Composite Analyses of Tropical Convective Systems Prior to Tropical Cyclogenesis

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Introduction

- In general, there are two methods of studying genesis:
  - Case Study: Allows for a detailed examination of a system, but the case may or may not be representative of the population of all cases (e.g. Helms and Hart 2012)
  - Composite Study: Identifies prominent features which are representative of the set of cases, but important, yet highly variable features may be lost in the compositing process (e.g. McBride and Zehr 1981)
- Solution: Composite on subset of similar cases
- The present study uses a phase space to generate subsets
- Similar approach successful in other studies
  - e.g. Hart et al. (2006), Wheeler and Hendon (2004)

Pre-Genesis Phase Space

- Select phase space metrics which will best identify current state of important system structures
  - e.g. system tilt, system strength (see Fig. 1)
- Some potential variables to use as metrics:
  - 500-850 hPa tilt direction and magnitude
  - 850 hPa and 500 hPa tangential velocities (V_λ)
  - Mid-level temperature anomaly and moisture
  - CAPE or other measure of instability
  - Shear direction and magnitude

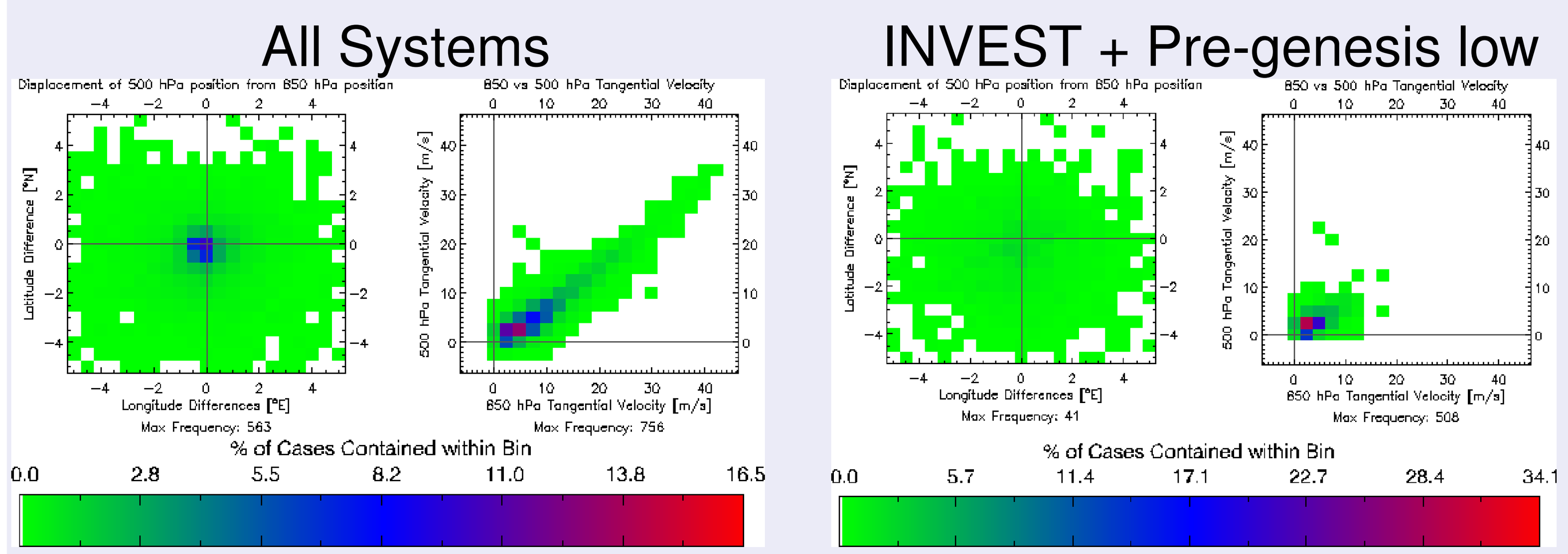

Fig. 1. Distributions of example phase space metrics constructed using the displacement of the 500 hPa center from the 850 hPa center and the 850 and 500 hPa mean tangential velocities. The left two panels are constructed using all positions from HURDAT2 and the INVEST files from 2005 through 2012. The right two panels are constructed using just the INVEST and pre-genesis low positions (IN+PG) during this period.

Data

- Atmospheric fields: CFSRv2 (Saha et al 2010)
- First guess positions: (2005–2012)
  - HURDAT2 (Landsea and Franklin 2013)
  - NHC INVEST files (Cossuth et al. 2013)

Methodology for locating 850 and 500 hPa circulation centers

1. Start with first guess position (currently taken from HURDAT2 or INVEST files)
2. Find maximum area-averaged V_λ as second guess position
   - Area average taken over 3° radius circle
3. Locate area of minimum difference between signed V_λ and unsigned total wind

Example of Improving Detail via Subsetting

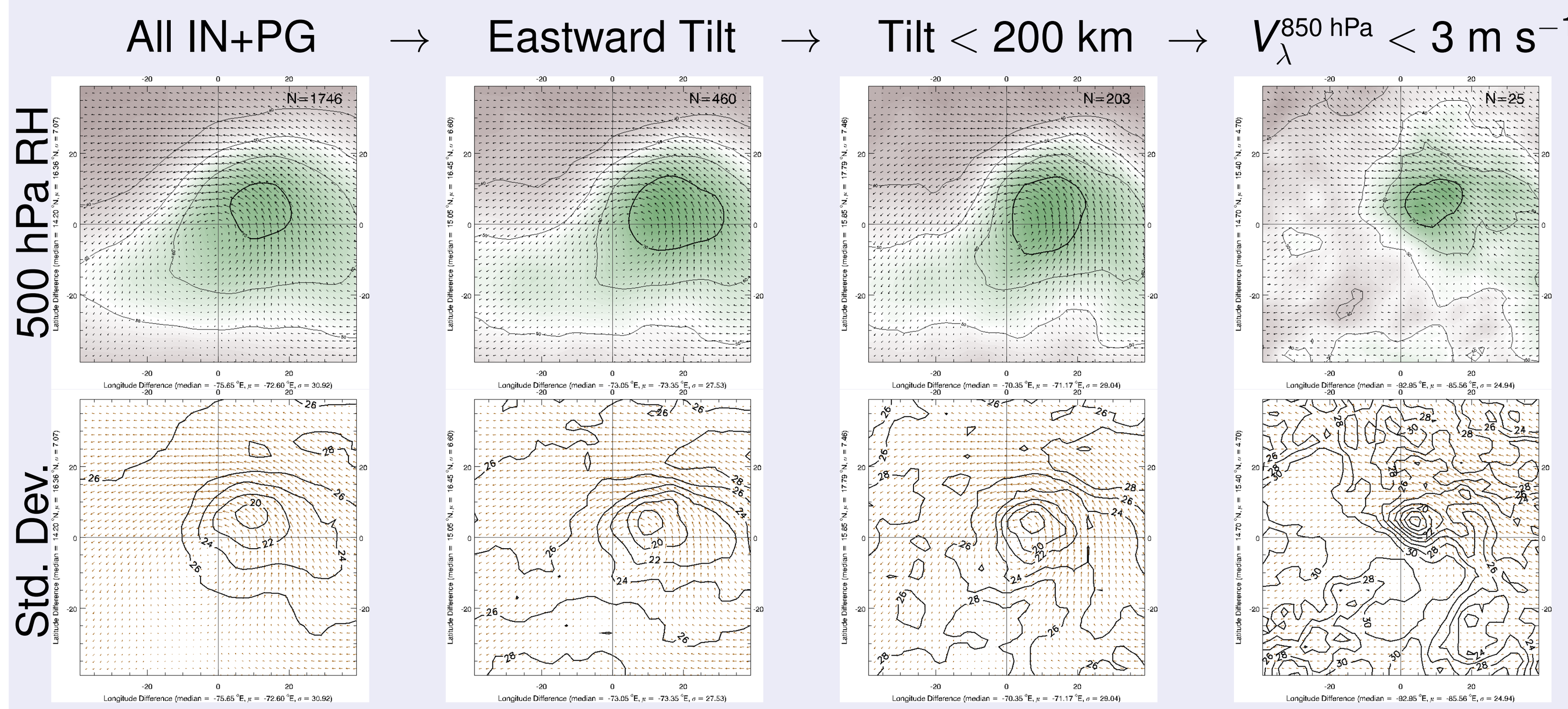

Fig. 2. Series of composited 500 hPa relative humidity (top row) and the corresponding standard deviation (bottom row) for INVESTs and pre-genesis lows. From left to right, the composites are generated using: (column 1) all invests and pre-genesis low positions, (column 2) the subset of column one systems which have an eastward tilt within 45° of due east, (column 3) the subset of column two systems which have a tilt magnitude of less than 200 km, and (column 4) the subset of column three systems with 850 hPa winds between 0 and 3 m s^{-1}.

Invest and Pre-genesis Composites Subset by 850 hPa V_λ and Zonal Tilt

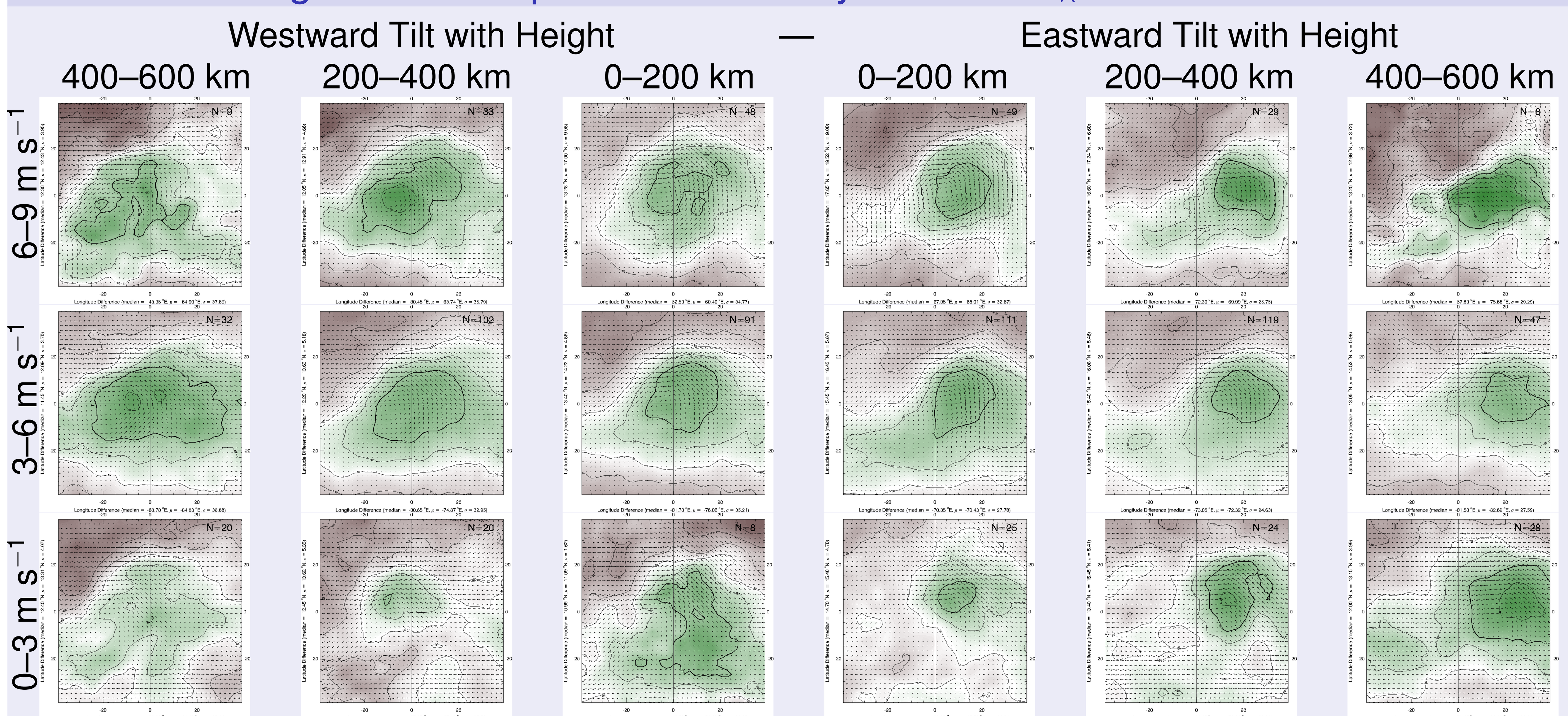

Fig. 3. Composites of 500 hPa relative humidity for INVEST and pre-genesis low positions subset based on system tilt and 850 hPa area-averaged tangential velocities. The panels are arranged such that lower panels have weaker tangential winds than higher panels and panels farther left have less eastward (more westward) system tilt. Relative humidity is contoured in increments of 10% and the thick contour is associated with 70% relative humidity. Vectors represent the composited 500 hPa total wind and are scaled for each plot separately based on the domain maximum wind.

Preliminary Results

- Subsetting appears to successfully reduce variance in composites (see Fig. 2)
- Informal testing suggests viability of using a phase space to subset cases (see Fig. 3)
- Additional details exposed by subsetting (see Fig. 3)
  - e.g. open versus closed circulation

Future Work

- Test and finalize phase space metrics
- Thorough examination of composites
- Extend center finding algorithm to generate first guess positions independent of best track
  - Allows for the inclusion of additional years
  - Reduce selection biases
- Generate composites using data from other models
- Examine how systems evolve via phase space trajectories
  - How do trajectories differ between developing and non-developing systems? Between basins? As a function of time of year?
- Generate real-time products using the pre-genesis phase space
  - e.g. Forecast diagnoses of genesis probability
- Adapt phase space to ingest observational data

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Acknowledgments

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