Spring Tornadoes and Drought over the Southern Mississippi River Valley

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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.
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.
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

<table>
<thead>
<tr>
<th>AMJ PDSI Correlation</th>
<th>Arkansas-Louisiana</th>
<th>Mississippi-West Tennessee</th>
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</thead>
<tbody>
<tr>
<td>Spearman p</td>
<td>0.0241</td>
<td>0.0047</td>
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<tr>
<td>Spearman r</td>
<td>0.3518</td>
<td>0.4329</td>
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</table>

<table>
<thead>
<tr>
<th>Z-Index Correlation</th>
<th>Arkansas-Louisiana</th>
<th>Mississippi-West Tennessee</th>
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</thead>
<tbody>
<tr>
<td>Spearman p (MAM)</td>
<td><strong>0.0049</strong></td>
<td>0.0115</td>
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<tr>
<td>Spearman p (AMJ)</td>
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<td><strong>0.0001</strong></td>
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<table>
<thead>
<tr>
<th>Seasonal Antecedent Z-Index Correlation (s-1)</th>
<th>Arkansas-Louisiana</th>
<th>Mississippi-West Tennessee</th>
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<tbody>
<tr>
<td>Spearman p (s-1) (JFM)</td>
<td><strong>0.0347</strong></td>
<td>0.3444</td>
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<tr>
<td>Spearman r (s-1) (JFM)</td>
<td><strong>-0.3308</strong></td>
<td>-0.1515</td>
</tr>
</tbody>
</table>

| 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.
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.
References and Works Cited


Questions?