Some Considerations for the Use of High-Resolution Mobile Radar Data in EF-Scale Assessments

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Introduction
Since 2011, graduate students and faculty at the University of Oklahoma have used RaPol (Pazmany et al. 2013) – a rapid-scan, polarimetric, mobile-radar – to collect data of tornadoes, supercells, and related phenomena in the central United States. On 31 May 2013, RaPol sampled a multiple-vortex tornado in El Reno, OK, with radial velocities ($V_r$) exceeding 135 m s$^{-1}$. Several of the observed subvortices moved at speeds of 75-80 m s$^{-1}$, limiting the duration of the extra strong winds were experienced at any one location. There is great uncertainty, however, regarding how the observed $V_r$ relates to a 3 second, ~10 m AGL wind speed standard such as that used in the Enhanced Fujita (EF) Scale. In addition, differential radial velocity ($V_d$), defined as the difference between the $V_r$ calculated using the H channel ($V_r^H$) and that calculated using the V channel ($V_r^V$), within several intense tornadoes is shown. Large $V_d$ tends to be associated with high $\sigma_v$ and low $\rho_v$, not surprising given the increased variance in the velocity estimates expected when those two conditions are observed. More details and discussion of these data can be found in Snyder and Bluestein (2014).

What does a $V_r$ observation represent?

The $V_r$ estimate at a given range gate represents the reflectivity-weighted average velocity of all scatterers within a radar resolution volume during a given integration period (i.e., dwell time) towards or away from the radar. How does this relate to a 3 s, 10 m AGL wind speed standard?

- $V_r$ estimate – Many pulsed Doppler weather radars use pulse-pair processing to calculate $V_r$, which often requires assumptions to be made about the shape of the power spectrum. The quality of the estimate is affected by factors such as the number and independence of samples used and the width of the power spectrum.
- Reflectivity-weighted average velocity – $V_r$ estimates are typically biased towards the largest and most abundant scatterers being sampled. Typically, in high acceleration flows such as tornades, the peak velocity of the more massive objects is likely to be less than the peak velocity of the wind.
- Within a radar resolution volume – The size of the volume illuminated by the antenna is affected by the distance from the radar, the transmitted pulse width, and the antenna's radiation pattern. An antenna with a 3 dB beamwidth of 1º has a cross-sectional width of ~87 m, ~260 m, and ~525 m at 5, 15, and 30 km ranges, respectively. It's highly likely that the peak velocity of scatterings being sampled exceeds the mean velocity owing to spatial averaging. In addition, owing to beam broadening, partial beam blockage, and potential multipath scattering, the illuminated radar volume is likely to be quite complex for elevation angles near 0º, making it extremely difficult to sample near the ground.
- During a given integration period – The data that are used to calculate commonly used radar quantities at each range gate are typically collected very quickly (i.e., dwell time per radial of ~0.005-0.05 s), so the calculated $V_r$ can be considered instantaneous velocities.

- Towards or away from the radar – Modeling and theory suggest that, within some tornadoes, the vertical component of the velocity may be similar to (or even exceed) the horizontal component. As such, minor deviations of elevation angle from true horizontal will result in an increasing contribution to the measured $V_r$ from the vertical velocity.

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