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Photos by Katy Christian

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Southern Climate Impacts Planning Program

A NOAA RISA Team

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Understanding the Role of Ammonia in Air Quality

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Understanding the dynamics of air pollution is vital to the health of all Americans. In the cities that struggle with poor air quality, many people are exposed to air pollutants on a daily basis. Keeping track of ammonia (NH_3) in the atmosphere is important for determining the quality of air within a region. Most of the excess NH_3 in the environment originates from agricultural activities such as livestock waste and fertilizer application. While surface runoff and leaching into inland and coastal waters are the most visible pathways for NH_3 to enter other systems, volatilization directly into the atmosphere accounts for as much as 50% of ammonia loss under certain conditions[1]. In addition, motor vehicles emit NH_3 in their exhaust and are the primary source of NH_3 in some urban areas[2]. NH_3 has a relatively short atmospheric residency time of about 24 hours and usually is deposited near its emission source. However, NH_3 has a much broader impact when it is allowed to react with sulfur dioxide and nitric acid to produce ammonium particulates. These reactions prolong the atmospheric residency time of NH_3 to approximately 15 days and expand the deposition range by hundreds of kilometers. In the southeastern US alone, nearly half of all fine particulate matter ($PM_{2.5}$) consists of ammonium particulates[3]. $PM_{2.5}$ is small enough to be inhaled into the lungs and is linked to various respiratory illnesses, including asthma in young children and older adults[4]. $PM_{2.5}$ is a criteria air pollutant in the Clean Air Act and its amendments. Therefore, it is important to study the behavior of PM precursors, such as NH_3, in an effort to understand and manage air quality.

Background

To minimize harmful effects of air pollution, it is imperative for scientists to track pollutants in different regions across the country and throughout the world. As part of its air chemistry program, the NOAA Air Resources Laboratory Atmospheric Turbulence and Diffusion Division (ATDD) conducts field studies of a number of atmospheric gases, including NH_3. Given ammonia's key role in $PM_{2.5}$ formation and its linkages to nutrient imbalances in soil and surface waters, it is essential that accurate measurements are conducted to determine the strength of emission sources and the extent of ammonia pollution in different regions of the US.

Methods

Air quality issues are not confined to large urban areas; in fact, many of the Asthma and Allergy Foundation of America's Top 10 Allergy Capitals are smaller cities like Jackson, MS; Chattanooga, TN; and McAllen, TX[5]. In 2009, NOAA ATDD conducted an NH_3 field study near Knoxville, TN, an area which is routinely included on the Allergy Capital list and is in non-attainment of the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$. The study focused on two terrestrial ecosystems near the Knoxville metropolitan area, which is located in the Valley and Ridge province of the Appalachian Highlands and is characterized by corrugated terrain of valleys and elongated ridges (Fig. 1). The first site was located near Interstate Highway 40/75 on a grassy embankment between the roadbed and an exit ramp. Nearly 100,000 vehicles (including ~17,000 trucks) bypass the site daily[6]. The second site was co-located at the NOAA Atmospheric Integrated Research Monitoring Network (AIRMoN) station at Walker Branch Watershed, which is a grassy clearing surrounded by deciduous forest. Annular denuder systems (Fig. 2) were deployed at both sites to measure atmospheric NH_3 concentrations. A vacuum draws air through the inlet, into a tube with an interior surface that has been chemically coated to capture NH_3. Any NH_3 present is adsorbed or denuded from the air stream. NH_3 concentrations in the samples can then be quantified with ion chromatography. Annular denuder samples were collected at 12-hour intervals for 26 days in July and August. Wind directions and speeds were collected for the duration of the study in 30-min averages.

Fig. 1. Topographic map of East Tennessee including the layout of major highways. (Background image courtesy of Google™Earth.)

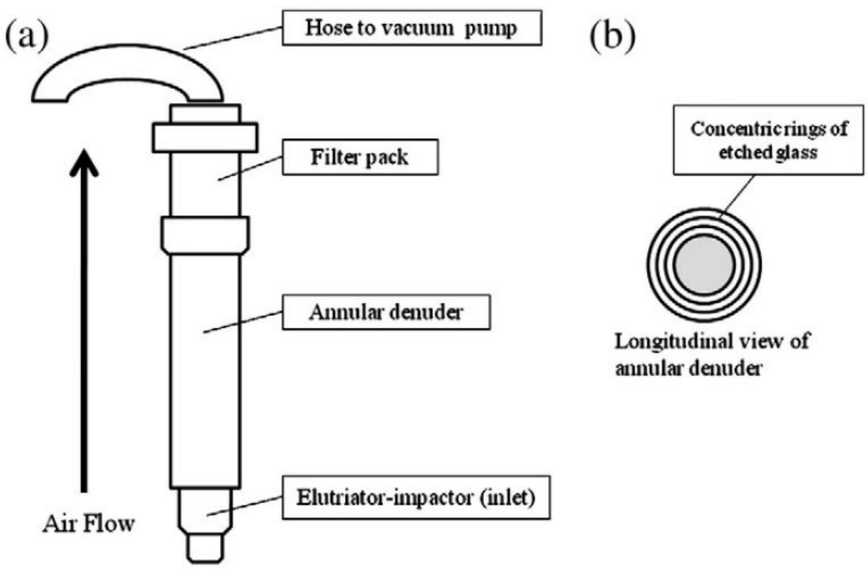

Fig. 2. Diagram of the annular denuder system.[7]

Results

Ammonia concentrations measured at both sites were ~1.6 μg/m^3, which seemed to indicate that the sites were not greatly impacted by large point sources such as fertilized fields. The similarity of NH_3 concentrations at both sites suggested that sites were likewise impacted by emissions from nonpoint sources such as soils[8]. Further examination of concentrations and wind direction at the interstate site showed that slightly higher levels of NH_3 emanated from the direction of the interstate highway, upwind from the site. Joint frequency graphs of NH_3 concentrations overlaid on a satellite image of of the region illustrate this point (Fig. 3). The joint frequencies shown here are bar graphs of ammonia concentration and wind direction with deeper reds indicating higher ammonia in winds from a certain direction. Winds at the interstate site were predominately from the southwest and contained higher NH_3 concentrations. Topography obviously influenced wind direction at the interstate site, which in turn affected NH_3 concentration measurements. Winds were channeled from the southwest to the northeast between higher elevation ridges. Overall, results from the study seemed to support a small contribution (a few percent) of NH_3 from vehicle emissions to the total budget. It is probable that a regionally ubiquitous source such as soils contributes a larger quantity.

Future Directions

The role of atmospheric NH_3 in air quality remains an active field of research. Scientists investigate not only ambient levels in the air but also the exchange of NH_3 with soil and vegetation. NOAA ATDD has a long history of measuring and modeling air-surface exchange of NH_3 and other atmospheric gases to understand sources, trajectories, and fates of pollutants. Future research at NOAA ATDD include the development of a sampling scheme using cavity-ring down spectroscopy to measure emission and deposition of NH_3 in the rural Midwest in Spring 2014. The goals of the study are to measure NH_3 emissions from fertilizer application at the local scale in an agricultural ecosystem and develop a method to facilitate connection between local and regional scale emissions. Results from field studies will be used to improve the understanding of the drivers that control the fate of NH_3 in the environment.

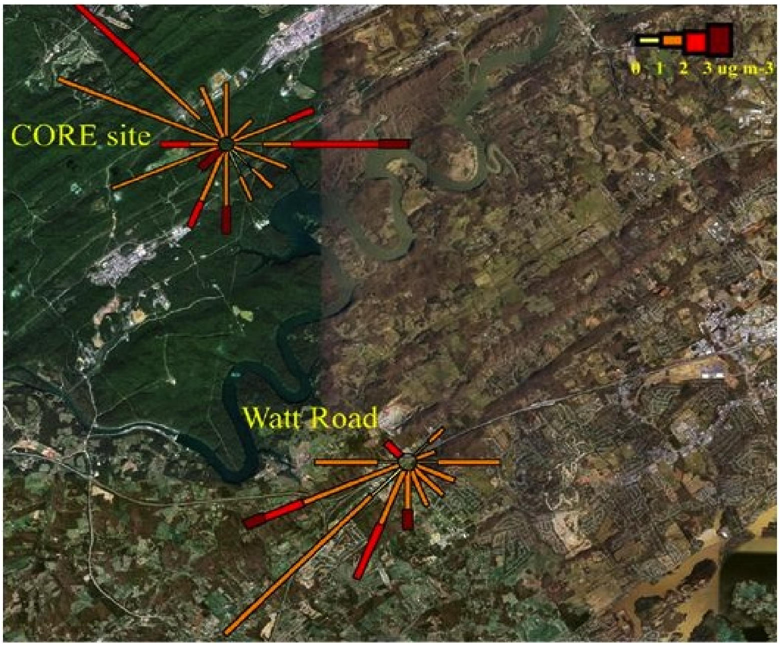

Fig. 3. Satellite view of study sites with overlay of NH_3 concentrations (μg/m³) by wind direction. Winds are from the direction shown. (Background image courtesy of Google™Earth.)

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Drought Update

Luigi Romolo
Southern Regional Climate Center

Drought conditions over the month of December remained relatively unchanged, with northwestern Texas and western Oklahoma experiencing moderate to severe drought conditions. A small area of extreme and exceptional drought persists along the southwestern Oklahoma-Texas border.

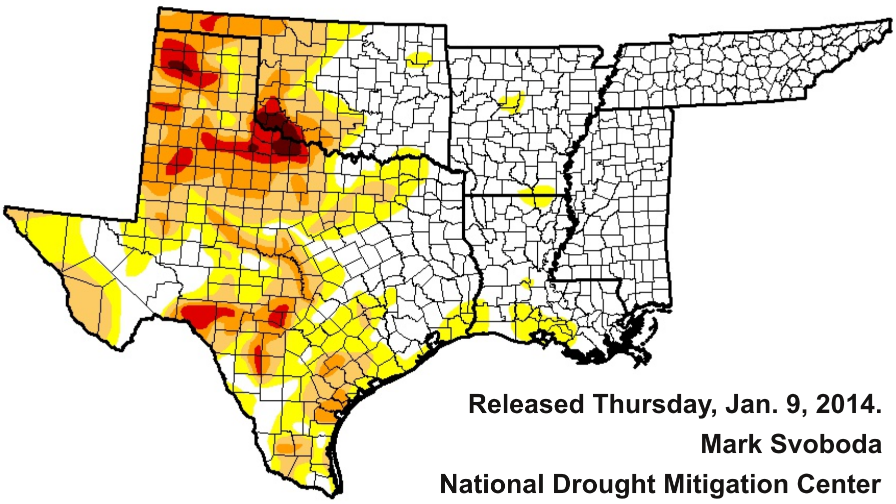
In Texas, an ice storm occurred in the Dallas-Fort Worth Metroplex. The storm hit overnight on December 5, 2013 and coated areas with one and four inches of ice, completely shutting down the region. The ice was responsible for the cancellation of over 1,100 flights out of DFW international Airport, the shutdown of nearly every major interstate into and out of the city, and the loss of power to over 260,000 people. Preliminary estimate believe there to be over 1 billion dollars of roadway damage to the Metroplex and $30 million in other damages. The cold weather also contributed to a variety of agricultural and ecological impacts around the state. Short-term dryness in the Panhandle is causing some concern over winter wheat, as snowfall has been below average, but cooler temperatures are helping prevent moisture loss. Grains in central Texas, in spite of the drought, saw record high production levels, leading to optimistic forecasts for next year. Ecologically, the cold weather has been hard on plants and wildlife.

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	55.41	44.59	27.25	13.05	3.58	0.72
Last Week 12/31/2013	55.85	44.15	27.23	13.21	3.58	0.72
3 Months Ago 10/8/2013	26.89	73.11	49.42	18.06	2.82	0.25
Start of Calendar Year 12/31/2013	55.85	44.15	27.23	13.21	3.58	0.72
Start of Water Year 10/1/2013	26.20	73.80	50.11	17.90	3.16	0.25
One Year Ago 1/8/2013	24.31	75.69	61.96	50.73	32.67	10.70

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**

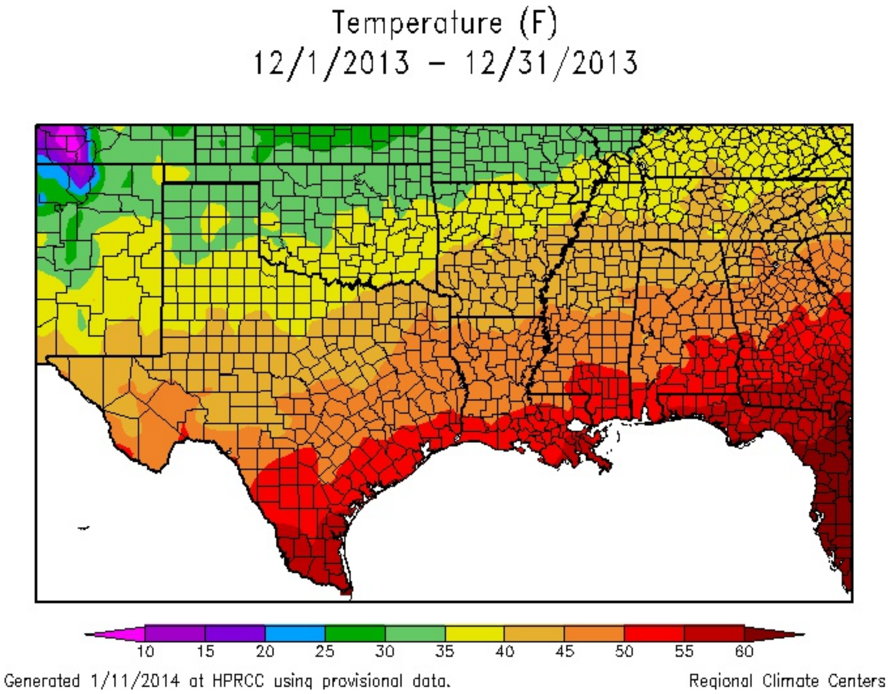


Above: Drought Conditions in the Southern Region. Map is valid for January 7, 2014. Image is courtesy of the National Drought Mitigation Center.

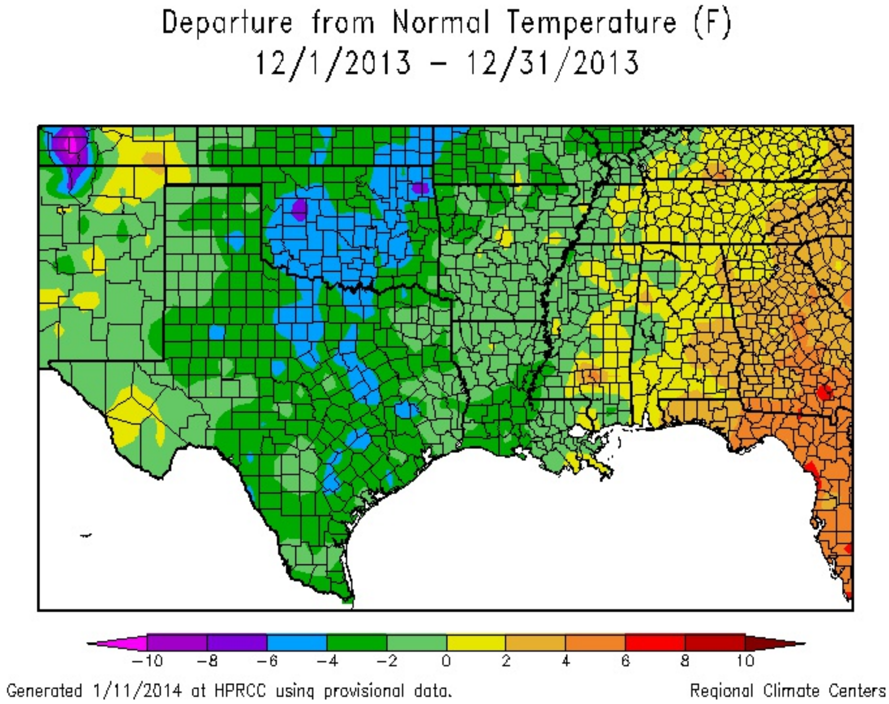
Temperature Summary

Luigi Romolo
Southern Regional Climate Center

The month of December was a slightly cooler than normal month for much of the Southern Region, with the exception of Tennessee and eastern Mississippi, which experienced a slightly warmer than normal month. Temperatures in Arkansas and Louisiana averaged between 0 to 2 degrees F (0 to 1.11 degrees C) below normal. This was also the case over most of Texas, expect in the north where some stations averaged between 4 to 6 degrees F (2.22 to 3.33 degrees C) below normal. Central Oklahoma also averaged between 4 to 6 degrees F (2.22 to 3.33 degrees C) below normal. The statewide average temperatures are as follows: Arkansas reported 39.70 degrees F (4.28 degrees C), Louisiana reported 49.60 degrees F (9.78 degrees C), Mississippi reported 46.40 degrees F (8.00 degrees C), Oklahoma reported 34.80 degrees F (1.56 degrees C), Tennessee reported 40.40 degrees F (4.67 degrees C), and Texas reported 44.60 degrees F (7.00 degrees C). For Oklahoma, it was their sixteenth coldest December on record (1895-2013), while Texas experienced its eighteenth coldest December on record (1895-2013). It was also the twenty-third coldest December on record (1895-2013) for the state of Arkansas. All other state rankings fell within the two middle quartiles.



Average December 2013 Temperature across the South.

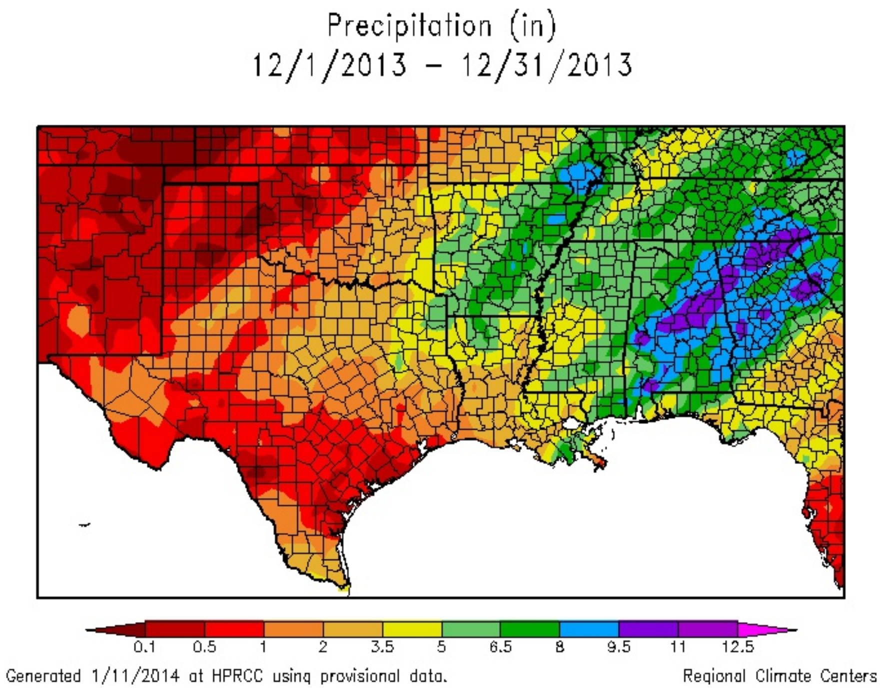


Average Temperature Departures from 1971-2000 for December 2013 across the South.

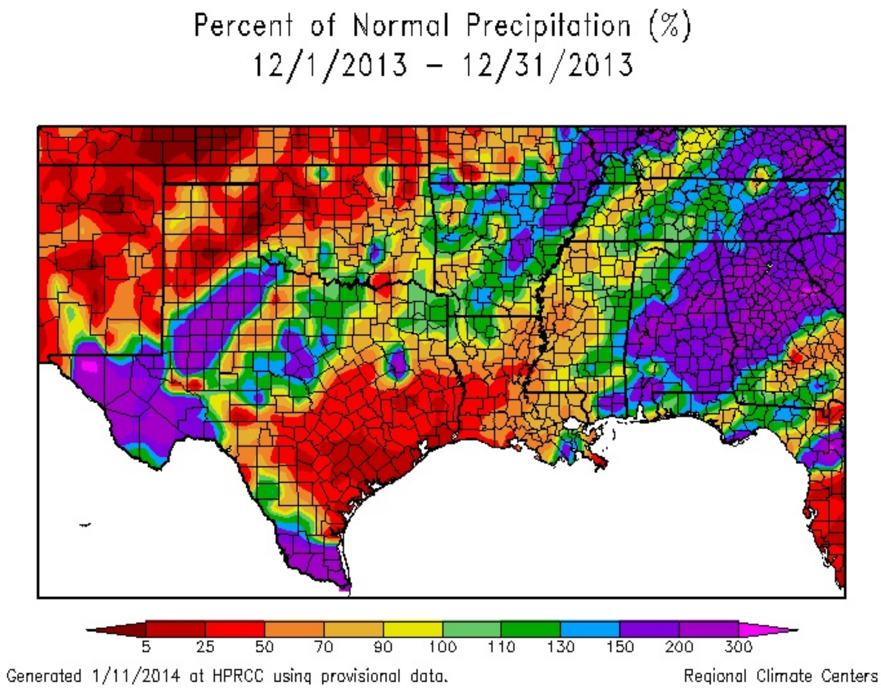
Precipitation Summary

Luigi Romolo
Southern Regional Climate Center

December precipitation totals in the Southern Region varied spatially, with parts of the region receiving anomalously high amounts of precipitation, while other parts remained quite dry throughout the month. Areas of above average precipitation include: the extreme south of Texas, the western Texas panhandle, west central Texas, northern Arkansas, and eastern Tennessee. Precipitation totals in these regions varied from 130 to over 200 percent of normal. Conversely, areas of dryness included: much of Oklahoma, southeastern Texas, and most of the state of Louisiana. Precipitation totals in those regions varied from half of normal to under 5 percent of normal. The statewide average precipitation totals are as follows: Arkansas recorded 6.25 inches (158.75 mm), Louisiana recorded 3.72 inches (94.49 mm), Mississippi recorded 5.55 inches (140.97 mm), Oklahoma recorded 1.11 inches (28.19 mm), Tennessee recorded 6.35 inches (161.29 mm), and Texas recorded 1.46 inches (37.08 mm). For Arkansas, it was their twentieth wettest December on on record (1895-2013), while for Louisiana, it was their twenty-first driest December on record (1895-2013). All other state rankings fell within the two middle quartiles.

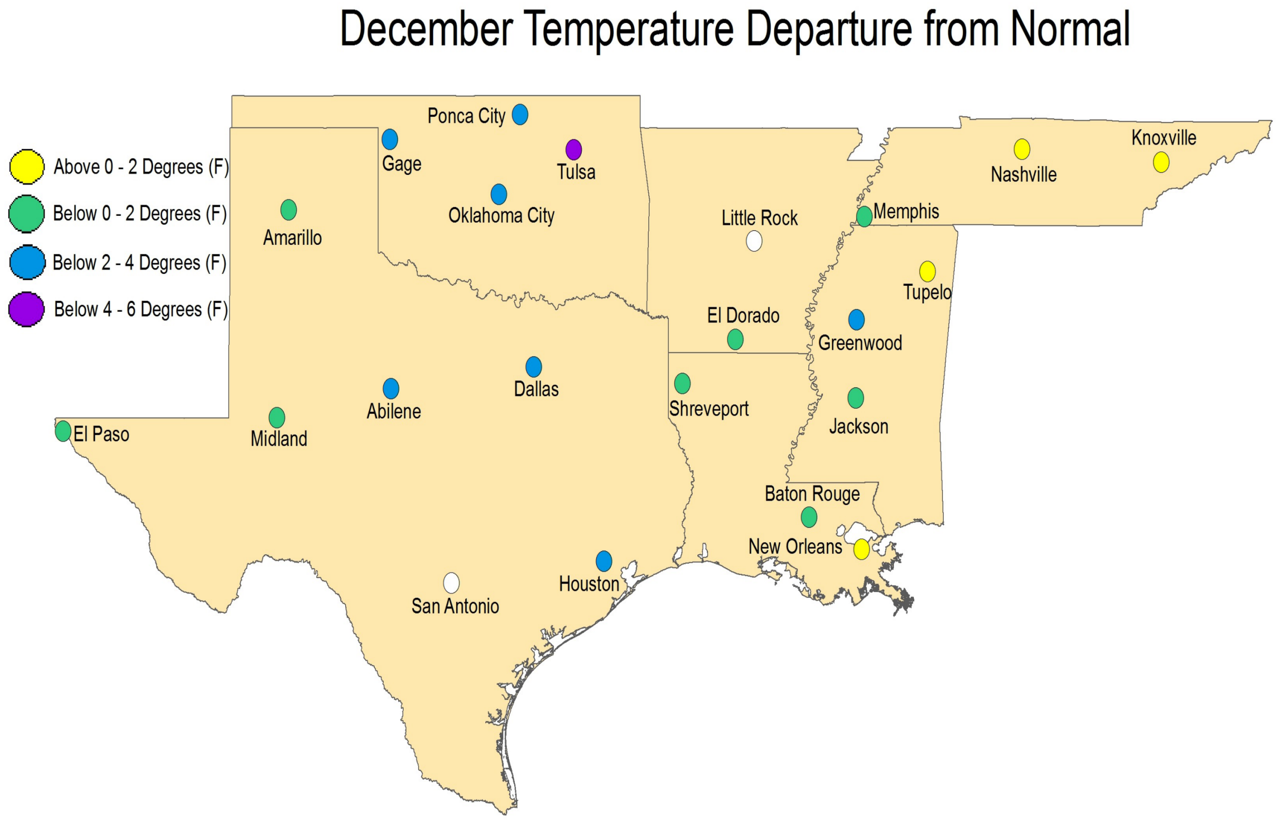


December 2013 Total Precipitation across the South.

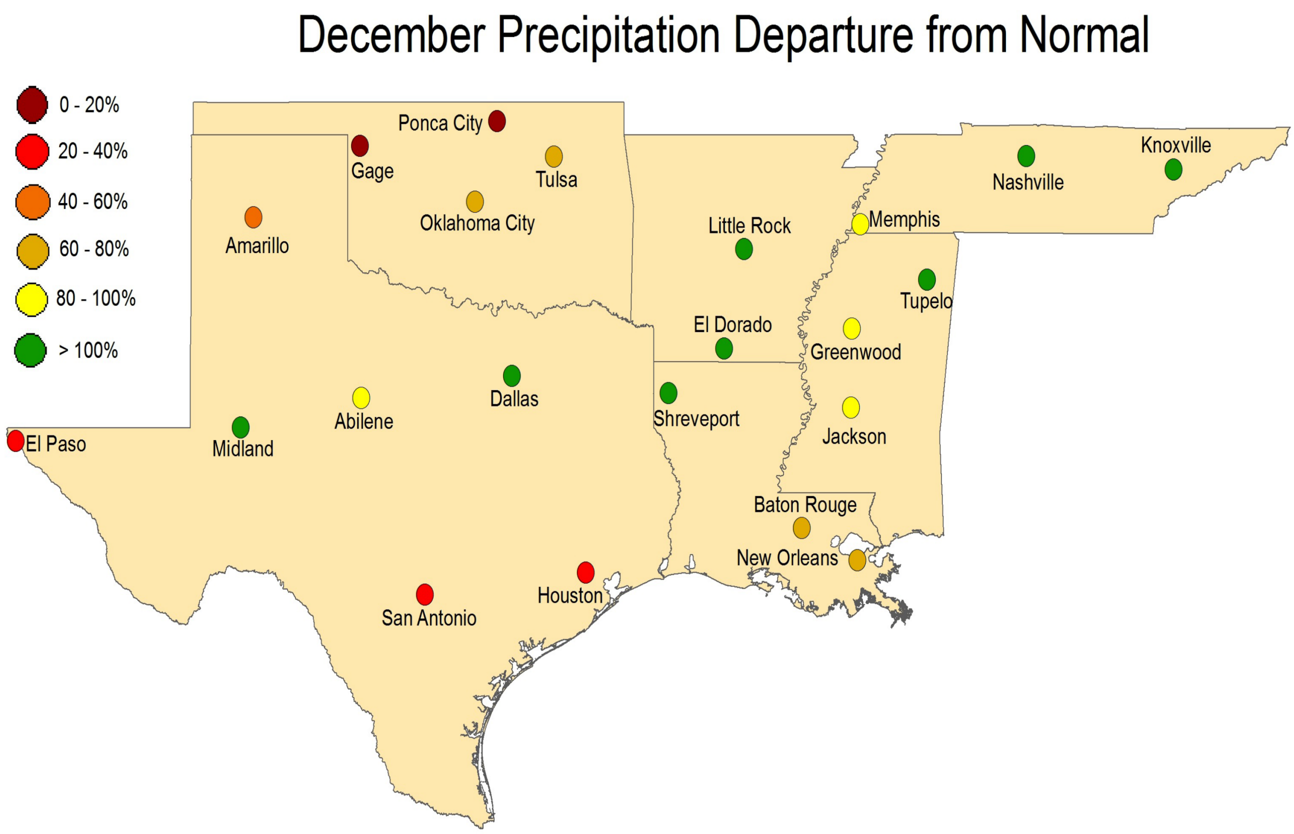


Percent of 1971-2000 normal precipitation totals for December 2013 across the South.

Regional Climate Perspective in Pictures



December 2013 Temperature Departure from Normal from 1971-2000 for SCIPP Regional Cities



December 2013 Percent of 1971-2000 Normal Precipitation Totals for SCIPP Regional Cities

Climate Perspective

State	Temperature	Rank (1895-2011)	Precipitation	Rank (1895-2011)
Arkansas	39.70	23rd Coldest	6.25	20th Wettest
Louisiana	49.60	32nd Coldest	3.72	21st Driest
Mississippi	46.40	50th Coldest	5.55	46th Wettest
Oklahoma	34.80	16th Coldest	1.11	42nd Driest
Tennessee	40.40	47th Warmest	6.35	30th Wettest
Texas	44.60	18th Coldest	1.46	49th Driest

State temperature and precipitation values and rankings for December 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	54.9	34.2	44.6	-1.5	78	12/4	23	12/11	6.56	1.76	137
Little Rock, AR	52.8	33.7	43.2	0.0	77	12/4	20	12/7	6.95	2.24	148
Baton Rouge, LA	62.4	42.0	52.2	-0.2	84	12/5	27	12/24	3.72	-1.54	71
New Orleans, LA	63.0	48.0	55.5	0.4	82	12/6+	35	12/16	3.21	-1.86	63
Shreveport, LA	57.4	37.3	47.4	-1.0	79	12/4	25	12/11	4.98	0.43	110
Greenwood, MS	54.4	34.7	44.6	-2.2	80	12/21	22	12/24	4.69	-0.72	87
Jackson, MS	58.1	36.5	47.3	-0.3	82	12/5	23	12/25	4.50	-0.84	84
Tupelo, MS	52.9	34.2	43.6	0.2	78	12/21	19	12/25	6.17	0.05	101
Gage, OK	46.9	17.2	31.6	-3.5	73	12/3	0	12/10	0.14	-0.74	16
Oklahoma City, OK	47.9	26.2	37.0	-2.5	69	12/19+	5	12/10	1.26	-0.63	67
Ponca City, OK	46.2	21.5	33.9	-3.2	71	12/18	3	12/10	0.11	-1.56	7
Tulsa, OK	46.0	25.2	35.6	-4.1	68	12/18+	7	12/7	1.78	-0.65	73
Knoxville, TN	51.1	32.2	41.6	2.0	74	12/22	17	12/26	5.87	0.78	115
Memphis, TN	51.9	34.4	43.2	-0.1	76	12/21+	22	12/7	4.83	-0.85	85
Nashville, TN	50.9	32.3	41.6	1.1	76	12/4	18	12/25+	7.98	3.44	176
Abilene, TX	54.5	30.5	42.5	-2.9	83	12/3	14	12/10+	1.11	-0.16	88
Amarillo, TX	49.3	22.1	35.7	-1.3	72	12/19+	3	12/7	0.32	-0.29	52
El Paso, TX	57.1	32.5	44.8	-0.6	72	12/3	22	12/28	0.26	-0.51	34
Dallas, TX	54.2	32.4	43.3	-3.4	79	12/4	19	12/10	2.76	0.19	108
Houston, TX	62.0	43.7	52.9	-3.2	81	12/4	32	12/16	0.87	-2.91	23
Midland, TX	55.3	31.3	43.3	-1.5	79	12/3	16	12/7	1.44	0.79	222
San Antonio, TX	63.3	41.6	52.4	0.0	86	12/3	29	12/7	0.56	-1.40	28

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

Climate Forecast for January 2014

Barry Keim, Louisiana State Climatologist, Louisiana State University

With 2014 now entering our reality, it is time to sneak a peek at what our climate may look like to get the year started. On average, January is our coldest month of year, and mid- to late-January brings us the coldest day of the year, climatically. This year, the Climate Prediction Center is forecasting a warm and dry January for all of the Gulf Coast states, including Louisiana (Figure 1). Just remember what these forecasts are actually telling us. In this case, these results indicate that the odds are somewhat tilted toward us having a January 2014 that is above normal in temperature and below normal in precipitation. There is also some probability that January will be near average, or the opposite of this forecast, only that the odds of that happening are lower than would be expected in an ordinary January.

These predictions are based on teleconnections across the globe, whereas we are currently ENSO-neutral, which means that we are neither in an El Nino, nor a La Nina. However, other indicators, like sea surface temperatures in various locations (e.g., the Pacific Decadal Oscillation) and disturbances in tropical pressure patterns and rainfall (e.g., the Madden-Julian Oscillation) suggest that the U.S. southeast will deviate somewhat from its normal climate patterns for January. Like with any long lead forecast, take it with a pound a salt. Happy New Year! Please contact me with any questions or complaints at keim@lsu.edu.

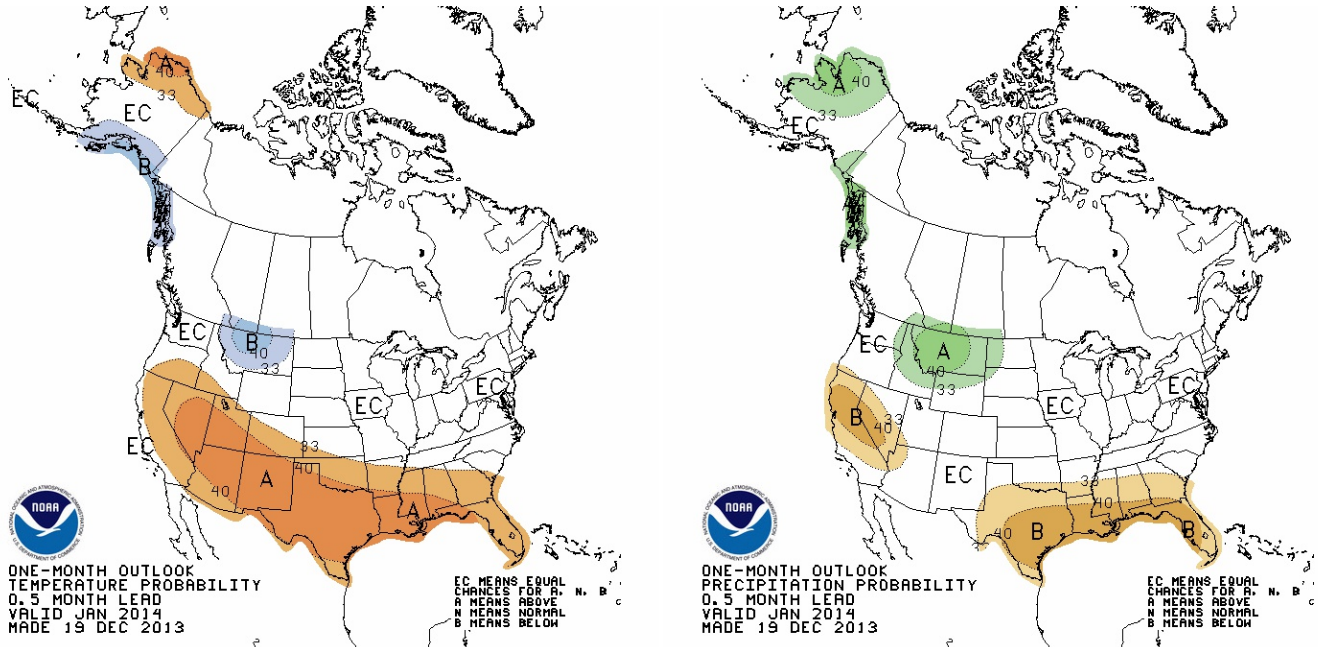


Figure 1. Long lead forecast for January 2014 by the Climate Prediction Center. Image available at http://www.cpc.ncep.noaa.gov/products/predictions/long_range/two_class.php.

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.