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 **2023**
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 15, 2023**

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 2023 had a few heavy rain events, a continuation of drought, and some very hot, humid weather. 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 https://www.weather.gov/tsa/climo_summary_e5list.

Monthly Summary

Using the radar-derived estimated observed precipitation from the RFCs (Fig. 1a), rainfall totals for August 2023 ranged from 0" to around 10" across eastern OK and northwest AR, with much of the area receiving 2"-4". These rainfall totals correspond to 0% to around 300% of the normal August rainfall (Fig. 1b).

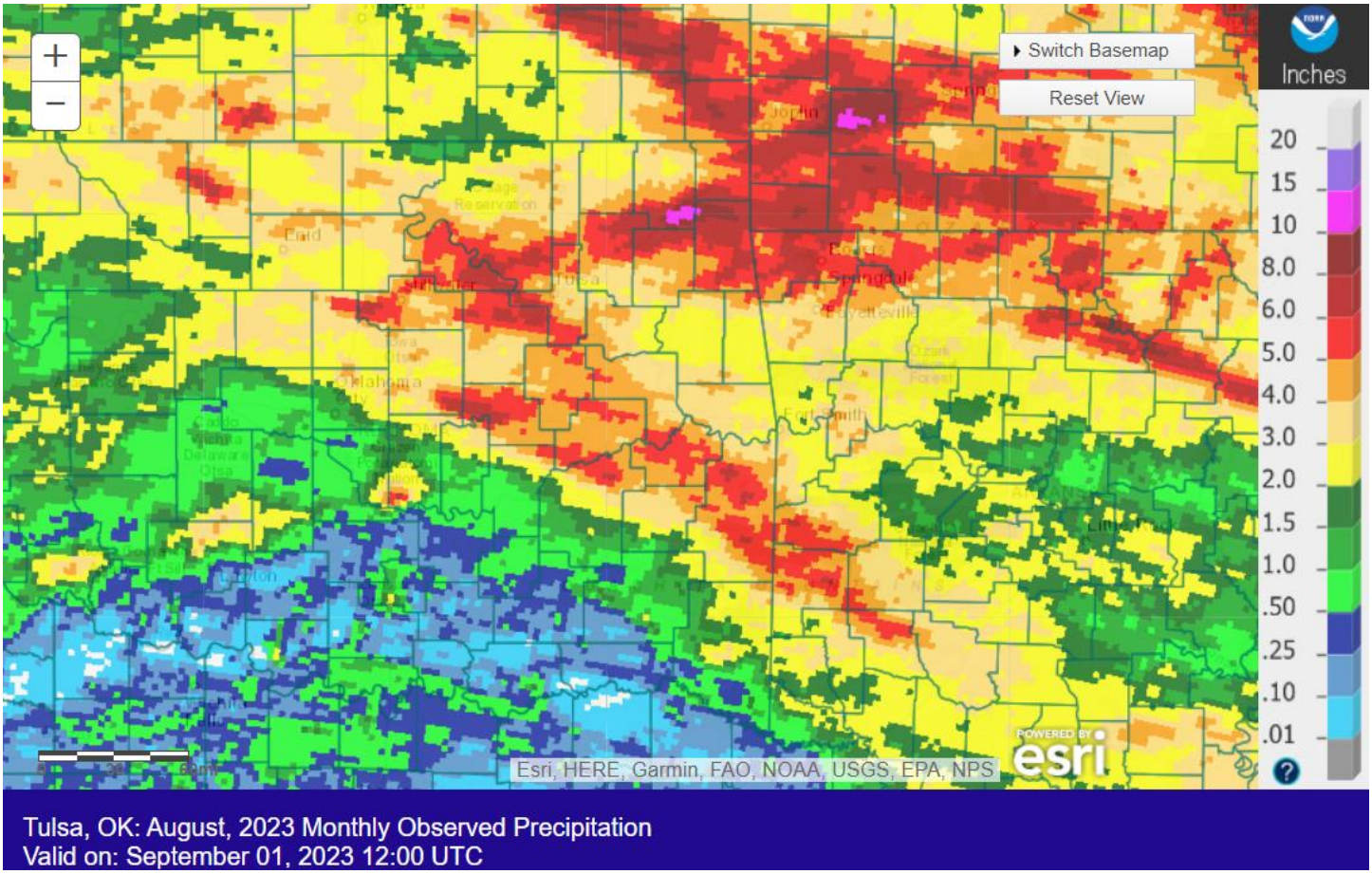


Fig. 1a. Estimated Observed Rainfall for August 2023

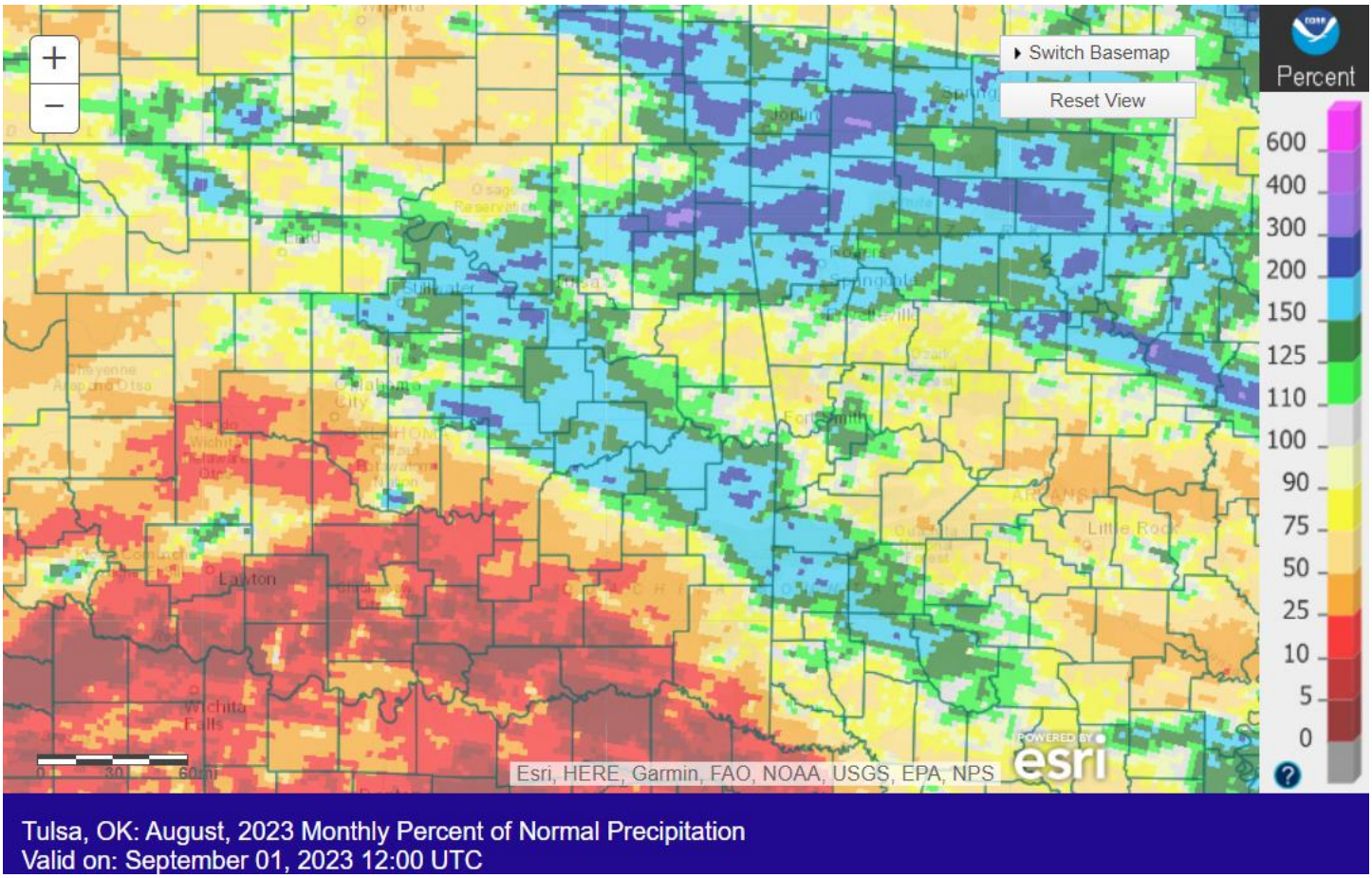


Fig. 1b. Estimated % of Normal Rainfall for August 2023

In Tulsa, OK, August 2023 ranked as the 35th warmest August (83.9°F; since records began in 1905) and the 55th wettest August (3.47"; since records began in 1888). Fort Smith, AR had the 11th warmest August (85.5°F; since records began in 1882) and the 70th wettest August (2.65"; since records began in 1882). Fayetteville, AR had the 11th warmest (80.7°F) and the 34th wettest (3.37") August since records began in 1949.

Some of the larger precipitation reports (in inches) for August 2023 included:

Wyandotte 7.3NE, OK (coco)	12.71	Vinita 8.6ESE, OK (coco)	10.49	Jay 3.3NNE, OK (coco)	7.24
Centerton 2.1SE, AR (coco)	7.23	Bentonville 6.6SSW, AR (coco)	7.16	Rogers 2.4SSW, AR (coco)	7.01
Jay, OK (meso)	6.86	Pea Ridge 0.2WSW, AR (coco)	6.69	Centerton 1.0E, AR (coco)	6.66

Some of the lowest precipitation reports (in inches) for August 2023 included:

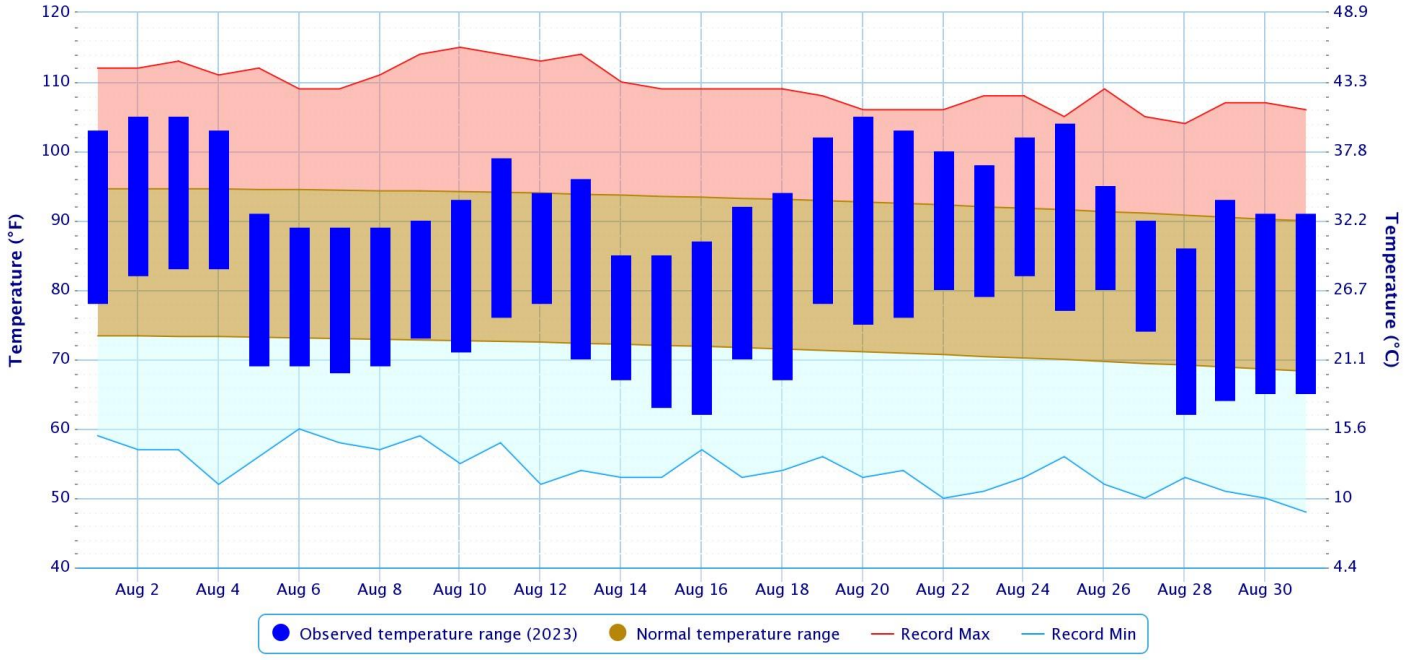
Antlers 6.3SE, OK (coco)	0.10	Antlers, OK (meso)	0.11	Hugo, OK (meso)	0.11
Cloudy, OK (meso)	1.03	Stuart, OK (meso)	1.07	Clayton, OK (meso)	1.55
McAlester, OK (ASOS)	1.83	Talihina, OK (meso)	2.16	Greenwood 0.9S, AR (coco)	2.48

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

Rank since 1921	Last 30 Days (Aug 2-31)	Summer 2023 (Jun 1 – Aug 31)	Growing Season (Mar 1 – Aug 31)	Last 60 Days (Jul 3 – Aug 31)	Year-to-Date (Jan 1 – Aug 31)	Water Year-to-Date (Oct 1 – Aug 31)	Last 365 Days (Sep 1, 2022 – Aug 31, 2023)
Northeast OK	26th wettest	48th wettest	37th driest	19th wettest	46th driest	46th driest	32nd driest
East Central OK	38th wettest	46th wettest	46th driest	20th wettest	42nd wettest	33rd wettest	47th wettest
Southeast OK	22nd driest	39th driest	51st driest	49th driest	36th wettest	30th wettest	46th wettest
Statewide	37th driest	28th wettest	49th wettest	20th wettest	41st wettest	41st wettest	47th driest

Daily Temperature Data – Tulsa Area, OK (ThreadEx)

Period of Record – 1905-01-06 to 2023-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



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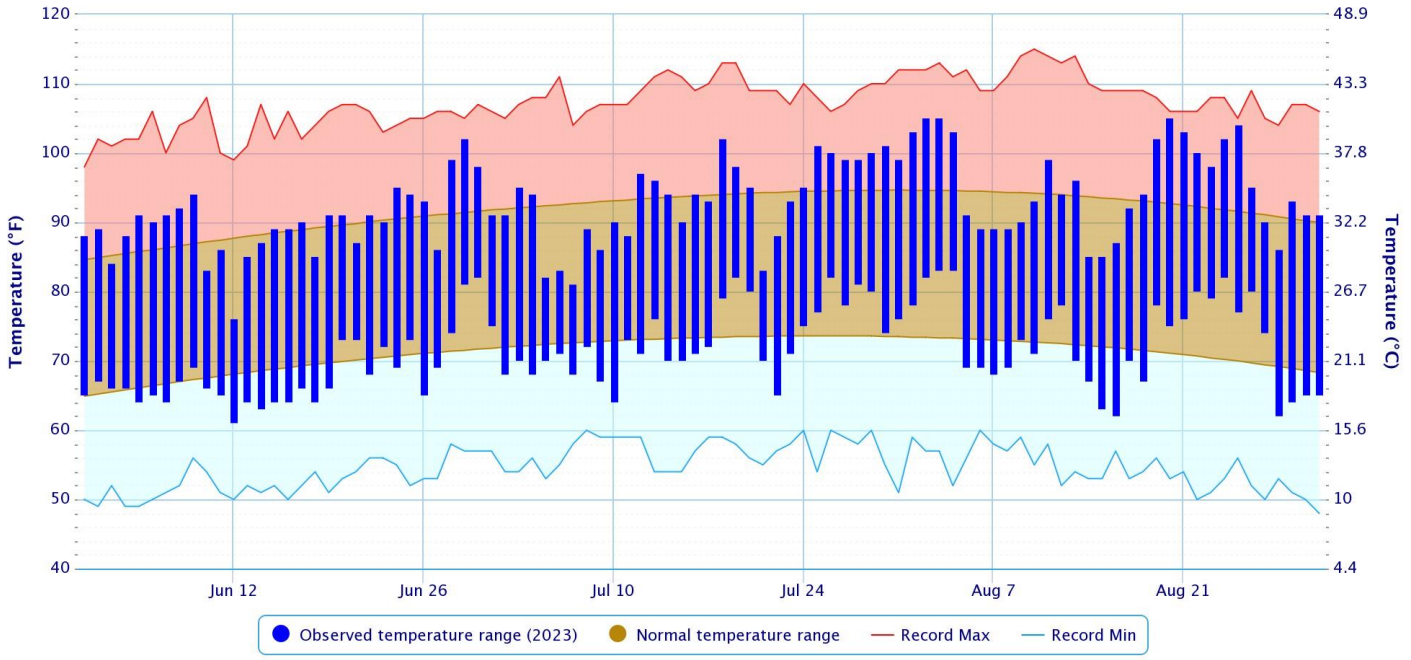

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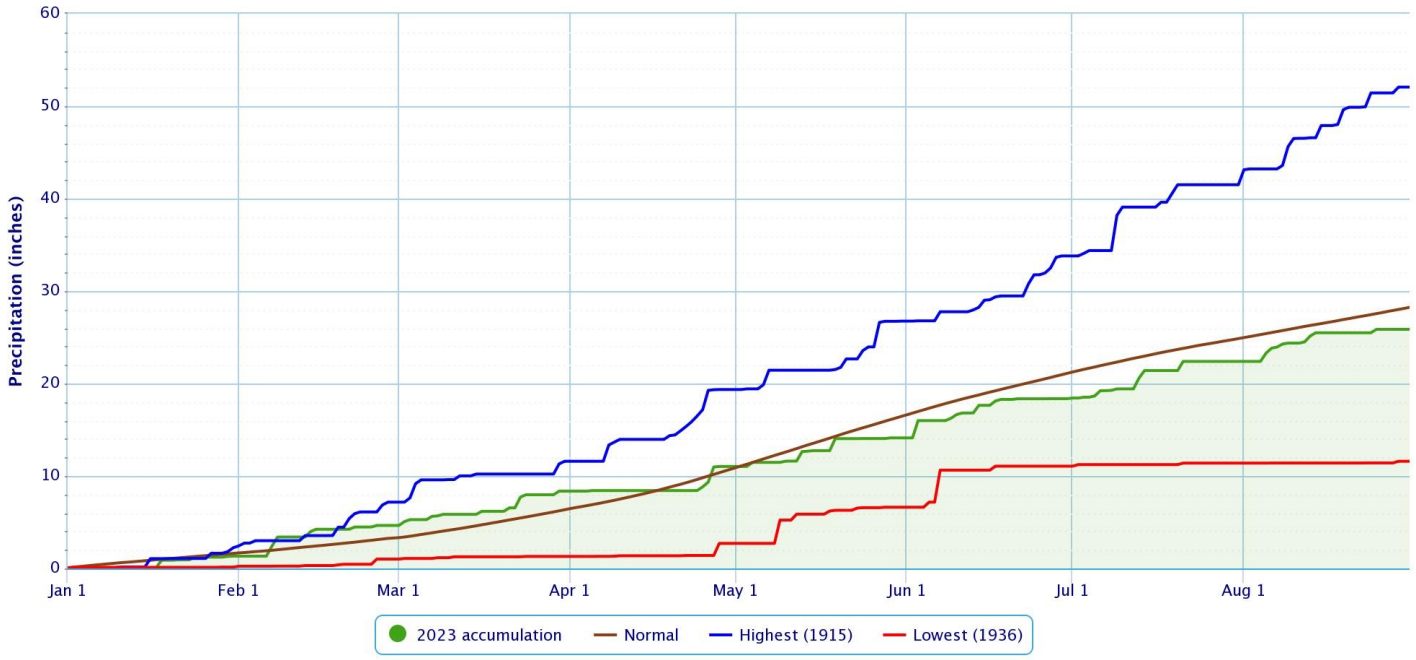
Accumulated Precipitation – Tulsa Area, OK (ThreadEx)

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



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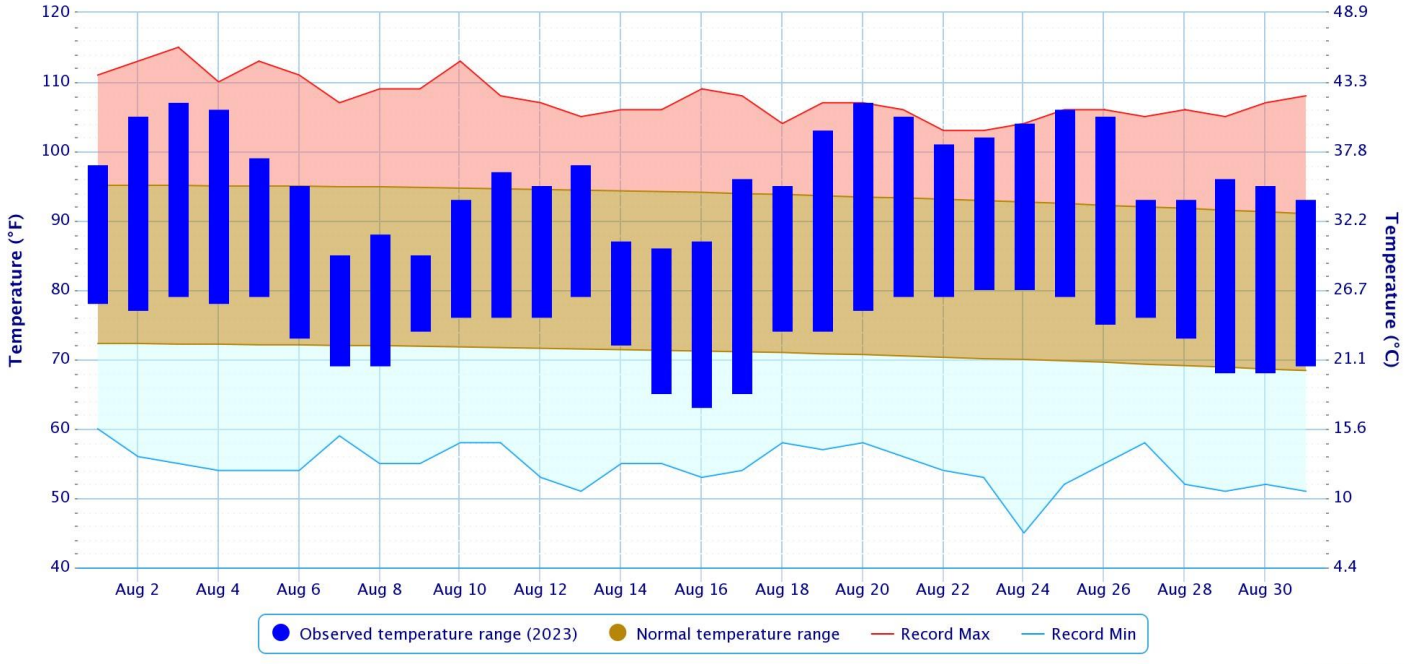
Daily Temperature Data – Fort Smith Area, AR (ThreadEx)

Period of Record – 1882-06-01 to 2023-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



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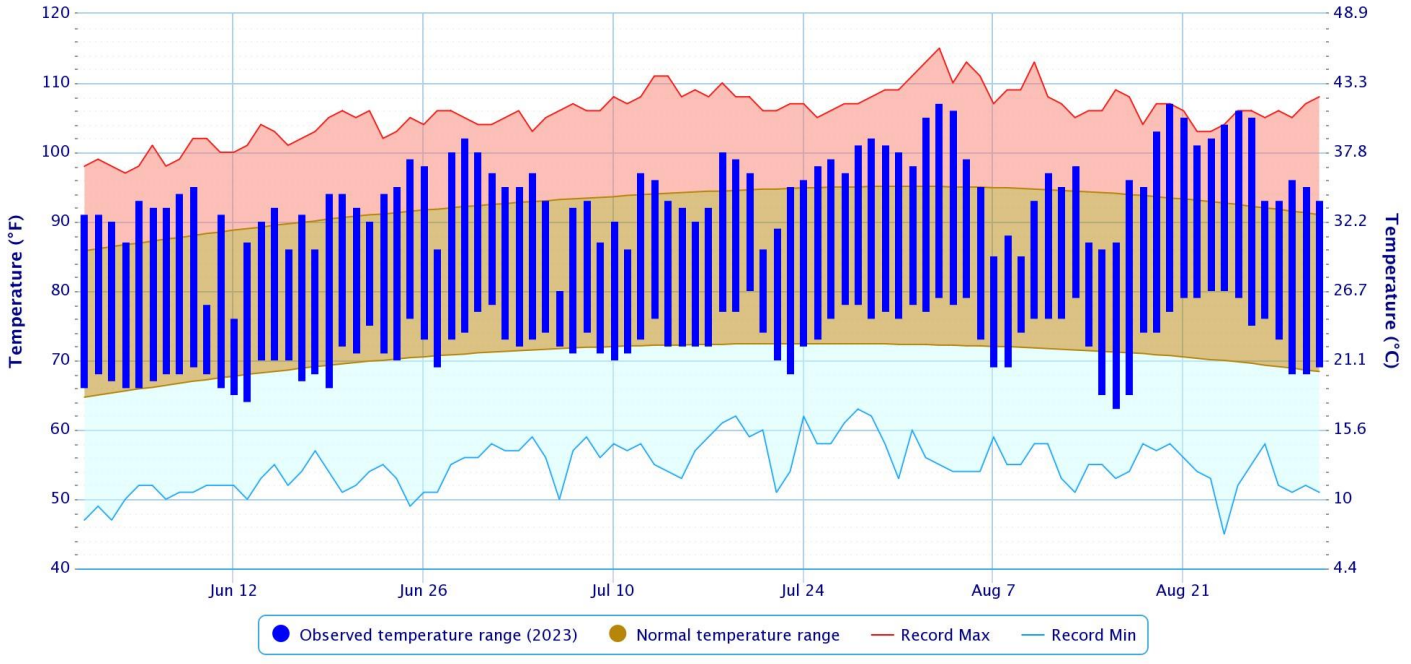
Daily Temperature Data – Fort Smith Area, AR (ThreadEx)

Period of Record – 1882-06-01 to 2023-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



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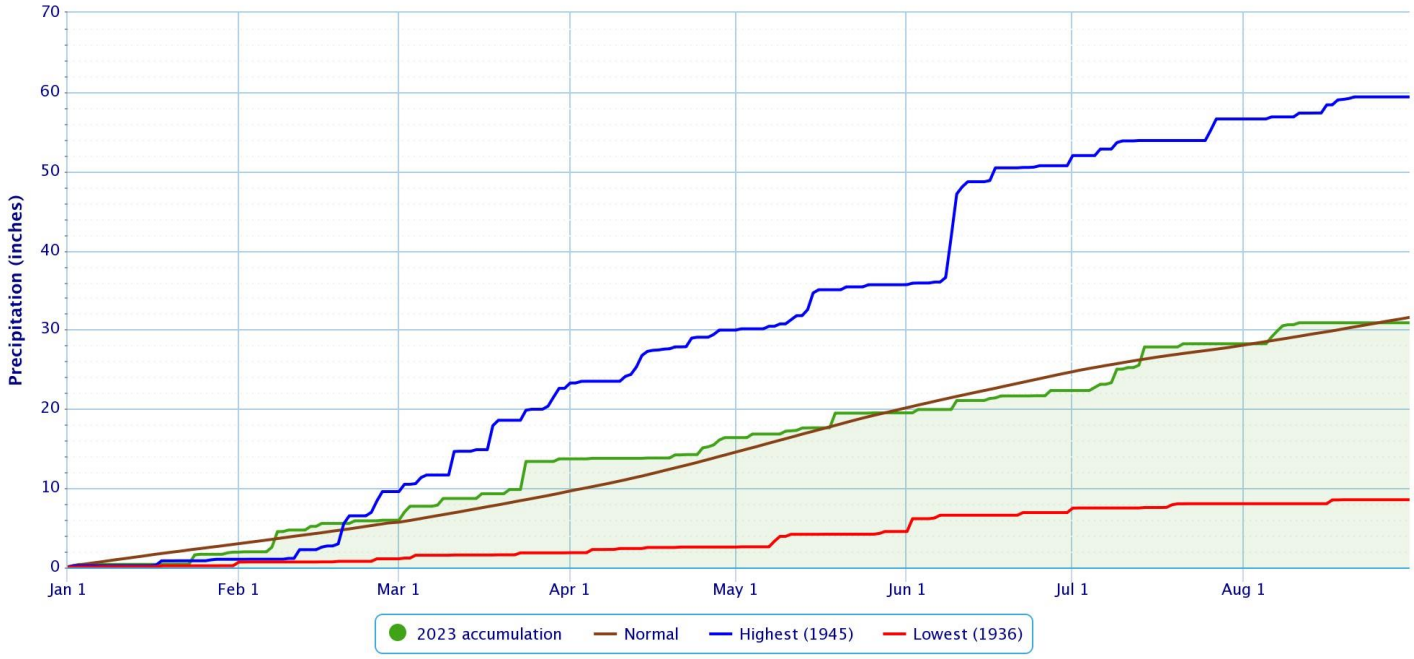
Accumulated Precipitation – Fort Smith Area, AR (ThreadEx)

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



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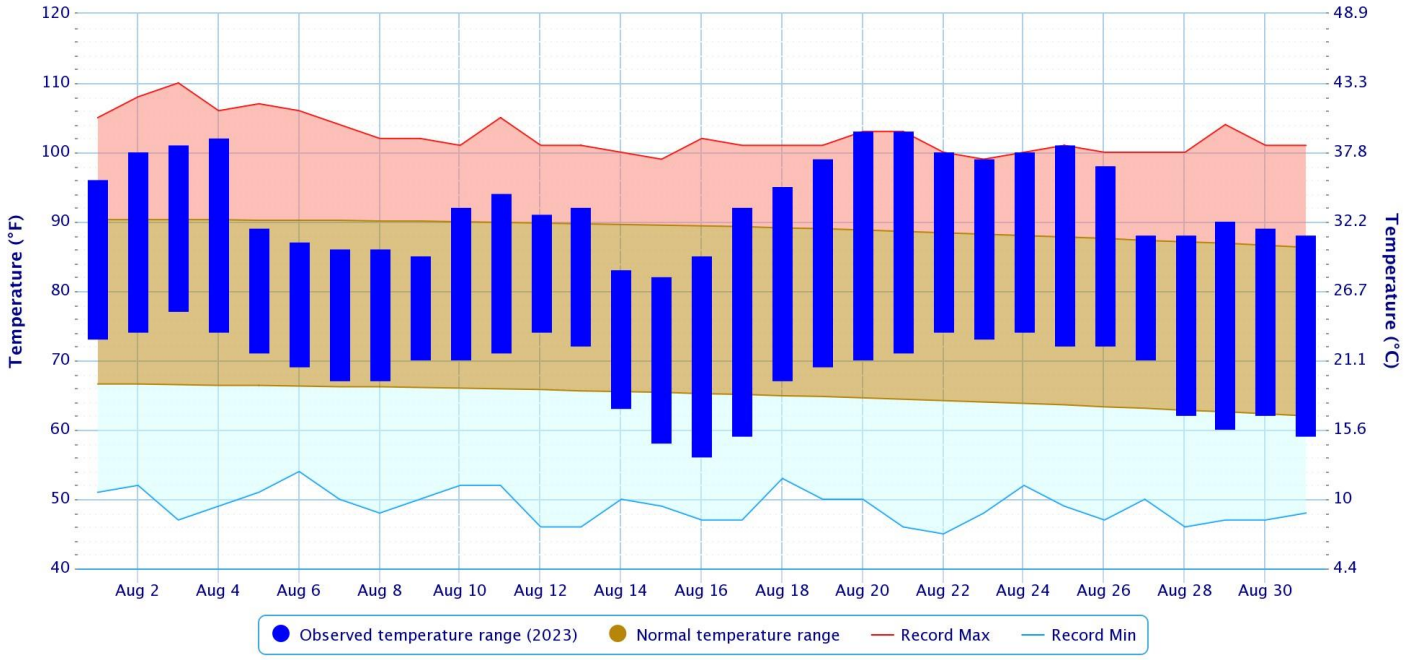
Daily Temperature Data – FAYETTEVILLE DRAKE FIELD, AR

Period of Record – 1949-07-14 to 2023-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



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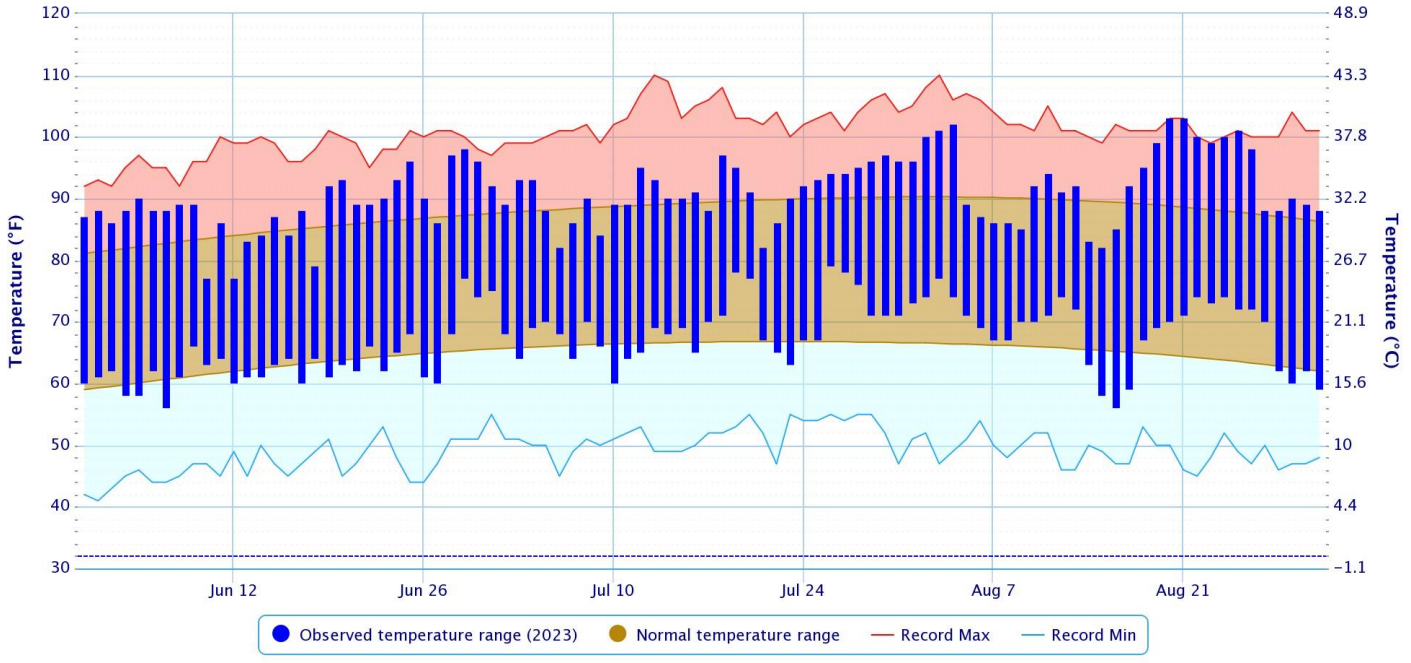
Daily Temperature Data – FAYETTEVILLE DRAKE FIELD, AR

Period of Record – 1949-07-14 to 2023-08-31. Normals period: 1991-2020. Click and drag to zoom chart.



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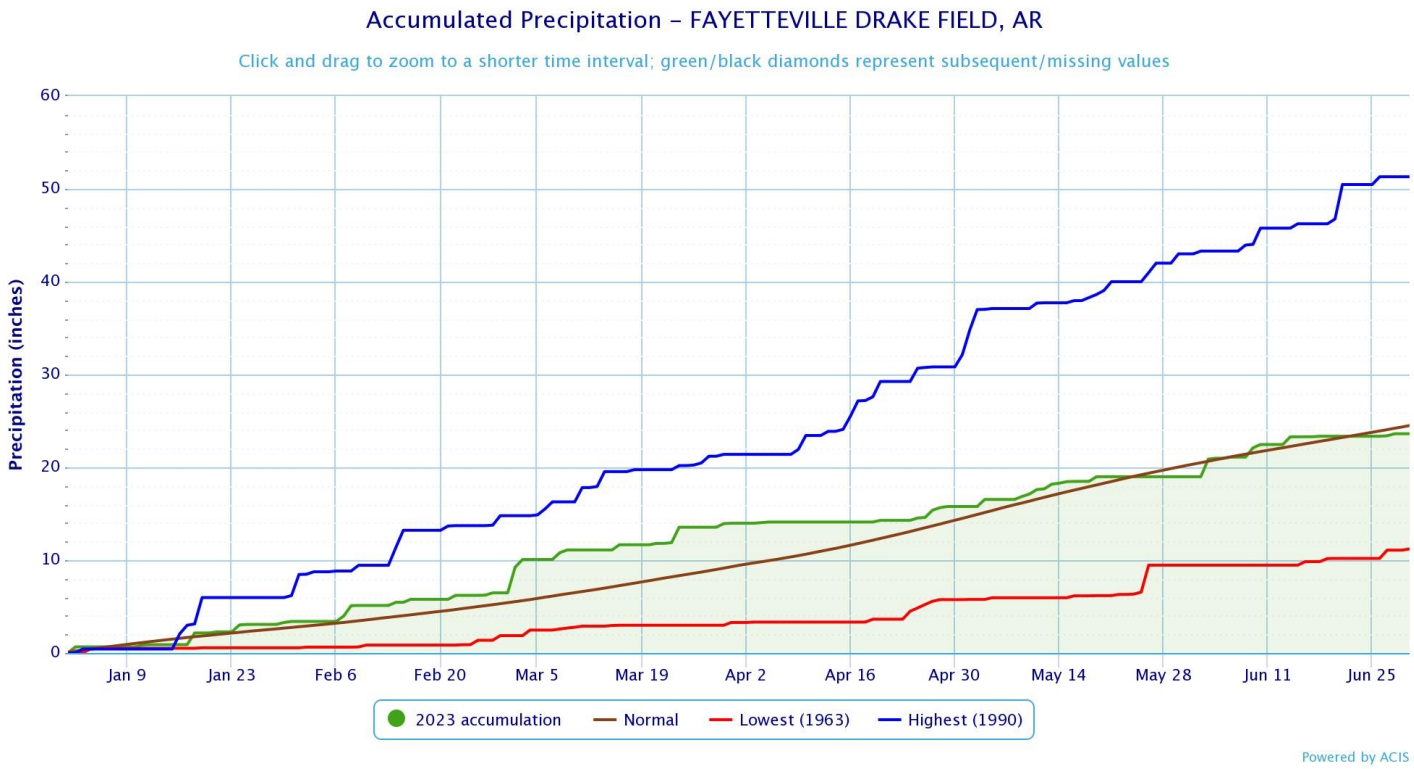


Summer (June-July-August) Summary

In Tulsa, OK, Summer 2023 ranked as the 32nd warmest Sumer (82.0°F, tied 1916, 1922; since records began in 1905) and the 54th wettest Summer (1.74”; since records began in 1888). Fort Smith, AR had the 11th warmest Summer (83.4°F; since records began in 1882) and the 53rd wettest Summer (11.36”; since records began in 1882). Fayetteville, AR had the 8th warmest (78.8°F) and the 26th wettest (12.95”) Summer since records began in 1950.

Some of the larger precipitation reports (in inches) for Summer 2023 included:

Pryor 6.9ESE, OK (coco)	20.45	Wyandotte 7.3NE, OK (coco)	20.10	Okemah, OK (meso)	17.03
Springdale 0.6E, AR (coco)	16.97	Vinita 8.6ESE, OK (coco)	16.93	Jay 3.3NNE, OK (coco)	16.28
Spavinaw, OK (coop)	16.24	Bella Vista 2.2E, AR (coco)	15.97	Bentonville 6.6SSW, AR (coco)	15.89

Using the radar-derived estimated observed precipitation from the RFCs (Fig. 1c), rainfall totals for Summer 2023 ranged from 6” to 20” across eastern OK and northwest AR, with much of the area receiving 10”-15”. These rainfall totals correspond to 50% to 200% of the normal Summer rainfall (Fig. 1d).

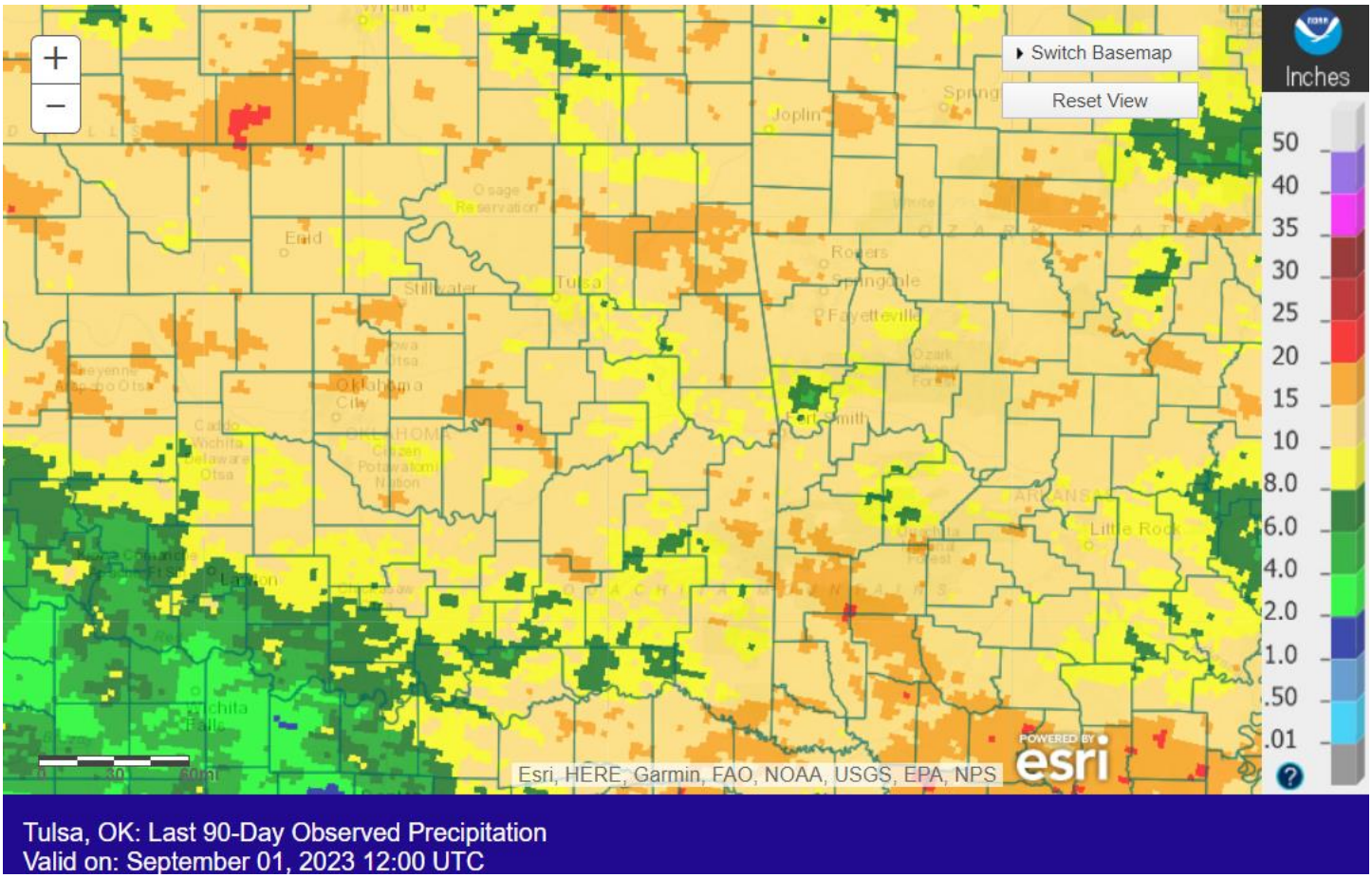


Fig. 1c. Estimated Observed Rainfall for Summer 2023

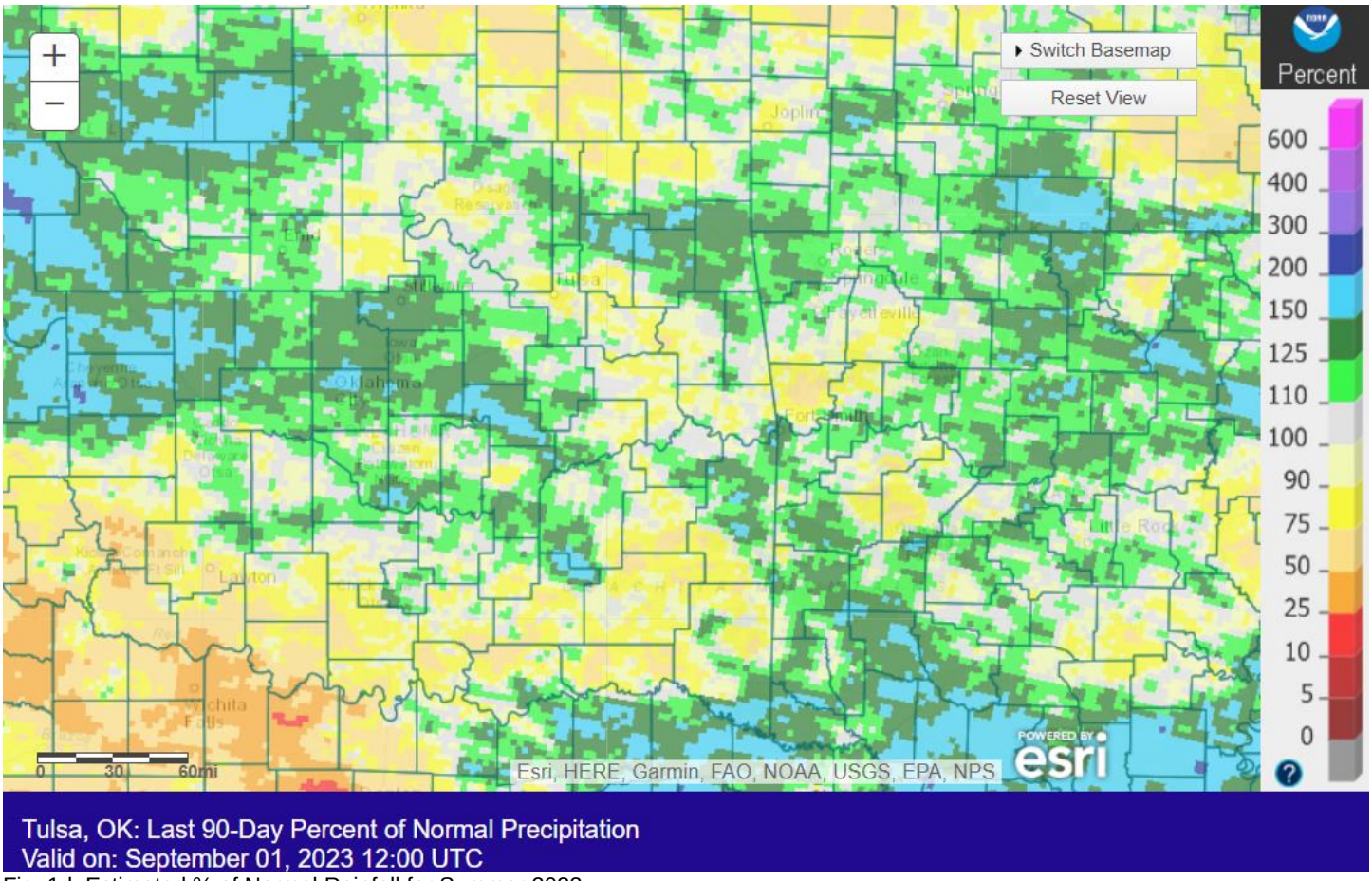
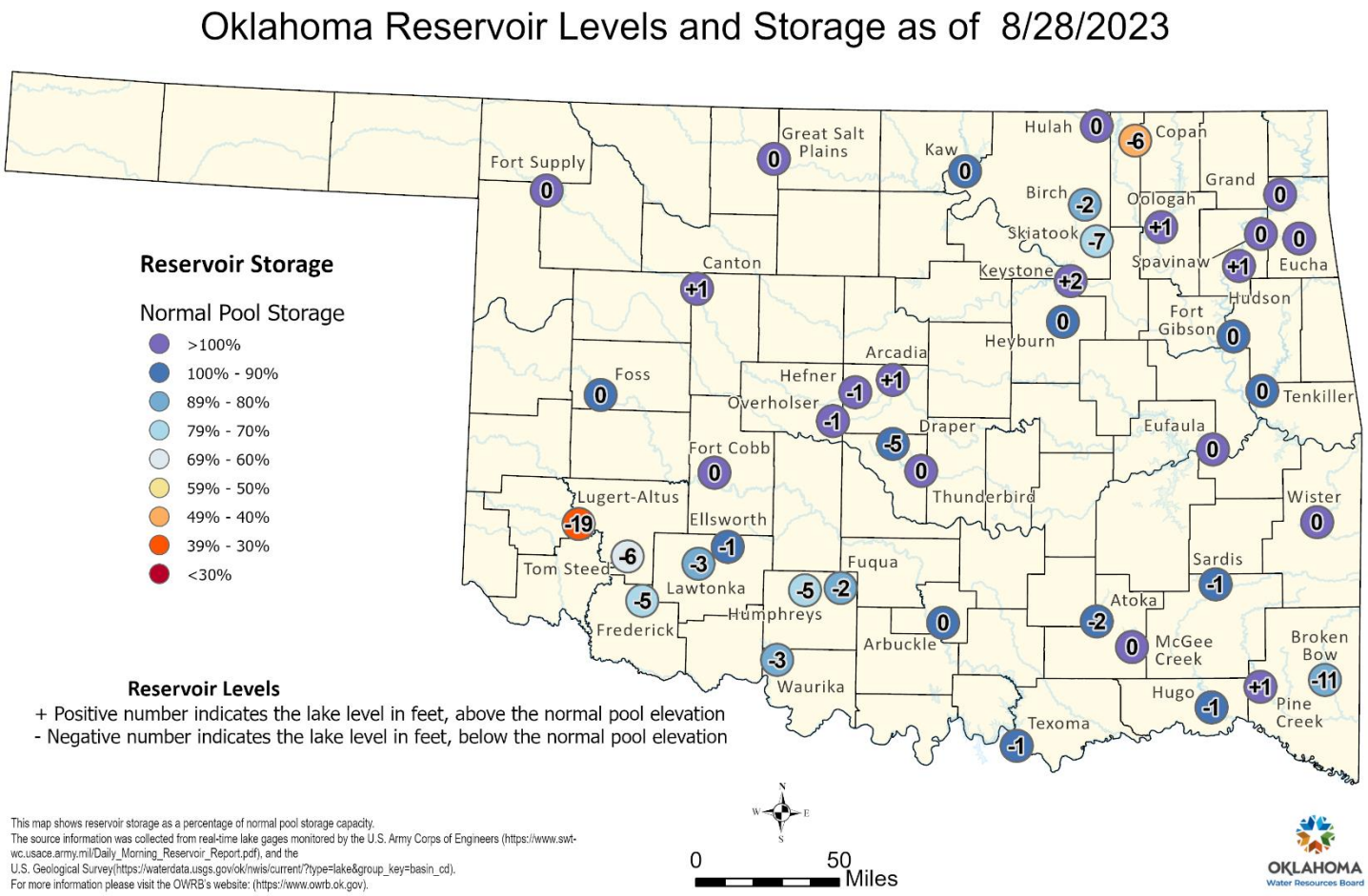


Fig. 1d. Estimated % of Normal Rainfall for Summer 2023

Reservoirs



According to the USACE, several of the lakes in the HSA were below 3% of top of their conservation pools as of 08/31/2023: Copan Lake 43%, Fort Gibson 74%, Skiatook Lake 77%, Beaver Lake 85%, Birch Lake 85%, Hugo Lake 92%, and Sardis Lake 96%. Two lakes were above 3% of the top of their conservation pools: Keystone Lake 4% and Hudson Lake 7%.

Drought

According to the U.S. Drought Monitor (USDM) from August 29, 2023 (Figs. 2, 3), Extreme (D3) Drought conditions were occurring in portions of eastern Kay, Osage, and Washington Counties in eastern Oklahoma. Severe (D2) Drought conditions exist in portions of Craig, Nowata, Washington, Osage, Pawnee, and Pushmataha Counties in eastern Oklahoma. Moderate (D1) Drought conditions were present in portions of Craig, Nowata, Washington, Osage, Pawnee, Latimer, Pushmataha, and Choctaw Counties in eastern Oklahoma. Abnormally Dry (D0) but not in drought conditions were occurring in Ottawa, Craig, Nowata, Washington, Rogers, Tulsa, Osage, Pawnee, Pittsburg, Latimer, Le Flore, Pushmataha, and Choctaw Counties in eastern OK No drought or abnormally dry conditions were occurring in northwest AR.

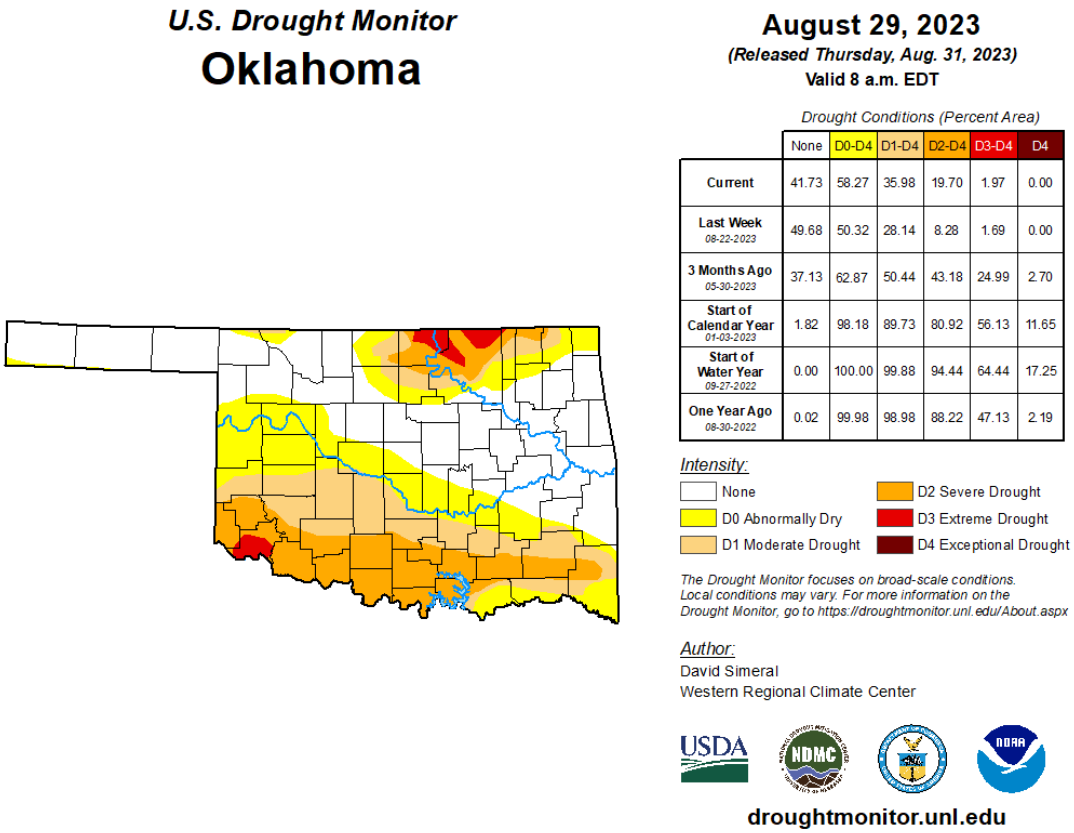


Fig. 2. Drought Monitor for Oklahoma

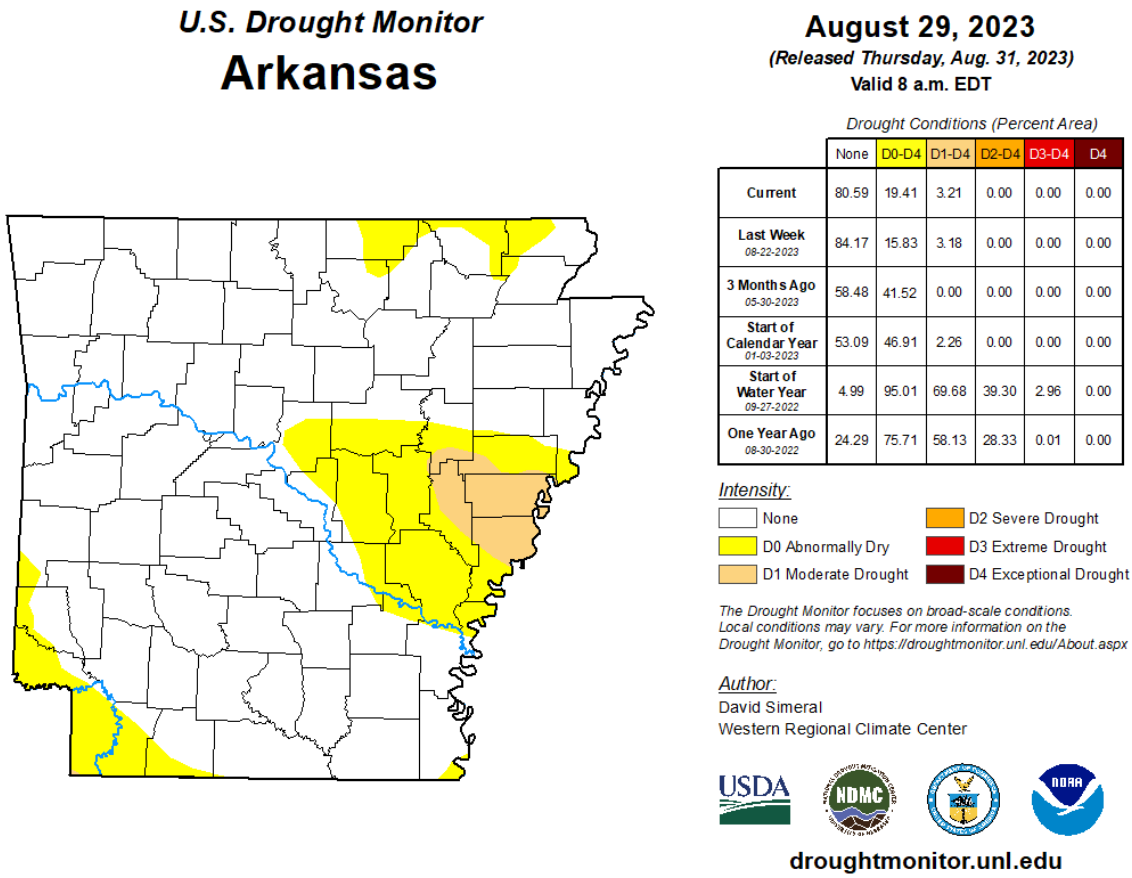


Fig. 3. Drought Monitor for Arkansas

Outlooks

The Climate Prediction Center (CPC) outlook for September 2023 (issued August 31, 2023) indicates an enhanced chance for above normal temperatures and below median precipitation across all of eastern OK and northwest AR. This outlook was based on dynamical model output, ENSO, and the Madden-Julian Oscillation (MJO) this month. The El Niño and MJO influences will counteract one another over the U.S. Other large scale climate patterns, including the AO, NAO, and PNA, look to enhance the MJO pattern. Overall, a high-pressure ridge is expected to persist for much of September over the area, supporting the enhanced chance for above normal temperatures and below median rainfall.

For the 3-month period September-October-November 2023, CPC is forecasting an enhanced chance for above normal temperatures south of I-40 and an equal chance for above, near, and below normal temperatures north of I-40 in eastern OK and northwest AR (outlook issued August 17, 2023). This outlook also shows an equal chance for above, near, and below median precipitation across all of eastern OK and northwest AR. This outlook is based on long-term trends, ENSO state, soil moisture, and incorporates both statistical and dynamical forecast tools. According to CPC, El Niño conditions are present in the equatorial Pacific Ocean, and El Niño is expected to strengthen and persist through the winter 2023-24. There is a greater than 95% chance of El Niño continuing through the winter and a 66% chance of a strong El Niño event. CPC continues the El Niño Advisory.

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

Convection developed around sunrise on the 5th in an area of weak warm air advection across northeast OK and northwest AR, aided by outflow boundaries from storms in KS and MO. Scattered showers and thunderstorms continued through the morning north of I-40, weakening and diminishing through the early afternoon. Shortly after midnight of the 6th, a small complex of storms moved into northeast OK from north central OK/south central KS. These storms continued to increase through the overnight hours, developing into a large mesoscale convective system (MCS) that impacted all of eastern OK and northwest AR as it moved southeast. The leading edge of the MCS moved southeast of the area by sunrise, with the rain ending from northwest to southeast. Rainfall totals by 7am ranged from 0.10" to around 3" (Fig. 4). While most of the activity ended by mid-morning, an area of showers and thunderstorms persisted across northeast OK in response to an upper-level jet streak. These storms weakened as the moved southeast, coming to an end by mid-afternoon. Scattered convection then developed during the early morning hours of the 7th in the vicinity of an elevated frontal boundary from northeast OK into west central AR. This activity slowly moved south, with most of the convection located along I-40 by 7 am. The 24-hour rainfall through 7 am ranged from 0.10" to 2" (Fig. 5). These storms continued to move south and exited the area shortly after noon. After midnight on the 8th, thunderstorms developed from north central OK to west central AR near and north of the elevated frontal zone as another disturbance dropped down the backside of a mid-level trough centered over the Midwest and interacted with a strengthening low-level jet. These storms persisted over the same area through sunrise, before then shifting more quickly to the east as the mid-level forcing shifted east. These storms then exited the area by noon. The training of the thunderstorms resulted in widespread heavy rain, with a heavy rain axis of 3"-5" from Okfuskee County through Le Flore County (Figs. 6-8). Flash flooding was reported in Canadian, OK. A large portion of the Poteau River basin in Le Flore County received 3"-5", resulting in a rise of approximately 17' in 17 hours at the Panama gage (Fig. 9). Due to the low river level ahead of this rain, the river remained within its banks.

Scattered showers and thunderstorms affected eastern OK and northwest AR during the early through late morning hours of the 9th. Some of these storms came from a complex moving southeast out of KS, while additional activity was due to development within an area of warm air advection. Another line of thunderstorms developed during the early evening hours across northeast OK and southwest MO as a shortwave trough moved into the area. These storms moved southeast across northwest AR during the evening. Most of the activity waned by midnight, though a few storms persisted for a couple more hours. Rainfall totals from the two rounds of storms were highest across Carroll County in northwest AR, where 1"-2.5" of rain fell (Fig. 10).

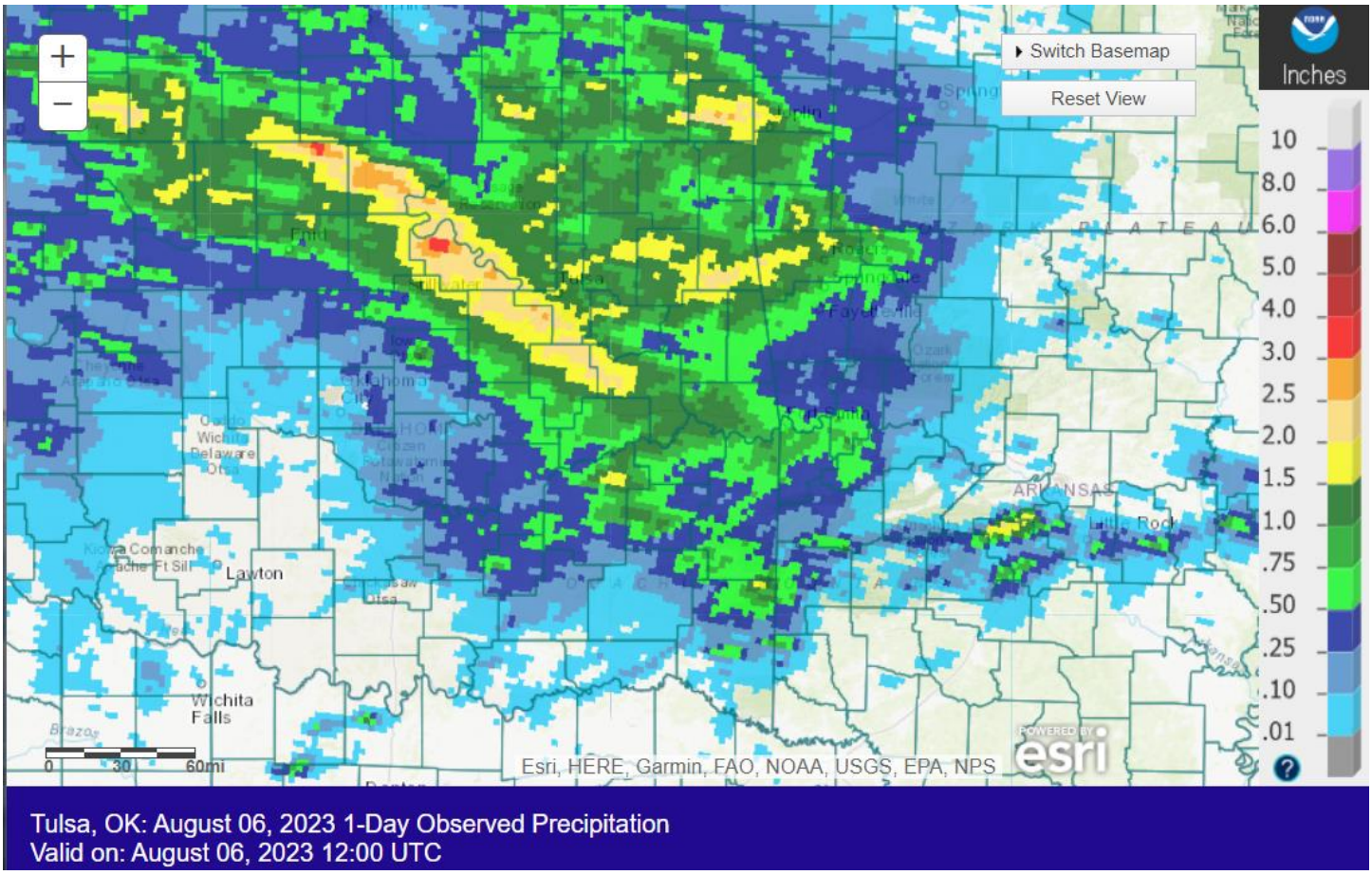


Fig. 4. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/06/2023.

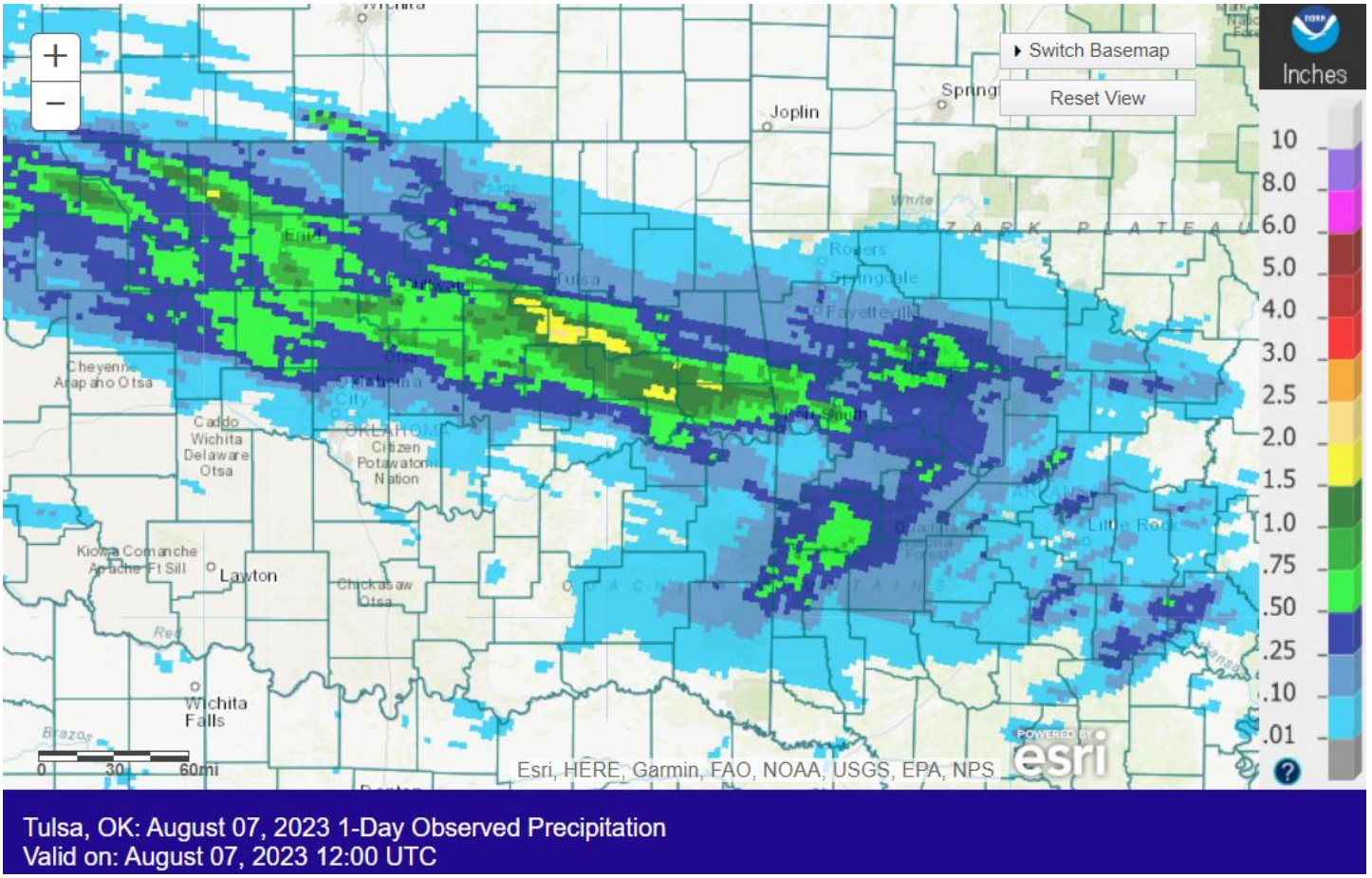


Fig. 5. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/07/2023.

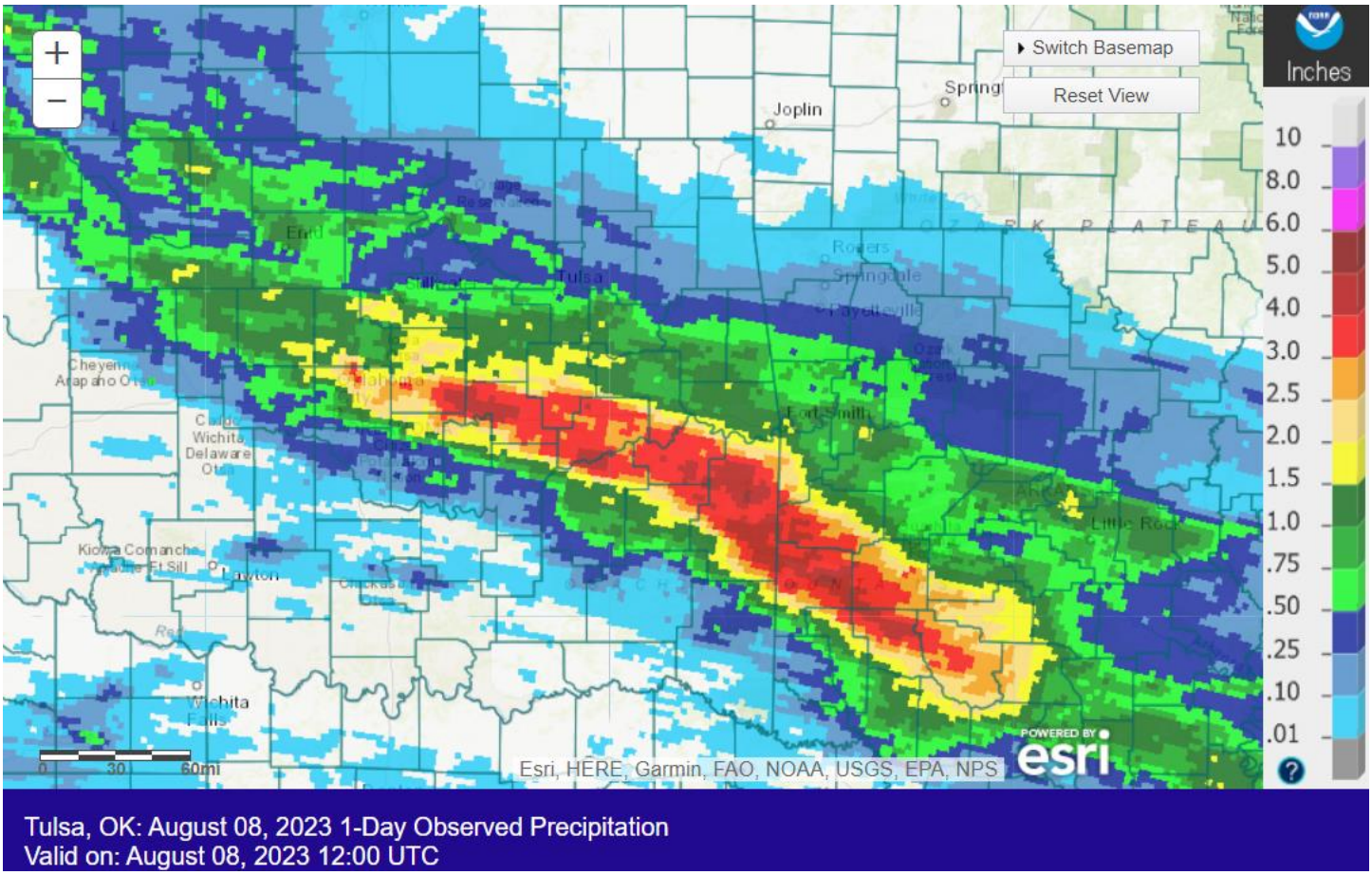


Fig. 6. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/08/2023.

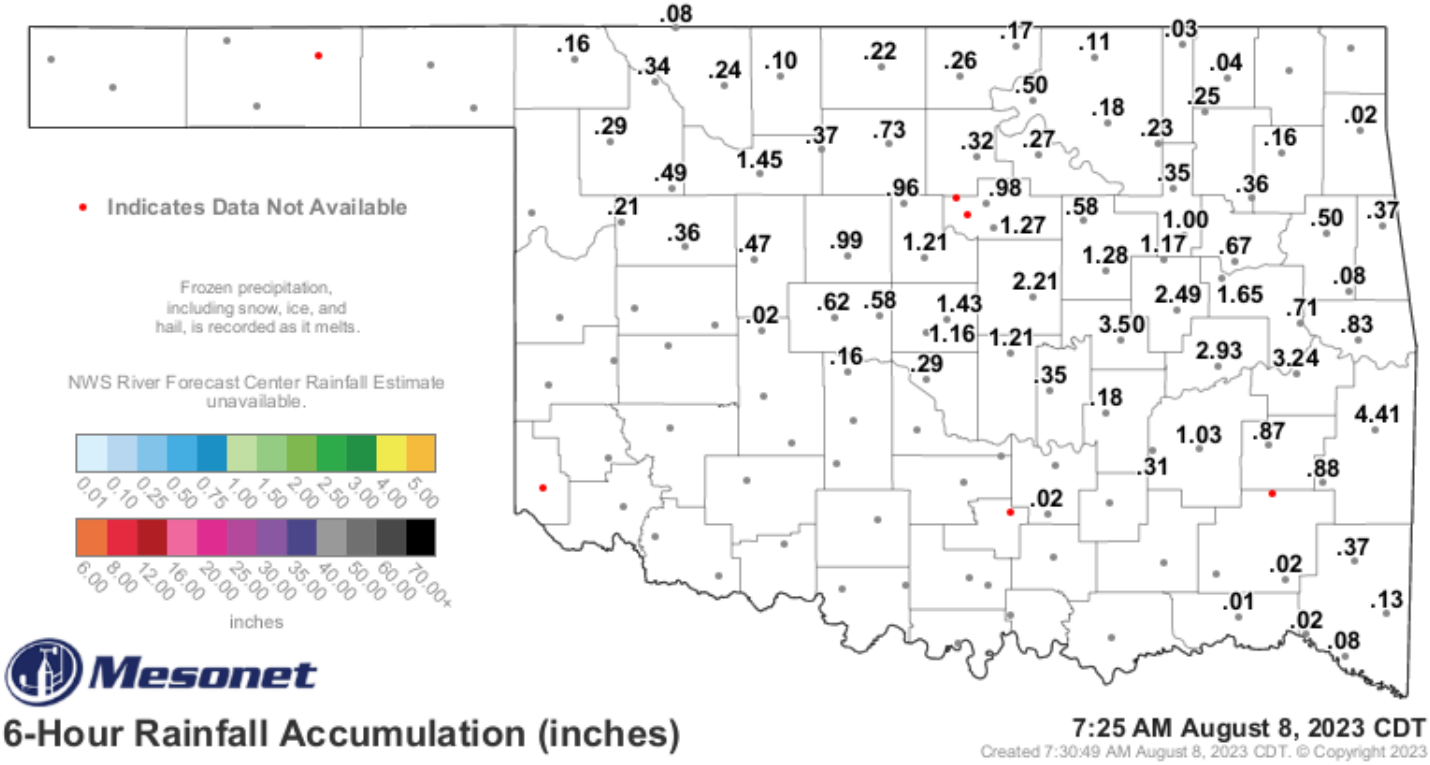


Fig. 7. OK Mesonet (values) 6-hour rainfall ending at 7:25 am CDT 08/08/2023.

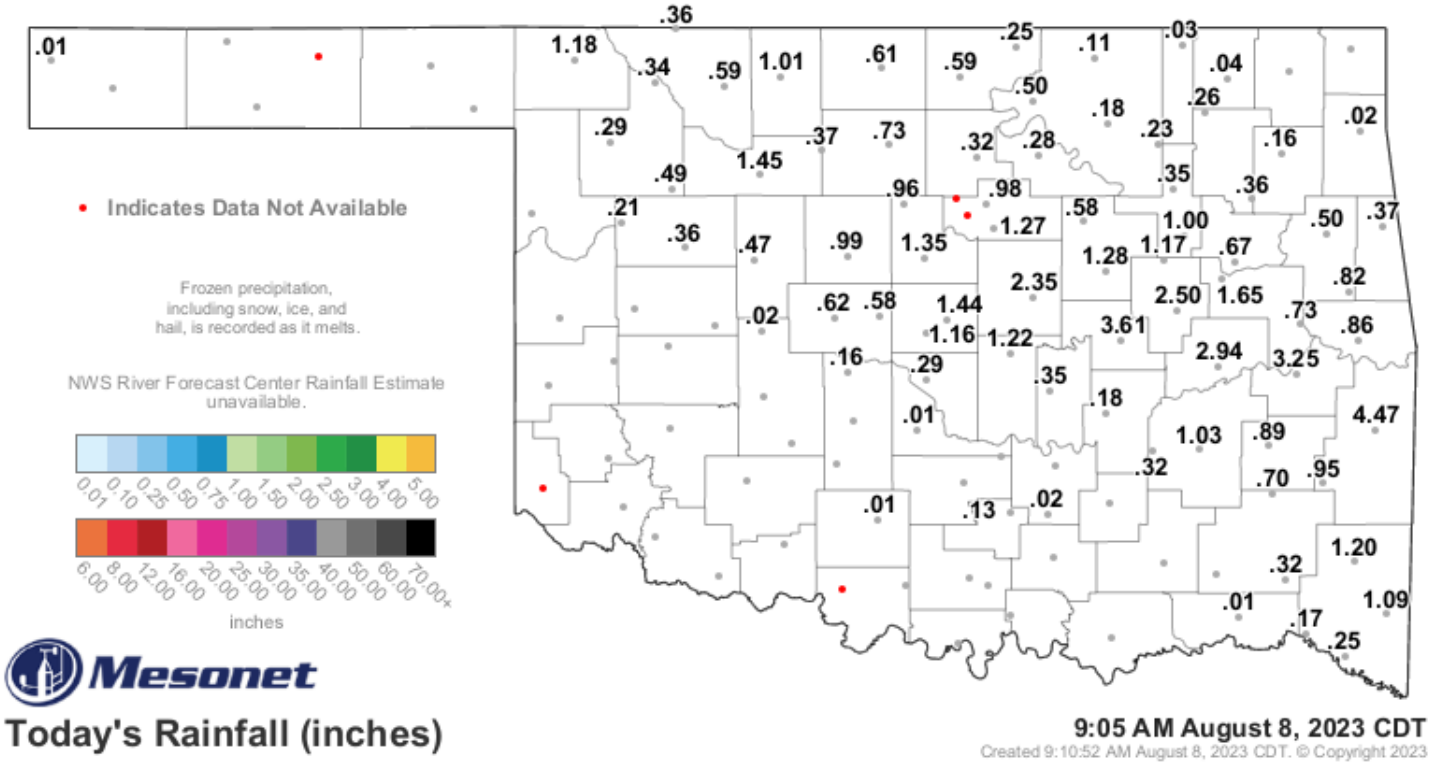


Fig. 8. OK Mesonet (values) 9-hour rainfall ending at 9:05 am CDT 08/08/2023.

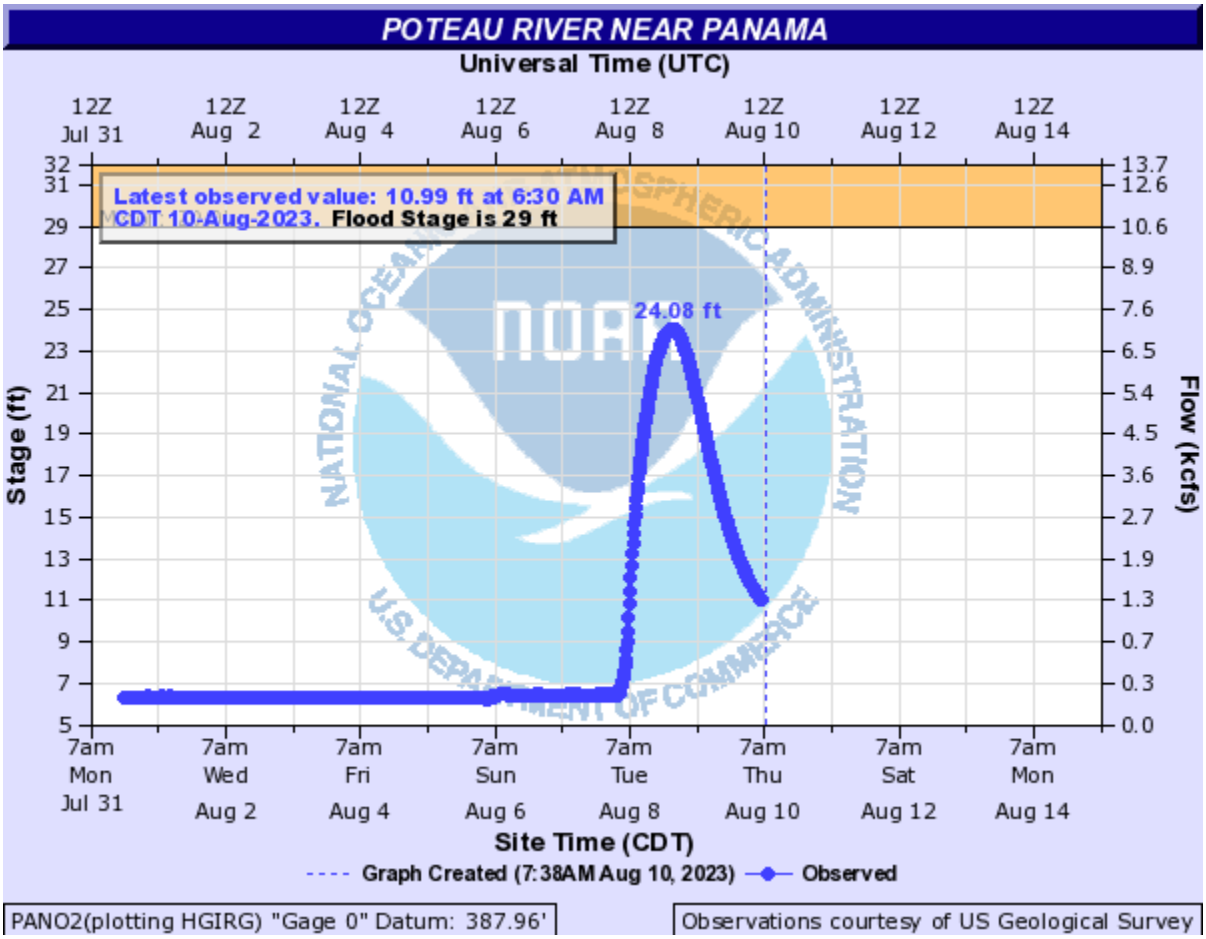


Fig. 9. Preliminary hydrograph of the Poteau River near Panama showing the rapid rise after 3”-5” of rain on Aug. 8, 2023.

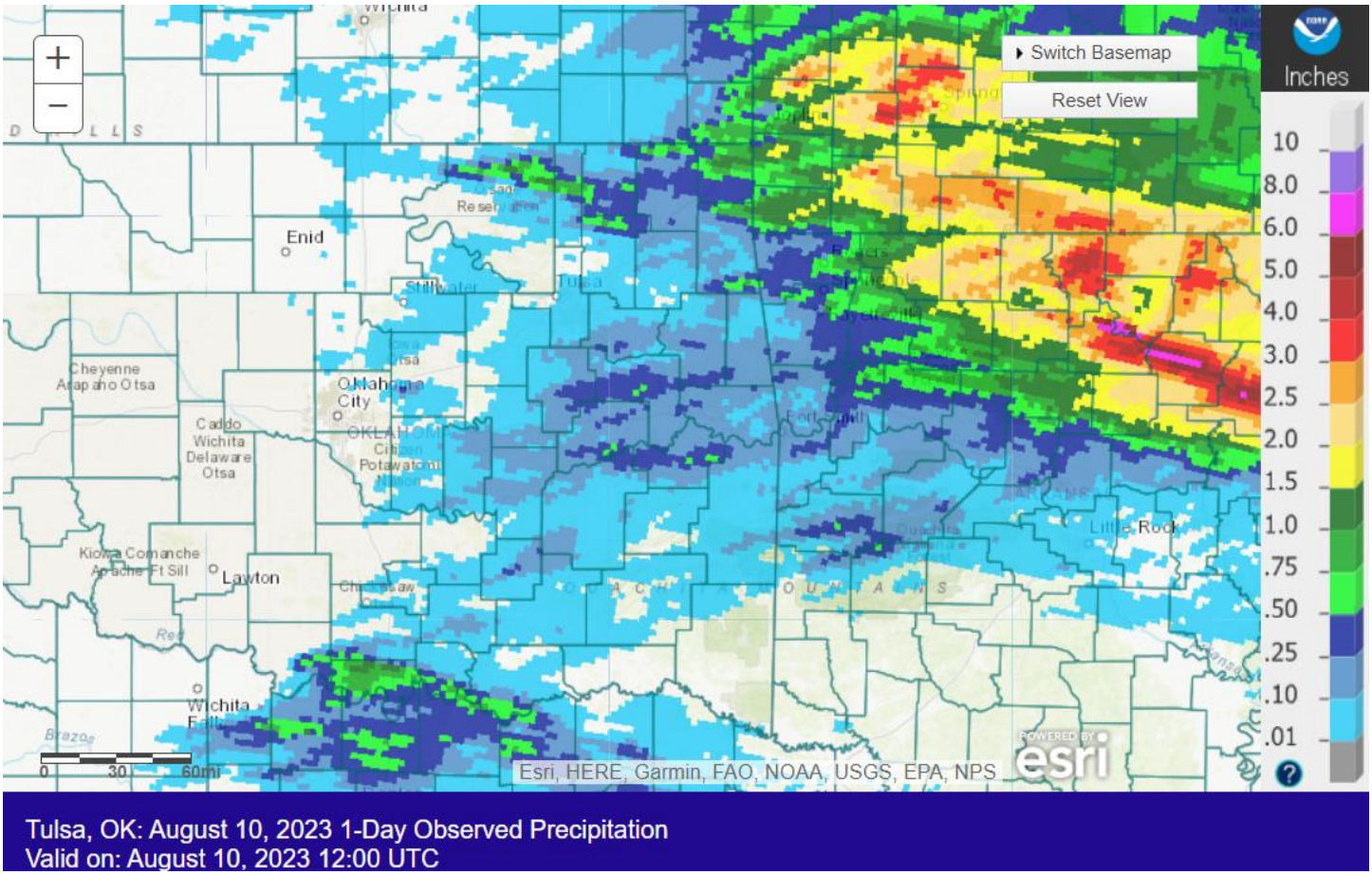


Fig. 10. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/10/2023.

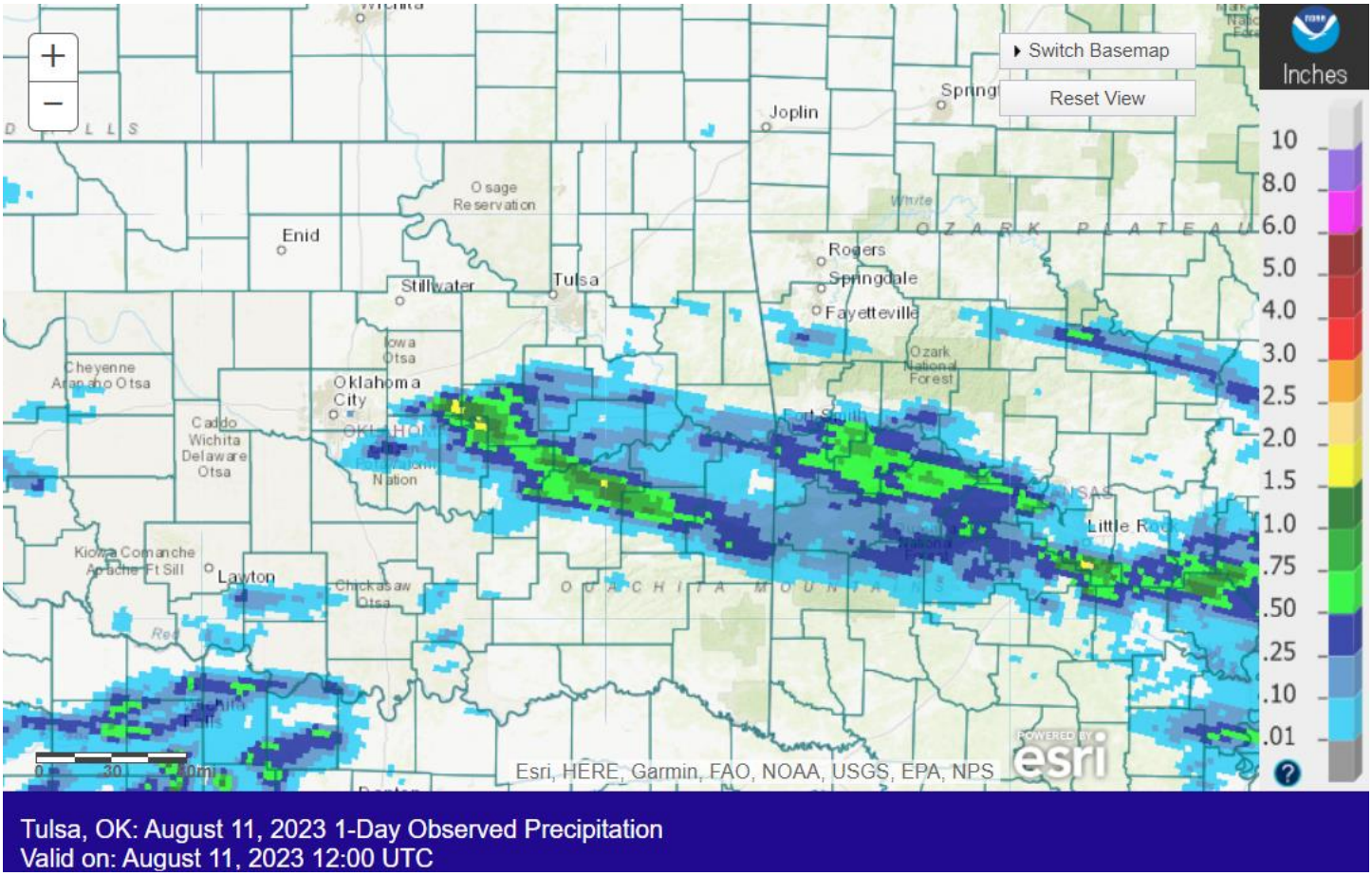


Fig. 11. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/11/2023.

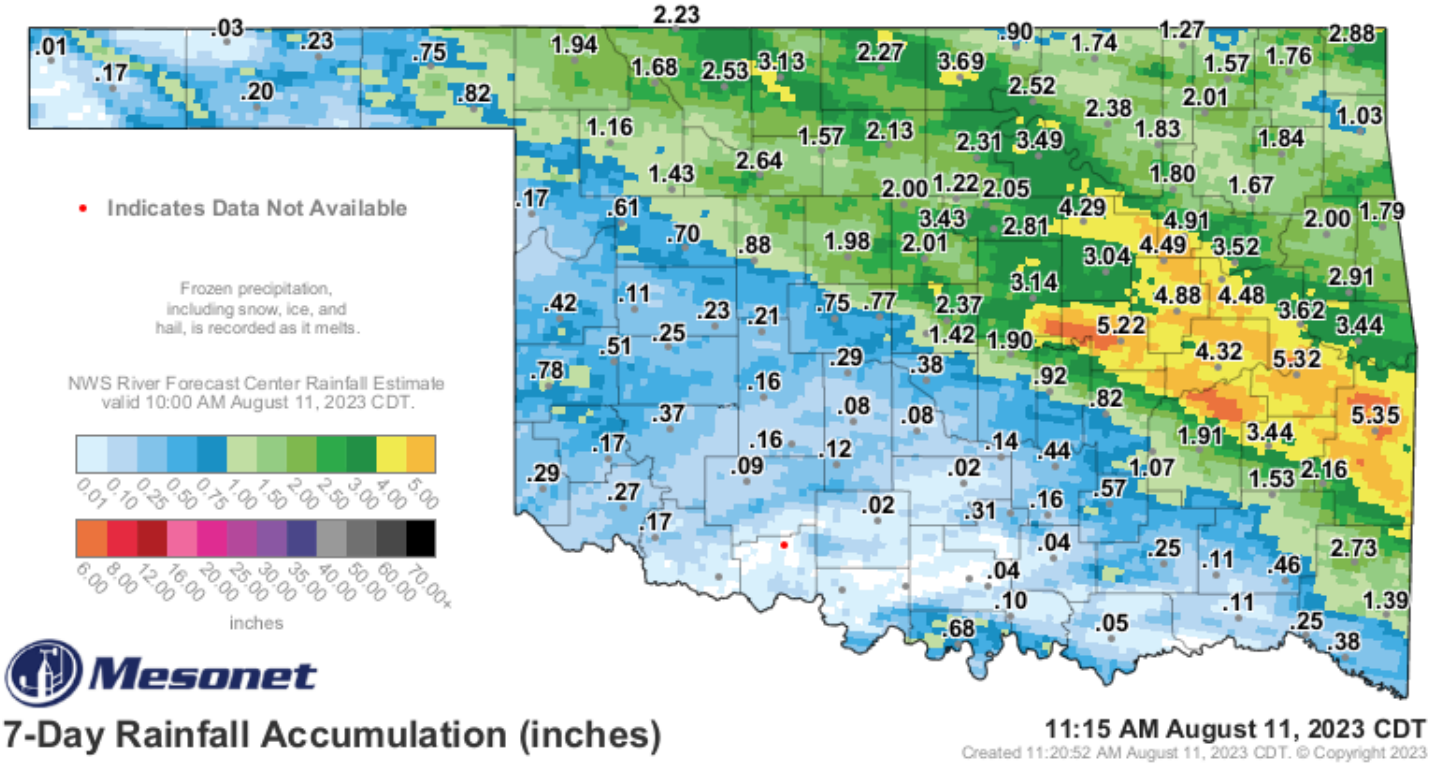


Fig. 12. OK Mesonet (values) and NWS RFC rainfall estimate (image) 7-Day rainfall ending at 11:15 am CDT 08/11/2023.

Just after midnight of the 11th, thunderstorms developed along an elevated frontal zone near I-40 in east central OK. This activity continued to shift east across east central OK and west central AR through the morning hours, dissipating soon after sunrise with the weakening of the low-level jet. Rainfall totals were primarily 0.5”-1.5” in the affected locations (Fig.11). The several rounds of precipitation resulted in a wide swath of 7-day rainfall totals of 4”-7” in eastern OK (Fig. 12).

In the pre-dawn hours of the 13th, elevated thunderstorms quickly developed over far northeast OK and far northwest AR due to an increase in the low-level jet and an approaching circulation from central OK. This cluster of storms moved east, exiting the area by mid-morning. These storms brought 0.50” to around 3” of rain to far northeast OK and far northwest AR (Fig. 13). Dewpoints were high across the region, especially in the region with the recent heavy rainfall, with many stations measuring dewpoint temperatures above 80°F (Fig. 14). According to the Oklahoma Climatological Survey, a new OK Mesonet record high dew point temperature of 84.6°F was set at Oilton, OK (Fig. 15; Mesonet records began in 1994). These high dewpoints, combined with the hot air temperatures, resulted in heat index values of 110°F -120°F across a large portion of eastern OK (Fig. 16). By late evening, thunderstorms began to develop across northeast OK along and ahead of a cold front that was moving south out of KS. These storms quickly evolved into a complex of showers and thunderstorms, moved east southeast across northeast OK and northwest AR during the overnight hours, and exited the area before sunrise on the 14th. These storms produced heavy rainfall, with totals ranging from 0.50”-8” (Figs. 17, 18). A swath of 3”-8” impacted locations from eastern Pawnee County to the OK/MO state line (Figs. 17, 18), and there were several reports of flash flooding across this area. These thunderstorms also produced widespread damaging winds (Figs. 19, 20). The official weather station for Tulsa, OK measured a wind gust of 64 mph at 12:20 am 8/14/2023. A storm chaser reported estimated wind gusts of 95 mph near Catoosa, OK, while an NWS employee estimated 75 mph winds in Owasso. Widespread wind damage was reported in the Owasso and Catoosa areas.

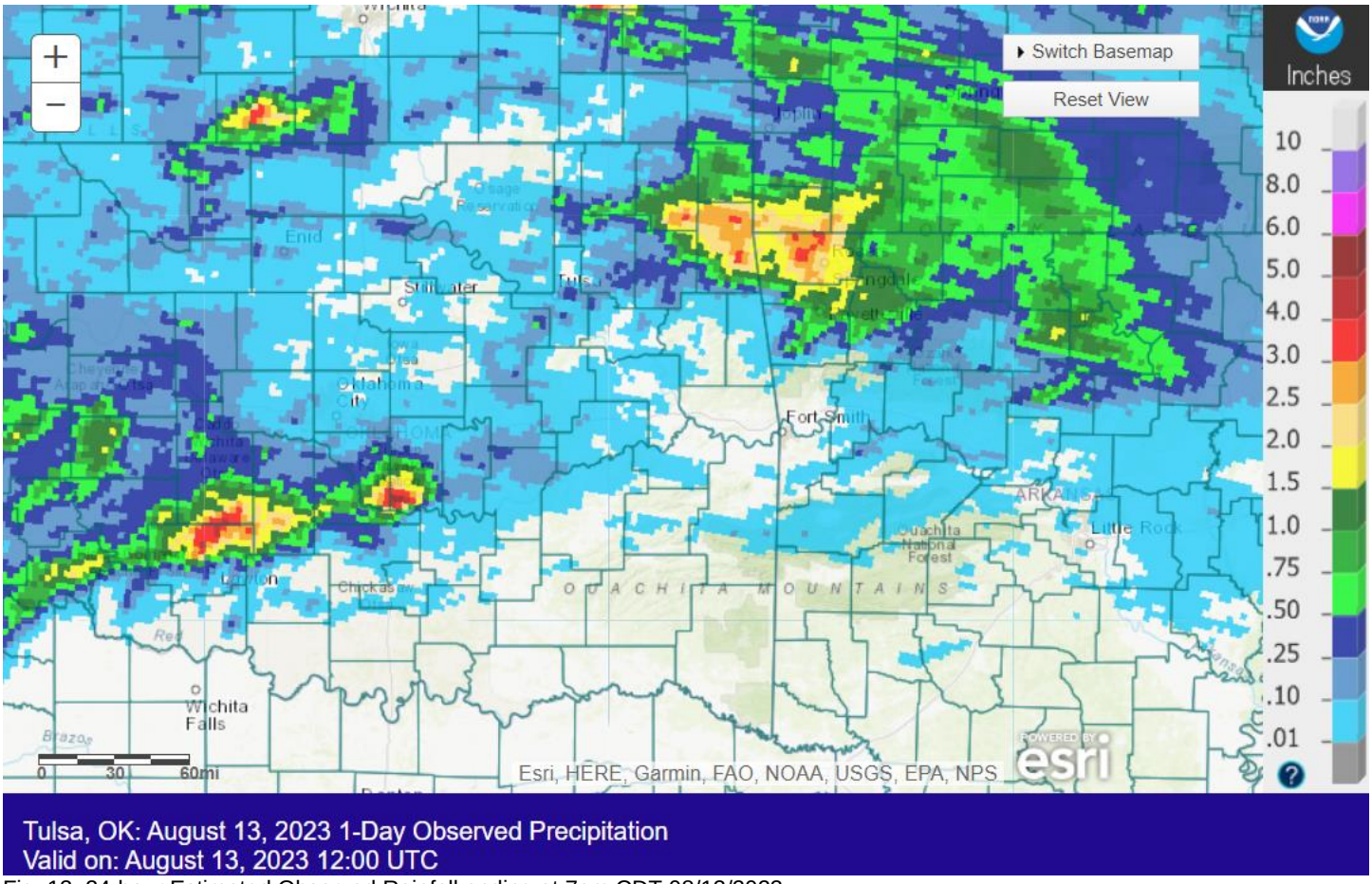


Fig. 13. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/13/2023.

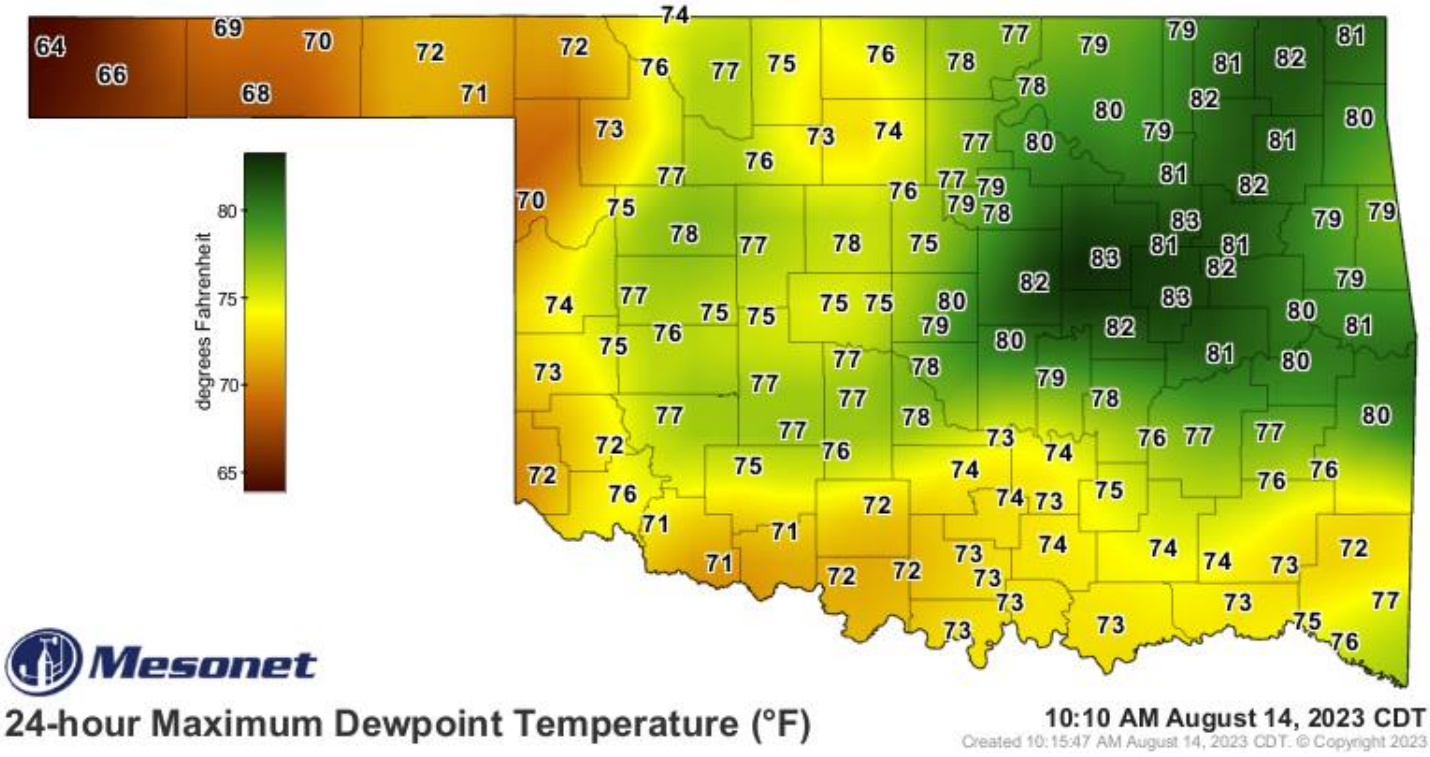


Fig. 14. OK Mesonet 24-hour Maximum Dew Point Temperatures ending at 10:10 am 08/14/2023.

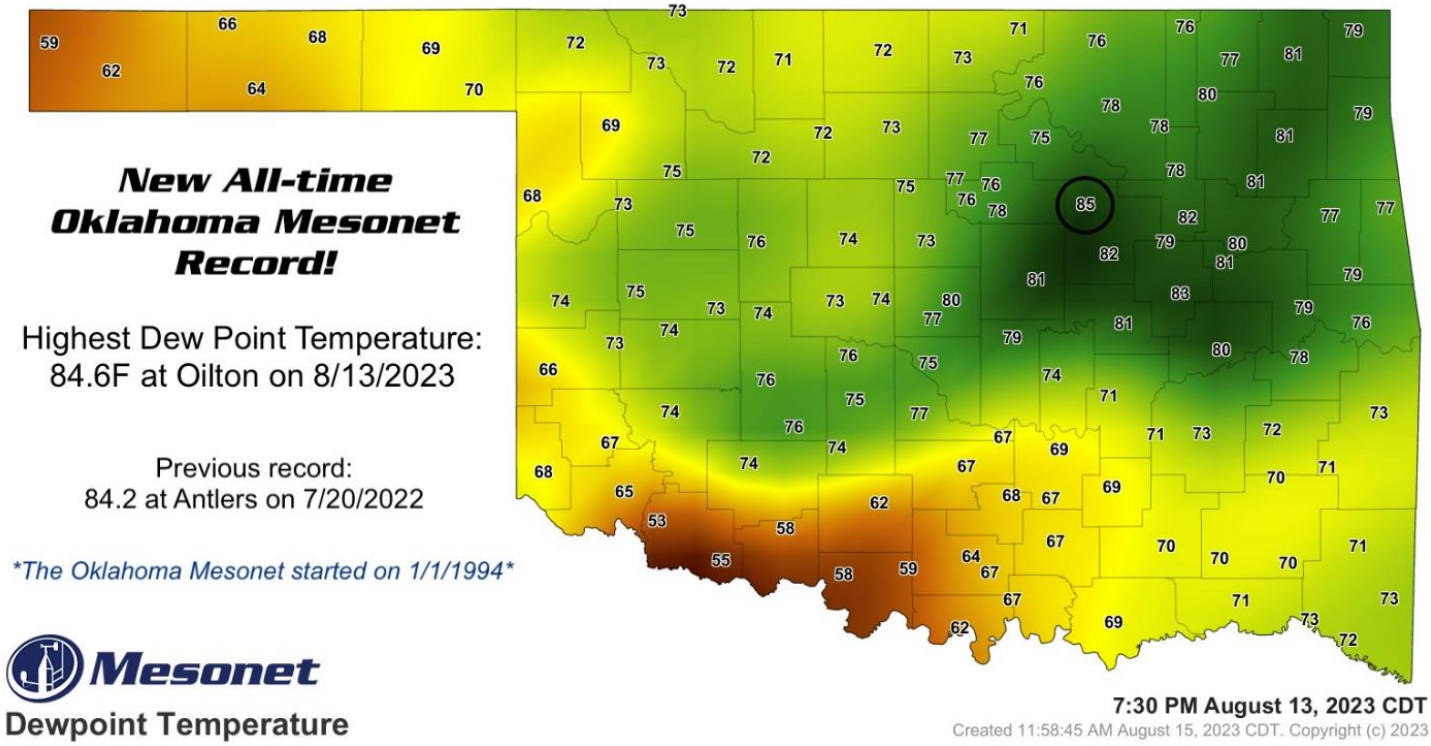


Fig. 15. OK Mesonet Dew Point Temperatures at 7:30 pm 08/13/2023. Image courtesy of the OK Mesonet.

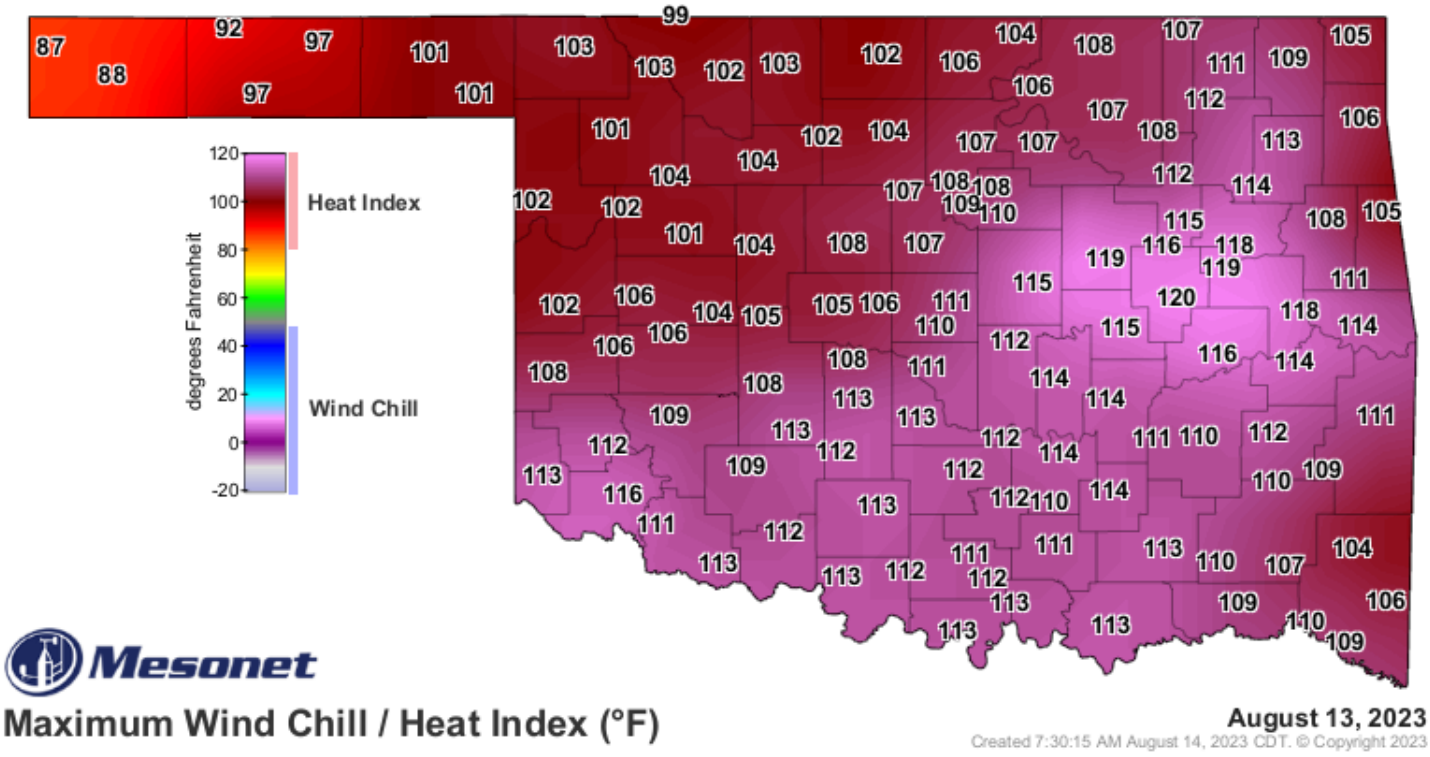


Fig. 16. OK Mesonet Maximum Heat Index for 08/13/2023.

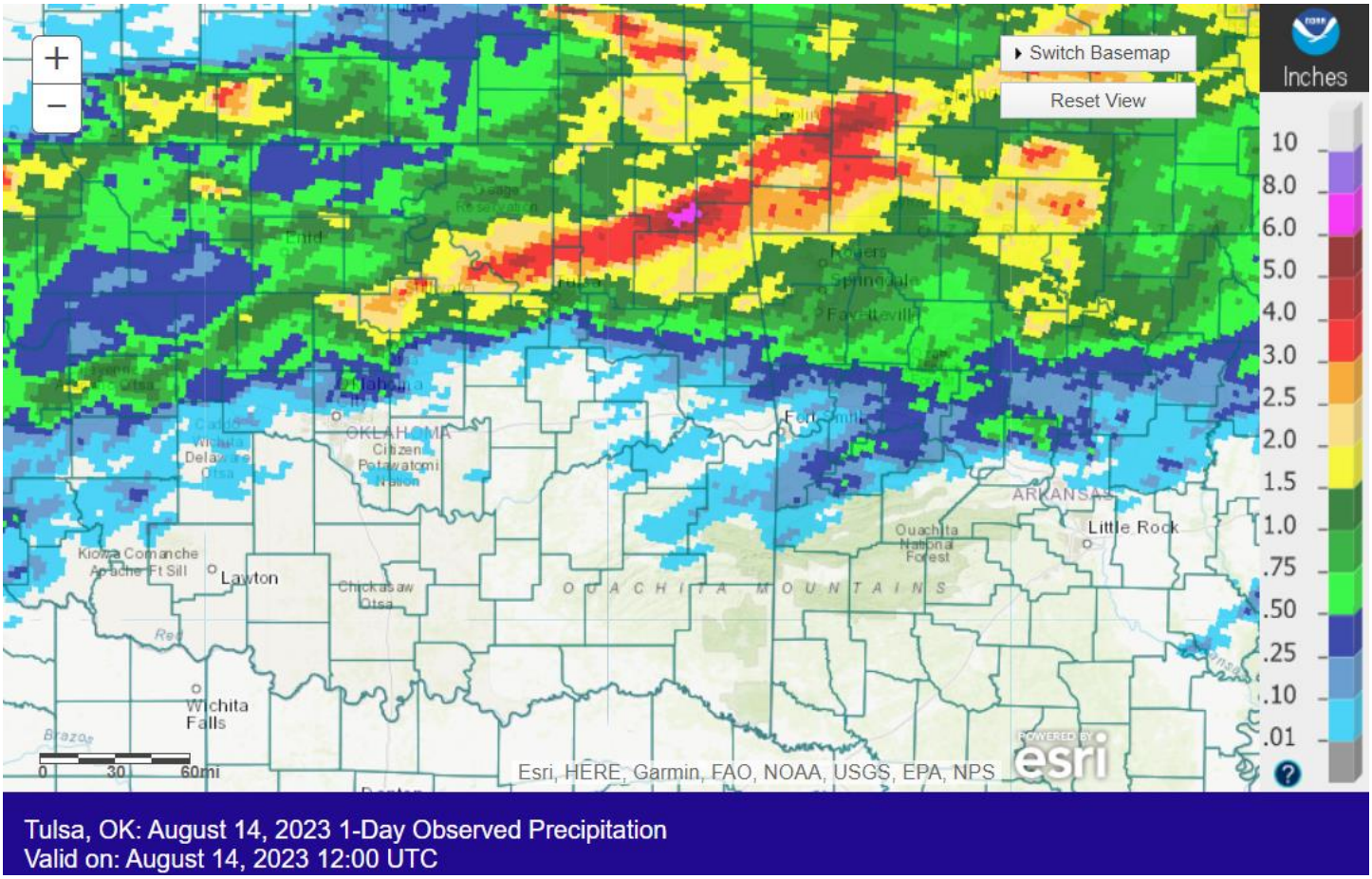


Fig. 17. 24-hour Estimated Observed Rainfall ending at 7am CDT 08/14/2023.

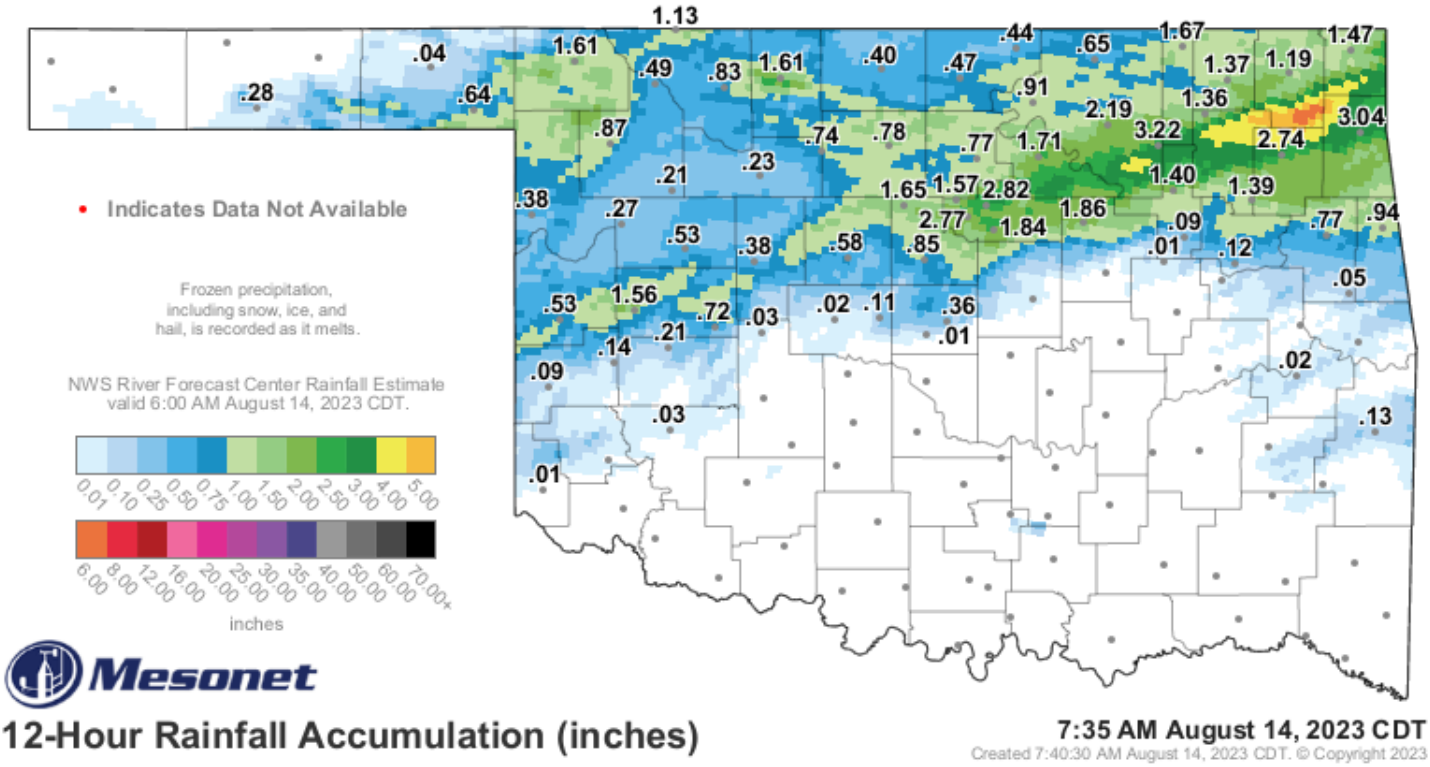


Fig. 18. OK Mesonet (values) and NWS RFC rainfall estimate (image) 12-hour rainfall ending at 7:35 am CDT 08/14/2023.

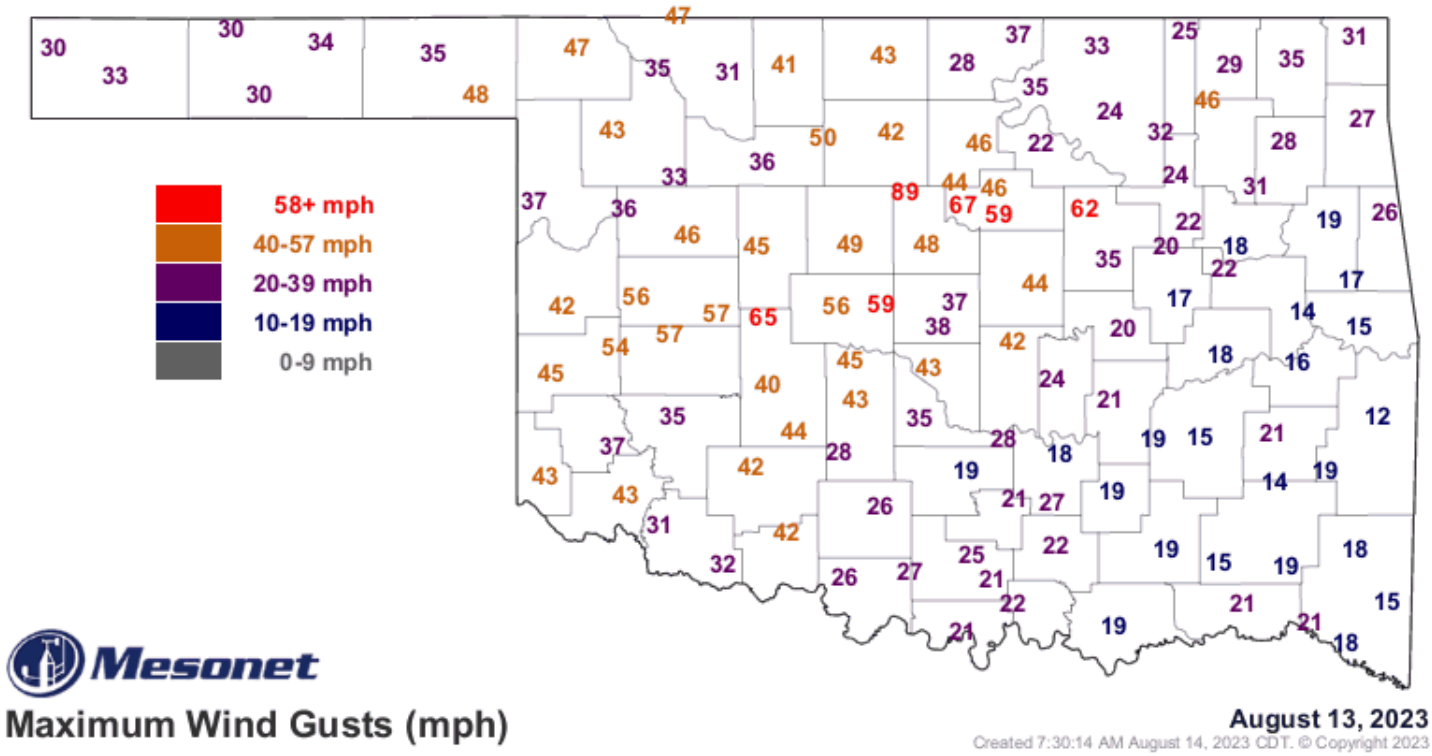


Fig. 19. OK Mesonet Maximum Wind Gusts for 08/13/2023.

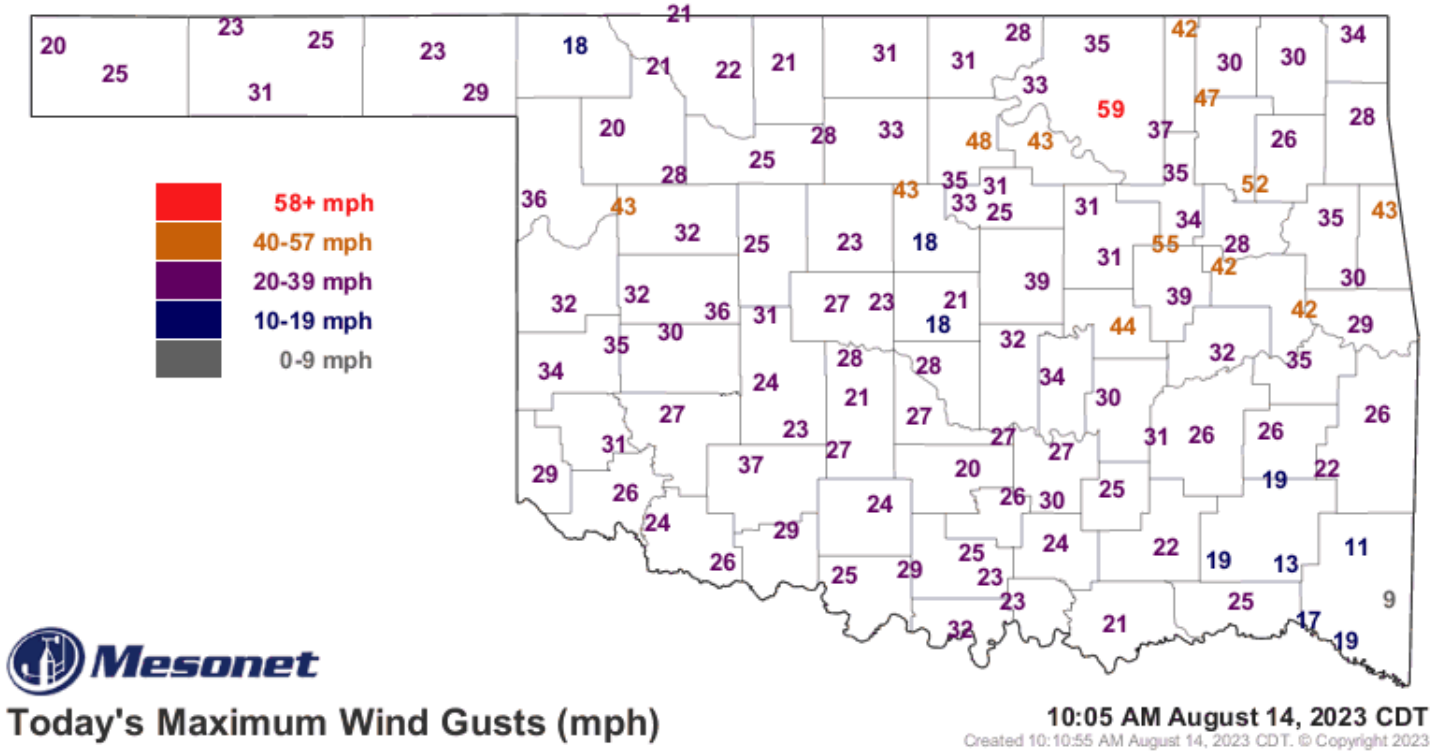


Fig. 20. OK Mesonet Maximum Wind Gusts as of 10:05 am CDT 08/14/2023.

Heat then began to build as an upper-level ridge strengthened over the region on the 19th. High temperatures in the 90s to low 100s combined with the high dew points from the recent rainfall to once again produce heat index values of 110°F -120°F across eastern OK and portions of northwest AR (Fig. 21). The 14-day rainfall footprint aligned with the highest heat index values. With the ridge remaining in place, the hot temperatures and high dew points resulted in high heat index values for several days. According to the OK Mesonet Ticker on August 22, 2023, “Not only did we see the all-time Mesonet max dewpoint fall yesterday for the third time in 8 days, but we also saw the network's max heat index record fall yesterday TWICE when Jay reached 126.74°F a couple of hours after Miami had risen to 126.19°F. Jay's dewpoint of 85.14°F was the new mark as well” (Figs. 22, 23).

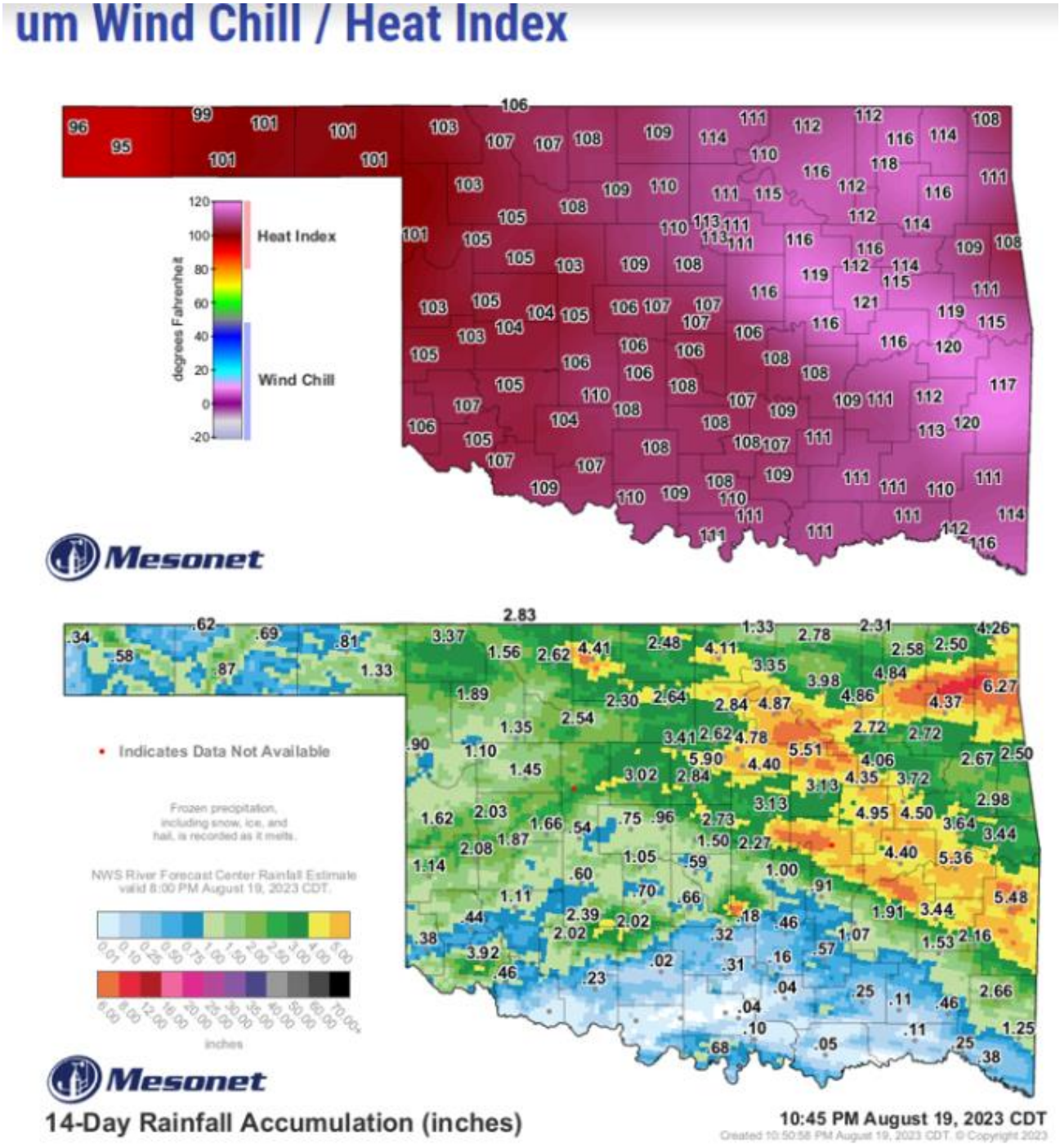


Fig. 21. OK Mesonet Maximum Heat Index (top) and OK Mesonet (values) and NWS RFC 14-Day rainfall estimate (image) (bottom) as of 10:45 pm 08/19/2023.

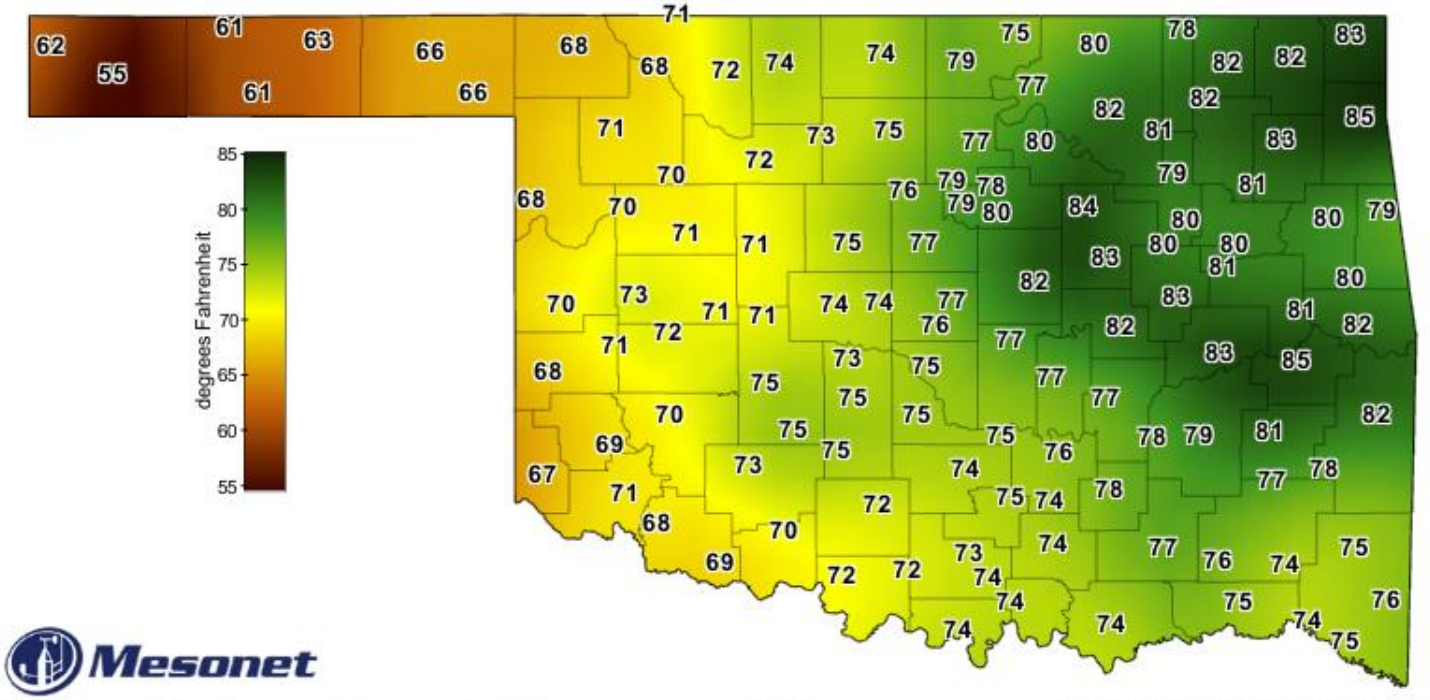


Fig. 22. OK Mesonet Maximum 24-hour Maximum Dew Point Temperature as of 7:20 am CDT 08/22/2023.

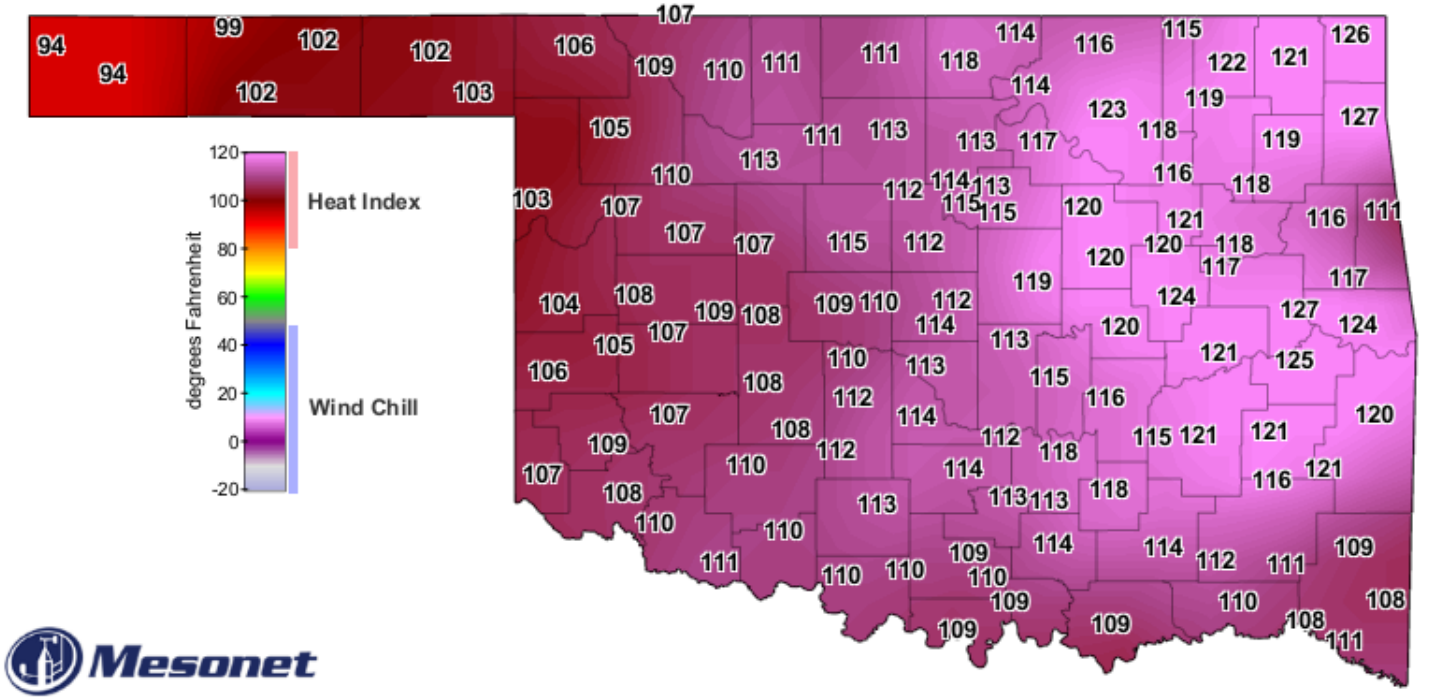


Fig. 23, OK Mesonet Maximum Heat Index for 08/21/2023.

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Products issued in August 2023:

11 Flash Flood Warnings (FFW)
3 Flash Flood Statements (FFS)
2 Flash/Areal Flood Watches (FFA) (2 Watch FFA CON/EXT/EXA/EXB/CAN)
10 Urban and Small Stream Advisories (FLS)
1 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