



Transitions in Precipitation Extremes in the Midwest

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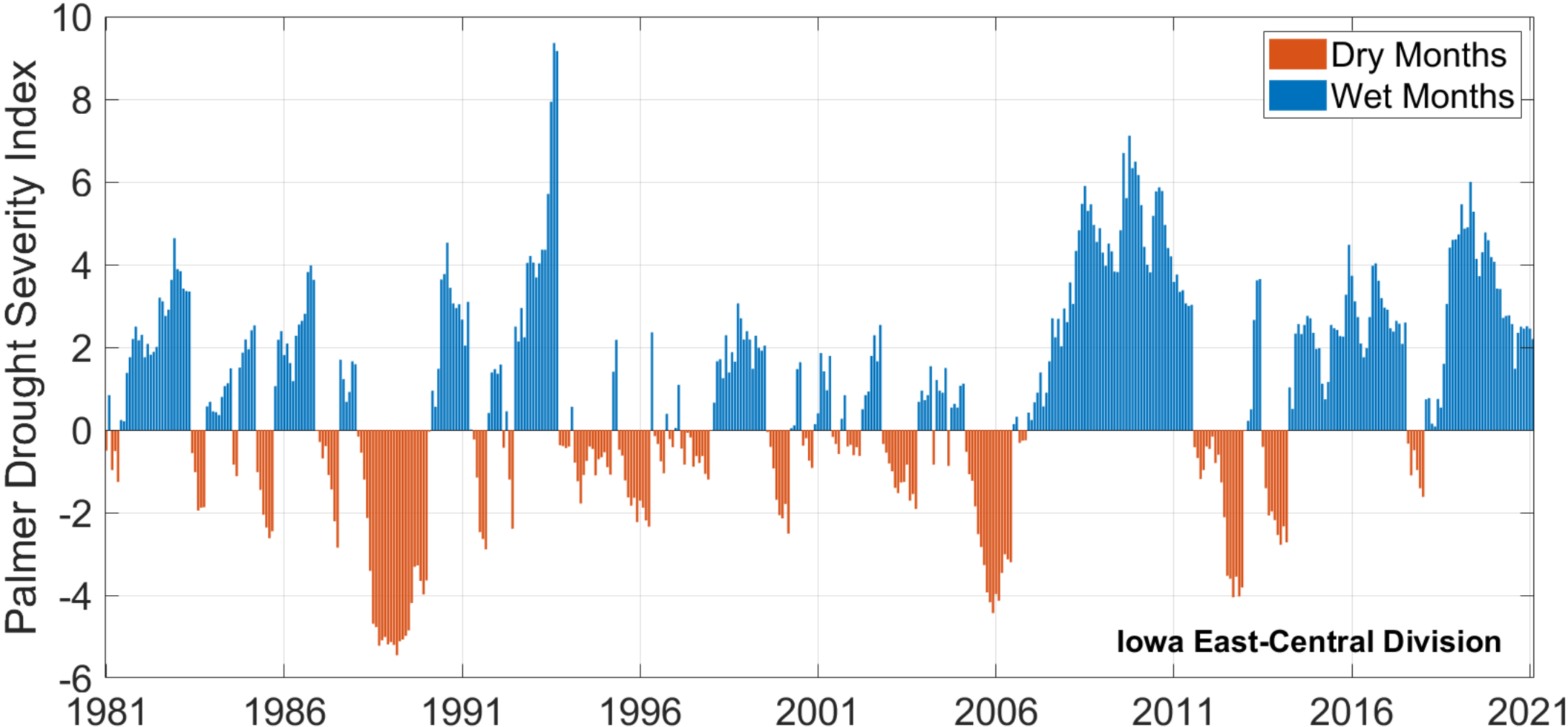


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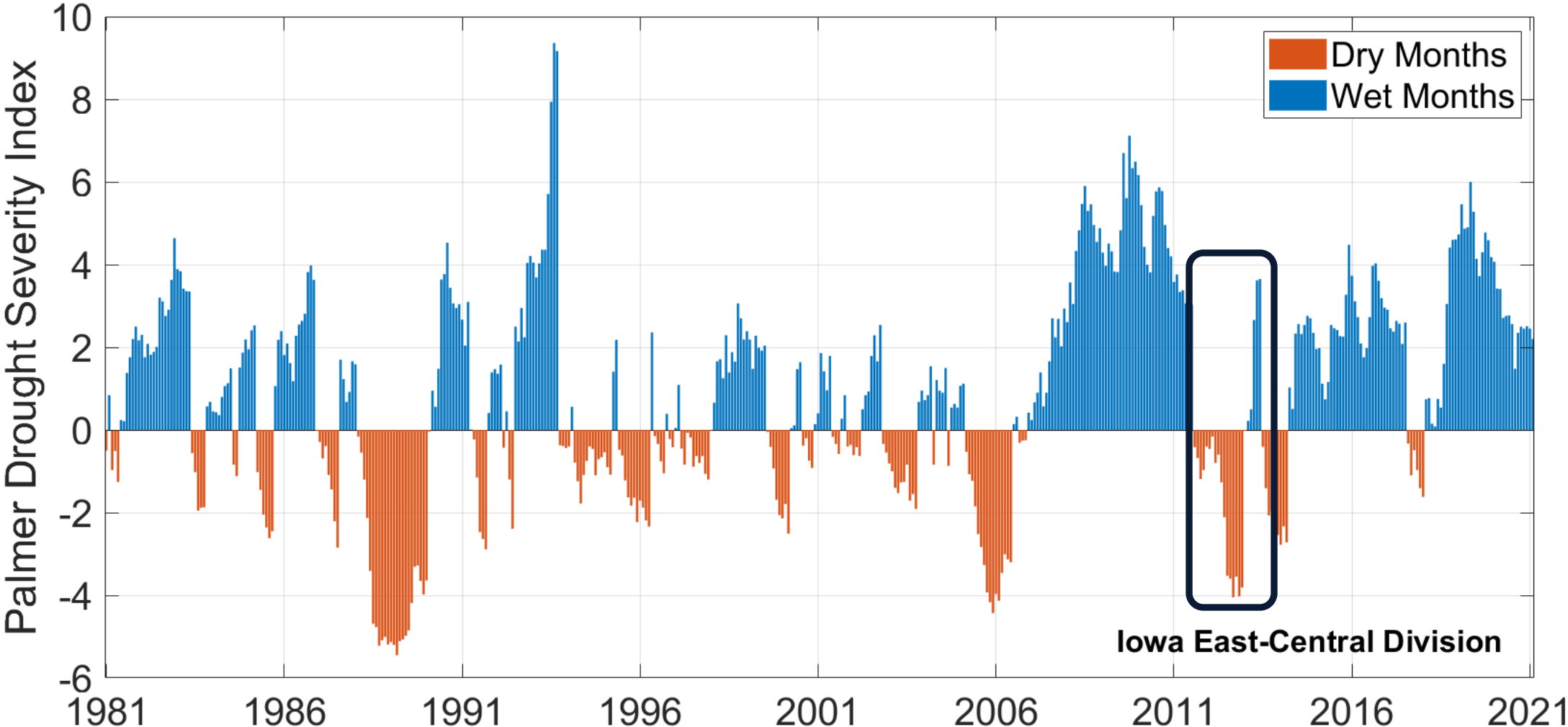
Illinois State Water Survey

PRAIRIE RESEARCH INSTITUTE

Flooding and Drought

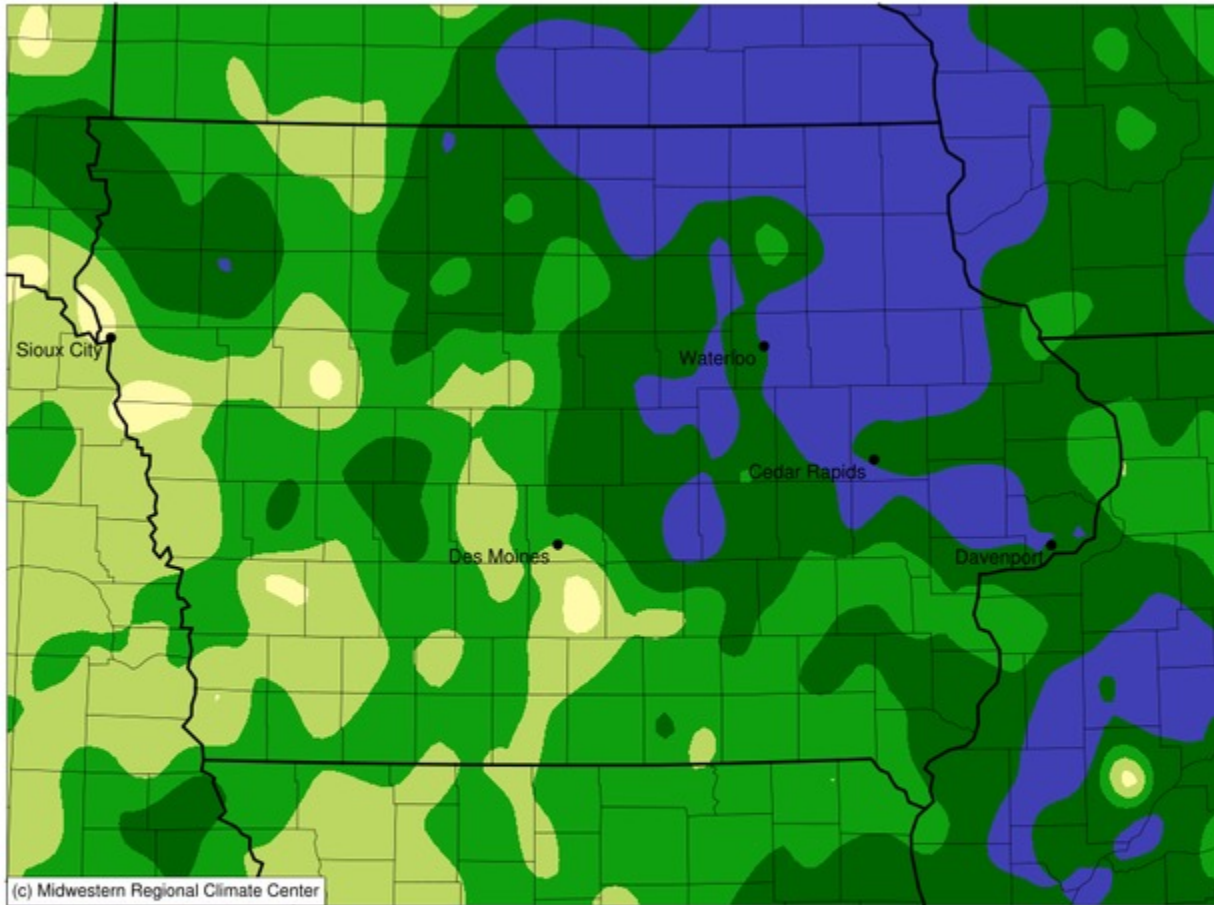


Rapid Variations or Transitions

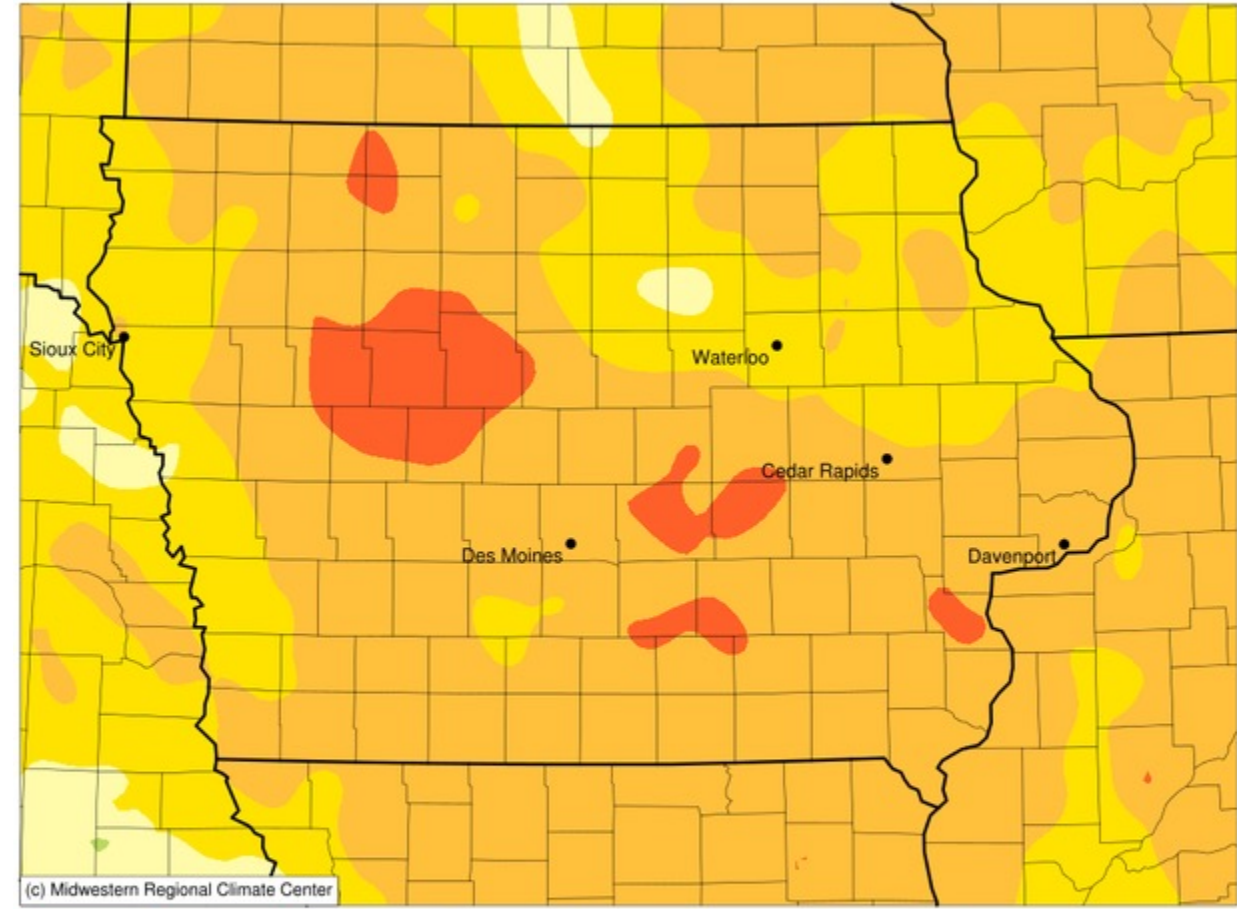


Rapid Wet-to-Dry Transition – 2013

April – June 2013 Precipitation (% Normal)



July – September 2013 Precipitation (% Normal)

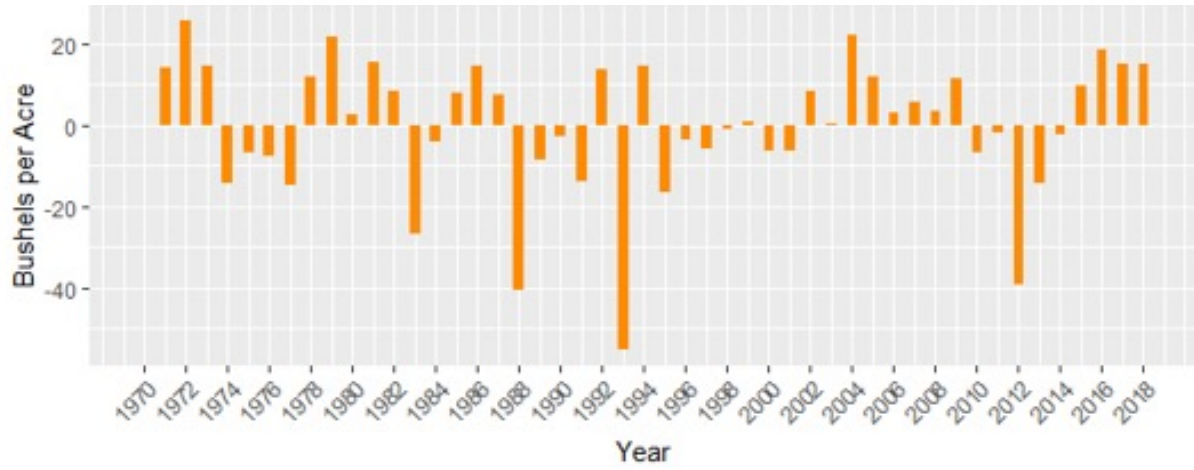


50 75 100 125 150 175

5 10 25 50 75 100 125 150



Rapid Transition Impacts



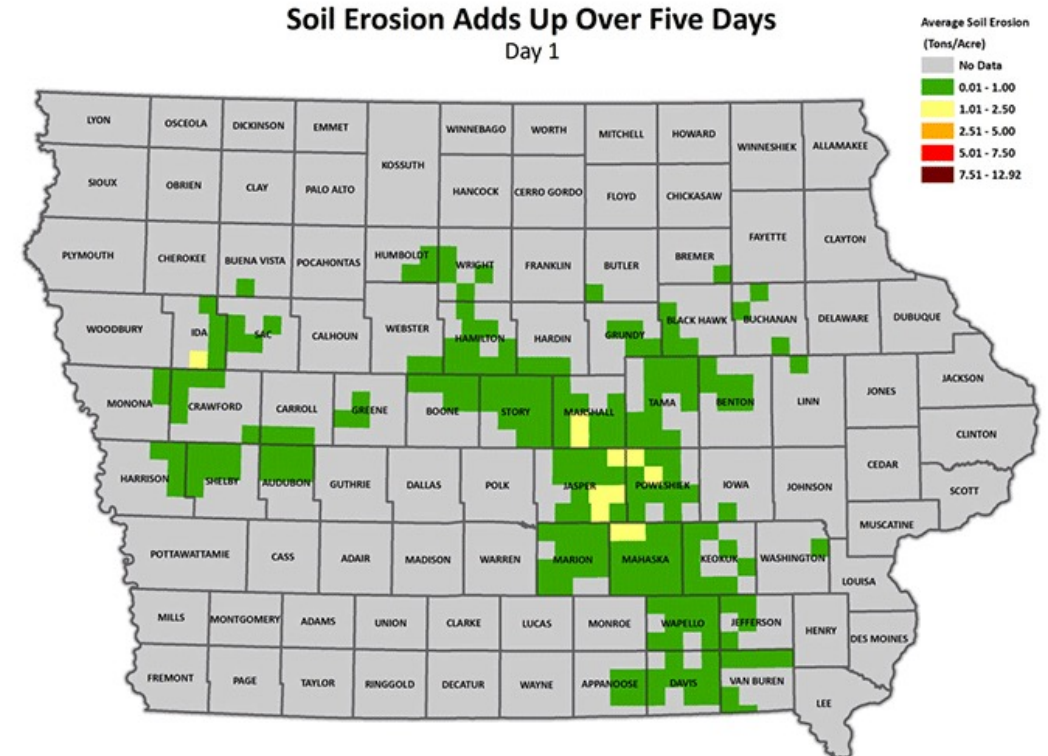
Statewide corn yields in 2013 10-15 bu./acre below trend



24 IA state park microcystin swim advisories in 2013 (then a record)

≡ *Sioux City Journal*

Iowa sees additional Lyme, West Nile cases in '13



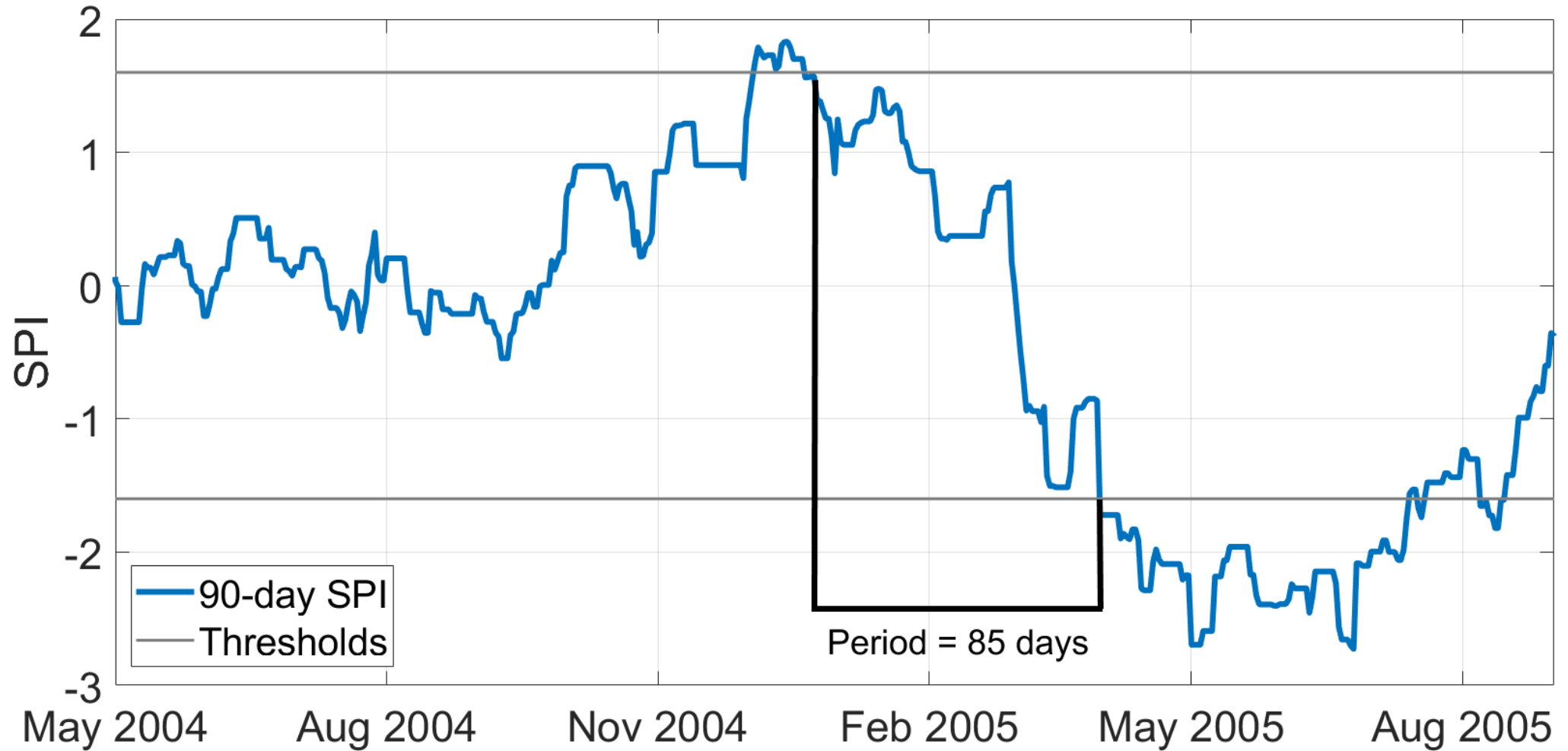
Average soil erosion of 5 tons per acre across 1.2 million acres between May 25-29, 2013 (EWG, 2013)



Primary Goal: Improve understanding of rapid transitions in extremes, their causes, and the risk they pose to the Midwest

- Identify rapid transitions in precipitation extremes using both historical observations and future climate projections – quantify risk of these events
- Analyze the large-scale drivers of rapid transitions in precipitation extremes, assess the potential predictability of such events on seasonal and inter-annual timescales

What is a transition? Says You



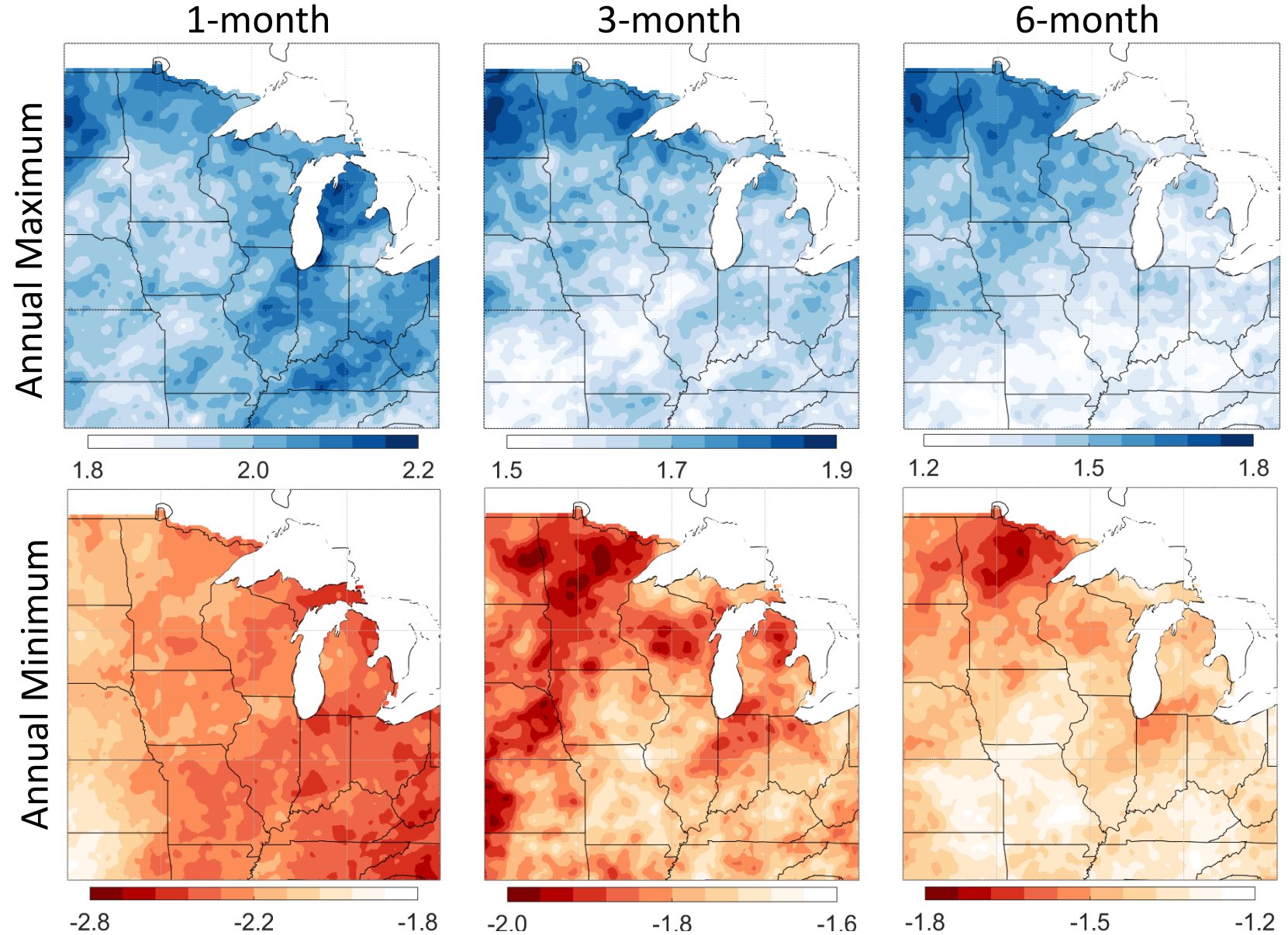
Precipitation Extremes – Standardized Precipitation Index (SPI)

Darker blues = wetter wets

Darker reds = drier dries

Southeast has a more variable climatology at 1-month

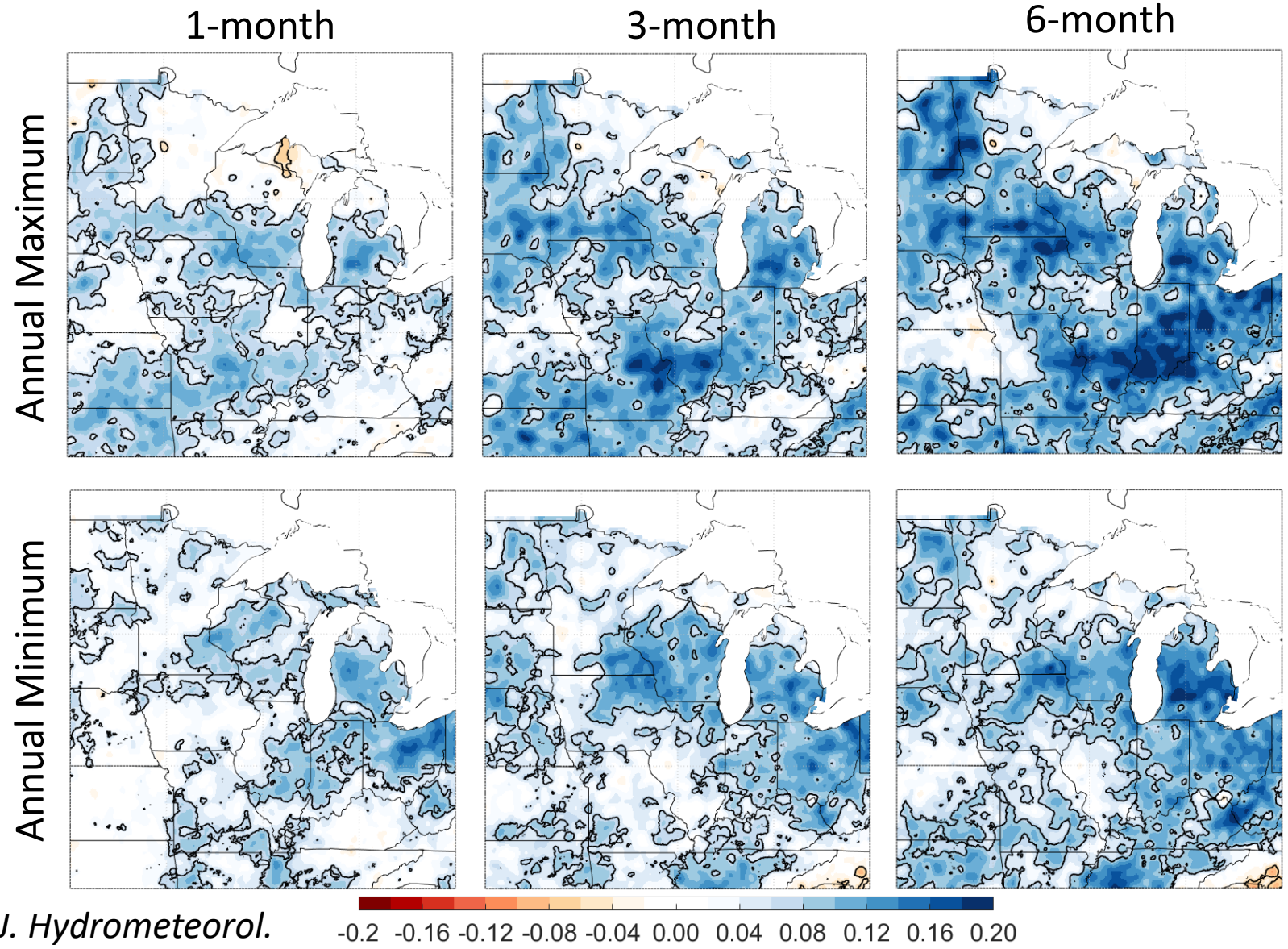
Northwest tends to be more variable at 3-6 months



Historical Changes in Extremes (1950 – 2020)

Wet & dry extremes have become wetter, larger change at 6-months

Wet extremes have intensified at a larger rate than dry extremes in OH Valley and Northwest



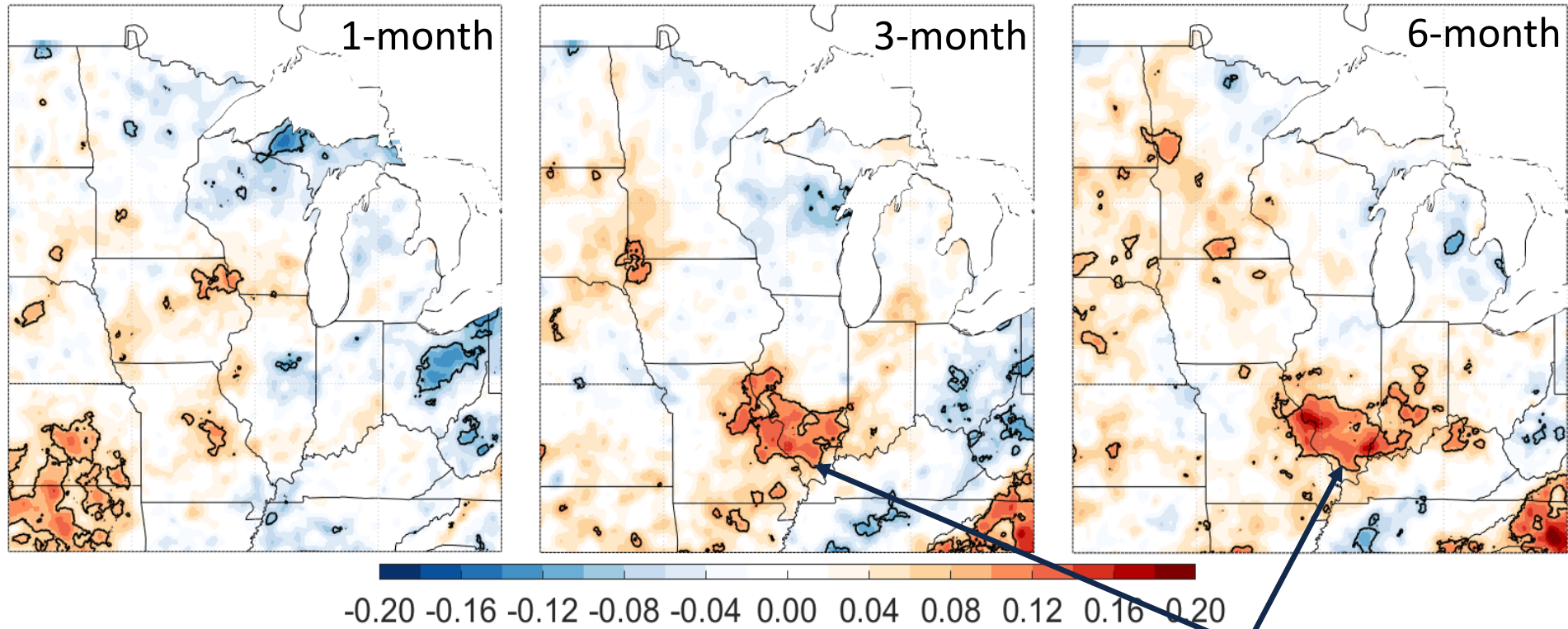
Ford et al. (2021), *J. Hydrometeorol.*



Wets Are Getting Wetter, Drys....

Ford et al. (2021), *J. Hydrometeorol.*

Trends in Difference Between Annual Maximum & Annual Minimum SPI

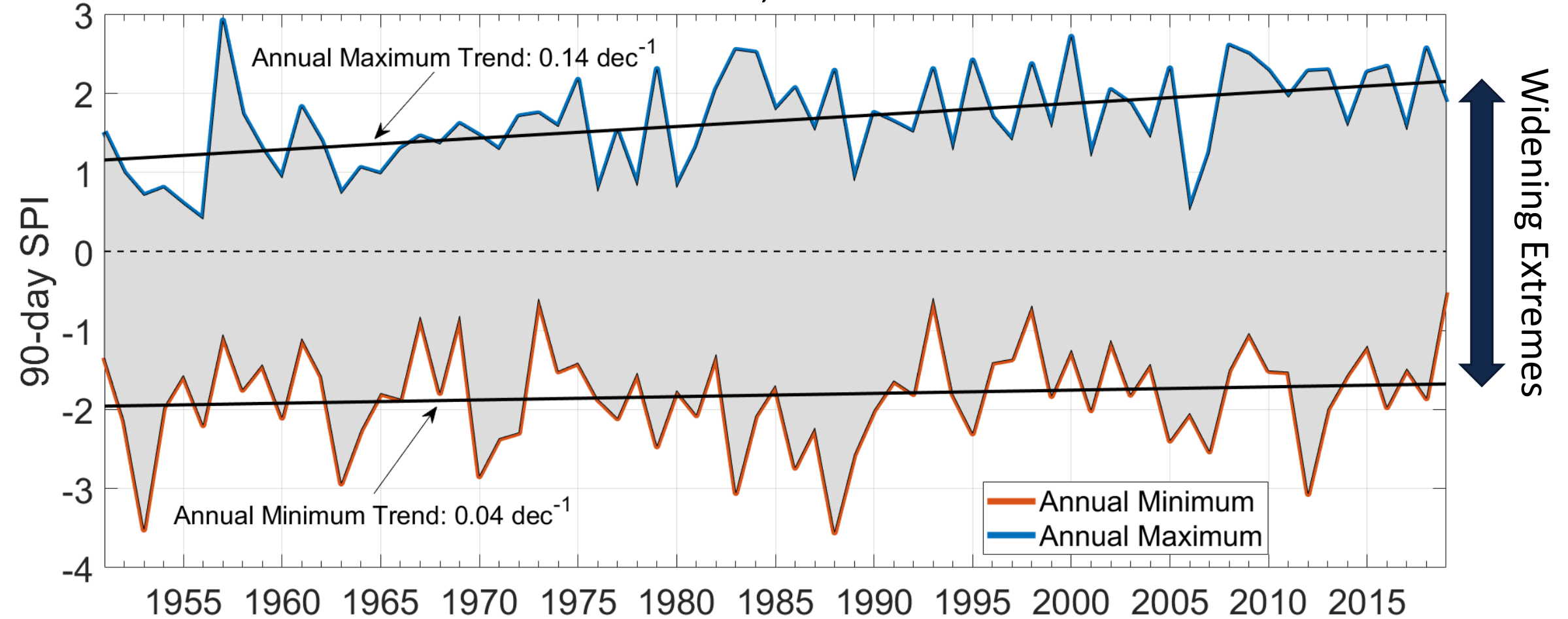


Similar change in wet & dry extremes results in little change in variability

Middle MS & Lower OH have seen widening of extremes, more variability

Wets Are Getting Wetter, Drys....

St. Louis, MO



Ford et al. (2021), *J. Hydrometeorol.*



What About Transitions Between Extremes?

Ford et al. (2021), *J. Hydrometeorol.*

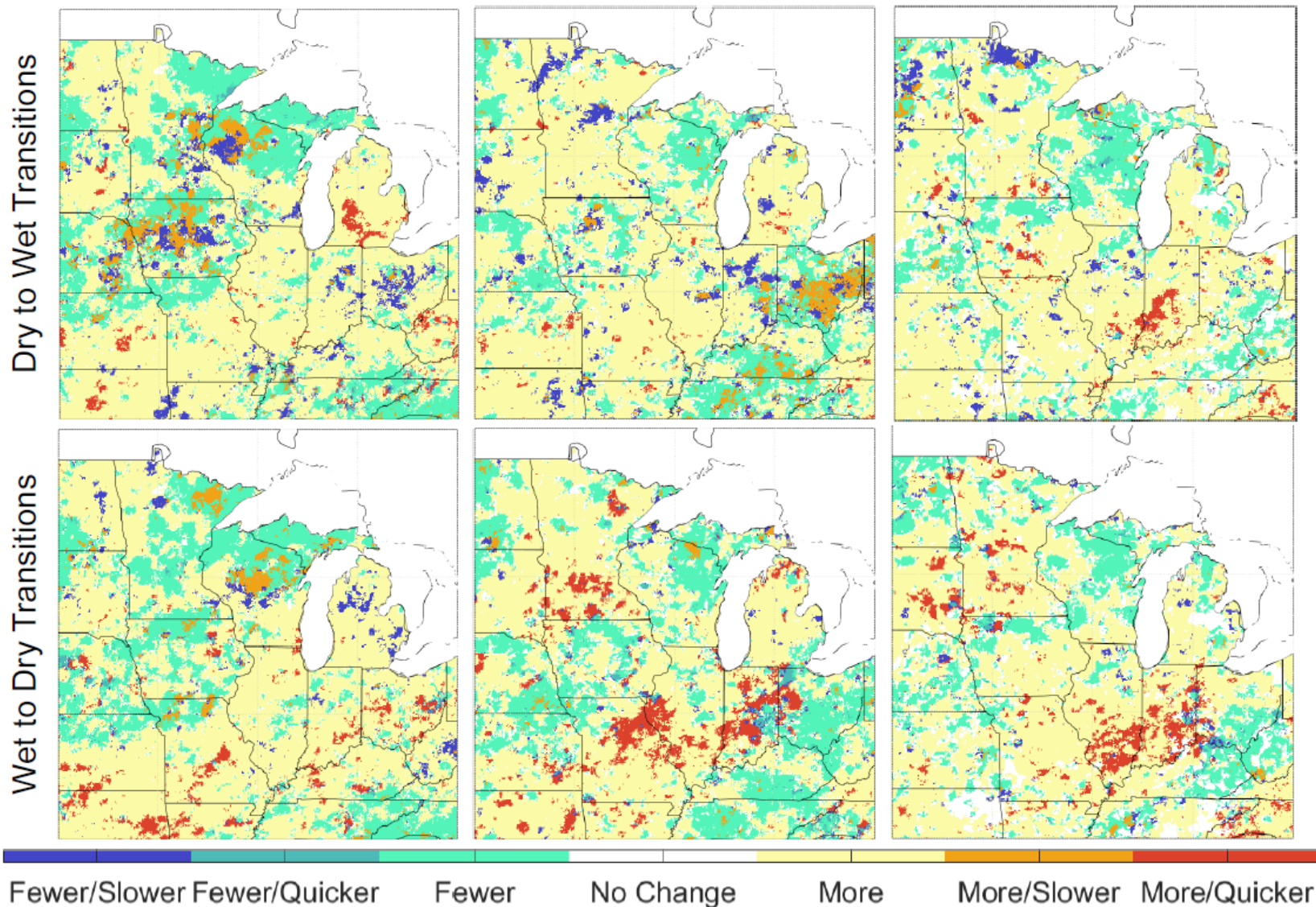
1-month

3-month

6-month

Most of the Midwest has experienced a slight increase in extreme frequency

Significantly more frequent, faster transitions from central MO to western OH at 3- and 6-month intervals

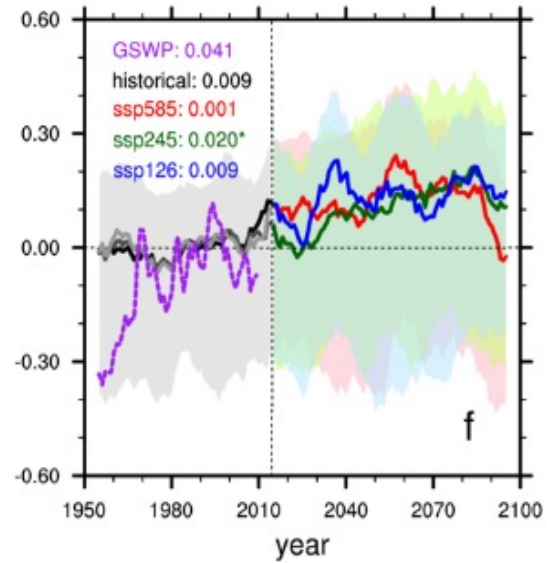
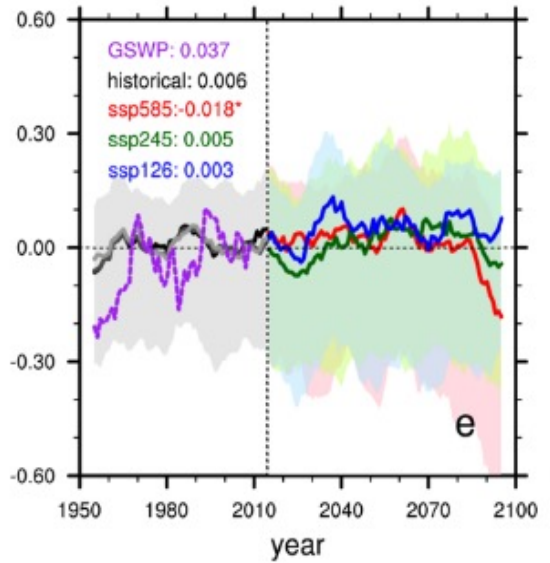
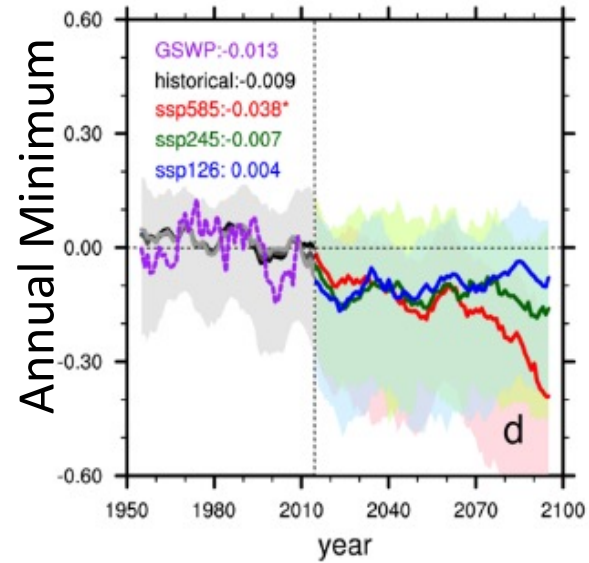
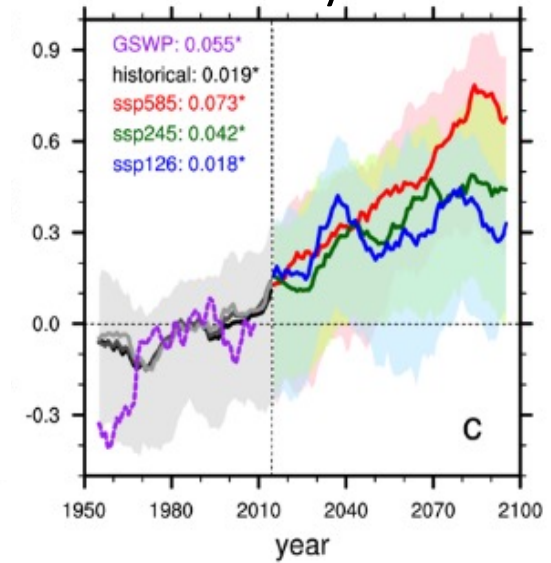
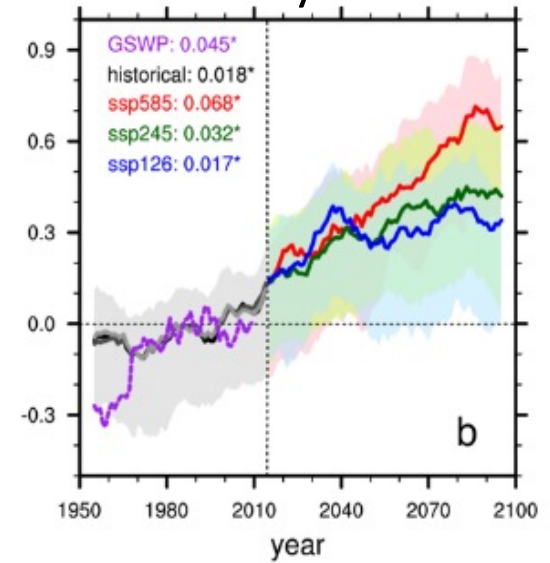
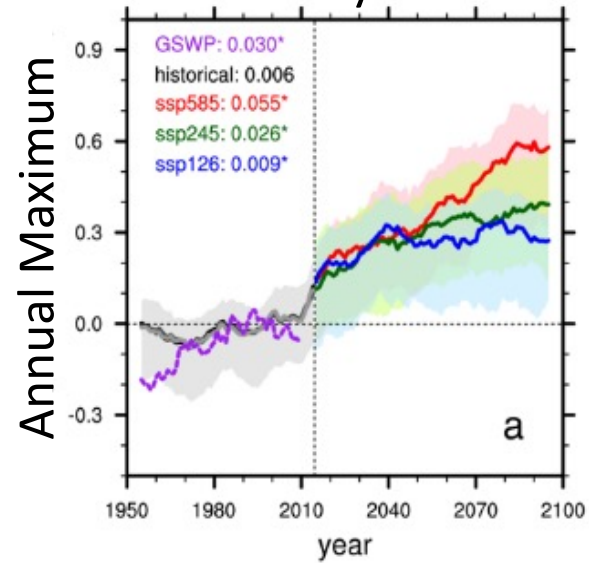


Looking Ahead – CMIP6 Projected Extremes

30-day SPI

60-day SPI

90-day SPI



Projections show intensified wet extremes at 1-, 3-, 6-months & intensified dry extremes at 1-month

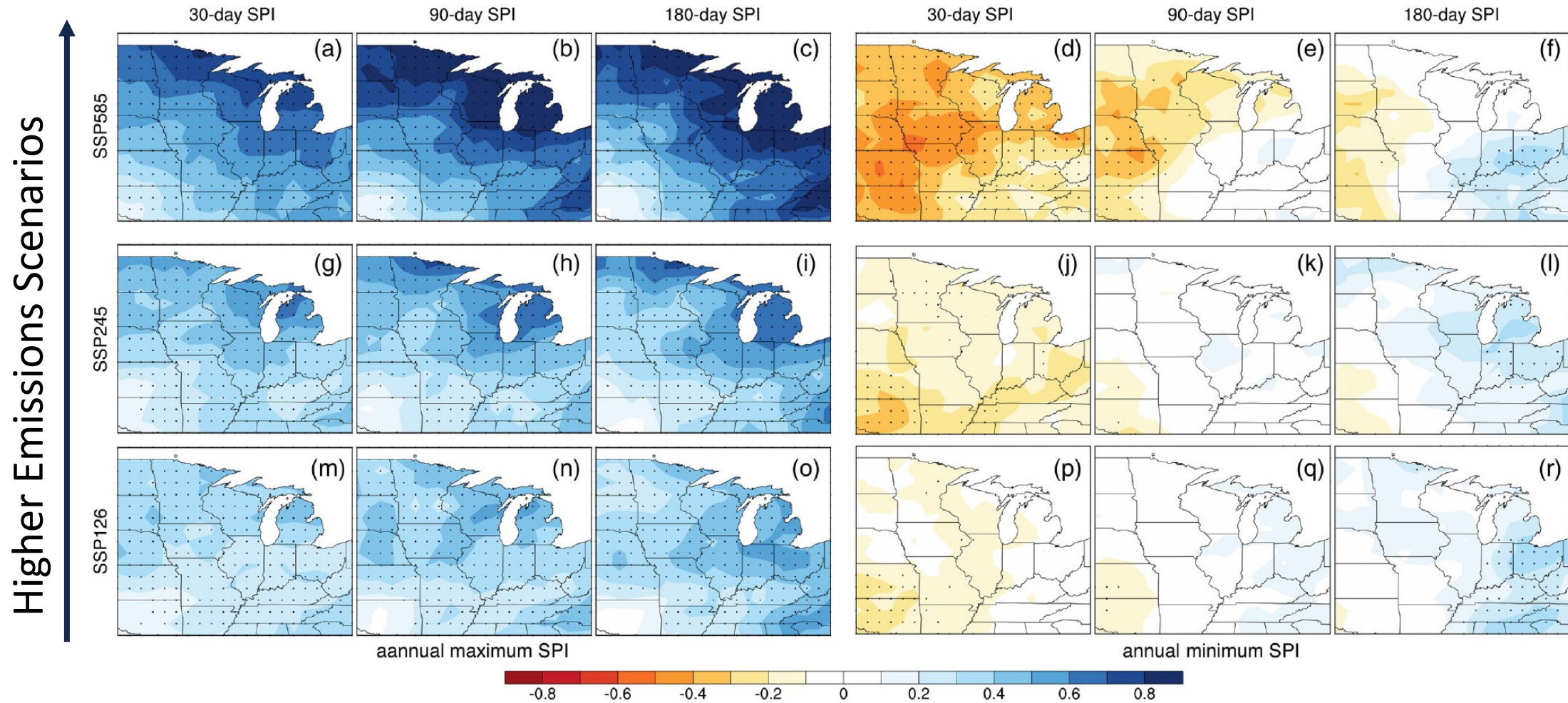
Overall wetter conditions superimposed with more extreme short-term variability

Chen and Ford, *Int. J. Climatol.*



Looking Ahead – CMIP6 Projected Extremes

Chen and Ford, *Int. J. Climatol.*

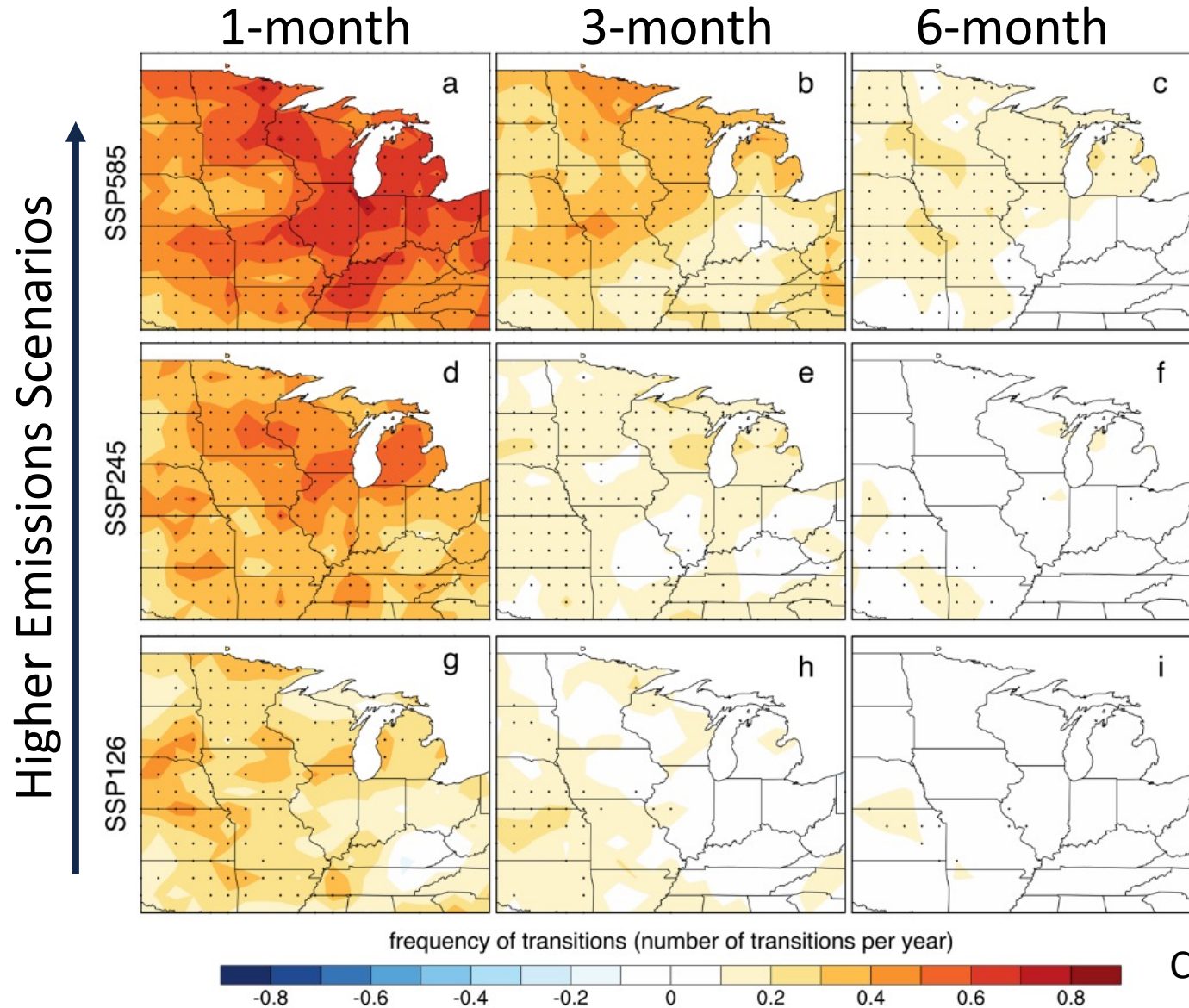


Larger wetting trend in Great Lakes region, significant for most of the region

Drying trend at 1- to 3-months is larger west, wetter trend at 3- to 6-months is larger east



Looking Ahead – CMIP6 Projected Transition Frequency



Largest projected increase in transition frequency at 1-month, western Midwest

Transition frequency is very sensitive to projection scenario... higher emissions = more transitions

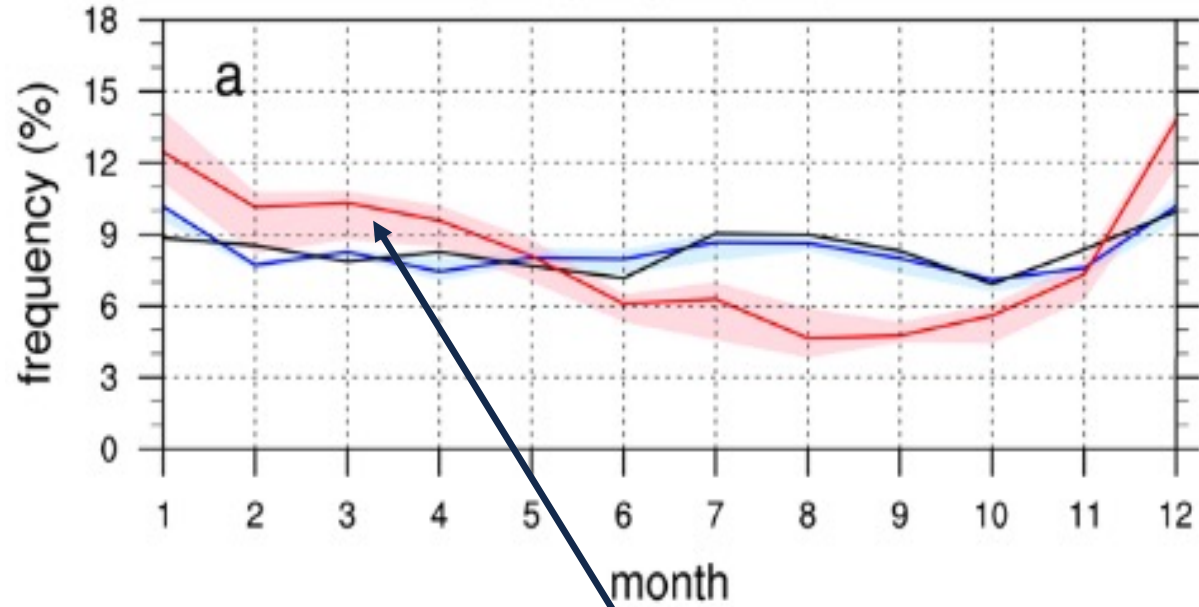
Chen and Ford, *Int. J. Climatol.*



Looking Ahead – CMIP6 Projected Changes in Seasonality

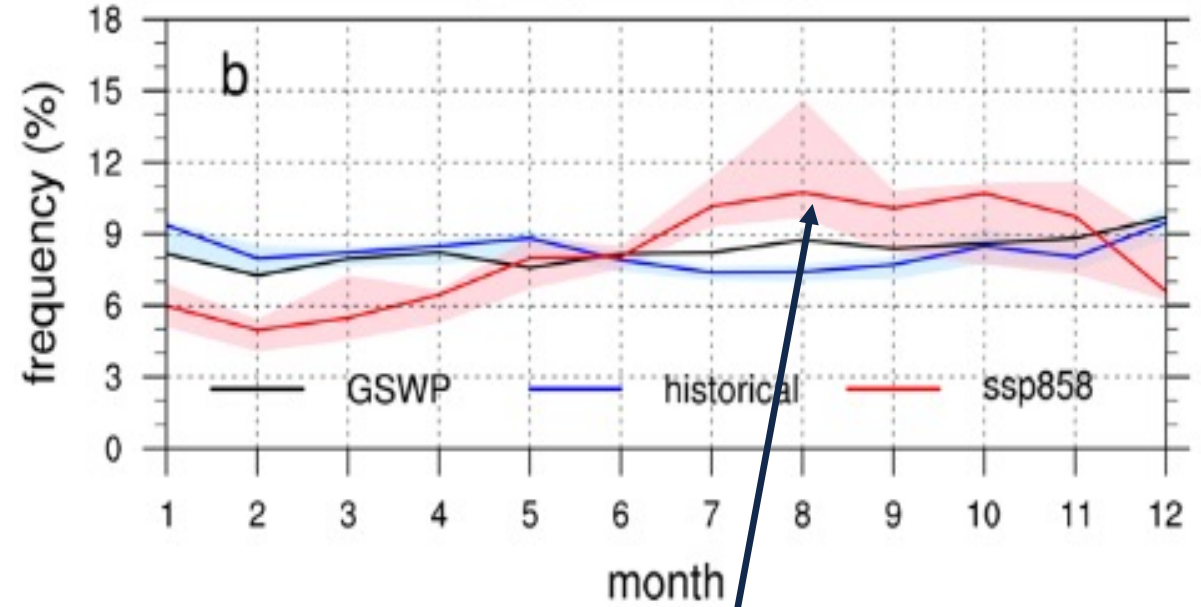
Chen and Ford, *Int. J. Climatol.*

annual maximum SPI



More frequent annual maximum wetness in winter & early spring

annual minimum SPI



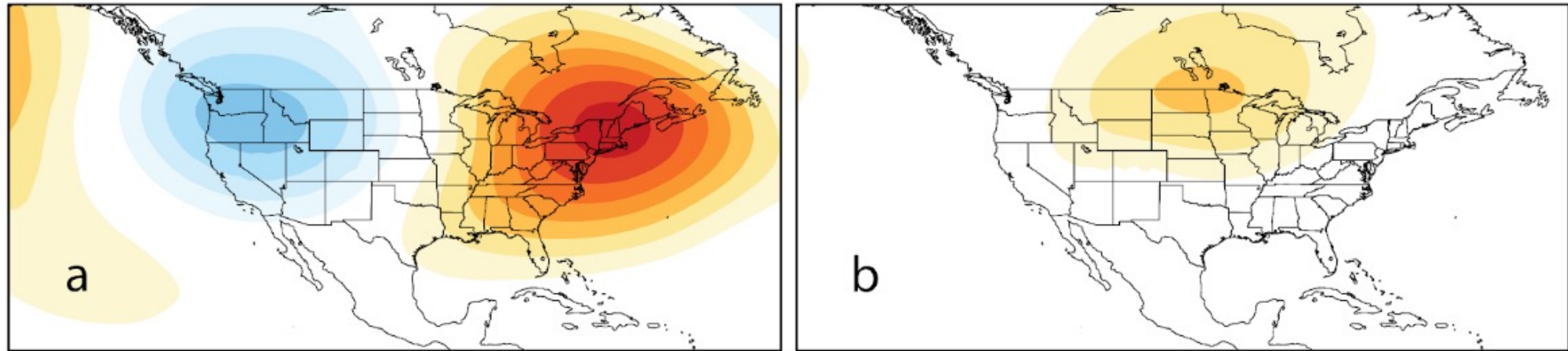
More frequent annual maximum dryness in late summer, early fall

Atmospheric Patterns Associated with Extremes (1981 – 2014)

Historical Wet Springs

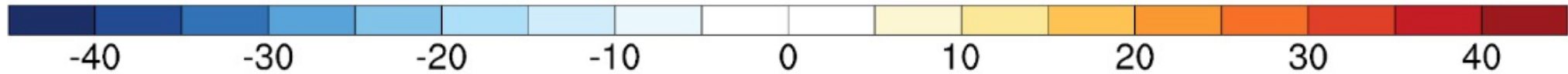
ERA5

Historical Dry Summers



500 hPa anomalies (m)

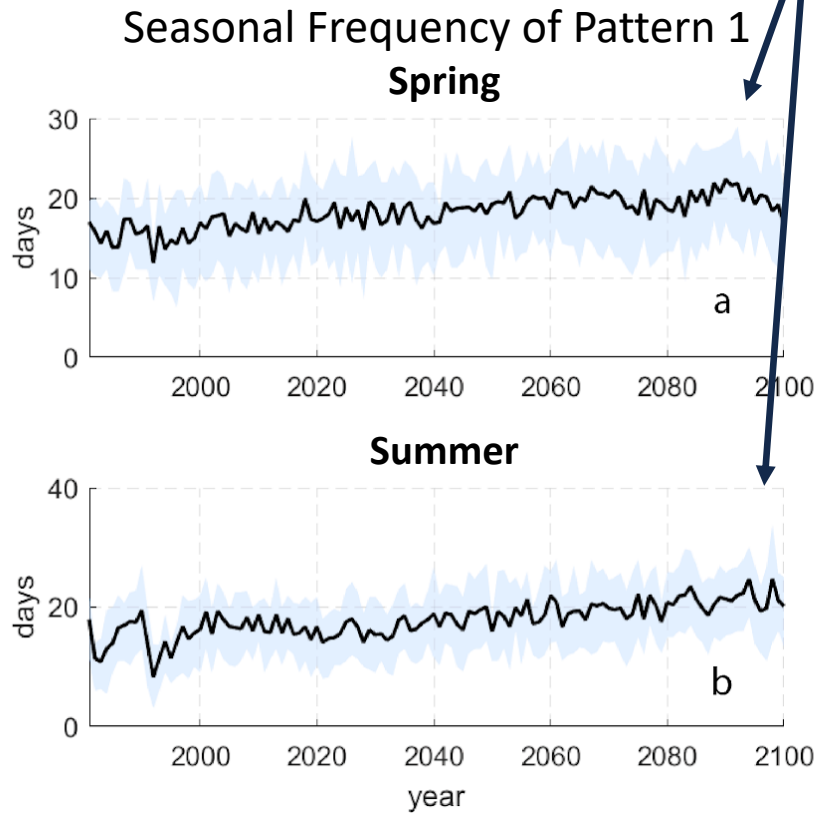
Chen *et al.* (in review), *J. Clim.*



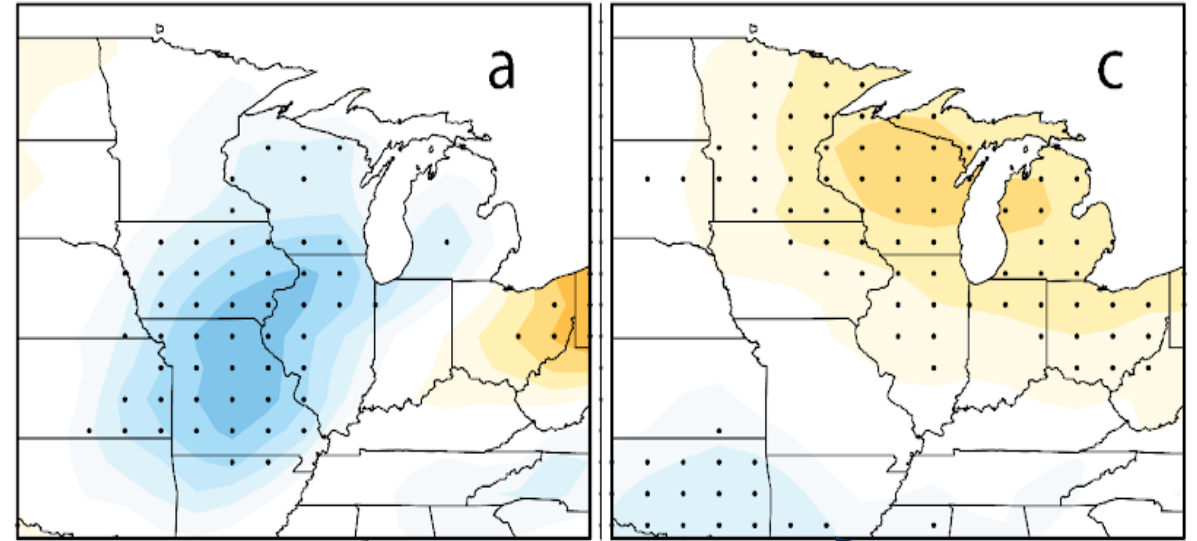
Composite analysis identified one pattern associated with majority of spring wet extremes in Midwest (left), and one associated with majority of summer dry extremes (right)

Projected Changes in Pattern Frequency & Precipitation

Large ensemble projections show increasing wet spring pattern & dry summer pattern by late century



Projected Pattern 1 Precipitation Changes
cluster 1 (MAM) cluster 1 (JAS)



Projected increase in spring precipitation during wet spring pattern, decreased precipitation during dry summer pattern

Chen *et al.* (in review), *J. Clim.*



Summary

- Observed increase in Midwest precipitation and precipitation variability is projected to continue & intensify through 21st Century
- Rapid transitions from wet to dry conditions have increased in **frequency** across the region, but are not happening more **rapidly**
- Projections indicate a changing seasonality of extremes – more spring wetness, more summer dryness (at 30-day timescale)... associated with more frequent “wet spring” & “dry summer” atmospheric patterns
- Projections of more wet2dry and dry2wet transitions, and more extremes overall at 30-day timescales
- Projected changes in precipitation extremes are mostly associated with changes in dynamic component of atmospheric circulation

Implications and Other Bits

- “Wets get Wetter, Dries get Drier” has not been true in the Midwest at-large, observations & projections both indicate overall wetting Midwest – especially at 3+ month timescales – with more intense monthly variability
- Flooding implications – mostly pointing to increased frequency & intensity of pluvial and fluvial flooding events, challenging for emergency management and response
- Drought implications are more complicated... Possibly more frequent & intense short-term (< 2 month) dry periods, juxtaposed by wetter & more frequent wet extremes at longer time periods
- Not sufficient to say drier summers = more impacts... magnitude, timing, spring wetness all need to be considered
- Use soil moisture to understand changes in water balance: <https://doi.org/10.1038/s43016-022-00592-x>, <https://doi.org/10.1038/s41558-022-01412-7>

