Institute for the
Study of Planet Earth

THE UNIVERSITY OF
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July 22, 2002

Dear Participant,

Welcome to the END InSight, (El Niño/Drought) Initiative, sponsored by the Climate Assessment for the Southwest (CLIMAS) project at the University of Arizona! We greatly appreciate your participation, and hope that the project will provide you with informative and usable climate information. This letter gives an overview of the initiative, and describes the contents of this month's packet. It also provides a preview of what to expect over the coming year.

The END InSight Initiative

The primary goal of the END InSight Initiative is to develop a better understanding of climate information needs and uses in the U.S. Southwest, and to use this understanding to improve the availability, content, format, and style of such information. Your participation in this initiative will assist us in serving, through focused research and outreach, the needs of our constituents throughout the region. We are partnering with colleagues at places like the Climate Diagnostics Center, Western Regional Climate Center, National Weather Service, Climate Prediction Center, and others to assemble monthly packets of climate information.

Some of the packet contents will change from one month to another, but will generally include background explanations of weather and climate phenomena, summaries of recent conditions, forecasts of various types, and historical information regarding the effects of past droughts and El Niño events. We do not anticipate that you will be interested in every item we provide; however, by providing an array of different kinds of information, we hope to broaden participants' awareness of the range of products available, and to address the specific needs of different interests. To make it easier to find individual informational products, each item will be labeled, numbered, and organized into sections. We will include a table of contents with each packet so that you can more easily home in on the information that most interests you. Complete information will also be made available on our website (http://www.ispe.arizona.edu/climas/forecasts/swoutlook.html).

Along with each packet, you will receive a brief questionnaire asking a few general questions, and a chart on which we ask that you evaluate the specific products included. A self-addressed, postage-paid envelope will be provided so that you can mail your questionnaires and evaluations back to us. You have the option of completing the survey by telephone, if you prefer. Simply contact us to schedule a mutually convenient time.

In either case, if we do not hear from you within 10 days, we will follow up with a telephone call to see if we can be of assistance. Occasions may also arise when we may need to contact you to clarify or obtain more information about particular responses. Rest assured, however, that we are cognizant of your busy schedules and will keep the amount of telephone follow-up to a minimum.

This Month's Packet

This month's packet includes a one-time background questionnaire, as well as the evaluation forms you will be filling out each month. The initial survey provides us with essential information we need in order to establish a baseline against which to measure the success of our initiative. This information will also help us to plan the most efficient way of meeting your information needs.

Please return the survey materials within the next 10 days, so that we can identify modifications we may wish to make in the materials we plan to provide you in the next monthly packet.

The July 2002 packet contains various types of temperature and precipitation reports and forecasts, as well as information to better understand the current drought. Although stream flow forecasts are not produced for this region in mid-summer, we are including the most recent stream flow outlook, as well as the best reservoir level data available. While we anticipate that you will spend most of your time assessing the products that are most relevant to your operation, we encourage you to browse all the items in the packet and to give us your assessment of each one, even if it is "neither useful nor interesting." This helps us understand which particular types of information you are most interested in. We include a broad range of weather and climate information in the hope that there will be something useful to everyone.

Over the next year, we will also be featuring information on topics of particular interest and/or reflecting emerging trends, newly available information, etc. This month's featured topic is the drought: When did it begin? What is causing it? And perhaps most importantly, when is it likely to end? We include historical information on droughts in the Lower Colorado and Rio Grande, so that you may compare the current situation with past droughts. You will also find a summary of what causes El Niño events, and a review of the impacts that this phenomenon has had on the Southwest in the past. We explain how the event predicted for this fall and winter is likely to interact with the current drought conditions. A final section summarizes the state of the science of monsoon forecasting, along with up-to-date predictions of how this year's summer rainy season is shaping up.

We hope that you find your review of the items contained in this first packet productive and informative. If you have any questions about the materials included, or about the initiative (or CLIMAS) more generally, please do not hesitate to contact us. We look forward to your feedback on the packet, and also to working with you over the course of the coming year.

Best regards,

Gregg Garfin

HUMAN SUBJECTS DISCLAIMER

Your participation in this project is completely voluntary and confidential. You are free to decline to participate in any component of the project, and you need not answer all of the questions posed in the surveys or any follow-up interviews. You may terminate your participation in the project at any time, and may request that we destroy any written materials related to our surveys and interviews with you.

Any information you provide to us will be aggregated in such a way that it will be impossible to identify individual participants or their responses, unless you expressly authorize us to use your name. The information gathered during the course of this project will be used to write scholarly articles, reports, and other publications designed to improve weather and climate-related materials, as well as to increase public and scientific understanding of the impacts of these issues.

Name _________________________

INITIAL SURVEY

Section 1 – Background Information

1. How long have you worked for this organization?

2. What is your job title?

3. How long have you been in your current position?

4. Which of the following constitutes your primary job-related tasks? (check all that apply)

    ____Gathering information

    ____Analyzing information

    ____Making decisions based on information provided by others

    ____Providing information to others

    ____Other (please specify)

5. Have you ever taken courses or professional training in any of following areas? (check all that apply):
    ___Climatology ____Meteorology ____Hydrology ____Other related (specify)

6. Please indicate your regular access to the following types of communications.

a. Internet access	____Always	____Sometimes	____Never
b. Internet speed	____Fast	____Slow	
c. Email	____Always	____Sometimes	____Never
d. Fax	____Always	____Sometimes	____Never

7. How would you prefer to complete and return a monthly survey (check one)?

    _____On-line _____ Mail _____Telephone ____Fax

8. Do you know of anyone else we should invite to participate in this initiative? If so, please indicate how we might contact them.

Section 2 – Climate Information

9. How often would you like to receive climate information? (check all that apply) *We define "climate" as conditions lasting two or more weeks and "weather" as conditions lasting two weeks or less.*

____Weekly	____Monthly	____ Once a year
____Every 2-3 weeks	____Seasonally	____Twice a year

10. How much lead time do you need to take advantage of climate forecasts? (check all that apply)

____One week ____1 month ____6 months ____More than 1 year

____2 to 3 weeks ____1 season ____1 year

11. Please rank the following communication types, from 1 to 6, according to the ways you currently receive climate information:

1 = most frequent, 6 = least frequent

______ Email ______ Web Page ______ Fax ______ Mail ______ TV ______ Radio

12. Please check any of the following factors that limit access or use of climate information in your organization:

____Technological ____Legal/Policy ____Low Utility/Not Relevant Information

____Organizational ____Budgetary ____Available Information Not Specific Enough

13. What are your organization's major climate-related concerns and sources of climate information that you have consulted at least once in the past? (check all that apply)

	We are concerned	**We have consulted forecasts**	**We have consulted historical information**
Floods			
Droughts			
Fire			
Lightning			
Frost			
Ecological health			
Human health			
Streamflow			
Surface water supply			
Groundwater recharge			
El Niño/La Niña/ENSO			
Temperature			
Precipitation			
Wind patterns			
Relative humidity			
Sea surface temps			
Atmospheric circulations			
Cooling degree days			
Heating degree days			
Oceanic circulations			
Cloud dynamics			

14. During which season(s) are your climate-related ***concerns*** the highest? (check all that apply)

____Spring ____Summer ____Fall ____Winter ____Year-round

15. For what season(s) is climate ***information*** most useful to your organization? (check all that apply)

____Spring ____Summer ____Fall ____Winter ____Year-round

16. The climate and weather in what geographical area(s) are of most concern to your organization? (check all that apply)

____Site
____Local area
____State
____Southwest
____Other region (Specify ________________________)
____US-Mexico border
____National
____Other country (Specify ________________________)
____ Global

17. Do you furnish job-related climate information to anyone else in your organization? If yes, please indicate the type of position(s) these individual(s) hold. (check all that apply)

____ Top management
____ Middle management
____ Field operations
____ Research/Analysis
____ Public relations/Education
____ Other (please specify)____

18. In your job, do you consult any of the following sources for climate forecasts and historical climate conditions? (check all that apply)

____NOAA's Climate Prediction Center web site (CPC)
____Local National Weather Service office
____Theme-specific website (e.g. drought, streamflow, fire)
____Western Regional Climate Center (WRCC)
____International climate information source (e.g. IRI, Mexican counterpart to NOAA)
____Popular news media (e.g. radio, television, newspaper)
____In-house analyst
____Consultant
____I collect my own data
____Other (please specify)____

Please complete the questions on the following page.

Section 3 – Climate Impacts and Responses

19. Has your organization ever experienced any adverse climate-related impacts? (check all that apply)

____Infrastructure damage
____Decreased profits
____Other budgetary impacts
____Stress on natural resource base
____Need to change staffing
____Staff or management stress
____Public relations issues
____Other (specify)_____________________

20. Has your organization ever benefited (monetarily or otherwise) from climate events or conditions?

21. What is your organization's worst climate nightmare?

22. Has your organization taken any steps to address the current drought conditions?
(If yes, please specify)

23. Additional comments

.

Name ______________________

Evaluation – Monthly Information Packet

For: July 2002 Packet Number: 1

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?

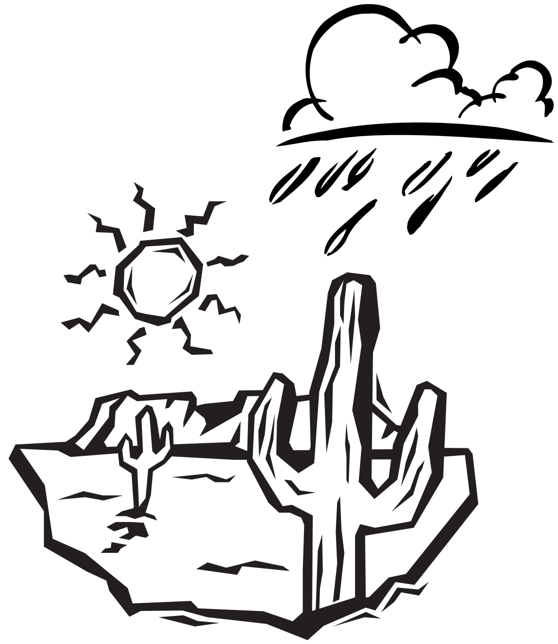
   ____Yes ____No

   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.

Figure #	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	**What action? Other comments?**
A	**Background**							
A1	END InSight Newsletter							
B	**Recent Conditions**							
B1	Temperature (Departure from average, water year)							
B2	Temperature (Average, water year)							
B3	Temperature (Departure from average, last 28 days)							
B4	Temperature (Average, last 28 days)							
B5	Precipitation (Departure from average, water year)							
B6	Precipitation (Total, water year)							
B7	Precipitation (Departure from average, last 28 days)							
B8	Precipitation (Total, last 28 days)							
B9	Latest U.S. Drought Monitor							
B10	Arizona Drought Map							
B11	New Mexico Drought Map							
B12	Current Palmer Drought Severity Index (PDSI)							
B13	Precipitation needed to bring PDSI to "normal"							
B14	Latest AZ reservoir report							
B15	Latest NM reservoir report							
C	**Forecasts**							
C1	Temperature (Monthly)							
C2	Temperature (3-Month)							
C3	Temperature (Multi-season)							
C4	Precipitation (Monthly)							
C5	Precipitation (3-Month)							
C6	Precipitation (Multi-season)							
C7	Palmer Drought Index Forecast							
C8	Southwest Seasonal Drought Outlook							
C9	Southwest Streamflow Forecast							
C10	Fire Forecast and Outlook							
C11	U.S. Threats Assessment							
C12	Tropical Pacific SST Forecast and El Niño Forecasts							
D	**Historical Drought Conditions**							
D1	Lower Colorado River Basin							
D2	Rio Grande River Basin							
D3	U.S. River Basins and Climate Divisions							
D4	1950s Drought History							
E	**Background on El Niño**							
E1	El Niño versus Average Winter Precipitation							
E2	Winter El Niño Atmospheric Circulation							
E3	Winter El Niño Temperature and Precipitation Impacts							

END InSight



CLIMAS El Niño-Drought Initiative

Information Packet #1
July 2002

Climate Assessment for the Southwest
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Section A

BACKGROUND

News from the CLIMAS El Niño-Drought Initiative

END InSight

July 2002

THE UNIVERSITY OF ARIZONA®

Southwest drought could persist despite monsoon, El Niño

by Melanie Lenart
Science Writer

Drought defies a precise definition. It's in the eye of the beholder. But more and more Southwest residents, including climatologists, are concurring that Arizona and New Mexico are indeed in a drought. Worse, climatologists see little hope for long-lasting relief from monsoonal rains—or even the predicted El Niño.

By the start of spring, most climatologists agreed that a drought had descended upon the Southwest. By then it seemed clear no winter rainstorms would come along to bail out these parched southwestern lands. Arizona was declared a drought disaster area on May 17 by U.S. Secretary of Agriculture Ann M. Veneman. In New Mexico, the Rio Grande's streamflow in early June was lower than it had been in the 102-year instrumental record, according to the National Climatic Data Center website operated by the National Oceanic and Atmospheric Administration (NOAA).

Both states are considered to be in "extreme drought" by the U.S. Drought Monitor. Even worse areas of "exceptional drought" are located in the northern parts of the Southwest, encompassing much of the Navajo Nation and the Grand Canyon in Arizona, as well as Santa Fe and a wide swath to the northwest in New Mexico.

Unfortunately, climatologists agree that the best southwesterners can hope for is an end with the coming year's winter rainfall, long after the wildfires have burned out and the shriveled grasslands have led ranchers to sell off their cattle. The worst we can fear goes beyond the worst droughts of the 20th century, generally acknowledged to be the 1950s drought for New Mexico or the early 1900s drought for Arizona, times when the only money to be made from cattle involved selling their bones as fertilizer.

Water supply and demand

Some parts of the Southwest have been in a state of drought since about the winter of 1996-97, noted Kelly Redmond, a climatologist with the Western Regional Climate Center in Reno, Nevada.

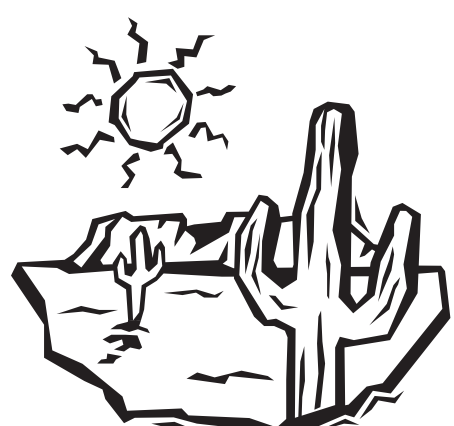
There is no definitive definition of drought based on measurable processes, so climatologists must interpret it by considering its impact on vegetation, water resources, and people.

"I use a definition of drought that has supply and demand built into it," Redmond said. "Basically, it's not enough water for what you need."

The NRCS's designation of extreme drought is used when there are threats to agriculture and of severe wildfire. An exceptional drought includes those threats as well as threats to shortages of water in reservoirs, streams, and wells.

Leaders from the Navajo and Tohono O'Odham Nations are reporting concern over dwindling water supplies from wells near the surface and the disappearance of some streams thought to be perennial. However, residents of areas served by deeper wells or the Colorado River might be blithely unaware of the ongoing drought, although they might notice that even prickly pears are looking desiccated.

continued inside



"If you're buffered from what the climate is doing out the window, to that extent you're not really experiencing a drought," Redmond noted.

Drought vs. dry

As one of the climatologists preparing the weekly Drought Monitor (the most recent example is included in this packet), Redmond was among the first to call the current dry spell a drought. But he acknowledges it's a tough call.

"Recognizing drought in a dry climate is a difficult one," he explained. Because 10% to 15% of annual rainfall in the Southwest can come in one day, usually a winter day, some southwestern climatologists were hesitant to apply that label until almost the arrival of spring, typically the driest season in the Southwest.

Charlie Liles, a climatologist with the National Weather Service office in New Mexico, concurred. "Drought is too complicated to attempt to use one index or cookbook approach," he explained.

When asked to give an informal explanation of when he knew this was a drought, Liles responded, "When the number of people at our monthly drought monitoring meeting (Governor Johnson's drought task force) suddenly doubled" in January. David S. Gutzler, a climate researcher and professor at the University of New Mexico in Albuquerque, gave this reply to the same question: "When no unusual springtime downbursts came along by the end of March to make up for a horribly deficient snowpack."

Fire and ice

The Southwest received less than half the usual amount of snowfall this past winter, with Arizona's snowpack trailing at only about 25% of an average year, the NRCS reported. Snow can boost soil moisture for months as it gently melts and trickles down to aquifers and reservoirs, so the landscape and water supplies continue to suffer from its relative absence throughout the spring and even summer.

The continuing dryness combined with high temperatures makes June the riskiest month for wildfires in the Southwest. This past June was particularly flammable for Arizona. As of July 17, about 623,000 acres had burned in Arizona wildfires, along with about 298,000 acres in New Mexico, according to a multi-agency tally shown on a USDA Forest Service web site.

Comparing these figures to the annual acreage burned for the past decade, New Mexico's total is only slightly higher than an average year, while Arizona's total is already more than five times higher than its average amount of about 117,000 acres a year. (In New Mexico, however, half a million acres burned in both 1999 and 2000, also considered drought years by some.)

Fire officials worry that the arriving monsoon could be counterproductive if lightning strikes increase without appreciable rainfall to follow.

Monsoon relief temporary

Although monsoon rains can spell temporary relief for plant life, they generally cannot provide the kind of large-scale rainstorms that could alleviate a regional water shortage, Redmond explained. In fact, the time frame of the current drought encompasses the summer of 1999, which was one of the four rainiest summers in the Arizona instrumental record.

"Summer provides a lot of splash and flash and a lot of glitz and glamour," Redmond said, but not much moisture makes its way to the soil column or to reservoirs. "It's so hot that a large part of it ends up evaporating and going right back up into the sky."

Besides being short-lived, the benefits from monsoonal rains tend to be small-scale. Monsoon storms tend to be measured in tens of square kilometers, which means a particular thunderstorm might cover only a portion of cities the size of Tucson or Albuquerque. Winter rains, on the other hand, tend to stretch across thousands of square kilometers, so a rainfall event might stretch across several states.

That's why winter rains provide the only real hope for relieving a drought as extensive as the one occurring now in the Southwest, Redmond said.

El Niño as savior?

There is some hope that winter rainfall could come through if the climatic pattern known as El Niño develops by this winter as is being predicted now (for more details, see El Niño background story on back page). Unusually high sea surface temperatures in the eastern Pacific, the telltale sign of El Niño's arrival, set up climatic conditions that favor greater precipitation in the southwestern United States and northwestern Mexico.

However, even a strong El Niño only increases the probability of precipitation in the Southwest—it does not guarantee it—so southwestern climatologists do not view

El Niño as a panacea for the drought. Currently, climatologists predict the El Niño will be weak to moderate.

"Even the moderate El Niño events can help New Mexico during the transitional seasons of autumn and (next) spring," Liles said. "That said, I think that it is unlikely that a weak or moderate El Niño will break the drought."

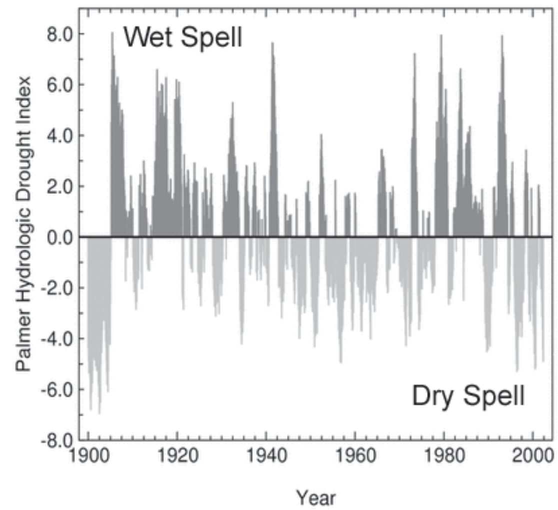
Another force: the PDO

Modern El Niño cycles tend to reverse every two to seven years, but there appears to be a climate pattern operating in a lengthier time frame of several decades, known as the Pacific Decadal Oscillation, or PDO. Redmond and others expressed concern that a switch in the PDO phase could set the stage for persistent drought in the Southwest. Unlike the El Niño pattern that governs the tropical Pacific, though, the PDO cycle of the northern Pacific Ocean remains somewhat speculative.

"With the PDO, we've had two phases since 1947. So we don't have a lot of cases to go on," Redmond explained. "We're not even really quite sure if the PDO is a thing or not."

The "negative" phase of cooler northern Pacific waters, which appears to have occurred between 1947 and 1976, seems to correlate with an increase in drought-like conditions in the Southwest. This covers the period of the 1950s drought, the worst drought of the century for New Mexico and no picnic for Arizona either. A composite instrumental record showing the hundred-year period from 1895 to 1995 shows Arizona faced drier hydrological conditions throughout much of the 1947-76 negative phase of the PDO (see illustration).

Many climatologists pinpoint 1976 as a time when the PDO switched abruptly into a "positive" phase, with a corresponding rise in sea surface temperatures in the northern Pacific. During that same time frame, the Southwest (and Arizona in particular, as reflected in the illustration) received a relative abundance of precipitation, along with an increasing number of El Niño events.



Arizona Statewide Palmer Hydrological Drought Index, January 1900 - May 2002. Note the abundance of dry spells and lack of wet conditions during the mid-1940s to the mid-1970s. Source: National Climatic Data Center/NESDIS/NOAA

"Some people are starting to think that we've switched back into PDO shift that was occurring to 1947-76 period," Redmond noted. "If that's the case, the odds could favor droughty years more often. Therefore it's sort of easier for a dry period to develop."

Historical droughts

The worst-case scenario would include droughts as great or greater than the 1950s drought as far as extent and duration. Tree-ring records and other natural archives employed to reconstruct drought events of the past 1,000 years indicate the Southwest was much harder-hit by a severe drought in the latter two-thirds of the 16th Century. The event, which some call a "megadrought" in part because it lasted for decades with only occasional relief, was particularly severe for New Mexico and Texas.

Even reliving the 1950s drought would be a challenge for the Southwest, given the incredible influx of people since then. So climatologists and virtually everyone else hope to avoid a drought as extensive and long-lasting as the 16th century drought.

"The same set of meteorological circumstances repeated with different demand structure—like gobs more people—leads to a different demand effect," Redmond noted. Reliving the 1950s drought would be more difficult on southwestern residents now that there are so many more of them.

Sustained drought has been known to challenge, and perhaps even uproot, sophisticated southwestern cultures of the past. The ancestors of the Pueblo people, known as the Anasazi by anthropologists, abandoned dozens of multi-storied structures in the Four Corners area of the Southwest during a "Great Drought" that stretched across the turn of the 13th Century.

Coming next month: Monsoon Basics. The Climate Assessment for the Southwest (CLIMAS) project will be providing updates of the Southwest climate status for every month throughout the coming year. Visit our web at http://www.ispe.arizona.edu/climas or call (520) 792-8712 for more information.

El Niño: A focus on variability

by Melanie Lenart
Science Writer

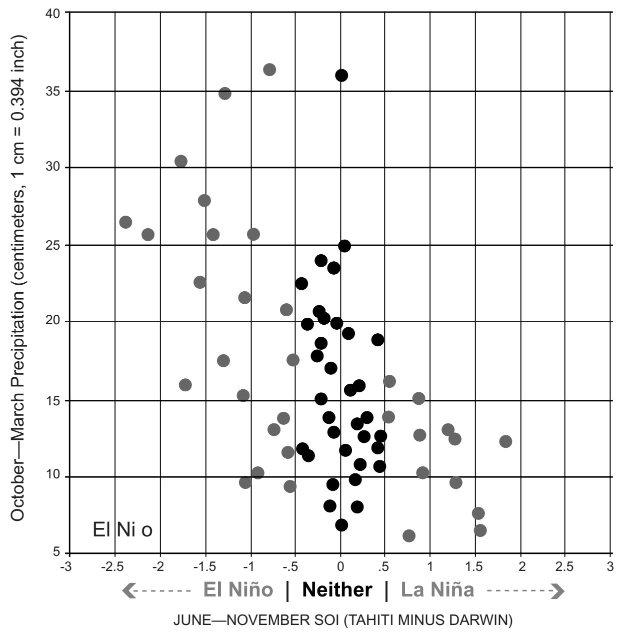
El Niño has a well-documented effect on precipitation fluctuations in the Southwest. Yet, like the snowflakes can help bring to southwestern highlands, no two El Niños are identical. As a result, climatologists can use only a probability approach to describe expectations for a coming El Niño, even once they know that an event is almost certainly underway.

Scientists at NOAA's Climate Prediction Center could report with confidence on July 11 that an El Niño is developing, even though most of its impacts will not be felt until at least fall. In the Southwest, the probable end result is higher winter precipitation. But there's no guarantee. During the weak El Niño of 1969-70, for instance, total precipitation actually dropped below normal for much of Arizona and was no better than average throughout the Southwest.

A series of events in the tropical Pacific Ocean set the wheels of El Niño in motion. First, the usual westerly trade winds die down or even change direction, a phenomenon climatologists detect by comparing atmospheric pressure in Darwin, Australia, with that of Tahiti.

When the trade winds let up during an El Niño event, the warm surface waters of the western equatorial Pacific that typically pool east of Indonesia can expand into the eastern Pacific, butting up against the western coast of the Americas. Sea surface temperature measurements, then, allow scientists to detect reliably a pending El Niño months beforehand.

This sea change brings with it a variety of impacts, but the nature and intensity of those impacts can vary substantially from one El Niño event to another and from one place to another. In the Southwest, El Niño impacts often (but not always) produce more precipitation and lower temperatures during winter months, both of which can add up to increased soil moisture. It's good for plants, but from the human perspective, too much of a good thing can lead to damaging storms and floods.



Arizona statewide winter precipitation versus the Southern Oscillation Index (SOI) for 1933-1997. The SOI is a measure of El Niño-Southern Oscillation activity. The shade of the dots indicates whether conditions were classified as El Niño, La Niña, or neither. Note that the winters with the highest precipitation totals were nearly all El Niño years. La Niña winters are reliably dry and virtually never have above average precipitation. Southwest El Niño winters, however, display a great range of precipitation totals, from very low to the record high.

For instance, winter floods are more likely to occur during El Niño years. Snowpack from precipitation during an El Niño winter contributed to the January, 1993, flooding in the Tucson metropolitan area following a series of Pacific storms. Similarly, the spectacular October, 1983, flood in Tucson may have been indirectly related to the ongoing El Niño. Although most of the downpour again came from a tropical storm, the storm itself may have been driven deeper into Arizona by El Niño conditions, which have a strong influence on subtropical wind patterns.

During the El Niño years that occurred during the 1895-1996 period, December-March precipitation rates for Arizona's seven regional climate divisions averaged 170% of their 102-year mean, while the eight stations in New Mexico averaged 154% of their mean for the same period, according to information from NOAA's Climate Prediction Center.

In some ways El Niño's main effect is to increase the variability of precipitation, as shown in the illustration. To sum up, it seems El Niño provides no real safeguard against below-average precipitation. But if departures above the norm are going to occur, there will probably be an El Niño in the vicinity to take the credit—or the blame, as the case may be.

Executive Summary, July 2002

Despite the arrival of summer monsoon moisture, long-term climate and drought indices show that severe drought continues to grip the Southwest. Forecasts show that drought is likely to persist during the short-term (1-3 months). For the vast majority of Arizona and New Mexico, there is a less than 50% likelihood of receiving enough precipitation to receive significant relief from drought conditions during the next 3 months. For northern Arizona and New Mexico, the likelihood of significant drought relief is less than 5% during the next 3 months.

Forecasters have high confidence that a weak-to-moderate El Niño event will develop during the next 3-9 months. 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.

Glossary of Terms

Anomaly: Difference between a given quantity or observation and its average value. This is the same as “departure from average.” For example, if the average rainfall for June is 5 inches and this year, there is 100 inches of rainfall in June, then the anomaly is +95 inches.

Climate: The general or typical conditions for a place and/or period of time. Conditions include rainfall, temperature, thunderstorms, lightening, freezes, …

Climate Division: a region within a state that is reasonably homogeneous with respect to climatic and hydrologic characteristics. Arizona is divided into 7 climate divisions and New Mexico, into 8.

Climate Prediction Center (CPC): a branch of the National Oceanographic and Atmospheric Agency (NOAA) whose mission is to assess and forecast the impacts of short-term climate variability. The CPC produces official U.S. climate forecasts.

CPC: See Climate Prediction Center.

Drought: There is no definitive definition of drought based on measurable processes; scientists evaluate precipitation, temperature, and soil moisture data for the present and recent past to determine drought status. Very generally, it refers to a period of time when precipitation levels are low, impacting agriculture, water supply, and wildfire hazard.

El Niño: Refers to a sustained warming of sea surface temperatures (SSTs) across a broad region of the eastern and central tropical Pacific Ocean. This tends to be associated with drier winters in the Pacific Northwest and wetter winters in the Southwest United States. El Niño events are also called warm events.

El Niño Southern Oscillation (ENSO): The term currently used by scientists to describe basin-wide changes every 2 to 7 years in air-sea interaction in the equatorial Pacific Ocean. El Niño/La Niña is the oceanic component and the Southern Oscillation is the atmospheric component of the phenomenon.

ENSO: See El Niño-Southern Oscillation.

Forecast: A prediction of future conditions by analysis of data. For example, precipitation forecasts are based on meteorological data.

Interpolate: To estimate values between measured values, usually using a mathematical function. Spatial interpolation involves estimating values on a map.

IRI: The International Research Institute for Climate Prediction; housed at Columbia University’s Earth Institute. Its mission is to accelerate the ability of societies worldwide to cope with climate, especially those events that cause devastating impacts to humans and the environment.

La Niña: Refers to a sustained cooling of sea surface temperatures (SSTs) across a broad region of the eastern and central tropical Pacific Ocean. This tends to be associated with wetter winters in the Pacific Northwest and drier winters in the Southwest United States. La Niña events are also called cold events.

Monsoon: A wind system that reverses its direction seasonally. In the North American Monsoon system, summer winds from the south bring moisture and rainfall to the Southwest United States.

Pacific Decadal Oscillation (PDO): A long-term El Niño-like pattern of North Pacific climate variability, with phases that persist from 20-30 years. The positive (warm) phase of the PDO is characterized by cooler than average SSTs and air pressure near the Aleutian Islands and warmer than average SSTs near the California coast; these conditions tend to enhance El Niño teleconnections. The negative (cool) phase tends to enhance La Niña teleconnections (i.e., winter wetness in the Pacific Northwest and winter dryness in the Southwest United States).

Pacific/North American teleconnection (PNA): Variability in atmospheric pressure over the Northern Pacific and North America is associated with variability in summer rainfall in the Southwest United States. Wetter summers are associated with PNA phases with strong North to South pressure gradients. Drier summers have tended to follow PNA phases with weak North to South pressure gradients.

Palmer Drought Severity Index (PDSI): An indicator, based on temperature, precipitation, and soil type, of long-term deficits or surpluses of soil moisture.

PDO: See Pacific Decadal Oscillation.

PDSI: See Palmer Drought Severity Index.

PNA: See Pacific / North American teleconnection.

Precipitation: Rainfall, snow, sleet, hail, etc.

Sea Surface Temperature Anomalies (SSTAs): Difference between the measured sea surface temperature at any given time and place and the mean (average) sea surface temperature.

SSTs: Sea surface temperatures.

Teleconnections: Atmospheric interactions between widely separated regions that have been identified through statistical correlations (in space and time). For example, the El Niño teleconnection with the Southwest United States involves large-scale changes in climatic conditions that are linked to increased winter rainfall.

Water Supply Outlook: A summary of snowpack, reservoir, stream flow, and precipitation for watersheds and basins, which is available bi-monthly from January through April from the U.S. Department of Agriculture’s National Resources Conservation Service.

Weather: Describes the daily conditions (individual storms) or conditions over several days (week of record-breaking temperatures) to those lasting less than two weeks.

Section B

RECENT CONDITIONS

Temperature: Recent Conditions (up to 7/19/02) (Source: Western Regional Climate Center)

Figure B1. Water year '01-'02 (through 7/17) temperature departure from average (°F).

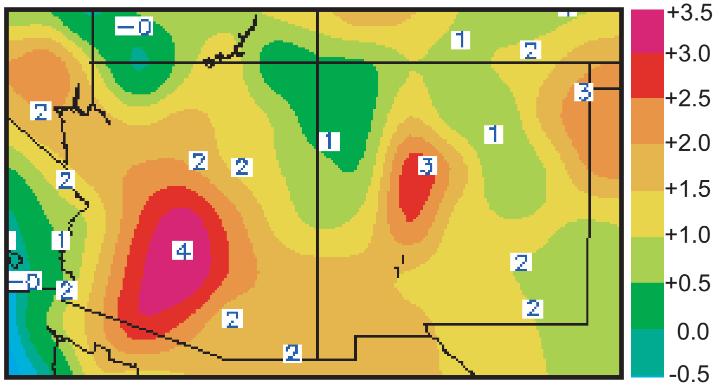


Figure B2. Water year '01-'02 (through 7/17) average temperature (°F).

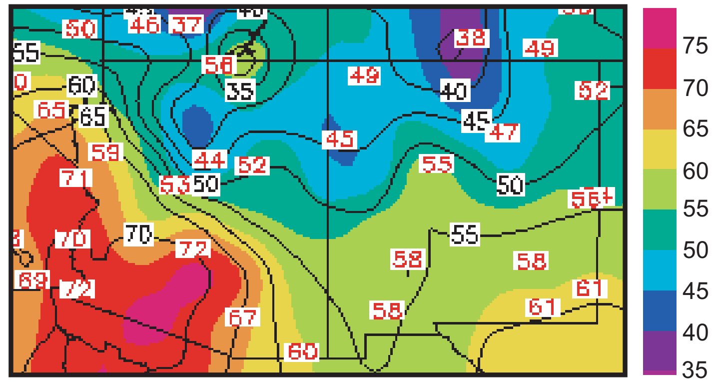


Figure B3. Previous 28-days (6/20 - 7/17) departure from average temperature (°F).

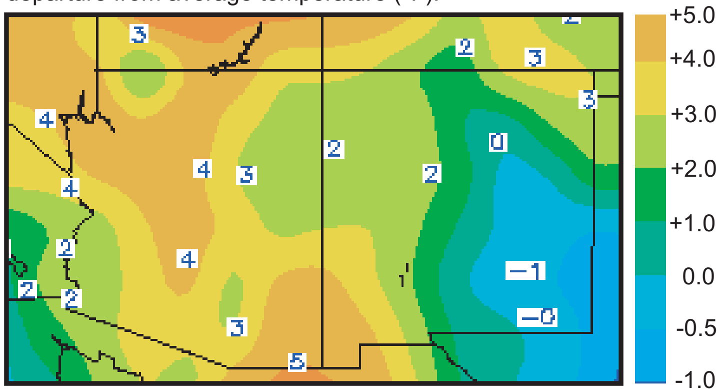
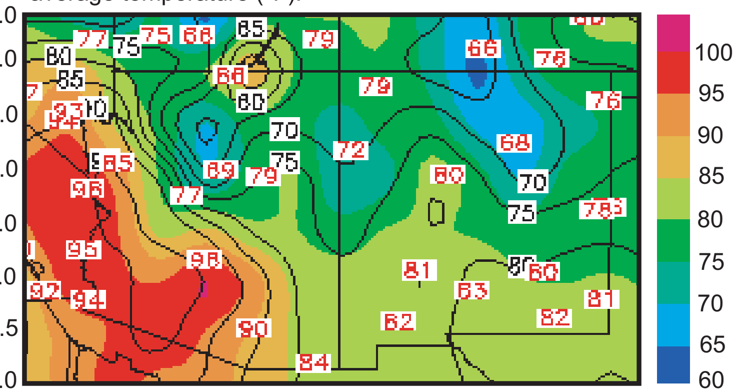


Figure B4. Previous 28-days (6/20 - 7/17) average temperature (°F).



Highlights: Since October 1, 2001, temperatures have been above average throughout our region. Albuquerque, NM, which has an average annual temperature of 57°F, is already at 55°F for the water year, and we haven't even gotten through the warmest months of the year! For the most recent 28 days, most of our region has recorded above average temperatures. Recent rains, which have brought flooding to parts of Texas, have also brought cooler temperatures to southeastern NM. Above average temperatures for western Arizona are consistent with a long-term trend (beginning in 1966) toward increasing annual temperatures.

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 precipitation is derived 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.

Precipitation: Recent Conditions (up to 7/19/02) (Source: Western Regional Climate Center)

Figure B5. Water year '01-'02 (through 7/17) departure from average precipitation (inches).

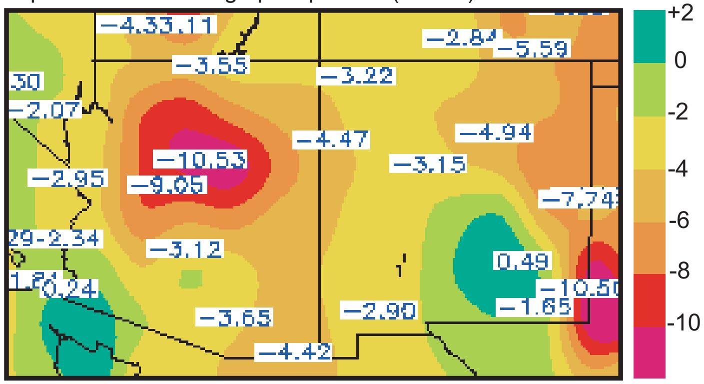


Figure B6. Water year '01-'02 (through 7/17) total precipitation (inches).

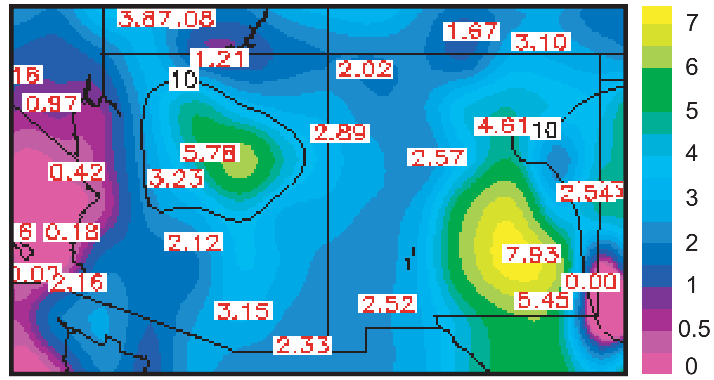


Figure B7. Previous 28-days (6/20 - 7/17) departure from average precipitation (inches).

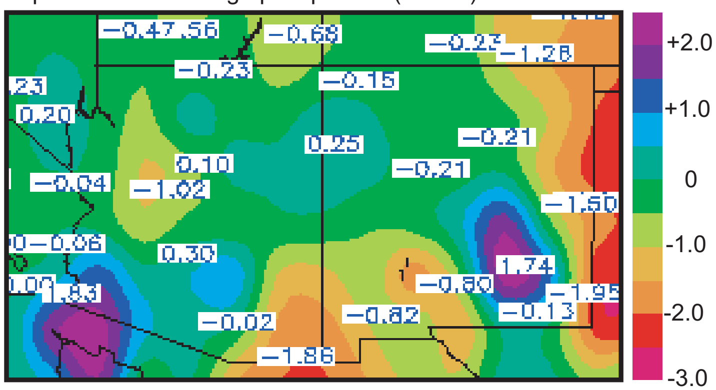
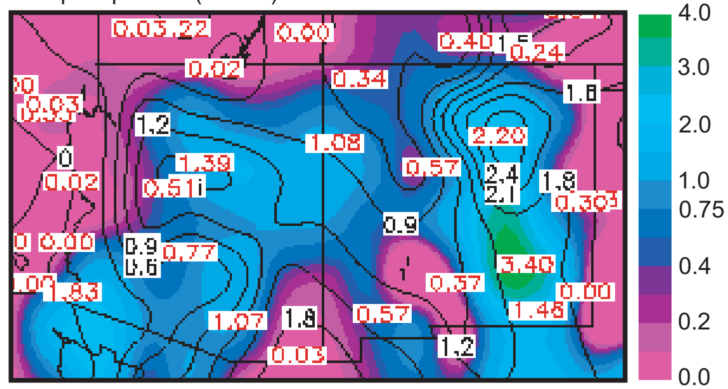


Figure B8. Previous 28-days (6/20 - 7/17) total precipitation (inches).



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. The scale for Fig. B8 is non-linear.

Departure from average precipitation is derived 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, has a precipitation deficit of over 9" (Figures B5-B6). During the most recent 28 days (Figures B7-B8), summer rainfall has brought a small degree of relief to parts of our region, in particular southeastern New Mexico and southwestern Arizona. High evaporation rates and high rates of rainfall runoff during summer mean that we will need substantial precipitation to ameliorate drought conditions brought on by months and, in some cases, years of below average precipitation.

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

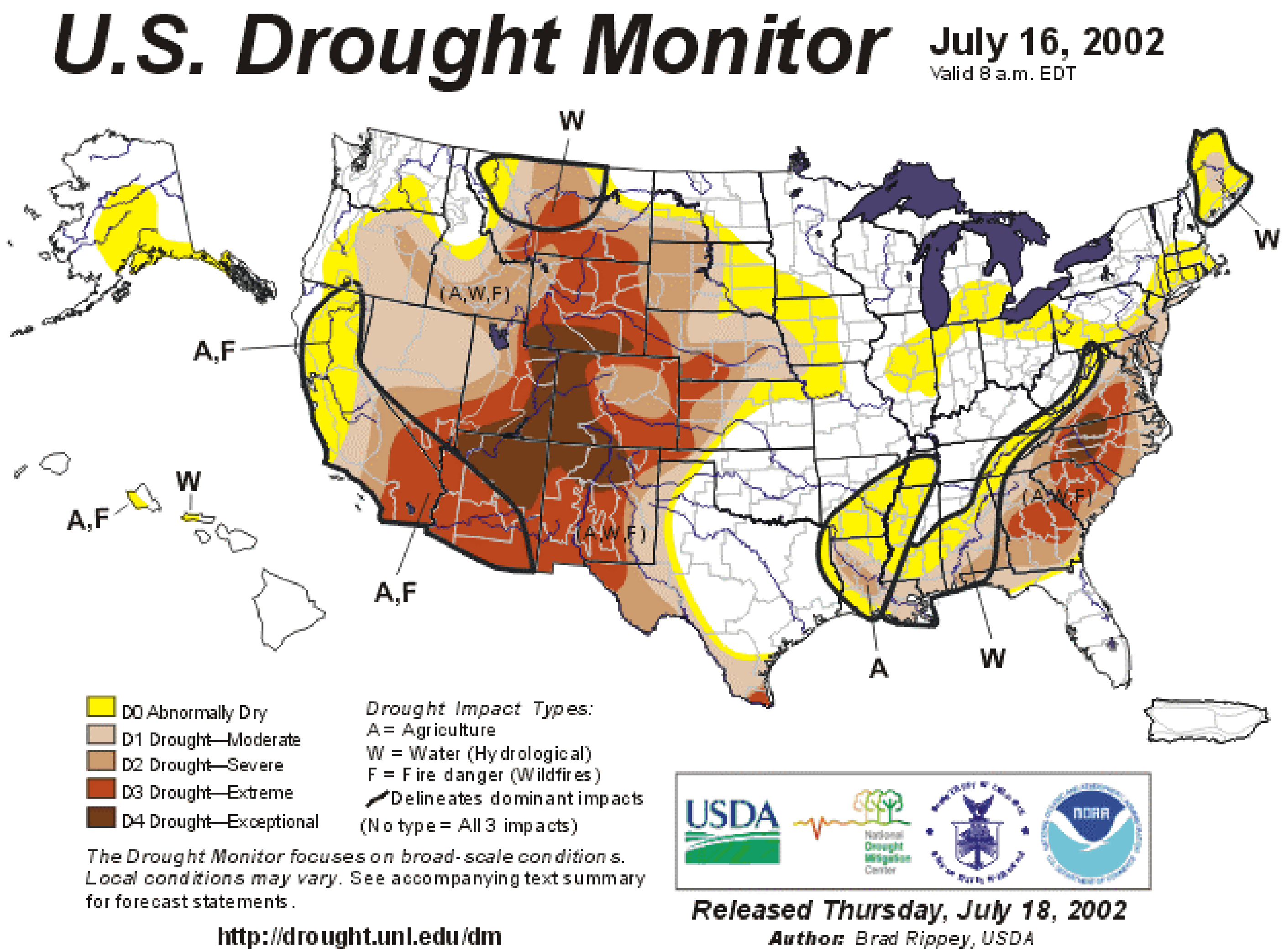


Figure B9

Notes:

The U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. This monitor was released on 7/18 and is based on data collected through 7/16 (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).

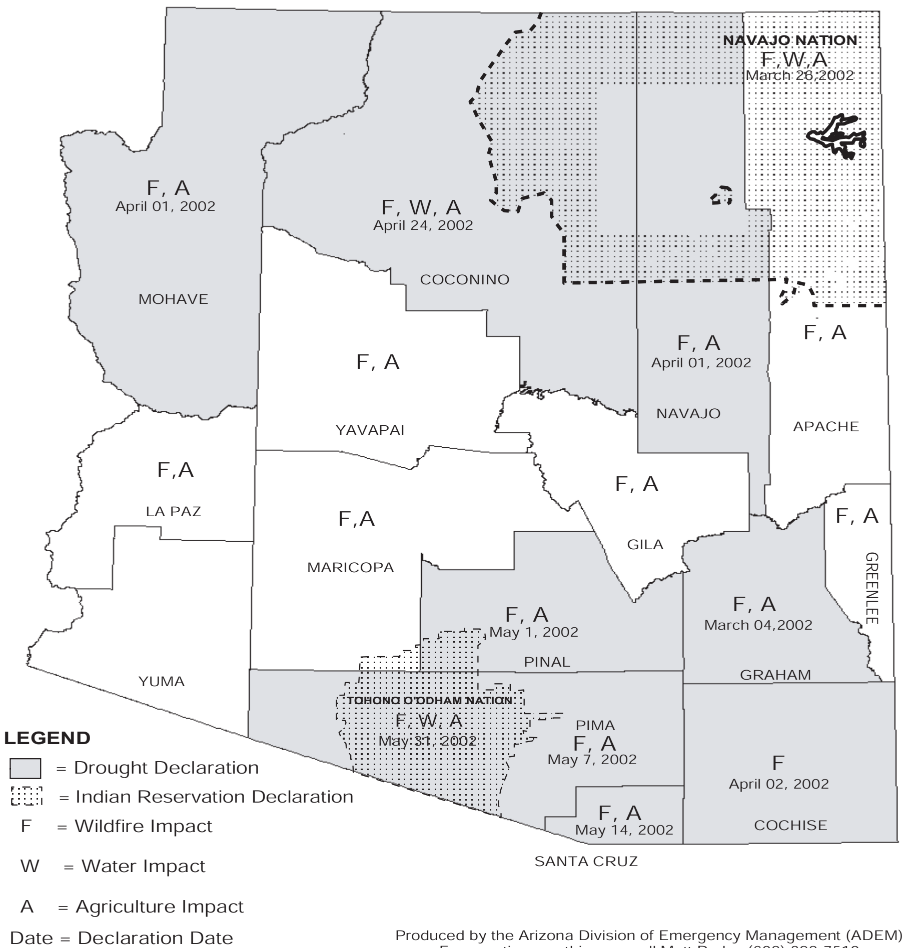
The U.S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) PDSI, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts.

Highlights: The monsoon's onset in the Southwest brought a gradual increase in humidity and shower activity, but provided little change in the overall drought picture. Following the end of Tucson's record spell without a drop of rain, 1.07" fell between July 8-14. Elsewhere in Arizona, early July rainfall exceeded precipitation received during the first half of the year in locations such as Flagstaff (1.30" from July 1-16 vs. 1.22" from January-June) and Phoenix (0.77" July 1-16 vs. a record-low 0.19" January-June). Northern Arizona and New Mexico continue to experience exceptional drought (the most extreme Drought Monitor rating). News and agricultural reports from media sources in AZ and NM indicate continued drought impacts on reservoirs and lakes, wildlife, power generation, and livestock. Both NM (83%) and AZ (82%) suffered from an exceedingly high percentage of range/pasture land in either very poor or poor condition.

Drought: Recent Drought Status Designations for Arizona and New Mexico

Figure B10. Arizona Drought Map

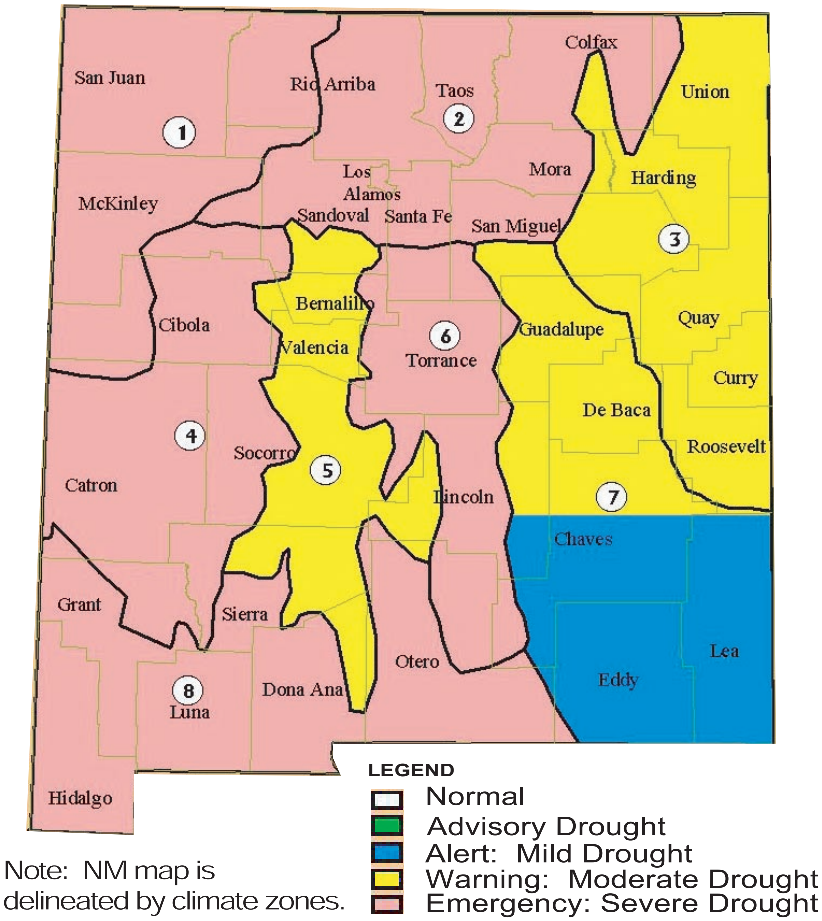
Drought Status As of May 31, 2002



Produced by the Arizona Division of Emergency Management (ADEM)
For questions on this map call Matt Parks, (602) 392-7510

Figure B11. New Mexico Drought Map

Drought Status As of June 18, 2002



Note: NM map is delineated by climate zones.

Source: NM Natural Resources Conservation Service (2002)

Notes: The Arizona and New Mexico drought maps are produced by the Arizona Division of Emergency Management (ADEM) and the New Mexico Natural Resource Conservation Service (NMNRCS), respectively. The New Mexico map is currently 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.

PDSI Indices of Recent Conditions (up to 7/18/02) (Source: NOAA Climate Prediction Center)

Figure B12. Current weekly palmer drought severity index (PDSI) ending 7/13/02 (accessed 7/18).

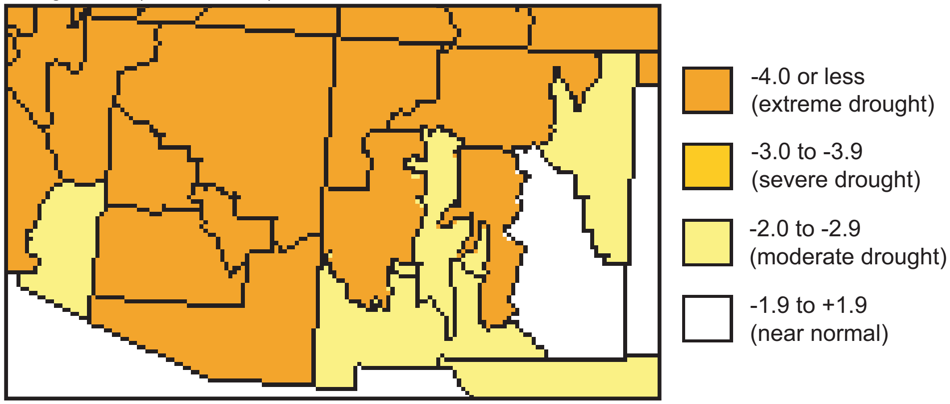
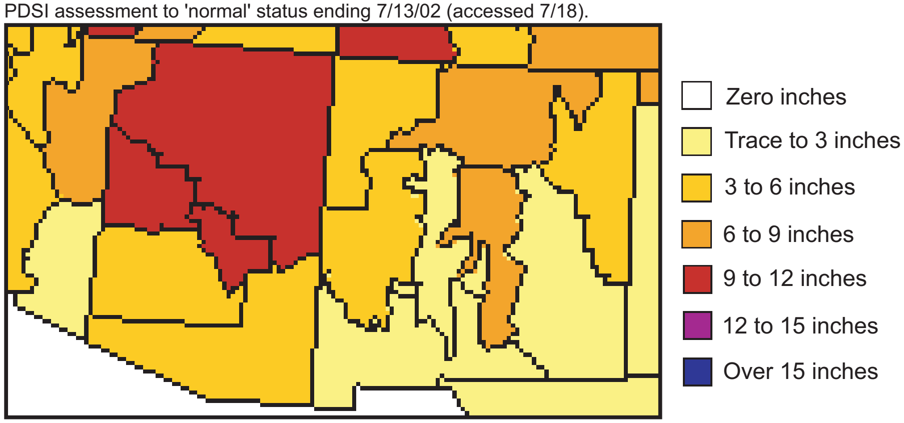


Figure B13. Precipitation (inches) needed to bring current weekly PDSI assessment to 'normal' status ending 7/13/02 (accessed 7/18).



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 moisture based on long-term climatological expectations.

AZ and NM 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 B12 (top) shows that recent soil moisture conditions indicate drought for most of our region. Figure B13 (bottom) shows that most of our region would require an extraordinary amount of precipitation to bring our drought status back to "normal" within one week. According to the National Climatic Data Center, there is a less than 20% chance of ending the current drought within the next 3 months, i.e., during our season of greatest precipitation. The probability of ending the drought increases as we head into the cool season, but even then it will take a lot of precipitation to end drought conditions in northern AZ and NM.

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

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

Arizona Reservoir Levels (through end of May 2002)
(Source: USDA Natural Resource Conservation Service)

Figure B14_a.

	Current Storage	Last Year Storage	Average Storage	Basin/Reservoir Capacity
Salt River Basin (One Reservoir)	659.0	985.2	1342.1	2335.0
Verde River Basin (One Reservoir)	86.8	162.2	194.3	310.0
San Francisco - Upper Gila River Basin				
San Carlos	53.9	232.6	450.9	875.0
Painted Rock Dam	0.0	0.0	199.9	2492.0
Total of 2 Reservoirs	53.9	232.6	650.8	3367.0
Little Colorado River Basin				
Lyman Reservoir	4.0	10.1	17.9	30.0
Show Low Lake	2.5	4.7	3.6	5.1
Total of 2 Reservoirs	6.5	14.8	21.5	35.1
Northwestern Arizona				
Lake Havasu	595.0	573.2	607.7	619.0
Lake Mohave	1736.1	1679.7	1715.3	1810.0
Lake Mead	17915.0	21127.0	21662.0	26159.0
Lake Powell	16536.0	19797.0	19656.0	24322.0
Total of 4 Reservoirs	36782.1	43176.9	43641.0	52910.0
Arizona Westwide Reservoir Storage				
San Carlos	53.9	232.6	450.9	875.0
Salt River	659.0	985.2	1342.1	2335.0
Verde River	86.8	162.2	194.3	310.0
Total of 3 Reservoirs	799.7	1380.0	1987.3	3520.0

Note: Units are in thousands of acre-feet

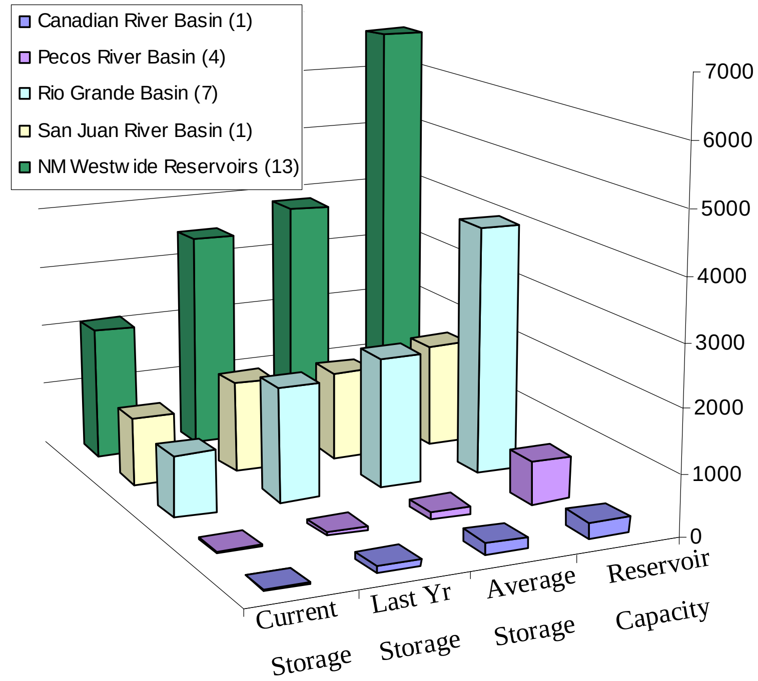
Figure B14_b.

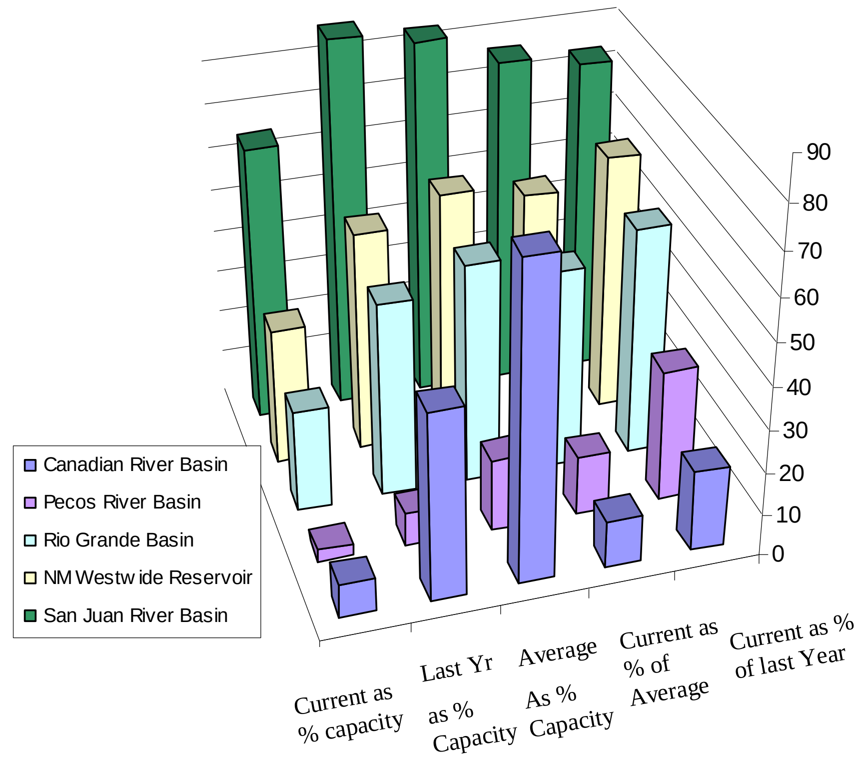
	Current as % Capacity	Last Year as % Capacity	Average as % Capacity	Current as % Average	Current as % of Last Year
Salt River Basin (1 Reservoir)	28	42	57	49	67
Verde River Basin (1 Reservoir)	28	52	63	45	54
San Francisco - Upper Gila River Basin					
San Carlos	6	27	52	12	23
Painted Rock Dam	0	0	8	0	0
Total of 2 Reservoirs	2	7	19	8	23
Little Colorado River Basin					
Lyman Reservoir	13	34	60	22	40
Show Low Lake	49	92	71	69	53
Total of 2 Reservoirs	19	42	61	30	44
Northwestern Arizona					
Lake Havasu	96	93	98	98	104
Lake Mohave	96	93	95	101	103
Lake Mead	68	81	83	83	85
Lake Powell	68	81	81	84	84
Total of 4 Reservoirs	70	82	82	84	85
Arizona Westwide Reservoir Storage					
San Carlos	6	27	52	12	23
Salt River	28	42	57	49	67
Verde River	28	52	63	45	54
Total of 3 Reservoirs	23	39	56	40	58

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 (NRCS). Reports can be accessed at their website (http://www.wcc.nrcs.usda.gov/water/reservoir/resv_rpt.html). As of 7/18/02, Arizona's report was not updated through the end of June.

Highlights: A key concern during this period of statewide extreme drought is the exceedingly low level of the reservoirs in the Salt, Verde, and Little Colorado River Basins. Water use restrictions have already been introduced in some communities, such as Flagstaff, AZ and Santa Fe, NM. Also note that large reservoirs, such as Lake Mead and Lake Powell, are at relatively low levels. Should drought conditions persist, communities and others reliant on water from these sources may be faced with challenging management decisions.

New Mexico Reservoir Levels: (through end of June 2002) (Source: USDA NRCS) (Figure B15_a and B15_b)





- Units are in thousands of acre feet
- The number of reservoirs in each basin is indicated next to basin name in the legend

- Units are in percent (%) of capacity, average or previous year
- Colors refer to individual Basins

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 June as of 7/18/02.

Highlights: The Pecos and Canadian River Basins are at exceedingly low levels. Of serious concern to the larger Rio Grande watershed, reservoir levels are at less than 60% of average and are only about one half of last year's levels.

Section C

FORECASTS

Temperature: Monthly (August) and 3-Month (Aug.-Oct. 2002) Outlooks (Source: NOAA CPC)

Figure C1. August 2002 U.S. temperature forecast (released 7/18).

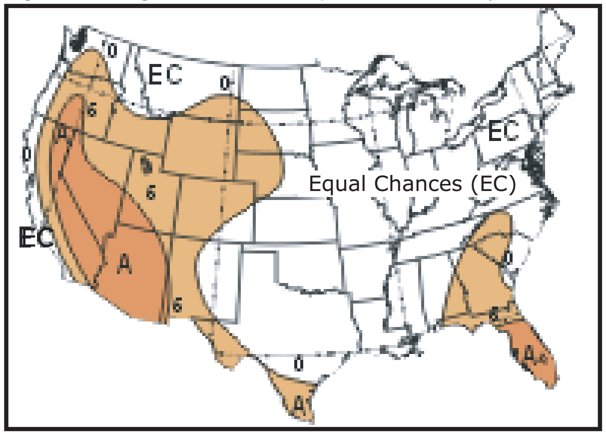
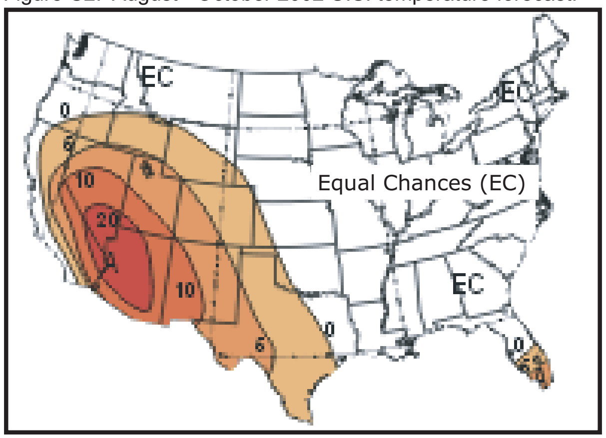


Figure C2. August - October 2002 U.S. temperature forecast.



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

NOAA CPC climate outlooks are released on the Thursday nearest the middle of each month.

Highlights: The CPC temperature outlook for August shows slightly increased probabilities of above average temperatures in our region (especially Arizona). For the rest of the summer (August-October), the outlook indicates increased probabilities of above average temperatures across our entire region, with the greatest forecast confidence centered over western Arizona. Probabilities for western Arizona are as follows: 55.3-63.3% probability of above normal, 33.3% probability of normal, and 3.3-13.3% probability of below normal temperature. These predictions are based chiefly on long-term trends for increased temperature in our region, plus the results of some statistical models.

For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/seasonal_forecast.html

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.

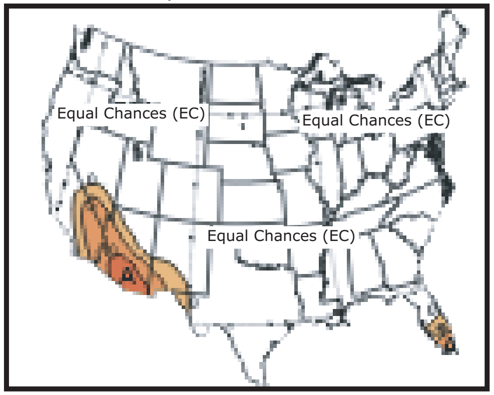
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

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

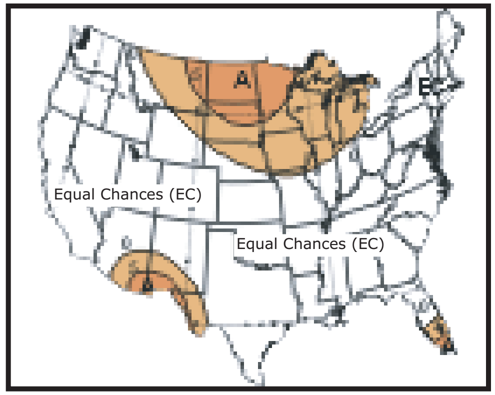
Temperature: Multi-season Outlooks (Source: NOAA Climate Prediction Center (CPC))

Figure C3. Overlapping 3-month long-lead temperature forecasts (released 7/18).

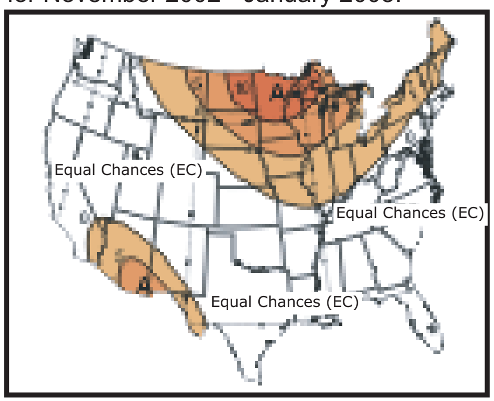
Long-lead national temperature forecast for September - November 2002.



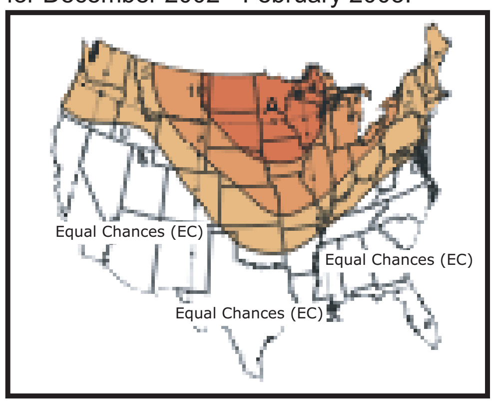
Long-lead national temperature forecast for October - December 2002.

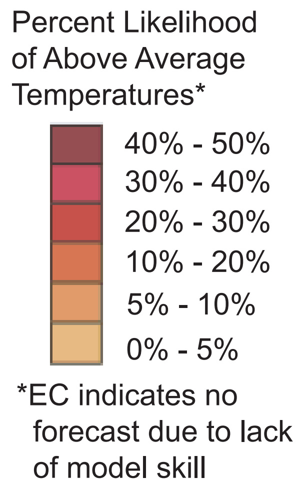


Long-lead national temperature forecast for November 2002 - January 2003.



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





Highlights: The CPC temperature outlooks for September 2002-February 2003 show increased probabilities of above average temperatures in our region (especially Arizona) gradually diminishing by the turn of the year. The greatest confidence in these predictions is centered over southern Arizona. These predictions are based on a combination of factors, including long-term trends, soil moisture, and El Niño. 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 nearest the middle of each month.

For more information, visit: http://www.cpc.ncep.noaa.gov/products/predictions/90day/

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.

Precipitation: Monthly (August) and 3-Month (Aug.-Oct. 2002) Outlooks (Source: NOAA CPC)

Figure C4. August 2002 national precipitation forecast (released 7/18).

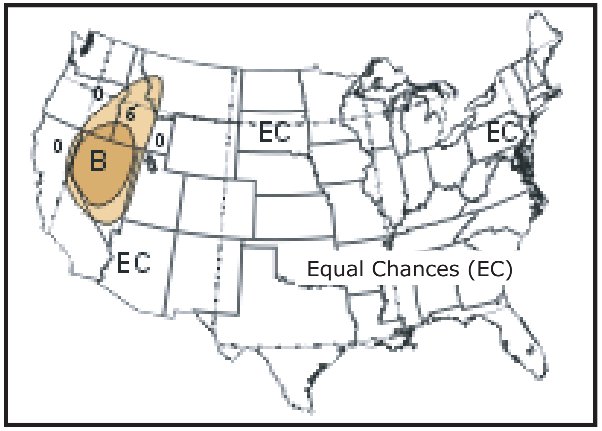
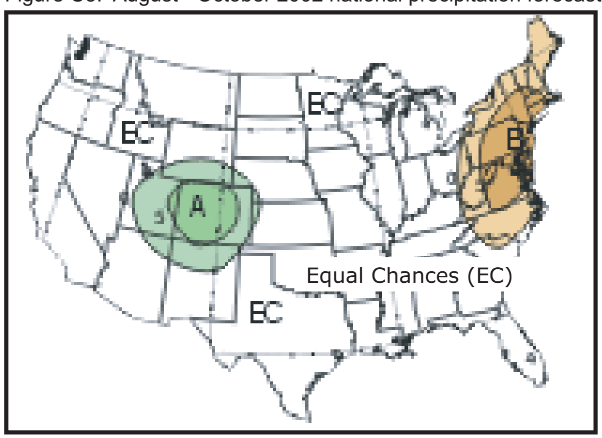


Figure C5. August - October 2002 national precipitation forecast.



Percent Likelihood
of Above or Below
Average Precipitation*

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

***EC indicates no forecast due to lack of model skill**

NOAA CPC climate outlooks are released on the Thursday nearest the middle of each month.

Highlights: The CPC has reserved judgment (i.e., “Equal Chances”) regarding August precipitation for Arizona and New Mexico. Summer monsoon precipitation is notoriously difficult to predict, especially when tropical ocean conditions are near average or in transition to El Niño. The August-October precipitation outlook shows very slightly increased probabilities of above average precipitation for northern New Mexico and northeastern Arizona. These predictions are based chiefly on the results of a statistical model.

For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/seasonal_forecast.html

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.

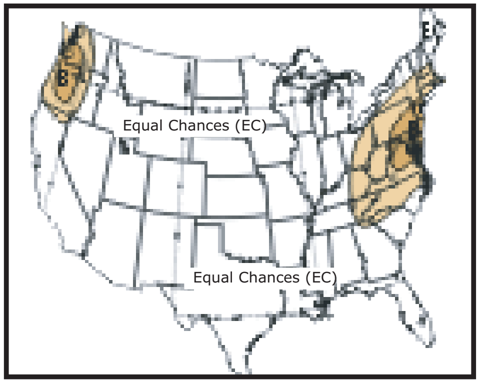
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

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

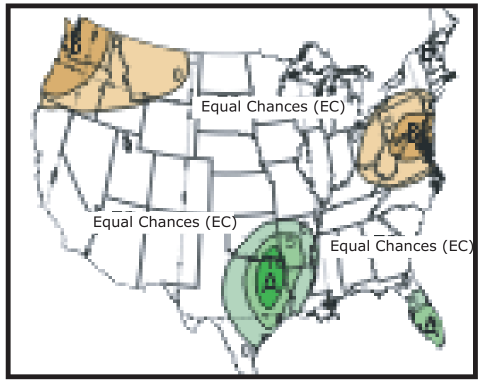
Precipitation: Multi-season Outlooks (Source: NOAA Climate Prediction Center (CPC))

Figure C6. Overlapping 3-month long-lead precipitation forecasts (released 7/18/2002).

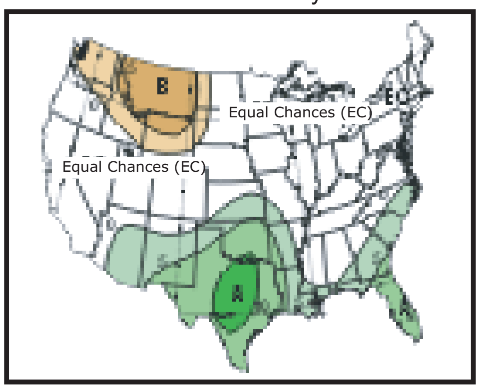
Long-lead national precipitation forecast for September - November 2002.



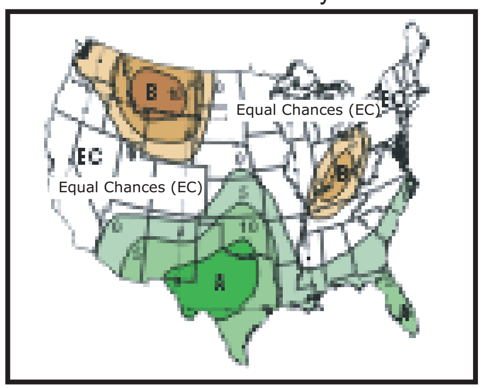
Long-lead national precipitation forecast for October - December 2002.



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



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



Percent Likelihood of Above or Below Average Precipitation*

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

*EC indicates no forecast due to lack of model skill

NOAA CPC climate outlooks are released on the Thursday nearest the middle of each month.

Highlights: The CPC precipitation outlooks for the next four overlapping seasons show increased probabilities of above average precipitation in our region beginning with the November 2002-January 2003 outlook. The greatest confidence in these predictions is centered over southeastern 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 has also produced below average precipitation in our region. Decision makers are advised to monitor the strength of the El Niño event as it progresses.

For more information, visit: http://www.cpc.ncep.noaa.gov/products/predictions/90day/

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.

Drought: PDSI Forecast and U.S. Seasonal Drought Outlook

Figure C7. Short-term Palmer Drought Severity Index (PDSI) forecast through 7/20/02 (accessed 7/18).

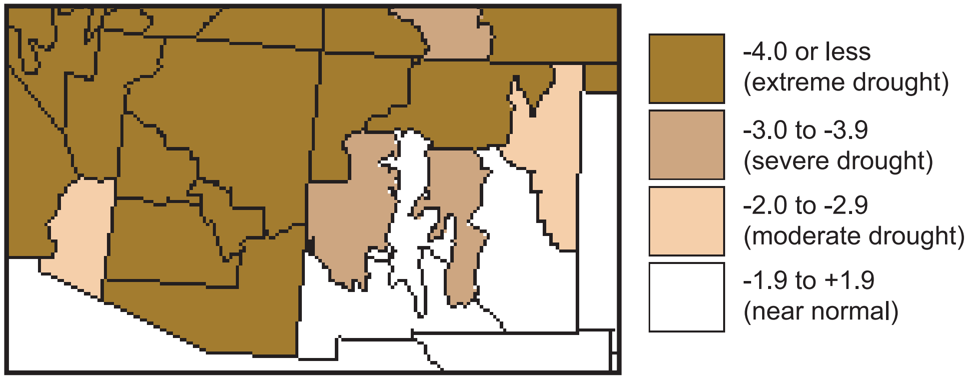
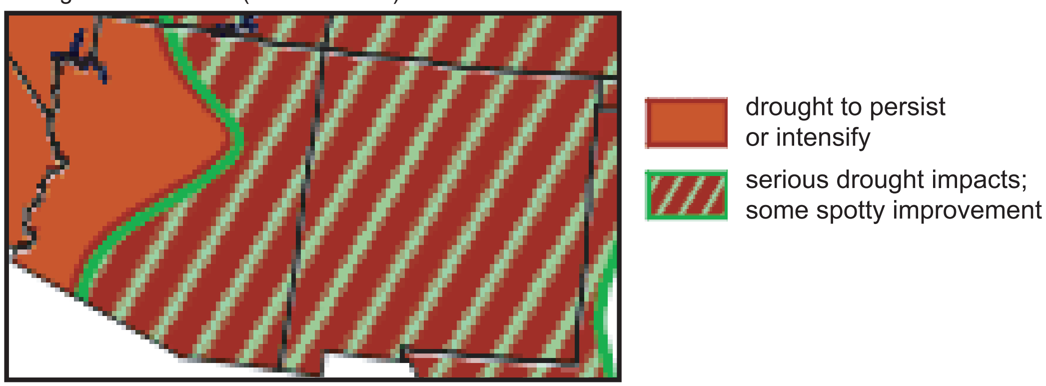


Figure C8. Seasonal drought outlook through October 2002 (released 7/18).



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 subjectively defined and are based on expert assessment of numerous indicators including outputs of short- and long-term forecast models.

Highlights: Figure C7 (top) is a short-term forecast for continued extreme drought conditions throughout much of our region. PDSI forecasts are updated each week and are available from the National Drought Monitor website http://www.drought.unl.edu/dm/monitor.html (click on *forecasts*).

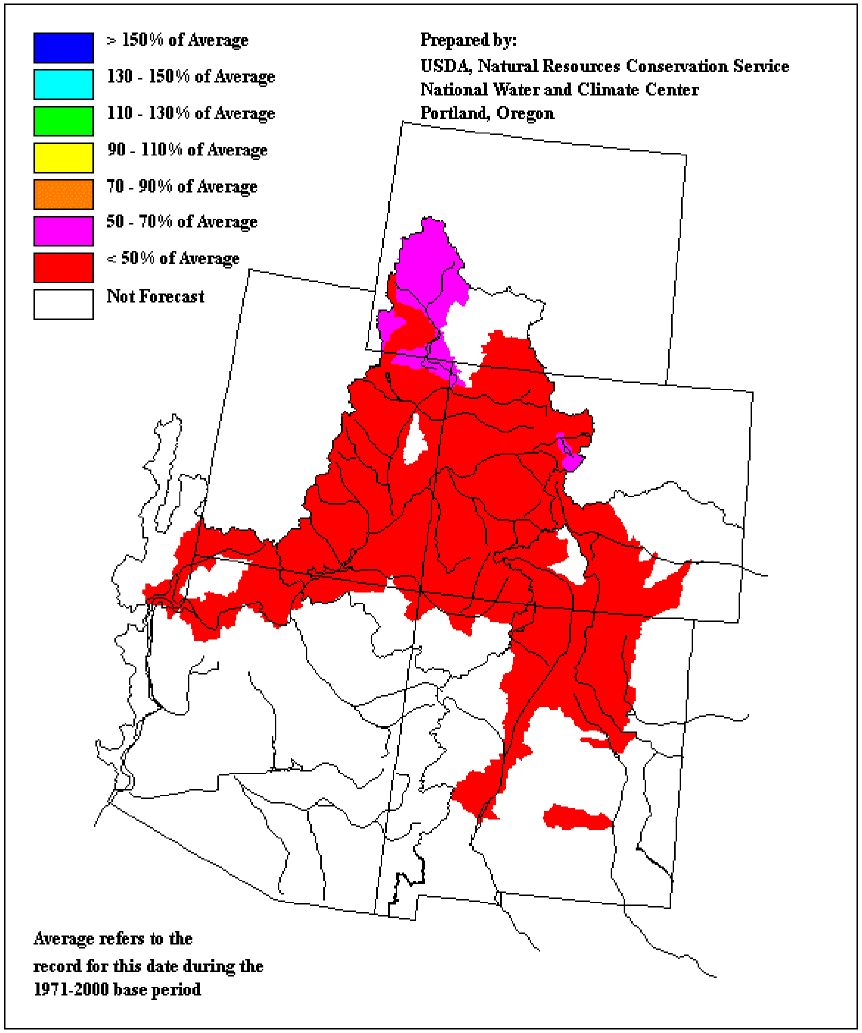
The U.S. Seasonal Drought Outlook (Figure C8) calls for no substantial drought improvement in western drought areas before next winter's snow season. However, summer thunderstorms will continue to offer some short-term improvement in dry conditions in scattered locations. Ongoing drought is likely to result in continued low streamflows, range deterioration, and other impacts. This Seasonal Drought Outlook is valid through October 2002.

U.S. Seasonal Drought Outlooks are updated each month at the following website:
http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html.

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

Streamflow Forecast: Latest Forecast (for May 1, 2002) for the Colorado, Rio Grande, and Arkansas Rivers (Source: USDA Natural Resource Conservation Service)

Figure C9. Southwest Streamflow Forecast.



Notes:
Unless otherwise specified, forecasts are naturalized flows occurring naturally without any upstream influences (such as dams).

Forecasts are made only during the months of January through May for these river drainages. While it is somewhat out of date, this is the most recent forecast available. Streamflow forecasts will resume in January 2003.

Highlights: Figure C9 indicates that virtually all of the Upper and Lower Colorado River basins were at less than 50% of flow (assumed to be expressed as meters per second). Such conditions, (i.e., low flows in both the Upper and Lower Colorado River basins), while rare, do occur on occasion, such as during the present drought. This map was accessed on 7/18/02.

For a more detailed description of how to interpret forecasted probabilities, visit: http://www.wcc.nrcs.usda.gov/factpub/intrpret.html

Fire: Forecasts and Outlooks

Figure C10_a. 2002 wildfire forecast, area burned.

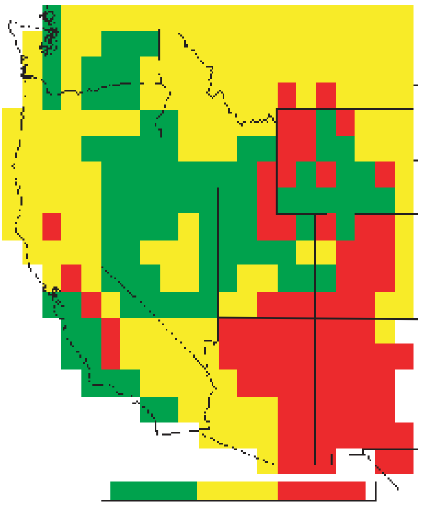


Figure C10_b. Percent likelihood of a correct above-normal forecast.

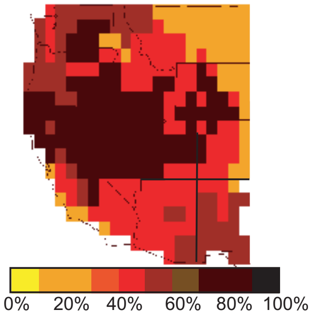


Figure C10_c. Percent Likelihood of a correct below-normal forecast.

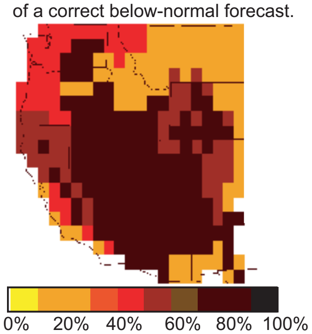
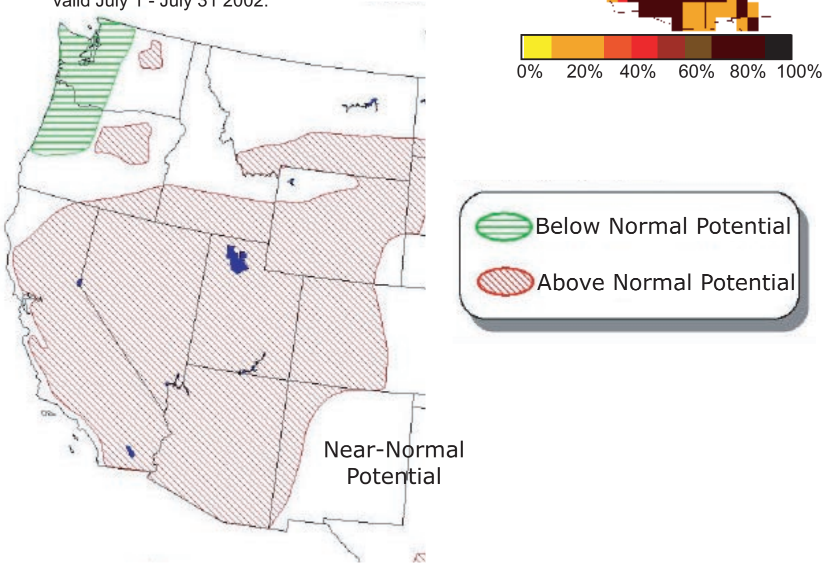


Figure C10_d. National Wildland Fire Outlook valid July 1 - July 31 2002.



Notes:
Wildfire area burned is forecast using a statistical methodology called canonical correlation analysis (CCA). CCA matches large-scale patterns in monthly U.S. climate division Palmer Drought Severity Index (PDSI) with spatial patterns in seasonal area burned in order to predict area burned one season in advance.

The forecast acres burned were assigned to one of three classes (Fig. C10a): above normal (red), normal (yellow), or below normal (green).

Based on data for 1980-2001, above- and below-normal area burned forecasts are successful better than 50% of the time for large parts of AZ and NM (Fig. C10b and C10c).

The CCA wildfire forecast for the western U.S. was issued in March 2002 (valid for summer 2002) by Dr. Anthony Westerling of Scripps Institution of Oceanography.

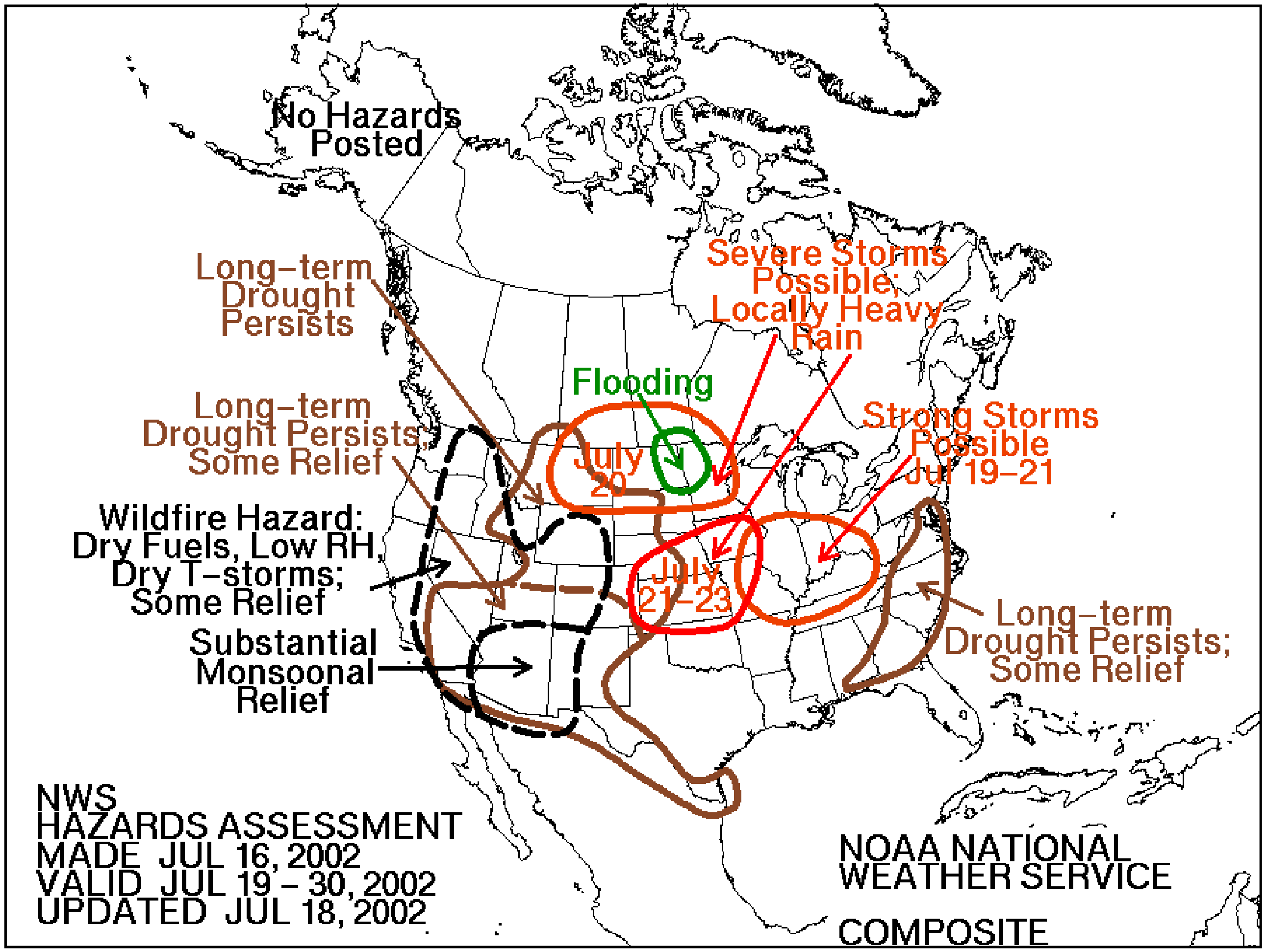
The National Wildland Fire Outlook (Fig. C10d) considers climate forecasts and surface fuels conditions to assess fire potentials. It is issued monthly by the National Interagency Fire Center.

Highlights: The Scripps CCA wildfire forecast (Fig. C10a) successfully predicted above normal area burned for most of AZ and NM. The NIFC National Wildland Fire Outlook (Fig. C10d) for July 1-31, 2002 (issued June 2002), however, illustrates that wildland fire potential changes throughout the course of the fire season. Regardless of the accuracy of pre-season fire forecasts, such as the Scripps CCA forecast, decision makers need to monitor changing fire potential and region-specific conditions during the fire season.

For more detailed discussions, visit the following webpages:
Scripps Wildfire Forecast: http://meteora.ucsd.edu/%7Emeyer/caphome.html
National Wildland Fire Outlook: http://www.nifc.gov/news/nicc.html

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

Figure C11. U.S. Threats Assessment map (valid July 19-30, 2002)



Notes:
This threats forecast is for July 19 – July 30, 2002.

The threats 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 threats assessments.

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

Highlights: The U.S. Threats Assessment indicates persistent long-term drought throughout our region, with short-term relief from monsoon precipitation in Arizona and western New Mexico. Higher relative humidity and more widespread showers currently are reducing wildfire risk in Arizona and New Mexico. However, computer models suggest that the Southwest monsoon may be suppressed for a time, as predicted towards the middle of the week of July 22-30, 2002.

The U.S. Threats Assessment is issued each Tuesday (updated on Thursday) for climate related-hazards occurring during the next 3-10 days.
For a more detailed description of CPC's threats assessment forecast, visit: http://www.cpc.ncep.noaa.gov/products/expert_assessment/threats.html

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

Figure C12_a.

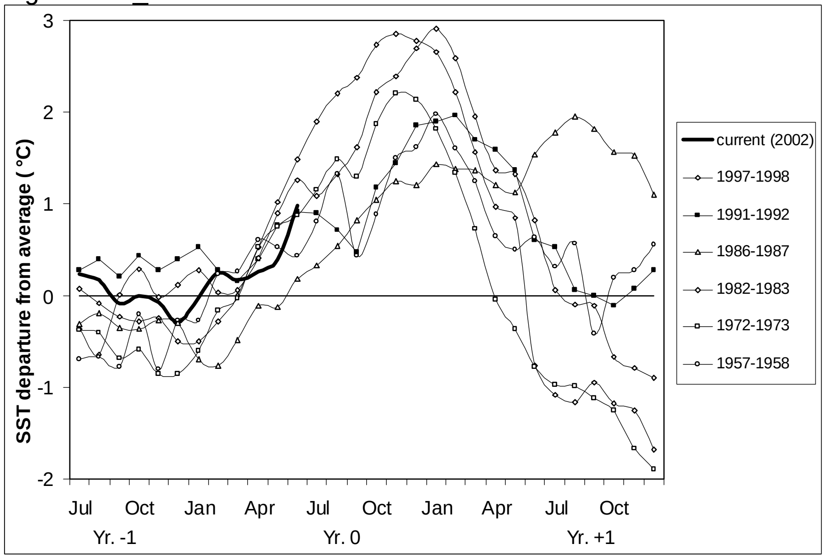
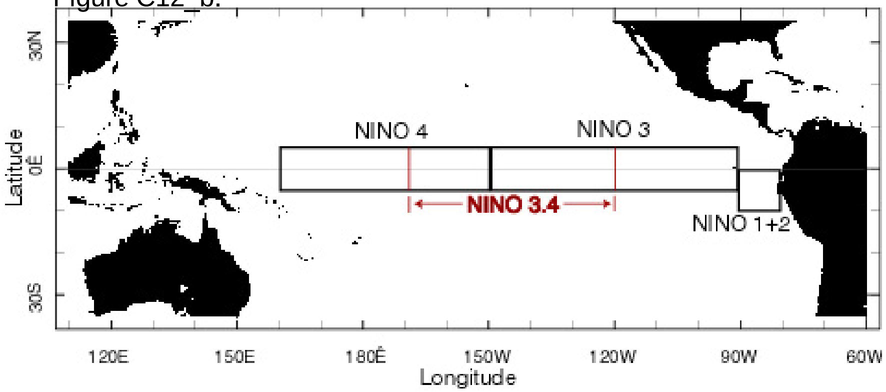


Figure C12_b.



Notes:

The graph (Fig. C12a) shows sea surface temperature (SST) departures from the long-term average for the Niño 3.4 region (Fig. C12b), which is 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 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 July 11, NOAA's Climate Prediction Center (CPC) declared that mature El Niño conditions likely will develop in a few months. The International Research Institute for Climate Prediction (IRI) concurs, and their experts have indicated a 90% probability of El Niño conditions lasting for the next 6-9 months (i.e., through early 2003). Both agencies caution that this winter's El Niño event will not be as powerful as the 1997-98 El Niño. The IRI predicts that this El Niño will be one-third to one-half the strength of the 1997-98 El Niño. For information on El Niño impacts on the Southwest, see the 'Historical El Niño Conditions' 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

HISTORICAL DROUGHT CONDITIONS

Historical Drought Conditions: Arizona and New Mexico in the 20th Century

Figure D1. Lower Colorado River Basin drought (1895-1995).

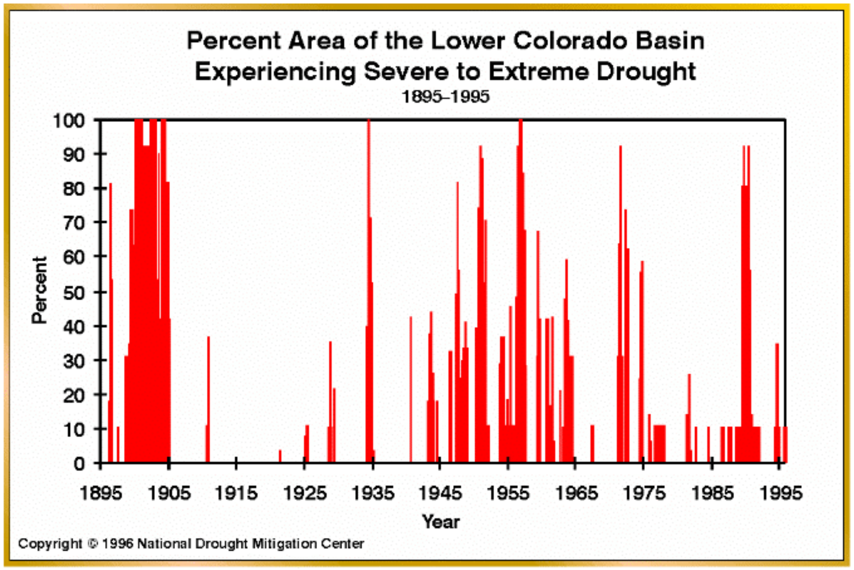


Figure D2. Rio Grande River Basin drought (1895-1995).

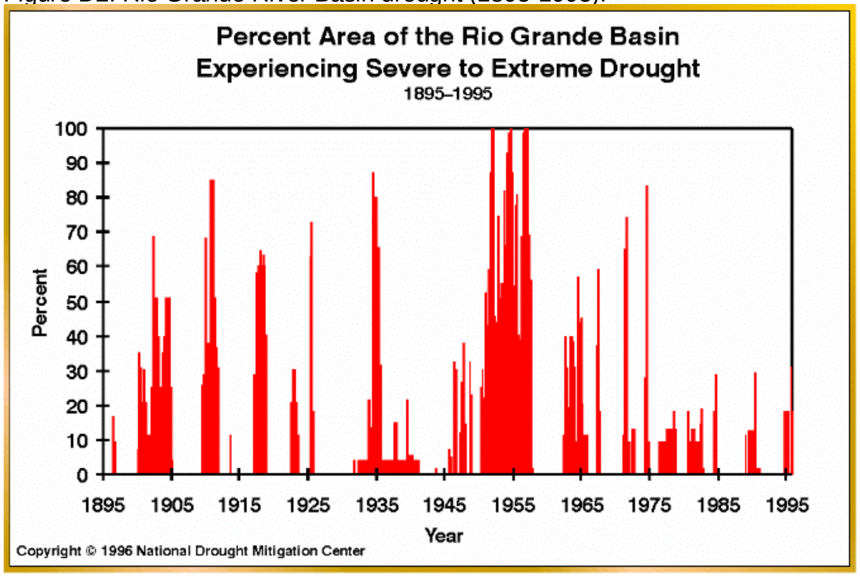
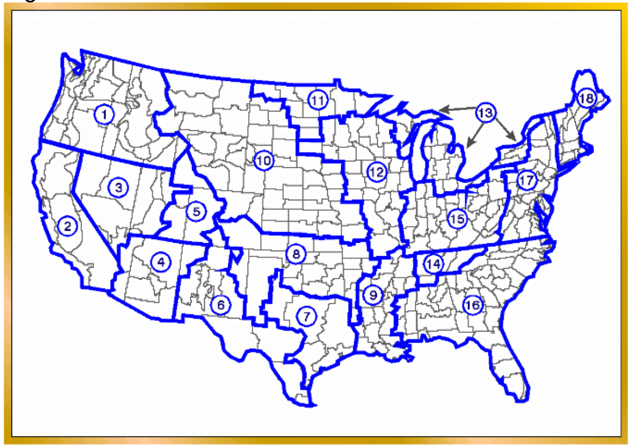


Figure D3. U.S. river basins and climate divisions.



Notes:

These graphs (Figures D1, D2) are derived from maps of the percent of the area in each river basin experiencing severe to extreme drought, based on climate divisions exhibiting a Palmer Drought Severity Index value less than or equal to –3.

The information presented in these graphs represents available instrumental records only.

The map at left (Fig. D3) displays the river basins (heavy blue lines) and climate divisions (lighter black lines) used in the percent area experiencing drought calculations. The Lower Colorado River Basin consists of all of AZ as well as a portion of northwestern NM. The Rio Grande Basin consists of most of NM as well as the southwestern part of Texas.

Highlights: While Arizona and New Mexico have similar climates, drought severity has differed in the two states over the last century. The graphs show a marked difference in duration and areal extent of severe to extreme drought in AZ and NM. The turn of the century and 1950s stand out as significant drought periods. Note that the Lower Colorado River Basin was more strongly affected by the turn of the century drought (Fig. D1), whereas the Rio Grande Basin was more strongly affected by the 1950s drought (Fig. D2).

For these and other graphs of historical drought, visit: http://drought.unl.edu/climate/palmer/pdsirivr.htm

Drought History: The 1950s in the U.S. Southwest

Figure D4_a. Cumulative PDSI assessment from 1950-59.

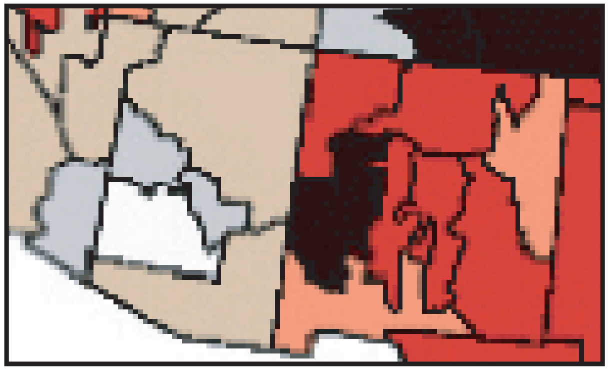
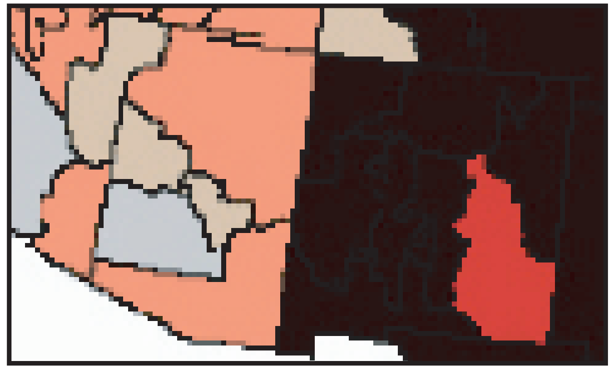


Figure D4_b. Cumulative PDSI assesssment from 1954-56.



% of time when PDSI was either severe or extreme*

- Less than 10%
- 10% to 19.99%
- 20% to 29.99%
- 30% to 39.99%
- 40% to 49.99%
- 50% or Greater

*PDSI values range from -4.0 to +4.0, with severe and extreme as >+3.0 and >+4.0, respectively.

Figure D4_c. Departure from average winter precipitation (December-February), 1950-56.

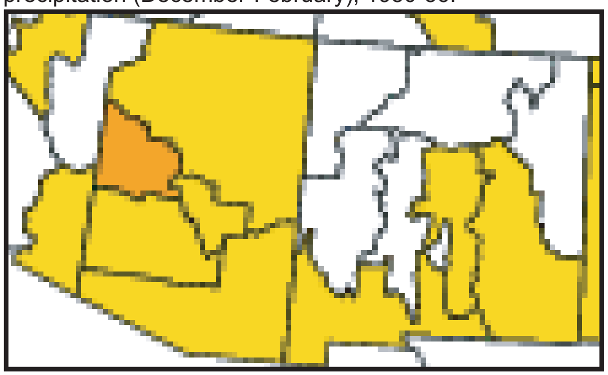
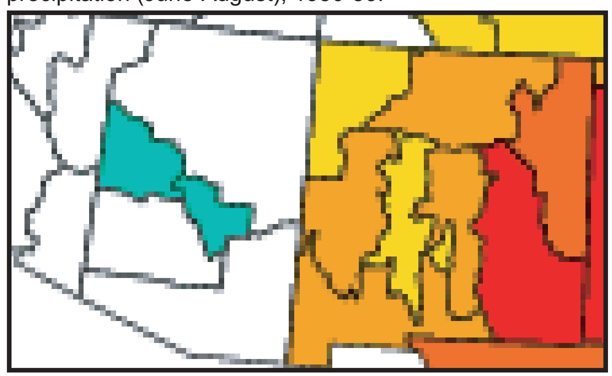


Figure D4_d. Departure from average summer precipitation (June-August), 1950-56.



Departure from average precipitation (in inches)

+1.0
-1.0
-3.0
-5.0

Notes: The PDSI (Palmer Drought Severity Index) attempts to measure the duration and intensity of long-term conditions that underlie drought. The values displayed on the PDSI maps are derived from the percent of time during which a PDSI value less than or equal to –3 (extreme drought) was registered in each climate division. The precipitation maps display the difference between the average seasonal precipitation (winter or summer, as noted) during the specified time period (e.g., winters from 1950-51 through 1955-56) and the average seasonal precipitation (winter or summer, as noted) for 1971-2000.

Highlights: Despite significant drought across the region, the 1950s drought affected AZ and NM differently (Fig. D4a). The peak of the drought (1954-56) was much more severe in NM than AZ (Fig. D4b). Why did drought severity differ in AZ and NM? Much of New Mexico receives the great majority of its precipitation during the spring, summer (especially) and fall seasons, whereas much of Arizona has two precipitation peaks during the year, one during the summer months and one during the winter months. In AZ the winter *precipitation* anomaly was relatively small (Fig. D4c), and summer precipitation was near or above average (Fig. D4d), whereas in NM, summer precipitation deficits were far greater and had greater impact, because NM receives most of its of annual precipitation during the summer months.

For these and other historical PDSI maps, visit: http://drought.unl.edu/climate/palmer/pdsihist.htm
To create your own PDSI and precipitation maps, visit: http://www.cdc.noaa.gov/USclimate/USclimdivs.html

Section E

BACKGROUND ON EL NIÑO

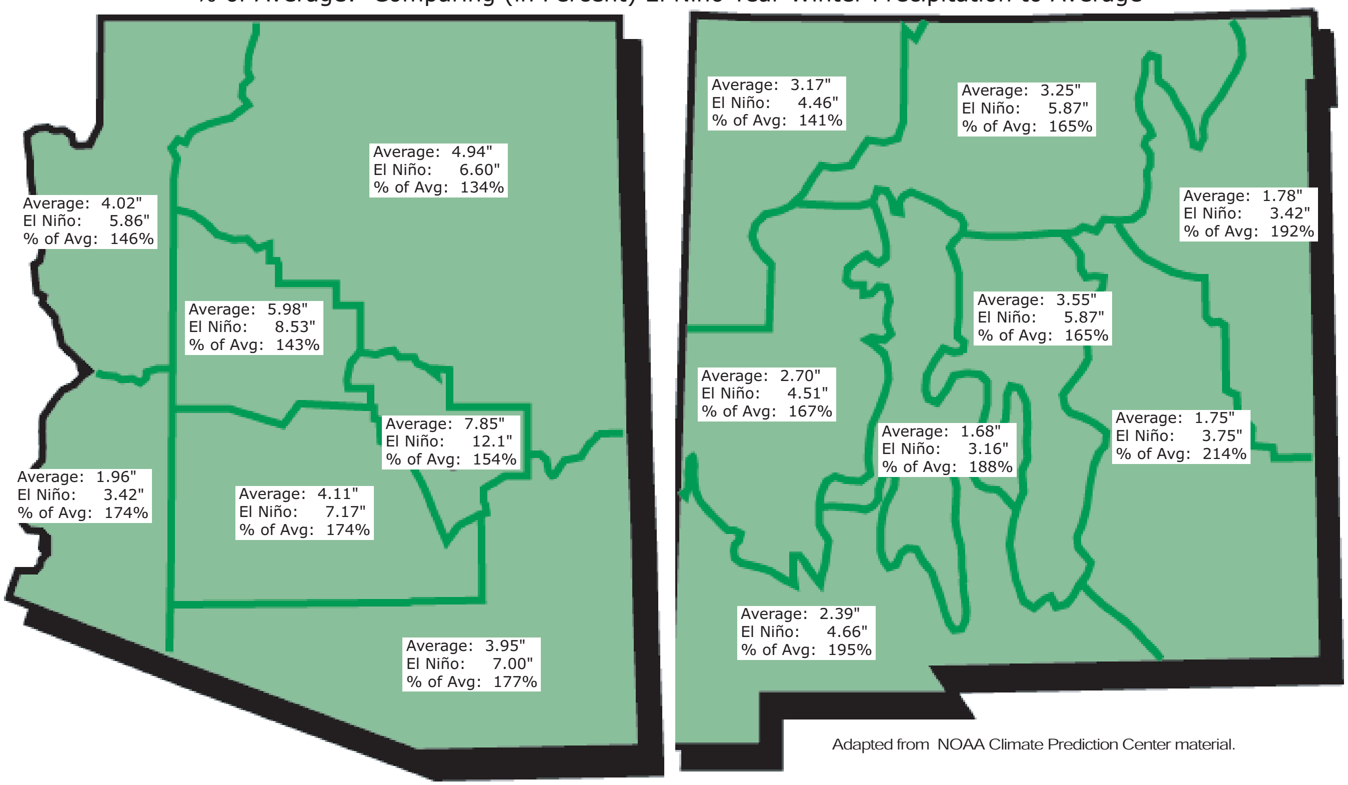
Historical El Niño Conditions: El Niño vs. Average Winter Precipitation (**Figure E1**)

Comparing Normal and El Niño Winter Precipitation (December - March)
by Climate Division

Average = average of 102-Year Instrumental Record (1895 - 1996)

El Niño = average of 1914 -1915, 1918-1919, 1940-1941, 1957-1958,
1965-1966, 1972-1973, 1982-1983, 1986-1987, 1991-1992

% of Average: Comparing (in Percent) El Niño Year Winter Precipitation to Average



Adapted from NOAA Climate Prediction Center material.

Highlights: This map shows the historical tendency for El Niño conditions to bring above average precipitation to the Southwest. Although the highest winter precipitation totals typically are associated with El Niño events, individual El Niño events also have resulted in below average winter precipitation in parts of our region. Winter precipitation impacts associated with El Niño are variable and depend on the strength of the El Niño event, the location of El Niño-related sea surface temperature warming in the equatorial Pacific Ocean, and interactions between various atmospheric circulation patterns.

For more information on El Niño and its effects, visit: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.html

Winter El Niño Atmospheric Circulation

Figure E2_a. Typical winter anomalies during moderate-strong El Niño events.

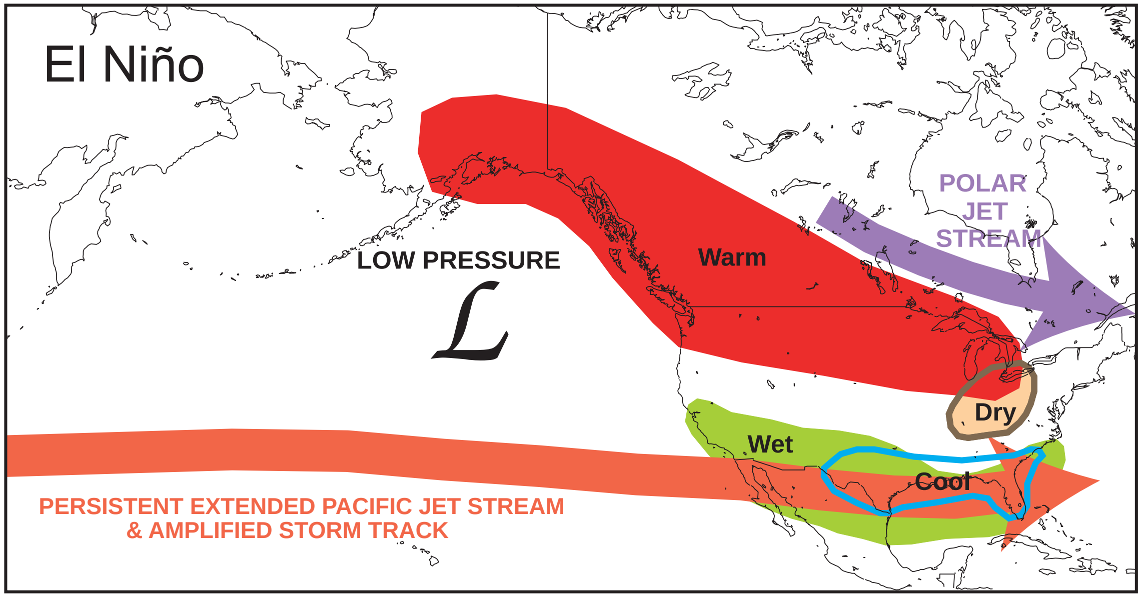
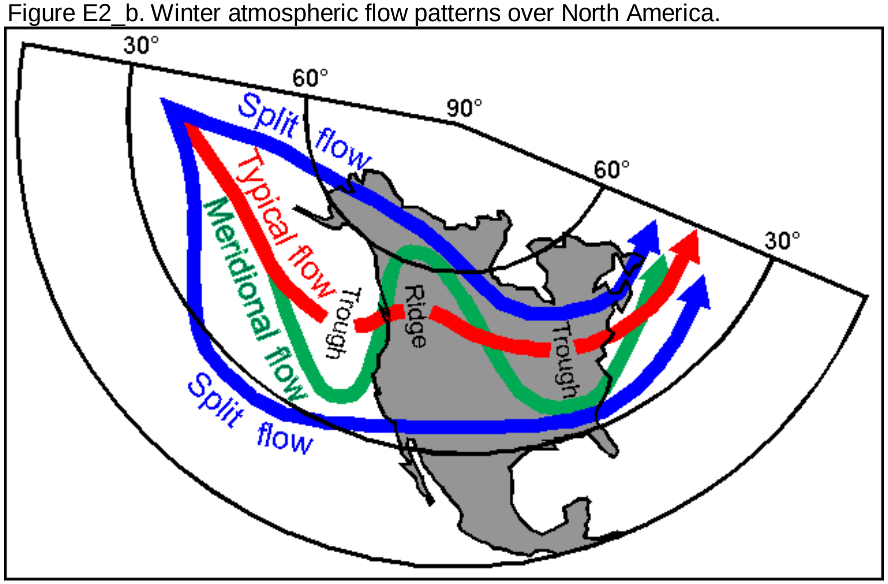


Figure E2_b. Winter atmospheric flow patterns over North America.



Highlights: When ocean temperatures in the central and eastern tropical Pacific Ocean warm sufficiently (El Niño), the release of energy to the atmosphere can result in major changes in atmospheric circulation as far as many thousands of miles away.

In the simplest sense, El Niño frequently results in an enhanced winter storm track at low latitudes (Fig. E2a), which brings increased moisture, more persistent winter storms, and greater than average winter precipitation to the Southwest U.S.

Enhancement of the low-latitude winter storm track over North America occurs through a variety of mechanisms (Fig. E2b). During El Niño, atmospheric flow from the west shifts southward by becoming more meridional (north-south oriented) or by splitting into two branches.

Storms that travel the southern branch may tap into moisture from lower latitudes over the eastern Pacific Ocean, resulting in an increase in low-intensity winter precipitation in the Southwest U.S.

Figure E2a. Source: NOAA Climate Prediction Center (http://www.cpc.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.html).

Figure E2b. Source: CLIMAS (http://www.ispe.arizona.edu/climas/test/pubs/CL1-99.html).

Winter El Niño Precipitation and Temperature Impacts

Fig. E3_a. Precipitation Anomaly for Strong El Niño Winters

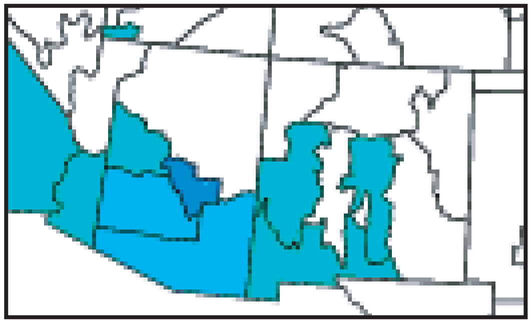
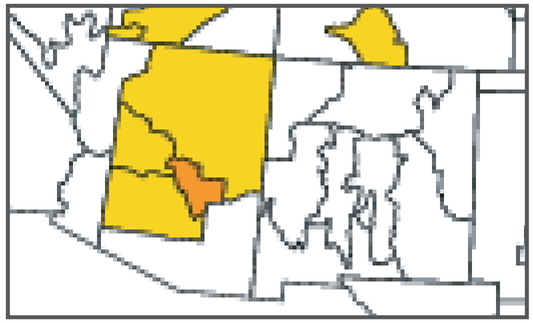


Fig. E3_b. Precipitation Anomaly for Weak El Niño Winters



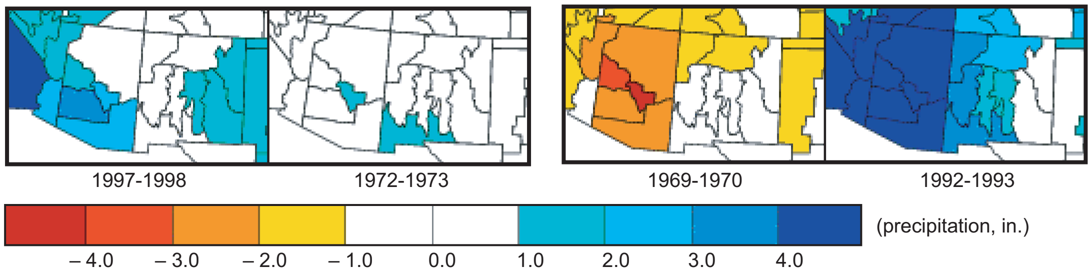


Fig. E3_c. Temperature for Strong El Niño Winters

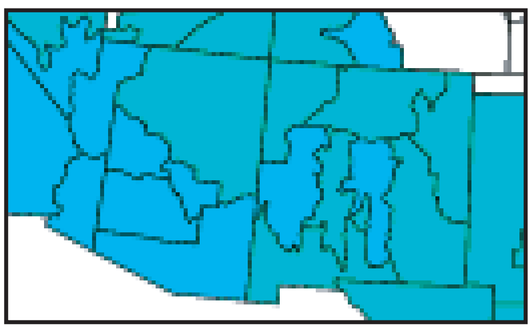
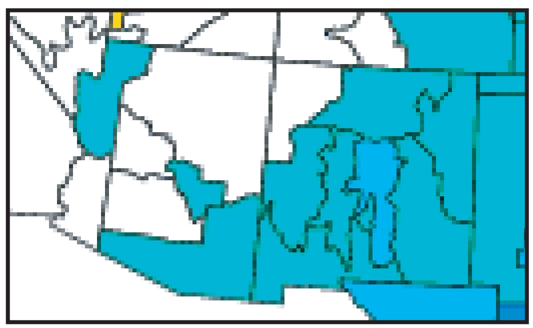


Fig. E3_d. Temperature Anomaly for Weak El Niño Winters



Notes:

The strong El Niño precipitation (Fig. E3a) and temperature (Fig. E3c) anomaly maps display the difference between the average winter (December-February) precipitation (or temperature) during 4 strong El Niño events (1965-66, 1972-73, 1982-83, 1997-98) and average winter precipitation for 1971-2000.

The weak El Niño precipitation (Fig. E3b) and temperature (Fig. E3d) anomaly maps display the difference between the average winter (December-February) precipitation (or temperature) during 4 weak El Niño events (1963-64, 1969-70, 1976-77, 1992-93) and average winter precipitation for 1971-2000.

Precipitation and temperature anomalies are expressed in inches and degrees Fahrenheit (°F), respectively.

The small inset maps show winter precipitation anomalies for selected individual El Niño events.

Highlights: El Niño generally brings cool, wet winters to the Southwest. However, these conditions 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 El Niño anomalies show that, depending upon the strength of the event, parts of the Southwest might even receive below average (based on the 1971-2000 average) precipitation. Effects during individual El Niño winters are highly variable. For example, a strong El Niño (e.g., 1972-73) can bring average winter precipitation, whereas a weak El Niño (e.g., 1992-93) can bring above average precipitation.

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