An Assessment of the Meteorological Severity of the 2008-09 Texas Drought through July 2009

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1. Summary

This report characterizes the meteorological severity of the 2008-09 Texas Drought as of August 1, 2009, putting the present drought into a historical perspective. The report draws upon multiple sources of information, including data and reports from the National Weather Service (NWS) and National Climatic Data Center (NCDC), the U.S. Drought Monitor, and our own analyses.

The present drought is most severe on a 1-3 month time scale. We find that, compared to historical droughts of the 20th and 21st centuries, the 2008-09 Texas Drought is probably the most severe drought on record from a precipitation standpoint alone in Bastrop, Caldwell, and Lee counties. When the impact of high temperatures is included, the drought is probably the most severe on record for an additional six counties: Victoria, Bee, San Patricio, Live Oak, Jim Wells, and Duval Counties. The drought of 1956 was of longer duration but its intensity was not as extreme, so it had a somewhat different set of impacts. In neighboring areas of central and south-central Texas, the intensity of the 2009 drought is greater than that of most but not all of the major historical droughts of the past 110 years, including 1910, 1917, 1918, 1925, 1953, 1955, 1956, and 1971.

2. Evolution of the 2008-09 Texas Drought

During 2007, Texas experienced its 7th wettest year on record out of the past 114 years (NCDC). The rains during 2007 were a welcome relief from the 2005-06 Texas Drought, which peaked in spring and summer 2006 and did not end in most areas until April 2007. By the end of September 2007, Victoria had received 66.20" inches of precipitation, breaking its annual record precipitation amount with three months to spare (NWS).

Statewide precipitation during September was fairly typical for Texas, but the following months through July 2009 brought less than typical (median) rainfall to Texas in 16 out of 22 months. Figure 1 shows a time series of drought coverage in Texas according to the US Drought Monitor. Drought first appeared in Texas in north-central and northeast portions of the state on November 20, 2007, and first appeared in southern Texas on January 1, 2008.

The drought reached its greatest severity in 2008 around the middle of June (Figure 2). At that time, the core drought area was in south-central Texas, but most of the state was suffering from drought to some degree and drought losses were widespread. Substantial rains came to west Texas, extreme south Texas, and eastern Texas over the following two months, in part associated with Hurricanes Dolly and Ike. The tropical moisture eliminated drought across much of the state, but the core drought area missed out on most of the rains and remained in extreme drought (Figure 3).

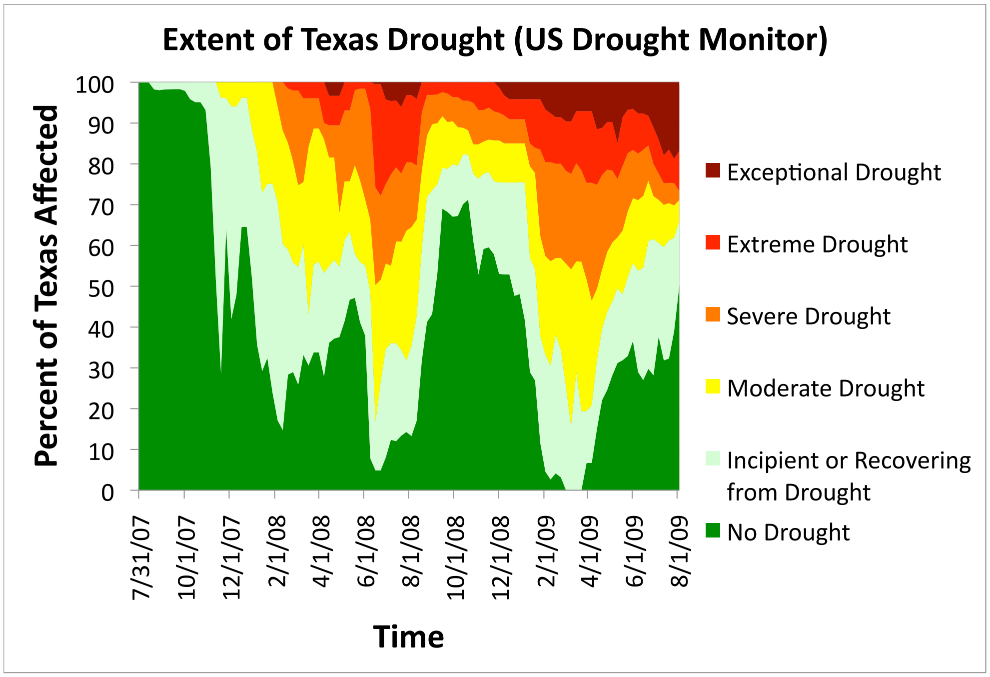

Figure 1: Drought extent in Texas over time

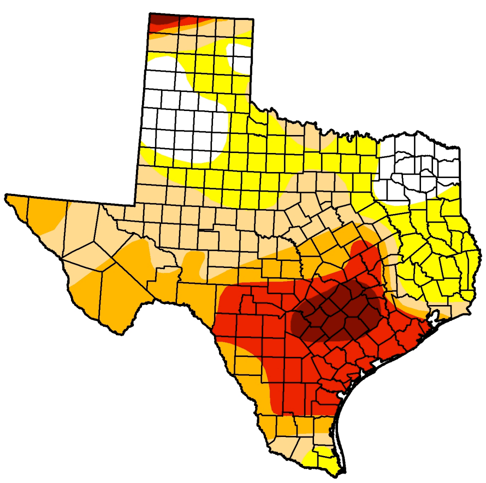

Figure 2: US Drought Monitor, June 08

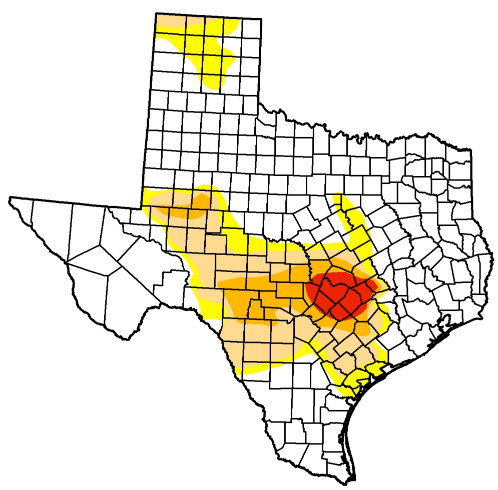

Figure 3: US Drought Monitor, Sept 08

The succeeding fall and winter again brought below-normal precipitation to Texas. The period December 2008 through February 2009 was the driest December-February in history, with statewide records going as far back as 1895. By early April 2009, drought was again widespread across Texas (Figure 4). Up to this point, increases in drought severity were accompanied by increases in drought coverage, but the period April through July produced a contraction of drought coverage combined with an intensification of drought in those areas suffering from drought. In addition, a substantial lack of May-June precipitation caused the drought to expand farther into southeast Texas. As of August 4, 2009, exceptional drought covered most of south-central and southern Texas, while most of the northern half of the state of Texas was drought-free.

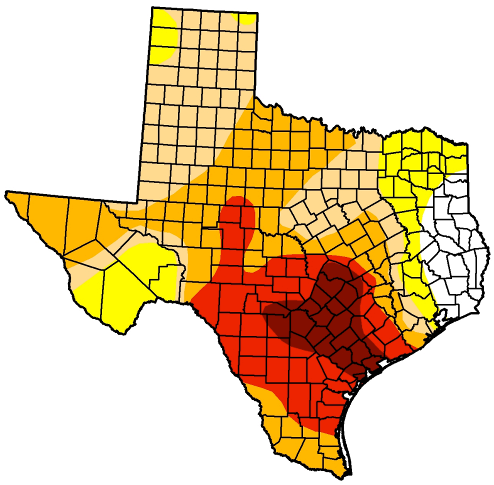

Figure 4: US Drought Monitor, Apr 09

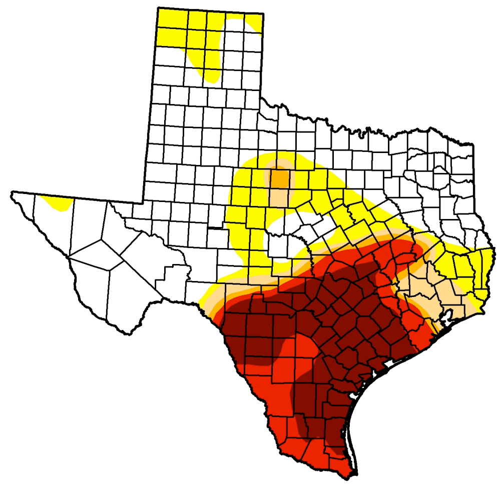

Figure 5: US Drought Monitor, Aug 4 2009

While summer 2008 was generally mild, both June and July 2009 ranked in the top 15 for their respective months for Texas temperatures as a whole. This ranking conceals an uneven distribution of temperature: near-normal conditions in northern Texas combined with record or near-record warmth in southern Texas. The unusually warm temperatures have increased the water stress due to drought, causing greater water demands by plants, animals, and humans.

3. Agricultural Impacts from the Texas Drought

Agricultural impacts were most recently addressed in July 2009 in a news release written by Blair Fannin for AgriLife News, with information from the Texas AgriLife Extension Service. Here is the text of the news release (http://agnews.tamu.edu/showstory.php?id=1311):

Lack of rainfall and record triple-digit temperatures have scorched crops and rangeland throughout parts of Texas causing drought losses to reach $3.6 billion, Texas AgriLife Extension Service economists reported Monday [July 20 2009].

By the end of the year, losses could exceed $4.1 billion, the loss estimated in Texas in 2006, if sufficient rainfall isn't received to revive crops and forage, economists said.

Total crop losses this year are estimated at $2.6 billion and livestock, another $974 million since November 2008.

“Extreme or exceptional drought conditions for the second year in a row and prolonged weather with over 100 degree temperatures have devastated agricultural crops and livestock operations, especially in Central and South Texas,” said Dr. Carl Anderson, AgriLife Extension economist and professor emeritus. “This area covers about 40 percent of Texas. With the exception of Northeast Texas, the trans Pecos and the Southern Panhandle areas, the entire state is suffering from lack of sufficient rain for more than a year.”

Dr. Travis Miller, AgriLife Extension agronomist and a member of the Governor’s Texas Drought Preparedness Council, said the drought is not only impacting major agricultural operations, but also water supplies “for more than 30 percent of the State of Texas.”

“Most dryland crops in South and Central Texas, the Gulf Coast and the Rio Grande Valley are either zeroed-out (total loss) or will yield a small fraction of their normal yields,” he said.

"The impact of this drought -the losses and associated wildfires - are devastating to Texas farmers and ranchers," Agriculture Commissioner Todd Staples said. "Intensive management and planning are essential during these extremely difficult times. It is because of this dire situation that last week I made a second request to USDA urging immediate action for assistance. I am committed to seeing that Texas producers, who work from sun-up to sun-down to provide us with the most abundant and affordable food supply in the world, get the assistance they need during these trying times."

It's the hottest, driest summer on record over a large portion of the state, but especially in the central, south and southwest regions, said Jose Pena, AgriLife Extension economist in Uvalde.

“Rainfall in a large part of South Texas has been less than 4 inches since the start of this year,” he said.

“Range and pasture conditions are in poor or only fair conditions over more than 85 percent of Texas,” Pena said. “The water supply for livestock and wildlife is diminishing, with many stock ponds dry.”

The statewide crop condition report by U.S. Department of Agriculture rates one-third of Texas cotton acreage very poor or poor. Dry moisture conditions indicate a large amount of acreage will likely be abandoned, Anderson said, and a small cotton crop is expected because of lost acreage and low yields.

Corn and sorghum were rated even worse with more than 40 percent in the poor category, he said.

“As a result, a large part of the planted cotton and grain acreage will be abandoned, and the rest of dryland production will produce below average yields,” said Dr. Mark Welch, AgriLife Extension grains marketing economist. “Many of the dryland cotton, grain sorghum and corn crops in the Coastal Bend and Lower Rio Grande Valley have been abandoned.”

Total crop losses estimated for the entire growing season include cotton, corn, grain sorghum, wheat, and miscellaneous crops. Current crop conditions reported by USDA are taken into consideration in estimating lost value, Welch said.

While West Texas cotton is in the early stages of the growing season, abandoned planted acreage and low projected yields indicate a loss of $540 million, Welch said. Compared to 2008, he expects the drought to cut the corn crop about 45 percent, the sorghum crop 69 percent, and wheat crop 62 percent. Grain sorghum losses stand at $258 million and corn, $618 million.

“The combined effects of drought, freeze and lower prices are estimated to have cut Texas wheat value by $506 million in 2009,” Welch said.

Meanwhile, the state’s livestock operations continue to suffer. Little or no hay has been baled this year or for 2008 in South, Central or East Texas. Much of Texas continues to be short on moisture. The hay loss at mid-year is estimated at $409 million, according to economists. Hay is being shipped into south Texas from northeast Texas and other states.

“Given the critical shortage of forage for grazing and hay, a soaking rain is needed soon to maintain the beef cow herd in Central and South Texas,” said Dr. David Anderson, AgriLife Extension livestock marketing economist. “The high cost of buying hay and supplemental feed is resulting in liquidation of some herds."

Counties in extreme and exceptional drought account for 40 percent of Texas’ cow herd and 6 percent of the U.S.’s beef cow herd, Anderson said. Ranchers have been forced to cull deeper into herds and to sell calves at lighter weights, earlier than normal.

“From November 2008 until March 2009, the loss was estimated at $569 million,” Anderson said. “Additional livestock costs since March 2009 are estimated to have totaled about $300 million. The total now is $869 million. Those include feed costs such as hay and other feed supplements, and do not include reduced future revenues due to losing breeding stock and lost revenue from selling calves earlier. In addition to the beef cattle losses, the estimated loss for goats, sheep, honey and horses totals $105 million.”

The drought will stress wildlife resources and reduce the amount and quality of wild animals and birds. Wildlife management programs are critical to maintaining the recreational value of land used for outdoor recreation during the intense drought, according to Anderson.

The early summer drought and high temperatures are damaging all dryland crops such as vegetables, horticulture plants, peaches, pecans and other crops by at least $214 million. Land-based recreation used for camping, hiking, birding, wildlife watching, and hunting is expected to lose some $100 million, according to AgriLife Extension estimates.

4. Reports from National Weather Service Offices

The NWS offices in the drought-stricken areas have been producing regular reports describing the unusual temperatures and precipitation in the area and the resulting impacts upon residents. Here is a compilation of those reports as of the end of July 2009:

<u>Lower Valley statement summary (NWS)</u>: A persistent upper level ridge has allowed high temperatures to reach between 100 and 110 degrees with the exception of the immediate coastline. McAllen recorded its hottest ever July with an average temperature of 92.8 °F, an amazing 7.0 °F above normal, shattering the previous record by 2.7 °F. Daily maximum temperature records were equaled or exceeded at McAllen on 23 of 31 days. July rainfall was almost non-existent in the area with totals of a tenth of an inch or less, worsening drought conditions for agricultural interests. Brownsville and McAllen both only have received about half their year-to-date expected rainfall. Port Mansfield is a staggering 10" below normal with only 1.47" inches of precipitation in the year to date.

The lack of precipitation has made the wildfire danger a major concern, with a moderate to high fire danger and burn bans in effect for the entire region. A severe lack of soil moisture and the triple-digit heat have scorched pastures and crops, and have severely stressed livestock, which has led to supplemental feeding. Most dryland crops are a total loss or will yield a small fraction of their normal value and daily evaporation rates continue to average over a half inch per day. There are currently four public water systems in the Lower Valley under a "Water Shortage Watch."

<u>Coastal Bend statement summary (NWS)</u>: Upper level high pressure has kept away any significant tropical waves or upper level systems from South Texas, leaving it hot, humid, and unfortunately dry. A few locations received 0.5" – 1.5" of rainfall on the 16th and 17th, but most locations have received little to no rain in recent weeks. Most of the precipitation has resulted from the sea breeze or outflow boundaries from convection to the north. More than half of South Texas received no more than 10% of normal July rainfall, and there appears to be no significant prospects for precipitation in the near future.

Exceptional drought exists in all counties across South Texas except most of LaSalle and Webb counties. The city of Victoria continues to impose mandatory water restrictions, including restrictions on watering the lawn between the hours of 6AM-10AM and 8PM-midnight. The effort to conserve water has lowered usage from 18 million gallons/day to 14 millions gallons/day, and the city of Victoria is pumping water from wells to supplement the water supply. The Corpus Christi water supply is in better shape and has only voluntary restrictions while following a "50 (voluntary), 40 (restriction of outdoor watering), 30 (mandatory lawn watering restrictions)" rule based on the percentage of water in supply.

All counties except Aransas and Goliad counties are under burn bans, with soil moisture at well below normals. The greatest deficit of soil moisture is in the Victoria vicinity, and combined with excessive heat, has left pastures burnt up and crop yield very low. Many farmers feel the lack of soil moisture is a once-in-a-lifetime event, and ranchers are watering their cattle at three to four times the normal amount. A moderate fire danger continues to exist across South Texas with Keetch-Byrum Index values above 600 in all of South Texas. The reservoirs continue to dwindle in Victoria and Corpus Christi with Choke Canyon Dam (72% of capacity) and Lake Corpus Christi (37.7% of capacity) becoming drier by the day.

<u>South Central Texas statement summary (NWS)</u>: Rainfall was at a minimum across the region during July with most locations reporting below to well below normal rainfall. Isolated areas of the Hill Country received 1-2" of July precipitation, but the majority of the region saw one inch or less of rainfall. The long-term drought that began 23 months ago is still prevalent, and its effects are on top of short-term drought impacts due to above normal temperatures and lack of significant rainfall this summer. Several consecutive wet months are needed to lessen the magnitude of the long-term precipitation deficits.

The 23-month period ending in July 2009 was the driest on record, which date back to 1885, in San Antonio with 24.38" of rainfall, compared to the previous record of 28.94 inches ending in September 1910. The same 23-month period ending this July was the 13th driest at Austin Mabry with 34.46", where records date back to 1856. For comparison, the driest 23-month period at Austin Mabry saw 31.94" of precipitation (only 2.52" less) and ended in August 1918.

The United States Drought Monitor as of July 28th showed exceptional drought across the majority of South Central Texas. 30 counties in South Central Texas are under burn bans, with fire danger being moderate to high across the region. The majority of the region has a Keetch-Byrum Drought Index between 600 and 800, with an index of 800 representing completely dry soil.

<u>Southeast Texas summary (NWS)</u>: There were some minor improvements in drought conditions over parts of Southeast Texas during the last half of July as an upper level ridge responsible for early summer record heat retreated to the west. However, extreme to exceptional drought conditions persist over much of the

region. A weak upper level trough brought slightly cooler temperatures and a rainy period between July 16th and July 26th. Even after the precipitation of this period, many locations are still suffering through one of the driest periods in recorded history.

College Station endured 56 consecutive days without measurable rainfall ending on July 19th, tying the longest such streak in its recorded history. The short-term drought has been made significantly more harsh due to the excessive heat since early June. The average high temperature for the month of July in College Station was 100.7°F, with 23 days of high temperatures at or above 100°F in July and 34 so far this summer.

5. Spatial Pattern of Drought

Using high-resolution precipitation analyses produced by the River Forecast Centers of the NWS (part of the Advanced Hydrologic Prediction System, or AHPS), the OSC has produced estimates of precipitation deficit (or excess) severity over the past 2-24 months across Texas. The precipitation amounts are expressed in terms of a drought index known as the Standardized Precipitation Index, or SPI, which can be related to the expected frequency of occurrence of conditions of similar severity,

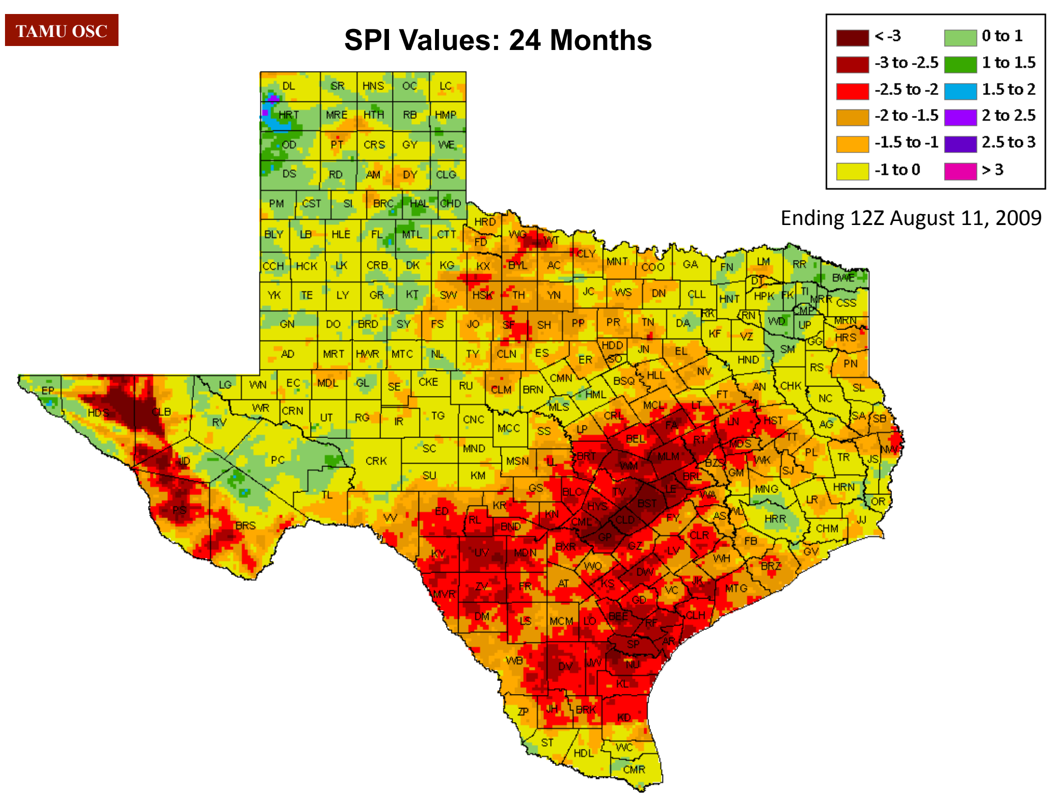

Figure 6: Standardized Precipitation Index values for 24-month period ending 7:00 AM CDT Aug 11 2009, based on OSC processing of AHPS precipitation analysis.

considering the time of year. An SPI value of -1 means that such dryness should be exceeded in about 16% of past years; an SPI value of -2 means that such dryness should be exceeded in about 2% of past years; an SPI value of -3 means that such dryness is likely to be record-breaking and based on historical data should have been expected to occur in less than 0.2% of past years.

The 24-month SPI (Fig. 6) is mostly negative, indicating that most of the state of Texas has received less than its expected amount of precipitation over the past two years. The precipitation analyses are suspect over parts of West Texas, particularly El Paso, Hudspeth, Culberson, Jeff Davis, Presidio, and Brewster counties, but are expected to be reliable in most other areas of the state. Any values below -2 would be considered exceptional according to the US Drought Monitor. Exceptional precipitation deficits extend across most of central, south-central, and southern Texas. An additional area of drought is in north-central Texas, centered on Shackelford county. The most extreme precipitation deficits are found in Bastrop, Caldwell, Guadalupe, Lee, Milam, and Williamson counties in central Texas, where the two-year rainfall deficits are probably record-breaking.

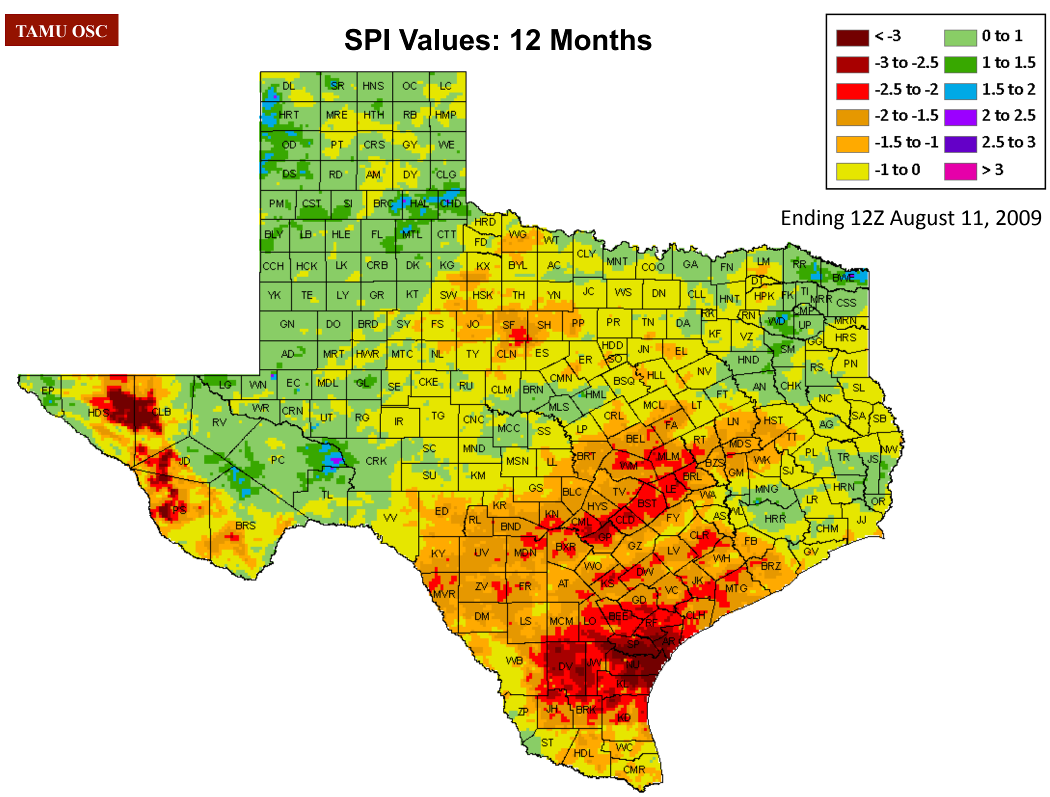

Figure 7

The 12-month SPI (Fig. 7) shows that the shorter-term precipitation deficit pattern is similar to the longer-term precipitation deficit pattern, except that the deficits are not quite as extreme in a historical sense. The primary exception to this statement is in the Coastal Bend area, where SPI values are generally below -2 and fall below -3 in several counties near Corpus Christi. While the most severe drought is found on the 24-month time scale in central Texas, it on the 12-month time scale in south Texas.

The 6-month SPI (Fig. 8) shows that rainfall during late winter, spring, and early summer of 2009 has been lacking across most of the drought-stricken area. Many areas south of Corpus Christi again have SPI values below -3, indicating probable record-breaking dryness. Most areas of longer-term drought in the northern half of the state received decent to plentiful rainfall during the past six months, resulting in a sharp boundary across central Texas dividing mostly drought-free conditions to the north from extreme drought conditions to the south.

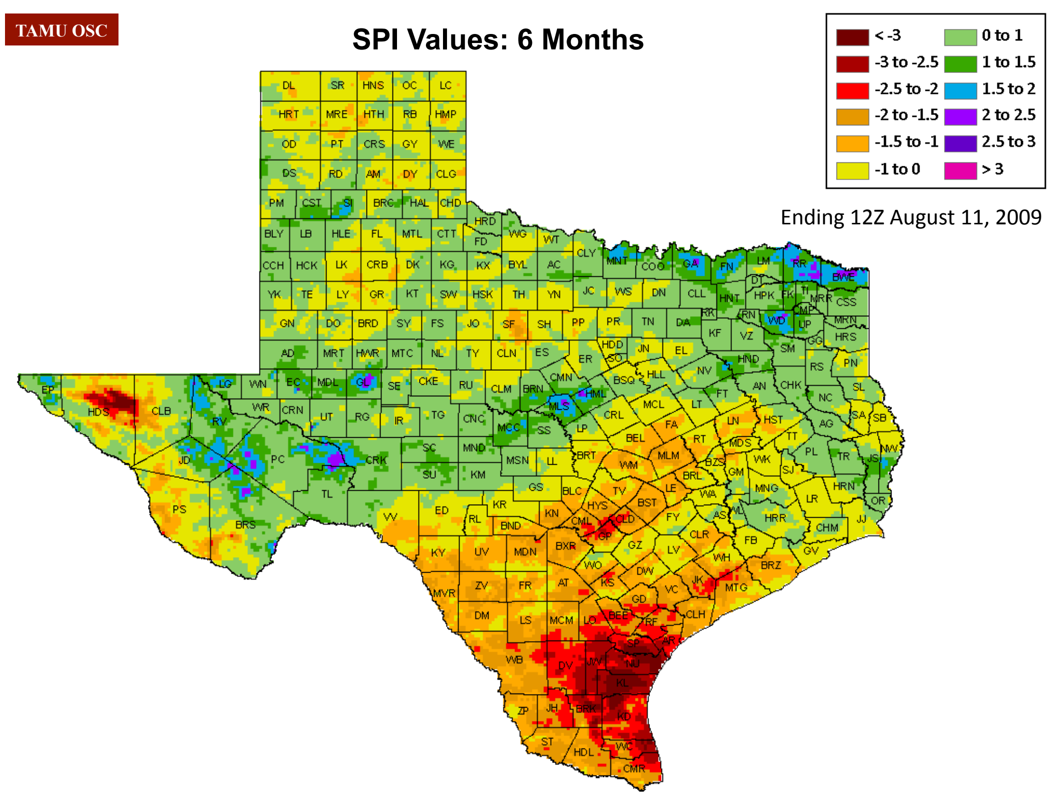

Figure 8

Figure 8 also shows the drought area partially bisected by a band with near-normal to above-normal rainfall stretching from southeast of San Antonio to north of Houston. This area received multiple heavy rain events during the spring, with some flooding. It is remarkable that the flooding rains were insufficient to relieve the longer-term rainfall deficits in the area, and those areas remain in drought.

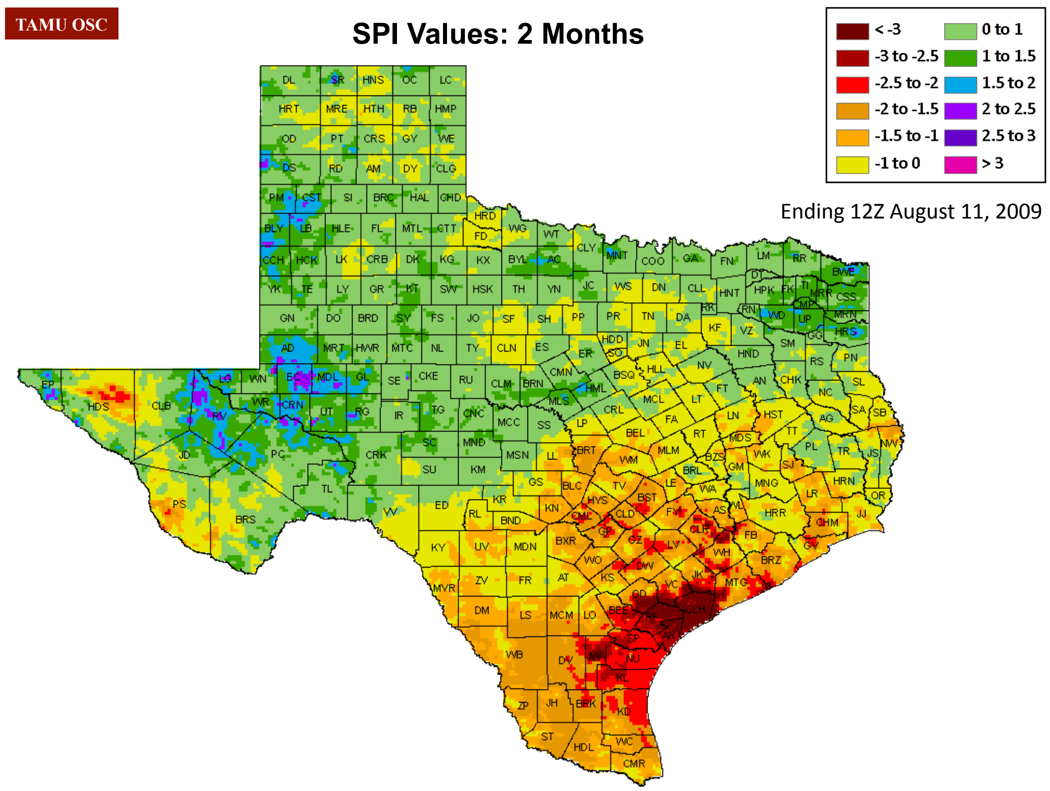

Figure 9

Finally, the 2-month SPI (Fig. 9) shows that, even on this short time scale, the rainfall deficits have been of an historic nature near the Coastal Bend. The map also indicates that short-term drought conditions spread during late spring and early summer into southeast Texas, where Houston Intercontinental Airport experienced its driest May-June on record. The map indicates the normally spotty nature of summertime precipitation in south-central Texas, with large variations in rainfall present within individual counties.

In summary, while many areas of the state have been affected by the 2008-09 Texas Drought, and drought conditions still exist in parts of north-central and southeast Texas, the primary drought areas are presently central and southern Texas. The most intense drought is found along a southwest-northeast oriented band from Eagle Pass across the San Antonio, Austin, and Bryan-College Station areas to Crocket, and in a separate area along the Gulf Coast from Matagorda Bay to Baffin Bay and inland as far as Cuero and George West.

6. Comparison to the Greatest Texas Droughts of the 20th and 21st Centuries

Figure 10 is an experimental product produced by the OSC that attempts to summarize drought conditions on a variety of time scales ranging from two months to three years. It highlights counties that, according to the SPI drought indices, are experiencing exceptional (twice a century) or extreme (five times a century) drought conditions across central and southern Texas. Places not marked as exceptional overall may still be experiencing exceptional drought conditions over particular time periods, and places without extreme drought in Fig. 10 may still be experiencing extreme or even exceptional drought for particular short- or long-term periods.

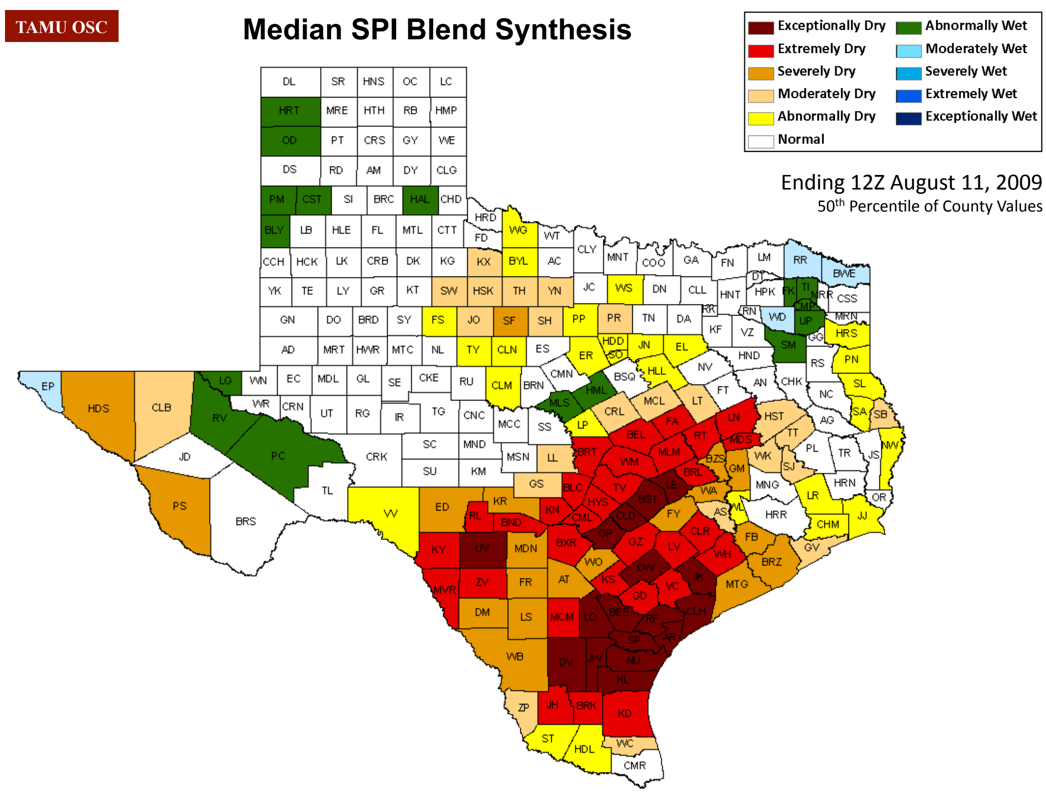

Figure 10: Experimental depiction of overall county-wide drought conditions based on rainfall accumulations over 1-36 months. Graphic generated by OSC.

Drought monitoring is traditionally done on a climate division basis. There are ten climate divisions in Texas (Fig. 11), most of which include 20 or more counties. The 2008-09 Texas Drought does not line up perfectly with any particular climate division, but the south-central division (light green), extending from the Austin and San Antonio areas south to Corpus Christi, fairly well encompasses most of the extreme drought areas. Data from this climate division is accurate back to 1931, and estimated values extend back as far as 1895.

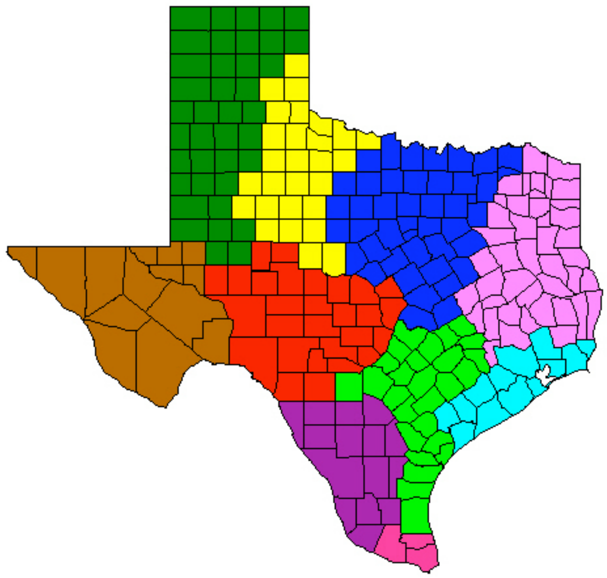

Figure 11: Texas climate divisions.

The most common drought index is the Palmer Drought Severity Index, or PDSI. The PDSI includes the effects of both precipitation and temperature. In the South-Central Texas climate division, as of the end of July 2009, the PDSI had reached an estimated value of -6.16, lower than any period except July-November 1956 and equaling the lowest value during the drought of 1917-1918. The Palmer Z-Index, a measure of short-term dryness, reached a value of -4.19 in June 2009, lower than any month since the beginning of Palmer records in 1895. So, for the South-Central Texas climate division as a whole, it appears that the 2008-09 Texas Drought is the second-worst drought on record, not quite as severe as the 1956 Texas drought but more severe than any other drought in the precipitation and temperature records.

Comparing historical droughts in Texas is challenging and subjective. Because rainfall occurs throughout the year, substantial rainfall deficits can develop at any time and last for a few months to a few years. Short-term rainfall deficits affect mainly crops, while longer-term deficits affect water supplies and streams. However, except for winter wheat areas, drought's effects are most strongly felt in the spring planting and growing season and the summer harvesting season. Summertime drought affects not just crops, but also livestock and water supplies, because potential evaporation is largest during the summer and water demand is greatest. So, in order to put the present drought into historical perspective, we will focus on drought conditions at the beginning of August and compare precipitation deficits over a range of time scales.

Our technical approach was to first identify climate (COOP) stations in the core drought areas with relatively complete, long-term weather records (Fig. 12). We examined rainfall deficits on the one- to two-year time scale and identified the driest years. We then determined which dry years affected several stations and were therefore associated with widespread drought. The following years were associated with extreme drought conditions affecting several stations in the core drought area: 1910, 1917, 1918, 1925, 1953, 1955, 1956, 1967, 1971, 1996, and 2009. We then graphed the accumulated precipitation for all drought years for which data was available and determined subjectively which droughts were most severe at particular stations. Sample graphs for selected stations are shown here.

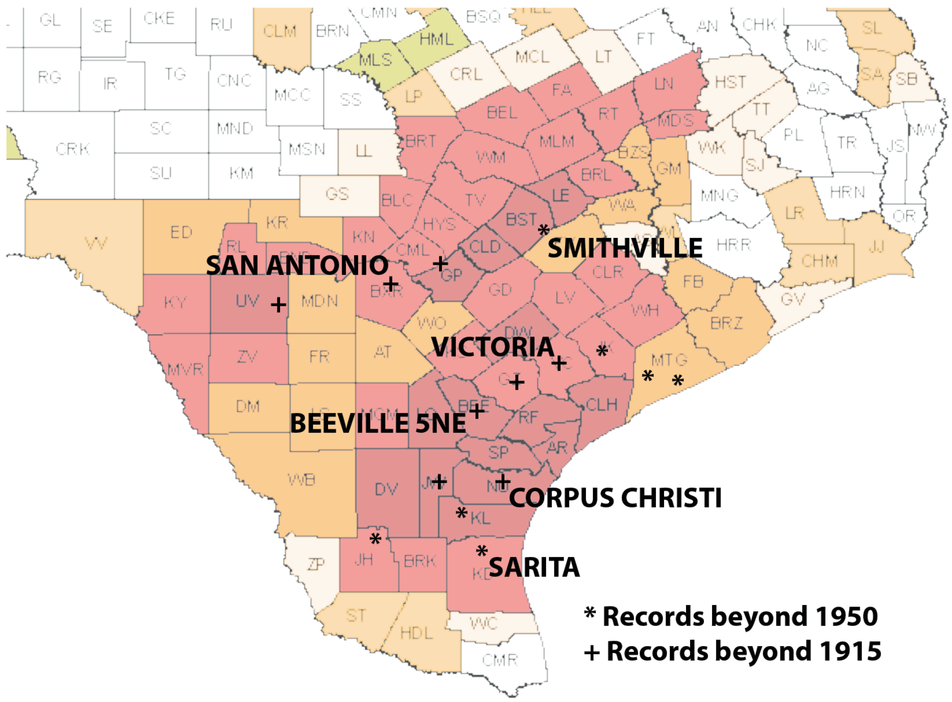

Figure 12: Locations of stations utilized in historical analysis of drought severity. Stations discussed explicitly in this section are labeled.

At the COOP station in Smithville (southern Bastrop county), whose 24-month SPI was about -3 in Figure 6, precipitation accumulations for the 10-25 months ending July 2009 were all record-setting. The period of record for Smithville extends back to 1931 and includes the droughts of the 1950s. Figure 13 depicts the accumulated precipitation through July 2009 and ending in July for selected drought years. Also shown is the normal precipitation accumulation. Precipitation deficits going back two years rival or exceed even the deficits ending in July 1956, the previous recorded year of worst drought, and precipitation deficits of longer duration are comparable in severity. Perhaps the most remarkable statistic is that, for the 15 months ending in July 2009, Smithville recorded 17.20" of precipitation, over two and a half feet below the normal value of 48.71", representing only 35% of normal precipitation, and breaking the previous record by 11.75". The smallest previous total for any 15-month period (not just periods ending in July) was 20.05".

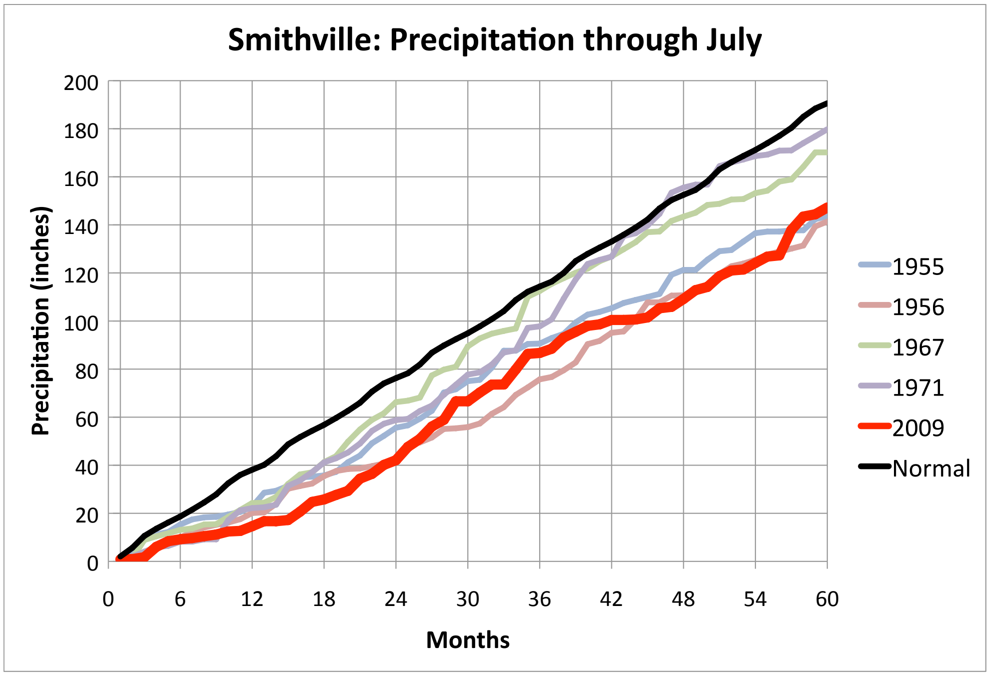

Figure 13: Accumulated precipitation for Smithville. Each point on a line represents the accumulation of precipitation for the labeled number of months through July of the indicated year. For example, Smithville received approximately 25 inches of precipitation in the 18-month period ending July 2009.

At San Antonio, the record-setting accumulations are primarily at 18-23 months (Fig. 14). As the Austin-San Antonio NWS office has noted, the 23 months ending July 2009 was the driest period on record for any 23-month period. Rainfall during that period was 24.38", only 39% of normal. Nonetheless, there are periods, such as the 6 months, 12 months, and 24 months ending July 2009, for which the 1956 drought was worse, and the 1956 drought was much worse according to longer-term (greater than 24 month) rainfall deficits. Although it is difficult to see in Fig. 14, the 1925 drought was similar in its short-term rainfall deficits to the present drought, was milder at 18-24 months, and was more severe at 30-42 months. Likewise, the 1910 drought was just slightly milder out to 24 months and somewhat more severe beyond 24 months. So 1910, 1925, and 2009 are essentially tied as the second-worst drought on record in San Antonio.

At Victoria, the remarkably wet 2007 was followed by a remarkably dry 2008 and 2009. Fig. 15 shows that the accumulated rainfall for the past 3-21 months, with just two exceptions, is smaller than any other drought year. The record-breaking 15-month accumulation to date is 18.16", 34% of normal and 7.06" below the previous record set in 1918. Assessment of overall drought severity in Victoria is complicated by the wet 2007. The drought as of summer 1956 was similarly dry for up to 9 month accumulations, wetter for 12-24 month accumulations, and much drier beyond 24 months. The year 1917 was slightly drier than 1956 over the short term and slightly wetter over the long term. All in all, and recognizing that the hydrological impacts of the 2009 drought would not be as severe as the 1956 drought, it seems that the historic short-term dryness makes the 2009 drought at Victoria more severe overall.

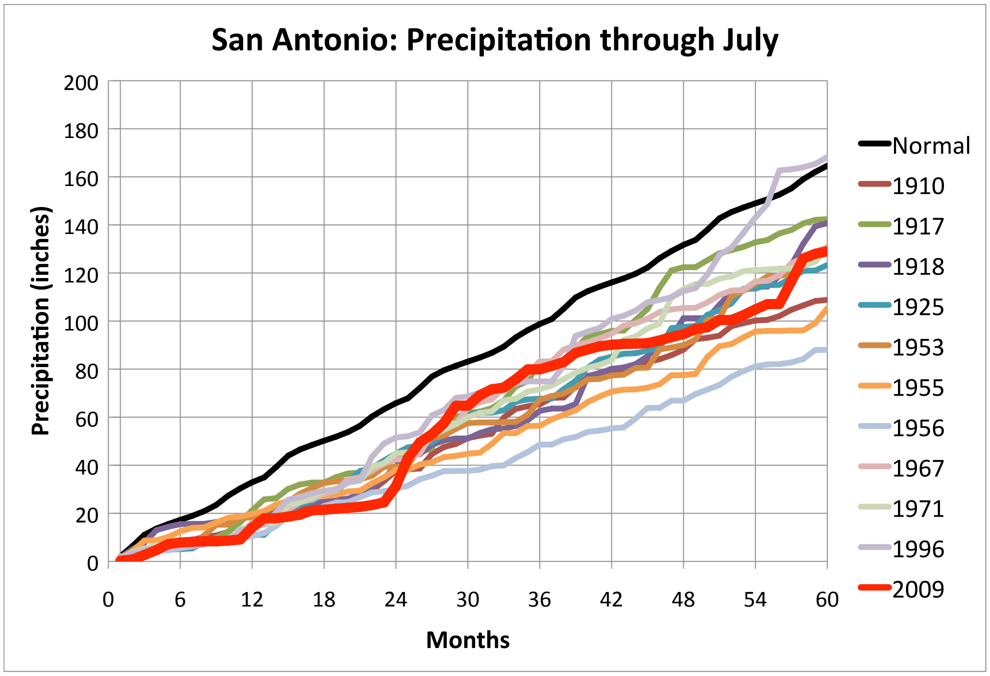

Figure 14

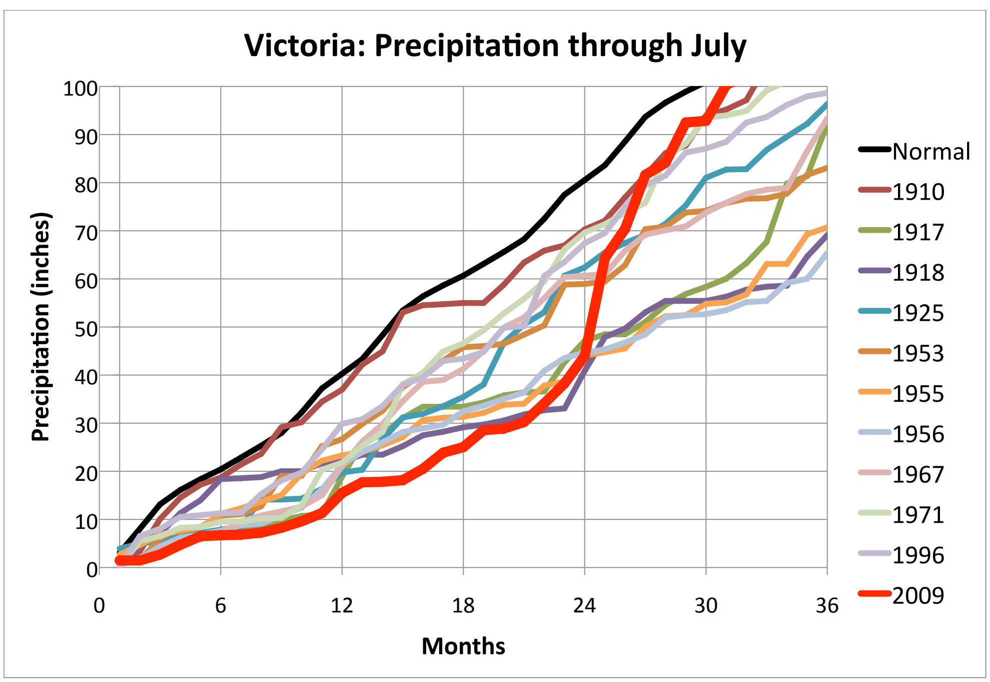

Figure 15

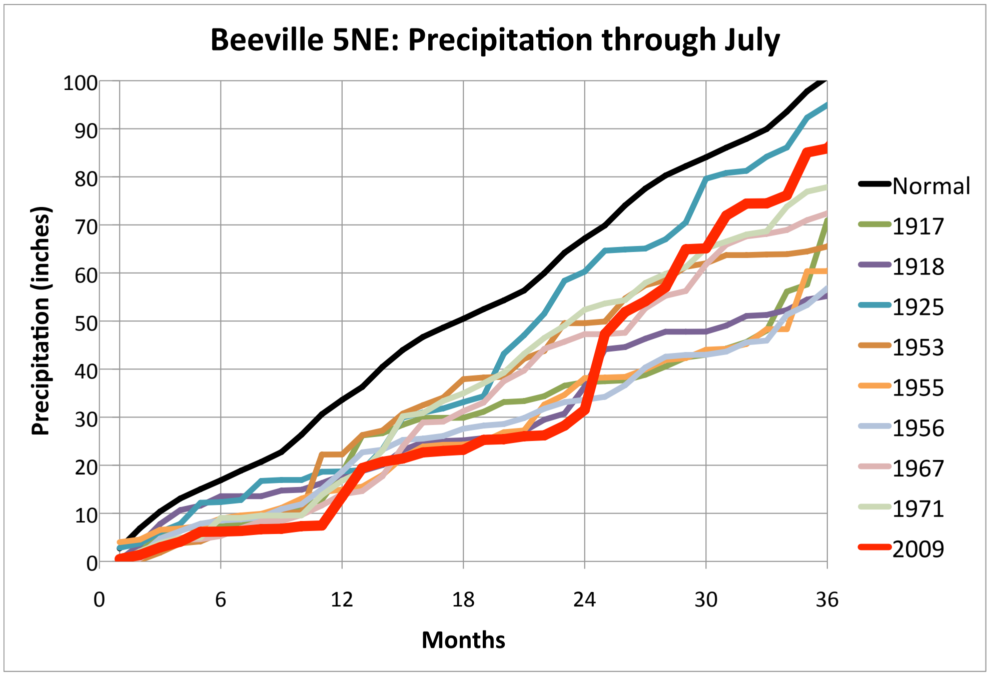

Figure 16

At Beeville 5NE (Fig. 16), conditions are neither as dry as Victoria over the short term nor as wet as Victoria over the longer term. Various other drought years are comparable to 2009 over various intervals. For up to 6-month accumulations, 1953 is drier, but it is much wetter beyond that. The year 1967 is similar out to 15 months but is wetter beyond that. The year 1955 is similar between 12-24 months and drier beyond that, but the 4" of rain in July 1955 brought temporary relief and made short-term deficits less severe. Overall, the only year that seems similar in severity to 2009 is, again, 1956. As at other stations, the 1956 drought has milder but significant short-term deficits and record-setting longer-term deficits.

At Corpus Christi (Fig. 17), multi-year rainfall deficits are not record-breaking, and the drought is primarily short-term due to above-normal rainfall received in summer 2008. Rainfall deficits in 2009 are less extreme at almost all accumulation intervals than those in 1917, and are less extreme than 1953 except for 6-12 month accumulations. Thus, the 2009 drought ranks third historically in terms of short-term dryness, and 1910 and 1955 are drier as well if longer-term deficits are taken into account. The 1956 drought was not as severe at Corpus Christi nor at stations farther south as it was in central Texas.

Finally, at Sarita (Fig. 18), south of Corpus Christi, the record is not as long so the 1917 drought does not appear. The 1953 drought was wetter than 2009 short-term, but drier long-term. The most severe drought at Sarita was 1955. Accumulated precipitation ending in July 1955 was similar to or smaller than accumulated precipitation ending in July 2009 for almost all time periods. Thus, 2009 is on a par with 1953 as the second-worst drought at Sarita behind 1955, and probably ranks behind 1917 as well.

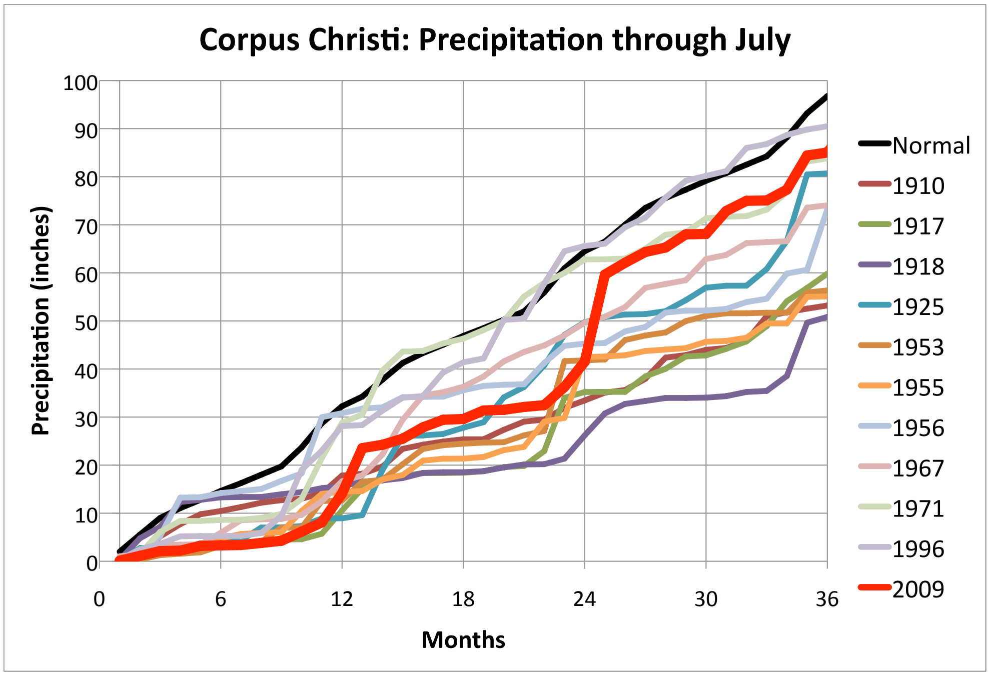

Figure 17

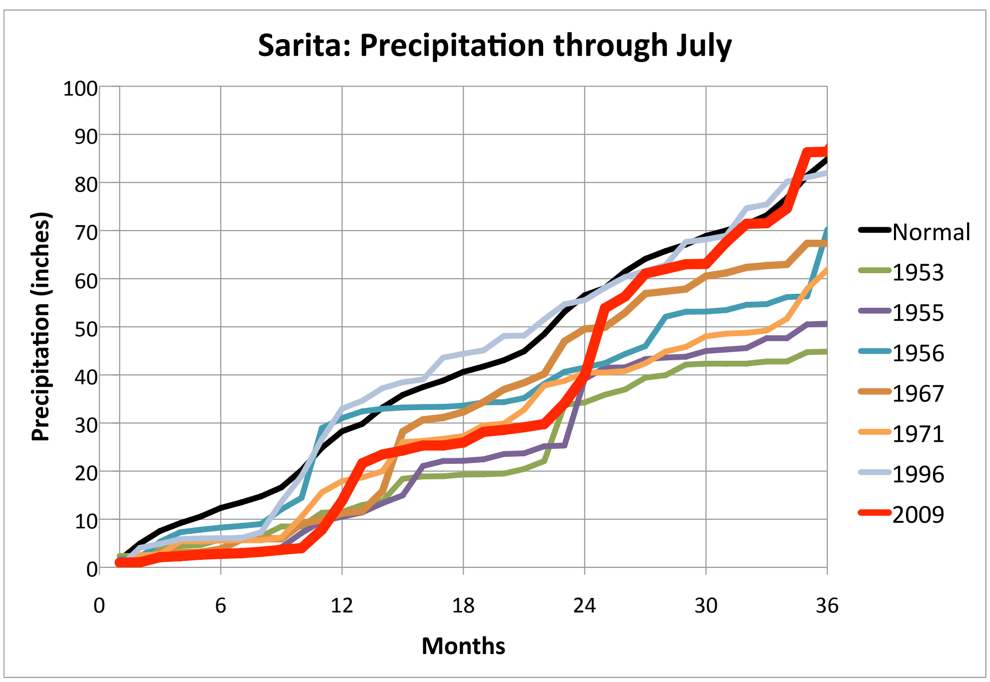

Figure 18

This analysis of individual stations has so far included only precipitation as a drought indicator. High temperatures can increase the severity of droughts. Given two periods with similar precipitation deficits, the one with the warmer temperatures will have the most severe drought. The average temperature in the South-Central Texas climate division in July 2009 was the warmest on record, with 1998 and 1925 nearly as warm. In the Southern Texas climate division, 2009 was tied for 1953 for fourth place behind 1897, 1925, and 1998. So, when comparing droughts, we will regard 1925, 1953, and 2009 as having simultaneous extreme drought and heat, while extreme heat was largely absent in other drought years in southern Texas.

The most extreme drought year in weather records is depicted in Fig. 19 for the core drought areas of the 2009 drought. Considering the precipitation data discussed here and other data not shown, it appears that the core drought area including Bastrop, Caldwell, and Lee counties (including Smithville) is presently experiencing its most severe drought conditions on record. To the west, Guadalupe and Bexar counties are experiencing drought conditions comparable to 1925 and second only to 1956. Farther west, Uvalde county's present drought is exceeded in severity only by 1918 (not shown). Thus, for the core of the central Texas drought area, the present drought ranks as the most extreme in eastern portions and second most extreme in central and western portions.

Most severe summertime drought years as of 2009

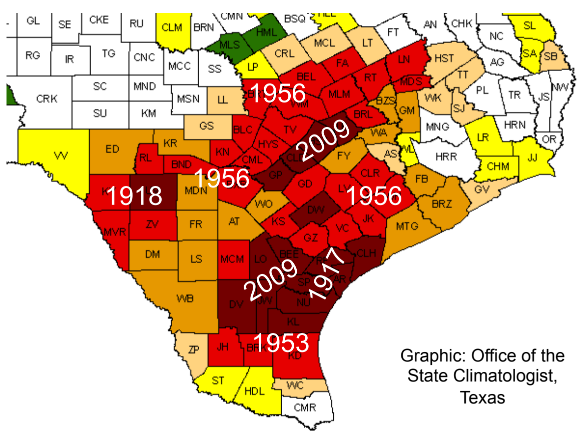

Figure 19

Farther south, of the stations with sufficient weather records, two indicate more severe drought in 1917 while three indicate less severe drought in 1917. North of Corpus Christi, the 1956 drought was also more extreme in some areas and less extreme in others. In the Corpus Christi region, the 1953 drought was one of the most severe on record, while farther south the 1955 drought was the most severe on record. The 2009 drought appears to be generally the most extreme on record from Victoria southwestward to Alice including Victoria, Bee, San Patricio, Live Oak, Jim Wells, and Duval Counties. In other core drought counties, including Jim Hogg, Brooks, Kenedy, Kleberg, Karnes, Goliad, and DeWitt counties, the 2009 drought appears to be the second worst on record, while in Nueces and Aransas counties the drought is only third worst.

6. Causes of the 2008-09 Texas Drought

Figure 1 showed that the 2008-09 Texas Drought evolved during several episodes. In fall and winter of 2007-08 and again in 2008-09, Texas received much less than its normal rainfall, and drought expanded and intensified across the state. This lack of rainfall can be largely attributed to La Niña, a temperature pattern in the tropical Eastern Pacific Ocean that typically leads to drier than normal weather across the southern United States during the wintertime. La Niña conditions were present during both winters. However, the sea surface temperature anomalies were not unusually large, and there is no obvious reason why December 2008 through February 2009 should have been the driest such period on record for Texas as a whole. La Niña was a contributing factor, but not the entire explanation.

The specific drought pattern was strongly influenced by three major weather events. Hurricane Dolly struck South Texas in 2008, producing a considerable portion of the total rainfall received by that area over the past two years and making the current drought less severe than it would otherwise have been. Similarly, Hurricane Ike struck East Texas in 2008 and brought considerable rainfall to eastern portions of the state. These two events served to confine the intense drought area to central and south-central Texas. The third event was the major springtime rainfall of 2009, which nearly bisected the drought area and produced copious rainfall in Houston and west of Houston along Interstate 10. The specific locations of all three rain events may be regarded as random weather occurrences. The lack of significant rain in the core drought region may be attributed to major weather systems that simply happened to avoid the core area.

The drought intensified to exceptional status during late spring and summer 2009. This intensification was associated with an upper-level jet stream pattern featuring troughs on the west and east coasts of the United States and a ridge across the central United States. This weather pattern persisted for close to two months, inhibiting convective activity and causing late spring storms to move farther north than usual. The unusual, persistent jet stream pattern simultaneously led to drought and heat in Texas and rain and cool weather in the Midwest and Northeast. The extent to which this particular jet stream pattern was a random event or was driven by particular patterns of sea surface temperatures is not known at this time.

Global warming has been identified as a possible cause of future extensive droughts in the subtropics, including the southwestern United States. Computer models on average project a precipitation decline of 5% over the next forty years. However, long-term precipitation trends across Texas remain upward. It is possible that the present drought is part of the beginning of a long-term decline in rainfall, but it is also possible that precipitation will remain steady or continue to increase. Based on present scientific knowledge, it is not possible to say whether global warming contributed to the present rainfall deficit. Indeed, whatever large-scale processes led to the overall upward precipitation trend may have caused rainfall to be greater than it otherwise would have been.

Global warming has, however, contributed slightly to the severity of the present drought through higher temperatures. Global temperatures have increase by about 0.7 °C over the past century, and long-term temperature trends across Texas are now at or above the sustained warm temperatures of the 1950s. It seems reasonable to assume that present temperatures in Texas are on average about 1 °F warmer than they would have been in the absence of global warming. This has increased potential evaporation and water demands by livestock and humans. Thus, if a similar precipitation deficit had developed in the absence of global warming, it would not have been quite as severe.

7. Outlook

In the core drought area, September is climatologically one of the wettest months of the year. However, precipitation during September is also difficult to predict at long range. The amount of rain received by Texas will depend on the specific locations of stalled cold fronts, the amount of influx of tropical moisture, and the occurrence and track of tropical waves and other tropical disturbances. There is no specific indicator that would lead to the expectation of above-normal precipitation during the month of September, but even near-normal September precipitation will be beneficial. The NWS's Climate Prediction Center predicts equal chances of above-normal, near-normal, and below-normal precipitation for the three-month period August through October (Fig. 20).

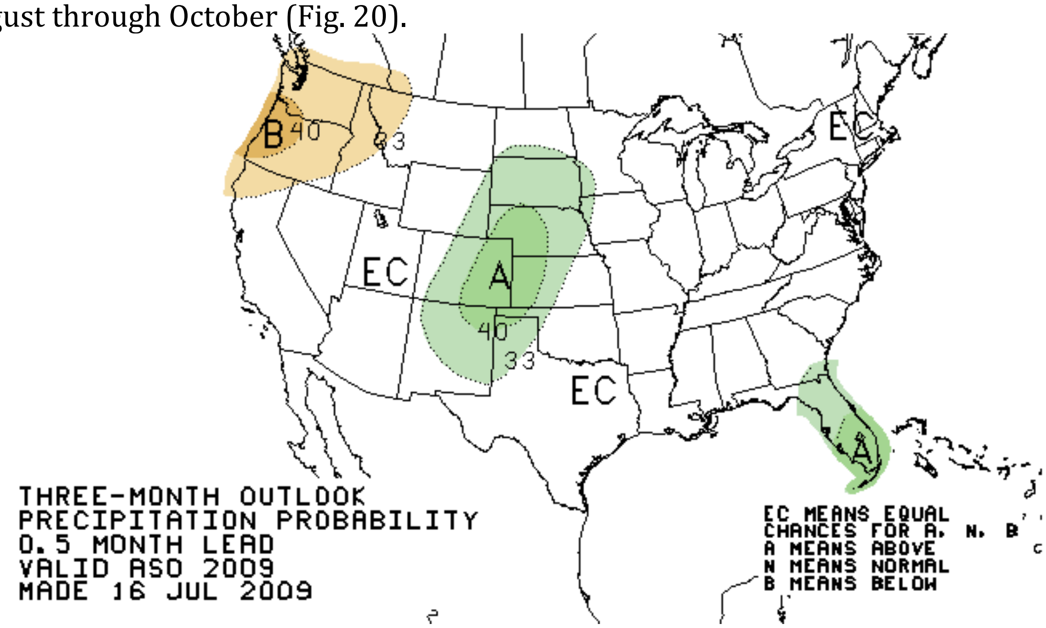

Figure 20. August-October precipitation outlook from NOAA's Climate Prediction Center.

As of this writing, El Niño conditions have developed in the tropical East Pacific Ocean. The NWS Climate Prediction Center expects a moderate to strong El Niño to persist through fall and winter. Skill in predicting such patterns is high. Therefore, since El Niño conditions are normally associated with above-normal precipitation across central and southern Texas, it is likely, but not guaranteed, that the drought will become much less severe during the upcoming fall and winter. The Climate Prediction Center projects that above-normal rainfall is especially likely in Texas during the period November 2009 through April 2010 (Figs. 21-22).

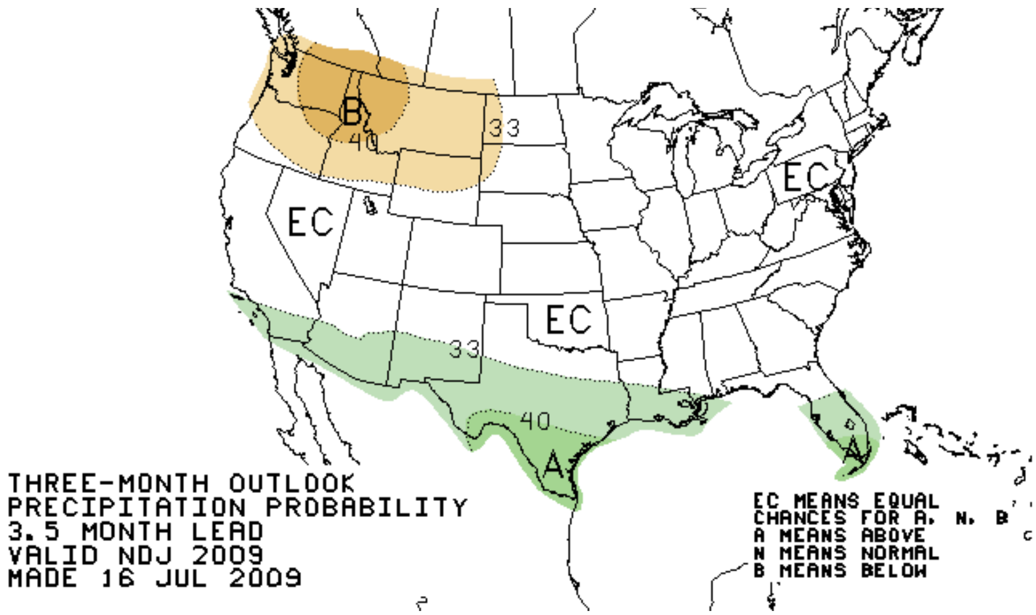

Figure 21: CPC precipitation outlook for November 2009 through January 2010.

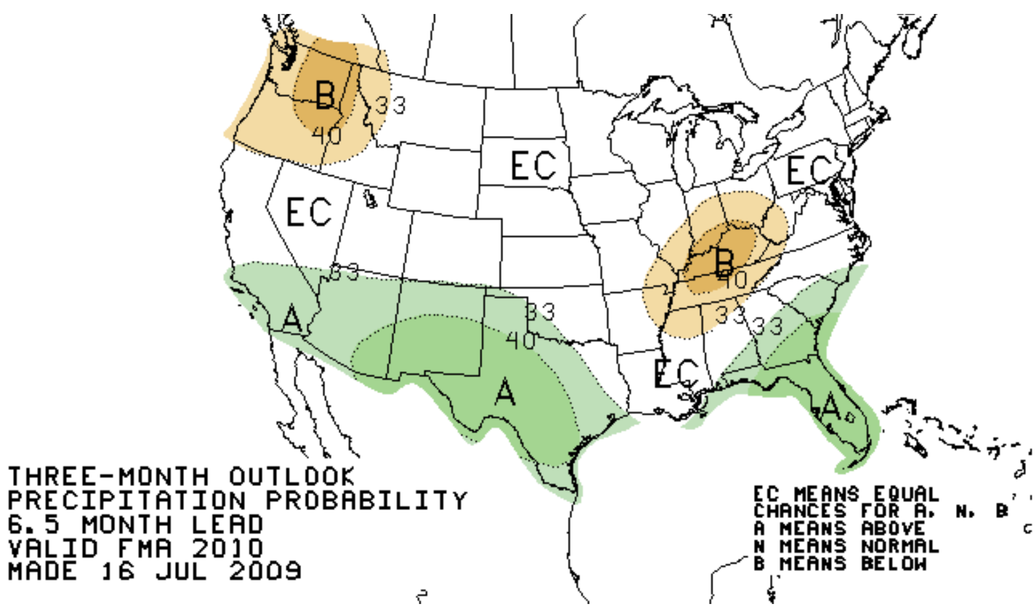

Figure 22: CPC precipitation outlook for February-April 2010.

8. Acknowledgments

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