Investigating Variability in the Number of Tornadoes Among Landfalling Hurricanes

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1. Introduction

Motivation

- Landfalling tropical cyclones (TCs) spawn tornadoes that can exacerbate other severe weather hazards (Blake and Zelinsky, 2018; Stewart and Berg, 2019).
- There is large variability in tornado production along and among TC tracks that is not well understood.
- Prior work has suggested TCs with larger radii and/or strong synoptic-scale (850–200-hPa) vertical wind shear often spawn more tornadoes TCs (Schenkel et al. 2020; Paredes et al. 2021).
- However, past studies have not examined differences in TC tornado characteristics between episodes of low versus high numbers of tornadoes.

Objective and Hypothesis

Objective: This study investigates differences in the characteristics of episodes of low and high numbers of tornadoes in landfalling TCs using multidecadal TC tornado and TC track data.

Hypothesis: There are distinct characteristics between episodes of low versus high numbers of tornadoes.

2. Methodology

Datasets

- **TC track data:** 6-h TC intensity and location data during 1995–2020 from IBTrACS Best-Track (Knapp et al. 2010);
- **TC tornado data:** tornado track and damage data during 1995–2020 from SPC TCTOR (Edwards 2022);

Methods

- **To consider variability in tornadoes along the TC track, we binned tornadoes by the closest 6-h TC track point;**
- **Our investigation categorizes TC tornado production based upon the terciles of 6-h TC tornado count:**
  1. Low (Lower 33rd percentile)
     a. 1 tornado spawned within 3-h of each 6-h TC track point.
  2. Moderate (Middle 33rd percentile)
     a. 2-3 tornadoes spawned within 3-h of each 6-h TC track point.
  3. High (Upper 33rd percentile)
     a. ≥4 tornadoes spawned within 3-h of each 6-h TC track point;
- **Our study examines differences in TC tornado characteristics among these three categories.**

3. Results: Tornado Location

Overview

Analyze the geographic location of TC tornadoes during low and high episodes of tornadoes.

Synopsis

1. Location of low numbers of tornadoes concentrated near the coast (Fig. 2a), whereas episodes of high numbers of tornadoes are associated with tornadoes further inland (Fig. 2b)
2. Episodes with high numbers of of tornadoes occur over a smaller section of coastline (Fig. 2b);
3. Tornadogenesis occurs further from the TC center during high episodes of tornadoes (Fig. 3b);

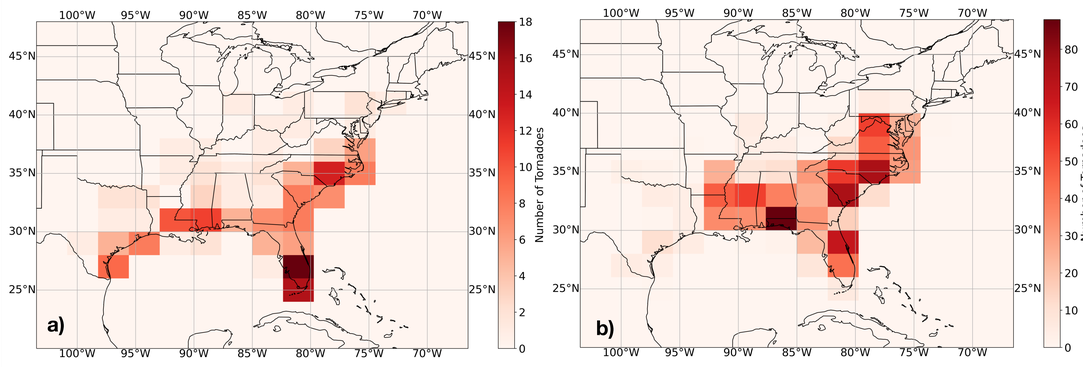

Fig. 2: Map view of tornadogenesis location for 6-h TC times with a) low and b) high numbers of tornadoes.

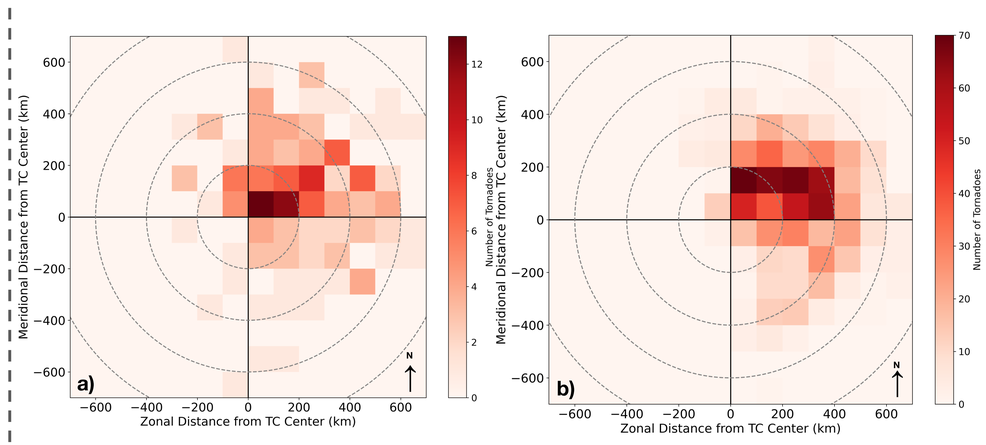

Fig. 3: TC-relative plot of tornadogenesis location in a true north coordinate in both a) low and b) high-producing TCs. North is oriented toward the top of the page.

4. Results: Local Time of Tornado Occurrence

Overview

Analyze the local standard time of tornadogenesis during low and high episodes of tornadoes.

Synopsis

1. Most tornadoes occur in the afternoon and evening hours for all three categories (Fig. 4);
2. Strong diurnal variability is observed in episodes of high numbers of tornadoes, whereas weaker diurnal variability is observed in episodes of low numbers of tornadoes (Fig. 4);

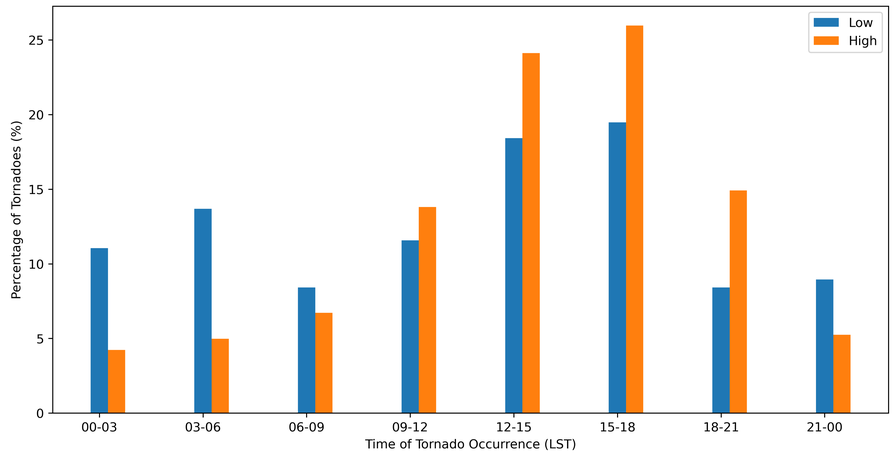

Fig. 4: Histogram showing the percentage of tornadoes for each category binned by local standard time.

5. Results: Tornado Damage Rating

Overview

Analyze the damage rating of TC tornadoes during episodes of low and high numbers of tornadoes.

Synopsis

1. Tornadoes are dominated by weak damage ratings among both low and high categories (Fig. 5);
2. More damaging tornadoes are favored when high numbers of tornadoes occur (Fig. 5);
3. EF-3 tornadoes are only observed to have occurred during high numbers of tornadoes (Fig. 5).

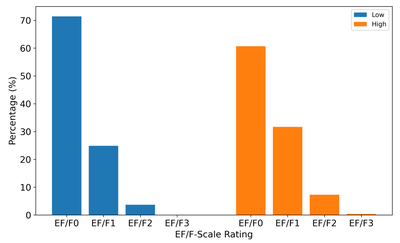

Fig. 5: Histogram of the damage ratings of TC tornadoes for periods with low and high numbers of tornadoes.

6. Summary and Discussion

- This study investigated the differences in characteristics of low and high numbers of tornadoes in landfalling TCs;
- Our most significant findings suggest that there are distinct characteristics between episodes of low and high numbers of tornadoes:
  1. **Tornado location:** Inland tornadoes are typically associated with episodes of high numbers of tornadoes.
  2. **Local time of tornado occurrence:** Episodes of high numbers of tornadoes are characterized by stronger diurnal variability.
  3. **Tornado damage rating:** Strong tornadoes (EF-2+) are more likely to occur when a TC produces a high number of tornadoes.
- Results from this study can be used to further improve forecast skill in landfalling TCs, which is typically lower skill than non-TC enviornments (Edwards 2012; Martinaitis 2017).

7. Acknowledgments

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