Surfing the outflow: VORTEX from the air

by Andrew I. Watson

Figure 1: F3 tornado near Newcastle, TX at 2312 UTC on 29 May 1994, taken from P-3 by C. Ziegler.

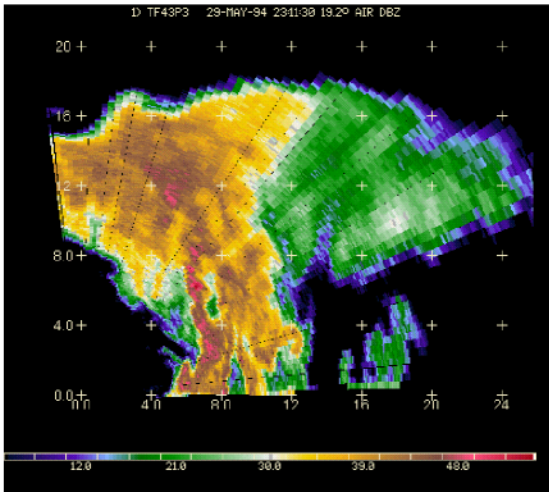

Figure 2: NOAA P-3 radar data from VORTEX mission on 29 May 1994. Tail-forward RHI reflectivity image at 2311 UTC showing a Bounded Weak Echo Region (BWER) and Echo Weak Hole (EWH).

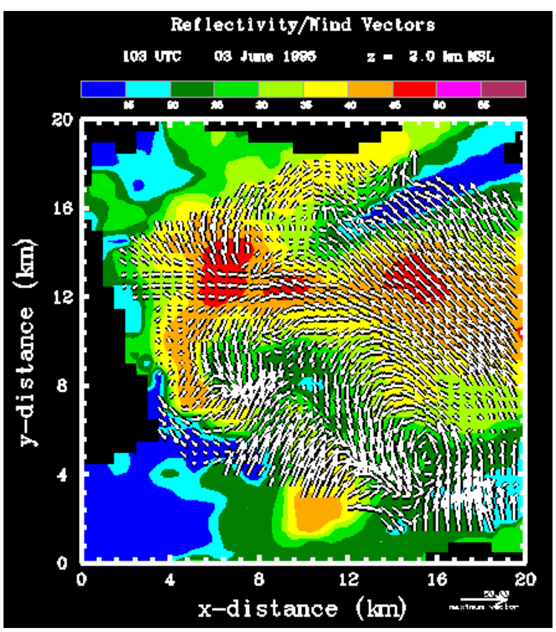

Figure 3: Dual-Doppler analysis of Dimmitt, TX tornado on 3 June 1995 at 0103 UTC at 2.0 km MSL (0.8 km AGL). Reflectivity (dBZ) is color-contoured showing mesocyclone hook. Vectors denote horizontal flow. Two vortices are apparent, one within the hook and the other approximately 8 km ESE of the hook.

In VORTEX-94 and 95, the National Oceanic and Atmospheric Administration's (NOAA) WP-3D aircraft, operated by the Air Craft Operations Center, was used to document the evolution of storm structure. The P-3 is equipped with two radars that allow several techniques in scanning. The lower-fuselage radar is a 5.6 cm (C-band) radar. It scans horizontally, giving the scientist the 'big picture' while also monitoring the evolution of the targeted storm in its lowest layers. The tail radar is a 3.2 cm (X-band) Doppler radar that scans vertically. To obtain pseudo dual-Doppler measurements, the radar antenna can be alternately slewed fore and aft of the direction perpendicular to the fuselage by as much as 25 degrees. To maximize the spatial resolution, the tail radar antenna can be sectorized to one side of the aircraft. To further increase the spatial, along-track resolution, we employ " the Alternate Fore-Aft Scanning Technique" (AFAST). Using AFAST, we execute only fore scans as we approach our target storm, and only aft scans as we pass and move away from the target.

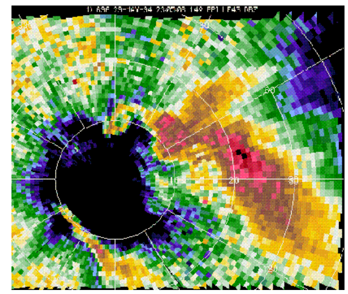

Figure 4: Dealiased tail-forward RHI velocity image at 2311 UTC on 29 May 1994 showing strong inbound velocities (green) over strong outbound velocities (tan) at location of EWH. Note only lower 8 km displayed.

During VORTEX (the Verification of the Origins of Rotation in Tornadoes EXperiment), back-and-forth aircraft patterns were flown on the inflow side of the storm targeted by the VORTEX Field Coordinator, Erik Rasmussen. The aircraft was flown in the lowest 300-2000 m above ground level (AGL) to optimize radar data collection in the region most likely to experience tornadogenesis. The turbulent ride along the boundary between warm moist inflow winds riding up over strong rain-cooled outflow was called "surfing the outflow" by the P-3 pilots. Usually this region was as close as we could come since the cloud boundary was just several hundred meters from the aircraft. The closest we flew to a tornado was on 29 May 1994. We were as close as 7 km to the F3 tornado (see Figure 1) which occurred in open country between Newcastle and Olney TX. Normally we tried to stay within 10 to 15 km of the storm center.

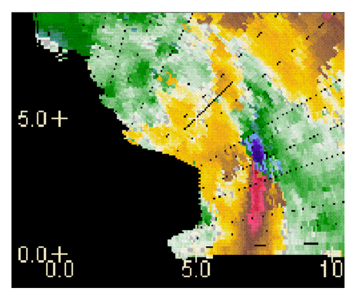

Figure 5: P-3 lower fuselage radar PPI image at 2305 UTC on 29 May 1994 showing tornadic hook.

The unique set of data that we were able to obtain from the air has provided a new set of challenges. With the tail radar's Nyquist velocity of +/- 13m/s, and expected radial velocities of 50 to 80 m/s, extensive clean-up of the radar data is required. NSSL scientists are working to analyze these data from the aircraft. They hope to find clues into the evolution of storms and the tornadoes they produce. ◆

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