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IN THIS ISSUE:

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COMPARISON OF REGIONAL CLIMATE MODEL OUTPUT AND OKLAHOMA OBSERVATIONS: A PILOT STUDY

Charlotte Lunday, University of Oklahoma

1. Introduction

Climate change is expected to impact water resource management in the future (Karl et al. 2009), but stakeholders and decision makers are currently unable to incorporate climate information into long-term planning. On May 10, 2011, the Southern Climate Impacts Planning Program and the Oklahoma Climatological Survey co-hosted a meeting of climate-aware stakeholders, including federal, state, tribal, and municipal decision makers in Oklahoma. Many of these stakeholders expressed concerns that long-term climate predictions are not local enough and do not effectively communicate the importance of observed and predicted trends to their specific needs (Riley et al. 2012). Although fully addressing those concerns requires a much broader scope, this study was motivated by these stakeholder concerns.

This pilot study compared regional climate model (RCM) precipitation simulations from the North American Regional Climate Change Assessment Program (NARCCAP; Mearns et al. 2012) with precipitation observations from the Oklahoma Mesonet, a county-level meteorological monitoring network with 120 stations that has been operating since 1994 (McPherson et al. 2007). NARCCAP's mission is to evaluate RCMs over the North American continent. RCMs are run with boundary conditions supplied by global climate models (GCMs), but make simulations by calculating physical relationships experienced in the region. Whereas GCMs simulate climate for the entire globe for grid areas of 200-km by 200-km (Bader et al. 2008), the RCMs allow simulations to be made on the continental-level for 50-km by 50-km grid spaces. Simulations are, therefore, higher resolution for RCMs in comparison to GCMs and more location specific.

2. Methods

For this pilot study, two NARCCAP RCMs were run by a GCM and an atmospheric reanalysis. Reanalyses are simulations of the "best guess" of the past atmosphere, and they are often used to test model runs against each other. In total, there were four model pairings, and the output of each was compared with Oklahoma Mesonet observations. The RCMs used are the Weather Research and Forecasting (WRF; Skamarock et al. 2005) model and the fifth generation Mesoscale Model (MM5; Grell et al. 1995); the GCM used is the Community Climate System model version 3 (CCSM; Collins et al. 2005); and the reanalysis used is the National Center for Environmental Prediction – Department of Energy (NCEP; Kanamitsu et al. 2002) Reanalysis II. (Model pairings are as follows: WRF-CCSM, MM5-CCSM, WRF-NCEP, and MM5-NCEP.) Overlapping model simulations and Mesonet observations were for the years 1995-2000 for the WRF-NCEP and MM5-NCEP, and the years 1995-1999 for the WRF-CCSM and MM5-CCSM, and observations were taken from 107 of the 120 Mesonet sites.

3. Results

NARCCAP RCMs usually simulated much less precipitation for Oklahoma than the Mesonet recorded. This is especially true for warm season months, such as late spring, summer, and early fall. Most of the precipitation Oklahoma receives comes from convective thunderstorms. At this time, climate models do not simulate this precipitation feature well. Figure 1 shows statistical bias monthly averages for an example warm season month, July, over all of the study years for each of the model pairings. The statistical bias is the difference between the model simulations and the Mesonet observations. The darker red colors signify strong dry biases, whereas the dark blue show strong wet biases. For July, and many other warm season months, strong dry biases exist in north, central Oklahoma and swing down towards the southeast. This verifies the original statement that NARCCAP RCMs tend to simulate less precipitation than actually observed. This pattern also suggests that the models do not resolve mesoscale convective systems, which frequent Oklahoma in warmer months, well.

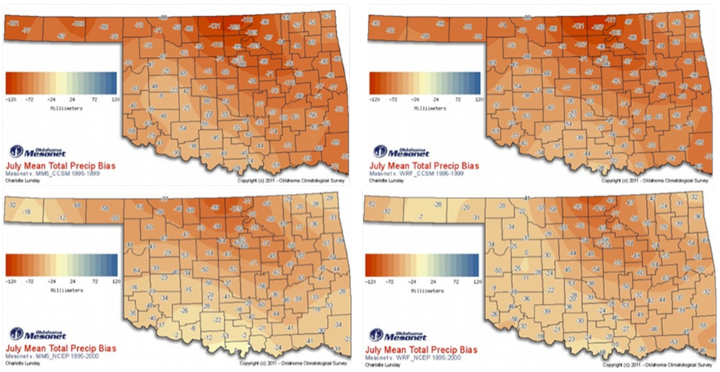

Figure 1: Example plots of model bias for July average total precipitation (in millimeters) for the years of 1995-1999 (for MM5-CCSM and WRF-CCSM) and 1005-2000 (for MM5-NCEP and WRF-NCEP).

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On the other hand, the RCMs portray slight wet biases in winter months (and a few of the surrounding months for a couple of the climate models), as Figure 2 illustrates. Figure 2 takes January as an example month. Many of the models have wet biases towards the west and drier biases towards the southeast. Examination of model output for the continent show similar dry biases in the southeast surrounding the Gulf Coast (Mearns et al. 2012). More research should be done to explain the causes of the dry biases in the coastal region, but one explanation is that the Gulf Coast area and parts of Oklahoma are so near the bounded spatial area of the models that the models cannot simulate all of the precipitation they otherwise might.

4. Discussion

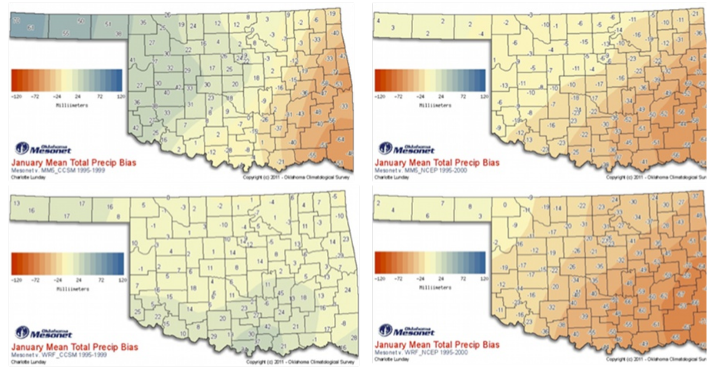

Figure 2: Statistical bias of each model for average January total precipitation (in millimeters) for the years of 1995-1999 (for MM5-CCSM and WRF-CCSM) and 1005-2000 (for MM5-NCEP and WRF-NCEP).

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The results of this research show that the NARCCAP models use spatial scales that are still too large to simulate convective precipitation, and more work should be done to understand how parameterizations of mesoscale convective systems may be created and incorporated into the models. Nevertheless, the models tend to exhibit smaller biases in winter months, and the west-to-east precipitation gradient often experienced in Oklahoma is somewhat well simulated.

Outside of Oklahoma, states do not have statewide, county-level monitoring networks, but similar studies may still be conducted. Studies such as this are especially important for the Gulf Coast region to explain large biases in the model portrayals. Evaluations of model data can lead to better understanding of how models function over intra-continental regions and to better interpretations of climate projections on more local levels.

This article presents student research. Any questions may be sent to clunday@mesonet.org. Another University of Oklahoma student, Emma Fagan, studied temperature data, so any interest or questions regarding temperature simulations will be forwarded to Ms. Fagan.

5. References

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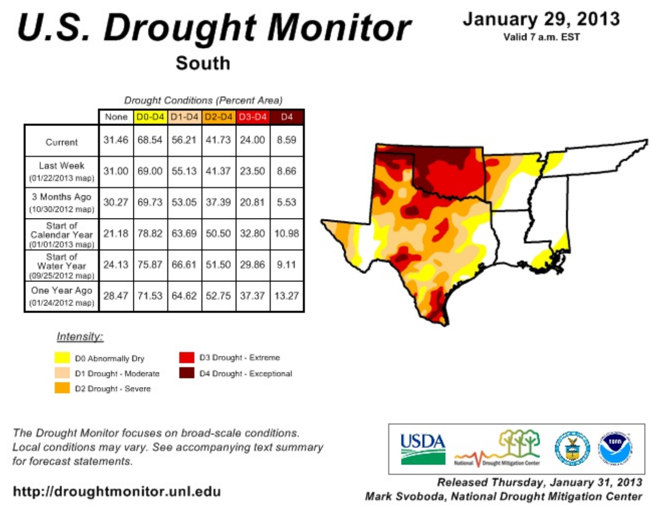
DROUGHT CONDITIONS

Luigi Romolo, Southern Regional Climate Center

Despite high precipitation totals, drought conditions did not change too much over the past month. This is due in part to the fact that much of the heavy rainfall occurred in areas that were not experiencing drought, such as in Louisiana, Tennessee and Mississippi for example. High precipitation totals in Arkansas did result in about a one category improvement, but much of the northwest portions of the state remain in moderate to extreme drought. In central Texas, above normal precipitation did result in some improvement, but a little over half the state is still experiencing severe drought conditions or worse.

For Texas, many AgriLife Extension agents expect that the January rainfall, while not ensuring a successful harvest, did prevent winter wheat from being lost entirely, with some believing it saved over a million dollars. Cotton farmers are less fortunate, with initial yield estimates dropping by 500,000 due to the persistently dry conditions across most of the state. While snow cover in the western parts of the state have farmers cautiously optimistic, the long-term conditions are so poor that it’s not believed that the melt water will be enough to replenish soil moisture. With soil moisture conditions so poor, ranchers are still having trouble keeping their herds fed, causing the Cargill Meatpacking Plant in Plainview to lay off 2000 workers. Longer-term ecological damage has also been seen in recent months, culminating in the Wildlife Department falling short $4.6 million last year (Information provided by the Texas Office of State Climatology).



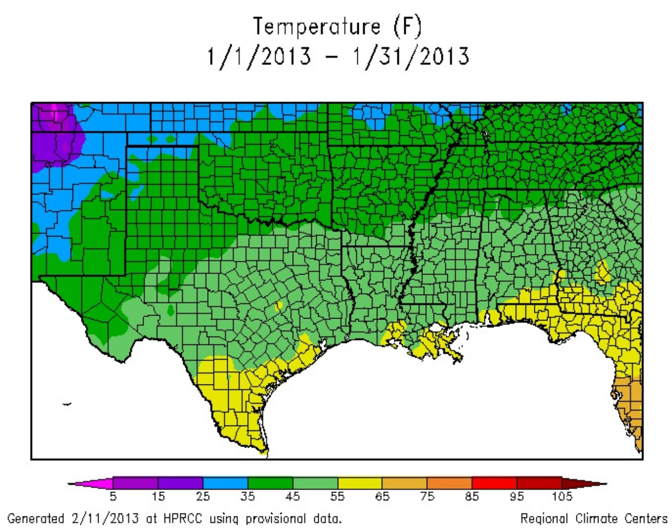
Above: Drought conditions in the Southern Region. Map is valid for December 2012. Image courtesy of the National Drought Mitigation Center.

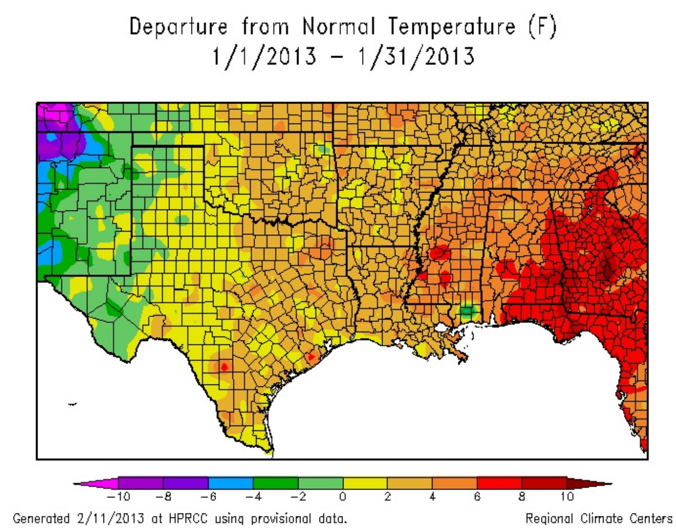
Despite high precipitation totals in Texas, many regions are still suffering from low water supply, notably west Texas. The Lower Colorado River Authority enacted emergency conservation plans in January, and various levels of government are attempting to tackle the problem. Potential solutions include implementation of a 100-year plan in Lubbock estimated to cost anywhere between $4.1 and $10 billion, and a $2 billion appropriation plan introduced in the state legislature (Information provided by the Texas Office of State Climatology).

TEMPERATURE SUMMARY

Luigi Romolo, Southern Regional Climate Center

January proved to be another consecutive warm month for the Southern Region. Temperatures throughout the region averaged between 0 to 6 degrees F (0 to 3.33 degrees C) above normal, with temperature anomalies increasing from west to east. The only exception to this was in the western panhandle of Texas and along the Texas western border, where temperatures averaged slightly below normal. The warmest anomalies were observed in Mississippi and southern Tennessee. All state temperature rankings were on the warm side of normal, but all fell within the middle two quartiles. The state-wide average temperatures were as follows: 41.70 degrees F (5.39 degrees C) in Arkansas, 52.20 degrees F (11.22 degrees C) in Louisiana, 48.50 degrees (9.17 degrees C) in Mississippi, 39.70 degrees F (4.28 degrees C) in Oklahoma, 41.00 degrees F (5.00 degrees C) in Tennessee, and 47.70 degrees F (8.72 degrees C) in Texas.



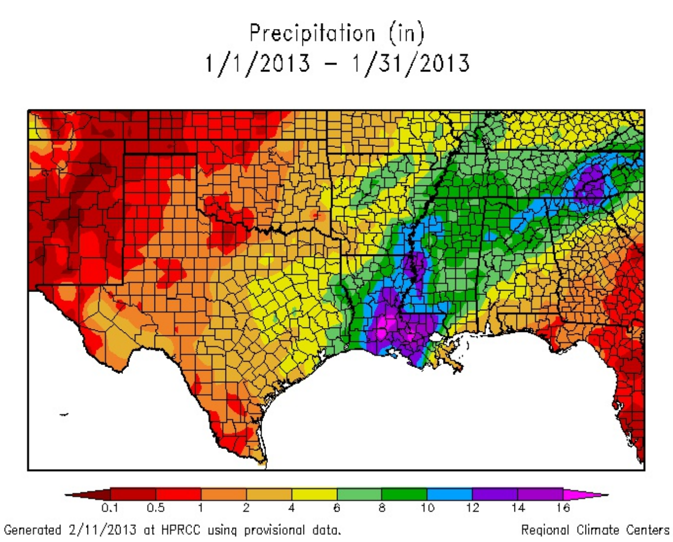


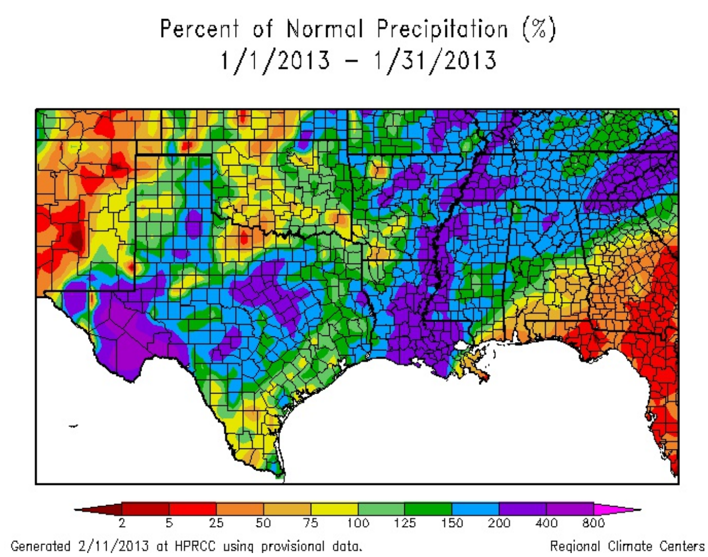
Average temperatures (left) and departures from 1971-2000 normal average temperatures (right) for November 2012, across the South.

PRECIPITATION SUMMARY

Luigi Romolo, Southern Regional Climate Center

January was a very wet month for most of the Southern Region. A majority of stations throughout the region reported precipitation totals that were well above the monthly normal. There were some areas in the region that received less than normal precipitation. This includes much of central and western Oklahoma, southern Texas, and a small pocket in north central Texas. Elsewhere, most stations reported over 150 percent of normal precipitation. The highest anomalies were observed in the western panhandle of Texas, where stations reported over three times the monthly normal. Because this is a fairly dry region, precipitation totals ranged only from 2 to 4 inches (50.80 to 101.60 mm). The highest precipitation totals for the country occurred in southern Louisiana and along the Louisiana-Mississippi border. Many stations in this area reported monthly totals of over 10 inches (254 mm), with some stations reporting over 20 inches (508 mm). The state of Louisiana averaged 11.20 inches (284.5 mm) of precipitation, which makes it the second wettest January there on record (1895-2013). Mississippi experienced their ninth wettest January on record, with a statewide precipitation total of 9.29 inches (236.00 mm). Conditions were also quite wet in Tennessee, where a statewide precipitation total of 8.81 inches (223.80 mm) was reported, or the eighth wettest January on record (1895-2013). For Arkansas, it was their eighteenth wettest January on record (1895-2013), with a statewide precipitation total of 6.15 inches (156.20 mm). The state of Texas averaged 2.64 inches (67.06 mm) of precipitation, while Oklahoma averaged 1.85 inches (46.99 mm) of precipitation. For Texas, it was the sixteenth wettest January on record (1895-2013), while for Oklahoma it was their thirty-eighth wettest.





Total precipitation values (left) and The percent of 1971-2000 normal precipitation totals (right) for December 2012.

THE BIGGEST BADDEST GULF COAST SNOW EVENT - FEB 1985

Barry Keim, Louisiana State Climatologist, Louisiana State University

As winter winds down, and snow pummels the Midwest, I thought I would write about the biggest baddest snowstorm to ever hit, Texas, Louisiana, Mississippi, and really, the entire Gulf Coast. On February 14-15, 1895, there was the perfect set up of conditions for snow in the Southeast, with a storm forming in the Gulf of Mexico, while very cold air moved southward from Canada toward the Sun Belt. The clash of these two systems along the Gulf Coast united Gulf of Mexico moisture with frigid air from the north to produce snow….and plenty of it, in this instance. Snow totals were impressive, including 4 inches in Corpus Christi, 15.4 inches in Galveston, 20 inches in Houston, 22 inches in Lake Charles, 24 inches in Rayne, LA (still the State Record), 12.5 inches in Baton Rouge, 8.2 inches in New Orleans, 16 inches in Shell Beach, 6.2 inches in Biloxi, 6 inches in Mobile, AL, and Tallahassee, FL even had 2 inches. At many of these locations, this is the record snow event. Furthermore, the total at Rayne – 24 inches – is the Louisiana State record, which has stood for over a century as THE snowstorm for Louisiana. What this storm demonstrates is that when all the ingredients come to together, we can have impressive snow events this far south. For better or worse, however, it doesn't happen often, and we may never see such an event in our lifetimes. BUT, you never know! There is a great summary of this storm, complete with a picture of Canal Street draped in snow at the following website; http://earlychurchfathers.org/fullcircle/index.php?entry=entry091211-213857. If you have any questions, feel free to contact me at keim@lsu.edu.

To the Left: Snow across the United States for February 1895. Note that the snow totals along the Gulf Coast were the result of the February 14-15, 1895 event. Source is the Monthly Weather Review, Volume 23, Issue 2, February 1895

Climate Perspective

State	Temperature	Rank	Precipitation	Rank
Arkansas	41.7	39th Warmest	6.15	18th Wettest
Louisiana	52.2	36th Warmest	11.20	2nd Wettest
Mississippi	48.5	31st Warmest	9.29	9th Wettest
Oklahoma	39.7	30th Warmest	1.85	38th Wettest
Tennessee	41.0	30th Warmest	8.81	8th Wettest
Texas	47.7	43rd Warmest	2.64	16th Wettest

State temperature and precipitation values and rankings for January 2013. 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 Name	Temperatures (degrees F)								Precipitation (inches)		
	Averages				Extremes				Totals		
	Max	Min	Mean	Depart	High	Date	Low	Date	Obs	Depart	%Norm
El Dorado, AR	55.7	37.0	46.3	2.8	75.0	1/28	26.0	1/18	3.66	-1.27	74
Little Rock, AR	53.6	33.7	43.7	3.6	76.0	1/28	24.0	1/15+	4.81	1.20	133
Baton Rouge, LA	63.9	44.9	54.4	4.3	81.0	1/29	33.0	1/19+	14.67	8.48	237
New Orleans, LA	64.6	49.0	56.8	2.8	78.0	1/29+	37.0	1/18	5.25	-0.27	95
Shreveport, LA	59.1	39.6	49.4	3.0	79.0	1/28	28.0	1/7+	4.76	0.16	103
Greenwood, MS	57.3	38.5	47.9	4.0	79.0	1/29	24.0	1/4	8.64	3.39	165
Jackson, MS	59.9	40.6	50.3	5.3	78.0	1/29+	28.0	1/18	8.58	2.91	151
Tupelo, MS	55.2	36.7	46.0	5.6	76.0	1/29+	23.0	1/22	8.71	3.57	169
Oklahoma City, OK	53.0	30.0	41.5	4.8	74.0	1/28	15.0	1/16	1.14	-0.14	89
Ponca City, OK	51.6	25.9	38.7	4.9	77.0	1/28	12.0	1/16+	2.35	1.17	199
Tulsa, OK	52.2	28.7	40.5	4.1	75.0	1/28	15.0	1/16	1.54	-0.06	96
Knoxville, TN	51.1	34.2	42.7	5.0	75.0	1/12	21.0	1/22	12.67	8.10	277
Memphis, TN	53.9	36.0	44.9	5.0	76.0	1/29	26.0	1/22+	9.72	5.48	229
Nashville, TN	50.8	33.2	42.0	5.2	73.0	1/30	18.0	1/22	7.14	3.17	180
Amarillo, TX	52.0	25.3	38.6	2.8	73.0	1/28+	11.0	1/13	0.76	0.13	121
El Paso, TX	54.4	30.7	42.5	-2.5	71.0	1/24	18.0	1/16+	0.30	-0.15	67
Dallas, TX	59.1	39.1	49.1	5.0	80.0	1/29	26.0	1/16	4.06	2.16	214
Houston, TX	65.2	45.8	55.5	3.7	81.0	1/28	29.0	1/17	3.21	-0.47	87
San Antonio, TX	64.7	43.1	53.9	3.6	86.0	1/29	29.0	1/16	2.83	1.17	170

Summary of temperature and precipitation information from around the region for January 2013. 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. Blue-shaded boxes represent cooler than normal temperatures; red-shaded boxes denote warmer than normal temperatures; tan shades represent drier than normal conditions; and green shades denote wetter than normal conditions.

Disclaimer: This is an experimental climate outreach and engagement product. While we make every attempt to verify this information, we do not warrant the accuracy of any of these materials. The user assumes the entire risk related to the use of these data. This publication was prepared by SRCC/SCIPP with support in part from the U.S. Department of Commerce/NOAA. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA

SOUTHERN CLIMATE MONITOR TEAM:

Luigi Romolo, Regional Climatologist
Southern Regional Climate Center (LSU)

Charlotte Lunday, Student Assistant
Southern Climate Impacts Planning Program (OU)

Lynne Carter, Program Manager
Southern Climate Impacts Planning Program (LSU)

Margret Boone, Program Manager
Southern Climate Impacts Planning Program (OU)

Rachel Riley, Associate Program Manager
Southern Climate Impacts Planning Program (OU)

Hal Needham, Research Associate
Southern Climate Impacts Planning Program (LSU)

Barry Keim, State Climatologist for Louisiana
Co-PI, Southern Climate Impacts Planning Program (LSU)

Mark Shafer, Principal Investigator
Southern Climate Impacts Planning Program (OU)

Gary McManus, Associate State Climatologist for Oklahoma
Southern Climate Impacts Planning Program (OU)

Kevin Robbins, Director
Southern Regional Climate Center (LSU)

CONTACT US

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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.