://www.nifc.gov/news/nicc.html
For more detailed information on regional fire danger, visit the Southwest Area Wildland Fire Operations web page: http://www.fs.fed.us/r3/fire/

14. U.S. Hazards Assessment Forecast (Source: NOAA Climate Prediction Center)



Notes:
This hazards forecast is for August 16 – August 27, 2002.

The hazards assessment incorporates outputs of National Weather Service medium- (3-5 day), extended- (6-10 day) and long-range (monthly and seasonal) forecasts and hydrological analyses and forecasts.

Influences such as complex topography may warrant modified local interpretations of hazards assessments.

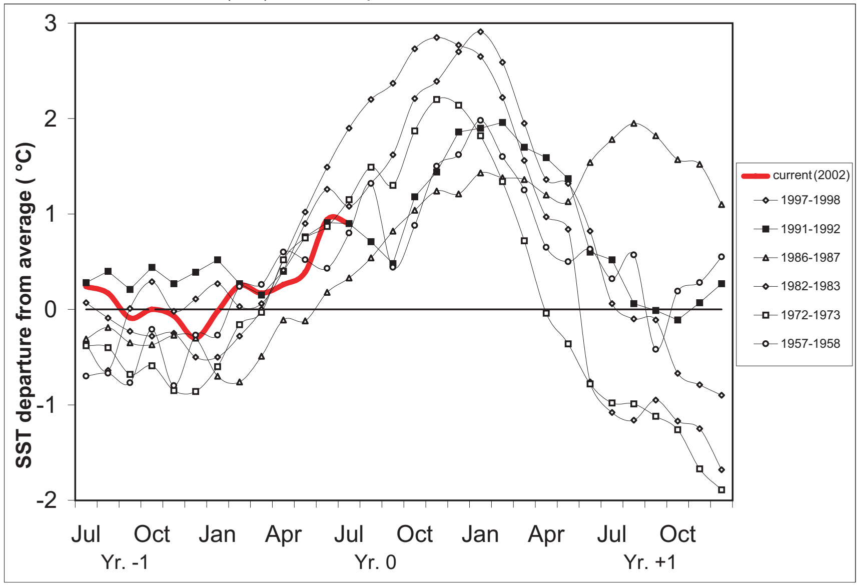
Please consult local National Weather Service offices for short-range forecasts and region-specific information.

Highlights: The U.S. Hazards Assessment indicates long-term, persistent drought for Arizona and all but the southeastern corner of New Mexico. Computer models suggest that the Southwest monsoon may be suppressed during this period and dry fuels, low relative humidity, and occasional windy, hot days are expected to exacerbate the wildfire danger over a large part of the Western United States, including northeastern Arizona and northern New Mexico. However, the wildfire risk area has diminished over much of New Mexico and southeastern Arizona, due to previous monsoon shower activity and elevated humidity levels.

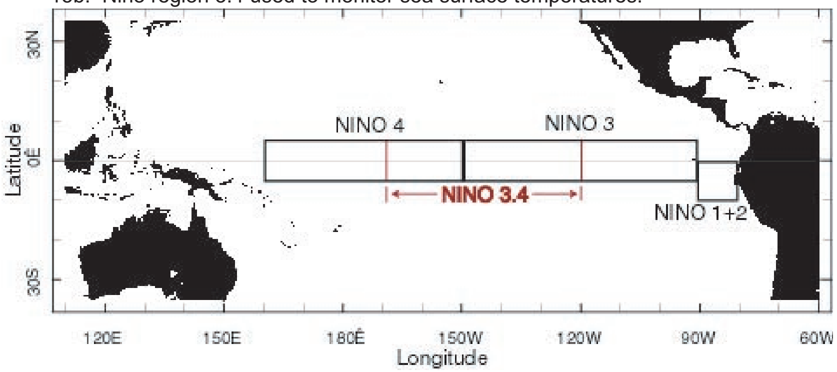
For more information, visit: http://www.cpc.ncep.noaa.gov/products/predictions/threats

15. Tropical Pacific SST and El Niño Forecasts (Sources: NOAA CPC; IRI)

15a. Past and current (red) El Niño episodes.



15b. Niño region 3.4 used to monitor sea surface temperatures.



Notes:
The graph (Fig. 15a) shows sea surface temperature (SST) departures from the long-term average for the Niño 3.4 region (Fig. 15b). These are a sensitive indicator of ENSO conditions.

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

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

The probability of an El Niño is based on observations of sustained warming of sea surface temperatures (SSTs) across a broad region of the eastern and central equatorial Pacific Ocean, as well as the results of El Niño forecast models.

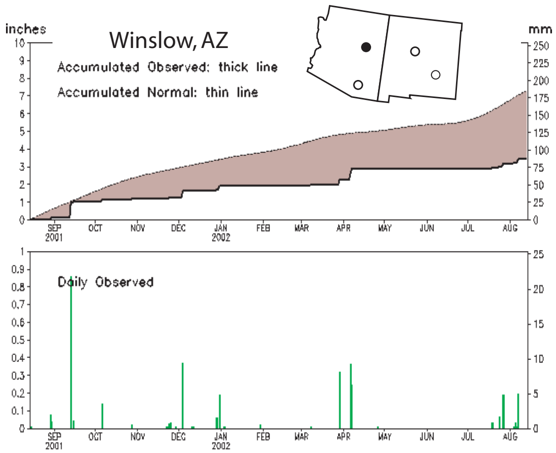
Highlights: On August 8, NOAA's Climate Prediction Center (CPC) declared that weak-to-moderate El Niño conditions will continue into early 2003. The International Research Institute for Climate Prediction (IRI) concurs, and their experts have indicated a 95% probability that current conditions represent the early stage of an El Niño event that will persist through early 2003. Both agencies caution that this winter's El Niño event will not be as powerful as the 1997-98 El Niño. For information on El Niño impacts on the Southwest, see the *Focus El Niño, Drought and Tropical Storms* section of this packet.

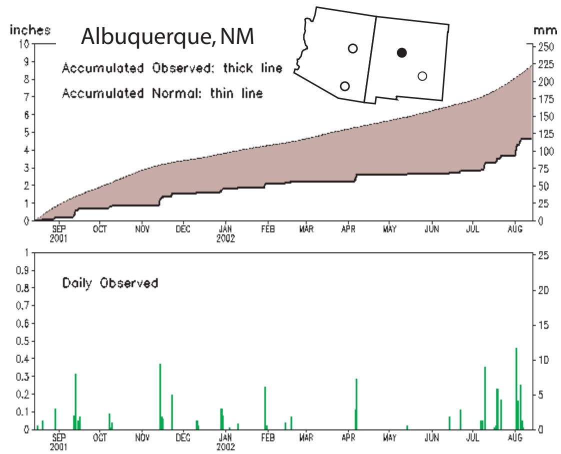
For a technical discussion of current El Niño conditions, visit: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/
For more information about El Niño and the graphics found on this page, visit: http://iri.columbia.edu/climate/ENSO/

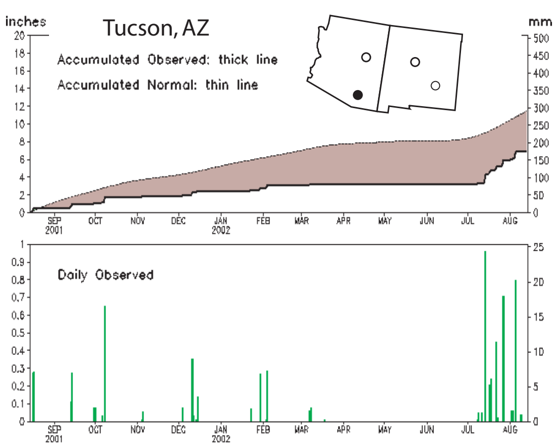
Section D

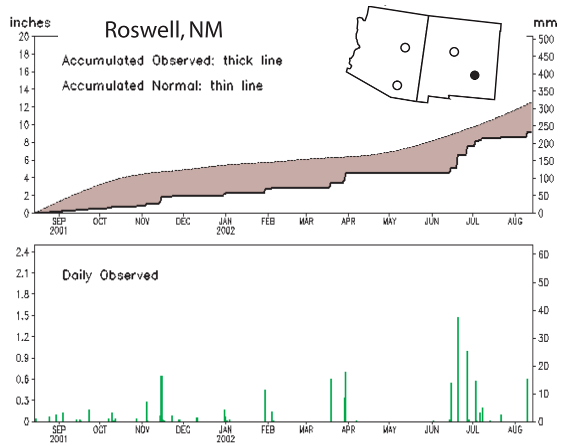
FOCUS ON
EL NIÑO, DROUGHT, AND
TROPICAL STORMS

16. AZ and NM Typical vs. Actual Accumulated Precipitation (8/12/01 – 8/13/02)
(Source: NOAA Climate Prediction Center)









Notes: These graphs contrast how much precipitation actually has accumulated at each station over the past year with how much precipitation typically is received, based on a long-term average (1971-2000) of daily precipitation.

The top of each of the pairs of graphs shows average (dotted line) and actual (solid line) precipitation. If accumulated precipitation is below the long-term average, the region between the long-term average and actual precipitation is shaded grey.The green bars in the bottom of each of the pairs of graphs show the daily precipitation amounts (in both inches and millimeters) for the past year.

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

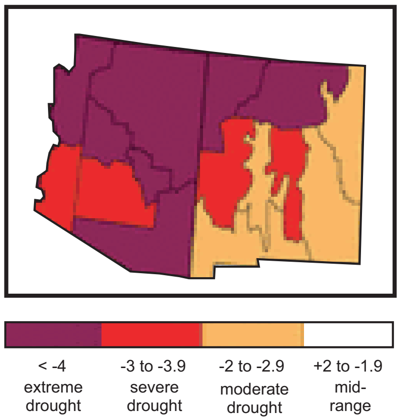
This type of graph is available for several other stations in Arizona and New Mexico (Phoenix, Yuma, Farmington, and El Paso, Texas) as well as for many other places in the world. The graphs are updated daily by NOAA CPC at the website noted at the bottom of the page.

Highlights: Taken together, these graphs illustrate the spatial variability in daily rainfall in Arizona and New Mexico. In July and August 2002, Tucson received much more daily rainfall than any of the other three stations. Thus far, the dynamics of this year's summer monsoon have resulted in higher precipitation totals in southeastern Arizona and southwestern New Mexico than elsewhere in the Southwest. However, all four stations exhibit below average precipitation (shaded in grey) for the last 365 days, as would be expected with the persistent drought conditions throughout the Southwest. For example, Tucson's precipitation deficit as of August 13, 2002 is almost 5 inches, whereas Roswell's deficit is about 3 inches.

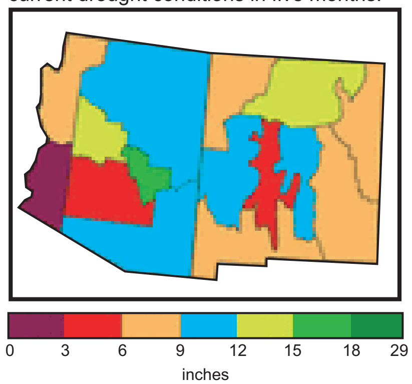
For more information about accumulated vs. typical precipitation for locations all over the world (including the Southwest), visit:
http://www.cpc.noaa.gov/products/global_monitoring/precipitation/global_precip_accum.html

17. Precipitation Required to End or Ameliorate Drought Conditions by December 31, 2002 For Arizona and New Mexico (Source: NOAA National Climatic Data Center)

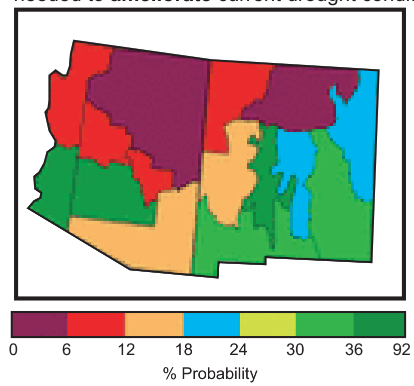
17a. Current Palmer Hydrological Drought Index (PHDI) long-term condition values



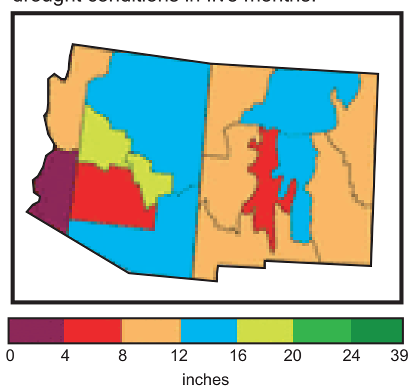
17b. Precipitation required to **ameliorate** current drought conditions in five months.



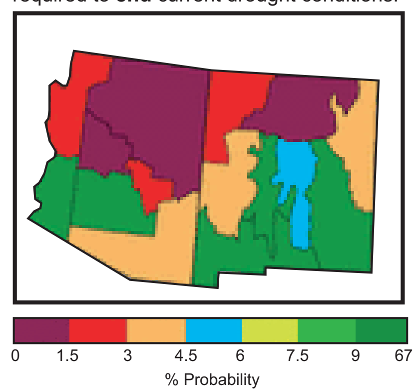
17c. Probability of receiving precipitation needed to **ameliorate** current drought conditions.



17d. Precipitation required to **end** current drought conditions in five months.



17e. Probability of receiving precipitation required to **end** current drought conditions.



Notes: The Palmer Hydrological Drought Index (PHDI) measures the long-term, hydrological impacts of drought. These impacts, such as reservoir and groundwater levels, etc., respond slowly to drought; in other words it takes longer for them to be impacted by drought conditions and longer for them to recover from drought conditions.

The precipitation amounts and probabilities of ending or ameliorating drought are calculated for each climate division from its PHDI value. The end of a hydrological drought is defined by a PHDI value of –0.5 whereas drought amelioration is achieved when a PHDI value of –2.0 is reached.

Please note that the numbers (inches or probability) associated with the scale bars for the figures vary.

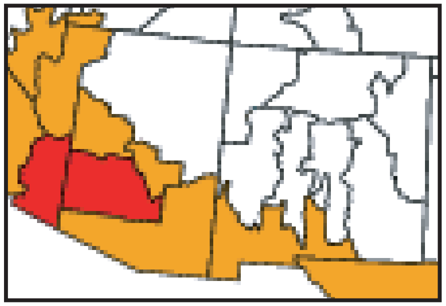
NOAA NCDC updates the PHDI values and figures for the nation monthly.

Highlights: Figure 17a shows that much of Arizona and northern New Mexico is experiencing extreme hydrological drought, the most severe category categorized by National Climatic Data Center. Moderate hydrological drought conditions are present in southern and northeastern New Mexico. All of Arizona (except the southwestern corner) as well as northern New Mexico has a 4.5 percent or less probability of ending hydrological drought by the end of 2002. Central Arizona requires up to 20 inches of precipitation to end drought conditions. Chances of ameliorating hydrological drought conditions by the end of the year in Arizona (except the southwestern corner) and northern New Mexico also are slim; with probabilities less than 18 percent and precipitation levels up to 18 inches required. South central New Mexico has the highest probability in our region of receiving enough precipitation to either ameliorate or end hydrological drought conditions.

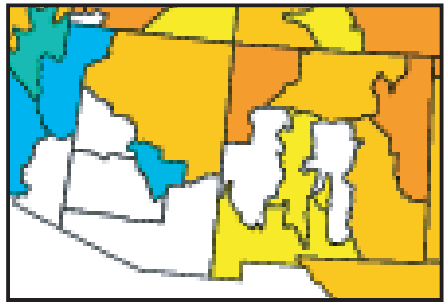
For more information, visit: http://lwf.ncdc.noaa.gov/oa/climate/research/drought/drought.html

18. September El Niño Precipitation and Temperature Impacts (Source: NOAA CPC)

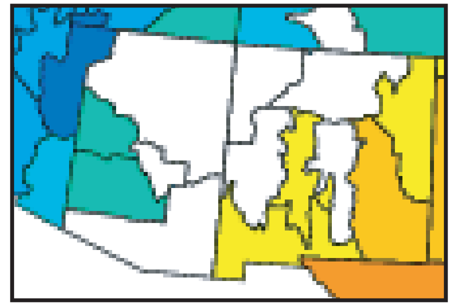
18a. Average mean daily temperature (°F) for September (1971-2000)

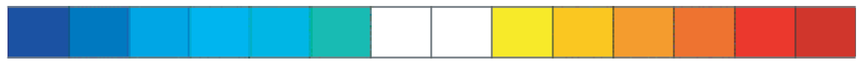


18b. Departure from average September temperature (°F) for weak El Niño years (1963, 1969, 1976, 1977)

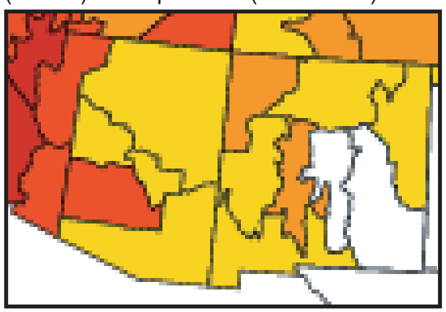


18c. Departure from average September temperature (°F) for strong El Niño years (1965, 1972, 1982, 1997)

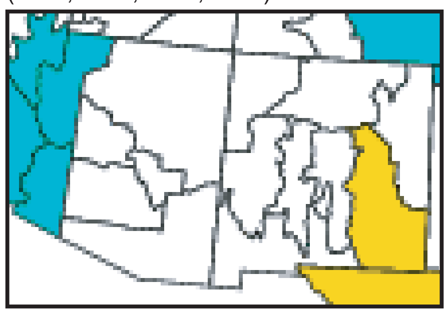




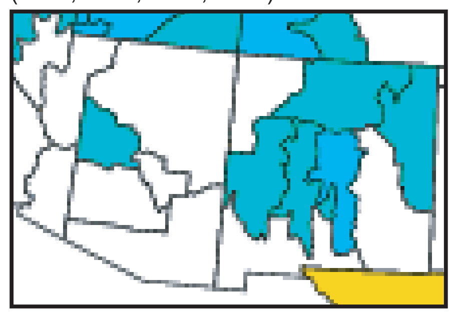
18d. Average monthly precipitation (inches) for September (1971-2000)



18e. Departure from average September precipitation (in.) for weak El Niño years (1963, 1969, 1976, 1977)



18f. Departure from Average September precipitation (in.) for strong El Niño years (1965, 1972, 1982, 1997)



Notes:

The weak El Niño temperature (Fig. 18b) and precipitation (Fig. 18e) anomaly maps display the difference between the average September temperature (or precipitation) during 4 weak El Niño events (1963-64, 1969-70, 1976-77, 1992-93) and average winter precipitation for 1971-2000.

The strong El Niño temperature (Fig. 18c) and precipitation (Fig. 18f) anomaly maps display the difference between the average September temperature (or precipitation) during 4 strong El Niño events (1965-66, 1972-73, 1982-83, 1997-98) and average winter precipitation for 1971-2000.

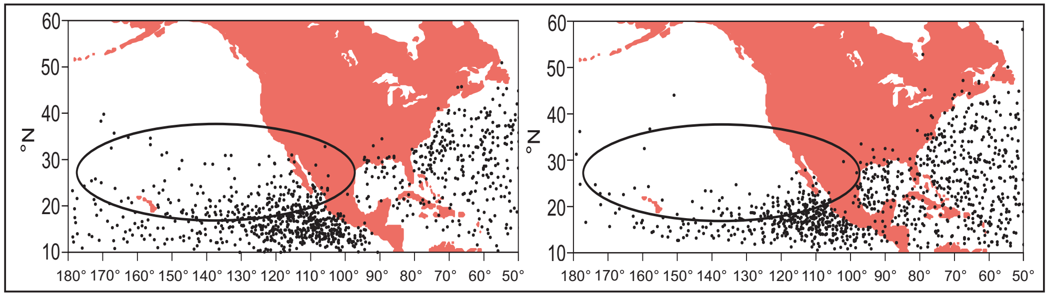
In all maps, precipitation and temperature anomalies are expressed in inches and degrees Fahrenheit (°F), respectively.

Highlights: In the Southwest, average September temperatures range from 50-90 F. Precipitation totals usually account for only a small fraction of annual precipitation. However, on occasion the confluence of receding monsoon rains, upper atmosphere disturbances along the west coast, and tropical storm conditions bring copious rainfall. El Niño effects on September climate lack definition and vary depending upon the intensity and location of unusually warm sea surface temperatures in the equatorial Pacific Ocean and interactions between low and high latitude wind patterns. The maps of strong and weak September El Niño temperature anomalies show that temperatures across New Mexico tend to be average to slightly above average. El Niño precipitation effects are even less well defined, and the most coherent effect is a region of 0.5-1.5 inches of above average precipitation in New Mexico during strong El Niño events.

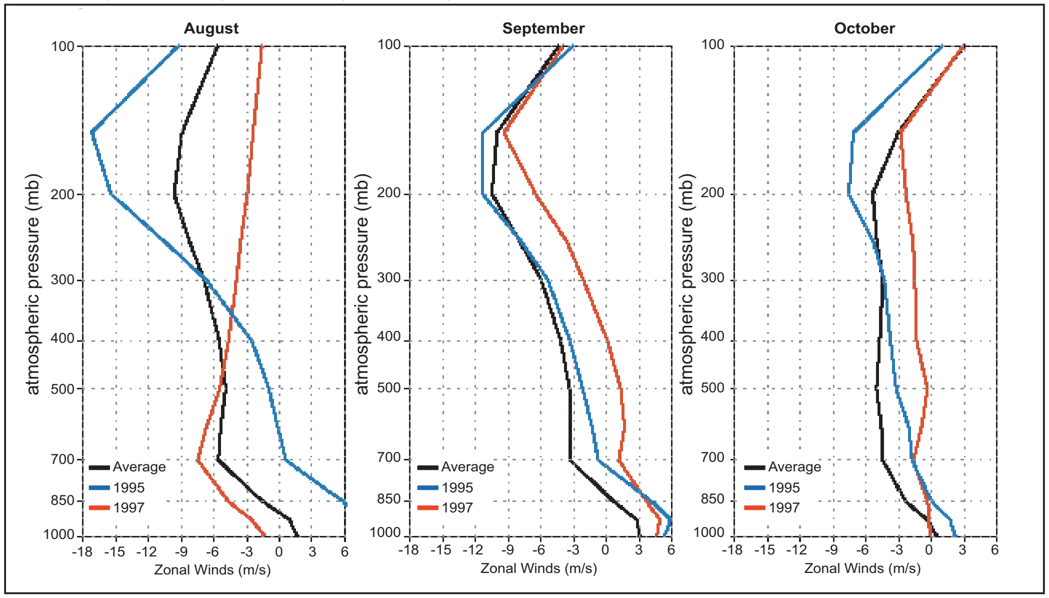
To create your own precipitation maps, visit the NOAA Climate Diagnostics Center website: http://www.cdc.noaa.gov/USclimate/USclimdivs.html

19. Tropical Storms, El Niño, and the Southwest

19a. Warm and cold Pacific equatorial SSTs and associated tropical storm locations.



19b. Geopotential heights associated with average (black), cold (blue - 1995) and warm (red - 1997) equatorial Pacific SSTs.



Notes:

Figure 19a shows daily hurricane and tropical cyclone positions during the 10 warmest (Figure 19a left) and 10 coldest (Figure 19a right) years based on sea surface temperature in the equatorial cold tongue region (a region known as a sensitive indicator of ENSO conditions), for the period of record 1949-2000.

Figure 19b shows the vertical profile of zonal (west-to-east direction) winds (in meters per second – m/s; horizontal axis) averaged over the eastern North Pacific during August, September and October. Atmospheric pressure (in millibars -- mb) decreases as altitude increases; the vertical axis of the graphs in figure 19b represent height above the Earth's surface, with 1000 mb at a lower altitude than 100 mb.

Negative values in Figure 19b indicate easterly winds (from east-to-west) and positive values indicate westerly winds (west-to-east). The black line indicates conditions in an average year, the red line indicates 1997 conditions (strong El Niño), and the blue line indicates conditions during 1995 (La Niña-like conditions).

High wind shear in the upper atmosphere (blue line) inhibits tropical storm formation and persistence.

Images in Figure 19a are provided courtesy of Todd Mitchell, the Joint Institute for the Study of the Atmosphere and Ocean. Images in Figure 19b are provided courtesy of the NOAA Climate Prediction Center.

Highlights: A comparison of the areas inside the ellipses in Figure 19a shows the tendency for eastern North Pacific tropical storms to track further north during years when central-to-east Pacific equatorial sea surface temperatures (SSTs) are warm as opposed to when they are cool. Warm SSTs in the central-to-east equatorial Pacific are usually associated with El Niño years. Research by CLIMAS and others indicates no obvious link between the number of eastern North Pacific tropical storms and ENSO; however, there is a tendency for storms of longer duration during *strong* El Niños and a tendency for a greater number of fall season (September-November) storms during El Niño years. Figure 19b shows reduced vertical wind shear in the upper atmosphere during the 1997 El Niño (red line) compared with 1995 (blue line), when equatorial Pacific SSTs were cool and eastern Pacific tropical storm activity was suppressed. The 1997 tropical storm season included Hurricane Nora, which brought large amounts of rainfall to western Arizona.

For more information on eastern North Pacific tropical storms, visit: http://tao.atmos.washington.edu/data_sets/tropical_cyclones/