The Evolution of Dropsonde-Derived Vorticity in Developing and Non-Developing Tropical Convective Systems

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Introduction

- Numerous studies have detailed how the structure of a developing tropical convective system evolves (e.g. Bister and Emanuel 1997)
- Comparatively fewer studies have examined structural differences between developing and non-developing systems (e.g. McBride and Zehr 1981)
  - Majority of these use composite means
- The present study aims to observationally examine individual cases of developing and non-developing systems in hopes of identifying key differences in the vorticity structure and evolution.

Important Signatures of Tropical Cyclogenesis

- Vorticity magnitude is greater, on average, in developing systems (McBride and Zehr 1981)
- Formation of an upright vortex (e.g. Bister and Emanuel 1997, Simpson et al. 1997, Ritchie and Holland 1997, Montgomery et al. 2006)
- High moisture and strong mid-level circulation (Nolan 2007)
- Vortex alignment, moist mid-levels, strengthening mid-level circulation (Davis and Ahijevych 2012)

Data and Methodology

Data

- GRIP and PREDICT dropsondes
- Time-space correction using mean zonal wind at each level

Method (as per Helms and Hart 2012)

- Vorticity calculated using Green's Theorem

$$\text{Vorticity} \approx \frac{\sum(u\Delta x + v\Delta y)}{area}$$

- Polygonal regions used for calculations (see Fig. 1)

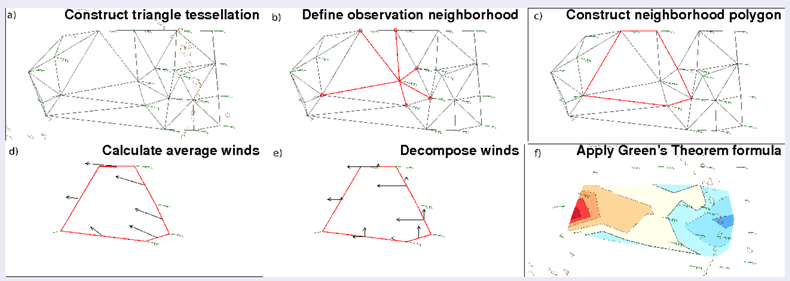

Fig. 1. Visual outline of method for calculating vorticity using Green's Theorem on polygonal regions (from Helms and Hart 2012).

Developing Case - PGI44L - Karl (2010)

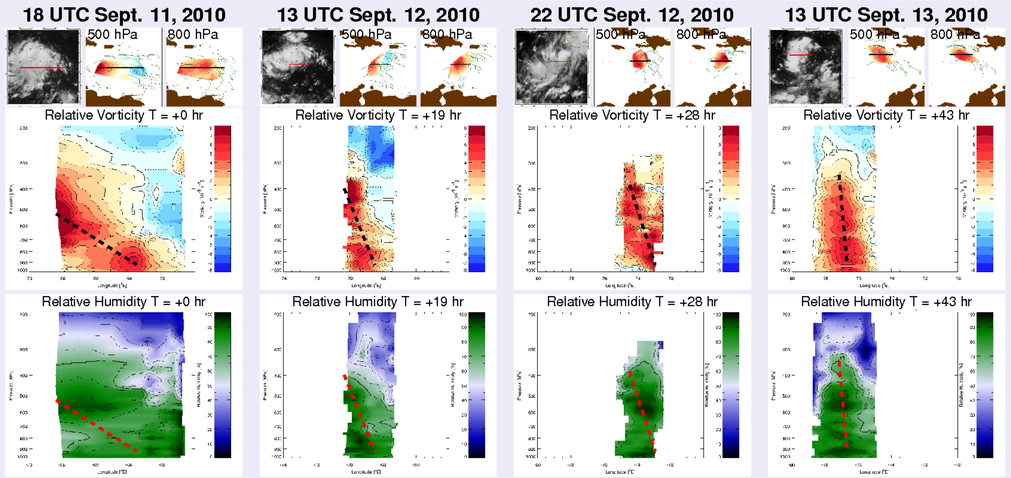

Fig. 2. Series of cross-sections (earlier times on left) from the developing Pre-Karl system which was declared a tropical depression on Sept. 14 at 12 UTC. For each time, plots of the corresponding IR satellite image (top row, left), 500 hPa relative vorticity (top row, middle), 800 hPa relative vorticity (top row, right), relative vorticity cross-section (middle row), and relative humidity cross-section (bottom row) are included. The red or black horizontal bars in the satellite image and the 800 hPa and 500 hPa relative vorticity plots represent the location of the cross-section data at the corresponding time. The dashed line in the vorticity and relative humidity cross-sections indicates the approximate axis of maximum vorticity.

Developing Case - PGI46L - Matthew (2010)

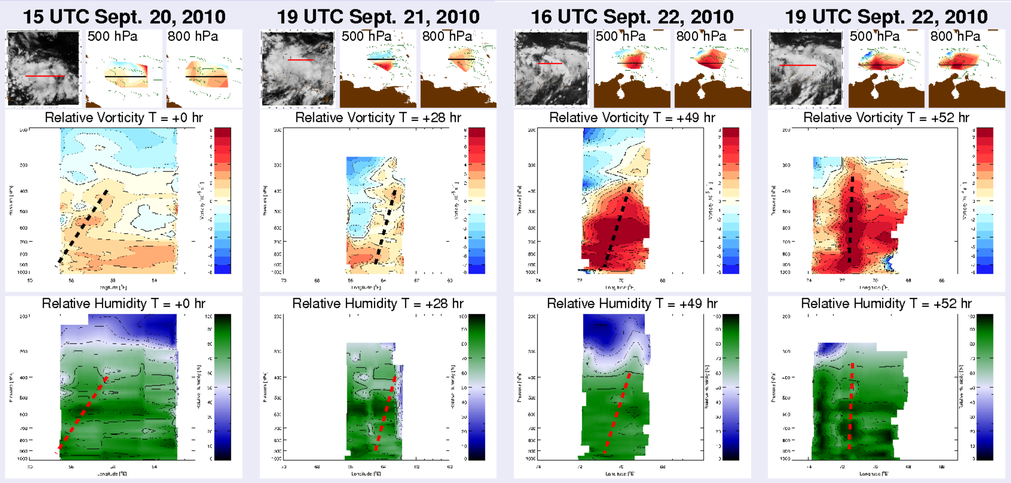

Fig. 3. As in Fig. 2, except for the developing Pre-Matthew system which was declared a tropical depression on Sept. 23 at 12 UTC.

Acknowledgments

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Non-Developing Case - PGI27L

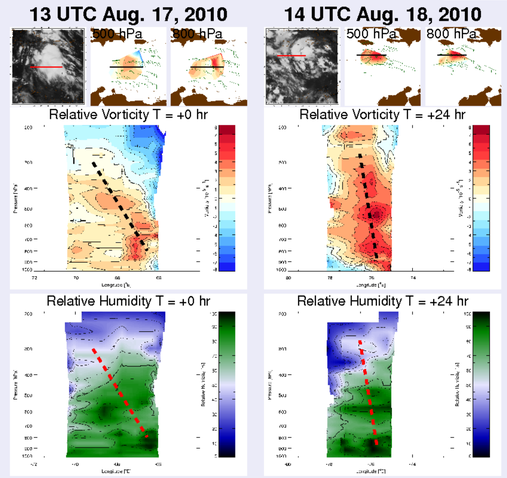

Fig. 4. As in Fig. 2, except for the non-developing PGI27L system.

Conclusions

With respect to the three systems analyzed here:

- Vorticity structure evolves from a highly tilted to a vertically aligned vorticity column in both developing and non-developing systems
- Although not shown here, no significant differences were found in divergence and temperature anomaly structures in relation to the vorticity structure
- Only noticeable structural difference is in the presence of dry air at mid-levels in the non-developing case
  - Confirms findings of Nolan (2007) and Davis and Ahijevych (2012)
- *These results suggest that the key determinant of genesis in these cases was the co-location of moisture with the column of maximum vorticity*

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