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GENESIS OF A HURRICANE IN A SHEARED ENVIRONMENT

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1. INTRODUCTION:

Considerable evidence exists that vertical wind shear is negatively correlated with development of hurricane-strength disturbances. It is less clear, however, that low shear is needed during earlier stages of storms. Bracken and Bosart (2000) found that tropical depression formation in the western Atlantic was accompanied by upper troughs to the west and north. The mean vertical wind shear over the forming depressions was 10.5 ms^{-1}, with many cases exceeding that value. Bracken and Bosart (2000) also showed that quasigeostrophic forcing generated upward motion over the developing depressions. It is possible that favorable forcing makes depression formation more likely in a moderately sheared than an unsheared environment. This view is not necessarily at odds with the negative impact of vertical wind shear found in observations. Depressions may develop in moderate wind shear (8-10 ms^{-1}), whereas subsequent hurricane development may require a relaxation of such shear. If indeed depressions and storms frequently form under moderate wind shear, the question is how the wind shear impacts the developing system.

In this work, the development of tropical depression, storm, and eventually Hurricane Danny in the Gulf of Mexico in July 1997 will be investigated using cloud to ground lightning distribution and reconnaissance aircraft data. The development occurred under persistent moderate wind shear.

2. DATA/METHODOLOGY:

Ground flash locations were obtained from the National Lightning Detection Network (NLDN). The storm remained within range of the NLDN from its initial appearance as an MCS over Louisiana and the northern Gulf of Mexico through to hurricane intensity and beyond. Vertical wind shear (850-200 mb) was calculated over a 500 km radius using analyses from ECMWF.

3. RESULTS:

Figure 1 shows a radius-time series of cloud-to-ground lightning in Danny from the beginning of tropical depression stage until just prior to landfall as a hurricane. Flash counts are plotted hourly for 20-km radial bins. Outer bands (which first appear in the lightning 100-150 km from the center) showed no apparent relation to intensity change. Instead, they had a distinct diurnal variation, appearing each day near the 150 km radius at about 1200 UTC (just before sunrise), and propagating outward with respect to the center. Inner core lightning behaved very differently. Four localized outbreaks occurred, starting near the 110 km radius, then shifting progressively inward and intensifying. The final, and also the most intense, outbreak occurred as the depression was named a tropical storm at 1200 UTC 17 July. Thereafter, fewer than 40 flashes (the smallest contour in Figure 1) occurred in any hour, even during and after the transition to hurricane stage. In this work we are most interested in the development from a depression on 16 July to the end of tropical storm stage at 0600 UTC 18 July.

At each time, azimuth was defined with respect to the vertical wind shear vector following Corbosiero and Molinari (2002). The vast majority of ground flashes occurred downshear during the inner core outbreaks, consistent with the findings of Corbosiero and Molinari (2002). During the most intense outbreak near 1200 UTC 17 July, the maximum flash count occurred downshear, but flashes occurred all around the storm.

Evidence will be shown in the talk for multiple vortex interactions associated with repeated downshear convection. Equivalent potential temperature values from reconnaissance aircraft flights will be shown. An

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attempt will be made to link several ideas concerning cyclogenesis: wind-speed dependent surface fluxes; mid-level moistening; vortex Rossby wave rearrangement of convectively generated asymmetric vorticity; and the probabilistic nature of tropical cyclogenesis.

5. ACKNOWLEDGEMENTS:

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6. REFERENCES:

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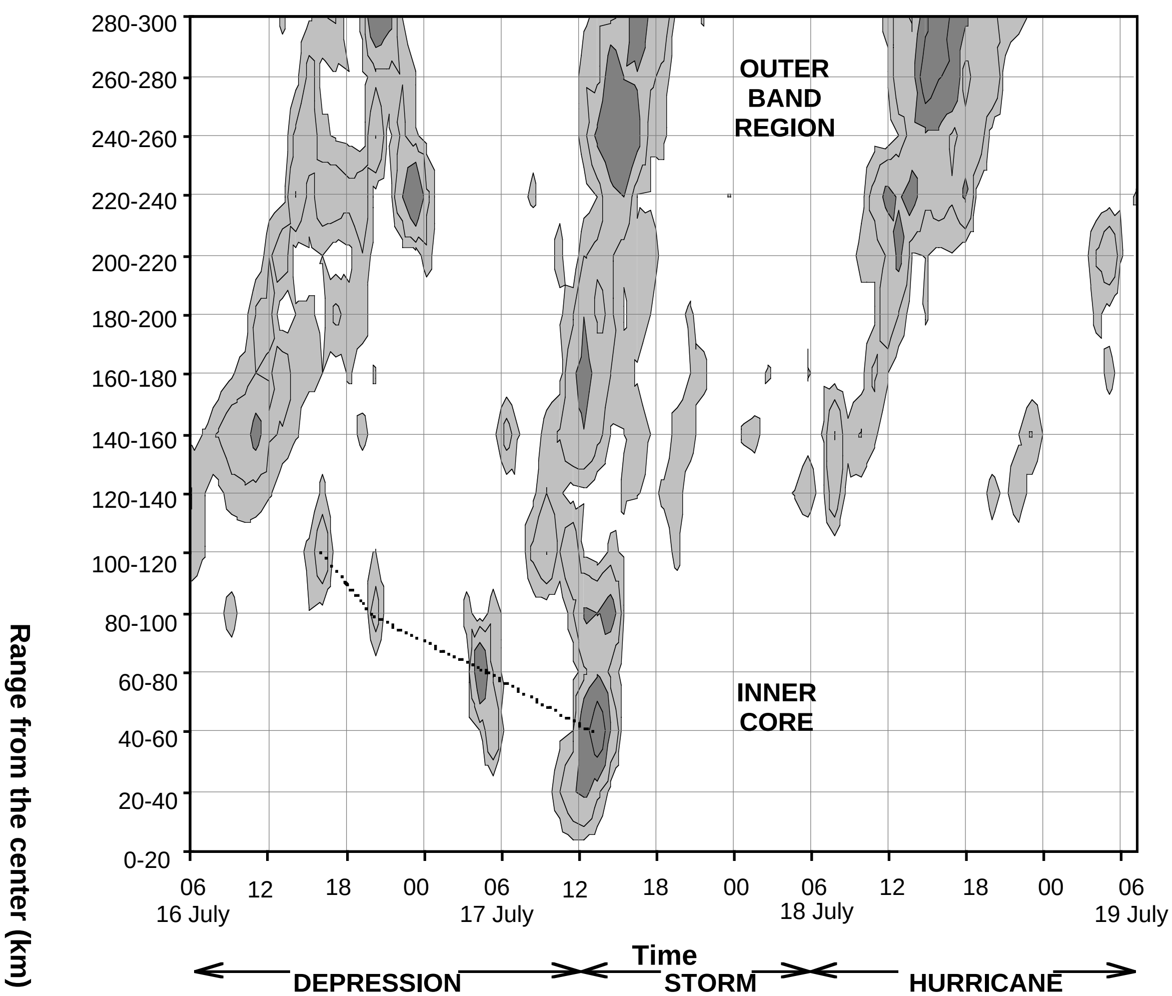

Figure 1. Radius-time plot of the number of flashes in each 20-km radial bin for each hour. The contours begin at 40 flashes per hour, then increase in a logarithmic fashion (80, 160, 320). Light shading represents 40-160 flashes per hour, dark shading greater than 160 flashes. Periods of depression, storm, and hurricane intensity are indicated.