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
MONTHLY REPORT OF RIVER AND FLOOD CONDITIONS	HYDROLOGIC SERVICE AREA (HSA): **Tulsa, Oklahoma (TSA)** REPORT FOR: MONTH **August** YEAR **2021**
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 8, 2021**

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.

It was a dry August for much of eastern OK and northwest AR, though southeast OK received above normal rainfall. Temperatures were above normal for the 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.weather.gov/tsa/hydro-monthly-summary.

Monthly Summary

Using the radar-derived estimated observed precipitation from the RFCs (Fig. 1a), rainfall totals for August 2021 ranged from around 0.5" to around 8" across eastern OK and northwest AR, with much of the area receiving 0.5"-3". These rainfall totals correspond to 125% to around 300% of the normal August rainfall in Pushmataha and Choctaw Counties in southeast OK and a portion of Muskogee and Sequoyah Counties in east central OK (Fig. 1b). Elsewhere, these totals were primarily 10% to 75% of the normal August rainfall.

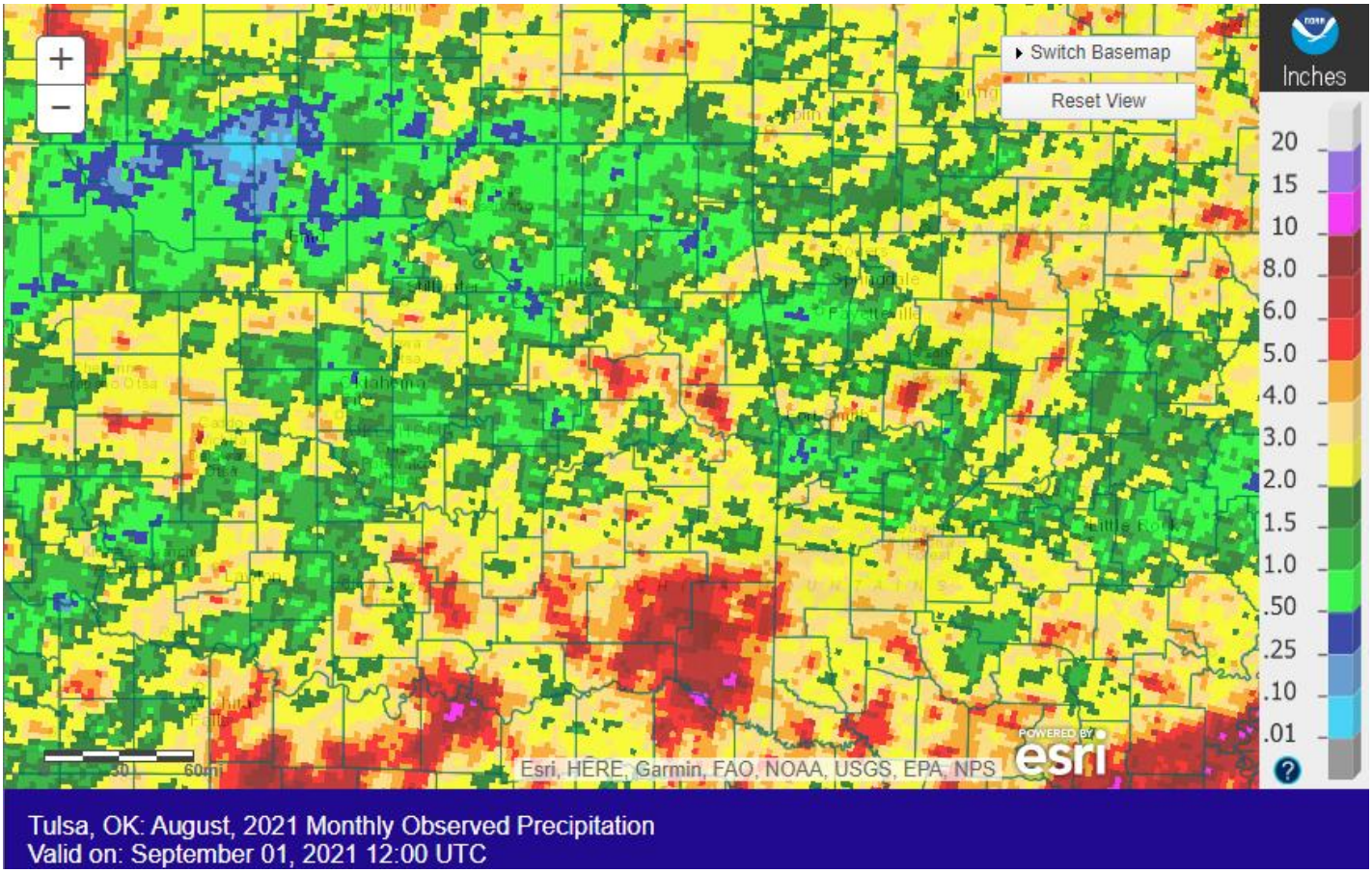


Fig. 1a. Estimated Observed Rainfall for August 2021

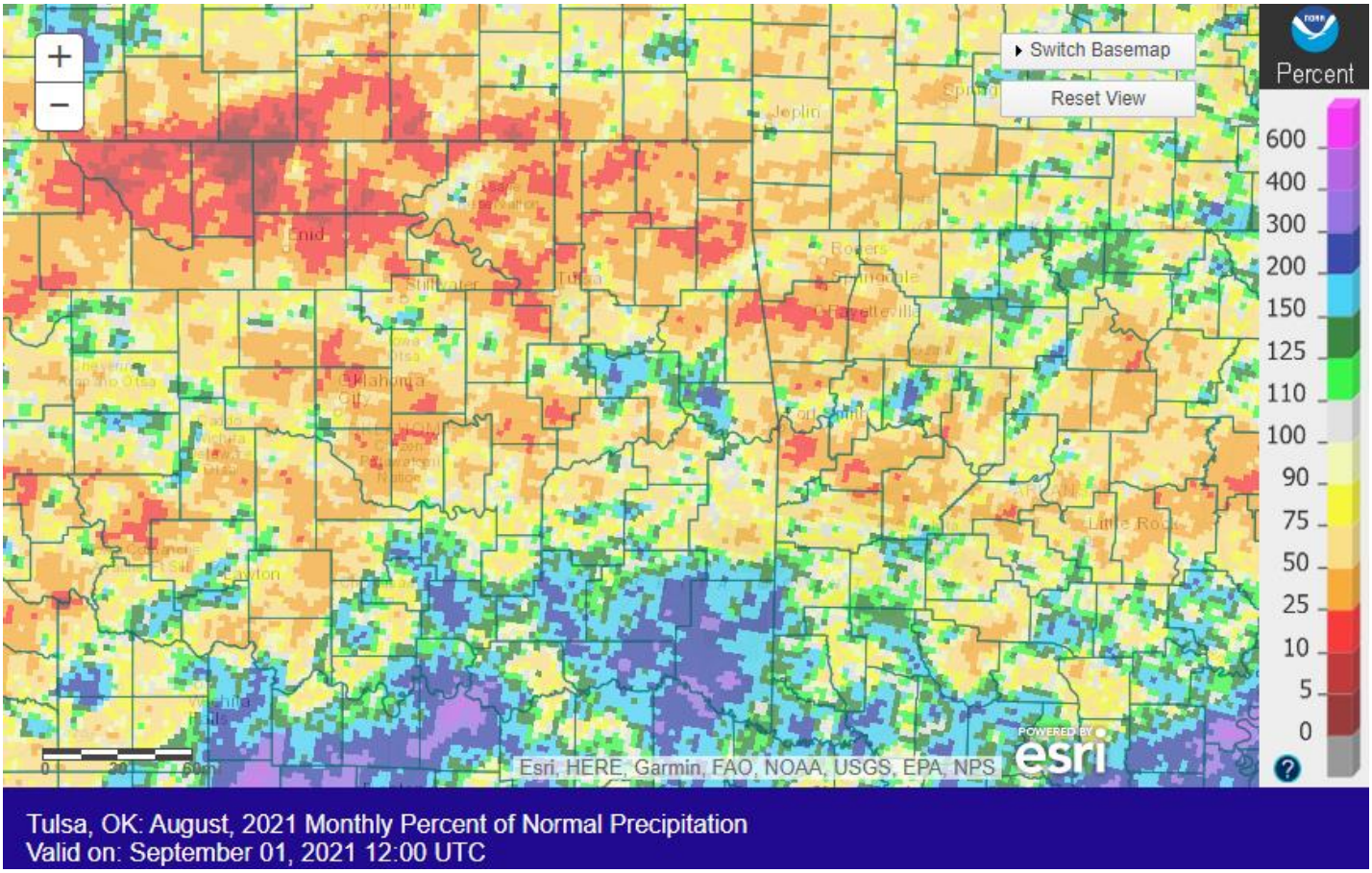


Fig. 1b. Estimated % of Normal Rainfall for August 2021

In Tulsa, OK, August 2021 ranked as the 34th warmest August (83.8°F, tied 1907; since records began in 1905) and the 19th driest August (0.78", tied 1901; since records began in 1888). Fort Smith, AR had the 37th warmest August (83.6°F; since records began in 1882) and the 18th driest August (0.86", tied 1963; since records began in 1882). Fayetteville, AR had the 18th warmest (78.8°F, tied 2003) and the 4th driest (0.56") August since records began in 1949.

Some of the larger precipitation reports (in inches) for August 2021 included:

Hugo 1.9ENE, OK (coco)	8.64	Vian 5.3ENE, OK (coco)	8.25	Hugo, OK (meso)	7.63
Haskell, OK (meso)	5.70	Cloudy, OK (meso)	5.50	Antlers 6.3SE, OK (coco)	5.23
McAlester, OK (meso)	4.96	Antlers, OK (coop)	4.94	Riverdale 4.2E, AR (coco)	4.68

Some of the lowest precipitation reports (in inches) for August 2021 included:

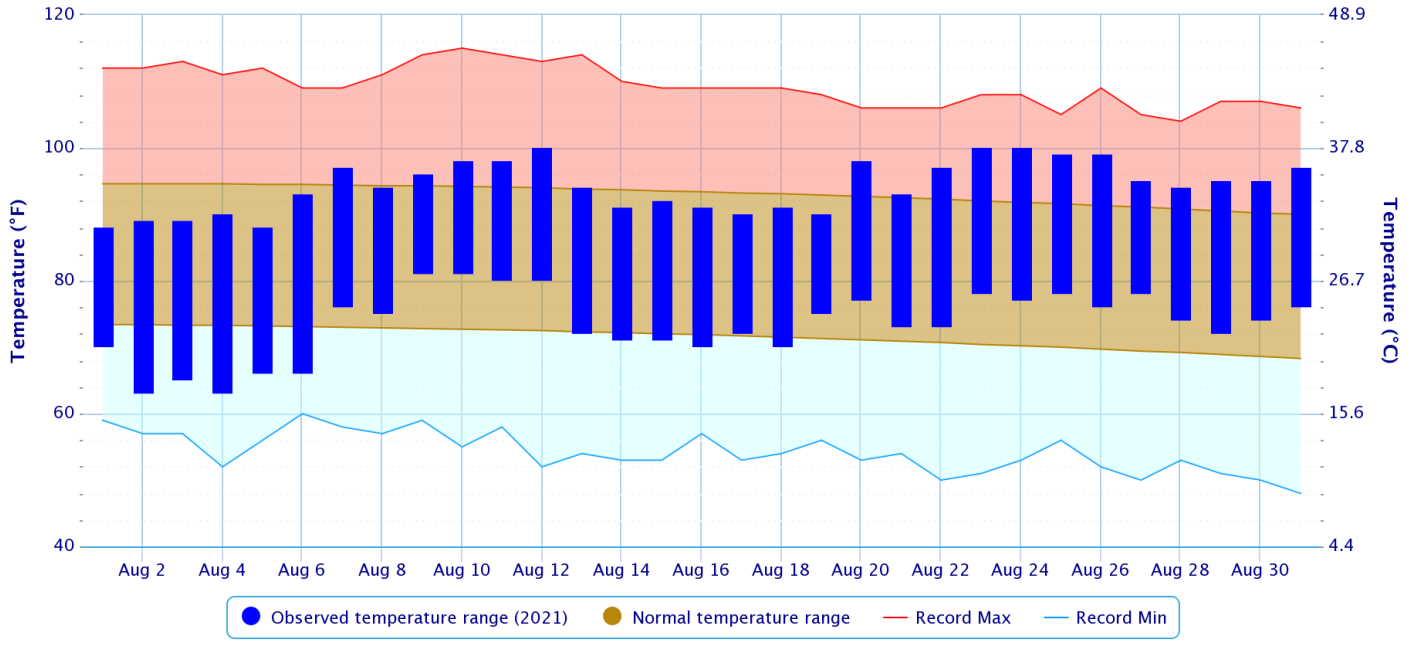
Spavinaw, OK (coop)	0.55	Fayetteville, AR (ASOS)	0.56	Westville, OK (meso)	0.56
Tulsa, OK (meso)	0.66	Nowata, OK (meso)	0.68	Tulsa, OK (ASOS)	0.78
Fort Smith, AR (ASOS)	0.86	Talala, OK (meso)	0.87	Bartlesville, OK (ASOS)	0.89

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

Rank since 1921	Last 30 Days August 2-31	Summer 2021 (Jun 1 – Aug 31)	Last 120 Days (May 4 – Aug 31)	Warm Growing Season 2021 (Mar 1 – Aug 31)	Year-to-Date (Jan 1 – Aug 31)	Water Year-to-Date (Oct 1, 2020 – Aug 31, 2021)	Last 365 Days (Sep 1, 2020 – Aug 31, 2021)
Northeast OK	20th driest	25th wettest	22nd wettest	21st wettest	23rd wettest	22nd wettest	29th wettest
East Central OK	50th wettest	41st driest	51st wettest	29th wettest	41st wettest	45th wettest	43rd wettest
Southeast OK	19th wettest	22nd wettest	12th wettest	15th wettest	21st wettest	33rd wettest	22nd wettest
Statewide	32nd driest	36th wettest	31st wettest	28th wettest	37th wettest	37th wettest	37th wettest

Daily Temperature Data – Tulsa Area, OK (ThreadEx)

Period of Record – 1905-01-06 to 2021-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



Powered by ACIS

Daily Temperature Data – Tulsa Area, OK (ThreadEx)

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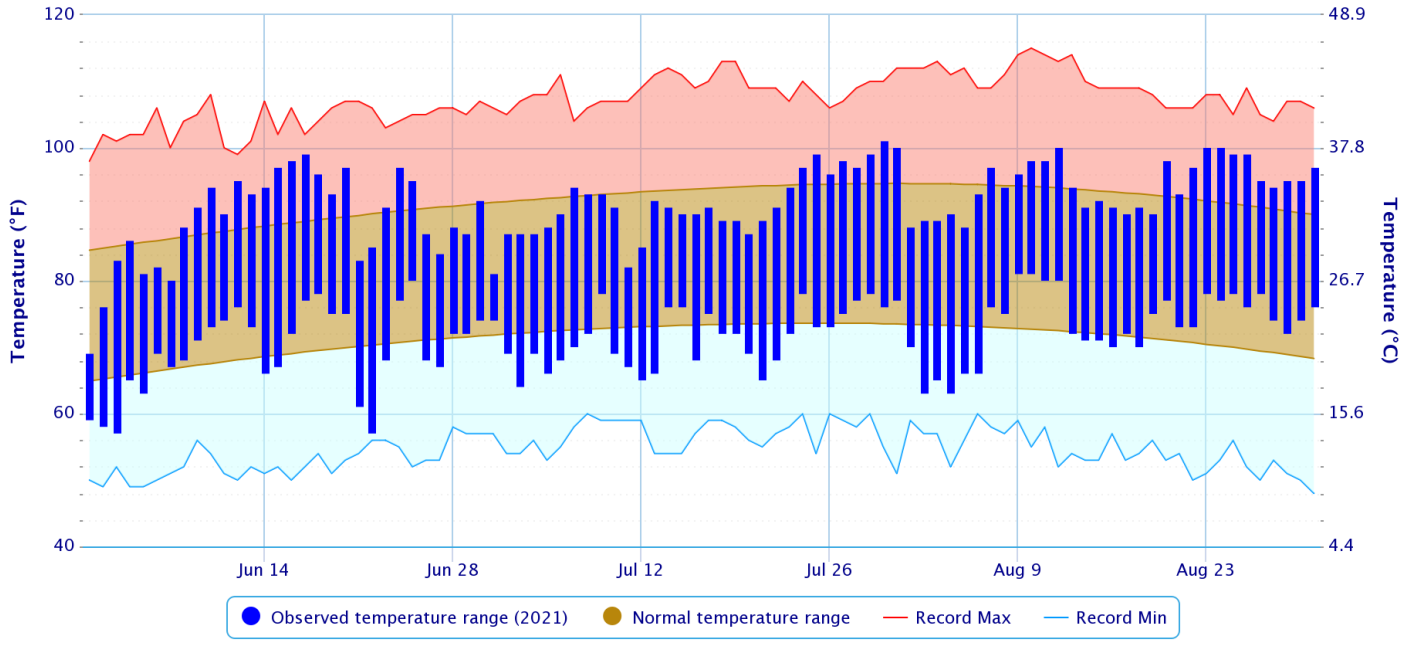
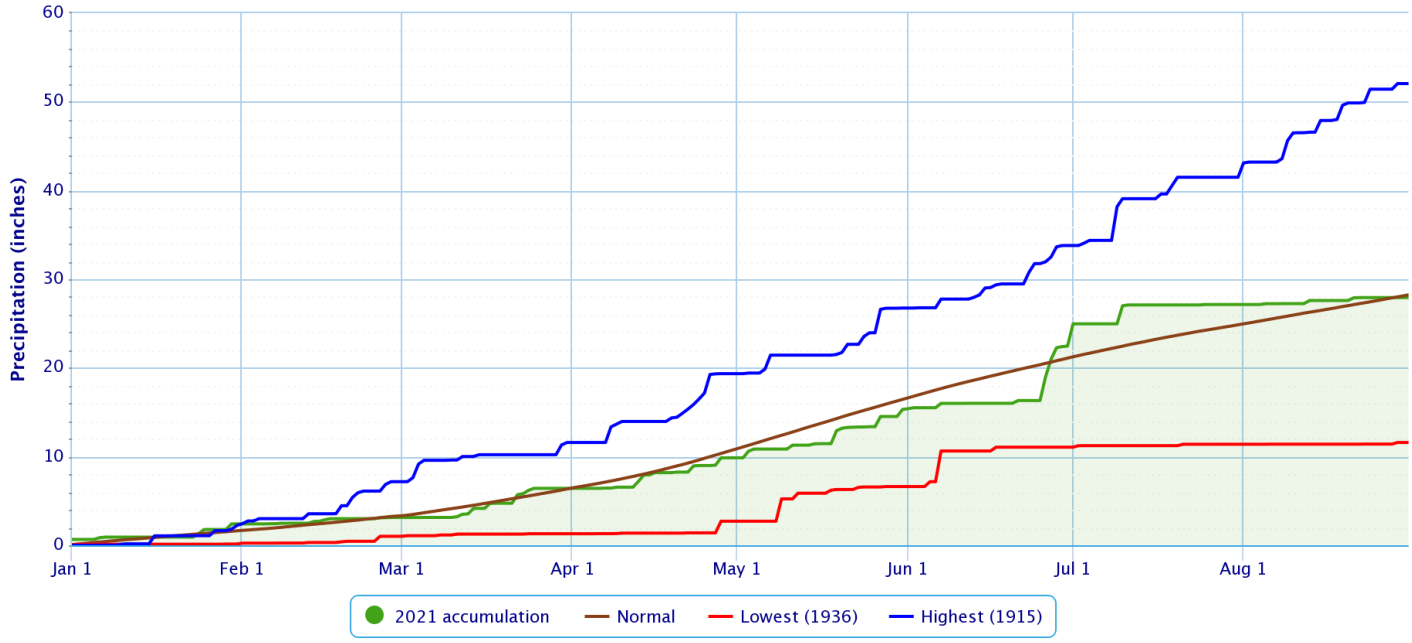


Powered by ACIS

Accumulated Precipitation – Tulsa Area, OK (ThreadEx)

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



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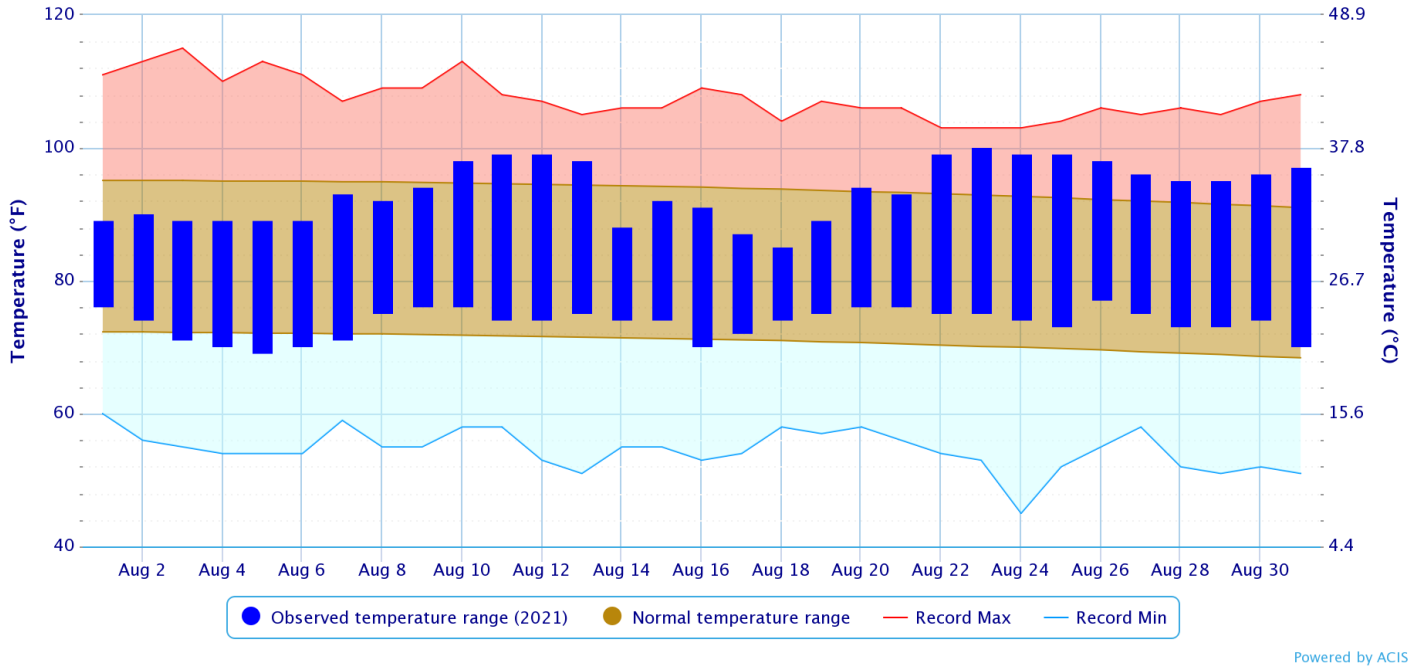
Daily Temperature Data – Fort Smith Area, AR (ThreadEx)

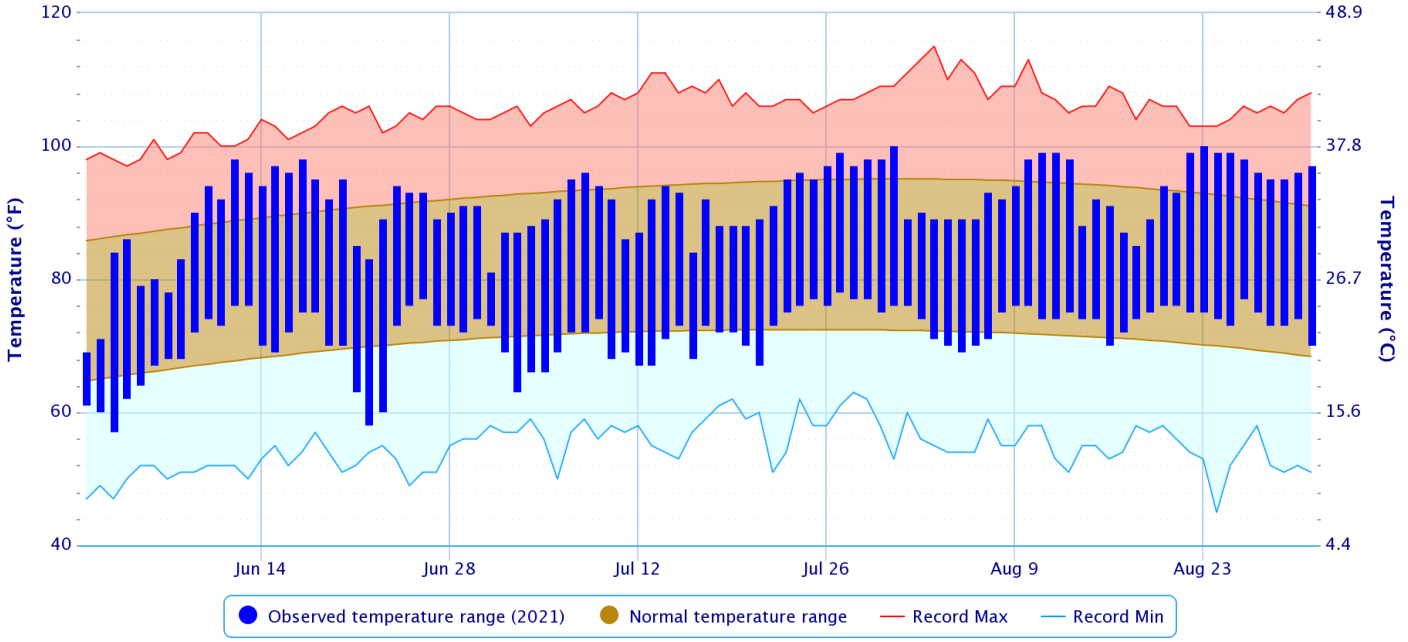
Period of Record – 1882-06-01 to 2021-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



Powered by ACIS

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

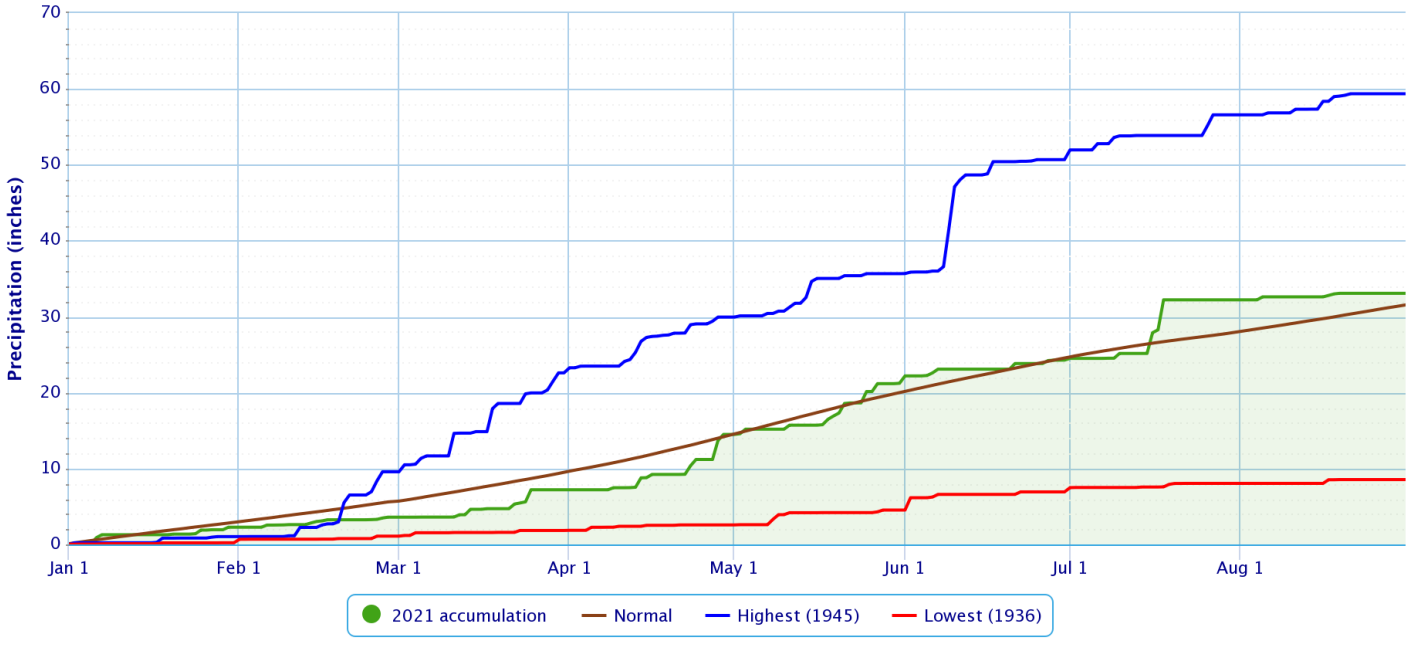
Period of Record – 1882-06-01 to 2021-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



Powered by ACIS

Accumulated Precipitation – Fort Smith Area, AR (ThreadEx)

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



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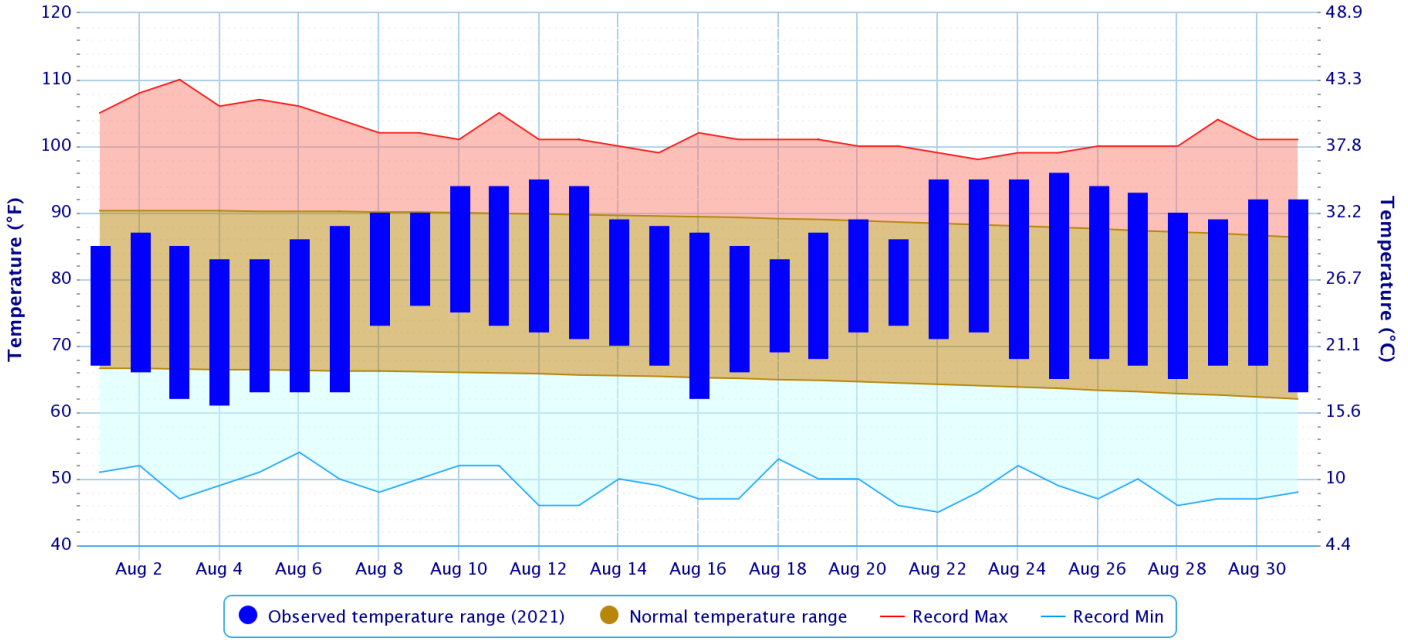
Daily Temperature Data – FAYETTEVILLE DRAKE FIELD, AR

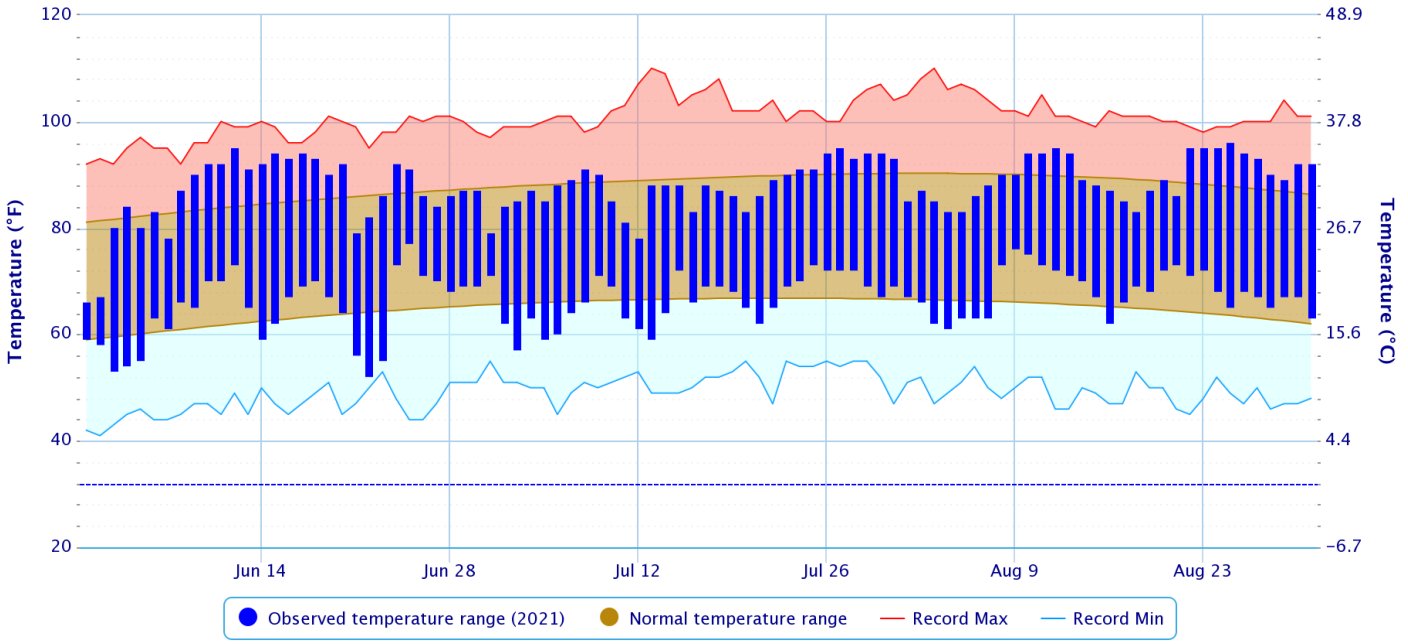
Period of Record – 1949-07-14 to 2021-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



Powered by ACIS

Daily Temperature Data – FAYETTEVILLE DRAKE FIELD, AR

Period of Record – 1949-07-14 to 2021-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



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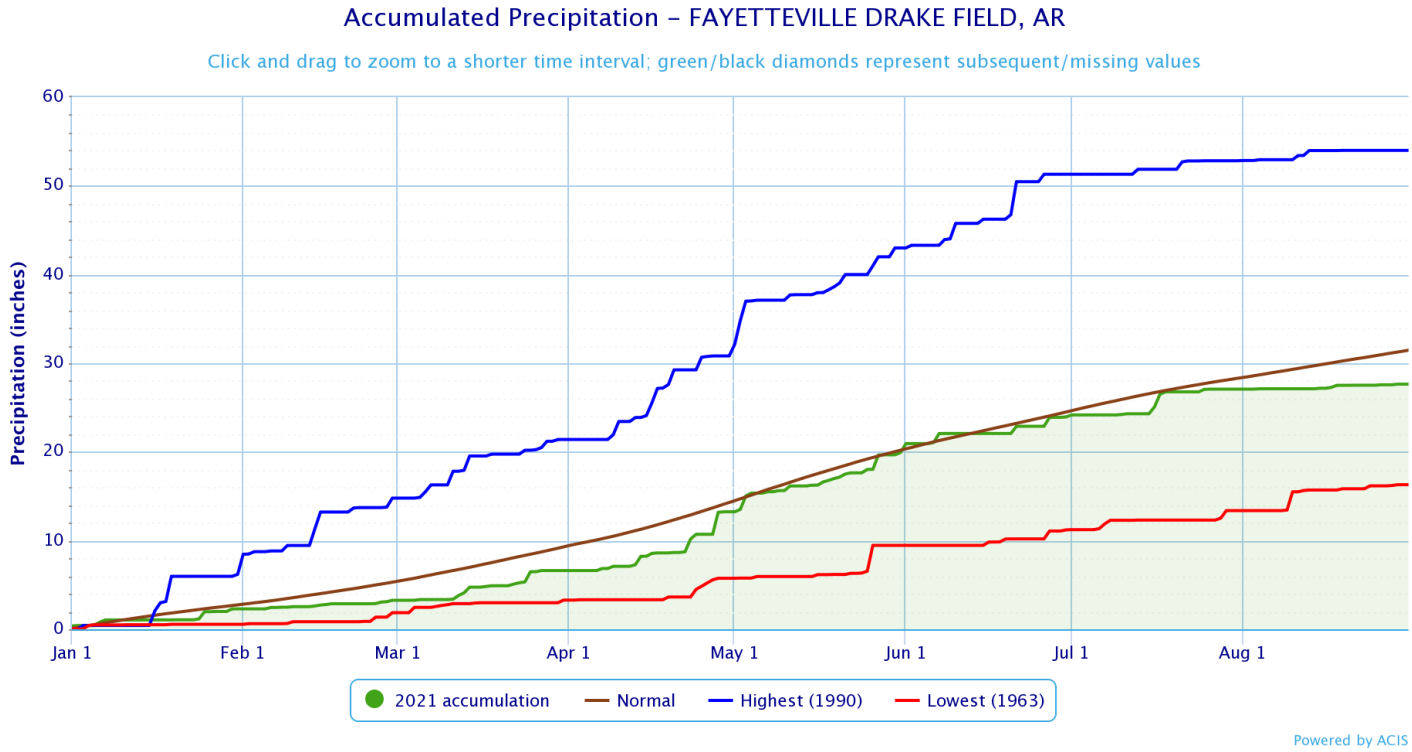
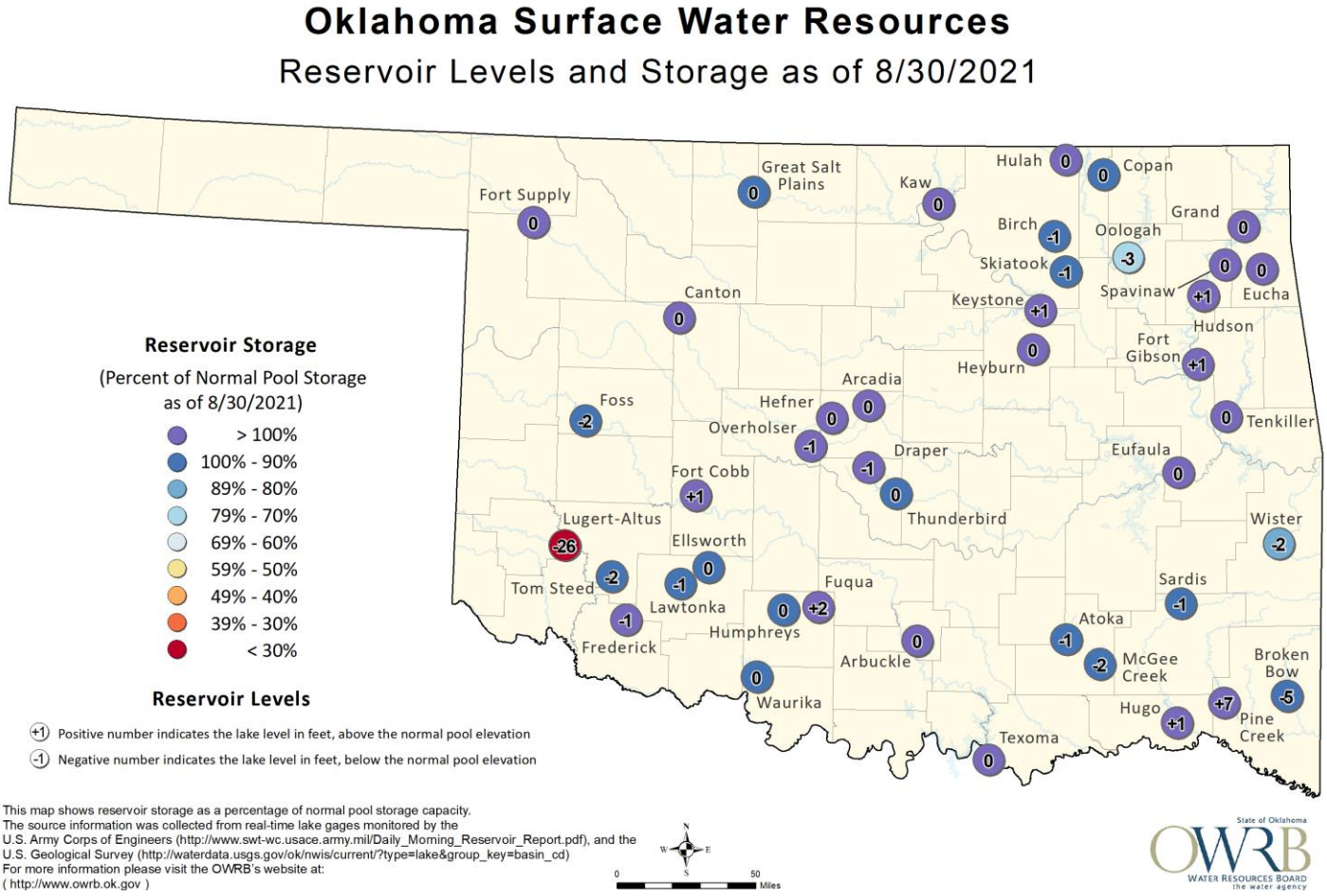


Fig. 3. An illustration of summer rainfall courtesy of the Oklahoma Mesonet. Image shows 30-day rainfall totals ending at 2:45 pm CDT August 16, 2021.

Summer (June-July-August) 2021 Summary

In Tulsa, OK, Summer 2021 ranked as the 42nd warmest Summer (81.5°F, tied 2015, 1999, 1986, 1982, 1957, 1932, 1931, 1929, 1921; since records began in 1905) and the 44th wettest Summer (12.61"; since records began in 1888). Fort Smith, AR had the 47th warmest Summer (81.3°F, tied 2013, 2000, 1957; since records began in 1882) and the 43rd wettest Summer (11.85", tied 2009; since records began in 1882). Fayetteville, AR had the 24th warmest (77.1°F) and the 13th driest (7.72") Summer since records began in 1950.

Reservoirs



According to the USACE, most of the lakes in the HSA were within ±3% of top of their conservation pools as of 9/01/2021. However, a few lakes were more than 3% below the top of their conservation pools: Wister Lake 79%, Oologah Lake 84%, Birch Lake 91%, Sardis Lake 96%, and Skiatook Lake 96%. One lake was more than 3% above its conservation pool: Hudson Lake 106%.

Drought

According to the U.S. Drought Monitor (USDM) from August 31, 2021 (Figs. 4a, 4b), no drought conditions were present across eastern OK and northwest AR. Abnormally Dry (but not in drought) conditions were occurring in eastern Carroll County in northwest AR and portions of Osage, Pawnee, Okfuskee, Okmulgee, McIntosh, Muskogee, Haskell, and Choctaw Counties in eastern OK.

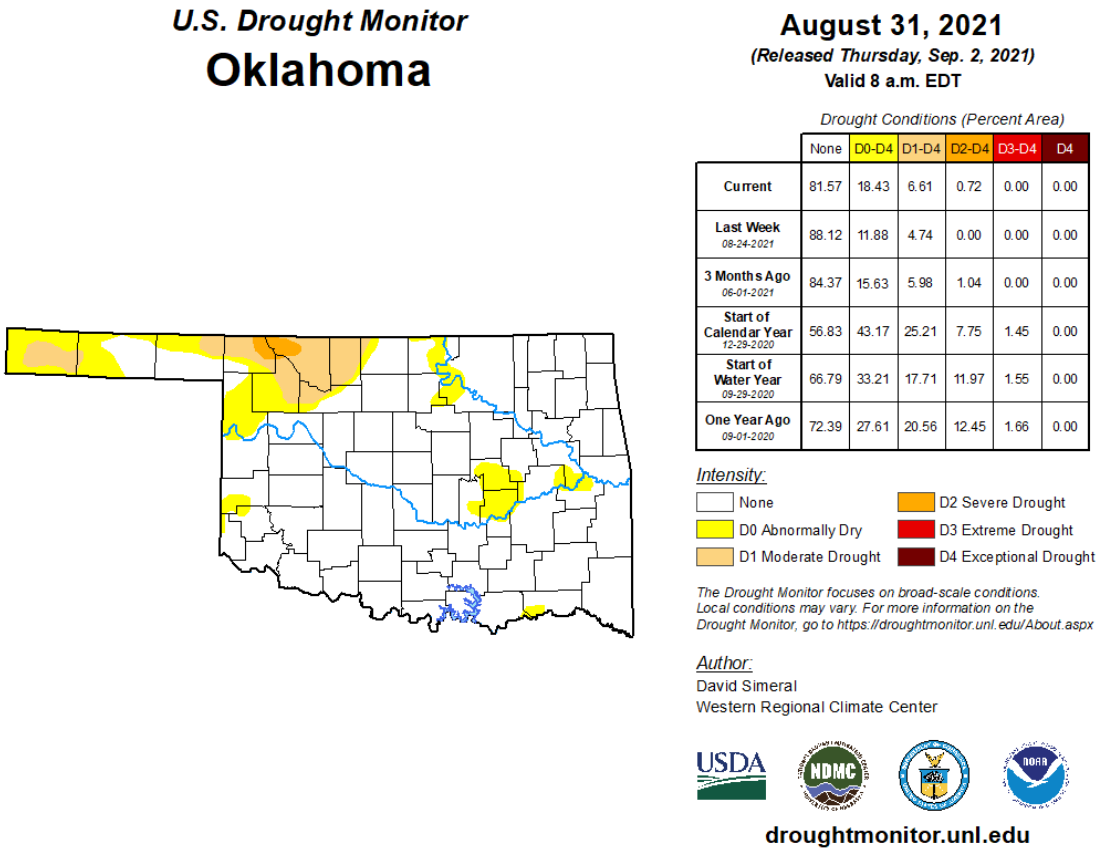


Fig. 4a. Drought Monitor for Oklahoma

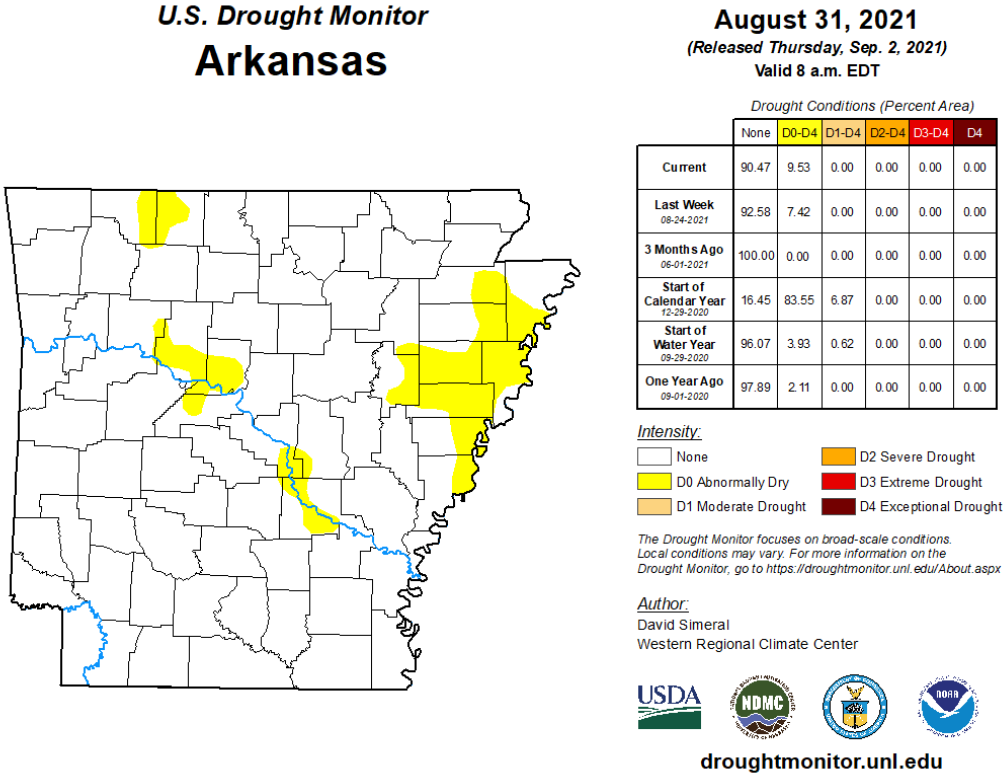


Fig. 4b. Drought Monitor for Arkansas

Outlooks
The Climate Prediction Center (CPC) outlook for September 2021 (issued August 31, 2021) indicates an equal chance for above, near, and below normal temperatures and precipitation across all of eastern OK and northwest AR. This outlook was largely based on dynamical model output combined with potential ENSO and Madden-Julian Oscillation (MJO) impacts. However, a lot of variability is present in the forecast resulting in no clear signals for much of the CONUS.

For the 3-month period September-October-November 2021, CPC is forecasting a slightly enhanced chance for above normal temperatures across northeast OK and an equal chance for above, near, and below normal temperatures elsewhere. This outlook also indicates an equal chance for above, near, and below median precipitation across all of eastern OK and northwest AR (outlook issued August 19, 2021). This outlook is based on long-term trends, La Niña impacts, and incorporates both statistical and dynamical forecast tools. According to CPC, the combined effect of the ocean-atmosphere system is consistent with ENSO neutral conditions. Odds have increase for a return of La Niña conditions during the August-October season and a 70% chance for La Niña conditions during winter 2021-22. CPC continues the La Niña Watch.

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

Late on July 31st, thunderstorms that had developed along a cold front in southern KS moved south into north central and northeast OK. This activity continued into the early morning hours of the 1st as the front moved southward. Precipitable water values were near 2", and heavy rain fell across Osage, Pawnee, and eastern Kay Counties where the biggest storms were. Rainfall totals in this area were around 0.50" to around 3" (Fig. 5).

Showers and thunderstorms developed during the afternoon hours across east central OK as a shortwave trough moved over the region. This activity moved east-southeast into northwest AR and southeast OK through the evening hours. Additional scattered storms developed further north over northeast OK during the late afternoon through early evening hours. All of this activity dissipated by late evening with the loss of daytime heating. Rainfall totals across east central OK ranged from 0.25" to near 4" (Fig. 6). The remainder of the area that had storms generally received around 1" or less, though a localized total of 1.5"-3" occurred in Osage County.

Around sunrise on the 13th, showers and thunderstorms moved south out of KS into far northeast OK. These storms dissipated by late morning, leaving behind an outflow boundary. In addition to the outflow boundary, a surface front moved southeast into northeast OK, with both boundaries providing a source of moisture pooling and thus storm development. During the heat of the afternoon hours, scattered showers and thunderstorms developed across eastern OK and northwest AR. While further south the storms were more isolated, the activity across northeast OK and northwest AR developed into a line of storms that then moved southeast through the evening hours. While most of this activity moved out of the region shortly after midnight, scattered storms remained across far southeast OK through the overnight hours. This rain continued until about noon on the 14th. Isolated summer-time thunderstorms affected eastern OK and northwest AR during the afternoon through early evening. By 7am on the 14th, 24-hour rainfall totals in areas that received rain were around 0.25" to around 3" (Fig. 7). An additional 0.25"-2.5" of rain fell after 7am in Choctaw and Pushmataha Counties in southeast OK, and less than 1.5" fell elsewhere (Fig. 8).

A broad, weak upper-level trough axis remained over the region for a few days starting on the 16th, resulting in diurnal, scattered shower and thunderstorm activity across eastern OK and northwest AR. Isentropic lift also resulted in scattered storms during the early morning hours on the 17th. By 7 am on the 17th, the 24-hour rainfall totals ranged from a few hundredths to around 4" (Fig. 9). Scattered storms continued through the afternoon and evening before dissipating by midnight. Heavy rain in Sequoyah County resulted in impassible roads, and the emergency manager reported a rainfall measurement of 4.5". Additional showers developed primarily over Choctaw County during the early morning hours of the 18th, once again due to isentropic lift. The 24-hour rainfall totals at 7 am on the 18th ranged from a few hundredths to near 2.5" (Fig. 10). Additional showers and thunderstorms began impacting west central AR during the morning of the 18th. At mid-morning, storms trained over an area of western Franklin County and adjoining portions of Crawford and Sebastian Counties in west central AR. Around 1" to near 5" of rain fell in this area (Fig. 11). For the remainder of the

afternoon and evening hours, isolated diurnal convection continued across eastern OK and northwest AR.

Deeper low-level moisture increased by early on the 19th as a weak upper-level short wave approached the region from the west, and precipitable water values were over 2". Once again, isentropic lift initiated convection in the pre-dawn hours across southeast OK. By 7 am Aug. 19, much of Choctaw and Pushmataha Counties in southeast OK had received 0.25" to 3" of rain (Fig. 11). Widespread showers and thunderstorms continued across far southeast OK through noon, bringing an additional 0.5"-4" to most of Pushmataha, eastern Choctaw, and southern Le Flore Counties (Figs. 12-14). Water was reported over Highway 93 in several spots, including both lanes at the Pushmataha/Choctaw county line where the highest rainfall occurred, and over Highway 3 near Rattan, OK. Scattered showers and thunderstorms then developed across all of eastern OK and northwest AR during the afternoon and early evening hours, bringing around 1" of rain or less to the impacted locations.

By the morning of the 20th, the moisture axis had shifted north and extended from south central into northeastern OK. Continued warm air advection within this zone resulted in scattered showers and thunderstorms across Osage, Pawnee, and northern Washington (OK) Counties through the morning hours. Weaker, isolated convection also occurred over northwest AR during the morning and early afternoon hours. After midnight, thunderstorms that had developed along a cold front in KS began to move south into northeast OK. These storms continued to progress southeast, bringing rain to northeast OK and far northwest AR by sunrise on the 21st. At 7 am Aug. 21, 24-hour rainfall totals ranged from a few hundredths to around 1", with higher totals of 1"-2.5" in northwest Osage County (Fig. 15). The convection continued to slowly push southeast during the morning hours and finally dissipated over east central OK and west central AR during the early afternoon. Outflow from this morning convection consolidated with the cold front across eastern OK and northwest AR during the afternoon. As the low-level jet increased and interacted with the front, new thunderstorm development occurred during the evening, primarily across east central OK. Precipitable water values over 2" remained over this region, resulting in heavy rainfall. A large area of Creek, Okmulgee, McIntosh, Muskogee, and Wagoner Counties, received 1.5"-4" of rain (Fig. 16), with only isolated storms elsewhere across northeast OK and northwest AR. This activity quickly dissipated by 3 am on the 22nd.

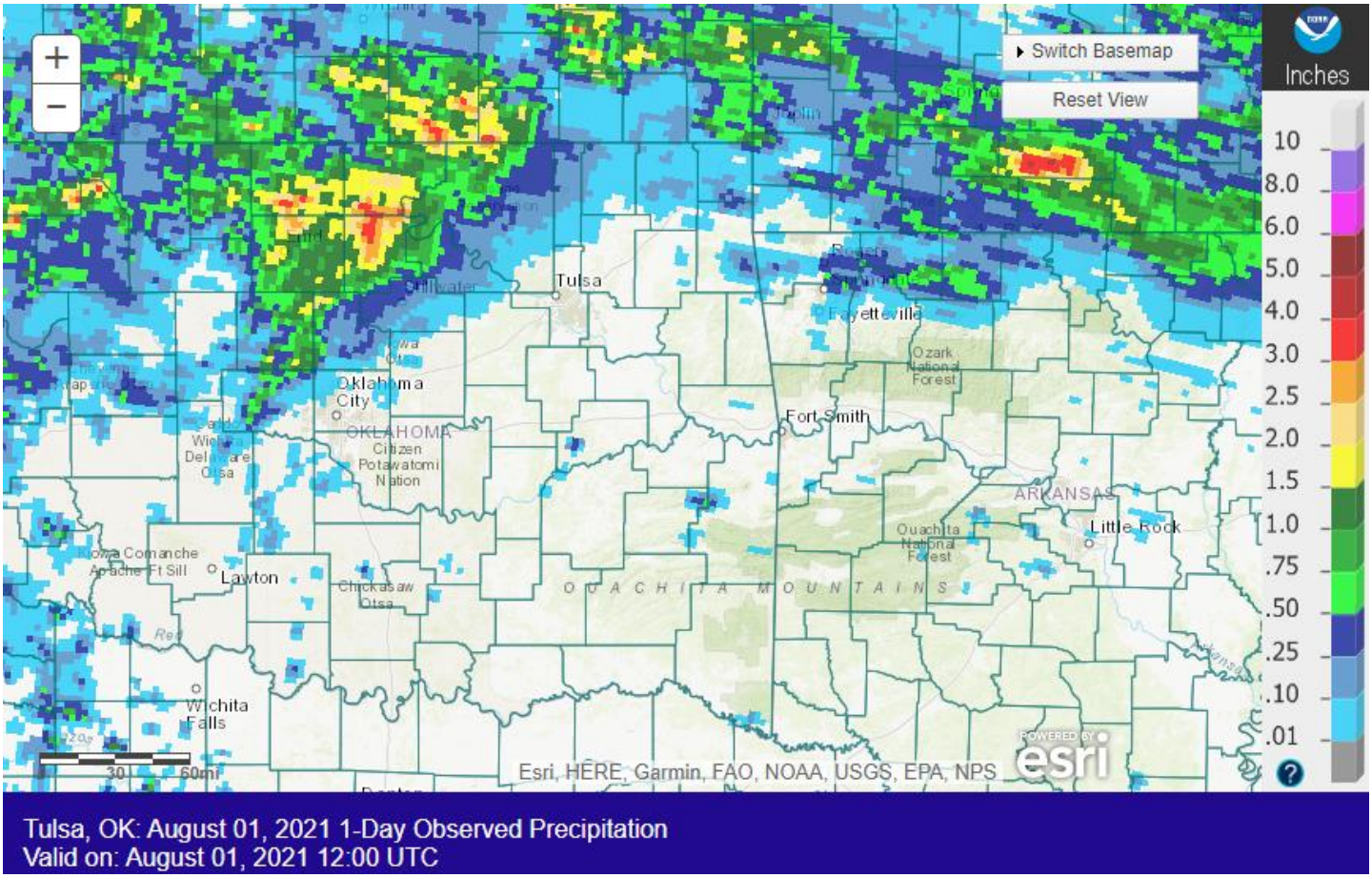


Fig. 5. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/01/2021.

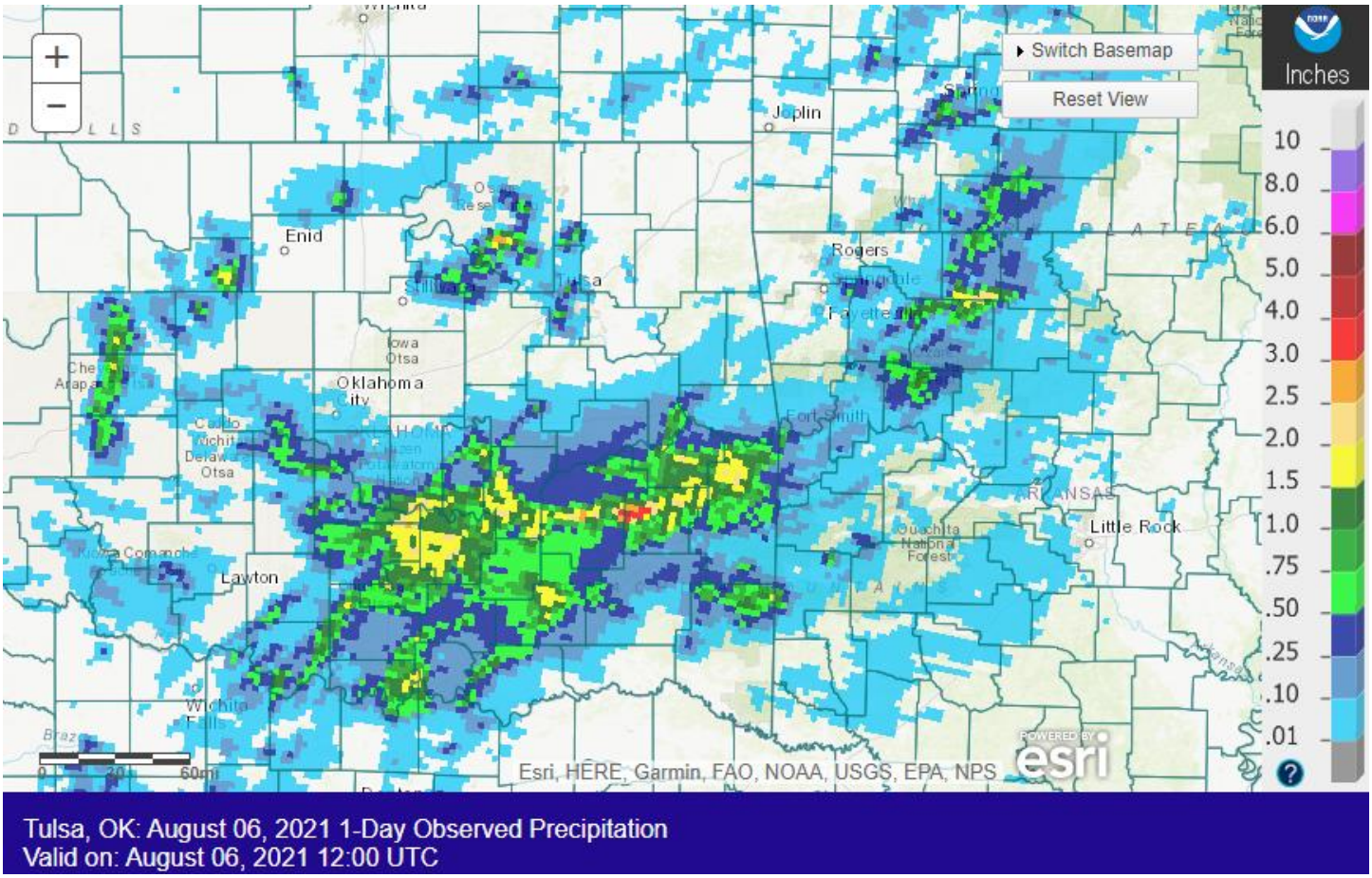


Fig. 6. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/06/2021.

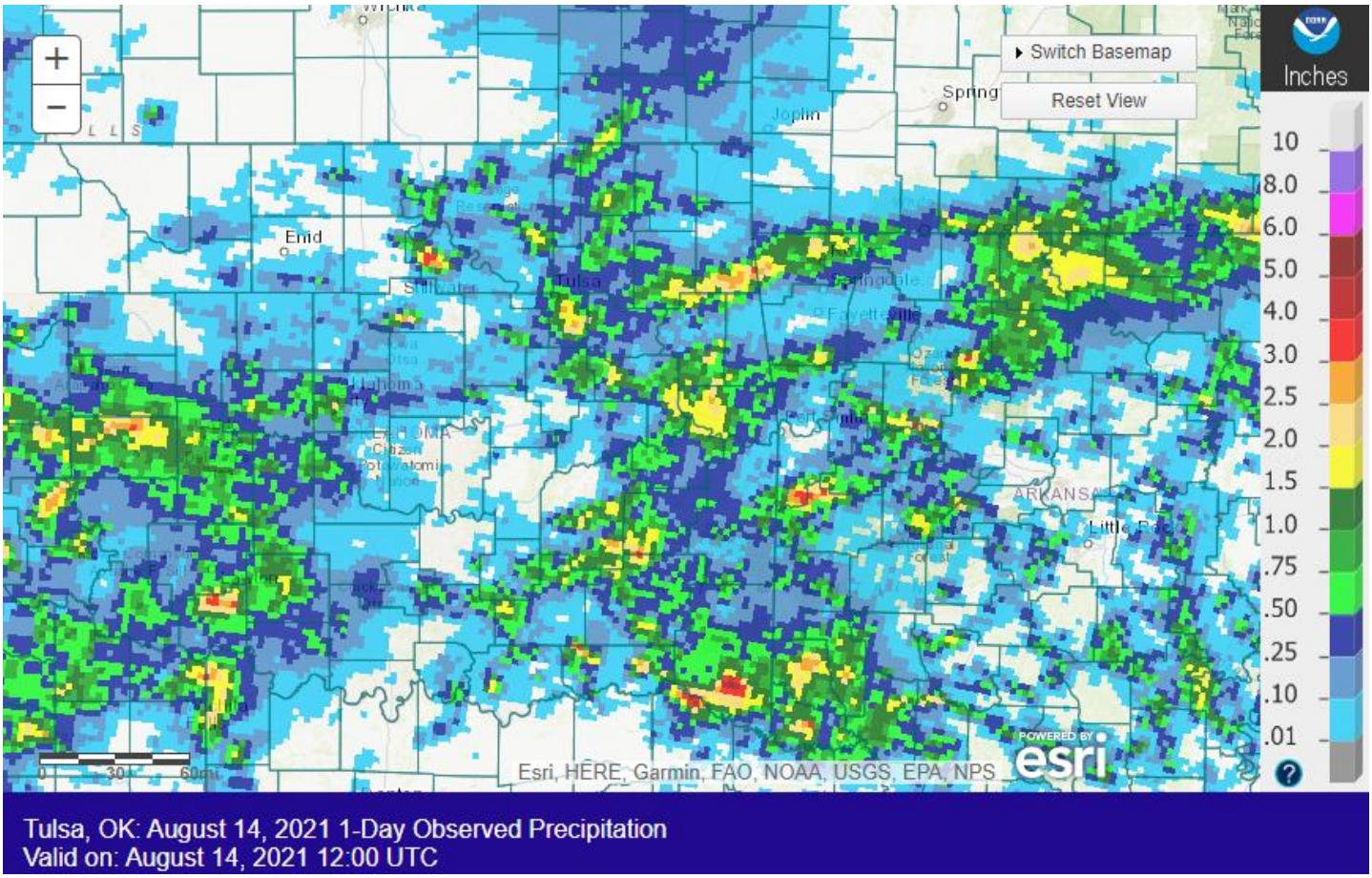


Fig. 7. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/14/2021.

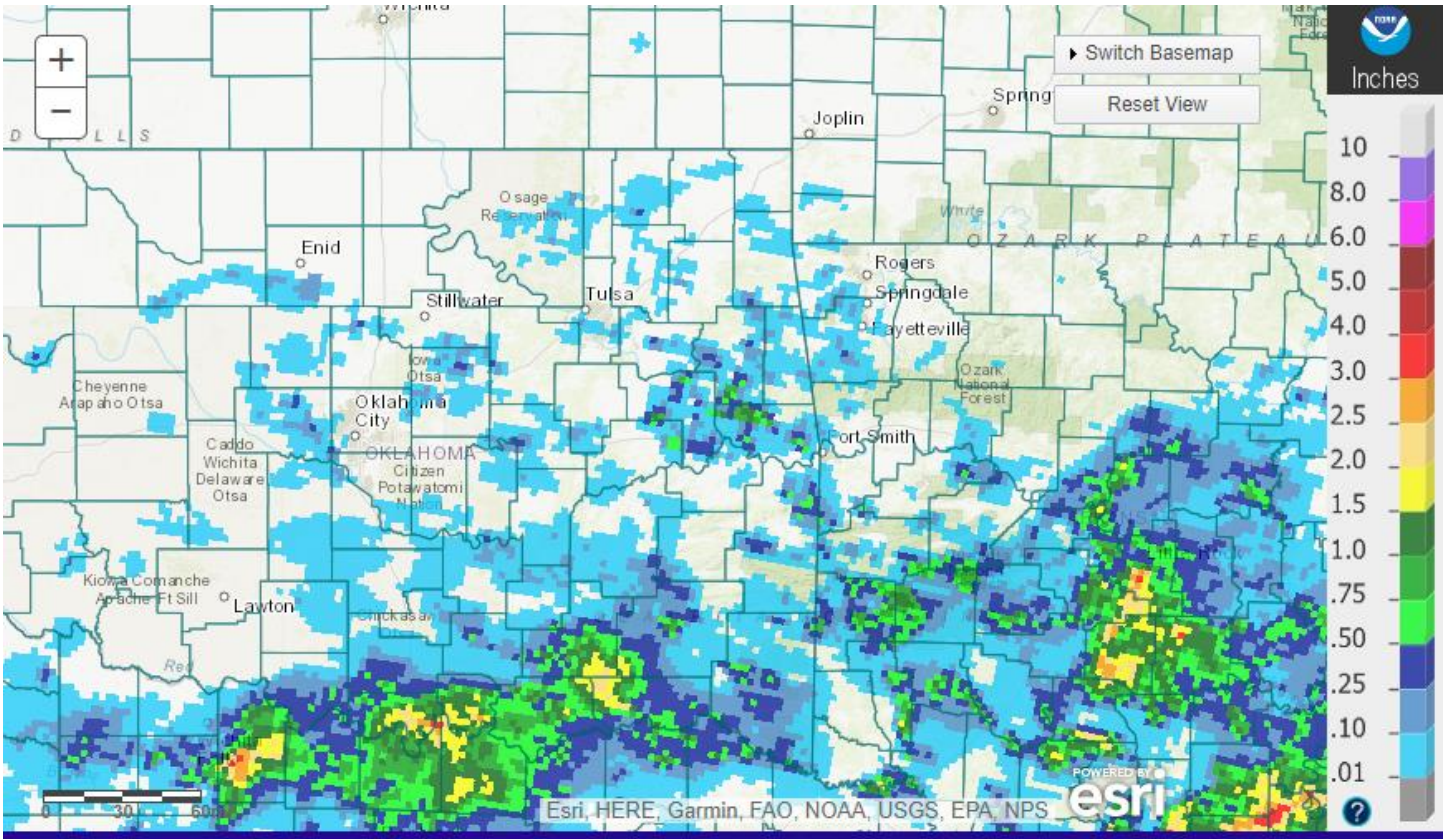


Fig. 8. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/15/2021.

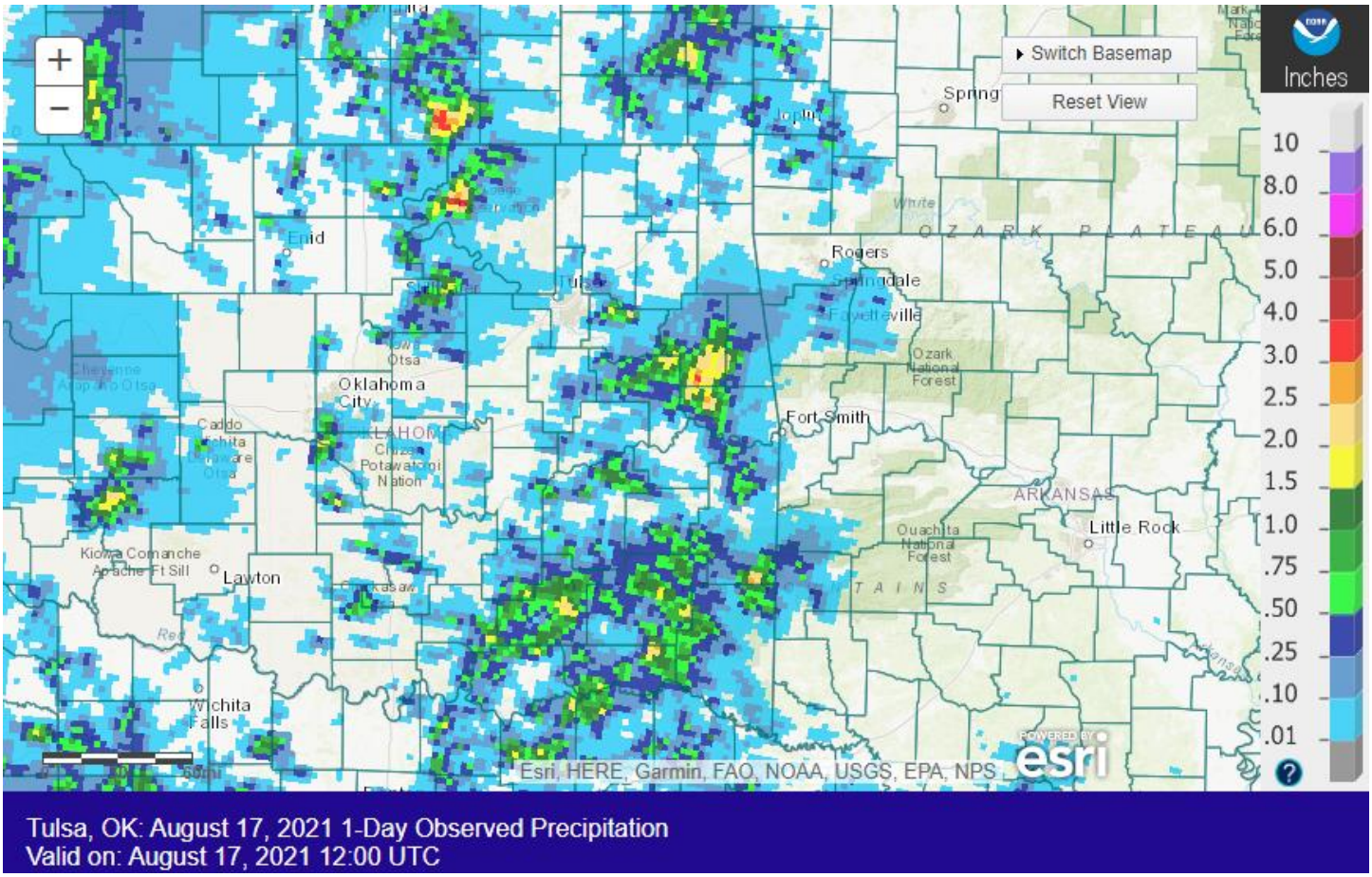


Fig. 9. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/17/2021.

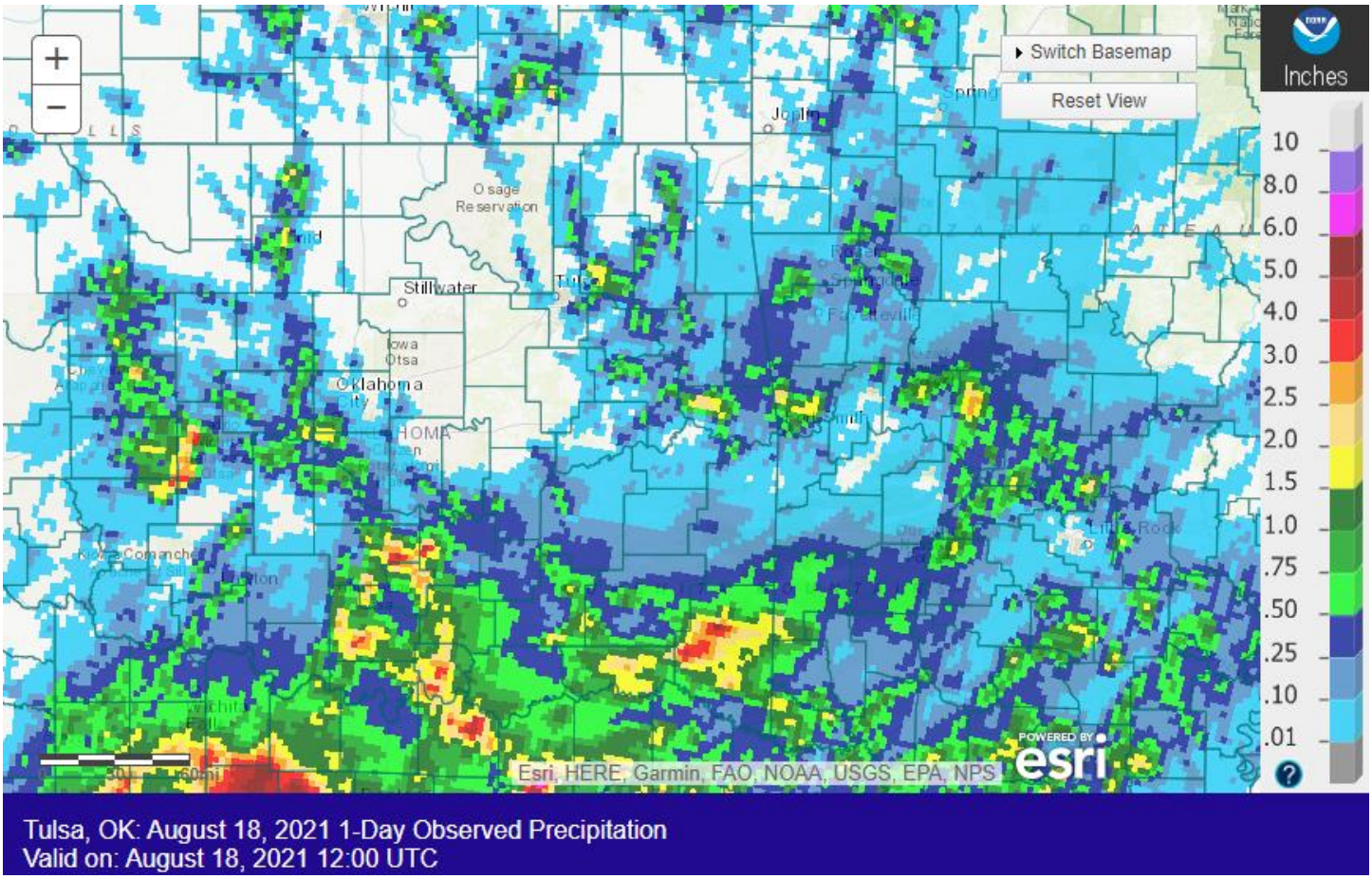


Fig. 10. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/18/2021.

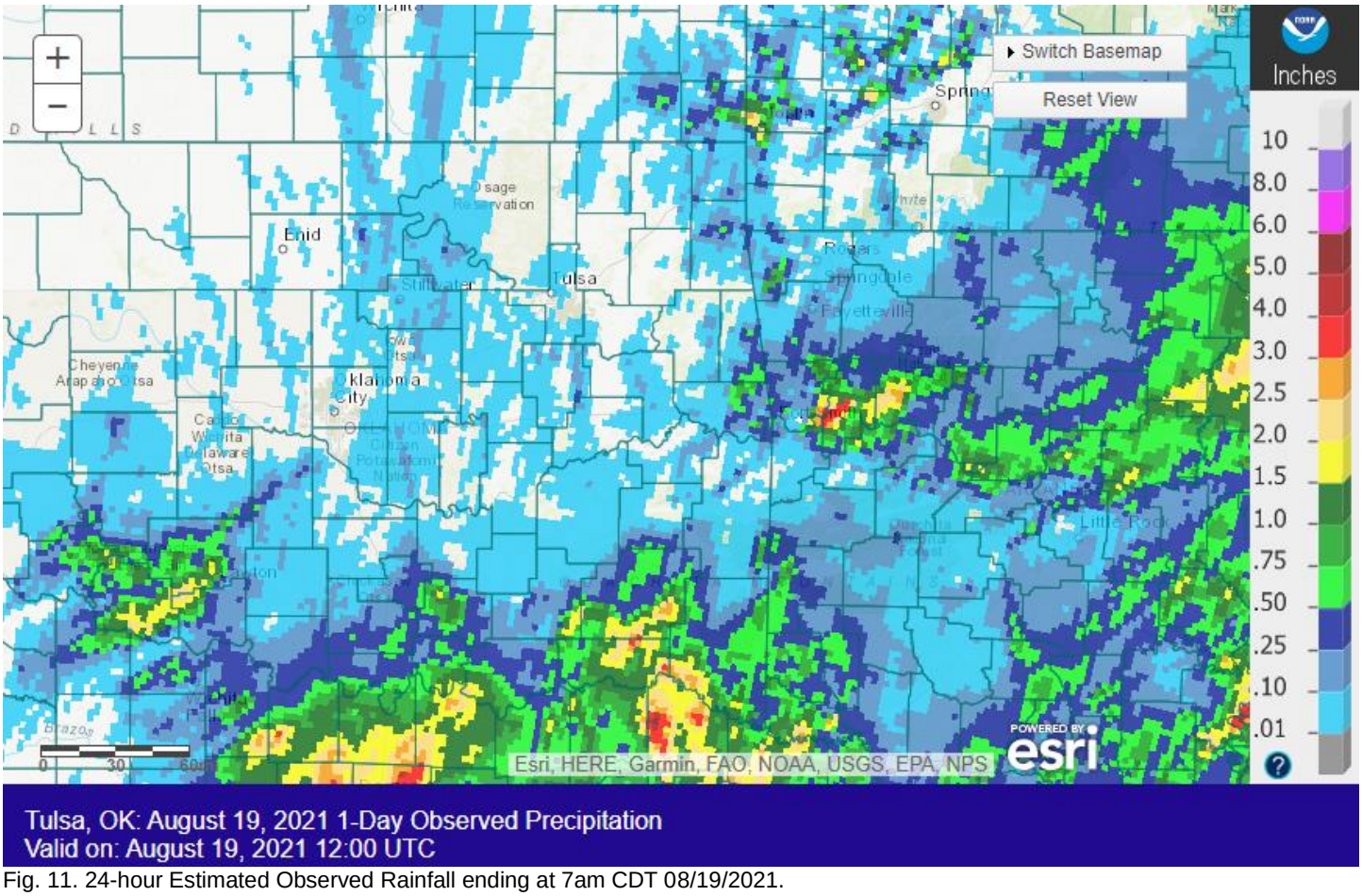


Fig. 11. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/19/2021.

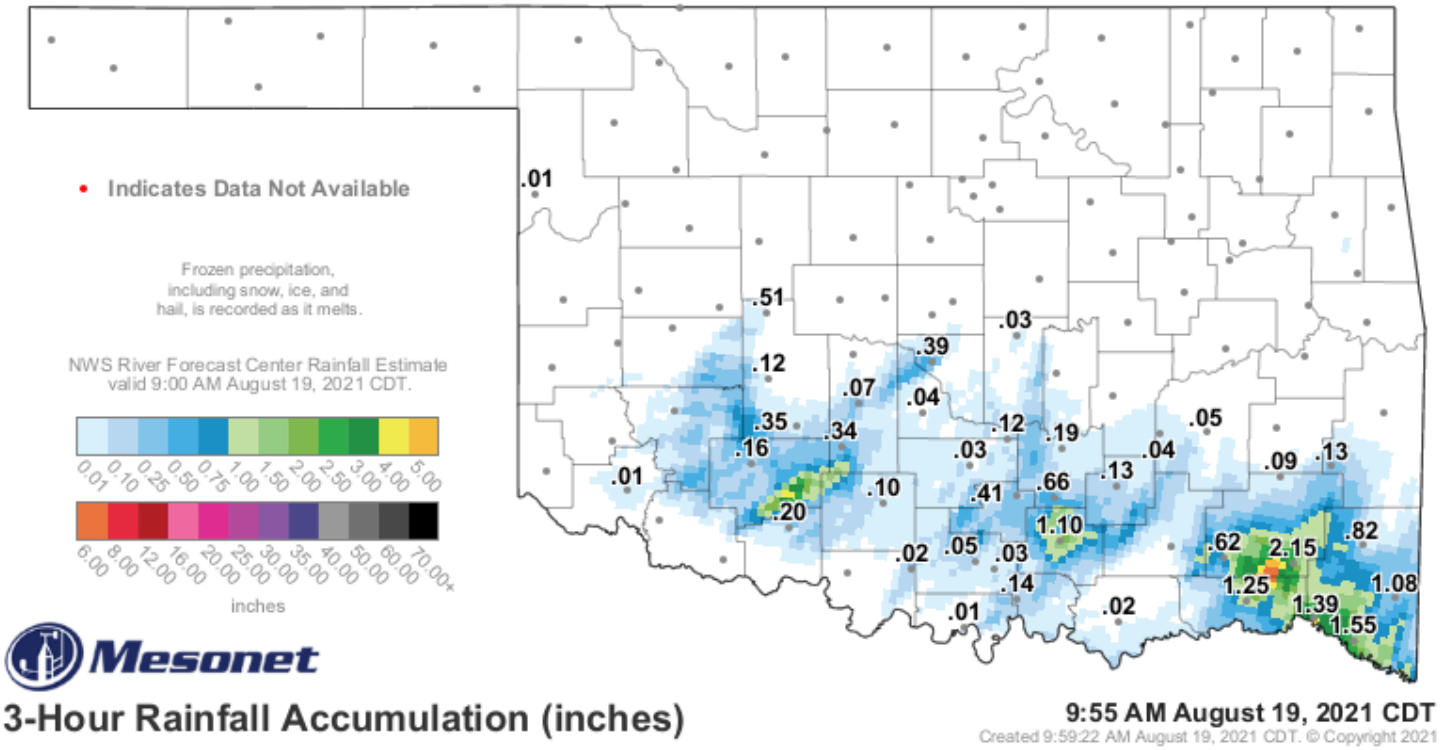


Fig. 12. OK Mesonet (values) and NWS RFC rainfall estimate (image) 3-hour rainfall ending at 9:55 am CDT 8/19/2021.

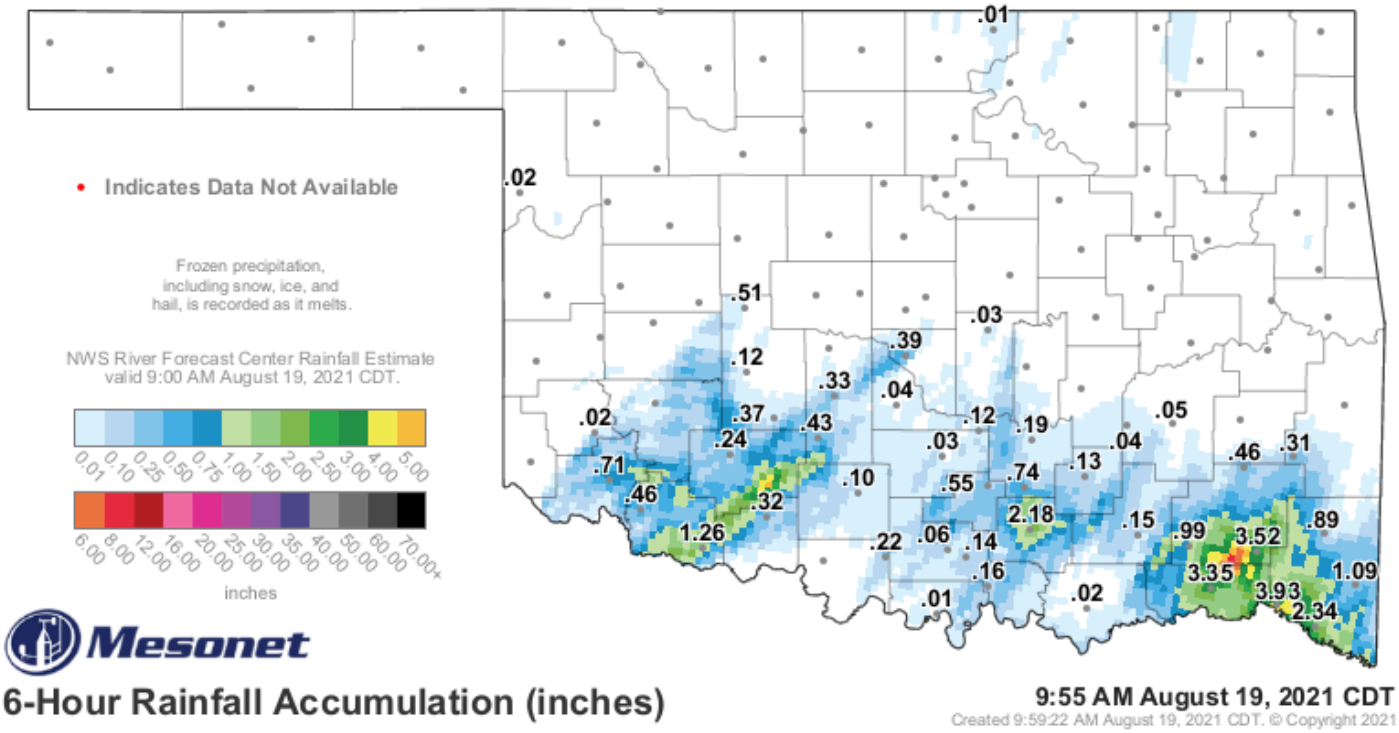


Fig. 13. OK Mesonet (values) and NWS RFC rainfall estimate (image) 6-hour rainfall ending at 9:55 am CDT 8/19/2021.

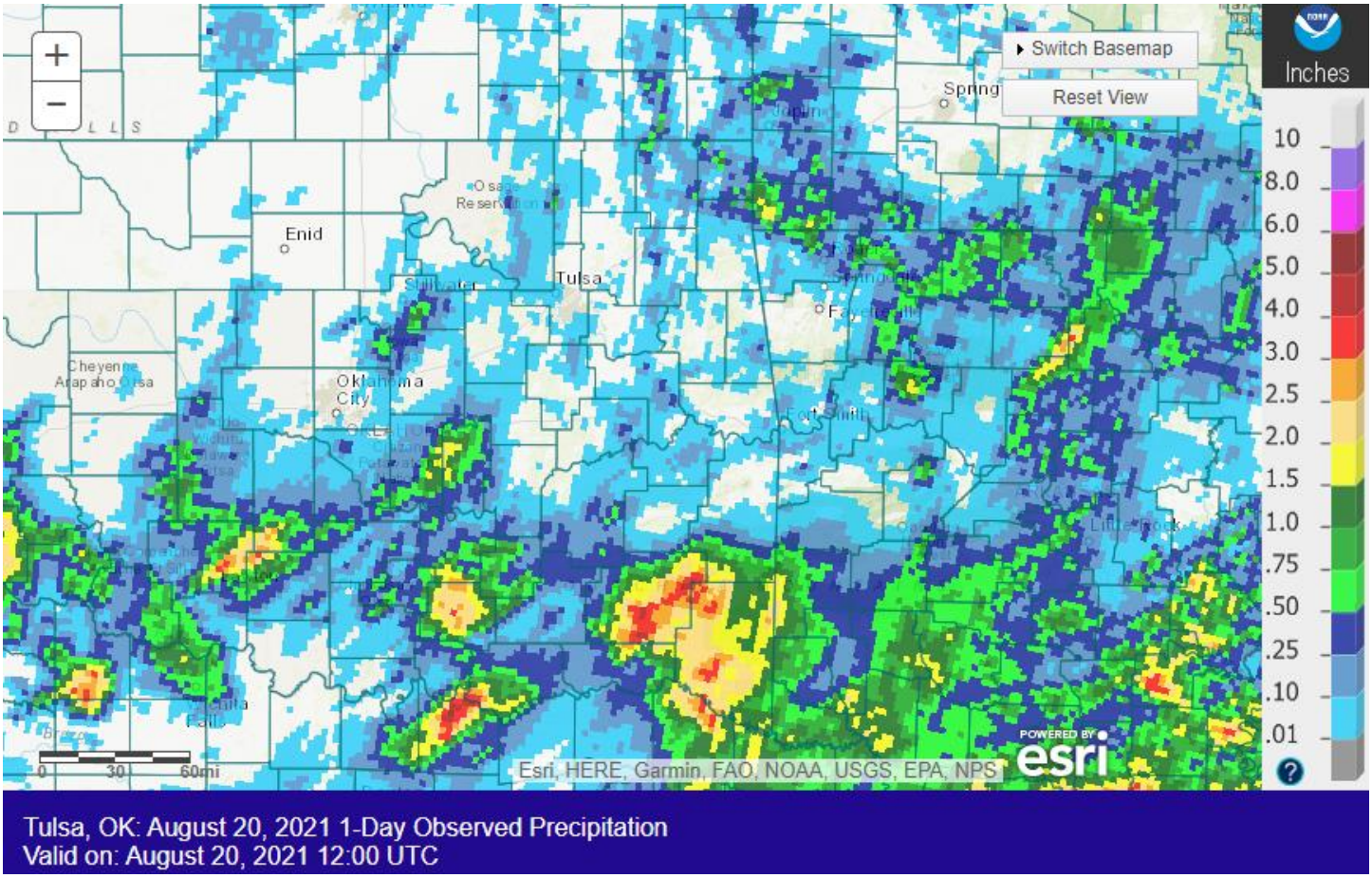


Fig. 14. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/20/2021.

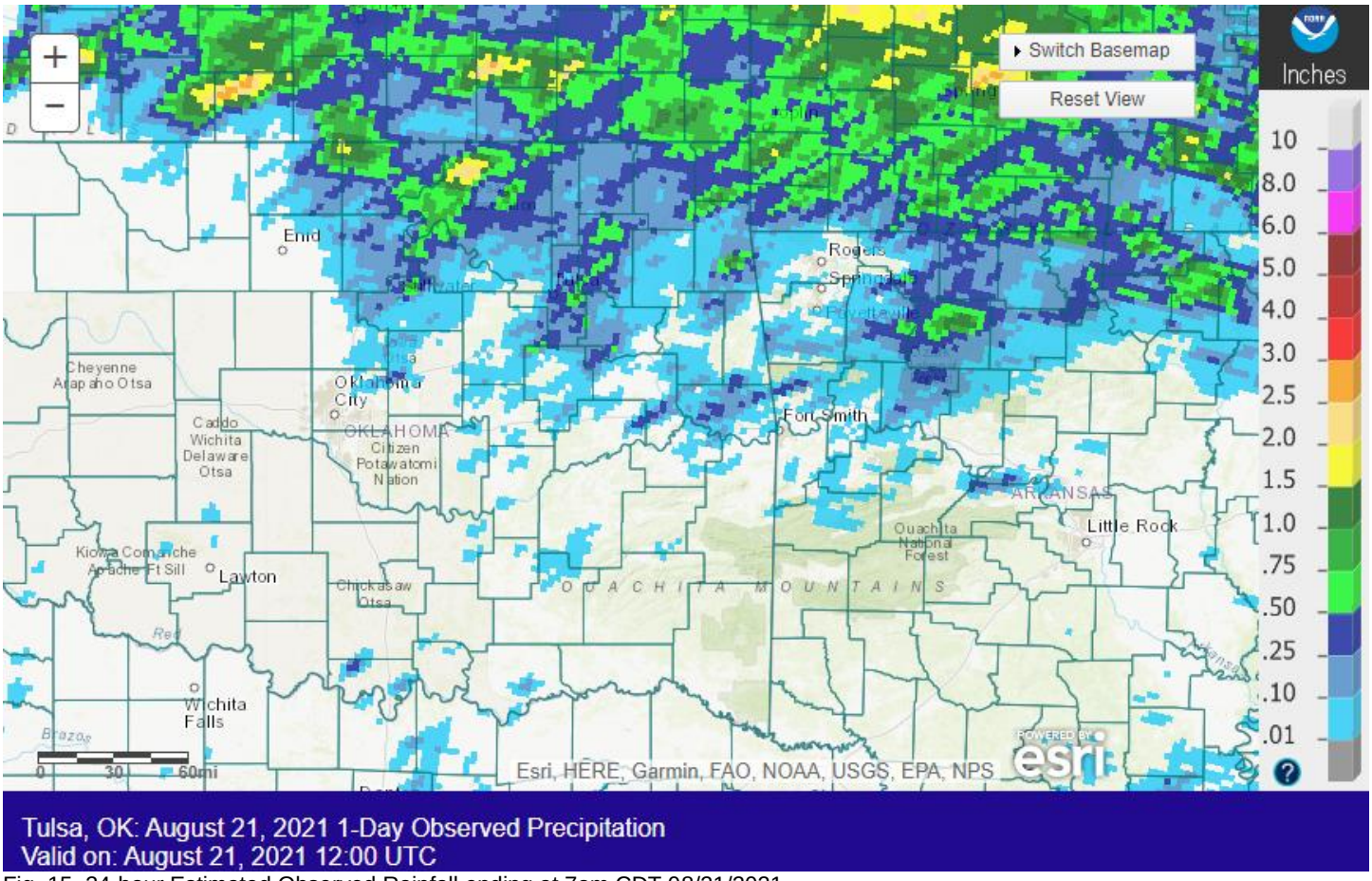


Fig. 15. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/21/2021.

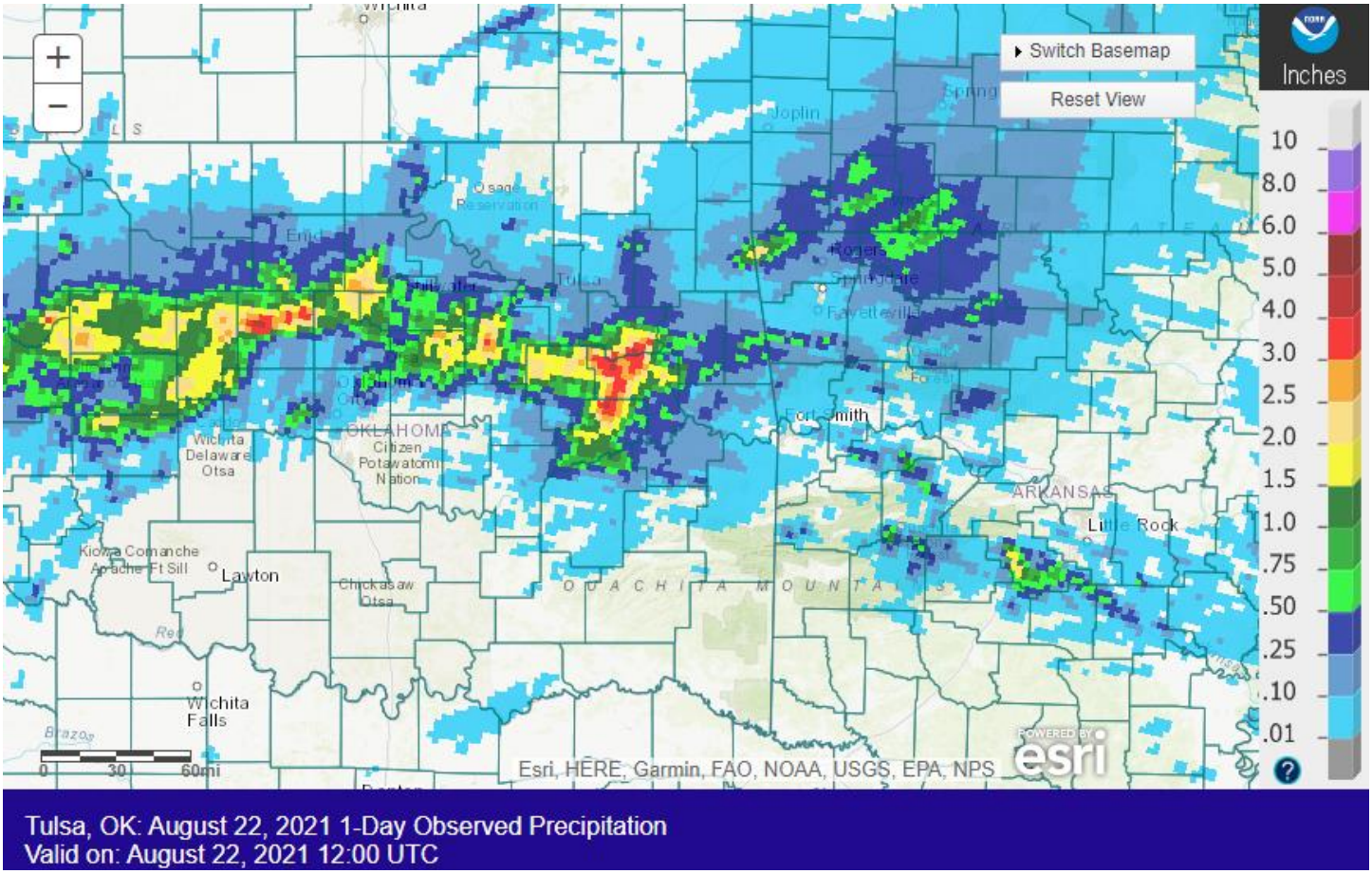


Fig. 16. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/22/2021.

Written by:

Nicole McGavock
Service Hydrologist
WFO Tulsa

Products issued in August 2021:

*CWYO2 became a daily river forecast point September 7, 2016
*MLBA4 and OZGA4 transferred to NWS Tulsa HSA February 5, 2014
*Mixed case River Flood products began July 31, 2013

5 Flash Flood Warnings (FFW)
5 Flash Flood Statements (FFS)
0 Flash/Areal Flood Watches (FFA) (0 Watch FFA CON/EXT/EXA/EXB/CAN)
18 Urban and Small Stream Advisories (FLS)
0 Areal Flood Warnings (FLW)
0 Areal Flood Statements (FLS)
0 River Flood Warnings (FLW) (includes category increases)
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