

An Apparent Eastward Shift in United States Tornadic Activity

Motivation & Background

<u>Why Study Tornadoes and the Significant Tornado Parameter?</u>

- Tornadoes are an extremely dangerous weather phenomena that can cause widespread damage and can even take lives.
- A common index for predicting tornado occurrence is the Significant Tornado Parameter (STP). Higher values of STP correlate with tornado-producing environments.
- According to Gensini and Brooks (2018), the highest STP values over the U.S have been **shifting eastward over time**, suggesting a shift in tornadic activity (Figure 1) that has been confirmed by actual storm reports (Figure 2).
- Is this change best characterized as a linear trend? Has it continued in recent years? And is it a signal of climate change, or does it arise from natural climate variability?



Figure 1. (from Gensini and Brooks (2018))



Figure 2. (from Gensini and Brooks (2018))

Objectives & Methods

This study addresses the following objectives:

- 1) Examine changes in STP accumulation in the United Stated over the past 44 years.
- 2) Explore possible causes of those changes, including the apparent eastward shift first documented by Gensini and Brooks (2018)

Data Sources and Parameters:

- Data is sourced from NCEP's North American Regional Reanalysis (NARR) **3-hourly** product
- Data from 01/01/1979 to 12/31/2022 is examined
- The primary analysis focus is on the Eastern and Central U.S.
- Primary analysis is of the Significant Tornado Parameter (STP), which is a unitless covariate parameter computed as the product of the following terms:

S06 x SRH01 x (2000-SFC LCL) SFC CAPE x STP = 1000 1500 20 150

• SST data originating from the Hadley Centre Sea Ice and Sea Surface Temperature dataset (Rayner, et al., 2003)

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Figure 3. NARR STP annual accumulation averaged over a 44-year period based on daily maximum values.



Figure 4. NARR STP annual linear trend over a 44-year period based on daily maximum values. Hatch marks represent statistical significance at 95% confidence, using a student t-test calculation. Colored boxes represent regions with relative maximum trend values, the "red box", and minimum trends values, the "blue box'.



Figure 5. Time series of NARR STP annual accumulation over a 44-year period based on daily maximum values, with the blue lines representing the "blue box" region and the red lines representing the "red box" region (Figure 4). Linear regression lines are plotted with their correlating trend values (left). Horizontal dashed lines represent epoch averages (1979-2007 and 2008-2022) for each area (right).

Epoch Difference Analysis



Figure 6. Change in average NARR STP annual accumulation from the 1979-2007 period to the 2008-2022 period.



Figure 7. Change in average annual accumulation for each term in the NARR Significant Tornado Parameter Equation from the 1979-2007 period to the 2008-2022 period.



Figure 8. Change in the HadISST average annual sea surface temperature from the 1979-2007 period to the 2008-2022 period in °C.

Upon completing the research, we were able to come to the following conclusions about STP accumulation in the United States:

- trend.

Future Work:

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Conclusions & Future Work

There is a significant positive trend since 1979 in the south-central US and a negative trend in Texas and Oklahoma.

2. Time series analysis suggests the changes over time in STP might be better described as a step change, with a rapid transition occurring in 2007.

3. An epoch difference calculation showed that the difference in STP between the two periods has a similar spatial pattern as the linear

4. When the component terms of STP are examined, CAPE and SR-Helicity are the primary positive terms in the "red box" region and all terms contribute to the decrease seen in the "blue box" region.

5. SST analysis using these same epochs shows that the Pacific was in a strongly-negative PDO phase, which may correlate with the change in STP accumulation observed in the U.S.

• I will remain engaged in this research!

• Continue to investigate the role of the PDO on the observed time evolution of STP

• Consider other distinct modes of variability that might also play a role in modulating STP

• Investigate how STP is projected to evolve in a future, warmer climate using the CESM2 Large Ensemble (LE)

• Use CESM2-LE to disentangle:

- ➢ Forced response/ensemble mean (change due to anthropogenic climate change)
- ≻Internal (or natural) variability, such as the PDO

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References