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In This Issue:

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The Coral Reefs of the Flower Garden Banks: *Sentinels of Change in the Northwestern Gulf of Mexico*

William E. Kiene, Scientist for NOAA's Office of National Marine Sanctuaries' Southeast, Gulf of Mexico and Caribbean Region

On any given week from June to September, a dedicated team of NOAA scientists can be found 100 nautical miles (185 km) south of the Texas and Louisiana border, 65 feet (20 m) below the surface of the Gulf of Mexico. They are diving at one of the most remarkable underwater locations in the entire Caribbean. On the summit of two submerged topographic features that rise 500 feet (150 m) above the seafloor, the Gulf's ecosystem has constructed spectacular coral reefs that have defied the trend of coral reef decline seen elsewhere in the tropical world. This place is Flower Garden Banks National Marine Sanctuary and surprisingly, given its northern location and proximity to extensive offshore oil and gas production facilities, it exhibits some of the healthiest coral populations to be found anywhere. Not surprisingly though, the team of divers is there to understand *why* by monitoring conditions and looking for small-scale changes in the composition of the reef's biology. Together with a close eye on the physical conditions in the Gulf, this effort seeks to ensure these coral reefs, remain in their healthy state and serve as critical sentinels of climatic and human impacts in the Gulf of Mexico.

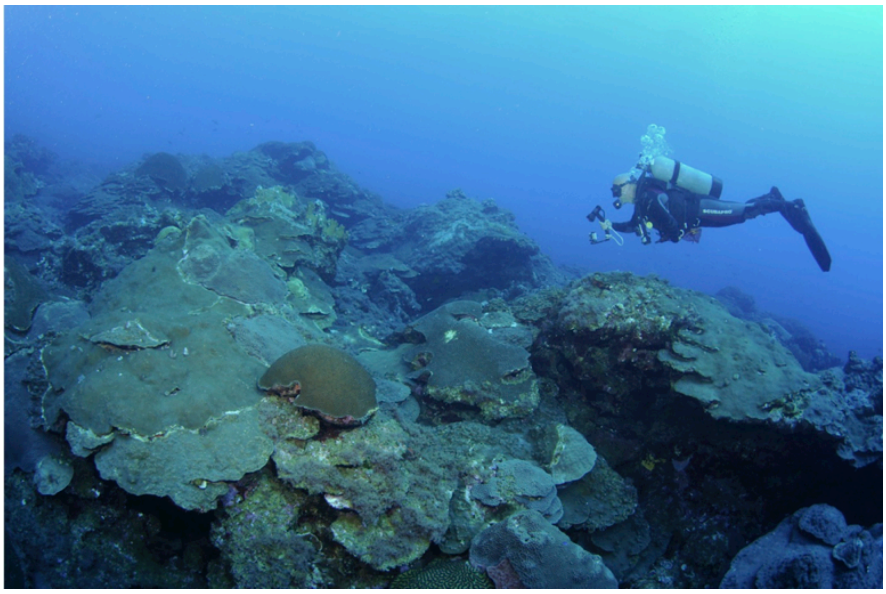

Image 1. The unusually healthy coral community at the Flower Garden Banks. Photo: G.P Schmahl, NOAA/FGBNMS.

The first biological assessments of the Flower Garden Banks were made in 1972 (Bright and Pequegnat 1974, Bright et al. 1985). These surveys helped to establish Department of Interior (DOI) regulations that protect the banks from adverse impacts that could result from routine oil and gas exploration activities. In 1989, DOI began long-term monitoring for impacts from industry activity, and in 1992, the National Oceanic and Atmospheric Administration designated Flower Garden Banks National Marine Sanctuary to focus a wider range of science, education and protection programs on the marine environments of the banks. Since that time, the monitoring program annually evaluates a suite of parameters, including coral cover and growth, fish abundance, water quality and other measures of coral reef vitality. The just released most

recent long-term monitoring report is a testament of the dedication of the scientists to the program (Johnston et al. 2015).

The results of the monitoring program have shown that while many coral reefs in the Western Atlantic and Caribbean region have experienced significant declines in coral cover and fish assemblages (Jackson et al 2014), the reefs of the Flower Garden Banks continue to support healthy coral and fish assemblages. More than 25 years of continuous monitoring has shown that the coral reefs of the Flower Garden Banks have maintained levels of coral cover above 50% and the factors that have been lethal to corals elsewhere have had minimal impact (Johnston et al. 2015).

Twenty-four species of hard corals are found at the Flower Garden Banks. The most abundant corals belong to the Orbicella annularis species complex and other boulder-shaped, rather than branching, species. These corals are large in size and many are hundreds of years old. Indications of stress to these corals are fortunately few, likely because of the reefs' relative isolation from natural and human impacts that have been harmful for reefs closer to coastlines. These conditions make the Flower Garden Banks an important location to evaluate ecosystem changes and to assess their causes. This is particularly true for the reefs' coral populations. The corals that live on the Flower Garden Banks attest to the long-term stability of good conditions at the site, but they also tell a story of how the reef community responds to changes in ocean conditions.

The branching coral species *Acropora palmata* and *Acropora cervicornis* dominated the shallow water habitats of most reefs throughout the Caribbean until the 1980s when these corals underwent a dramatic decline, mainly due to coral diseases (Aronson and Precht 2001). In addition to their vulnerability to disease and storms, these delicate corals are among the most sensitive reef building corals to cold-temperature stress and generally do not occur in areas where winter time water temperatures drop below 18 °C, like at the Flower Garden Banks. However, in 2003 and 2005, two living colonies of *A. palmata* were discovered at the Flower Garden Banks (Zimmer et al. 2006). What does this discovery say about the changing conditions for corals at the Flower Garden Banks?

Geological studies at the Flower Garden Banks have identified that *Acropora* coral species were an important part of the reef-building community that constructed the limestone foundation on which the present coral reefs thrive, and *Acropora sp* were present on the reefs a thousand years ago, but died during the global cooling events that occurred around 1500 (Precht et al. 2014). The Flower Garden

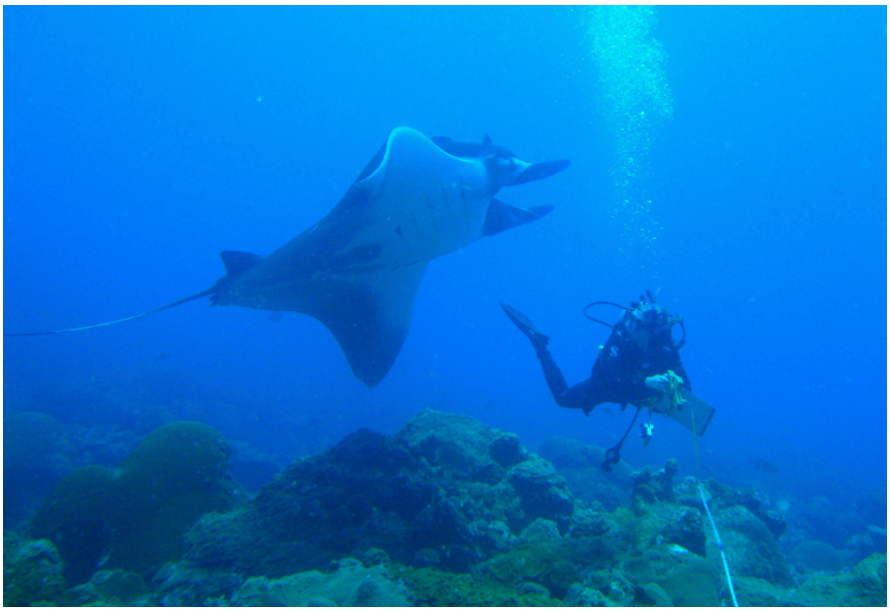

Image 2. Flower Garden Banks National Marine Sanctuary Scientist Michelle Johnston is greeted by a large manta ray while doing coral surveys in 2014. Photo: Amanda Sterne, Texas A&M Univ. Galveston.

Banks are located more than 400 miles (640 km) from coral reefs in the southern Gulf of Mexico that have reproducing *A. palmata* colonies. Currents that brought the larvae of these corals to the Flower Garden Banks must have had temperatures and other conditions favorable to allow the larvae to survive over possibly several months and to eventually recruit to the coral reefs at the Flower Garden Banks.

The *A. palmata* colonies are now about 15 years old, and monitoring their condition and exploring for new colony recruitment will help to know if their presence is a random, short-lived event, or if this species is re-establishing on the reefs after centuries of absence. One possibility is that currents reaching the Flower Garden Banks, and supplying them with new coral from reefs in Mexico and Cuba, are warmer than in the recent past.

A recent analysis of physical and biological data of the Gulf of Mexico spanning three decades suggests that an ecosystem-wide reorganization occurred in the Gulf in the mid-1990s that aligned with a cool to warm phase-change in the Atlantic Multidecadal Oscillation (Karnaukas et al. 2015). This could account for a change in conditions in the Gulf that allowed *A. palmata* to establish at the Flower Garden Banks.

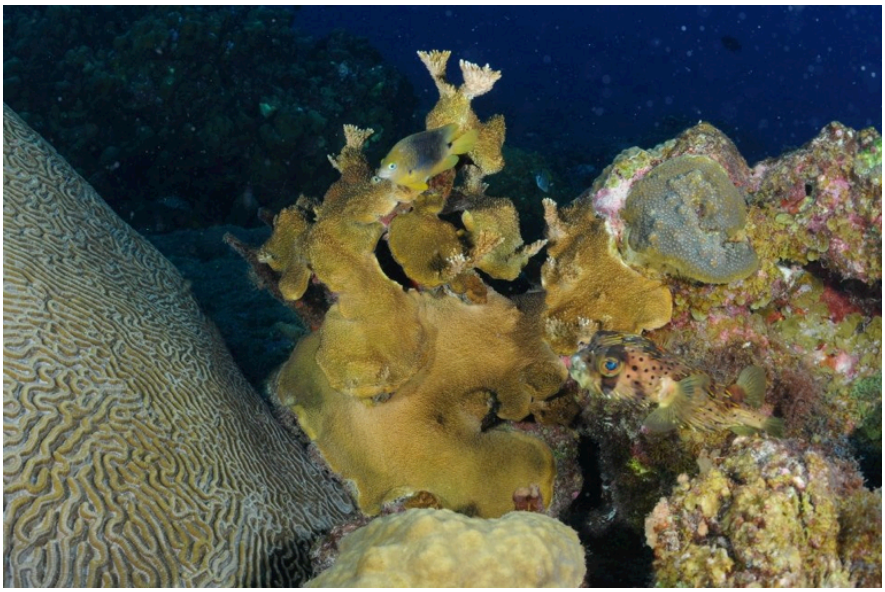

Image 3. A colony of the branching coral Acropora palmata at the Flower Garden Banks in 2012. Photo: G.P. Schmahl, NOAA/FGBNMS.

No matter the reason for a possible warming of currents or the improvement of conditions for *A. palmata* at the Flower Garden Banks, it is in contrast to the major negative effects of ocean warming on coral populations around the world.

Coral bleaching, during periods of elevated sea temperature, combined with other stresses, have taken a dramatic toll on the health of the world's coral reefs. Bleaching results from the coral's expulsion of its symbiotic partner, a dinoflagellate (generally called "symbiotic algae" or "zooxanthellae") that corals host within their tissue and provides them with nutrition that aids metabolism and growth. This occurs when the corals are stressed by changes in certain water conditions, particularly a rise in water temperatures to unusual levels, i.e. above 29° C (Brown 1997). If high temperature conditions last too long, a bleached coral will die. If the temperatures decrease, corals can regain their symbiotic algae and survive – that is as long as other impacts, such as diseases or water quality problems, don't kill the coral while it is weakened by its lack of zooxanthellae-supplied nutrition.

The frequency and severity of coral bleaching events have increased in the Tropical Western Atlantic since the 1980s, especially during years of intense El Niño-Southern Oscillation (ENSO) conditions (Eakin et al. 2010). In response, NOAA established the Coral Reef Watch Program, which uses satellite derived data to monitor global coral reef environmental conditions

areas at risk for coral bleaching. Coral Reef Watch is a partnership between NOAA's Coral Reef Conservation Program and National Environmental Satellite Data and Information Service. This continuous monitoring of sea surface temperature allows better understanding of the dynamics of global ocean temperatures and the opportunity to manage the complex interaction of factors that can lead to coral bleaching and death.

Bleaching of corals has been observed at the Flower Garden Banks several times in the past (Hagman and Gittings 1992, Precht et al. 2008, Johnson et al. 2013), but due to the high latitude and depth of its coral reefs, the warm water conditions that caused it were fortunately short-lived and kept the bleaching events from becoming lethal to most of its affected corals. The question however is: Can the Flower Garden Banks continue their resistance to a warming ocean?

In August 2015, NOAA's Climate Prediction Center released an advisory indicating that ENSO conditions have developed and are expected to remain strong through the first quarter of 2016 and warning that widespread bleaching of corals in the coming months is possible. Coral Reef Watch has also released a prediction of higher than usual coral beaching for this year and next for much of the Caribbean and the Flower Garden Banks based on their models. This has the Flower Garden Banks National Marine Sanctuary scientists on alert to identify if and when bleaching may occur. Coupling their field observations with the satellite derived data and models will be an important part in determining just how resistant the Flower Garden Banks' reefs are to coral bleaching.

To better link observed changes to local conditions, new instruments are being installed at the Flower Garden Banks that are designed to monitor in detail a range of parameters at the sea surface and sea floor. Procedures for monitoring water temperature, quality and chemistry, the growth of calcifying organisms, bioerosion, and invertebrate biodiversity are being put in place in response to the growing concern for ocean acidification as well as temperature, and how these conditions are changing the community of organisms on coral reefs (NOAA Coral Program 2014).

The Flower Garden Banks are among the longest-monitored coral reef environments anywhere. Given that there is much uncertainty about the ability of coral reefs to survive impacts caused by a changing climate, human impacts and the intensity of natural phenomena, the exceptional condition and resistance to change seen at the Flower

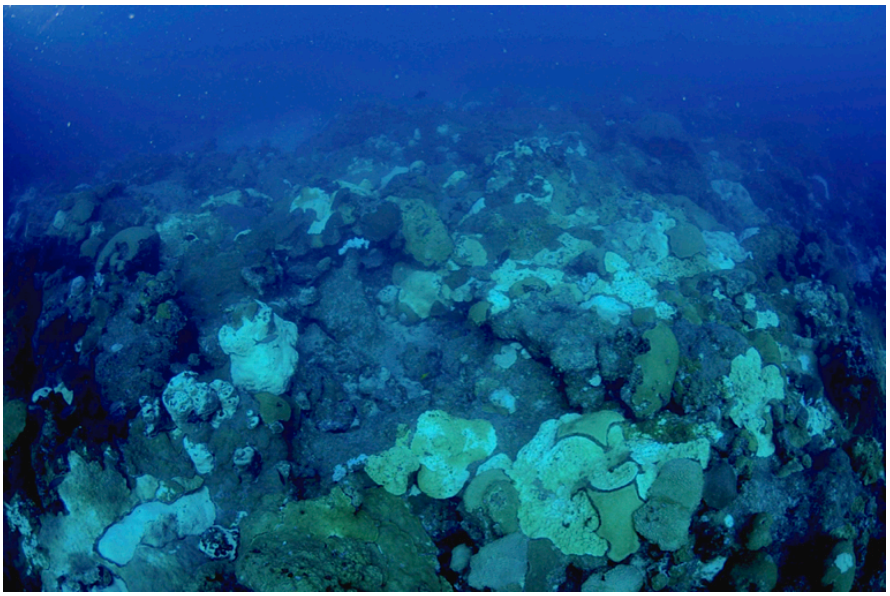

Image 4. Bleached corals at the Flower Garden Banks in late summer 2010 when water temperatures exceeded 30° C. Pale and white colors are due to the corals losing their symbiotic zooxanthellae. Most of these corals survived this bleaching event. Predictions for higher temperatures in the Gulf of Mexico in 2015-2016 could again cause coral bleaching at the Flower Gardens Banks. Photo: Emma Hickerson, NOAA/FGBNMS.

Garden Banks makes the monitoring programs in the sanctuary vital to deciphering what exactly is causing changes to coral reefs and what can be done to mitigate them. As a result, the Flower Garden Banks are important sentinels for change, not only for the Northwest Gulf of Mexico, but also for all the coral reefs of the world.

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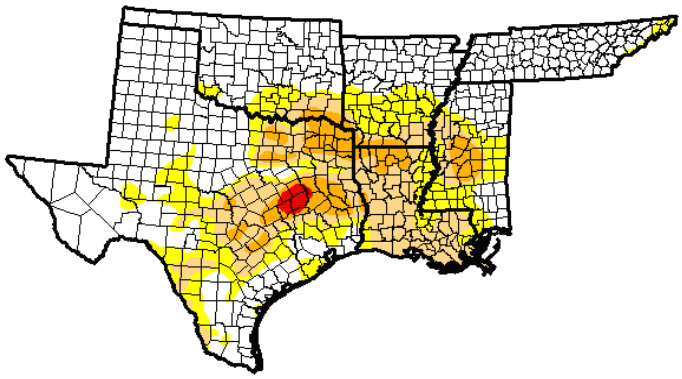
Drought Update

Luigi Romolo,
Southern Regional Climate Center

Drier than expected weather over much of the region has resulted in the expansion of drought conditions throughout much of Louisiana, central Tennessee, and eastern Texas. In Louisiana, most of the state is now experiencing moderate drought, with some severe drought conditions in the northern Parishes along the southern border of Arkansas. This severe drought extends through north eastern Texas and south eastern Oklahoma. In east central Texas, there is an small area of extreme drought.

On August 17, 2015, a tornado in Covington County, Mississippi downed numerous tree limbs and power lines. Fortunately, there were no injuries or fatalities reported. In general, there was very little in the way of severe weather for the Southern Region.



Released Thursday, September 3, 2015
Anthony Artusa, NOAA/NWS/NCEP/CPC

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	56.77	43.23	24.61	7.93	0.67	0.00
Last Week *8/25/2015*	57.70	42.30	20.79	4.47	0.00	0.00
3 Months Ago *6/2/2015*	91.32	8.68	0.32	0.00	0.00	0.00
Start of Calendar Year *12/30/2014*	41.57	58.43	33.88	18.43	8.80	2.36
Start of Water Year *9/30/2014*	41.74	58.26	35.49	22.66	8.47	1.98
One Year Ago *9/2/2014*	42.82	57.18	40.69	25.29	10.37	1.69

Intensity:

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

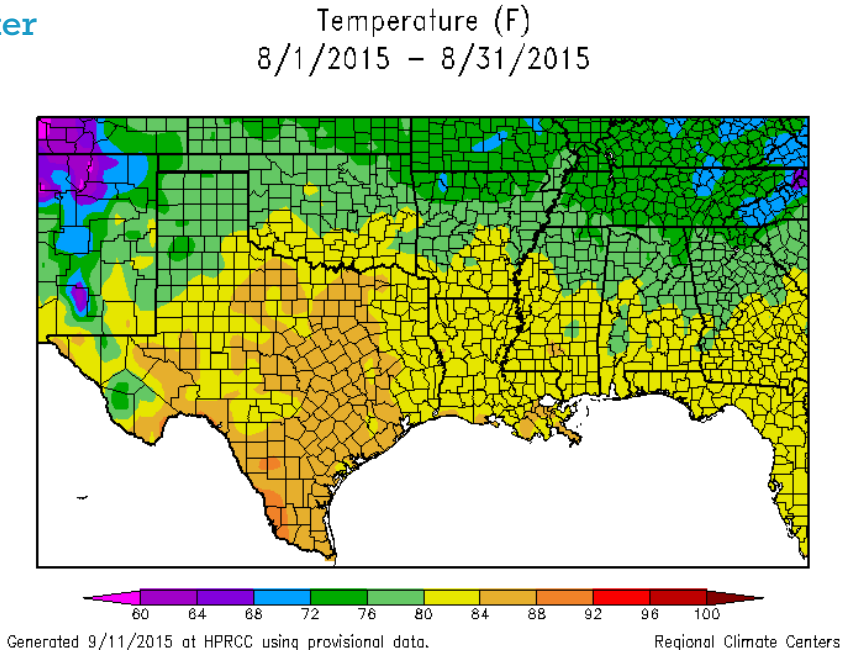
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Above: Drought conditions in the Southern Region. Map is valid for September 1, 2015. Image is courtesy of National Drought Mitigation Center.

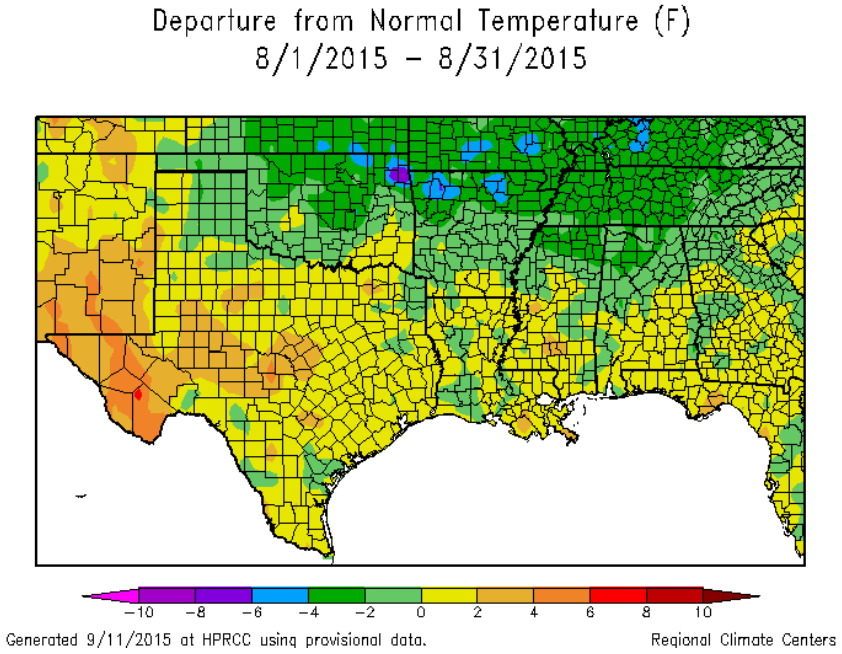
Temperature Summary

Luigi Romolo,
Southern Regional Climate Center

August temperatures in the Southern Region were generally near normal across much of Oklahoma, Arkansas, and Tennessee, with temperatures averaging between 0-4 degrees F (0 – 2.22 degrees C) below normal. Elsewhere temperatures were also near normal, but averaged between 0-4 degrees F (0 – 2.22 degrees C) above normal, except for the Trans Pecos Climate Division in Texas, where temperatures averaged between 4-6 degrees F (2.22-3.33 degrees C) above normal. The state-wide average temperatures for the month are as follows: Arkansas averaged 78.10 degrees F (25.61 degrees C), Louisiana averaged 82.70 degrees F (28.17 degrees C), Mississippi averaged 80.20 degrees F (26.78 degrees C), Oklahoma averaged 79.50 degrees F (26.39 degrees C), Tennessee averaged 74.20 degrees F (23.44 degrees C), and Texas averaged 83.40 degrees F (28.56 degrees C). For Tennessee, it was the fifteenth coldest August on record, while Texas experienced its twentieth warmest August. All other state rankings fell within the two middle quartiles. All records are based on the period spanning 1895-2015.



Average August 2015 Temperature across the South

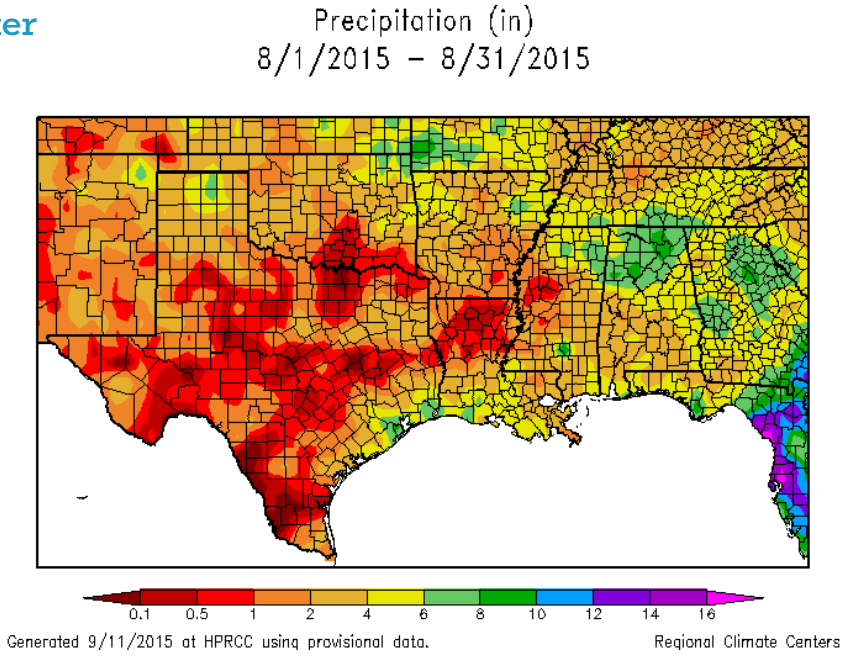


Average Temperature Departures from 1971-2000 for August 2015 across the South

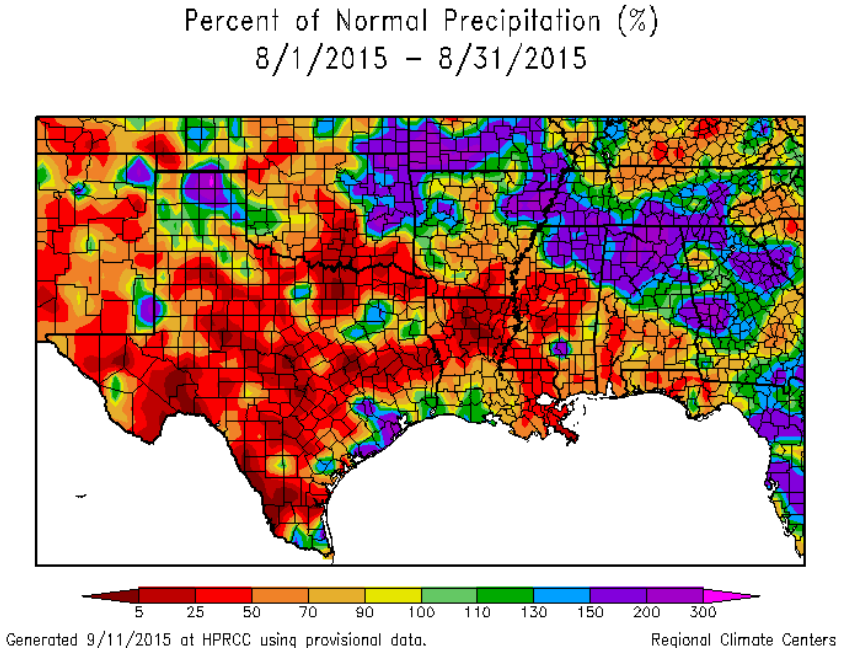
Precipitation Summary

Luigi Romolo,
Southern Regional Climate Center

August precipitation in the Southern Region varied spatially from extremely dry across much of Texas and southern Oklahoma, to very wet in northeastern Arkansas, northern Mississippi, and western Tennessee. The driest areas of the region occurred in northern Louisiana and in central Texas, where stations averaged between 0 to 25 percent of normal rainfall for the month. Along northeastern Arkansas and western Tennessee, stations averaged more than two times normal precipitation. The state-wide average precipitation totals for the month are as follows with: Arkansas reporting 2.88 inches (73.15 mm), Louisiana reporting 2.49 inches (63.25 mm), Mississippi reporting 2.92 inches (74.17 mm), Oklahoma reporting 2.44 inches (61.98 mm), Tennessee reporting 4.60 inches (116.84 mm), and Texas reporting 1.40 inches (35.56 mm). Louisiana experienced its tenth driest August on record, while Texas and Mississippi reported their twenty-sixth and twenty-eight driest August, respectively. Tennessee recorded its twenty-fourth driest August on record. All other state rankings fell within the two middle quartiles. All records are based on the time period spanning 1895-2015.

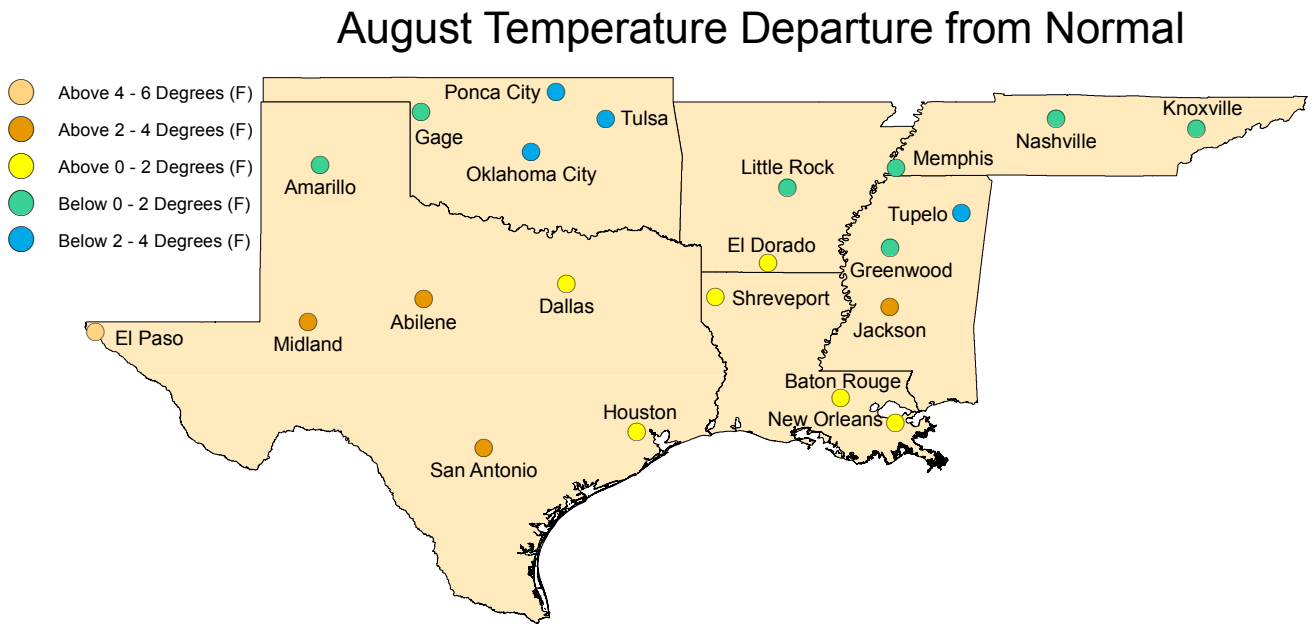


August 2015 Total Precipitation across the South

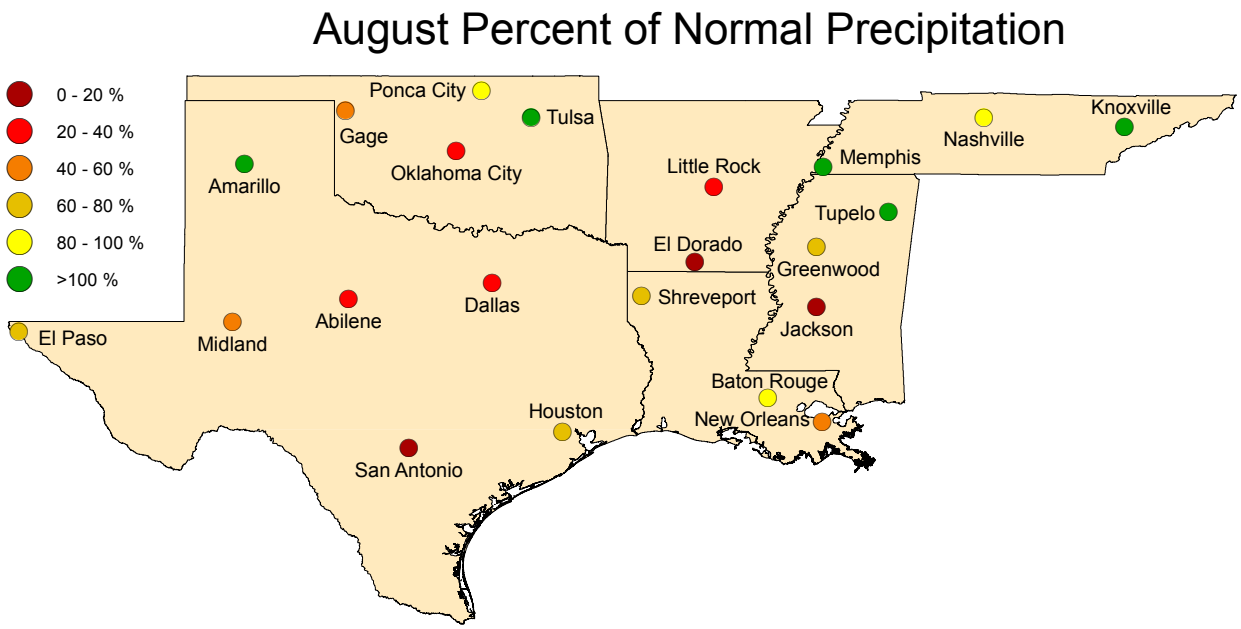


Percent of 1971-2000 normal precipitation totals for August 2015 across the South

Regional Climate Perspective in Pictures



August 2015 Temperature Departure from Normal from 1971-2000 for SCIPP Regional Cities



August 2015 Percent of 1971-2000 Normal Precipitation Totals for SCIPP Regional Cities

Climate Perspective

State	Temperature	Rank (1895-2011)	Precipitation	Rank (1895-2011)
Arkansas	78.10	34th Coldest	2.88	50th Driest
Louisiana	82.70	25th Warmest	2.49	10th Driest
Mississippi	80.20	56th Warmest	2.92	28th Driest
Oklahoma	79.50	34th Coldest	2.44	51st Driest
Tennessee	74.20	15th Coldest	4.60	24th Wettest
Texas	83.40	20th Warmest	1.40	26th Driest

State temperature and precipitation values and rankings for August 2015. Ranks are based on the National Climatic Data Center's Statewide, Regional, and National Dataset over the period 1 895-201 1.

Station Summaries Across the South

Station Summaries Across the South

Station Name	Temperatures								Precipitation (inches)		
	Averages				Extremes				Totals		
	Max	Min	Mean	Depart	High	Date	Low	Date	Obs	Depart	%Norm
El Dorado, AR	94.2	68.8	81.5	0.2	105	08/10	57	08/28+	0.57	-2.54	18
Little Rock, AR	93.2	70.6	81.9	-0.6	102	08/07	61	08/28	0.56	-2.03	22
Baton Rouge, LA	93.6	72.8	83.2	0.3	103	08/10	60	08/27	5.30	-0.52	91
New Orleans, LA	92.7	77.1	84.9	1.6	98	08/10	69	08/28	3.28	-2.70	55
Shreveport, LA	96.4	73.5	84.9	1.8	107	08/10	63	08/28+	2.12	-0.61	78
Greenwood, MS	92.2	68.4	80.3	-0.7	100	08/10	54	08/27+	1.76	-1.07	62
Jackson, MS	95.9	71.0	83.4	2.1	103	08/10+	56	08/27	0.40	-3.84	9
Tupelo, MS	88.6	69.0	78.8	-2.0	98	08/04	57	08/26	6.50	3.05	188
Gage, OK	92.3	66.0	79.2	-0.1	105	08/06	52	08/30+	0.97	-1.42	41
Oklahoma City, OK	90.4	68.5	79.5	-3.0	102	08/07	50	08/20	1.17	-2.11	36
Ponca City, OK	89.6	67.4	78.5	-2.5	102	08/08	53	08/25	2.69	-0.56	83
Tulsa, OK	90.2	68.5	79.3	-2.9	102	08/09+	56	08/25+	5.16	2.26	178
Knoxville, TN	86.1	67.0	76.5	-1.3	93	08/04	60	08/26+	3.66	0.39	112
Memphis, TN	90.4	71.0	80.7	-1.3	98	08/04+	61	08/26+	4.11	1.23	143
Nashville, TN	87.7	66.8	77.2	-1.5	97	08/04	57	08/26+	2.99	-0.18	94
Abilene, TX	97.6	72.2	84.9	2.1	104	08/09	60	08/19	0.62	-1.97	24
Amarillo, TX	89.0	64.6	76.8	0.0	97	08/06	55	08/20	3.68	0.77	126
El Paso, TX	97.6	73.4	85.5	4.4	103	08/06+	68	08/30+	1.55	-0.46	77
Dallas, TX	97.8	76.8	87.3	1.7	106	08/10+	65	08/20	0.46	-1.45	24
Houston, TX	95.7	74.4	85.0	0.5	106	08/11	69	08/30+	2.94	-0.82	78
Midland, TX	97.8	71.4	84.6	3.4	104	08/14+	62	08/30	1.01	-0.83	55
San Antonio, TX	98.1	76.6	87.4	2.1	104	08/11	71	08/29	0.29	-1.80	14

Summary of temperature and precipitation information from around the region for August 2015. 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 wdays. 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.

50th Anniversary of Hurricane Betsy This Week

Barry Keim, Louisiana State Climatologist, Louisiana State University

Just when we put the 10th anniversary of Hurricane Katrina to rest, we're now faced with the 50th anniversary of Hurricane Betsy. Betsy hit this region on September 9, 1965 - which I might add was on my second birthday. My earliest childhood memory was was the day before Hurricane Betsy hit Louisiana. It was raining outside on September 8, 1965, and I was playing with my brother and parents in our living room on my new merry-go-round - which was my birthday present. After that, however, I have no other recollection of the storm nor its aftermath. Afterall, according to my mom, I was running fever through the storm surge flood, as my parents waded through waist-deep water to escape the surge. Clearly the early rains were from the feeder bands of the very large Betsy, which had an eye that extended 40 miles across. This storm was comparable in size to Hurricane Katrina. The storm produced winds in New Orleans of 125 mph and it also produced a peak storm surge of 15.25 feet near Pointe ala Hache, and over 12 feet in and around Da Parish. The flooding in the New Orleans metro area was nearly on a Katrina-like scale, though not quite as deep as in Katrina. Figure 1 shows an image taken from Air Force One, which is of Arabi and the Lower Ninth Ward. The image is apparently taken with the view to the west, with Arabi making up the the bottom half of the image, the Industrial Canal is visible at the top of the image, and it includes the Upper Ninth and Central City at the top.

Figure 1. Flooding during Hurricane Betsy on September 10, 1965. Image taken from Air Force One which was carrying President Lyndon B. Johnson and is avaliable at https://en.wikipedia.org/wiki/Hurricane_Betsy#/media/File:HurricaneBetsyFloodingAirForceONE.jpg.

My parents had 4 feet of water in their house for this one, and like most others in Da Parish at the time, they simply rebuilt without giving it much thought! There were 58 deaths in Louisiana from the storm, though none of these were in St. Bernard - most (41) were in Orleans Parish, as reported in the Climatological Data publication. Also noted for St. Bernard, there were 3100 injuries, 7000 homes damaged, and 10,000 families with losses. Hurricane Betsy served as THE signature storm for the region for 40 years, all the way up until Hurricane Katrina ravaged the region 40 years, and 2 weeks later. Betsy was surely supplanted by Katrina to serve as the measuring stick for all other storms to be compared to, but Betsy's imprint on the region, and especially in St. Bernard and the Lower Ninth, is/was profound. It ranks right up there and probably ahead of the Hurricanes of 1915 and 1947, but certainly behind Katrina. OK.... enough anniveraries! It's time to stop reflecting back and to look forward to the continued recovery of our Great Parish. Go ahead.... carry on. If you have any questions, feel free to contact me at keim@lsu.edu.

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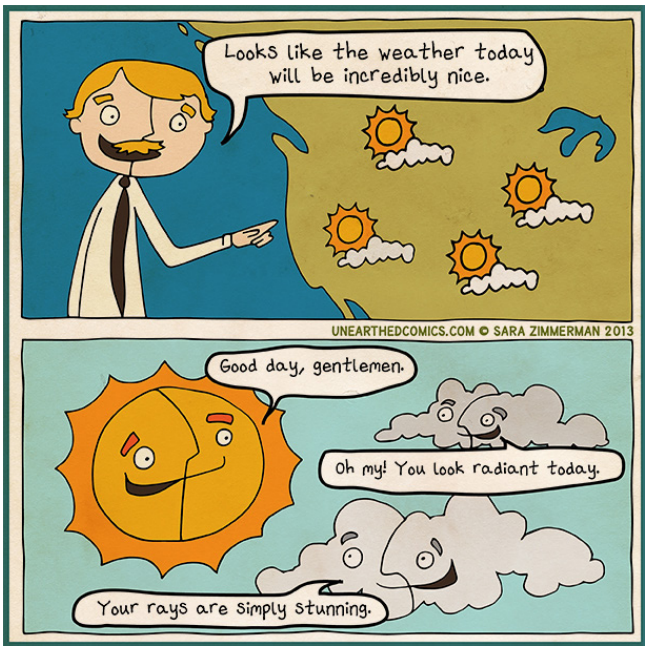
For questions or inquiries regarding research, experimental tool development, and engagement activities at the Southern Climate Impacts Planning Program, please contact us at 405-325-7809 or 225-578-8374.

Monthly Comic Relief



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