

# Border Climate Summary

## Resumen del Clima de la Frontera

Issued: February 18, 2010

### Tree Rings and the Monsoon in the Southwestern U.S.

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The monsoon is a major component of southwestern North America's climate regime and arguably one of the most anticipated regional climate events of the year, delivering varying doses of life-giving rains to the U.S.-Mexico border region each summer. On average, the monsoon brings three-fourths of northwestern Mexico's annual rainfall and up to half of the annual rain in the U.S. Southwest.

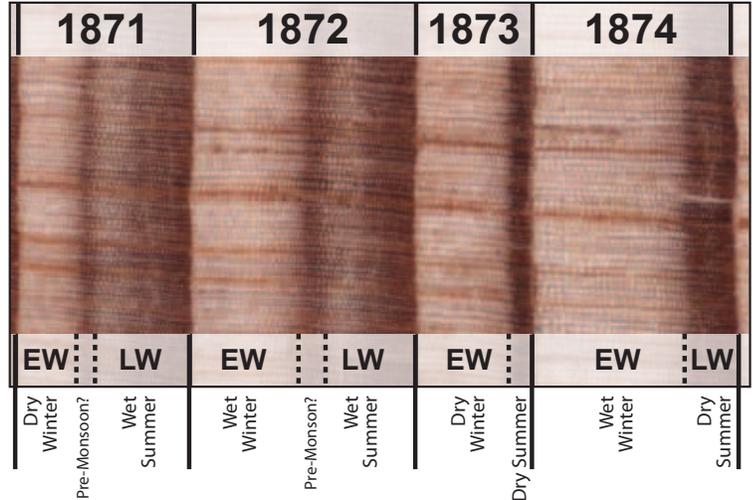
Variability in monsoon rainfall in time and location increases northward with distance from the "core region" in western and northwestern Mexico and is notably dramatic along the border and into the southwestern U.S. These year-to-year changes influence ecosystems, rangelands, agriculture, public health, water resources, and water demand, yet the mechanisms behind the changes are not completely understood.

To better grasp the full range of spatial and temporal variability that is possible under natural (non-human) conditions, researchers at the University of Arizona are studying the long-term climate history of the monsoon using annual growth rings from long-lived, moisture-stressed trees.

#### Tree Rings and the Monsoon

Our understanding of the monsoon climate system has improved greatly in recent years, largely through the cooperative efforts of research associated with the North American Monsoon Experiment (<http://www.eol.ucar.edu/projects/name/>) and improved seasonal forecasts. For longer time scale climate change projections, global climate models robustly predict that the region's cool season will be drier in the future, but predictions of future North American Monsoon precipitation, in response to human-caused climate change, are varied.

Natural proxy records in the form of tree rings can help put these projections and future changes in long-term perspective. As described in the July 2009 Border Climate Summary (available online: <http://www.climas.arizona.edu/forecasts/border/archive.html>), tree rings provide



**Figure 1.** This photomicrograph illustrates a sequence of four Douglas-fir tree rings (1871–1874) from southwestern New Mexico. Each annual growth ring is composed of light-colored earlywood (EW) and dark-colored latewood (LW). Both 1871 and 1872 contain intra-annual density variations known as “false rings,” which are probably related to reduced soil moisture in the May–June pre-monsoon period. Note the variability of EW-width, a function of cool-season precipitation, and the independent variability of LW width, which corresponds to warm-season precipitation.

excellent records for reconstructing environmental history, including natural climate variability at time-scales of years to decades to centuries.

Southwestern North America has a dense network of tree-ring collections that extend back more than 400 years. Historically, scientists have used these records to learn about the long-term history of drought and wetness in the winter season, but these tree-ring samples also can be used to study moisture history associated with the North American Monsoon.

The annual growth rings in many southwestern conifer species, such as pine and fir trees, are composed of light colored “earlywood” that forms in the spring and dark colored “latewood” that forms in the summer (Figure 1). In the Southwest U.S. and northwest Mexico,

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## Executive Summary

**In General** – El Niño is expected to influence the winter storm track and bring an increased chance of above-average precipitation to the U.S. Southwest and northwestern Mexico in the February–April period. Servicio Meteorológico Nacional predicts well above-average precipitation for the Baja California peninsula and northwestern Sonora in March and April. Northwestern Mexico and the southwestern United States received above-average precipitation during the second half of January.

**Temperature** – In northwestern Mexico and the southwestern U.S., temperatures were mostly average to above average during June–November 2009.

**Precipitation** – Thanks to several tropical storms in September and October, Baja California Sur and Sonora received above-average fall precipitation. November was mostly a dry month for the entire region.

**Precipitation Forecast** – SMN predicts well above-average precipitation for the Baja California peninsula and northwestern Sonora in March and April, and well above-average precipitation for Baja California Norte and northwestern Sonora in May.

**ENSO** – The chance of El Niño persisting through at least April stands at more than 90 percent, according to the latest IRI ENSO forecast. Neutral conditions are expected to return rapidly in the May–July period, which is typical of El Niño events.

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# A look back at the 2009 summer monsoon

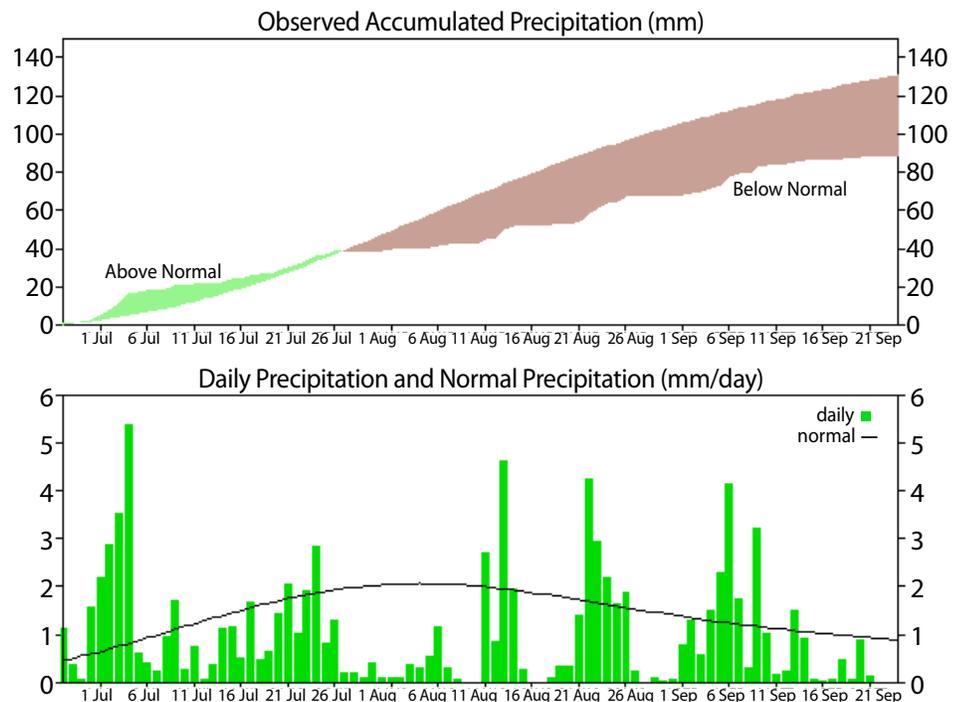
By DAVID J. GOCHIS, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

On May 21, 2009, the monsoon message was clear. During an online briefing, or webinar, forecasters and researchers outlined their forecasts and expectations for the 2009 North American Monsoon (NAM) season (<http://ag.arizona.edu/climate/ws/052109.htm>): a wet start to the monsoon tempered by uncertainty beginning in August. Yet as the season progressed, conditions took an unexpectedly severe turn as the rains all but disappeared. So, what happened during the 2009 NAM season, and how accurate were those predictions?

The consensus statement from the webinar was for an early and robust onset of monsoon rains in the Southwest U.S. and northwest Mexico, with conditions becoming very uncertain by mid-season due to the development of an El Niño event (warmer-than-average ocean temperatures) in the tropical eastern Pacific Ocean. This consensus statement was based on independent forecasts made by the U.S. and Mexican national weather services, as well as analyses by climate researchers.

To a certain degree, this general forecast turned out to be accurate for a limited region of the NAM, including the border regions of Arizona, Sonora, New Mexico, and Chihuahua. Figure 1 shows the accumulated rainfall averaged throughout southern Arizona and northern Sonora from July 1 through September 24, and evidence exists of the forecasted early and robust onset of monsoon rainfall.

However, what was not predicted was the severity and extent of dry conditions that enveloped much of the NAM region through July into early September. Figure 1a shows the map of the 90-day precipitation anomalies



**Figure 1.** Summer monsoon precipitation in 2009 for northwest Mexico and the Southwest U.S. Top: green indicates cumulative precipitation greater than the 1979–1995 average, and brown indicates cumulative precipitation below the average. By the end of the monsoon season, the average cumulative deficit for the region was around 40 mm. Bottom: green bars indicate the daily precipitation rate (mm/day) for the region; the black curve shows the average daily precipitation rate. Note the substantial decline in precipitation rate between July 5 and August 10, and the near cessation of precipitation between July 27 and August 10.

(departures from average conditions) for the period ending September 24. Areas of northeast and eastern Mexico (Coahuila, Nuevo León, Tamaulipas, and Veracruz) and portions of southern Mexico (Yucatán, Chiapas, Guerrero, and Michoacán) were drier than average nearly all summer and faced some of the worst drought conditions in recent history. Similarly, parts of western Arizona and the broader regions of the lower Colorado River region experienced rainfall totals approaching only 50 percent of average.

Although it is always difficult to determine exactly what combination of meteorological events lead to observed seasonal patterns of rainfall, a basic analysis of regional atmospheric circulation features (weather patterns) offers some explanation.

As suspected at the time of the seasonal forecast webinar, El Niño appears to have played a significant role in suppressing monsoon rainfall, particularly over southern and eastern Mexico. Figure 1c shows the average sea surface temperature anomalies for June 2b through September 16. A strong band of warmer-than-average sea surface temperatures (around 2 degrees Celsius above average) persisted across much of the tropical eastern Pacific Ocean during the summer months and has continued into 2010.

A broader region of generally warmer-than-average sea surface temperatures also existed across the eastern Pacific, Gulf of Mexico, and Intra-America Seas regions. Past research has shown that such conditions tend to weaken the overall monsoon circulation,

continued on page 5

## tree-rings, continued

the widths of these components of tree rings can be distinguished using a microscope, and they are most often related to seasonal moisture conditions; wide earlywood bands result from wet winters and wide latewood bands form in wet summers. Conversely, earlywood is narrow following dry winters and latewood is narrow in dry summers.

Earlywood- and latewood-widths vary independently, and these widths can be measured to produce distinct records of cool- and warm-season precipitation variability. This concept was demonstrated by David Meko and Christopher Baisan of the UA's Laboratory of Tree-Ring Research in a small-scale pilot study that focused on southeastern Arizona (Meko and Baisan 2001). An early tree-ring study of the monsoon in Mexico was published in 2002 by Matthew Therrell, David Stahle, and Malcolm Cleaveland from the University of Arkansas Tree-Ring Laboratory, and Jose Villanueva-Diaz of the Instituto Nacional de Investigaciones Forestales, Agrícolas, y Pecuarias (INIFAP) in Durango, Mexico (Therrell et al. 2002). Their research in Mexico is ongoing.

### Current Research

In 2008, with funding from the National Science Foundation, a team of experts from the UA's Laboratory of Tree-Ring Research and the Department of Atmospheric Sciences initiated a new large-scale research project to study tree rings and the history of the monsoon in the southwestern U.S. This three-year project will produce the first network of monsoon-sensitive tree-ring chronologies for the southwestern U.S. (Figure 2).

The researchers have collected samples from the original tree-ring sites to update the chronologies to the 2008 calendar year and are measuring the earlywood- and latewood-widths. In previously collected tree-ring records, only total ring width was measured by earlier researchers.

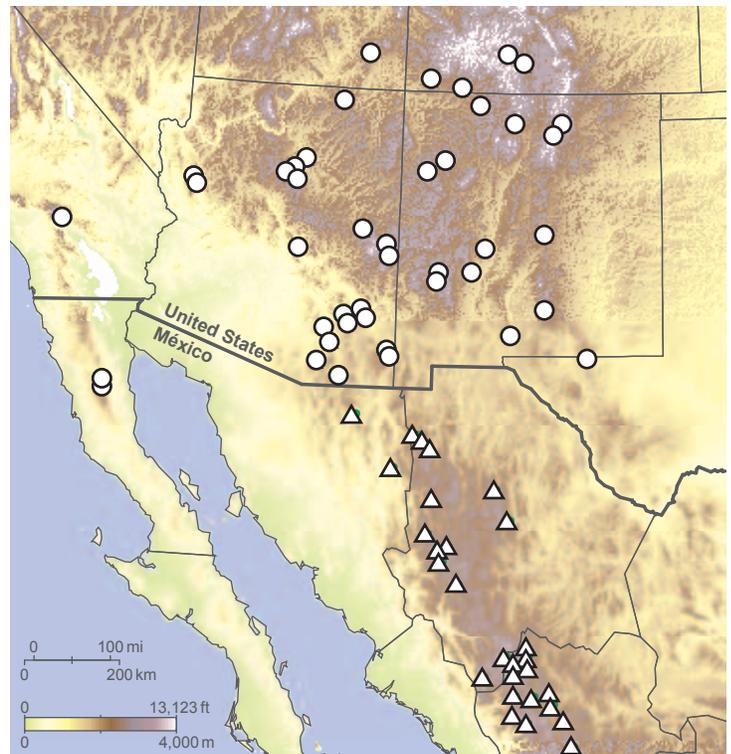
The scientists' primary goal is to study the spatial and temporal history of the monsoon over the southwestern U.S. for the last 500 years and address many research questions: When were the worst droughts during the last five centuries? How extreme were these summer-season droughts, and how long did they last? Were there prolonged periods of wetter-than-average monsoons? How does the monsoon moisture history compare to that of the winter season? What

happened to the monsoon during the severe winter-season droughts (such as the late 1500s megadrought)? How frequently has major drought occurred during both the cool and warm seasons? What is the relationship between the monsoon and large-scale circulation features such as the El Niño Southern Oscillation and the Pacific Decadal Oscillation? How well do regional climate models reproduce the full range of variability evident in the tree-ring data?

A primary thrust of the project is to work with regional stakeholders to

### References

- Meko, D.M., and C.H. Baisan. 2001. Pilot study of latewood-width of conifers as an indicator of variability of summer rainfall in the north American Monsoon region: *International Journal of Climatology*, 21: 697–708.
- Therrell, M.D., D.W. Stahle, M.K. Cleaveland, and J. Villanueva-Diaz, 2002. Warm season tree growth and precipitation over Mexico. *Journal of Geophysical Research*, 107, no. D14, 4205, 10.1029/2001JD000851.



**Figure 2.** Circles on this map illustrate the monsoon-sensitive tree-ring chronology network currently being developed for the southwestern United States by researchers from the University of Arizona's Laboratory of Tree-Ring Research. Triangles illustrate the complementary Mexican chronology network developed by our colleagues from the Instituto Nacional de Investigaciones Forestales, Agrícolas, y Pecuarias (INIFAP) in Mexico and the University of Arkansas Tree-Ring Laboratory.

provide information that is useful for resource management. In the summer of 2011, once the long-term monsoon reconstruction datasets are complete, the researchers plan to host a technical workshop for stakeholders in the greater border region. In the meantime, information will be available at <http://monsoon.ltrr.arizona.edu>.

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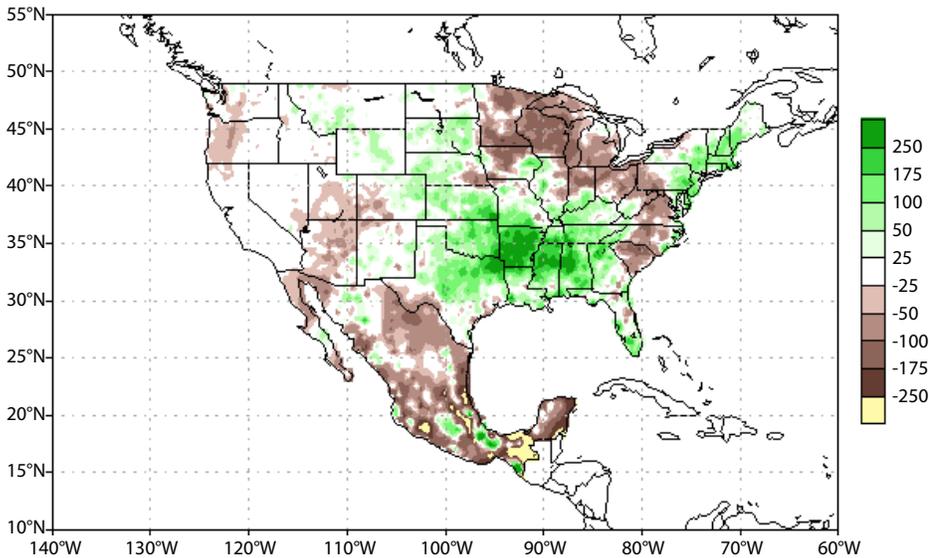
## summer monsoon, continued

because one of the key factors influencing monsoon strength is the contrast between ocean and land temperatures, with relatively cool ocean and warm land temperatures leading to increased monsoon activity.

Another factor that inhibited monsoon rainfall during summer 2009 was an eastward displacement of high pressure near the top of the atmosphere between June 24 and September 16. Upper atmosphere high pressure usually helps

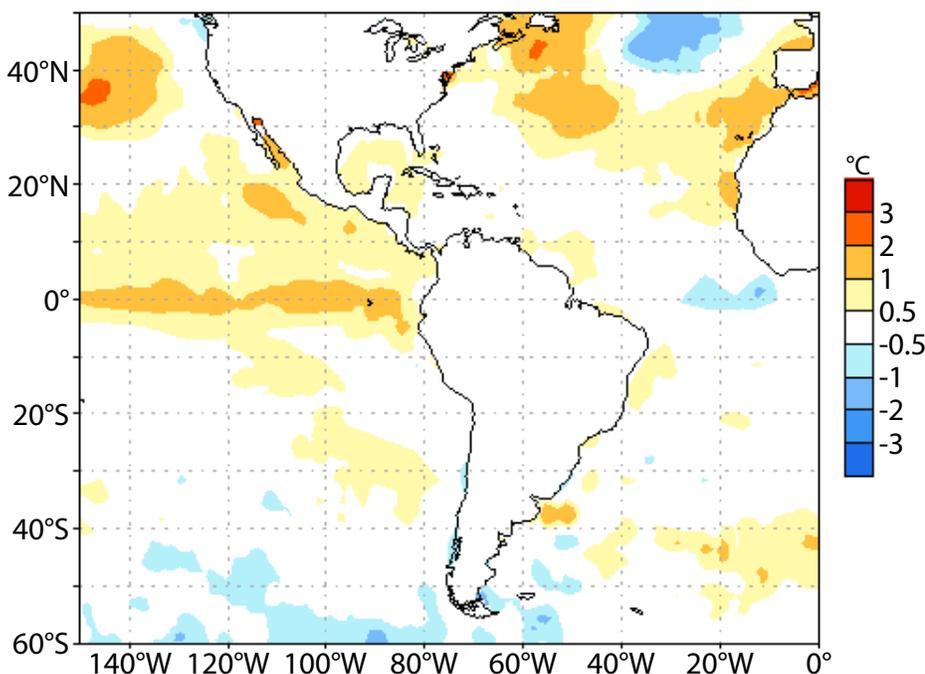
steer moisture into Southwest U.S. and northwestern Mexico, but the eastward displacement of high pressure resulted in drier-than-average flow from the west and north into the monsoon region.

90-Day Accumulation Anomalies Ending August 24, 2009



**Figure 2a.** Accumulated precipitation anomalies (observed precipitation minus the 1979–1995 average) for June 26–September 24, 2009. Note the widespread region of below-average precipitation across most of Mexico and the Southwest U.S.

Average SST Anomalies 24 Jun, 2009–16 Sep 2009



**Figure 2b.** Sea surface temperature (SST) anomalies (observed minus 1979–1995 average) for the 2009 monsoon season. The large region of above-average SSTs along the equator in the eastern Pacific Ocean is characteristic of an El Niño event. El Niño usually inhibits summer monsoon precipitation in northern Mexico and the Southwest U.S., but it enhances winter precipitation in the region.

Related to this upper atmosphere circulation pattern is the fact that fewer-than-average tropical storms hit land in both the eastern and western portions of the NAM region. In 2008, four named Pacific systems made direct landfall or came within 50 miles of Baja and the west coast of mainland Mexico, whereas only two named systems (Hurricane Andres on June 21–24 and Hurricane Jimena on August 29–September 4) made landfall from the Pacific during the 2009 monsoon season.

Forecasts from computer models (“dynamical model forecasts”) were one component of the consensus forecast described above. While the dynamical models predicted a later-than-observed onset of the monsoon, they did a reasonable job of predicting the spatial patterns of wet (northwest Mexico) and dry conditions (southern and eastern Mexico) during July. However, by mid August they had largely underestimated the increasing degree of dryness throughout much of the monsoon region. This shortcoming in predicting the magnitude of wet and dry periods is somewhat similar to the 2008 monsoon forecasts (see the October 2008 Border Climate Summary at <http://www.climas.arizona.edu/forecasts/border/archive.html>).

In summary, the 2009 monsoon season was characterized by drier-than-average conditions across much of the region. While seasonal forecasts showed some skill during 2009, much room for improvement remains in predicting the severity of wetter- or drier-than-average conditions.

## Temperature

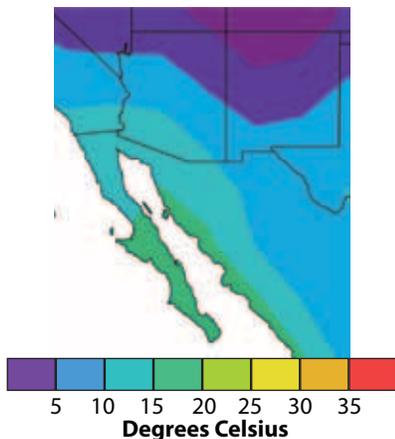
Looking back at June–November 2009, temperatures were well above average across the entire Mexico-U.S. border region during the summer months (not shown); areas in southeastern Arizona across to west Texas were 2 degrees Celsius warmer than the long-term average. For September–November (Figure 1b), above-average temperatures occurred mostly from California to southwestern New Mexico, while some areas of south-central New Mexico to west Texas saw average to below-average temperatures. Above-average temperatures in the southwestern U.S. were associated with below-average summer monsoon precipitation and long, relatively dry spells from mid-July until late August. Some of this can be ascribed to the El Niño episode that began during the summer; El Niño has a tendency to suppress the northward extent of monsoon moisture. In northwestern Mexico, temperatures

were mostly average to above average during June–November 2009. Temperatures were mostly above average during September–November (Figure 1d), with some cooler than average temperatures in Durango during November (Figure 1c).

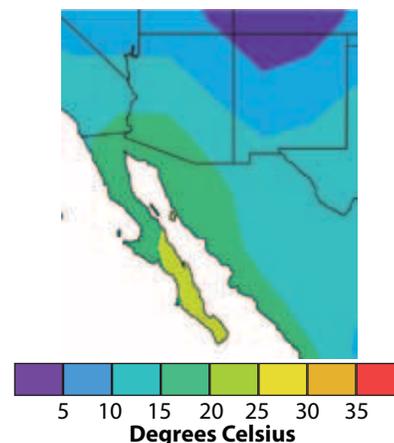
### Notes:

Maps of recent temperature conditions were produced by the National Oceanic and Atmospheric Administration's Climate Prediction Center (NOAA-CPC). Temperature anomalies refer to departures from the 1971–2000 arithmetic average of data for that period.

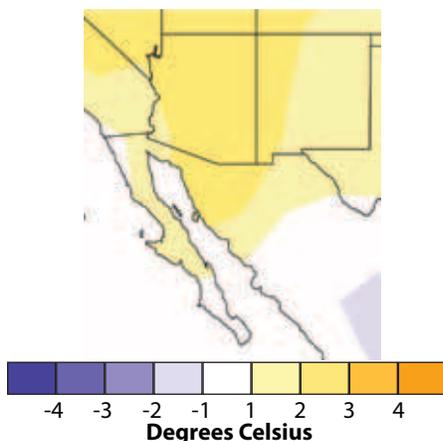
**Figure 1a.** Mean temperature at 2-m elevation for November 2009.



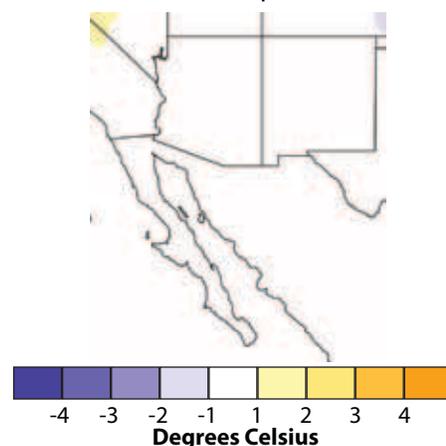
**Figure 1b.** Mean temperature at 2-m elevation for September–November 2009.



**Figure 1c.** Mean temperature departure from 1971-2000 average at 2-m elevation for November 2009.



**Figure 1d.** Mean temperature departure from 1971-2000 average at 2-m elevation for September–November 2009.



### On the Web:

For more information:

[http://www.cpc.ncep.noaa.gov/products/Drought/Atm\\_Circ/2m\\_Temp.shtml](http://www.cpc.ncep.noaa.gov/products/Drought/Atm_Circ/2m_Temp.shtml)

## Precipitation

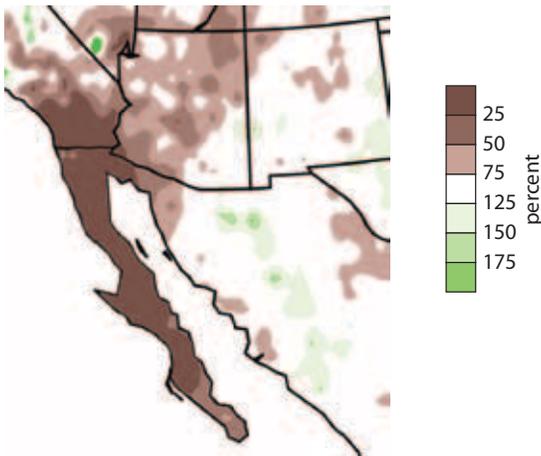
Precipitation was mostly below average during the summer and early fall months north of the border but ranged from below average (Baja California Sur) to above average (Chihuahua) south of the border. Near the border, areas of above-average summer precipitation included southeastern New Mexico, northern Chihuahua, and west Texas. Further south, June was wetter than average in Chihuahua, Durango, Sinaloa and Sonora, and statewide summer precipitation was near average for most of northern Mexico, with the following exceptions: Chihuahua recorded above-average precipitation and Sinaloa recorded below average. Thanks to several tropical storms in September and October, Baja California Sur and Sonora received above-average fall precipitation. In rain-related news, around 200,000 people in Guaymas

and Empalme were cut off from basic services and at least 30 neighborhoods of both cities were flooded when more than 632.5 millimeters of rain fell during Hurricane Jimena between August 29–September 4. Florencio Díaz Armenta, a delegate from the Comisión Nacional del Agua (Conagua), noted that precipitation near the port surpassed the record set in 1948 of 340 millimeters (*El Imperial*, September 4).

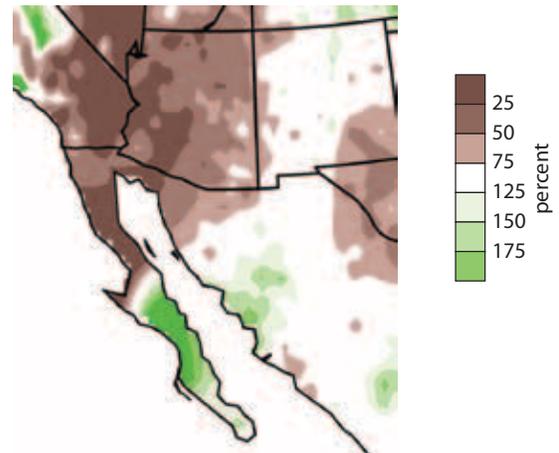
### Notes:

Maps of recent precipitation conditions were produced using data from the National Oceanic and Atmospheric Administration's Climate Prediction Center (CPC). Precipitation anomalies refer to departures from the 1971–2000 arithmetic average of data for that period. Percentage of normal is masked out where normal precipitation is less than 0.1 mm per day.

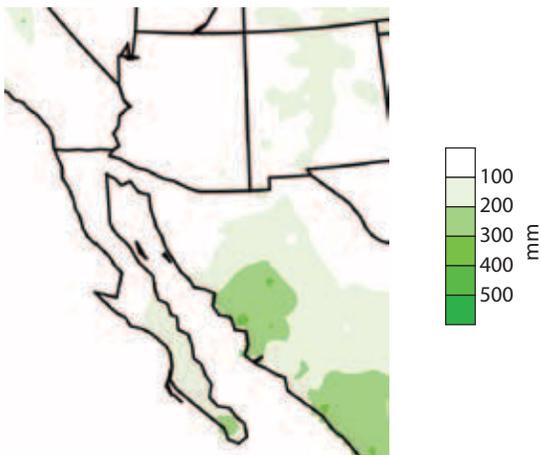
**Figure 2a.** United States and Mexico precipitation percent of 1971–2000 average for June–August 2009.



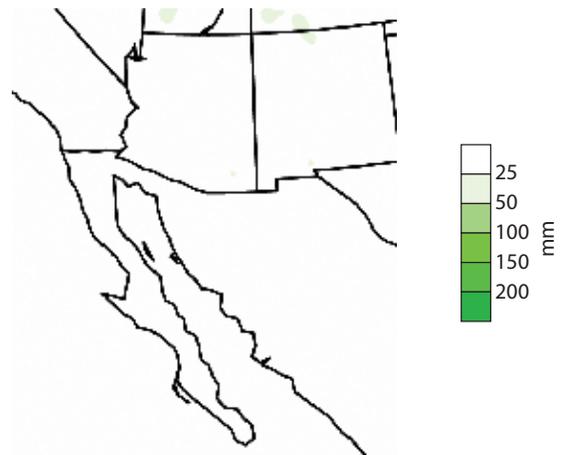
**Figure 2b.** United States and Mexico precipitation percent of 1971–2000 average for September–November 2009.



**Figure 2c.** United States and Mexico precipitation for September–November 2009.



**Figure 2d.** United States and Mexico precipitation for November 2009.



### On the Web:

For more information:

[http://www.cpc.ncep.noaa.gov/products/Drought/Atm\\_Circ/2m\\_Temp.shtml](http://www.cpc.ncep.noaa.gov/products/Drought/Atm_Circ/2m_Temp.shtml)

## North American Drought Monitor

The North American Drought Monitor map (Figure 3) shows drought across the southwestern U.S. and northwestern Mexico. Following a moderately wet 2008–09 winter but exceedingly dry 2009 summer and fall, Arizona and southern California exhibited severe drought conditions. The major impacts in Arizona included draw down of the San Carlos Reservoir on the Upper Gila River to almost historically low levels and degradation of rangeland conditions. Between August and November, reservoir levels increased in most reservoirs in Sonora (not shown; based on data from Comisión Nacional del Agua), with the exception of the most southern Sonoran reservoirs.

In drought-related news, water savings from the moisture accumulation from previous rainfall reached nearly 80 million cubic meters, according to the Irrigation District of the Rio Yaqui (IDRY). The director of operations, Humberto Borbón, estimated that the volume not used by the reservoir system would irrigate between 7,000 and 8,000 hectares (about 17,300 to 19,700 acres) during an entire crop cycle (*El Imperial*, November 2).

On the U.S. side of the border, University of California researchers estimated that 2009 water shortages led to losses of 21,000 jobs and \$703 million in central California's San Joaquin Valley (California Drought Update, September 30). In other California drought news, the California Building Standards Commission approved the California Dual Plumbing Code, which delineates statewide standards to install both potable and recycled water plumbing systems in certain types of buildings. The code applies to commercial, retail, and office buildings, and several other public buildings. Recycled water will be used for building cooling and toilet flushing (California Drought Update, November 30).

### Notes:

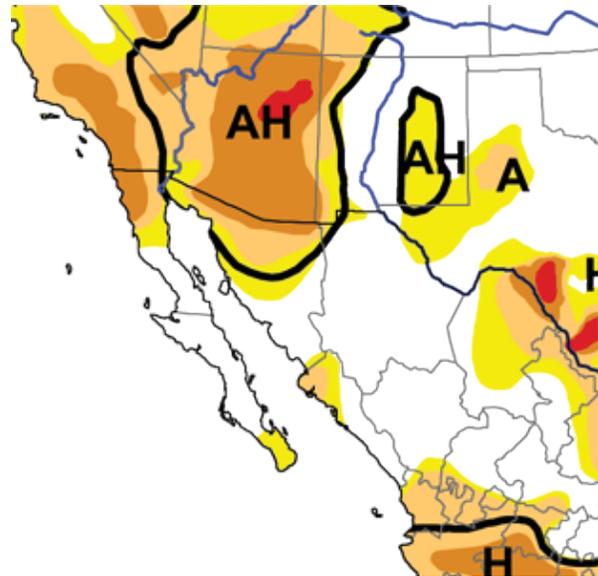
The North American Drought Monitor maps are based on expert assessment of variables including (but not limited to) the Standardized Precipitation Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies, including NOAA's National Climatic Data Center, NOAA's Climate Prediction Center, the U.S. Department of Agriculture, the U.S. National Drought Mitigation Center, Agriculture and Agrifood Canada, the Meteorological Service of Canada, and the National Meteorological Service of México (SMN - Servicio Meteorológico Nacional).

### On the Web:

For more information:

<http://www.ncdc.noaa.gov/oa/climate/monitoring/drought/nadm/>

**Figure 3.** North American Drought Monitor (released November 30).



### Drought Intensity

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

### Drought Impact Types

 Delineates Dominant Impacts

A = Agricultural (crops, pastures, grasslands)

H = Hydrological (water)

AH = Agricultural and Hydrological

## Sonoran Reservoir Levels

Most of Sonora's reservoirs are well below maximum storage capacity but several, including Lázaro Cárdenas, P. Elías Calles, Álvaro Obregón, Abraham González, and A. Ruiz Cortines, are at near- or above-average storage capacity (Figure 4). November storage levels in Lázaro Cárdenas and Abraham González were above 2008 levels, but other reservoirs were below 2008 levels. Total November 2009 reservoir storage for Sonora was 170 cubic hectometers below 2008 levels.

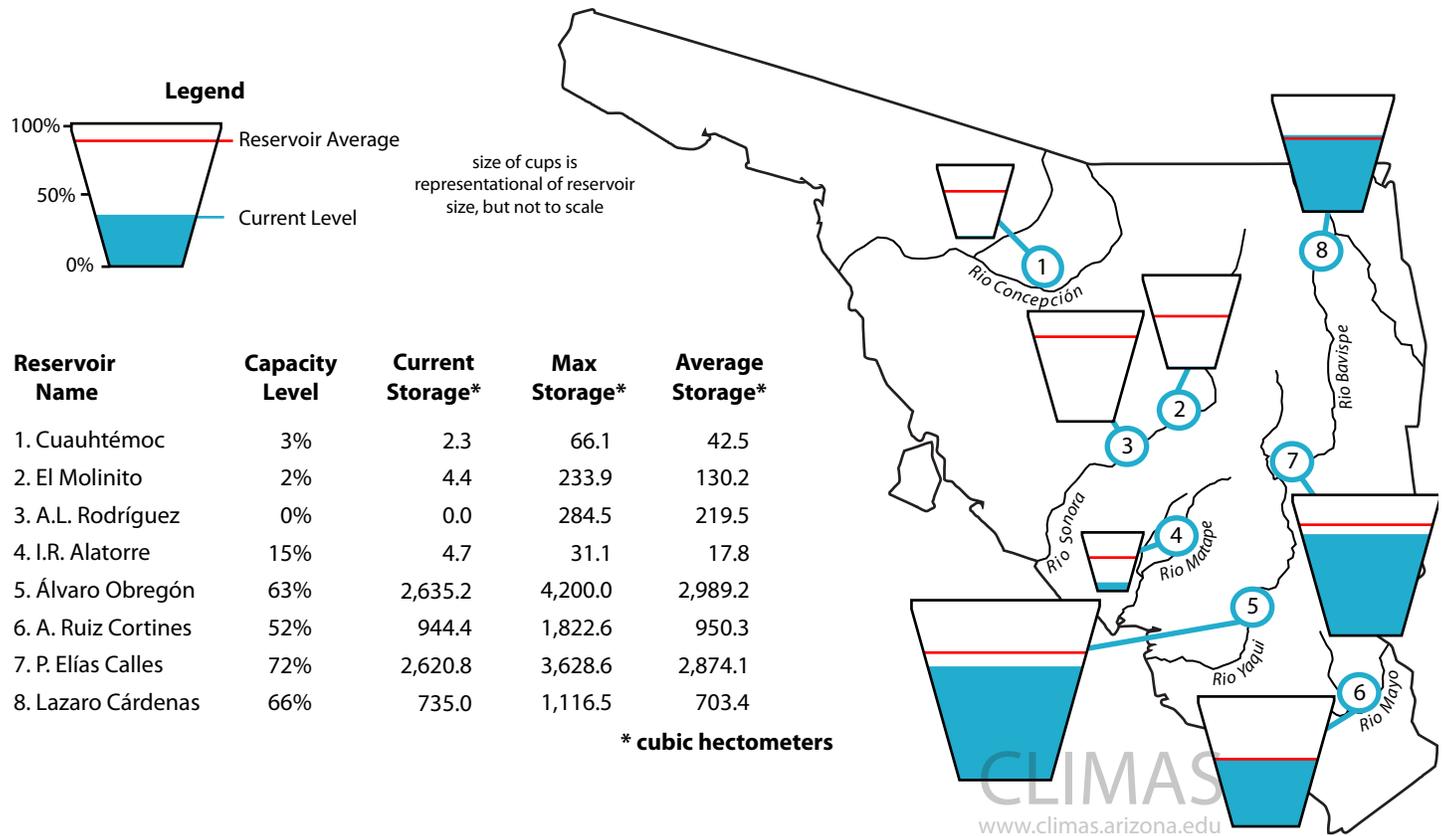
**Notes:**

The map gives a representation of current storage levels for reservoirs in Sonora. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total capacity. Note that while the size of each cup varies with the size of the reservoir, these are representational and not to scale.

The table details more exactly the current capacity level (listed as a percent of maximum storage, and percent of average storage). Current and maximum storage levels are given in cubic hectometers for each reservoir. One cubic hectometer is one billion liters.

This map is based on reservoir reports updated daily in El Imparcial (<http://www.elimparcial.com>), using data provided by Comisión Nacional del Agua.

**Figure 4.** Sonoran reservoir levels for November 2009 as a percent of capacity. The table lists current, average, and maximum storage levels.



CLIMAS  
www.climas.arizona.edu

**On the Web:**

For more information:  
<http://www.elimparcial.com>

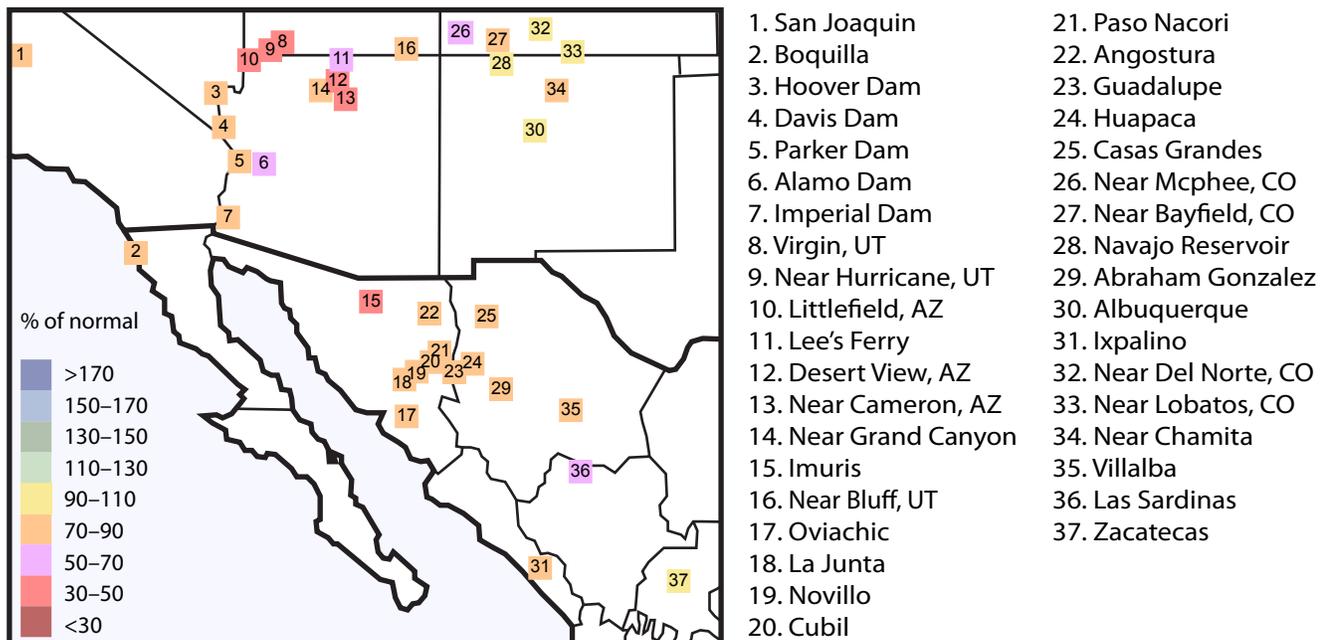
## Streamflow Forecast

The six-month Ensemble Streamflow Prediction (ESP) forecast, released January 18 by the University of Washington and Princeton University, predicts mostly below-average streamflow for the period January–June (ranging from 30 percent below average to 10 percent above average) for gages on both sides of the Mexico–U.S. border region. The average flow is based on the period from 1960 through 1999. Most of the streamflow forecasts for the region in Figure 5 predict six-month streamflow volumes of 70 to 90 percent of average. Even lower flows are predicted for the gages at Imuris (#15) in northern Sonora and Las Sardinas in northern Durango (#36). Low streamflows also are forecast for tributaries of the Colorado River in the U.S. It is very likely that most of these predictions will change when the forecasts are updated, because these forecasts were initiated before a series of late January and early February storms brought large amounts of precipitation to the Lower Colorado River Basin and northern Mexico.

### Notes:

The forecast information provided in Figure 5 is updated monthly by the University of Washington and Princeton University using ensemble streamflow prediction (ESP) techniques. The average of a group (ensemble) of forecasts is generated by using recent meteorology to initialize the Variable Infiltration Capacity (VIC) hydrologic model. Streamflow volume estimates are based on 40 VIC model runs, using meteorological data from the period 1960–1999. These estimates, shown in Figure 5, are expressed in terms of the percent of the 1960–1999 average streamflow at each gage.

**Figure 5.** United States and Mexico streamflow forecast for January–June.



### On the Web:

For more information:

[http://www.hydro.washington.edu/forecast/westwide/sflow/index.6mons.shtml#seas\\_vol](http://www.hydro.washington.edu/forecast/westwide/sflow/index.6mons.shtml#seas_vol)

## Precipitation Forecast

The Servicio Meteorológico Nacional (SMN) forecasts, issued in early February, are based on years with similar patterns of precipitation, atmospheric circulation, and ocean temperatures, which affect the climate of the region; for this forecast, the years are 1969, 1980, 1988, and 1992. SMN predicts well above-average precipitation for the Baja California peninsula and northwestern Sonora in March and April, and well above-average precipitation for Baja California Norte and northwestern Sonora in May (Figures 6a–c). Forecasts for April and May show increasing chances of below-average precipitation in Baja California Sur. SMN forecasts average to above-average precipitation for most of Chihuahua and Durango, and more than 50 percent greater-than-average precipitation for these states in May, a month with a relatively low percent of the annual total precipitation for these states. Forecasts of below-average precipitation for states along continental Mexico’s west coast are consistent with climate patterns for El Niño events. These forecasts from the NOAA-Climate Prediction Center (not shown) agree well with forecasts for the U.S.-Mexico border states.

### Notes:

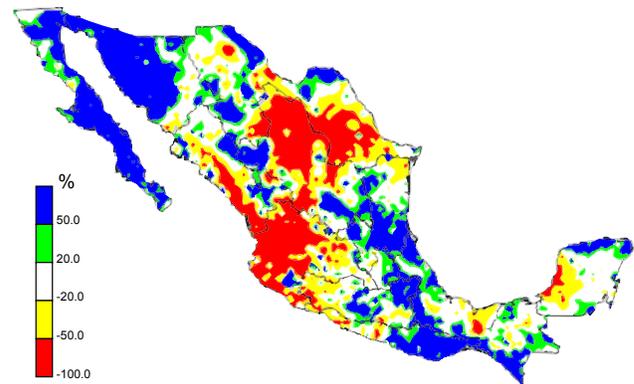
This forecast was prepared by the Servicio Meteorológico Nacional (SMN). The forecast methodology was developed by Dr. Arthur Douglas (Creighton University, retired) in collaboration with SMN scientists.

The forecasts are based on the average of precipitation values from analogous years in the historical record. Selection of analogous years is based on statistical analysis of factors in oceanic and atmospheric circulation known to influence precipitation in Mexico. Unique combinations of climate indices are used in the forecasts each month. A statistical method known as cluster analysis is used to identify evolving climate patterns observed in the historic record and place each year in historical context; the years with the evolving climate patterns most similar to the current year are selected. Average atmospheric flow patterns and surface precipitation anomalies are constructed with the historic data and compared with the climatological average.

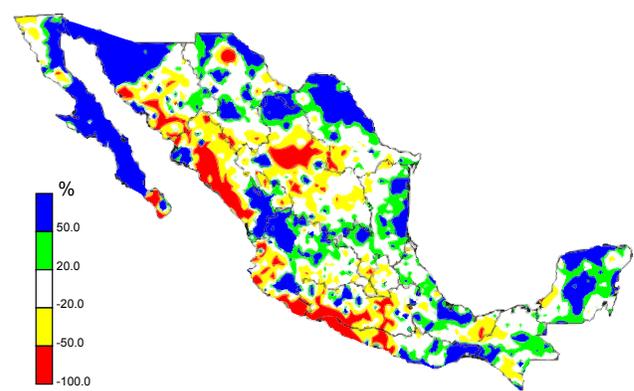
Examples of atmospheric and oceanic factors used in identifying analogue years, include: Pacific and Atlantic Ocean temperatures, tropical upper atmosphere oscillations, the position and strength of persistent high and low atmospheric pressure centers, and other factors.

The maps show predicted percent of monthly average precipitation. The legend shows the ranges of predicted percent of average precipitation associated with each color. Blues and greens indicate above-average precipitation; yellows and reds indicate below-average precipitation. White indicates precipitation within 20% of the climatological average (based on data from 1941-2002).

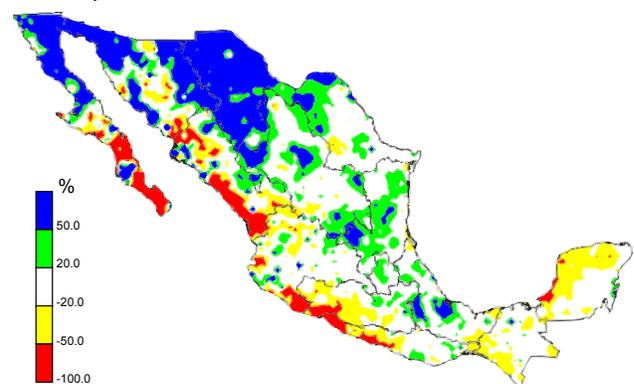
**Figure 6a.** Precipitation forecast for March 2010 (released February 1, 2010).



**Figure 6b.** Precipitation forecast for April 2010 (released February 1, 2010).



**Figure 6c.** Precipitation forecast for May 2010 (released February 1, 2010).



### On the Web:

For more information:  
<http://smn.cna.gob.mx/productos/map-lluv/p-clim02.gif>

## ENSO (El Niño – Southern Oscillation)

Moderate El Niño conditions in the equatorial Pacific Ocean continued through December and January, with sea surface temperatures (SSTs) remaining 1.5 degrees Celsius above average across much of the central and eastern parts of the basin. The International Research Institute for Climate and Society (IRI) notes that the pattern of above-average SSTs has become more organized; thus this initially weak El Niño event has evolved into a pattern more typical of past El Niño events. The Southern Oscillation Index (SOI; Figure 7a) remained negative in December, indicating that the atmosphere was responding to the above-average SSTs. In recent weeks, subsurface water temperatures along the equator also have remained well above average, indicating that this warm water will help increase SSTs in coming weeks.

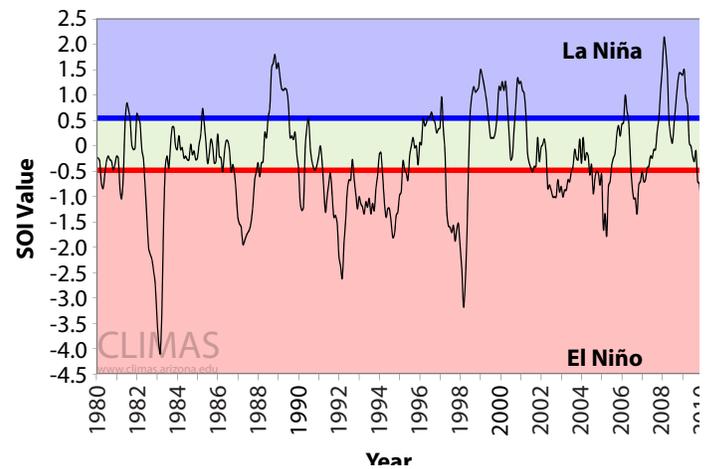
All of these signs point towards the continuation of at least weak to moderate El Niño conditions for the next several months. The chance of El Niño persisting through at least April stands at more than 90 percent, according to the January 21 IRI ENSO forecast (Figure 7b). Neutral conditions are expected to return rapidly in the May–July period, which is typical of El Niño events, because they normally dissipate in the spring. In the meantime, El Niño is expected to impact winter weather in the U.S.-Mexico border region over the next several months. A strong subtropical jet stream, forming in response to the unusually warm waters in the eastern Pacific, is expected to influence the winter storm track and bring an increased chance of above-average precipitation to the U.S. Southwest and northwestern Mexico in the February–April period.

### Notes:

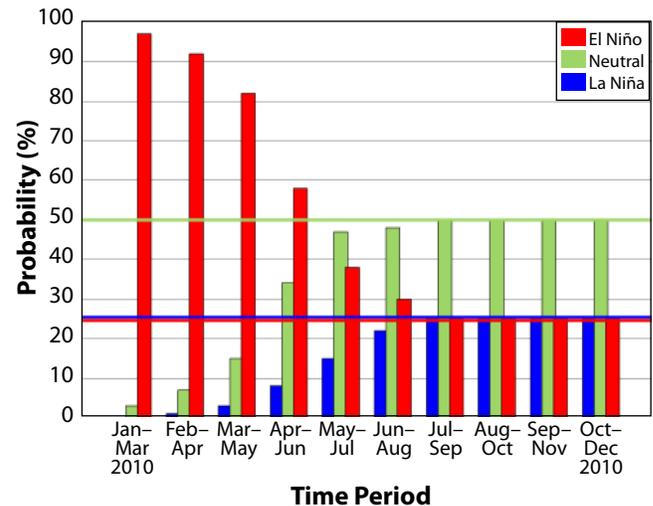
Figure 7a shows the standardized three-month running average values of the Southern Oscillation Index (SOI) from January 1980 through May 2009. The SOI measures the atmospheric response to sea surface temperature (SST) changes across the tropical Pacific Ocean. The SOI is strongly associated with climate effects in parts of Mexico and the United States. Values greater than 0.5 represent La Niña conditions, which are frequently associated with dry winters and sometimes with wet summers in the southwestern U.S. and northwestern Mexico. Values less than -0.5 represent El Niño conditions, which are often associated with wet winters in those regions.

Figure 7b shows the IRI probabilistic El Niño-Southern Oscillation (ENSO) forecast for overlapping three month seasons. The forecast expresses the probabilities (chances) of the occurrence of three ocean conditions in the ENSO-sensitive Niño 3.4 region, as follows: El Niño is defined as the warmest 25 percent of Niño 3.4 SSTs during the three month period in question, La Niña is defined as the coolest 25 percent of Niño 3.4 SSTs, and neutral conditions are defined as SSTs falling within the remaining 50 percent of observations. The IRI probabilistic ENSO forecast is a subjective assessment of monthly model forecasts of Niño 3.4 SSTs. The forecast takes into account the indications of the individual forecast models (including expert knowledge of model skill), an average of the models, and other factors.

**Figure 7a.** The standardized values of the Southern Oscillation Index from January 1980–December 2009. La Niña/El Niño occurs when values are greater than 0.5 (blue) or less than -0.5 (red) respectively. Values between these thresholds are relatively neutral (green).



**Figure 7b.** IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released January 21). Colored lines represent average historical probability of El Niño, La Niña, and neutral.



### On the Web:

For more information:

<http://iri.columbia.edu/climate/ENSO/currentinfo/update.html>