OBSERVATIONS OF TORNADOGENESIS USING A MOBILE, PHASED-ARRAY, DOPPLER RADAR

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I. INTRODUCTION

Tornadoes and many severe convective storms evolve on very short time scales (~ 10 s), owing to very high horizontal wind speeds and vertical velocities. This paper documents the formation of a tornado in the U. S. with a mobile, rapidly scanning, Doppler radar. This radar, the MWR-05XP (Meteorological Weather Radar, 2005, X-band, Phased Array), electronically scans in elevation and azimuth over limited sectors, and mechanically in azimuth at high speed. While the radar scans electronically in elevation, the attitude of its beam is held nearly fixed in space because it electronically back scans in azimuth at the same rate as it mechanically scans. The half-power beamwidth is ~ 2^0 and the range resolution is 150 m.

II. PRESENTATION OF RESEARCH

In 2008 data were collected in several tornadic storms. The focus of this paper is on a tornado that formed in Kansas on 23 May. Data slightly oversampled in the vertical were collected when the tornado formed at range as close as ~ 16 km, from near the surface to 20^0 elevation angle (~6.5 km AGL). The update time for the volume scans was ~ 13 s over a ~ 50 min period, from ~ 15 min prior to tornadogenesis to well after the tornado had dissipated.

Edited Doppler velocity data shown in Figs. 14a – depict the entire life cycle of a cyclonically rotating tornado at low elevation angle, ~ 300 m AGL. Also seen in this storm and in another tornadic storm on the same day are nearby, intense, anticyclonic vortices, both of whose life cycles were captured. Analyses of these features are ongoing and some of the preliminary results will be shown at the conference. [More details on the data and the radar are found in Bluestein et al. (2010).] Owing to the strong attenuation by precipitation in the high-precipitation (HP) supercell parent storms, analyses of the cyclonic vortices are not possible at the highest elevation angles. For the anticyclonic vortices, there is less attenuation, so analyses of these vortices are possible up to higher altitudes.

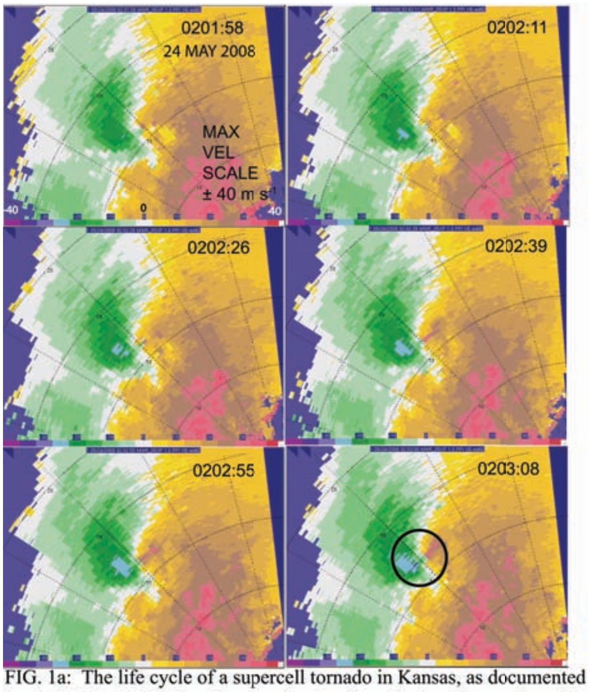

FIG. 1a: The life cycle of a supercell tornado in Kansas, as documented by the MWR-05XP. Doppler velocity ($m\ s^{-1}$) at 1° elevation angle on 23 May 2008 (24 May UTC). Range markers shown every 5 km. Circle highlights cyclonic vortex signatures at a selected time.

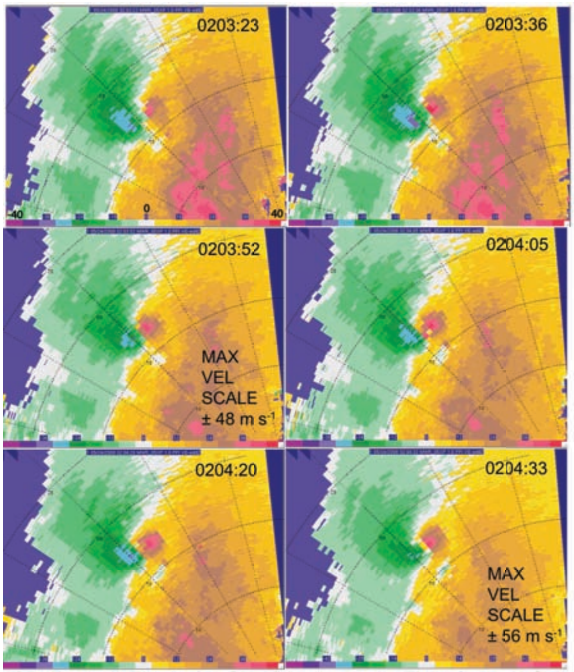

FIG. 1b: As in Fig. 1a, but for subsequent scans. The color scale for Doppler velocity ($m\ s^{-1}$) is changed while the isodop maximum exceeds the maximum allowed by the color scheme; when this is done, the new range is indicated at the lower-right hand side of the panel.

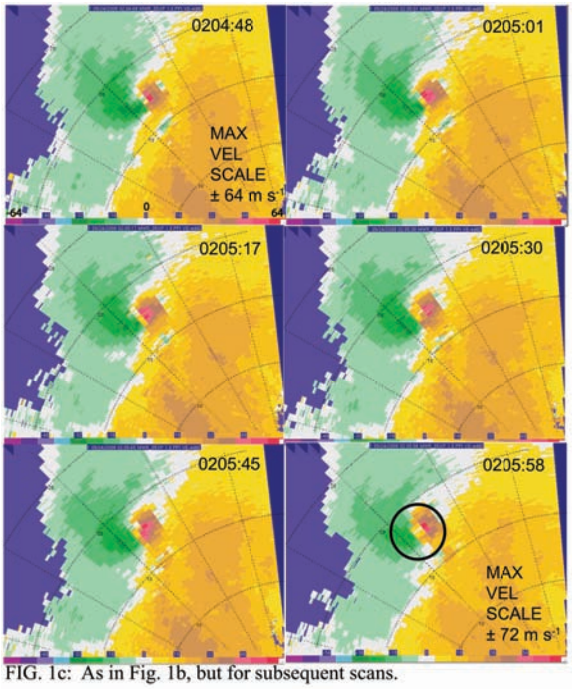

FIG. 1c: As in Fig. 1b, but for subsequent scans.

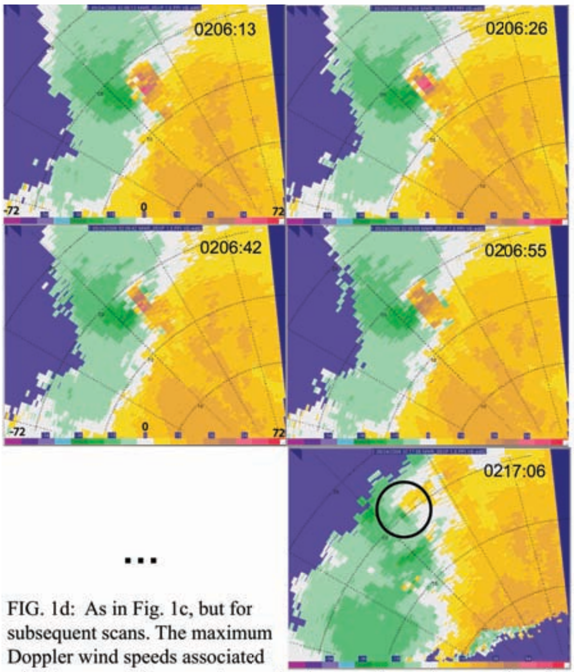

FIG. 1d: As in Fig. 1c, but for subsequent scans. The maximum Doppler wind speeds associated with the vortex signature that marks the tornado weaken steadily after 0206:55; data are not shown until 0217:06, when the maximum wind speeds are much weaker (ellipsis denotes panels that are not shown for the sake of brevity).

III. RESULTS AND CONCLUSIONS

The data shown in Figs. 1a – d show that there is excellent temporal continuity in the locations of the cyclonic vortex signature associated with the mesocyclone/tornado at low levels. In 2009, during VORTEX-2 (Verification of the Origins of Rotation in Tornadoes Experiment-2) in the Plains of the U. S., an excellent dataset was collected depicting the entire life cycle of a tornadic storm at close range (Figs. 2 and 3). Owing to the addition of frequency hopping in 2009, the update time was cut down to ~ 7 s for each volume scan (up to 20^0). As the tornado approached the radar, the vertical range of the sectors was increased. Some of these data will be shown at the conference if time permits.

FIG. 2: Photograph of a tornado being probed by the MWR-05XP in southeastern Wyoming during VORTEX-2 at 2218:46 UTC on 5 June 2009. Courtesy of Chad Baldi (ProSensing, Inc.).

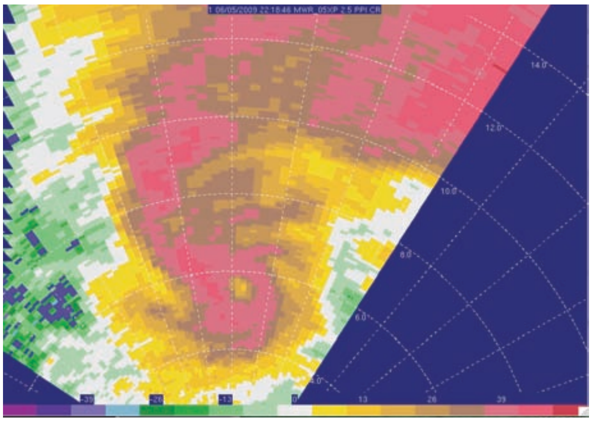

FIG. 3: Unedited radar reflectivity (dBZ) from the MWR-05XP at 2.5^0 elevation angle, of the parent supercell for the tornado seen in Fig. 2. Range markings shown every 2 km. Tornado was located at the weak-echo hole seen at 5.5 km range.

IV. ACKNOWLEDGMENTS

Chad Baldi (ProSensing) led the data collection and field operations. Bethany Seeger (ProSensing) did much of the data processing. Jana Houser (OU) contributed to the field efforts. Jeff Snyder (OU) and Mark Laufensweiler (OU) provided computer-related assistance. Paul Buczynski (NPS) also contributed to the project. This work was supported in part by NSF grant ATM-0637148 to OU and contracts to ProSensing from the Navy SBIR program at the Office of Naval Rsearch.

V. REFERENCES

Bluestein, H. B., M. M. French, I. Popstefanija, R. T. Bluth, and J. B. Knorr, 2010: A mobile, phased-array Doppler radar for the study of severe convective storms: The MWR-05XP. *Bull. Amer. Meteor. Soc.*, 91 (accepted subject to revisions).