

# Tulsa Tornado Tribune



Where People Who Know the Weather Get Their Weather

National Weather Service Tulsa, Oklahoma

Winter 2016-17

Friday, December 30, 2016

## ONE YEAR AGO - CHRISTMAS WEEKEND FLOODS

*Record late December rainfall led to widespread major flooding across a large portion of eastern Oklahoma and northwest Arkansas just after Christmas. Combined with spring rainfall, this made 2015 one of the wettest years on record.*



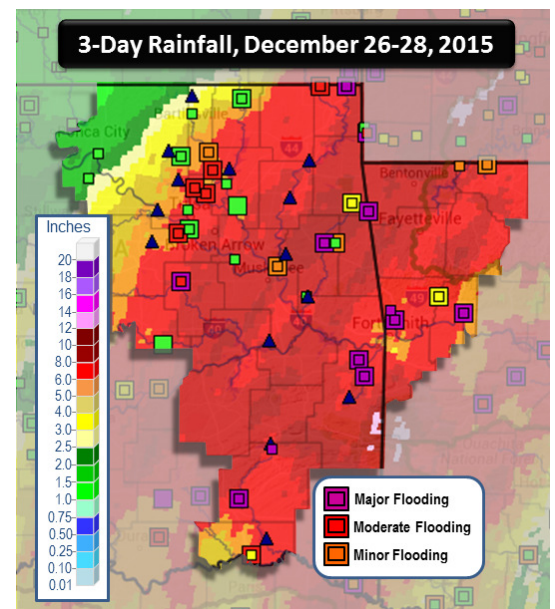
Aerial view of the devastating flooding along the Illinois River east of Tahlequah, Oklahoma in late December, 2015

Photo courtesy of KOKI-TV Tulsa

If there was a common theme to the weather in our area for the year 2015, it was wet! Sure, it was a nice reprieve from drought, but as we saw back in May of 2015, sometimes there really can be too much of a good thing!

Extreme rainfall occurred over most of eastern Oklahoma and northwest Arkansas from December 26-29, 2015, with the majority of the rain falling from the 26th-27th. The rain resulted in record river flooding along the Illinois River in eastern Oklahoma and Lee Creek in west central Arkansas. Additional major floods occurred along Flint Creek, Baron Fork, the Poteau River, the Arkansas River, the Spring River, the Deep Fork River, and the Kiamichi River.

low that lifted northeast across western Texas and approached eastern Oklahoma and western Arkansas from the southwest. Tremendous lift in the diffluent region of the slow-moving low, along with near historically high atmospheric



Rainfall estimates from December 26-28, 2015, with observed river flooding levels at official forecast points overlaid.

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The devastating Christmas 2015 weekend flood resulted from a strong upper-level

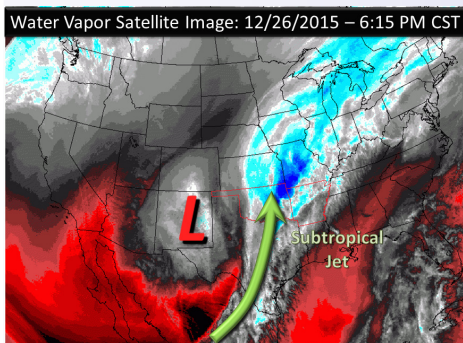
Floods *Continues on page 2*

**FLOODS** (Continued from page 1)

moisture content for late December, resulted in an extended period of heavy rain. The initial bands of rain and thunderstorms developed over northeast Oklahoma and northwest Arkansas during the early morning hours of the 26th as a warm front lifted north. Rain eventually increased across southeast Oklahoma and west central Arkansas through the morning. By midday, widespread

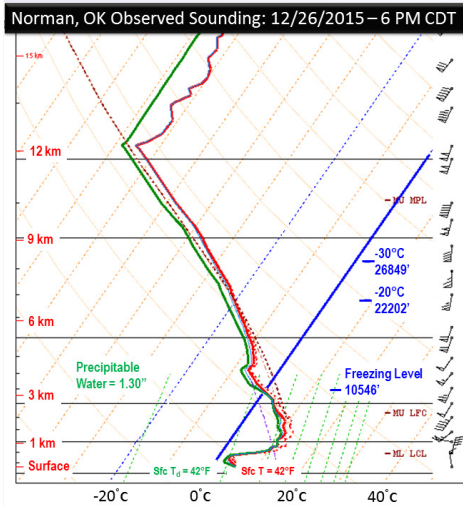
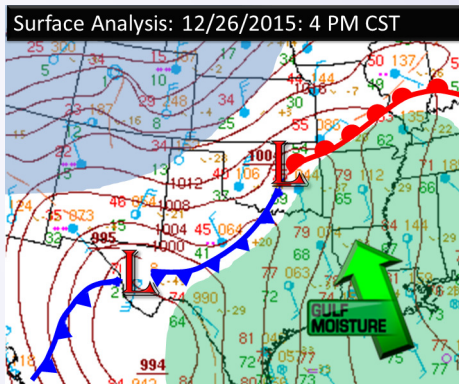
showers and thunderstorms were affecting much of eastern Oklahoma northwest of a McAlester to Grove line. Moderate to heavy rain continued over this area through the afternoon and evening, while also spreading southeast. By midnight on the 27th, rain had also spread over southeast Oklahoma and west central Arkansas. Primarily moderate rain continued for the next 14 hours as the frontal boundary remained in the area.

**Meteorology Behind the Floods**



A deep low pressure system in the upper levels provided ample large-scale lifting, and a connection to deep subtropical moisture. The slow movement of the system allowed this to persist for several days.

At the surface, a frontal boundary draped across the area helped lift unseasonably warm and moist air streaming north from the Gulf of Mexico. Cold air north of the front eventually moved into northeast Oklahoma, causing some winter precipitation.



The observed sounding from Norman, OK sampled a layer of near saturated air from the surface up to several kilometers deep. The moisture content through the depth of the atmosphere observed here was near record levels for late December. The result was extreme rainfall rates for a prolonged period.

As colder air began to filter into the back side of the system, light freezing rain developed on the morning of the 27th across northwest Osage county, with up to a quarter inch of ice accumulation on trees by noon. But the rain was becoming much more of an issue, as moderate to heavy rain continued southeast of I-44, while precipitation came to an end during the evening northwest of I-44. The more persistent rain shifted into western Arkansas by midnight on the 28th, but additional bands of rain moved north across eastern Oklahoma through early the next afternoon as the closed low moved northeast along the Oklahoma/Arkansas state line. Snow and sleet occurred across northeast Oklahoma and northwest Arkansas the morning of the 28th within this “wrap-around” precipitation as the bands interacted with the colder air-mass. Reports of a quarter-inch to 1 inch of sleet accumulation were reported, along with up to 1.5” of snow accumulation. All of the precipitation finally exited the area by early afternoon on the 28th.



A pickup truck stranded in high water in Tulsa, OK on December 28, 2015, with snow beginning to cover it.

Image from The Tulsa World

The end result was widespread 5 to 12 inch rainfall amounts over most of eastern Oklahoma and northwest Arkansas, with the majority of the rain occurring from the 26th-27th. This amount of rain is 2 to 4 times the normal for the entire month of December.



**FLOODS** (Continued from page 2)

Highest Rain Totals: Dec 26-28	
2.4 NW Viney Grove, AR	11.82"
Tahlequah, OK (Mesonet)	11.80"
Talihina, OK (Mesonet)	11.39"
0.6 SW Farmington, AR	11.29"
1.2 NE Muskogee, OK	11.25"
2.6 ESE Decatur, AR	11.19"
3.2 E Siloam Springs, AR	10.86"
Wilburton, OK (Mesonet)	10.68"
6.4 WSW Springdale, AR	10.57"
2 E Bella Vista, AR	10.55"

One of the highest amounts measured during this event was 11.80 inches of rain at Tahlequah, OK. This amount of rain in a 2-day period has about a 0.5% annual chance of occurrence (also referred to as a 200-year event). Similarly, the 6.82 inches of rain measured in a 24-hr period from the 26th-27th at Fayetteville, AR, has between a 4% and 2% annual

chance of occurrence (or between a 25- and 50-year event).

Because of the time of year this occurred, live vegetation was not present to absorb much of the water, so a sub-

**Rainfall Amounts: December 2015**

	Tulsa	McAlester	Ft. Smith	Fayetteville
<b>Total</b>	<b>8.60"</b>	<b>10.50"</b>	<b>10.81"</b>	<b>10.95"</b>
Rank	2 <sup>nd</sup> wettest	<b>1<sup>st</sup> Wettest</b>	<b>1<sup>st</sup> Wettest</b>	<b>1<sup>st</sup> Wettest</b>
Normal	2.49"	2.98"	3.29"	3.24"
Previous Record	8.70" (1984)	8.34" (1987)	10.09" (1971)	8.54" (1982)

stantial portion of it ran off into the river system. As a result, record and major river flooding was observed in several area river basins, along with several reports of flash flooding. Two fatalities occurred during this event, one near Bixby, OK (Tulsa Co.) and another near Scipio, OK (Pittsburg Co.); both in vehicles. High river levels and very fast flows along the Arkansas River halted barge traffic on the McClellan-Kerr Arkansas River Navigation System, causing significant financial impact to related commerce activities. This 445-mile navigation channel allows for commerce from the Mississippi River to eastern Oklahoma. Also, several reservoirs neared or exceeded the top of their flood control pools for the second time in 2015. ⚡

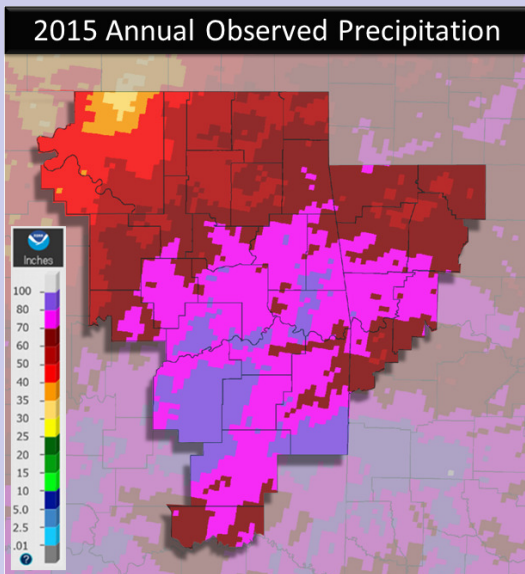
**An Amazing Year**

Needless to say, 2015 went down in the history books as one of the wettest. Most locations along and south of I-44 in eastern Oklahoma and western Arkansas saw between 150 and 200 percent of the normal (1981-2010) annual rainfall amount. Only northern Osage County ended the year with be-

low normal rainfall, receiving 75 to 90 percent of the annual average.

For specific locations, Fort Smith, AR set a new annual record rainfall in 2015 with 73.93" of rain (records began in 1882), breaking the previous record of 71.81" set in 1945. Normal annual rainfall in Fort Smith is 45.46". McAlester, OK also set a new annual record rainfall in 2015 with 78.65" (records began in 1954; data missing in 1996-98, 1953, 1955). The previous record was 66.40" in 1973 and the normal annual rainfall is 42.04". Tulsa and Fayetteville saw their 3rd (61.79") and 4th (65.71") wettest years, respectively.

The 2015 statewide average rainfall total for Oklahoma is 52.96" (from the National Centers for Environmental Information (NCEI) formerly NCDC). This sets a new annual rainfall record for the state of Oklahoma, besting the previous record of 47.88" in 1957. The majority of this rain fell in 6 of the 12 months in 2015. According to the Oklahoma Climatological Survey, this equates to 64.3 trillion gallons of water! ⚡



Highest Rain Totals for 2015	
Stigler, OK	88.27"
McAlester, OK	87.03"
Cookson, OK	85.66"
7 NE Winslow, AR	85.26"
Eufaula, OK	84.77"
0.8 N Bunch, OK	84.81"
Wilburton, OK	83.37"
0.1 SE Sallisaw, OK	83.85"

# ILLINOIS RIVER FLOODS

Record flooding occurred along the Illinois River in northeast Oklahoma as 8 to 12 inches of rain fell over much of its basin. Both forecast points, Tahlequah and Watts, recorded record crests during this flooding.

Water inundated numerous homes and businesses along the Illinois River in Delaware, Adair, and Cherokee Counties, and all secondary county roads in the immediate river area were damaged. State Highway 10 north of Tahlequah was closed during the flooding. Many cabin parks and permanent campgrounds were severely flooded or overtopped. Thousands of acres of agricultural land were also inundated.

Right: Damage at Fiddler's Bend area along the Illinois River. The small cabin in the center of the photo was one of several that washed downstream several hundred yards from the adjacent property.



Above: This bathhouse (built in 2011) at War Eagle Resort Island on the Illinois River was destroyed by flood waters. Debris was found in the trees up to 17 feet above ground level nearby.



Left: High water on the Illinois River along State Highway 10 near Falcon Flats. Scenes like this were common all along the river during the last few days of December.

Photo by: Ed Fite, OSRC

## The Power of Water

Soon after the flood waters receded, several members of the NWS Tulsa staff surveyed the areas most impacted by flooding. In many locations, the incredible power of flood waters was evident, such as canoes wrapped around trees several feet above the ground, and entire buildings displaced.



A dramatic example was found at Diamondhead Resort (see satellite image right), where a guard shack (below) from War Eagle Island was found. The structure was moved roughly 1/3 mile downstream by the flood waters!

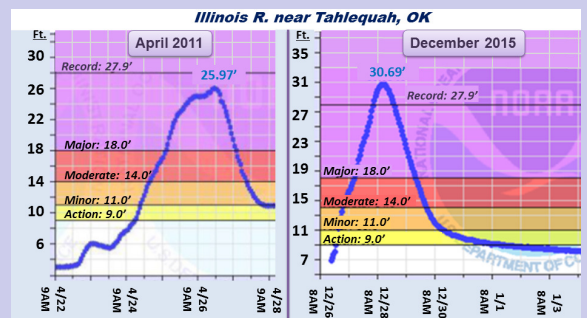


## Comparing Events



Comparison of high water marks (yellow line) at Fiddler's Bend on the Illinois River.

Record and major flooding also occurred on the Illinois River in April 2011. The Illinois River near Watts reached nearly the same level in both 2015 and 2011, each time breaking the previous records. However, the Illinois River near Tahlequah remained just below the record flood stage in 2011. This time, the Illinois River near Tahlequah exceeded the 2011 flood by 4.7 feet and exceeded the all-time record by 2.8 feet. This was mainly due to the significant rainfall that occurred between the Watts and Tahlequah river gages in 2015.





## ARKANSAS RIVER FLOODS

Major flooding occurred along the Arkansas River from Muskogee County through the Fort Smith area. Significant impacts occurred to navigation channel commerce along the McClellan-Kerr Arkansas River Navigation System due to high water. Damaging flooding occurred along the Arkansas River floodplain throughout east central Oklahoma, affecting thousands of acres of agricultural land. Many areas on the grounds of the OG&E power plant near Muskogee were flooded. Significant flooding also occurred in and around Webbers Falls, OK (Muskogee Co.) and in Moffett, OK (Sequoyah Co.). Several suburban neighborhoods near the river were flooded in Fort Smith, and two other residences were flooded as Vache Grasse Creek backed up near the Arkansas River in Sebastian County. One home was flooded near Kibler in Crawford County, and a marina was washed out near the location of the Arkansas river gage in Van Buren.

Record flooding also occurred along Lee Creek in Crawford County, where an RV trailer park was inundated. Most residents evacuated, but two people remained and had to be rescued. Three residences were flooded by several feet of water. Two individuals remained in a 2-story house while the first floor was inundated. After the crest, the river remained above major flood stage for four days due to back water from the Arkansas River.

Below: Arkansas River flooding in a residential neighborhood in Fort Smith (approximately the same area as aerial photo far right). The top photo was taken across the street December 28, 2015, when the river level was about 34 feet (about a half-foot below the crest). The bottom image is the same home as seen on Google Street Maps.



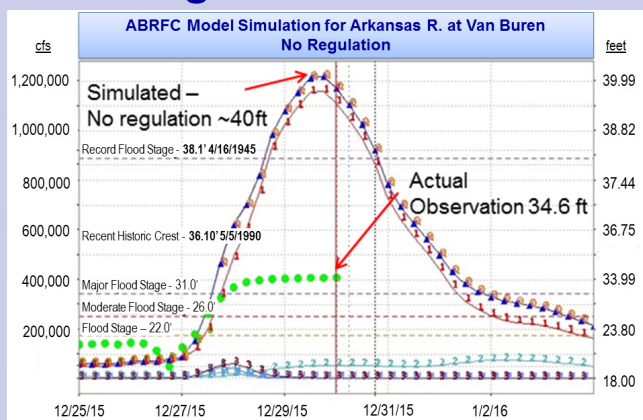
Above: Flood waters at the Van Buren, AR train bridge over the Arkansas River on December 29, 2015 (top), compared with a picture of more normal river levels. Bottom photo by Jamie Lopez.



Below: Arkansas River flooding in a residential area of Ft. Smith taken January 1, 2016. The river level at this time is about 2.5 feet below the crest.



### What Might Have Been



The Arkansas-Red Basin River Forecast Center (ABRFC) ran their river computer models to simulate what would have happened along the Arkansas River at Van Buren had none of the upstream USACE reservoirs been in place. They estimated the crest at Van Buren would have been around 40 feet, about 5 feet higher than the actual crest, and the flow would have been near 1.1 million cfs, or nearly three times the actual flow during the flood!

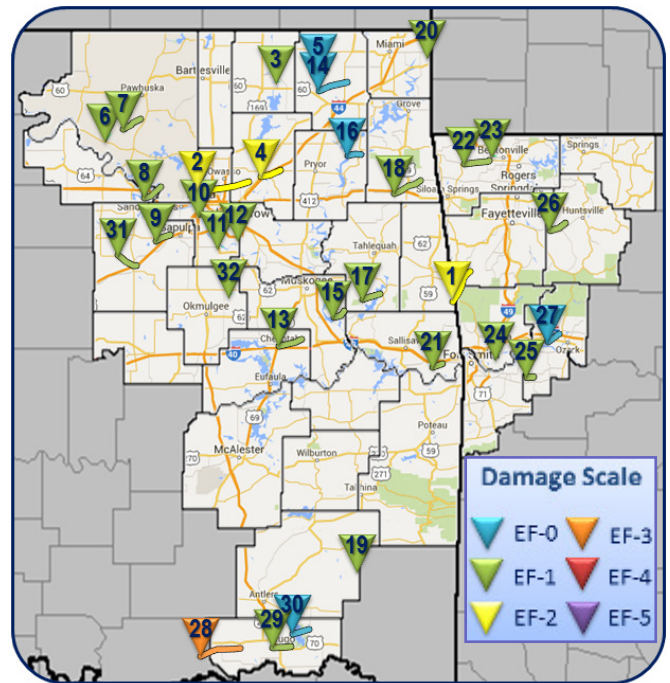
By comparison, at 37 feet, near catastrophic flooding would have occurred along the Arkansas River. The port of Fort Smith and nearby businesses would have been severely flooded, along with several residential subdivisions around Fort Smith. Backwater flooding would also have occurred in the trailer parks next to Lee Creek.

# TORNADOES OF 2016

For the second consecutive year, and for the fifth time in the last seven years, eastern Oklahoma and western Arkansas had an above average number of tornadoes in 2016 (as of November 15). At this time, 32 have been confirmed, compared with a mean of about 19. This will rank as the 9th most tornadoes in a single year.

Tornadoes were reported on five different days (24 hour periods), with 22 occurring on April 26-27. This ties for the second most in a 24-hour period. The EF-3 tornado in Choctaw County on May 9 was the strongest tornado in the forecast area since May of 2011.

Some of the more significant events are summarized on pages 7 and 8.



Date	Time (CDT)	Counties	Start/End Location	Length (miles)	Width (yards)	Max Wind (mph)	Remarks
1	3/23 951 pm	Adair, Crawford, Washington	11SE Stilwell-5.5 NE Evansville	11.1	800	120-130	4 Injured; See section on this tornado
2	3/30 713 pm	Osage, Tulsa, Rogers	10.5 SSW Skiatook-2 N Verdigris	20.0	800	110-120	7 Injured; See section on this tornado
3	3/30 748 pm	Nowata	4.7 ENE - 7.4 ENE Nowata	2.7	120	100-110	Barns destroyed; homes/outbuildings damaged
4	3/30 800 pm	Rogers	2.3 SW - 4.5 E Claremore	6.4	550	120-130	See section on this tornado
5	3/30 818 pm	Craig	3 NE - 5 NE Centralia	2.5	unk	unk	Over open country; witnessed by several chasers
6	4/26 944 pm	Osage	9.6 WNW - 8.8 NW Hominy	3.8	450	85-95	Snapped/uprooted trees
7	4/26 952 pm	Osage	7.4 SW - 1.5 NW Wynona	6.9	900	95-105	Damaged homes/outbuildings; snapped/uprooted trees
8	4/26 1000 pm	Pawnee, Osage	3.6 SE Westport - 2.7 SE Prue	7.0	800	90-100	Homes damaged; boat docks destroyed
9	4/26 1000 pm	Creek	3.4 NW Kellyville - 2.9 WNW Sapulpa	5.6	550	90-100	Church, several homes damaged
10	4/26 1018 pm	Tulsa	4.2 SSW - 4.4 SE Tulsa	3.8	600	95-105	Damaged church/homes; snapped/uprooted trees
11	4/26 1026 pm	Tulsa	0.5 SW - 2.1 ENE Bixby	2.7	350	90-100	Damaged industrial buildings; roofs off homes
12	4/26 1036 pm	Tulsa, Wagoner	4.4 SSE Broken Arrow-6.5 WNW Coweta	1.0	150	95-105	Damaged homes, snapped/uprooted trees
13	4/26 1111 pm	McIntosh	Checotah - 7.5 NE Checotah	7.5	400	90-100	Damaged roofs of homes and businesses, outbuildings
14	4/26 1116 pm	Craig	8.9 WNW Vinita - 5.5 SW Bluejacket	10.1	500	70-80	Uprooted trees; damaged outbuildings
15	4/26 1134 pm	Muskogee	3.8 SSW - 3.9 ESE Braggs	5.1	800	100-110	Snapped/uprooted trees; damaged buildings
16	4/26 1135 pm	Mayes	2 S Strang - Spavinaw	4.7	750	75-85	Uprooted trees; damaged outbuildings
17	4/26 1146 pm	Cherokee	7.3 W - .9 NW Cookson	7.2	700	100-110	Destroyed outbuildings/boat docks; damaged homes
18	4/26 1158 pm	Delaware	Twin Oaks - Colcord	10.1	850	90-100	Destroyed outbuildings; damaged homes
19	4/27 1203 am	Pushmataha	10.5 SE - 10 ESE Nashoba	1.5	500	85-95	Destroyed chicken house; destroyed outbuilding
20	4/27 1207 am	Ottawa	5.5 NE - 7.1 NE Wyandotte	1.6	350	90-100	Damaged home; destroyed outbuildings
21	4/27 1223 am	Sequoyah	3.2 SW - 2.4 ESE Muldrow	4.3	500	100-110	Damaged homes; snapped/uprooted trees
22	4/27 1229 am	Benton	0.9 NE Decatur - Centerton	9.1	600	100-110	Destroyed outbuildings; damaged homes
23	4/27 1241 am	Benton	1.4 N - 2.5 NE Centerton	2.0	350	85-95	Damaged homes; uprooted trees
24	4/27 1253 am	Crawford	2.1 SW Kibler - Kibler	2.4	300	90-100	Damaged homes/chicken houses; snapped trees
25	4/27 106 am	Franklin	2.6 NW - 2.2 NNE Charleston	3.2	500	85-95	Uprooted tree; blew down power poles
26	4/27 112 am	Madison	1 W - 5.1 NE Wesley	6.2	500	100-110	Destroyed outbuildings; damaged homes
27	4/27 118 am	Franklin	7 W - 4.4 NW Ozark	5.9	700	75-85	Damaged chicken houses, homes; destroyed outbuilding
28	5/9 627 pm	Choctaw	4.9 SW - 6.4 ESE Boswell	10.4	3100	135-145	2 Injured; See section on this tornado
29	5/9 702 pm	Choctaw	3.1 W - 3 E Hugo	6.1	650	95-105	Damaged homes/businesses; storage buildings destroyed
30	5/9 718 pm	Choctaw	6.3 NW Sawyer - 2.4 S Spencerville	6.0	150	unk	Chasers/spotters observed; no damage found
31	5/23 528 pm	Creek	5.5 E Shamrock - 2.6 NE Bristow	8.0	900	100-110	Home severely damaged; multiple outbuildings destroyed
32	5/24 129 am	Okmulgee	7.1 NNE Morris - 8.4 NNE Morris	1.8	350	95-105	Snapped/uprooted trees; snapped power pole



## Tulsa/Claremore, OK Tornadoes 3/30/2016

A supercell storm produced two strong tornadoes on the north side of the Tulsa metro area on the evening of March 30, 2016. The first developed about 2.5 miles southwest of Turley, where numerous trees were snapped and uprooted, one home sustained major damage to the roof, a horse trailer was thrown about 50 yards into a lake, and several barns were destroyed.

The tornado moved generally east across the northern portion of the City of Tulsa, roughly along East 46th St. North. A number of homes and businesses were damaged west of Highway 75, before the tornado moved across Mohawk Park, where it snapped and uprooted numerous trees. Several industrial metal buildings were significantly damaged north-northeast of the Tulsa International Airport on N. Mingo Road, with EF-2 damage noted in this area. The tornado continued across Highway 169 just south of the Bird Creek bridge, destroying several barns and snapping numerous trees along East 56th St. North before moving into Rogers County.



Left: One of several metal buildings damaged near Tulsa International Airport. This was the only area within the 20 mile path where EF-2 damage was found.



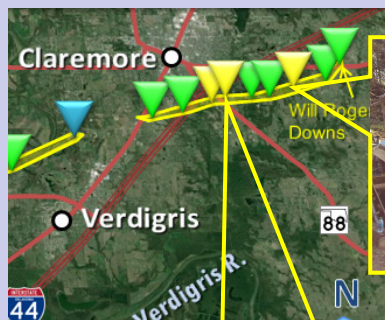
EF-1 damage to a home under construction (above), and a nearby completed home (below).



Based on radar data and the ground survey, the supercell appears to have cycled north of Verdigris where the first tornado dissipated, with a second tornado developing southwest of Claremore. Numerous homes were damaged east of Highway 66 and west of Interstate 44. Some of the worst damage in this path occurred in a housing area near Highway 88 where several homes received severe damage to their roofs and wall structures, indicative of EF-2 damage. The tornado moved along the East 500 Road, where trees were snapped and uprooted, homes were damaged, and barns were destroyed. The tornado then moved east-northeast toward Will Rogers Downs on Highway 20, where it turned sharply to the northeast and dissipated after damaging several large barns.



Tornado moving across the north side of Tulsa on March 30 as seen from the National Weather Service office in Tulsa.



After crossing the Rogers County line, the tornado moved east-northeast across the northern portion of the Patriot Golf Club and into the Stone Canyon subdivisions on the southeast side of Owasso. Numerous homes were damaged in this area. Several homes under construction were destroyed. The tornado moved across Highway 266 where it destroyed a business, damaged several homes, and snapped or uprooted numerous trees. This tornado dissipated north of Verdigris.



Above and Left: The second segment of this tornado path featured more extensive EF-2 damage. Near one of the homes in this area, 27 people rode the storm out safely in an underground shelter.



## Choctaw County, OK Tornadoes 5/9/2016

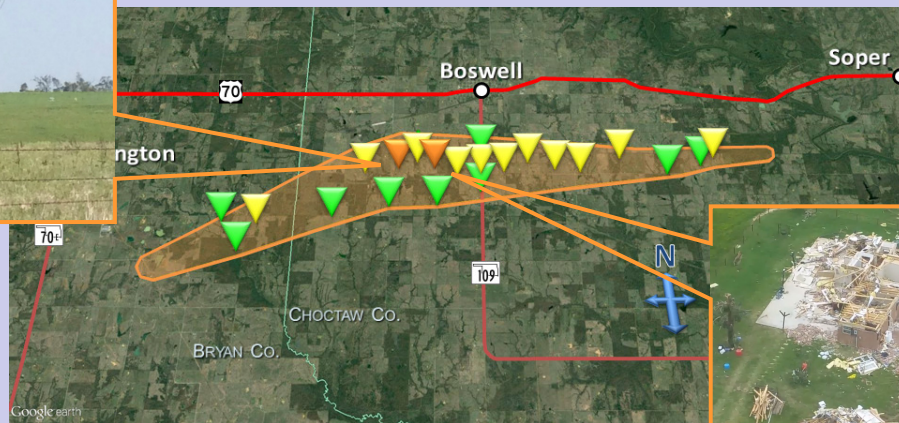
The first EF-3 tornado to strike the NWS Tulsa forecast area since 2011 developed southeast of Bennington (Bryan County) and quickly became very large. Tree damage suggested it intensified to EF-2 strength before it crossed into Choctaw County, a little over 2 miles into its path. The tornado continued to widen as it moved east, with the damage path reaching nearly 2 miles across southwest of Boswell. It was in this area that the most intense damage occurred, along with two injuries...one of them critical. Choctaw County Emergency Management and State of Oklahoma Office of Emergency Management reported that 46 homes were damaged in western

Choctaw County. Also, trees were snapped and uprooted along the tornado's path, many of them reduced to shortened trunks with short stumps where large limbs existed.

A second tornado (not shown here) developed west of Hugo and moved eastward across the central part of town. Numerous homes and businesses were damaged, trees were uprooted, signs were blown down, and storage buildings were destroyed. Hugo Emergency Management and the State of Oklahoma Office of Emergency Management reported 37 homes and business were damaged. ⚡



Above: A large metal transmission tower destroyed near Boswell, OK. This corresponds to EF-3 damage.



Below: EF-3 damage to a home with walls collapsed, except small interior rooms.

Photo courtesy of James Dalton, Bryan Co. EM



## Evansville, AR Tornado 3/23/2016

The first confirmed tornado of 2016 developed in extreme southeastern Adair County, OK over heavily wooded and rugged terrain. The tornado moved roughly along Highway 59 where it snapped or uprooted numerous trees and destroyed a mobile home, severely injuring two people. The tornado moved into southwestern Washington County, AR east of Highway 59, where it destroyed a number of outbuildings, destroyed several mobile homes, severely damaged a couple of permanent homes, snapped or uprooted numerous trees, and snapped numerous power poles. Two people received minor injuries when their mobile home was rolled off its footings. ⚡



Above: The mobile home at this location was separated from its undercarriage and rolled a considerable distance. Two people in this mobile home were seriously injured. Tree damage in the area was also consistent with an EF-2 rating.





# OUTLOOK FOR WINTER 2016-17

*Unlike last year, conditions in the Pacific Ocean are more favorable for the development of a weak La Niña. So, what can we expect the rest of winter?*

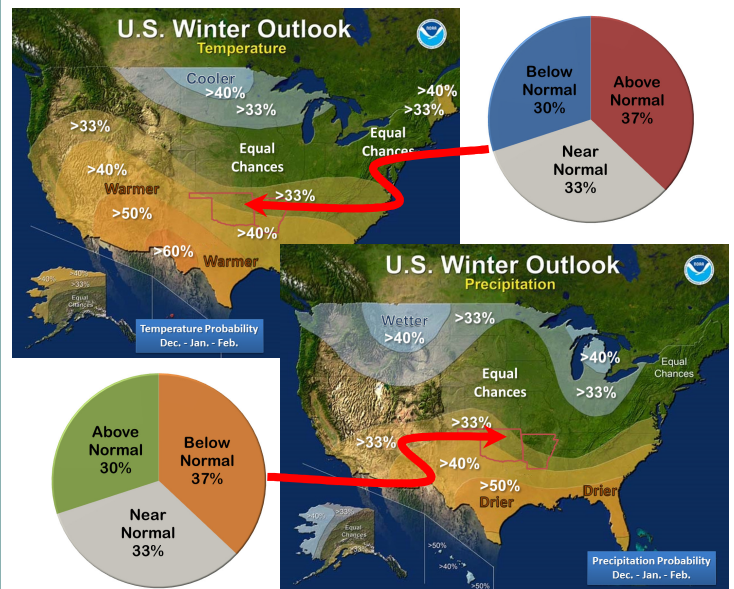
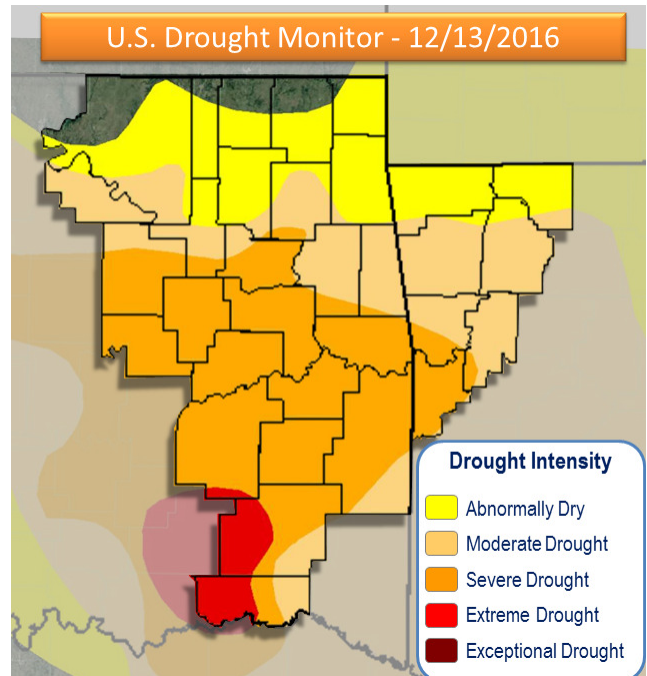
As you might recall, last winter we were under the influence of a strong (Godzilla) El Niño, which tends to favor wetter than normal weather in our area from December through February. Last year was indeed above normal for winter precipitation, mainly due to the December flooding rains. January and February were actually drier than normal in much of the area, but because December had so much rainfall, seasonal totals were well above average.

This year, conditions in the Pacific Ocean are more favorable for the development of a weak La Niña, which implies a small tilt in the odds toward warmer overall temperatures and below normal precipitation. The latter is not welcome news considering drought is expanding once again thanks to the warm and dry fall weather.

Looking at some more specific data for weak La Niña winters for the Tulsa area, while the odds favor warmer average temperature, there is actually a tendency for colder minimum temperatures and warmer maximum temperatures, as well as more days where the temperature falls below freezing.

As for snowfall, while there is no clear signal for above or below normal snow in Tulsa, there appears to be a small shift towards more days with snowfall. Also, La Niña winters tend to favor a jet stream pattern which brings more frequent arctic fronts into the lower 48, some of which may impact Oklahoma and Arkansas (we have already seen this in December, but moisture has really been lacking thus far). With that in mind, the potential for a significant winter weather event could be higher, if we can just tap into some moisture! ⚡

Below: The Drought Monitor issued on December 13 shows an expanding area of drought conditions over much of eastern Oklahoma and western Arkansas, as a result of below normal precipitation during the summer and fall. The outlook favoring below normal precipitation implies that drought conditions are most likely to persist through the winter months.



Above: The site specific probabilities of temperatures and precipitation to be above, near, or below normal for Tulsa for December 2016 through February 2017 are shown. This shows how the odds are "tilted" in favor of above normal temperatures and below normal precipitation, but also shows that some probability of other outcomes still exist. Keep in mind these values are for a three-month period as well.