NWS FORM E-5 (11-88) (PRES. by NWS Instruction 10-924)	**U.S. DEPARTMENT OF COMMERCE** NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NATIONAL WEATHER SERVICE	HYDROLOGIC SERVICE AREA (HSA) **Tulsa, Oklahoma (TSA)**
MONTHLY REPORT OF RIVER AND FLOOD CONDITIONS		REPORT FOR: MONTH **August** YEAR **2016**
TO: Hydrometeorological Information Center, W/OH2 NOAA / National Weather Service 1325 East West Highway, Room 7230 Silver Spring, MD 20910-3283		SIGNATURE **Steven F. Piltz** (Meteorologist-in-Charge) DATE **September 12, 2016**

When no flooding occurs, include miscellaneous river conditions, such as significant rises, record low stages, ice conditions, snow cover, droughts, and hydrologic products issued (NWS Instruction 10-924)

[X] An "X" in the box indicates no flood stages were reached in this Hydrologic Service Area (HSA) during the month above.

August 2016 was a dry month for most of eastern OK and northwest AR despite rain occurring on many days this month. Temperatures were near normal on average, though the first and last parts of the month were above normal, while below normal temperatures prevailed mid-month. Normal rainfall for August ranges from 2.6 inches in McIntosh County to 3.8 inches in Ottawa County. In the Ozark region of northwest Arkansas, rainfall averages 3.7 inches for the month. This report, past E-5 reports, and monthly hydrology and climatology summaries can be found at http://www.srh.noaa.gov/tsa/?n=hydro-monthly-summary.

Monthly Summary

Using the radar-derived estimated observed precipitation from the RFCs (Fig. 1a), rainfall totals for August 2016 ranged from around 0.25" to around 10". A large portion of the HSA received 1"-3" of rain this month, with the greatest deficits over Okfuskee and Okmulgee Counties. This corresponds to 10% to near 300% of the normal August rain for most of eastern OK and northwest AR (Fig. 1b). However, most of the area saw below normal rainfall this month, with the above normal rainfall occurring over far southeast OK, west central AR, and isolated locations elsewhere.

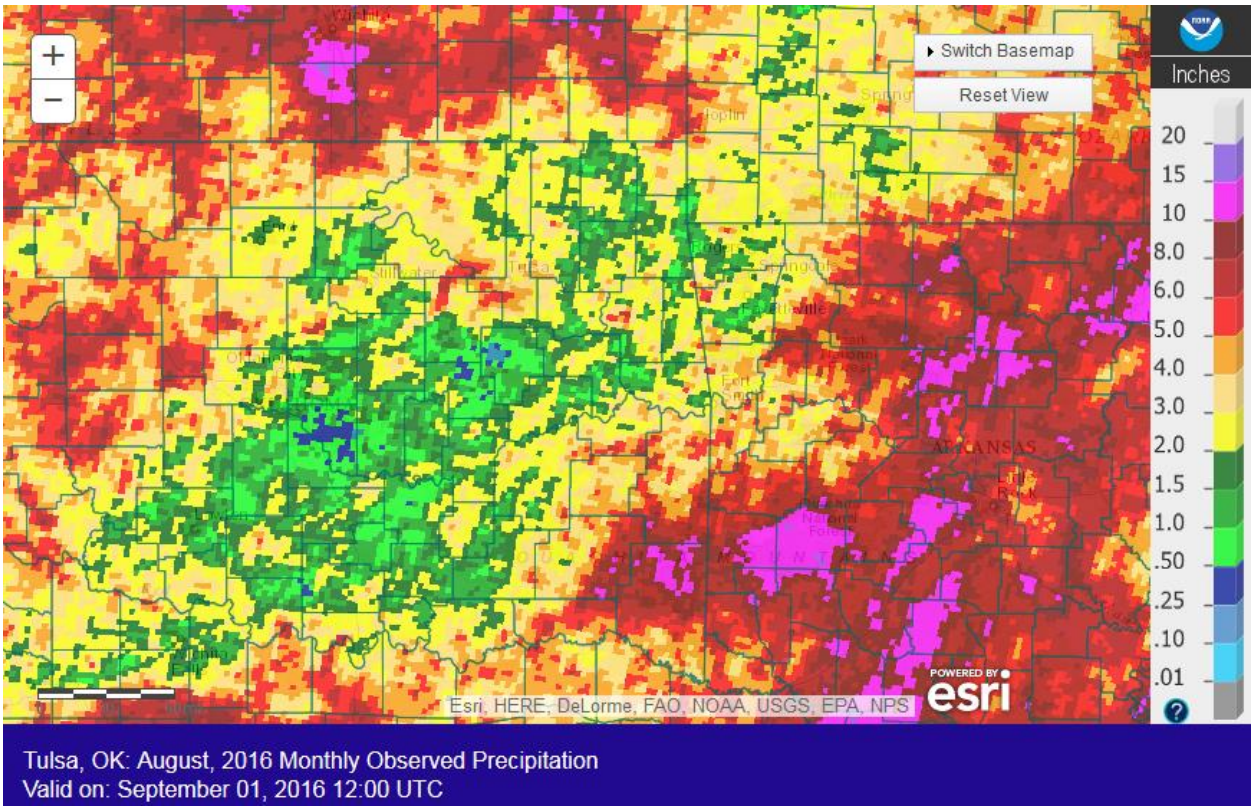


Fig. 1a. Estimated Observed Rainfall for August 2016

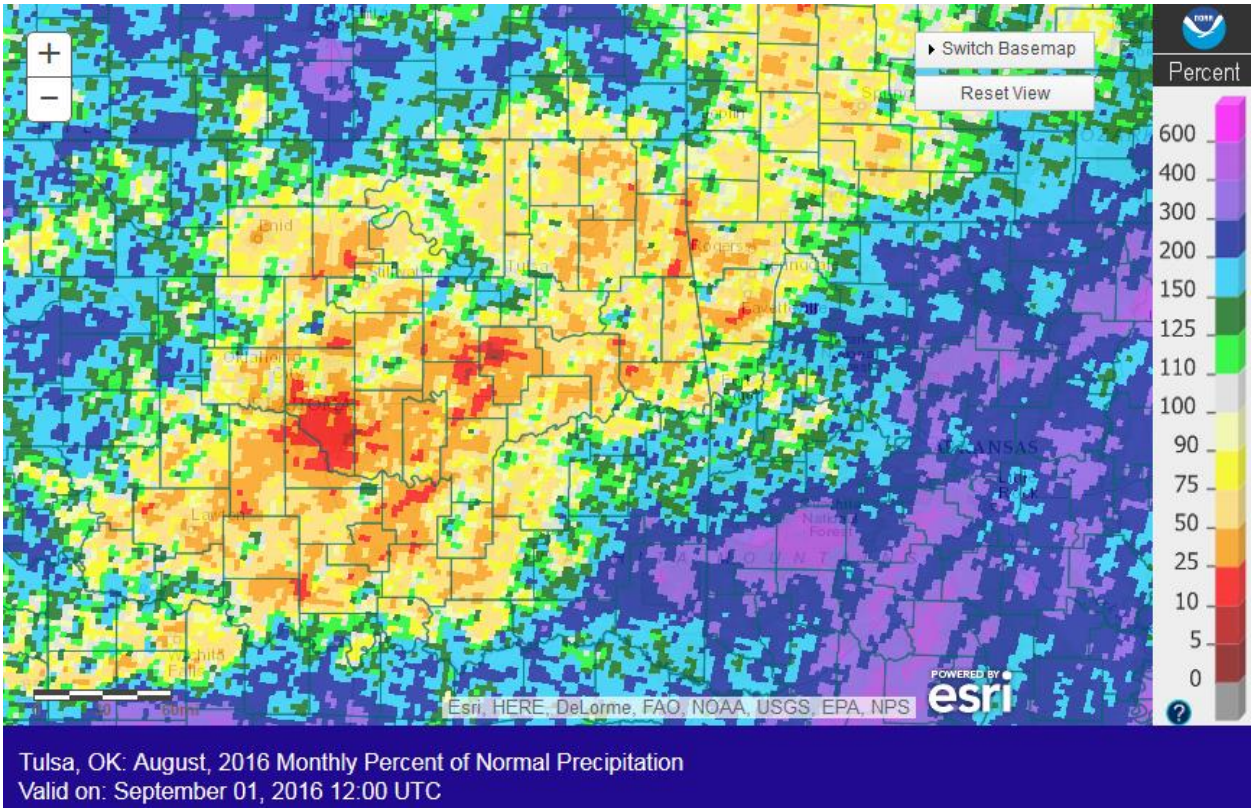


Fig. 1b. Estimated % of Normal Rainfall for August 2016

In Tulsa, OK, August 2016 ranked as the 42nd warmest August (83.0°F, tied 2002, 2005; since records began in 1905) and the 53rd driest August (2.31"; since records began in 1888). Fort Smith, AR had the 46th warmest August (82.6°F, tied 1952, 1926; since records began in 1882) and the 37th wettest August (3.88"; since records began in 1882). Fayetteville, AR had the 32nd warmest (77.0°F, tied 1991, 1989, 1984) and the 9th driest (1.09") August since records began in 1949.

Some of the larger precipitation reports (in inches) for August 2016 included:

Cloudy, OK (meso)	8.68	Ozark 4.6S, AR (coco)	6.42	Sallisaw 1.0SE, OK (coco)	5.82
Sand Springs 8.2NW (coco)	5.81	Jenks Riverside Airport, OK (ASOS)	5.56	St. Paul 1E, AR (coop)	5.53
Hugo, OK (meso)	5.50	Talihina, OK (meso)	5.05	Charleston 1.7E, AR (coco)	5.03

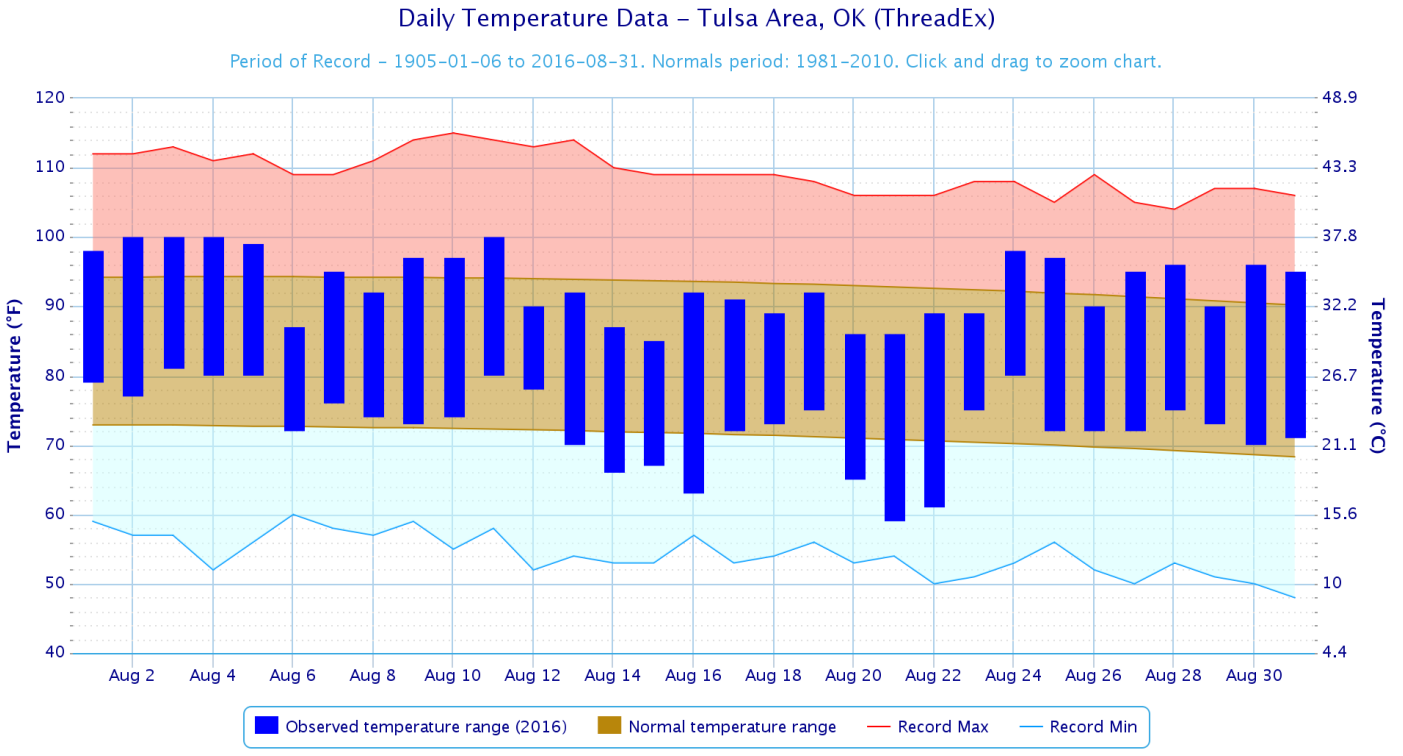
Some of the lowest precipitation reports (in inches) for August 2016 included:

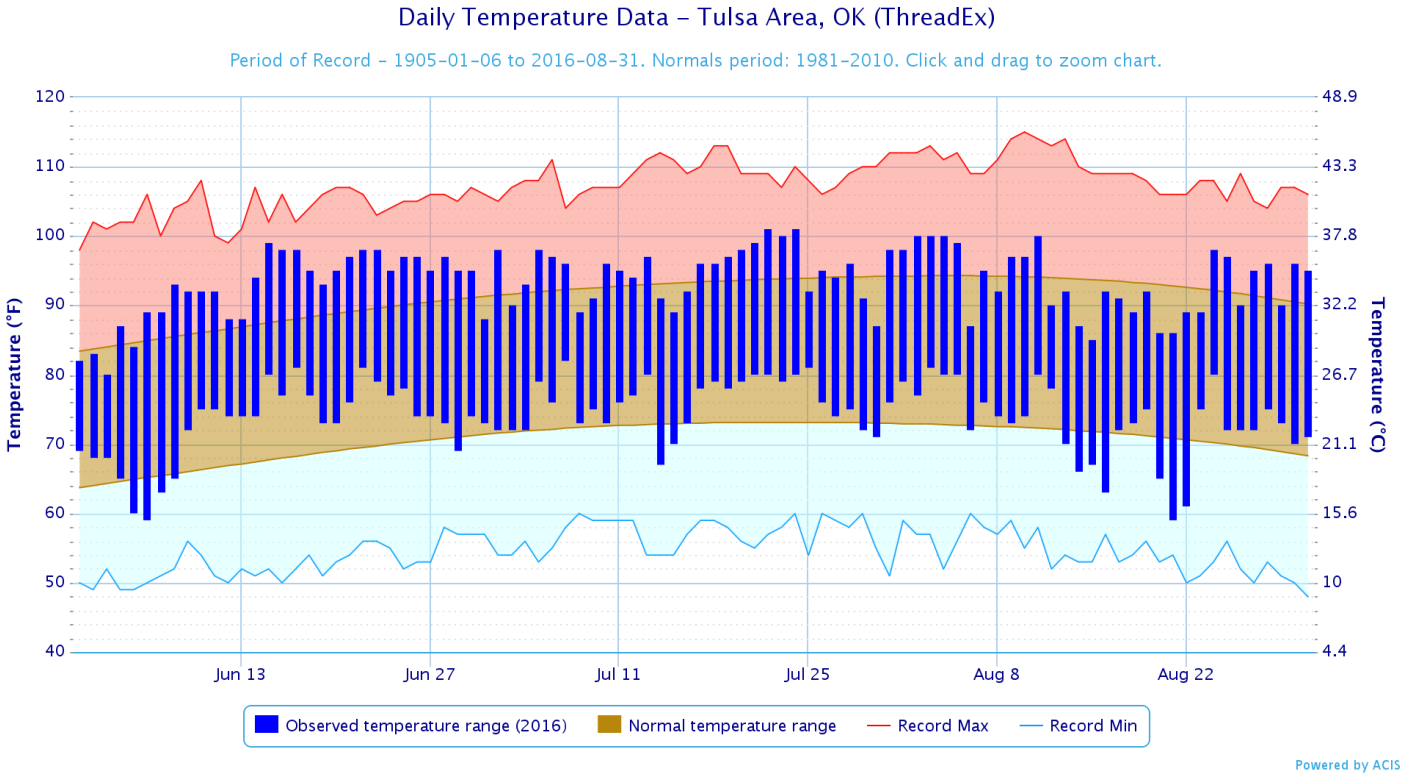
Spavinaw, OK (coop)	0.31	Okemah, OK (meso)	0.41	Vinita 8.6ESE, OK (coco)	0.51
NW AR Regional Arpt, AR (ASOS)	0.76	Bristow, OK (meso)	0.78	Okmulgee, OK (meso)	0.96
Porter, OK (meso)	1.05	Fayetteville Drake Field, AR (ASOS)	1.09	Webbers Falls, OK (meso)	1.11

According to statistics from the Oklahoma Climatological Survey (OCS) Mesonet:

Rank since 1921	Last 30 Days (Aug 2-31)	Last 60 Days (Jul 3 – Aug 31)	Summer (Jun 1 – Aug 31)	Last 120 Days (May 4 – Aug 31)	Warm Growing Season (Mar 1–Aug 31)	Year-to-Date (Jan 1 – Aug 31)	Water Year-to-Date (Oct 1–Aug 31)	Last 365 Days (Sep 2, 2015-Aug 31, 2016)
Northeast OK	36th driest	32nd wettest	29th driest	32nd driest	38th driest	26th driest	22nd wettest	33rd wettest
East Central OK	37th driest	27th wettest	39th driest	38th driest	48th driest	34th driest	**7th wettest**	**10th wettest**
Southeast OK	**6th wettest**	15th wettest	48th driest	48th driest	15th wettest	28th wettest	**2nd wettest**	**2nd wettest**
Statewide	37th wettest	29th wettest	48th wettest	48th wettest	31st wettest	39th wettest	11th wettest	15th wettest

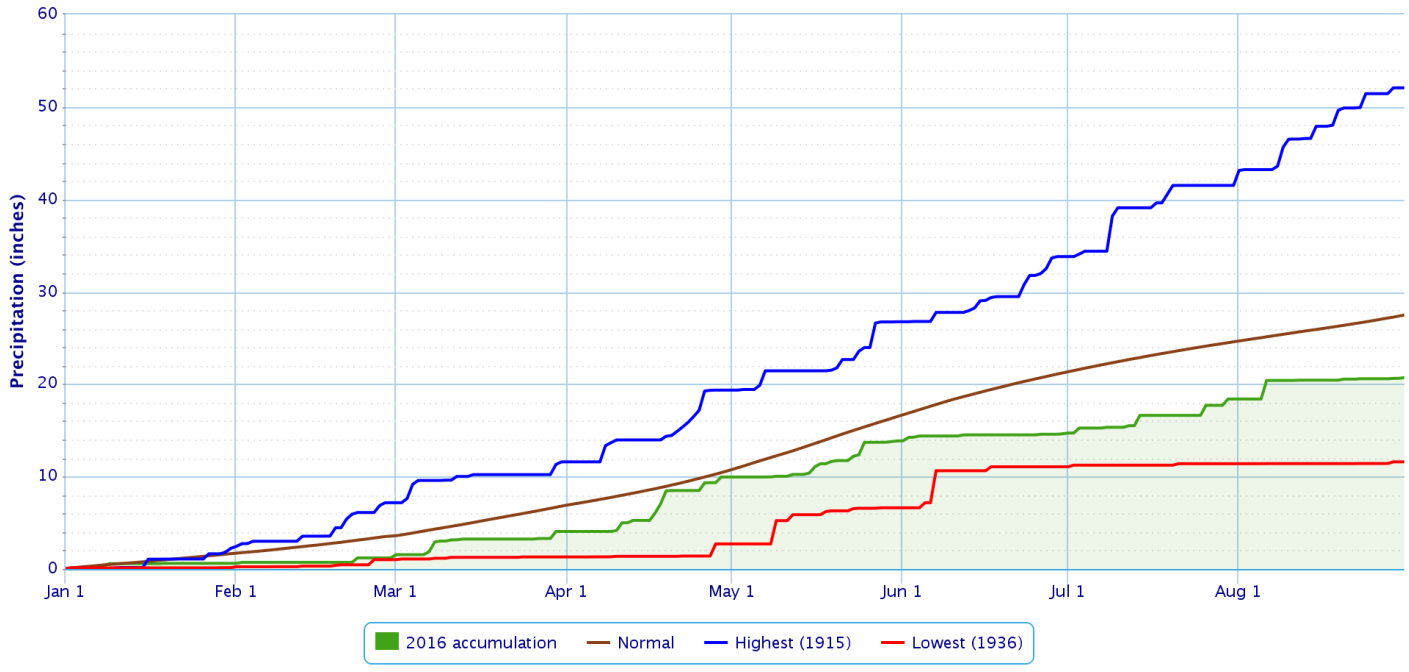
In Tulsa, OK, Summer 2016 ranked as the 11th warmest Summer (83.6°F; since records began in 1905) and the 25th driest Summer (6.84”; since records began in 1888). Fort Smith, AR had the 13th warmest Summer (82.8°F; since records began in 1882) and the 67th driest Summer (9.44”; since records began in 1882). Fayetteville, AR had the 20th warmest (77.2°F, tied 2005, 1983) and the 28th driest (10.84”) Summer since records began in 1950.





Accumulated Precipitation – Tulsa Area, OK (ThreadEx)

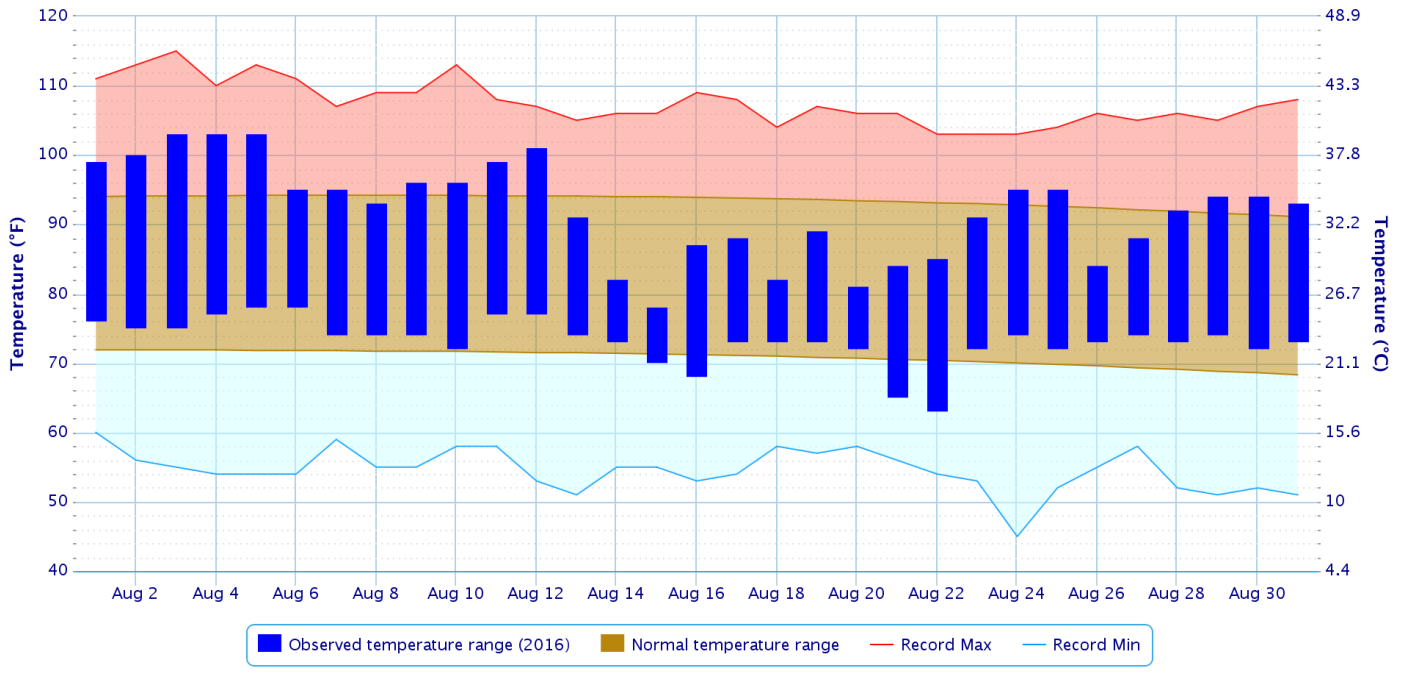
Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



Powered by ACIS

Daily Temperature Data – Fort Smith Area, AR (ThreadEx)

Period of Record – 1882-06-01 to 2016-08-31. Normals period: 1981-2010. Click and drag to zoom chart.



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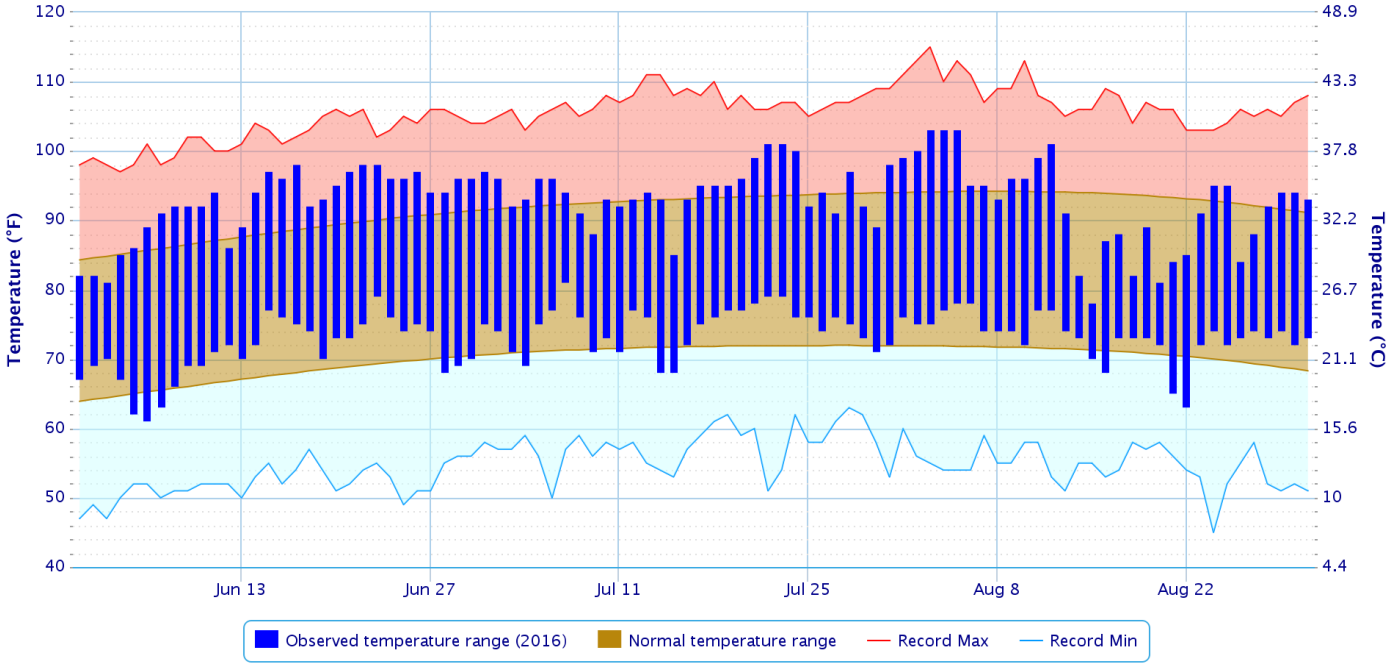

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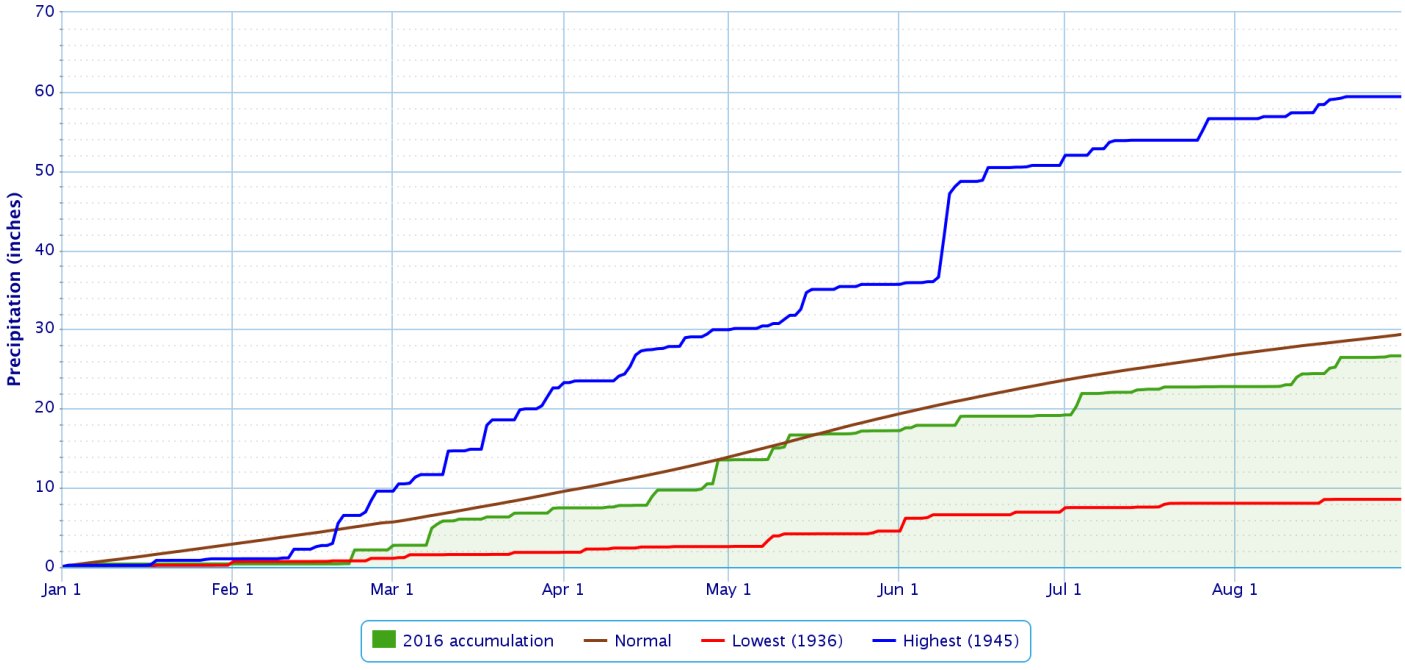

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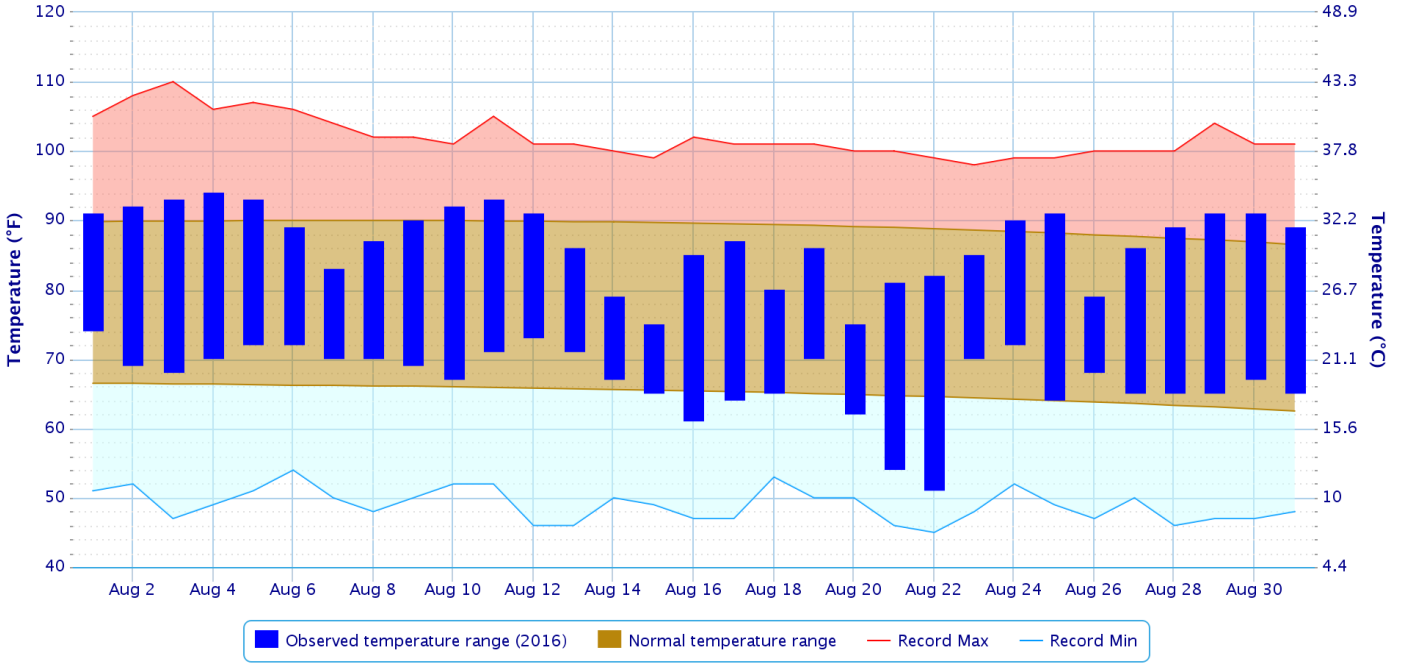
Daily Temperature Data – FAYETTEVILLE DRAKE FLD, AR

Period of Record – 1949-07-14 to 2016-08-31. Normals period: 1981-2010. Click and drag to zoom chart.



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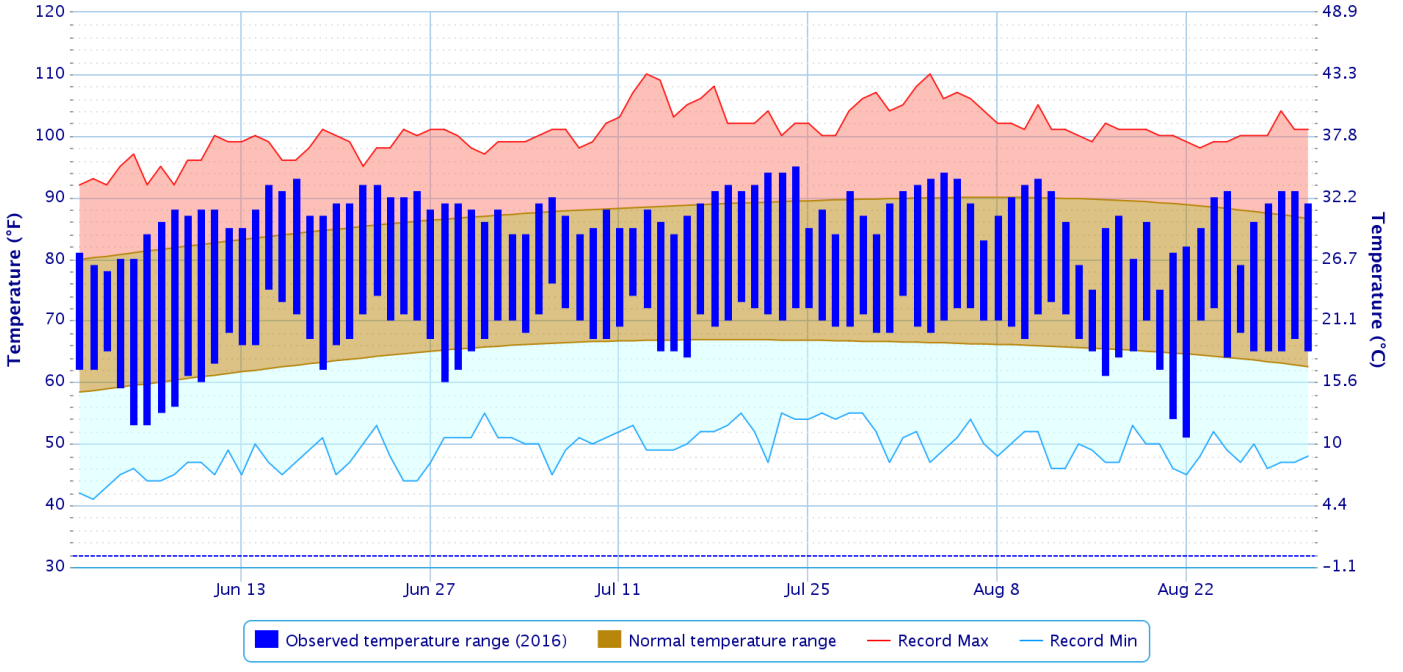
Daily Temperature Data – FAYETTEVILLE DRAKE FLD, AR

Period of Record – 1949-07-14 to 2016-08-31. Normals period: 1981-2010. Click and drag to zoom chart.



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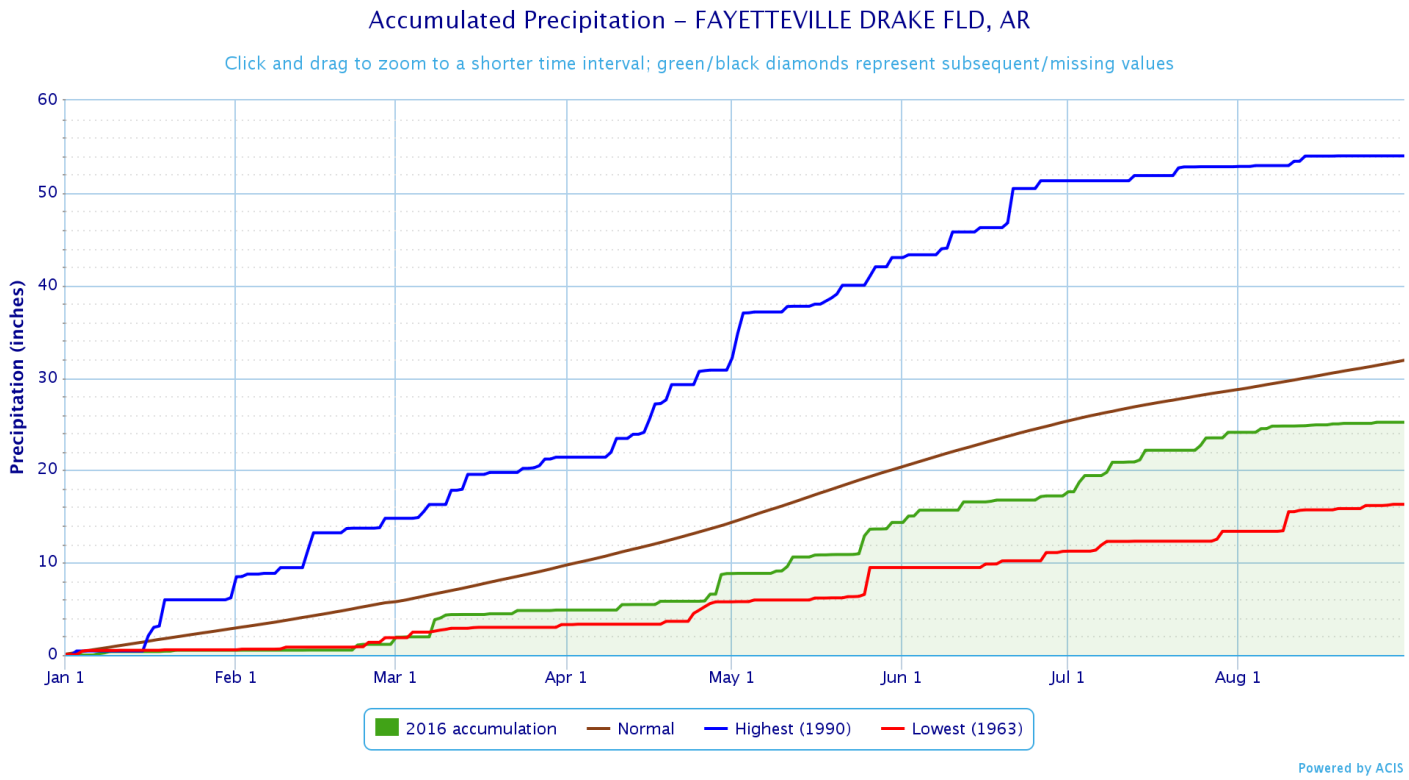


Drought

According to the U.S. Drought Monitor (USDM) from August 30, 2016 (Figs. 2, 3), D2 (Severe Drought) had developed over eastern Wagoner County. D1 (Moderate Drought) conditions existed over portions of Rogers, Wagoner, Muskogee, Mayes, far western Cherokee, far southern Craig, far southern Nowata, and western Choctaw Counties in northeast OK. D0 (abnormally dry conditions but not in drought) were present across portions of eastern Osage, Creek, Tulsa, Washington (OK), Nowata, Craig, Ottawa, Muskogee, Okfuskee, Okmulgee, McIntosh, far southern Pittsburg, Delaware, Cherokee, Adair, Sequoyah, western Pushmataha, and Choctaw Counties in OK. No drought or abnormally dry conditions were occurring in Arkansas.

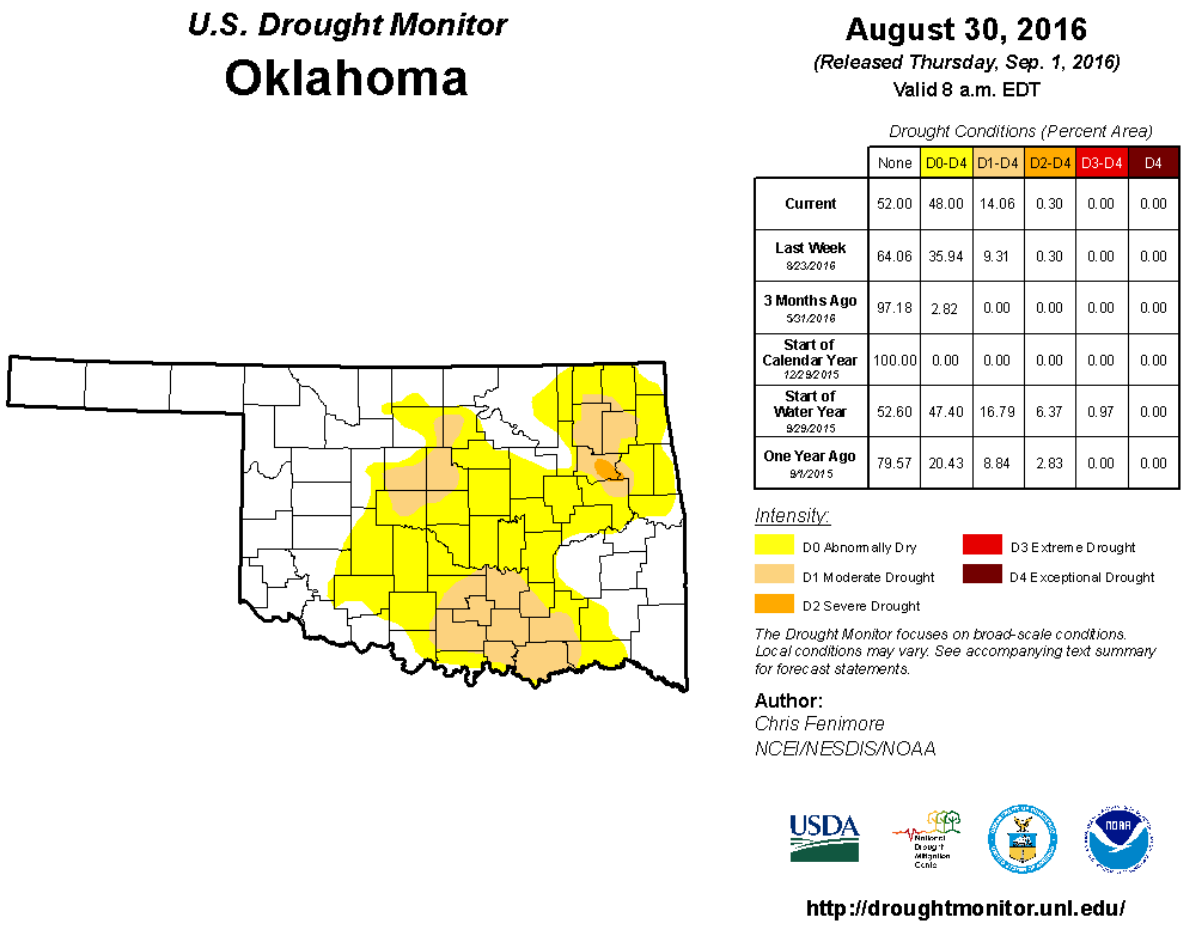


Fig. 2. Drought Monitor for Oklahoma

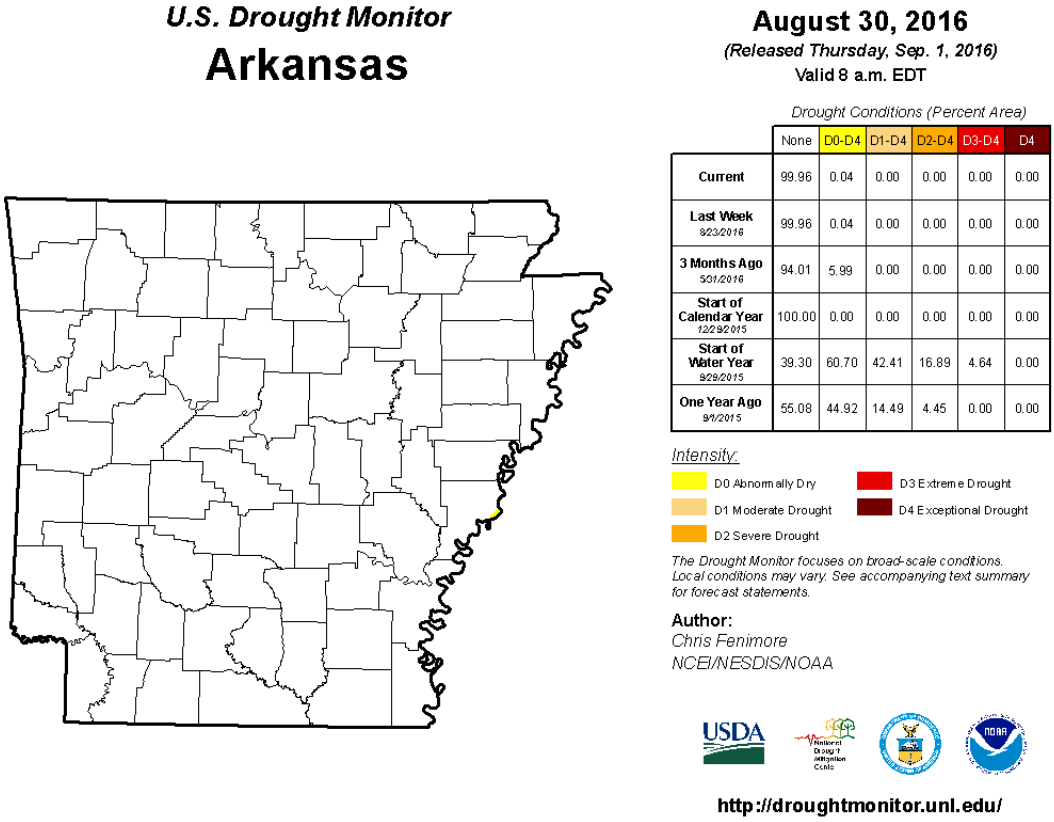
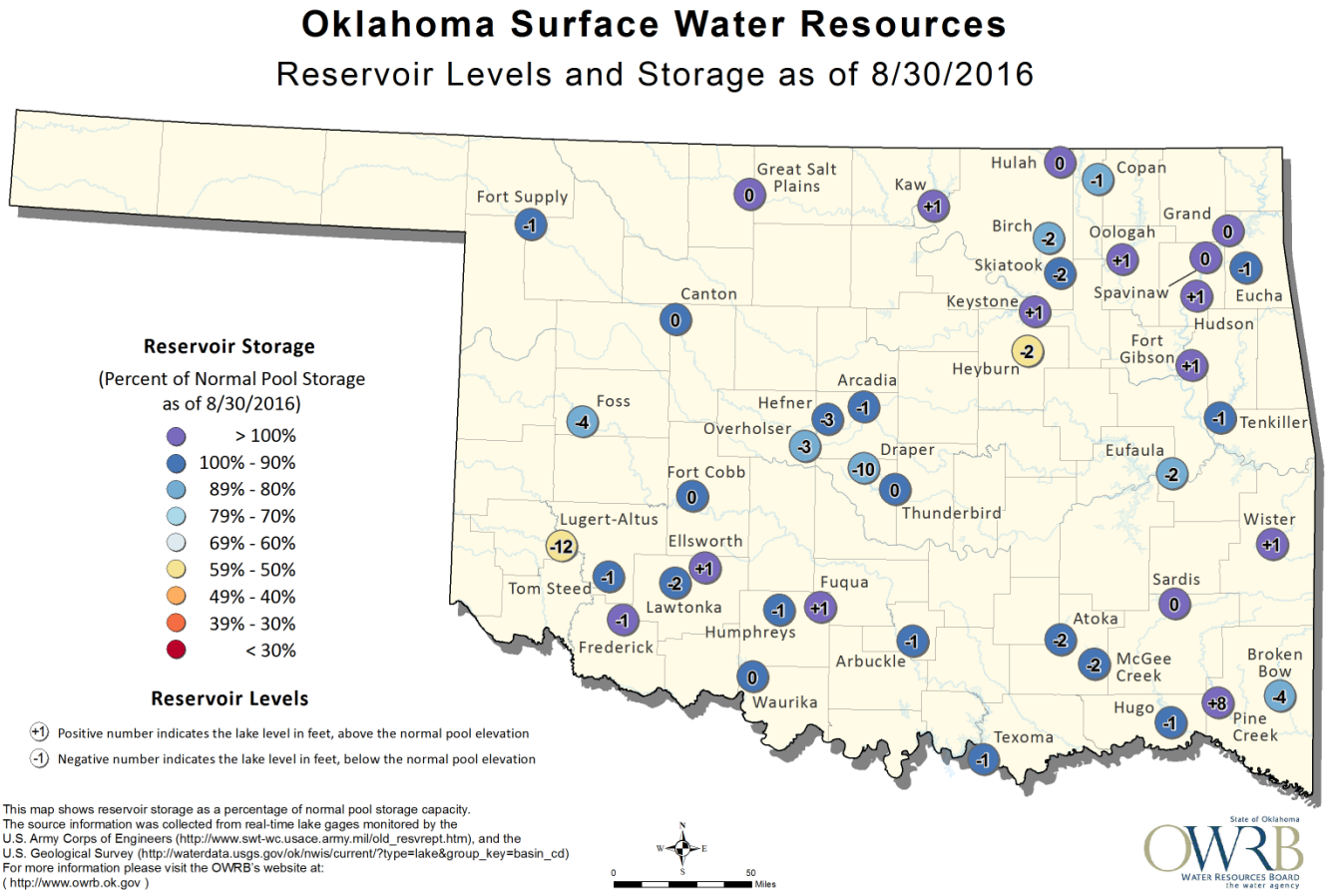


Fig. 3. Drought Monitor for Arkansas

Reservoirs



According to the USACE, several lakes in the HSA were falling and were below the top of their conservation pool levels as of 09/1/2016. Reservoirs operating above 3% of the top of their conservation level include: Oologah Lake 105% and Hudson Lake 104%. Reservoirs operating more than 3% below of the top of their conservation level include: Heyburn Lake 61%, Birch Lake 83%, Beaver Lake 86%, Copan Lake 87%, Eufaula Lake 87%, Hugo Lake 88%, Skiatook Lake 92%, and Tenkiller Lake 95%.

Outlooks

The Climate Prediction Center (CPC) outlook for September 2016 (issued August 31, 2016) indicates equal chances of above, near, and below normal temperatures across all of eastern OK and northwest AR. This outlook is based on both short- and extended-range weather forecasts, with quite a bit of uncertainty.

For the 3-month period September-October-November 2016, CPC is forecasting an enhanced chance for above normal temperatures across all of eastern OK and northwest AR (outlook issued August 18, 2016). This outlook also indicates a slightly enhanced chance for below median rainfall in west central AR, and equal chances for above, near, and below median precipitation elsewhere. According to CPC, Pacific sea surface temperatures along the equator indicate ENSO-neutral conditions (near average), with a transition to weak La Niña conditions expected during the August-September-October season. This outlook is based primarily on both statistical and dynamical forecast tools and decadal timescale climate trends. Outlooks for October-November-December through March-April-May include anticipated impacts due to a weak La Niña. The chance of La Niña conditions during Autumn and early Winter is 55%-60%.

Summary of Precipitation Events Daily quality controlled rainfall maps can be found at: http://water.weather.gov/precip/index.php?location_type=wfo&location_name=tsa

August 1-15

Showers and thunderstorms moved into northeast OK during the pre-dawn hours of the 5th, but remained west of a Bristow to Nowata line until they dissipated by noon. Widely scattered showers and thunderstorms then developed during the late afternoon through the evening hours, primarily between I-44 and I-40 in eastern OK and northwest AR. At midnight on the 6th, a new round of elevated showers and thunderstorms developed over Kay, Osage, and Pawnee Counties near a surface frontal zone. These storms expanded in coverage through the morning hours, affecting a large portion of northeast OK and far northwest AR. A few afternoon storms brought rain to Choctaw County as well. Rainfall totals ranged from 0.25" to around 2.5".

On the afternoon of the 7th, an area of thunderstorms moved south out of MO and into northwest AR. Additional afternoon storms developed over far southeast OK and west central AR. During the late night hours, showers and thunderstorms affected western OK north into south central and southeast OK along a northward moving warm front. This activity brought some light rain to eastern Kay County, but otherwise did not impact the HSA. The affected areas received 0.25" to near 3" of rain. From a wider perspective, the resultant 24-hour rainfall totals looked like a wave crashing over the HSA (Fig. 4).

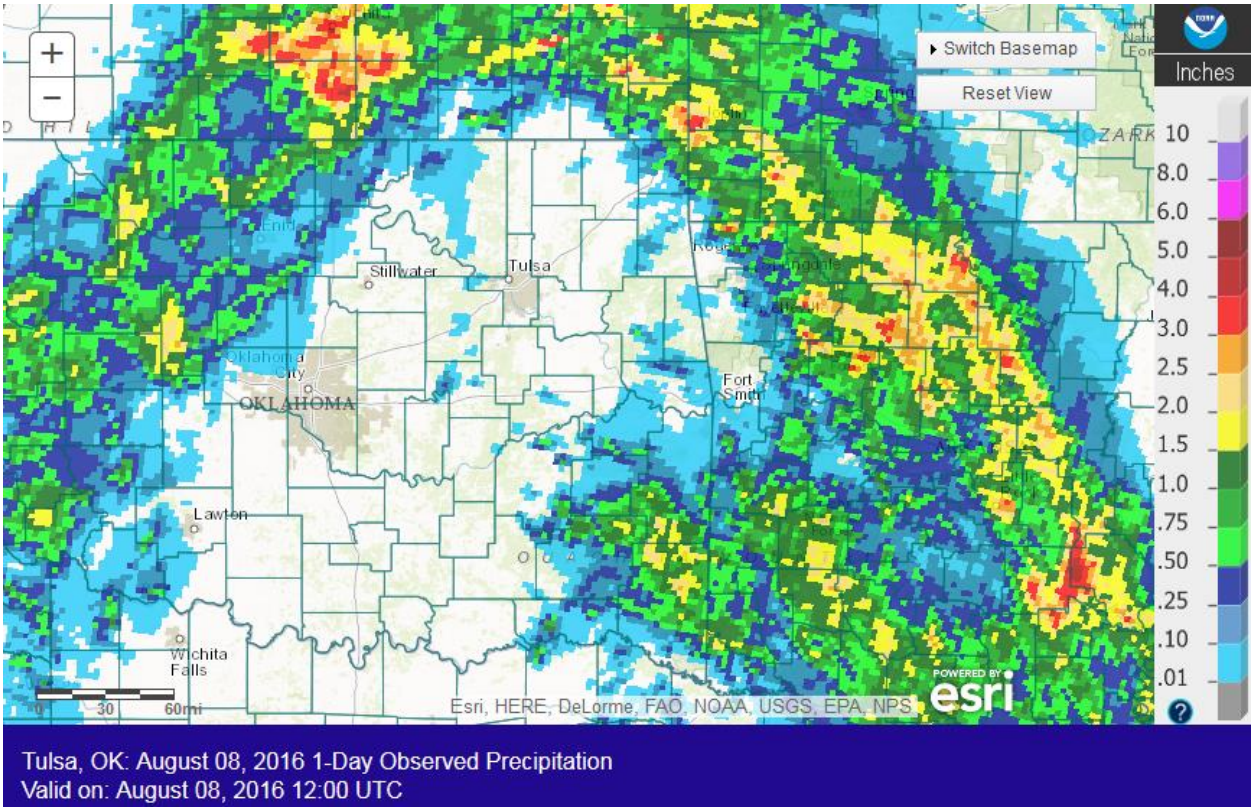


Fig. 4. 24-hour Estimated Observed Rainfall ending at 7am CDT 8/08/2016.

Showers and thunderstorms developed around sunrise on the 8th across northwest AR and moved east by noon. Diurnally driven convection developed over south central into southeast OK later in the day, dissipating by midnight. Rainfall values ranged from 0.25" to isolated 2". Typical summer-time convection occurred during the afternoon and evening hours of the 9th, 10th, and 11th. These storms produced 0.25" to around 1.5" of rain.

Around midnight on the 12th, widely scattered showers and thunderstorms affected eastern Kay and Osage Counties for a couple of hours. Then around sunrise, additional showers and thunderstorms redeveloped over this area near a cold front and outflow boundaries, and spread further south and east through the morning. Shortly after noon, scattered storms stretched from Bartlesville to McAlester. This activity continued eastward into western AR, while also developing further south over southeast OK during the afternoon hours as the front moved south. These storms exited the region by mid-evening, but new storms developed near the slow

moving front over west central AR and southeast OK during the late evening hours. Rain, heavy at times, continued through the overnight hours and finally pushed southeast of the region around sunrise on the 13th. Rainfall totals were typically around 0.10" or less northwest of a McAlester to Fayetteville line, though northern Osage and eastern Kay Counties got 0.25" to 0.75" of rain. Southeast of the McAlester to Fayetteville line, rainfall totals were higher, ranging from 0.50" to around 3" in some spots (Fig. 5). During the afternoon and evening hours of the 13th, isolated thunderstorms developed over portions of Choctaw, Pushmataha, Le Flore, Sebastian, and Franklin Counties, north of the front, but still within an area conducive for storms. This activity brought 0.25" to near 1.5" of rain.

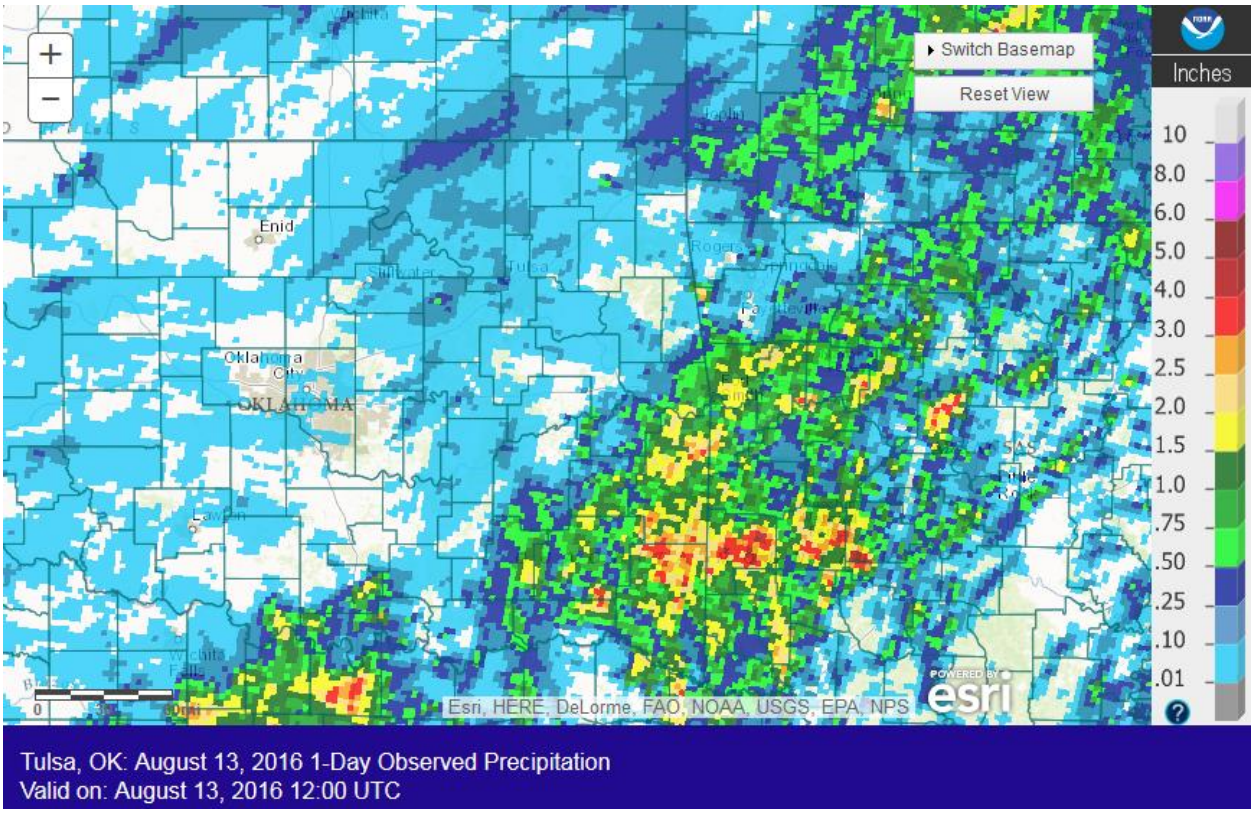


Fig. 5. 24-hour Estimated Observed Rainfall ending at 7am CDT 8/13/2016.

A center of low pressure was centered over the ArkLaTex area on the 14th, with scattered showers moving across portions of northwest AR to the north of the low. This resulted in a 0.10" to near 0.50" of rain across mainly Carroll, Madison, Franklin, and Sebastian Counties, with lesser amounts in Benton and Washington Counties. Showers affected eastern OK and northwest AR, primarily southeast of a McIntosh County to Ottawa County line on the 15th as a shortwave trough lifted into eastern KS and western MO. Rainfall remained light, with a few hundredths to around 0.10" of rain falling.

August 16-31

Through the morning hours of the 17th, scattered showers and thunderstorms moved north out of TX and affected Pushmataha and Choctaw Counties as deep layer moisture increased from the south. A few storms also developed over Le Flore and Sebastian Counties during the afternoon. Rainfall amounts were 0.25" to around 1". More showers and isolated thunderstorms developed over southeast OK and west central AR during the morning of the 18th. This activity expanded through the afternoon, with widely scattered showers along and southeast of I-44. During the evening, the northern edge of thunderstorm activity in TX reached into Choctaw and Pushmataha Counties. Affected areas generally received 0.25" to near 1.5", with higher totals of 1.5" to 3" in eastern Pushmataha County and near the Madison/Franklin County border.

Morning convection once again developed over Le Flore County and into west central AR on the 19th. Isolated showers and thunderstorms continued through the afternoon from southeast OK into northwest AR. A decaying thunderstorms complex also brought some light rain to Pushmataha and Choctaw Counties during the evening. Just before midnight, widespread convections stretched from western OK into southeast KS

along a cold front. The front and associated showers and thunderstorms moved southeast into eastern OK through the early morning hours of the 20th. While the storms moved east of the region by noon, the cold front lagged behind and additional scattered showers and thunderstorms redeveloped along it south of I-44 during the afternoon hours. Most of eastern OK and northwest AR saw some rain from the 19th-20th, though most of it was less than 0.25". Locations along the OK/KS state line received 0.50"-1.5" of rain, while many locations along and south of I-40 ended up with 0.50" to around 2.5" of rain.

Scattered showers and thunderstorms developed along the Red River north of a warm front and affected Choctaw and southern Pushmataha Counties during the afternoon and evening of the 22nd. This activity brought 0.10" to 1" of rain. Scattered showers and isolated thunderstorms moved quickly northeast across northeast OK and far northwest AR on the 23rd as an upper-level wave moved out of north TX. This activity brought around 0.33" of rain to Washington County, OK and around 0.10" or less to the remainder of the affected locations. Storms developed across north central OK on the evening of the 24th in response to another short-wave and moved northeast across eastern Kay County far western Osage County through the late evening. These storms brought 0.25" to near 0.75" of rain.

A quasi-stationary front stalled across the far northern reaches of northeast OK on the 25th, with thunderstorms developing along and north of I-44 through the afternoon and through the late night hours. These storms brought 0.25" to around 2" of rain. A deeper plume of moisture supported showers and thunderstorm development south of the stalled front on the 26th. As these storms dissipated, additional storms developed across central OK as a result of a mid-level shortwave lifting out the panhandle region. These storms moved into eastern OK during the afternoon and evening. Rainfall totals ranged from around 0.25" to isolated 2.5"-4" (Fig. 6).

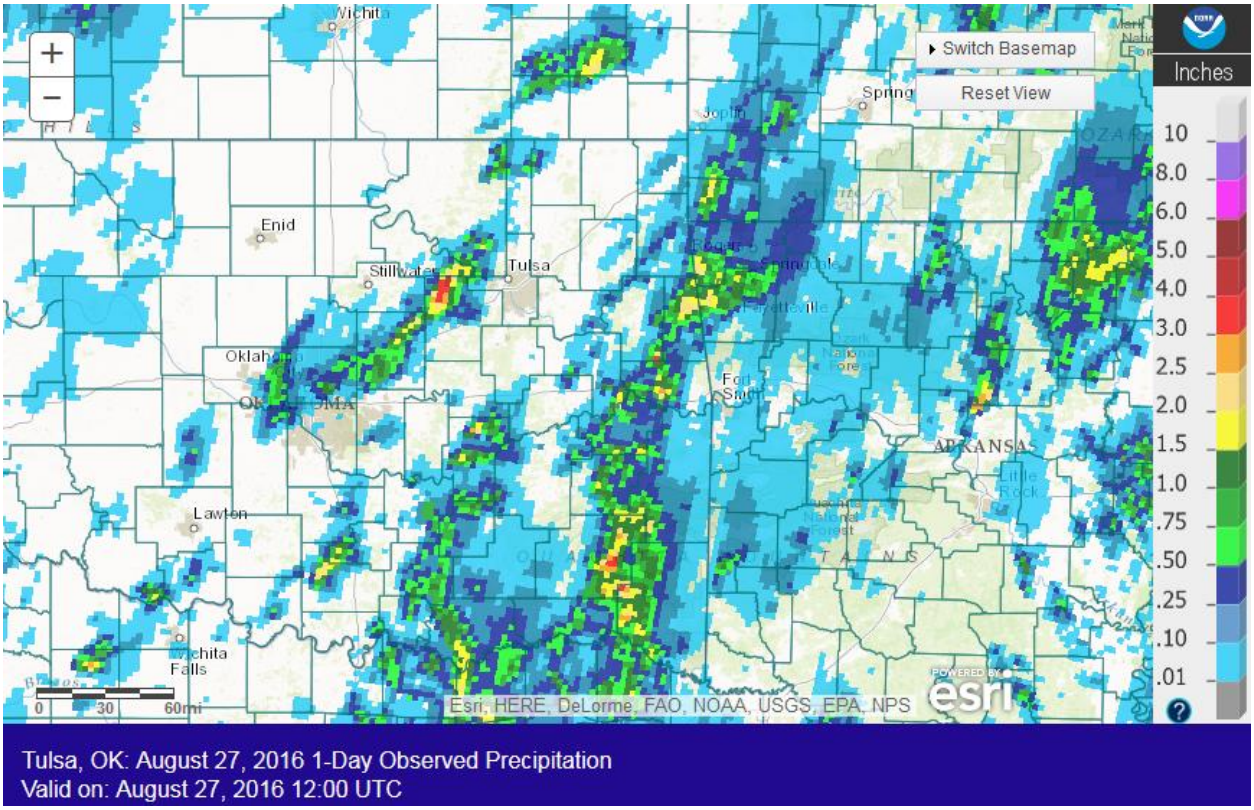


Fig. 6. 24-hour Estimated Observed Rainfall ending at 7am CDT 8/27/2016.

A mid-level ridge then set up over the Southern Plains, with typical diurnal showers and thunderstorms occurring over eastern OK and northwest AR on the 27th and 28th. Those locations that experienced rain received from a few hundredths of an inch to near 1.5". Elevated thunderstorms developed during the morning of the 29th in a level of mid-level moisture near I-44 in northeast OK. Left over outflow boundaries from the morning, as well as the previous day, provided a focus for additional diurnal storm activity during the afternoon and evening. While most affected locations receive 0.25"-1" of rain, a few spots got 1"-2.5". Diurnal thunderstorm activity continued on the 30th, bringing an additional 0.25"-1.5" of rain.

Greater thunderstorm coverage occurred during the morning and afternoon of the 31st as modest height falls occurred over the HSA ahead of a weak cold front. Rainfall totals ranged from around 0.10" to around 1" in most of the affected areas, though some locations received 1.5"-3" of rain (Fig. 7), including Drumright 0.6SW, OK which measured 3.57" in the 24-hours ending at 7am 9/01/2016.

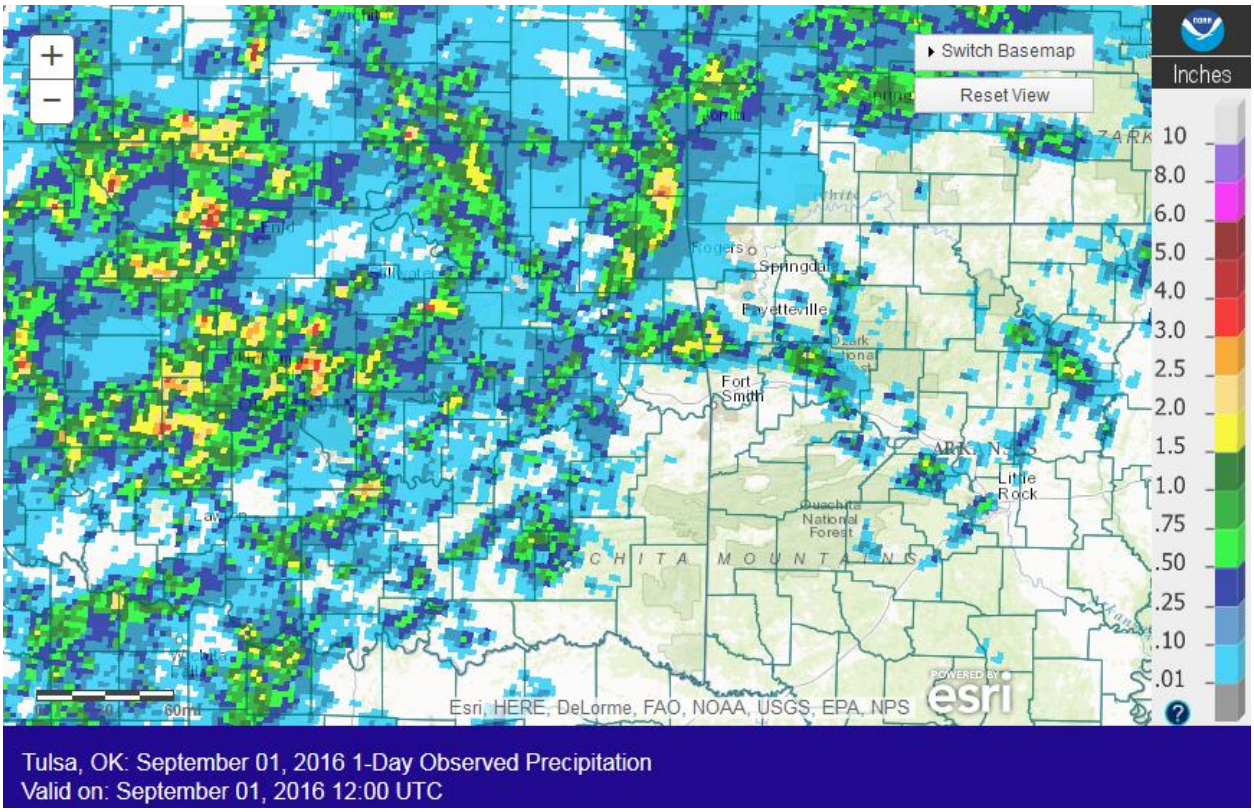


Fig. 7. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/01/2016.

Written by:
Nicole McGavock
Service Hydrologist
WFO Tulsa

Products issued in August 2016:

*MLBA4 and OZGA4 transferred to NWS Tulsa HSA February 5, 2014
*Mixed case River Flood products began July 31, 2013

1 Flash Flood Warnings (FFW)
2 Flash Flood Statements (FFS)
0 Flash/Areal Flood Watches (FFA) (0 Watch FFA CON/EXT/EXA/EXB/CAN)
14 Urban and Small Stream Advisories (FLS)
0 Areal Flood Warnings (FLW)
0 Areal Flood Statements (FLS)
0 River Flood Warnings (FLW)
0 River Flood Statements (FLS)
0 River Flood Advisories (FLS) (0 Advisory FLS CON/EXT/CAN)
0 River Flood Watches (FFA) (0 Watch FFA CON/EXT/CAN)
0 River Statements (RVS)
0 Hydrologic Outlooks (ESF)
0 Drought Information Statements (DGT)

Preliminary Hydrographs:

None