16A.3

HIGH-RESOLUTION OBSERVATIONS OF THE EYEWALL IN AN INTENSE HURRICANE: BRET ON 21-22 AUGUST 1999

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1. INTRODUCTION

On 21 and 22 August, 1999, the Hurricane Research Division of the National Oceanographic and Atmospheric Administration (NOAA) conducted two single-plane experiments in Hurricane Bret with P-3 aircraft from NOAA's Aircraft Operations Center (AOC). The flight pattern on the 21st was intended to survey the vortex and its environment, when Bret was a Category 4 hurricane, with winds > 63 m/s (Pasch, 1999). The flight on the 22nd occurred as Bret, now a Category 3 storm with surface winds still > 50 m/s, made landfall on the South Texas coast between Corpus Christi and Brownsville.

On both days there was a module where the aircraft flew upwind in the eye, just inward from the eyewall at flight level. The eyewall sloped inward below the aircraft so GPS sondes dropped during the pattern sampled the wind maxima at lower altitudes, finding winds > 74 m/s on the 21st, and > 70 m/s on the 22nd. Usually in hurricane penetrations the tail radar only slices the eyewall a few times as the aircraft quickly crosses the eye, but during the eye circles many sweeps were collected at close ranges (<5 km) that can provide details of the three-dimensional windfield in portions of the eyewall on successive days. We will present the radar reflectivity and wind fields to show the eyewall features the sondes fell through, with the goal of describing the variability of the windspeed maxima in the hurricane eyewall.

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°. On the 21st data from the tail radar sweeps were combined to solve for the horizontal and vertical winds in a pseudo-dual Doppler analysis, using Gamache's variational technique (Gamache, 1997). This technique 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. On 22 August the KBRO and KCRP WSR-88D's collected full volume scans every 5 minutes, scanning from 0.5* to 19.5* in elevation.The WSR-88D data were added to create triple-Doppler analyses of the eyewall on 22 August. The winds were analyzed on domains with 0.75 km vertical and 0.5 to 1.0 km horizontal resolution.

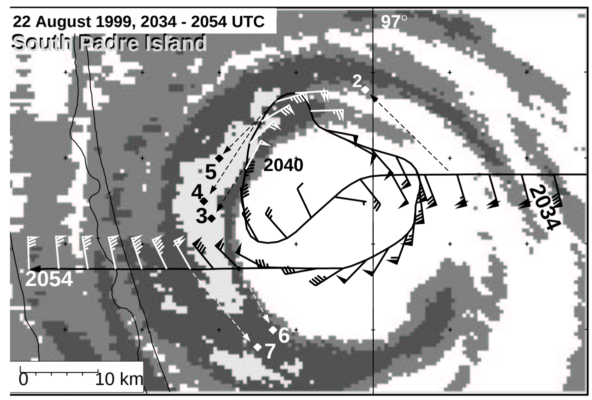

Figure 1. NOAA 43 flight track in Hurricane Bret, 22 August 1999, 2034-2054 UTC. Gray shades are for reflectivity from BRO WSR-88D at 2035. Lightest gray is > 45 dBZ in eyewall. Numbered diamonds indicate splash locations of sondes.

3. RESULTS

The first eyewall circle on 22 August was from 2034 to 2054 UTC. 6 sondes were deployed in the eyewall (Fig 1), one (2) in the east eyewall, three within100 s on the inner edge of the west eyewall (3-5), and two in the west eyewall (6 and 7) as the aircraft headed for the Texas coast. Figure 2 shows a sweep from the tail radar at 204102, shortly before sonde #4 was launched. The aircraft was right up aginst the eyewall at ~ 3900 m

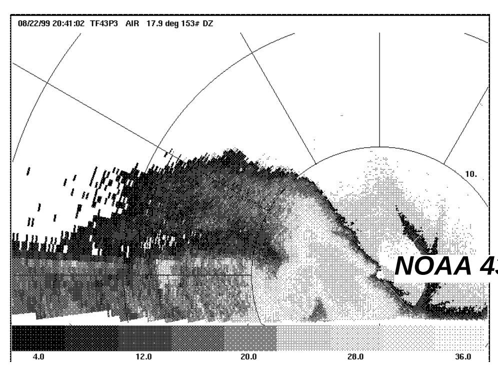

Figure 2: Sweep from tail radar at 204102. Reflectivity increases with lighter shade of gray. Slightly darker shade in eyewall is > 40 dBZ. Range rings are at 10 km intervals from aircraft.

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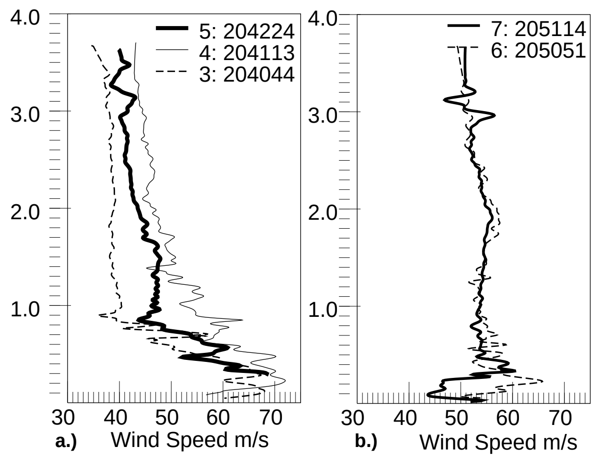

Figure 3 Vertical profiles of horizontal wind from GPS sondes. Heights are in km, winds in m/s. a) sondes dropped just inside western eyewall from 2040 to 2042 UTC. b.)sondes dropped in western eyewall at 2050 and 2051 UTC.

in altitude. There was a bulge in the eyewall just above the aircraft As the aircraft flew upwind, this protrusion increased in altitude and probably corresponds to one of the spiral striations visible in the eyewall of strong hurricanes like Bret.

Figure 3a shows the vertical profiles of the horizontal windspeed of sondes 3-5. The wind increases dramatically below 1 km as the sondes finally intersect the inward-sloping wind maximum. Contrast this with the profiles from sondes 6 and 7 (Figure 3b), which were dropped near the flight-level wind maximum; the profiles are almost constant at 55-60 m/s.

The Doppler analysis from the airborne and WSR-88D radar data, centered at 2037 UTC , has the maximum windspeed > 60 m/s in the northern eyewall (Fig. 4) in the layer from 800 m to the surface. The sonde data indicate that there were windspeeds >65 m/s in portions of the western eyewall in that layer, but the sonde winds nearest the surface are 55-60 m/s which agree well with the Doppler analysis.

Ultimately one wants to obtain as much information as possible from each sonde transmitted to the National Hurricane Center in real time, to help the forecaster in interpreting the surface wind speeds. Black and Franklin (2000) studied data from ~300 sondes dropped in hurricane eyewalls, including the sondes from the Bret flights. They found that some of the variability in profiles of the horizontal winds could be explained by examining whether the sondes fell in convective environments, determined from the vertical velocity profiles. The Bret Doppler radar data may provide further details on the sonde environments. There are two more eyewall circles to examine, one on the previous day, and one ~3 h after the circle described here. At the conference we will present more details of the eyewall wind maxima gleaned from this unique data set.

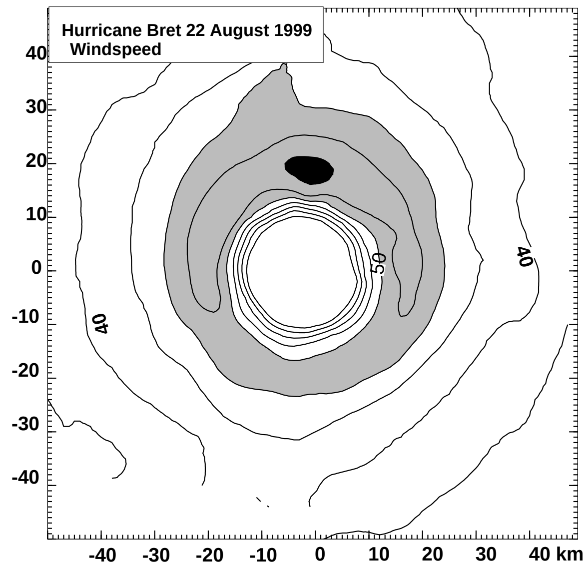

Figure 4. Horizontal windspeed from Doppler analysis, for layer from surface to 0.8 km at 2037 UTC. Contours in 5 m/s increments start at 30 m/s. Gray encloses winds > 50 m/s, and black encloses winds > 60 m/s. Domain is 100 x 100 km.

4. ACKNOWLEDGEMENTS

The AOC flight crew and scientific staff aided us in many ways in collecting this data set. The MIC's and staff at the Brownsville and Corpus Christi Weather Service Forecast Offices ensured that WSR-88D data were archived. The National Climatic Data Center responded quickly to requests for the WSR-88D data. Erin McCormick, a graduate student of the University of Miami, processed the Bret sonde data after the 1999 Hurricane Field Program.

5. REFERENCES

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