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 **June** 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 **July 20, 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.

It was another below normal rainfall month for most of eastern OK and northwest AR, with no mainstem river flooding. A notable MCS brought damaging winds and tornadoes late in the month. Normal rainfall in the month of June ranges from 3.9 inches in McIntosh County to 5.9 inches in Wagoner County. The Ozark region of northwest Arkansas averages 5.1 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 June 2023 ranged from around 1" to around 10" across eastern OK and northwest AR, with much of the area receiving 2"-4". These rainfall totals correspond to 50% to 90% of the normal June rainfall for a large portion of the HSA, with smaller areas receiving 100% to around 200% and 20%-50% of the normal June rainfall (Fig. 1b).

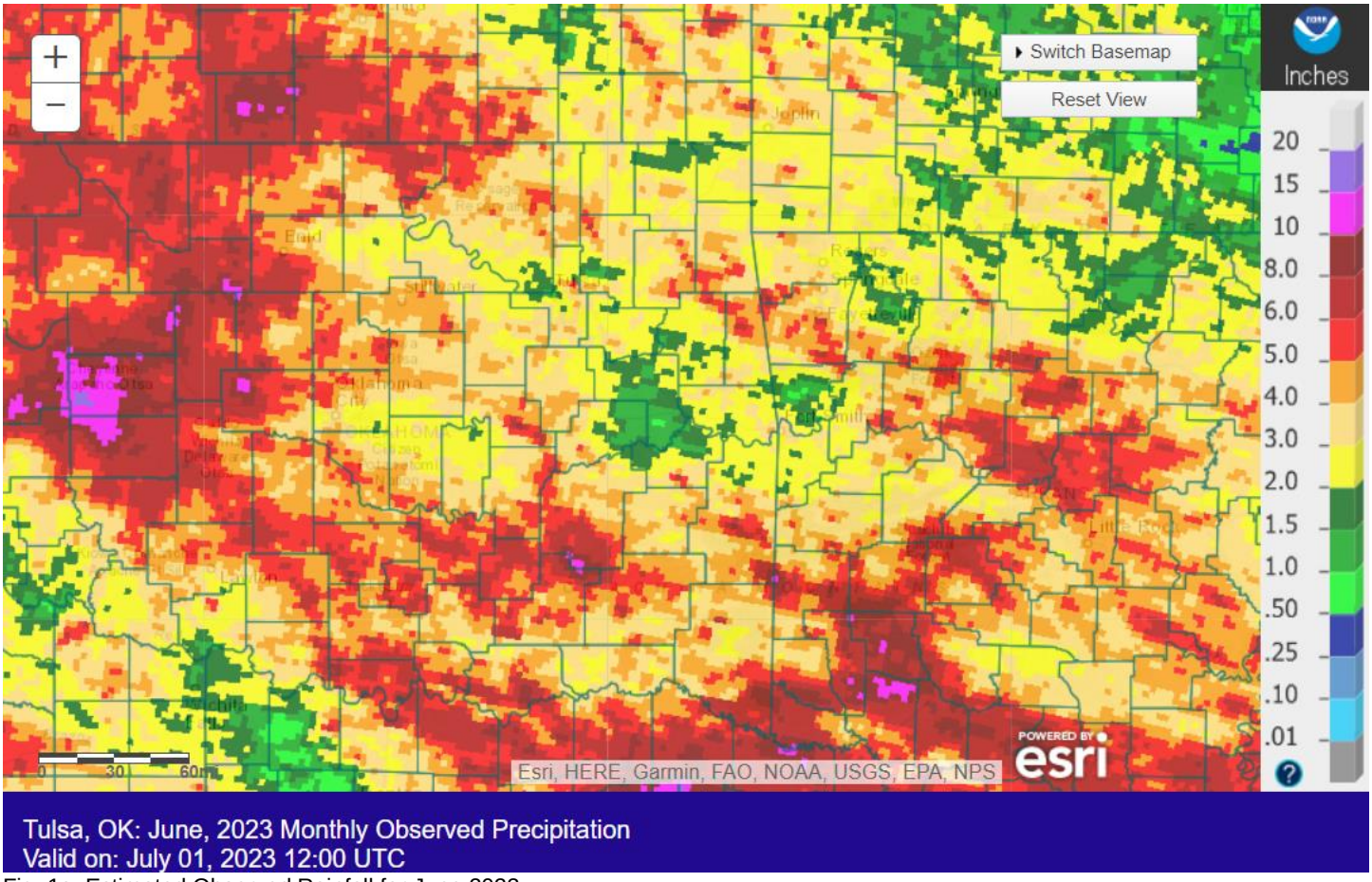


Fig. 1a. Estimated Observed Rainfall for June 2023

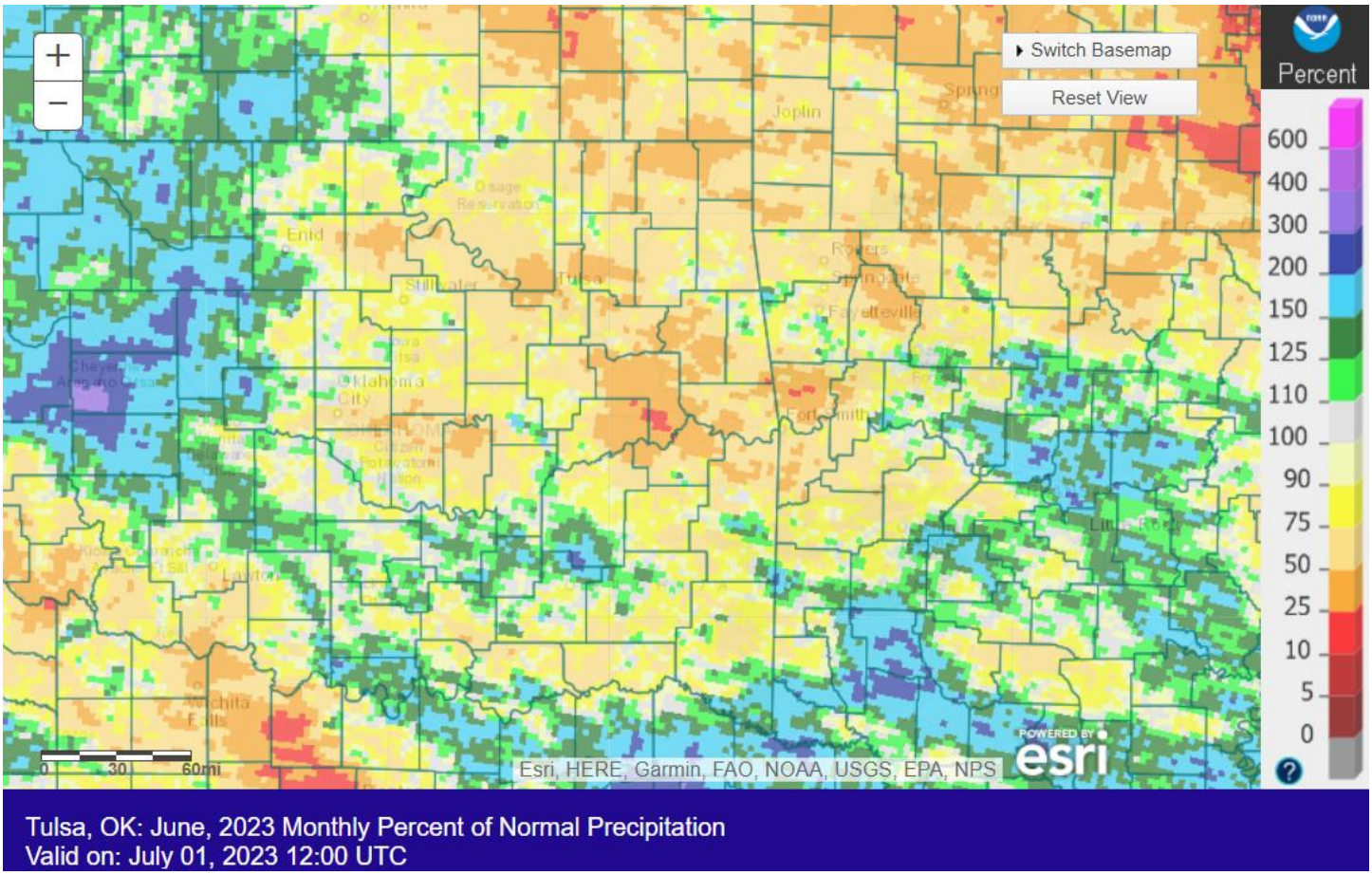


Fig. 1b. Estimated % of Normal Rainfall for June 2023

In Tulsa, OK, June 2023 ranked as the 44th warmest June (78.8°F, tied 1956; since records began in 1905) and the 67th driest June (4.24"; since records began in 1888). Fort Smith, AR had the 24th warmest June (80.4°F, tied 1954; since records began in 1882) and the 52nd driest June (2.81"; since records began in 1882). Fayetteville, AR had the 19th warmest (75.6°F) and the 32nd wettest (4.63") June since records began in 1950.

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

Wyandotte 7.3NE, OK (coco)	10.45	Winslow 7NE, AR (coop)	6.28	Okemah, OK (meso)	6.23
Bella Vista 0.6WSW, AR (coco)	6.15	Watts 7.2WSW, OK (coco)	5.63	Springdale 0.6E, AR (coco)	5.15
Berryville 0.9E, AR (coco)	4.92	Pryor 6.9ESE, OK (coco)	4.90	Wister, OK (meso)	4.88

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

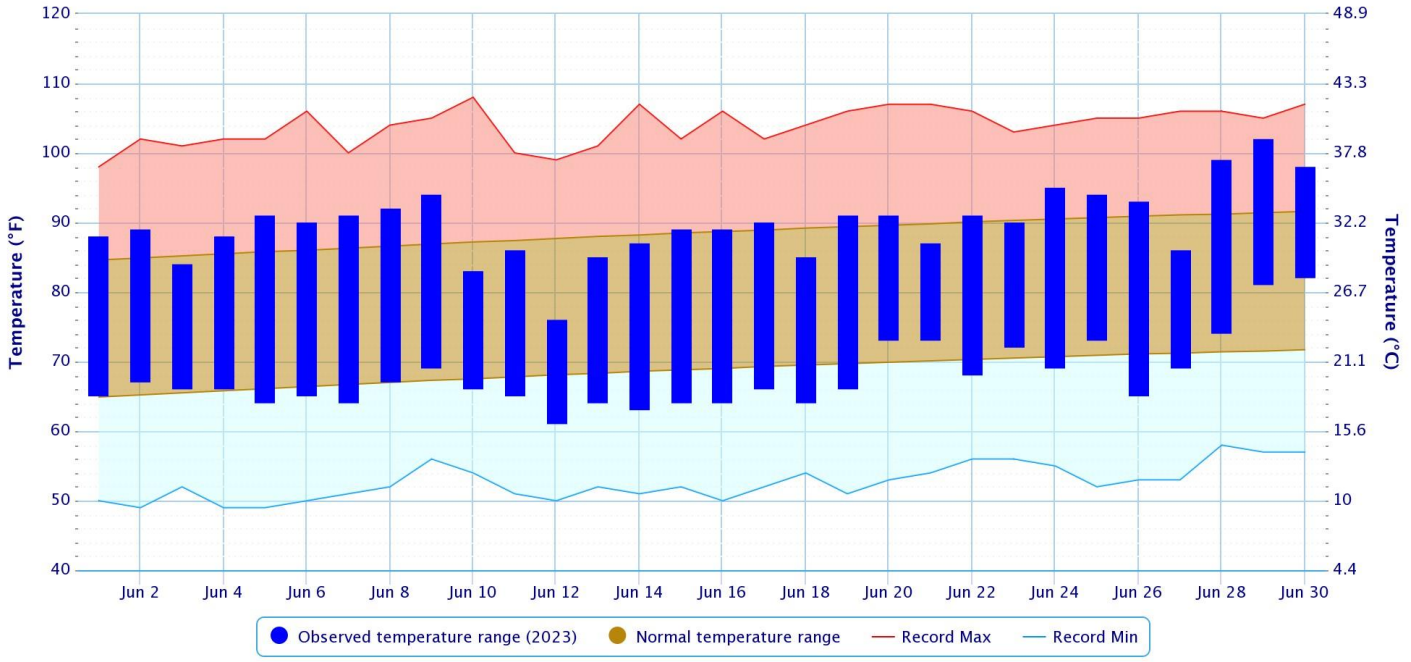
Kingston 2S, AR (coop)	1.16	Owasso 3.6ENE, OK (coco)	1.41	Tulsa 3.4W, OK (coco)	1.54
Tulsa 4.4S, OK (coco)	1.54	Owasso 1.5ESE, OK (coco)	1.70	Webbers Falls, OK (meso)	1.80
Claremore 7.5W, OK (coco)	1.82	Sallisaw, OK (meso)	1.83	Jenks Riverside Arpt, OK (ASOS)	1.85

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

Rank since 1921	June 2023	Growing Season (Mar 1 – Jun 30)	Last 60 Days (May 2 – Jun 30)	Year-to-Date (Jan 1 – June 30)	Last 90 Days (Apr 2 – Jun 30)	Water Year-to-Date (Oct 1 – June 30)	Last 365 Days (Jul 1, 2022 – June 30, 2023)
Northeast OK	33rd driest	16th driest	25th driest	25th driest	11th driest	34th driest	12th driest
East Central OK	23rd driest	30th driest	21st driest	51st driest	**10th driest**	42nd wettest	37th driest
Southeast OK	48th wettest	48th wettest	27th driest	24th wettest	18th driest	28th wettest	51st wettest
Statewide	36th wettest	43rd driest	47th driest	52nd wettest	32nd driest	50th wettest	27th driest

Daily Temperature Data – Tulsa Area, OK (ThreadEx)

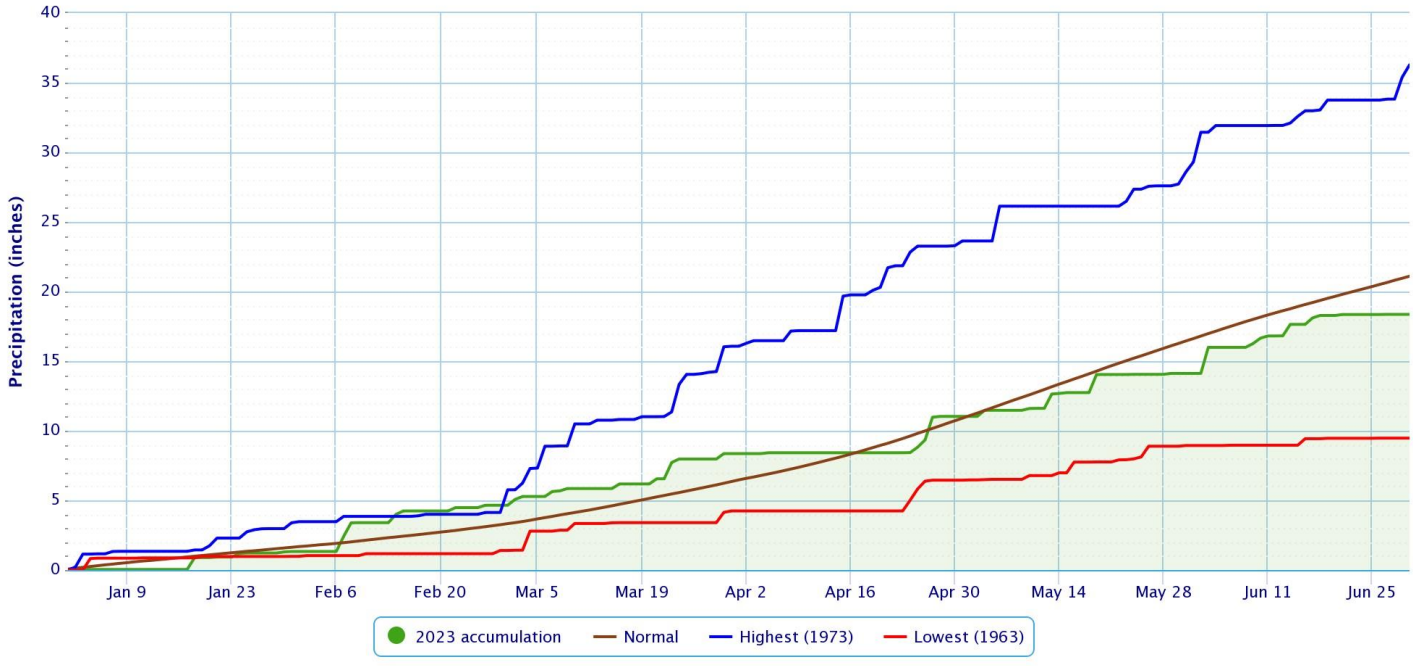
Period of Record – 1905-01-06 to 2023-07-17. Normals period: 1991-2020. Click and drag to zoom chart.



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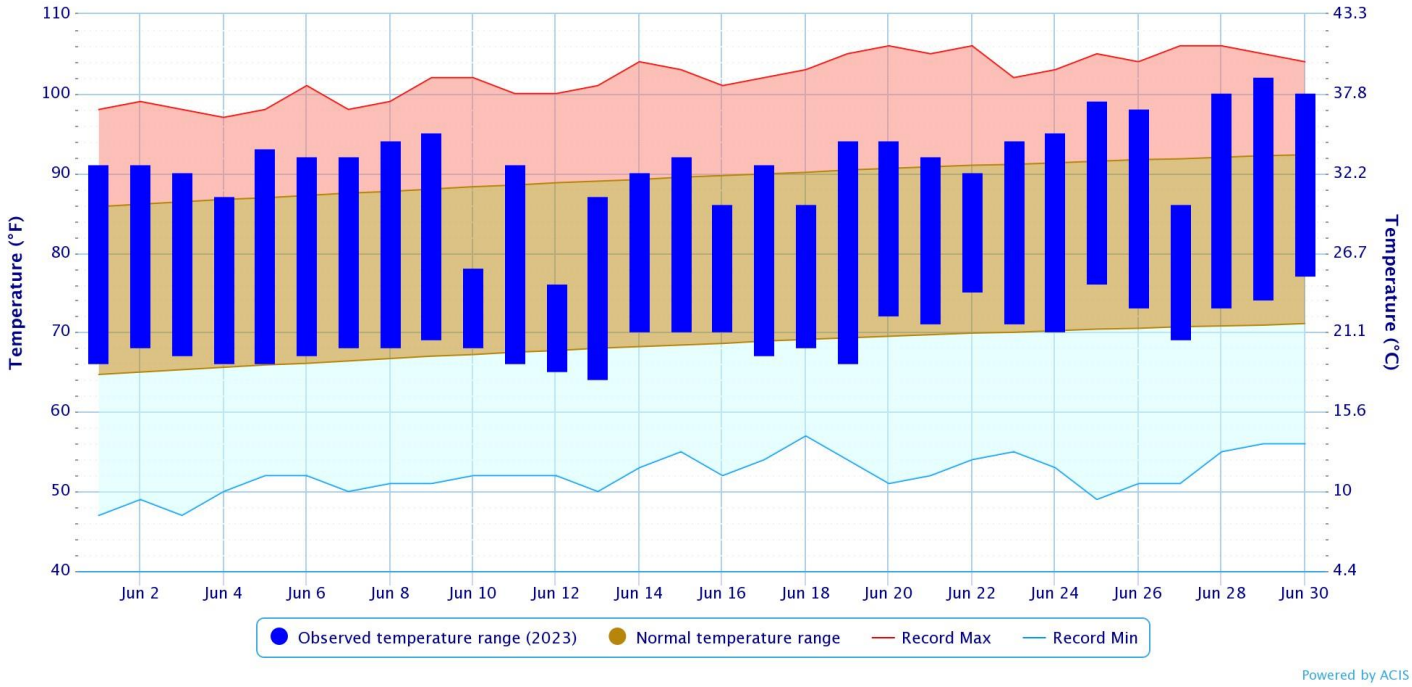
Daily Temperature Data – Fort Smith Area, AR (ThreadEx)

Period of Record – 1882-06-01 to 2023-07-17. Normals period: 1991-2020. Click and drag to zoom chart.



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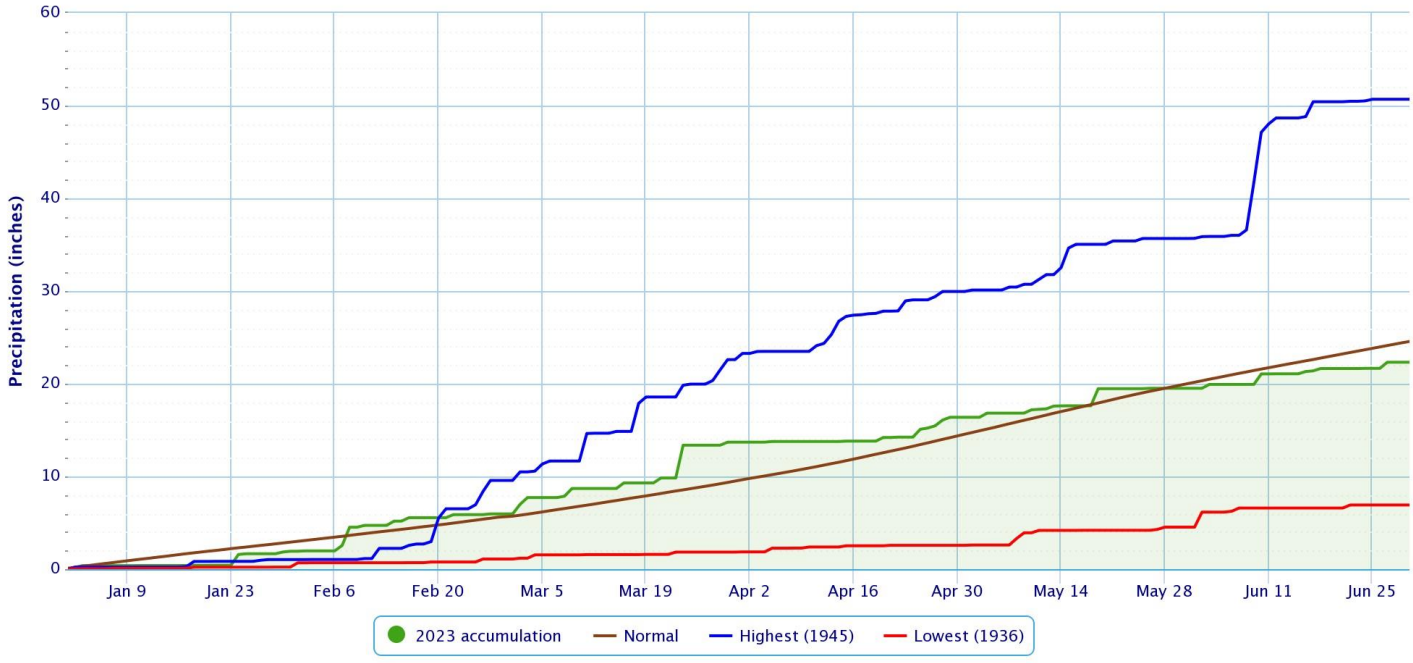
Accumulated Precipitation – Fort Smith Area, AR (ThreadEx)

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



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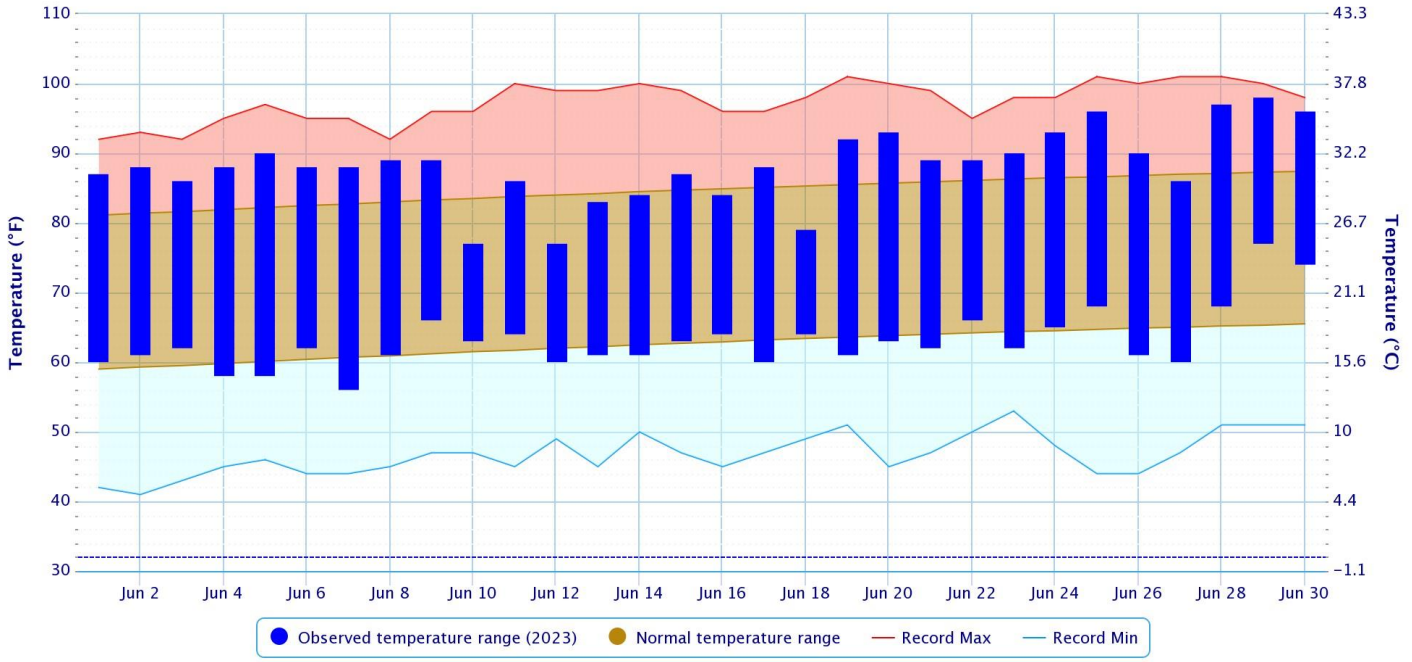
Daily Temperature Data – FAYETTEVILLE DRAKE FIELD, AR

Period of Record – 1949-07-14 to 2023-07-17. Normals period: 1991-2020. Click and drag to zoom chart.



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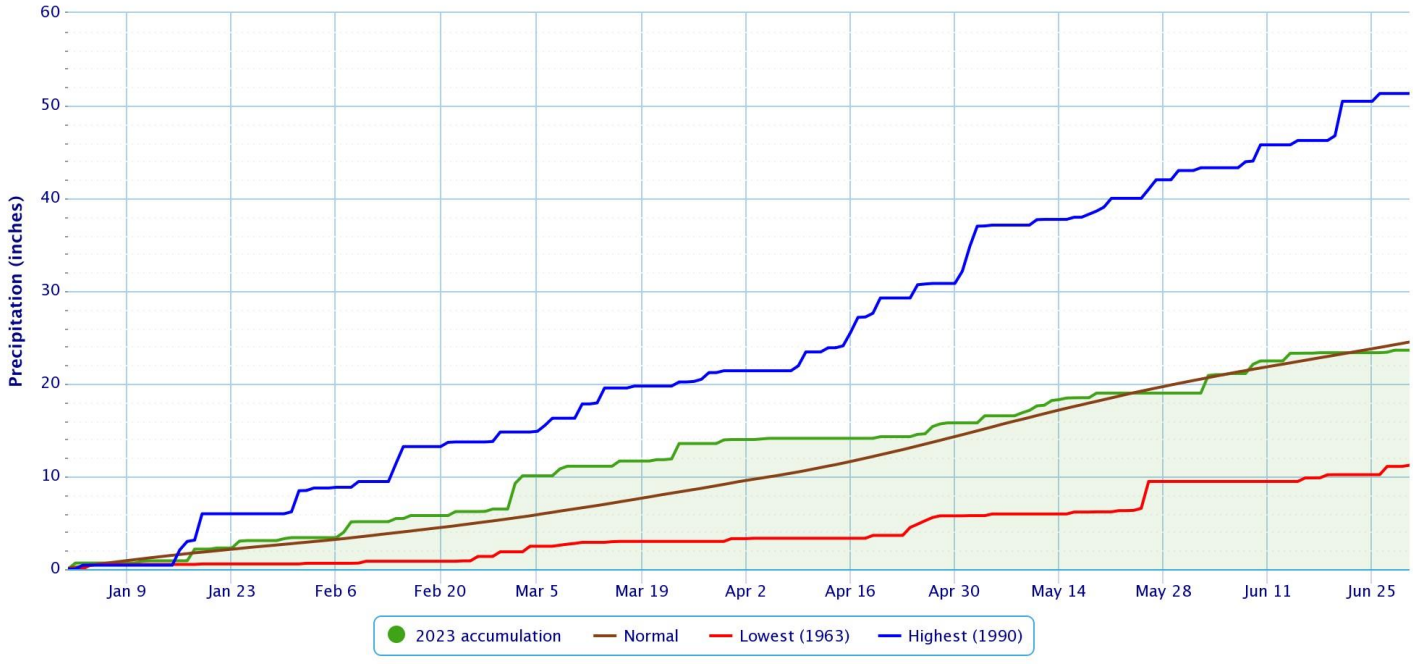
Accumulated Precipitation – FAYETTEVILLE DRAKE FIELD, AR

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



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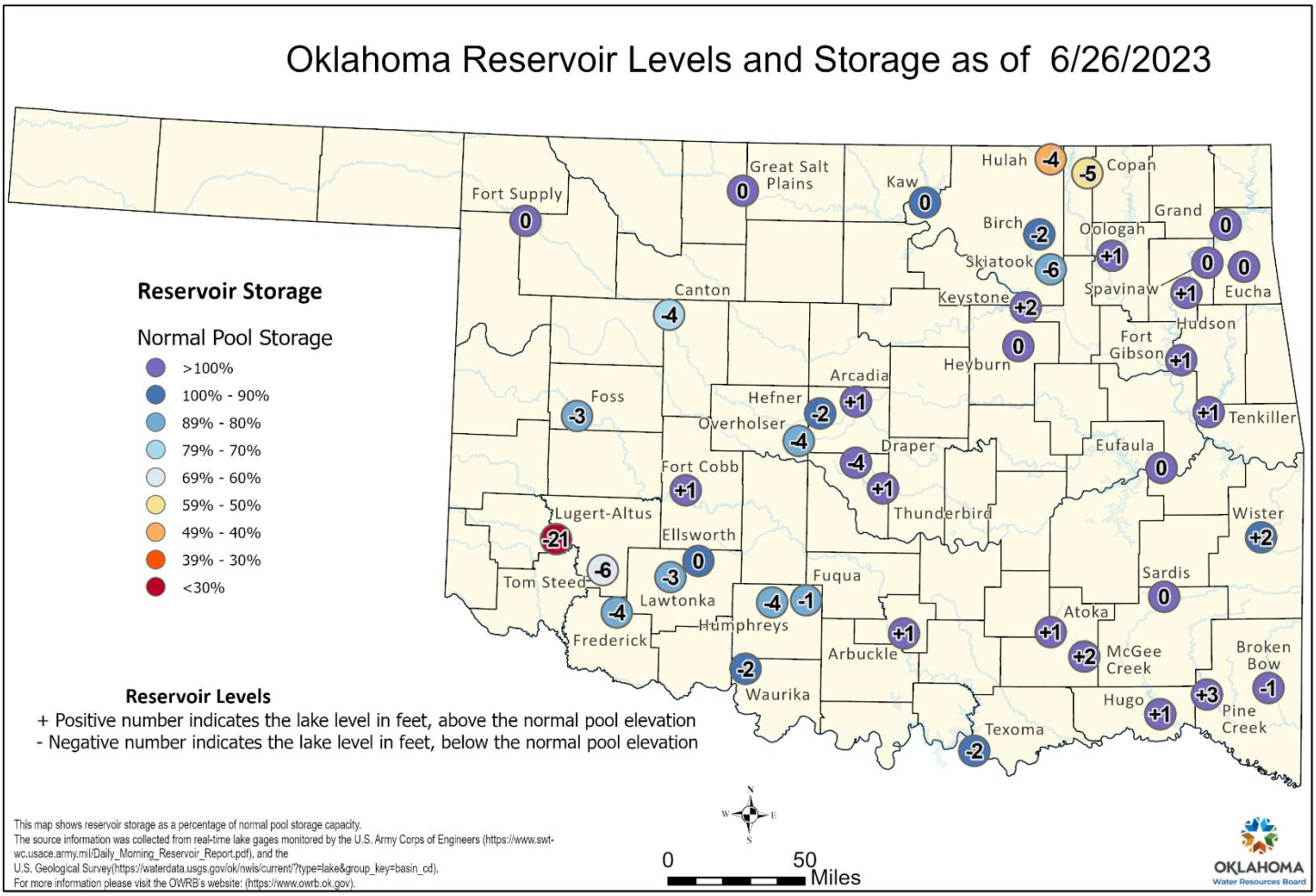
Reservoirs



According to the USACE, several of the lakes in the HSA were below 3% of top of their conservation pools as of 06/28/2023: Hulah Lake 47%, Copan Lake 52%, Skiatook Lake 81%, Birch Lake 88%, and Wister Lake 95%. One lake was above 3% of the top of its conservation pool: Hudson Lake 5%.

Drought

According to the U.S. Drought Monitor (USDM) from June 27, 2023 (Figs. 2, 3), Exceptional (D4) Drought conditions persisted across the northern portion of Osage County in eastern OK. Extreme (D3) Drought conditions were occurring in portions of eastern Kay, Osage, Pawnee, and Washington Counties in eastern Oklahoma. Severe (D2) Drought conditions exist in portions of Craig, Nowata, Washington, Osage, and Pawnee Counties in eastern Oklahoma. Moderate (D1) Drought conditions were present in portions of Ottawa, Craig, Nowata, Washington, Osage, Pawnee, Tulsa, Rogers, McIntosh, Muskogee, Haskell, and Sequoyah Counties in eastern Oklahoma. Abnormally Dry (D0) but not in drought conditions were occurring in Ottawa, Craig, Rogers, Tulsa, Osage, Pawnee, Creek, Wagoner, Mayes, Delaware, Adair, Cherokee, Muskogee, McIntosh, Pittsburg, Haskell, Sequoyah, Le Flore, Pushmataha, and Choctaw Counties in eastern OK, and Benton, Carroll, Madison, Washington, Crawford, Franklin, and Sebastian Counties in northwest AR.

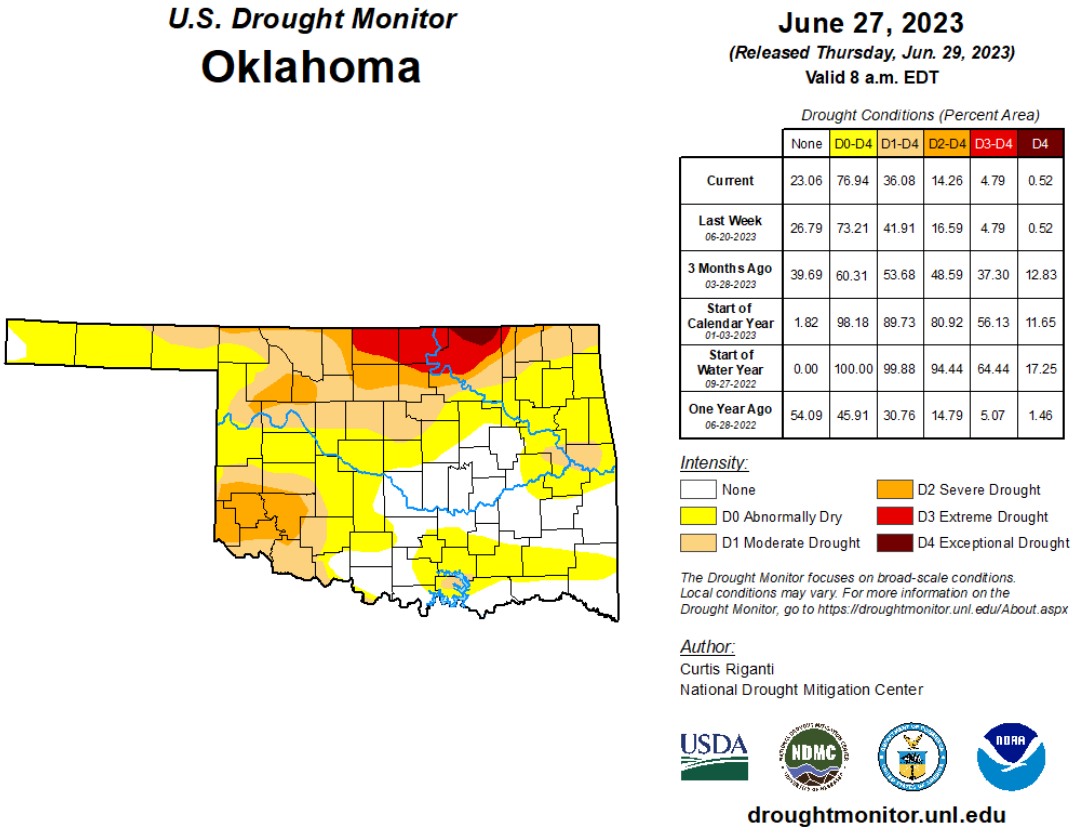


Fig. 2. Drought Monitor for Oklahoma

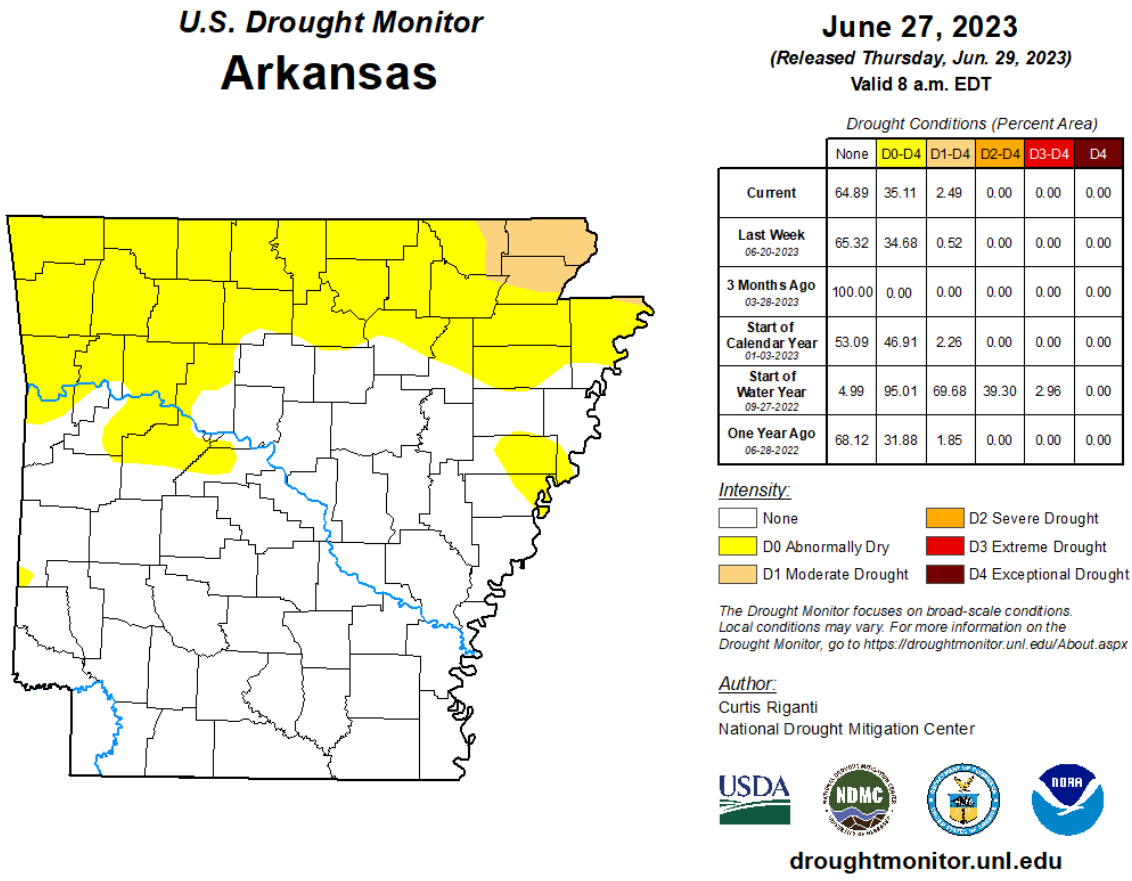


Fig. 3. Drought Monitor for Arkansas

Outlooks

The Climate Prediction Center (CPC) outlook for July 2023 (issued June 30, 2023) indicates an enhanced chance for above normal temperatures and above median precipitation across all of eastern OK and northwest AR. This outlook was largely based on dynamical model output, as soil moisture and the Madden-Julian Oscillation (MJO) are not expected to have much influence this month.

For the 3-month period July-August-September 2023, CPC is forecasting an enhanced chance for above normal temperatures and above median precipitation across eastern OK and northwest AR (outlook issued June 15, 2023). 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 90% chance of El Niño continuing through the winter and a 56% chance of a strong El Niño event.

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

A diffuse upper-level low moved into the region on the 3rd, sparking showers and thunderstorms around noon across eastern OK and northwest AR. These storms continued through the afternoon and evening before dissipating with the loss of daytime heating. Above normal precipitable water (PWAT) and some training of storms resulted in locally heavy rainfall, with totals ranging from around 0.10" to around 3" (Fig. 4).

Scattered storms developed shortly after noon on the 8th across northwest AR, and a few isolated thunderstorms developed across eastern OK through the peak heating of the day. Then, during the early morning hours of the 9th, a thunderstorm complex moved southeast out of southwest MO into northwest AR. The 24-hour rainfall totals by the morning of the 9th ranged from 0.25" to around 2" across Carroll County, with less than 1.5" in the other locations that had storms (Fig. 5). A remnant surface boundary from the day before, oriented northwest to southeast across northeast OK and northwest AR, provided a focus for thunderstorm development during the afternoon and evening hours. A plume of deeper moisture also set up along and to the east of this shear axis. Heavy rain from training storms over Catoosa resulted in flash flooding. Outflow from these storms ignited some additional activity across west central AR and far eastern OK before all the of storms dissipated with the loss of daytime heating. In the pre-dawn hours of the 10th, a large thunderstorm complex moved southeast out of KS and central OK into eastern OK. The leading edge of this complex moved quickly southeast across eastern OK and northwest AR, with trailing showers and thunderstorms continuing through around noon. Another, much smaller, cluster of thunderstorms moved southeast out of southeast KS/southwest MO during the early morning hours of the 11th. These storms clipped the far northeast corner of OK and moved across northwest AR before sunrise. Isolated showers and thunderstorms also occurred during this time across primarily Osage, southern Washington, Tulsa, and Rogers Counties. The 24-hour rainfall total ending at 7am on the 10th ranged from around 0.10" to near 5" (Fig. 6), with an additional 24-hour total of around 0.10" to around 2" through 7am on the 11th (Fig. 7).

Thunderstorms began to move into southeast OK shortly after sunrise on the 12th in response to an elevated axis of frontogenetic forcing near the Red River. A larger thunderstorm complex from the OK/TX panhandles continued to move eastward across OK, making their way into southeast and east central OK and west central AR during the late morning. Much of this activity ended by early afternoon as the low-level jet weakened, though a thin line of showers and thunderstorms remained near the forcing axis as it began to lift north across southeast OK. A mid-level trough provided support of additional thunderstorm development along and south of I-40 from afternoon through mid-evening. Stronger forcing over southern OK developed again in the pre-dawn hours of the 13th due to an increase in the low-level jet and available elevated instability, which ignited clusters of thunderstorms across southern OK. These storms impacted southeast OK through 7am. Rainfall totals from the multiple rounds of storms ranged from around 0.10" to 2" (Fig. 8).

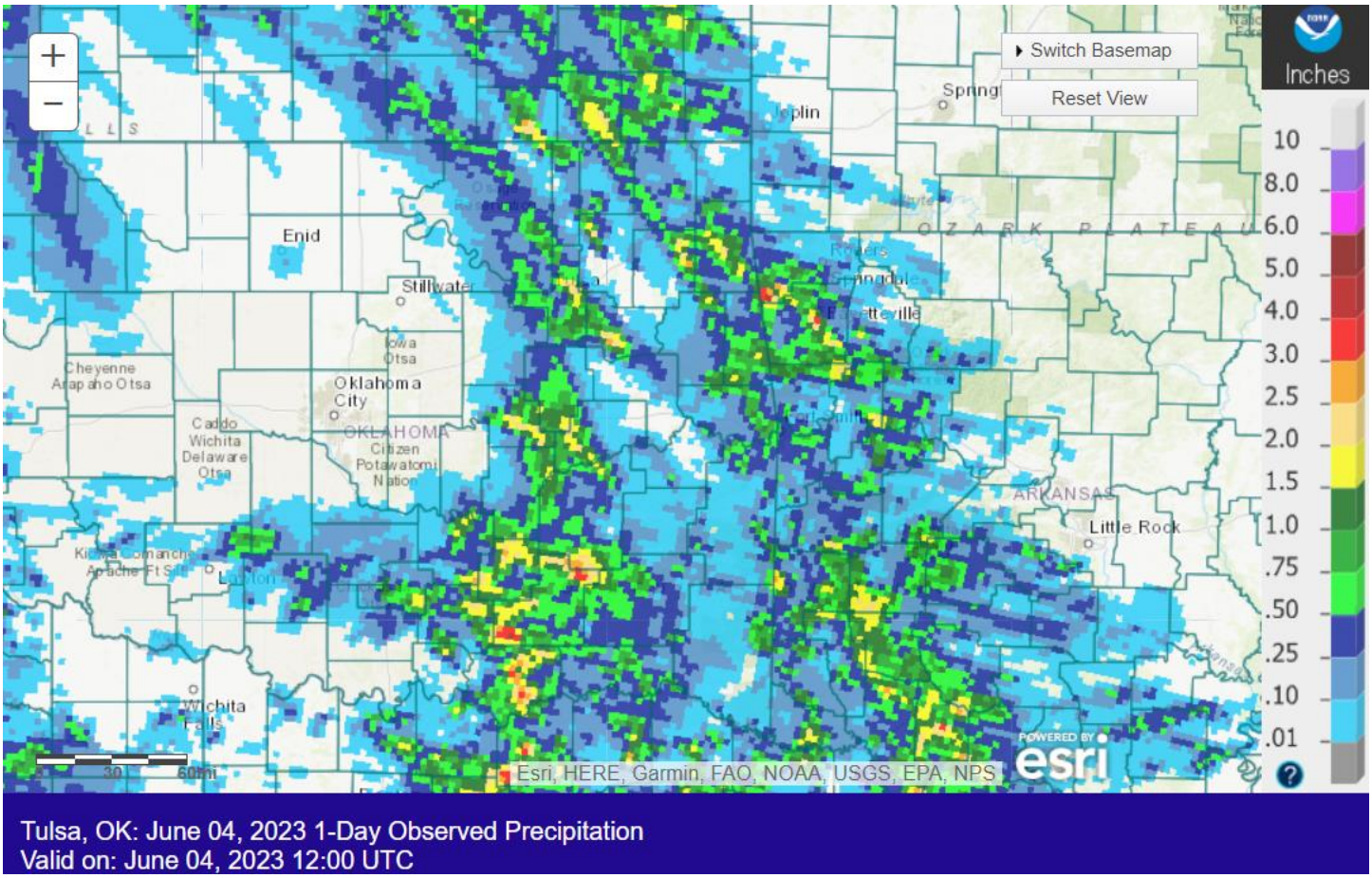


Fig. 4. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/04/2023.

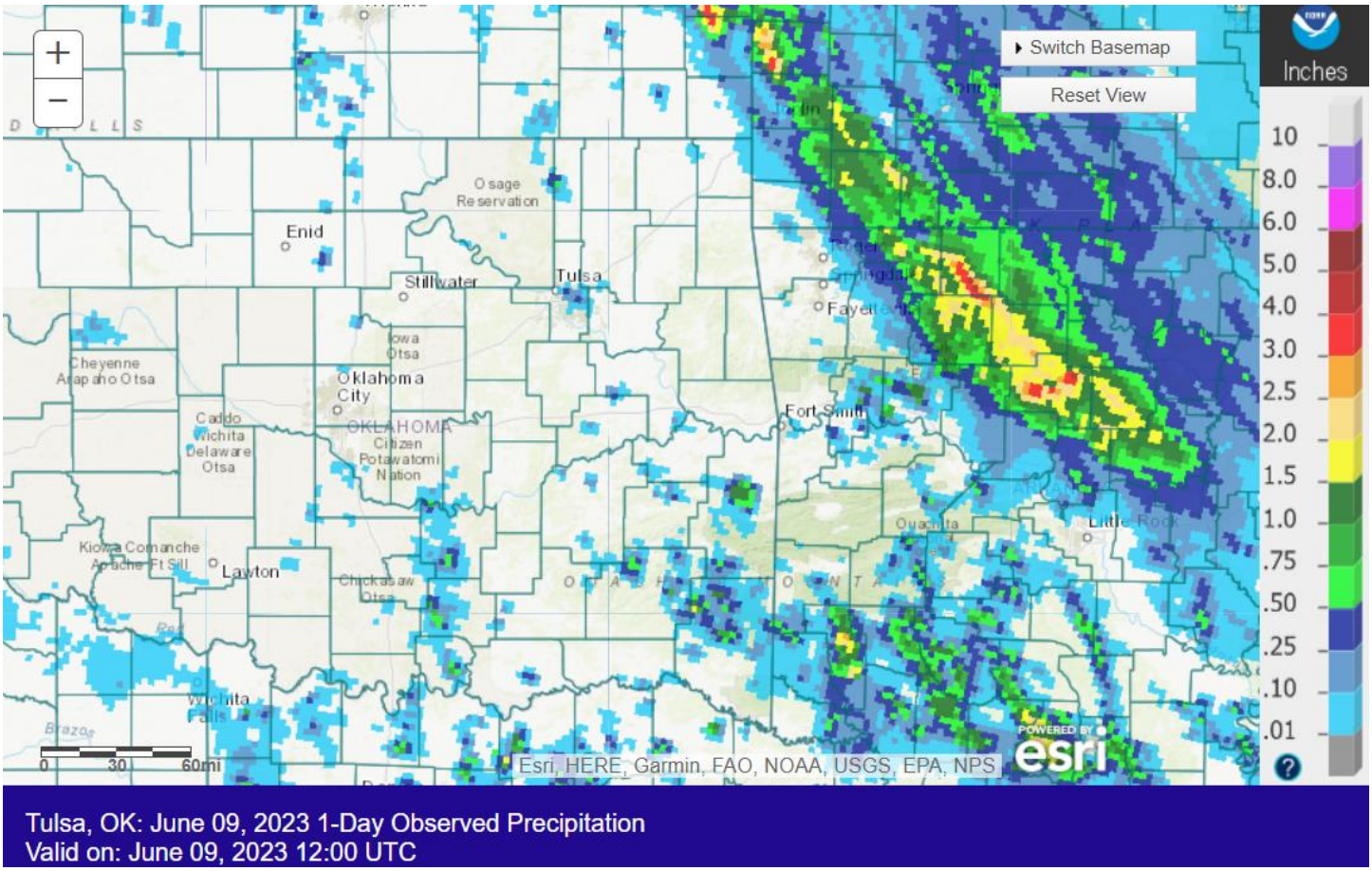


Fig. 5. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/09/2023.

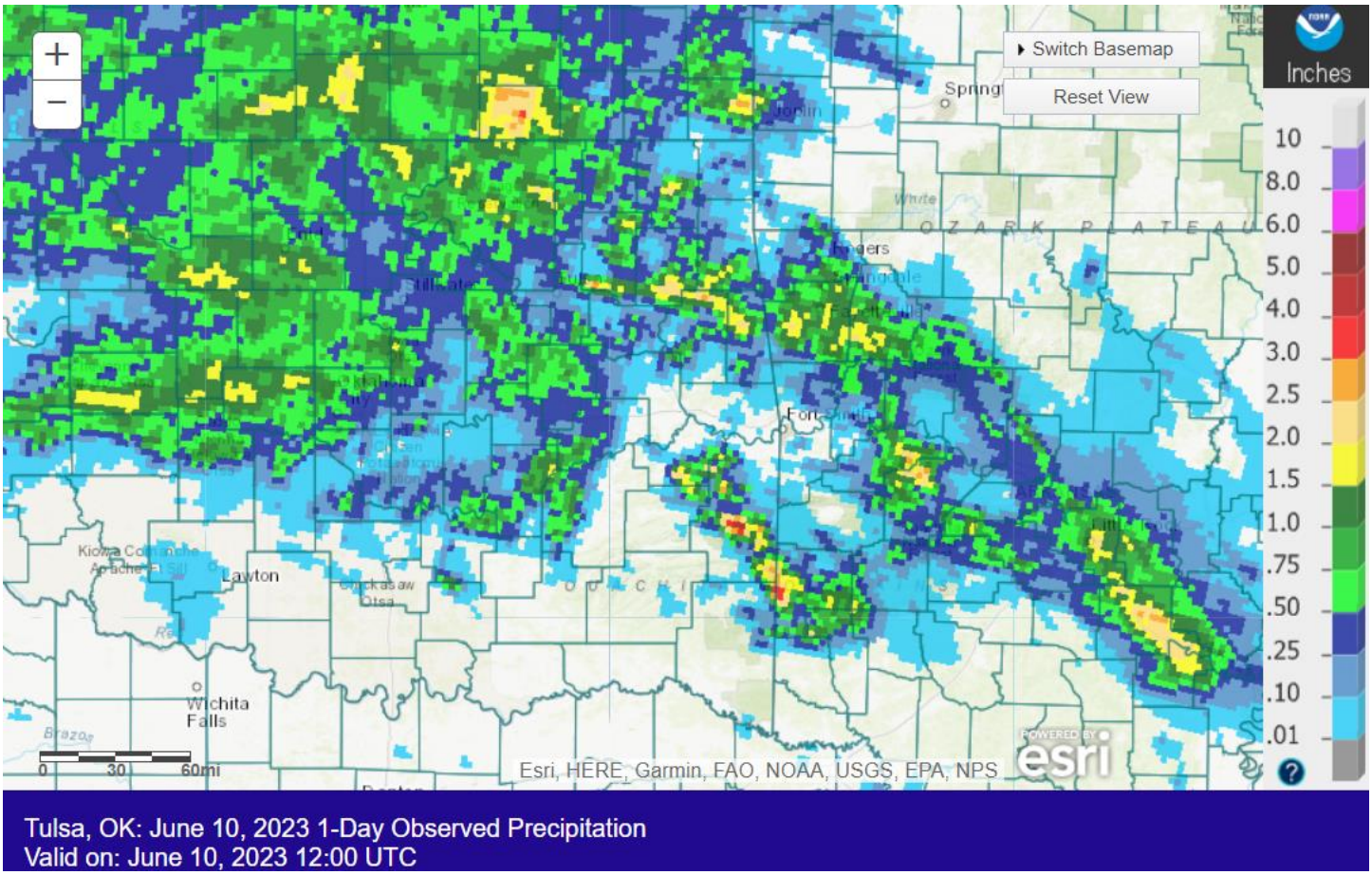


Fig. 6. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/10/2023.

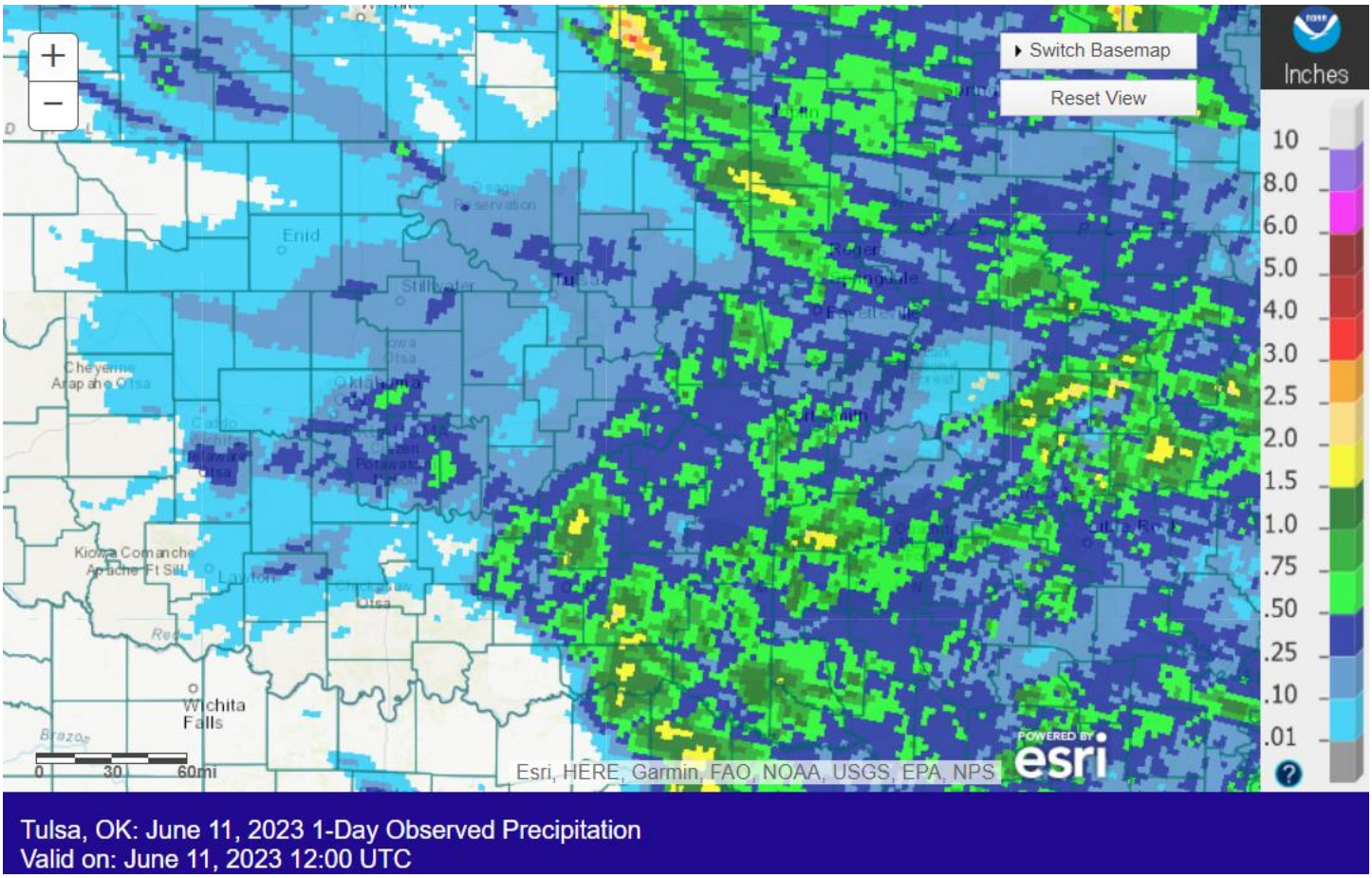


Fig. 7. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/11/2023.

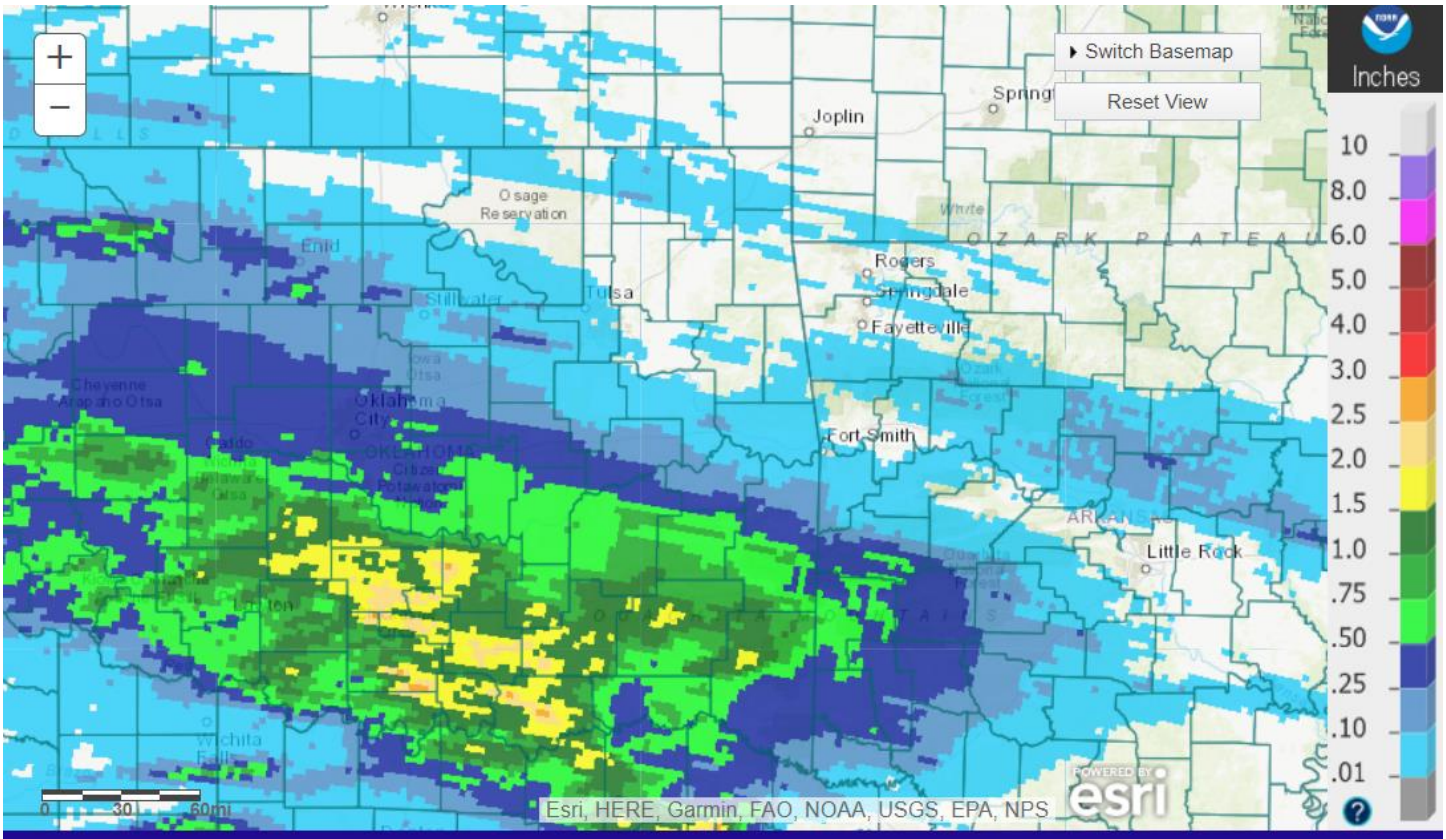


Fig. 8. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/13/2023.

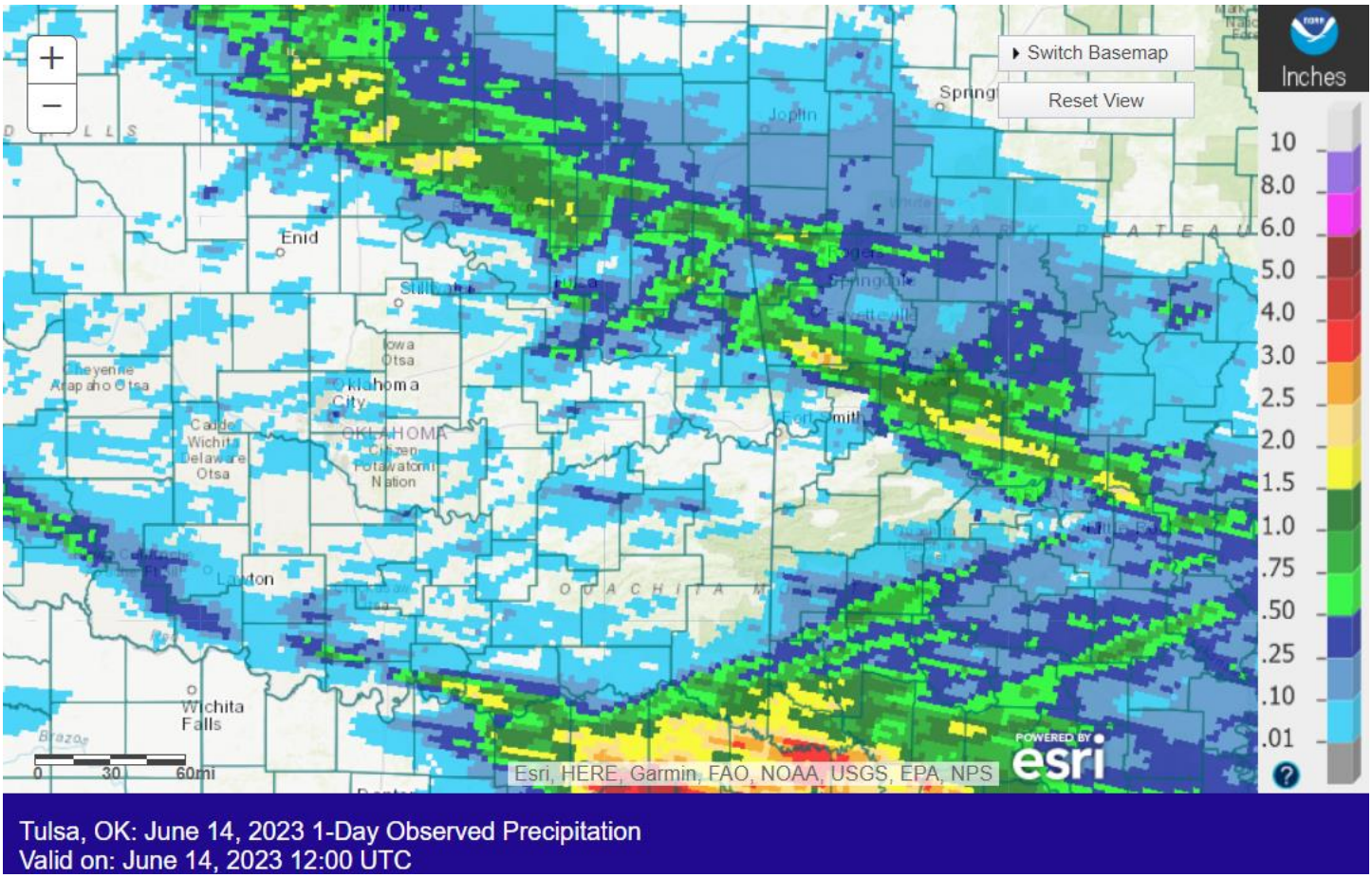


Fig. 9. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/14/2023.

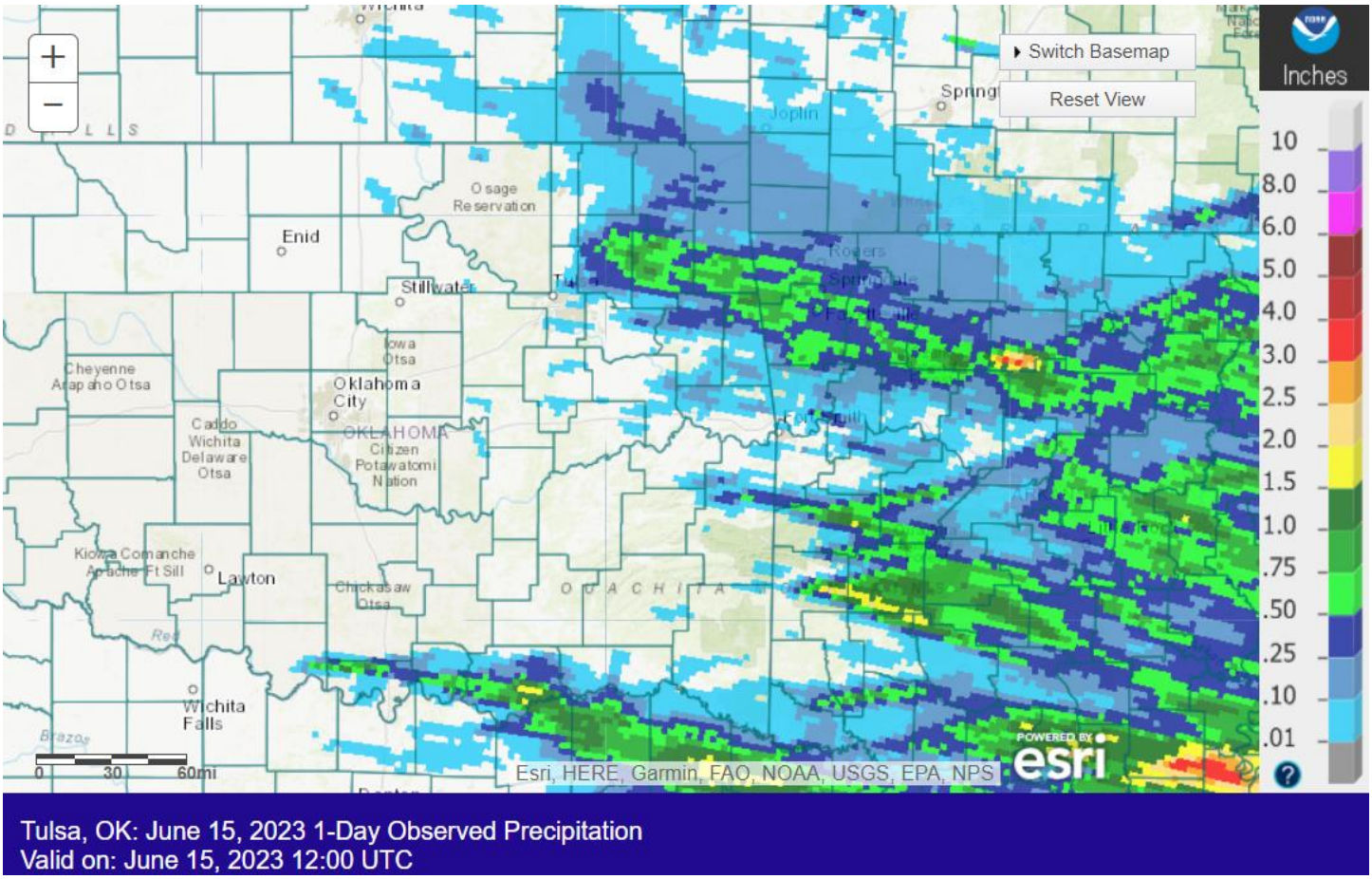


Fig. 10. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/15/2023.

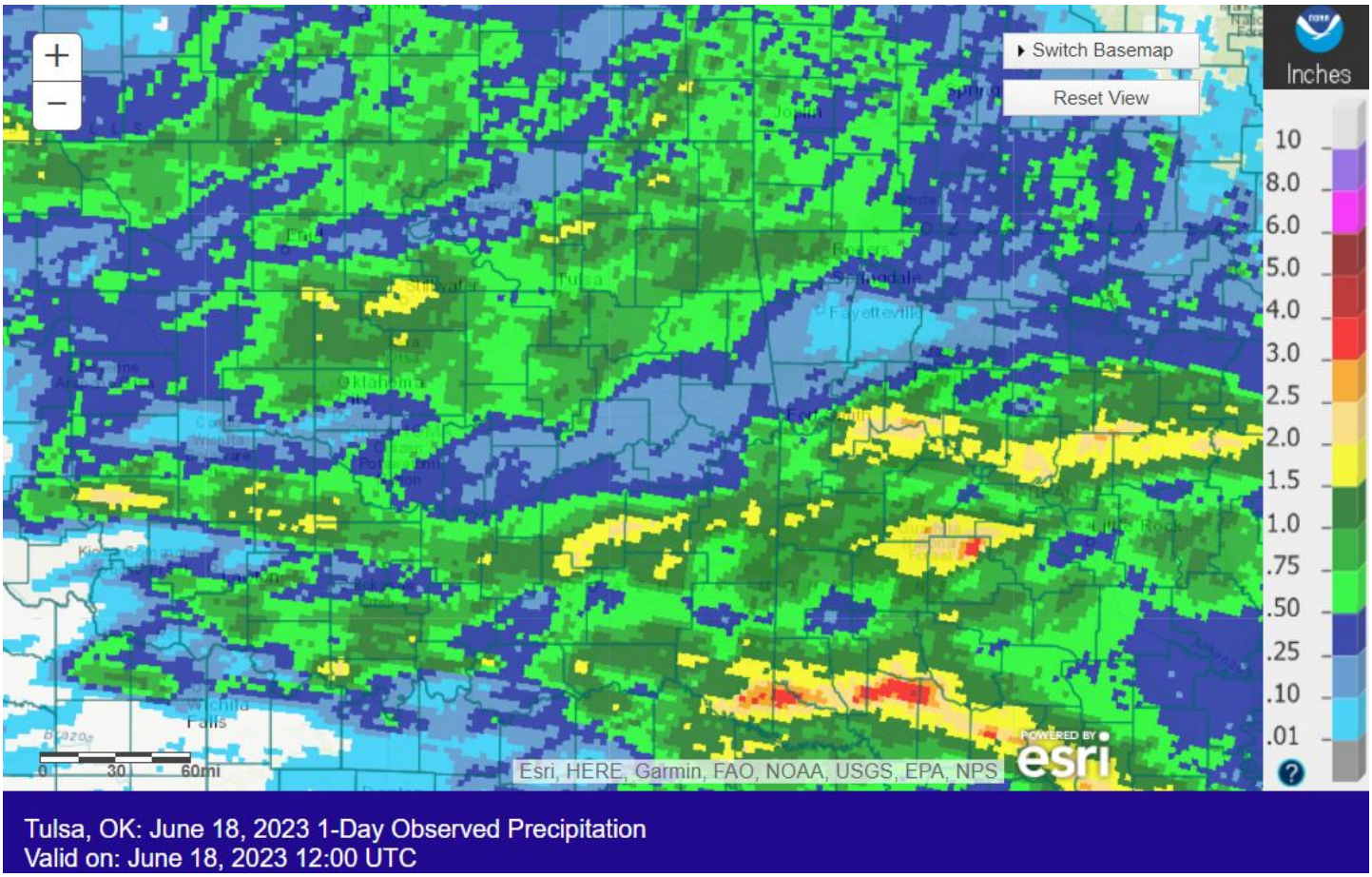


Fig. 11. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/18/2023.

Soon after midnight of the 14th, a couple of thunderstorm clusters developed across northern OK/southern KS in response to an elongated mid-level vorticity maximum across KS. These thunderstorms moved east across northeast OK and northwest AR during the overnight through late morning hours and brought around 0.25" to around 2.5" of rain (Figs. 9, 10).

A well-defined shortwave trough was located across southwestern CO by mid-morning on the 17th, and this trough continued eastward through the day with a line of thunderstorms developing across SE CO into the TX Panhandle by mid-afternoon. Additional severe storms developed across southwest KS into northwest OK by early evening and eventually merged into the approaching line of storms. The merger marked the development of a severe Mesoscale Convective System (MCS) that produced both severe hail and wind reports across northwest OK and southwest KS. The aforementioned shortwave trough continued eastward into the Plains and wind fields in the low- to mid-levels of the atmosphere strengthened in response. Additionally, a broad corridor of strong instability existed ahead of the MCS and, along with the strengthening winds, supported further strengthening of the MCS as it developed eastward through north central OK with continued severe wind reports. The MCS gained further organization as it moved into northeast OK just before midnight of the 18th, and a well-defined rear inflow jet developed, marking peak intensity of the MCS as it tracked east and northeast across much of northeast OK. The rear inflow jet served to transport winds aloft down to the surface, producing a long fetch of intense damaging winds along the Interstate 44 corridor, including through the Tulsa metro area (from approximately midnight to 1 am in the Tulsa metro area). Widespread thunderstorm wind damage occurred across northeastern Oklahoma and northwestern Arkansas from these storms, with a swath of wind damage consistent with 80 to 100+ mph wind gusts. The anemometer at the official Tulsa weather station located at the Tulsa International Airport measured a wind gust of 77 mph. In addition to the widespread, high-end, straight-line wind damage, the squall line also produced three EF-1 tornadoes, which all formed on the leading edge of the thunderstorm line. Visit https://arcg.is/8jKjj for more details on this event. The MCS continued into southwest MO and far northwest AR around 2 am on the 18th before gradually weakening. Another severe MCS tracked from southern OK through west central AR during a similar time frame producing numerous severe wind reports along its path. These storms first moved into southeast OK during the late evening hours of the 17th and into west central AR around midnight of the 18th before exiting the area a couple hours later. Additional showers and thunderstorms continued through the early morning hours across eastern OK and northwest AR in the wake of the two MCSs. The activity finally exited the region shortly after sunrise on the 18th. Rainfall totals from these storms ranged from 0.10" to around 2" (Fig. 11).

An MCS moved southeast across southeast OK from the mid-afternoon through mid-evening hours of the 23rd, bringing around 0.10" to 2.5" of rain (Fig. 12). The heaviest rain primarily affecting southern Pittsburg and western Pushmataha Counties.

Thunderstorms developed over northwest AR, primarily southern Madison County, during the afternoon of the 25th in a moist and unstable atmosphere that set up ahead of a cold front. 0.25" to around 2.5" of rain fell across southern Madison County from these storms (Fig. 13), along with reports of 1.5" hail. Ahead of the cold front in southeast OK, dew point temperatures climbed into the low 80s, which is a rare occurrence, making for some very hot and humid conditions (Fig 14).

An MCS entered northeast and east central OK during the late morning of the 27th. This storm complex continued to move eastward through the morning, entered northwest and west central AR around noon, and exited the area by mid-afternoon. Another MCS tracked east along the OK/KS state line during the evening, entering northeast OK at midnight. This complex affected locations primarily north of Highway 412 in northeast OK and north of I-40 in northwest AR before exiting the area before sunrise on the 28th. Locations impacted by the MCSs received from 0.10" to around 2" of rainfall (Fig. 15).

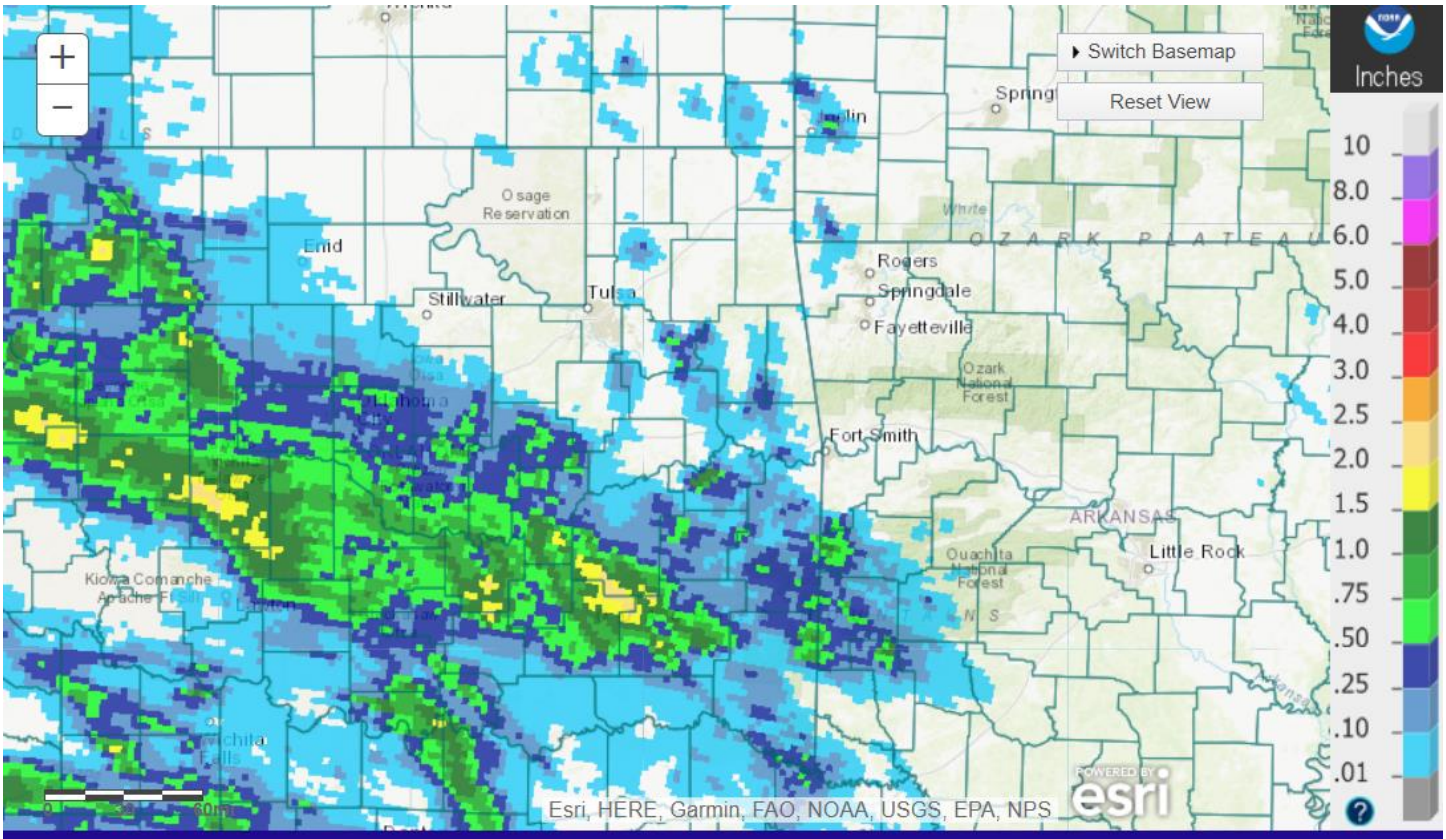


Fig. 12. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/24/2023.

Fig. 13. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/26/2023.

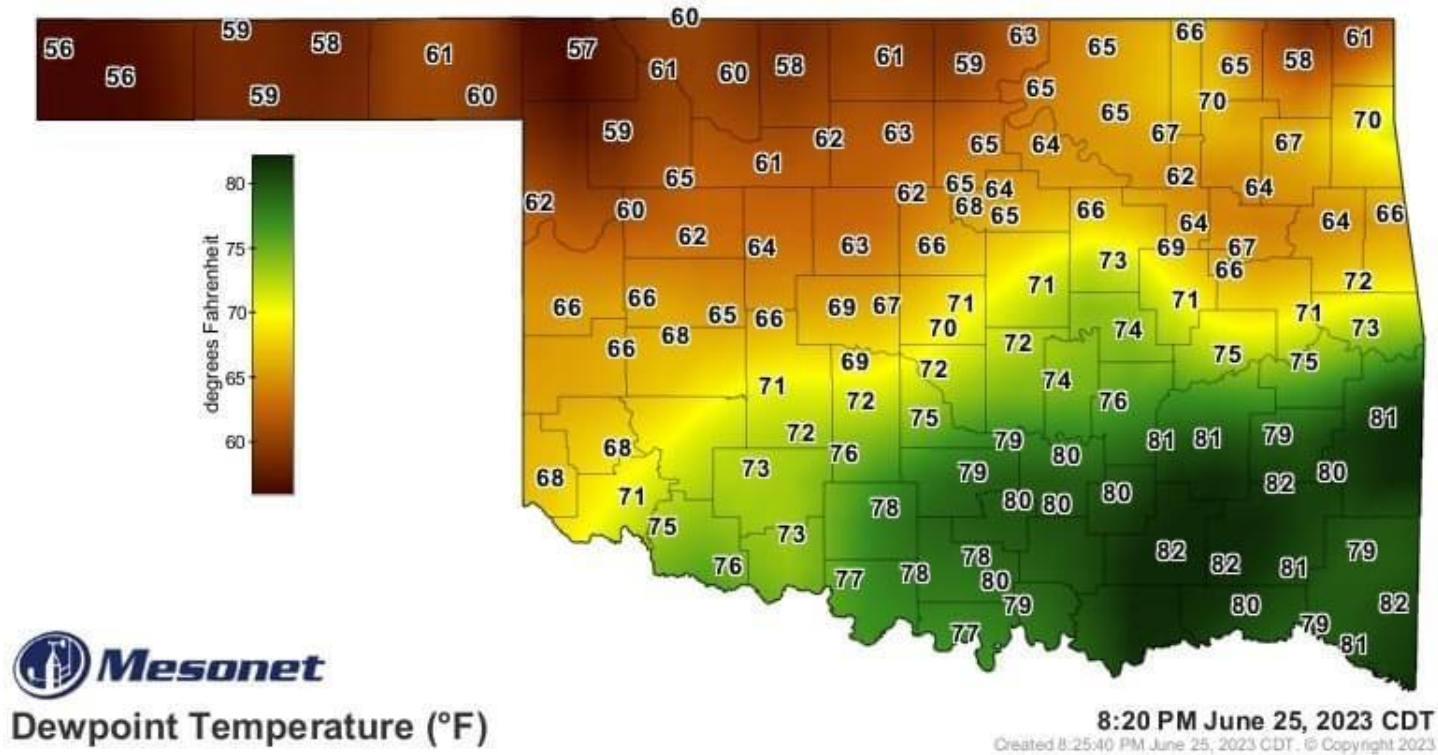


Fig. 14. OK Mesonet dewpoint temperatures at 8:20 pm CDT 6/25/2023.

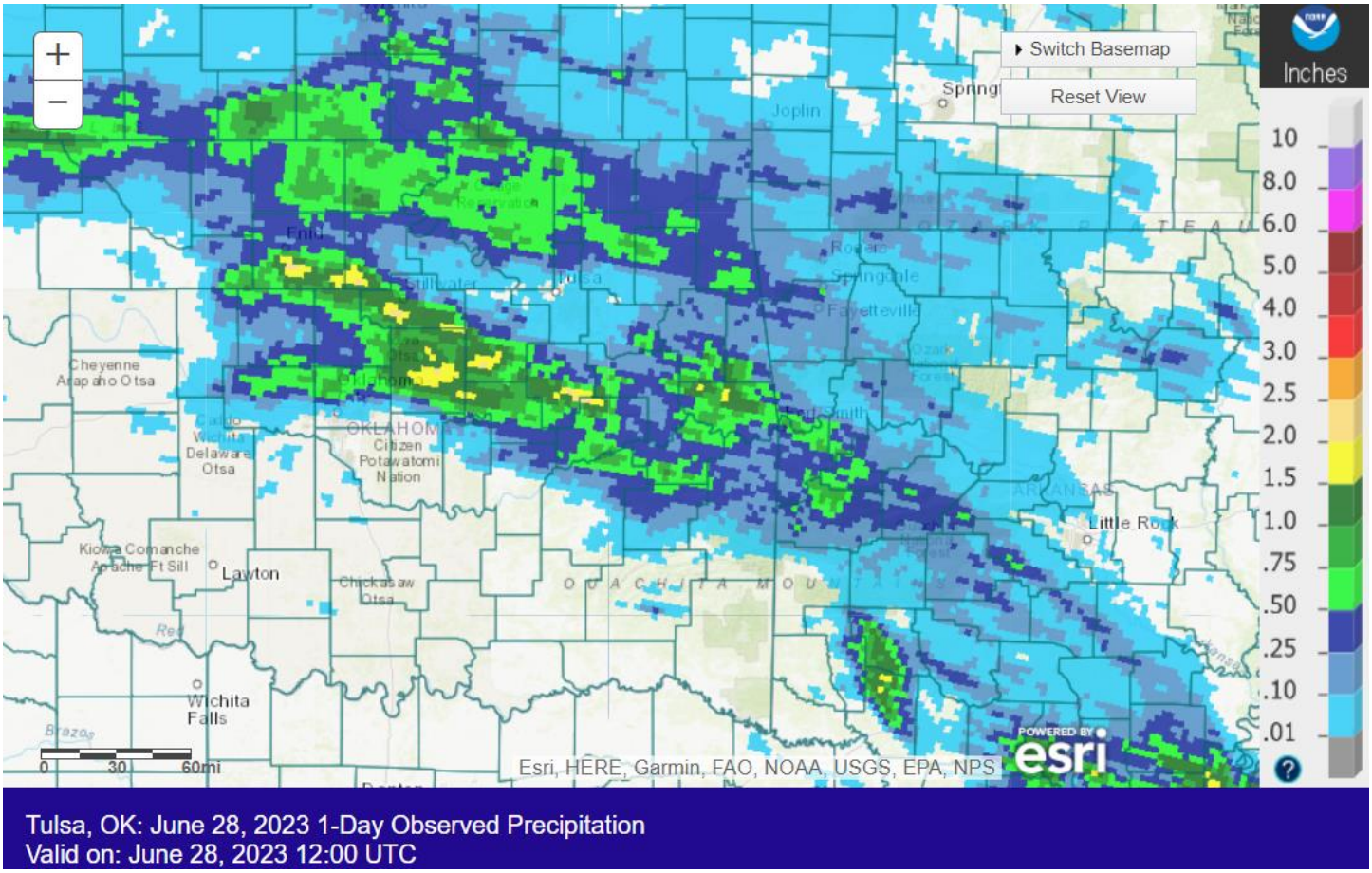


Fig. 15. 24-hour Estimated Observed Rainfall ending at 7am CDT 6/28/2023.

Written by:
Nicole McGavock
Service Hydrologist
WFO Tulsa

Products issued in June 2023:

1 Flash Flood Warnings (FFW)
1 Flash Flood Statements (FFS)
0 Flash/Areal Flood Watches (FFA) (0 Watch FFA CON/EXT/EXA/EXB/CAN)
12 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) (50 Advisory FLS CON/EXT/CAN)
0 River Flood Watches (FFA) (0 Watch FFA CON/EXT/CAN)
0 River Statements (RVS)
0 Hydrologic Outlooks (ESF)
1 Drought Information Statements (DGT)

Preliminary Hydrographs:
None