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Photo by Katy Strnad

Southern Climate Impacts Planning Program

A NOAA RISA Team

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Tornado Safety in Schools: Risk and Preparedness

Harold Brooks, National Severe Storms Laboratory

The tornadoes that struck the Oklahoma City metropolitan area in May 2013 illustrated a number of issues associated with how society prepares for and responds to disasters. One of the most noteworthy was the tragedy at Plaza Towers Elementary School in Moore (Fig 1), where 7 students lost their lives. Two other schools in the Moore Public Schools district, Briarwood Elementary and Highland East Junior High were seriously damaged or destroyed. Safety plans and decisions made at critical moments by staff at the schools likely saved many more lives.

In the aftermath of Plaza Towers, an examination of school safety in tornadoes has begun in earnest in the state of Oklahoma and much of the rest of the country. None of the schools that were damaged had specially-built safe areas in the schools. It is important to note that, in the aftermath of the May 3, 1999 Oklahoma City area tornado, the Moore Public Schools built safe areas when reconstructed. Safe areas in these previously damaged schools were used in the May 20, 2013 tornado, although the schools were not hit.

Legislation has been introduced in the Oklahoma Legislature to fund shelters in schools to the amount of $500 million dollars. The proposals bring up a number of issues for public policy and planning. As a sidelight, some have suggested that dismissing schools would be an option. It is important to note that there were more deaths in the housing area immediately surrounding Plaza Towers than at the school, including two younger siblings of students who survived at Plaza Towers.

Assuming that schools will not be dismissed for possibly tornadic weather, we're still faced with many questions. First, would shelters be limited to just the students and staff of the schools? Would publicly-funded shelters be open at times other than schools being opened? Who would be responsible for accidents that happened at the school during sheltering? What if more people arrive than can be housed in the shelter?

In order provide background for these large policy questions and to perhaps provide guidance for developing best practices, it's useful to look at the historical record of tornadoes and their impacts. For the southern US, using data from the National Weather Service's Storm Prediction Center, we see that the fraction of tornadoes that strike during the day ranges from less than 10% to a little over 25% (Table 1).

Fig. 1: Before and after images of Plaza Towers Elementary School and surrounding neighborhood, from Google Earth images.

State	Percentage
Arkansas	17.3
Louisiana	27.1
Mississippi	24.2
Oklahoma	8.8
Tennessee	21.5
Texas	18.0

Table 1: Percentage of total tornadoes that touch down during the school day by state (1950-2012) (Raw data from www.spc.noaa.gov/wcm#data).

Louisiana has the highest fraction of tornadoes that strike during the school day of any state in the country at 27% and the national average was a little over 14%. In order for funded shelters to the public or to a reduced school population (those students and staff engaged in extracurricular activities or class preparation) to be maximized, a majority of tornados outside of school hours needs to be considered. Perhaps more importantly, it is useful to step back and evaluate the threat to life from tornadoes at schools.

The Plaza Towers deaths marked the second time a tornado had killed people during the school day at a public school in Oklahoma in state history, with the previous event in 1930. (There were two other killer events in the evening, with 3 killed at a dormitory in the state School for the Blind and another killed at a basketball practice, and a third tornado killed students at a remote Indian mission school in 1917.)

Nationally, since 23 people were killed in two tornadoes in northwestern Mississippi in 1955, a total of 39 people have died in tornadoes at school, including Plaza Towers, for a rate well below 1 death per year nationally (Fig. 2). To put that number into perspective, we can consider two common activities that put students at risk. The National Center for Catastrophic Sport Injury Research puts out an annual report on fatalities associated with football for the American Football Coaches Association with numbers for every level of football for each year going back to 1966. In the last 47 years, 664 high school football players have died as a result of direct or indirect effects from football (14.1/year). Last year, the National Highway Transportation Safety Administration released data on fatalities associated with school transportation (busses or vehicles used as bus). From 2001-2010, 166 children from 5-18 years of age were killed in accidents involving school transportation, either as passengers in school busses or as pedestrians hit by busses (16.6/year). Although deaths in tornadoes at schools are tragic, they are also rare and fatality rates are more than an order of magnitude lower than for other common activities (Table 2).

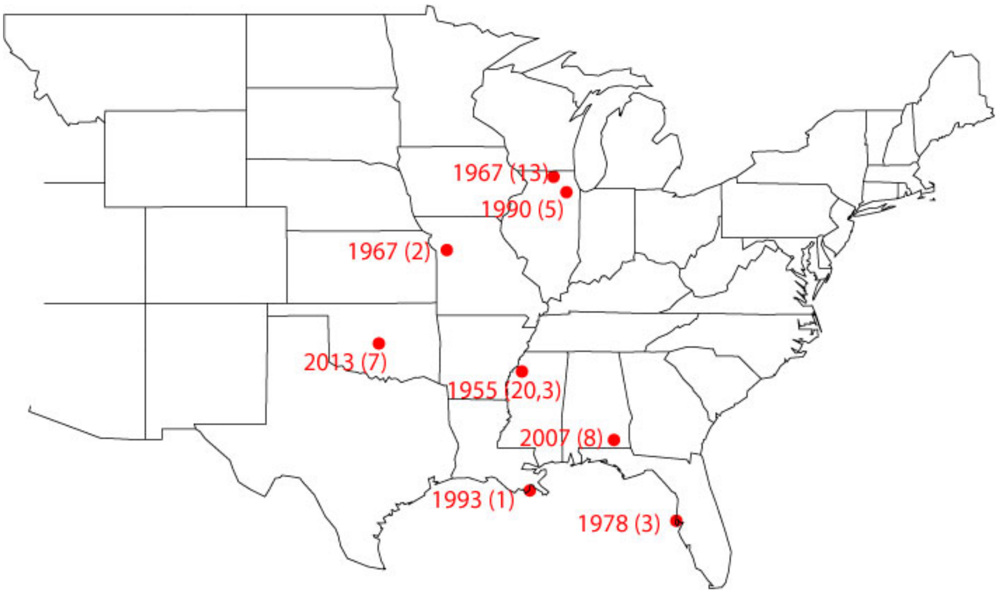


Fig. 2: Map showing locations of killer tornadoes affecting schools since 1950 with year of occurrence and number of deaths in parentheses.

Hazard	Direct	Direct+Indirect
Tornado (1966-2013)	0.8	0.8
High School Football (1966-2012)	7	14.1
School Transportation (2001-2010)	5.5	16.6

Table 2: Deaths per year from various hazards at schools. Tornado deaths include 33 students and 6 staff. For football, direct deaths are from injuries suffered in practice or games with indirect deaths including things such as heat stroke and cardiac arrest. School transportation only includes 5-18 year olds, with direct deaths occurring in the bus and indirect deaths being pedestrians struck by busses or vehicles used as busses. Non-tornadic data from http://www-nrd.nhtsa.dot.gov/Pubs/811618.pdf and http://www.unc.edu/depts/nccsi/2012FBInj.pdf.

What's the best course to take, then, to protect students and staff from tornadoes? In the long run, better construction practices and, in particular, safe rooms at schools, are excellent ideas. In new construction, the added cost of safe rooms is relatively low compared to overall construction costs. The expense of retrofitting is likely to be prohibitive in many cases. As a result, the space that currently exists at schools needs to be used well. In Norman, where I live, an effort has started to review and prepare plans for tornado safety at all schools in the area. I had the privilege of going with Rick Smith, the Warning Coordination Meteorologist for the local National Weather Service Forecast Office, to look at the first school as part of this effort. (In the interest of full disclosure, my wife teaches there and Rick has a son there.) We educated the principal on the fundamentals of storm safety (get as low as you can in interior, preferably small, rooms, away from windows and unsupported outside cinder block walls, using specially-built rooms, such as locker rooms). It was important that she, and her staff, understand these fundamentals because situations will always come up where a large number of students might not be in classroom areas or something is going on or, in the future, remodeling might take place that would alter the structure. We recommended that a "weather-aware" staff person be identified who would pay enough attention to the weather. This staff member would identify days where there is a potential weather threat. Tools from the Storm Prediction Center (historical occurrence maps, forecasts out to 8 days in advance) could help that person give a heads-up to the rest of the staff. Monitoring local National Weather Service Office forecasts and the use of NOAA Weather Radio provide crucial updates with high spatial resolution information to narrow threats. Our goal is to develop a checklist of things for all of the schools to consider when developing their plans and to empower their staff to use the best possible information to make life-saving decisions to protect themselves and their students.

More to Learn

-http://www.srh.noaa.gov/media/hun/tornadosafety_schools.pdf

-http://www.spc.noaa.gov/faq/tornado/school.html

Drought Update

Luigi Romolo
Southern Regional Climate Center

Drought conditions changed significantly over the month of August. Much of western and northern Louisiana is now experiencing severe drought. This is also the case for southern Arkansas, and west central Mississippi, which also saw little in the way of precipitation. In Texas, the central counties of the state saw a one category deterioration, while the northwestern corner of the state experienced some improvements. Despite this, much of that portion of Texas is still under the severe grip of drought.

In Texas, August started and ended with high temperatures pushing triple digits; warranting several days of high heat warnings across the state.

Drought Conditions (Percent Area)

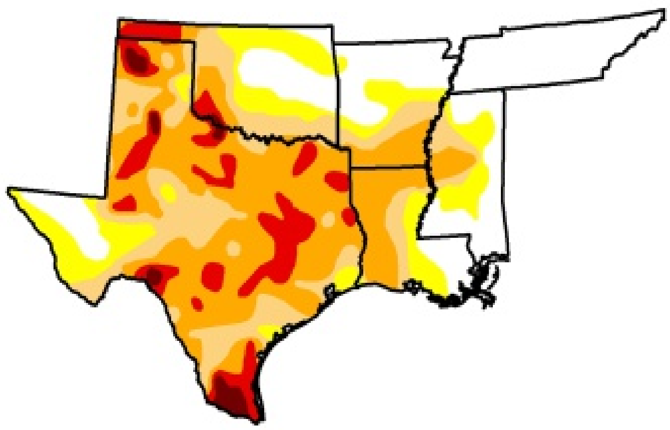
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	25.37	74.63	60.57	42.02	10.78	1.55
Last Week (08/27/2013 map)	26.96	73.04	59.57	42.02	11.08	1.45
3 Months Ago (06/04/2013 map)	41.93	58.07	51.68	35.56	20.24	9.83
Start of Calendar Year (01/01/2013 map)	21.18	78.82	63.69	50.50	32.80	10.98
Start of Water Year (09/25/2012 map)	24.13	75.87	66.61	51.50	29.86	9.11
One Year Ago (08/28/2012 map)	20.94	79.06	66.22	46.19	28.33	11.29

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**

Drought conditions throughout the month have been particularly taxing to Texas farmers. Cotton yields are expected to be only half of that planted due to dry conditions, while rice farmers along the coast will not see a second crop at all because of low water on the Brazos River. The middle of the month, however, did see some rainfall and cooler temperatures, but not without problems of their own. Storms dropped several inches of rain and hail in the Panhandle, ruining late season crops and possibly prompting disaster declaration, and caused over 100,000 customers in Houston to go without power on August 16, 2013. The high heat has compounded the already problematic hydrological drought with new short-term deficits, leading to high fire risks and poor crop moisture profiles, particularly in the eastern and southern parts of Texas. Burn bans are present in 190 counties and most cities are seeing some sort of water restriction in place

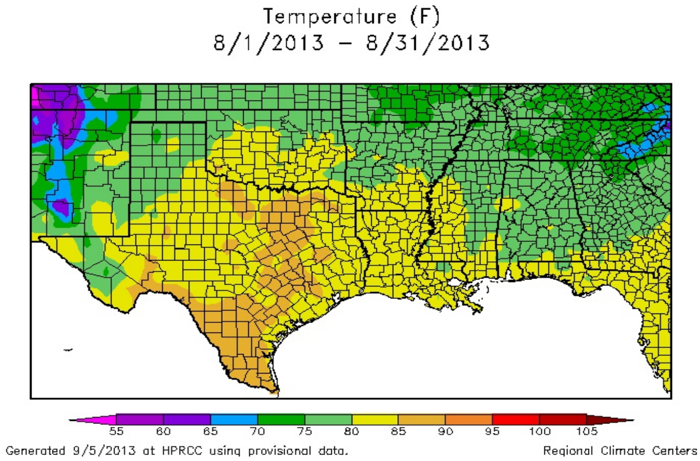


Released Thursday, September 5, 2013
National Drought Mitigation Center

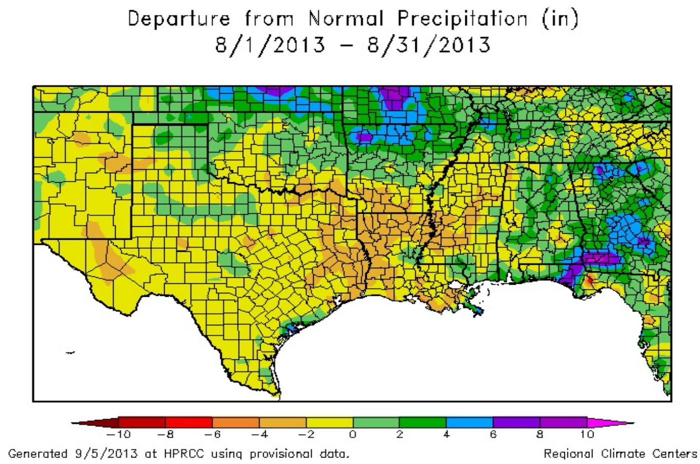
Above: Drought Conditions in the Southern Region. Map is valid for September 3, 2013. Image is courtesy of National Drought Mitigation Center.

Temperature Summary

Luigi Romolo
Southern Regional Climate Center



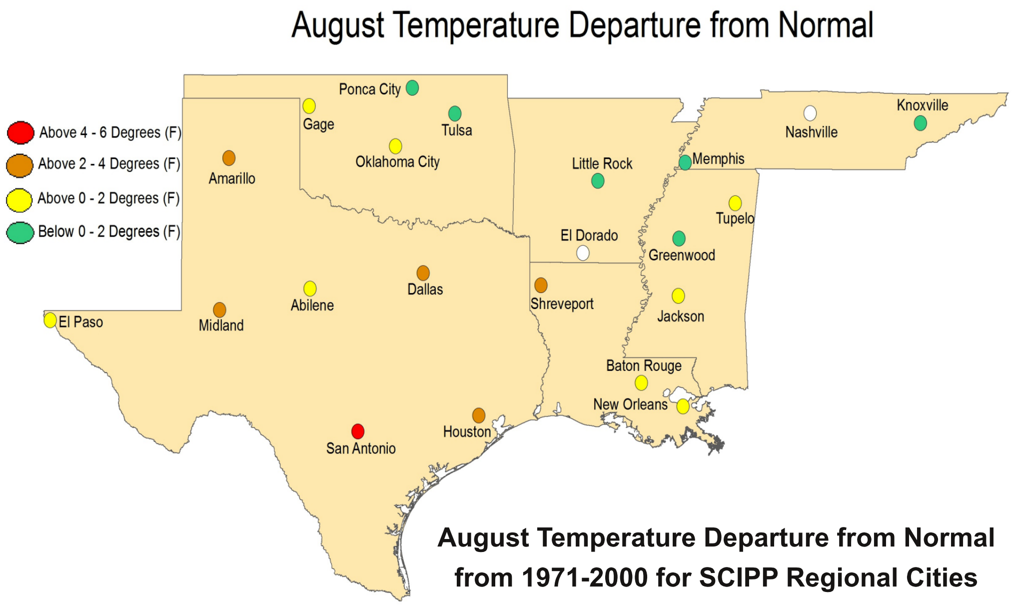
Average August 2013 Temperature across the South.



Average Temperature Departures from 1971-2000 for August 2013 across the South.

With the exception of Texas, August was slightly cooler than normal month across the Southern Region. In Texas, temperatures averaged between 1-4 degrees F (0.55-2.22 degrees C) above normal for the month. Texas reported a state-wide average temperature of 83.30 degrees F (28.50 degrees C), which was their twenty-fifth warmest August on record (1895-2013). Elsewhere in the region, temperatures generally averaged between 1-2 degrees F (0.56-1.11 degrees C) below normal, and in the case of northern Arkansas and central Tennessee, between 2-4 degrees F (1.11-2.22 degrees C) below normal. The other state-wide average temperatures for the month are as follows: Arkansas averaged 78.40 degrees F (25.78 degrees C), Louisiana averaged 81.60 degrees F (27.56 degrees C), Mississippi averaged 79.50 degrees F (26.39 degrees C), Oklahoma averaged 80.30 degrees F (26.83 degrees C), and Tennessee averaged 74.80 degrees F (23.78 degrees C).

Tennessee experienced its twenty-second coldest August on record (1895-2013), while Mississippi experienced its twenty-eighth coldest August on record (1895-2013). All other state temperature rankings fell within the middle two quartiles.

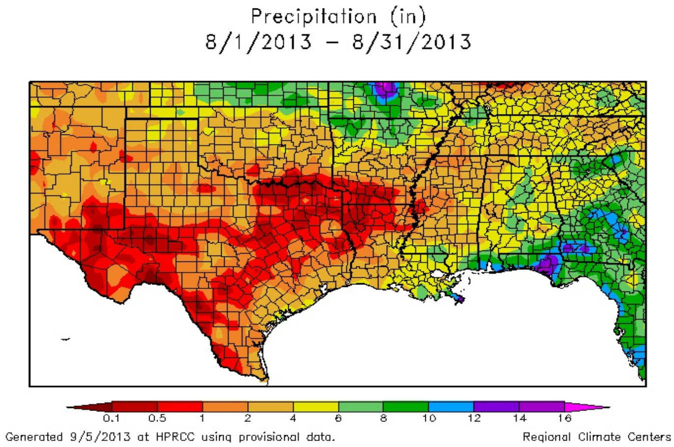


August Temperature Departure from Normal from 1971-2000 for SCIPP Regional Cities

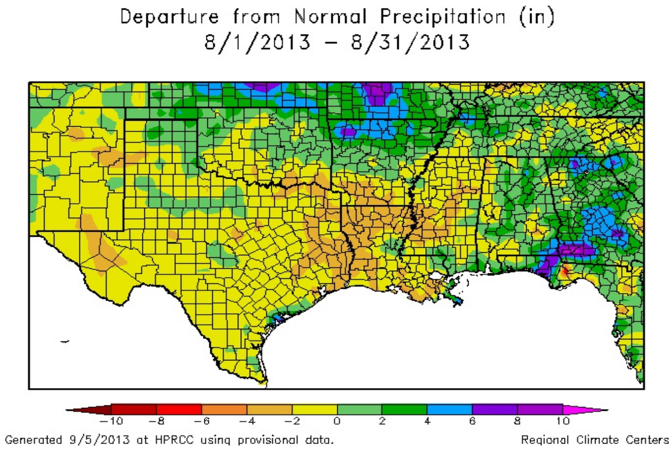
Precipitation Summary

Luigi Romolo
Southern Regional Climate Center

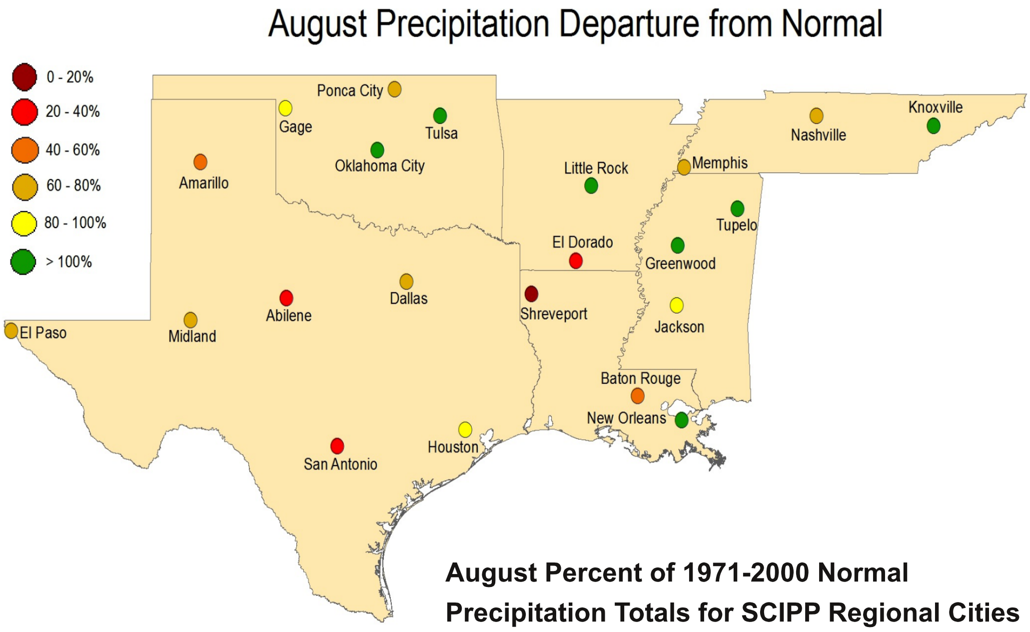
Precipitation totals in the month of August varied significantly over the Southern Region. Central portions of the region received, on average, less than half the expected precipitation. This was also the case for the western and west central counties of Texas. In Arkansas, southern counties experienced an extremely dry month, with many stations reporting less than twenty-five percent of normal rainfall. In contrast, the northern counties in Arkansas experienced a much wetter than normal month, with many stations reporting between one and a half to two times of normal. The state-wide average precipitation totals for the month are as follows: Arkansas recorded 3.95 inches (100.33 mm), Louisiana recorded 3.05 inches (77.47 mm), Mississippi recorded 3.28 inches (83.31 mm), Oklahoma recorded 2.95 inches (74.93 mm), Tennessee recorded 4.01 inches (101.85 mm), and Texas recorded 1.42 inches (36.07 mm). For Louisiana, it was their seventeenth driest August on record (1895-2013), while for Texas, it was their twenty-eighth driest August on record (1895-2013). All other state rankings for the month fell within the two middle quartiles.



August 2013 Total Precipitation across the South.



Percent of 1971-2000 normal precipitation totals for August 2013 across the South.



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

Climate Perspective

State	Temperature	Rank (1895-2011)	Precipitation	Rank (1895-2011)
Arkansas	78.40	35th Coldest	3.95	34th Wettest
Louisiana	81.60	58th Coldest	3.05	17th Driest
Mississippi	79.50	28th Coldest	3.28	42nd Driest
Oklahoma	80.30	52nd Coldest	2.95	53rd Wettest
Tennessee	74.80	22nd Coldest	4.01	45th Wettest
Texas	83.30	25th Warmest	1.42	28th Driest

State temperature and precipitation values and rankings for August 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 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	93.2	69.3	81.2	0.0	98	08/30/	57	08/16	1.02	-2.20	32
Little Rock, AR	91.0	71.4	81.2	-0.1	99	08/31/	60	08/16	3.56	0.63	121
Baton Rouge, LA	90.9	72.7	81.8	0.4	96	8/10+	66	8/29+	3.36	-2.50	57
New Orleans, LA	90.0	75.4	82.7	0.2	97	08/07/	69	08/28	7.22	1.07	117
Shreveport, LA	97.0	73.0	85.0	2.1	102	8/31+	64	8/17+	0.18	-2.53	7
Greenwood, MS	91.9	69.1	80.5	-0.9	97	08/07/	58	08/16	2.53	0.09	104
Jackson, MS	92.0	71.2	81.6	0.7	99	8/8+	62	8/28+	2.96	-0.70	81
Tupelo, MS	89.8	70.0	79.9	0.3	97	08/30/	59	08/15	3.87	1.20	145
Gage, OK	91.7	67.1	79.4	0.2	104	08/06/	60	08/22	2.15	-0.33	87
Oklahoma City, OK	92.3	70.7	81.5	0.3	103	08/31/	64	8/17+	3.50	1.02	141
Ponca City, OK	89.7	70.2	79.9	-2.0	102	08/31/	60	08/18	2.49	-0.87	74
Tulsa, OK	90.6	70.9	80.8	-1.4	102	08/31/	62	8/18+	2.88	0.03	101
Knoxville, TN	85.2	67.5	76.4	-0.5	90	8/31+	61	08/15	3.20	0.31	111
Memphis, TN	89.6	72.5	81.1	-0.1	97	8/31+	60	08/15	2.18	-0.82	73
Nashville, TN	86.9	68.9	77.9	0.0	96	08/30/	58	08/15	2.00	-1.28	61
Abilene, TX	96.2	72.5	84.3	1.7	104	08/07/	64	08/16	0.54	-2.09	20
Amarillo, TX	92.4	66.0	79.2	2.9	104	08/06/	57	08/10	1.42	-1.52	48
El Paso, TX	93.7	72.2	82.9	1.8	100	8/17+	66	8/29+	1.12	-0.63	64
Dallas, TX	98.3	75.9	87.1	2.7	105	8/31+	64	08/17	1.32	-0.71	65
Houston, TX	95.2	75.4	85.3	2.0	101	08/13/	69	08/18	3.33	-0.50	87
Midland, TX	96.4	72.1	84.2	3.9	106	08/06/	67	08/29	1.18	-0.59	67
San Antonio, TX	100.7	76.5	88.6	4.4	105	08/06/	71	8/20+	0.85	-1.72	33

Summary of temperature and precipitation information from around the region for August 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. 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.

Why Do We Have Hurricanes?

Barry Keim, Louisiana State Climatologist, Louisiana State University

Have you ever wondered what is the purpose of a hurricanes? Well, the answer is to transfer heat from warm regions to cooler locations in an effort to disperse the energy. So, in this case, warmer sea surface temperatures tend to cause more (and more severe) hurricanes. A typical hurricane begins its evolution as a cluster of thunderstorms. These thunderstorms often have origins on the African continent, whereby they move along in the easterly trade winds into the Atlantic Ocean. Once over the ocean, these storms begin to feed off of the energy stored there through means of evaporation off of the Ocean surface, which is followed by cloud formation (condensation). The thunderstorms first create a little blip in the surface pressure pattern surrounding the storms – this is called an easterly (or tropical) wave. Once the storm system forms a closed circulation pattern – meaning that the winds are converging in on the central area of low pressure from all sides – we call the system a tropical depression. With further development, a tropical depression graduates into a tropical storm when the sustained wind speeds reach a minimum of 38 mph, which can then range up to 74 mph. Once 74 mph is attained, the storm will form an eye, and we call the storm a hurricane. Hurricanes are then measured on the Saffir-Simpson scale, ranging from Category 1 to Category 5 (See Figure 1). Category 1 hurricane winds range from 74-95 mph, while Category 5 hurricanes have winds greater than 157 mph. Fortunately, Category 5 storms are not all that common and we have had only 3 landfalls of Category 5 hurricanes since 1851 – The Labor Day Hurricane of 1935 in the Florida Keys, Hurricane Camille in 1969 in Mississippi, and Hurricane Andrew in 1992 in South Florida. If you have any questions, feel free to contact me at keim@lsu.edu.

Scale Number (Category)	Hurricanes Sustained Winds (MPH)	Types of Damage
1	74-95	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111-129	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	130-156	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	> 157	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Figure 1. Saffir-Simpson scale for hurricanes. Graphic from <http://www.nyc.gov/html/oem/html/hazards/storms_saffirsimpson.shtml>.

Monthly Comic Relief

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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.