Does Tropical Cyclone Size and Outer Structure Change During Extratropical Transition?

Dzuy Nguyen[1,2] (dzuy.d.nguyen-1@ou.edu) and Ben Schenkel[2,3]

1: University of Oklahoma School of Meteorology, 2: **Cooperative Institute for Severe and High-Impact Weather Research and Operations**, University of Oklahoma, and 3: 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);
- Prior work suggests an increase in size (Hart and Evans 2001) and change in storm symmetry (Loridan et al. 2014) occur during ET.
- However, more recent analyses show little change in lower-tropospheric outer size and structure (Schenkel et al. 2018; Chavas et al. 2019).
- Therefore, we present our own analysis of outer size and storm asymmetry using modern reanalysis data .

Objective and Hypothesis

Objective: This study aims to evaluate the outer size and asymmetry of transitioning Atlantic basin TCs using reanalyses. We hypothesize that changes in size and asymmetry during ET period are minimal.

2. Methodology

Datasets

- **TC track data:** 6-h TC data during 1979–2019 from IBTrACS Best-Track are examined (Knapp et al. 2010);
- **Reanalysis data:** 0.25° x 0.25° 6-h ECMWF 5th generation reanalysis data (Hersbach et al. 2020) used to determine ET start and end times.
- **Outer size metric:** The 6 m/s azimuthal-mean azimuthal wind is well defined in the reanalysis. (Schenkel et al. 2017, Bian et al. 2020)

Methods

- ET start and end time are objectively calculated from reanalysis data using the cyclone phase space (Hart 2003):
  1. **Start time:** begin transition from *non-frontal*, warm-core cyclone to *frontal*, cold-core cyclone;
  2. **End time:** complete transition from non-frontal, *warm-core* cyclone to frontal, *cold-core* cyclone;
- Our analysis examines how TC wind field structure and size change during ET as determined from the cyclone phase space.

3. Results: Outer size evolution following ET

Overview

How does outer size change during the ET period?

Synopsis

- Size for all storms tends to increase following ET independently of initial size in the mid-troposphere.
- No significant change in size is observed during ET at any level for any initial TC size.

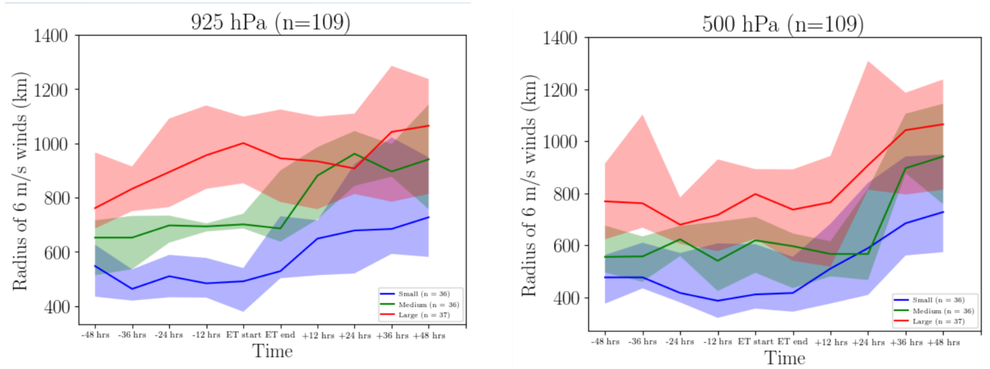

Figure 1. Median size and 95% confidence interval for radius of 6 m/s winds for transitioning storms, organized into tertiles by initial size at start of ET for the 925 hPa and 500 hPa levels, respectively.

5. Results: Vertical cross-sections

Overview

How does size continue to change following the onset of ET? At what pressure levels is this change most pronounced?

Synopsis

- Strengthening of the upper-level anticyclone can be observed immediately following ET.
- Significant changes in lower-level outer size only occur 24 hours after ET.

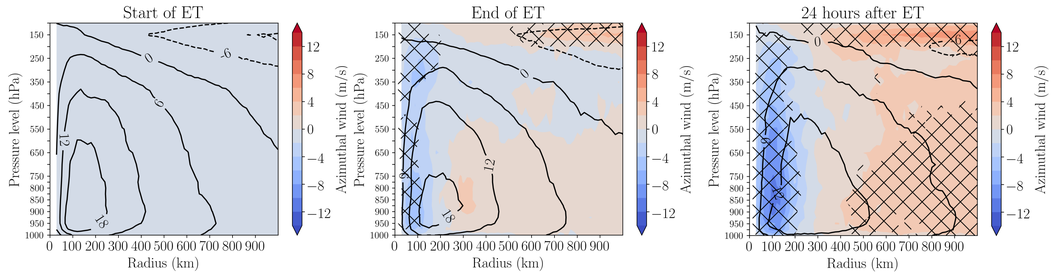

Figure 3: Vertical cross section of azimuthal-mean azimuthal wind relative to beginning of ET for the start of ET, end of ET, and 24 hours after ET respectively. Hatching indicates a value exceeding the 95% confidence interval.

4. Results: Plan-view composite plots

Overview

We examine the overall structural evolution of TC outer size over the ET period through composite plots of azimuthal-mean azimuthal wind relative to storm motion.

Synopsis

- Previous studies suggest significant expansion occurs during ET, but no such expansion occurs close to the surface.
- Little difference in outer size and structure between the start and end of ET.
- Short timespan of ET ~24 hours suggests that more significant changes in outer size may occur after ET.

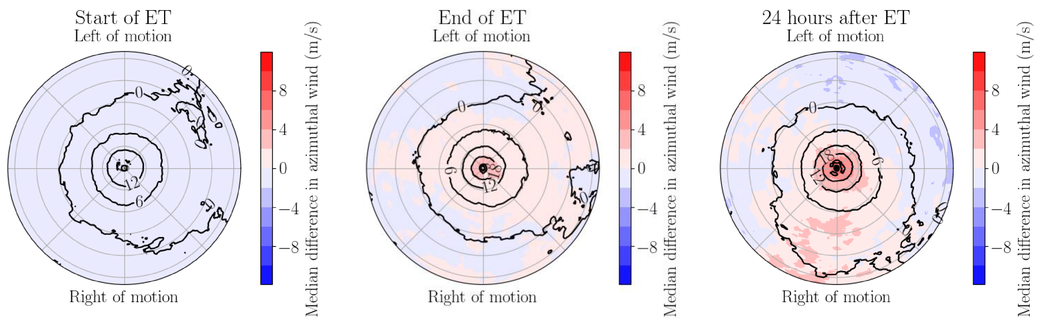

Figure 2: Difference in the composite median azimuthal-mean azimuthal wind relative to storm motion at 925 hPa for transitioning storms from the start of ET for the start of ET, end of ET, and 24 hours following the end of ET respectively.

6. Summary and Discussion

- Impacts of extratropical transition on TC outer size and structure

1. TC outer size remains consistent throughout ET, with some outliers.
2. TC outer size tends to increase immediately following ET rather than during ET.

- Future work:

1. Case studies of storms that increase in outer size more significantly – are these storms more representative of previous work?
2. Compare to warm seclusion cases that currently cannot be identified by the cyclone phase space.

7. Acknowledgements

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