In This Issue:

Improving Impact-Based Seasonal Outlooks for South Central Texas

Ty Dickinson, University of Oklahoma
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"Is this an above normal year?" Meteorologists get questions like this on a regular basis. While for different reasons, the answer to that question may be useful to both meteorologists and members of the public, but how does one truly answer it? Currently, the meaning of "above normal", in general, lies in terms of subjective perceptions based on experiences as opposed to objective measures (temperature and precipitation being two notable exceptions). As the National Weather Service (NWS) moves towards being impact-based, one question arises immediately: "Can we accurately quantify impacts, especially for extreme weather?" Thus, this study looked at improving the impact-based seasonal outlook and verification process begun by the NWS Weather Forecast Office (WFO) Austin/San Antonio in fall 2015.

The Verification Index

The overarching question of this study is how does one quantify impacts, and can they be objectively predicted and measured/verified? We attempt to design our objective metrics in such a way that it matches public perception for any given season as well as be a repeatable but customizable process. The first step in objective forecasts is to have a baseline climatology for this WFO's county warning area (CWA) in South Central Texas. Baseline climatologies are created for severe weather, river and flash flooding, and fire weather; river flooding and flash flooding are combined due to most river flooding occurring as a result of flash flooding. These climatologies utilize "indicators", various data to describe one aspect of the weather phenomena that, when used collectively, will fully depict the season as it pertains to the respective weather event. We call these climatologies complete with

indicators as verification indices since they are initially acting to verify outlooks done by the office.

We began by defining seasons to be tested: December, January, February; March, April, May; June, July, August; and September, October, November. For each index, indicators fall into one of three categories: occurrence, impacts, or meteorology/severity. These categories capture a full description of a season offering the strongest overall quantification. The basis for each index utilizes the number of reports and the number of report days for occurrence, damages and a blend of injuries and fatalities for impacts, and total CWA rainfall for meteorology/severity. Damages are adjusted to 2010 levels using the consumer price index (DOL 2017). Total CWA rainfall was found using Texas Water Development Board quadrangles (TWDB 2017). These quadrangles divide Texas into a 1° latitude by 1° longitude grid. Each month, rainfall totals are collected for each quadrangle. Any quadrangle that contained more that 75% of the CWA was considered in the analysis. An average of each quadrangle's seasonal value then was used as total CWA rainfall. A further discussion of our fatalities/injuries blend is saved for later. Additional indicators were then added to each index to hone in on specifics from each hazard. Our verification indices are modelled after the Climate Prediction Center's nonparametric tercile approach. Each indicator in the index in ranked, where l is the greatest number (i.e., the most number of reports/most damages) and n is the smallest number, n being the number of years in the climatology. Total CWA rainfall in the fire weather index is the only exception (smallest rainfall value given 1, largest given 30). In the case of a tie, all tied values are

Reports	Report Days	Report Rank	Days Rank	Sum	Sum Rank
22	6	3	3	6	3
279	35	1	1	2	1
8	4	4	4.5	8.5	4
7	4	5	4.5	9.5	5
25	8	2	2	4	2

Table 1: An example of how ranking works in the verification index using only two indicators. Note that a low sum is given a higher rank as low sums indicate more significant indicator values.

assigned the rank that is equal to the midpoint of the unadjusted ranks. Then, we take the sum of all indicator ranks across a year and find the rank of this sum. The final rank analysis thus weights all indicators equally throughout the index (see Table 1 for a simplistic example of this process). The final rank analysis is done so that the smallest sum is given the top rank. The upper third ranks are deemed above normal, middle third are near normal, and bottom third are below normal.

Severe Weather

Severe weather was analyzed first, and the storm reports were collected from the National Center for Environmental Information's Storm Events Database (NCEI 1993). Our climatology is 1981-2010 and includes storm reports for severe thunderstorm wind, severe hail, tornadoes, and lightning. We kept all hail reports of 0.75 inches since this was the severe criteria for virtually the entire climatology. Although lightning is not considered in making a thunderstorm severe, if it was listed as a storm report it means that there was either a fatality, injury, or damage figure associated with it, which by definition is an impact. Lightning reports were not added to the Storm Events Database until 1996 under NWS Directive 10-1605 so all Storm Data Publications prior to 1996 were read and appropriate additions were made.

Initially, fatalities and injuries were two separate indicators. Upon looking at the data, it was seen that there were a significant number

of zeros for fatalities, especially in the winter. This presents a problem in statistical analysis (although certainly not in societal analysis!) since all the zeros would share a common rank. As a result, there was not much differentiation between any given year when looking at the fatalities (and injuries) ranks alone. As a result, we define a blend of fatalities and injuries to capture both impacts while also providing differentiation among years. This blend ranks fatalities as normal but then looks to injuries in the case of the ties. This provided a solution that allowed the impacts of a fatality to have more weight than an injury and still accounted for both fatalities and injuries since the range and variability of fatalities was not large.

To hone in on the impacts on severe weather, we added the following indicators into the index: total tornado path length (occurrence) and maxima of tornado width, hail diameter, and non-tornadic wind magnitude (meteorology/severity). Total CWA rainfall was removed after statistical analysis of its contribution revealed that it added no useful information to the overall severe weather index.

River and Flash Flooding

Like severe weather, storm reports were collected from NCEI's Storm Events Database. However, the database only has reports from 1996 forward, again due to NWS Directive 10-1605. To expand our climatology to 30 years, Storm Data Publications and archived E-5 reports were thoroughly investigated. Although it may not have been perfect, since our index uses ranks, and not the raw data for each indicator, it is not so much the actual values as much as where it falls in comparison to the other years; it is almost certain that highly unusual years would become evident.

In addition to the foundational indicators, we added the number of times river gages went above moderate flood stage (occurrence)

and maximum one- and two-day rainfalls (meteorology/severity) to the index. 52 river gages located on major rivers throughout the CWA were selected. All instances of a river gage going over its moderate flood stage threshold were recorded and then split into the seasons of each year. The collective total among all river gages for a single season was used as the indicator. This data was collected from AWIPS. In determining maxima in rainfall, 54 Cooperative Observer Program (COOP) stations were used. COOP stations were selected to cover all counties in the CWA, with several in larger population areas. The overall maximum for both one day and two days in these 54 stations was used as the indicators. COOP station data was collected from the xmASIS2 tool.

Fire Weather

Fire weather was the last hazard we investigated. We were able to obtain an extensive dataset from the Texas State Fire Marshal's Office spanning from 1982-present. This dataset contained all fires, including prescribed burns. Any prescribed burn that did not have acres burned entered was discarded from the dataset. After analysis, it was noticed that there were zero acres burned for every fire entered from 1982 through 1999. Thus, we were forced to use a 15-year climatology of 2000-2014.

3 indicators were added to the fire weather index: total acres burned (impacts), average maximum temperature (meteorology/ severity), and a blend of frontal passages and a Keetch-Bynum Drought Index analysis (meteorology/severity).

Results, Conclusions, and Next Steps

An example of a plot made after analysis using the verification index is shown in Figure 1 and a list of the years in each tercile for severe weather is shown in Table 2. Now that there is a baseline climatology, objective verification techniques can be undertaken to verify outlooks already issued by the WFO. After collection of a season's data, the closest value to each indicator in the index is found and the indicator is given that associated rank from the index. Then, like before, all the individual ranks are summed and ranked for an overall index value. The season in consideration is given the rank of the year with the closest overall sum (see Figure 2 for a depiction of this process). This verification scheme has been done completely for 21 forecasts made: 9 severe weather, 6 river and flash flooding, and 6 fire weather. Modified Heidke Skill Scores (Livezey and Timofeyeva 2008) were computed for each weather hazard and were 0.50, 0.25, 0.25 for severe weather, river and flash flooding, and fire weather, respectively. In other words, their forecasts are 50% and 25% better than climatology.

Above Normal	Near Normal	Below Normal
1983	1981	1982
1987	1984	1985
1988	1990	1986
1992	1994	1989
1993	1995	1991
1996	1997	1999
2000	1998	2003
2001	2006	2005
2002	2009	2007
2004	2010	2008

Severe Weather SON Years by Tercile

Table 2: A listing of years in the climatology by tercile. Analysis was done with consider- ation with the 33 coun- ties in WFO Austin/San Antonio's CWA in South Central Texas.

Fall Season	Reports	Report Days	Fatalities Injuries	Tornado Track	Adjusted Damages	Largest Hail Size	High Wind	Widest Tornado
2015	19	6	0	18.6 mi.	$2.07M	1.0 in.	71 mph	440 yd.
Rank	9th	9th	20th	3rd	6th	20th	5th	3rd
Value (Year)	18 (1997)	6 (3 times)	0 (21 times)	26 mi. (2004)	$1.75M (2000)	1.0 in. (1994)	70 mph (3 times)	400 yd. (2004)

Table 3: A depiction of the verification process for severe weather. For example, fall 2015 had 19 severe reports. The closest value in the severe weather index was 18 in 1997. Fall 2015 was then assigned the 1997 rank of 9. The index score is the sum of all ranks (e.g., 75), the closest value is again found, and given that rank (in this case, is 6).

Overall, objective verification indices that capture impacts can be created and are meaningful to both meteorologists and the public. Impacts are captured from an aggregation of various data describing the season quantitatively. There are currently several areas of work still being explored to improve this process. For example, streamflow is being considered as an additional indicator to the river and flash flooding index. In addition, some measure of fuel moisture, such as fuel release component, looks to replace the KBDI blend in the fire weather index. Winter weather is an additional index being designed with guidance from WFO Detroit. The overarching process has been shown to have successes thus far and has also been designed in a repeatable but customizable way so that indices can be tailored to specific regional nuances.

References:

Department of Labor Bureau of Labor Statistics, 2017: Consumer Price Index. Accessed June 2017, https://www.bls.gov/cpi/

Livezey, R.E., and Timofeyeva, M.M., 2008: The First Decade of Long-Lead U.S. Seasonal Forecasts: Insights from a Skill Analysis. Bull. Amer. Meteor. Soc., 89, 843-854, https://doi.org/10.1175/2008BAMS2488.1

NOAA/NCEI, 1993: Storm Events Database, Version 3.0 (updated monthly). National Center for Environmental Information. Subset used: December 1980 – February 2017, accessed June 2017, https://www.ncdc.noaa.gov/stormevents/

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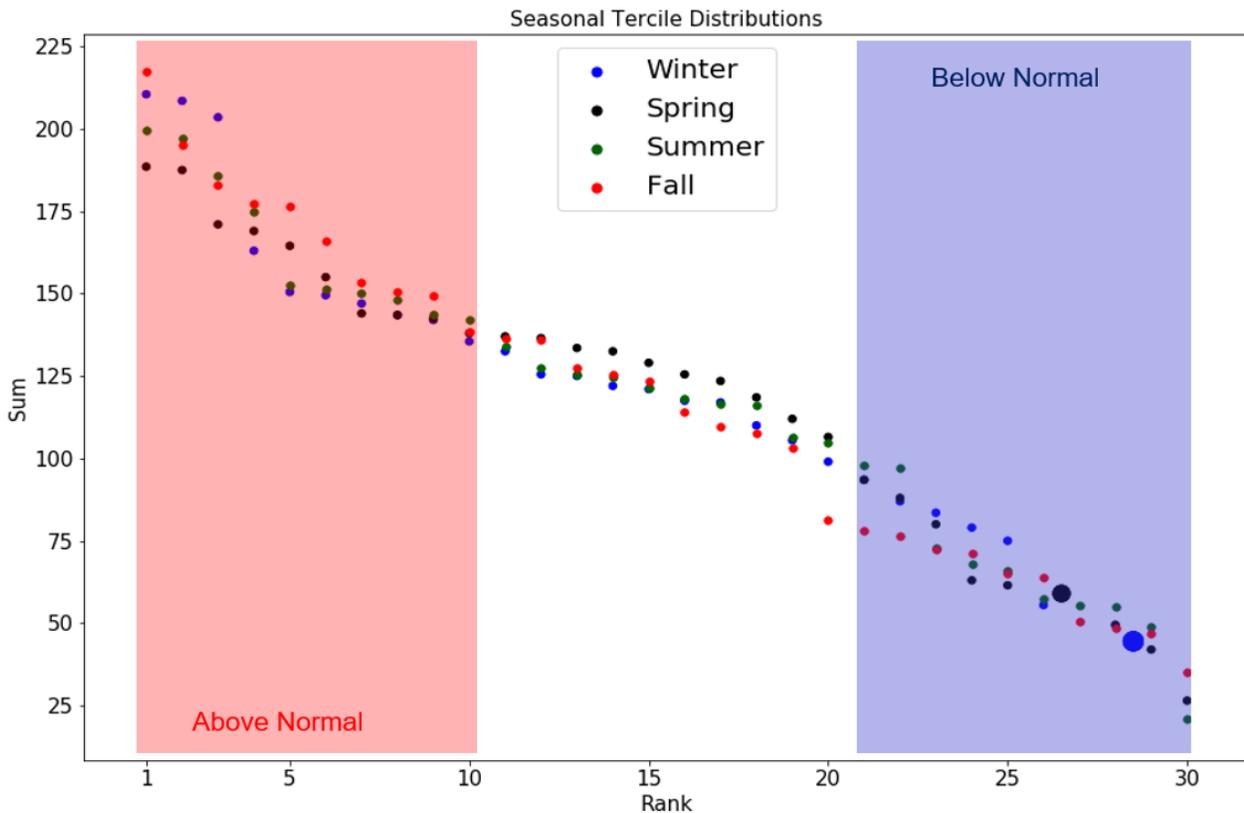
Figure 1: A plot displaying the distribution the distibution of years in the climatology. A larger dot means more than one year was tied for a final rank. Note that winter is DJF, spring is MAM, summer is JJA, and fall is SON. The y-axis is the sum of the indicators and is reversed so that a larger sum correlates with above normal impacts.

Drought Update

Kyle Brehe and Rudy Bartels,
Southern Regional Climate Center

Over the month of December 2017, drought conditions worsened from severe to extreme drought in north central Arkansas and a small area in northern Texas. Conditions worsened from moderate to severe drought in northern Oklahoma, northern Texas, northern Louisiana, and central Mississippi. Moderate drought conditions expanded throughout central Oklahoma and abnormally dry conditions appeared in southeast Tennessee. In contrast, conditions improved from extreme to severe and moderate drought in central Arkansas. Conditions improved from severe to moderate drought in northeast Texas, southeast Oklahoma, and southern Arkansas. Moderate drought improved to abnormally dry conditions in northern Mississippi and southeast and western Texas. Conditions improved to normal in extreme southern Mississippi and south central Louisiana.

In December there were 32 severe weather events (15 tornadoes, 14 wind, and three hail events) were reported throughout the Southern Region. All 15 tornado events occurred during December 19 in Texas and Louisiana. Most of the wind events also occurred in Texas and Louisiana during December 19. The three hail events occurred on December 4 in Oklahoma and Arkansas. The only state not reporting any severe weather during December was Tennessee.
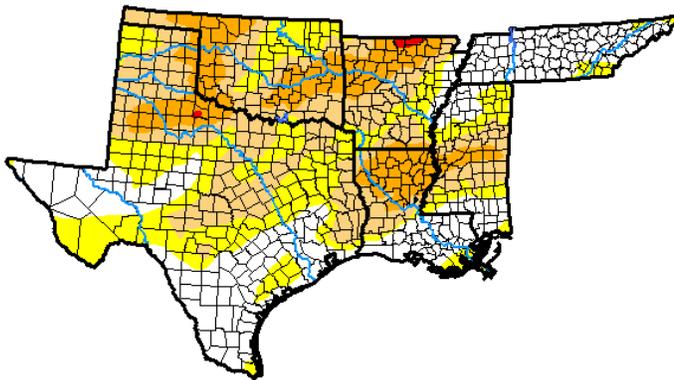
Released Thursday, January 4, 2018
Eric Luebehusen, U.S. Department of Agriculture

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	31.09	68.91	42.64	15.33	0.30	0.00
Last Week 12-26-2017	34.14	65.86	41.30	8.42	0.30	0.00
3 Months Ago 10-03-2017	77.07	22.93	6.19	0.00	0.00	0.00
Start of Calendar Year 01-02-2018	31.09	68.91	42.64	15.33	0.30	0.00
Start of Water Year 09-26-2017	72.17	27.83	2.38	0.02	0.00	0.00
One Year Ago 01-03-2017	53.95	46.05	27.69	11.09	1.11	0.00

Above: Drought Conditions in the Southern Region. Map is valid for January 2, 2018. Image is courtesy of the National Drought Mitigation Center.

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.

Temperature Summary

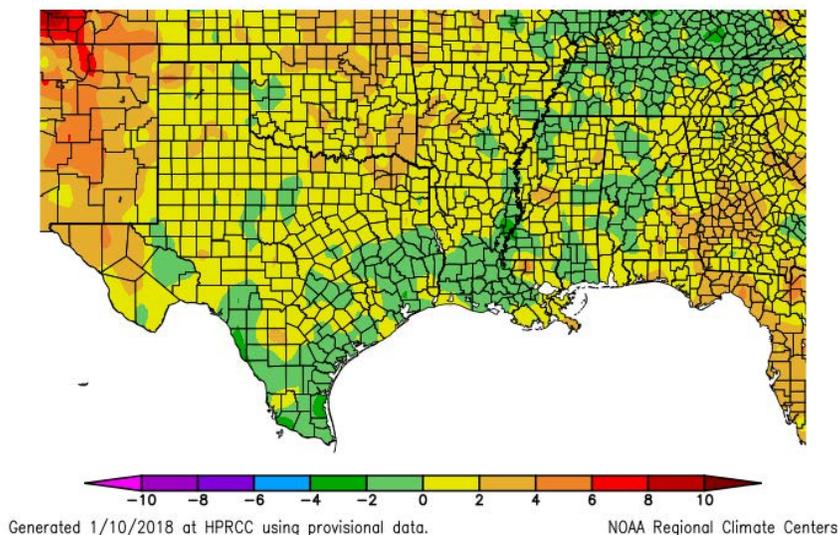Kyle Brehe and Rudy Bartels,
Southern Regional Climate Center

December temperatures were slightly above normal for most of the Southern Region. A few areas in central Oklahoma and western Texas were 4 – 6 degrees F (2.22 to 3.33 degrees C) above normal. Central and southeastern Oklahoma, parts of northern and northeastern Texas, western and central Arkansas, central Mississippi, and extreme southeastern Louisiana were 2 – 4 degrees F (1.11 to 2.22 degrees C) above normal. In contrast, southern and a part of western Texas were 2 – 4 degrees F (1.11 to 2.22 degrees C) below normal. Southern and central Louisiana, eastern and southern Texas, and a few areas throughout Tennessee, Mississippi, eastern Arkansas, and western Oklahoma had slightly below normal temperatures. The statewide monthly average temperatures were as follows: Arkansas – 42.80 degrees F (6.00 degrees C), Louisiana – 51.10 degrees F (10.61 degrees C), Mississippi – 47.80 degrees F (8.78 degrees C), Oklahoma – 41.10 degrees F (5.06 degrees C), Tennessee – 39.90 degrees F (4.39 degrees C), and Texas – 48.20 degrees F (9.00 degrees C). The statewide temperature rankings for December were as follows: Arkansas (forty-fourth warmest), Louisiana (fifty-second warmest), Mississippi (forty-fourth warmest), Oklahoma (fortieth warmest), Tennessee (fifty-second warmest), and Texas (forty-seventh warmest). All state rankings are based on the period spanning 1895-2017.

Temperature (F)
12/1/2017 – 12/31/2017
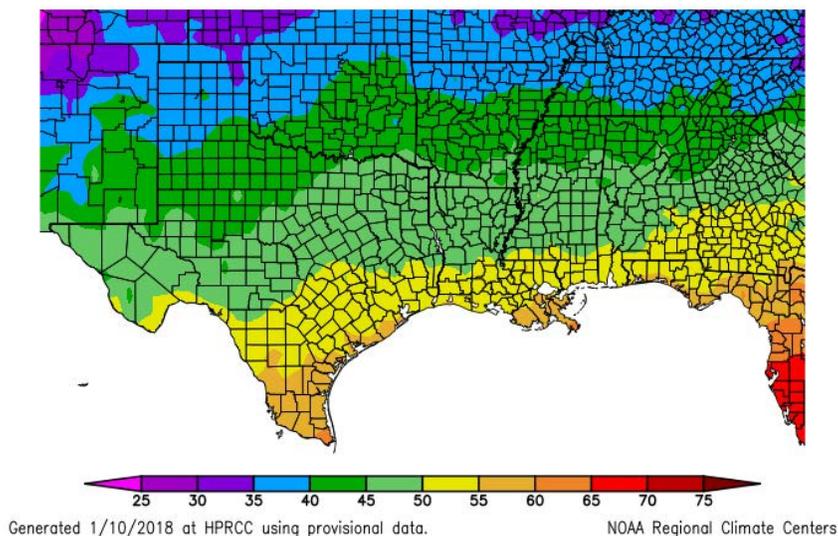
Average December 2017 Temperature across the South

Departure from Normal Temperature (F)
12/1/2017 – 12/31/2017

**Average Temperature Departures from 1981-2010 for December 2017 across the South**

Precipitation Summary

Kyle Brehe and Rudy Bartels, Southern Regional Climate Center

Precipitation values for the month of December varied spatially throughout the Southern Region. Northwestern Oklahoma and northern Texas received 25 percent or less of normal precipitation. Areas of central, eastern, and northern Oklahoma, central and extreme eastern Texas, north, central, and extreme southeastern Louisiana, central and eastern Tennessee, northern Arkansas, and central Mississippi received 25 – 70 percent of normal precipitation. In contrast, southwest Texas received 300 percent or more of normal precipitation. South, northeast and west Texas, southeast Louisiana, southwest Mississippi, and southwest and central Arkansas received 150 – 200 percent of normal precipitation. The state-wide precipitation totals for the month were as follows: Arkansas – 5.04 inches (128.02 mm), Louisiana – 4.83 inches (122.68 mm), Mississippi – 5.24 inches (133.40 mm), Oklahoma – 0.92 inches (23.37 mm), Tennessee – 4.24 inches (107.70 mm), and Texas – 1.96 inches (49.78 mm). The state precipitation rankings for the month were as follows: Arkansas (forty-first wettest), Louisiana (fifty-fourth driest), Mississippi (fifty-sixth wettest), Oklahoma (thirty-second driest), Tennessee (fifty-fourth driest), and Texas (forty-third wettest). All state rankings are based on the period spanning 1895-2017.
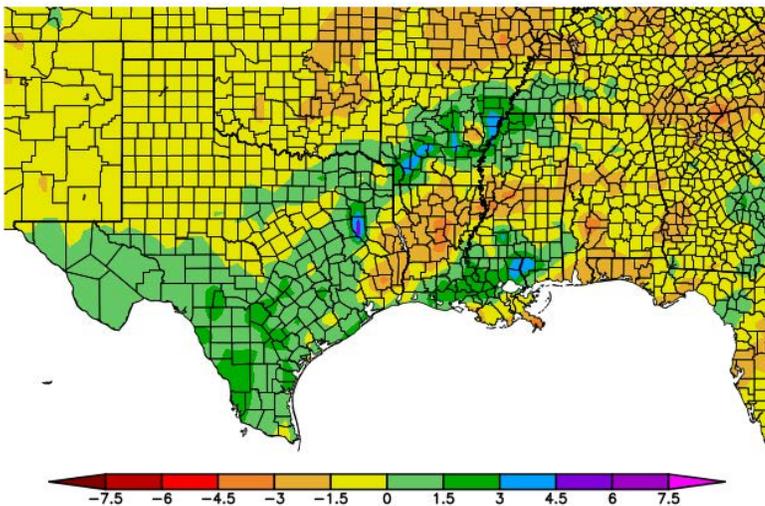
December 2017 Total Precipitation across the South
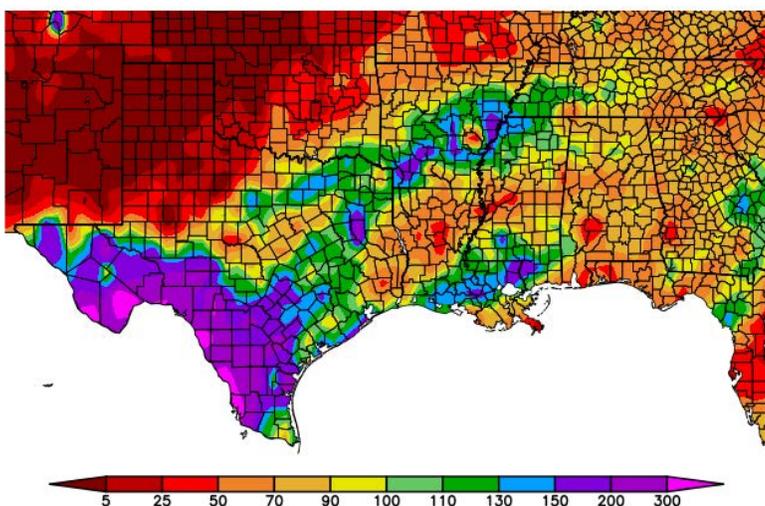
Percent of 1981-2010 normal precipitation totals for December 2017 across the South
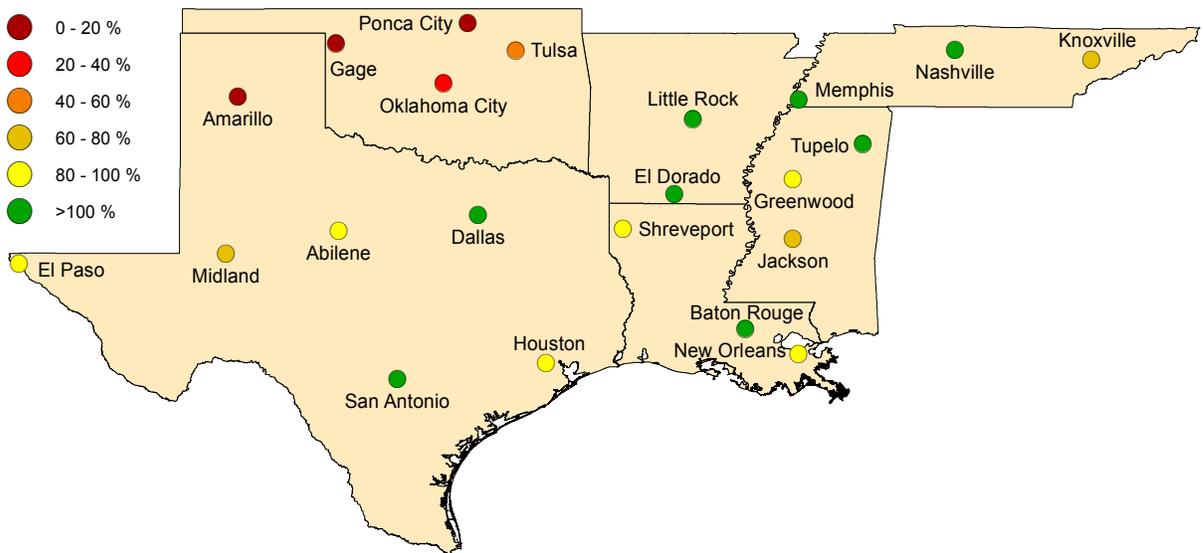
Regional Climate Perspective in Pictures

December Temperature Departure from Normal
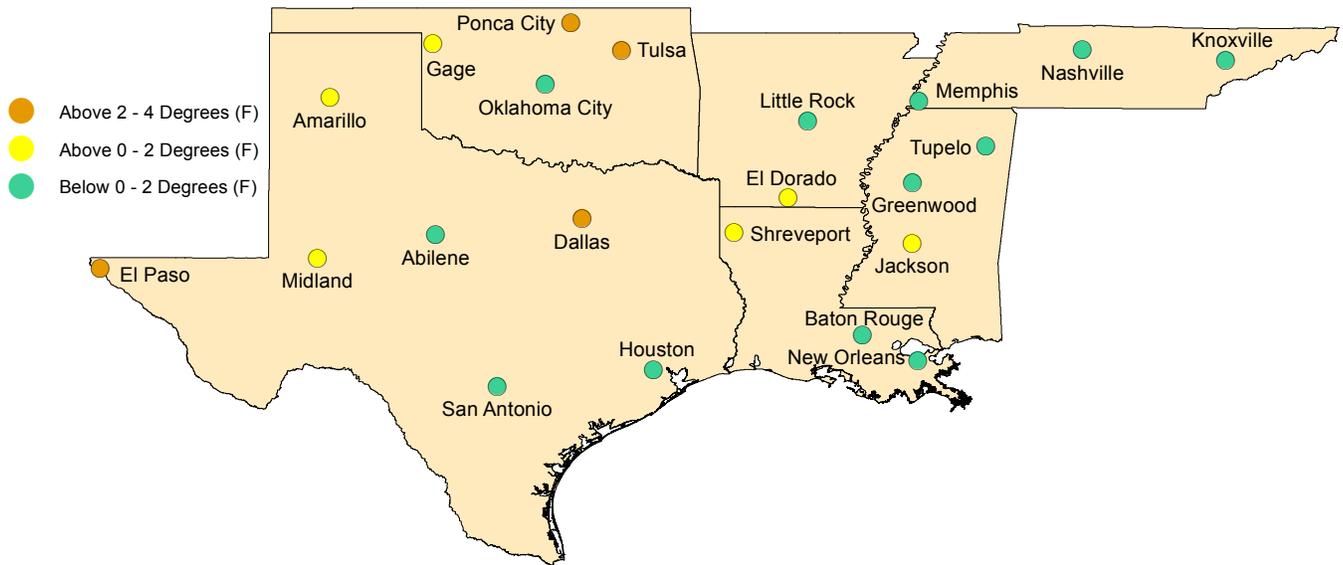
December 2017 Temperature Departure from Normal from 1981-2010 for SCIPP Regional Cities

December Percent of Normal Precipitation

December 2017 Percent of 1981-2010 Normal Precipitation Totals for SCIPP Regional Cities

Climate Perspective

State	Temperature	Rank (1895-2017)	Precipitation	Rank (1895-2017)
Arkansas	42.8	44th Warmest	5.04	41st Wettest
Louisiana	51.1	52nd Warmest	4.83	54th Driest
Mississippi	47.8	44th Warmest	5.24	56th Wettest
Oklahoma	41.1	40th Warmest	0.92	32nd Driest
Tennessee	39.9	52nd Warmest	4.24	54th Driest
Texas	48.2	47th Warmest	1.96	43rd Wettest

State temperature and precipitation values and rankings for December 2017. Ranks are based on the National Climatic Data Center's Statewide, Regional, and National Dataset over the period 1895-2017.

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	56.4	34.9	45.7	0.2	76.0	12/22	22.0	12/09	5.63	0.45	109
Little Rock, AR	52.7	33.4	43.0	0.0	73.0	12/03	15.0	12/28	7.74	2.77	156
Baton Rouge, LA	62.0	43.0	52.5	-0.9	82.0	12/05	26.0	12/31	5.94	0.34	106
New Orleans, LA	63.9	47.2	55.5	-0.1	85.0	12/05	29.0	12/09	5.16	-0.08	98
Shreveport, LA	58.8	38.1	48.5	0.4	80.0	12/22+	23.0	12/09	4.12	-0.65	86
Greenwood, MS	56.6	35.0	45.8	-0.1	78.0	12/22	19.0	12/31	5.28	-0.37	93
Jackson, MS	60.3	39.2	49.7	1.9	82.0	12/22	22.0	12/31	3.67	-1.48	71
Tupelo, MS	53.5	33.3	43.4	-0.7	75.0	12/22	18.0	12/31	6.46	0.18	103
Gage, OK	51.2	21.8	36.5	1.4	78.0	12/03	6.0	12/31	T	-0.89	0
Oklahoma City, OK	50.3	29.3	39.8	-0.8	76.0	12/04+	11.0	12/31	0.68	-1.20	36
Ponca City, OK	49.7	27.6	38.7	2.1	74.0	12/04	7.0	12/31	0.03	-1.39	2
Tulsa, OK	51.1	32.3	41.7	2.2	78.0	12/04	11.0	12/31	1.43	-1.06	57
Knoxville, TN	49.1	32.2	40.6	-0.1	67.0	12/23	17.0	12/31	3.38	-1.12	75
Memphis, TN	51.2	33.6	42.4	-1.2	71.0	12/04	14.0	12/31	7.26	1.52	126
Nashville, TN	49.5	31.0	40.3	-0.1	70.0	12/04	13.0	12/31	4.56	0.32	108
Abilene, TX	55.8	33.4	44.6	-0.7	78.0	12/04	16.0	12/31	1.05	-0.18	85
Amarillo, TX	53.7	23.6	38.7	1.8	77.0	12/03	8.0	12/31	T	-0.71	0
El Paso, TX	61.0	36.0	48.5	3.7	74.0	12/03	24.0	12/08	0.68	-0.10	87
Dallas, TX	59.6	39.9	49.7	2.6	84.0	12/04	22.0	12/08	4.56	1.98	177
Houston, TX	63.4	44.0	53.7	-0.7	81.0	12/22+	29.0	12/08	3.72	-0.02	99
Midland, TX	59.3	32.9	46.1	1.7	79.0	12/04	19.0	12/31	0.39	-0.21	65
San Antonio, TX	62.7	43.0	52.9	0.0	83.0	12/04	28.0	12/31	4.04	2.13	212

Summary of temperature and precipitation information from around the region for December 2017. 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.

Senior Meteorology Student Receives Undergraduate Research Award

Erica Lopez - Student Media Assistant, University of Oklahoma

Ty Dickinson, a senior meteorology student in the School of Meteorology, received the James Bruce Morehead award for undergraduate research in weather and climate. Dickinson received the award during his spring semester before participating in an internship opportunity through the NOAA Ernest F. Hollings Scholarship in the summer. "I was nervous but excited... I was excited to take my experiences from the summer and continue to use them right away," Dickinson said. "This summer I was a research intern at the National Weather Service Weather Forecast Office Austin/San Antonio.

Dickinson's research involves creating an objective process to make and verify impact-based seasonal outlooks. "In Texas, we did this for severe weather, river and flash flooding, and fire weather," Dickinson said. "The main goal of the project is to expand the region of focus to the Southern Plains, which I have dubbed as Texas, Oklahoma, and Kansas, and focus on severe weather. I will apply the same process as I did this summer in creating a seasonal outlook verification index for severe weather and look for correlations between severe weather impacts and the El Niño Southern Oscillation." There are other possible climatic mechanisms that may impact weather such as the dipole between Caribbean Sea surface temperatures (SSTs) and the Gulf of Mexico SSTs that have an effect on the strength of the low-level jet, which Dickinson hopes to investigate further. If time allows, Dickinson also hopes to collaborate with several NWS offices and forestry services to improve the fire weather index. This research is a nice blend of weather and climate according to Dickinson, which is very enjoyable for him. "I am focusing on severe weather and its impacts while also examining it from a climatology perspective. To me, it is the best of both worlds!" Dickinson said. "I see myself working to improve our prediction of weather based on the impacts of various climate modes. I believe it is one of the integral next steps in improving atmospheric predictability". Dickinson has collaborated with forecasters from NWS Austin/San Antonio and is working directly with Dr. Cameron Homeyer and a few others. "I have collaborated with so many people to get their thoughts and inputs on since these types of outlooks have never been done before." Dickinson says. "I owe huge thank you to my mentor, Dr. Larry Hopper, the best mentor I could have asked for and he has helped me grow as a person and scientist."

The award was left to the college by retired USAF Col. James B. Morehead, a former Sooner and one of the most highly decorated Ace fighter pilots of World War II. Colonel Morehead was born and raised in Oklahoma and had a distinguished military career, followed by a successful work in real estate. He dedicated a portion of his estate to support the research endeavors of the OU College of Atmospheric and Geographic Sciences, and his legacy allows young researchers such as Ty to study and solve complex problems. We thank the Morehead family for their support of the study of atmospheric sciences at the University of Oklahoma.

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From Our Partners

USDA Southern Plains Climate Hub:

December 13, 2017 : Southern Plains Climate Hub team members Clay Pope and David Brown organized and facilitated the 2016-2017 Kansas and Oklahoma Wildfire Assessment Stakeholder Listening Session held on December 13, 2017 at the ARS station in Woodward OK in partnership with the Southern Climate Impacts Planning Program (SCIPP). Approximately two dozen ranchers, cattlemen, fire managers, conservation district officials, and state and federal agency representatives participated in a series of semi-structured discussions regarding post-wildfire recovery and preparedness.

This event will be followed up with a larger agriculture producer meeting to be held in the Panhandle on Feb. 13. The Hub also hopes to pursue additional training opportunities for both prescribed burn associations and volunteer rural fire departments through the course of 2018. For more information contact Clay Pope, USDA Southern Plains Climate Hub Coordinator at 405-699-2087 or claygpope@gmail.com

Southern Climate Monitor

Contact Us

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 & 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)578-5021.

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