



Impacts of Extratropical Transition on Tropical Cyclone Tornado Occurrence

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1. Introduction

Motivation

- Tornadoes account for 3% of fatalities caused by landfalling TCs (Rappaport 2014).
- 42% of landfalling tropical cyclones (TCs) in the Atlantic Basin undergo extratropical transition (Hart 2001).
- Only one study has investigated and compared the difference in tornado location between TCs in different stages (phases) of extratropical transition (Hill et al. 1966).
- There is an incomplete understanding regarding how the process of extratropical transition impacts tornado occurrence.

Objective

This study investigates how extratropical transition impacts the number, timing, and location of tornadoes.

2. Data/Methods

Data

- TC Tornado Data** – Tornado timing, track, and damage rating from 1995-2020 were obtained from SPC TCTOR (Edwards 2010)
- TC Data** – 6-h TC data from 1995-2020 were obtained from IBTrACS Best-Track (Landsea and Franklin 2013)
- Reanalysis Data** – 6-hourly ERA5 (Hersbach et al. (2020); extratropical transition stage/phase designation.

Methods

- Cyclone Phase Space** – Utilized to objectively define start and end of transition with 2 parameters (Hart 2003)
 - Thermal Symmetry**: Measures TC motion-relative lower-tropospheric layer thickness symmetry. Quantifies frontal structure of TC.
 - Thermal Wind**: Measures TC lower-level thickness. Quantifies whether TC is warm or cold core.
- 3 Phases throughout Extratropical Transition**:
 - Tropical Phase: Warm core and non-frontal (N=562 tornadoes)
 - Transition Phase: Warm core and frontal (N=434)
 - Extratropical Phase: Cold (sometimes warm) core and frontal (N=161)
- 9 TCs discarded due to disagreement between Best-Track and Phase Space transition times, resulting in 49 total TCs in dataset.

3. Results: TC-Relative Tornado Location

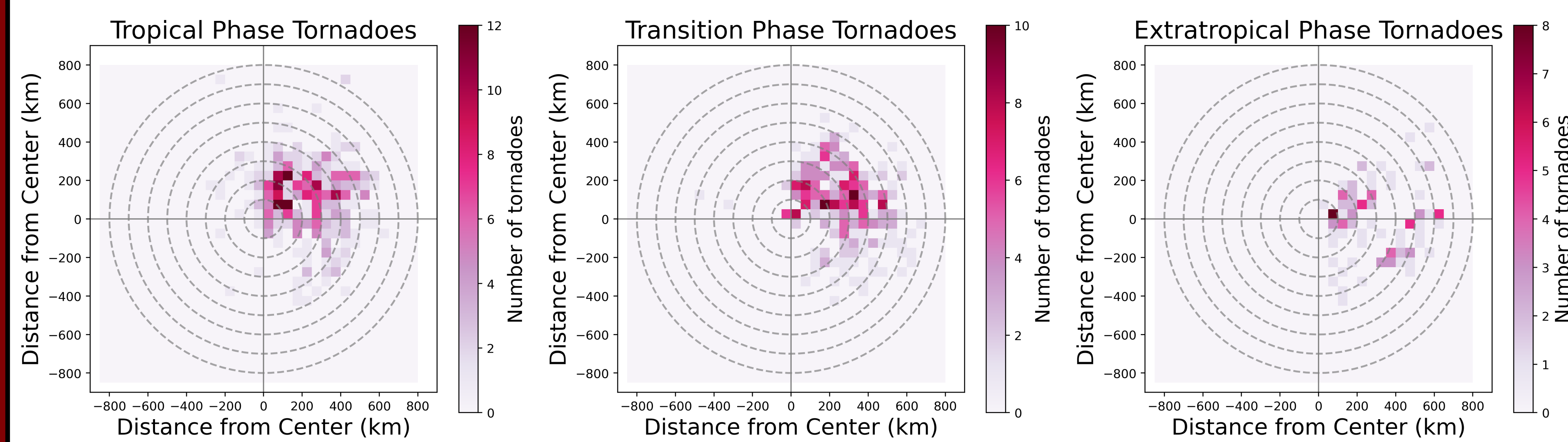


Figure 1. TC-relative and true north-relative location of tornadoes for the tropical, transition, and extratropical phases. Shading indicates number of tornadoes. Dashed gray lines indicate distance from the center for every 100 km.

- Tropical and Transition Phases: Most tornadoes in **northeast quadrant of TC** within a **500 km** radius.
- Extratropical Phase: Most tornadoes within **300 km**. Higher percentage of tornadoes occur in the west half of a TC when compared to tropical and transition phases.

4. Results: Tornado Location

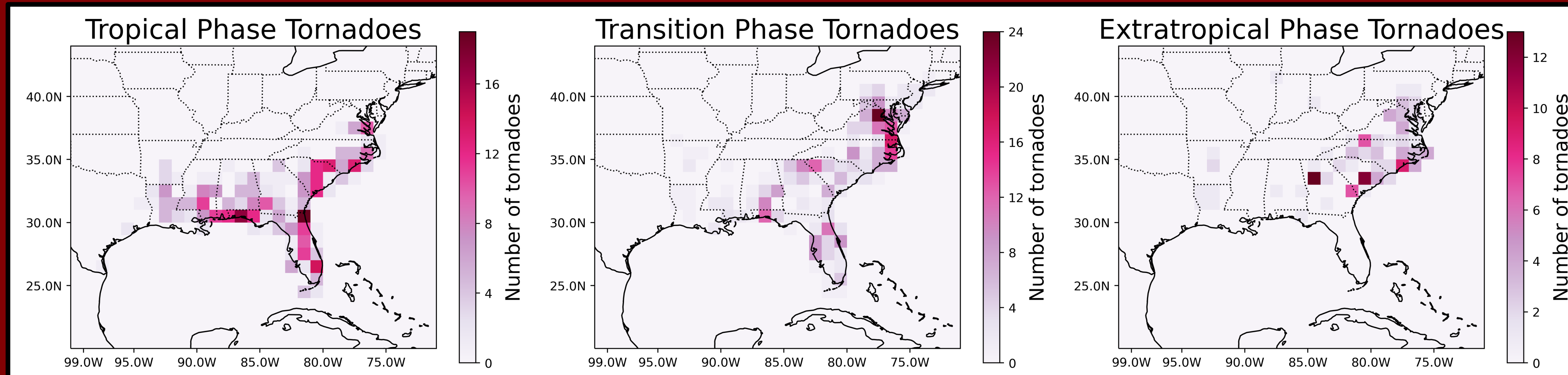


Figure 2. TC location on the United States at the time of tornado occurrence for the tropical, transition, and extratropical phases.

- As transition progresses, tornadoes become **less concentrated along the coast** and are more likely to occur **farther north**
- Transition phase tornadoes have **greatest spread**, reaching from the southeast US to Mid-Atlantic.

7. Discussion and Summary

This study examined the difference in characteristics of tornadoes between the tropical, transitioning, and extratropical phase of cyclones.

As transition progresses...

- Most tornadoes remain within the **northeast quadrant**, but a higher portion occur outside of this quadrant in the extratropical phase.
- The location of tornadoes becomes **less confined to the U.S. coast** and trends to the **north**.
- The maximum **frequency of tornadoes decreases**, the extreme frequencies occurring during the transition phase.
- The time of day at which the most tornadoes occur becomes **later**, with most occurring in the **afternoon/evening**.

Future work will focus on analyzing radiosonde and dropsonde data to understand the difference in environments between the phases and to explain the results discovered thus far.

5. Results: Tornado Frequency

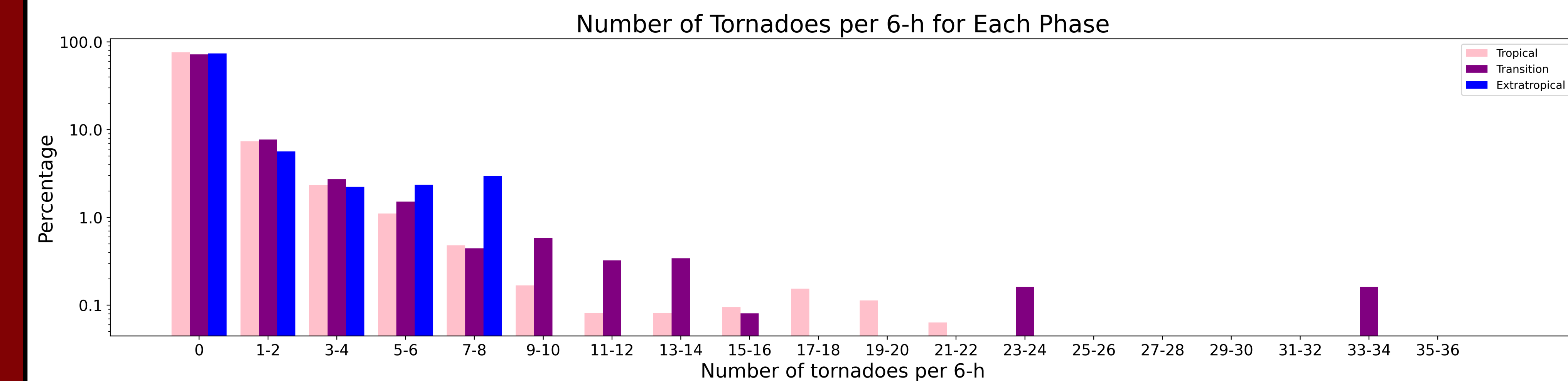


Figure 3. Frequency of tornado occurrence shown by number of tornadoes per 6-h for tropical, transition, and extratropical phases.

- Most 6-h periods have **no tornadoes**.
- Transition phase contains the extreme frequencies, with the maximum of 33 tornadoes in 6 hours.
- In general, as transition progresses, the **maximum frequency of tornadoes decreases**.

6. Results: Local Standard Time of Tornadoes

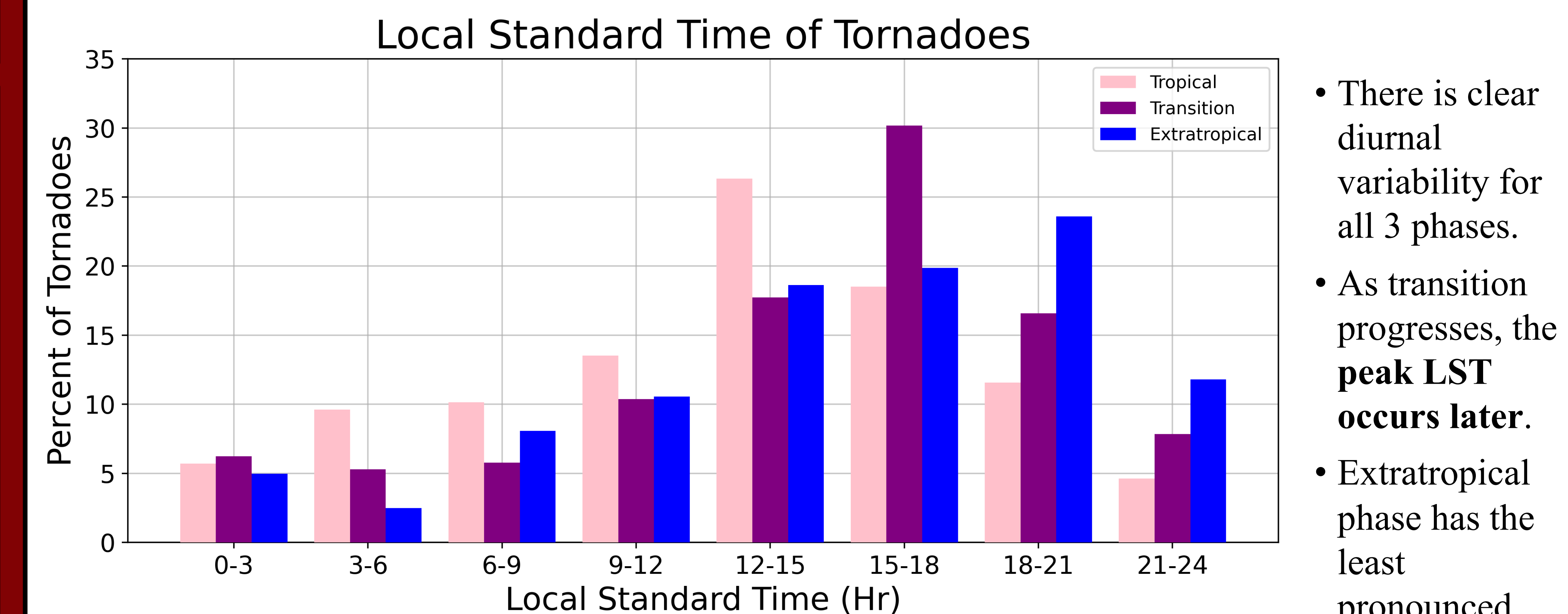


Figure 4. Local standard time of tornado occurrence for the tropical, transition, and extratropical phases.

- There is clear diurnal variability for all 3 phases.
- As transition progresses, the **peak LST occurs later**.
- Extratropical phase has the least pronounced peak.

8. Acknowledgements

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9. References

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