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Stakeholder-Based Flood Modeling for Urban Adaptation to Climate Change

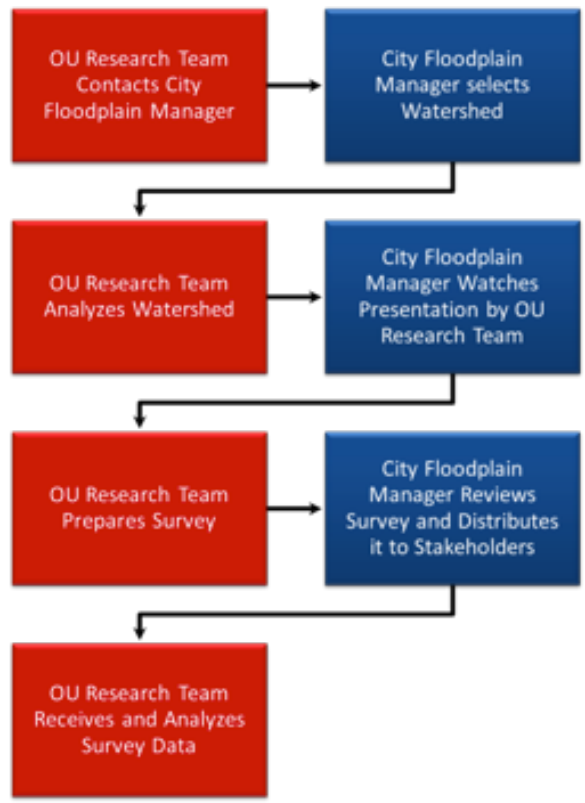
Mark Meo, Professor of Geography and Environmental Sustainability, University of Oklahoma

Urban flooding is a recurrent problem for cities, and is expected to become worse in the future. How cities can anticipate future conditions, assess the implications of flood impacts, and develop adaptive plans are the subjects of a research project that was completed recently by a University of Oklahoma faculty team that included Profs. Scott Greene, Yang Hong, Mark Meo and Baxter Vieux. In an earlier article (Southern Climate Monitor, October, 2012) the project team and its preliminary activities were described up to the point where the first urban watershed was being analyzed. In this article, I present an overview of the project and discuss the results that the team derived. The research was supported by the NOAA Sectoral Applications Research Program in water.

The importance of urban flooding has been singled out by the 2014 National Climate Assessment (NCA) which reports that:
Heavy rainfall events are projected to increase, which is expected to increase the potential for flash flooding. Land cover, flow and water-supply management, soil moisture, and channel conditions are also important influences on flood generation and must be considered in projections of future flood risks.

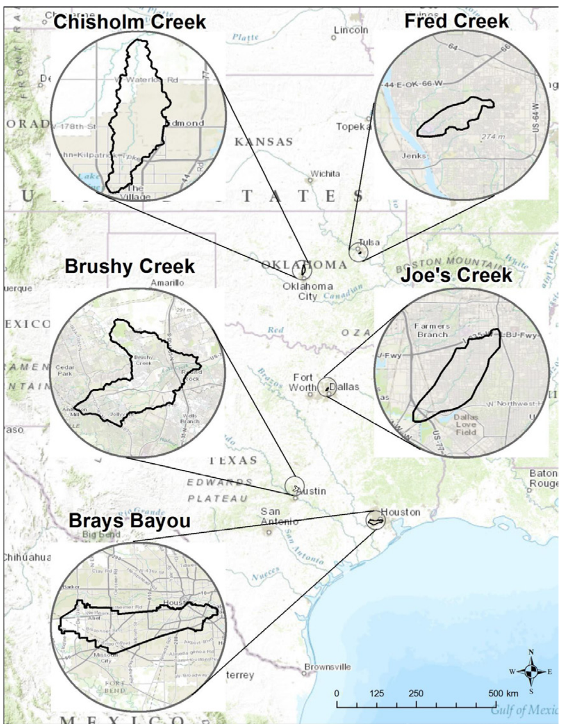
Moreover, the interagency NCA concludes that:
To provide decision makers with more timely, concise, and useful information, a sustained assessment process would include both ongoing, extensive engagement with public and private partners, and targeted, scientifically rigorous reports that address concerns in a timely fashion.

The OU team shares the concerns voiced by the National Climate Assessment and thus designed a project that captured several of the key points mentioned in the NCA statement above. Since local watershed managers are generally the most knowledgeable people responsible for flood planning, the team adopted the interactive protocol shown in the figure below.

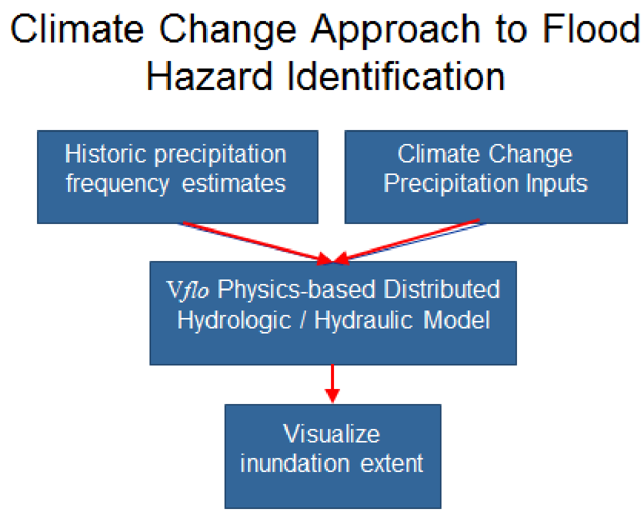


This iterative approach illustrates the role of the city floodplain manager, the OU research team, and watershed stakeholders. The research project had as its goal the need to develop a cost-effective technique to help planners and managers make better decisions about future events that linked the best available climate and hydrologic information with appropriate decision making techniques. To this end, the team first contacted city floodplain managers in Tulsa and Oklahoma City in Oklahoma and Austin, Dallas, and Houston in Texas, and asked them to select an appropriate watershed that the research team could analyze. Once this task was completed, the team arranged to make a formal presentation of its findings to each floodplain manager and his staff to describe its analysis and answer any questions that might arise. Next, the team developed a web-based survey instrument that was first reviewed by the floodplain manager and subsequently distributed to a small group of watershed stakeholders. The goal of the survey was to determine the effectiveness of science-based visual animations to assist planners and managers with climate adaptation challenges.

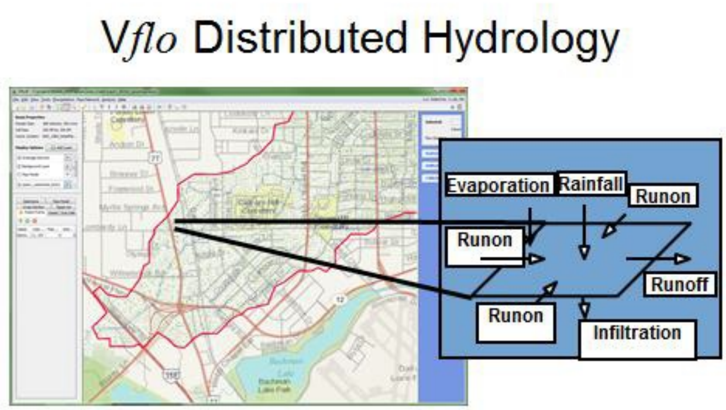
The urban watersheds examined in this project are shown in the figure below.



The team began its watershed analysis in Tulsa with Fred Creek. As a result of previous work with Tulsa, and its proximity to campus, the team used its familiarity with Tulsa to present its analytical work, address any questions about the approach, and develop a survey that was based on the analysis of Fred Creek. The figure below illustrates the analytic steps that were followed by the team. Initially, the team had addressed projected climate changes by downscaling local conditions from Atmospheric-Oceanic General Circulation Models that simulated global conditions. After spending time with the local watershed managers, however, alternative scenarios were adopted that projected events based on the historic record and the probability of extreme events.

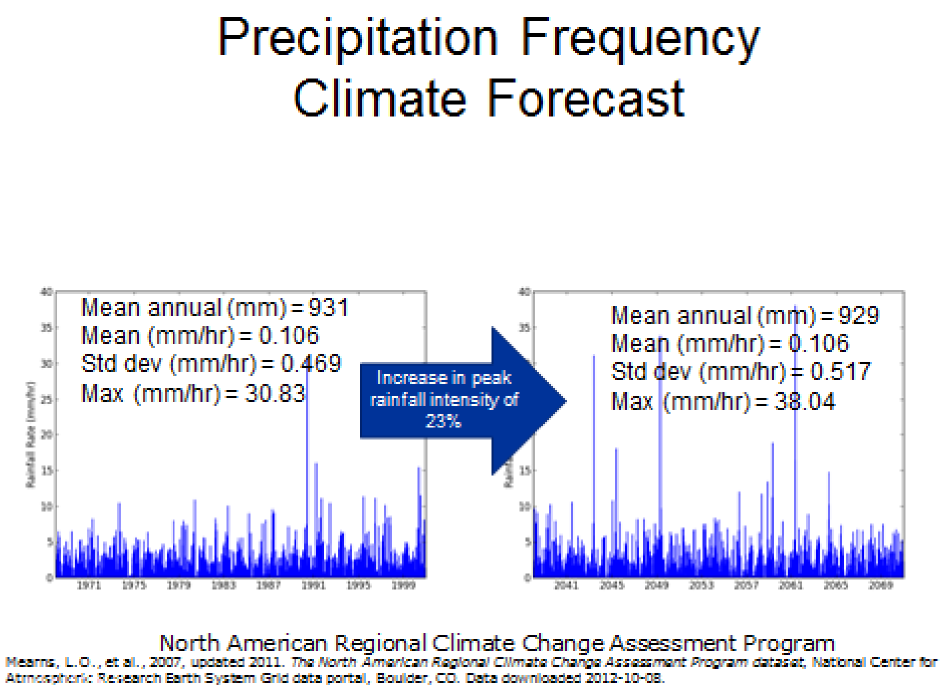


The figure above depicts the research steps that Baxter Vieux and his former student, Jonathan Looper, took to analyze each of the five research watersheds. The different parameters Baxter and Jonathan used in their Vflo distributed hydrologic model are shown in the figure below for Joe's Creek in Dallas. Data included evaporation, rainfall, run-on, run-off, and infiltration. Additional data layers were supplied by the Dallas watershed manager, which when examined together, addressed the location-specific concerns expressed by the NCA statement above.



Joe's Creek, Dallas, TX

The first figure below shows the shift in peak rainfall intensity projected for the Dallas watershed, Joe's Creek. In this case it is projected to be an increase of 23 percent. The figure below the precipitation frequency climate forecast is a visual depiction of a one-hundred year flood event enhanced by the projected 23 percent. Jonathan Looper prepared the visual animations using Google Earth.



After the team's presentation to the city staff members in Tulsa, the team prepared a survey questionnaire that included the animations of future flood events in the study watershed and several questions about alternative methods of presenting technical information that is germane to floodplain planning and management. Since the survey replicated a good deal of the technical presentation, Qualtrics survey software was employed which enables respondents to easily view the watershed animations. The surveys were developed for stakeholders to access on the Web by Amy Goodin, the director of OU POLL. After the survey was reviewed and approved by the watershed manager, he distributed a team cover letter and website URL to a small group of stakeholders to elicit responses.

The watershed survey contained twelve questions which could be answered by respondents in about ten to fifteen minutes. Respondents were asked to indicate their preferences on a five-interval scale that ranged from strongly agree to strongly disagree. Questions 1 and 2 addressed historic and projected precipitation; Question 3 asked respondents about different climate models and the topic of climate change; Question 4 asked respondents to assess potential impacts associated with climate change; Question 5 asked respondents to assess data presentation in maps and tables; Question 6 asked respondents to assess the vulnerability of drainage infrastructure; Questions 7, 8, and 9 asked respondents to evaluate hydrographs and maps for presenting information; Question 10 asked respondents to view the watershed animation developed by the OU team; Question 11 asked respondents to evaluate the usefulness, information provided, and credibility of the animation; and Question 12 asked respondents about their level of formal education and professional credentials in watershed management.

After the distribution of the watershed surveys and follow-up reminders, the data were collected and analyzed to determine the degree to which stakeholders favored the use of visual animations for planning for projected climate conditions. Some of the key findings are discussed here. In response to Question 7, 61.5% and 20.5% agreed and strongly agreed, respectively, that hydrologic models and images are effective in discussions with stakeholders about capital improvement project needs. For Question 8, 56.4% and 17.9% agreed and strongly agreed, respectively, that hydrologic models enable people to understand increases in flooding due to increases in precipitation. Respondents who viewed the watershed animation responded to Question 10 with 74.3% indicating that it was more effective than a static map, and 71.4% indicated that they would prefer to see more animations used in watershed planning and management. With respect to their usefulness, 29% responded to Question 11 that the animations were extremely useful, and 29% indicated that they were extremely informative.

The positive character of these findings reveals the level of receptivity the case study watershed managers had to the study and the faculty team that conducted it. The disciplinary composition of the team as well as the active participation of the team in holding a formal presentation with city staff helped to build trust and credibility with the stakeholders. The answers that team members gave stakeholders concerning specific watershed characteristics appeared to favor the acceptability of the detailed hydrologic model used by the OU team and its visual animation of their analysis. The finding that amost three-quarters of the stakeholders who responded to the survey favored the use of more visual animations is evidence that the project goals had been met successfully. Nevertheless, skepticism of climate science, and anthopomorphic global warming in particular, led the team to adopt an alternative approach to the project. While a majority of the respondent stakeholders approved the use of animations, the central role of AGW as a causal factor altering the future of urban flooding was not emphasized.

In sum, the project illustrates how academic teams can partner with urban communities to facilitate planning for climate adaptation. Should the recommendations stated in the NCA lead to calls for better partnerships between academeme and local government to enhance their capabilities, projects such as this one are likely to become more frequent. The iterative model used in this project could be more widely applied to related urban adaption issues to aid the building of more resilient communities.

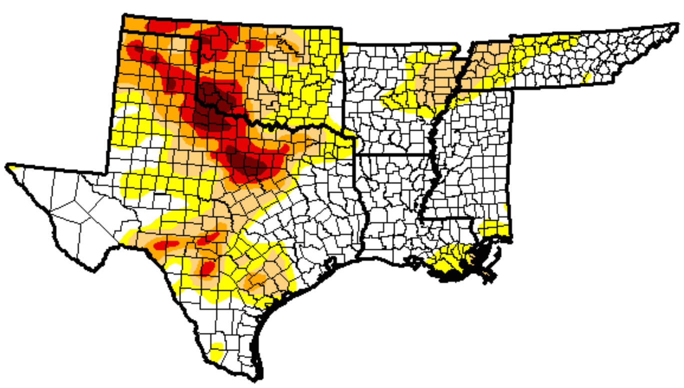
Drought Update

Luigi Romolo,
Southern Regional Climate Center

Drought conditions did not change much over the past month. Areas of northern Texas and southern Oklahoma are still experiencing extreme and exceptional drought. Similarly, counties in south central Texas are still categorized as moderate to extreme drought. Dry conditions along the Arkansas and Tennessee border have resulted in some expansion of moderate drought.

Several tornadoes were reported in Central Mississippi on January 3, 2015. Most of these occurred in the counties of Lawrence, Covington and Jasper. Fortunately, no injuries or fatalities were reported. Most of the damage was limited to trees and power lines, however, a home and mobile home were reported damaged in Covington County.

In a positive turn of events with respect to the ongoing lingering drought in Texas, The Houston Chronicle reported that Texas cattle herds are starting to rebound. The article reported that bovine inventories in the state had hit a 48 year low in 2014, but a report by the United States Department of Agriculture have numbers increasing by as much a 6 percent as of January, 2015.



Released Thursday, January 29, 2015

Brian Fuchs, National Drought Mitigation Center

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	48.91	51.09	31.26	18.12	8.68	2.30
Last Week 1/20/2015	48.33	51.67	33.13	18.34	8.73	2.30
3 Months Ago 10/28/2014	43.89	56.11	34.58	21.54	9.07	2.74
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 1/28/2014	40.31	59.69	31.75	15.26	4.95	0.72

Intensity:

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

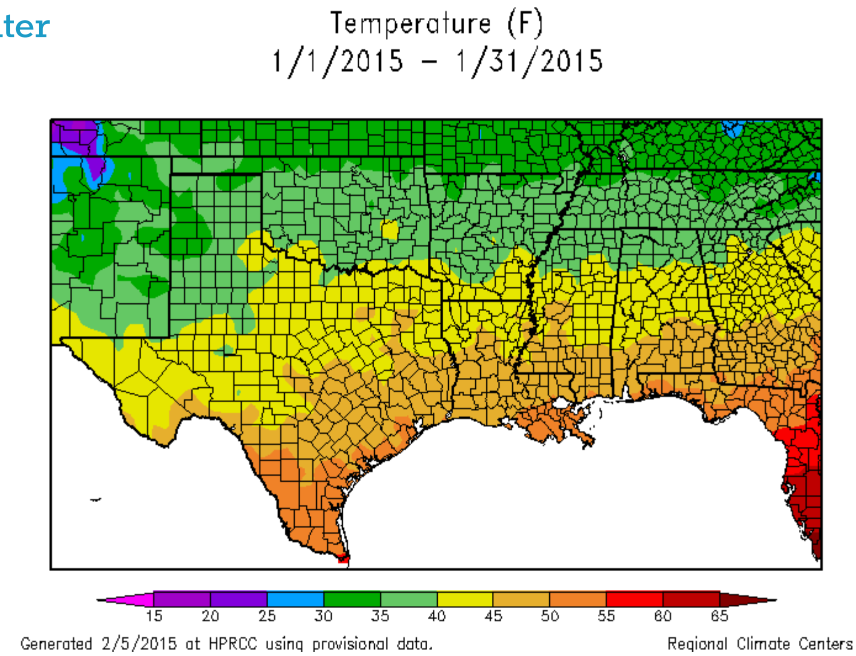
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Above: Drought conditions in the Southern Region. Map is valid for January 27, 2015. Image is courtesy of National Drought Mitigation Center.

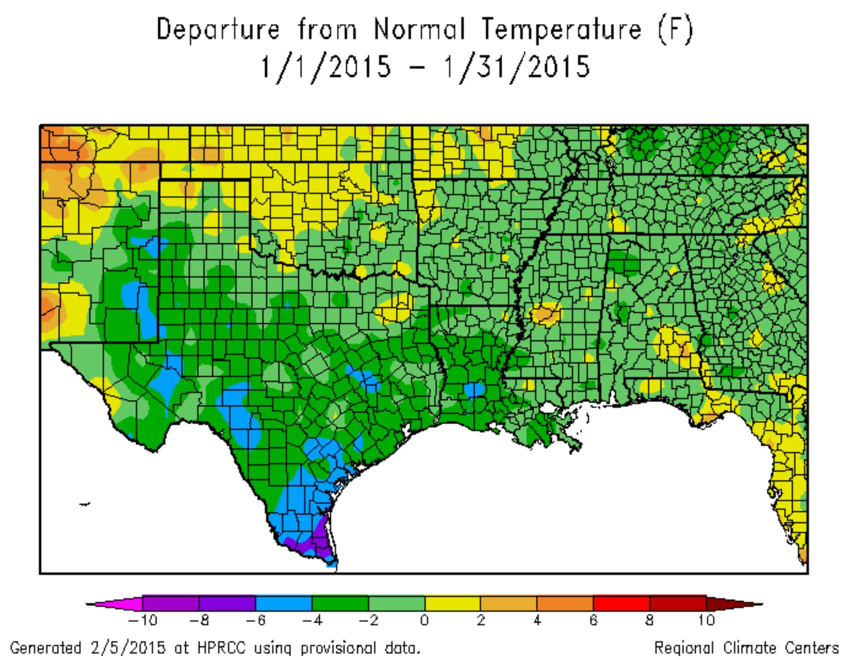
Temperature Summary

Luigi Romolo,
Southern Regional Climate Center

With the exception of northern and central Oklahoma, January was a slightly cooler than normal month across the Southern Region. Average temperatures for the month generally ranged between 0 and 2 degrees F (0 and 1.11 degrees C) below normal. In central and southern Texas however, temperatures averaged between 2 and 4 degrees F (1.11 and 2.22 degrees C) below normal. The coldest departures occurred in the extreme south of Texas, with temperatures averaging as much as 6 degrees F (3.33 degrees C) below normal. The state-wide average temperatures for the month are as follows: Arkansas averaged 38.60 degrees F (3.67 degrees C), Louisiana averaged 47.20 degrees F (8.44 degrees C), Mississippi averaged 43.80 degrees F (6.56 degrees C), Oklahoma averaged 37.70 degrees F (3.17 degrees C), Tennessee averaged 36.10 degrees F (2.28 degrees C), and Texas averaged 44.00 degrees F (6.67 degrees C). All state-wide temperature rankings fell within the two middle quartiles.



Average January 2015 Temperature across the South

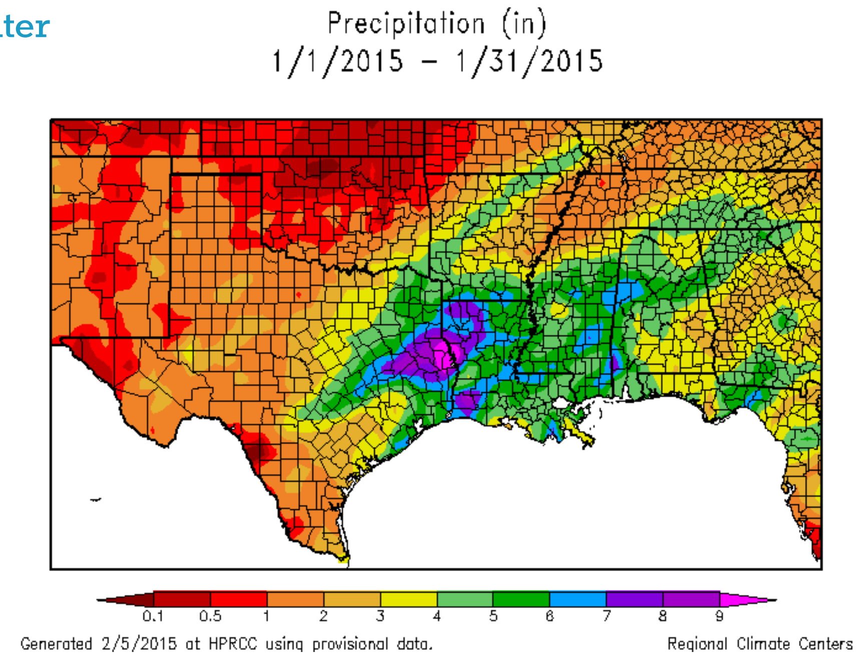


Average Temperature Departures from 1971-2000 for January 2015 across the South

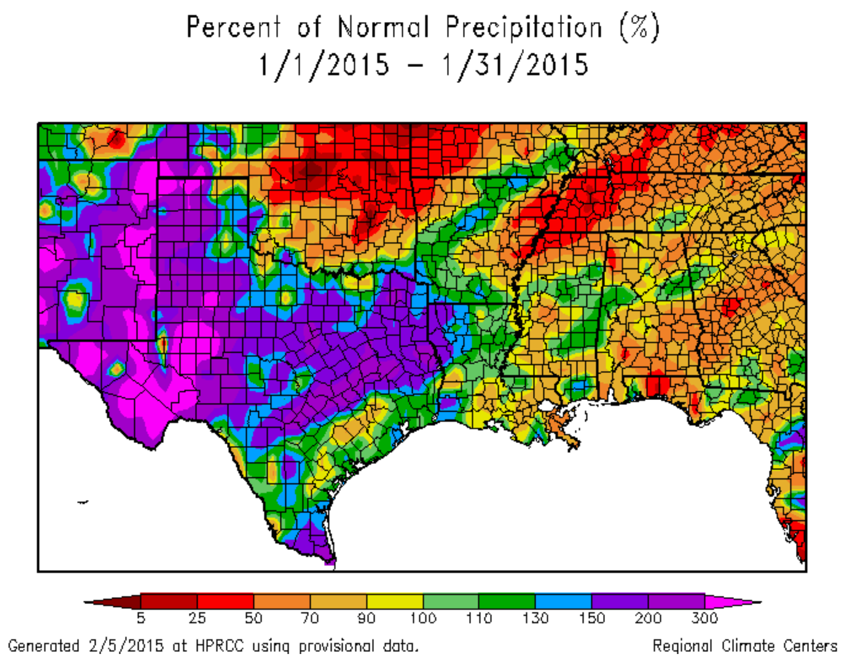
Precipitation Summary

Luigi Romolo,
Southern Regional Climate Center

January was a drier than normal month for all states in the Southern Region except for Texas, and Louisiana. Counties in western Tennessee and eastern Arkansas only received between 25 to 50 percent of normal, while surrounding counties faired only slightly better with totals ranging between 50-75 percent of normal. Similar anomalies were also observed throughout most of Oklahoma. Precipitation totals were near to slightly above normal across much of Louisiana and central Arkansas. Conversely, conditions were quite wet in Texas, with a bulk of the stations in the state reporting over 150 percent of normal. Many stations in the Trans Pecos climate division reported over twice the monthly expectation. The state-wide average precipitation totals are as follows: Arkansas averaged 3.51 inches (89.15 mm), Louisiana averaged 5.63 inches (143.00 mm), Mississippi averaged 4.75 inches (120.65 mm), Oklahoma averaged 0.99 inches (25.15 mm), Tennessee averaged 2.73 inches (69.34 mm), and Texas averaged 2.54 inches (64.52 mm).

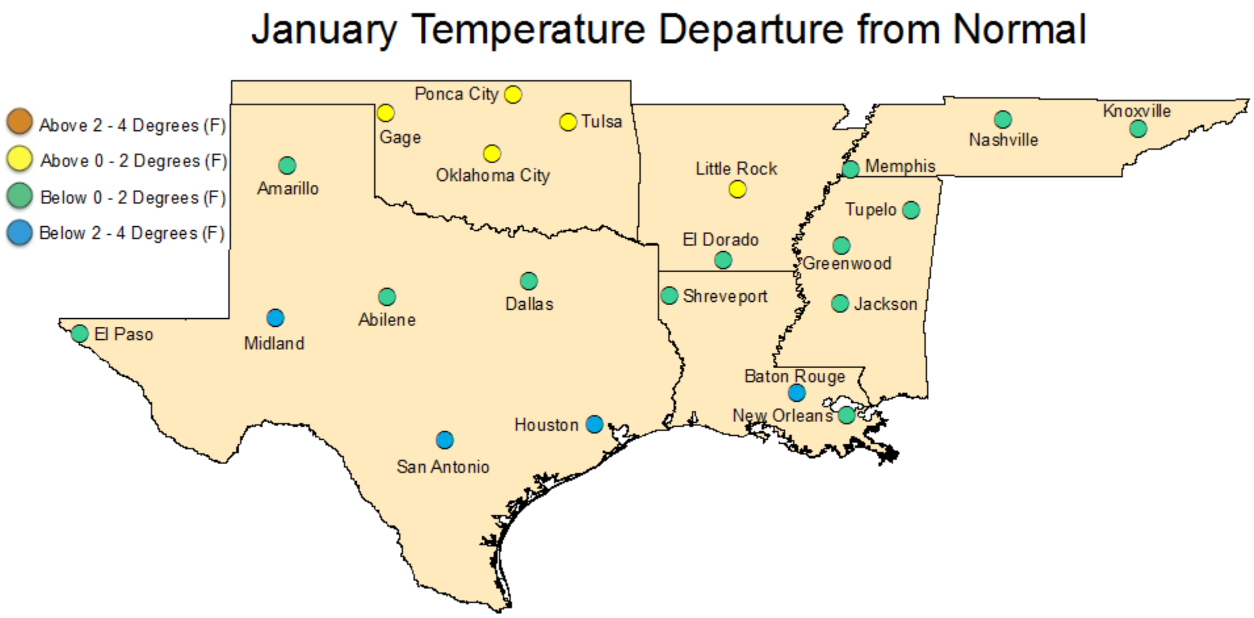


January 2015 Total Precipitation across the South

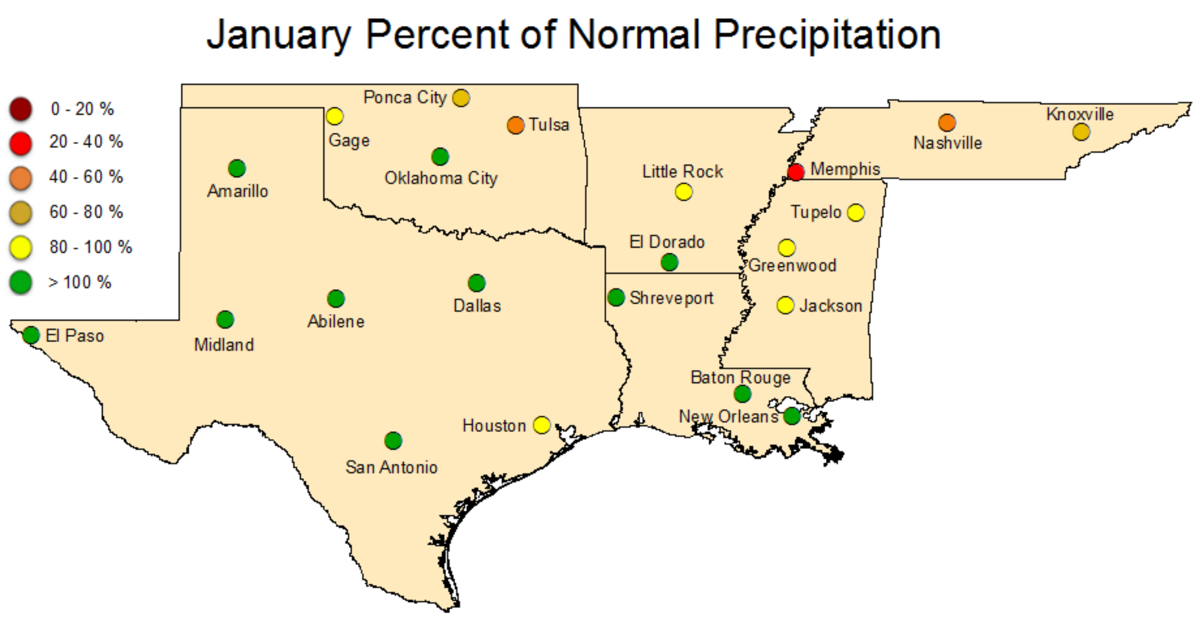


Percent of 1971-2000 normal precipitation totals for January 2015 across the South

Regional Climate Perspective in Pictures



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



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

Climate Perspective

State	Temperature	Rank (1895-2011)	Precipitation	Rank (1895-2011)
Arkansas	38.60	50th Coldest	3.51	58th Driest
Louisiana	47.20	40th Coldest	5.63	46th Driest
Mississippi	43.80	45th Coldest	4.75	54th Driest
Oklahoma	37.70	53rd Warmest	0.99	46th Driest
Tennessee	36.10	46th Coldest	2.73	21st Driest
Texas	44.00	38th Coldest	2.54	14th Wettest

State temperature and precipitation values and rankings for January 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	53.5	30.5	42	-1.88	74	1/28	13	1/8	4.89	0.59	114
Little Rock, AR	51.8	31	41.4	0.56	68	1/27+	10	1/8	2.97	-0.58	84
Baton Rouge, LA	60.1	37.8	48.9	-2.83	78	1/29	20	1/8	6.37	0.65	111
New Orleans, LA	60.8	43.1	52	-1.45	77	1/29+	25	1/8	5.67	0.52	110
Shreveport, LA	55.8	34.4	45.1	-1.65	77	1/29	18	1/8	7.45	3.25	177
Greenwood, MS	53	31.1	42.1	-1.26	69	1/29+	10	1/8	4.44	-0.08	98
Jackson, MS	56.8	33.5	45.1	-0.55	77	1/29	13	1/8	4.73	-0.25	95
Tupelo, MS	51.4	30.1	40.8	-0.94	68	1/29	8	1/8	4.24	-0.24	95
Gage, OK	49.8	22.6	36.2	1.53	81	1/27	9	1/7	0.49	-0.07	88
Oklahoma City, OK	51.4	29.5	40.4	1.18	79	1/28	11	1/8	1.8	0.41	129
Ponca City, OK	49.1	22.2	35.6	0.78	80	1/28	5	1/8+	0.79	-0.21	79
Tulsa, OK	50.2	26.6	38.4	0.65	80	1/28	7	1/8+	0.75	-0.91	45
Knoxville, TN	45.7	28.3	37	-1.25	64	1/4	6	1/8	3.39	-0.93	78
Memphis, TN	50.1	31.9	41	-0.23	65	1/19	9	1/8	1.3	-2.68	33
Nashville, TN	47.4	27.9	37.6	-0.01	67	1/29+	4	1/8	2.22	-1.53	59
Abilene, TX	53.2	32.7	42.9	-1.95	81	1/28	16	1/8	1.77	0.75	174
Amarillo, TX	48.1	25.2	36.6	-0.37	73	1/27	9	1/4	1.61	0.89	224
El Paso, TX	56.1	32.3	44.2	-0.91	73	1/28	22	1/23+	0.85	0.45	213
Dallas, TX	54.4	34.7	44.5	-1.41	80	1/28	16	1/8	3.62	1.49	170
Houston, TX	59.3	40.4	49.8	-3.21	81	1/27	28	1/8	3.17	-0.21	94
Midland, TX	52.3	31.1	41.7	-2.15	79	1/28	20	1/8	2.43	1.87	434
San Antonio, TX	59.9	39.1	49.5	-2.28	82	1/27+	28	1/8	3.67	1.91	209

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

Snowstorm Pounds Northeastern U.S.

Barry Keim, Louisiana State Climatologist, Louisiana State University

A noreaster hit the northeastern United States, bringing snow to the American Midwest, and especially to New England (Figure 1). Snow totals topped out at about 3 feet at many locations across the region, setting records at some sites. This storm was also forecasted to hammer New York City, and great efforts went into preparation, including moving most planes out of LaGuardia and JFK Airports prior to the storm. However, the storm didn't quite deliver in NYC, whereby it had snow totals more like 10 inches rather than 30. However, the storm did live up to its billing in New England. This storm produced a little farther eastward than initially expected, leaving some in the weather business issuing apologies. Nevertheless, this storm did impact a vast region, including numerous states. My old stomping grounds in New Hampshire accumulated about 25-30 inches. Admittedly, I found these snow storms fun when they were occurring, but the aftermath and associated cold temperatures simply wore me out. I will also admit that I thoroughly enjoyed watching this storm from the comforts of Louisiana, with afternoon temperatures in the 70s, while this storm was raging. I'll take Louisiana weather and all of its pit-falls every time! Please contact me at keim@lsu.edu with any comments.

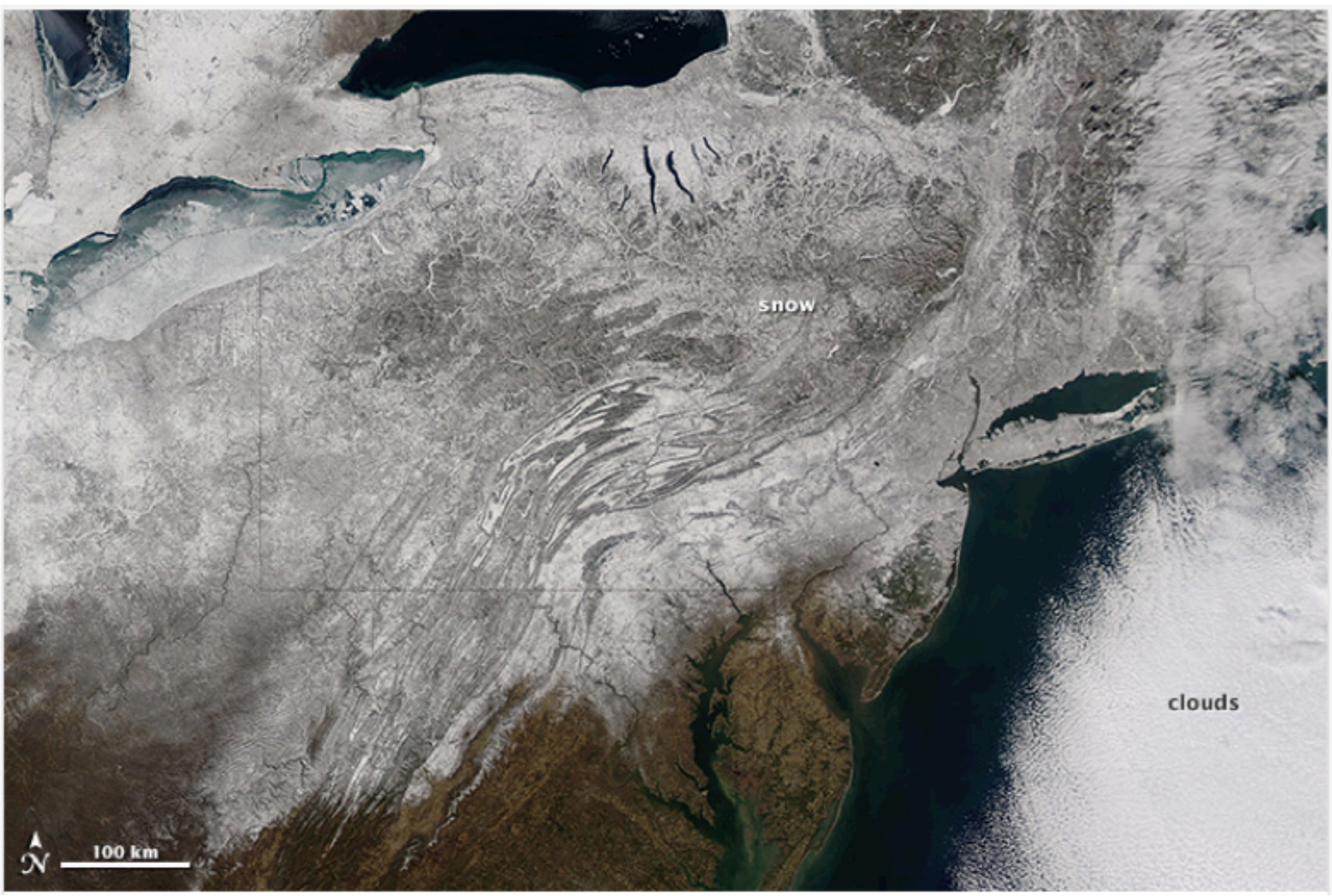


Figure 1. Snow on the ground left behind by the Noreaster that pounded the northeastern United States on January 26-27, 2015. Image is from NASA, courtesy of Jeff Schmaltz, and can be found at http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=85204&eocn=home&eoci=nh.

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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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