P2.10

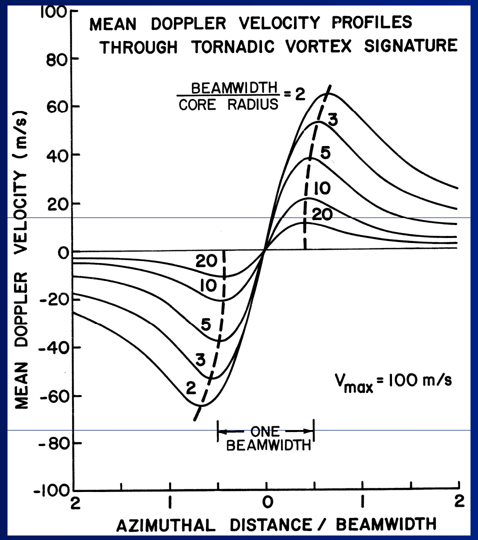
SIMULATED TORNADIC VORTEX AND REFLECTIVITY SIGNATURES OF NUMERICALLY MODELED TORNADOES HAVING WEAK ECHO HOLES

Vincent T. Wood and Rodger A. Brown, NOAA/National Severe Storms Laboratory, Norman, Oklahoma

Tornadic Vortex Signature (TVS)

- TVS – a degraded Doppler velocity shear signature – with peak Doppler velocity values about *one beamwidth* apart – that occurs when the core diameter of a tornado is smaller than the radar's beamwidth.

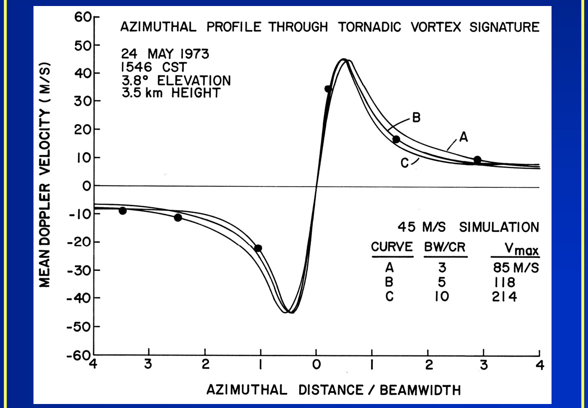
The TVS Simulation



- This figure shows that although the TVS associated with a given tornado decreases in magnitude as the radar beam becomes broader, the peak values of the TVS remain essentially the same distance apart – about one beamwidth apart for *uniform reflectivity* across an assumed Rankine tornado vortex.

AMS 35th Conference on Radar Meteorology
Pittsburgh, PA, 26-30 September 2011
Contact: Vincent.Wood@noaa.gov

Union City TVS

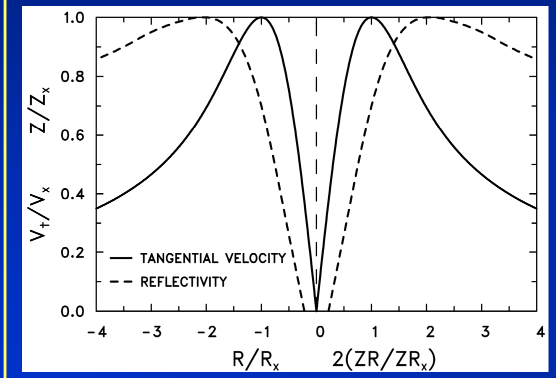


- To confirm that the TVS represents a tornado, a simulated radar scanned past Rankine vortices that were smaller than the radar beamwidth, assuming that reflectivity was *uniform* across the vortices.
- The above figure presents Doppler velocity measurements (dots) through the center of the Union City, OK tornado of 24 May 1973 using an NSSL research Doppler radar.
- Three theoretical TVS curves are produced by scanning the radar past three Rankine vortices having different sizes (ratio of beamwidth BW to core radius CR) and peak tangential velocities (V_{max}). Reflectivity across the vortices was assumed to be uniform.
- Doppler velocity data points nicely fit the simulated TVS curves that represent tornadoes having various sizes and strengths.
- The TVS strength does not reveal the strength or size of the tornado itself.

TVS in WSR-88D Velocity Data

- When a radar scans as it collects the number of pulses needed to compute the mean Doppler velocity, the radar beam is effectively widened, -- the widened beam is called "effective beamwidth" (EBW).
- For example, when a WSR-88D collects data at 1.0° azimuthal *legacy* intervals (ΔAZ = 1.0°), the beamwidth effectively increases from 0.9° to 1.4°.
- For 0.5° azimuthal *super-resolution* data collection, the EBW broadens to only 1.0°.
- With uniform reflectivity across the simulated tornado vortex, the TVS peak values are separated by about one EBW.
- For *legacy resolution* (with ΔAZ = 1.0° and EBW = 1.4°). TVS peak values therefore are expected to be separated by ΔAZ = 1.0°.
- For *super-resolution* (with ΔAZ = 0.5° and EBW = 1.0°). TVS peak values also are expected to be separated by ΔAZ = 1.0°.
- However, recent WSR-88D observations indicate that some *super-resolution* TVS peaks are separated by ΔAZ = 0.5° → WHY?
- To answer this question, we ran new Doppler radar simulations using a more realistic vortex model (instead of the Rankine model) and a more representative reflectivity distribution having a weak-reflectivity eye across the vortex.

Vortex and Reflectivity Models

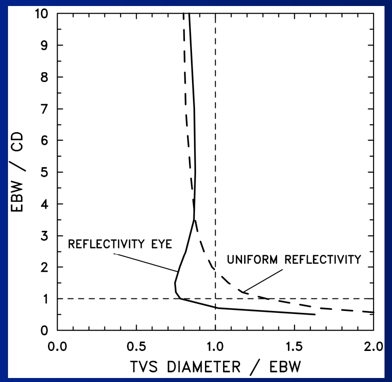


- The above figure is based on proximity mobile Doppler radar data:

  (a) the presence of a weak reflectivity eye at the center of the tornado, and

  (b) a radial profile of tangential velocity (V_t) that favorably resemble that of the Burgers-Rott vortex.
- The peak reflectivity (ZR_X) occurs at twice the core radius (R_X) at which the peak tangential velocity (V_X) occurs, indicative of the centrifuging of radar targets.

TVS with Weak-Reflectivity Eye and Uniform Reflectivity



- The most obvious differences in the TVS diameters between two different reflectivity profiles occur when the EBW is from 1.0 to approximately 2.5 times larger than the tornado's core diameter (see the above figure).
- In a uniform reflectivity region, TVS diameters are 0.9-1.3 times the EBW.
- For a reflectivity eye, TVS diameters are 0.7-0.8 times the EBW.
- Thus, with *super-resolution* data (EBW=1.0°, ΔAZ=0.5°), it is reasonable that Doppler velocity extremes would be either 0.5° or 1.0° apart.
- For *legacy resolution* data (EBW=1.4°, ΔAZ=1.0°), one would expect Doppler velocity extremes to be 1.0° or 2.0° apart.

Conclusions

- Doppler radar simulation results indicate that using 2 different reflectivity profiles in which the Burgers-Rott vortex is embedded, there is a significant difference in TVS diameter when the EBW is less than 2.5 times larger than the vortex's core diameter.
- With the presence of a reflectivity eye, it is possible for the distance between the peak Doppler velocity values to be separated by 0.5° for super-resolution data collection.
- However, when the EBW is greater than 2.5 times the core diameter, the peak values are expected to have an azimuthal separation of 1.0° for both legacy-resolution (one azimuthal increment) and super-resolution (two azimuthal increments) data collection.