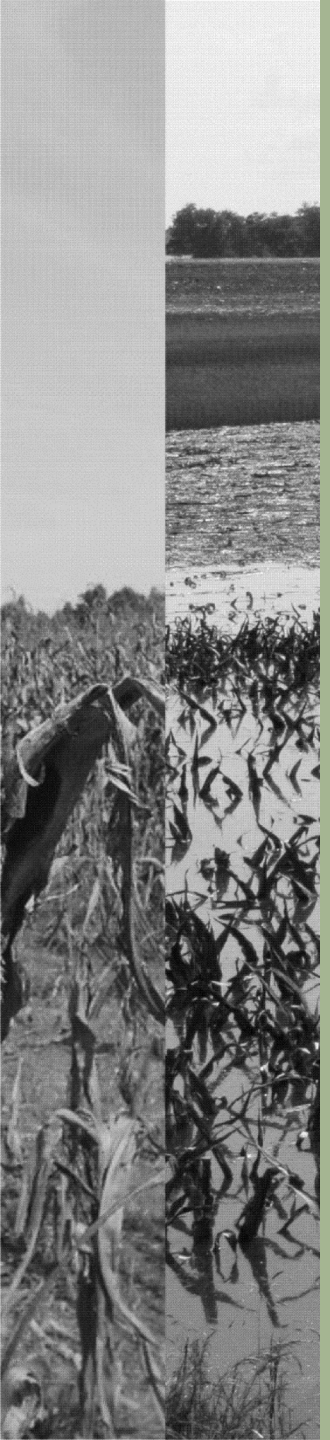


Exploring Rapid Transitions Between Hydrological Extremes in the Midwest

Aaron Wilson & Trent Ford

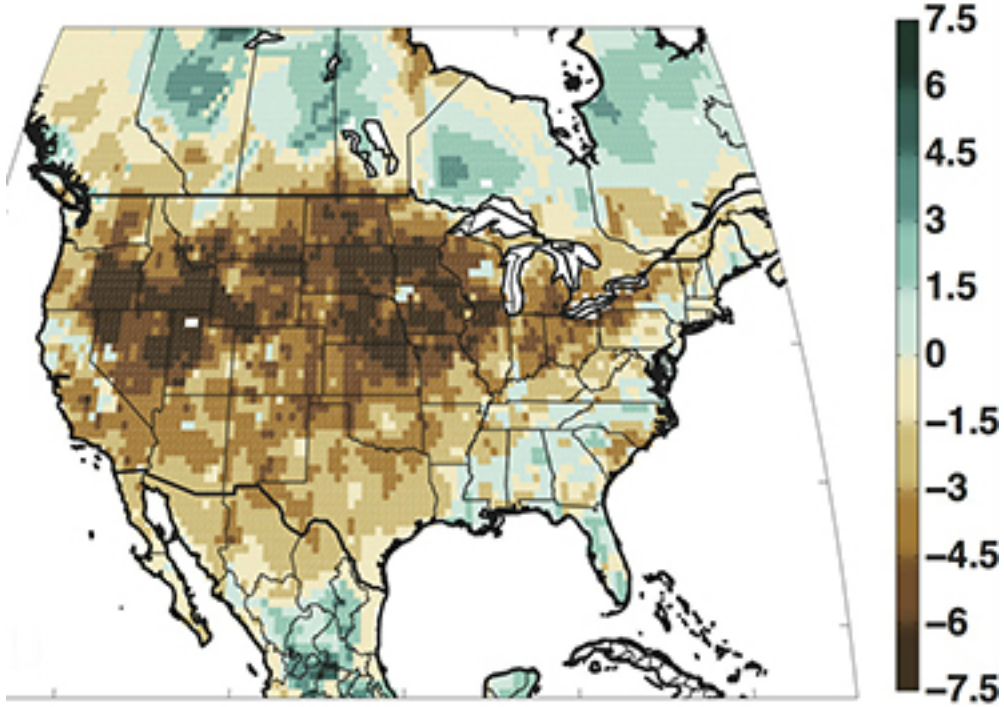
Midwest Drought Early Warning System Regional Partner Meeting

November 19-20, 2019

Thinking Historical Drought

- Drought historically regarded as a slowly evolving climate phenomenon over an extended period (e.g., we think of Dust Bowl; 50s)

Summer of 1934



PDSI uses temperature and precipitation data to estimate relative dryness. Standardized and spans -10 (dry) to +10 (wet).

Brown colors of the Palmer Drought Severity Index, or PDSI, indicate strong drought conditions across the United States in the summer of 1934. PDSI was calculated from monthly averages of precipitation, temperature and other factors from 1934, available from the Climate Research Unit. Credit: GISS/Lamont-Doherty

Our Evolving Understanding of Drought Onset

- Rapidly intensifying droughts have occurred throughout history
- A lot of recent attention on ***Flash Drought***
- "…if below-normal precipitation is accompanied by above-normal evaporative demand due to high temperatures, low humidity, strong winds, and sunny skies, agricultural and ecological drought conditions signified by increasing soil moisture deficits and declining vegetation health can rapidly emerge."

Otkin, J.A., Svoboda, M., Hunt, E.D., Ford, T.W., Anderson, M.C., Hain, C., and Basara, J.B., 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, https://doi.org/10.1175/BAMS-D-17-0149.1.

Predicting Flash Droughts

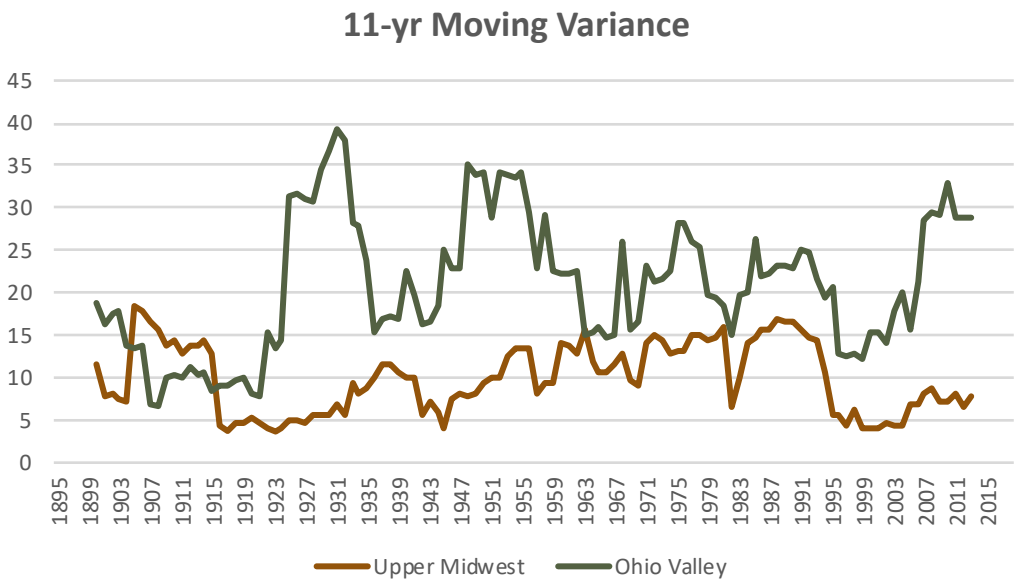
- Sudden decreases in Evapotranspiration (ET) anomaly over the drought regions before onset.
- Soil moisture was plentiful prior to the drought, but rapidly evaporated due to heat/wind/radiation.
- Sharp declines in soil moisture anomaly associated with the sudden decreases in ET anomaly.
- Temperatures were warmer than normal, due to heatwaves in the regions
- Three-month Standardized Precipitation Indexes were negative for all five droughts.

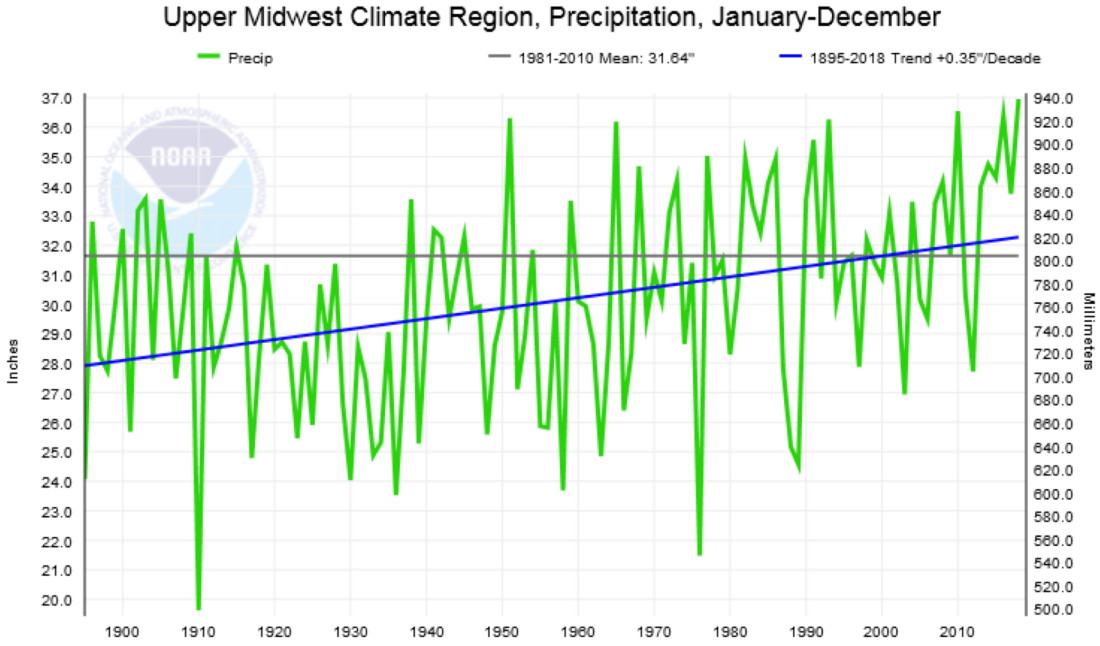
https://www.drought.gov/drought/news/predicting-flash-drought

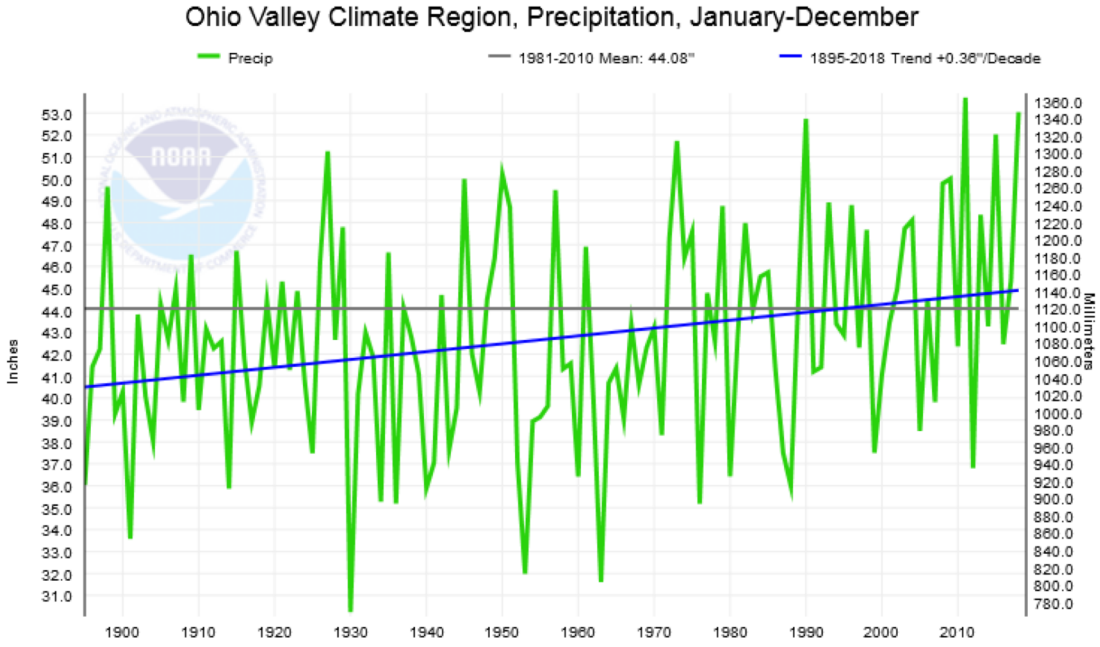
Chen, G., J. Gottschalck, A. Hartman, D. Miskus, R. Tinker, and A. Artusa, 2019: Flash drought characteristics based on U.S. Drought Monitor. Atmopshere, **10(9)**, 498, doi:10.3390/atmos10090498

Swings in Hydro-Climate Extremes

- Are they new?
- Has the variability between dry/wet extremes evolved over the last few decades?
- What impacts are linked to higher variability between extremes?







Extreme Flip – From Pluvial to Drought to Pluvial…

Data:

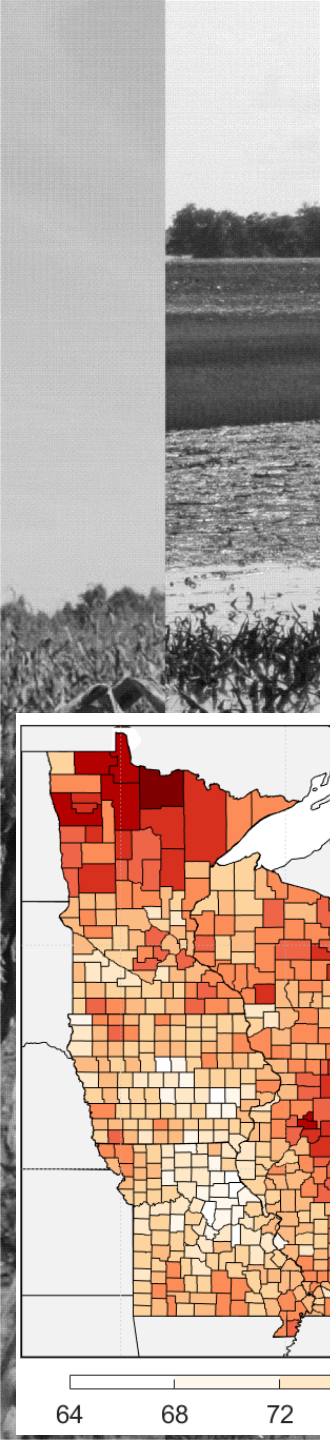
- Precipitation from nCLIMDIV
  - 1951 – 2018, county-level daily precipitation
  - Computed 30-, 90-, 180-, and 360-day SPI

Method:

- "Tail swing" (S_a, DeGaetano and Lim, 2019)
  - Shift from one SPI extreme to the opposite (drought to pluvial, pluvial to drought)
  - 1.3 (-1.3) used to represent pluvial (drought), roughly corresponds with 90th and 10th percentiles, "severe drought"
- S_a frequency = # of occurrences of tail swings over historical record
- S_a period = time in days between occurrences of extremes
- Average frequency and period calculated over entire 68 year record, change calculated as difference in means of 2 34-year periods

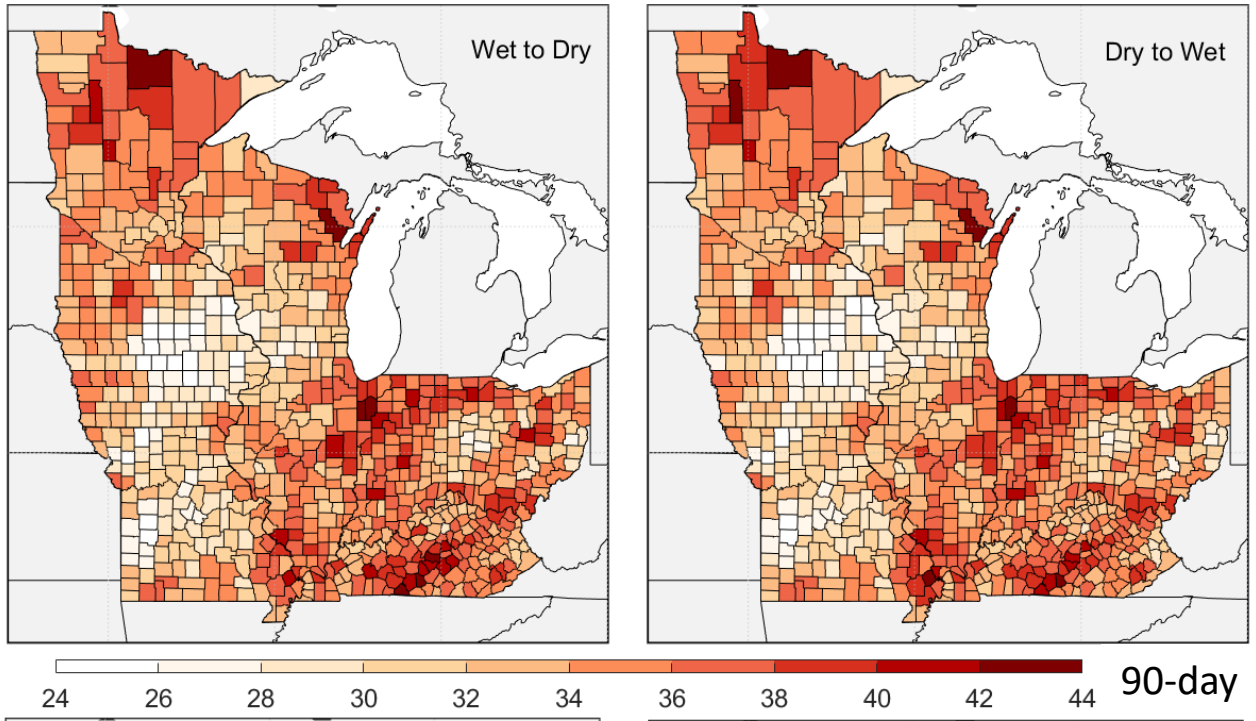
Tail Swing

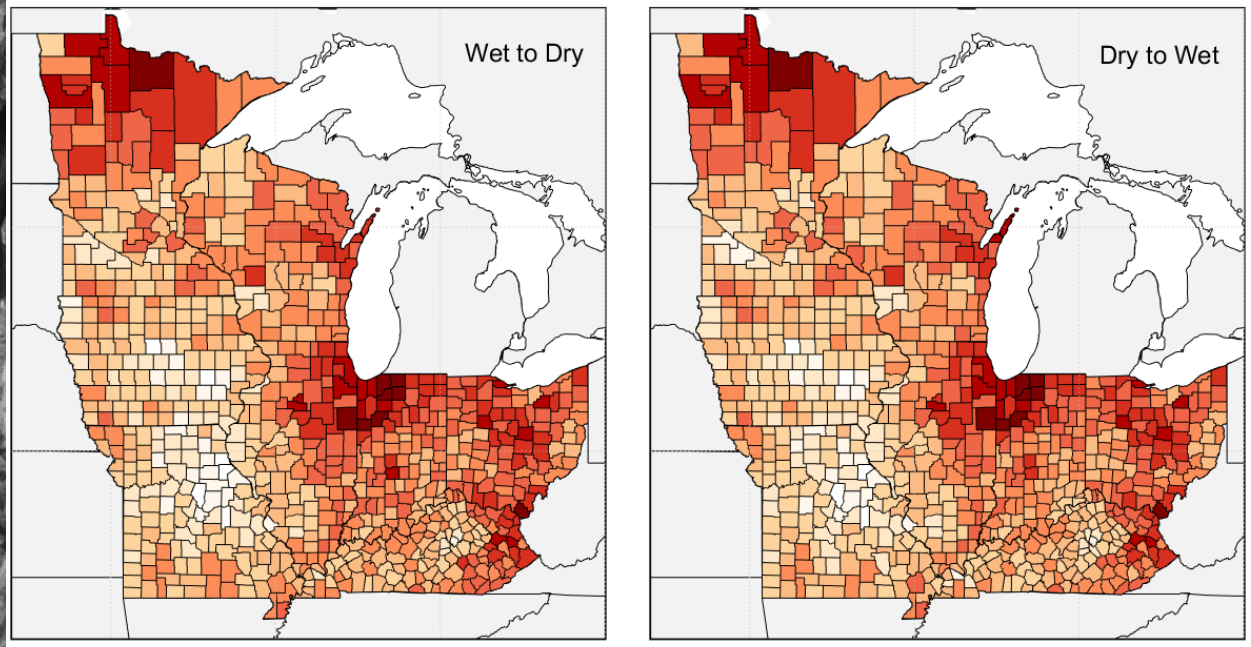
- "Swing" classified as event with an extreme followed by an extreme of the opposite sign
- "Swing" period is the time elapsed between last occurrence of one extreme and first occurrence of opposite extreme

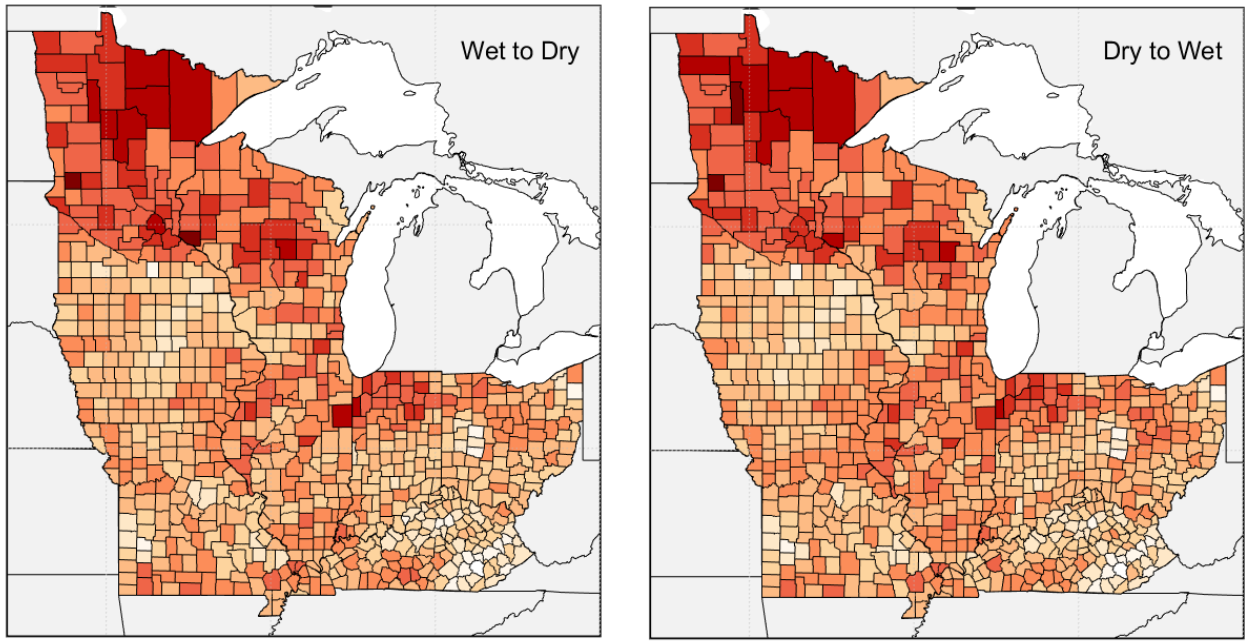


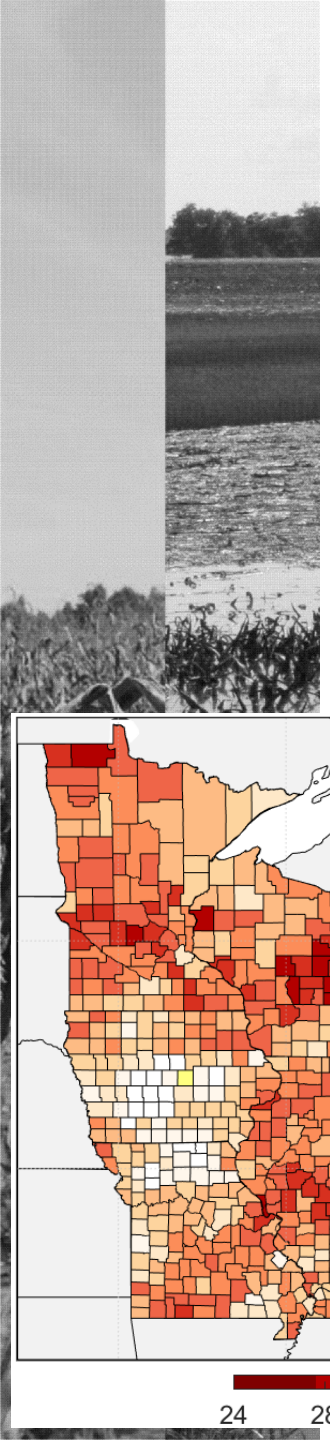
S_a Frequency

- Frequency of occurrence of wet to dry and dry to wet swings between 1951 and 2018



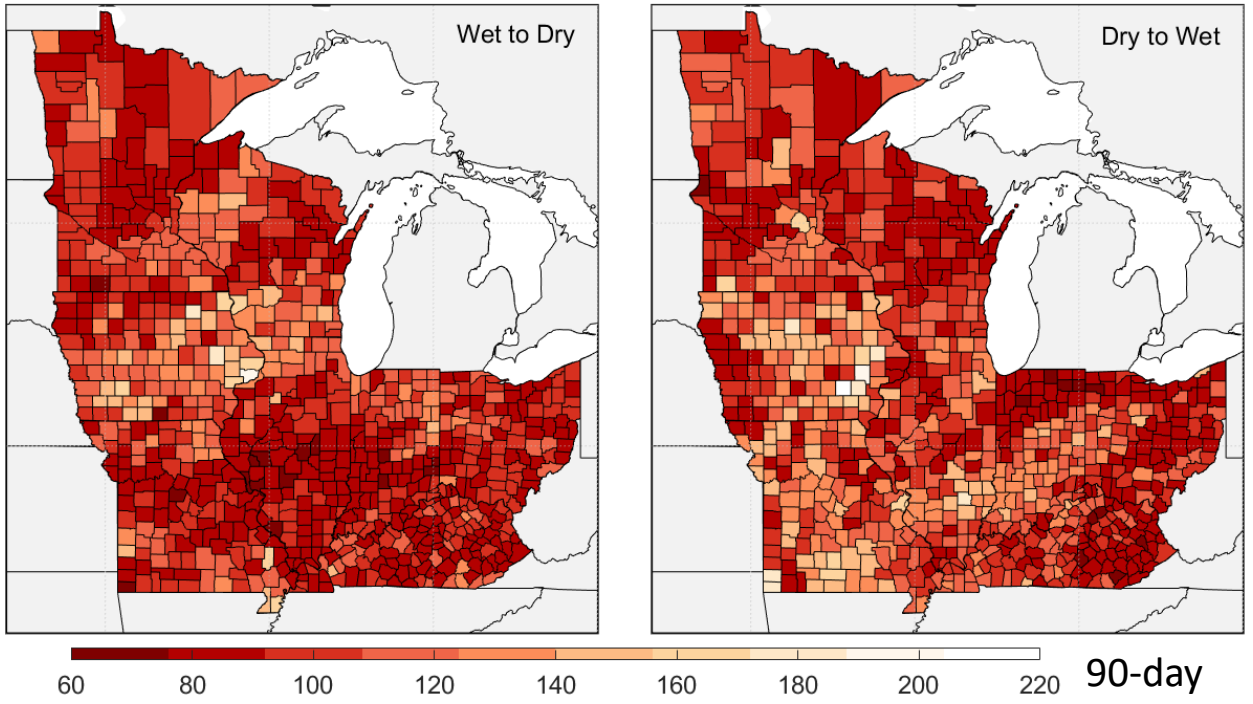


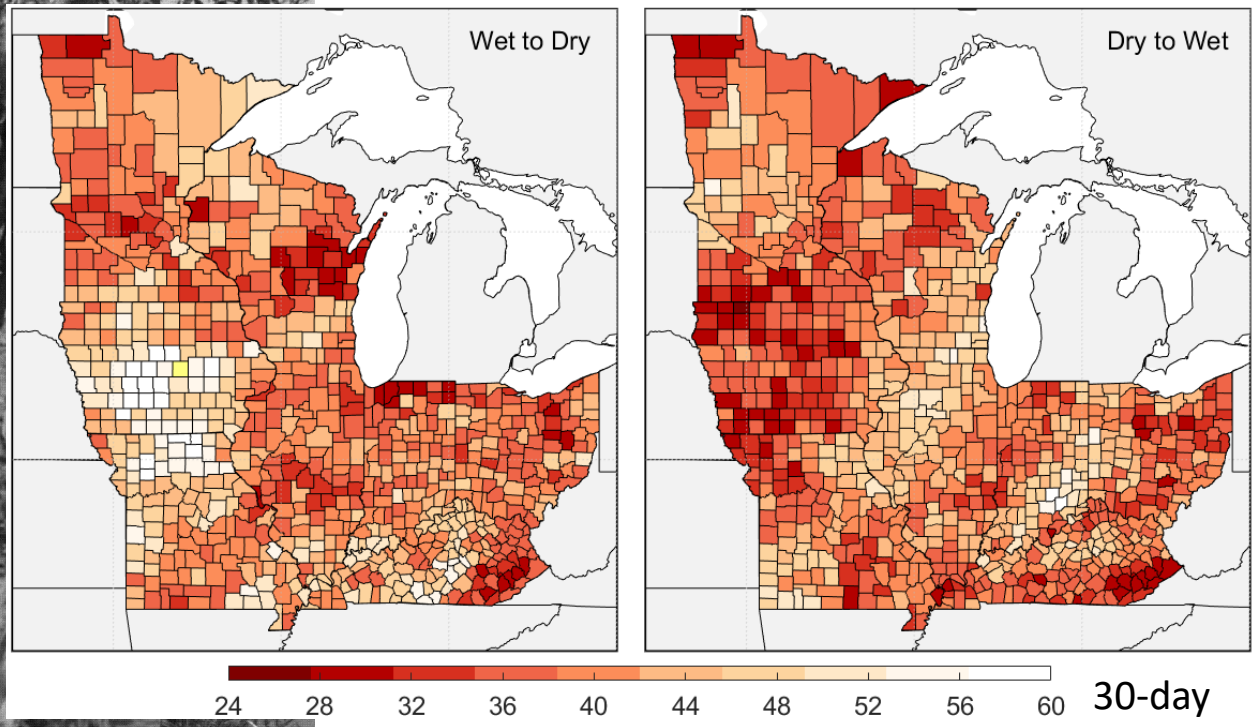


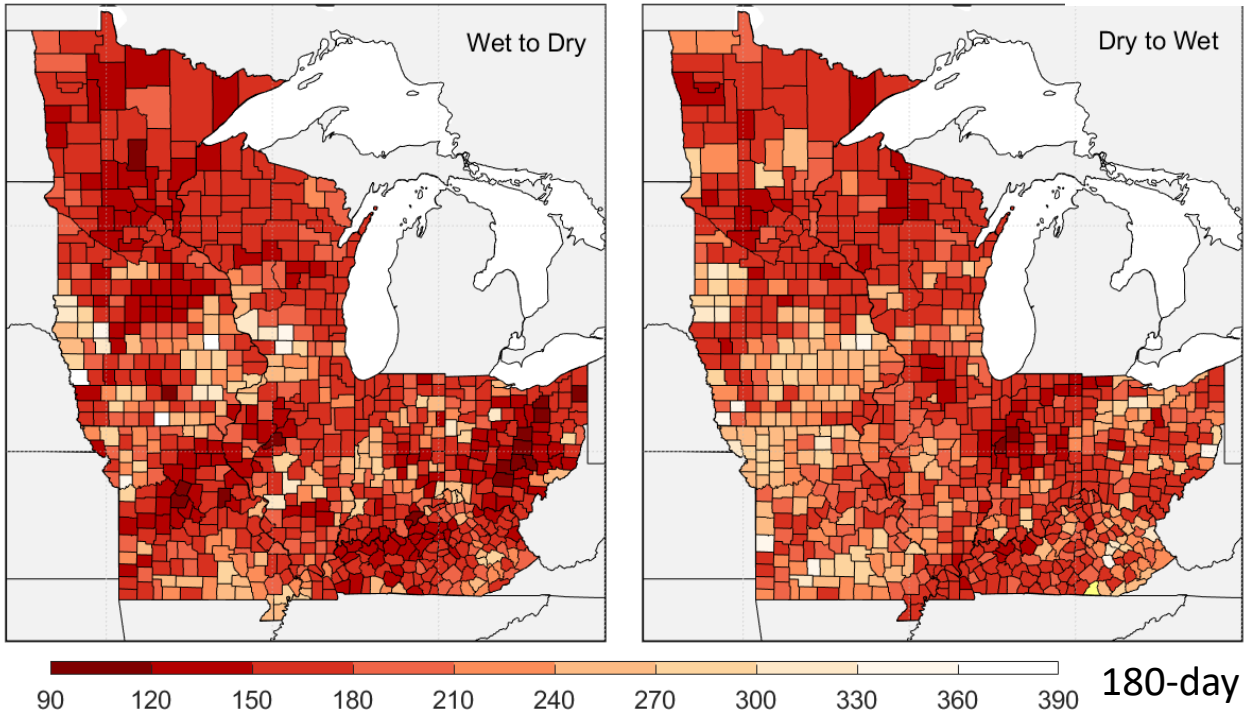


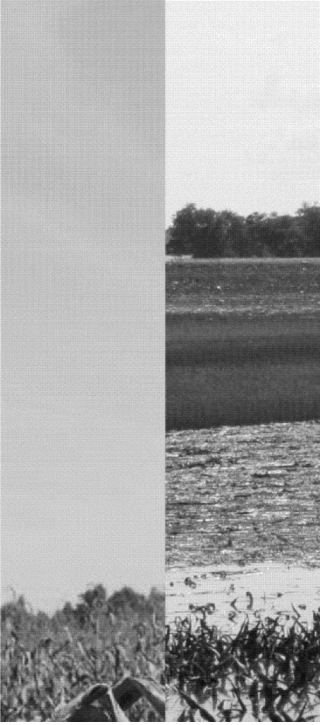
S_a Period

- Median time (days) between opposite extremes between 1951 and 2018



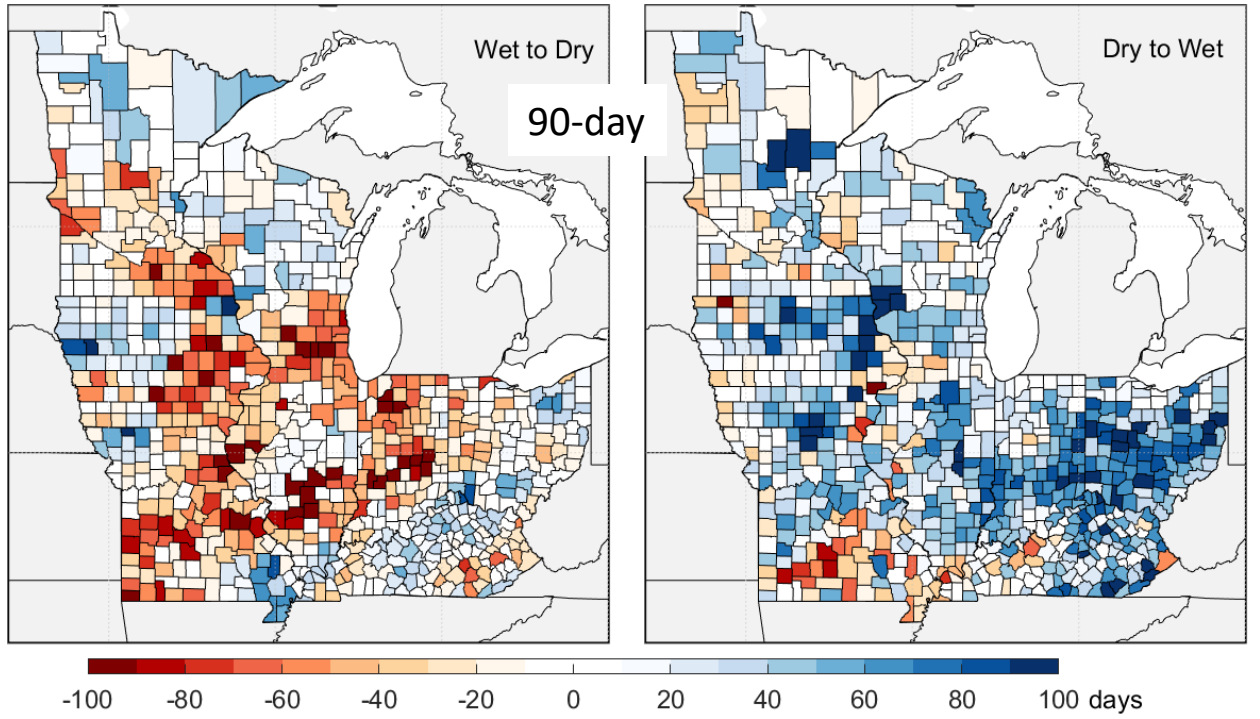


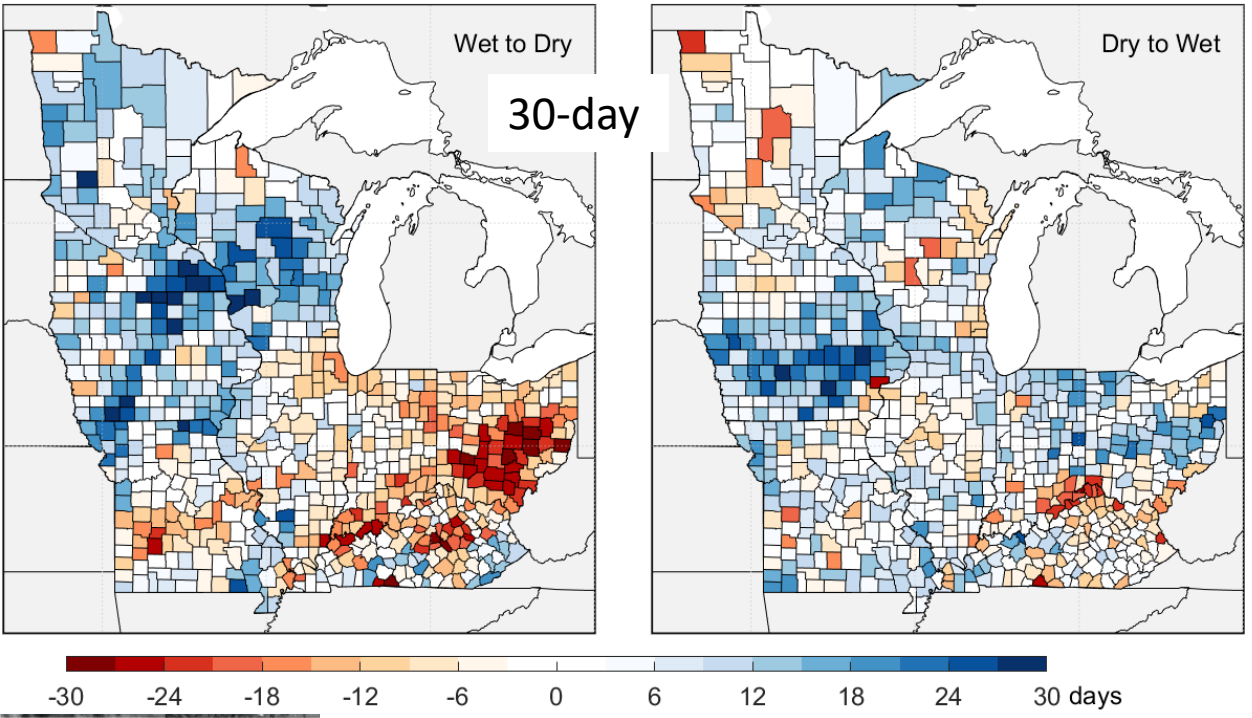


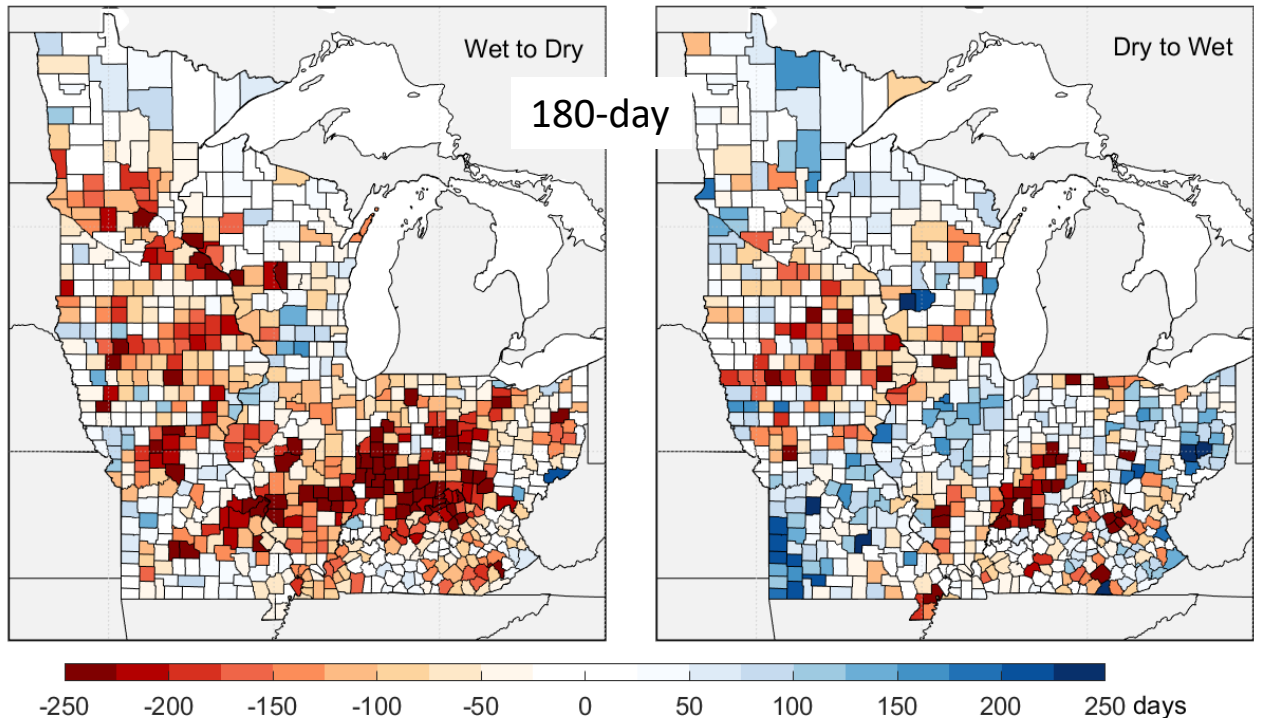


S_a Period Change

- S_a period difference (days) between first 34 and last 34 years
- Red (blue) counties experienced decreased (increased) time between swings

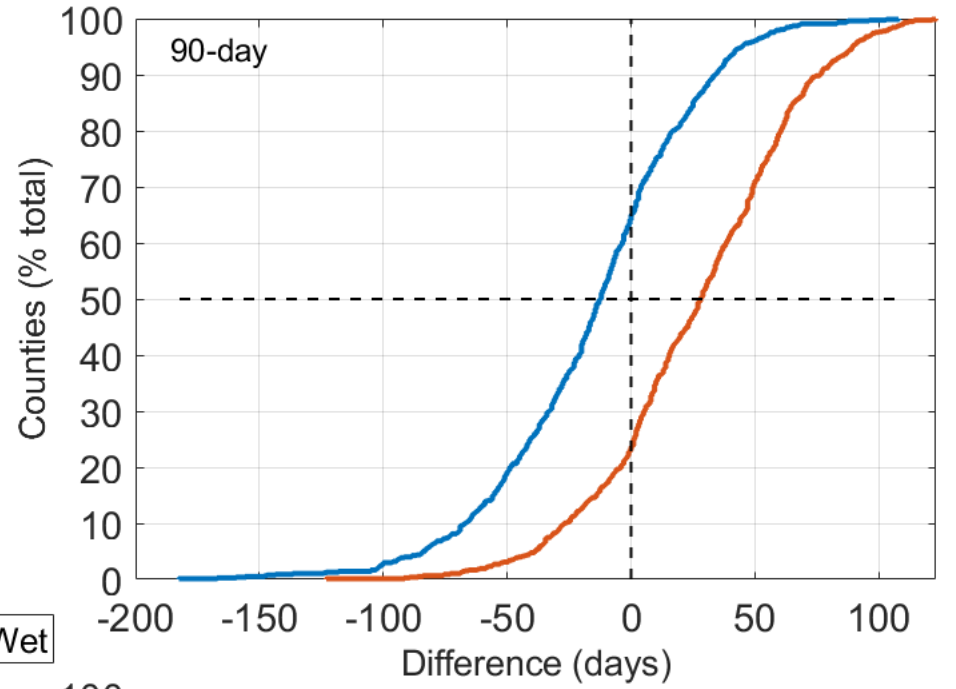


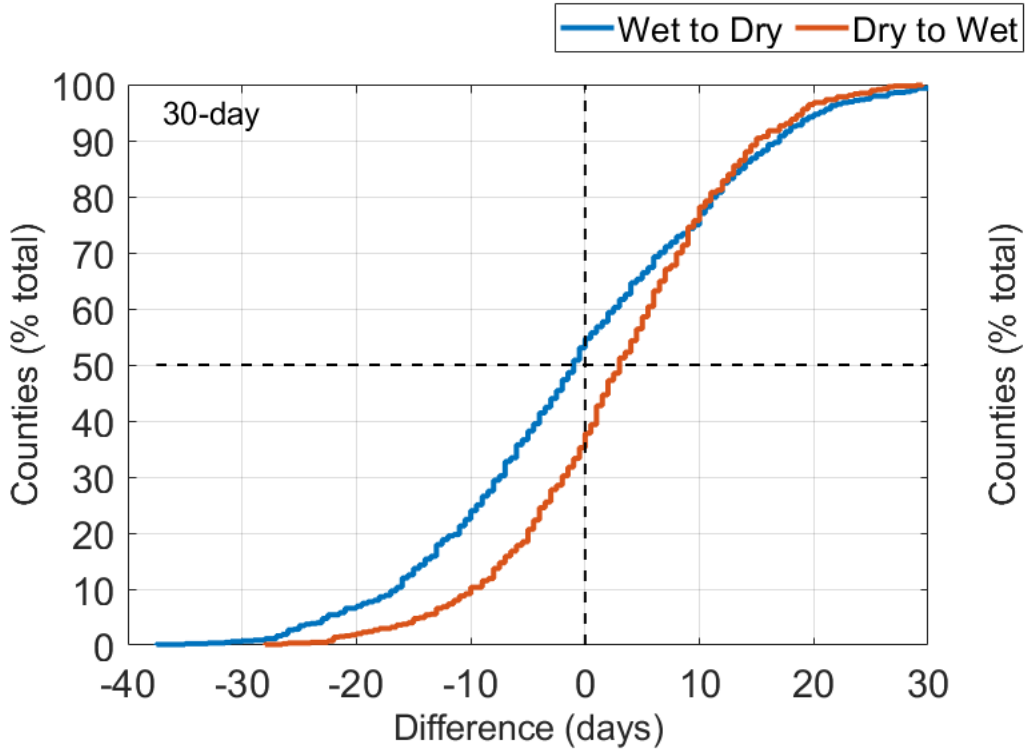


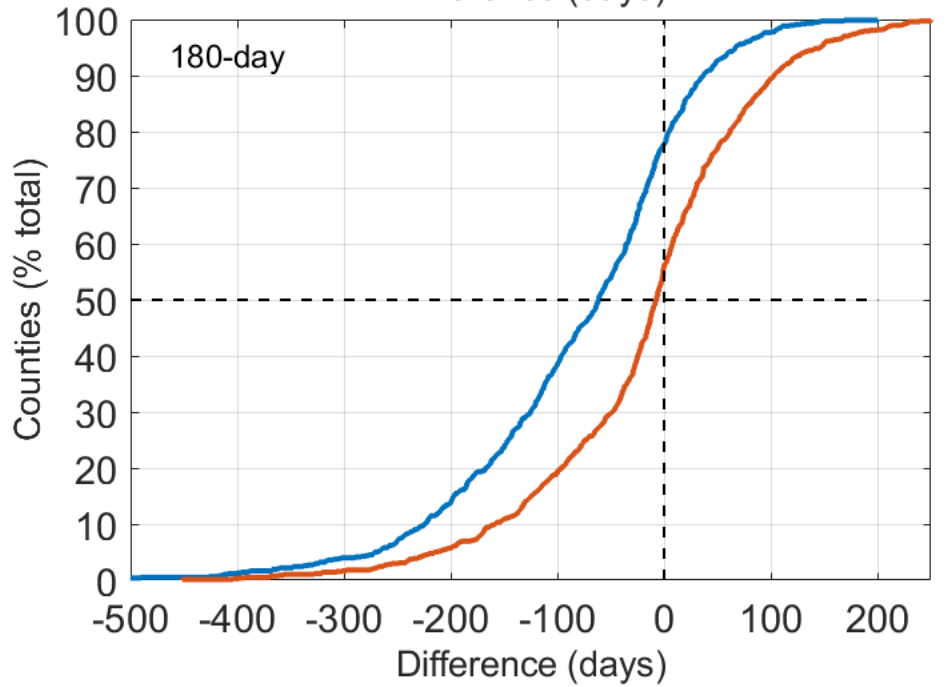


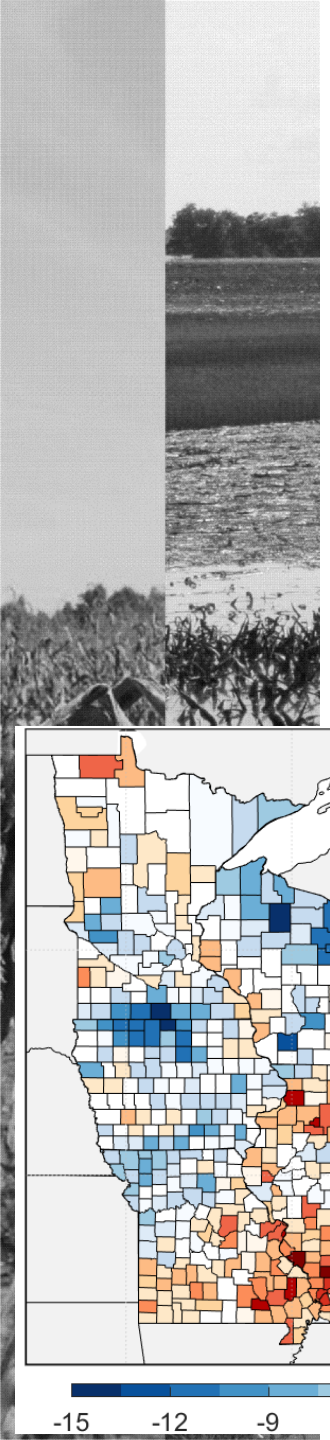
S_a Period Change

- Cumulative distribution functions of county S_a period change (days) between first and last 34 years
- 80% of counties have experienced a decrease in 180-day wet to dry S_a period during the latter half of the record, 65% of counties for 90-day wet to dry
- 75% of counties have experienced an increase in 90-day dry to wet S_a period, 65% of 30-day dry to wet



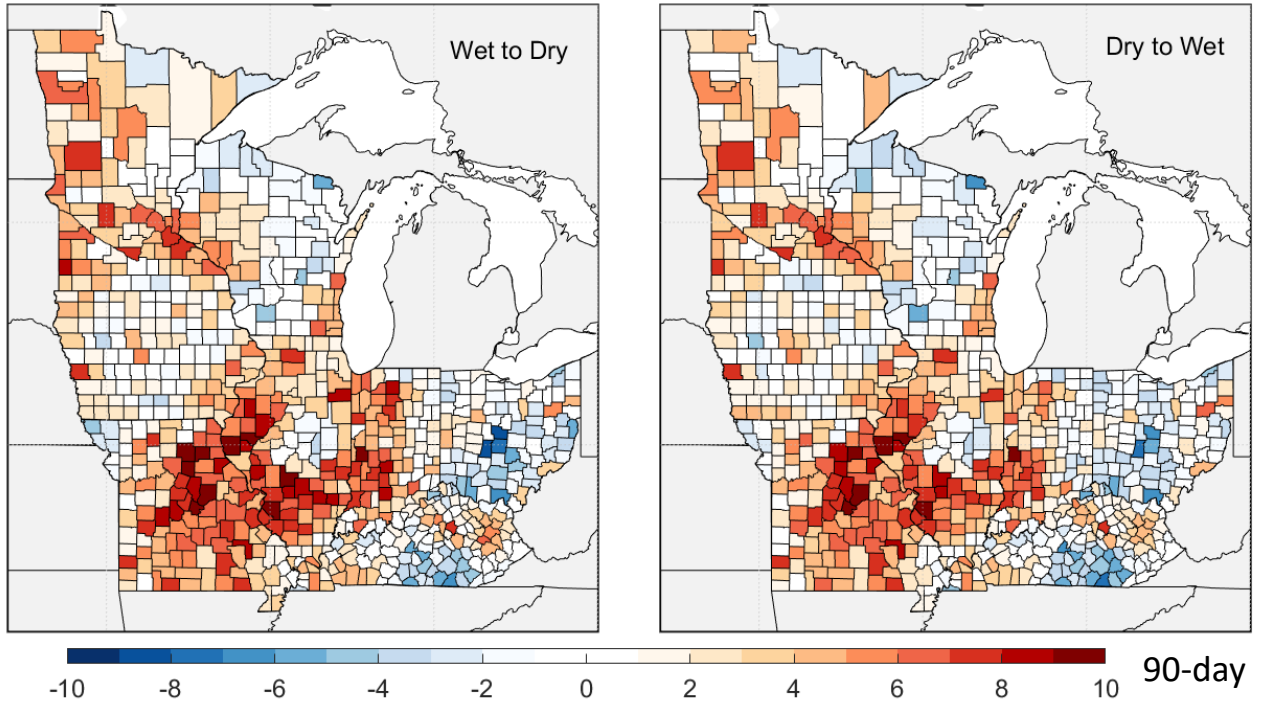


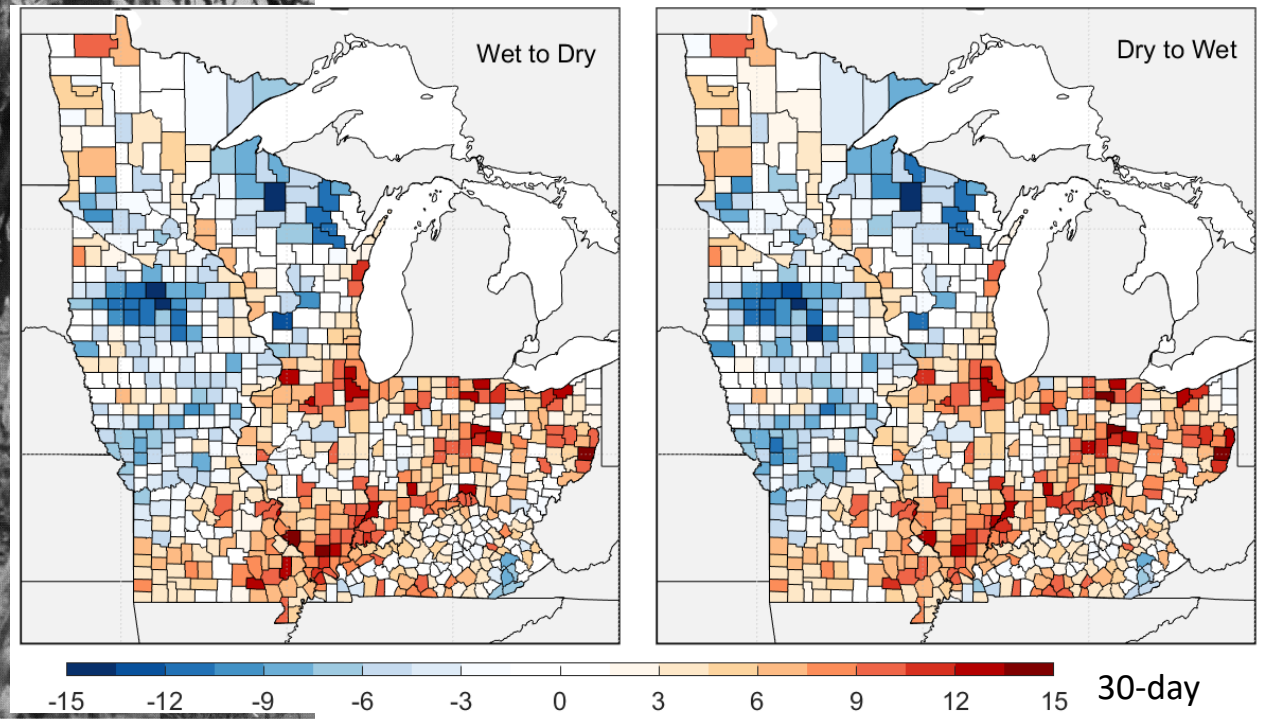


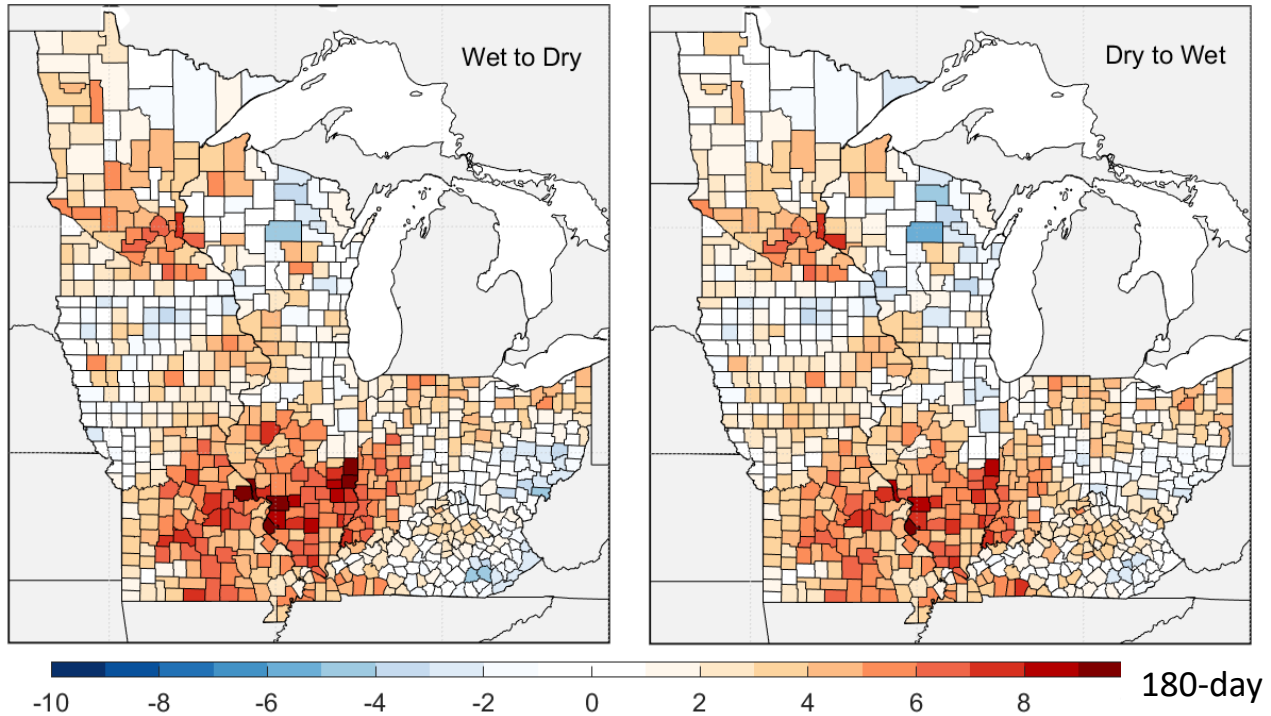


S_a Frequency Change

- S_a frequency difference between first 34 and last 34 years
- Red (blue) counties experienced increased (decreased) extreme swings

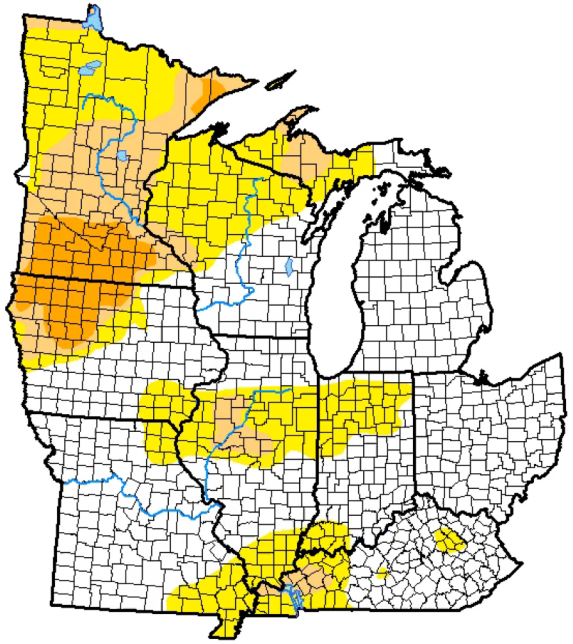






2012

U.S. Drought Monitor
Midwest



May 1, 2012
(Released Thursday, May. 3, 2012)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	56.78	43.22	16.58	5.35	0.00	0.00
Last Week 04-24-2012	58.78	41.22	16.08	5.98	0.00	0.00
3 Months Ago 01-31-2012	71.78	28.22	20.07	6.80	0.00	0.00
Start of Calendar Year 01-03-2012	71.84	28.16	13.47	6.80	0.00	0.00
Start of Water Year 09-27-2011	58.85	41.15	14.01	5.03	0.00	0.00
One Year Ago 05-03-2011	94.80	5.20	0.00	0.00	0.00	0.00

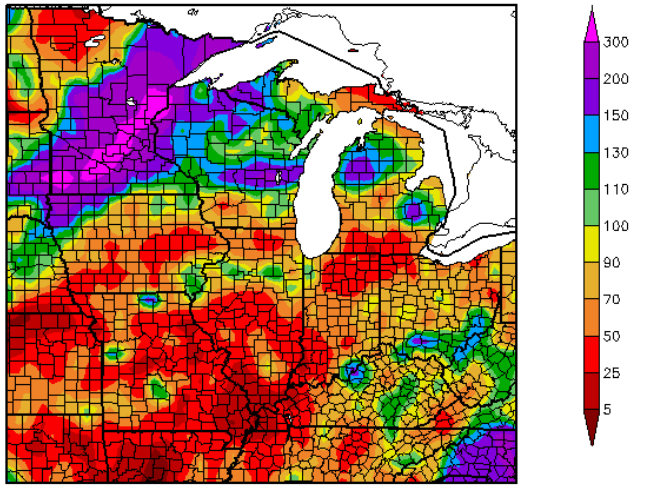
Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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

Author:
Matthew Rosencrans
CPC/NCEP/NWS/NOAA

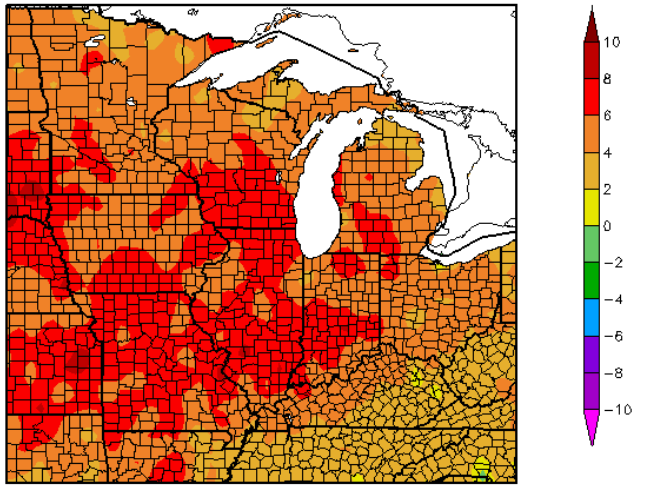
http://droughtmonitor.unl.edu/

Percent of Normal Precipitation (%)
5/1/2012 – 5/31/2012



Generated 6/11/2012 at HPRCC using provisional data. Regional Climate Centers

Departure from Normal Temperature (F)
7/1/2012 – 7/31/2012

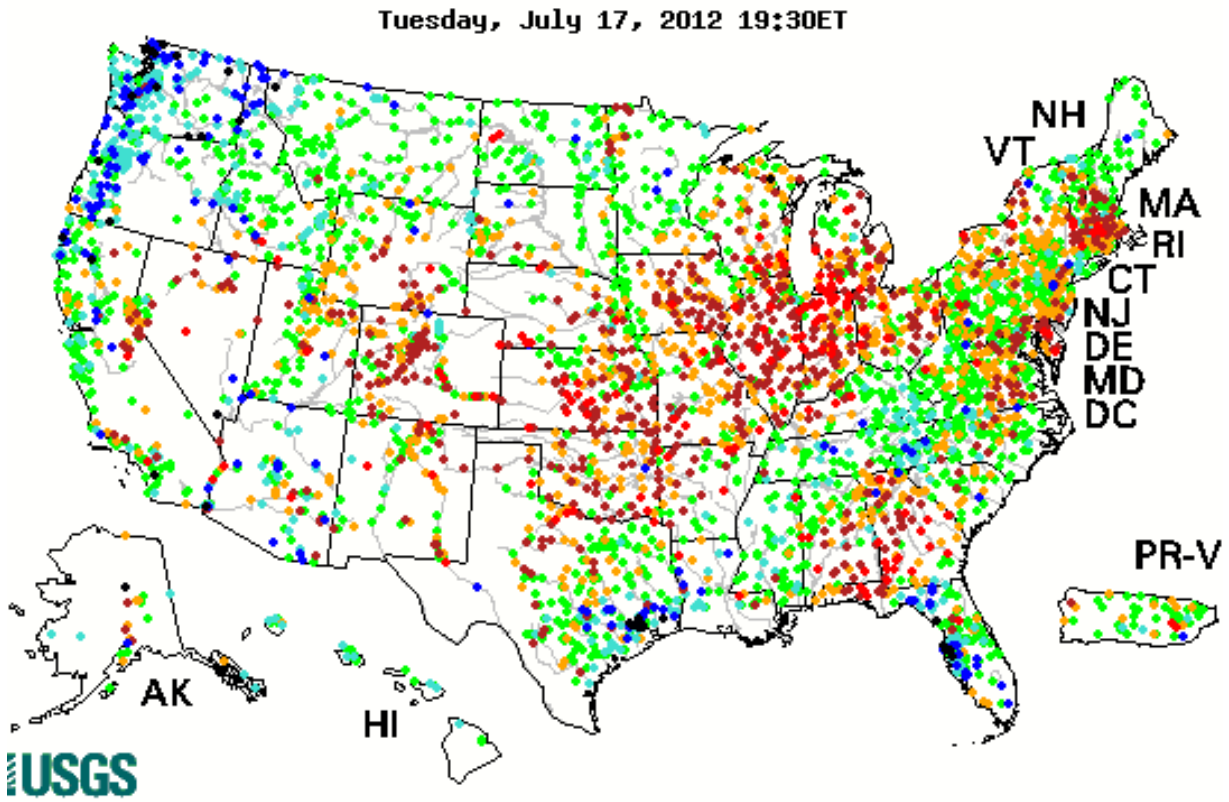


Generated 8/11/2012 at HPRCC using provisional data. Regional Climate Centers

- Lingering early season dryness across the western areas; rapid intensification across the eastern corn belt
- Record July heat driving ET up

2012 Impacts

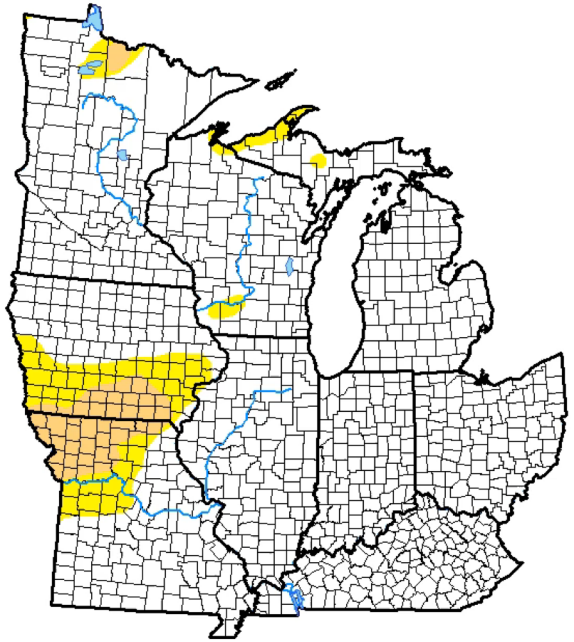
- Moderate to extreme drought conditions affected more than half the country for the majority of 2012.
- Widespread harvest failure for corn, sorghum and soybean crops, among others.
- Indemnity payments/% Eligible Aces (Illinois: 2.8B/79, Indiana: 1B/72)



https://waterwatch.usgs.gov/?id=pamap

2018

U.S. Drought Monitor
Midwest



May 1, 2018
(Released Thursday, May. 3, 2018)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	89.44	10.56	4.15	0.00	0.00	0.00
Last Week 04-24-2018	91.96	8.04	3.19	0.00	0.00	0.00
3 Months Ago 01-30-2018	64.86	35.14	12.52	3.44	0.18	0.00
Start of Calendar Year 01-02-2018	69.93	30.07	9.46	3.44	0.18	0.00
Start of Water Year 09-26-2017	58.41	41.59	8.86	0.77	0.25	0.00
One Year Ago 05-02-2017	100.00	0.00	0.00	0.00	0.00	0.00

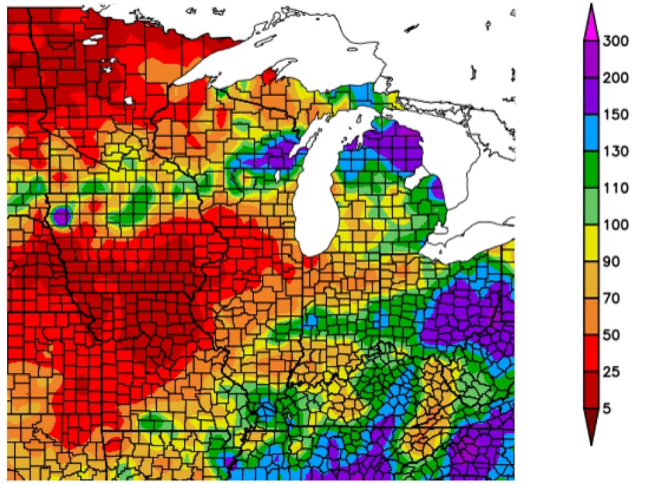
Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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

Author:
David Simeral
Western Regional Climate Center

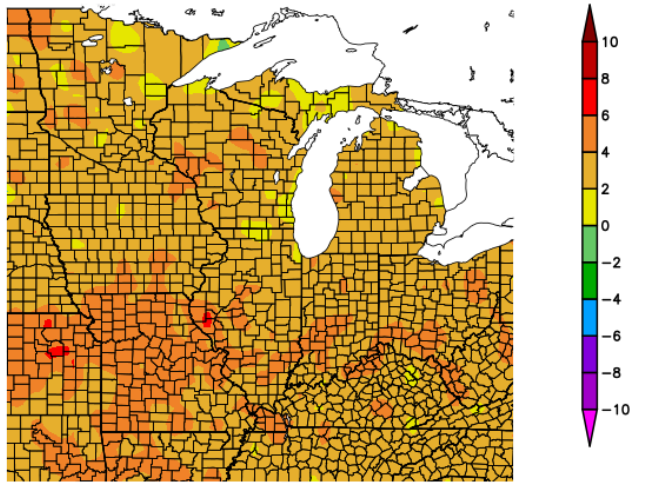
http://droughtmonitor.unl.edu/

Percent of Normal Precipitation (%)
4/1/2018 – 4/30/2018



Generated 5/20/2018 at HPRCC using provisional data. NOAA Regional Climate Centers

Departure from Normal Temperature (F)
5/1/2018 – 7/31/2018



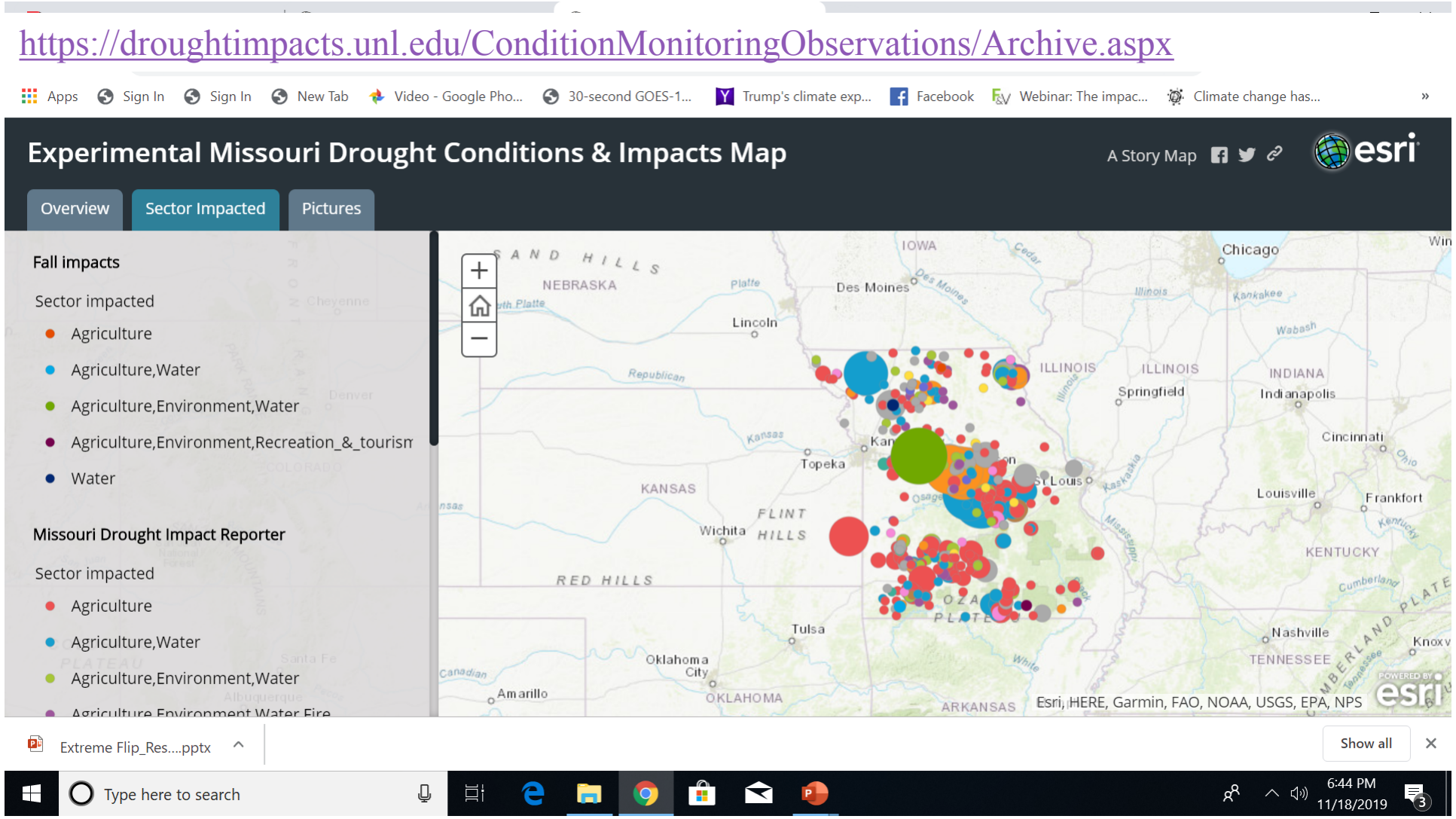
Generated 8/20/2018 at HPRCC using provisional data. NOAA Regional Climate Centers

The Triple Whammy

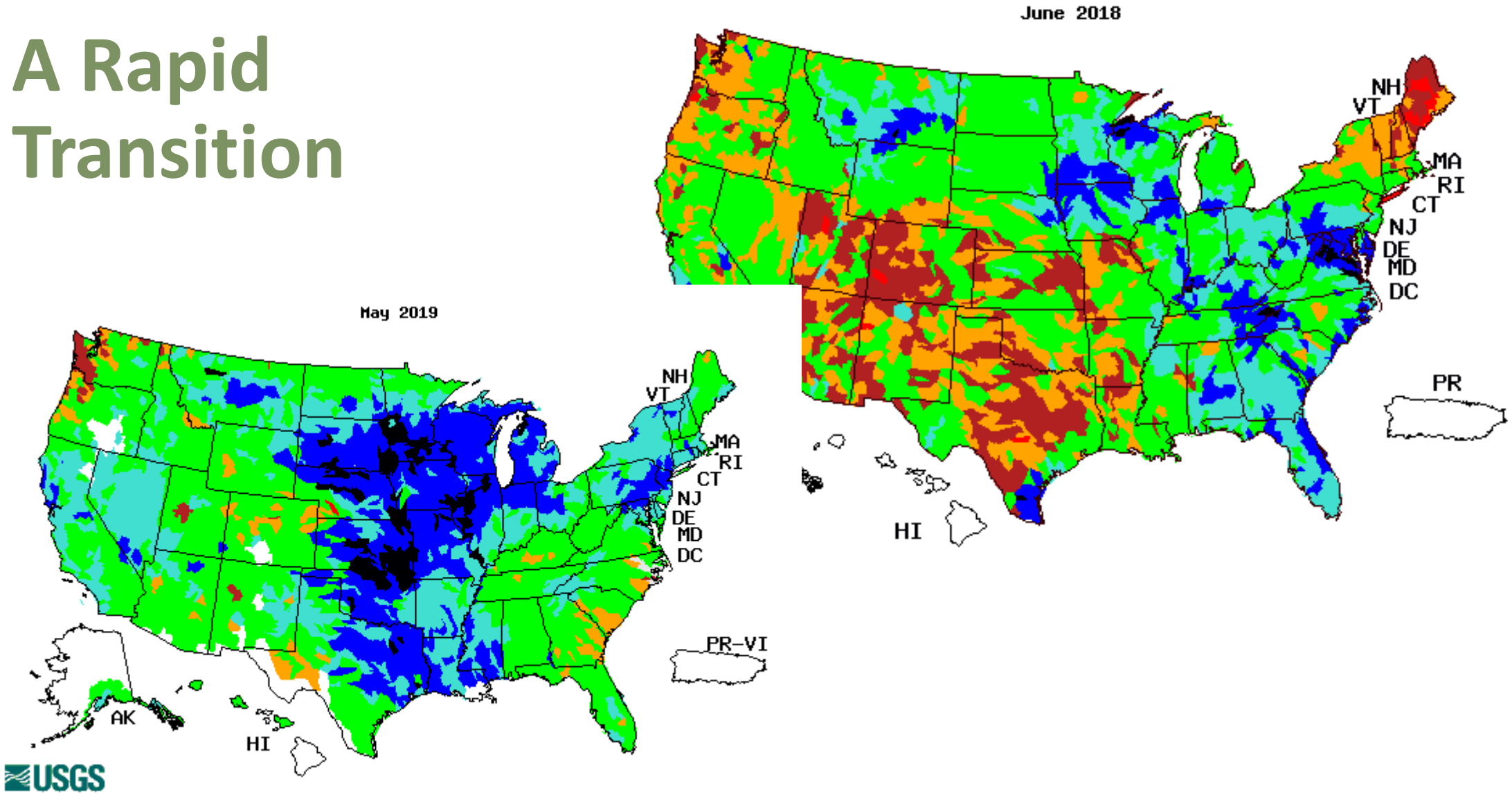
1.Fall and early winter drought;
2.Unprecedented spring flip in monthly temperature anomalies (2nd coldest April followed by hottest May on record;
3.Summer heat and drought – Pat Guinan

Wide Array of Impacts

https://droughtimpacts.unl.edu/ConditionMonitoringObservations/Archive.aspx



A Rapid Transition



USGS

Explanation - Percentile classes							
Low	<10	10-24	25-75	76-90	>90	High	No Data
	Much below normal	Below normal	Normal	Above normal	Much above normal		

2018 Impacts

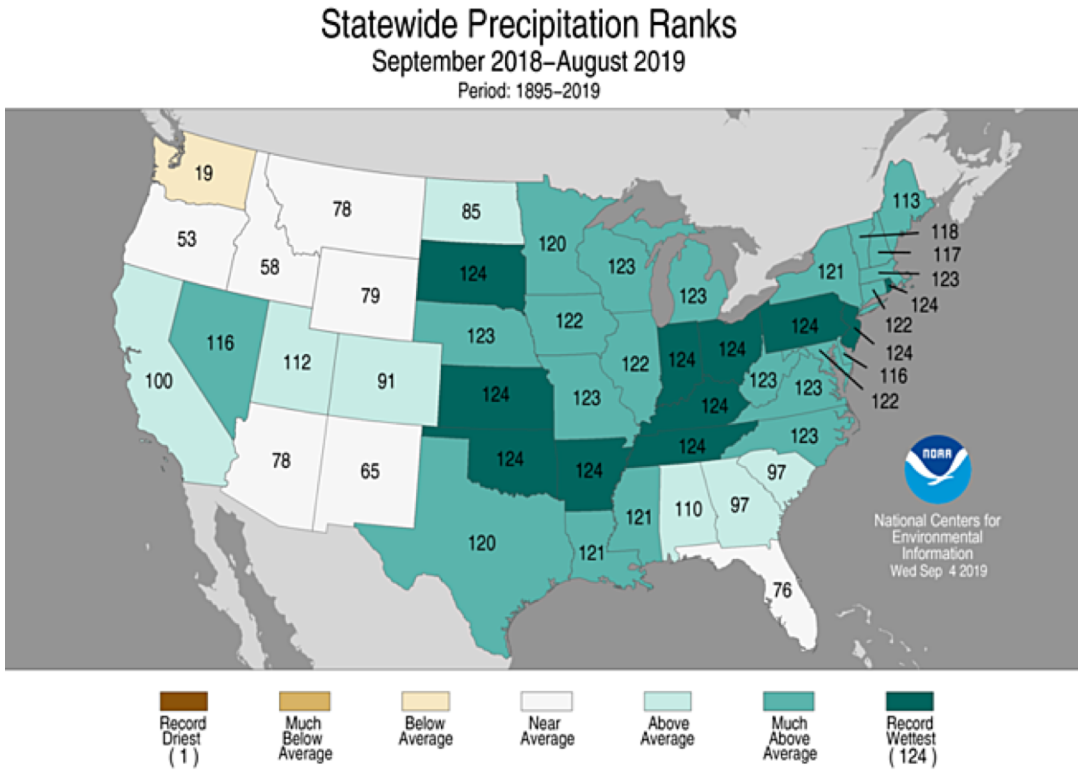
- Large impacts on reservoirs and pastures in Missouri

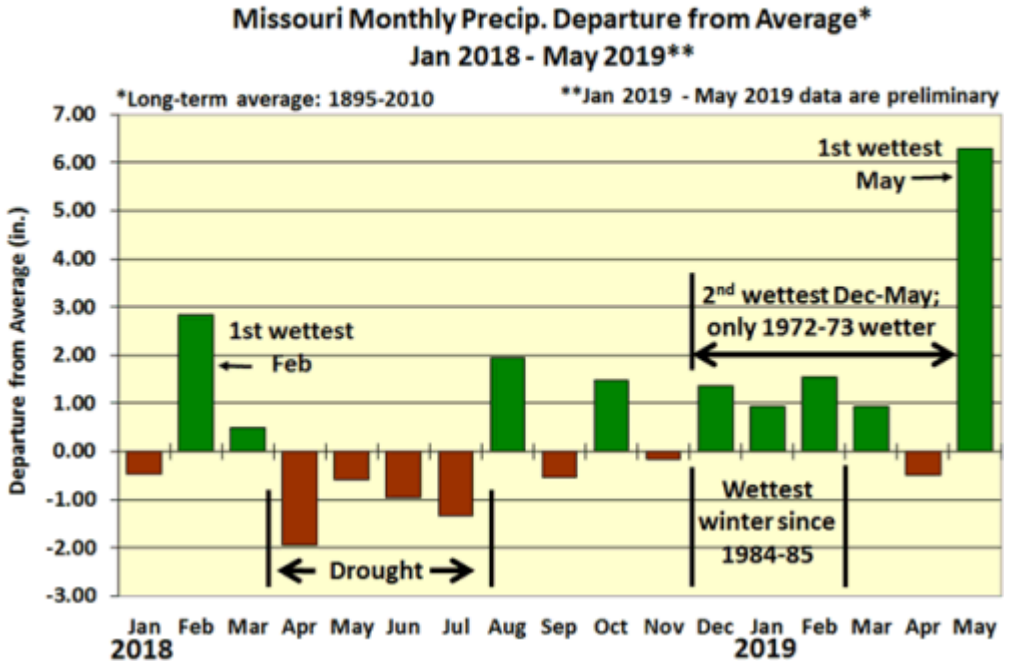
- The Missouri Department of Natural Resources awarded $1 million to assist eight drought-stricken communities. The Governor has also enabled emergency funding to help the City of Cameron and Caldwell County Public Water Supply #2 provide adequate drinking water.

City Reservoir near Hamilton, MO, Caldwell County.
Photo taken in mid-July 2018 by Tim Baker.

Daviess County Courthouse, Gallatin, MO.
Photo taken in mid-July 2018 by Tim Baker.

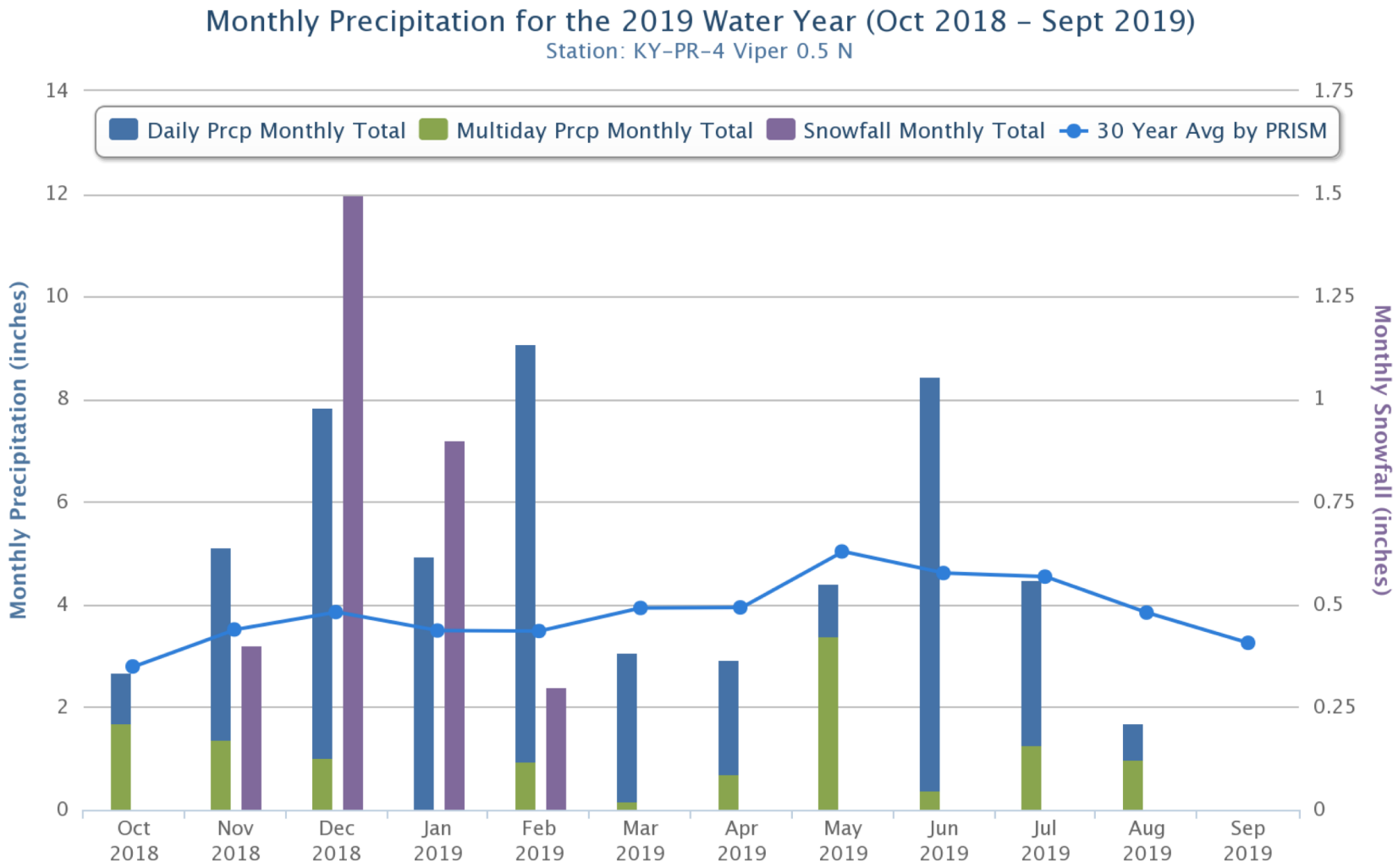
2019





- Note the transitions in Missouri for instance from 2018
- The extreme wetness across all of the Midwest, especially high across the eastern states

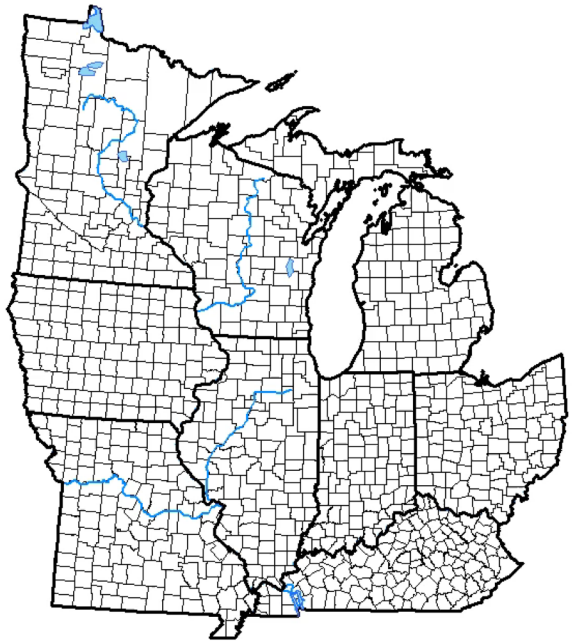
2019


Monthly Precipitation for the 2019 Water Year (Oct 2018 - Sept 2019)
Station: KY-PR-4 Viper 0.5 N
Daily Prcp Monthly Total
Multiday Prcp Monthly Total
Snowfall Monthly Total
30 Year Avg by PRISM
Monthly Precipitation (inches)
Monthly Snowfall (inches)
0
2
4
6
8
10
12
14
0
0.25
0.5
0.75
1
1.25
1.5
1.75
Oct 2018
Nov 2018
Dec 2018
Jan 2019
Feb 2019
Mar 2019
Apr 2019
May 2019
Jun 2019
Jul 2019
Aug 2019
Sep 2019

2019

U.S. Drought Monitor

Midwest



May 7, 2019

(Released Thursday, May. 9, 2019)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	100.00	0.00	0.00	0.00	0.00	0.00
Last Week *04-30-2019*	100.00	0.00	0.00	0.00	0.00	0.00
3 Months Ago *02-05-2019*	99.72	0.28	0.00	0.00	0.00	0.00
Start of Calendar Year *01-01-2019*	99.27	0.73	0.00	0.00	0.00	0.00
Start of Water Year *09-25-2018*	81.26	18.74	8.55	1.71	0.37	0.01
One Year Ago *05-08-2018*	78.59	21.41	3.97	0.00	0.00	0.00

Intensity:

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

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

Author:

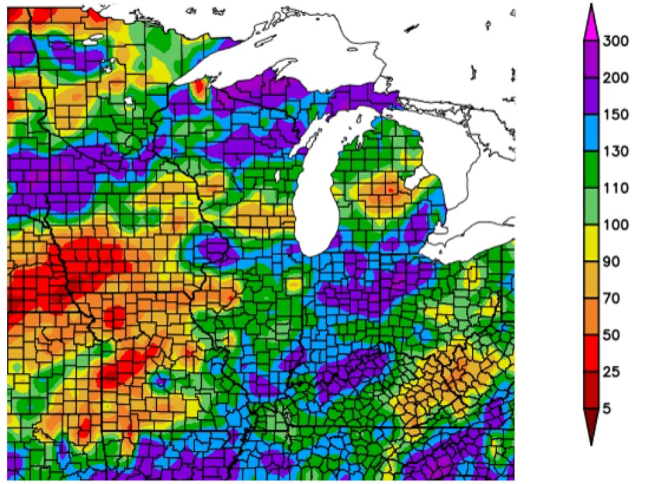
Curtis Riganti

National Drought Mitigation Center

http://droughtmonitor.unl.edu/

Percent of Normal Precipitation (%)

4/1/2019 – 4/30/2019

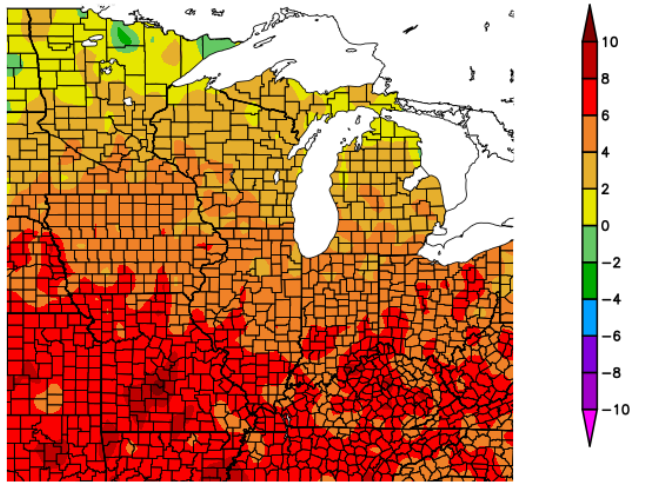


Generated 5/20/2019 at HPRCC using provisional data.

NOAA Regional Climate Centers

Departure from Normal Temperature (F)

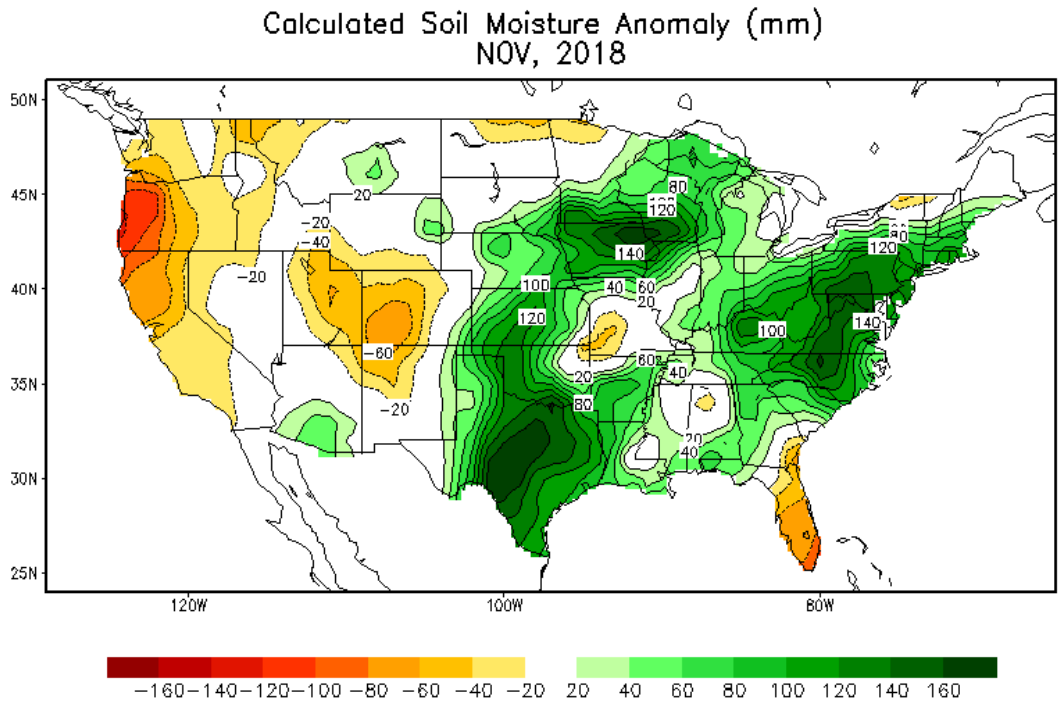
9/1/2019 – 9/30/2019

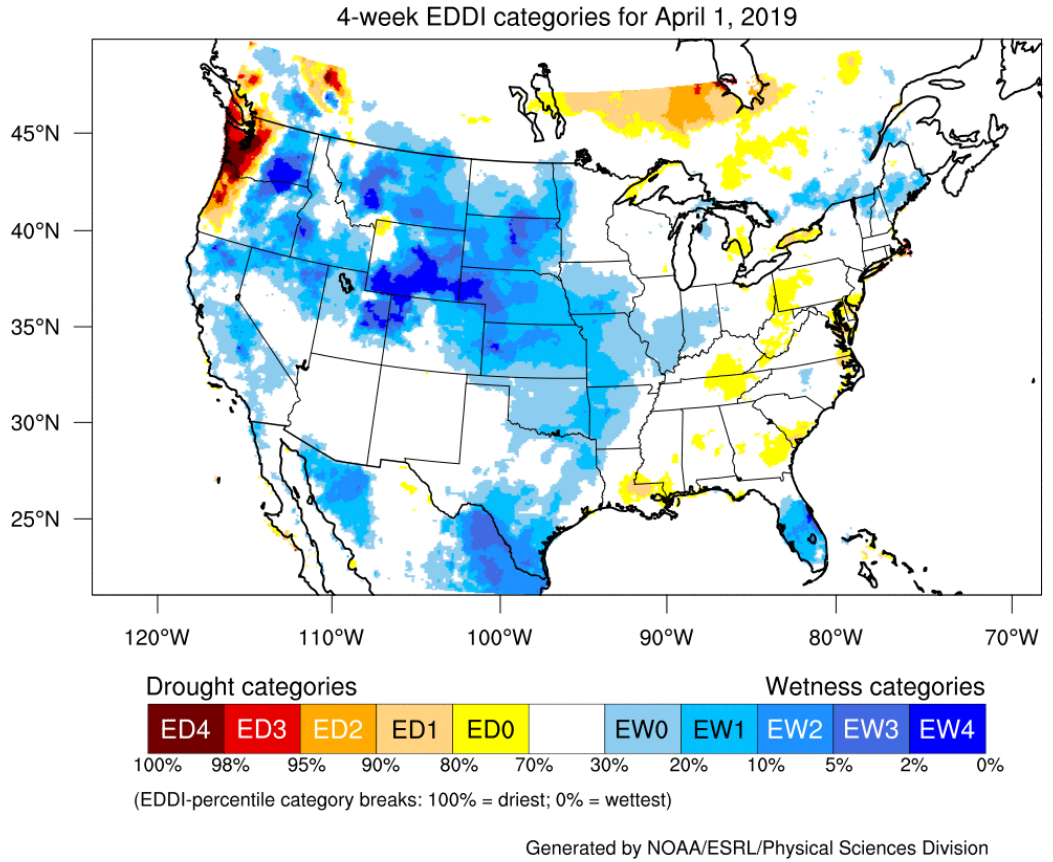


Generated 10/20/2019 at HPRCC using provisional data.

NOAA Regional Climate Centers

2019


Calculated Soil Moisture Anomaly (mm)
NOV, 2018
50N
45N
40N
35N
30N
25N
120W
100W
80W
−160 −140 −120 −100 −80 −60 −40 −20 20 40 60 80 100 120 140 160


4-week EDDI categories for April 1, 2019
45°N
40°N
35°N
30°N
25°N
120°W
110°W
100°W
90°W
80°W
70°W
Drought categories
Wetness categories
ED4 ED3 ED2 ED1 ED0 EW0 EW1 EW2 EW3 EW4
100% 98% 95% 90% 80% 70% 30% 20% 10% 5% 2% 0%
(EDDI-percentile category breaks: 100% = driest; 0% = wettest)
Generated by NOAA/ESRL/Physical Sciences Division

2019 Impacts

- Cattle impacts from pastures
- Low ponds and retention basins

Photos courtesy of Chip Zimmer

COMBINED EXTREMES: Fourth time since 1895 that any month has placed in both the top 5 warmest and driest of all time here in KY. The others were July of 1901 and 1930, in addition to August of 2007. –Chip Zimmer

Today's Charge

- How do these transitions from extreme wet to extreme dry affect your specific sector? (challenges you face, negative impacts, management decisions, your bottom line, etc.)
- Can you recall a recent tangible example to answer the above?
- Are there things you could do to help reduce the impacts of the rapid transition from flood to drought and back again on your stakeholders/clientele?
- What do you need to know to make these decisions? Would more advanced warning of extremes be helpful, or are there things you can do regardless of what's happening 'now' that makes you more resilient to both of these extremes?

Let's Talk About Resilience and DEWS Roles

- Long term tillage impacts on soils; reducing organic matter and thus water holding capacity – increases risk issues because of lack of "water in the bank".
- Are these areas sensitive to "extreme" events
- Temps/no rain/ = Compounding Extremes – A piece of the forecasting puzzle?