Spring Tornadoes and Drought over the Southern Mississippi River Valley

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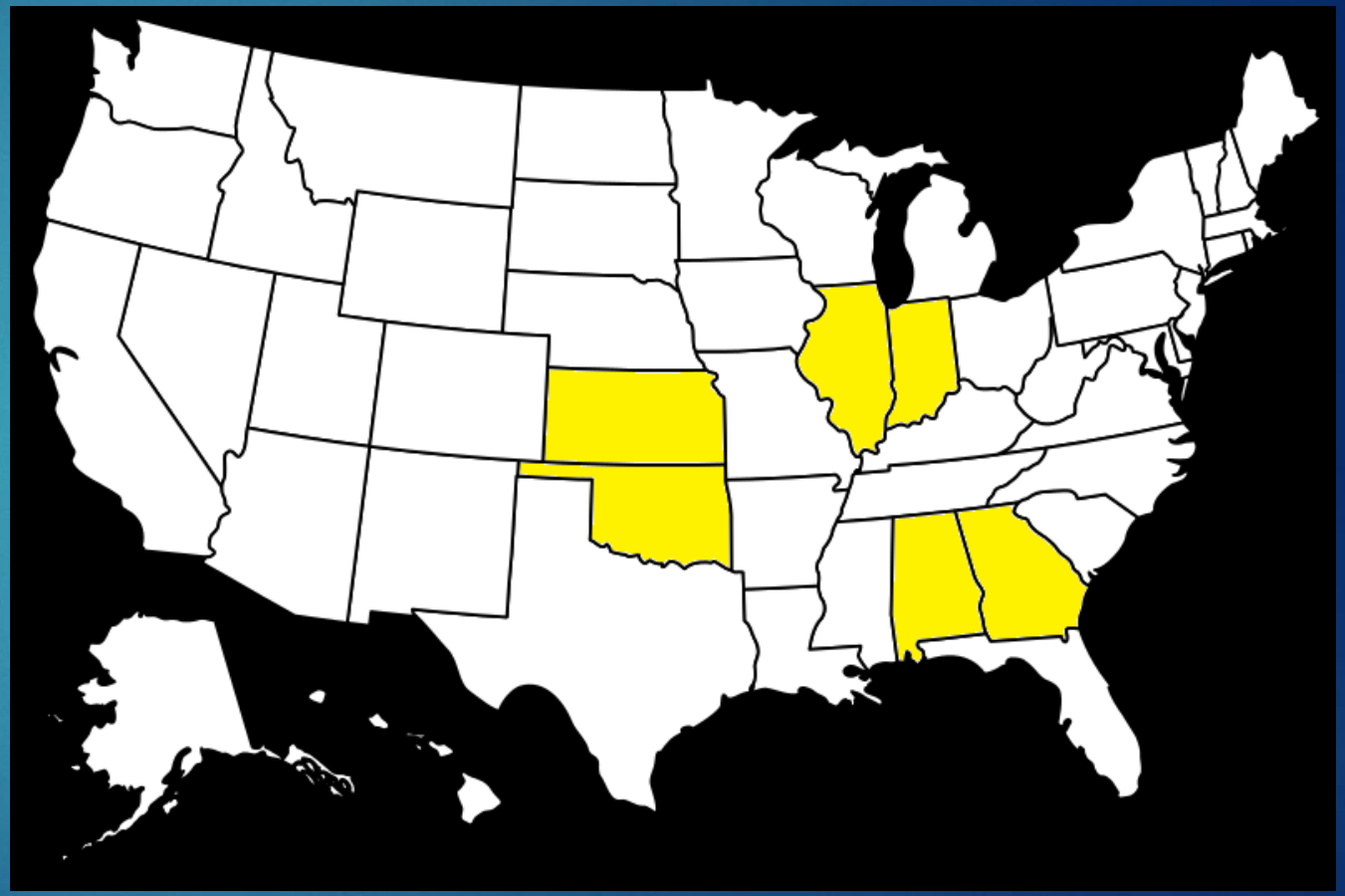
Abstract

- Recent studies have shown that internal ocean-atmospheric forcing affects tornado activity over parts of the United States
- The relationship between precipitation (annual and seasonal) and tornado activity has been studied as well.
  - Soil moisture component has not been fully assessed, however.
- Impacts of soil moisture on tornado activity will be studied using the Palmer Drought Severity Index (PDSI) and the Palmer Z-Index
- Tornado day counts from tornado path data
- Incorporation of teleconnections and antecedent soil moisture conditions

Introduction (Background)

- Over the past few decades, correlations between precipitation and tornadic activity have been identified over different portions of the United States
  - Galway (1979)
  - Shepherd et al. (2009)
  - Andersen (2010)
- Highlights the need for more research regarding this relationship over other tornado prone regions



Problem Statement/Hypothesis

- Study will focus on the potential influence of drought conditions on tornadic activity in the "Southern Mississippi River Valley"
  - Area of research includes the states of Arkansas, Louisiana, Mississippi, and part of West Tennessee
- Research will attempt to address the following:
  - Connection between drought and spring tornado activity?
  - Can fall and winter soil moisture conditions be useful for forecasting tornado seasons?
  - The role of teleconnections
    - La Nina and sea surface temperatures in the Gulf of Mexico

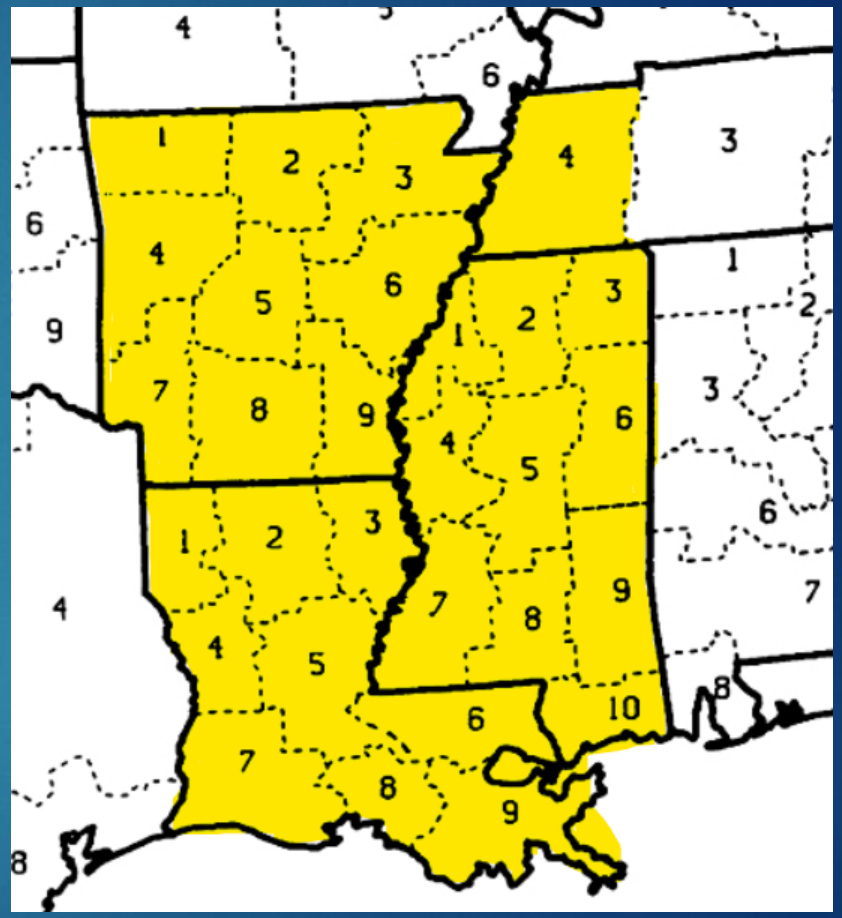


Figure: Area of study denoted as the Southern Mississippi River Valley

Problem Statement/Hypothesis

- Expectations
  - Positive relationship between percent of normal tornado days and drought over the Southern MS Valley
  - Ocean-atmospheric variability affecting this relationship

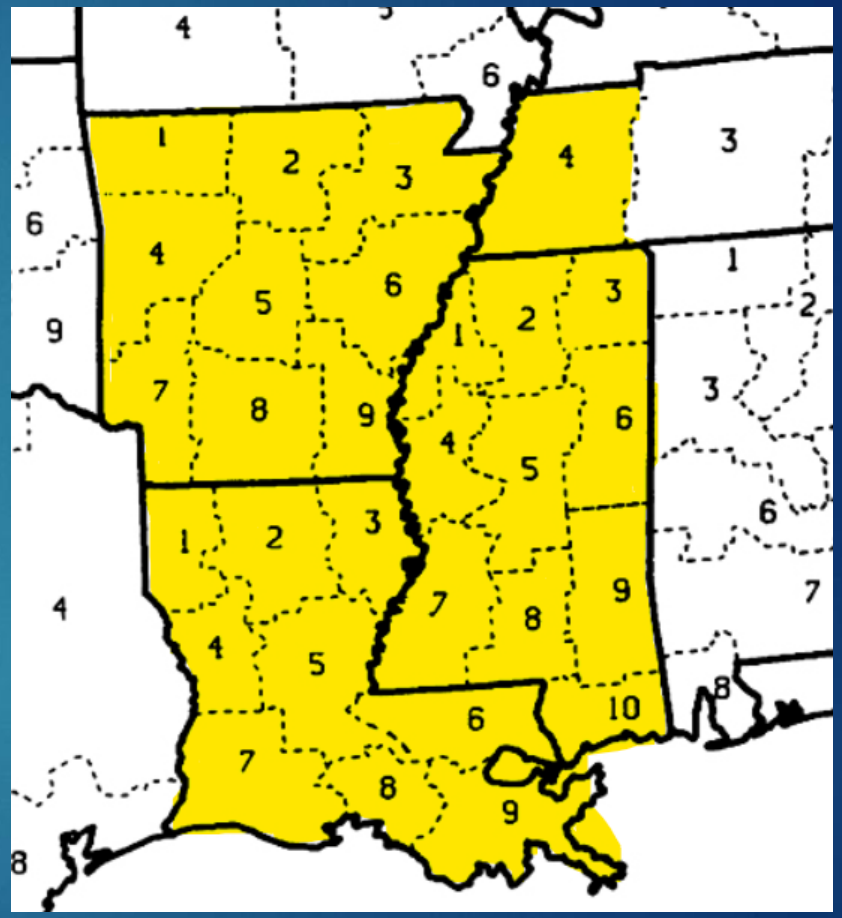


Figure: Area of study denoted as the Southern Mississippi River Valley

Data and Methods

- Drought and tornado data will be limited to the last four decades (Doswell and Burges 1988; Grazulis 1993; Verbout et al. 2006)
- Palmer Z-Index and PDSI data will be obtained from the NOAA Monthly U.S. Climate Divisional Database (nClimDiv) (Vose et al. 2014)
  - For each climate division

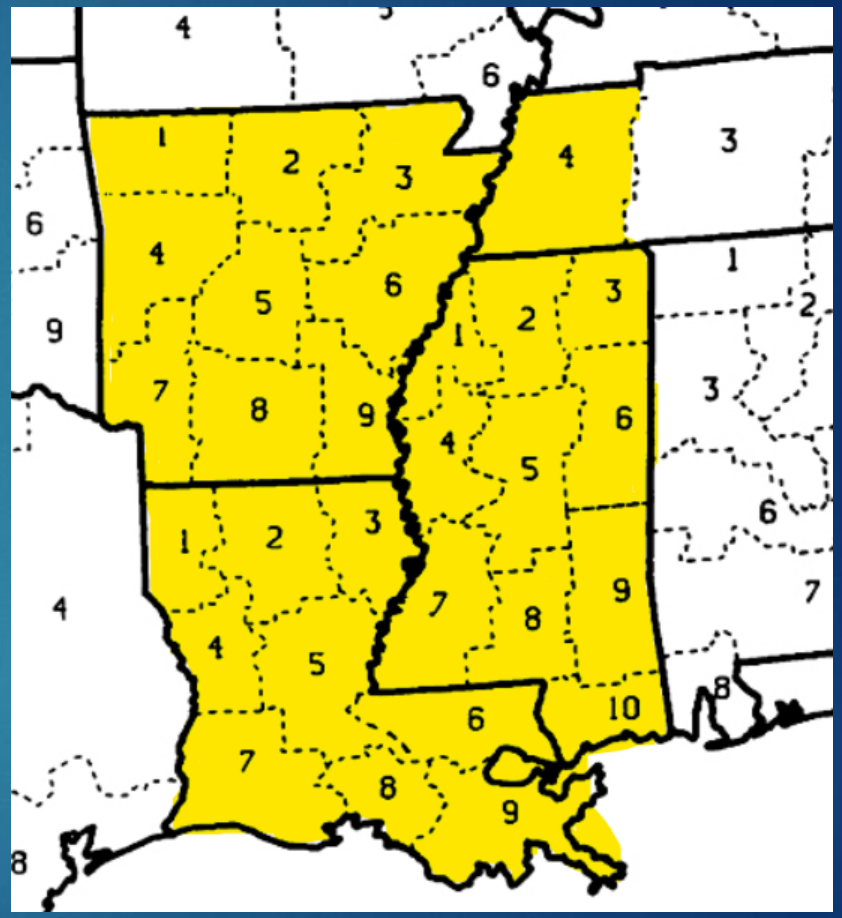


Figure: Area of study denoted as the Southern Mississippi River Valley

Data and Methods

- Tornado path data from the NOAA Storm Prediction Center
- Calculating tornado days
  - Total number of tornado days to be transformed into a percent of normal
- Correlation analysis to explore the relationship between PDSI, Z-Index, and percent of normal tornado days over the region
- Teleconnection data
  - Gulf of Mexico sea surface temperatures
  - Oscillations
  - Additional correlation analysis

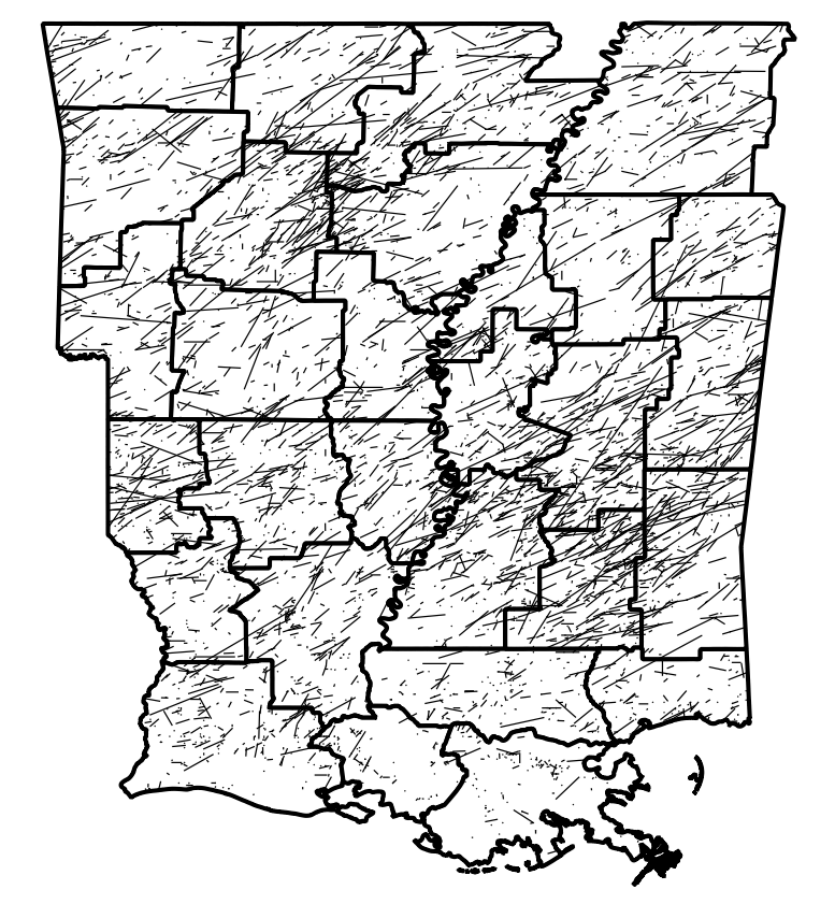


Figure 2: Tornado paths within the Southern MS River Valley from 1980-2020 (SVRGIS; NOAA 2022a)

Results

- A positive correlation between the PDSI and percent normal of tornado days during the late spring (Figure 3).
- A strong and positive correlation also exists between the Z-Index and percent normal of tornado days during the spring season (Figure 4).
- Negative correlation between antecedent fall Z-Index and percent normal tornado days during the following spring season.

Results

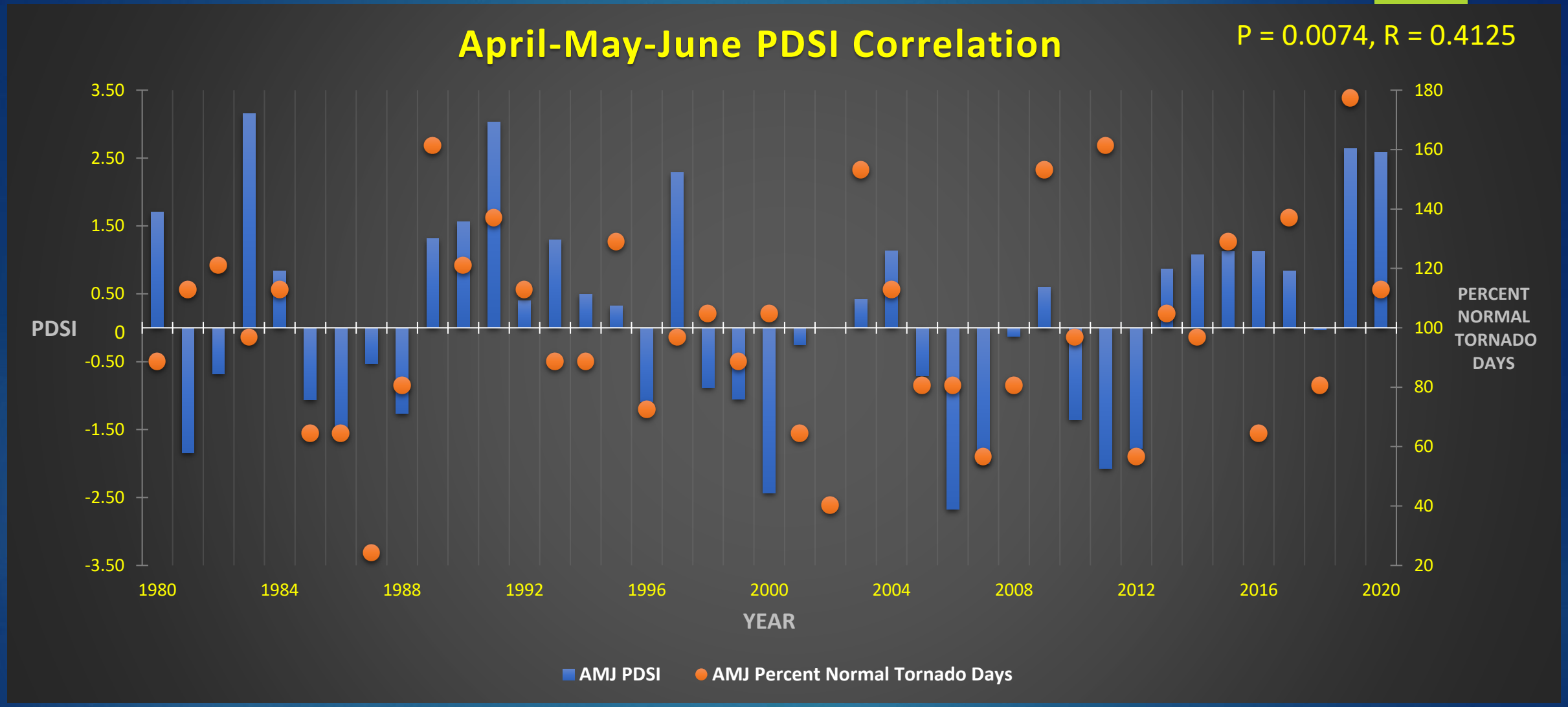


Figure 3: Palmer Drought Severity Index (PDSI) correlation with the percent of normal tornado days in the Southern Mississippi River Valley during the three-month period of April, May, and June (1980-2020).

Results

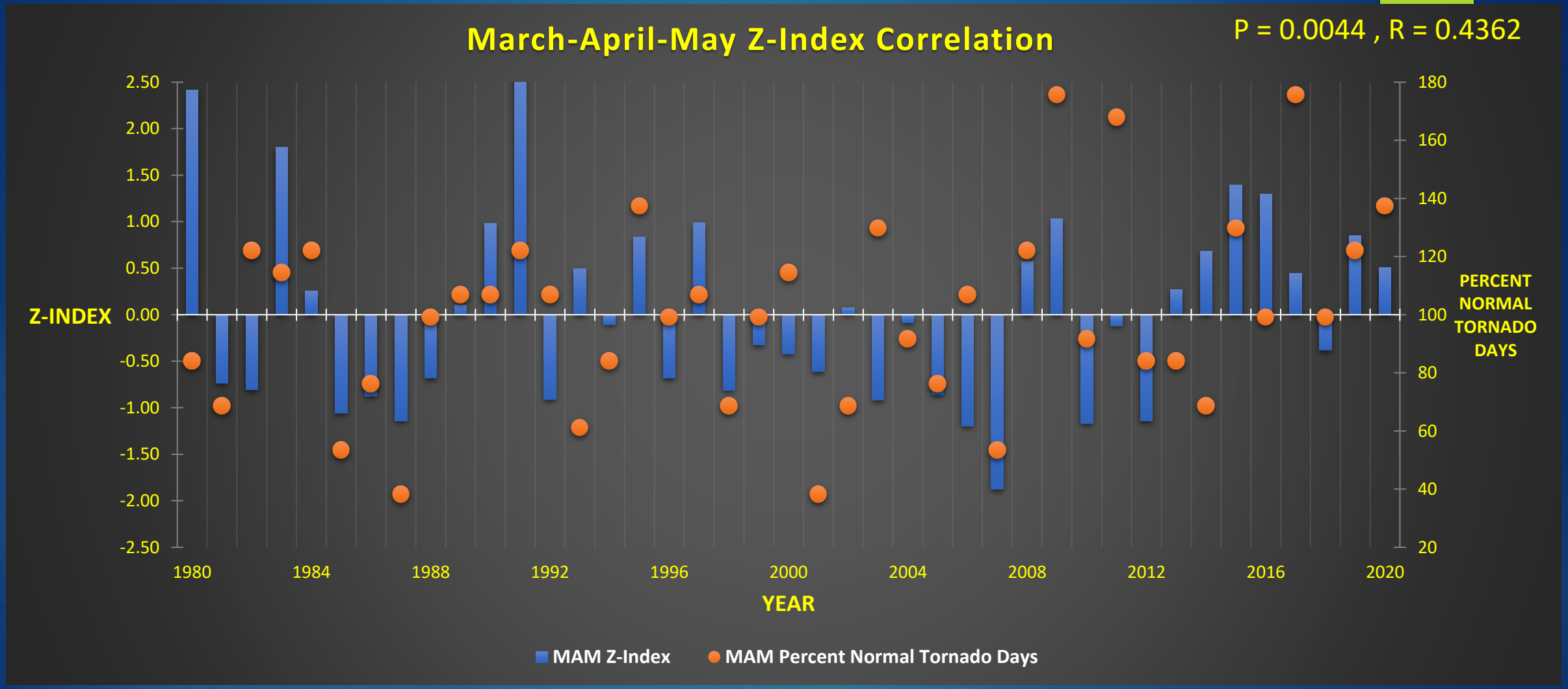
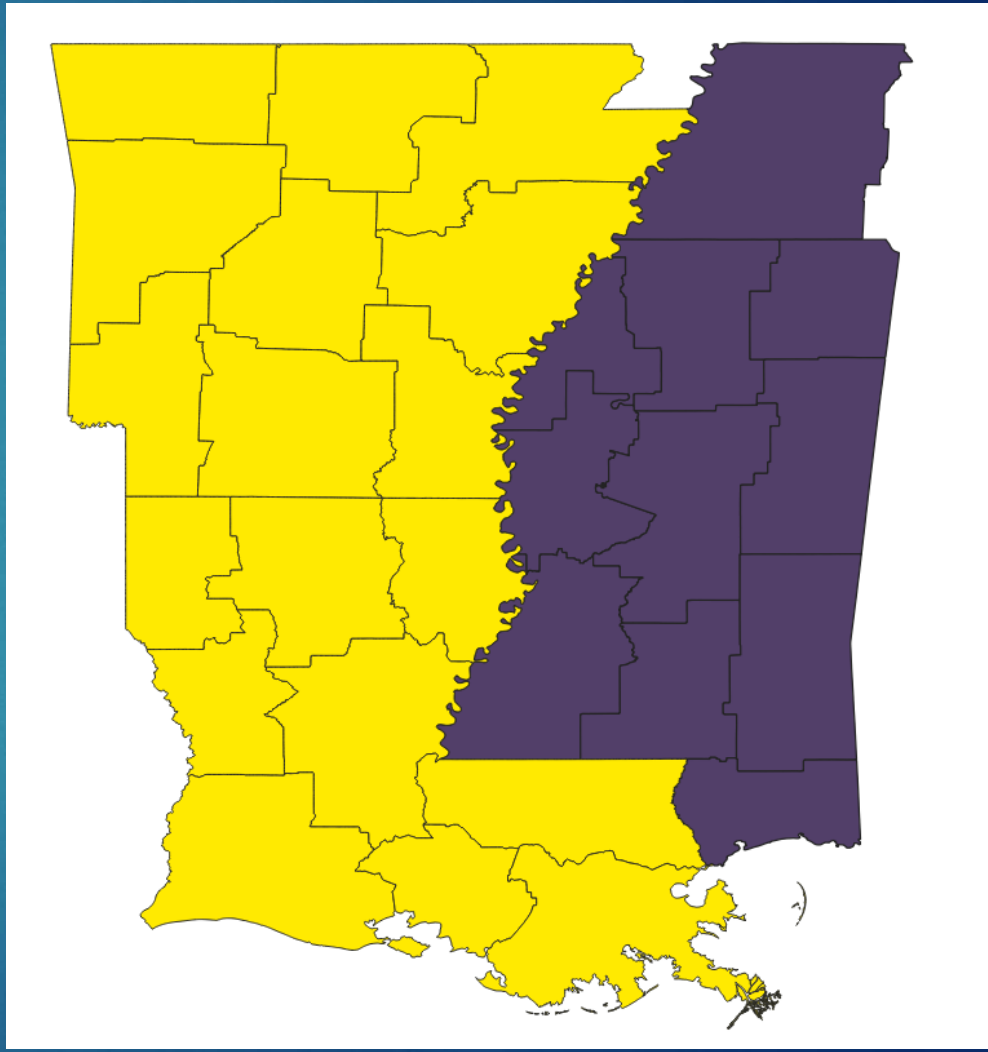


Figure 4: Z-Index correlation with the percent normal of tornado days in the Southern Mississippi Valley during the spring season (1980-2020).

Results

- Statistically significant correlations of the PDSI and Z-Index with tornadic activity, but stronger signals with the Z-Index.
- Differing signals between the western half of the study area (Arkansas and Louisiana) and the eastern half (Mississippi and West Tennessee).



Results – West vs. East

AMJ PDSI Correlation	Arkansas-Louisiana	Mississippi-West Tennessee
Spearman p	0.0241	**0.0047**
Spearman r	0.3518	**0.4329**
Z-Index Correlation		
Spearman p (MAM)	**0.0049**	0.0115
Spearman p (AMJ)	0.001	**0.0001**
Seasonal Antecedent Z-Index Correlation (s-1)	**Arkansas-Louisiana**	**Mississippi-West Tennessee**
Spearman p (s-1) (JFM)	**0.0347**	0.3444
Spearman r (s-1) (JFM)	**-0.3308**	-0.1515
Seasonal Antecedent Z-Index Correlation (s-2)		
Spearman p (s-2) (March-April-May)	**0.0069**	0.749
Spearman r (s-2) (MAM)	**-0.4156**	-0.0515

Figure 5: Correlation analyses used for comparison between Arkansas-Louisiana and Mississippi-West Tennessee.

Antecedent correlation signals appear more evident further west, while Z-Index correlation results are consistent across the study area.

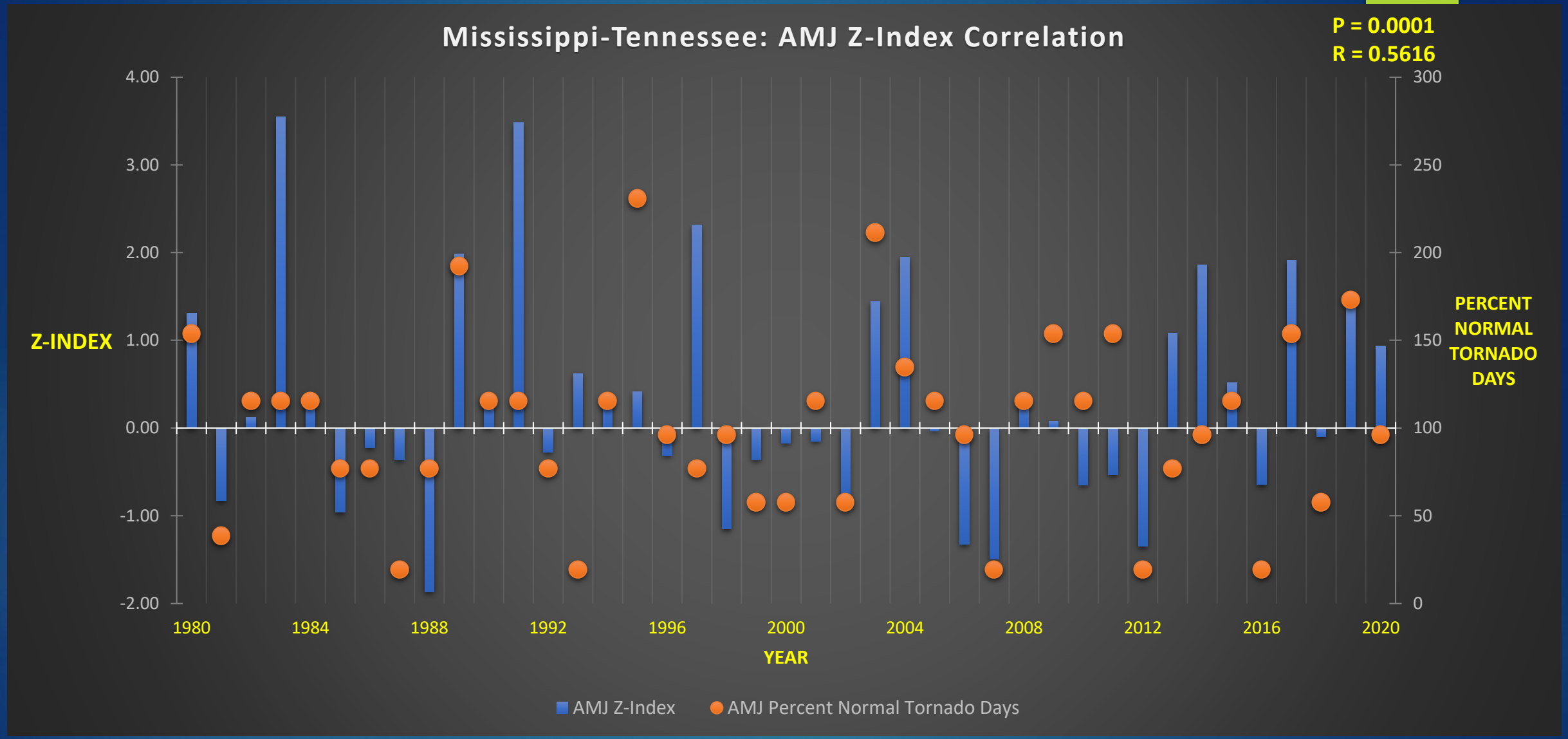


Figure 6: Late Spring Z-Index Correlation with the percent normal of tornado days during the months of April, May, and June in Mississippi and West Tennessee (1980-2020)

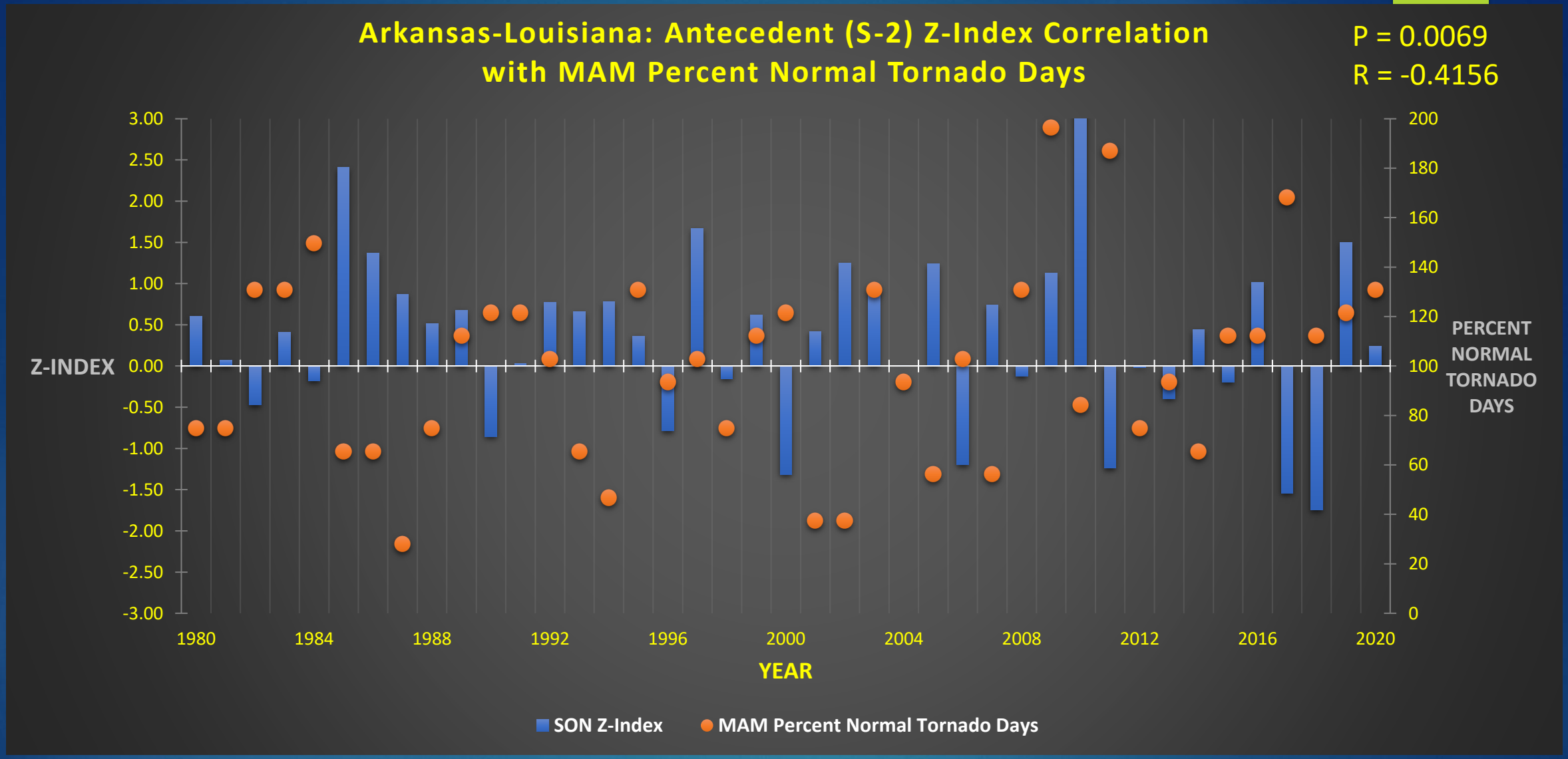


Figure 7: Antecedent fall Z-Index correlations (September-October-November) with the percent normal of tornado days from the following spring in Arkansas and Louisiana.

Note: Antecedent (s-2) Z-Index values are plotted alongside the percent normal tornado days from the following year.

Discussion

- Correlations have been identified between drought indices and tornadic activity, but variations exist.
- The role of teleconnections and its potential impacts
  - El Niño Southern Oscillation (ENSO)
  - Gulf of Mexico Sea Surface Temperatures
- Preliminary analysis shows a connection between Gulf of Mexico SSTs and tornado days during the spring season ($p=0.0301$)
- Weak signals elsewhere.
- This area of research is currently being explored.

Conclusions

- Evidence of a relationship between drought and tornadic activity in the Southern Mississippi River Valley.
- This relationship especially evident during the spring season.
- Z-Index correlations are more consistent across the study area in comparison to the PDSI.
- Remains to be determined if teleconnections play a role in overriding or offsetting drought correlations.

Budget

- Not expecting costs.
- Data currently being used is accessible online.
- R and GIS software are being utilized for statistical analysis and data management, respectively.

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Questions?