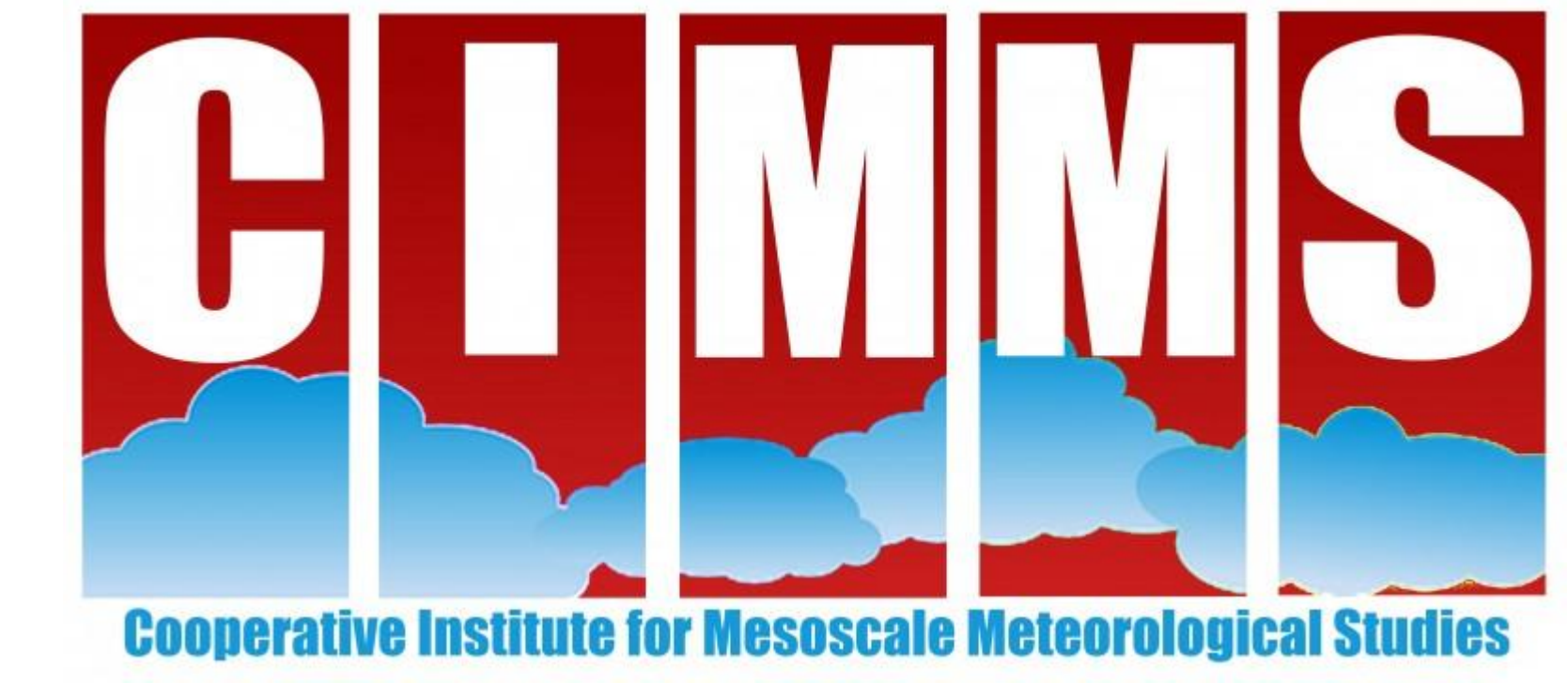




Does Extratropical Transition Impact Tornado Occurrence in Tropical Cyclones?

Neil Crosby^{1,2} (ncrosby97@gmail.com) and Ben Schenkel^{3,4}

1: Jackson State University, 2: National Weather Center NSF REU Program, 3: Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, and 4: National Severe Storms Laboratory



1. Introduction

Motivation

- Extratropical transition (ET) is defined as the process by which a tropical cyclone (TC) becomes an extratropical cyclone, which is characterized by the transition from a *non-frontal, warm-core* cyclone to a *frontal, cold-core* cyclone (Evans et al. 2017);
- Approximately 50% of all TCs and 50% of landfalling TCs eventually undergo ET (Hart and Evans 2001; Bieli et al. 2019);
- These statistics suggest that at least some tornadoes occur during ET;
- However, there have been no prior studies of how ET may impact tornado occurrence.

Objective and Hypothesis

Objective: This study aimed to quantify the differences in tornado frequency and location during the ET and non-ET TCs. We hypothesize that ET should lead to changes in the number and location of tornadoes compared to non-ET cases.

2. Methodology

Datasets

- TC track data:** 6-h TC data during 1995–2019 from IBTrACS Best-Track are examined (Knapp et al. 2010);
- TC tornado data:** tornado track and damage data during 1995–2019 from SPC TCTOR are studied (Edwards 2010);
- ET calculations:** 0.25° x 0.25° 6-h ECMWF 5th generation reanalysis data (Hersbach et al. 2020) used to determine ET start and end times.

Methods

- ET start and end time are objectively calculated from reanalysis data using the cyclone phase space (Hart 2003):
 - Start time:** begin transition from *non-frontal, warm-core* cyclone to *frontal, cold-core* cyclone;
 - End time:** complete transition from *non-frontal, warm-core* cyclone to *frontal, cold-core* cyclone;
- Using cyclone phase space, each 6-h TC track point is classified as either: 1) ET or 2) non-ET;
- Our analysis examines how number, damage rating, and location of tornadoes differs between ET and non-ET TCs.

3. Results: Differences in Frequency and Damage Rating of Tornadoes

Overview

Statistically assess the impact of ET on the number and damage rating of tornadoes.

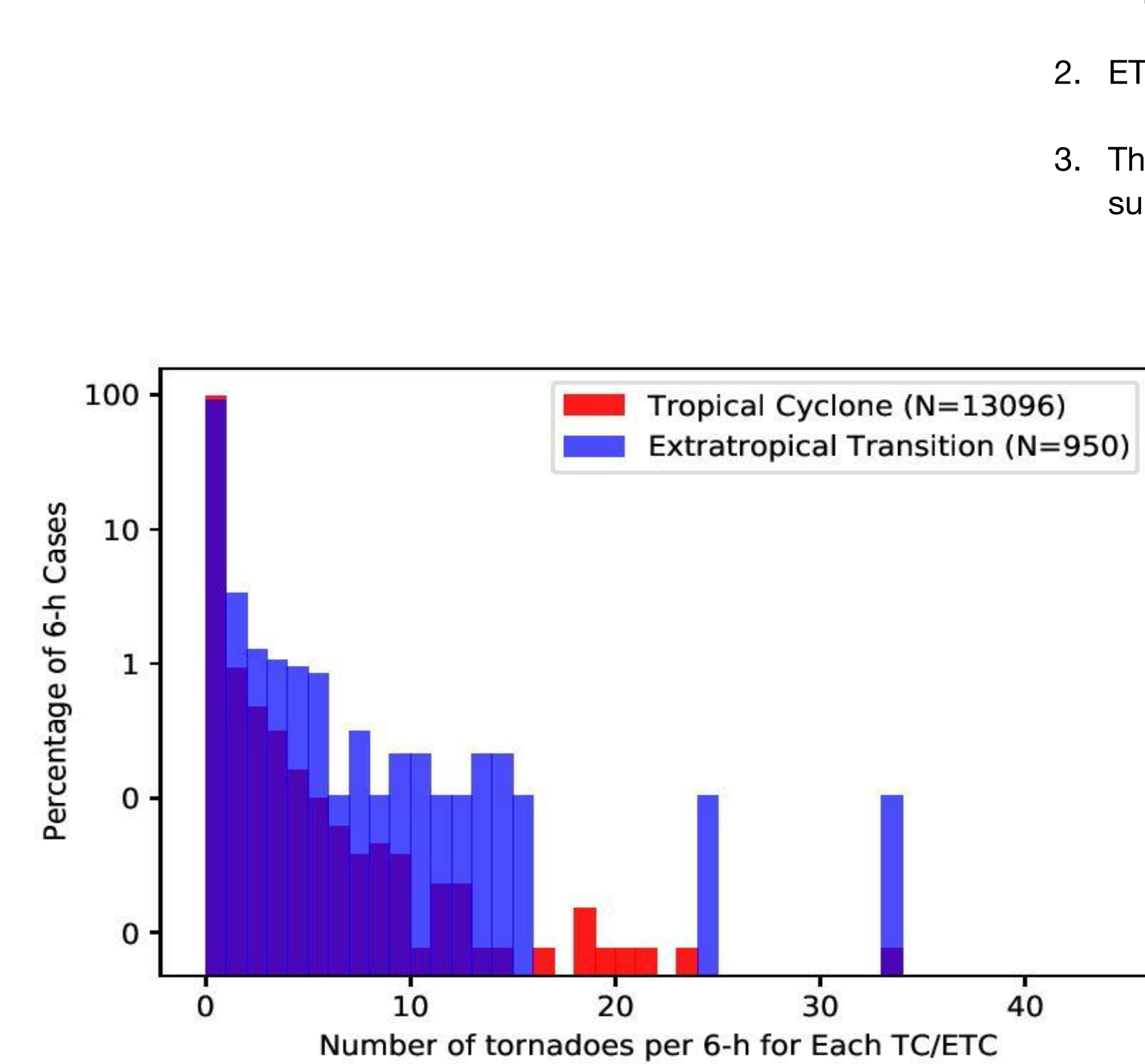


Figure 1: Bar plot of 6-h tornado frequency (%) for ET and non-ET TCs plotted on a logarithmic scale. The percentage is computed relative to the total number of 6-h cases in each subset. The number of total 6-h cases in each subset is given in the legend.

Synopsis

- 6-h times during ET typically have more tornadoes compared to non-ET cases, especially for large numbers of tornadoes (i.e., ≥ 10 tornadoes; Fig. 1).
- ET TCs produce approximately 30% of TC tornadoes (in legend of Fig. 2)
- There are little to no differences between damage ratings between the two TC subsets (Fig. 2).

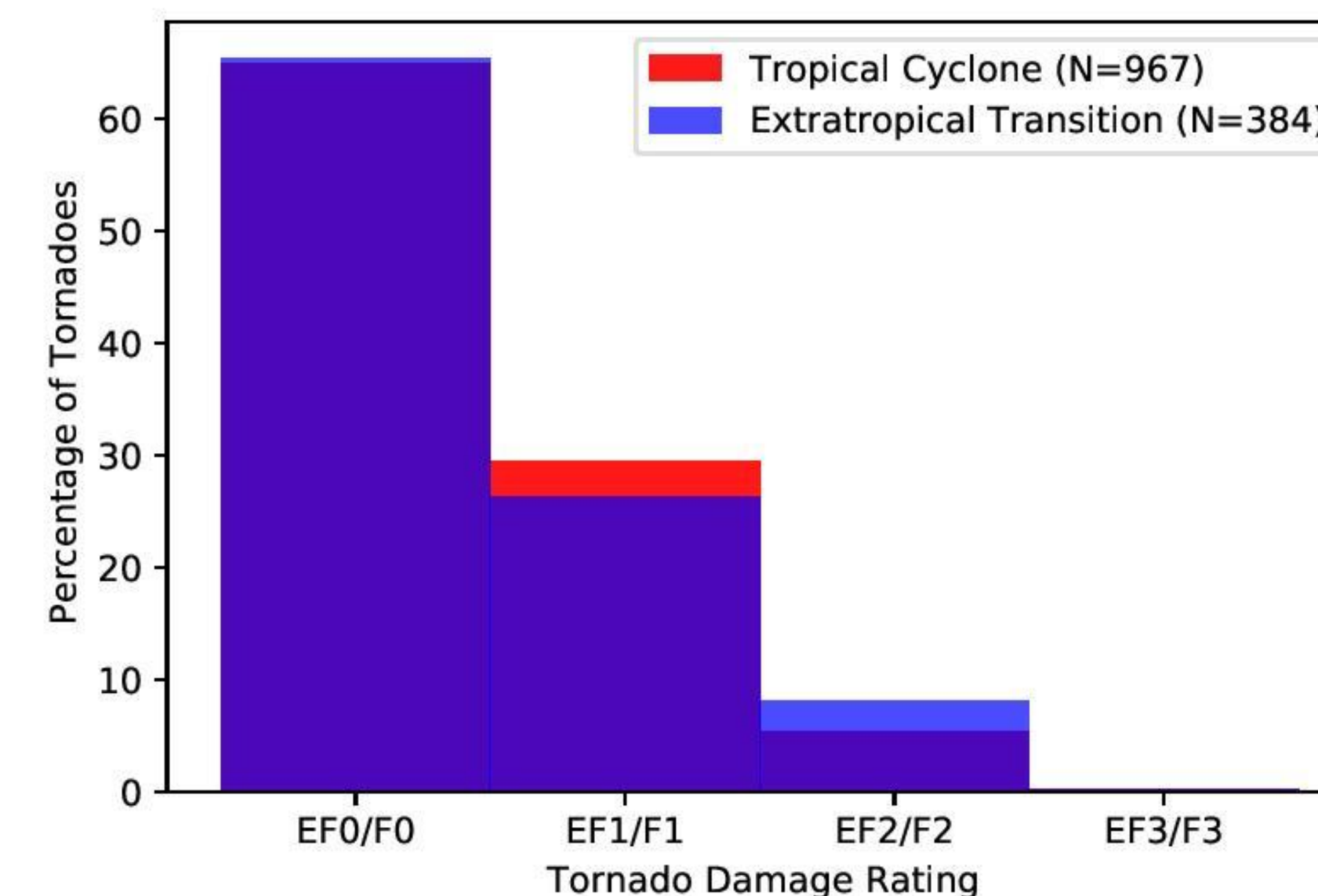


Figure 2: Bar plot of tornadoes in each damage rating category (%) during ET and non-ET TCs. The percentage is computed relative to the total number of tornadoes in each subset. The number of tornadoes in each subset is given in the legend.

5. Results: Changes in Geographic Location of Tornadoes

Overview

Statistically examine how the geographic location of tornadoes changes with ET.

- Non-ET tornadoes are distributed over a large portion of the southern U.S. (left panel);
- ET tornadoes are confined to the U.S. east coast with a maximum in the Mid-Atlantic region (right panel);
- We see that ET occurrences are much fewer and further east than non-ET cases consistent with most ET TCs recurring over the Eastern U.S. (Hart and Evans 2001).

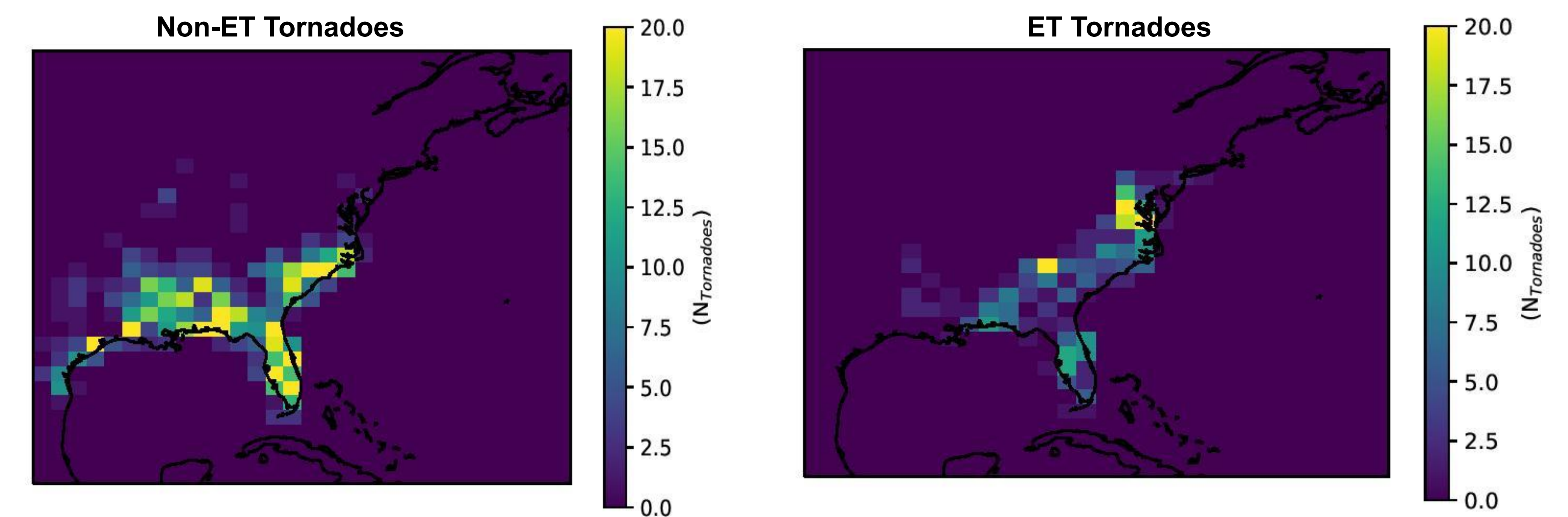


Figure 4: Map view of the number of tornadoes (shaded boxes) in (left) non-ET and (right) ET cases.

4. Results: TC-Relative Location of Tornadoes

Overview

Examine response of TC-relative location of tornadoes in non-ET versus ET cases.

Synopsis

- Tornadoes occurring during ET TCs most frequently occur at 400 km from storm center.
- Tornado distance from the TC center in ET cases are slightly more broadly distributed than non-ET cases;
- However, these differences in the radial distance of tornadoes between the two subsets are marginal suggesting small impacts of ET on tornado location.

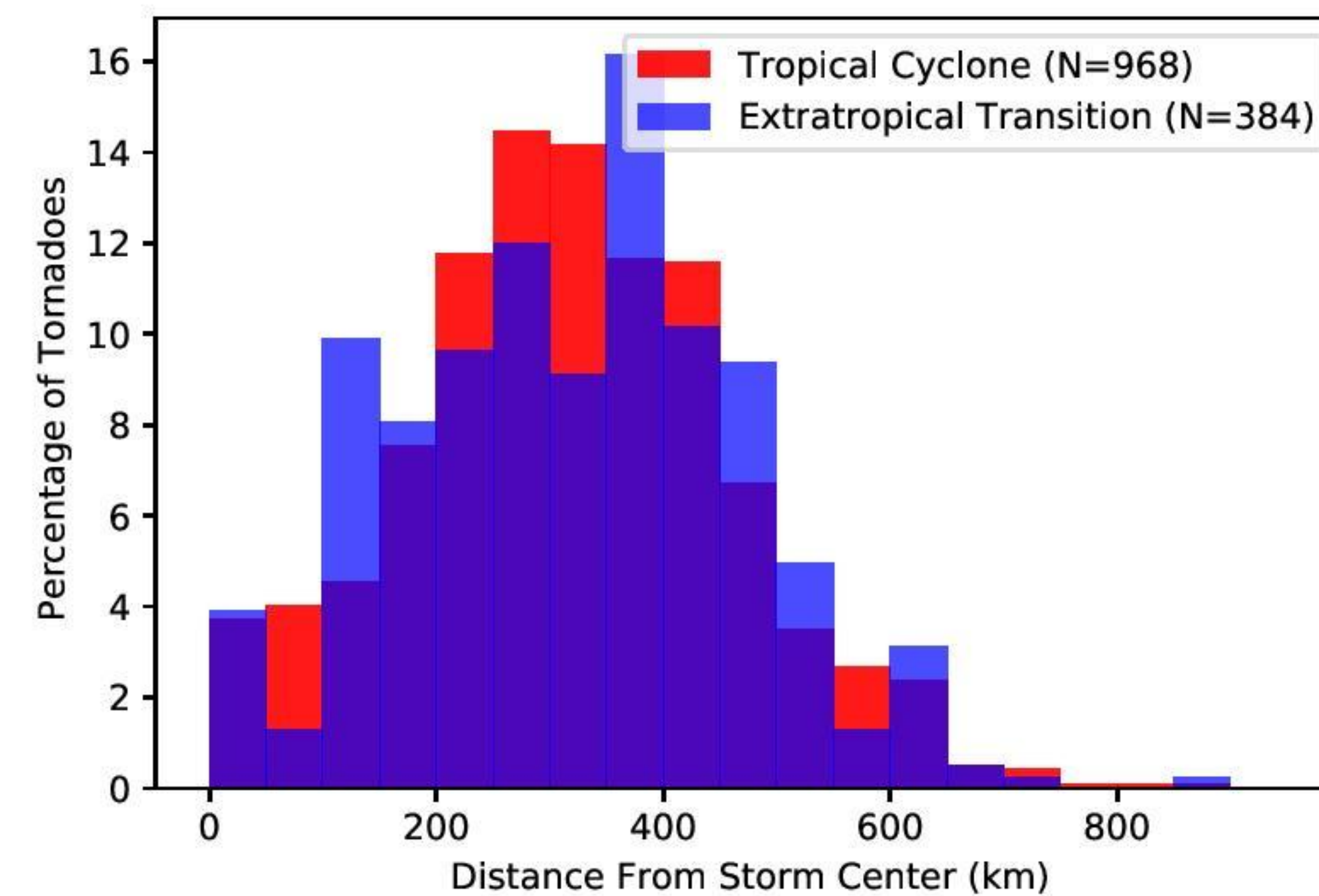


Figure 3: Bar plot of radial distance of tornadoes from TC center (%) for tornadoes in non-ET and ET TCs. The percentage is computed relative to the total number of tornadoes in each subset.

6. Summary and Discussion

- Impacts of extratropical transition on tornadoes are as follows:
 - Major differences:
 - ET cases produce more tornadoes per 6-h period than non-ET TCs, especially for enhanced level of tornado production.
 - ET tornadoes are located almost strictly along the east coast, while non-ET tornadoes are primarily concentrated in the southern U.S.;
 - Marginal or no differences:
 - There are practically no differences in the damage rating of tornadoes between the two subsets; in conjunction with the results regarding tornado frequency, this may suggest that ET environments become more favorable for tornadoes, but not necessarily supportive of more damaging events.
 - There are no difference in radial distances of tornadoes from the TC center between non-ET and ET cases.
- In closure, the results confirm that ET has noticeable impacts on tornado production – specifically, tornado frequency and geographic location.
- Future work will further investigate case studies, as well as the impacts of strong and weak ambient deep-tropospheric vertical wind shear on tornado production during ET cases.

7. Acknowledgments

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