Institute for the
Study of Planet Earth

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September 25, 2002

Dear Participant,

By now, receiving your monthly packet, reviewing the information and returning your surveys to us is probably becoming routine. You may have identified certain forecasts or reports in the packets that are particularly interesting and useful to you, and are perhaps still assessing the accuracy and relevance of others. For our part, we are working to incorporate your survey responses and comments into future packets, to make the information we provide more accessible and usable for the spectrum of participants that the END InSight Initiative encompasses.

You'll notice that several of the products you've come to expect are included in this month's packet, along with some new features. This month's newsletter, as well as some of the background historical information pages, focus on a topic that is timely during autumn in the Southwest: floods. We explore floods in the distant and more recent past, as well as current precipitation conditions and the chances of increased flooding in the coming months due to the moderate El Niño that continues to develop.

In addition, now that monsoon rainfall has faded throughout the Southwest, your packet contains a summer precipitation summary for several locations around the region. As the summary shows, drawing conclusions regarding summer rainfall amounts for the entire region is impossible; as is often the case, some areas received copious amounts of rainfall, while others continued to be left high and dry.

This month's packet also focuses on forecast interpretation. It contains expanded forecast interpretation pages, which will allow you to better understand how monthly, 3-month and seasonal forecasts for rainfall and temperature are produced, what they mean and how certain forecasters are that the conditions indicated will indeed occur.

Expanded forecast interpretation will also be evident in updates we plan to incorporate into our web pages as the month progresses (www.ispe.arizona.edu/climas/end). We intend to include alternative forecasting products that you may find useful as they become available. For example, the International Research Institute for Climatic Prediction (IRI) has recently issued its global climate outlooks for different regions of the world, including North America, for the period of October 2002 through March 2003. In addition to the forecasts, the IRI provides thorough explanations of how their forecasts are produced, and tutorial features to aid in their interpretation. We also plan to create and add tables to the web pages that will allow you to compare the forecasts produced by different agencies, over various time periods and for multiple locations.

The forecast interpretation pages are a prelude to an exciting new tool that will soon be available to you. Based on in part on stakeholder-centered forecast evaluation research conducted by CLIMAS, the forecast evaluation tool is being produced by the HyDIS project at the University of Arizona. The Southwest Precipitation Mapper, which is in the late stages of development, will allow users to specify the amount of lead-time and season they are interested in. The forecast evaluation tool will then provide information regarding the skill level of the forecast (giving an indication of how accurate it is likely to be, and what factors may confound forecasting for a given region). It will allow this type of evaluation of forecast skill for over 100 U.S. regions. Users will also be able to view the "past as prologue" to create forecasts based on comparisons of current conditions with similar past conditions, and to see how rainfall and temperature trends have played out over comparable seasons in the past. Furthermore, the HyDIS tool will provide a tutorial and quiz regarding forecast evaluation, to help users learn more about the meaning and implications of forecast skill levels.

Keep your eyes on the web pages for these new additions, and enjoy this month's packet. As always, we appreciate your comments or suggestions regarding any aspect of the project. We'd be most grateful to receive your completed surveys in our office by October 17, 2002. Thanks very much for participating in our project!

Best regards,

Rebecca Carter
Research Associate

Gregg Garfin
Assistant Staff Scientist

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Evaluation – Monthly Information Packet

For: September 2002 Packet Number: 3

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?

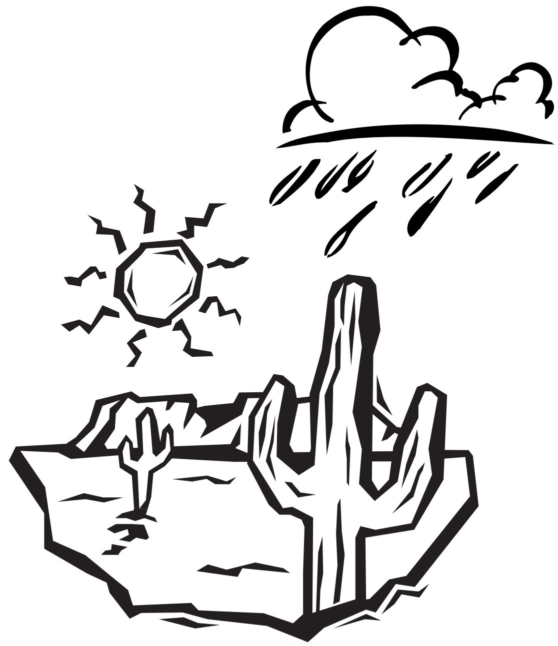
   ____Yes ____No

   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	September 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) Measures							
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 Summer Rain, Floods, and Forecasts							
16	Southwest U.S. Summer Precipitation Summary							
17	Floods in the Southwest							
18	Paleoflooding in the Southwest							
19	Interpreting the NOAA CPC Climate Outlooks: Changes in Probability							
20	Interpreting the NOAA CPC Climate Outlooks: What is Normal?							

END InSight



CLIMAS El Niño-Drought Initiative

Information Packet #3
September 2002

Climate Assessment for the Southwest
Institute for the Study of Planet Earth
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Section A

BACKGROUND

Executive Summary, September 2002

Recent rains have provided the eastern two-thirds of our region with much needed short-term drought relief. Consequently, water restrictions have been reduced for some Arizona municipalities and fire danger has been reduced to the point where prescribed fires have been reintroduced in our region. Agriculture and range conditions improved slightly, but topsoil and range conditions remain poor to very poor over a majority of Arizona and New Mexico. Temperatures have continued to be above average for the southern half of our region.

Our water supply, including streamflow, groundwater, reservoir and lake levels, continues to be affected by persistent drought. Thus, water supply-related issues have been in the headlines in New Mexico and will continue to be of concern in our region until we receive substantial winter precipitation.

Climate outlooks for October-December indicate uncertainty with regard to both temperature and precipitation. Long-term climate outlooks indicate increased probabilities of above-average precipitation for our region this winter. For our region, there is only a small probability of significant drought amelioration or termination by the end of the year. Most Arizona and New Mexico climate divisions will require 150-200% of normal precipitation to end the drought entirely during the next 6 months.

El Niño conditions strengthened during the past month, and atmospheric indicators, such as weakening easterly (“trade”) winds in the equatorial Pacific Ocean, have developed. The El Niño event 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. Research on interactions between the equatorial and north Pacific Ocean indicates little confidence in winter precipitation much above average for our region.

News from the CLIMAS El Niño-Drought Initiative

END InSight

September 2002

THE UNIVERSITY OF ARIZONA®

Floods in the Southwest

By Rebecca Carter

A flood may be defined as any relatively high stream flow event that overflows the natural or artificial banks of a river or stream, according to Katie Hirschboeck of the Laboratory for Tree Ring Research at the University of Arizona. Hydrologists define stream flooding based on the volume of water flowing and use the term "peak-above-base" to identify large flows or floods that exceed a specified "base" discharge. These peaks-above-base are relatively rare (on average, one or two a year), but in wet years many peaks can occur, while in dry years the base discharge level might not even be met. The largest peak flows may negatively impact people through river channel erosion, riverbank collapses, road closures, and other related flood hazards. However, any significant flow of water can be important for aquifer recharge, especially in the Southwest, where many streams are dry a good part of the year.

No single weather pattern can account for all floods in the Southwest. Instead, winter frontal storms, late summer and fall tropical cyclones from the eastern North Pacific, and summer storms can cause floods. Floods can be divided into two types: localized flash floods, often caused by summer monsoon storms, and more extensive storms, such as the remnants of tropical storms or winter frontal systems. Whereas widespread storms can cause greater property damage, flash floods are far more dangerous to people. In fact, the National Weather Service office in Flagstaff, Arizona notes that flash floods are the number one weather-related killer in the United States, leading to about 150 deaths every year (1).

In the Southwest, monsoon-related thunderstorms typically occur from July through September. The damage that floods caused by monsoon storms inflict may be limited to the relatively small areas these storms affect. However, they are treacherous because storms miles away can cause them, sometimes leading to fatal surprises. This was the case in Lower Antelope Canyon in northern Arizona on August 12, 1997. Twelve hikers were caught in a 10- to 30-foot high wall of water as they hiked through a slot canyon; only one survived (2).

New Mexico offers examples of the damage that more widespread flooding can cause. On June 17, 1965, a hurricane in the Gulf of Mexico brought intense, widespread rainfall to the state, causing record discharges on some rivers and tens of millions of dollars in losses. Although this flood occurred during a major dry spell, it did not have an appreciable effect on the drought because of the short duration of the rainfall.

Arizona's largest flood in recorded history also was caused by widespread storms. During February 1891, heavy rainfall caused the Salt River at Phoenix to peak at 300,000 cubic feet per second. The river swelled to two to three miles wide and extended two miles north of the channel in central Phoenix.

Not all rainfall leads to flooding… It takes more than just any old rainfall to produce a flood. Specific atmospheric and soil conditions are often the decisive factors that separate flood-causing rains from less remarkable precipitation. Flash floods, which have been described as "more water than you want in less time than you have," become more likely when a large storm gathers moisture from continuous, low-level flows and is held in place for several hours by the topography or weak upper-level winds. Flash floods can also result from dam failures, which may send huge quantities of water downstream and lead to great destruction. Rainfall on snow, which causes rapid melting, has also unleashed abrupt torrents of water in the Southwest (3).

Particular atmospheric conditions over the North Pacific are conducive to more extensive winter floods on rivers in the Southwest. A 1994 study (4) found that the largest winter floods in the Southwest occur when there is both an exceptionally strong low-pressure

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Floods, continued

anomaly off the California coast and a high-pressure anomaly in the vicinity of either Alaska or the Aleutian Islands. The low-pressure system controls whether large floods will occur, whereas shifts in the high-pressure anomaly dictate which regions will experience floods. Topography and other air masses also play a role. The peak months for these occurrences, known as cutoff lows, are April and October, and they are unlikely in July and August (5).

The El Niño Effect

Recent results from streamflow studies by investigators at the U.S. Geological Survey, the Scripps Institute of Oceanography, and the Desert Research Institute show that 1) El Niño years bring, on average, increased mean flows and flood sizes to the Southwest and 2) the variability of annual stream flow and floods in the Southwest is two or more times greater during El Niño years than during either La Niña or non-Niño years. El Niños tend to bring either very wet or very dry winter stream flow conditions to the Southwest, with few years falling in the average range. Flow records were examined from the Salt River in central Arizona, which tends to react strongly to ENSO conditions. The mean annual flood on the Salt River is 585 cubic meters per second (cms) during El Niño years, 226 cms in La Niña years, and 630 cms during years that are neither, indicating that El Niño does not bring overall higher flow levels to the Salt River. However, the researchers found that El Niño does consistently bring a drama-tic increase in the *range* of river flows, while both La Niña and neutral years tend to have rela-tively narrow ranges. Floods on the Salt River are four times more variable during El Niño years.

The researchers further examined the impact of the Pacific Decadal Oscillation (PDO; see July END InSight newsletter) on stream flows during El Niño and La Niña years. They found that a positive PDO phase, such as the one that is believed to have ended recently, tends to strengthen El Niño's potential for bringing wetter conditions and higher stream flows to the Southwest. A negative PDO phase, which climatologists believe the Pacific has recently entered and is expected to bring generally drier conditions, tends to reinforce the ability of La Niña to bring drier than average conditions. The combination that currently exists, of El Niño and a negative PDO, also correlates with increased variability. However, it is not likely to lead to as high river flows as positive PDO conditions in the recent past would have.

In 1998 researchers (6) also found that in North America when the cool season coincides with an El Niño event and warm tropical Pacific conditions, there is an increase in the frequency of days with high precipitation and stream flow in the Southwest and a decrease in the number of such days in the Northwest. For several basins in the Southwest, ex-tremely high flows are at least 10 times as likely to occur during El Niño years as during neutral or La Niña years.

Several other researchers agree that El Niño and La Niña conditions affect rainfall totals, particularly during the fall and spring. A study in 1992 (5) found that of 35 years with El Niño conditions, rainfall totals in 29% of the years were above normal, 54% were normal, and only 17% were below normal. The aforementioned 1994 study (4) also concluded that in the Southwest, there is an increased frequency of large winter floods during multiple-year El Niños and a virtual absence of large floods during the intervening periods.

An important factor in determining whether floods will occur is the condition of the soil when rainfall hits it. Rainfall is more easily and rapidly absorbed into dry soils, compared to soils that are already saturated by previous rainfall. Researchers in 1999 (6) also found that during El Niño years, not only were there more rainy days, but also more two-day- and three-day-in-succession precipitation events, which are more likely to lead to flooding. In fact, there were twice as many multi-day rains compared to neutral and La Niña years. They also found that there is a 30% greater likelihood of extreme events during El Niño and La Niña years than during neutral years.

Floods and Fire

The lack of vegetative cover caused by forest fires in areas of Arizona and New Mexico increases the likelihood of floods in these areas. When forest fires scar the land, there is often little vegetation left to catch runoff from heavy rains (3). Worse yet, the heat from such fires can leave the ground parched and unable to absorb water. Relatively modest rainfall amounts that would normally cause no problems can lead to dangerous flash floods in these areas. For example, this year monsoon thunderstorms over the Rodeo/Chediski fire burn area have produced large peak stream flows in response to relatively small amounts of rainfall. Such runoff can be toxic to fish and other organisms. The sediment-laden water running off the burn area contains organic debris, dissolved nutrients, and other chemical compounds released by the fire's combustion (7).

While New Mexico and Arizona have largely been spared the ravages of fire-induced flooding so far this year, the Durango, Colorado area has not been so fortunate. An inch and a half of rain fell in a little over an hour on September 7, 2002, on areas recently burned in the Missionary Ridge fire. The resulting mudslides

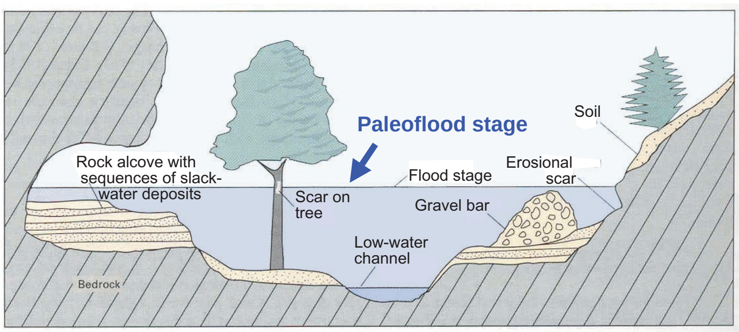
continued on page 3

Floods, continued

damaged homes and property. Flooding is anticipated to continue in the area for up to five years (8).

Past Floods

Current climatic conditions tell us something about the likelihood of flooding in the Southwest this winter; by the same token, evidence of previous flooding can tell us something about past climatic conditions. Researchers examining evidence of past flood events, such as erosion features, scars on trees, and slack-water deposits, have detected periods when flooding was a more frequent experience in the Southwest (see figure below). They also have learned that past floods were similar in volume in this region to more recent flood events, such as those that occurred in the Lower Colorado River Basin in 1993. See the Historical Background section of this packet for more information on paleo- and historical floods.



Paleoflood information: Where it comes from. Diagram showing a section across a stream channel with flood stage and paleoflood evidence (slack-water deposits, tree scars, gravel bars, and erosional scars). After Jarrett, R.D. 1991. Paleohydrology and its value in analyzing floods and droughts. Pages 105-116 in National Water Summary 1988-1989, Hydrologic Events and Floods and Droughts. U.S. Geological Survey Water Supply Paper 2375 and Baker, V.R. 1987. Paleoflood hydrology and extraordinary flood events. *Journal of Hydrology*, vol. 96, p. 79-99.

For More Information About Floods

(1) http://www.wrh.noaa.gov/Flagstaff/summer/flood.html
(2) http://geochange.er.usgs.gov/sw/impacts/hydrology/state_fd/
(3) http://www.wrh.noaa.gov/flagstaff/science/flashfld.htm
(4) L.L. Ely, Y. Enzel, and D.R. Cayan. 1994. Anomalous north Pacific atmospheric circulation and large winter floods in the southwestern United States. *Journal of the American Meteorological Society*, vol. 7, p. 977-87.
(5) Richard Hereford and R.H. Webb. 1992. Historic variation of warm-season rainfall, southern Colorado Plateau, Southwestern U.S.A. *Climate Change*, vol. 22, p. 239-56.
(6) D.R. Cayan, K.T. Redmond, and L. Riddle. 1999. Accentuation of ENSO effects on extreme hydrologic events over the western United States. *Journal of Climate*, vol. 12, p. 2881-93.
(7) http://www.usgs.gov/public/press/public_affairs/press_releases/pr1613m.html.
(8) Kostka, Jennifer. 2002. Between rocks and a hard place. *Durango Herald*, Sept. 10. http://www.durangoherald.com/

Product of the Month: Climate Prediction Center's Hazards Assessment

When emergency managers, planners, forecasters, and anyone else with a stake in planning for severe weather conditions need advance notice of potential hazards related to climate, weather, and hydrologic events, the Climate Prediction Center's (CPC) Hazards Assessment (formerly the Threats Assessment) may fit the bill.

Every Tuesday, the NOAA/National Weather Service (NWS) CPC issues an assessment of weather- and climate-related hazards to the United States for the next three to ten days. The assessment is a review of current weather and climate information that integrates existing official NWS medium- (3-5 day), extended- (6-10 day) and long- (monthly and seasonal) range forecasts, along with hydrologic analyses and forecasts. The goal is to help decision-makers to mitigate against weather- and climate-related losses and maximize economic gains.

In creating assessments, CPC meteorologists and oceanographers review climate and weather observations and data along with model results; assess their meaning, significance, and current status; and predict likely future climate impacts.

One limitation on the reliability of the hazards assessment is that the models used to produce this assessment change, sometimes markedly, from one day to the next, even over the shortest time ranges. Also, the medium-range forecast models have crude topography and do not, in general, handle local variations very well. Local forecasters are in the best position to interpret such local effects, especially in the shorter forecast time ranges.

Even so, the Hazards Assessment provides the valuable service of evaluating information from multiple sources and highlighting the most significant events on a national basis for its users.

You can view the current Hazards Assessment Map, along with a summary of impending weather, at http://www.cpc.ncep.noaa.gov/products/expert_assessment/threats.html. The most recent hazards assessment map is on page 14 of this packet.

Wet Winter? Dry Winter? What's the Scoop?

by Nan Schmidt, based on a briefing document prepared by Randy Dole, NOAA CDC

Most forecasts indicate that El Niño conditions are likely to persist during the rest of 2002 and into early 2003; however, these forecasts also indicate that this event is likely to be weaker than the 1997-1998 event, with more uncertain climate impacts. The uncertainty in forecasting climate impacts stems, in part, from uncertainties in predicting moderate-to-weak El Niño conditions. Results from two climate models, one from the National Oceanic and Atmospheric Administration's (NOAA) National Center for Climate Prediction (NCEP) and the other from the National Aeronautics and Space Administration (NASA), illustrate the predicament that forecasters face this winter.

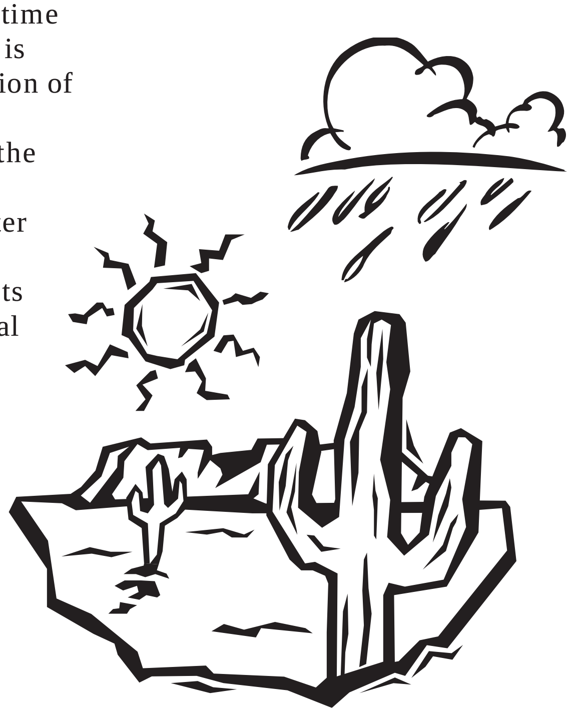
Although El Niño conditions are present, this does not ensure a wet winter in the southwestern United States. Uncertainties in forecasting precipitation for the upcoming winter are due primarily to differences in the predicted position and extent of warm sea surface temperature (SST) anomalies over the tropical Pacific and their subsequent impact on large-scale circulation patterns. By later in the fall, these conditions will develop fully, allowing more certain forecasts for the winter months. Until then, researchers rely on model results to build forecasts of precipitation impacts. Research at the NOAA CDC indicates that precipitation over the Southwest and much of the rest of the United States is sensitive not only to conditions in the central and eastern Pacific—where El Niño is usually defined—but also to SST conditions in the western tropical Pacific and eastern Indian Ocean "warm pool" region. Climate modeling results suggest that if the warming occurs predominantly in the eastern Pacific as simulated in the NOAA NCEP model (figure 1, upper left panel), a classical El Niño pattern will persist and there is an increased chance for above normal precipitation across the Southwest and much of the rest of the United States (figure 1, lower left panel).

If, however, the maximum warming occurs further west, as simulated by the NASA seasonal-interannual prediction model (figure 1, upper right), there is an increased chance for average precipitation across most of the Southwest and below average to average precipitation for most of the rest of the United States (figure 1, lower right). Because the ensuing impacts on U.S. precipitation of the two model scenarios are so different, there remains considerable uncertainty in the wintertime precipitation outlook. NOAA is monitoring closely the evolution of SSTs in both the Pacific and Indian Oceans, but details of the SST pattern for the winter are unlikely to be known until later this fall. The SST pattern that sets up by fall typically persists through the winter, so physical sources for uncertainty in the current suite of winter season forecasts can be expected to diminish over the next few months.

A comparison of Figures 1 and 2 illustrate the diminishing uncertainty as the lead time of the forecast shortens. Figure 1 is based on model forecasts made in September for November 2002 through January 2003; Figure 2 on forecasts made in July for the same time period. The NASA seasonal-interannual prediction model's results vary from July to September. In the July forecast (figure 2), there is an increased chance for below normal precipitation across the Southwest and much of the rest of the United States. The September forecast (figure 1) shows an increased chance of normal precipitation, bringing in more in line with the NCEP forecast..

As a positive aside to this story of uncertainty, the knowledge that will be gained by observing this winter's SST conditions and their subsequent impacts on large-scale circulation and precipitation will help researchers to refine both their understanding of the impacts of moderate-to-weak El Niño events and the models they use to forecast ENSO conditions.

For figures see page 5



Wet Winter? Dry Winter? continued

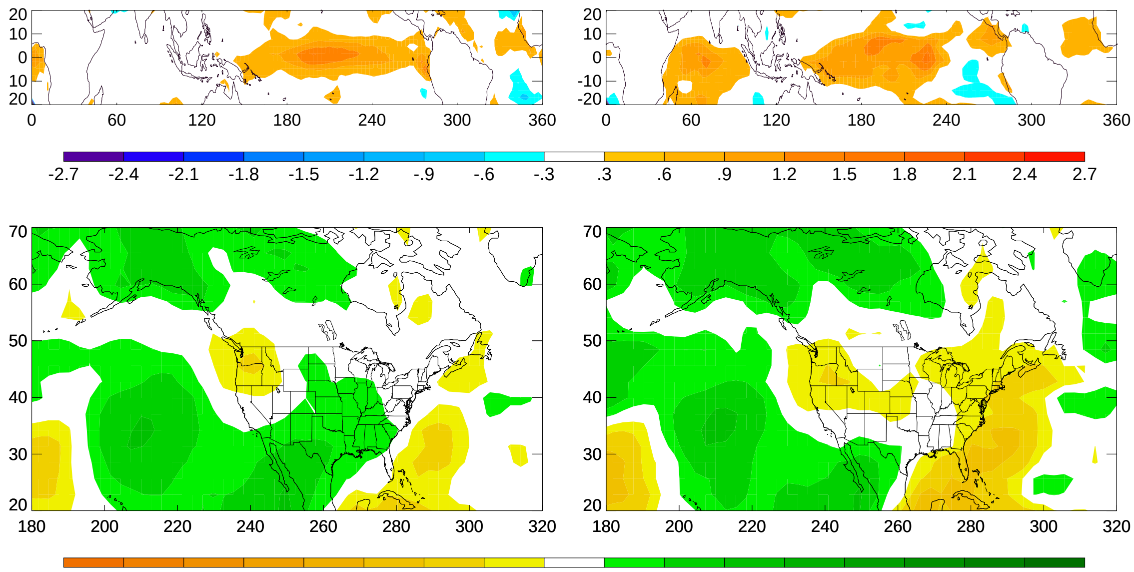


Figure 1. SST predictions for November 2002–January 2003 and associated U.S. precipitation impacts, September 2002. The NOAA NCEP model predicts continued warming in the central and eastern tropical Pacific, a typical El Ni o pattern (top left). In contrast, the NASA seasonal-interannual prediction model predicts warm SSTs further west (top right). Orange and red colors indicate above normal SSTs; blues below normal. Lower panels show the predicted impacts on U.S. precipitation, based on the SSTs. Greens indicated above normal precipitation, and yellows indicate below normal precipitation. The vertical axis is latitude, and the horizontal is longitude. Image courtesy NOAA-CIRES Climate Diagnostics Center.

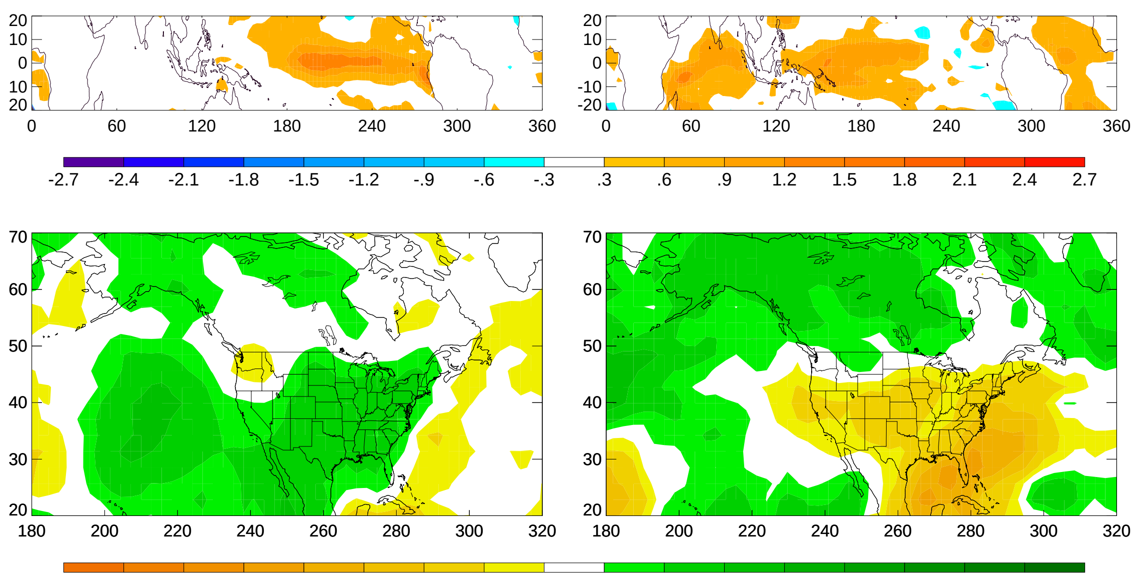


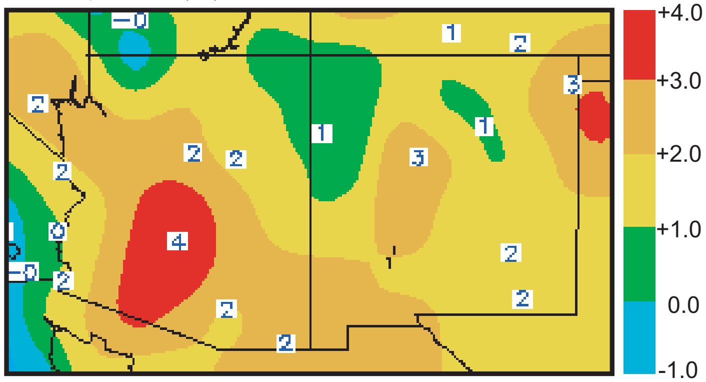
Figure 2. SST predictions for November 2002–January 2003 and associated U.S. precipitation impacts, July 2002. The NOAA NCEP model predicts continued warming in the central and eastern tropical Pacific, a typical El Ni o pattern (top left). In contrast, the NASA seasonal-interannual prediction model predicts warm SSTs further west (top right). Orange and red colors indicate above normal SSTs; blues below normal. Lower panels show the predicted impacts on U.S. precipitation, based on the SSTs. Greens indicated above normal precipitation, and yellows indicate below normal precipitation. The vertical axis is latitude, and the horizontal is longitude. Image courtesy NOAA-CIRES Climate Diagnostics Center.

Section B

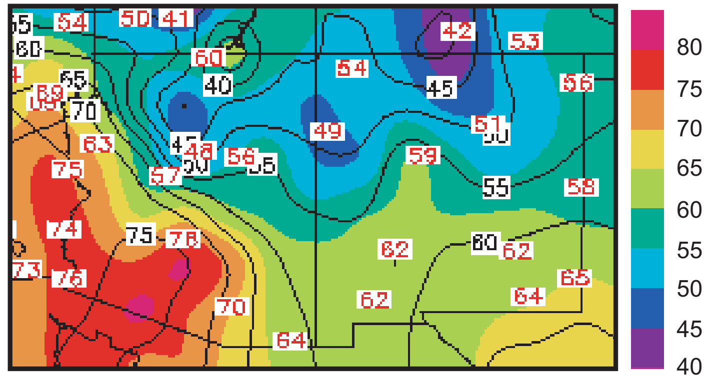
RECENT CONDITIONS

1. Recent Conditions: Temperature (up to 9/18/02); Source: Western Regional Climate Center

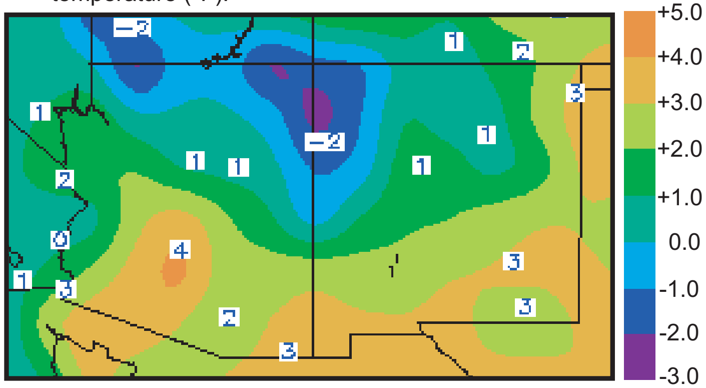
1a. Water year '01-'02 (through 9/18) departure from average temperature (°F).



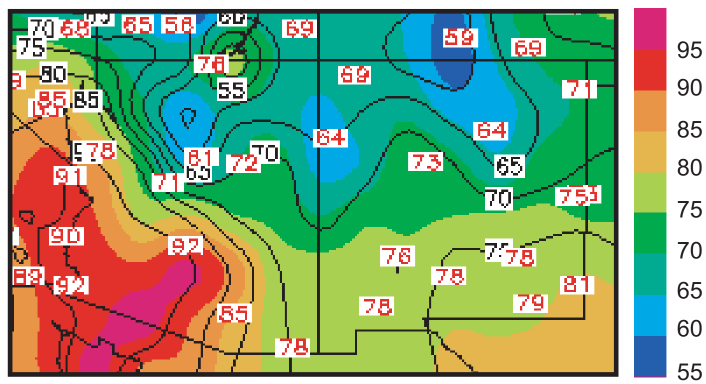
1b. Water year '01-'02 (through 9/18) average temperature (°F).



1c. Previous 28-days (8/22 - 9/18) departure from average temperature (°F).



1d. Previous 28-days (8/22 - 9/18) average temperature (°F).



Highlights: The water year concludes on September 30th. Since October 1, 2001, temperatures have been two degrees or more above average throughout much of our region (Figures 1a-b). Much of the increase has been due to above average maximum temperatures. Phoenix temperatures have been particularly high for the period, due to both above average maximum and minimum temperatures. The high minimum temperatures suggest an enhanced urban heat island effect. Albuquerque, New Mexico, which has an average annual temperature of 57°F, is currently at 59°F for the water year. In the past 28 days, temperatures have been above average for most of the region, but below normal in the Four Corners area (Figures 1c-d). Phoenix, which did not receive much of the late monsoon season storm activity, stands out with the highest above average temperature for the recent and long-term periods.

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

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).

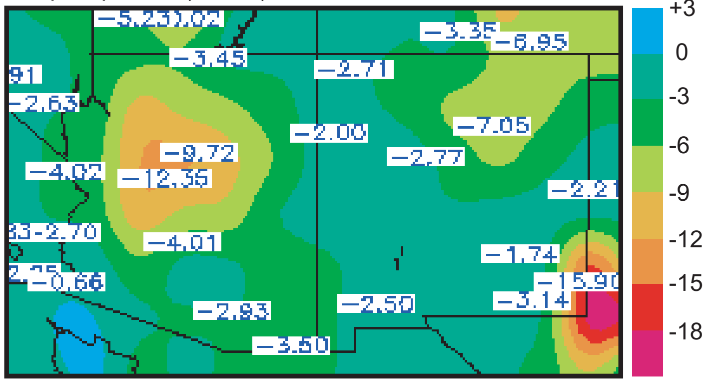
Departure from average temperature is calculated by subtracting current data from the average and can be positive or negative.

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.

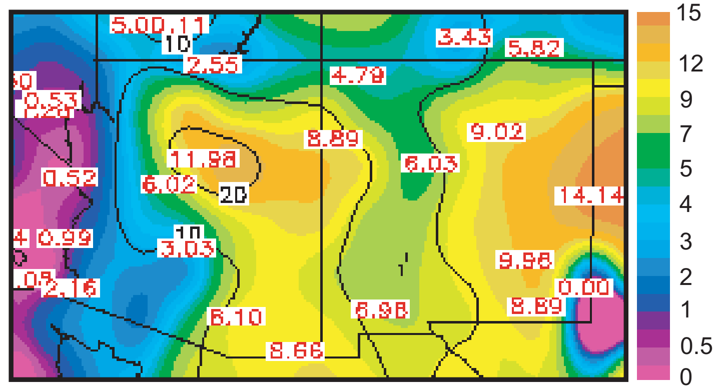
The red and blue numbers shown on the maps represent individual stations. The contour lines and black numbers show average temperatures.

2. Recent Conditions: Precipitation (up to 9/18/02); Source: Western Regional Climate Center

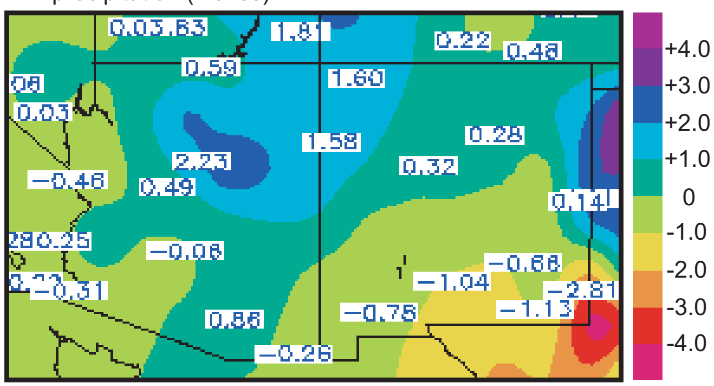
2a. Water year '01-'02 (through 9/18) departure from average precipitation (inches).



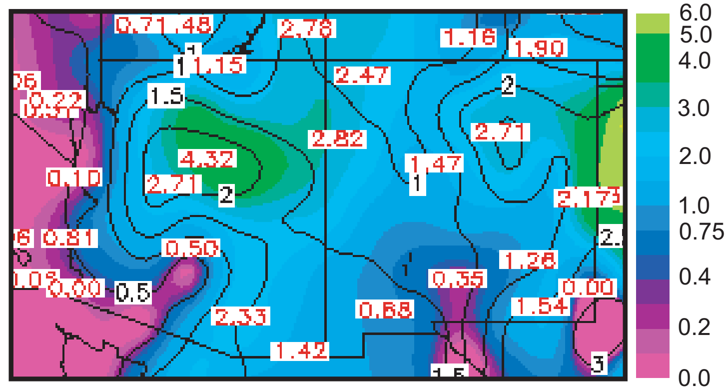
2b. Water year '01-'02 (through 9/18) total precipitation (inches).



2c. Previous 28-days (8/22 - 9/18) departure from average precipitation (inches).



2d. Previous 28-days (8/22 - 9/18) total precipitation (inches).



Highlights: Despite a favorable monsoon season for some areas, precipitation in the region has been far below average since the beginning of the water year. Flagstaff, Arizona receives about 23" of precipitation each year on average but has a current precipitation deficit of almost 10" (Figures 2a-b). Some areas in southern and northeastern New Mexico have seen precipitation deficits increase in the last month. During the most recent 28 days (Figures 2c-d), significant summer rainfall has brought relief to parts of our region and was greatest in northeast Arizona and northern New Mexico in early September. This precipitation was rather intense and short-lived and characterized by high runoff, which limited long-term drought relief. Regardless of the summer precipitation thus far, much of the region is still in the grip of a severe hydrological drought.

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

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.

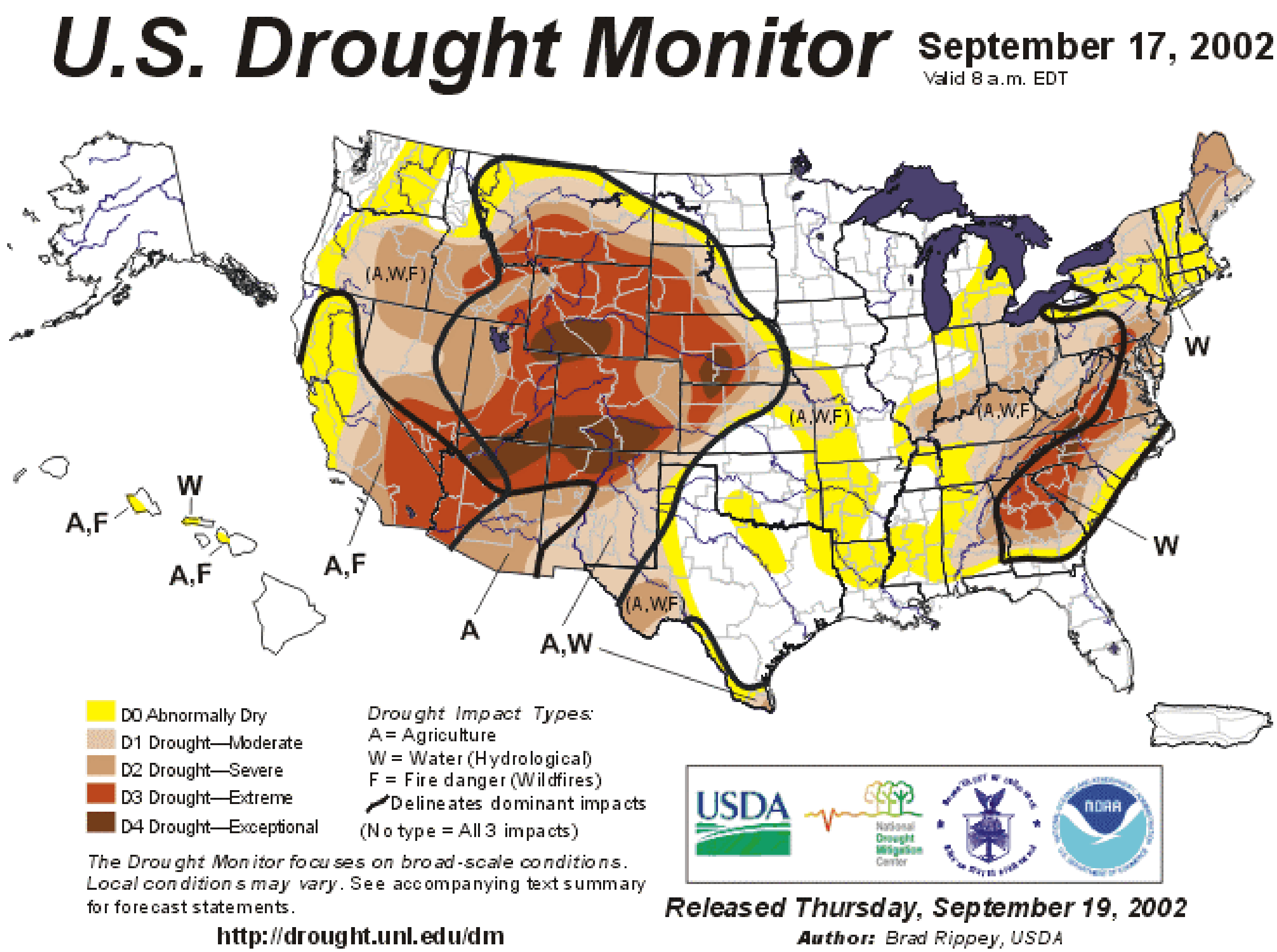
The data are in inches of precipitation. **Note: The scales for Figures 2b & 2d are non-linear.**

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 precipitation.

3. U.S. Drought Monitor (9/17/02)



Notes:

The U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. This monitor was released on 9/19 and is based on data collected through 9/17.

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.

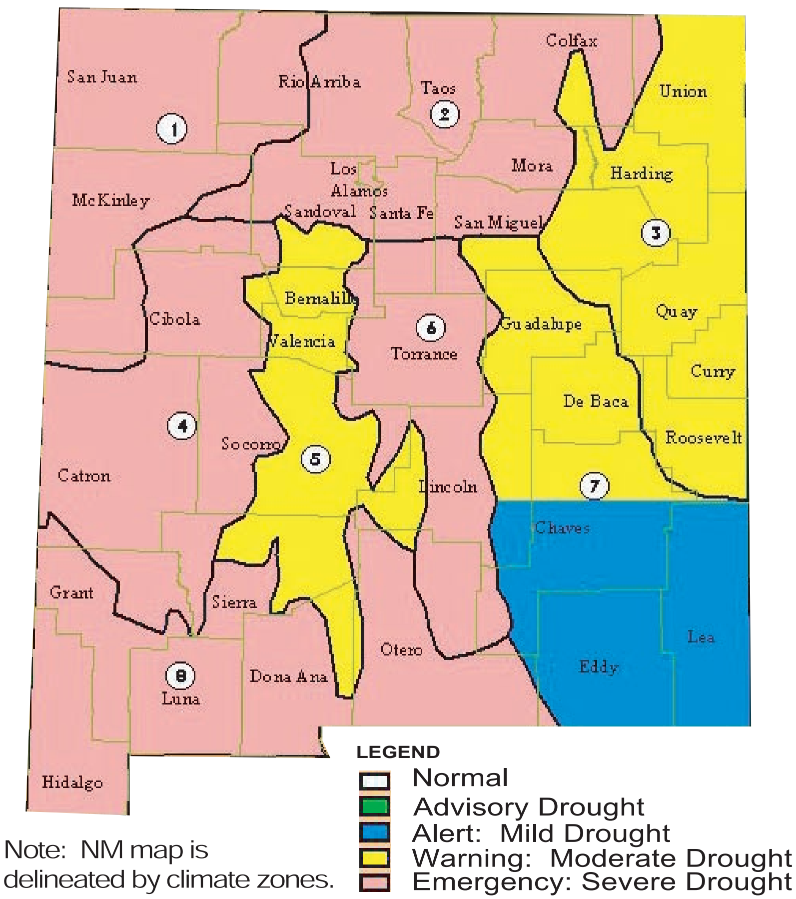
Highlights: Compared to a month ago, the drought designation for much of Arizona and New Mexico remains unchanged while the drought status for some areas in eastern Colorado, Kansas and Nebraska has been downgraded from exceptional to extreme. Drought relief in southeast Arizona has been spotty, with excellent summer rainfall and *green-up* for some localities (e.g., Tucson), but below average summer rainfall and just a hint of green-up only a few miles away. Much of northern Arizona and New Mexico continue to experience 'exceptional' drought (the most extreme Drought Monitor rating) because of minimal summer precipitation in these areas through July and August. Heavy rains between September 1st – 15th produced relief for northern Arizona and the Four Corners area, resulting in 45% of year-to-date precipitation in Flagstaff, Arizona.

Animations of the current and past weekly drought monitor maps can be viewed at: http://www.drought.unl.edu/dm/monitor.html

4. Drought: Recent Drought Status Designation for New Mexico

New Mexico Drought Map

Drought Status as of September 12, 2002



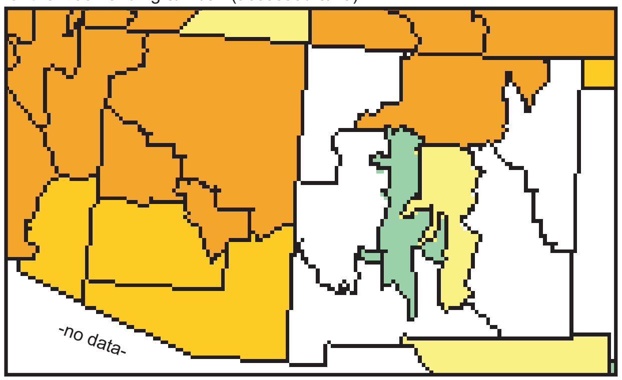
Note: NM map is delineated by climate zones.

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 September 12, 2002. New Mexico drought status has remained the same since last month. The Arizona Division of Emergency Management (ADEM) has not updated the Arizona drought map since May 31, 2002; 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.

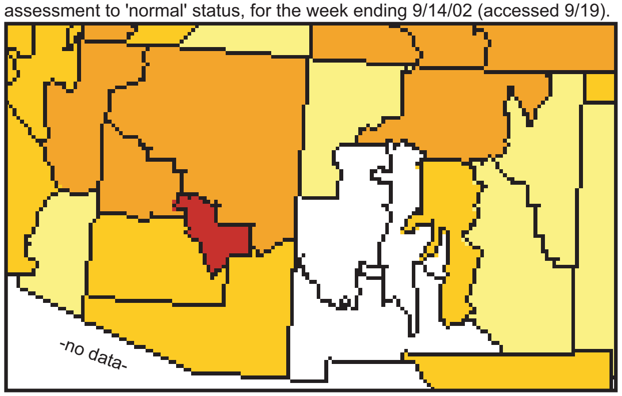
5. PDSI Measures of Recent Conditions (through 9/14/02)
Source: NOAA Climate Prediction Center

5a. Current weekly Palmer Drought Severity Index (PDSI), for the week ending 9/14/02 (accessed 9/19).



- -4.0 or less (extreme drought)
- -3.0 to -3.9 (severe drought)
- -2.0 to -2.9 (moderate drought)
- -1.9 to +1.9 (near normal)
- +2.0 to +2.9 (unusual moist spell)

5b. Precipitation (inches) needed to bring current weekly PDSI assessment to 'normal' status, for the week ending 9/14/02 (accessed 9/19).



- Zero inches
- Trace to 3 inches
- 3 to 6 inches
- 6 to 9 inches
- 9 to 12 inches
- 12 to 15 inches
- Over 15 inches

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: Over the last month, negative PDSI values for southeast Arizona have increased (i.e., worsened), but have remained the same for the rest of the state (Figure 5a). There has been significant improvement in meteorological drought status in New Mexico, which exhibits near-normal PDSI values for much of the state and even positive PDSI values for parts of the Rio Grande valley. Central northern New Mexico's extreme drought status remains unchanged (same as the last two months). Figure 5b shows that most of our region continues to require an extraordinary amount of precipitation to bring our drought status back to normal *within one week*. Meteorological drought conditions in the northern tier of our region have worsened since last month, despite summer rains. For our region, there is a very probability of ending long-term hydrological drought during the next six months. The highest probabilities for drought relief during the next six months are in southern and central New Mexico climate divisions and in southwestern Arizona.

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 August 2002); Source: USDA NRCS

Table 6.

	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	528	814	1122	2335	23	35	48	47	65
Verde River Basin System	70	164	136	310	23	53	44	52	43
San Francisco - Upper Gila River Basin									
San Carlos	45	113	316	875	5	13	36	14	40
Painted Rock Dam	0	0	25	2492	0	0	1	0	0
Total of 2 Reservoirs	45	113	342	3367	1	3	10	13	40
Little Colorado River Basin									
Lyman Reservoir	1	6	12	30	4	21	39	9	18
Show Low Lake	2	3	3	5	39	65	51	77	61
Total of 2 Reservoirs	3	10	14	35	9	27	41	22	33
Northwestern Arizona									
Lake Havasu	560	582	580	619	90	94	94	96	96
Lake Mohave	1698	1669	1559	1810	94	92	86	109	102
Lake Mead	17209	20137	21645	26159	66	77	83	80	85
Lake Powell	14569	19321	20367	24322	60	79	84	72	75
Total of 4 Reservoirs	34036	41708	44151	52910	64	79	83	77	82

* 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 August as of 9/10/02.

Highlights: Reservoir levels in Arizona continue to be below average and significantly lower than last year at this time. Overall reservoir levels decreased during the last month and will not begin to increase until we see fall precipitation begin. Restrictions on water use have been in place for many municipalities in the Southwest, but some places are beginning to reduce restrictions. Flagstaff has been at level 3 restrictions since late June. As of September 23rd the city had reduced consumption levels below 'safe' levels for more than 14 consecutive days, triggering a lessening of water restrictions from level 3 to level 2 restrictions (on a scale up to level 5). At only 9.6 percent of capacity, Lake Mary is Flagstaff's only surface water source for municipal use.

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

Table 7.

	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)	18	72	191	254	7	28	75	9	25
Pecos River Basin									
Lake Avalon	2	1	1	6	25	20	23	107	125
Brantley	9	9	23	148	6	6	16	37	100
Santa Rosa	5	12	59	447	1	3	13	8	40
Sumner	0	1	28	102	0	1	27	1	29
Total of 4 Reservoirs	16	24	112	703	2	3	16	14	66
Rio Grande Basin									
Abiquiu	57	122	133	555	10	22	24	43	47
Caballo	28	45	81	332	9	14	24	35	62
Cochiti	49	49	59	502	10	10	12	83	101
Costilla	1	5	4	16	4	31	25	15	12
El Vado	11	142	114	186	6	76	61	10	8
Elephant Butte	351	879	1213	2065	17	43	59	29	40
Heron	169	341	318	400	42	85	80	53	50
Total of 7 Reservoirs	666	1583	1923	4056	16	39	47	35	42
San Juan River Basin (Navajo Reservoir)	917	1449	1388	1696	54	85	82	66	63

*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 August as of 9/10/02.

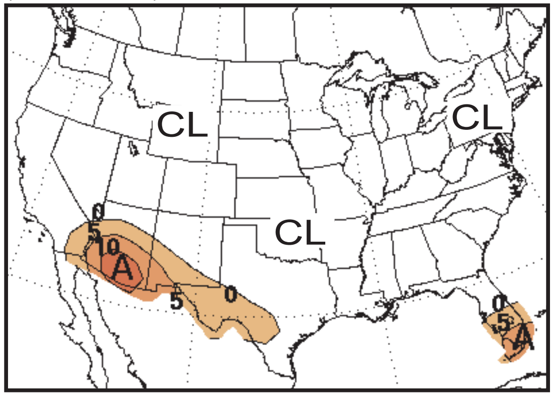
Highlights: Reservoir levels in New Mexico continue to be below last year's levels for this time of year and significantly below average levels. The Pecos river reservoir system is currently at less than 2% of capacity and less than 13% of average levels for this time of year. The Rio Grande river reservoir system is currently at about one third of average levels for this time of year. As a result of such low levels, portions of the Rio Grande have or are expected to run dry. Recently, lawsuits were filed under the Federal Endangered Species Act (ESA) by environmental groups in Albuquerque to release water in the Rio Grande to sufficiently protect the endangered silvery minnow. Despite the view of the Fish and Wildlife Service that the water should be saved for next year's minnow population and the likelihood of the Middle Rio Grande Conservancy District being unable to meet all of its current water demands, a federal judge upheld the ESA and ruled in favor of the environmental groups on September 18, 2002.

Section C

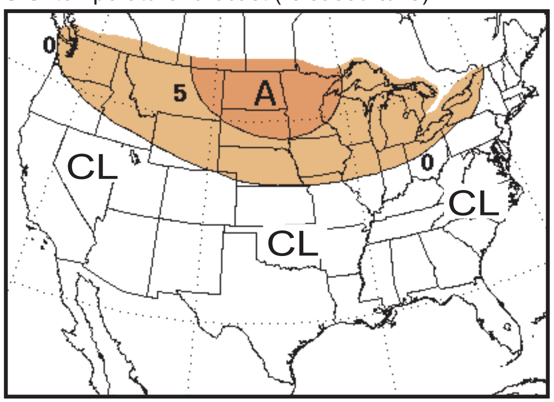
FORECASTS

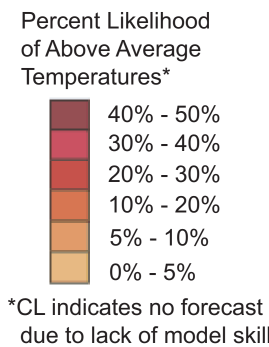
8. Temperature Outlooks: Monthly (Oct.) and 3-Month (Oct.-Dec. 2002); Source: NOAA CPC

8a. October 2002 U.S. temperature forecast (released 9/19).



8b. October - December 2002 U.S. temperature forecast (released 9/18).





Highlights: The CPC temperature outlook for October (Figure 8a) shows increased probabilities of above average temperatures in our region (centered on Arizona). 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. For the next three months (October-December), the outlook indicates increased probabilities of above average temperatures for northern areas of the United States. (Figure 8b). While no forecast ('CL') is made for the Southwest for October through December, this is no assurance that above average temperatures will diminish or that average temperatures are most likely. These predictions are based chiefly on long-term temperature trends in our region, along with results of statistical models. The next NOAA CPC climate outlook is scheduled to be released on Thursday, October 17, 2002.

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 (A), average, and below average (B) 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.

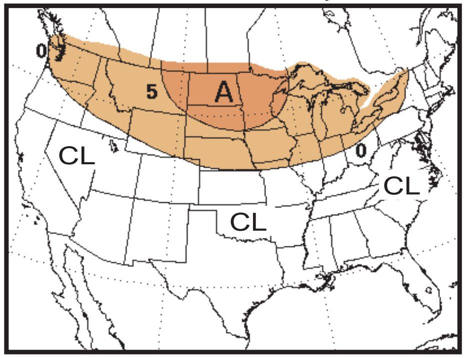
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

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

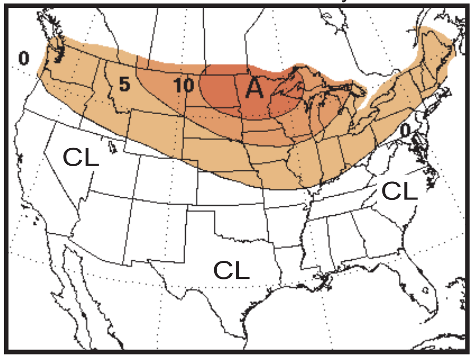
9. Temperature Outlooks: Multi-season; Source: NOAA Climate Prediction Center

Overlapping 3-month long-lead temperature forecasts (released 9/19/02).

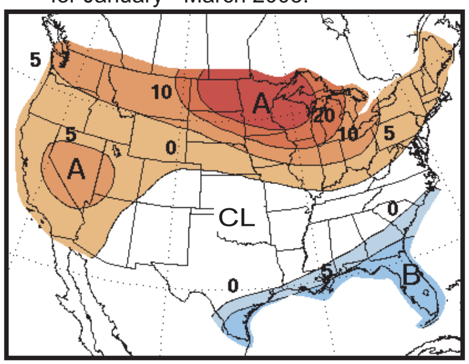
9a. Long-lead national temperature forecast for November 2002- January 2003.



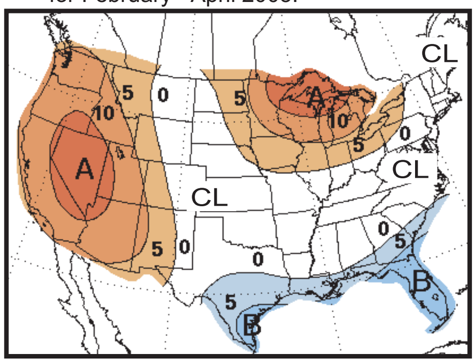
9b. Long-lead national temperature forecast for December 2002 - February 2003.



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



9d. Long-lead national temperature forecast for February - April 2003.



Percent Likelihood of Above/ Below Average Temperatures*

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

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

*CL indicates no forecast due to lack of model skill

Highlights: The CPC temperature outlooks for November 2002-April 2003 show increased probabilities of above average temperatures for the northern United States in in the fall and early winter (Figures 9a-b) but no forecast for the Southwest. The area of increasingly probable above average temperatures expands into much of the western United States as the winter progresses (Figure 9c). Increased probability of above average temperature returns to Arizona and New Mexico in the winter and early spring (Figures 9c-d). No prediction (“CL”) is offered for the Southwest until January and even into February for New Mexico. 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. The next NOAA CPC climate outlook is scheduled to be released on Thursday, October 17, 2002.

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 (A), average, and below average (B) 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.

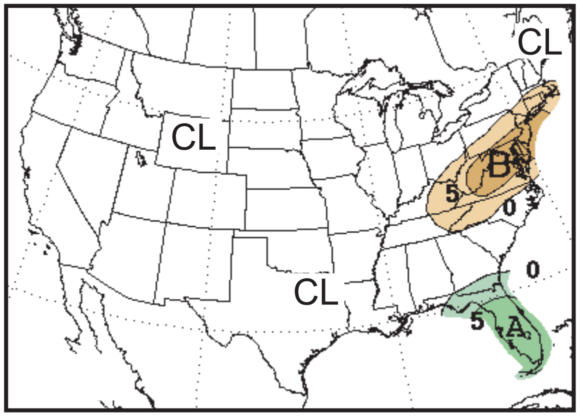
Thus, using the NOAA CPC excess likelihood forecast, in areas with light brown shading (0-5% excess likelihood of above average) there is a 33.3-38.3% chance of above average, a 33.3% chance of average, and a 28.3-33.3% chance of below average temperature.

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

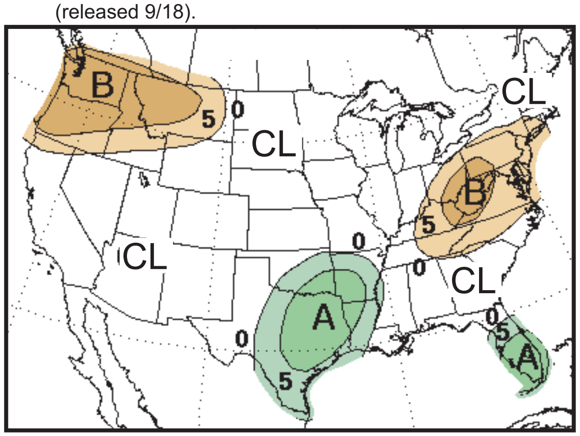
Climatology (CL) indicates areas where reliability (i.e., the ‘skill’) of the forecast is poor and no prediction is offered.

10. Precipitation Outlooks: Monthly (Oct.) and 3-Month (Oct.-Dec. 2002); Source: NOAA CPC

10a. October 2002 national precipitation forecast (released 9/18).



10b. October - December 2002 national precipitation forecast (released 9/18).



Percent Likelihood of Above or Below Average Precipitation*

10% - 20%		
5% - 10%	Above	
0% - 5%		
0% - 5%		
5% - 10%	Below	
10% - 20%		

*CL indicates no forecast due to lack of model skill

Highlights: The CPC has reserved judgment (i.e., CL or "Climatology") regarding both October and October-December precipitation in Arizona and New Mexico (Figures 10a-b). The lack of forecast certainty during the 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 seasonal shifts in the jet-stream track. While the effects of a moderate El Niño on the southwest United States are uncertain (CL) for both figures, the increase in the probability of below-average precipitation for the northwest United States, related to El Niño effects in that region, is indicated (Figure 10b). These forecasts are based on a combination of factors, including the results of statistical models, moderate El Niño conditions, and long-term trends. The next NOAA CPC climate outlook is scheduled to be released on Thursday, October 17, 2002.

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 (A), average, and below average (B) 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.

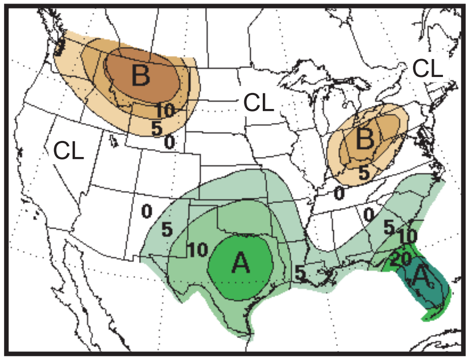
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

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

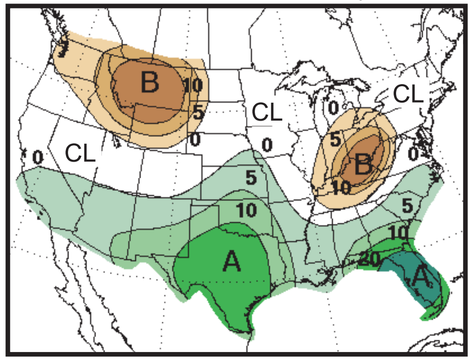
11. Precipitation Outlooks: Multi-season; Source: NOAA Climate Prediction Center

Overlapping 3-month long-lead precipitation forcasts (released 9/18/02).

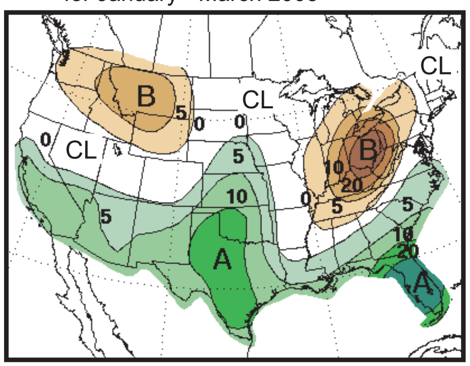
11a. Long-lead national precipitation forecast for November 2002 - January 2003.



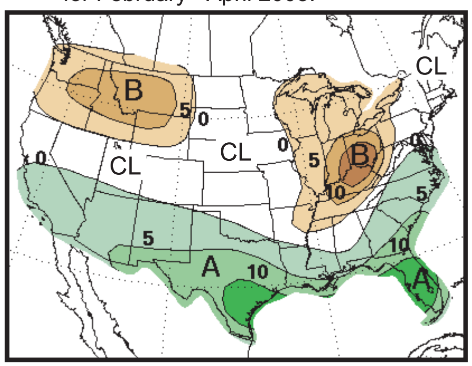
11b. Long-lead national precipitation forecast for December 2002 - February 2003.



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



11d. Long-lead national precipitation forecast for February - April 2003.



Percent Likelihood of Above or Below Average Precipitation*

- 10% - 20% Above
- 5% - 10% Above
- 0% - 5% Above
- 0% - 5% Below
- 5% - 10% Below
- 10% - 20% Below

*CL indicates no forecast due to lack of model skill

Highlights: The effects of a moderate El Niño are indicated by the increased probability of above-average precipitation in the southern United States. The greatest confidence in these predictions is centered over central Texas. Relatively small shifts in the probability of above-average precipitation expand into Arizona, New Mexico and California as the winter progresses (Figures 11a-c) and remain into early spring (Figure 11d). 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. The next NOAA CPC climate outlook is scheduled to be released on Thursday, October 17, 2002.

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 (A), average, and below average (B) 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.

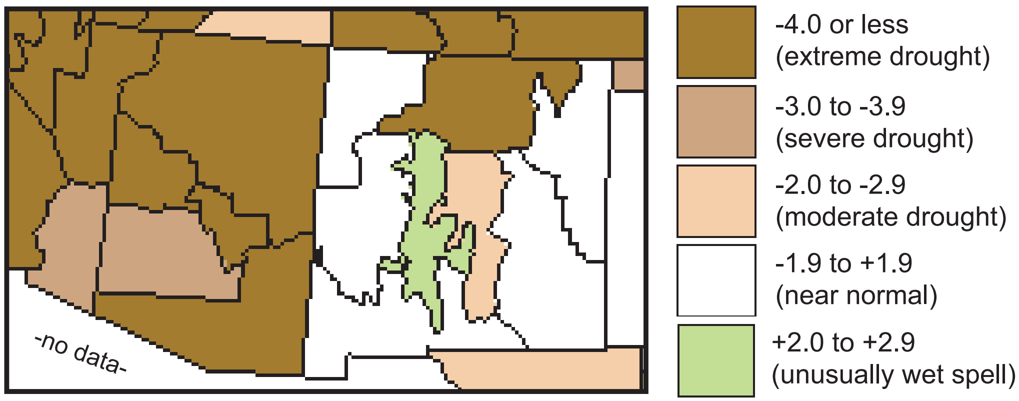
Thus, using the NOAA CPC excess likelihood forecast, in areas with light green shading (0-5% excess likelihood of above average) there is a 33.3-38.3% chance of above average, a 33.3% chance of average, and a 28.3-33.3% chance of below average precipitation.

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

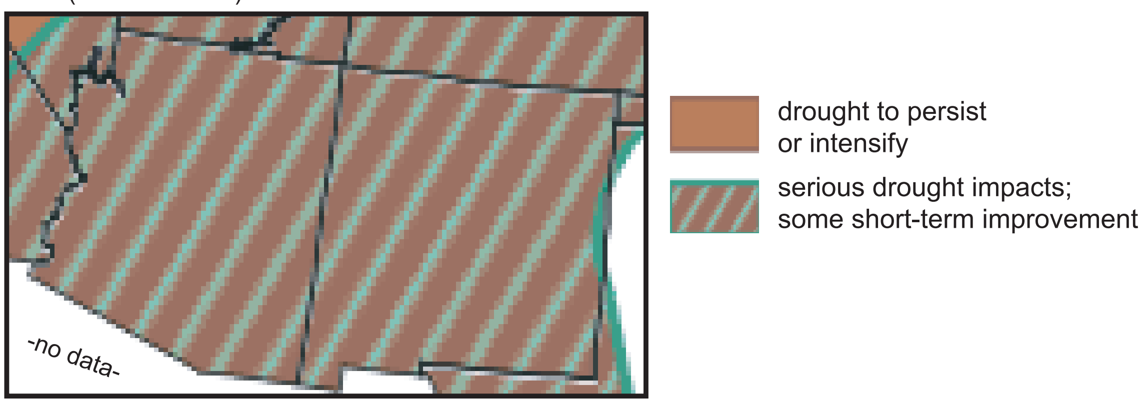
Climatology (CL) indicates areas where reliability (i.e., the 'skill') of the forecast is poor and no prediction is offered.

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

12a. Short-term Palmer Drought Severity Index (PDSI) forecast through 9/21/02 (accessed 9/19).



12b. Seasonal drought outlook through December 2002 (accessed 9/19).



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

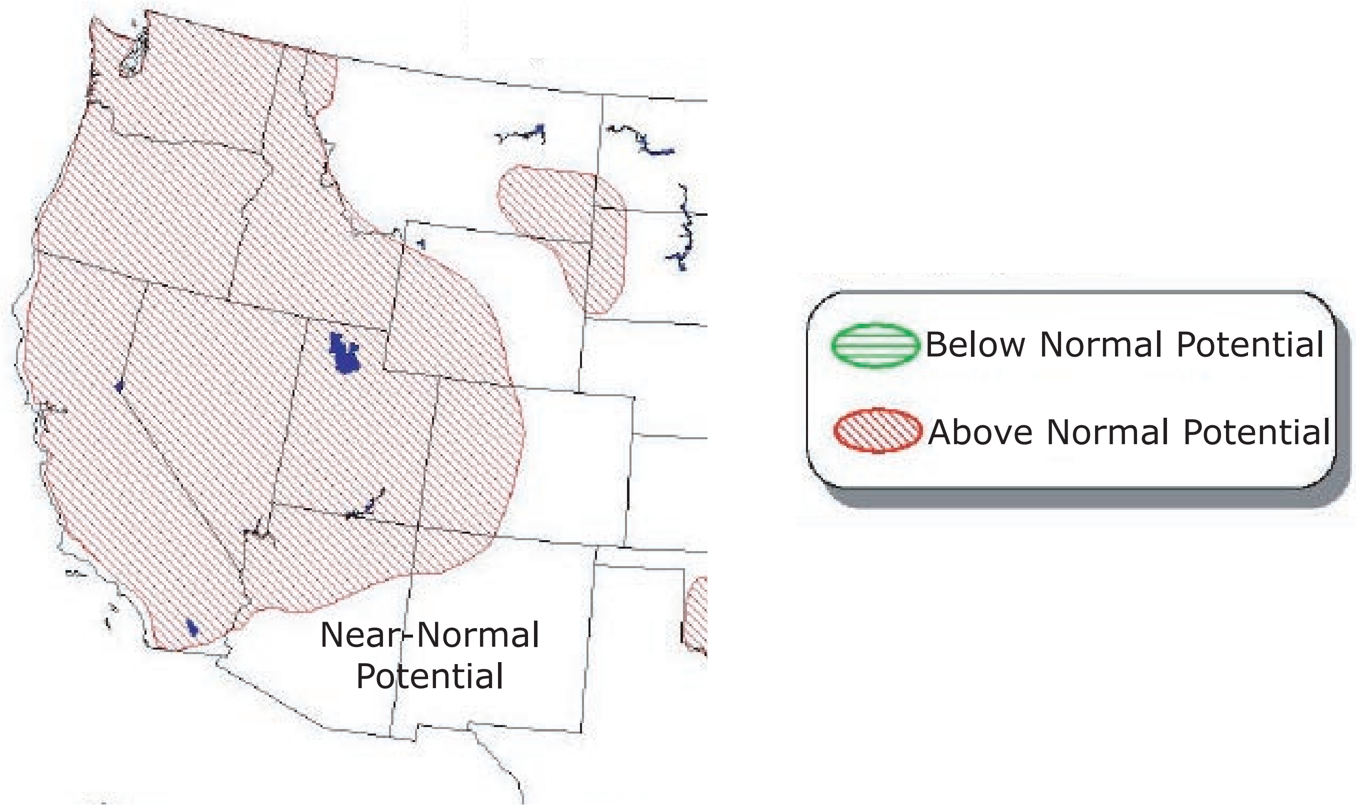
'Normal' on the PDSI scale is defined as amounts of moisture that reflect long-term climate expectations.

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.

Highlights: The short-term PDSI forecast (Figure 12a) indicates extreme to severe drought conditions for all of Arizona and some parts of New Mexico, although much of New Mexico is at near normal conditions for this time of year (except northern central New Mexico). The Rio Grande basin in central New Mexico received good summer rains and is unusually wet by PDSI standards (Figure 12a). However, the PDSI responds to relatively short-term conditions (meteorological drought) and does not consider persistent effects such as those related to slowly varying resources like water supply. The seasonal drought outlook (Figure 12b) reflects the relief brought on by summer precipitation and expectations of enhanced precipitation in the Southwest due to El Niño this late fall and winter. Long-term drought conditions are likely to persist, as much of the Southwest is many inches below average precipitation for the calendar year.

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

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

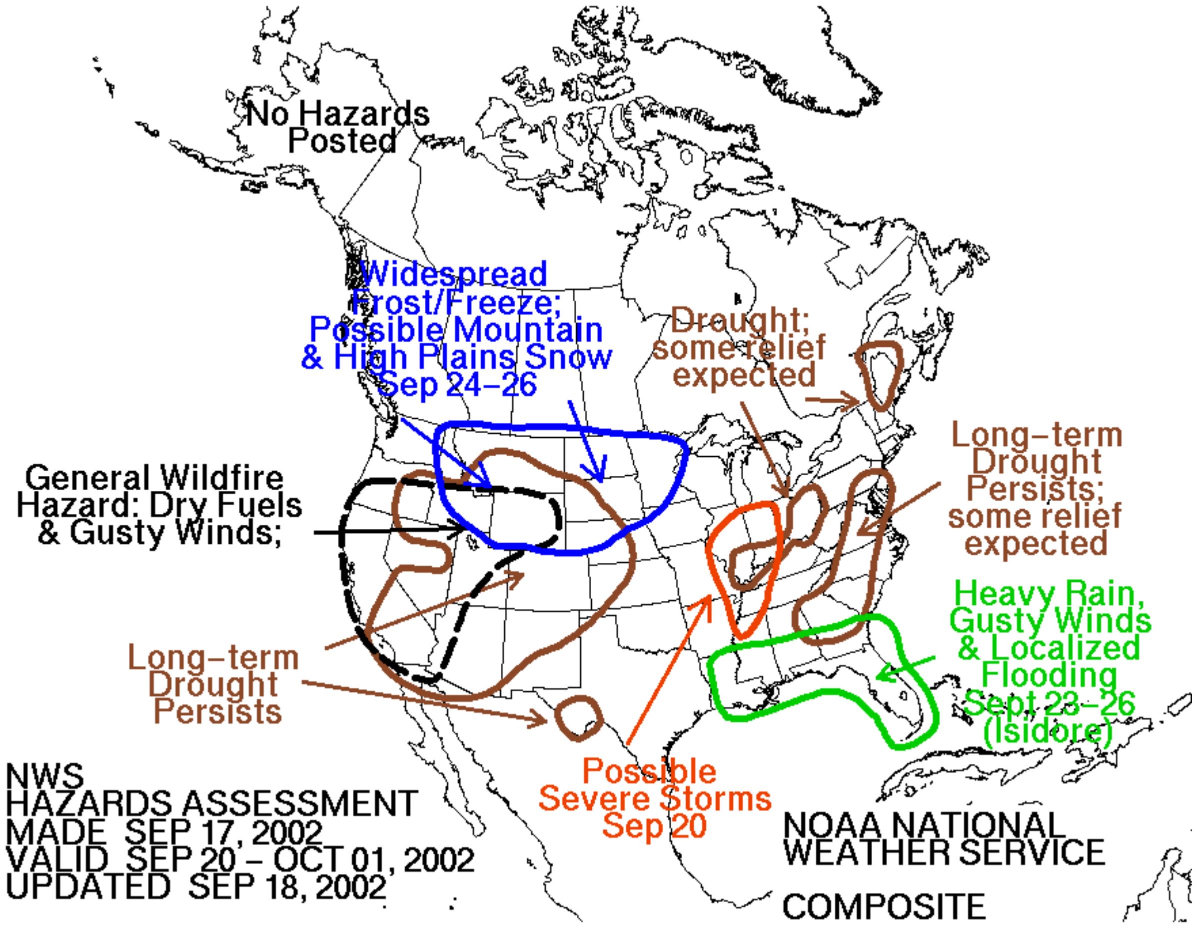


Notes: The National Wildland Fire Outlook (Figure 13) considers climate forecasts and surface fuels conditions to assess fire potentials. It is issued monthly by the National Interagency Fire Center.

Highlights: The high fire danger exhibited in the Southwest during the early summer months diminished with summer precipitation and increased humidity and continues to be near-normal for this time of year as summer precipitation fades. According to the Southwest Coordination Center, weather conditions have allowed fire management agencies to resume prescribed burning throughout the Southwest. However, below-average summer precipitation totals in the northwestern part of our region might cause a reinstatement of fire restrictions and possible forest closures. To date, 955,642 acres have burned on public lands this year in Arizona and New Mexico (including reservation lands).

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 September 20 – October 1, 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.

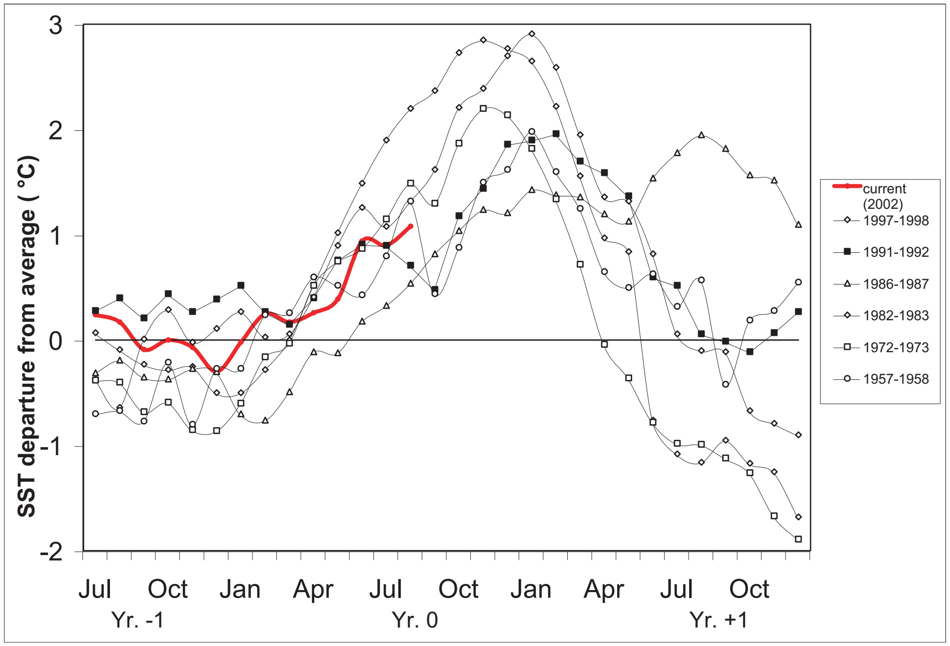
Influences such as complex topography may warrant modified local interpretations of hazards assessments.

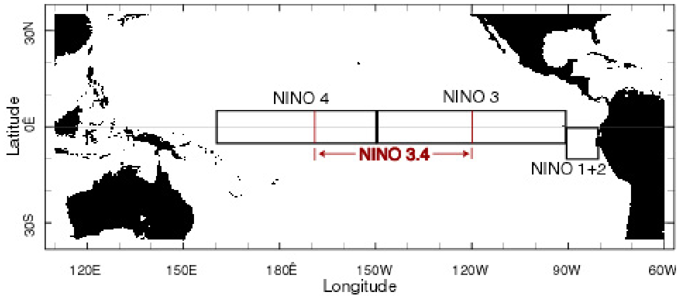
Please consult local National Weather Service offices for short-range forecasts and region-specific information.

Highlights: The U.S. Hazards Assessment indicates long-term, persistent drought for Arizona and all but the southeastern corner of New Mexico. Although recent rains have helped to ease the threat of fire across much of the Southwest, high fire danger is expected for western Arizona. Westerly wind shear (often associated with El Niño) is expected to inhibit the development of high-intensity tropical storms.

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





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 black 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 September 17, the International Research Institute for Climate Prediction (IRI) updated their El Niño assessment. They conclude that there is a nearly 100% probability that El Niño conditions will continue for the remainder of 2002 and into early 2003. Substantially warmer than average SSTs in the equatorial Pacific are likely to continue for the next two to three seasons; thus, IRI has upgraded the probable magnitude of this El Niño to *moderate*. The NOAA Climate Prediction Center (CPC) noted that atmospheric indicators of El Niño, including a weakening of equatorial Pacific easterly winds and dry conditions in the west Pacific, have been present during past month. Both the IRI and CPC caution that the effects of this El Niño event are expected to be weaker than those associated with the 1997-98 El Niño, though strong impacts are possible in some locations .

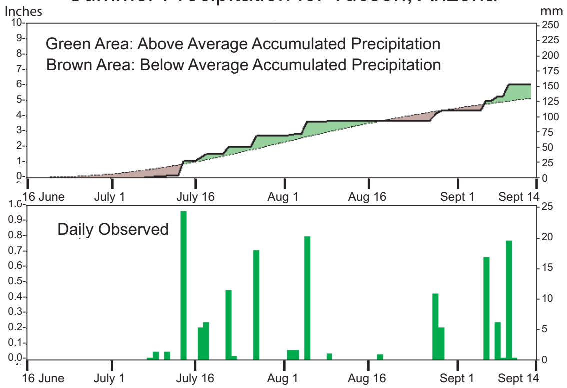
For a technical discussion of current El Niño conditions, visit http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/
For more information about El Niño and the graphics found on this page, visit http://iri.columbia.edu/climate/ENSO/

Section D

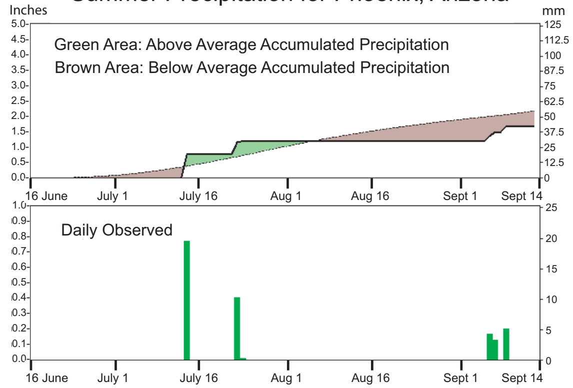
FOCUS ON SUMMER RAIN, FLOODS, AND FORECASTS

16. Southwest U.S. Summer Precipitation Summary (6/16/02 – 9/14/02)
Source: NOAA Climate Prediction Center

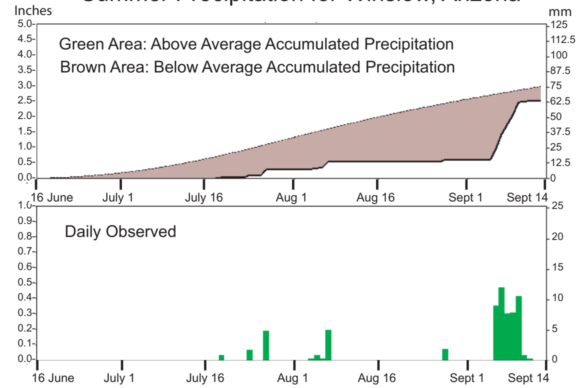
Summer Precipitation for Tucson, Arizona



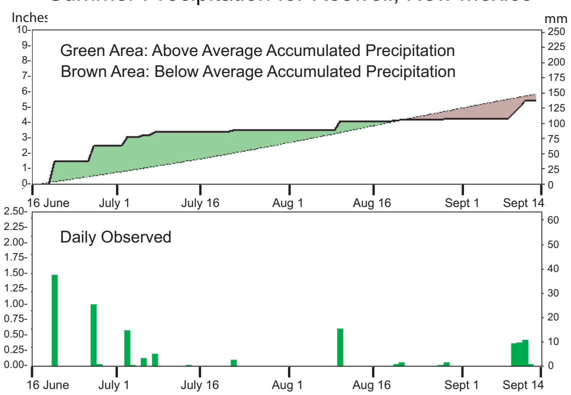
Summer Precipitation for Phoenix, Arizona



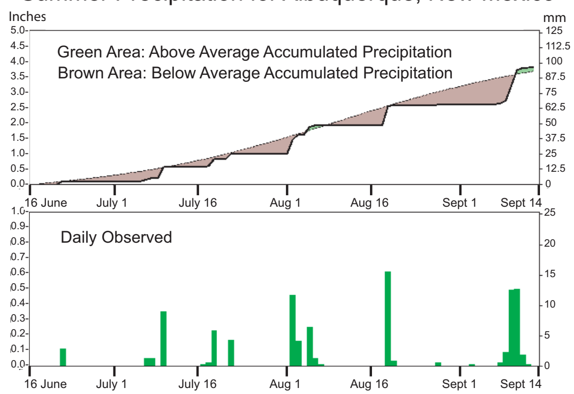
Summer Precipitation for Winslow, Arizona



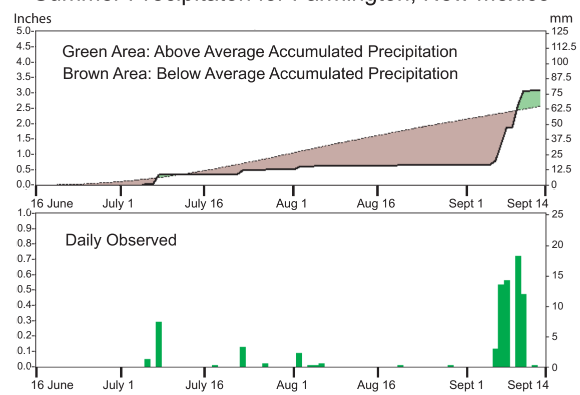
Summer Precipitation for Roswell, New Mexico



Summer Precipitation for Albuquerque, New Mexico



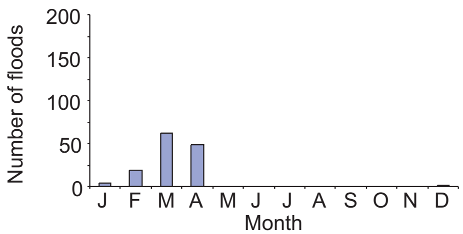
Summer Precipitaton for Farmington, New Mexico



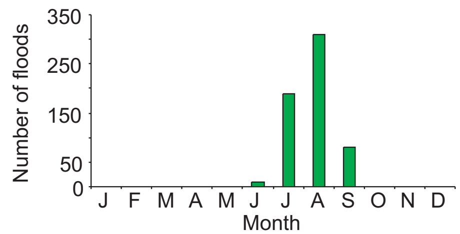
Highlights: These figures illustrate the spatial variability in this past summer's daily precipitation in Arizona and New Mexico. In Arizona, Tucson (and much of southeast Arizona) received above-average precipitation for the period while Phoenix and Winslow (as well as much of northern Arizona) received below-average precipitation. Added to this contrast is the greater number of precipitation events in Tucson vs. the more spotty occurrence of precipitation for other areas. In New Mexico, precipitation totals were above average in Roswell early on but diminished as the summer progressed. Albuquerque received slightly above-average precipitation for the period but rarely exhibited above-average totals for any time during the summer. Farmington (and much of the Four Corners area) lacked any significant rainfall until early September, when approximately 2.5 inches of rain fell in a few days. While the majority of the precipitation events indicated in the figures can be attributed to the North American monsoon, the precipitation 'episode' that occurred in early September (evident in all the figures) was the result of a combination of monsoon moisture, large-scale synoptic patterns, and moisture from a nearby Pacific tropical storm. The intensity and short duration of the precipitation in early September was not sufficient to lessen the severity of long-term drought for the areas with greatest summer precipitation deficits (i.e., northern Arizona and New Mexico).

17. Floods in the Southwest

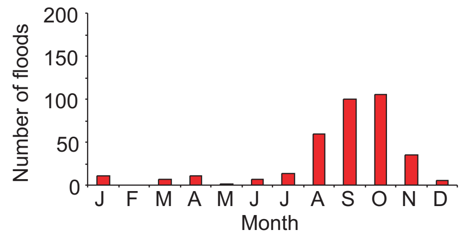
17a. Total number of floods per month associated with snowmelt.



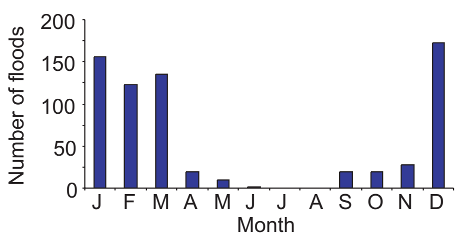
17b. Total number of floods per month associated with local monsoon storms.



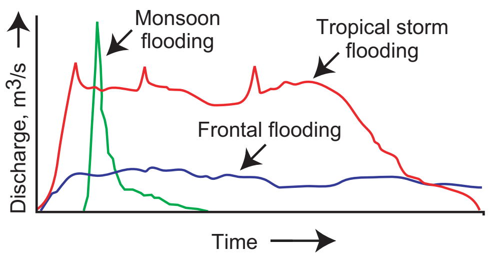
17c. Total number of floods per month associated with tropical storms and/or cutoff lows.



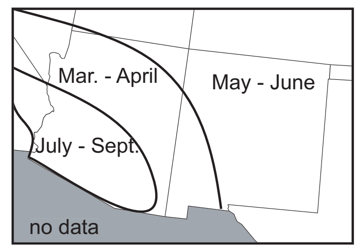
17d. Total number of floods per month associated with frontal storms.



17e. Influence of storm type on magnitude and duration of flooding.



17f. Typical timing of regional flooding in the Southwest.



Highlights: Taken together, these graphs illustrate the tremendous variability in the timing, duration, and weather phenomena associated with floods in the Southwest. Flood peaks can occur in any month, but in much of the Southwest, floods are concentrated in two seasons: winter/early spring and summer/early fall. The Southwest experiences flooding due to several types of mechanisms: summer convective storms of the monsoon season, tropical storms, winter storms and their associated fronts, snowmelt, and the persistence of precipitation related to cutoff lows. These mechanisms may operate alone or in combination and determine sub-regional differences in the flooding regimes of the Southwest (Figure 17f). In summer, flood peaks are produced by convective thunderstorm rainfall associated with the summer monsoon season (Figure 17b). These storms are characterized by high intensity rainfall that runs off the landscape rapidly leading to extreme but short-lived flood peaks (e.g., "flash floods;" Figure 17e). Flooding in summer typically is more localized than winter flood events, but under certain conditions, widespread summer flooding can occur. Floods associated with winter and spring frontal precipitation also can occur throughout the Southwest (Figures 17d and 17e) but are more frequent where watersheds encompass higher elevation areas and in more northerly locations closer to typical mid-latitude storm tracks. Floods associated with tropical storms are infrequent events that are more likely to occur in the southern and southwestern parts of the Southwest (Figures 17c-d). The largest floods of all usually are associated with some type of atmospheric circulation pattern or mechanism that slows or stalls rain-producing storms so that precipitation falls for an extended time. Slow-moving winter storms and areas of tropical storm moisture often are associated with upper-level atmospheric circulations called cutoff lows, which may persist for several days in approximately the same location. Cutoff lows are most likely to affect the Southwest in spring, fall, and winter (Figure 17c).

Notes:

Figures 17a-d on this page are based on data from the Gila River Basin for the period 1950-1980.

For more information about floods, peaks-above-base flows, and the impacts of flooding in the Southwest, please see the article on flooding in the Newsletter.

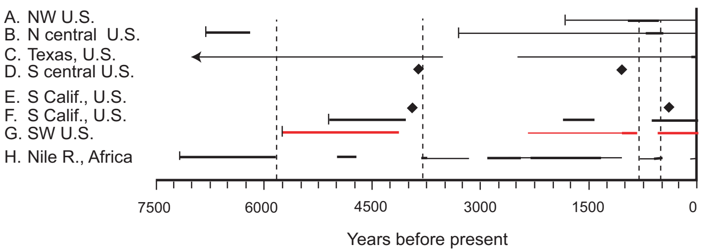
All of the figures depicting flood information on this page are based on analyses of “peaks-above-base” recorded at USGS gauging stations in Arizona and New Mexico.

Figures 17a-f and much of the text are provided courtesy of Katie Hirschboeck, Laboratory of Tree-Ring Research, The University of Arizona, and are based on her research.

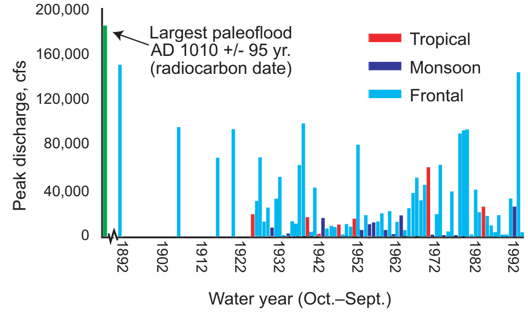
For more information about climate and flooding in the Southwest, visit: http://geochange.er.usgs.gov/sw /changes/natural /floods/

18. Paleoflooding in the Southwest

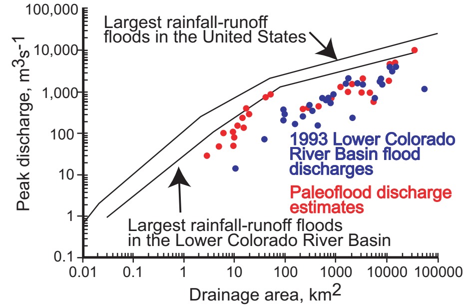
18a. Paleoflood episodes in different regions (Hirschboeck et al., 2000).



18b. Floods on the Verde River below Tangle Creek by hydroclimatological type.



18c. Comparison of paleoflood and recent flood discharges for the Lower Colorado River Basin (House and Hirschboeck, 1997).



Notes:

Discharge (the volume of water that flows in a given period of time) commonly is measured in cubic feet per second (cfs) or cubic meters per second (m^3s^{-1}). One m^3s^{-1} equals about 35 cfs.

In Figure 18a, time is shown as years before present (with "present" = 1950). The solid heavy lines indicate periods of frequent large paleofloods; the solid thin lines indicate periods of moderate-size paleofloods, the diamonds indicate evidence of a single paleoflood, and blank areas indicate periods with few or no paleofloods. The vertical dashed lines mark times of major changes in the long historical record of the Nile River, which typically does *not* flood during strong El Niño years, making the Nile River useful for comparison.

Figures 18a-c and much of the text are provided courtesy of Katie Hirshboeck, Laboratory of Tree-Ring Research, The University of Arizona, and are based on her studies combined with those of many other paleoflood researchers. Please see our website for the full references for the figures and please see the article on flooding in the Newsletter for information on paleofloods and paleoflood evidence.

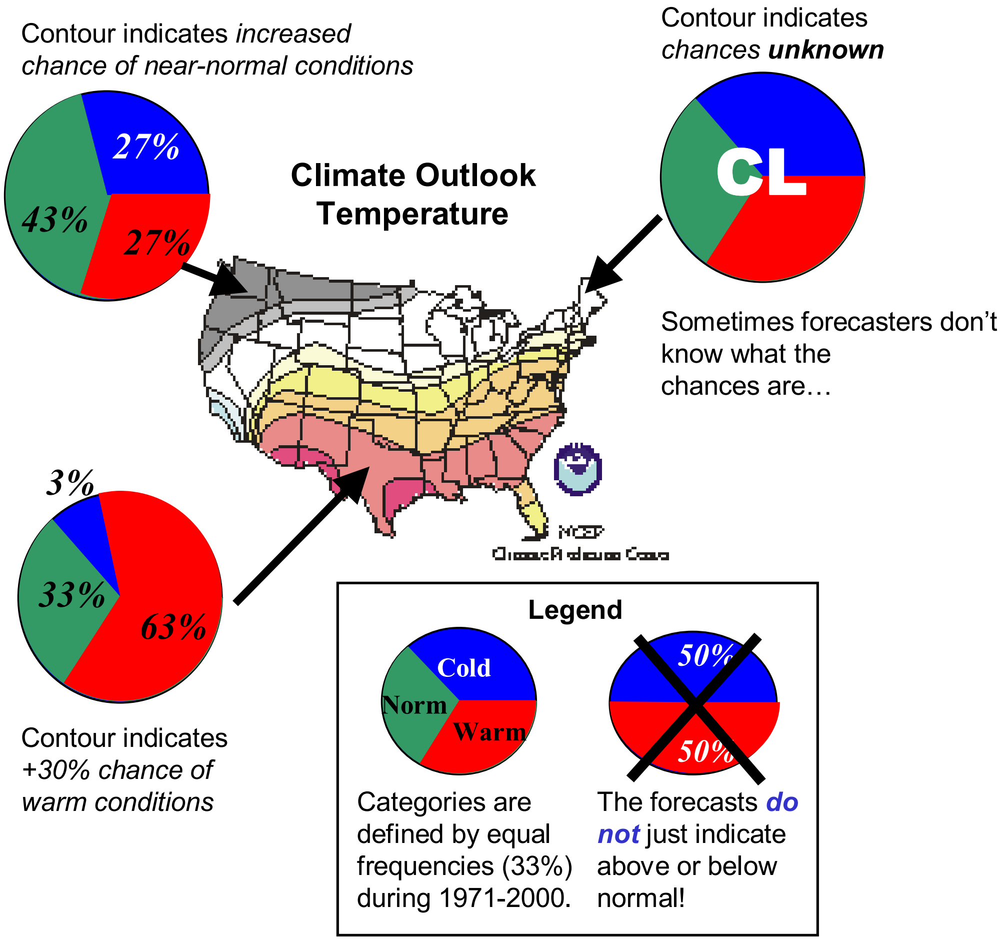
Please note that the axes in Figure 18c are scaled logarithmically (i.e., nonlinearly).

Highlights:

A comparison of paleoflood evidence from several different parts of the world suggests that past flooding episodes have not always occurred at the same time globally, or even within the boundaries of the United States (Figure 18a). Some regions, however, *have* experienced synchronous flooding over roughly the same time period (e.g., southern California, the Southwest). The comparison with the ancient Nile River flood record suggests a possible link between strong El Niño years and paleoflood clusters in the Southwest (see Notes).

A comparison between the paleoflood record and the gauged flood record allows us to evaluate whether or not flooding during the last 50–100 years in the Southwest differs significantly from that of the past. In winter 1993, extreme flood peaks occurred in the Lower Colorado River Basin that were unprecedented in the gauged records of many watersheds of the Southwest (even in the almost century-long record of the Verde River Basin in Arizona, Figure 18b). A regional study comparing the 1993 floods with paleoflood evidence from basins of different drainage areas indicates that the 1993 floods were comparable in magnitude to some of the largest paleofloods that have occurred in mid- to large-size drainage basins (Figure 18c), suggesting that conditions have been similar in the past.

19. Interpreting the NOAA CPC Climate Outlooks: Changes in Probability



Highlights: The CPC climate outlook maps (above) give the forecast as a probability anomaly for only the most likely category. Each category has a base probability of 33%, so the anomaly is added to 33% for the indicated category and subtracted for the opposite one. The probability for near-normal changes only if the anomaly is really big. For example, there is a 33% base probability of warm conditions, but in the figure above, central Texas has an *additional* 30% chance of warm conditions; therefore a 63% chance of warm conditions.

CPC forecasts are available at http://www.cpc.noaa.gov/products/predictions/90day/
For more information about seasonal climate forecasts, including their historical performance, contact CLIMAS researcher Holly Hartmann at 520-626-8523 or hollyh@hwr.arizona.edu

Notes:
Weather forecasts track the movement and evolution of specific air masses over short periods of time (minutes to several days). Climate forecasts make statements about average or cumulative conditions, rather than specific events, anticipated to occur over an extended period of time (one month to over a year).

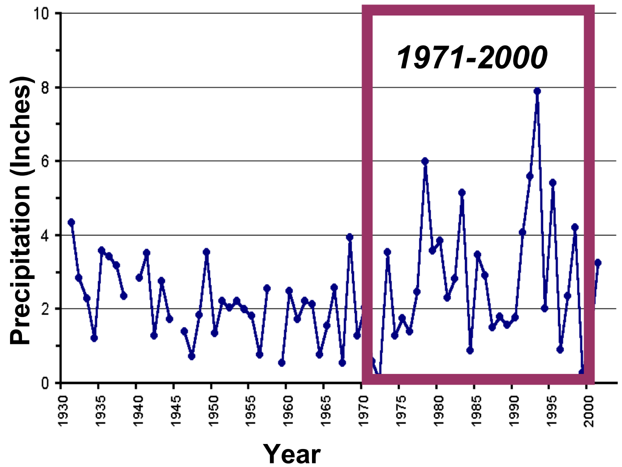
Each month, CPC forecasters make a new set of forecasts. The forecasts are created by combining results from several scientific techniques, including statistical analysis of long-term trends, statistical comparison of similar past situations, and computer simulations with global climate models. A large group of climate experts meets to assess recent conditions and discuss findings from recent research. Then 4 or 5 lead forecasters prepare the final product, using their expert judgement to decide how to combine results from all the scientific techniques.

Some forecast situations are more difficult than others. Occasionally there can be disagreement among results from different forecast techniques; or the ability to accurately predict the climate of a certain region may not yet exist. When the CPC forecasters don't know what will happen, they indicate complete uncertainty by using "*CL*" or "*Climatology*" on their map and in their legend. This ***does not*** mean that conditions will be normal. There is simply no forecast.

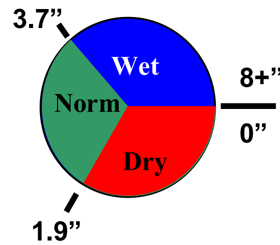
Climate is a chaotic system. Even if you know what the conditions are like right now, the interactions are so complex that the future conditions can develop in a variety of ways, some of which are unexpected. In addition, forecasters realize there is still much to learn about how our climate behaves. Therefore, the NOAA CPC climate outlooks are expressed as a probability, or chance, that something will happen. This means there is also a chance, usually significant, that the condition being forecast will not happen!

20. Interpreting NOAA CPC Climate Outlooks: What is Normal?

Willcox, AZ January-March
Total Precipitation 1930-2001

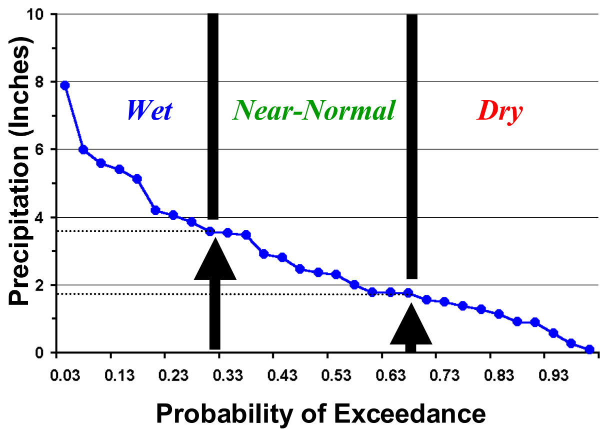


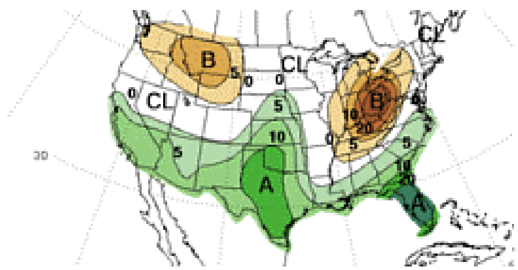
Normal chances are based only on 30 years of data.



The data are ranked and divided into three categories of equal probability, with 10 years in each category.
10 years had more than 3.7"
10 years had less than 1.9"
10 years were in the middle

Willcox, AZ January-March
Total Precipitation 1971-2000





The above CPC climate outlook map shows the forecast for January-March 2003 (issued in September 2002). Willcox, in southeastern Arizona, has an additional 10% chance of wet conditions (i.e., greater than 3.7" of precipitation), or 43% chance of wet conditions. The probability of near-normal precipitation, however, does not change.

CPC forecasts are available at http://www.cpc.noaa.gov/products/predictions/90day/
For more information about seasonal climate forecasts, including their historical performance, contact Holly Hartmann at 520-626-8523 or hollyh@hwr.arizona.edu

Notes:
CPC climate forecasts show the chance of conditions falling into three different categories: *Above, Near Normal,* and *Below.* The categories are not defined by all of the past, but only by a specific 30-year period: 1971-2000. Each category has a base probability of 33%.

Precipitation
Above. Total precipitation will be something like the 10 wettest years in the 30-year period.
Near Normal. Total precipitation will be something like the 10 middle years in the 30-year period.
Below: Total precipitation will be something like the 10 driest years in the 30-year period.

Temperature
Above. Average temperatures will be something like the 10 warmest years in the 30-year period.
Near Normal. Average temperatures will be something like the 10 middle years in the 30-year period.
Below: Average temperatures will be something like the 10 coldest years in the 30-year period.

The graph (left, top) shows 1971-2000 precipitation for Willcox, Arizona. Note that this 30-year period is wetter overall than the period 1941-1970. Another graph (left, bottom) shows how Willcox 1971-2000 precipitation breaks down into probability categories. There is a relatively low probability (less than 33%) of exceeding precipitation during the wettest 10 years, and a relatively high probability (greater than 66%) of exceeding the driest 10 years.

The pie chart (top, right) shows the precipitation associated with the 3 probability categories. Note that while the probability of precipitation in each historical category is 33%, dry and normal refer to narrow ranges of precipitation (dry = 0.00-1.89"; norm = 1.90-3.69"), whereas wet refers to any precipitation greater than 3.70" (up to 8" in the historical record).