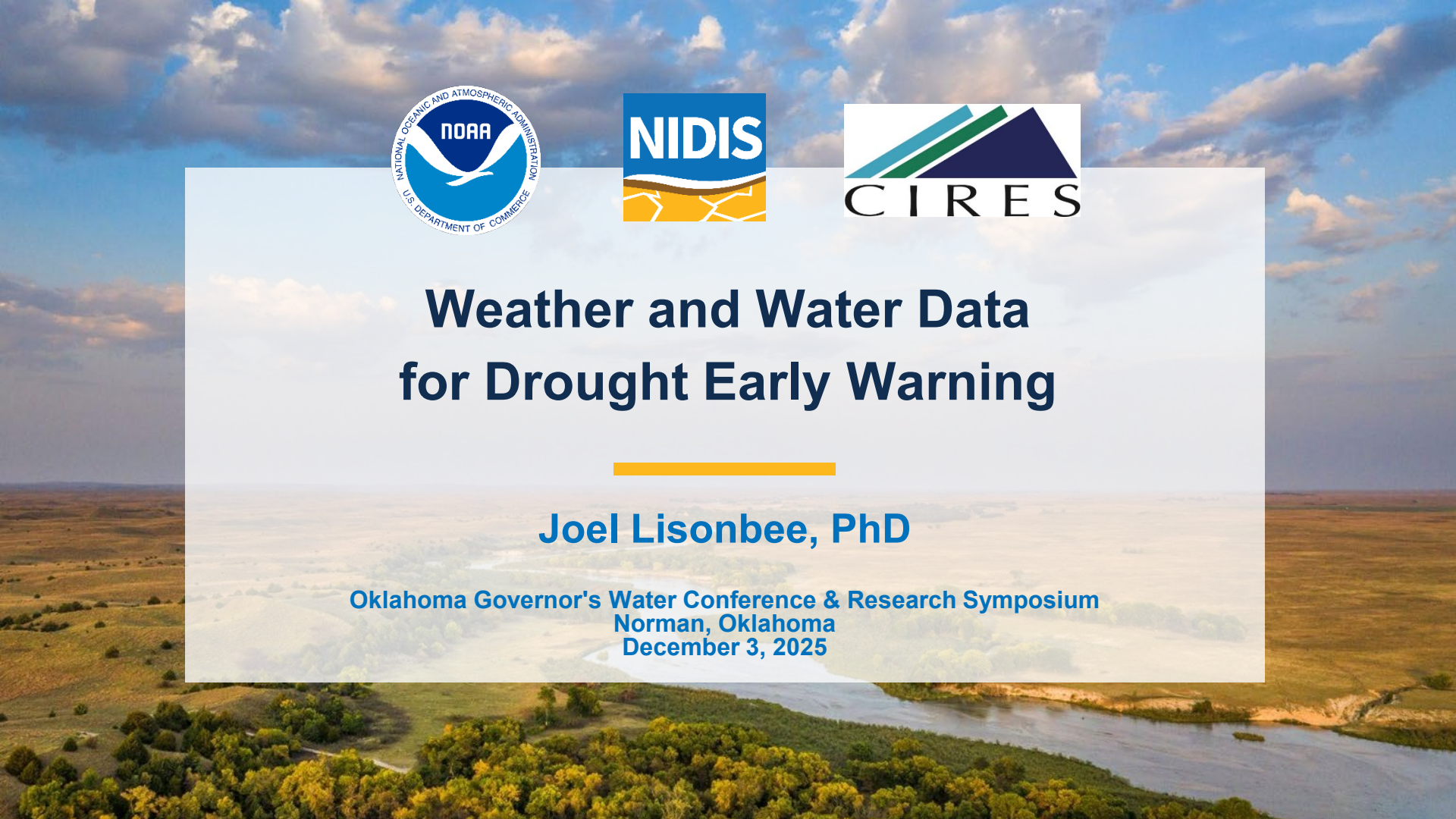


Weather and Water Data for Drought Early Warning

Joel Lisonbee, PhD

Oklahoma Governor's Water Conference & Research Symposium
Norman, Oklahoma
December 3, 2025

Over the last 5 years drought in the Southern Plains has cost about

$23 Billion

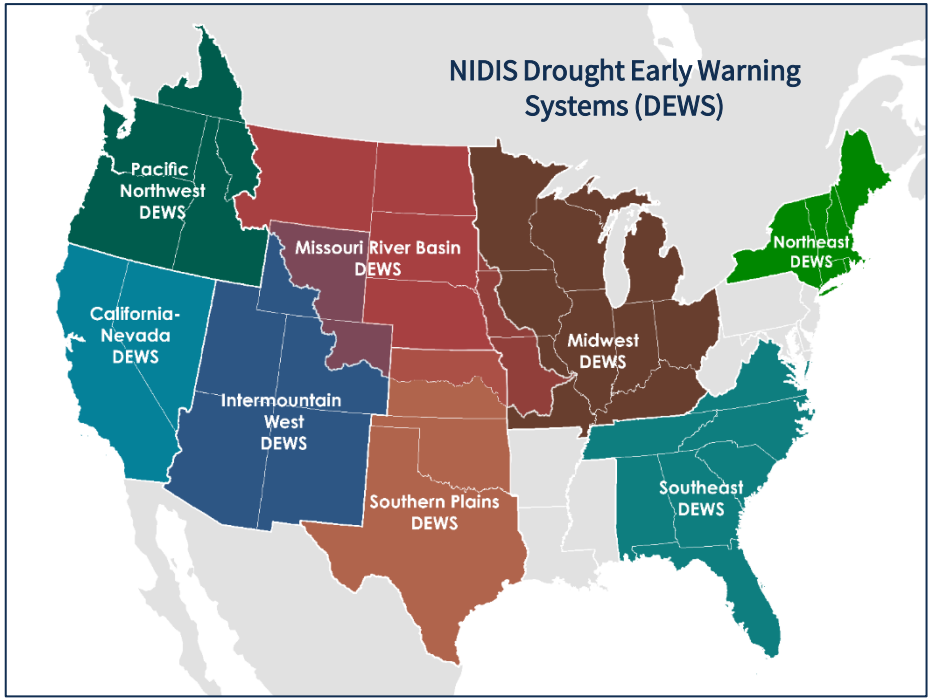
About $2.5B of that was from agricultural losses in Oklahoma

National Integrated Drought Information System (NIDIS)

NIDIS is a multi-agency partnership with a mission to mitigate the impacts and costs of drought by improving the nation's capacity to proactively manage drought-related risks.

How do we do this work?

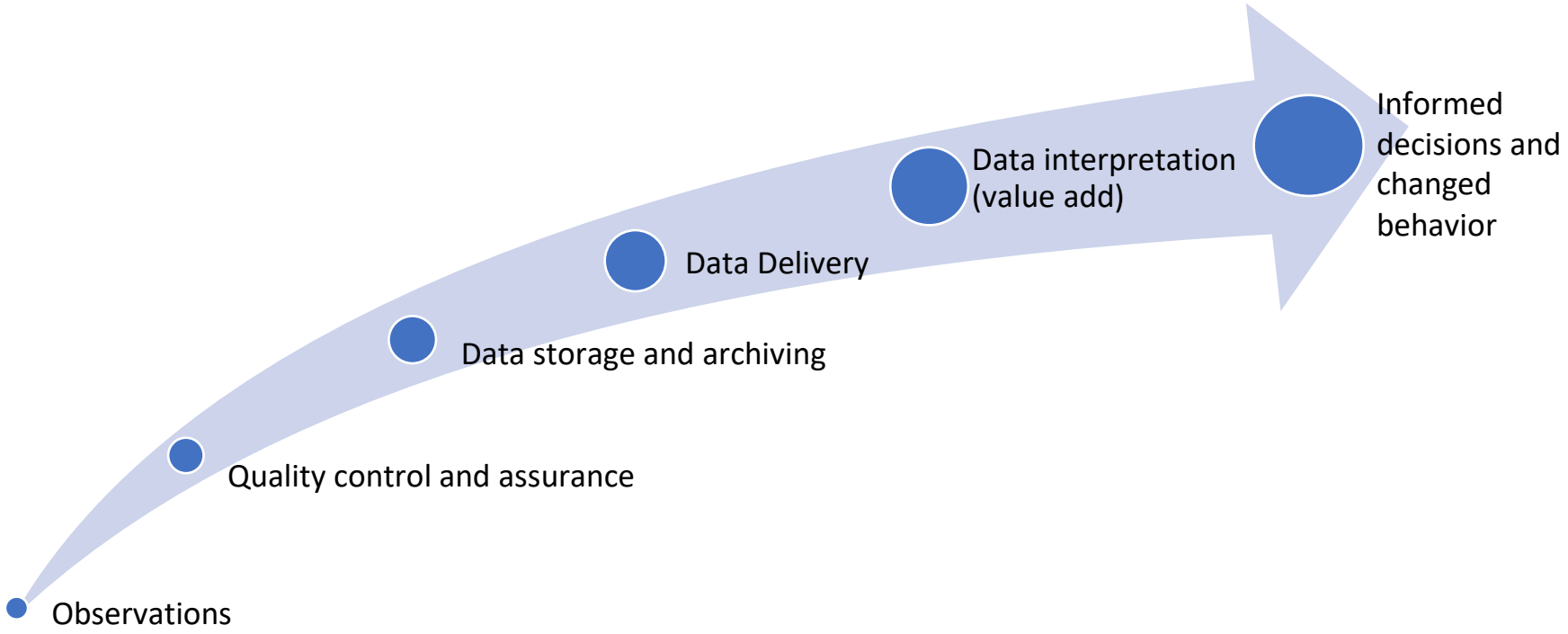
- The U.S. Drought Portal: www.drought.gov
- Regional Drought Early Warning Systems
- Improving drought prediction and forecasting
- Collaborate with partners to build state & local drought capacity
  - Supporting drought planning and preparedness
  - Supporting drought impact assessments



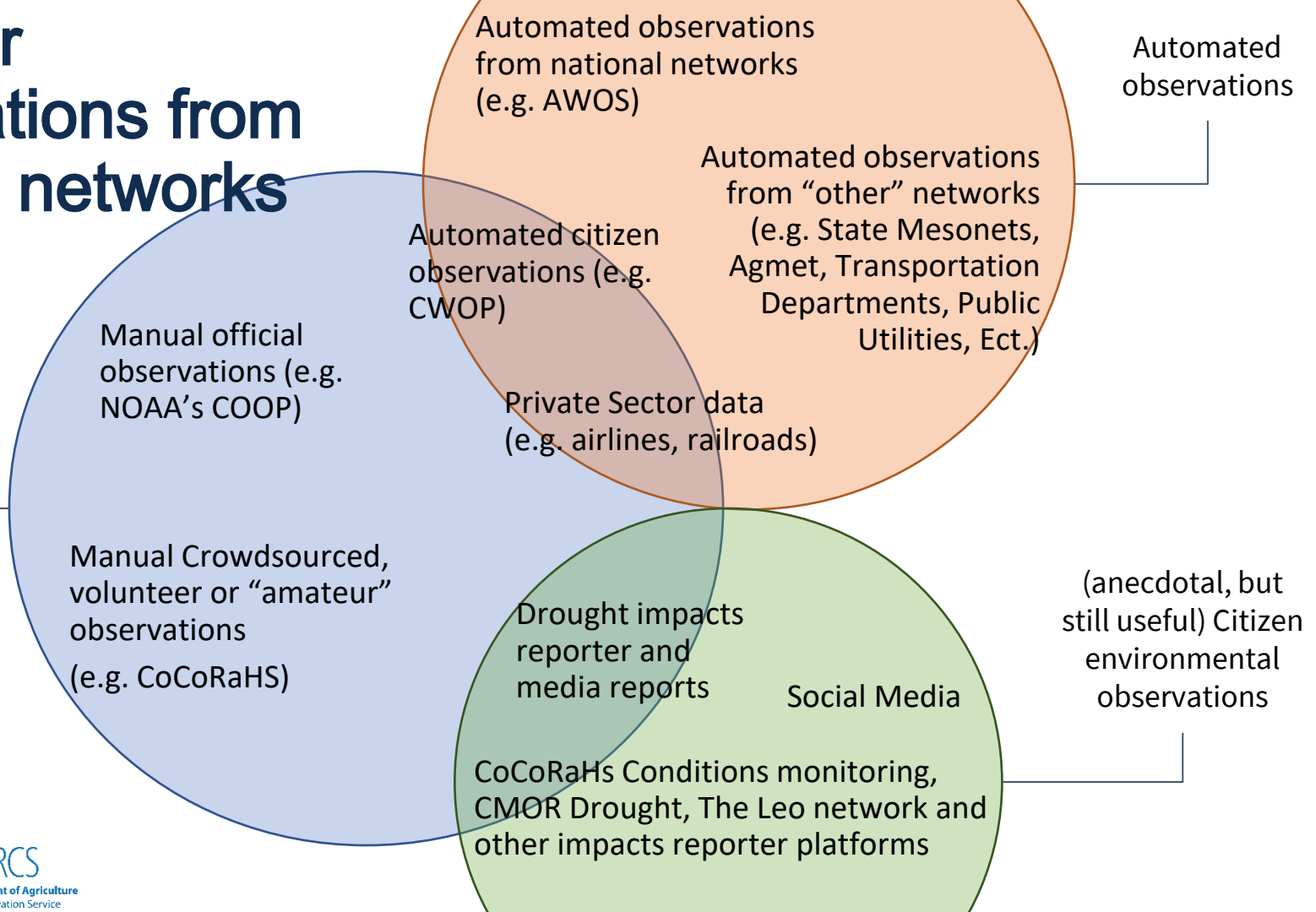
CIRES

Weather and Climate Data for Drought Early Warning

Data Value Chain



Weather observations from multiple networks



NATIONAL GROUND-WATER MONITORING NETWORK

NATIONAL MESONET

NASA

NOAA

USGS science for a changing world

USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

How Does State -Collected Data Support National -Scale Forecasts and drought monitoring?

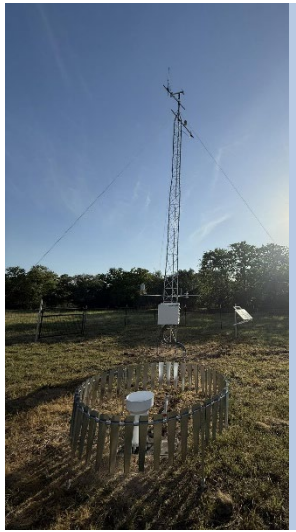
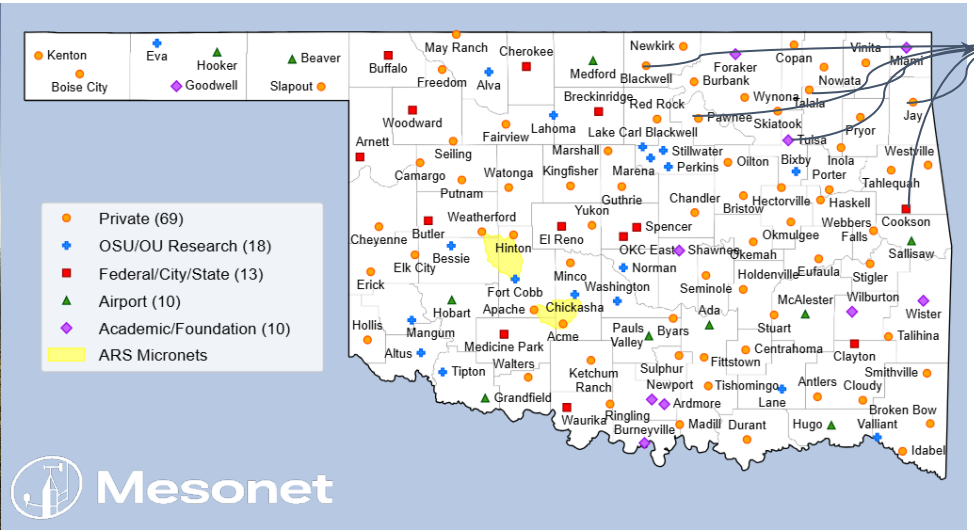


Photo credit: Jason Gerlich



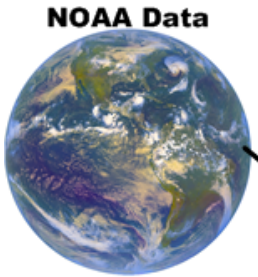
OKLAHOMA CLIMATOLOGICAL SURVEY

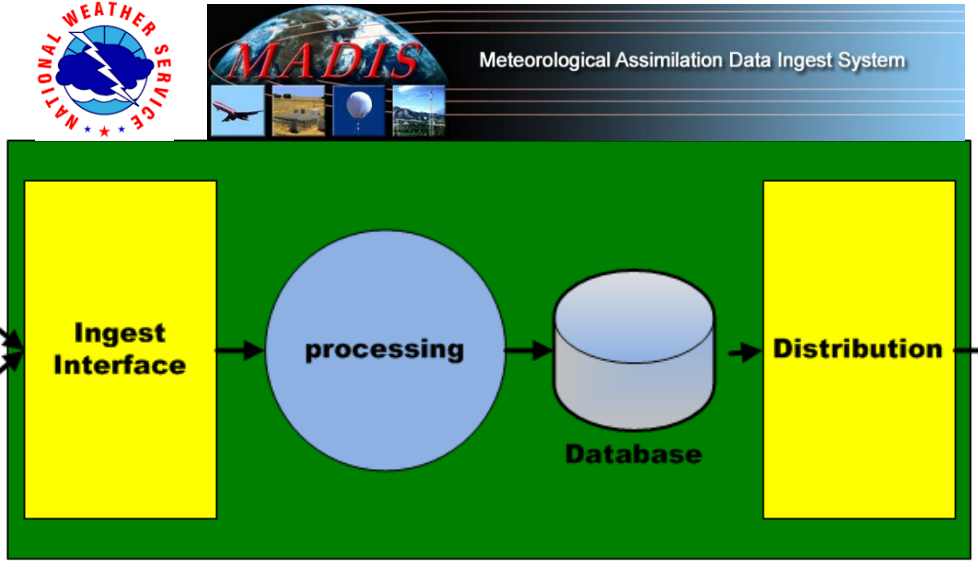
- Receives the observations,
- Verifies the quality of the data
- Provides the data to Mesonet customers.

"Mesonet" is a combination of the words "mesoscale" and "network".

In meteorology, "mesoscale" refers to weather events that range in size from about one mile to about 150 miles, and can last from several minutes to several hours.

CIRES NOAA NIDIS





Source: https://madis.ncep.noaa.gov/

How Does State -Collected Data Support National -Scale Forecasts and drought monitoring?

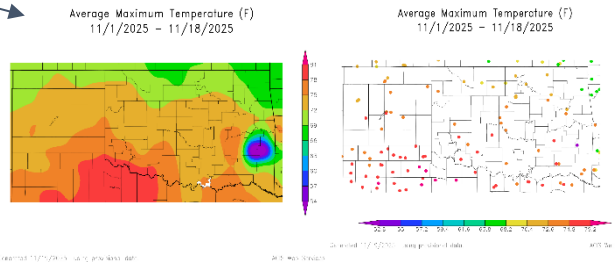
Weather Forecasts

Meteorological Community

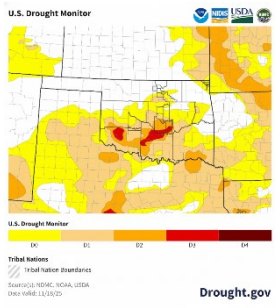
Global Circulation Models

$$
\begin{aligned}
r:\ & \rho\left(\frac{\partial u_r}{\partial t}+u_r\frac{\partial u_r}{\partial r}+\frac{u_\phi}{r\sin(\theta)}\frac{\partial u_r}{\partial \phi}+\frac{u_\theta}{r}\frac{\partial u_r}{\partial \theta}-\frac{u_\phi^2+u_\theta^2}{r}\right)=-\frac{\partial p}{\partial r}+\rho g_r+\\
&\mu\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u_r}{\partial r}\right)+\frac{1}{r^2\sin(\theta)^2}\frac{\partial^2 u_r}{\partial \phi^2}+\frac{1}{r^2\sin(\theta)}\frac{\partial}{\partial \theta}\left(\sin(\theta)\frac{\partial u_r}{\partial \theta}\right)-2\frac{u_r+\frac{\partial u_\theta}{\partial \theta}+u_\theta\cot(\theta)}{r^2}-\frac{2}{r^2\sin(\theta)}\frac{\partial u_\phi}{\partial \phi}\right]\\
\phi:\ & \rho\left(\frac{\partial u_\phi}{\partial t}+u_r\frac{\partial u_\phi}{\partial r}+\frac{u_\phi}{r\sin(\theta)}\frac{\partial u_\phi}{\partial \phi}+\frac{u_\theta}{r}\frac{\partial u_\phi}{\partial \theta}+\frac{u_r u_\phi+u_\phi u_\theta\cot(\theta)}{r}\right)=-\frac{1}{r\sin(\theta)}\frac{\partial p}{\partial \phi}+\rho g_\phi+\\
&\mu\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u_\phi}{\partial r}\right)+\frac{1}{r^2\sin(\theta)^2}\frac{\partial^2 u_\phi}{\partial \phi^2}+\frac{1}{r^2\sin(\theta)}\frac{\partial}{\partial \theta}\left(\sin(\theta)\frac{\partial u_\phi}{\partial \theta}\right)+\frac{2\sin(\theta)\frac{\partial u_r}{\partial \phi}+2\cos(\theta)\frac{\partial u_\theta}{\partial \phi}-u_\phi}{r^2\sin(\theta)^2}\right]\\
\theta:\ & \rho\left(\frac{\partial u_\theta}{\partial t}+u_r\frac{\partial u_\theta}{\partial r}+\frac{u_\phi}{r\sin(\theta)}\frac{\partial u_\theta}{\partial \phi}+\frac{u_\theta}{r}\frac{\partial u_\theta}{\partial \theta}+\frac{u_r u_\theta-u_\phi^2\cot(\theta)}{r}\right)=-\frac{1}{r}\frac{\partial p}{\partial \theta}+\rho g_\theta+\\
&\mu\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u_\theta}{\partial r}\right)+\frac{1}{r^2\sin(\theta)^2}\frac{\partial^2 u_\theta}{\partial \phi^2}+\frac{1}{r^2\sin(\theta)}\frac{\partial}{\partial \theta}\left(\sin(\theta)\frac{\partial u_\theta}{\partial \theta}\right)+\frac{2}{r^2}\frac{\partial u_r}{\partial \theta}-\frac{u_\theta+2\cos(\theta)\frac{\partial u_\phi}{\partial \phi}}{r^2\sin(\theta)^2}\right].
\end{aligned}
$$

Gridded and point data sets



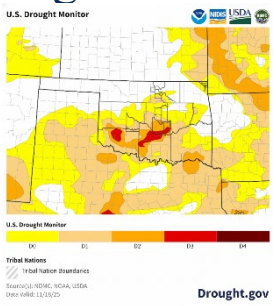
Drought Monitoring



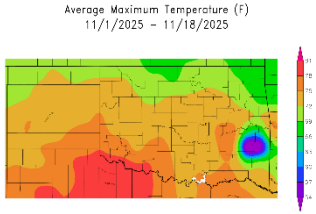
But wait…There's more.

Global Circulation Models

Drought Monitoring



Gridded and point data sets



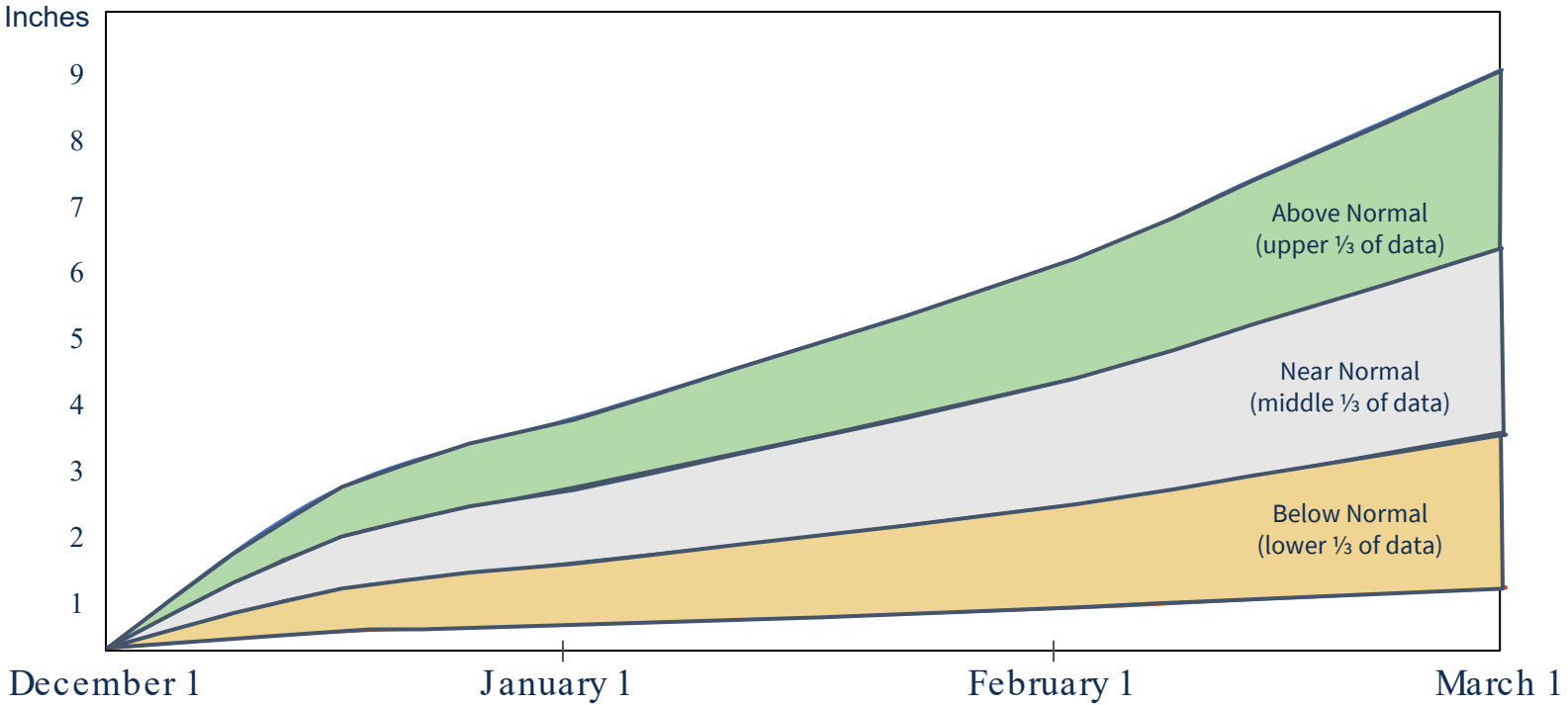
North-American Multi-Model Ensemble (NMME)

- **NOAA's The Climate Forecast Model version 2 (CFSv2-2011)**
- NCAR's Community Climate System Model version 4 (CCSM4)
- The Canadian Coupled Climate Model versions 3 and 4 (CanCM3, CanCM4)
- The Global Environmental Multiscale/Nucleus for European Modeling of the Ocean (GEM/NEMO)
- NASA's The Goddard Earth Observing System Model version 5 (GEOS-5)
- **Geophysical Fluid Dynamics Laboratory (NOAA) SPEAR Model**

Ensemble Forecasting

The basics

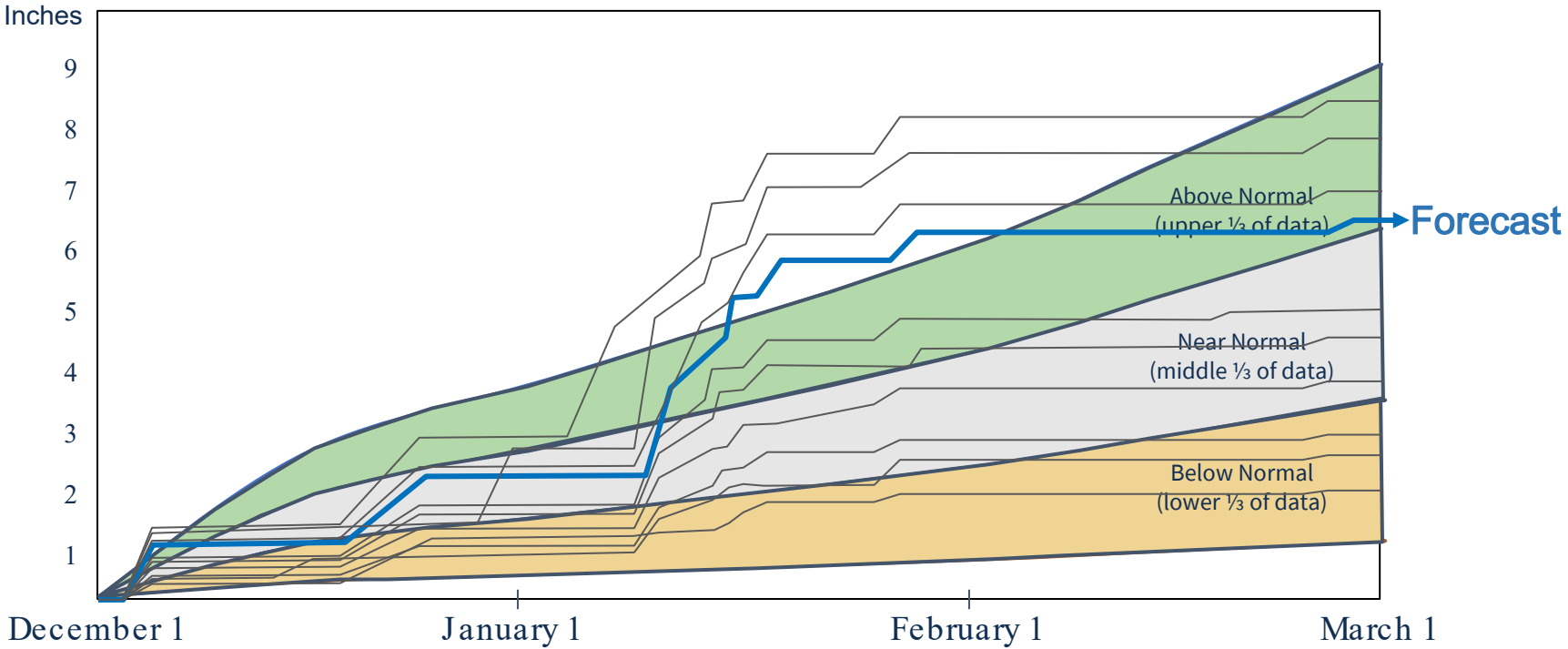
Establish historical "normals"



Ensemble Forecasting

The basics

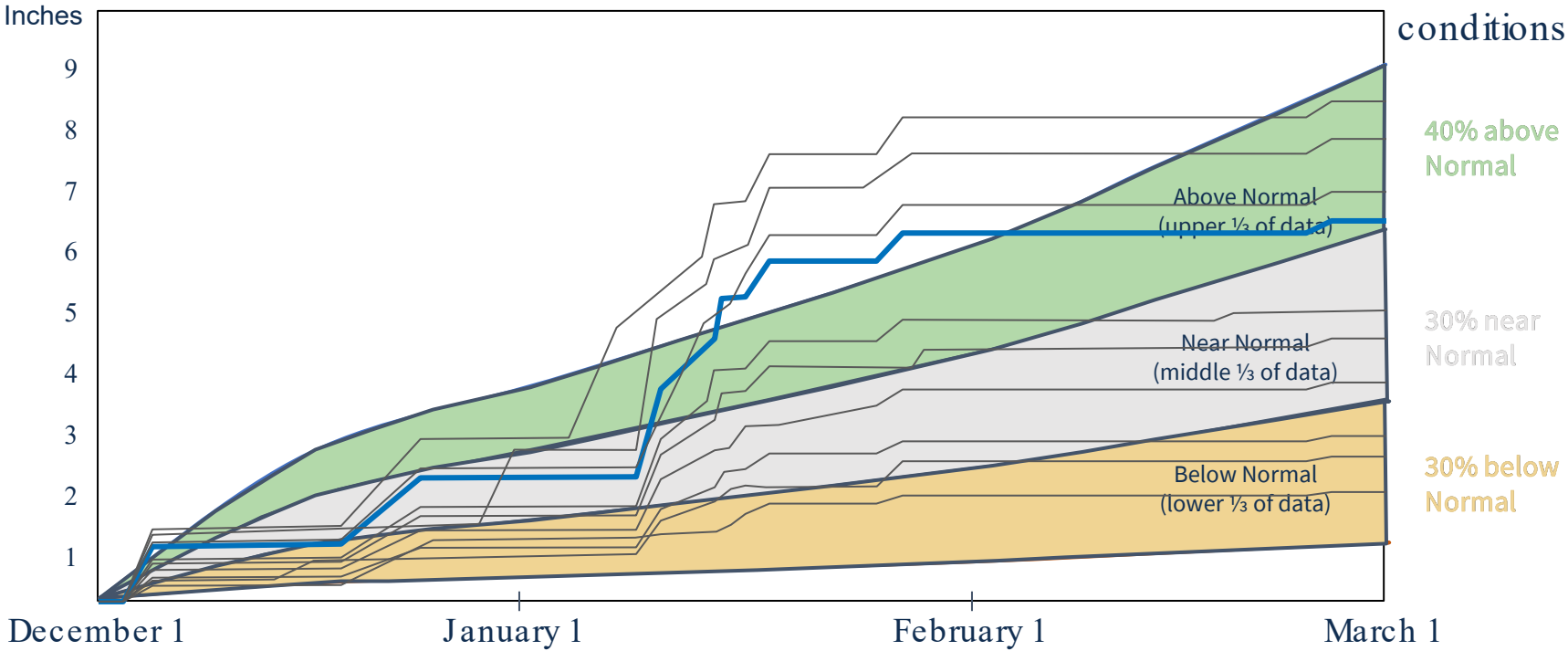
Compare model output to "normal"



Ensemble Forecasting

The basics

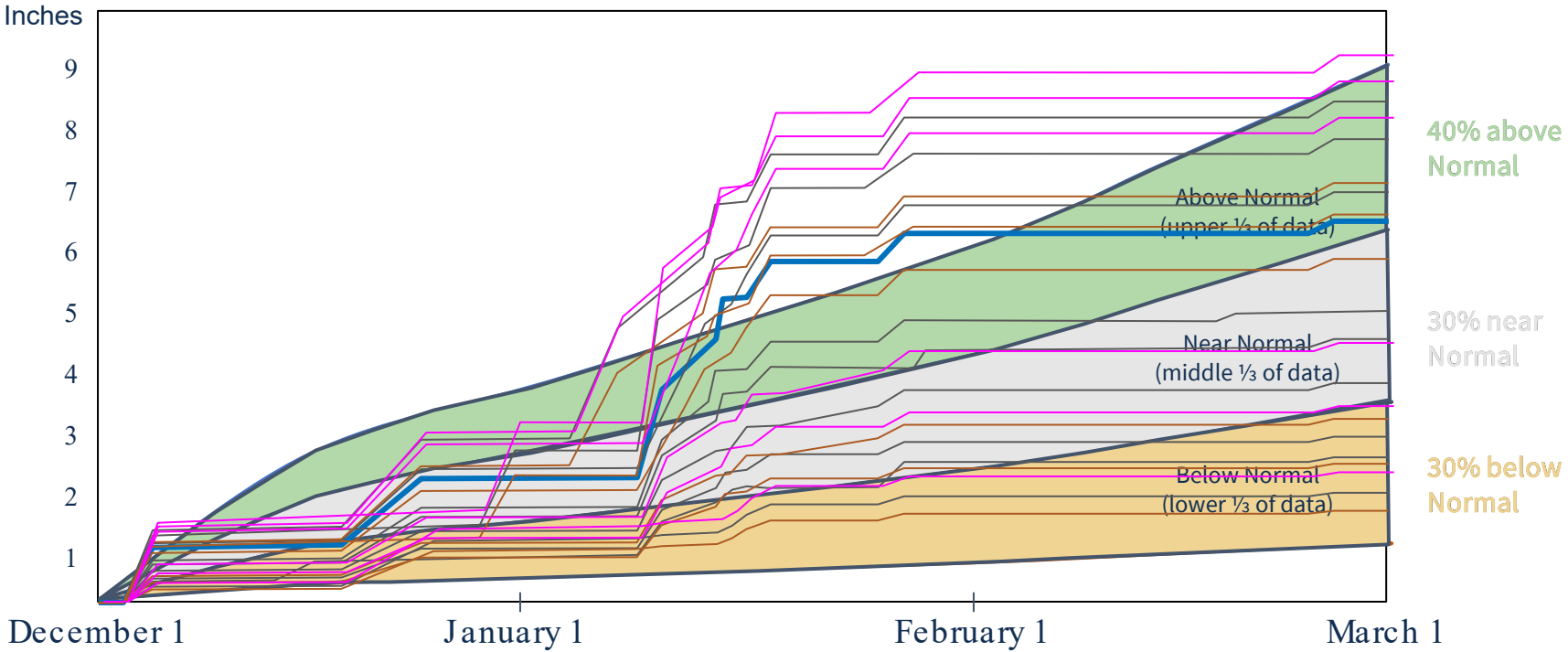
Re-run the model to account for variability in initial conditions



Ensemble Forecasting

The basics

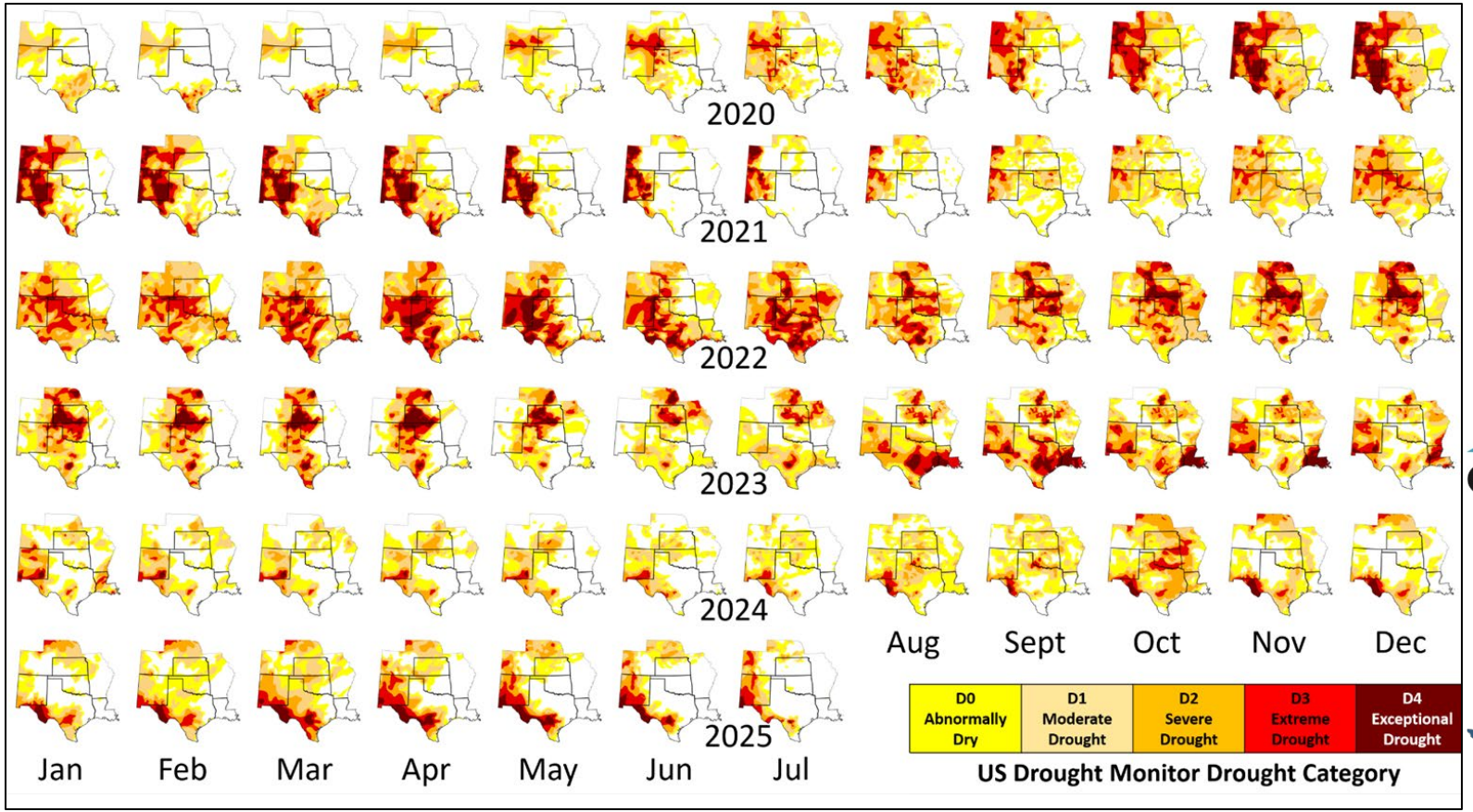
Include output from multiple models



Observations Vs. Forecasts

Which is better for Drought Early Warning?

Southern Plains Drought Assessment 2020 -2025



CIRES

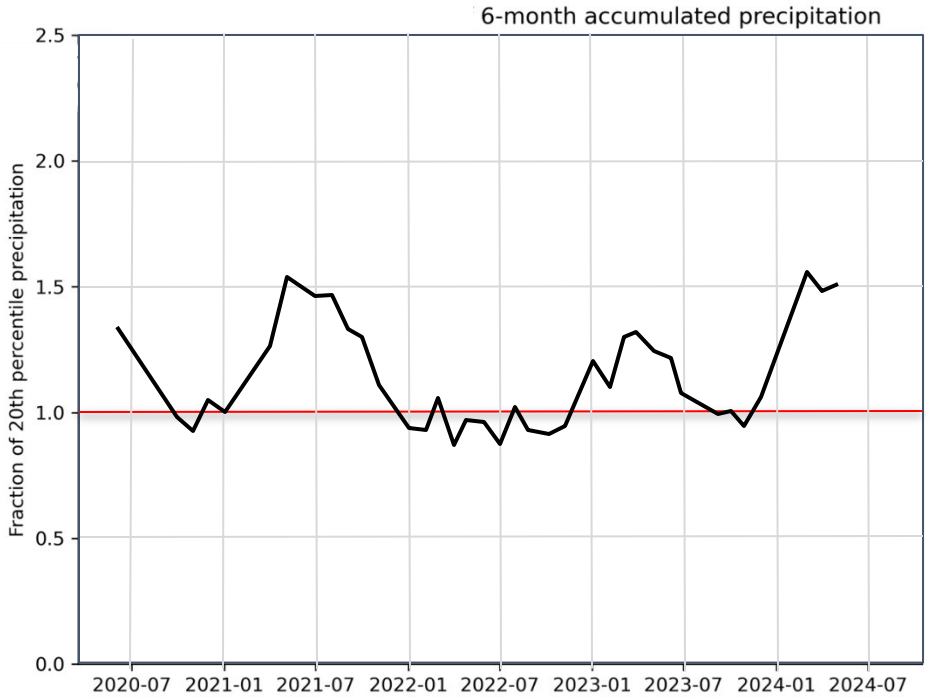
NOAA

NIDIS

SRCC

The Gap: Observations vs. Forecasts

Why are observations important even when forecasts are available?

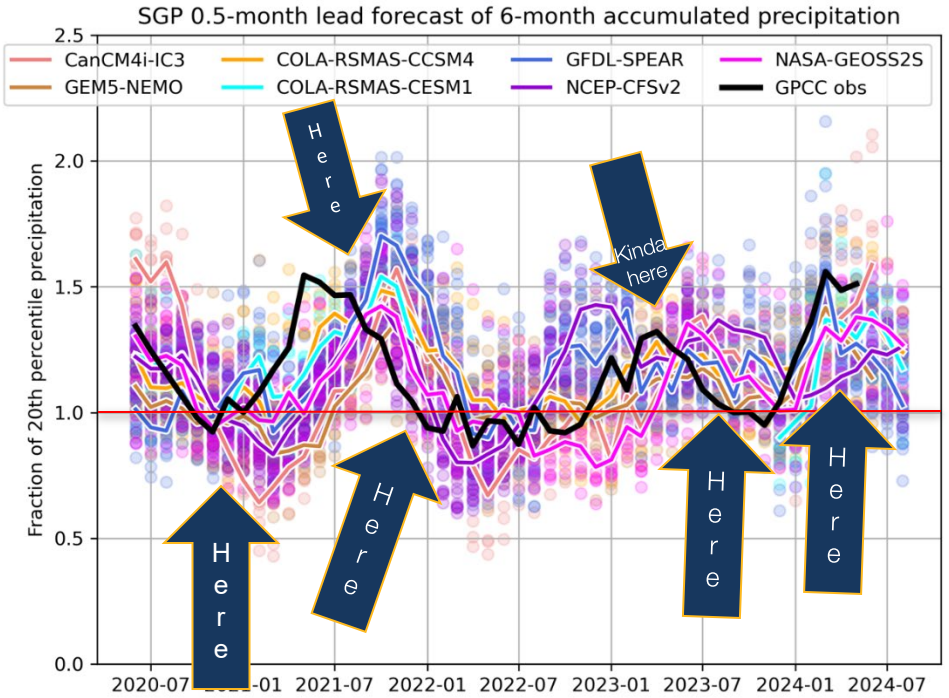


6-month accumulated precipitation for KS, OK, and TX

The Gap: Observations vs. Forecasts

Why are observations important even when forecasts are available?

Models lagged observations



6-month accumulated precipitation for KS, OK, and TX

Forecasts at 2-week lead time.

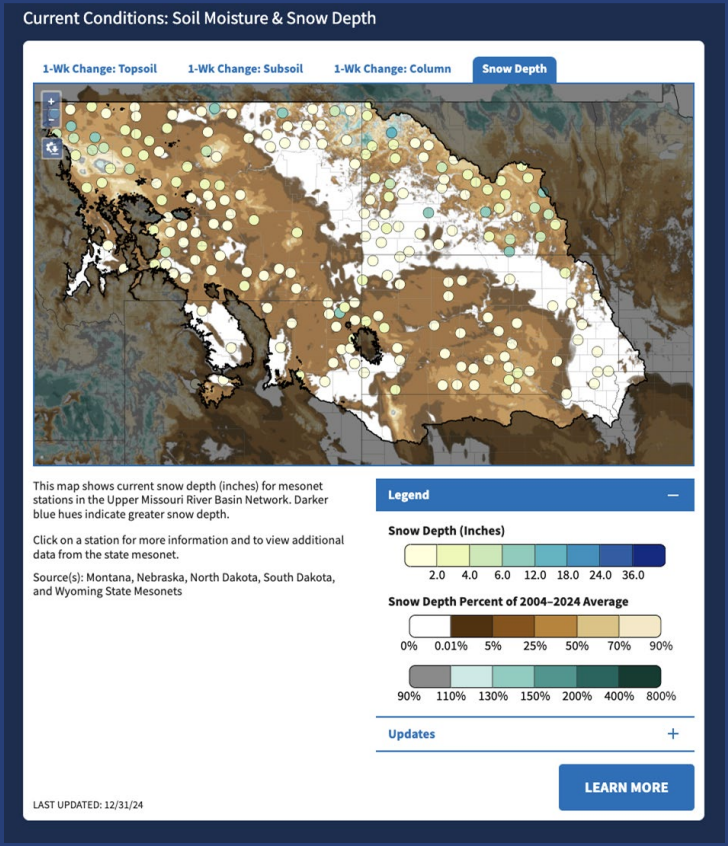
Data Value Study:
Upper Missouri River Basin

Goals/Intent:

Identify value of the data for:

- Improving forecast skill to better understand streamflow, flood risk, and water supply
- Improving model outputs to better identify and track drought
- Communicating and representing information to those who need it
- Identifying advice and recommendations about the process to future projects here or in other regions

Data Value Study:
Upper Missouri River Basin

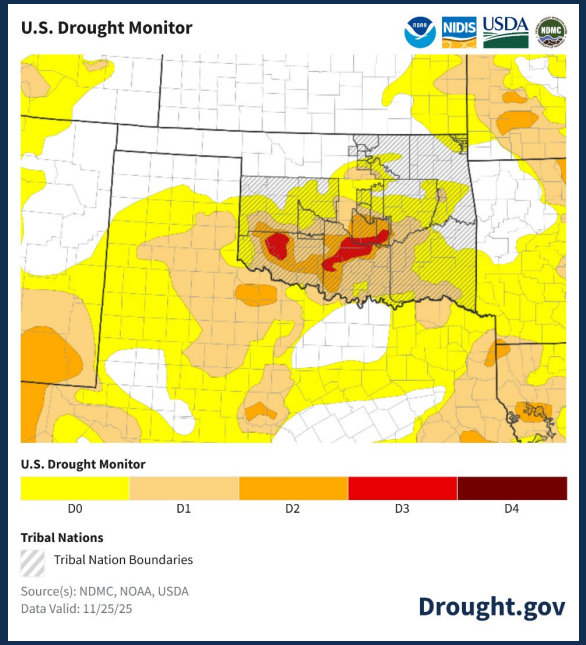


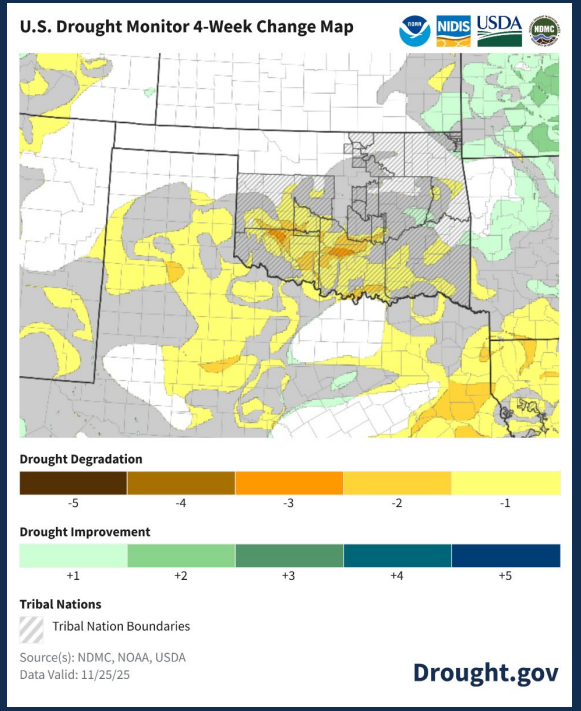
Still a work in progress, but here are some key takeaways:

- *In situ* soil moisture data provides economic benefit on the order of $10s of Millions. source: Wang & Wyatt, 2025 ⇒
- Knowledge-guided machine-learning soil moisture models captured rapid drying weeks before traditional monitoring tools.
  - Accuracy of these model increased with increasing number of stations. (Hoylman & Jencso, in press)
- Improved spatial coverage of precipitation data, showed potential to increase accuracy runoff forecasts. ⇒

Current Drought Conditions and Forecasts

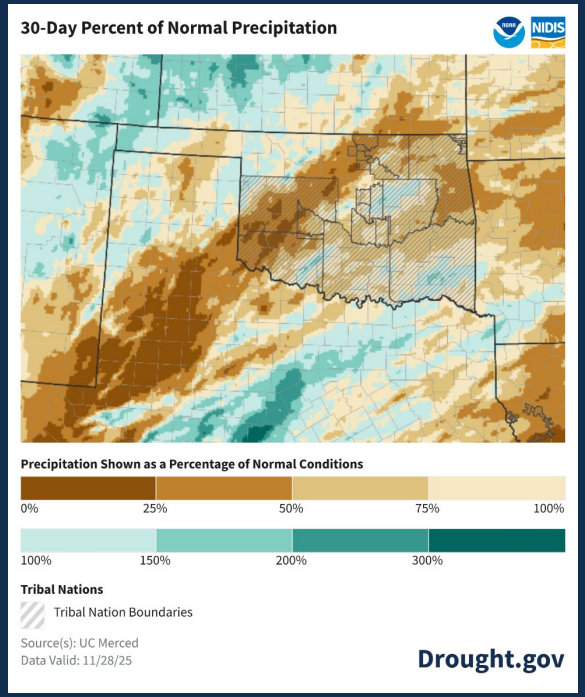
Current Drought Conditions





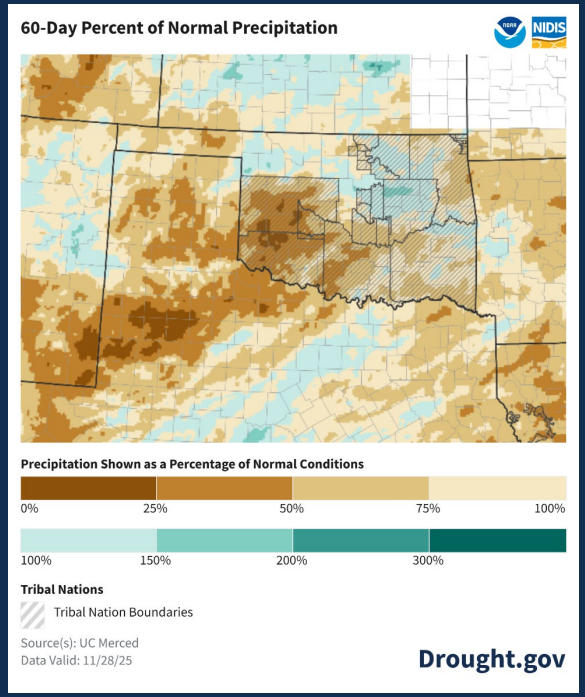
Precipitation

October 29–November 28, 2025



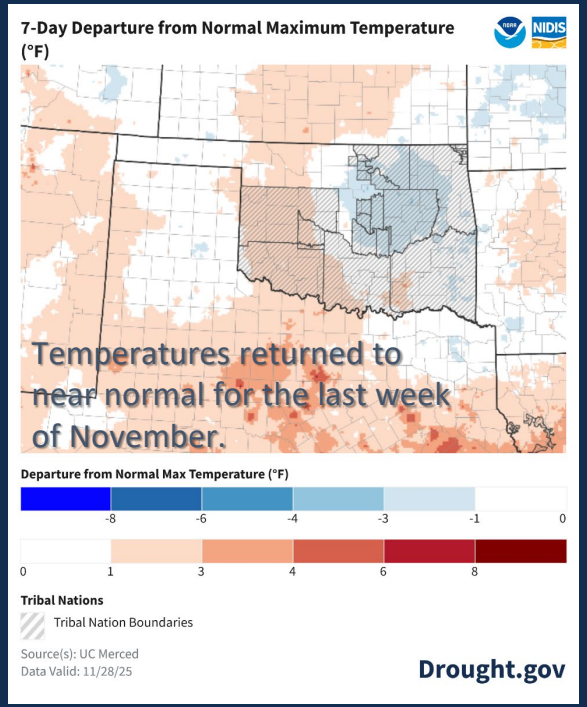
Dry in the west and south.

September 29–November 28, 2025

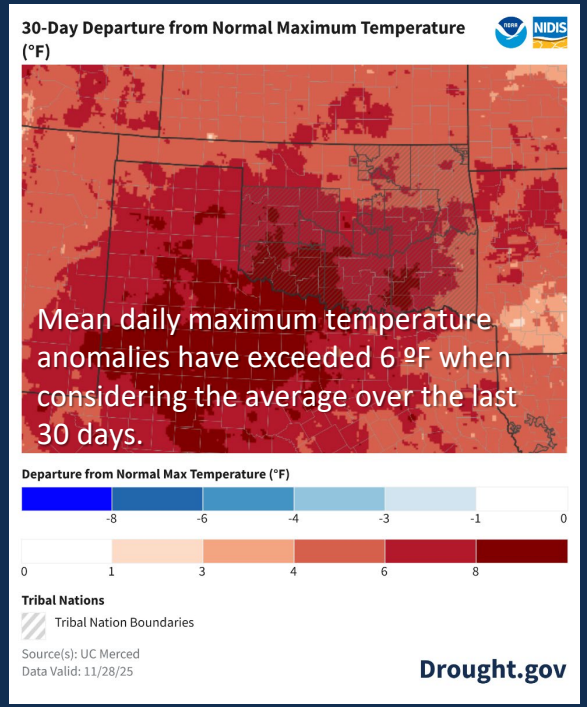


November Temperature s

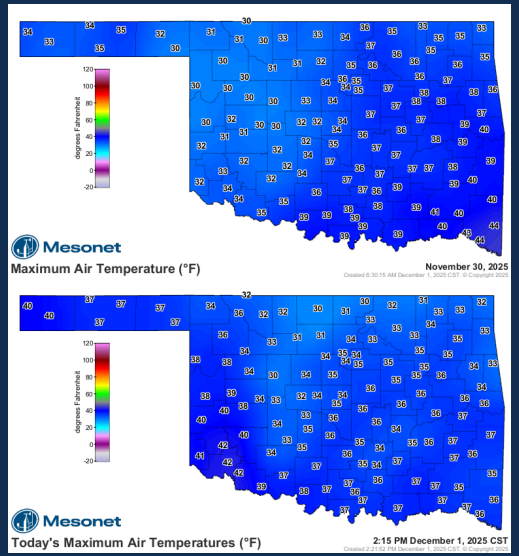
November 21–28, 2025



October 29–November 28, 2025



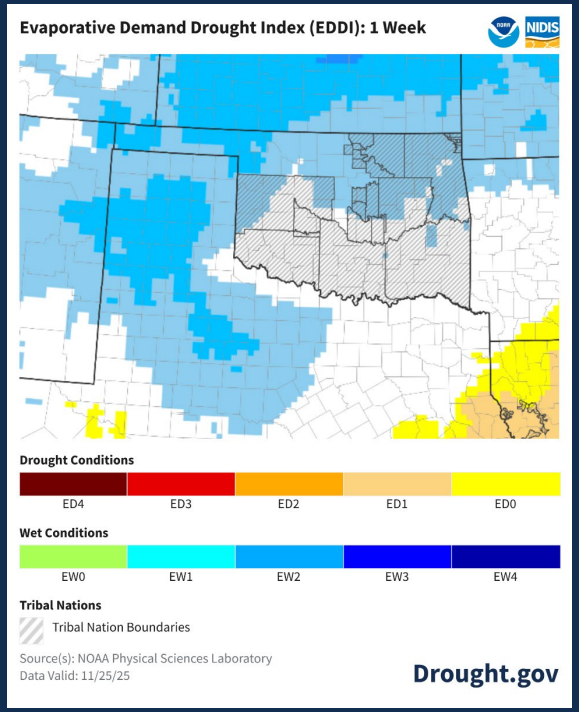
December so Far…



Brrrrr!

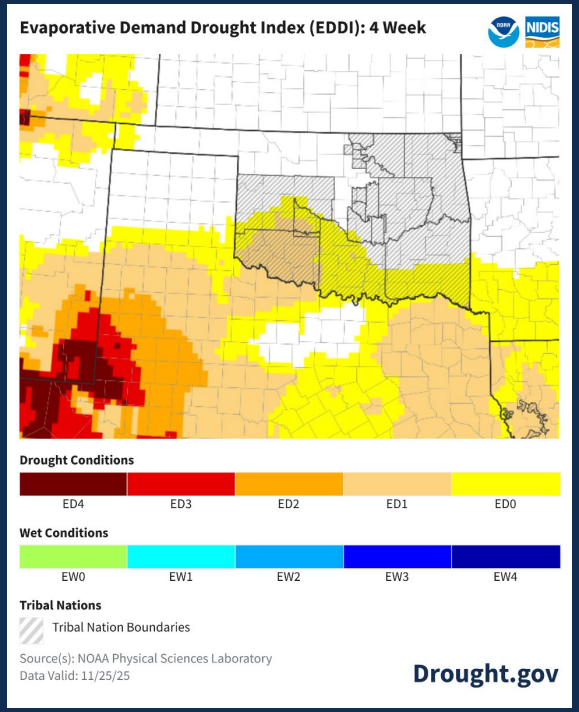
Evaporative Demand

November 17–25, 2025



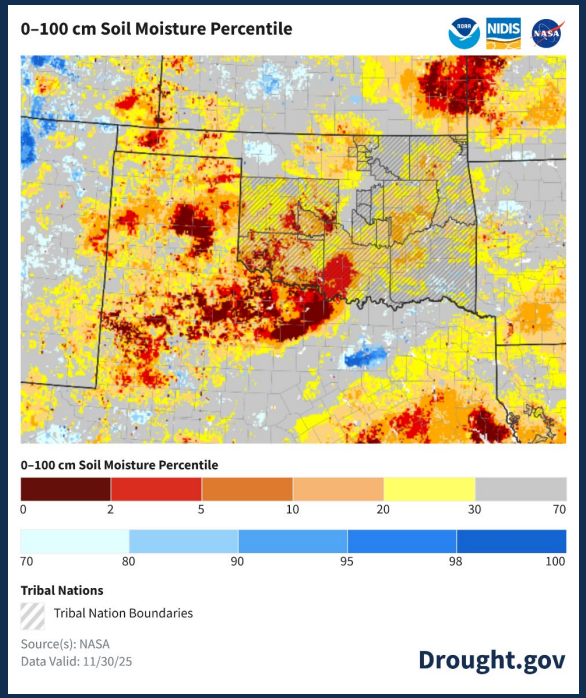
The Evaporative Demand Drought Index (EDDI) shows increased evaporative demand in the regions that have also seen increased temperatures and decreased precipitation.

October 28–November 25, 2025



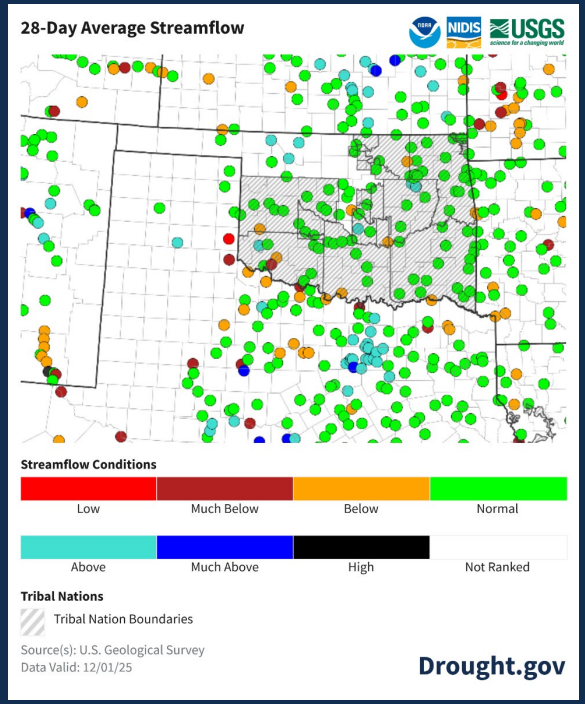
Soil Moisture & Streamflow

November 30, 2025

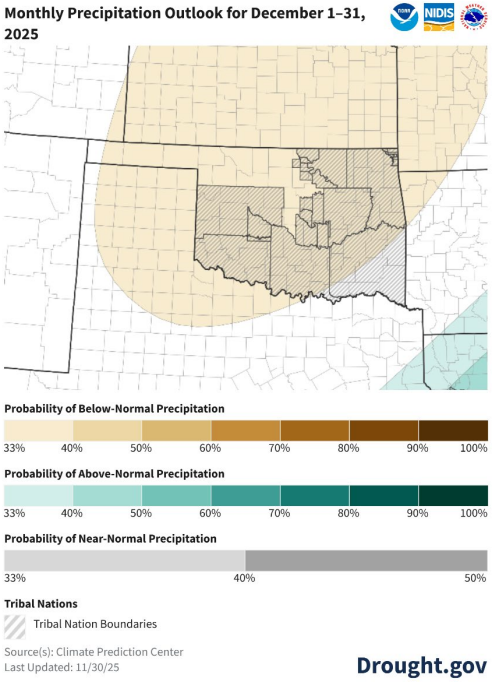


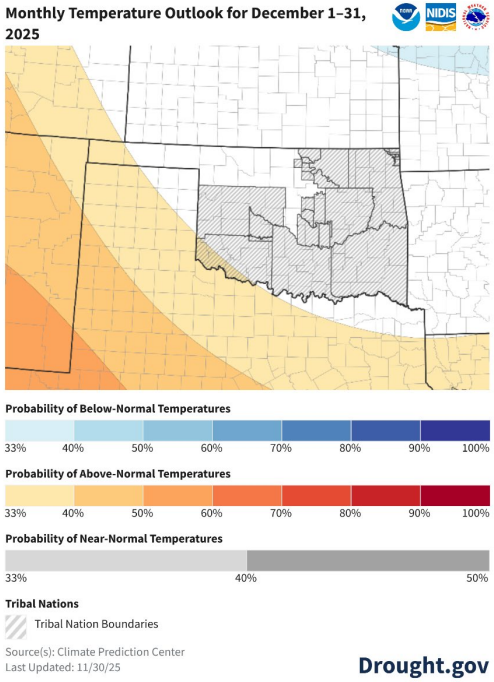
Southern Oklahoma saw significant drops in both Soil Moisture and Streamflow over the past month

November 2–December 1, 2025



Outlooks
December (Whole Month)

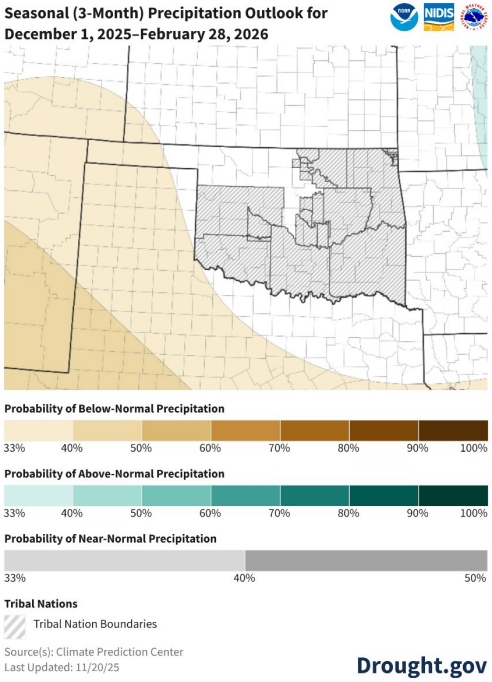


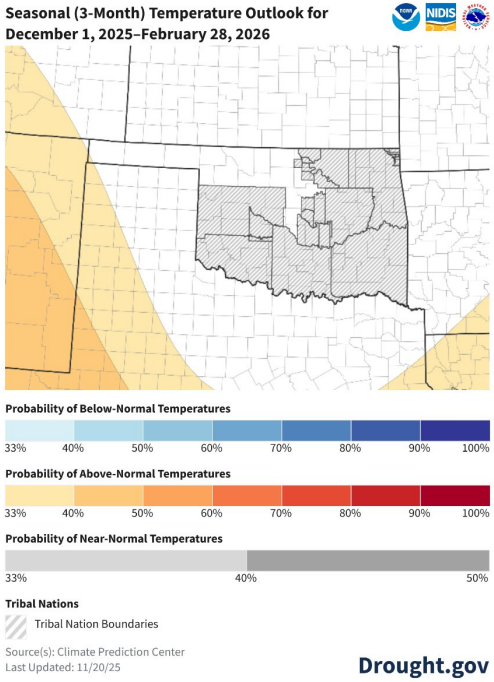


Equal changes of above or below normal temperatures.

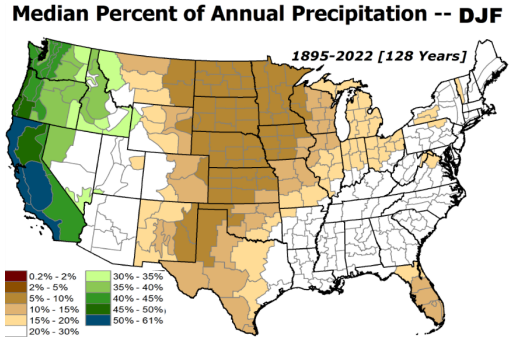
Odds slightly lean toward below normal precipitation for December.

Outlooks
Winter (3-month)



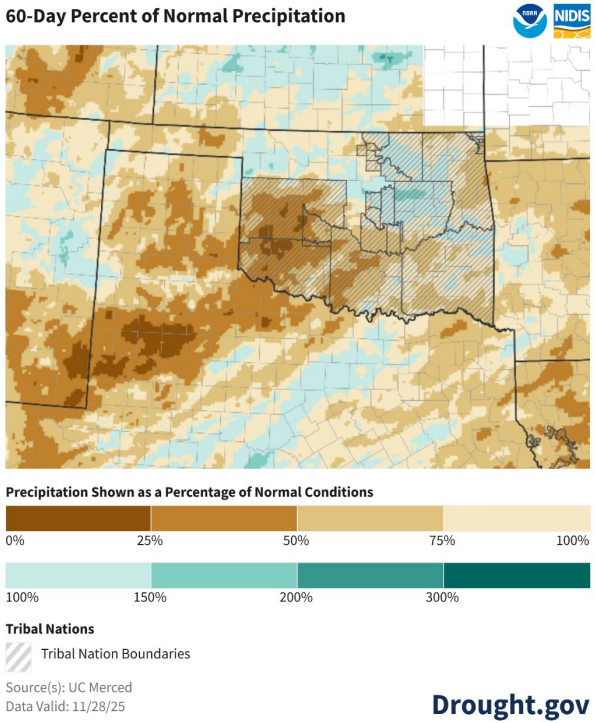


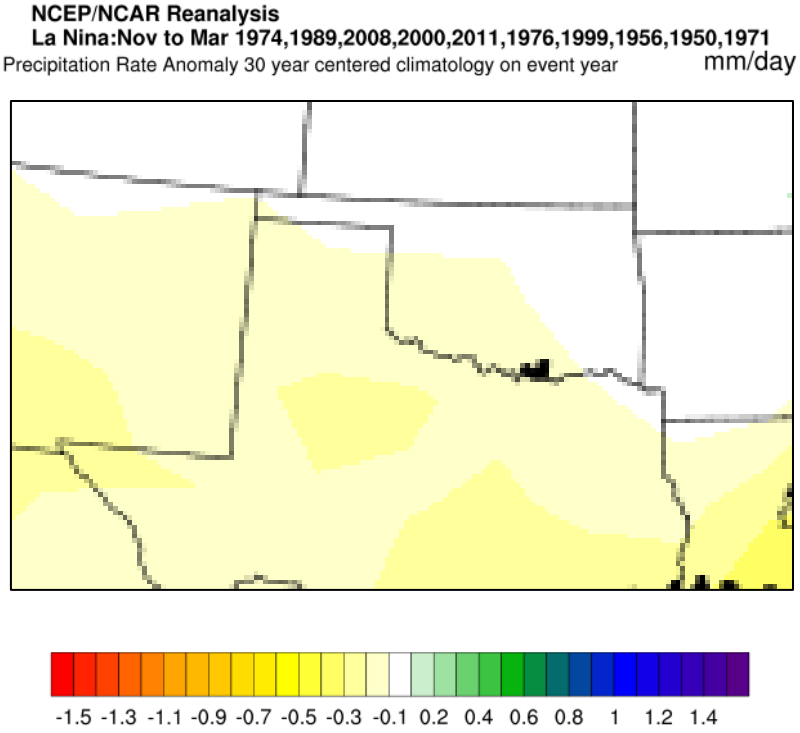
Winter…¯_(ツ)_/¯



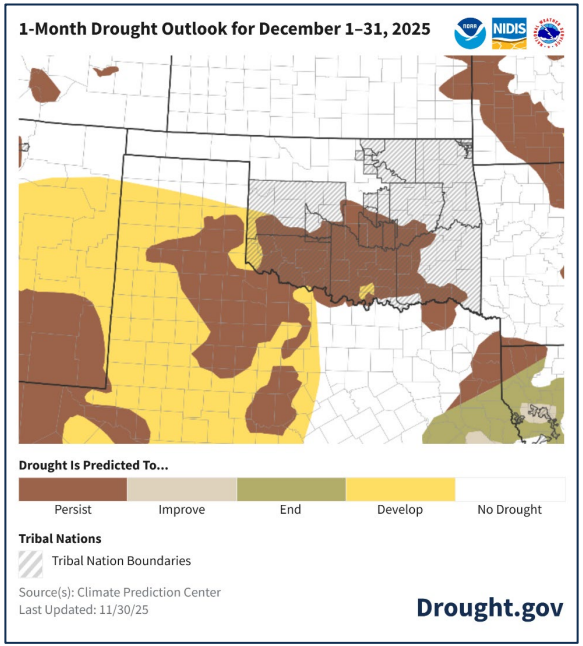
Acknowledgement: Rich Tinker
NOAA/NWS/NCEP/CPC

ENSO Status

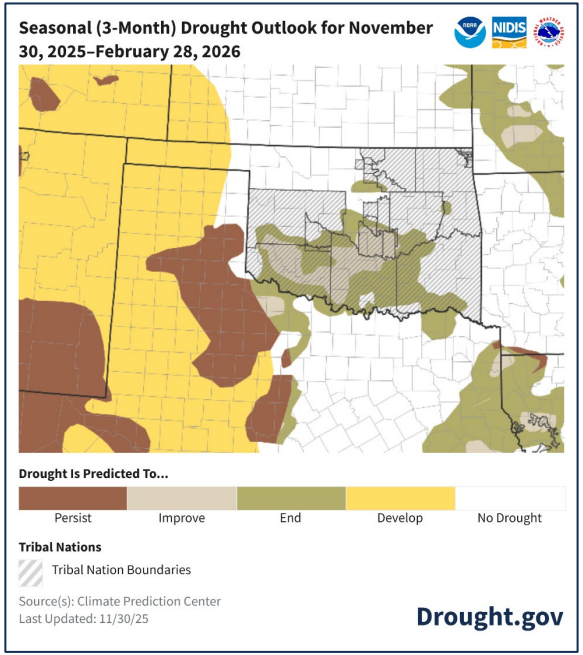

60-Day Percent of Normal Precipitation
Precipitation Shown as a Percentage of Normal Conditions
0%
25%
50%
75%
100%
100%
150%
200%
300%
Tribal Nations
Tribal Nation Boundaries
Source(s): UC Merced
Data Valid: 11/28/25
Drought.gov


NCEP/NCAR Reanalysis
La Nina:Nov to Mar 1974,1989,2008,2000,2011,1976,1999,1956,1950,1971
Precipitation Rate Anomaly 30 year centered climatology on event year
mm/day
-1.5 -1.3 -1.1 -0.9 -0.7 -0.5 -0.3 -0.1 0.2 0.4 0.6 0.8 1 1.2 1.4

Drought Outlooks



Drought is likely to continue through December, and Improve over winter.



Thank You

Contact me at
joel.lisonbee@noaa.gov

www.drought.gov

@DroughtGov

@DroughtGov

National Integrated Drought Information System