17D.3 SYNOPTIC COMPOSITES OF THE EXTRATROPICAL TRANSITION LIFECYCLE OF NORTH ATLANTIC TCs AS DEFINED WITHIN CYCLONE PHASE SPACE

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1. Introduction

The evolution of 34 extratropically transitioning (ET) tropical cyclones (TCs) from 1998 to 2003 are examined using the cyclone phase space (CPS; Hart 2003, Evans and Hart 2003). Composite mean CPS evolution, variability about that composite mean CPS trajectory, and composites of the synoptic patterns at various key milestones throughout the ET trajectory highlight representative stages of ET. Storms are partitioned into post-transition intensifiers and weakeners; comparison of their synoptic evolution distinguishes key factors affecting post-transition evolution.

2. Methodology

Operational NCEP AVN and Navy NOGAPS 1° analyses are used to calculate CPS trajectories for each of the 34 storms considered. The objective starting (T_B) and ending (T_E) times for extratropical transition (as defined by Evans and Hart 2003) are used as reference points for compositing the entire ET cyclone phase trajectory. Two additional points are also examined: T_B-24 (24hr prior to the start of transition), and T_E+24 (24hr after the end of transition). Compositing of synoptic fields is done using storm-relative coordinates, although no accounting for storm motion (coordinate rotation) is performed.

3. Mean ET Phase Evolution & Variability

For all 34 cyclones, the mean CPS values of T_B-24, T_B, T_E, and T_E+24 were determined to define the mean phase trajectory for extratropical transition (Fig. 1). These calculations were based upon grids from the U.S. Navy 1° NOGAPS analyses. While there is model/analysis dependence, the AVN-based composite was qualitatively similar (not shown). One day prior to the start of transition (T_B-24), the cyclone has achieved its strongest warm-core structure, on average. This also indicates that a typical transitioning cyclone has been weakening for only 24hr before transition begins (in agreement with Hart and Evans 2001), suggesting that most tropical cyclones are still relatively intense when first becoming frontogenetic. The mean transitioned cyclone reaches the strongest cold-core structure (including associated significant baroclinic tilt; Hart 2003) approximately 24hr after transition completes (T_E+24). By 48hr after transition, the occlusion process, on average, has already commenced, and is nearly completion on average by 72hr after ET has completed.

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While the evolution from warm-core symmetric to cold-core asymmetric (with a period of hybrid status) is well-defined by the 34-member composite trajectory, there is considerable variability about the mean trajectory (Fig. 2). Once transition completes, variability increases dramatically peaking 24hr after transition. This variability illustrates the large range of cyclone structure that can occur once ET has completed. Storm and environment factors dictating the nature of post-transition evolution are under investigation.

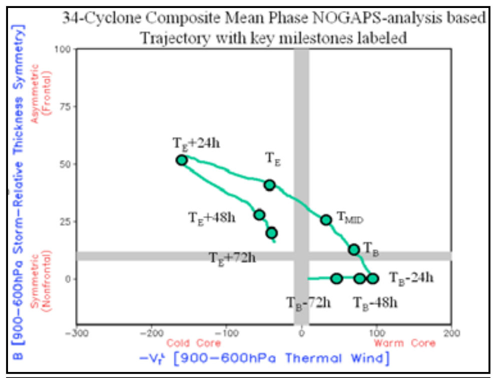

Figure 1: 34-cyclone composite mean cyclone phase trajectory with numerous key milestones labeled.

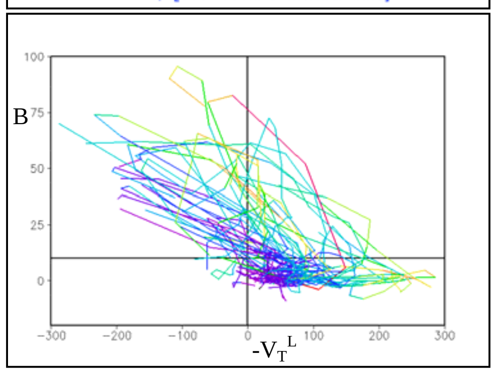

Figure 2: CPS spaghetti plot of 34 cyclone phase trajectories. Color indicates minimum MSLP cyclone intensity.

4. Synoptic Composites of CPS Mean Evolution

The 700hPa composite mean height and K-index for each of the four milestones in the ET lifecycle are shown in Figure 3. The evolution of a symmetric, unstable vortex at T_B-24hr to frontogenetic warm-core cyclone at T_B, to transitioned cyclone at T_E, and cold-core asymmetric cyclone at T_E+24hr is illustrated. While the initially convectively unstable cyclone stabilizes, the remnant moist core remains throughout the ET lifecycle. The advection of cool, dry air from the north to the west of the cyclone center is evident, as is the nature of the mid-latitude trough tilt: from initially positive tilt to neutral or weakly negative tilt once ET has commenced.

Although not shown, 300hPa divergence increases dramatically by T_B, becoming a max. just prior to T_E, then weakening through T_E+24hr. The potential vorticity (PV) maximum at 320K is distinct from the midlatitude trough through T_E, and then merges by T_E+24hr. A latitudinal cross section of PV through the storm center (not shown) reveals an upright column of maximum PV throughout ET, although the magnitude of the low-level PV maximum decreases steadily beyond T_E

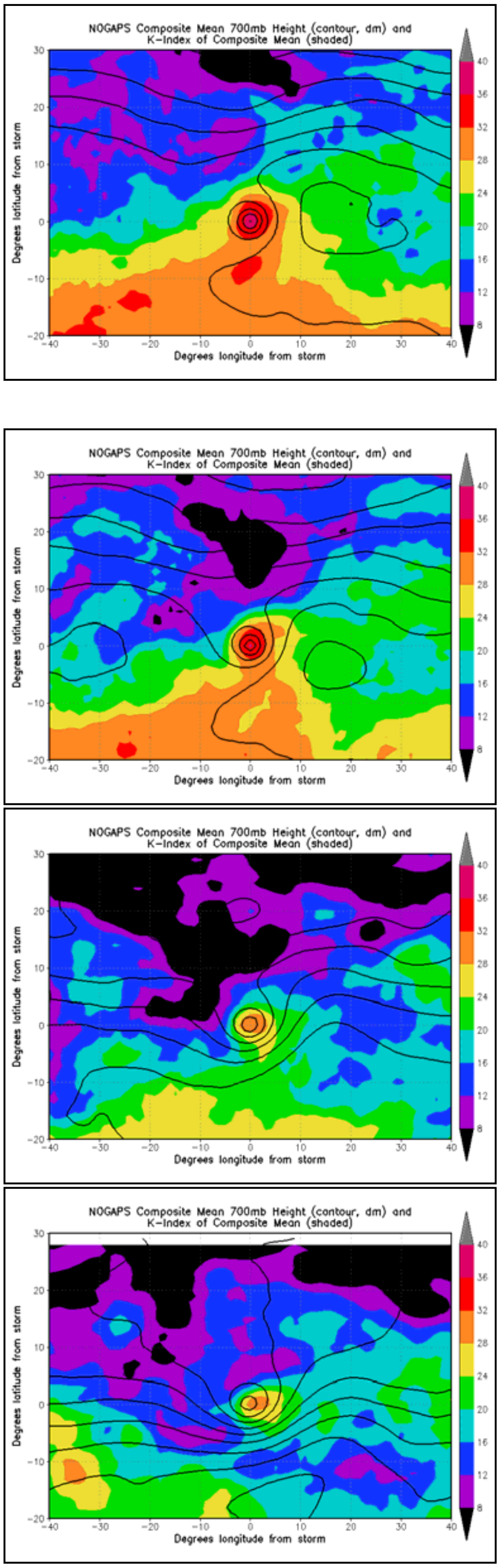

Figure 3: Composite mean storm-relative conditions for 700hPa height (contour) and K-index (shaded) for a) T_B-24hr b) T_B c) T_E d) T_E+24hr The evolution of a symmetric, unstable cyclone core into an increasingly asymmetric hybrid cyclone and ultimately moist, unstable, but cold-core cyclone is illustrated. Although the cyclone reaches cold-core structure, the transitioned cyclone retains the moist, unstable remnant TC core.

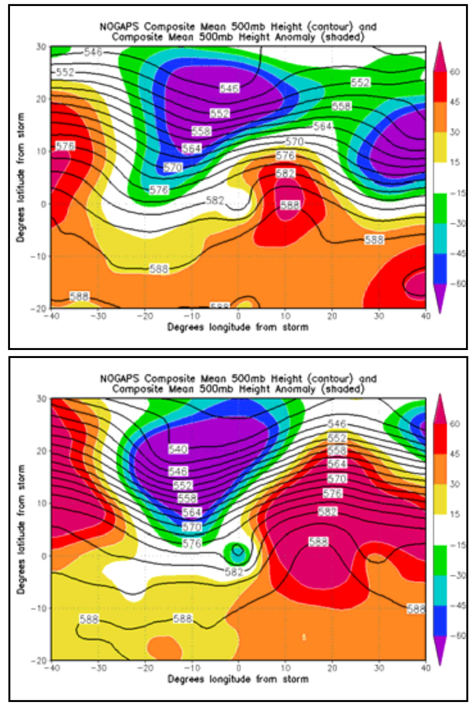

Figure 4: Mean 500hPa height (contour) and anomaly (shaded) at T_B for top) TCs that underwent post-tropical, $T_E \rightarrow T_E$+24hr, weakening (at least +4hPa SLP change) and bottom) post-tropical intensification (at least -4hPa SLP change). The TC locn. is at (0,0). Note the difference in tough tilt.

5. Post-transition intensity change

The precursor environments (at T_B) favoring post-transition cyclone weakening vs. decay are shown in Fig. 4. As is evident, a positively (negatively) tilted 500hPa trough axis is associated with post-transition weakening (strengthening). Although not shown here, the mean T_B position of the TC that weakens (strengthens) after ET is within the right front (right rear) quadrant of the jet streak associated with the trough. Thus, a TC that will ultimately undergo post-transition intensification is located, at the beginning of transition, within a jet streak quadrant favorable for enhanced divergence aloft and ascent.

6. Concluding Summary

A well-defined 34-member ensemble mean trajectory through cyclone phase space is defined for extratropical transition in the North Atlantic. Variability from this mean trajectory is small in the tropical phase, and then increases dramatically once ET has completed. The TC reaches peak warm-core intensity within the CPS around or just after T_B-24h. The unstable cyclone core remains through transition to T_E. TC intensity, trough intensity and tilt, separation distance, and jet streak orientation all modulate the post-tropical intensity change. It remains to be answered what dictates the structure of the resulting post-tropical cyclone: cold-core, hybrid, or warm-seclusion, although this is being actively pursued.

7. Acknowledgements and References

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Evans, J.L. and R. Hart, 2003: Objective indicators of the extratropical transition lifecycle of Atlantic tropical cyclones. *Mon. Wea. Rev.*, **131**, 909-925.

Hart, R.,2003: A cyclone phase space derived from thermal wind and thermal asymmetry.*Mon. Wea. Rev*.,**131**,585-616.