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In This Issue:

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Seasonal Predictability of Freezing Rain?

Dr. Esther Mullens, Southern Central Climate Science Center

Have you ever heard a statement a little like this: '*There's an El Niño this winter, I guess we're going to have more ice...*' Ever since I've lived in Oklahoma, I've heard sayings such as these, and I've wondered to what extent it might be true. Certainly, if you were around last winter in the El Reno area, you could easily believe it. According to NOAA, the El Niño that developed Spring 2015 intensified over the winter to become one of the strongest on record. In the southern United States, the December 2015 to February 2016 mean temperature was much above average. Nonetheless, despite a conspicuous lack of snow for much of Oklahoma, areas just west and north of Oklahoma City were impacted by two ice storms in the space of a month, leading to widespread power outages, tree damage, and several house fires, according to news reports. A single event, or even a small cluster of significant events, does not necessarily imply a link, but it got me to thinking: (1) Does our data support increased frequency of freezing rain during El Niño winters, and (2) What other types of natural variability may influence freezing rain frequency? Is there the potential to develop seasonal forecasts for ice storm risks?

Let's review our winter precipitation types: For both snow and freezing precipitation to accumulate, the surface air temperature should be at or less than freezing. With snow, the temperatures throughout the lower part of the atmosphere are also below freezing, leading to the formation of ice crystals that aggregate into snowflakes. Snow often occurs to the north and west of a mid-latitude cyclone in the presence of strong lift and ample moisture. Freezing rain also needs lift and moisture, but forms when a layer of the lower atmosphere is above freezing, supporting the melting of snow into liquid water. A shallow layer of sub-freezing air at the surface leaves little time for this water to freeze into an ice pellet or snow, and it hits the ground as a supercooled liquid drop. Conditions favorable for freezing rain are not uncommon in the Southern Plains, as cold arctic air is often shallow here, and the nearby Gulf of Mexico provides a ready supply of warm moist air. The depth and frequency of cold air outbreaks into our region are likely influenced by large-scale climate variability. However, as far as relating winter precipitation types to large-scale circulation, not much has been done. What little research that is available is also not for the Southern Plains. This may be because the south experiences winter weather much less frequently than other areas, and so drawing out enough events for a representative statistical sample is more difficult. The Northeast U.S. has had better luck (or not...if you don't like winter). Durkee et al. (2008) noted that the North Atlantic Oscillation, an atmospheric teleconnection that impacts storm tracks and cold air outbreaks in the Euro-Atlantic zone, modulates the proportion of precipitation falling as snow versus rain in the Northeast. Dupigny-Giroux (1999) looked at cases of ice and snow storms, and identified some synoptic and large-scale differences in atmospheric flow, including the El Niño Southern Oscillation (ENSO), however the strength of any relationship was inconclusive. Kovacik (2014) evaluated how the spatial location and frequency of ice storms in the Northeast were impacted by four teleconnections: ENSO, The Arctic Oscillation (AO), North Atlantic Oscillation (NAO), and the Atlantic Multidecadal Oscillation (AMO). That work identified some spatial shifts, typically north and south modulation on ice storm occurrence, associated with phases of the AMO and ENSO.

Feeling motivated by these studies, and my own forays into the dynamics of ice storms (Mullens et al. 2016a,b), I decided to do a little analysis of my own. However, freezing rain is a pain, and I'm not just talking about that moment when you unload ten cans of deicer just to get into your car (best stay home!). Since ice has the habit of freezing everything it touches, the equipment responsible for logging precipitation type and amount can also struggle in particularly adverse conditions, or when a power interruption occurs. Climate-length (30 years or more) data records for freezing rain are based on National Weather Service (NWS) automated stations (ASOS), and cooperative observers (COOP). Prior to 1993, precipitation type was typically reported by an observer, but is now recorded by instrument. The most complete and extensive temporal records are available from 'first-order' stations sited in the larger cities, typically near the airport. Fortunately for me, Changnon (2004) has compiled hourly and daily freezing rain reports from NWS stations into a dataset, extending back into the 1930's at some locations, to the year 2001. From this product I gathered hourly freezing rain counts from six stations across the region: Amarillo TX, Wichita KS, Oklahoma City OK, Dallas Fort Worth TX, Little Rock AR, and Springfield MO. Hourly counts were accumulated from December through February ('boreal winter') for each available year.

The next step was to determine which modes of climate variability might play a role in modulating freezing rain frequency. As per my research question, ENSO was at the top of the list. The Arctic Oscillation made the cut, based on its connection to the polar vortex. The AMO was also included, based on the work of Kovacik. This teleconnection evolves much more slowly, and results in warmer or cooler north Atlantic sea surface temperatures over multiple decades. Many of the other patterns therefore superimpose on this slowly varying oscillation. Finally, the Pacific North American (PNA) pattern was considered, as it is a prominent mode of variability over the U.S that influences the potential for blocking over the north Pacific, with associated downstream effects on weather systems and their movement. Table 1 provides some additional information on each of these teleconnections, including brief descriptions of their known effects in the Southern Plains. This is by no means an exhaustive list of potentially impactful natural variability, but it's a good first start.

I began by simply plotting the

Teleconnection and Periodicity	Data Source/Description	Positive Phase	Negative Phase
El Niño Southern Oscillation (ENSO) (2-7 years)	Climate Prediction Center 'Oceanic Nino Index' (ONI) – 3 month running mean of east central Pacific SST anomalies	Cooler to average winter temperatures, and wetter (El Niño). Southerly storm track	Warmer and drier winters (La Niña). Increased blocking northwest Pacific, and variable storm track
Atlantic Multidecadal Oscillation (AMO) (20-50 years)	NOAA ERSL, smoothed monthly north Atlantic SST anomalies (0-70°N)	Warm N. Atlantic SSTs. Generally linked to drought in the Southern Plains, particularly when the Pacific SSTs are cooler.	Cool N. Atlantic SSTs. Generally wetter conditions over the Southern Plains, particularly when Pacific SSTs are warmer.
Pacific North American Pattern (PNA) (sub-seasonal to interannual)	Climate Prediction Center. Pattern from a Rotated principal component of the standardized 500 hPa height field 20-70°N, which is interpolated and regressed to obtain monthly indices	Ridging over the western U.S. Above average temperatures in the west, and increased cold air outbreaks in the east, including the Plains.	Troughing in the western U.S, and a ridge over the SE U.S. Warmer temperatures in the southeast, cooler in the west.
Arctic Oscillation (AO) (sub-seasonal to interannual)	Climate Prediction Center. Pattern is the leading mode of variability of monthly 1000 hPa height anomalies north of 20°N. Indices generated by projecting mean height anomalies onto this mode.	Strong polar vortex and maid-latitude storm track. Generally drier and neutral to warmer than average winter temperatures in the Southern Plains.	Weak polar vortex. Results in high-amplitude flow and more frequent cold air outbreaks into the Plains.

Table 1: The analyzed Teleconnections, the source of the data, and their archetypal impacts for the U.S and the Southern Plains.

timeseries of boreal winter ice hours against the AMO. The result was intriguing, shown in Figure 1 for Oklahoma City. The frequency of freezing rain was generally *higher during positive AMO years* (1930-60, 1995-present), and when smoothed *generally co-varied with the winter AMO index*. While this dataset ends in 2001, we

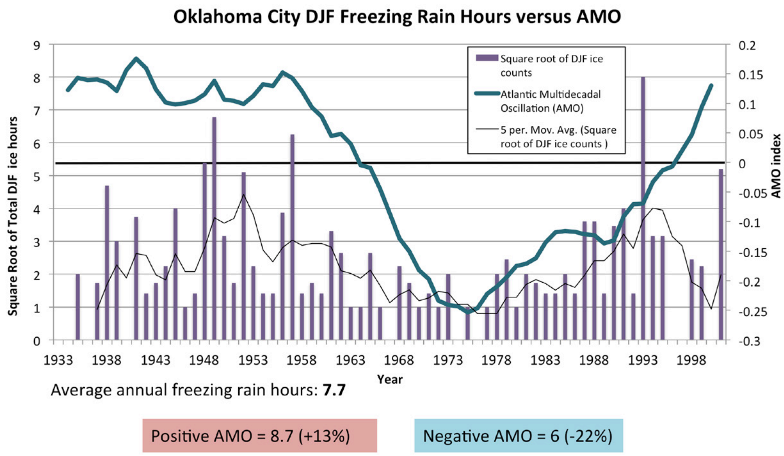


Figure 1. The square root of total boreal winter freezing rain hours in Oklahoma City, OK, plotted against the smoothed AMO index. The square root used to constrain peak magnitudes for better visual representation of interannual variability. The mean number of ice hours during positive (n=34) and negative (n=33) AMO phase is also shown. www.ncdc.noaa.

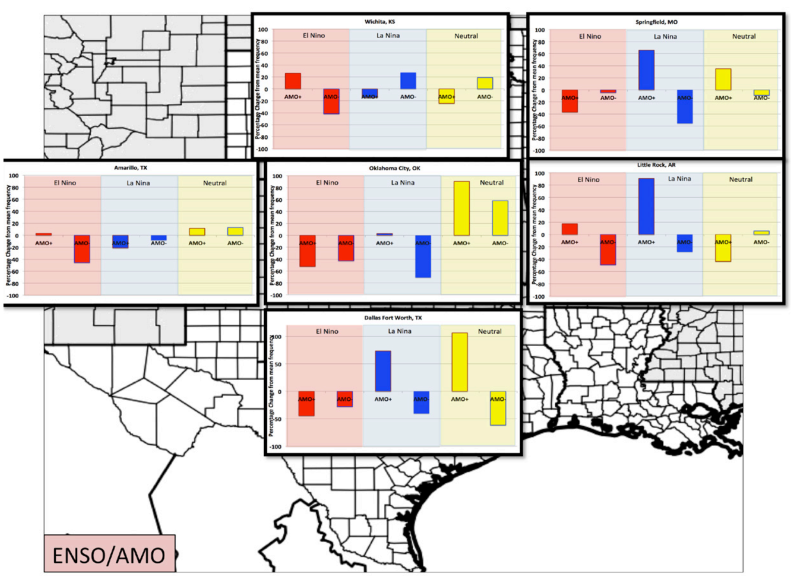


Figure 2: Percentage difference in mean winter freezing rain hours associated with positive, negative, and neutral ENSO (modulated by AMO phase) for the six stations. The total mean number of freezing rain hours for each station (1950-2001): Amarillo (5.2), Wichita (7.4), Oklahoma City (7.5), Dallas Fort Worth (4.7), Springfield (13.9), and Little Rock (6.8).

can take it from experience that freezing rain frequencies were variable, but occasionally substantial, during the 2000s. Armed with this information, it seemed appropriate to examine the role of other teleconnections superimposed on AMO phase. For each year, the phase of each pattern was determined by taking the boreal winter mean. For all except the AMO (where the positive and negative index threshold was zero), the index value cut off was ≥0.5 and ≤-0.5 for positive and negative phase respectively. Neutral conditions were assumed between these thresholds. Although the AMO data extended back to the 1900s, other teleconnection indices began in 1950. For most stations, the period 1950-2001 was used, apart from Wichita, whose record started in 1955. This constrains the sample of positive AMO years to be approximately 40% less than negative AMO years (50% for Wichita). The number of boreal winter ice hours were calculated for each phase, and averaged by the total number of years the applicable teleconnection(s) occurred, to create an event-weighted average. Event years ranged from 2 (AMO+, AO+) to 16 (AMO-, PNA-) with a mean of 9 years. Finally, the data was expressed as a percentage difference from the mean freezing rain frequency obtained over the duration of record. Figure 2, 3 and 4 show the results for each station site for ENSO, PNA, and AO respectively.

Let's break down the key information:

1. *There is little evidence to support increased ice storms with El Niño (Fig. 2).* Now, to be fair, I considered the frequency of freezing rain, not ice storms explicitly. Nevertheless, it appears that this myth is busted. For most stations, ENSO neutral or La Niña years bring as least as much

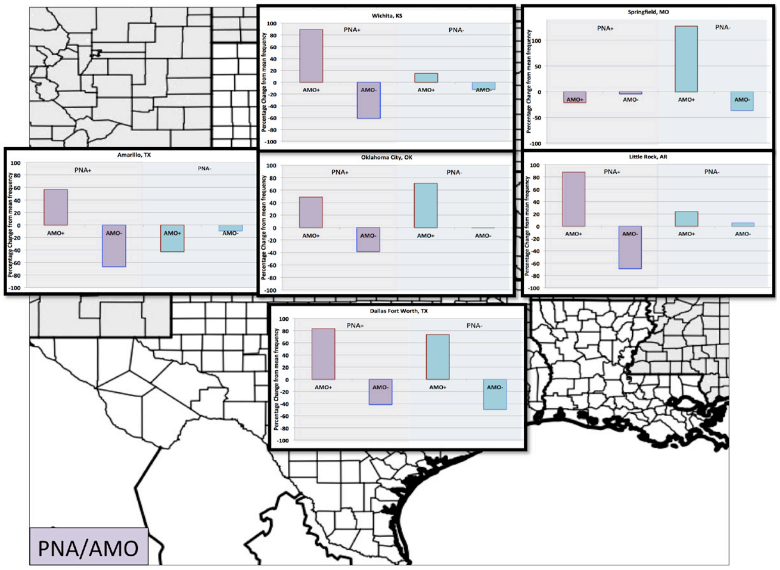


Figure 3. Similar setup to Fig. 2, but for positive and negative PNA pattern.

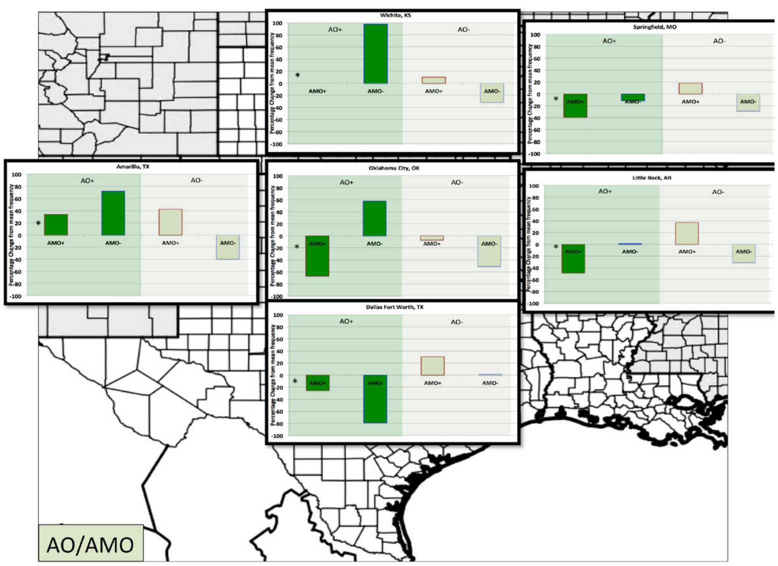


Figure 4. Similar setup to Fig. 2, but for positive and negative AO. The asterisk against the positive AO/AMO indicates that the sample size was small (n=2), and so the results should be interpreted with caution.

chance, and typically more chance of freezing rain in locations such as Oklahoma City, Dallas Fort Worth, Springfield, and Amarillo. It's also interesting to observe the extent to which the AMO phase modulates freezing rain frequencies during ENSO. For example, La Niña episodes during a positive AMO are associated with over twice as many freezing rain hours than those during a negative AMO, for all stations apart from Wichita and Amarillo.

2. *The AMO modulates freezing rain frequencies associated with each teleconnection, favoring more ice in positive phase at most stations (Figs 2-4).* Dallas Fort Worth, for example, shows much higher freezing rain frequencies during a positive AMO for ENSO neutral, La Niña, and both PNA phases. All stations except for Springfield indicate that freezing rain is more likely during positive PNA years with a positive AMO, as oppose to negative AMO. Greater than average freezing rain frequencies are also associated with negative PNA years during a positive AMO for Oklahoma City, Dallas Fort Worth, and Springfield (Fig. 3). The number of positive AMO with positive AO years is low in this time series (n=2), so no conclusions can be drawn, however, the negative AO phase also favors more freezing rain during a positive AMO (Fig. 4).

3. *Patterns such as the AO and PNA may affect the spatial location of freezing rain (Fig. 3 and 4).* Over the central Southern Plains, with a positive AMO there is about an equal chance of freezing rain (both higher than average), shifting to a substantial preference for negative PNA in Springfield, and positive PNA in Amarillo (the trend is generally reversed and weakened during a negative AMO). This implies that a positive (negative) PNA may be more conducive to ice in the western (northeastern) Southern Plains. A negative AO is more conductive to freezing rain in the south (Dallas Fort Worth) regardless of AMO, and also in the east during a positive AMO.

Clearly, these large-scale modes of variability have some influence of freezing rain frequency. Some of these differences appear large, but have not yet been assessed for statistical robustness. Furthermore, while most stations have upwards of 50 years of data, we could always benefit from a larger sample. It is unclear whether these trends would persist when extending the record to present day, particularly in light of an underlying warming trend associated with anthropogenic climate change. One big question that also may be on your mind is *why*? What are the physical mechanisms that may support more or less freezing rain due to these atmospheric and oceanic modes? We could contend that a warmer ocean during a positive AMO provides an enhanced reservoir of warm moist air that could maintain or enhance a low-level warm layer. Ideally, we'd want more than one single oscillation of the AMO to compare with, but freezing rain records do not extend that far. Furthermore, a positive PNA and negative AO both increase the potential for cold air outbreaks supplying the sub-freezing surface air further to the south and east in the Plains. There is also the question of how snow could be modulated by climate variability, and to what extent it co-varies or opposes the behavior shown for freezing rain. In order to investigate these processes, we could examine event-based or sub-seasonal evolutions of winter storms associated with each of these large-scale drivers. If this is of interest to you, then you may be in luck! To supplement current resources, we have compiled and validated a reanalysis-based gridded freezing precipitation dataset from 1979-2015 (Mullens and McPherson 2017) that could be used for spatial and synoptic analyses of freezing precipitation and it's attendant meteorological environment.

My main takeaway from this preliminary work is that there is *potential* for seasonal or sub-seasonal predictability for freezing rain frequency, insofar as we are able to adequately predict the important modes of large-scale variability examined here, and can identify the physical connection. Future work should identify the robustness of the links established by this preliminary work, particularly on the sub-seasonal scale, that could supply seasonal forecasts for the benefit of public safety, energy agencies, and other sectors that use this information in their hazard planning.

References

Changnon S.A., 2004: Long-term datasets about Freezing Rain and Ice Storms in the United States. Dataset. Available at [https://www.ncdc.noaa.gov/nespls/olstore.prodspecific?prodnum=5035]

Dupigny-Giroux, 1999: The influence of the El Niño Southern Oscillation and other teleconnections on winter storms in the North American Northeast – a case study. Physical Geography, 20, 394-412. DOI: 10.1080/02723646.1999.10642685

Durkee, J. D., J. D. Frye, C. M. Fuhrmann, M. C. Lacke, H. G. Jeong, and T. L. Mote, 2008: Effects of the North Atlantic Oscillation on precipitation-type frequency and distribution in the eastern United States. Theoretical and Applied Climatology, 94, 51-65. DOI: 10.1007/s00704-007-0345-x

Kovacik, C. 2014: Changes in ice storm frequency, Southern Climate Impacts Planning Program report, Available at [http://www.southernclimate.org/pages/news/changes-in-ice-storm-frequency]

Mullens, E.D., and McPherson R.A, 2017: A Multi-algorithm reanalysis-based freezing precipitation dataset for climate studies in the South-Central U.S. J. Appl. Meteor. Clim, Accepted

Mullens, E. D., L. M. Leslie, and P. J. Lamb, 2016b: A synoptic climatology of ice and snow storms in the Southern Great Plains 1993-2011. Weather and Forecasting, 31, 1109-1136, doi: http://dx.doi.org/10.1175/WAF-D-15-0172.1.

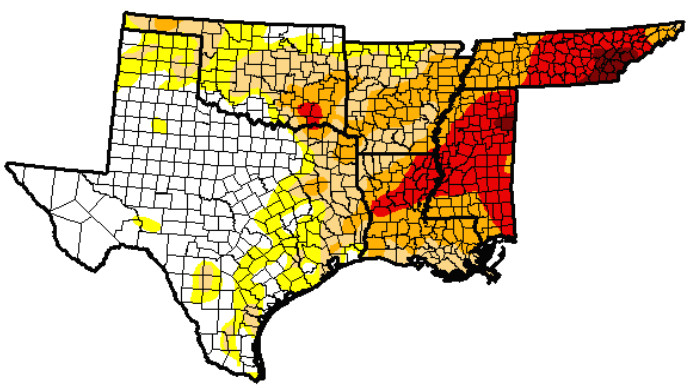
Mullens, E. D., L. M. Leslie, and P. J. Lamb, 2016a. Impact of Gulf of Mexico SST anomalies on Southern Plains freezing precipitation: WRF-ARW sensitivity study of the January 28-30 2010 winter storm. Journal of Applied Meteorology and Climatology, doi: http://dx.doi.org/10.1175/JAMC-D-14-0289.1.

Drought Update

Luigi Romolo,
Southern Regional Climate Center

Drought conditions over the month of November have deteriorated in the Southern Region. This is primarily due to the combination of the higher water demand produced by above normal temperatures, and a significant lack in precipitation. Though the amount of total drought coverage has changed little over the past month, the severity of the drought areas has changed significantly. Over the past month, the amount of areal coverage of extreme drought (D3) or worse has increased from 3.60 percent at the start of the month, to just over 13 percent near the end of the month. Extreme drought is currently observed in central Louisiana, central and eastern Tennessee, and over the majority of Mississippi. The state of Arkansas has also observed an increase in the amount of severe drought (D2) or worse.

Twenty people were reported injured when a tornado touched down in McMinn County, Tennessee on November 29, 2016. The twister developed near the intersection of county roads 700 and 705. This tornado was a part of a larger tornadic outbreak from a squall line that resulted in dozens of tornadoes spanning Louisiana, Mississippi, Alabama and Tennessee.



Released Thursday, December 1, 2016
Richard Heim, NCEI/NOAA

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	35.60	64.40	49.52	32.07	13.67	1.34
Last Week *11/22/2016*	37.62	62.38	49.11	36.57	14.45	1.34
3 Months Ago *8/30/2016*	82.95	17.05	5.45	1.28	0.00	0.00
Start of Calendar Year *12/29/2015*	97.72	2.28	0.00	0.00	0.00	0.00
Start of Water Year *9/27/2016*	76.89	23.11	6.74	1.89	0.28	0.11
One Year Ago *12/1/2015*	96.28	3.72	0.00	0.00	0.00	0.00

Intensity:

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

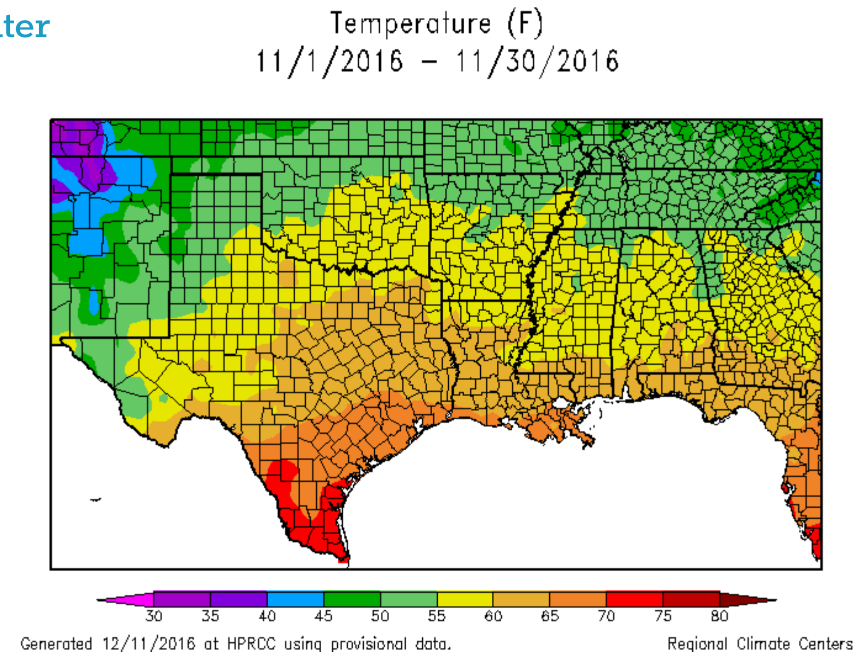
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Above: Drought conditions in the Southern Region. Map is valid for November 29 , 2016. Image is courtesy of National Drought Mitigation Center.

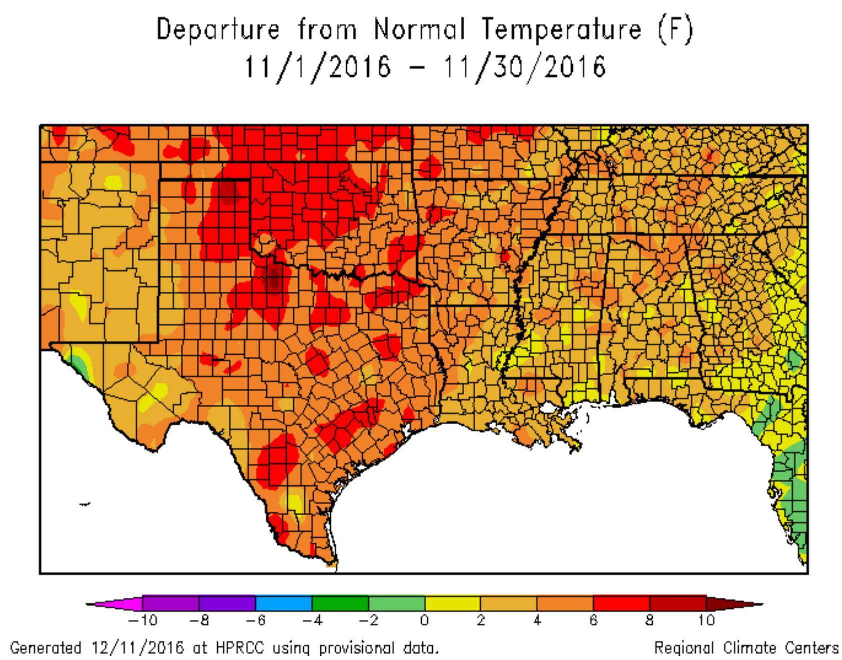
Temperature Summary

Luigi Romolo,
Southern Regional Climate Center

As was the case in October, 2016, all six states in the Southern Region posted state-wide average monthly temperatures that were much warmer than normal. Three states, Arkansas, Oklahoma, and Texas all recorded their top five warmest November on record. The remaining three states of Louisiana, Mississippi, and Tennessee all experienced monthly temperatures in their top 20 of all Novembers on record. In Arkansas, Louisiana, Mississippi and Tennessee, temperatures ranged from 2-6 degrees F (1.11-3.33 degrees C) above normal. In the western states of Oklahoma and Texas, temperatures ranged from 2-8 degrees F (1.11-4.44 degrees C) above normal. The statewide monthly average temperatures were as follows: Arkansas reporting 55.60 degrees F (13.11 degrees C), Louisiana reporting 62.00 degrees F (16.67 degrees C), Mississippi reporting 58.30 degrees F (14.61 degrees C), Oklahoma reporting 55.50 degrees F (13.06 degrees C), Tennessee reporting 52.60 degrees F (11.44 degrees C), and Texas reporting 61.10 degrees F (16.17 degrees C). The state-wide temperature rankings for May are as follows: fifth warmest for Arkansas, thirteenth warmest for Louisiana, fifteenth warmest for Mississippi, second warmest for Oklahoma, eleventh warmest for Tennessee, and second warmest for Texas. All state rankings and records are based on the period spanning 1895-2016.



Average November 2016 Temperature across the South

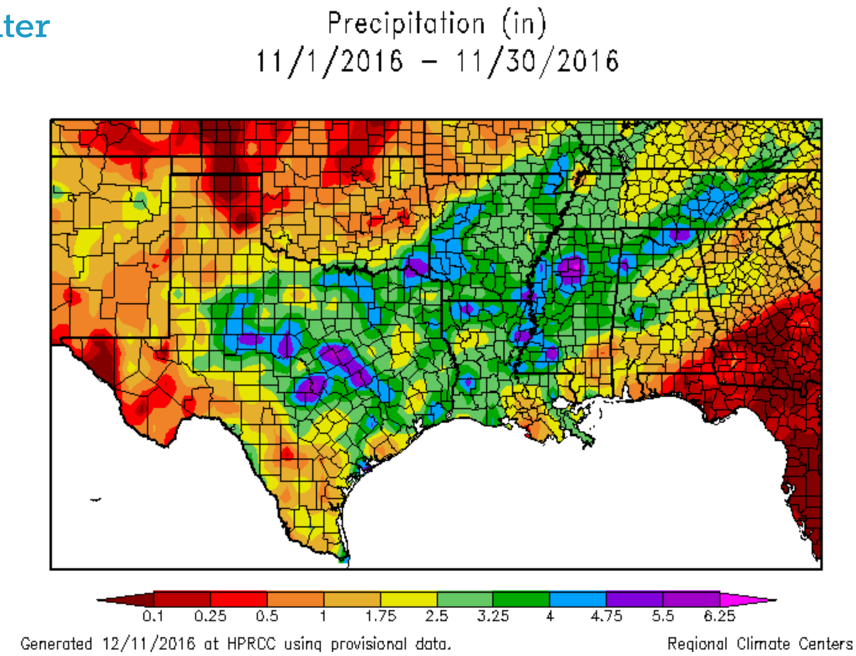


Average Temperature Departures from 1971-2000 for November 2016 across the South

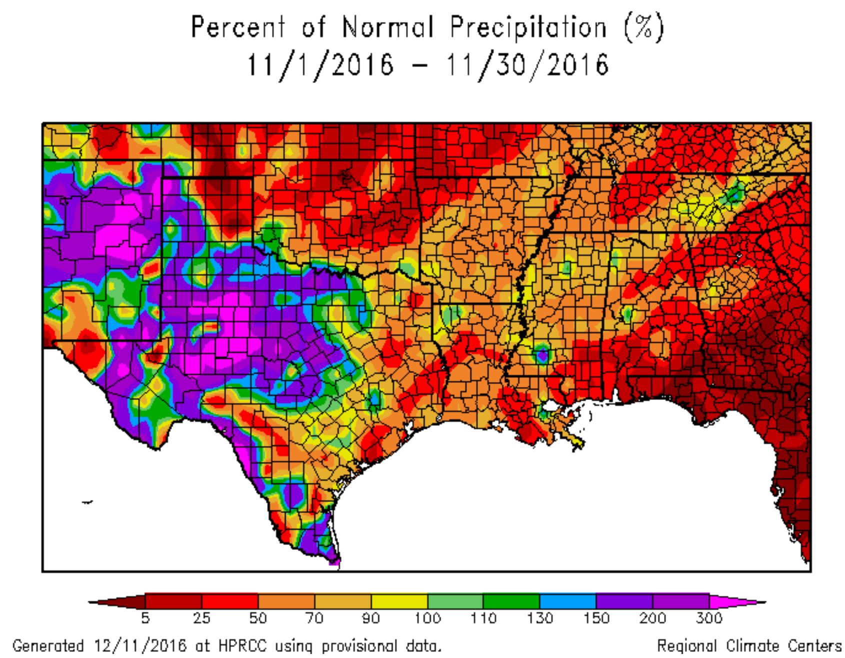
Precipitation Summary

Luigi Romolo,
Southern Regional Climate Center

With the exception of west-central Texas, the Southern Region experienced a third consecutive drier than normal month. Precipitation totals ranged from 50 to 70 percent of normal in Louisiana, Arkansas, Mississippi, and Tennessee. In Oklahoma, conditions were slightly drier, with many stations reporting less than half the expected precipitation, particularly in the north eastern quadrant of the state. In Texas, conditions were generally quite wet in the west central counties, with most stations reporting over twice the amount of normal precipitation. The state-wide precipitation totals for the month are as follows: Arkansas reporting 3.25 inches (82.55 mm), Louisiana reporting 3.07 inches (77.98 mm), Mississippi reporting 3.14 inches (79.76 mm), Oklahoma reporting 1.24 inches (31.50 mm), Tennessee reporting 3.10 inches (78.74 mm), and Texas reporting 2.30 inches (58.42 mm). The state precipitation rankings for the month are as follows: for Arkansas it was the forty-sixth driest, for Louisiana it was the forty-third driest, for Mississippi it was the forty-first driest, for Oklahoma it was the forty-first driest, for Tennessee it was the thirty-eighth driest , and for Texas it was the thirty-seventh wettest. All state rankings are based on the period spanning 1895-2016.

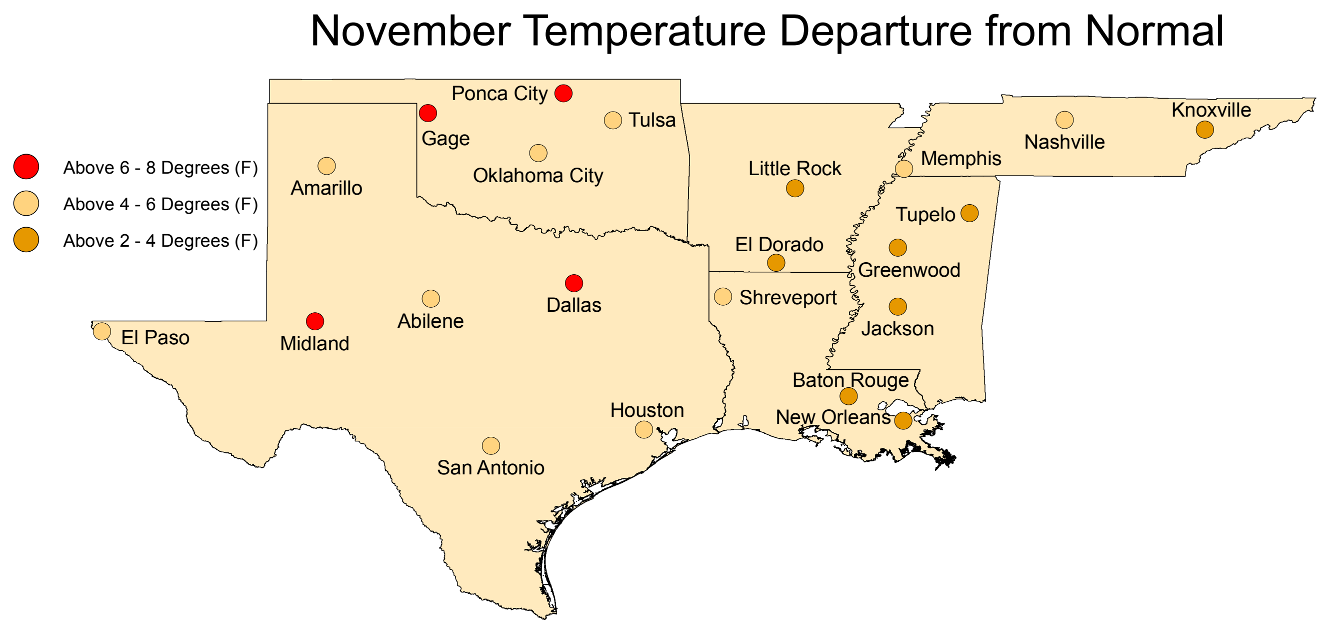


November 2016 Total Precipitation across the South

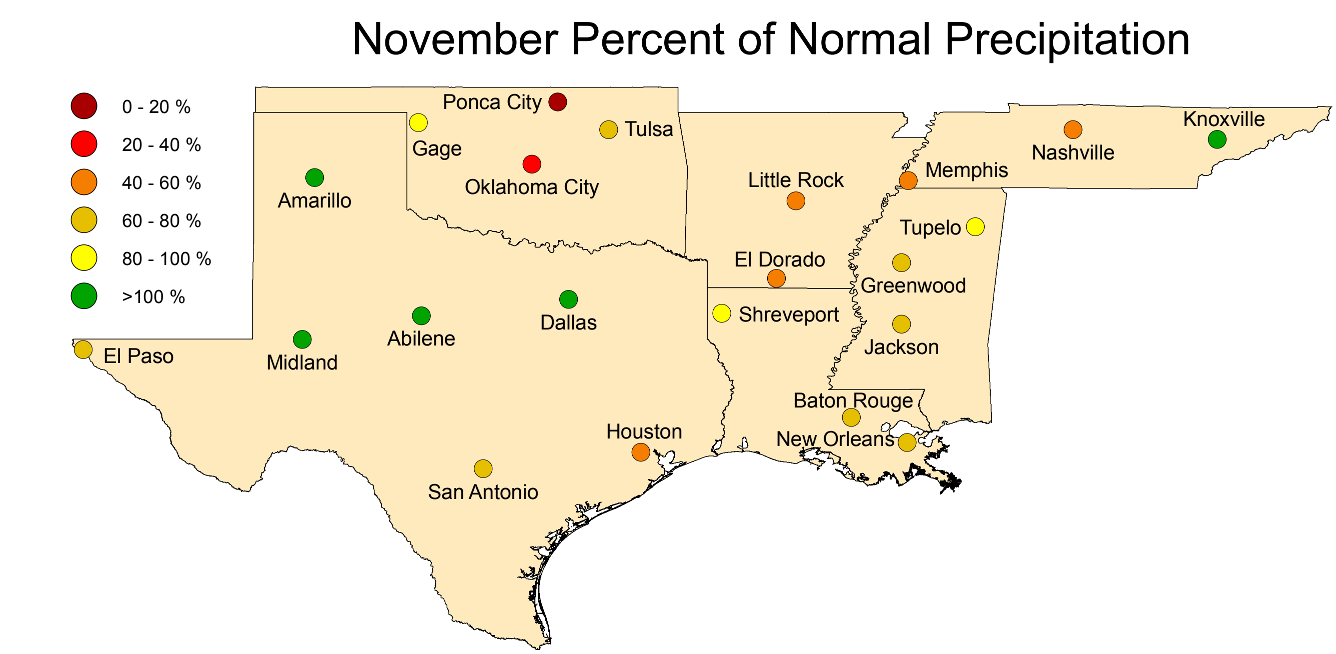


Percent of 1971-2000 normal precipitation totals for November 2016 across the South

Regional Climate Perspective in Pictures



November 2016 Temperature Departure from Normal from 1971-2000 for SCIPP Regional Cities



November 2016 Percent of 1971-2000 Normal Precipitation Totals for SCIPP Regional Cities

Climate Perspective

State	Temperature	Rank (1895-2011)	Precipitation	Rank (1895-2011)
Arkansas	55.60	5th Warmest	3.25	46th Driest
Louisiana	62.00	13th Warmest	3.07	43rd Driest
Mississippi	58.30	15th Warmest	3.14	41st Driest
Oklahoma	55.50	2nd Warmest	1.24	41st Driest
Tennessee	52.60	11th Warmest	3.10	38th Driest
Texas	61.10	2nd Warmest	2.30	37th Driest

State temperature and precipitation values and rankings for November 2016. 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								Precipitation (inches)		
	Averages				Extremes				Totals		
	Max	Min	Mean	Depart	High	Date	Low	Date	Obs	Depart	%Norm
El Dorado, AR	69.9	44.5	57.2	3.3	83	11/16	29	11/20	2.78	-2.11	57
Little Rock, AR	66.7	43.6	55.1	2.5	83	11/01	29	11/20	2.56	-2.72	48
Baton Rouge, LA	76.4	50.9	63.6	3.2	89	11/04	32	11/21	2.59	-1.51	63
New Orleans, LA	75.4	57.2	66.3	3.6	88	11/04+	38	11/21	2.77	-1.72	62
Shreveport, LA	73.6	49.4	61.5	5.1	87	11/02+	32	11/20	4.36	-0.17	96
Greenwood, MS	71.3	42.1	56.7	2.4	87	11/01	26	11/20	3.61	-0.91	80
Jackson, MS	73.9	44.8	59.4	3.6	87	11/02+	27	11/21	3.63	-1.13	76
Tupelo, MS	70.6	42.5	56.5	3.6	88	11/01	25	11/27	4.65	-0.05	99
Gage, OK	68.4	38.5	53.4	7.7	89	11/16	18	11/19	0.97	-0.15	87
Oklahoma City, OK	68.0	44.6	56.3	5.6	86	11/16	27	11/26	0.52	-1.46	26
Ponca City, OK	68.5	41.6	55.0	7.3	87	11/16	24	11/26	0.14	-1.67	8
Tulsa, OK	67.7	44.7	56.2	5.9	85	11/02	28	11/26	1.88	-0.93	67
Knoxville, TN	66.2	40.7	53.5	3.8	85	11/01	25	11/27+	5.78	1.77	144
Memphis, TN	68.2	46.5	57.4	4.2	85	11/03+	33	11/27+	2.56	-2.93	47
Nashville, TN	67.6	43.0	55.3	5.5	88	11/01	26	11/27+	1.87	-2.44	43
Abilene, TX	70.3	49.8	60.0	5.4	88	11/01	31	11/19	2.51	1.10	178
Amarillo, TX	66.3	38.1	52.2	5.9	83	11/16+	19	11/19	1.10	0.30	138
El Paso, TX	68.9	46.5	57.7	4.6	81	11/01	26	11/30	0.39	-0.10	80
Dallas, TX	72.9	54.1	63.5	6.9	88	11/01	37	11/20	3.22	0.51	119
Houston, TX	77.9	55.5	66.7	4.4	88	11/03+	36	11/20	1.99	-2.35	46
Midland, TX	69.2	48.8	59.0	6.1	90	11/01	29	11/30	2.01	1.32	291
San Antonio, TX	76.4	56.4	66.4	5.3	87	11/02+	34	11/20	1.79	-0.49	79

Summary of temperature and precipitation information from around the region for November 2016. 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.

2016 Hurricane Season Comes to a Close

Barry Keim, Louisiana State Climatologist, Louisiana State University

The 2016 hurricane season is now in the record books (Figure 1). It ends with 15 named storms, 7 hurricanes, and 3 major hurricanes (Category 3-5). At the beginning of the season, NOAA predicted between 10-16 named storms, so I guess they achieved success. Klotzbach from Colorado State University initially predicted 14 named storms for 2016 at the start of the season, which was upgraded to 15 in his July 1st update. That is a quite impressive forecast and I definitely call that a success!

The season officially began with Hurricane Alex, which formed on January 13th, making it one of the earliest hurricanes on record, and it ended, we think (we could still get a December storm) on November 25th with the close of Hurricane Otto, which moved from the Caribbean to the Pacific Ocean after crossing over Nicaragua and Costa Rica in late November. The most serious of the 2016 storms was Hurricane Matthew which attained Category 5 status, and was the 1st Category 5 hurricane in the Atlantic Basin since Hurricane Felix in 2007. Matthew wreaked havoc on Haiti, Cuba, and the Dominican Republic, before heading up the East Coast and having serious impacts on Florida, Georgia, and the Carolinas. And did I mention that if affected the LSU-Florida football game that was supposed to take place in "the swamp"? I guess that is a topic for another section of the paper! In the U.S, the storm (Matthew) hugged the Florida coast as a major hurricane, but it never made landfall. It eventually came on shore in South Carolina as Category 1 storm. Interestingly, the U.S. has now gone for 11 straight hurricane seasons without a major hurricane making landfall on our shores. This is longest period on record for the U.S. coast, as the previous record was 8 straight seasons over a century ago from 1861-1868. For the Gulf Coast, this ties a record dating back to the period from 1861 to 1872, when the U.S. Gulf Coast went without a major hurricane. Just for the record, the last major hurricane to make a U.S. landfall was Hurricane Wilma, which did so in south Florida on October 24, 2005. YUP, the same season on Hurricanes Katrina and Rita. That is truly a season I think we'd all like to forget. However, I am growing accustomed to these seasons without a major hurricane landfall, with hopes of the trend continuing to the 2017 season. E-mail me with questions or feedback at keim@lsu.edu.

Saffir-Simpson Scale

The chart color codes intensity (category based on Saffir-Simpson scale):

Type	Category	Pressure (mb)	Winds (knots)	Winds (mph)	Line Color
Depression	td	-----	< 34	< 39	Green
Tropical Storm	TS	-----	34-63	39-73	Yellow
Hurricane	1	> 980	64-82	74-95	Red
Hurricane	2	965-980	83-95	96-110	Light Red
Hurricane	3	945-965	96-112	111-130	Magenta
Hurricane	4	920-945	113-135	131-155	Light Magenta
Hurricane	5	< 920	>135	>155	White

NOTE: Pressures are in millibars and winds are in **knots** where one knot is equal to 1.15 mph

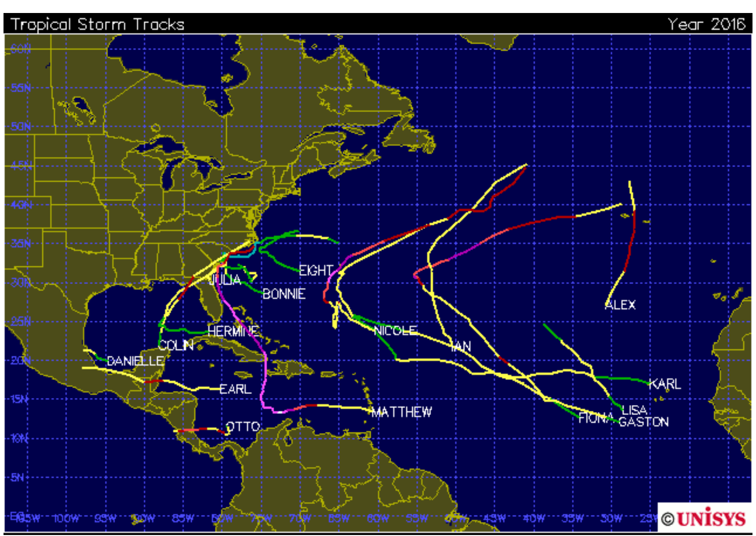


Figure 1. Tracks and intensities of all 2016 Atlantic Basin tropical storms and hurricanes. Image is from the Unisys and can be found at http://weather.unisys.com/hurricane/atlantic/2016/index.php.

Southern Climate Monitor Team

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

Gina Fujan, Student Assistant SCIPP (OU)

Margret Boone, Program Manager SCIPP (OU)

Alan Black, Program Manager SCIPP (LSU)

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