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SCIPP
Southern Climate Impacts Planning Program
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In This Issue:

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A Climatology of Dipole Drought and Pluvial Events within the Great Plains

Jordan Christian, Katarina Christian, and Jeffrey Basara, University of Oklahoma, Southern Climate Impacts Planning Program

Over the years, various scientific studies have been conducted over drought within the Great Plains. Dong et al. (2011) first discovered a dipole drought and pluvial event with a year of severe drought in 2006 followed by a year of abundant rainfall in 2007 within Oklahoma and the surrounding Southern Great Plains. Dong et al. (2011) suggested there exists a dipole relationship between a drought year and a pluvial (abundant rainfall) year. While many studies have been conducted on specific drought events, no research has ever investigated the climatology of such dipole events. Therefore, the objective of this study was to examine and analyze the existence and frequency of dipole drought and pluvial events within the Great Plains.

Broader Impacts

The Great Plains is a region heavily utilized for agriculture, livestock, and crop farming purposes. A report by the United States Global Change Research Program stated that 70% of the land area within the Great Plains is used for agriculture (Karl et al. 2009). In addition, according to a past report from the U.S. Census Bureau, the population within the Great Plains has nearly doubled from 4.9 million in 1950 to 9.9 million people in 2007 (EPA 2013). By increasing the population of a region highly influenced by agriculture, the effects of a severe drought are exacerbated and felt by many. A severe drought acts to worsen already strained water resources in urban cities within the Great Plains in addition to damaging agriculture and croplands, resulting in billions of dollars in losses. According to Basara et al. (2008), six major drought/heat waves from 1980-2003 accounted for 131.7 billion dollars, or 38% of total weather related losses within the Great Plains. These large monetary losses from severe drought events convey the message that the climatology of the Great Plains is poorly understood. A poor understanding of the climatology of a region results in misuse and abuse of the land, in addition to a negligence in mitigation strategies, resulting in billions of dollars in damage when a severe drought does occur. By creating a climatology of dipole drought and pluvial events within the Great Plains, this study will help to improve that lack of understanding regarding the climatology of the Great Plains by observing periods of extreme variability in rainfall. Through identifying and understanding the frequency and strong signals indicative of dipole drought and pluvial events within the past, this study will aid both the farmer and city conservationist in mitigating for periods of sudden drought and wisely planning for periods of rapid recovery.

Methodology

1. Dataset

This study utilized rainfall values from the National Climatic Data Center's (NCDC) nClimDiv dataset. This dataset dated from 1895 to 2013. MATLAB was used to process the data and retrieve any dipoles that fit the criteria and thresholds described in the following sections. It is important to also note that any retrieved dipoles were analyzed on a hydrological year. By definition, a hydrological year begins in the month of October and ends in the month of September. Therefore, when referencing a year in this study, such as 1987, this would refer to a year beginning in October of 1986 and ending in September of 1987. Analysis of dipoles based on a hydrological year was chosen as hydrological years take into account snowmelt between the winter and spring months. While regions within this study do not necessarily involve snowmelt, if future research was conducted for other regions within the United States, a hydrological year should be used for comparison's sake.

2. Spatial Scales and Averaging Methods

Various spatial scales were utilized in examining dipole events within the Great Plains. First, the nine climate divisions within Oklahoma were each individually analyzed for dipole events. The same procedure was also conducted for the state of Oklahoma. Finally, the Southern Great Plains (SGP), the High Plains (HP), and the Northern Great Plains (NGP) were also analyzed for dipole events. In this article, only results from the SGP, HP, and NGP will be discussed. Climate divisions that compose the SGP are shown in Figure 1. It is important to note that only climate divisions one through four were chosen from Texas. The reason for not selecting climate divisions further south was due to the presence of the Edwards Plateau in western Texas and Gulf Coastal climates in southeastern Texas. Climate divisions that compose the HP are shown in Figure 2 and were chosen in order to capture the smaller precipitation gradient on the western edge of the Great Plains. Lastly, climate divisions within the NGP can be seen in Figure 3 and were chosen in order to observe how dipole events might vary, if at all, in more northern latitudes.

3. Dipole Definitions

Two different climatologies were created for analyzing dipole drought and pluvial events. The first dipole climatology was defined as a year with 10% or more below the average annual rainfall followed by a year with 10% or more above the average annual rainfall the very next year. This dipole was labeled as a significant drought to a significant pluvial (SD to SP). It is imperative to quickly note that when averaging the climate divisions within the SGP, HP, and NGP, a weighted averaging method was utilized. The weighted averaging method takes into account the

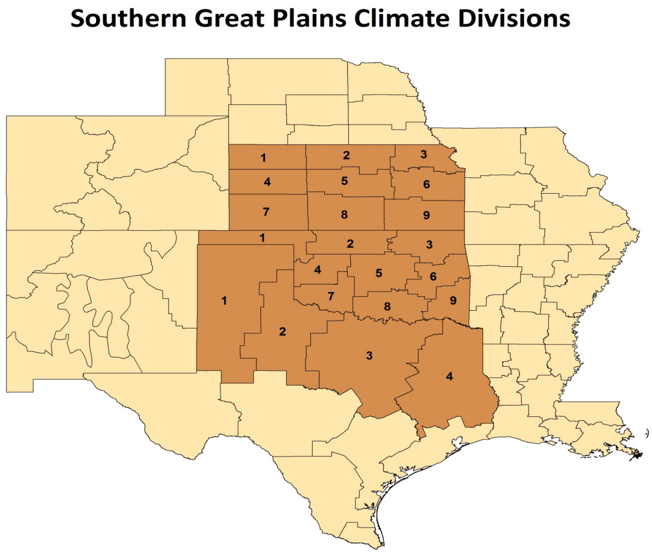

Figure 1: Climate Divisions within the Southern Great Plains

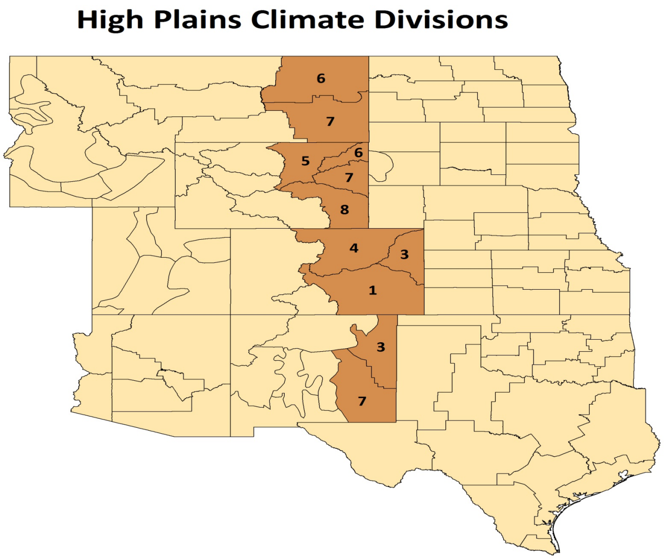

Figure 2: Climate divisions within the Northern Great Plains

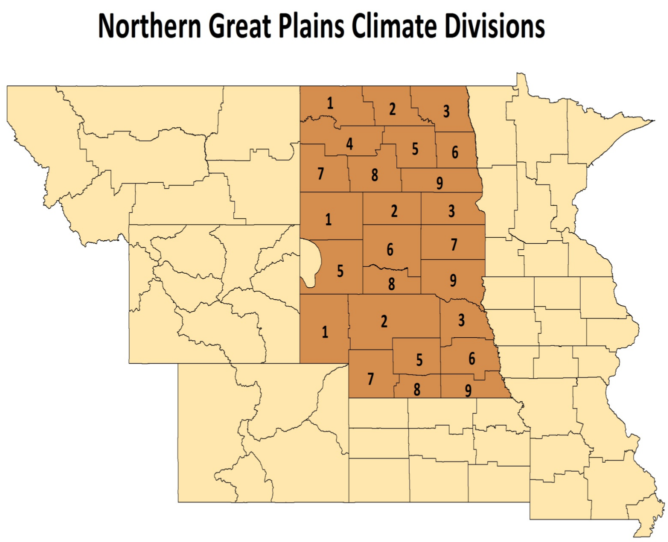

Figure 3: Climate divisions within the High Plains

areas of each climate division in order to provide a more accurate depiction of rainfall amounts in larger versus smaller climate divisions. The weighted averaging method is also used by NCDC for rainfall datasets that span over larger regions (NCDC 2014). In addition to the SD to SP climatology, the second dipole climatology developed captured dipoles one standard deviation or more above the mean positive change. This dipole climatology was labeled as a standard deviation (STDEV) climatology. As well as the two previously mentioned climatologies, pluvial months that contributed to the pluvial year in each dipole climatology were analyzed and the results displayed in a histogram. While very little literature exists on what specifically defines a pluvial, Findell et al. (2010) defined a pluvial month as a month with 80% or more above the average rainfall for that specific month. Therefore, a pluvial month was defined as a month with 80% or more above the average rainfall for smaller spatial scales, i.e. the Oklahoma climate divisions. However, for larger spatial scales, i.e. the state of Oklahoma, SGP, HP, and NGP, a pluvial month was defined as a month with 40% or more above the average rainfall. This reduction in pluvial threshold for larger spatial scales was necessary as once larger spatial scales were reached, an averaging effect took place that made large departures from normal difficult to obtain. Therefore, 40% was chosen in order to capture pluvial months that contributed to the pluvial year for larger spatial scales.

Results

1. The Southern Great Plains, High Plains, and Northern Great Plains

Looking first at the SGP, the STDEV dipole climatology can be seen in Figure 4. One interesting observation from Figure 4 is the increase in STDEV dipoles over time with the first spacing between the 1918 dipole and 1940 dipole being 22 years yet the last spacing between the 2006 dipole and 2011 dipole being only 5 years.

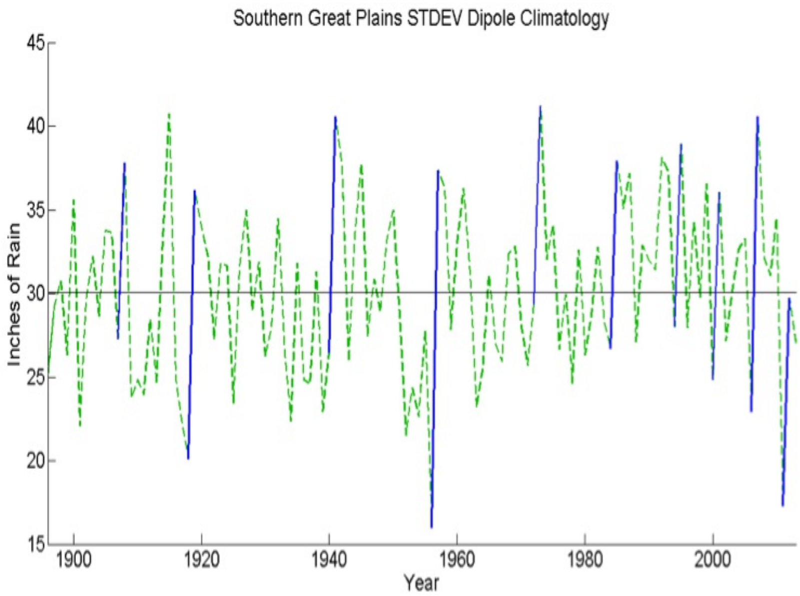

Figure 4: Southern Great Plains STDEV dipole climatology

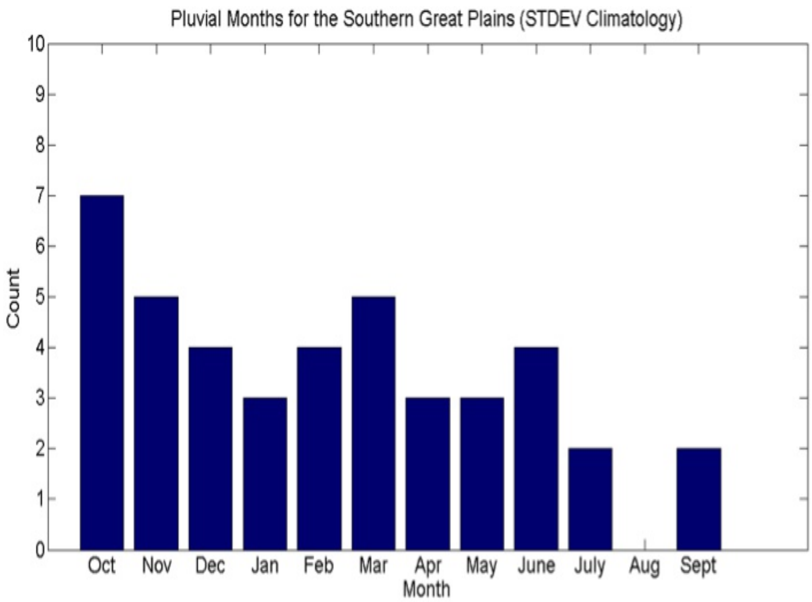

Figure 5: Pluvial months for the Southern Great Plains in the STDEV dipole climatology

While these results are incredibly important to note, a discussion of plausible causes for the increase in precipitation dipoles over time is beyond the scope of this study. Pluvial months that contributed to the pluvial year for the STDEV dipole climatology are shown in Figure 5. It can be seen that the spring months are not nearly as important as the fall months, especially October, for initiating a pluvial year (Figure 5). In other words, in order to break out of a severe drought within the SGP, above average rainfall in the fall months is essential. Regarding the High Plains, pluvial months that contributed to the pluvial year for the STDEV HP dipole climatology can be seen in Figure 6. As shown in Figure 6, the month of September consistently appeared as being important for receiving above average rainfall. The lack of many spring and winter months suggests that above average rainfall in the winter and spring months is not necessarily important for initiating a pluvial year within the HP in contrast to the SGP.

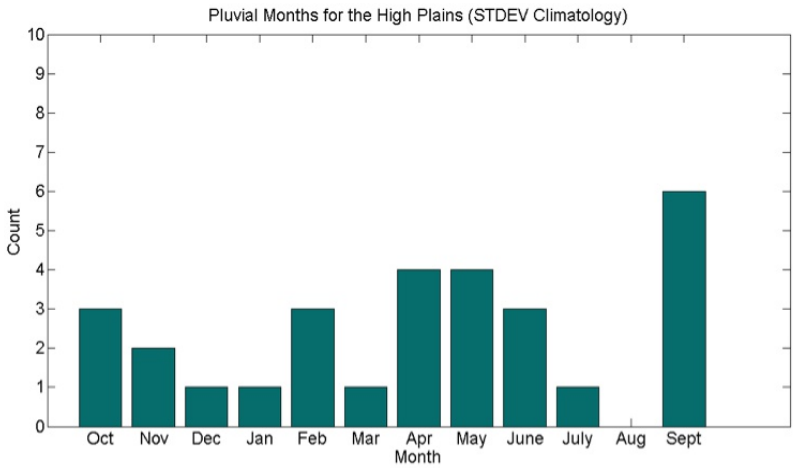

Figure 6: Pluvial months for the High Plains in the STDEV dipole climatology

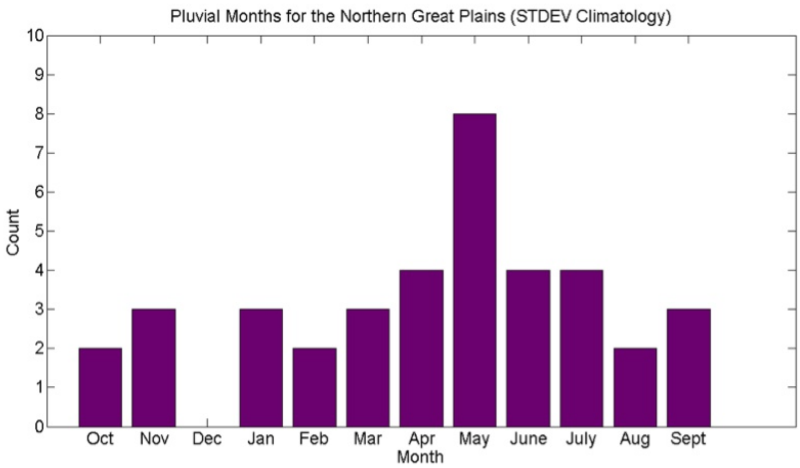

Figure 7: Pluvial months for the Northern Great Plains in the STDEV dipole climatology

However, plausible reasons for this difference within the HP is yet again beyond the extent of this project. In addition to the HP, pluvial months that contributed to the pluvial year for the STDEV dipole climatology within the NGP can also seen in Figure 7. While the NGP did not reveal much in terms of notable results, the month of May was shown to be essential for initiating a pluvial year within the NGP (Figure 7).

2. Further Analyses

A number of comparisons were made between the large subdivisions within the Great Plains. The first comparison was a count of the SD to SP dipoles for each region (Figure 8). For regions falling within large precipitation gradients (the SGP and NGP), there were numerous SD to SP dipoles with the SGP having nine and the NGP having eight. On the other hand, the HP region, a region characterized by a smaller precipitation gradient, had only 4 SD to SP dipoles. This suggests that the relative variability for the SGP and NGP is higher compared to the HP. In addition, the percent chance of initiating a SD to SP dipole in the three regions within Great Plains was also explored. Figure 9 shows that for the SGP and NGP, SD to SP dipoles tend to initiate from a significant drought year approximately one out of every four times, while only about one out of every six times for the HP. This suggests that the SGP and NGP have a higher chance of experiencing a significant pluvial year immediately after a significant drought year compared to the HP.

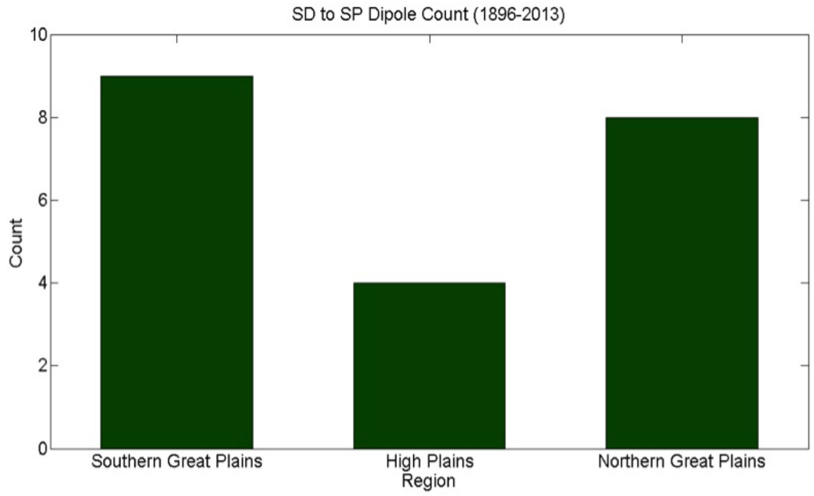

Figure 8: SD to SP dipole count for the Southern Great Plains, High Plains, and Northern Great Plains from 1895 to 2013.

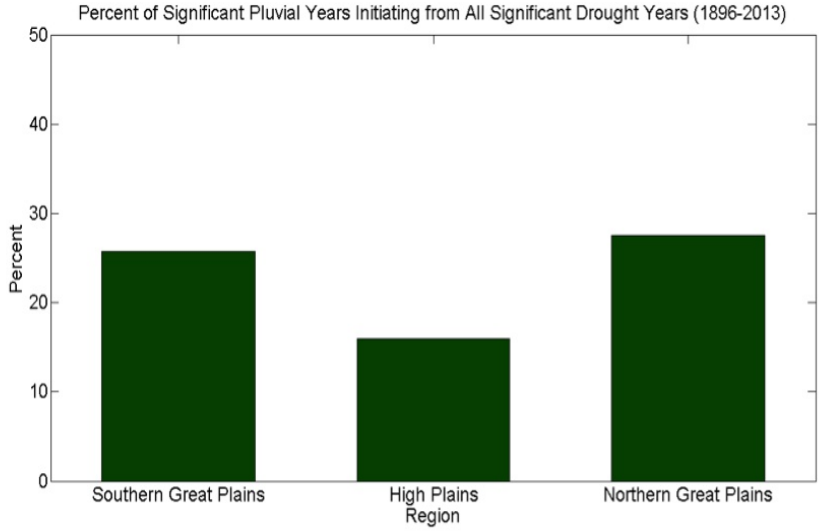

Figure 9: Percent of significant pluvial years initiating from all significant drought years between 1895 and 2013 for the Southern Great Plains, High Plains, and Northern Great Plains.

Conclusion

The SGP STDEV dipole climatology revealed an increase in STDEV dipoles over time, suggesting that extreme changes from a significant drought one year to a significant pluvial the next year are increasing with time. Furthermore, more SD to SP dipoles were found in the SGP (9 SD to SP dipoles) and NGP (8 SD to SP dipoles) compared to the HP (4 SD to SP dipoles). This suggests that the relative variability of rainfall in the SGP and NGP is greater than the variability of rainfall in the HP. It was also found that SD to SP dipoles initiating from a significant drought year occurred approximately one out of every four times for the SGP and NGP and one out of every six times for the HP.

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Drought Update

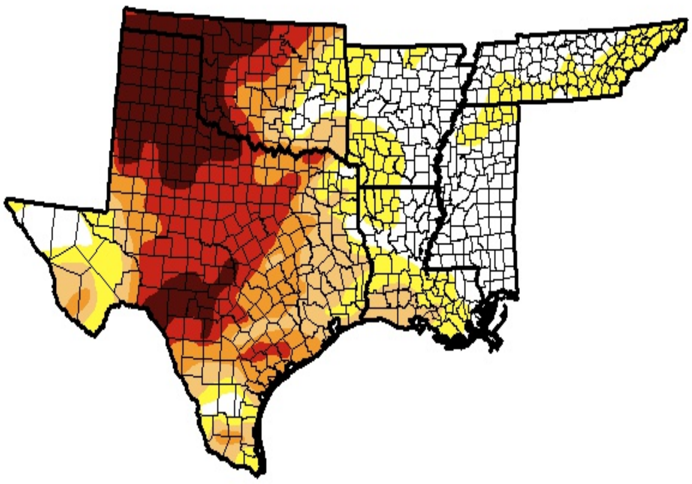
Luigi Romolo
Southern Regional Climate Center

Drought conditions in the Southern Region worsened significantly over the past month. Most of the northern panhandle of Texas is now classified as exceptional drought (D4), the highest possible drought category that can be assigned by the National Drought Mitigation Center. The D4 drought also extends into western and northern Oklahoma. A second, but smaller area of D4 drought is also now evident in the south of Texas, centered near Edwards County. Moderate drought was expanded to include a larger portion of eastern Texas. Elsewhere, drought conditions did not change too much, except for a small area in northern Mississippi that is now classified as moderate drought.

The biggest severe weather story for the month concerns a major tornado outbreak that occurred over two days, spanning April 27-28. In Mississippi, approximately two dozen twisters hit the state, resulting in major damage and numerous fatalities. According to the storm prediction center, nineteen fatalities resulted from a twister that tore through Leake County, Mississippi. Though these numbers are still preliminary, they do point to the fact that this was a major event that rivals the super outbreak that occurred just a few years ago in April, 2011. In Arkansas, an EF4 tornado passed through Mayflower and Vilonia resulting in approximately one dozen deaths and over one hundred injuries.

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	25.93	74.07	54.44	41.67	29.82	14.72
Last Week 4/29/2014	34.03	65.97	48.77	34.02	24.32	11.66
3 Months Ago 2/4/2014	37.26	62.74	36.75	15.67	5.70	0.68
Start of Calendar Year 12/31/2013	55.85	44.15	27.23	13.21	3.58	0.72
Start of Water Year 10/1/2013	26.20	73.80	50.11	17.90	3.16	0.25
One Year Ago 5/7/2013	36.77	63.23	56.17	43.82	24.87	7.66



Intensity:

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

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompany text summary for forecast statements. **http://droughtmonitor.unl.edu**

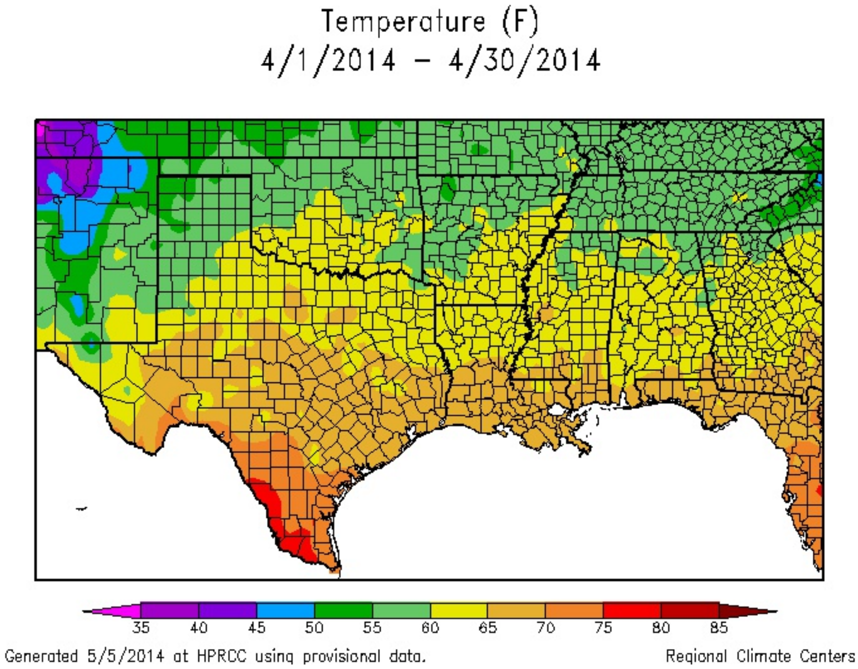
Released Thursday, May 8, 2014.
Mark Svoboda National Drought Mitigation Center

Above: Drought Conditions in the Southern Region. Map is valid for May 6, 2014. Image is courtesy of National Drought Mitigation Center.

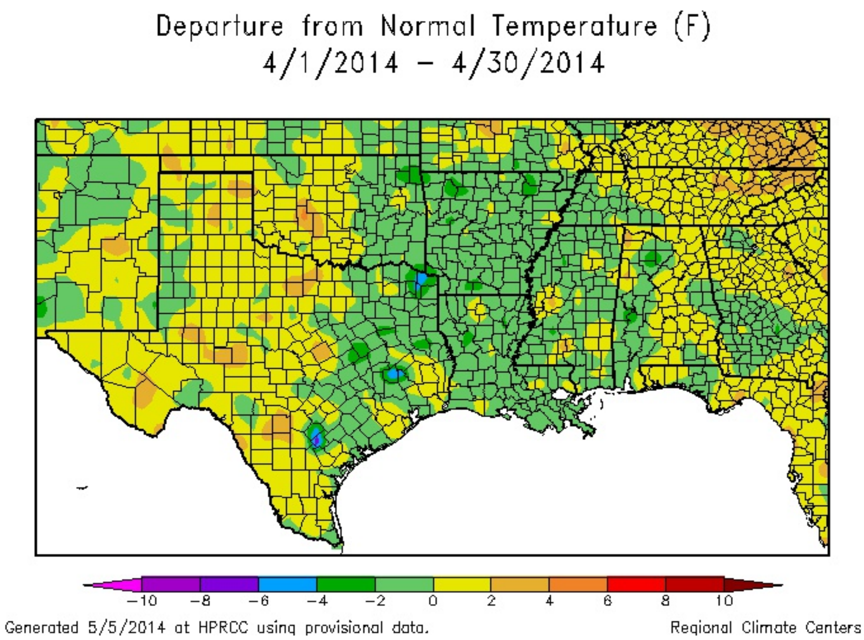
Temperature Summary

Luigi Romolo
Southern Regional Climate Center

April temperatures varied spatially across the Southern Region, however, average temperature anomalies were low, with the majority of stations averaging withing 2 degrees F (1.11 degrees C) of normal for the month. For the most part, the central portions of the Southern Region experienced a slightly cooler than normal month. This includes Arkansas, Louisiana, Mississippi, eastern Texas, eastern Oklahoma, and the western tip of Tennessee. Elsewhere, temperatures for the month averaged slightly above normal. The state wide average temperatures are as follows: Arkansas reported 59.80 degrees F (15.44 degrees C), Louisiana reported 65.60 degrees F (18.67 degrees C), Mississippi reported 62.80 degrees F (17.11 degrees C), Oklahoma reported 59.40 degrees F (15.22 degrees C), Tennessee reported 58.80 degrees F (14.89 degrees C), and Texas reported 65.60 degrees F (18.66 degrees C). All state temperature rankings for the month fell within the two middle quartiles.



Average April 2014 Temperature across the South.

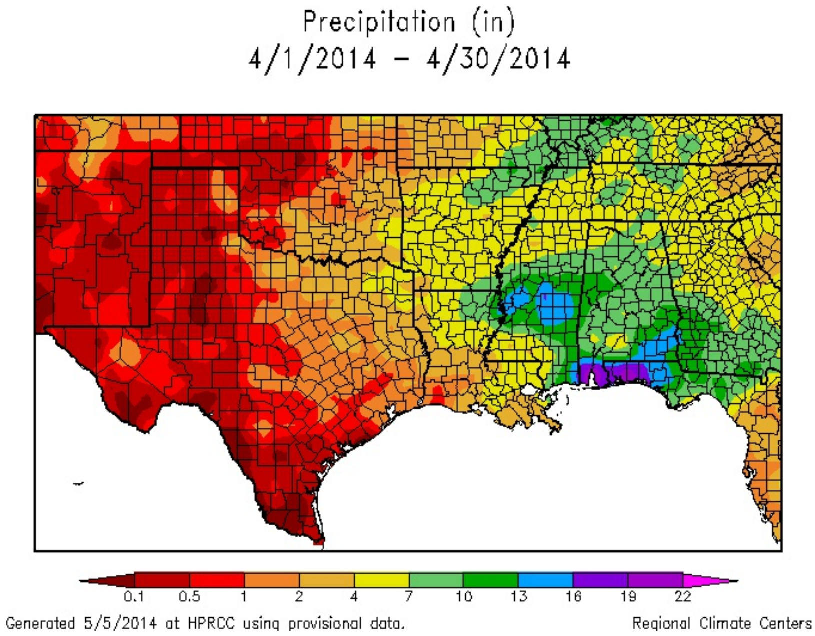


Average Temperature Departures from 1971-2000 for April 2014 across the South.

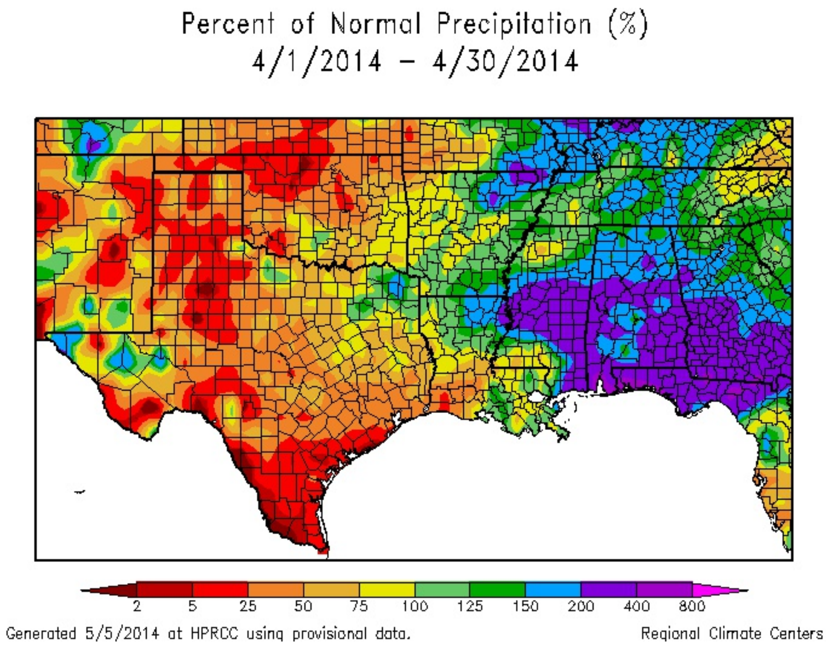
Precipitation Summary

Luigi Romolo
Southern Regional Climate Center

Precipitation totals for the month of April were plentiful in some parts of the Southern Region, while other portions experienced a very dry month. A series of cold fronts that swept through the Gulf Coast, allowed for heavy rainfall amounts in central and southern Mississippi. Stations in this part of the Southern Region averaged over twice the normal precipitation for the month. In northern Louisiana, eastern Arkansas, and Tennessee, precipitation totals varied from near normal to just under twice the monthly expectation. Most of Oklahoma and Texas remained very dry throughout the month. Stations in the southern tip of Texas averaged less than one fourth of normal precipitation. Similar departures from normal were also experienced in northern Oklahoma and in the west central counties of Texas. The statewide average precipitation totals for the month of April are as follows: Arkansas recorded 5.36 inches (136.14 mm), Louisiana recorded 4.32 inches (109.73 mm), Mississippi recorded 8.74 inches (222.00 mm), Oklahoma recorded 1.70 inches (43.18 mm), Tennessee recorded 5.81 inches (147.57 mm), and Texas recorded 1.01 inches (25.65 mm). Oklahoma experienced its twelfth driest April on record (1895-2014), while Texas had its thirteenth driest April (1895-2014). Conversely, Mississippi experienced its twelfth wettest April on record (1895-2014). For Tennessee it was the twenty-third wettest April on record (1895-2014). All other state rankings fell within the two middle quartiles.

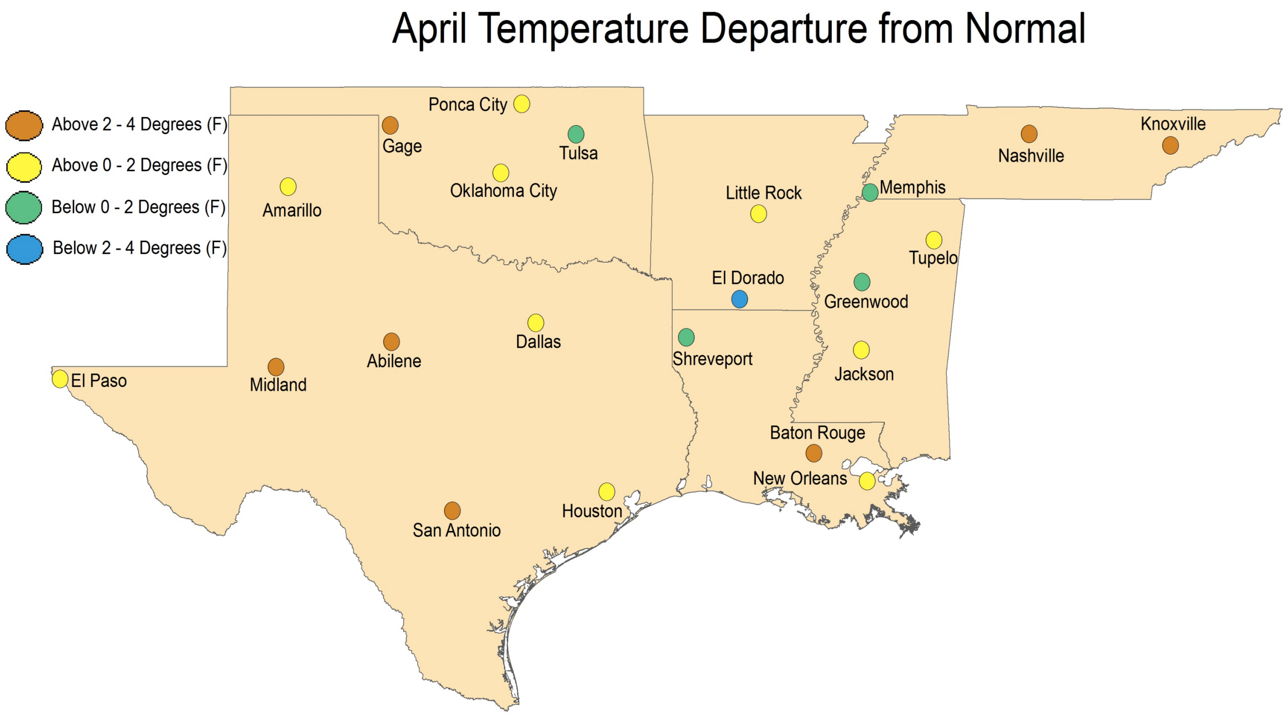


April 2014 Total Precipitation across the South.

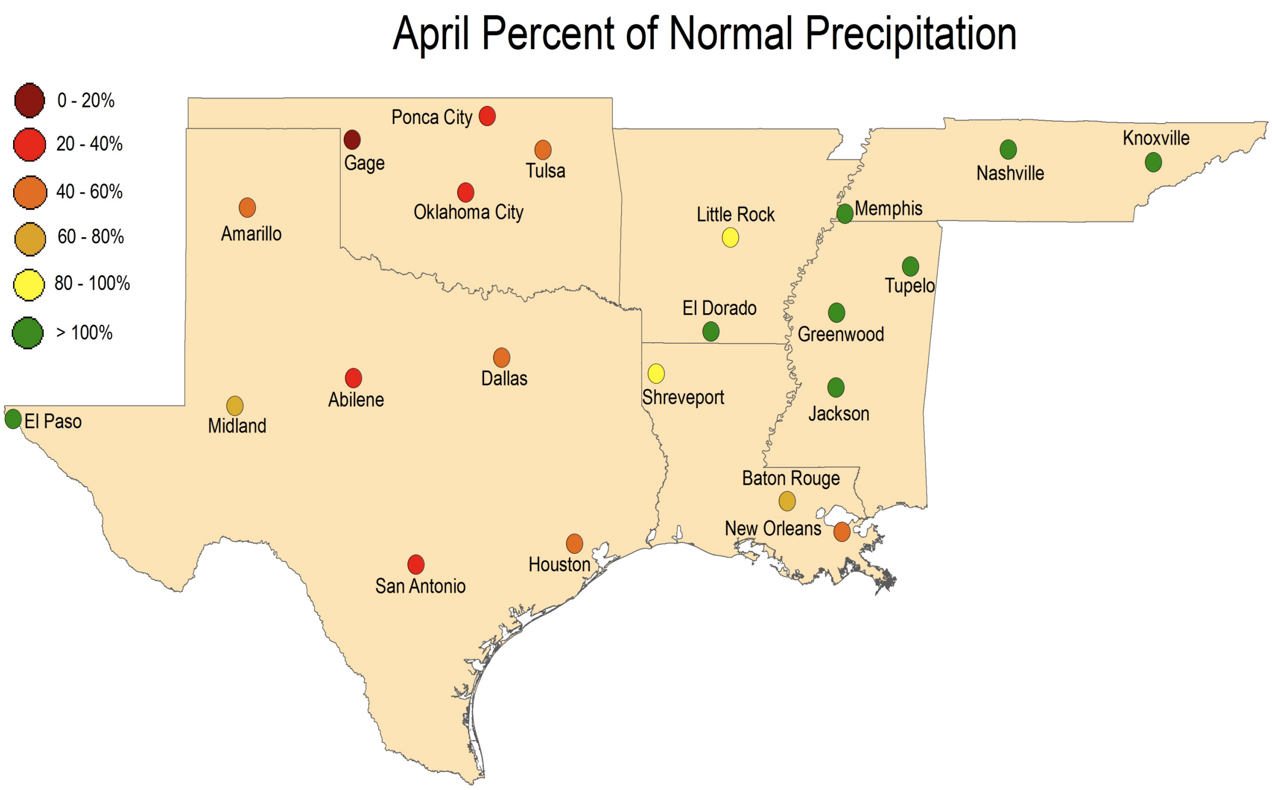


Percent of 1971-2000 normal precipitation totals for April 2014 across the South.

Regional Climate Perspective in Pictures



April 2014 Temperature Departure from Normal from 1971-2000 for SCIPP Regional Cities



April 2014 Percent of 1971-2000 Normal Precipitation Totals for SCIPP Regional Cities

Climate Perspective

State	Temperature	Rank (1895-2011)	Precipitation	Rank (1895-2011)
Arkansas	59.80	48th Coldest	5.36	44th Wettest
Louisiana	65.60	47th Coldest	4.32	57th Driest
Mississippi	62.80	50th Coldest	8.74	12th Wettest
Oklahoma	59.40	60th Coldest	1.70	12th Driest
Tennessee	58.80	43rd Warmest	5.81	23rd Wettest
Texas	65.50	38th Warmest	1.01	13th Driest

State temperature and precipitation values and rankings for April 2014. Ranks are based on the National Climatic Data Center's Statewide, Regional, and National Dataset over the period 1895-2011.

Station Summaries Across the South

Station Summaries Across the South

Station Name	Temperatures (degrees F)								Precipitation (inches)		
	Averages				Extremes				Totals		
	Max	Min	Mean	Depart	High	Date	Low	Date	Obs	Depart	%Norm
El Dorado, AR	73.0	49.2	61.1	-2.6	86	4/27	32	4/16	5.64	1.09	124
Little Rock, AR	72.6	50.7	61.7	0.3	84	4/10+	34	4/15	4.95	-0.52	90
Baton Rouge, LA	79.6	57.6	68.6	2.0	89	4/27	37	4/16	3.53	-2.03	64
New Orleans, LA	77.2	60.2	68.7	0.5	86	4/28+	46	4/9	2.31	-2.71	46
Shreveport, LA	75.9	53.2	64.5	-0.7	91	4/27	37	4/16	4.10	-0.32	93
Greenwood, MS	73.6	50.0	61.8	-1.9	86	4/3	35	4/16	9.63	3.97	170
Jackson, MS	75.9	51.2	63.6	0.2	88	4/26	37	4/16	12.52	6.54	209
Tupelo, MS	73.5	48.9	61.2	0.3	85	4/3	31	4/16	6.61	1.67	134
Gage, OK	73.8	42.6	58.2	2.0	96	4/12	22	4/15	0.36	-1.73	17
Oklahoma City, OK	74.5	47.6	61.0	1.3	90	4/26	27	4/15	1.00	-2.00	33
Ponca City, OK	73.9	44.6	59.2	0.4	91	4/26	25	4/15	1.30	-2.21	37
Tulsa, OK	72.5	46.0	59.2	-1.6	87	4/10	30	4/15	2.14	-1.81	54
Knoxville, TN	72.7	48.5	60.6	2.8	85	4/27	30	4/16	4.32	0.33	108
Memphis, TN	72.3	51.7	62.0	-0.1	83	4/26+	36	4/15	6.14	0.35	106
Nashville, TN	73.8	48.5	61.1	2.6	83	4/26	31	4/16	7.29	3.36	186
Abilene, TX	79.8	53.8	66.8	2.2	96	4/10	28	4/15	0.61	-1.06	37
Amarillo, TX	73.4	41.8	57.6	1.4	90	4/25	24	4/15	0.57	-0.76	43
El Paso, TX	79.3	52.7	66.0	1.4	89	4/22	38	4/15+	0.45	0.22	195
Dallas, TX	76.6	55.9	66.2	1.2	91	4/27	35	4/15	1.74	-1.46	54
Houston, TX	79.0	59.8	69.4	0.9	92	4/28	41	4/16+	1.56	-2.04	43
Midland, TX	80.9	52.8	66.9	3.2	93	4/26+	30	4/15	0.45	-0.28	61
San Antonio, TX	83.0	59.5	71.2	2.7	99	4/28+	39	4/15	0.68	-1.92	26

Summary of temperature and precipitation information from around the region for April 2014. Data provided by the Applied Climate Information System. On this chart, "depart" is the average's departure from the normal average, and "% norm" is the percentage of rainfall received compared with normal amounts of rainfall. Plus signs in the dates column denote that the extremes were reached on multiple days. Blueshaded boxes represent cooler than normal temperatures; redshaded boxes denote warmer than normal temperatures; tan shades represent drier than normal conditions; and green shades denote wetter than normal conditions.

National Climate Assessment Released Last Week

Barry Keim, Louisiana State Climatologist, Louisiana State University

The National Climate Assessment was released last week and can be found at <http://nca2014.globalchange.gov/>. In Figure 1 below, they show the pattern of temperature across the southeastern United States since 1900. It appears that the warmest year on record occurred in the 1920s for the region, with relatively warm temperature in the 1920s and 1930s. Then something happened to our temperatures in the late 1950s, with the noticeable drop in annual temperatures that occurred rather abruptly and persisted through the 1960s and early 1970s. Interestingly, the Southeast is the only region in the entire Northern Hemisphere that has experienced this cooling pattern, and for this time period, the region is known as the "warming hole," representing the only region without a long-term trend in annual average temperatures for the past century. Note, however, since the late 1970s, temperatures have been increasing again. Figure 1 also includes modeled estimates of what our temperatures might look like out to the year 2100. The Assessment graphic includes 2 scenarios, one with a high greenhouse gas emissions scenario (A2) and the other a lower emissions scenario (B1). Both scenarios project a warmer future across the Southeast, but the A2 scenario has our average annual temperatures increasing by over 6 degrees over current levels in 2100, while the B1 scenario holds it to a 2-3 degree increase. Either case will have impacts, but obviously A2 would potentially be much worse. One of the biggest impacts across our region, however, is the combination of subsidence and sea level rise. Southeastern Louisiana has some of the highest subsidence rates and relative sea level rise rates in the world, as recently reported by NOAA, with Grand Isle sinking into the Gulf at a rate of over one-third of an inch per year. There are even higher rates across the New Orleans area. NOAA reports that roughly 36 percent of the land in St. Bernard could be below sea level by 2050, and a 53 percent by 2100. Let's hope the levees hold! Please contact me with any questions or complaints at keim@lsu.edu.

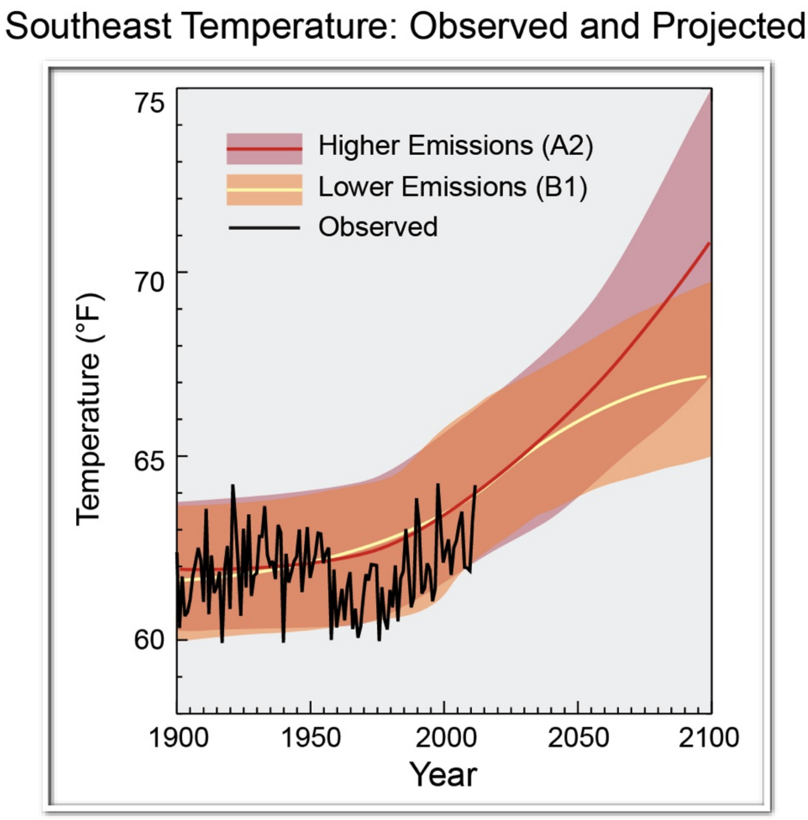


Figure 1. Observed annual temperatures across the Southeast United States over the past century, with projections out to the year 2100, using a high greenhouse gas emissions scenario (A2) and a lower emissions scenario (B1). Source is the National Climate Assessment found at <http://nca2014.globalchange.gov/>.

Monthly Comic Relief

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The Monitor is an experimental climate outreach and engagement product of the Southern Regional Climate Center and Southern Climate Impacts Planning Program. To provide feedback or suggestions to improve the content provided in the Monitor, please contact us at monitor@southernclimate.org. We look forward to hearing from you and tailoring the Monitor to better serve you. You can also find us online at www.srcc.lsu.edu and www.southernclimate.org.

For any questions pertaining to historical climate data across the states of Oklahoma, Texas, Arkansas, Louisiana, Mississippi, or Tennessee, please contact the Southern Regional Climate Center at 225-578-502. For questions or inquiries regarding research, experimental tool development, and engagement activities at the Southern Climate Impacts Planning Program, please contact us at 405-325-7809 or 225-578-8374.

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