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DUAL-DOPPLER ANALYSES OF MESOVORTICES IN A HURRICANE RAINBAND

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1. INTRODUCTION

Hurricane Bonnie made landfall in North Carolina as a Category 2 hurricane on the evening of 26 August 1998 (Pasch 1999). As part of the Tropical Cyclone Windfields at Landfall experiment (Powell 1999) there were two Hurricane Research Division (HRD) missions on 26 August. The first flight (NOAA 42) concentrated on examining thermodynamics of the inflow (Wroe and Barnes 2000) and the second flight (NOAA 43) surveyed the hurricane as it interacted with the coast. Both aircraft flew legs near the Morehead City, North Carolina, Weather Service Doppler radar (KMHX WSR-88D).

Both aircraft passed close to intense cells in a strong rainband about 180 km NE of the center, and NOAA 43 was forced to deviate around the stronger cells as it passed up and down the coast near KMHX. The WSR-88D detected several mesocyclones in this rainband, one of which produced an F1 tornado around 1725 UTC as it crossed the coast near Beaufort, North Carolina. Both aircraft launched GPS sondes near these cells, as well as collecting airborne Doppler data.

We use the Doppler radar data to derive the three-dimensional strucuture of the mesocyclones, and in a companion paper we examine the GPS sondes and other upper-air data to describe the environment of the mesocyclones (Spratt et al. 2000).

2. RADAR DATA ANALYSIS.

The tail Doppler radar antenna scanned forward and aft of the heading (F/AST, Jorgensen et al. 1996), yielding intersecting rays with a seperation of ~45°. The KMHX WSR-88D collected a full volume scan every 5 minutes, scanning from 0.5° to 19.5° in elevation. Data from these two platforms were combined to solve for the horizontal and vertical winds in a pseudo-triple Doppler analysis, using Gamache's variational technique (Gamache, 1997), which applies two constraints: the windfield must closely satisfy the equation of continuity, and the projection of the windfield back on the Doppler rays must closely match the observed Doppler velocities. The winds were analyzed on 66 x 66 km domains with 0.75 km vertical resolution.

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3. RESULTS

Three analyses have been completed, for 1600 UTC (NOAA 42), 1725 and 1805 UTC. We will discuss the last analysis here. NOAA 43 deviated around a strong cell in the rainband from 1757 to 1811 before resuming the track SW along the coast (Fig. 1). Tracking feature A in the 0.5° scans showed that the cell closest to the aircraft moved toward 330° at 37 ms^{-1}. This advection speed was used to position the Doppler data in the analysis grid.

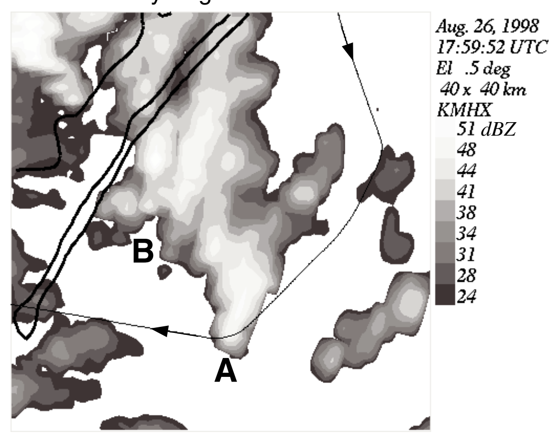

Figure 1. Reflectivity image from KMHX WSR-88D at 1759 UTC, 26 August 1998. Succesivel lighter shades of gray correspond to higher dBZ. Coastline and flight track shown in black.

The analyzed horizontal winds were 35-40 ms^{-1} along the band (Fig. 2). Note the minmum and maximum at cell B. When the cell motion is removed from the total wind velocities mesoscale circulations

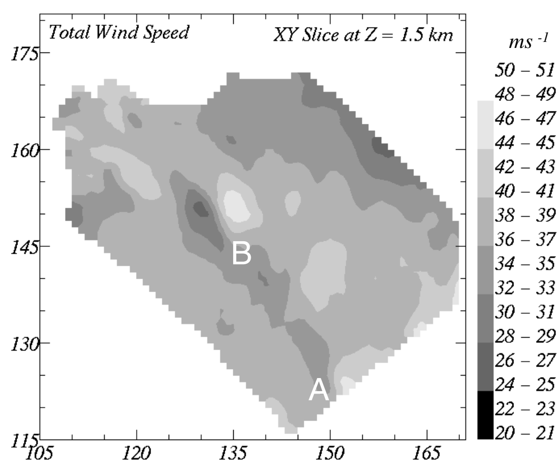

Figure 2. Total windspeed at 1.5 km altitude from Doppler analysis. Succescively lighter shades of gray denote increasing windspeeds. Axes are labeled with distance from center of hurricane, in km.

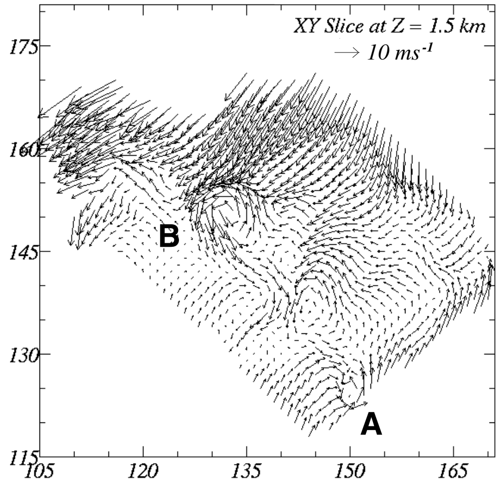

Figure 3. Cell relative wind velocity at 1.5 km. Cell motion of 37 ms^{-1}, 330°, removed from total winds. Axes labeled as in Figure 2.

are clearly revealed (Fig. 3) at the southern, upwind ends of cells A and B. There is another circulation located between the two cells. The vertical component of vorticity in these cells (Fig. 4) is 4-8 x 10^{-3} s^{-1}, comparable to that seen in weaker mesoscyclones in mid-latitude supecells. The 45 dBZ core of cell B, the strongest in

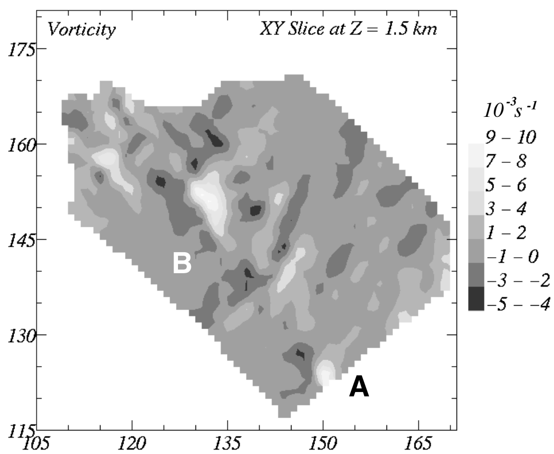

Figure 4. Vertical component of vorticity at 1.5 km. Successively lighter shades of gray denote higher values, contoured in units of 0.001 s^{-1}.

this part of the band, extended to > 7km in height, but the storm relative rotation only extended to 3.8 km. Similar shallow circulations have been documenteed in previous studies of tropical cyclone rainbands (Spratt and Sharp 1999, Spratt et al. 1997).

The analyses from 1600 and 1720 have similar storm-relative circulation features. Unfortunately, the tornadic cell at 1725 was out of range of the tail Doppler radar. Single sweeps from the tail radar that we will show at the conference have features reminiscent of super-cells, such as weak-echo vaults, and narrow, vertical precipitation features extending to the surface that are very suggestive of vortices associated with the mid-level circulations.

This research is a collaboration between the Hurricane Research Division and the National Weather Service. It is also a good example of serendipity! Because of flexible flight planning, with the cooperation of NOAA's Aircraft Operation's Center (AOC) crews, high resolution Doppler data were collected within10 km of these cells, and extra GPS sondes could be launched in the inflow regions.

The WSR-88D data, tail Doppler data, and GPS sonde data will be examined further to better define the life cycle, vertical stucture, and inflow environment of the mesoscyclones. HRD collected airborne Doppler data near convective cells in outer rainbands in Hurricanes Earl and Georges (1998) and Floyd and Irene (1999), where similar mesoscale circulations might be found. HRD will continue to plan flights in land-falling hurricanes that take advantage of the WSR-88D radars, as well as other portable sytems, such as those that might be deployed as part of the United States Weather Research Program's Hurricanes at Landfall field program in 2001.

4. ACKNOWLEDGEMENTS

The AOC flight crew and scientific staff aided us in many ways in collecting this data set. The MIC and staff at the Morehead City Weather Service Forecast Office helped to obtain surface data after the storm. The National Climatic Data Center responded quickly to our requests for the WSR-88D data.

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