Extreme Weather and Climate in the Great Plains – Impacts on Agriculture

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University of Oklahoma

KRC Farm and Food Conference
Wichita, KS
8 November 2019

CHEWe Research Group:
Interdisciplinary Research Focus

http://hydrometeorology.oucreate.com

Acknowledgments

Co-authors and Collaborators:

Paul Flanagan*, Jordan Christian*, Ryann Wakefield*, Hayden Mahan**, Jean Liu**, Jason Furtado, Elinor Martin, Cameron Homeyer, Xiangming Xiao, Rajen Bajgain, Yuting Zhou, Jason Otkin, Eric Hunt, Jean Steiner, Amber Campbell, Daniel Devlin, Chuck Rice

Sponsors:

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- National Science Foundation grant ICER 1663840.
- NASA Water Resources Program grant 80NSSC19K1266
- USDA Southern Plains Climate Hub

“There are known knowns. These are things we know that we know.

There are known unknowns. That is to say, there are things that we know we don't know.

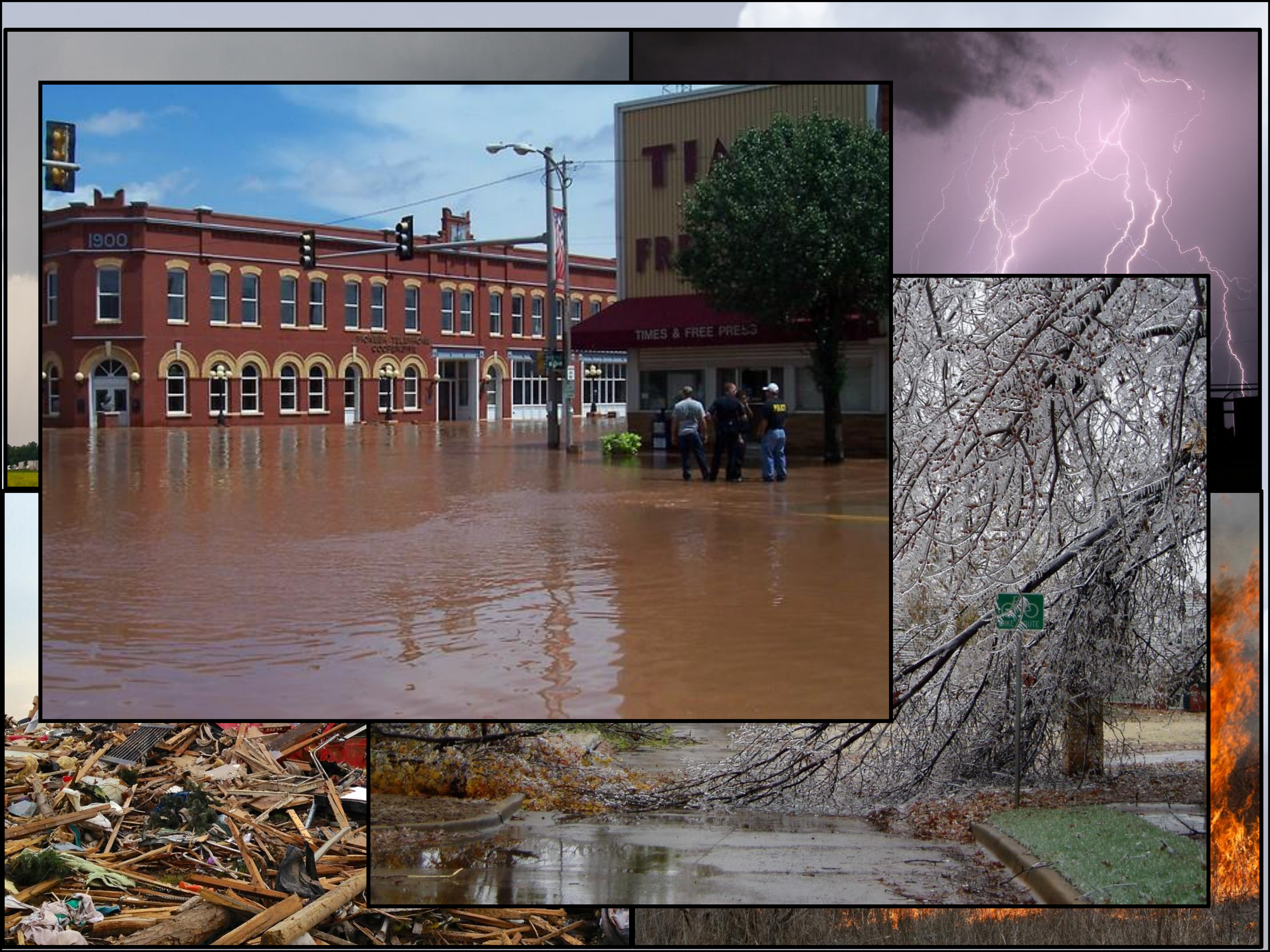
But there are also unknown unknowns. There are things we don't know we don't know.”

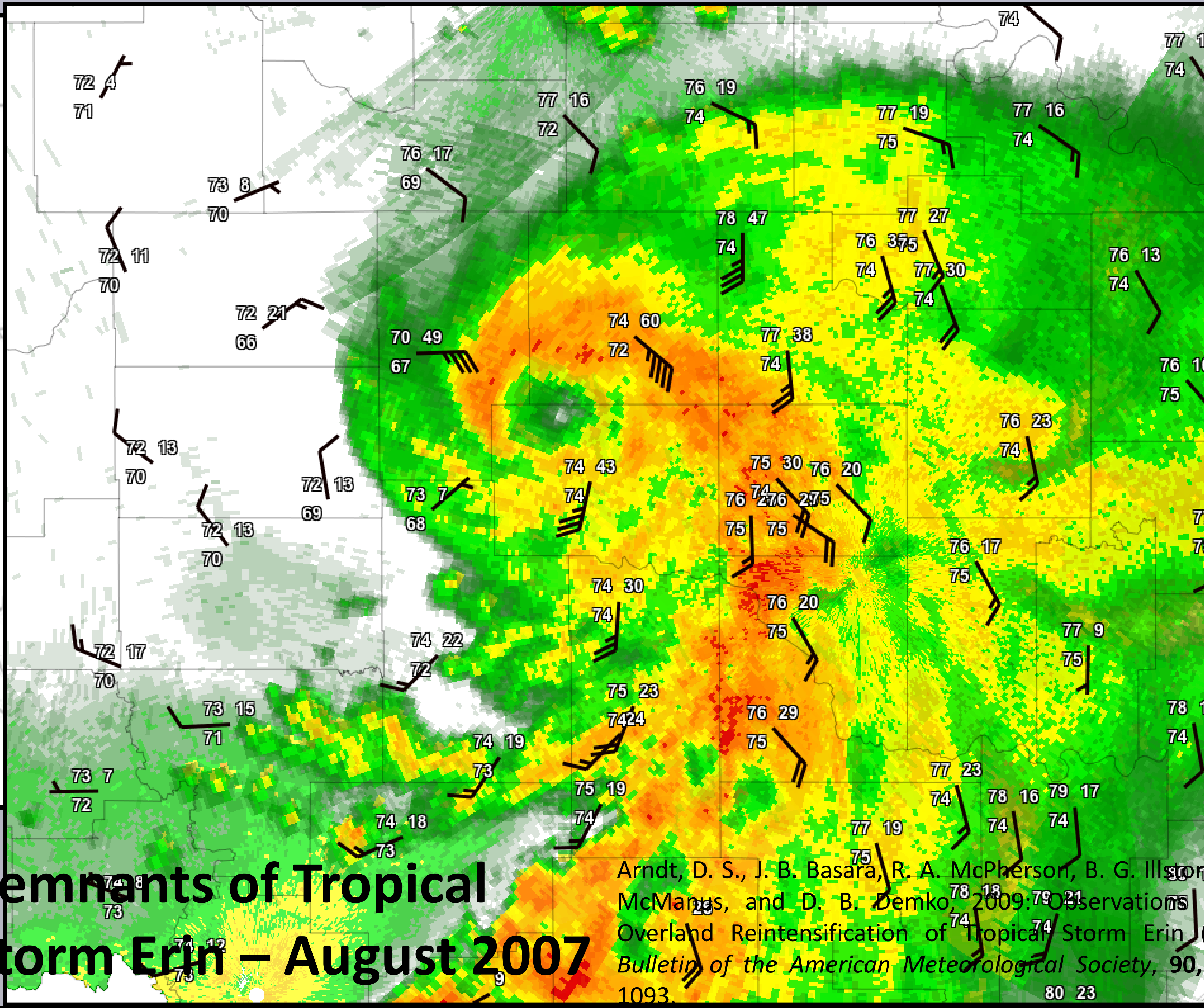
– Donald Rumsfeld

Cattle Populations in the Southern Great Plains

	Cattle By State	Humans By State
Oklahoma	4.4 M	3.85 M
Kansas	5.8 M	2.89 M
Texas	10.9 M	26.45 M

Total	21.1 M	33.19 M

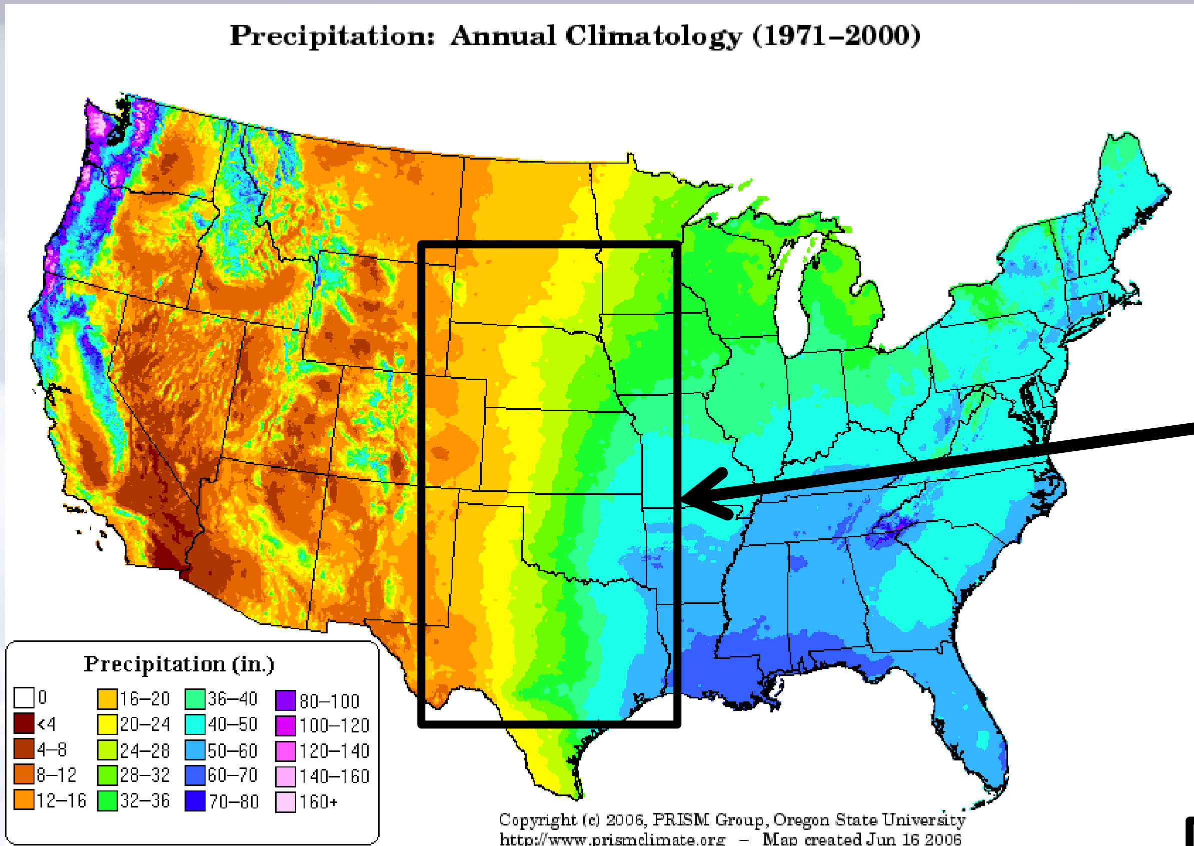

1900
TIMES & FREE PRESS

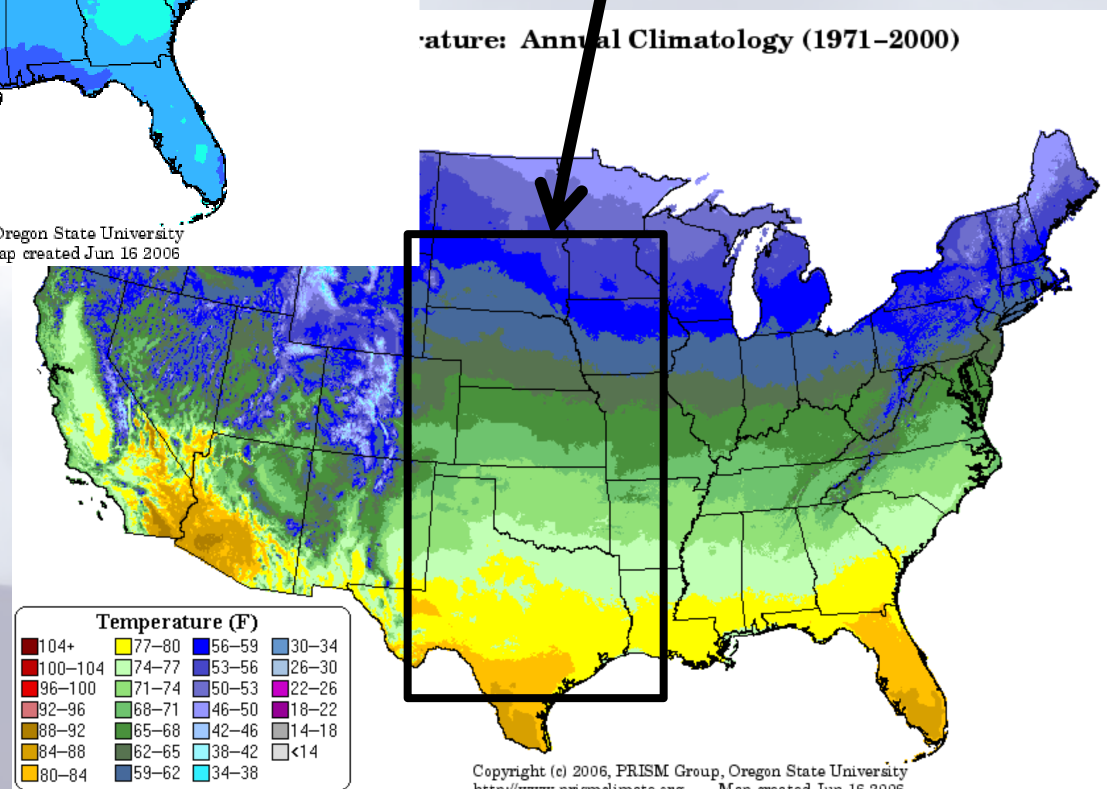


Remnants of Tropical Storm Erin – August 2007

Arndt, D. S., J. B. Basara, R. A. McPherson, B. G. Illston, G. D. McManus, and D. B. Demko, 2009: Observations of the Overland Reintensification of Tropical Storm Erin (2007). *Bulletin of the American Meteorological Society*, **90**, 1079-1093.

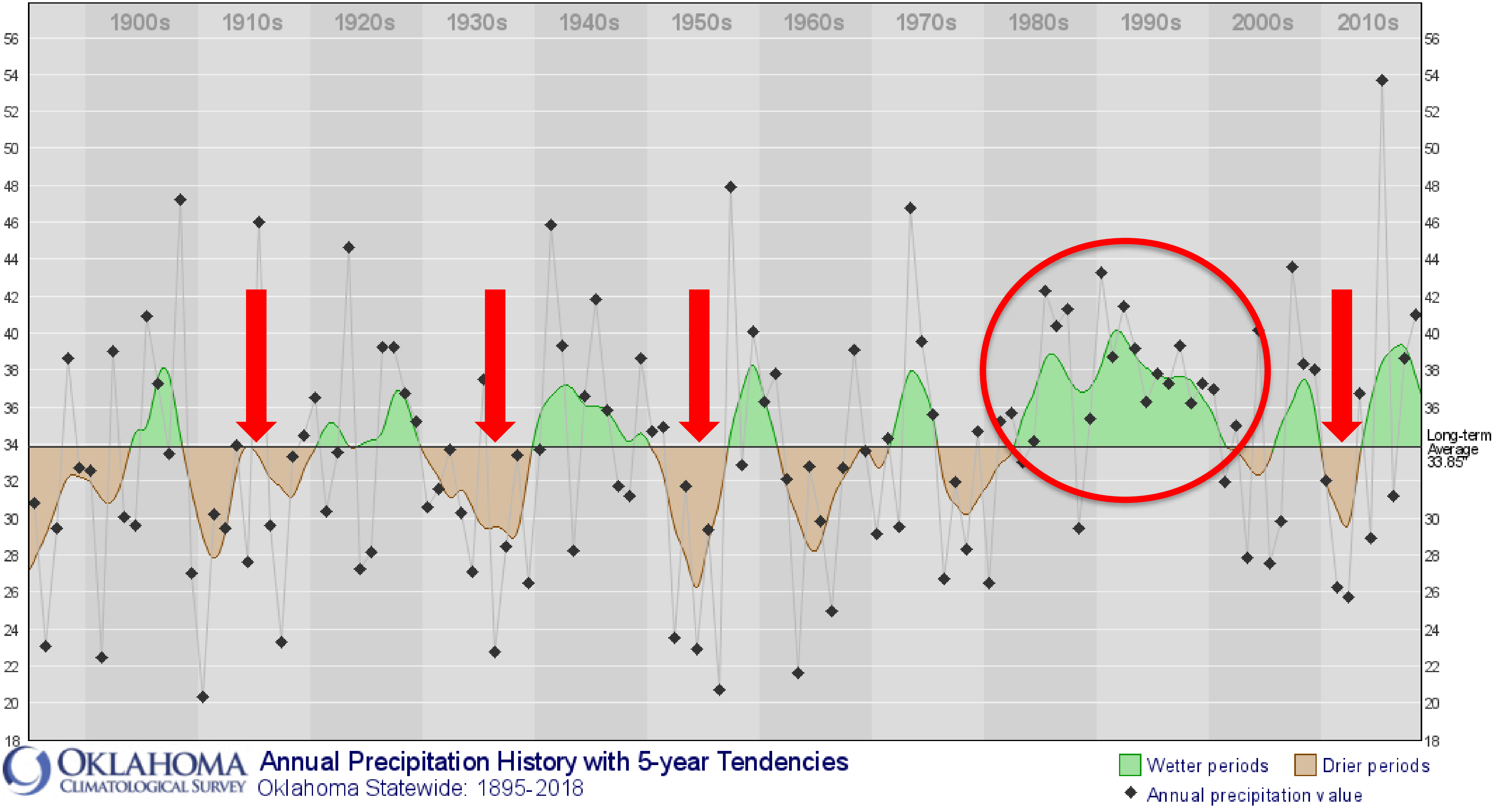
Orthogonal Gradients of Temperature and Precipitation



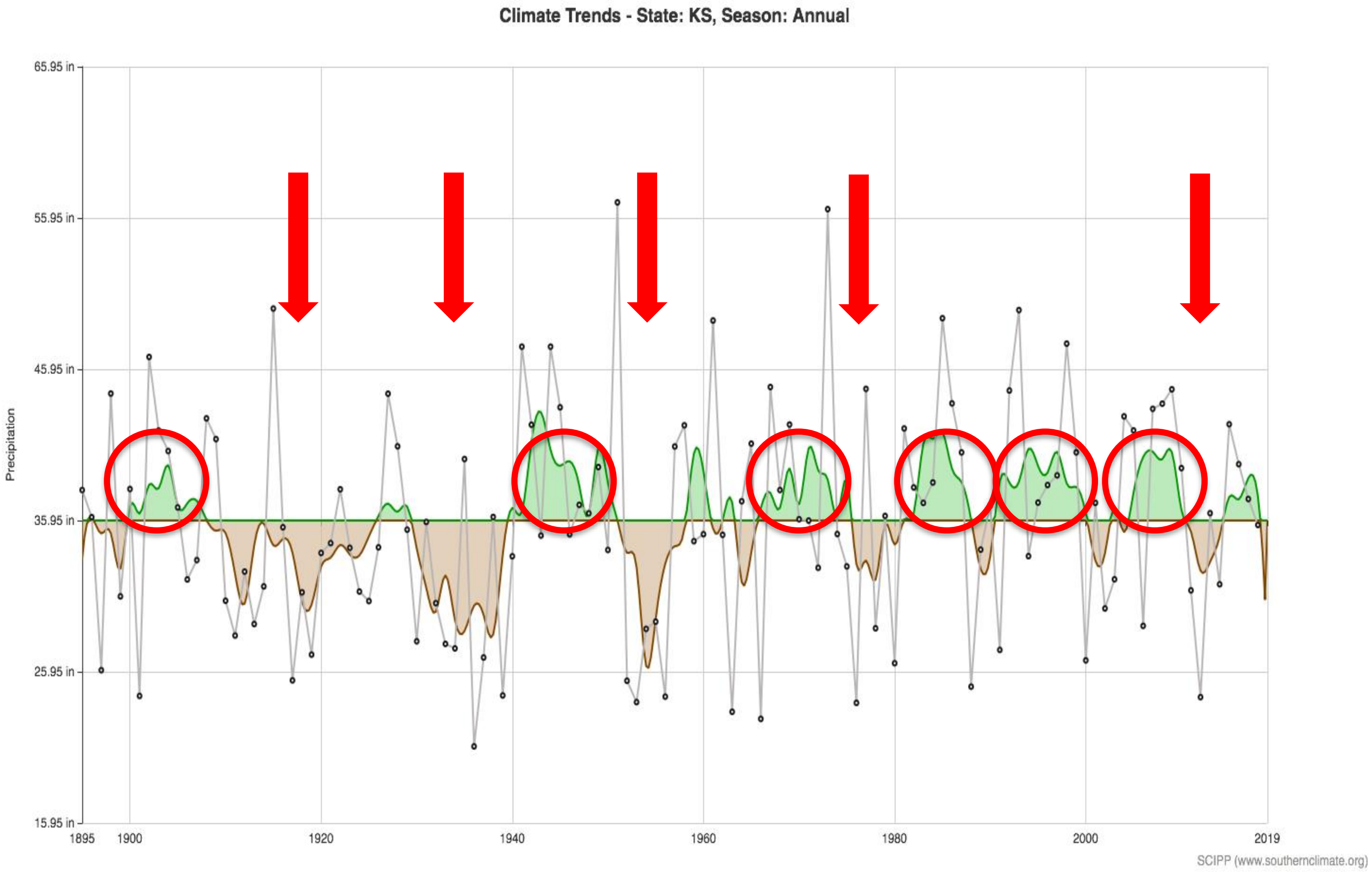


Dynamic Climate

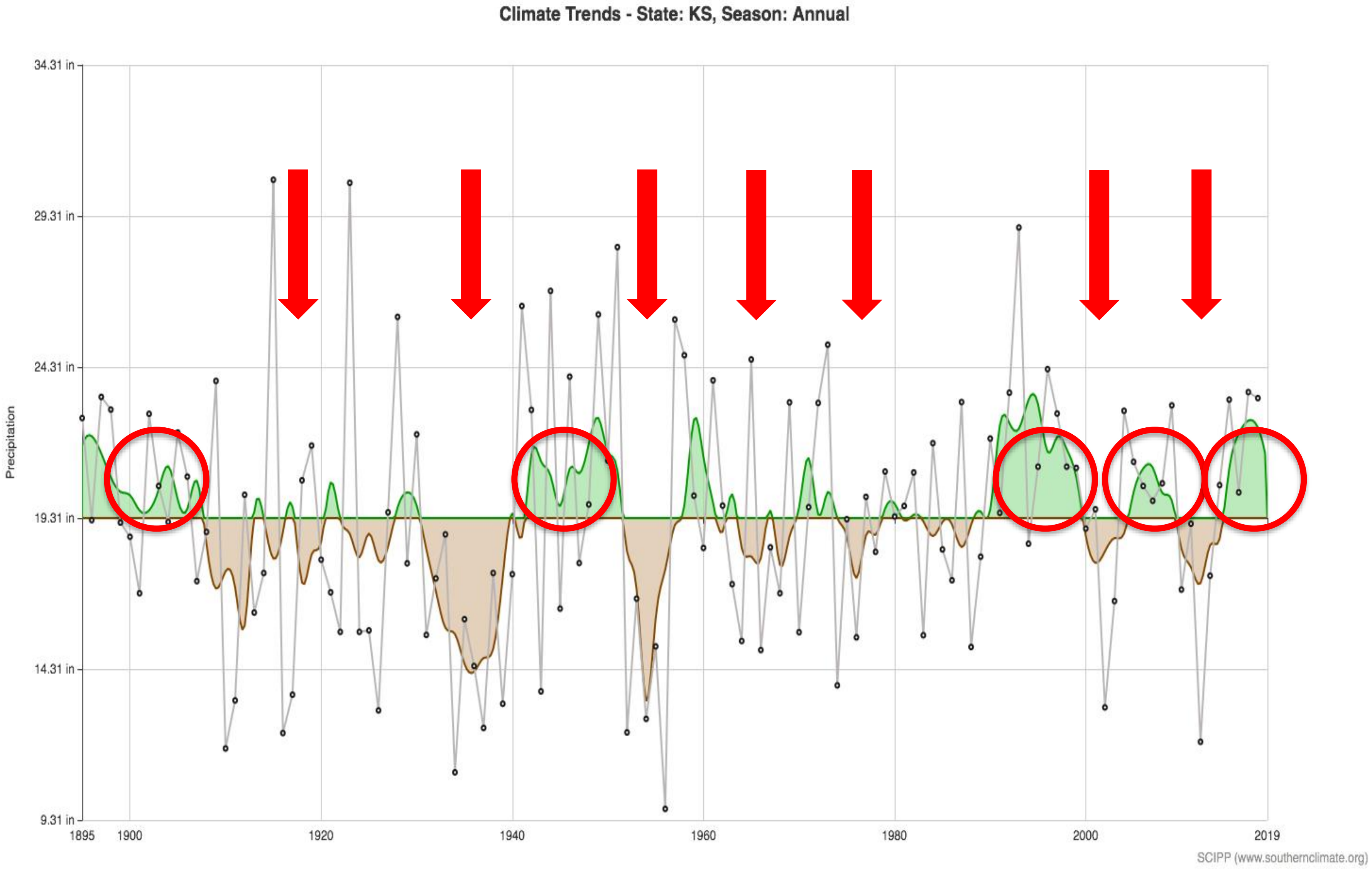
Historical Droughts (and Pluvials) in Oklahoma



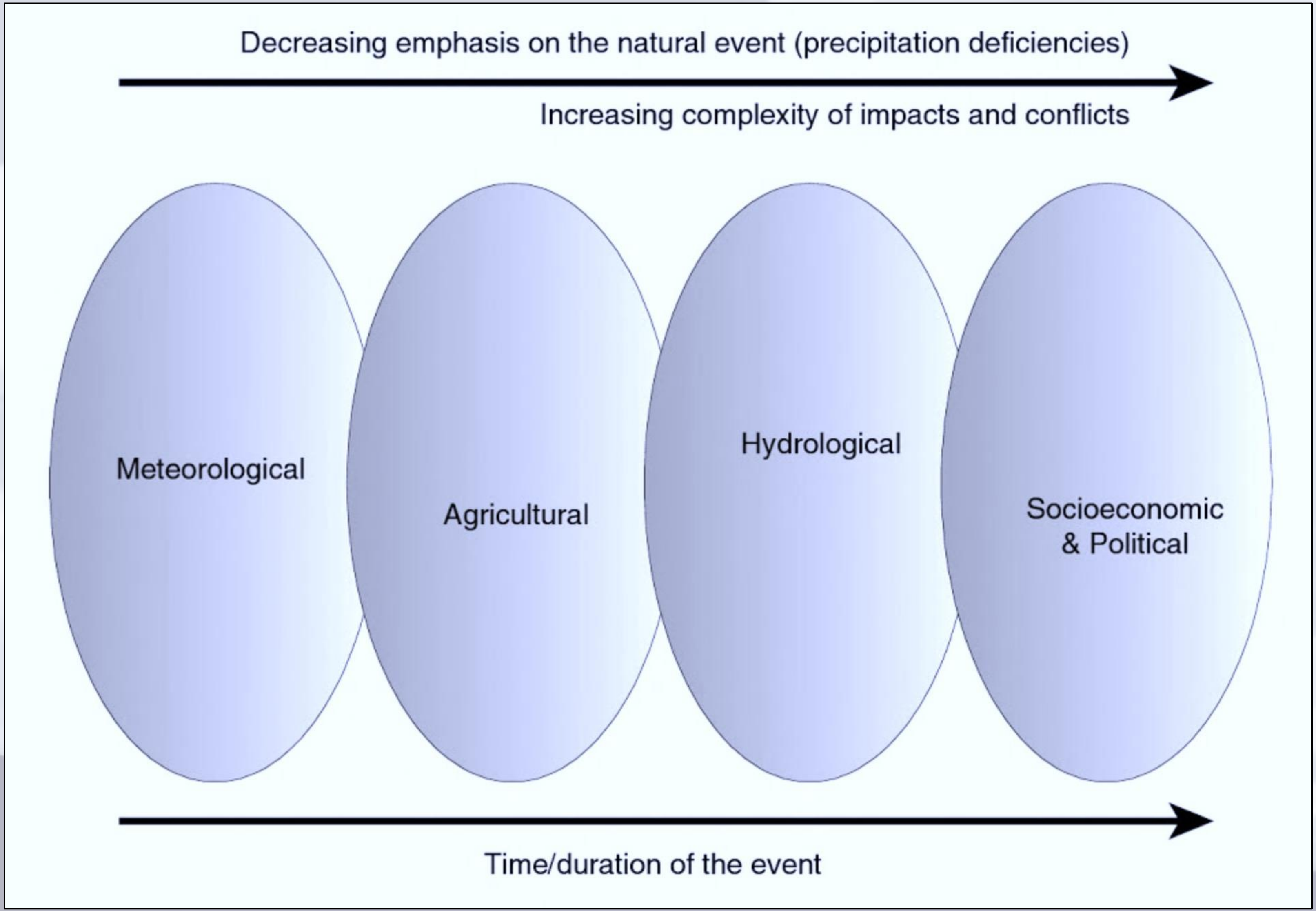
Historical Droughts (and Pluvials) in East-Central KS



Historical Droughts (and Pluvials) in West-Central KS

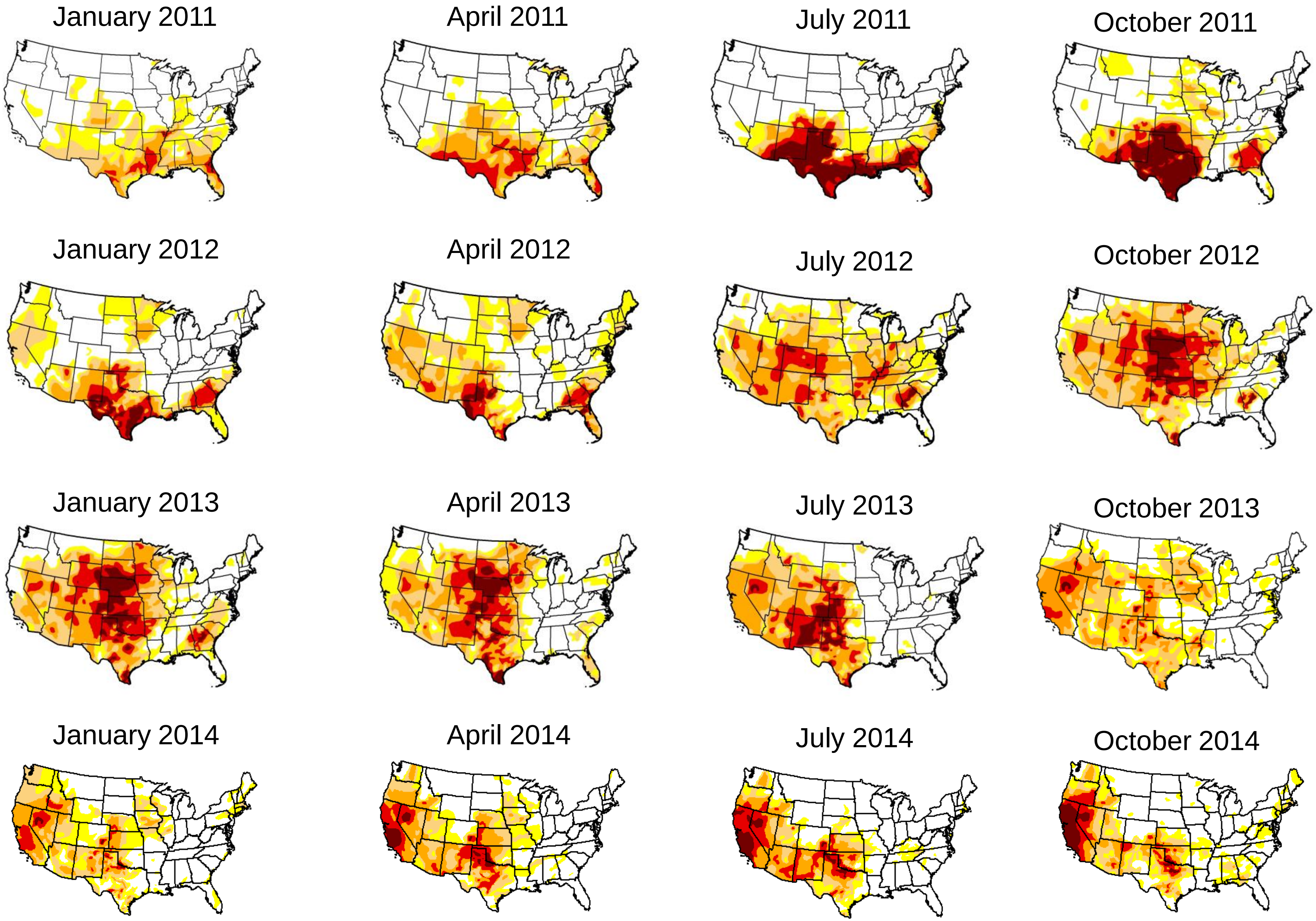


Types of Drought



Wilhite 2005



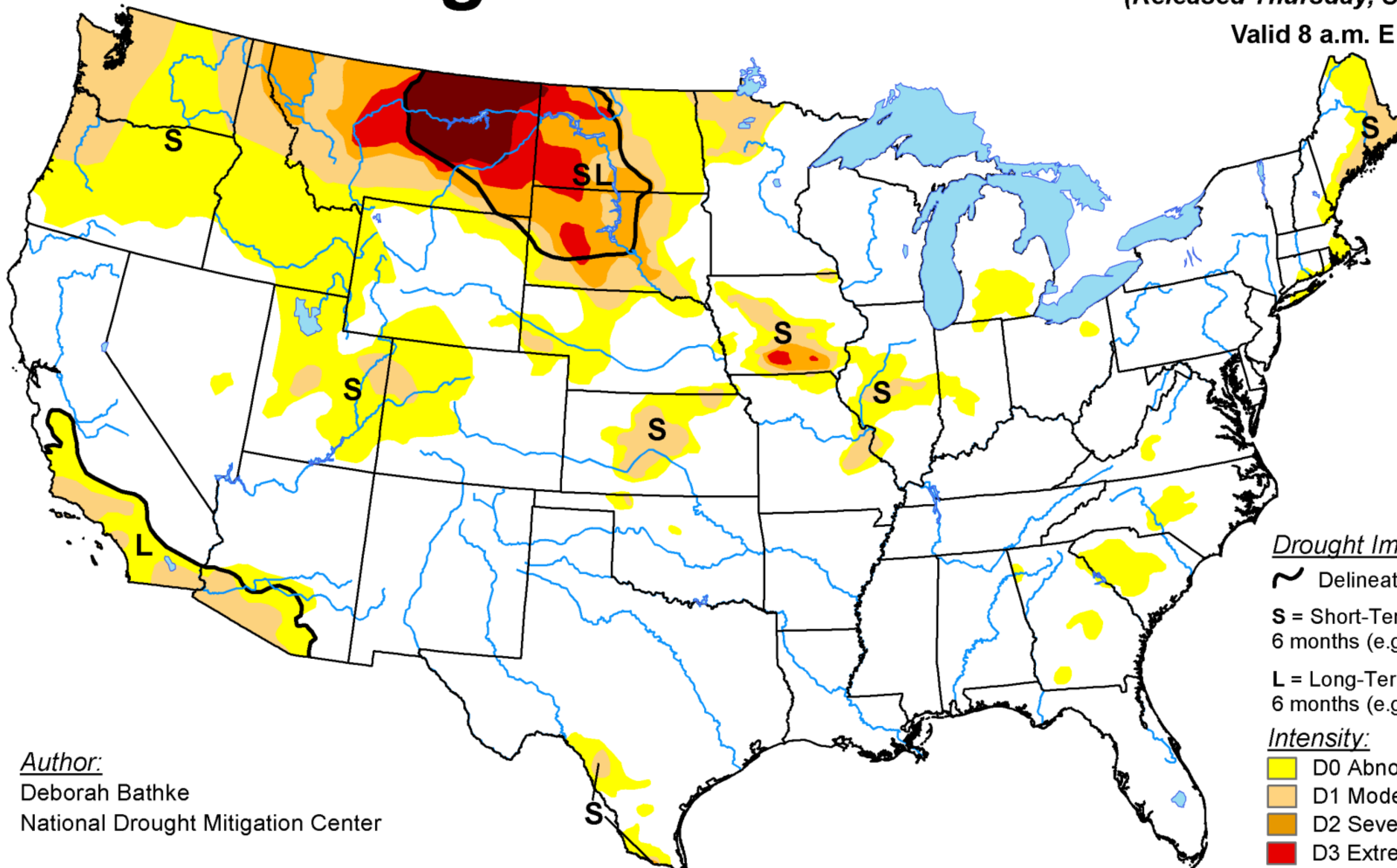
January 2011
April 2011
July 2011
October 2011
January 2012
April 2012
July 2012
October 2012
January 2013
April 2013
July 2013
October 2013
January 2014
April 2014
July 2014
October 2014

U.S. Drought Monitor

September 5, 2017

(Released Thursday, Sep. 7, 2017)

Valid 8 a.m. EDT



<u>Drought Impact Types:</u>

~ Delineates dominant impacts

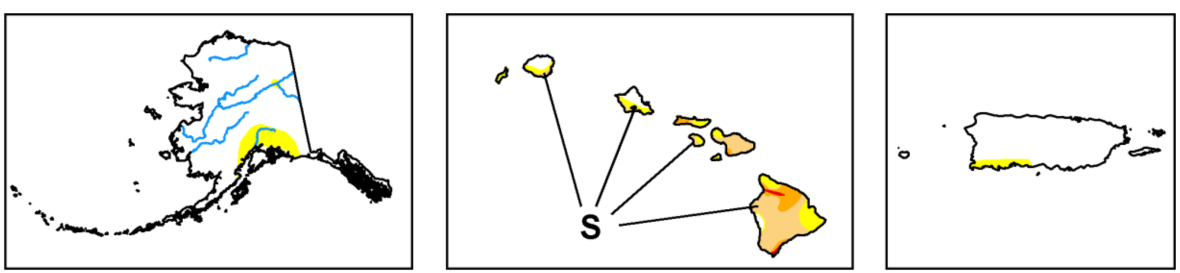
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

<u>Intensity:</u>

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

<u>Author:</u>
Deborah Bathke
National Drought Mitigation Center



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

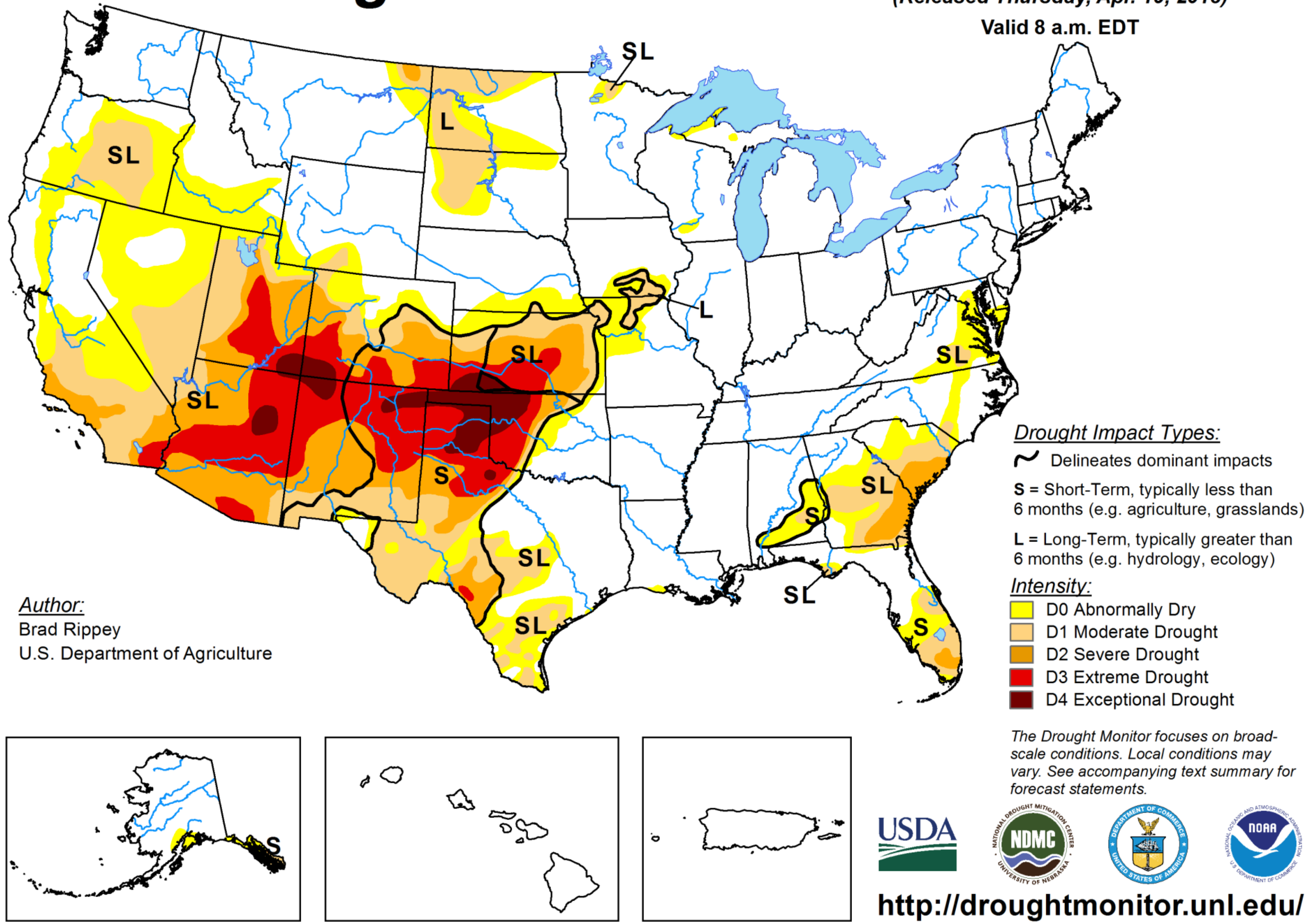
http://droughtmonitor.unl.edu/

U.S. Drought Monitor

April 17, 2018

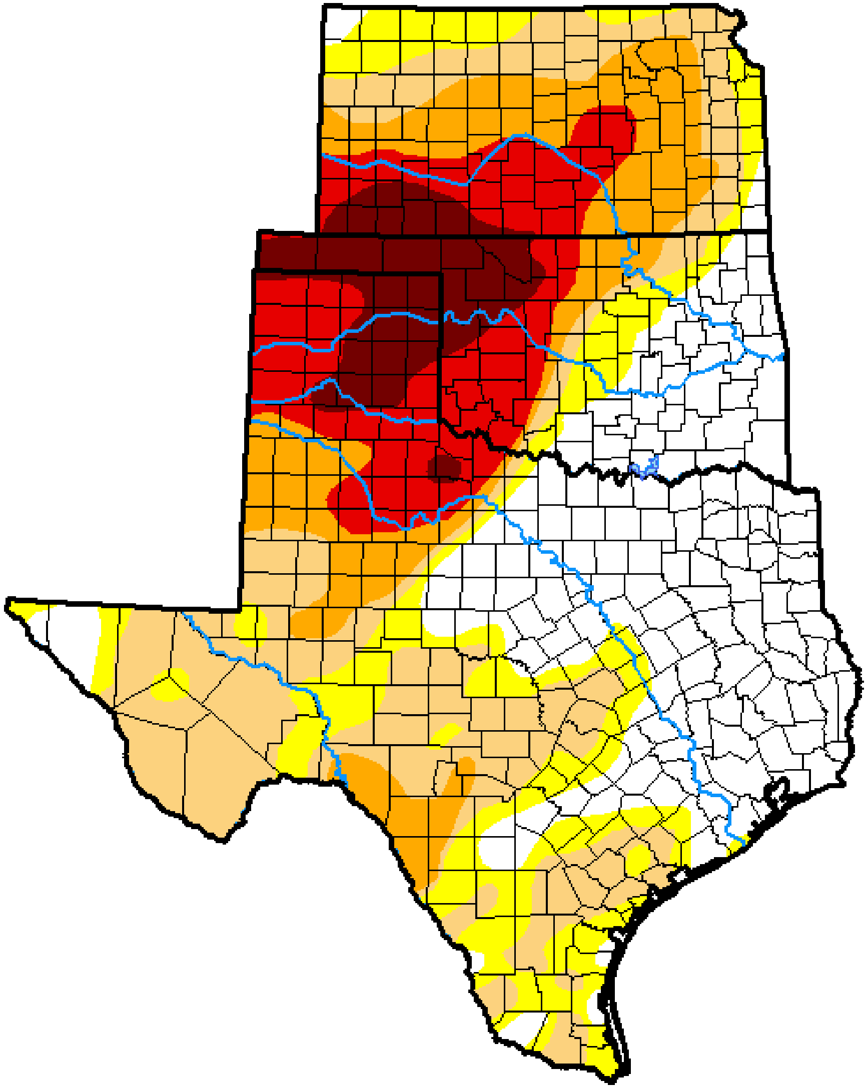
(Released Thursday, Apr. 19, 2018)

Valid 8 a.m. EDT



U.S. Drought Monitor

USDA Southern Plains Climate Hub



April 10, 2018

(Released Thursday, Apr. 12, 2018)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	29.68	70.32	55.52	32.88	19.57	7.19
Last Week *04-03-2018*	28.66	71.34	55.45	31.83	19.28	4.32
3 Months Ago *01-09-2018*	17.21	82.79	47.64	17.28	1.72	0.00
Start of Calendar Year *01-02-2018*	21.20	78.80	40.69	11.99	0.07	0.00
Start of Water Year *09-26-2017*	67.42	32.58	4.77	0.29	0.00	0.00
One Year Ago *04-11-2017*	67.53	32.47	11.30	2.29	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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Author:

David Miskus

NOAA/NWS/NCEP/CPC

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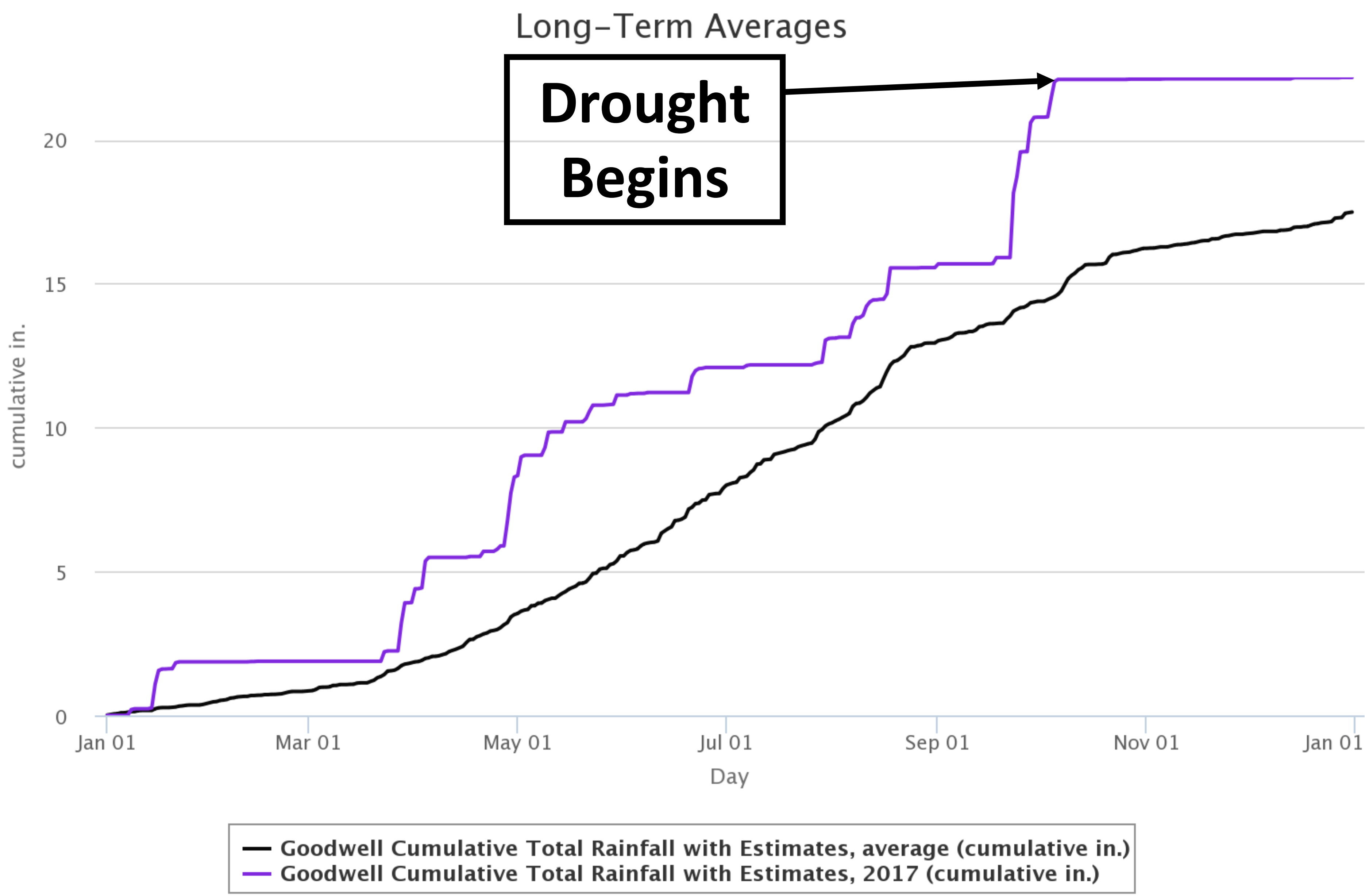
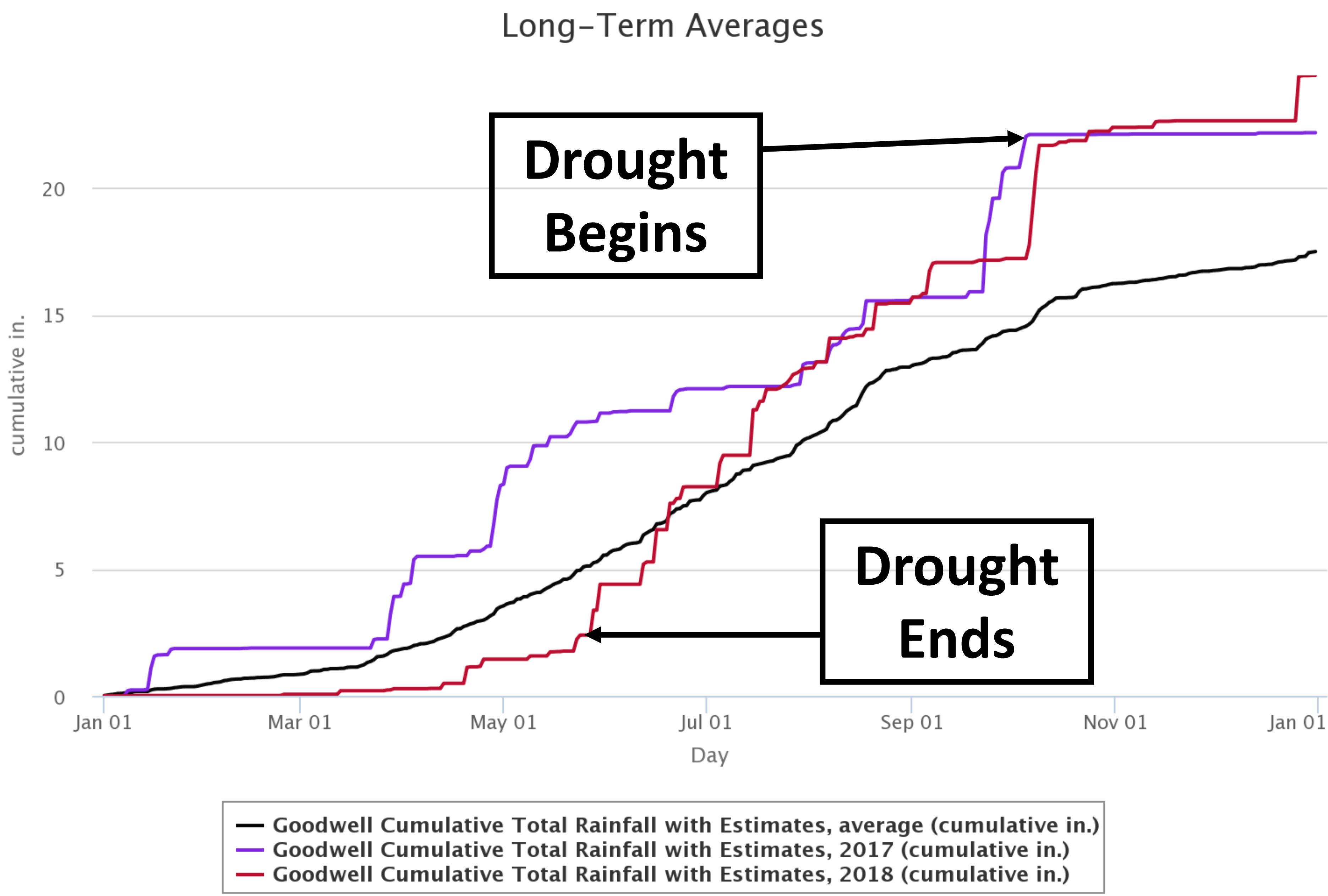


Long-Term Averages
Drought Begins
cumulative in.
0
5
10
15
20
Jan 01
Mar 01
May 01
Jul 01
Sep 01
Nov 01
Jan 01
Day
Goodwell Cumulative Total Rainfall with Estimates, average (cumulative in.)
Goodwell Cumulative Total Rainfall with Estimates, 2017 (cumulative in.)


Long-Term Averages
Drought Begins
Drought Ends
cumulative in.
0
5
10
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Jan 01
Mar 01
May 01
Jul 01
Sep 01
Nov 01
Jan 01
Day
Goodwell Cumulative Total Rainfall with Estimates, average (cumulative in.)
Goodwell Cumulative Total Rainfall with Estimates, 2017 (cumulative in.)
Goodwell Cumulative Total Rainfall with Estimates, 2018 (cumulative in.)

metro VOICE

Fires, dust storms plague Kansas this week

Winds approaching hurricane force and dry conditions fueled dangerous fires yesterday with gusts of 70 miles per hour in western Kansas challenging firefighters. Wildfires continue to burn across several Kansas Counties Wednesday after a day of raging flames.

Across western Kansas, winds were gusting 55 to 65 miles an hour, and dust storm conditions were reported in Thomas and Logan counties in northwest Kansas. School districts in those counties did not run afternoon bus routes because of zero visibility is some areas with blowing dust. Numerous roads were closed because of dangerous visibility and wind conditions.

Residents in northwestern Oklahoma evacuated after multiple wildfires break out

POSTED 6:37 PM, APRIL 12, 2018, BY K. BUTCHER, *UPDATED AT 09:30PM, APRIL 12, 2018*

This is an archived article and the information in the article may be outdated. Please look at the time stamp on the story to see when it was last updated.

WOODWARD COUNTY, Okla. – Residents in northwestern Oklahoma were evacuated after multiple wildfires broke out Thursday evening.

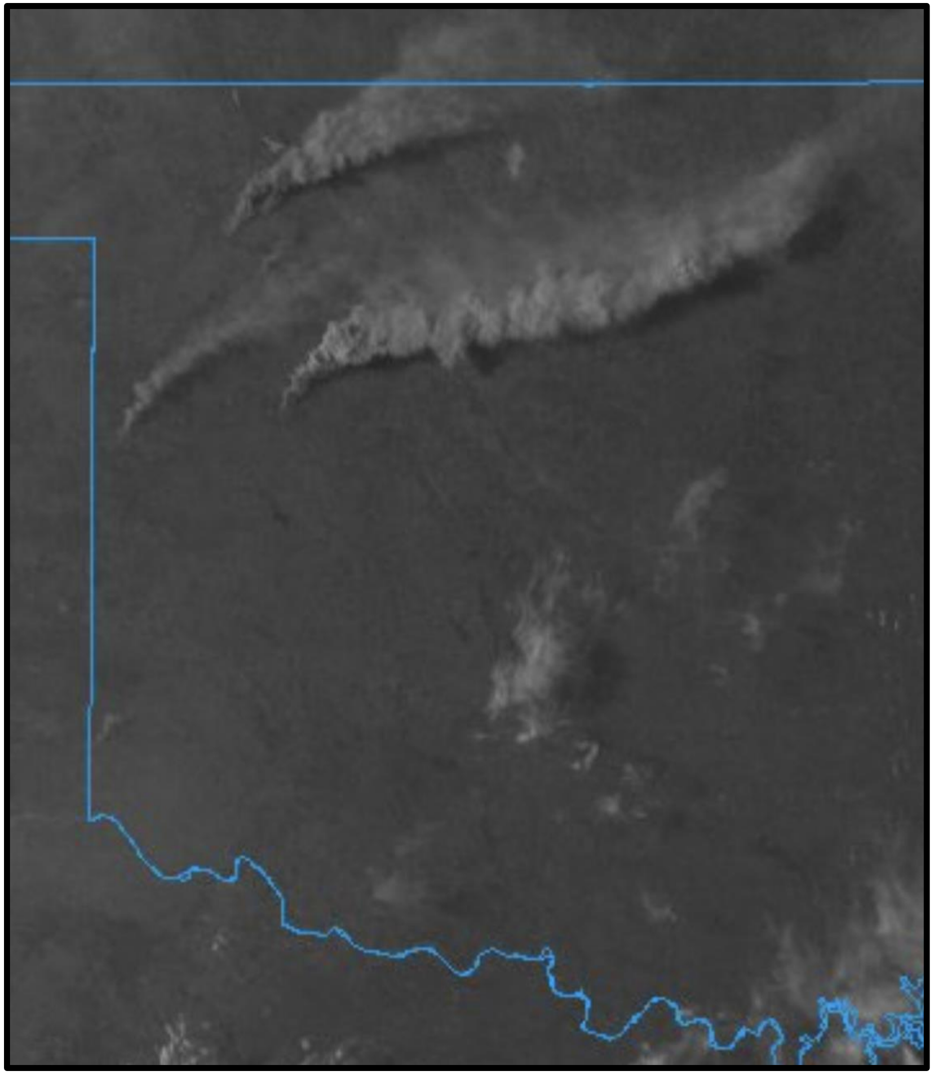
According to the Oklahoma Forestry Services, multiple fires were spreading near Woodward.

OK Forestry Services
@OKForestService

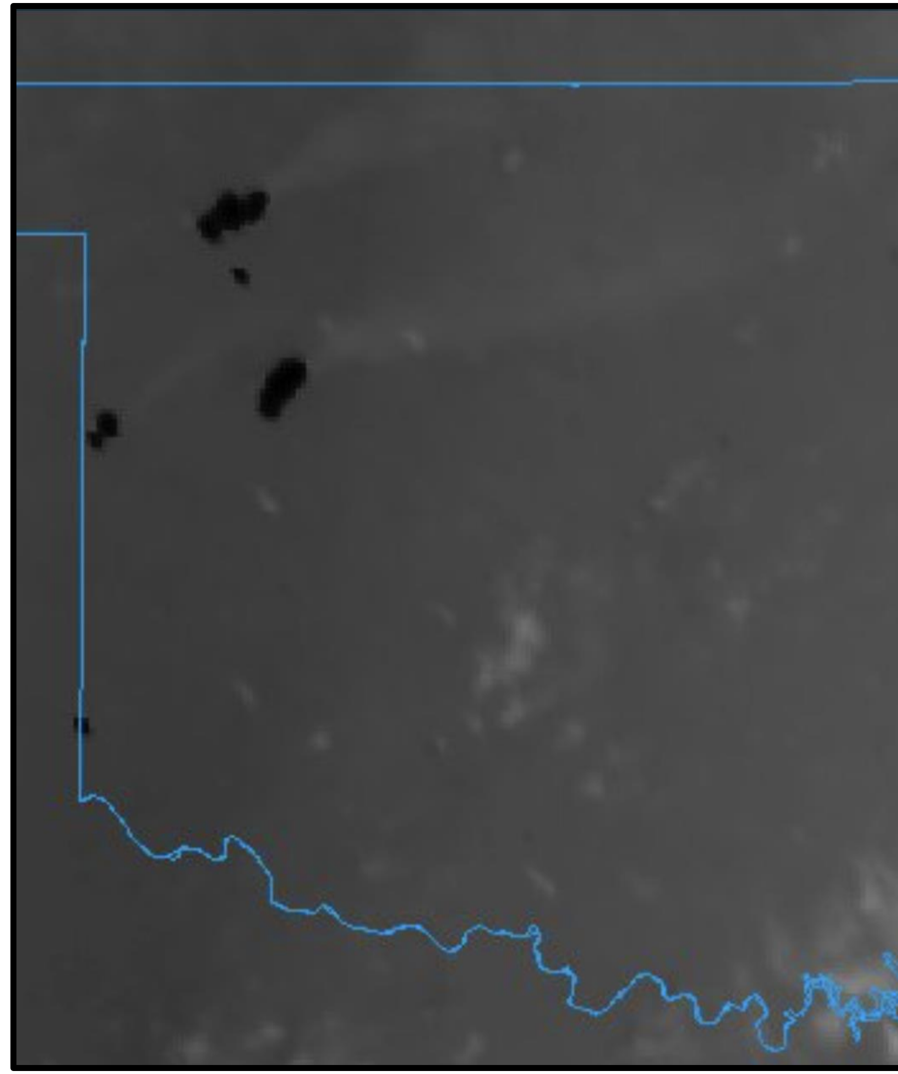
NEW fire: 34 Complex 4 miles NW of Woodward. Multiple structures threatened; multiple fires; evacuations in progress with a Red Cross Shelter established at Faith United Methodist Church 1402 Texas Ave in Woodward.

11 5:38 PM - Apr 12, 2018

Wildfires in Northwest Oklahoma – April, 2018



Smoke Plumes



Hot Spots

Causes of Drought

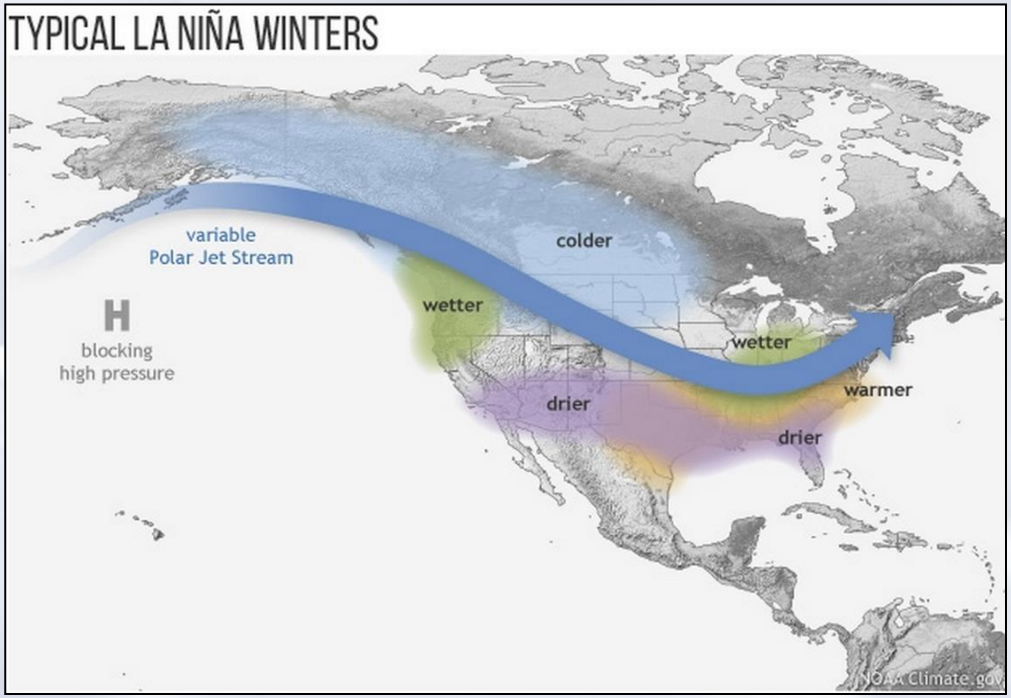
<u>Teleconnections</u>

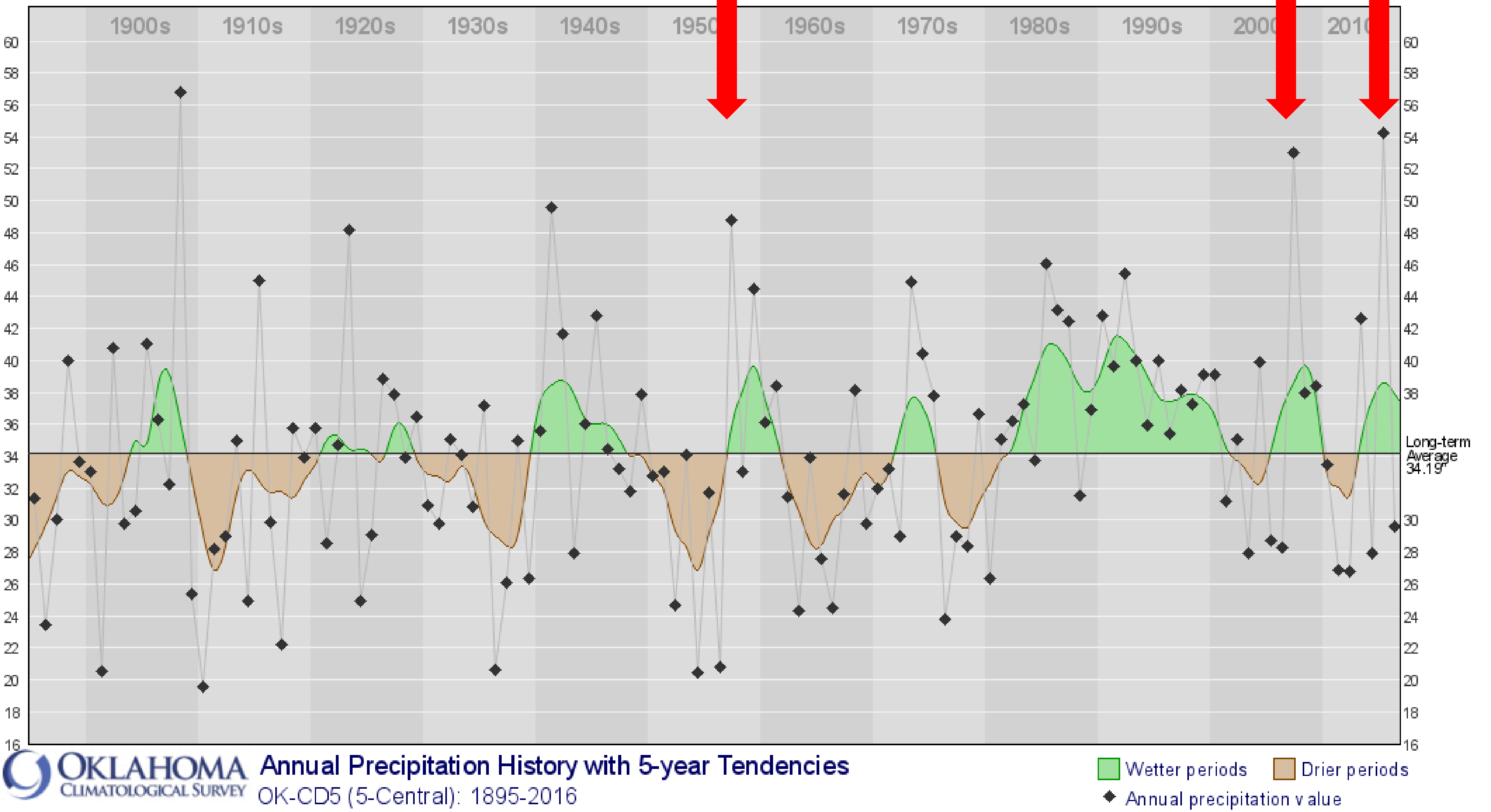
Sea surface temperature (SST) anomalies can contribute to drought conditions by affecting synoptic patterns and atmospheric circulations.

El-Nino Southern Oscillation (ENSO)

Pacific Decadal Oscillation (PDO)

Atlantic Multidecadal Oscillation (AMO)





1900s
1910s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
Long-term Average 34.19"
OKLAHOMA CLIMATOLOGICAL SURVEY
Annual Precipitation History with 5-year Tendencies
OK-CD5 (5-Central): 1895-2016
Wetter periods
Drier periods
Annual precipitation value

Dipole Transitions

A pair of equal and opposite electric charges or magnetic poles of opposite sign separated especially by a small distance.

An abrupt year-to-year transition from drought to pluvial (flood).

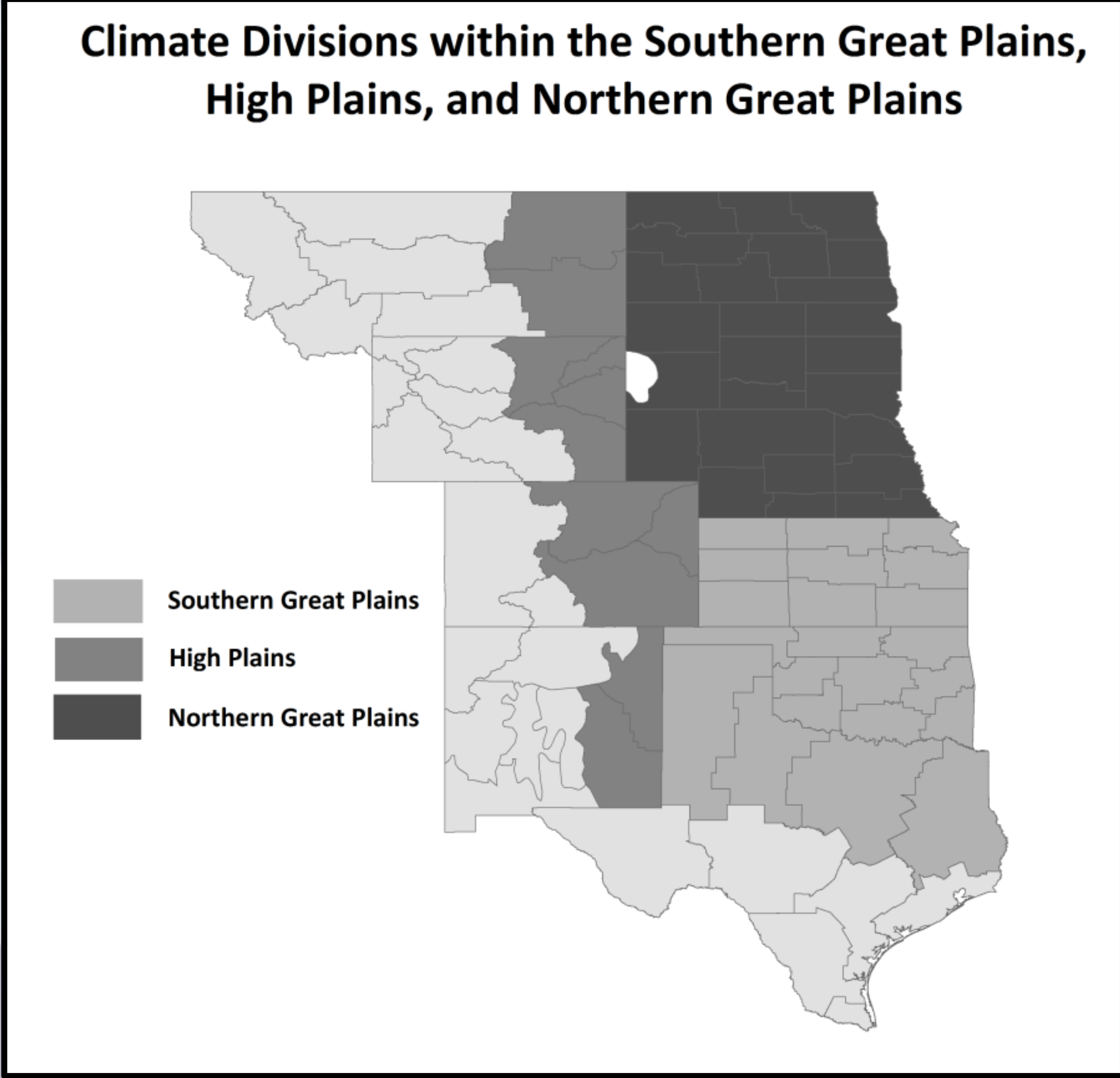
Able to erase multi-year droughts in a matter of months.

Christian J., K. Christian, and J. B. Basara, 2015: Drought and Pluvial Dipole Events within the Great Plains of the United States. *J. Appl. Meteor. Climatol.*, **54**, 1886–1898.

Study Area

Three regions with different climatological characteristics
- Southern Great Plains (SGP)
- Northern Great Plains (NGP)
- High Plains (HP)

Probability of a significant drought year followed by a pluvial year:
- SGP: 25%
- NGP: 25%
- HP: 16%



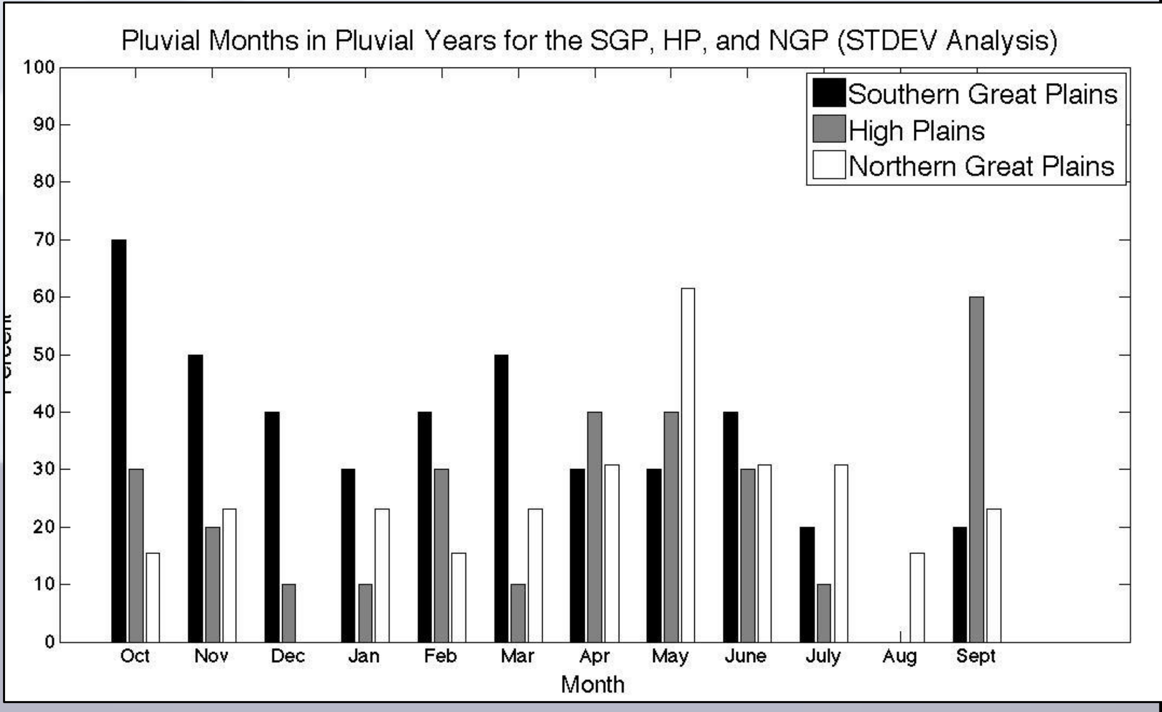
When Does It Happen?

Wettest months of pluvial year varies
- Months with 40% or more above normal precipitation

SGP transition most likely fall / late winter

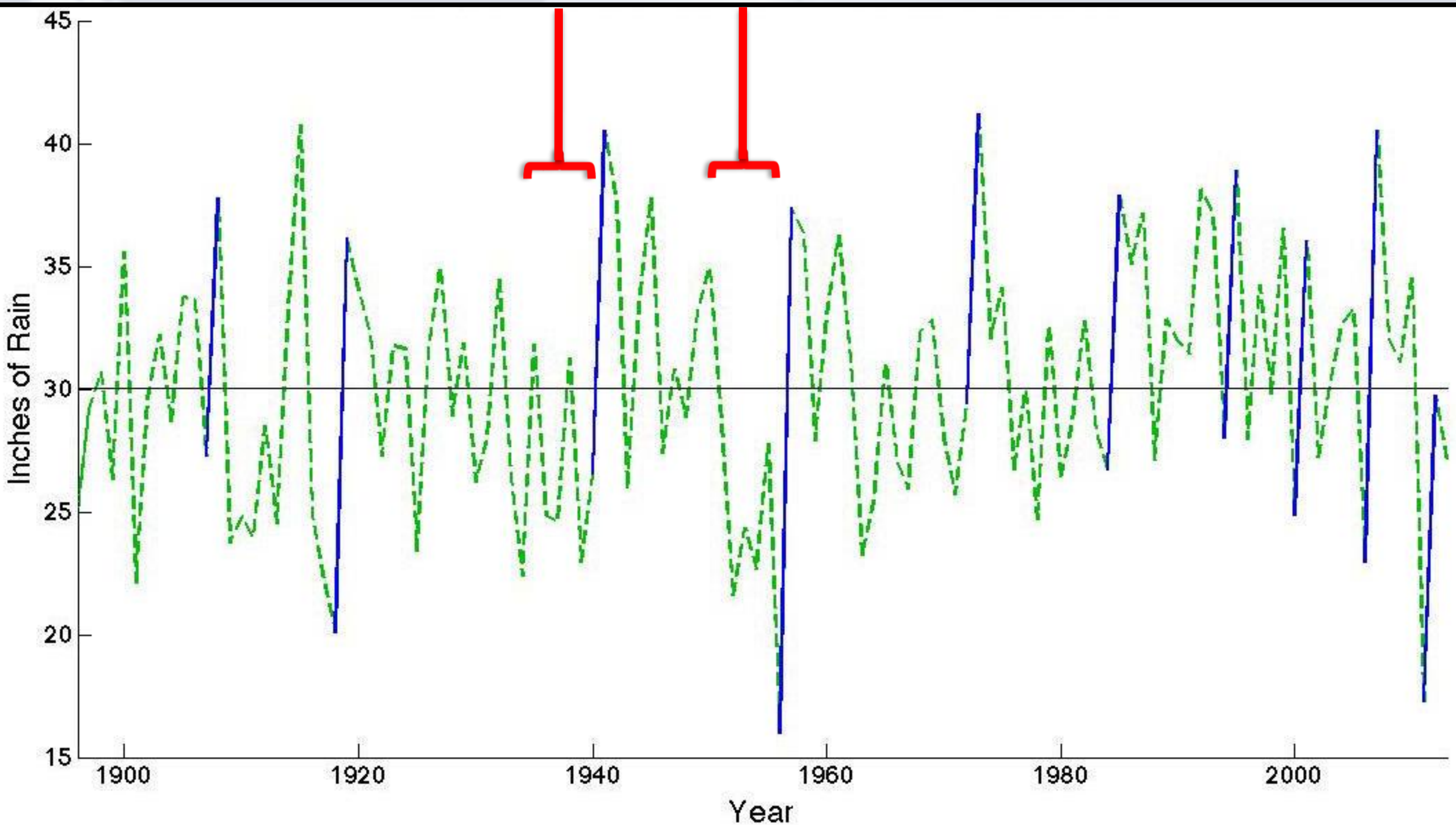
NGP transition most common in spring, especially May

HP transition most
Common in September
with a secondary peak
in the Spring



Notable STDEV Occurrences in SGP

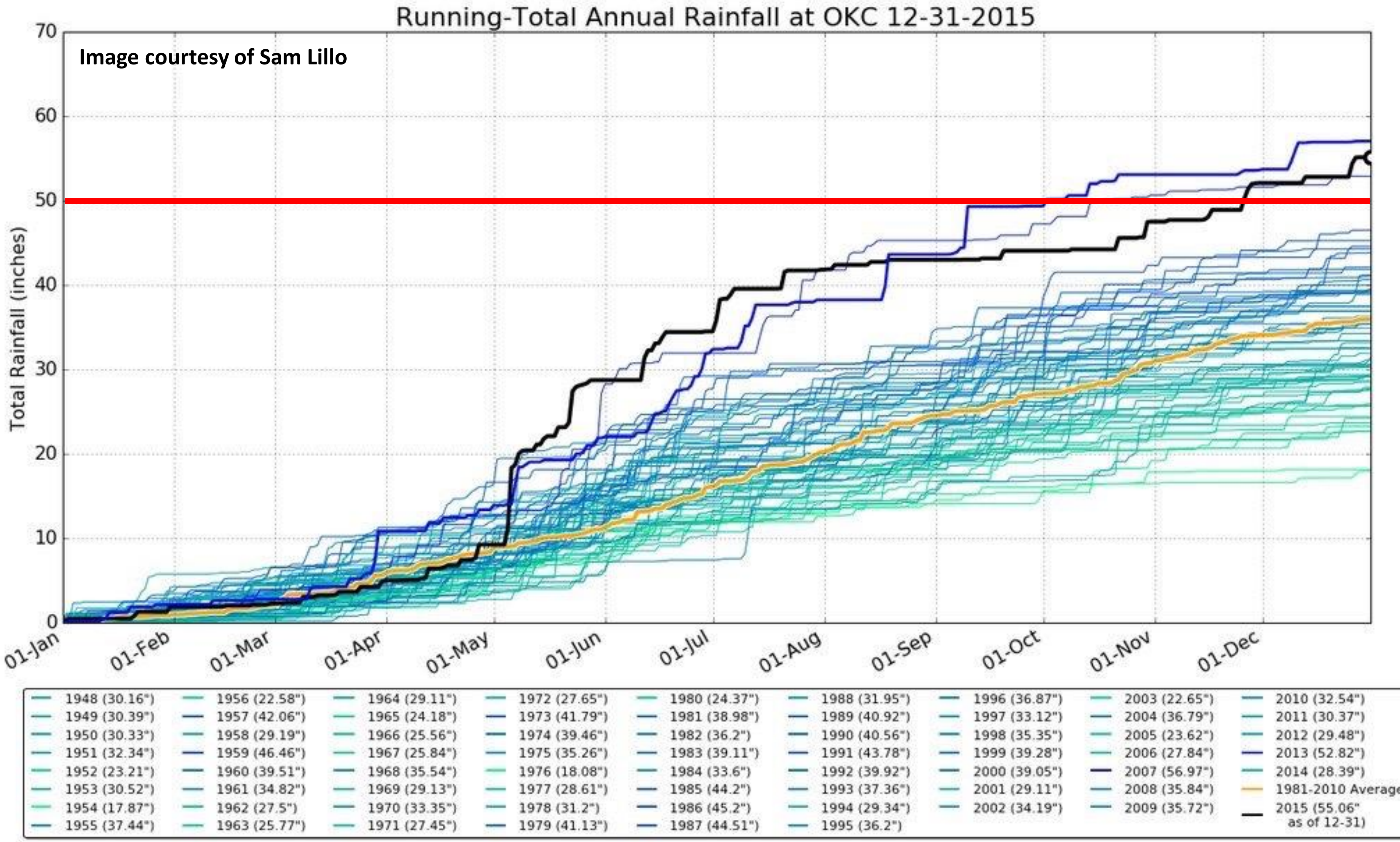
Droughts of Record




October 2014


May 2015

Increasing Variability



Years in Oklahoma City with greater than 50” of rain: 1908, 2007, 2013, 2015

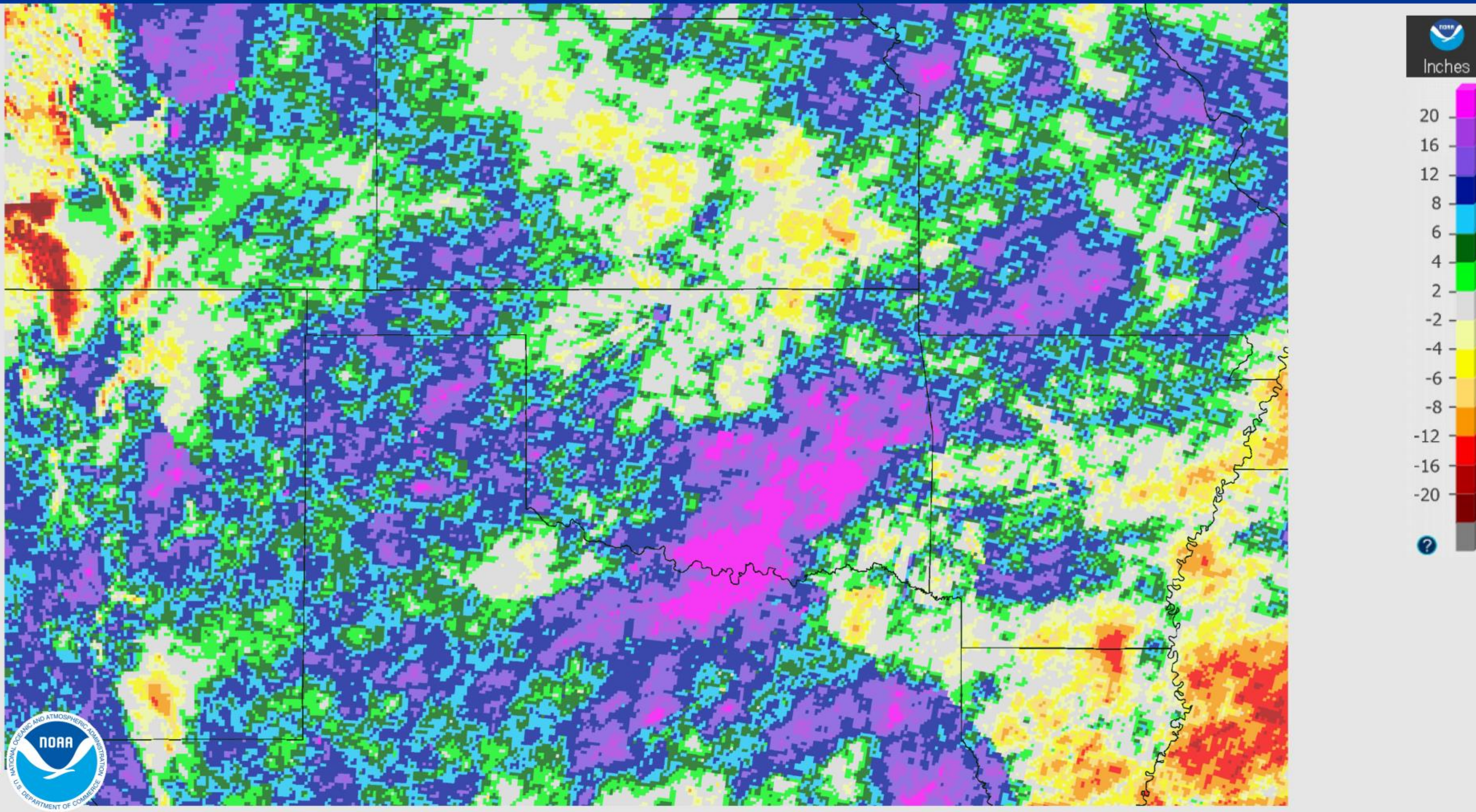
*Currently at 43.96” for 2019

May 2015: Grand Lake Oklahoma; Little Blue State Park

October 01, 2015 Water Year (Oct. 1) Departure Precipitation

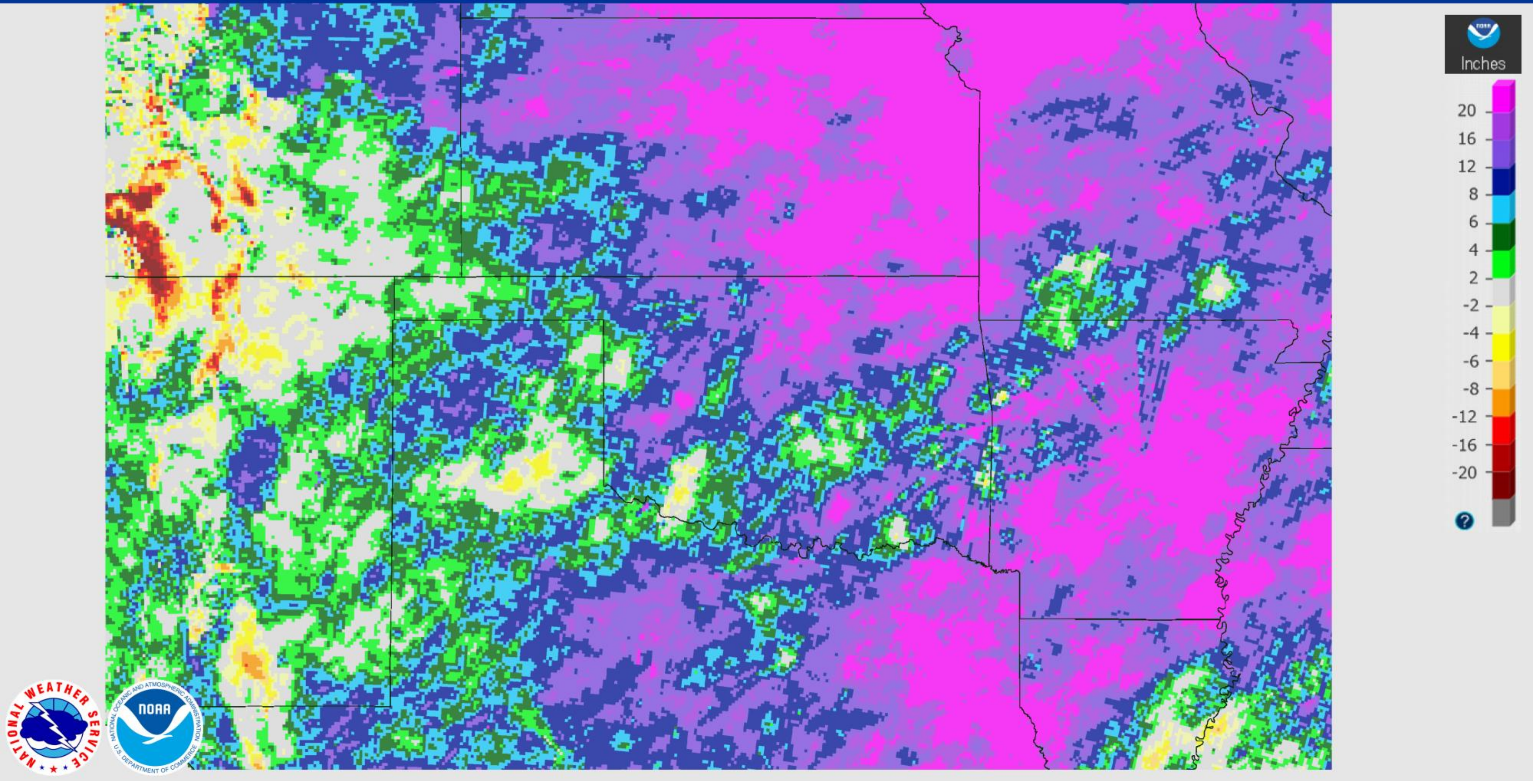
Created on: November 07, 2019 - 20:15 UTC

Valid on: October 01, 2015 12:00 UTC



October 01, 2019 Water Year (Oct. 1) Departure Precipitation

Created on: November 07, 2019 - 20:12 UTC
Valid on: October 01, 2019 12:00 UTC

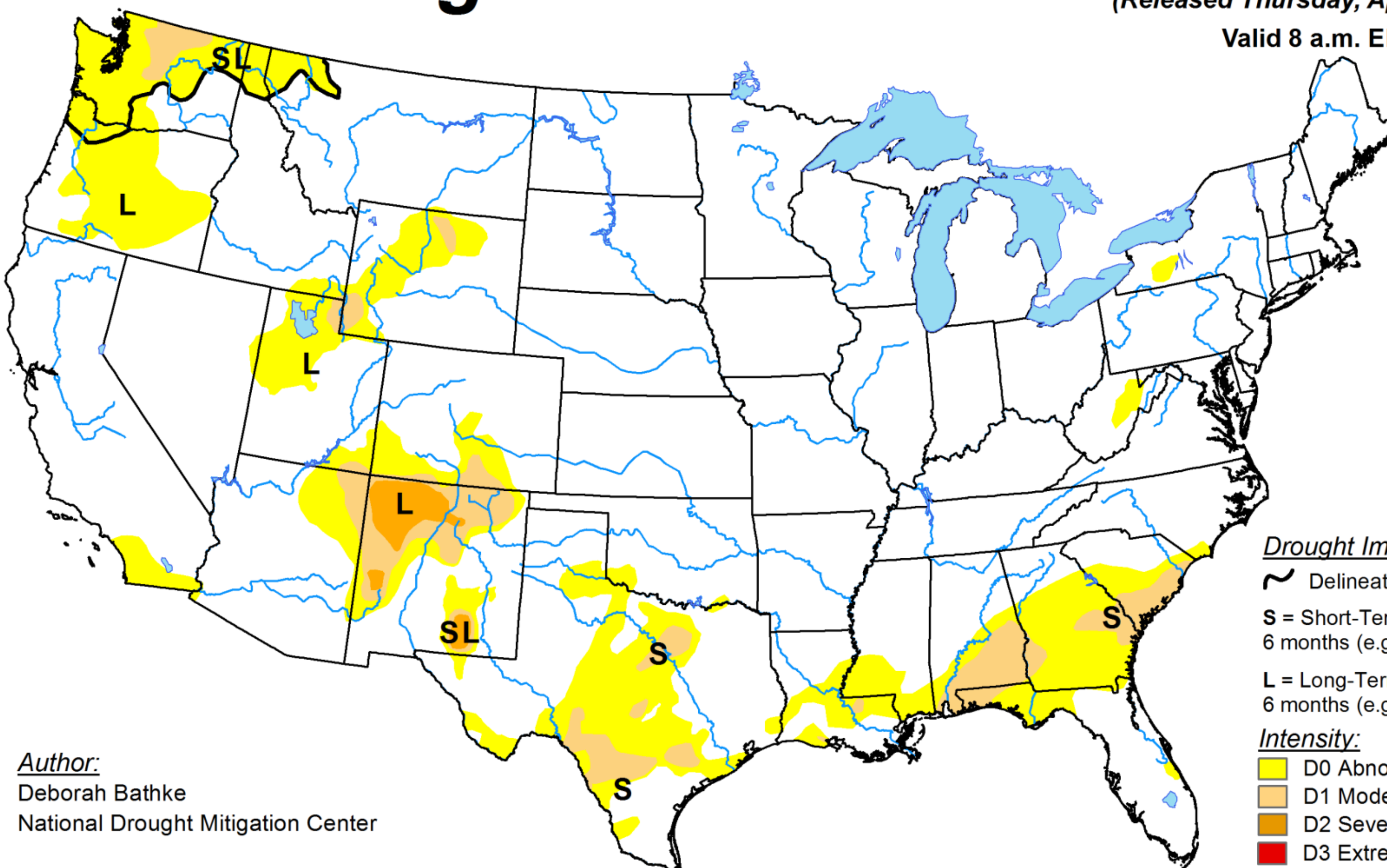


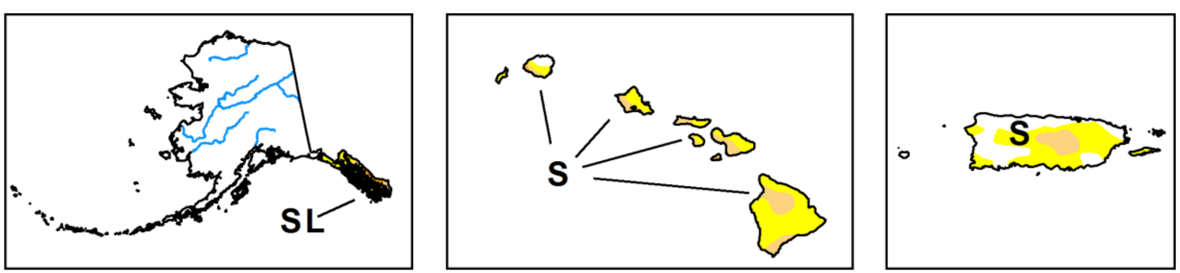
U.S. Drought Monitor

April 9, 2019

(Released Thursday, Apr. 11, 2019)

Valid 8 a.m. EDT





Drought Impact Types:

~ Delineates dominant impacts

S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:

- D0 Abnormally Dry
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Author:

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National Drought Mitigation Center

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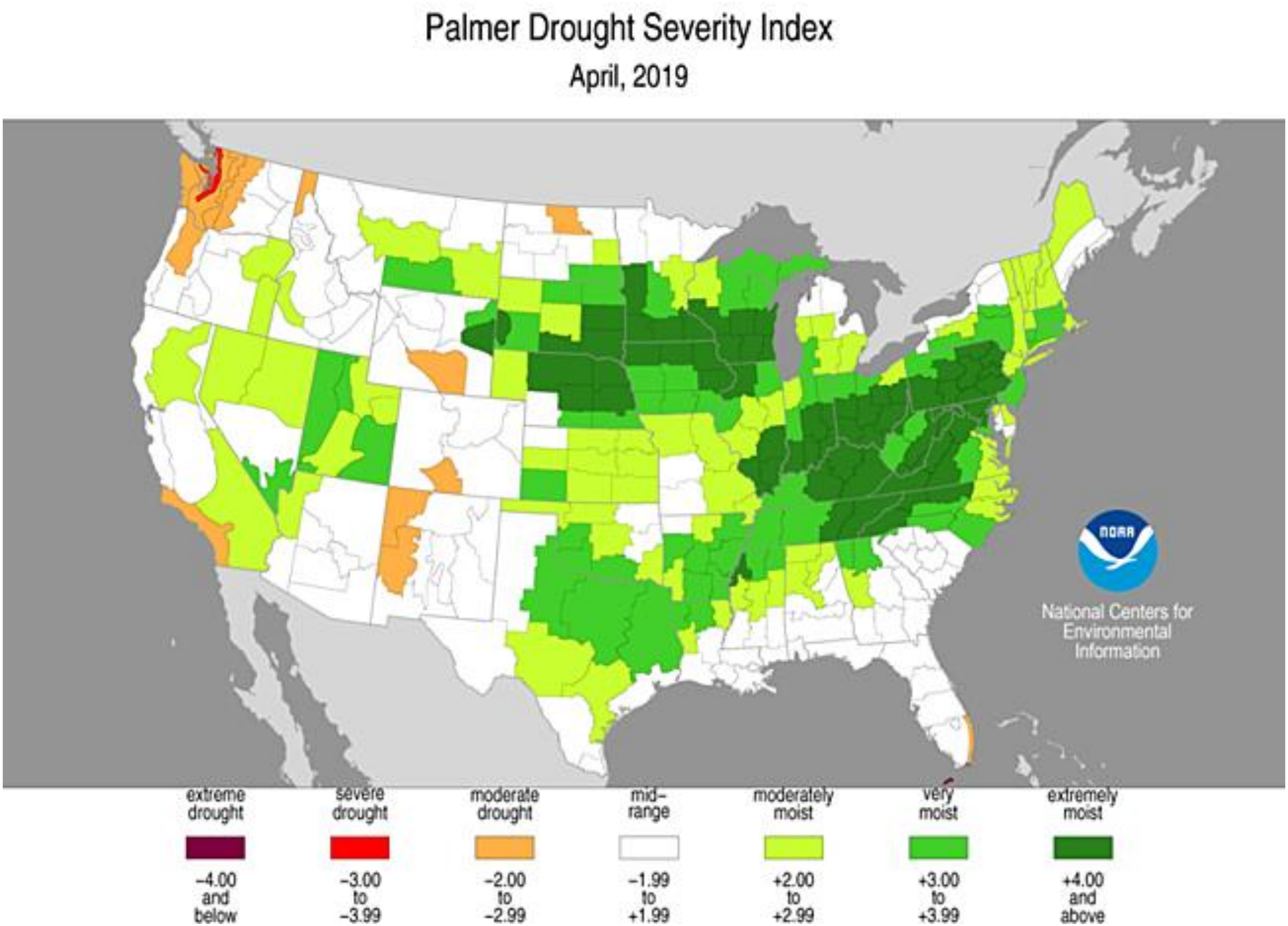
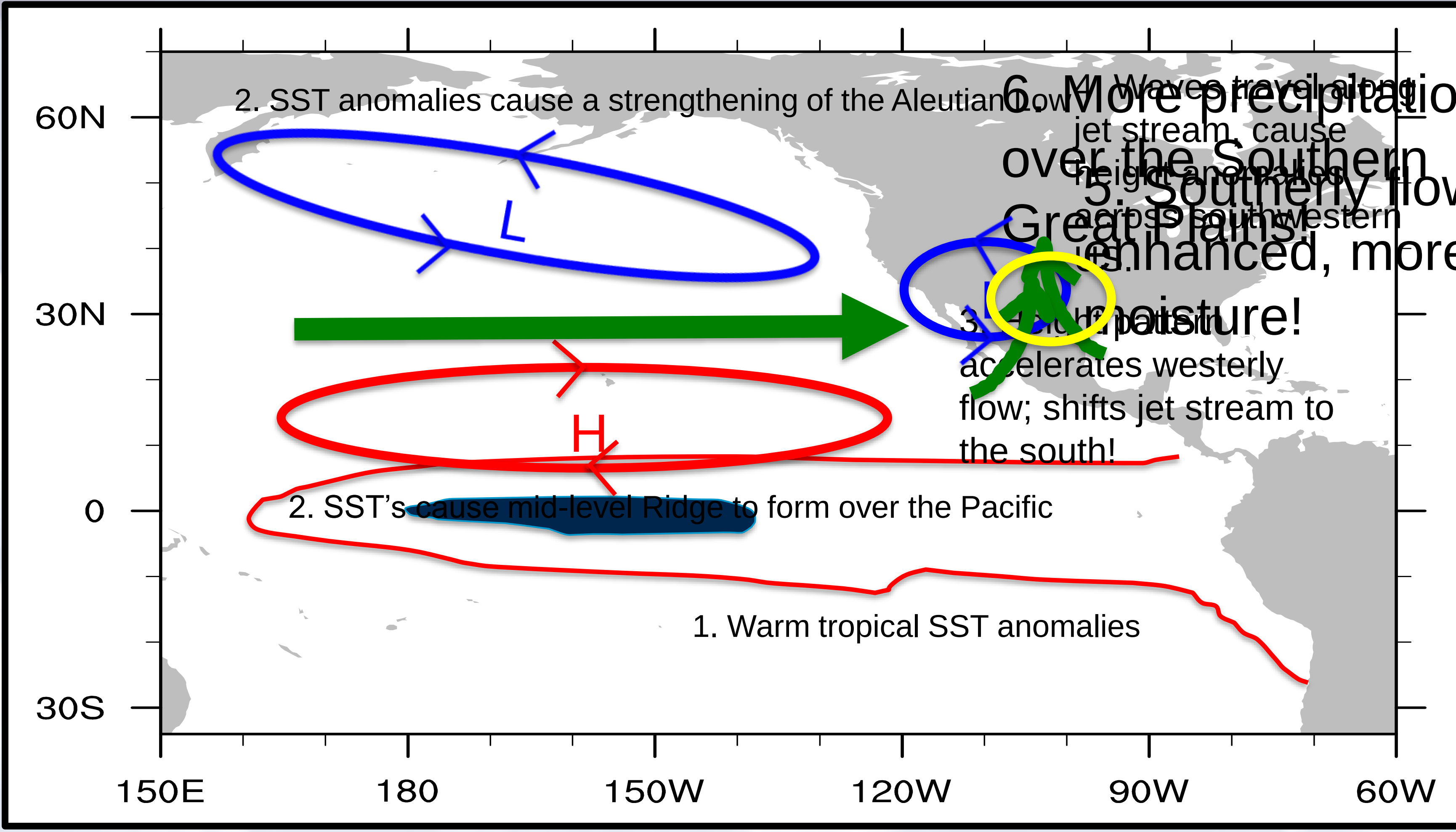


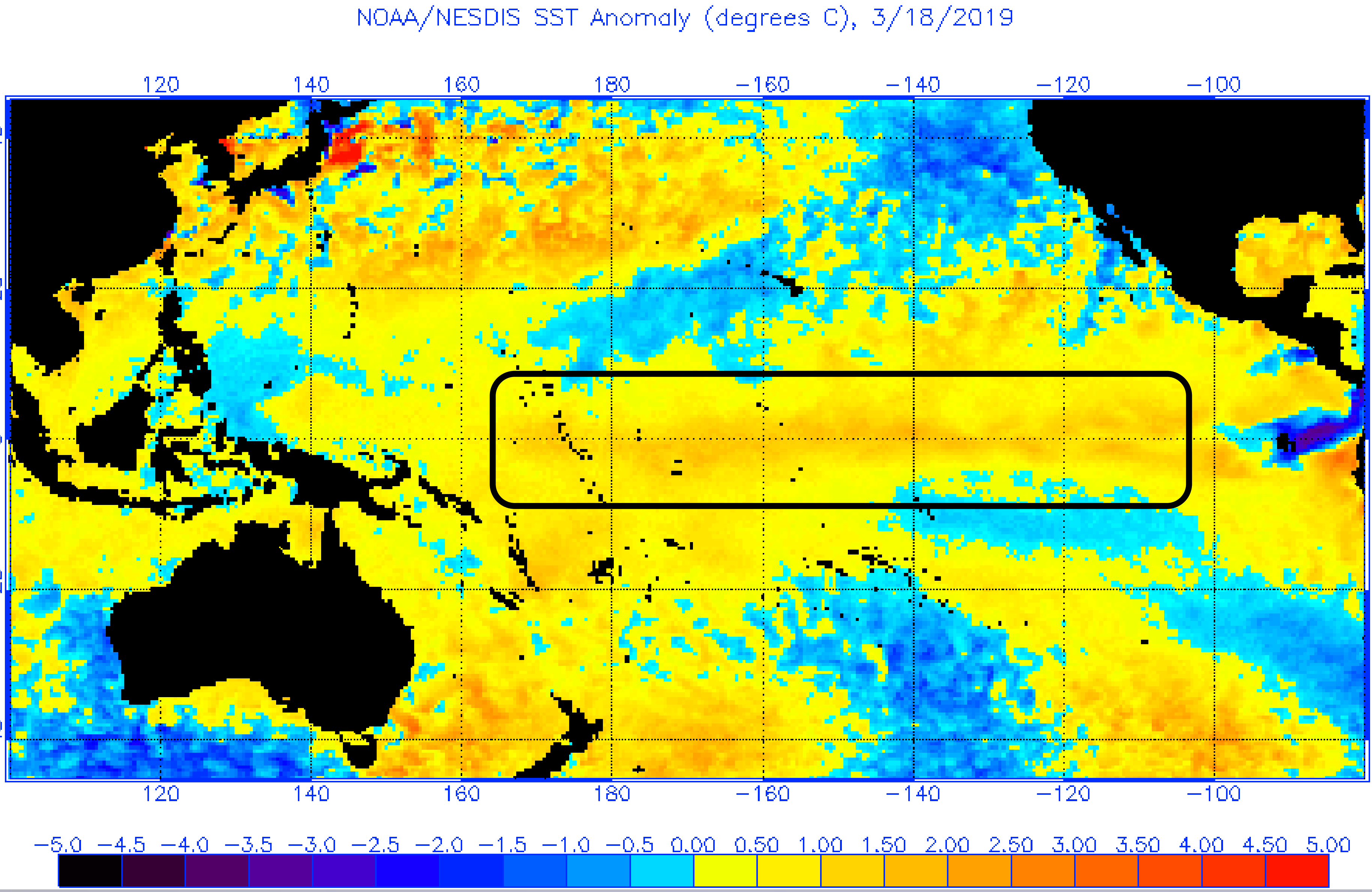
Palmer Drought Severity Index
April, 2019
NOAA
National Centers for Environmental Information
extreme drought
-4.00 and below
severe drought
-3.00 to -3.99
moderate drought
-2.00 to -2.99
mid-range
-1.99 to +1.99
moderately moist
+2.00 to +2.99
very moist
+3.00 to +3.99
extremely moist
+4.00 and above

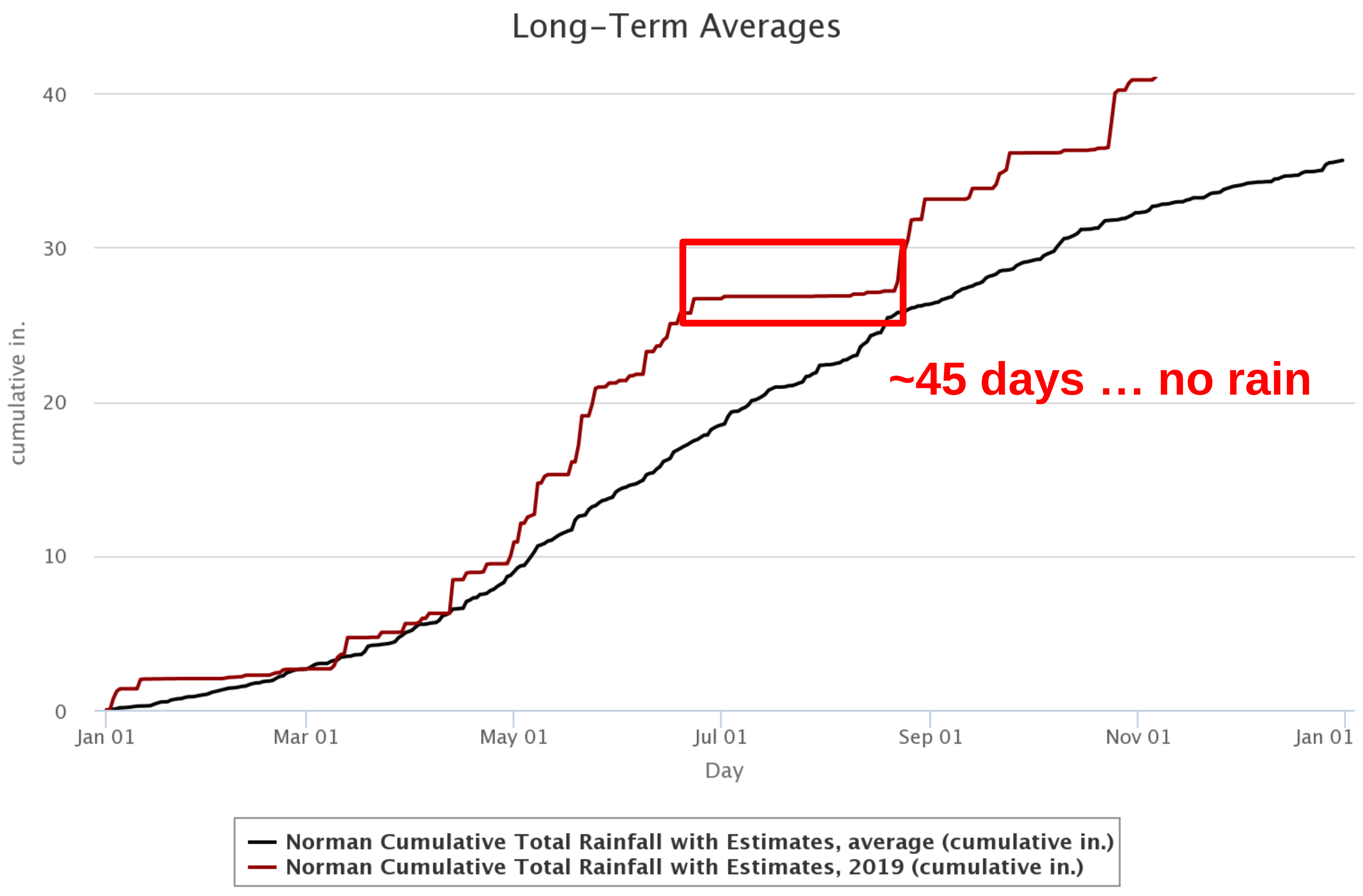


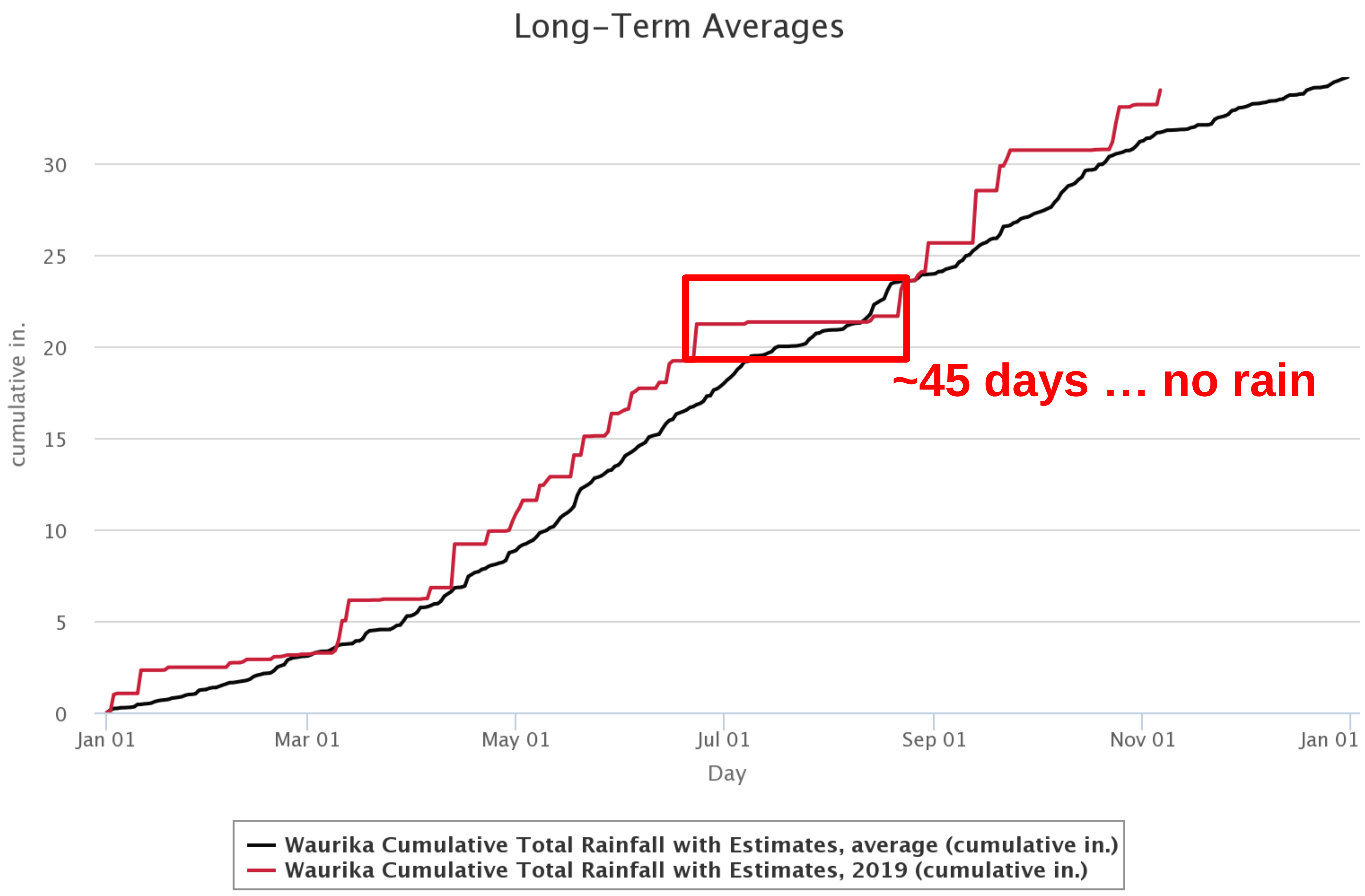
Flanagan, P. X., J. B. Basara, J. C. Furtado, X. Xiao, 2018: Primary atmospheric drivers of pluvial years in the United States Great Plains. *J. Hydrometeor.*, **19**, 643–658, doi: https://doi.org/10.1175/JHM-D-17-0148.1

Flanagan, P.X., J. B. Basara, J. C. Furtado, E. R. Martin, X. Xiao, 2018: Role of Pacific sea surface temperatures in United States Great Plains pluvial years. *J. Climate.,* **32**, 7081–7100.


NOAA/NESDIS SST Anomaly (degrees C), 3/18/2019
120 140 160 180 −160 −140 −120 −100
40 20 0 −20 −40
−5.0 −4.5 −4.0 −3.5 −3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00



Long-Term Averages
40
30
20
10
0
cumulative in.
Jan 01
Mar 01
May 01
Jul 01
Sep 01
Nov 01
Jan 01
Day
~45 days … no rain
Norman Cumulative Total Rainfall with Estimates, average (cumulative in.)
Norman Cumulative Total Rainfall with Estimates, 2019 (cumulative in.)

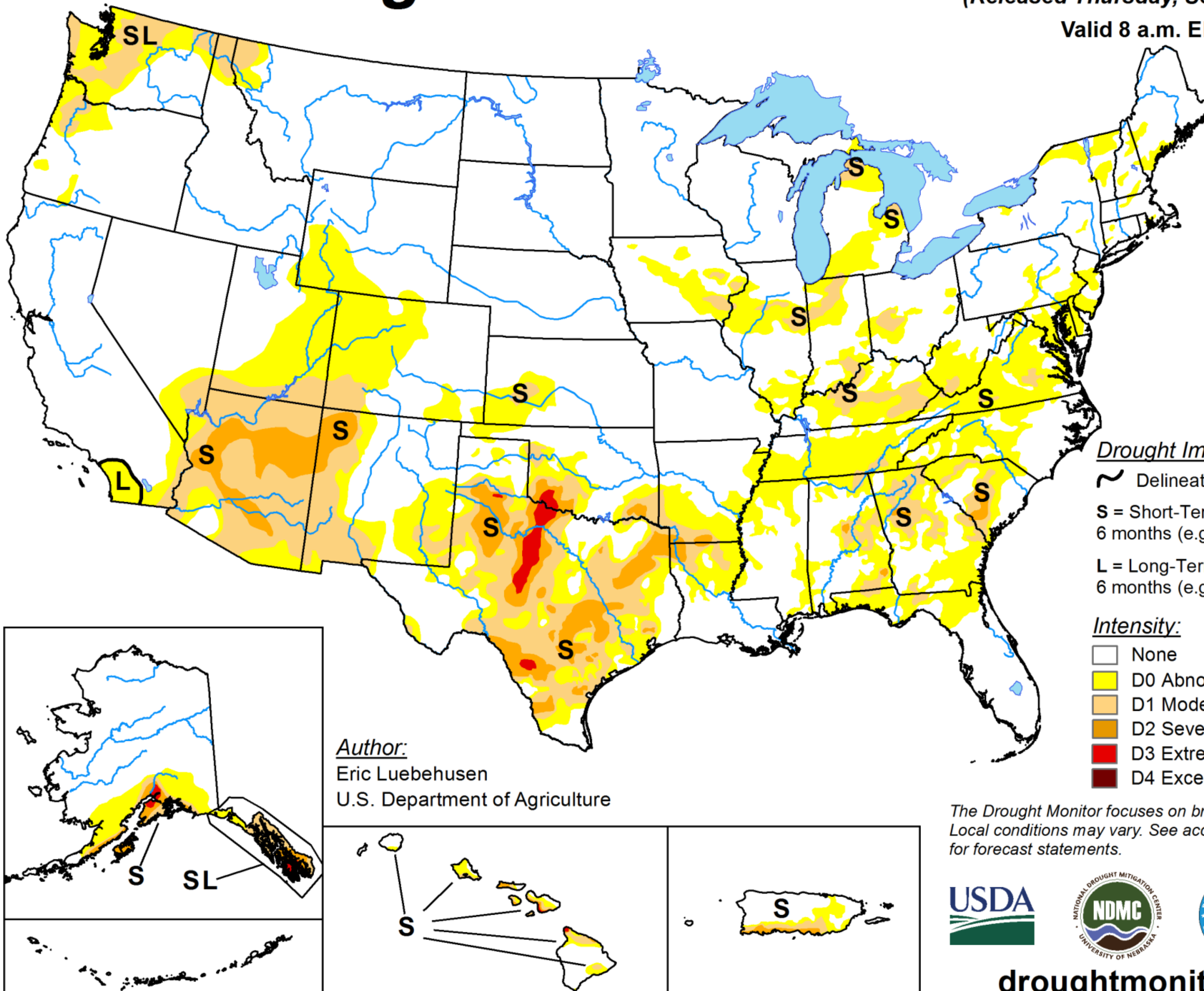

Long-Term Averages
cumulative in.
30
25
20
15
10
5
0
Jan 01
Mar 01
May 01
Jul 01
Sep 01
Nov 01
Jan 01
Day
~45 days … no rain
Waurika Cumulative Total Rainfall with Estimates, average (cumulative in.)
Waurika Cumulative Total Rainfall with Estimates, 2019 (cumulative in.)

U.S. Drought Monitor

September 17, 2019

(Released Thursday, Sep. 19, 2019)

Valid 8 a.m. EDT



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- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

Author:

Eric Luebehusen

U.S. Department of Agriculture

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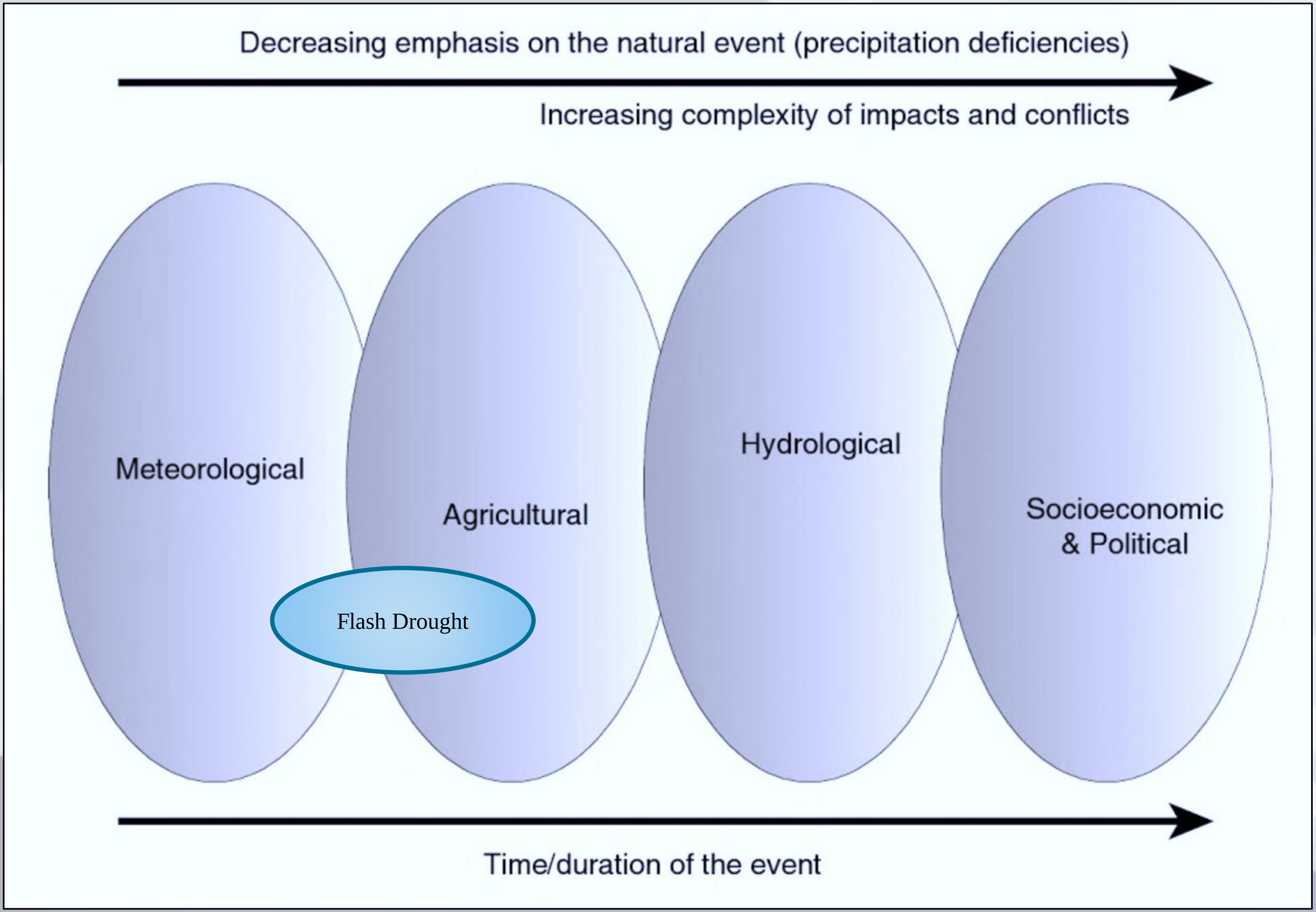
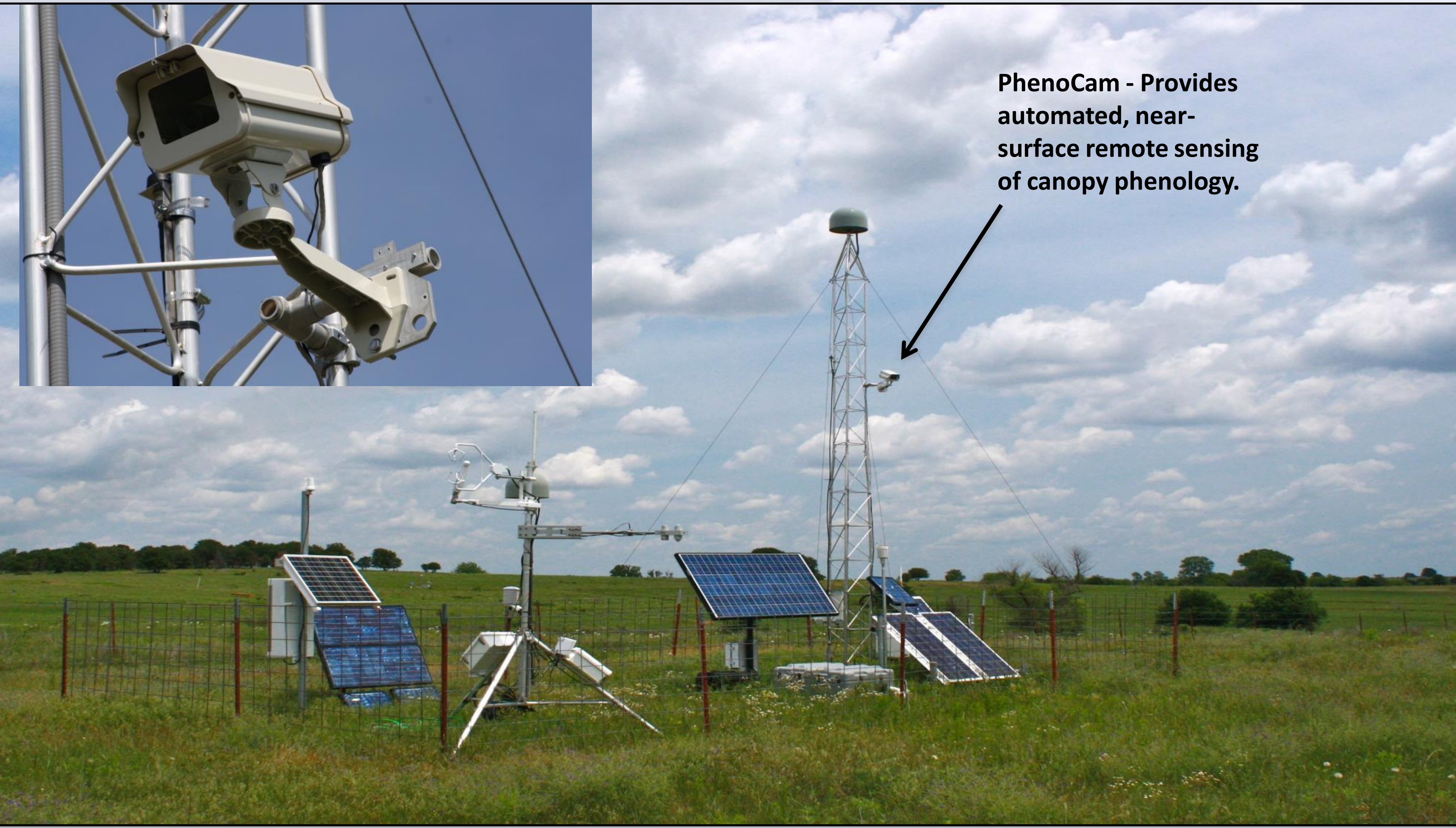
droughtmonitor.unl.edu

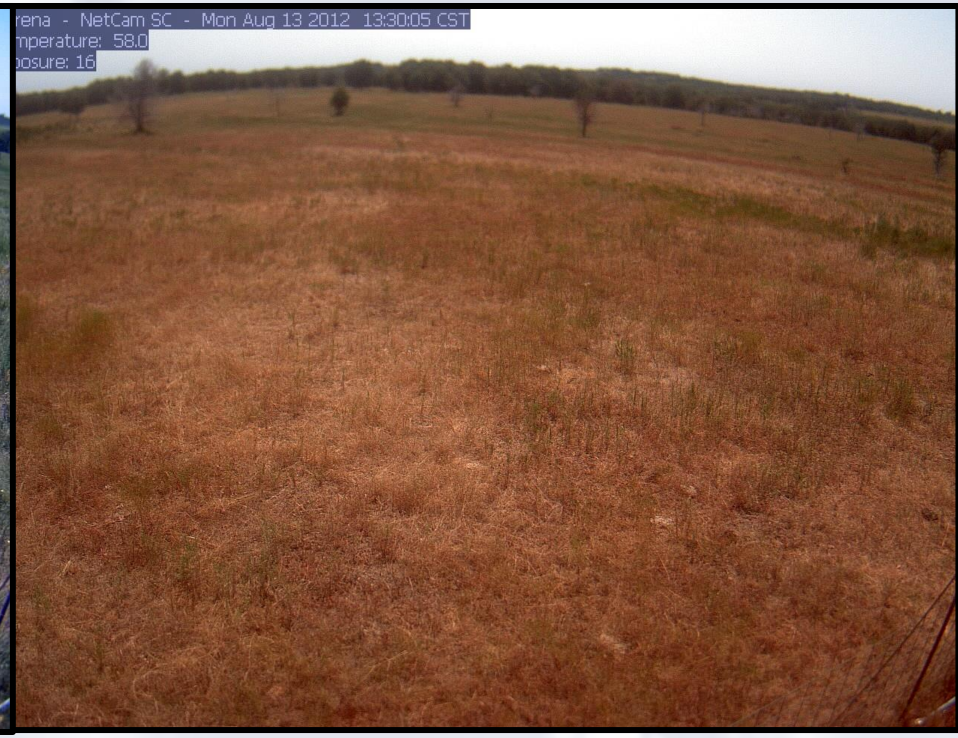
Types of Drought



Wilhite 2005


PhenoCam - Provides automated, near-surface remote sensing of canopy phenology.

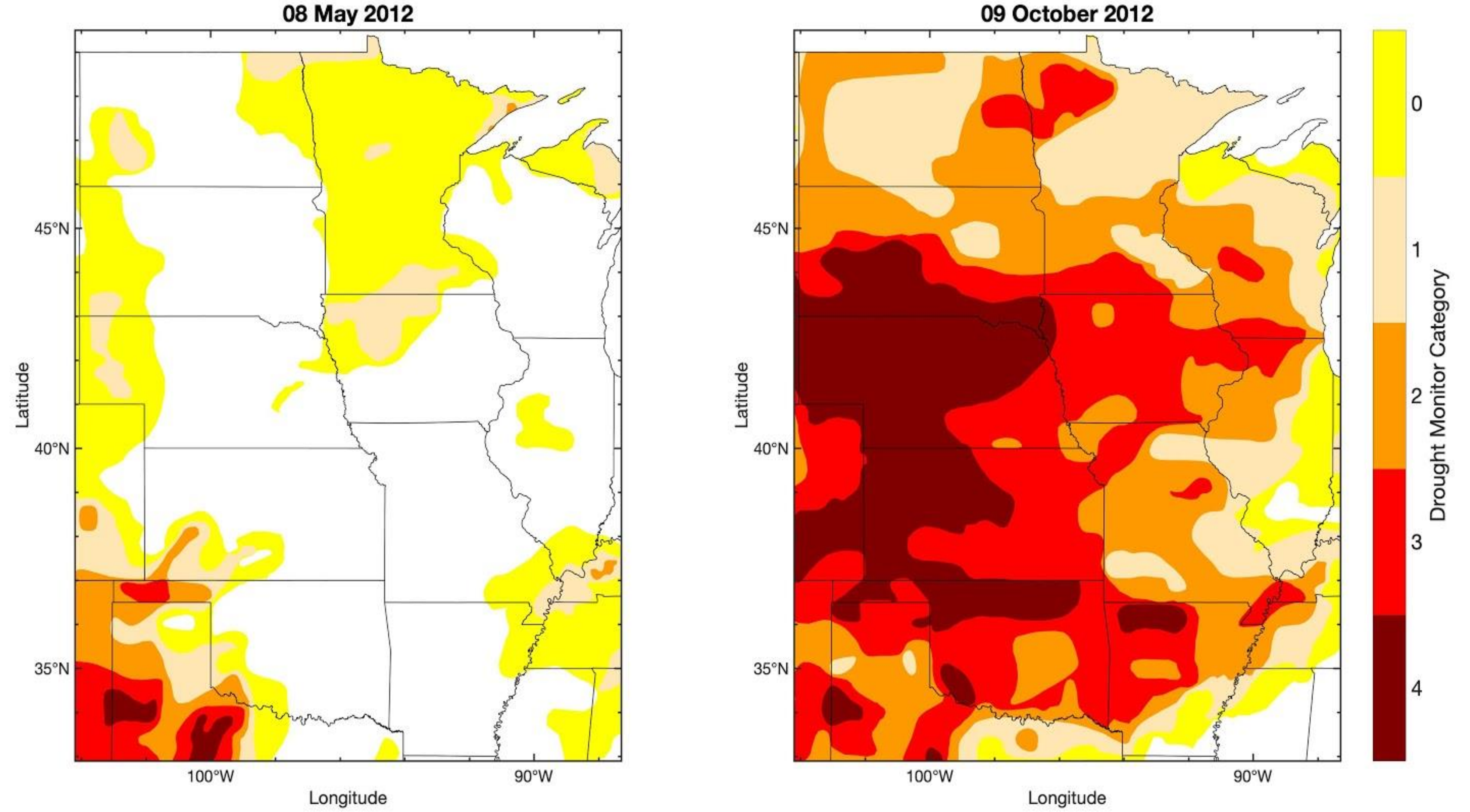
Vegetation Change at the MOISST Site During the 2012 “Flash” Drought



July 1, 2012

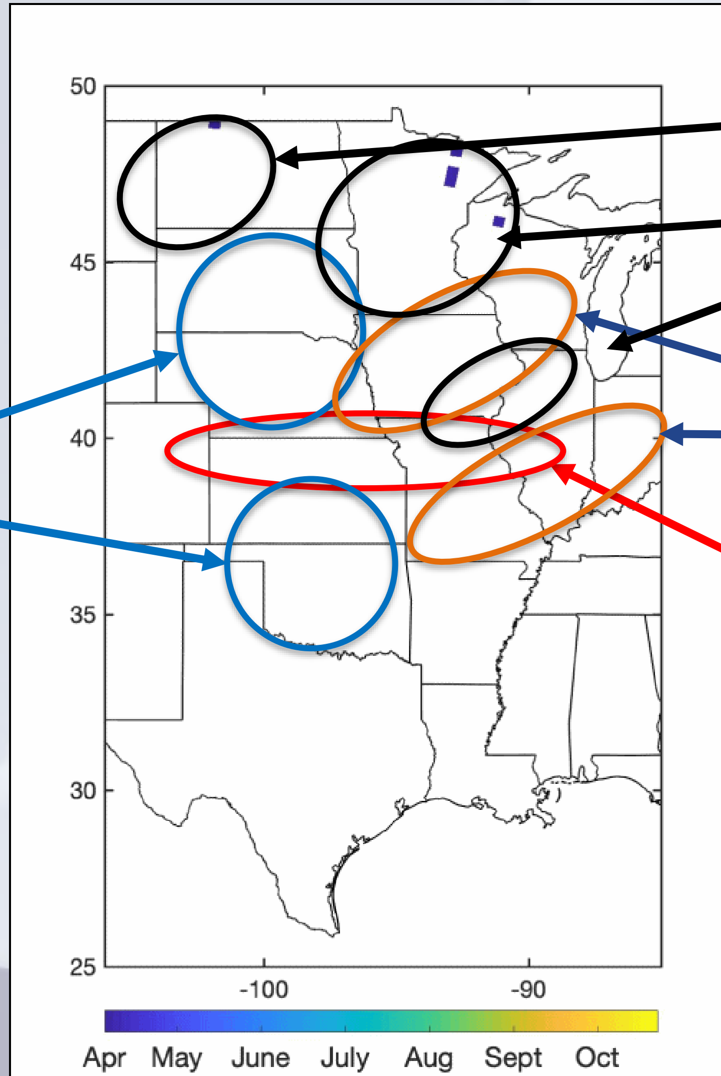
August 13, 2012

Central US Drought of 2012



Expansion of Flash Drought During 2012

Dataset: NARR



Drought Expansion via Flash Drought Development During September - October

Drought Expansion via Flash Drought Development During July - August

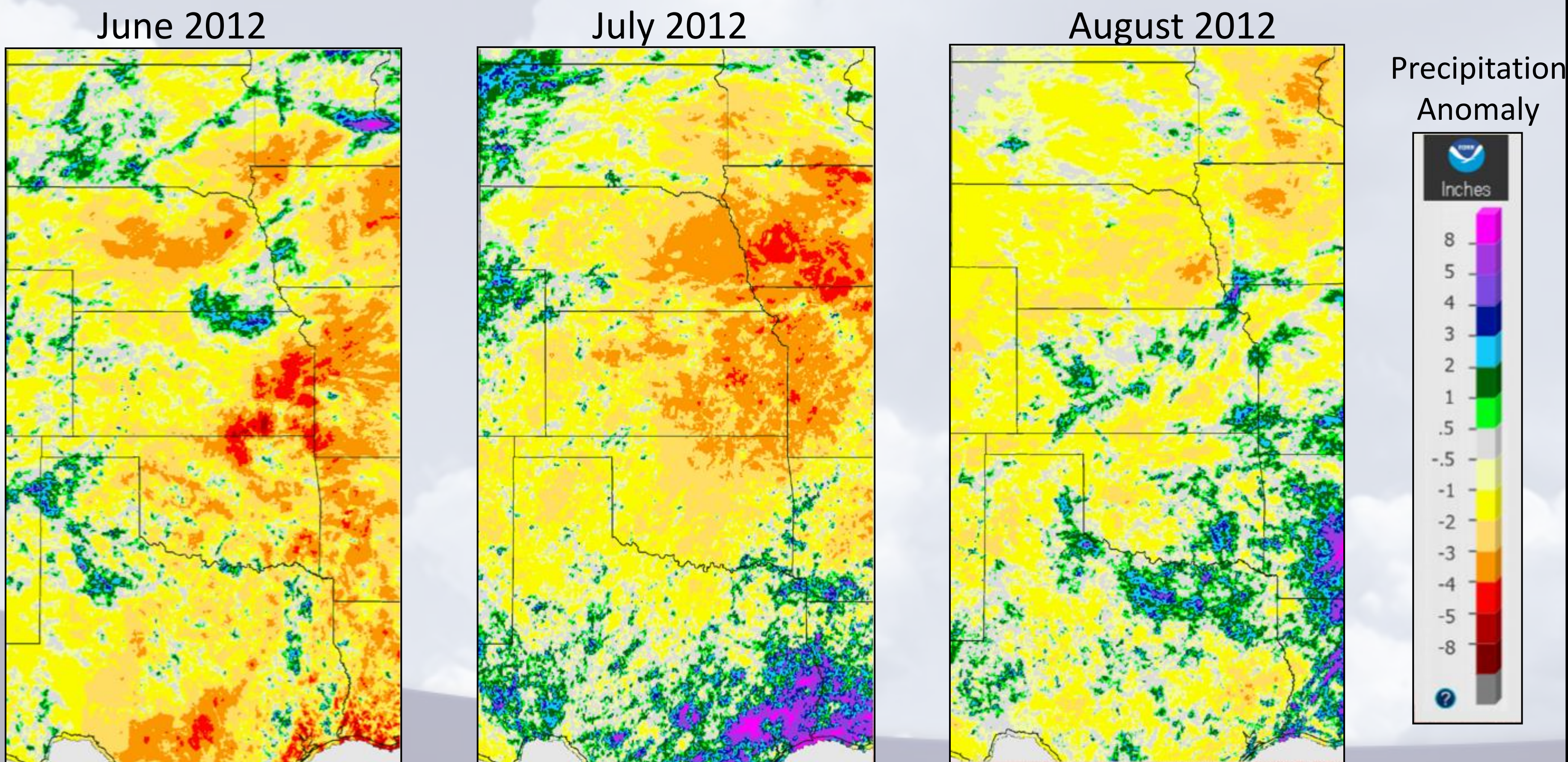
"Epicenter" of Flash Drought Development - May

Drought Expansion via Flash Drought Development During June-July

Based on:

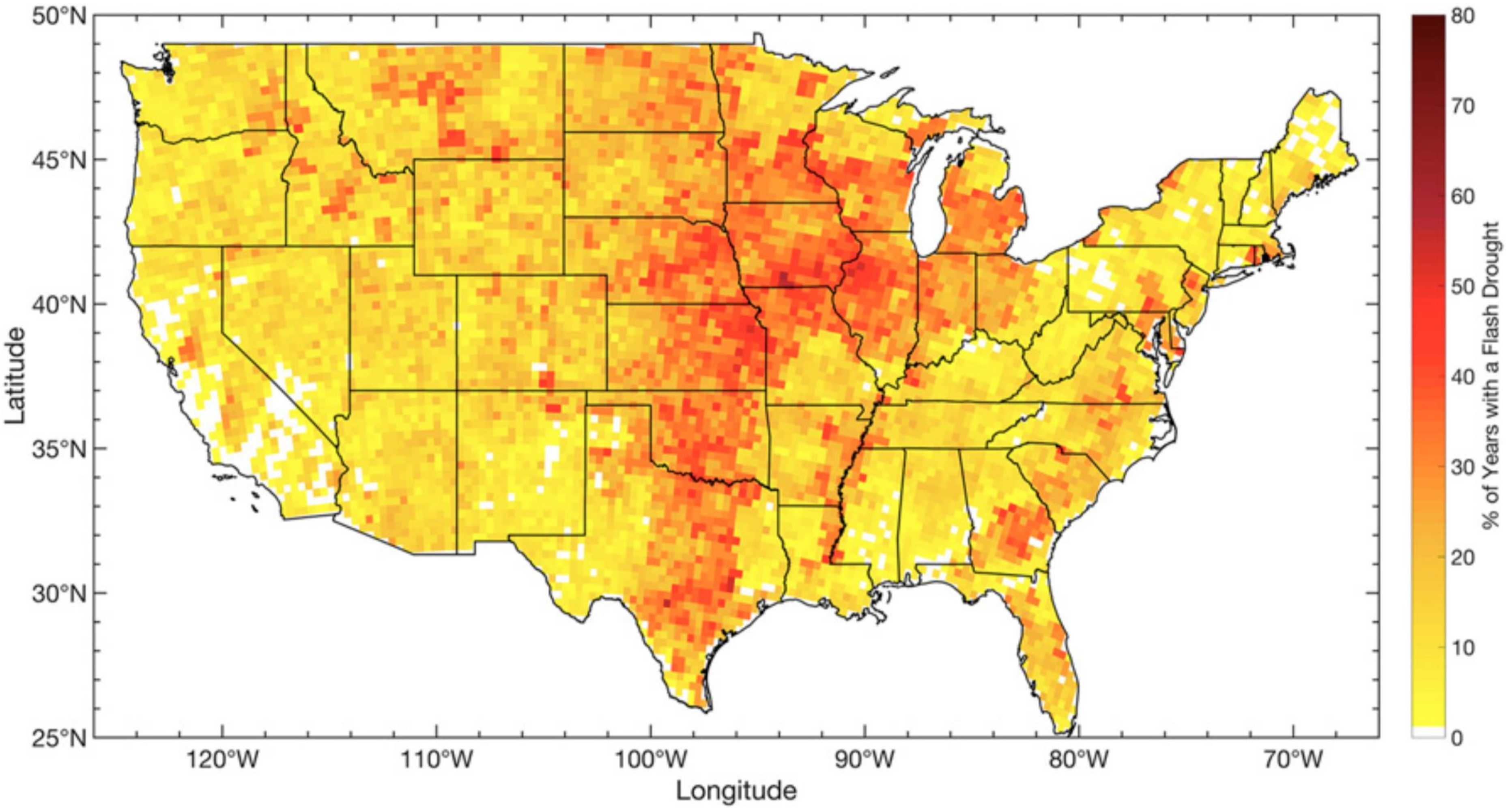
Otkin, J.A., M. Svoboda, E.D. Hunt, T.W. Ford, M.C. Anderson, C. Hain, and J.B. Basara, 2018: Flash Droughts: A Review and Assessment of the Challenges Imposed by Rapid Onset Droughts in the United States. *Bulletin of the American Meteorological Society*, **99**, 911–919.

Christian, J.I., J.B. Basara, J.A. Otkin, E.D. Hunt, R.A. Wakefield, P.X. Flanagan, X. Xiao, 2019: A Methodology for Flash Drought Identification: Application of Flash Drought Frequency Across the United States. *Journal of Hydrometeorology*, In Review.



2012 Drought Across the Great Plains

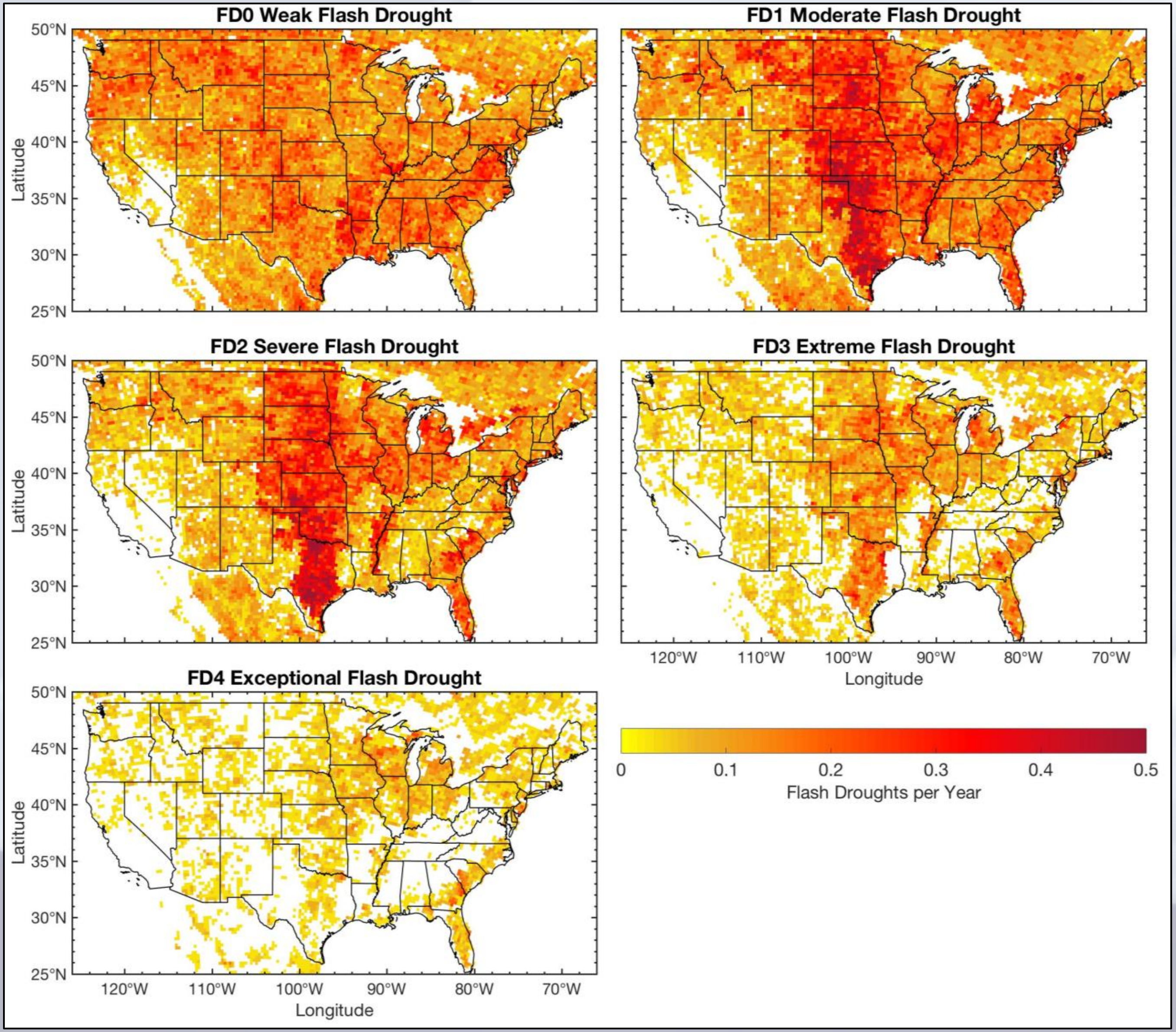
Flash Drought Research



Christian, J.I., J.B. Basara, J.A. Otkin, E.D. Hunt, R.A. Wakefield, P.X. Flanagan, and X. Xiao, 2019: A Methodology for Flash Drought Identification: Application of Flash Drought Frequency Across the United States. *J. Hydrometeor.*, https://doi.org/10.1175/JHM-D-18-0198.1

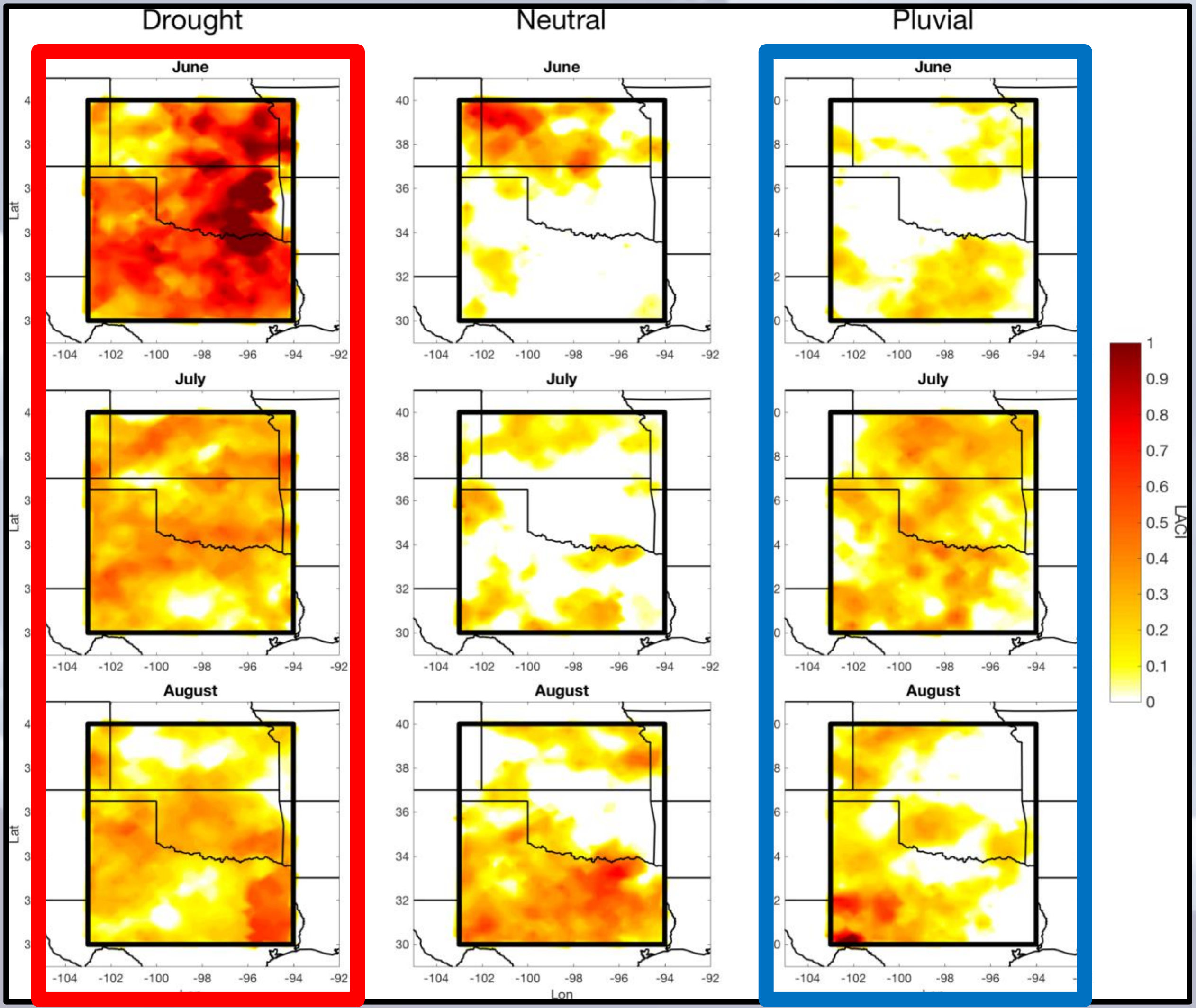
Flash Drought Research

Flash Drought Intensity Index	Flash Drought Intensity
FD0	Weak Flash Drought
FD1	Moderate Flash Drought
FD2	Severe Flash Drought
FD3	Extreme Flash Drought
FD4	Exceptional Flash Drought



Drought Versus Pluvial – Local/Mesoscale Coupling

Dry Coupling



Wet Coupling

Basara, J. B., and J. I. Christian, 2017: Seasonal and interannual variability of land–atmosphere coupling across the Southern Great Plains of North America using the North American regional reanalysis. *International Journal of Climatology*, 10.1002/joc.5223.

Variability of Precipitation

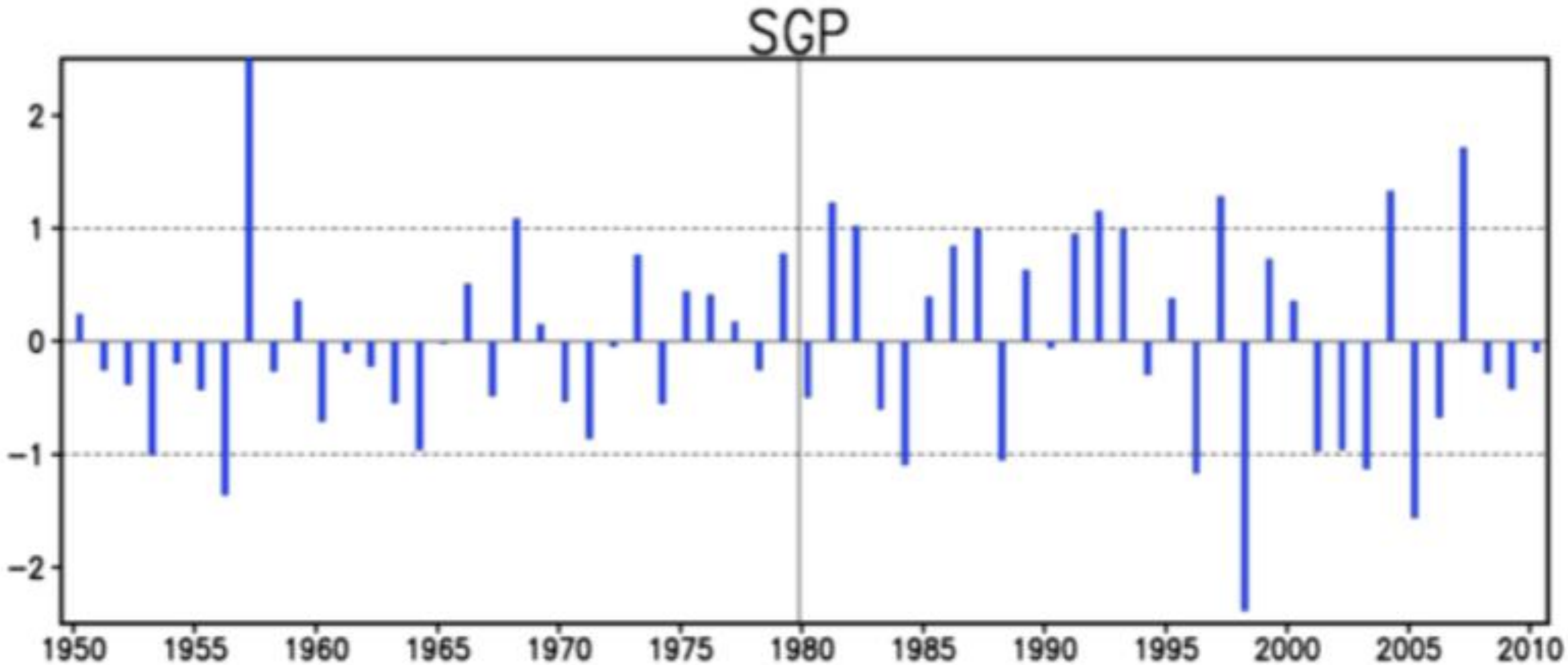


Figure 2. Normalized time series of AMJ precipitation anomaly indices for 1950-2010 for the NGP (upper), SE (middle), and SGP (lower) regions. Area averaging is conducted within the latitude and longitude regions shown in Figure 1 and values are expressed in units of standard deviation.

Weaver, S., S. Baxter, and K. Harnos, 2016: Regional Changes in the Interannual Variability of U.S. Warm Season Precipitation. J. Climate. doi:10.1175/JCLI-D-14-00803.1.

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Long-term analysis of the asynchronicity between temperature and precipitation maxima in the United States Great Plains

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ABSTRACT: Agriculture is a critical industry to the economy of the Great Plains (GP) region of North America and sensitive to change in weather and climate. Thus, improved knowledge of meteorological and climatological conditions during the growing season and associated variability across spatial and temporal scales is important. A distinct climate feature in the GP is the asynchronicity (AS) between the timing of temperature and precipitation maxima. This study investigated a long-term observational data set to quantify the AS and to address the impacts of climate variability and change. Global Historical Climate Network Daily (GHCN-Daily) data were utilized for this study; 352 GHCN-Daily stations were identified based on specific criteria and the dates of the precipitation and temperature maxima for each year were identified at daily and weekly intervals. An asynchronous difference index (ADI) was computed by determining the difference between these dates averaged over each decade. Analysis of daily and weekly ADI revealed two physically distinct regimes of ADI (positive and negative), with comparable shifts in the timing of both the maximum of precipitation and temperature over all six states within the GP examined when comparing the two different regimes. Time series analysis of decadal average ADI yielded moderate shifts (~5 to 10 days from linear regression analysis) in ADI in several states with increased variability occurring over much of the study region.

KEY WORDS climate; climatology; precipitation; temperature; Great Plains

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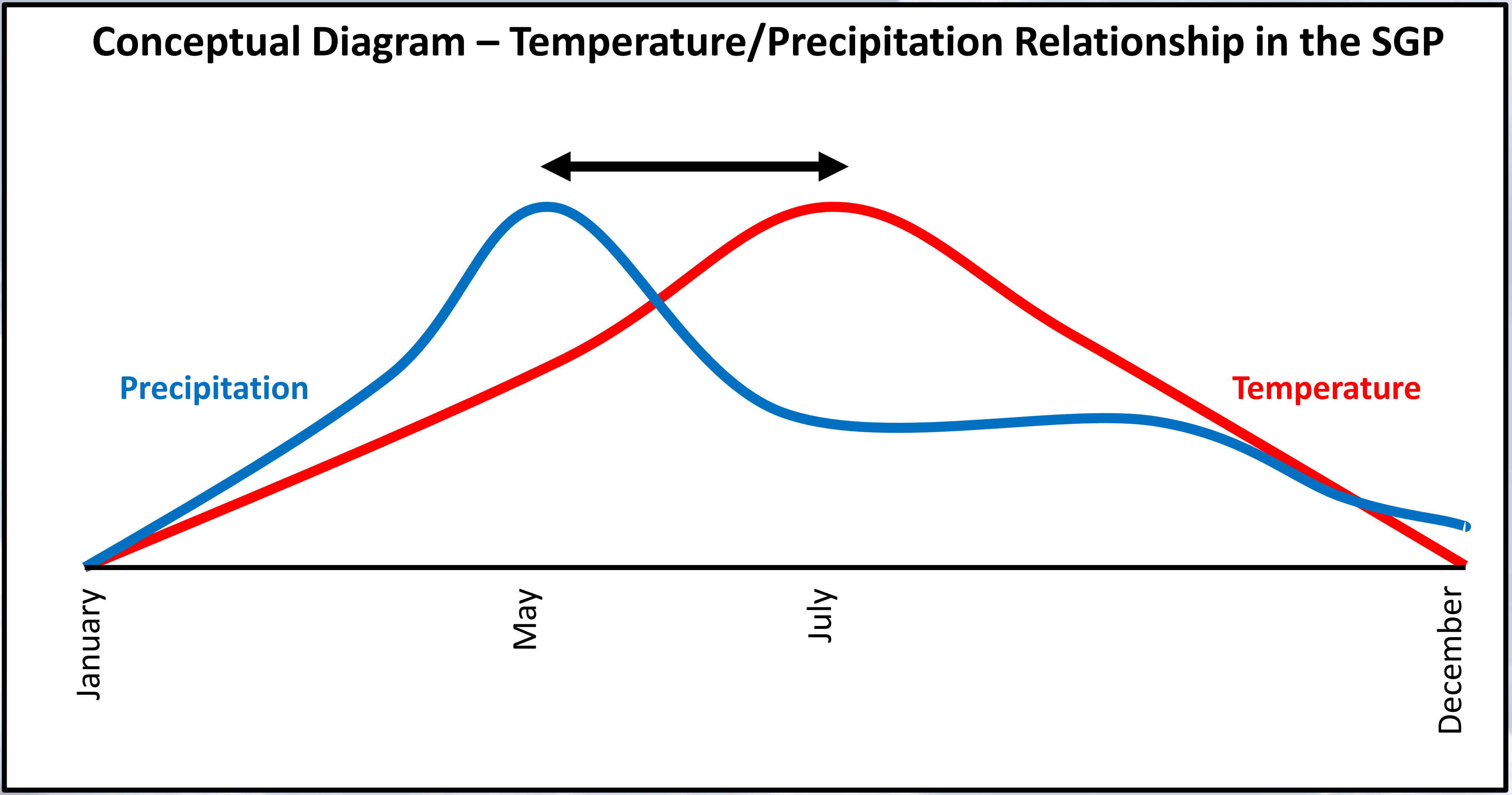
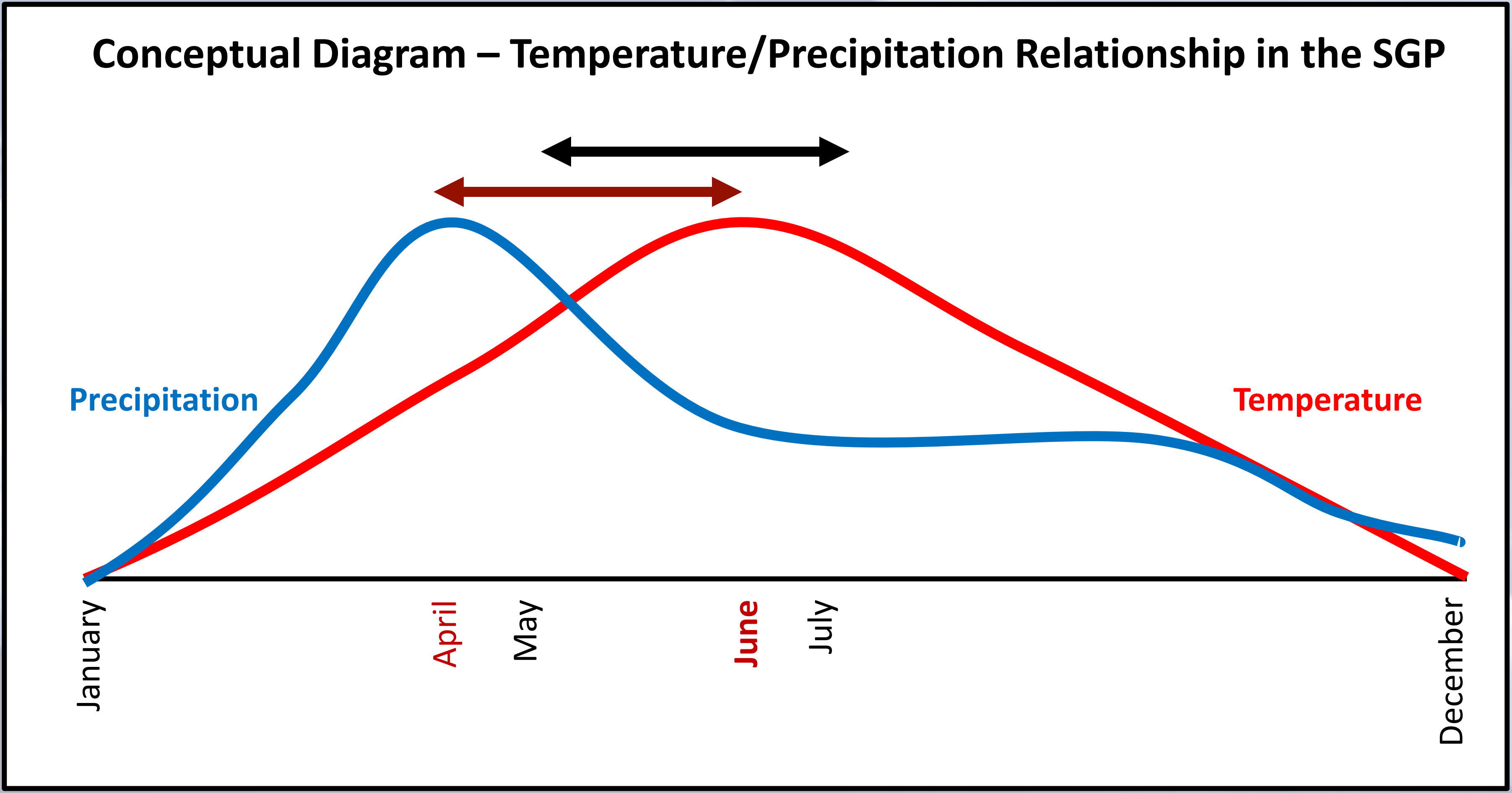


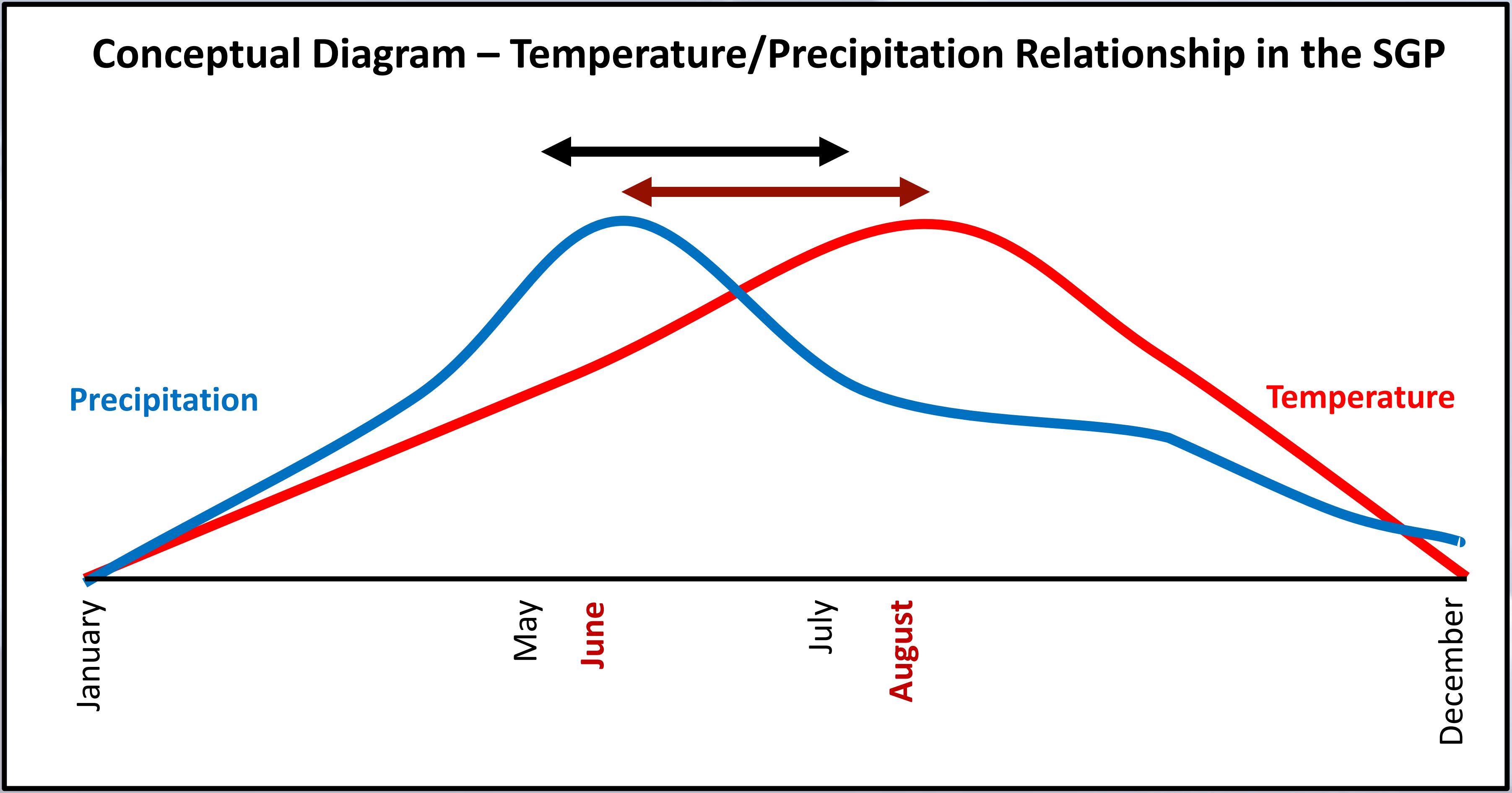
Question: Is the annual timing between the *peak* of precipitation versus the *peak* of temperature changing?

Was there a consistent shift to earlier in the year?



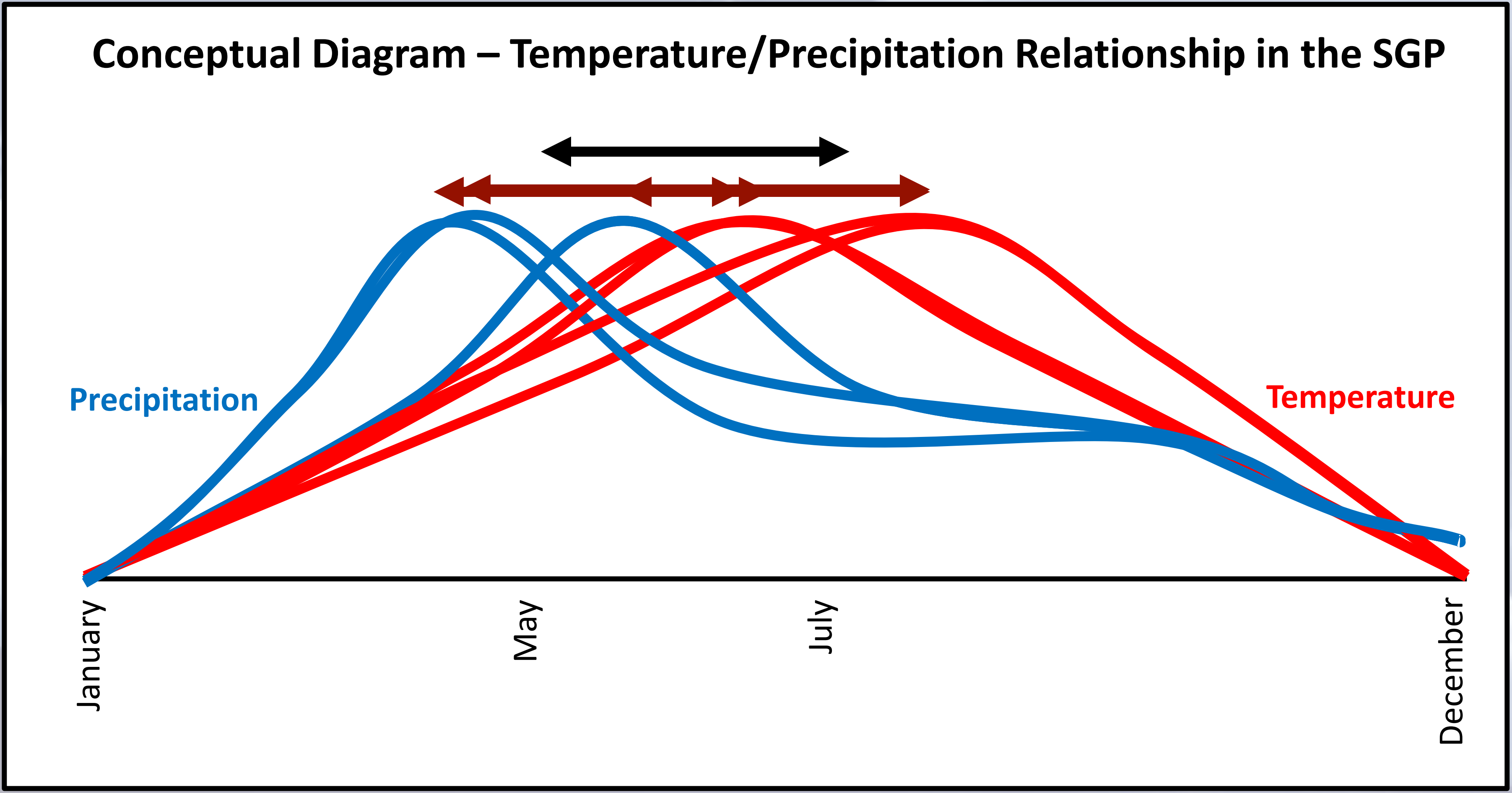
Answer: NO!

Was there a consistent shift to later in the year?



Answer: NO!

What was the result of the analysis?



Answer: The overall variability is increasing.

Take-Away Message

- The Great Plains domain is a region defined by dynamic weather/climate variability – includes subseasonal to seasonal extremes.

- Precipitation variability is increasing.

- The results of the increase in precipitation variability is that:
    - Increased frequency in the oscillations between drought/pluvial periods,
    - Impacts the asnychonicity between the annual peaks in temperature and precipitation,
    - May be impacting the generation of flash drought conditions,
    - May be “driven” by to local to global processes.

- Impacts span many socioeconomic sectors … especially agriculture.

- Still, much work to be done …

Questions?

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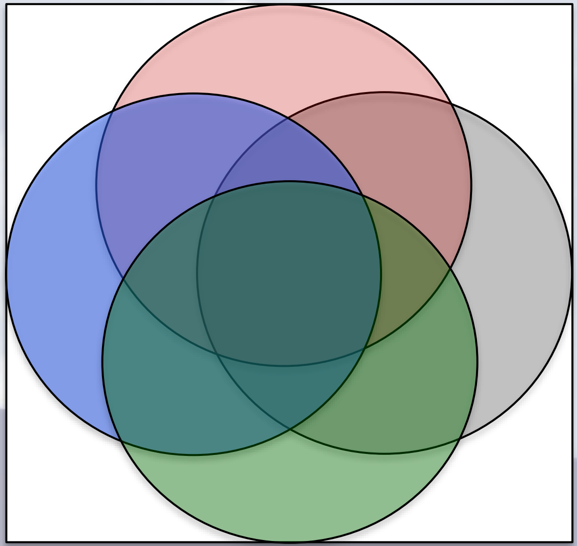
http://hydrometeorology.oucreate.com

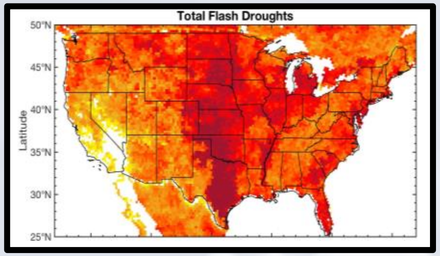
Climate

Hydrology



Weather

Ecosystems



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