15.3A TORNADO VISUALIZATION AND DOPPLER RADAR ANALYSIS PROJECT

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1. INTRODUCTION

Tornadoes play a significant role in the weather of the United States and the Tornado Visualization and Doppler Radar Analysis Project accumulated 10 years of field research on tornado events. The project documents tornado formation using 3D analysis utilizing the existing Doppler Radar data which is available in the field in near real time and can be used in post event analysis from the archived Doppler Radar data. Figure 1 shows a blend of Base Velocity and Rotation of the Joplin, MO EF-5 tornado from May 22, 2011 using GRAnalyst software and the Springfield, MO Doppler Radar data. Figures 2 and 3 are examples of blending the radar data images on the Joplin, MO Tornado.

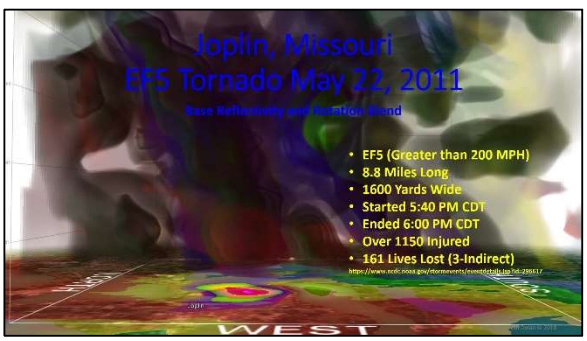

Fig 1 Base Velocity and Rotation Blend

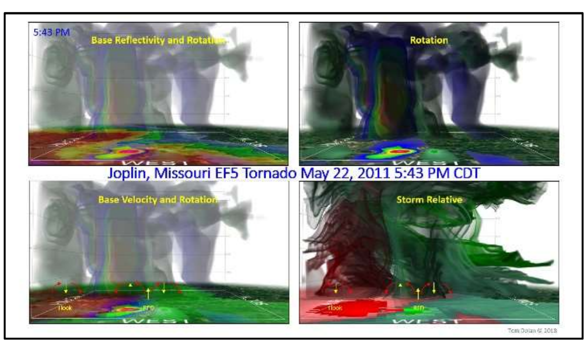

Fig 2 Joplin, Missouri EF-5 5:43 PM Blends

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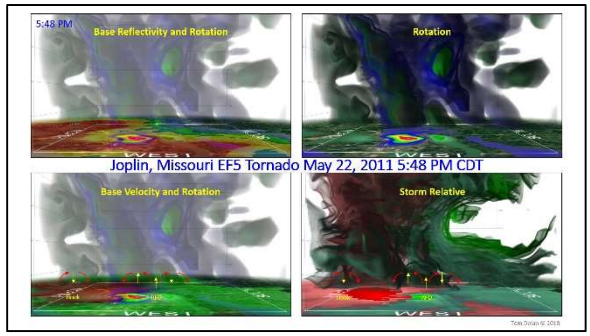

Fig 3 Joplin, Missouri EF-5 5:48 PM Blends

2. METHODS

The Doppler Radar data is filtered to allow for specific data images to be created of the Base Reflectivity, Base Velocity, Storm Relative and Normalized Rotation radar scans of a tornadic storm. Figures 4-8 represent examples of the filters applied using the Moore, OK May 20, 2013 EF-5 Tornado as the base image. These images are then used to blend to see the relationships they have with the other radar images during the specific tornado event time and this information is compared to ground damage observed, photos and videos taken and correlated to the Radar. These images can then put in sequence to better visualize the life cycle of the tornado and the images are put into to motion to see the tornado structure evolution.

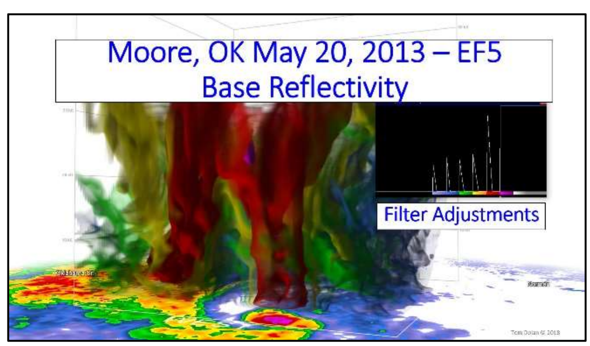

Fig 4 Base Reflectivity Filter Adjustments

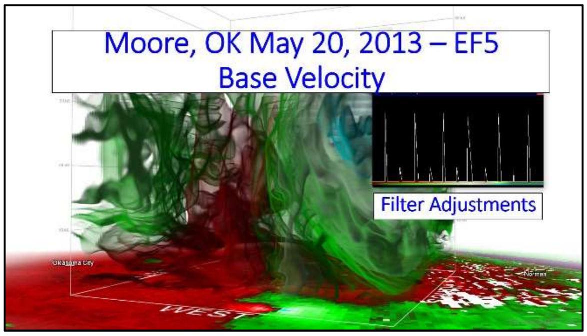

Fig 5 Base Velocity Filter Adjustments

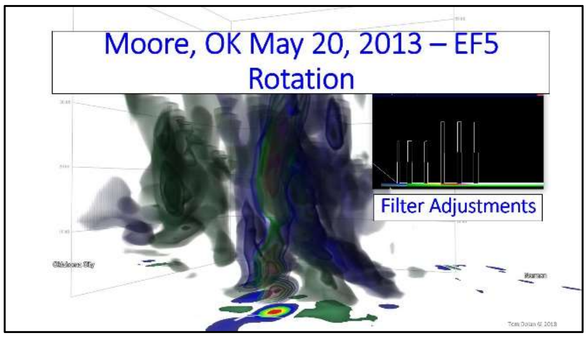

Fig 6 Rotation Filter Adjustments

Fig 7 Storm Relative Filter Adjustments

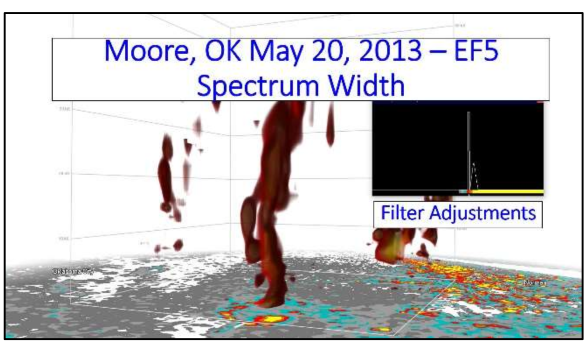

Fig 8 Spectrum Width Filter Adjustments

3. OBJECTIVES

This work assists in seeing where in the storm the tornado is developing as the wind flows are blocked by the developing and mature thunderstorm along with dissipation and cycling. The work from the Doppler Radar Analysis project assists in seeing the role wind flow blocking that develops in the Base Reflectivity plays in the tornado life cycle management. This field work complements the extensive efforts made by the weather research and operations community to better understand these significant tornado weather events. Figures 9-12 are from the Moore, OK May 3, 1999 F5 Tornado blending Rotation with Base Reflectivity. Matching the information can display the strong cyclonic tornado and the associated anti-cyclonic rotations adjacent.

Fig 9 Moore, OK May 3, 1999 F5 Tornado

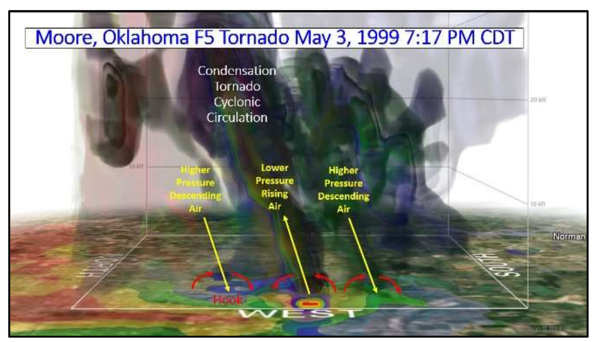

Fig 10 May 3, 1999 7:17 PM Rotation Blend

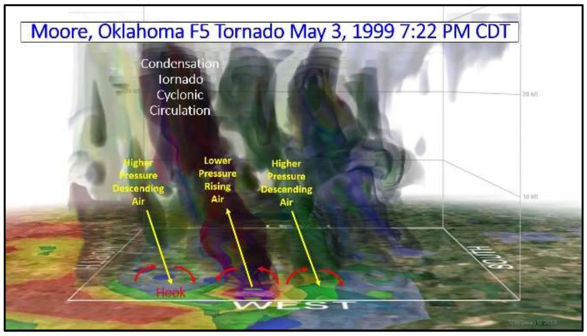

Fig 11 May 3, 1999 7:22 PM Rotation Blend

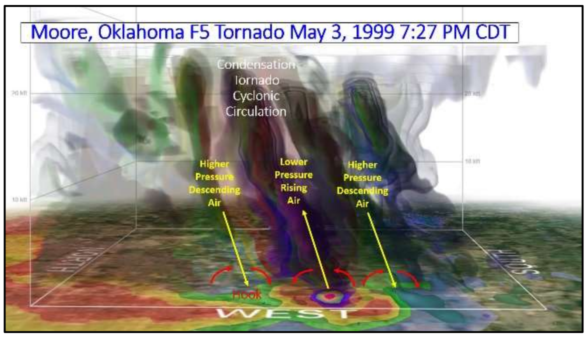

Fig 12 May 3, 1999 7:27 PM Rotation Blend

4. RESULTS

On May 25, 2016 26-mile EF-4 Tornado that was field observed from Niles, Kansas through Chapman, Kansas. Figure 13 is the tornado as it runs east just south of Interstate 70. The tornado intensifies rapidly when it formed and traveled east on its path directly towards the Topeka Doppler radar. This tornado was at an ideal distance between 40 and 70 Nautical miles from the radar which provides full volume scans that are work well for the 3D analysis work. Figure 14 is a comparison of the rotation with the different radar views. Figure 15 has the radar rotation image when the tornado was rated at EF-3 at this stage by the National Weather Service survey. With the flows going past the higher Base Reflectivity provides blocking as shown in the example in Figure 16. By 8:08 PM the tornado has now been on the ground for almost an hour. The tornado is shown in Figure 17 as it is moving to cross interstate 70 in Kansas west of Chapman, KS.

Fig 13 May 25, 2016 EF-4 Tornado

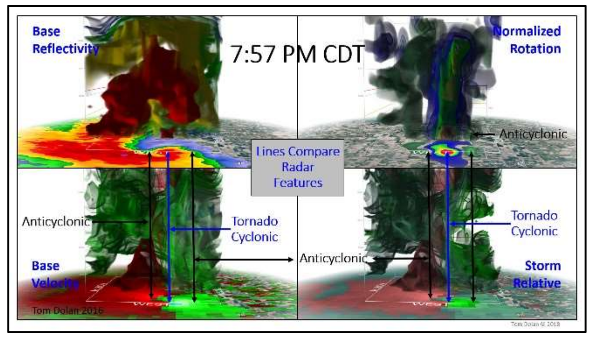

Fig 14 Rotation Compares

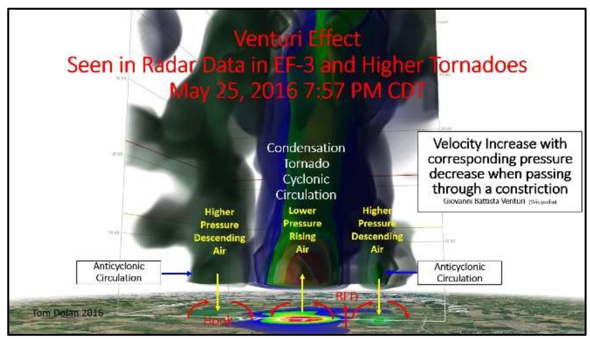

Fig 15 Niles-Chapman Tornado Circulation

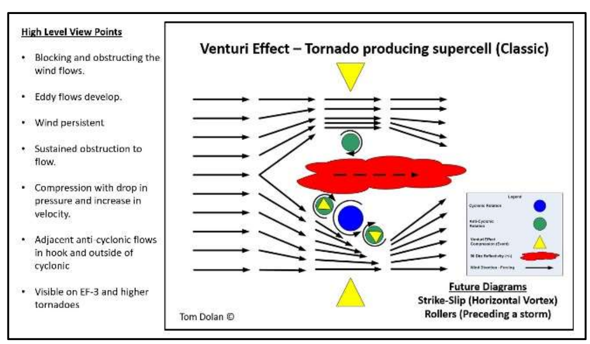

Fig 16 Venturi Effect Example

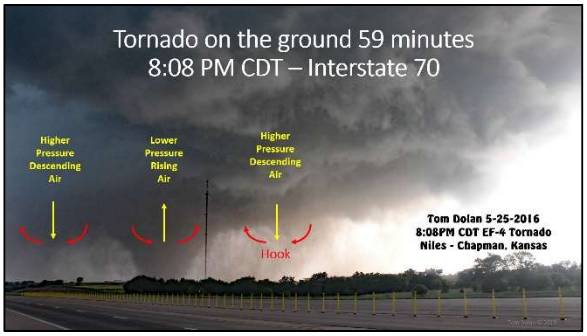

Fig 17 Niles-Chapman EF-4 Rotation

The radar comparison of the tornado at 8:09 PM in Figure 18 has arrows depicting the circulation locations as shown in Figure 17. Photos taken of the tornado as it is approaching and passing south of Chapman, KS are shown in Figure 19. These same photos are used to compare with the corresponding rotation in Figure 20. During these four volume scan intervals the tornado strengthens and then subsequently collapsed. Damage to trees was extensive and homes were extensive but fields were found undamaged in places as shown in Figures 21 and 22.

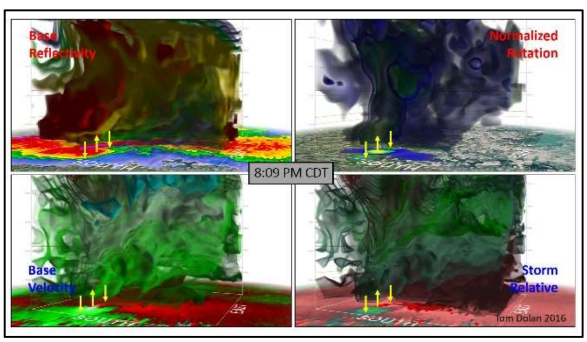

Fig 18 Radar Comparison of Rotation

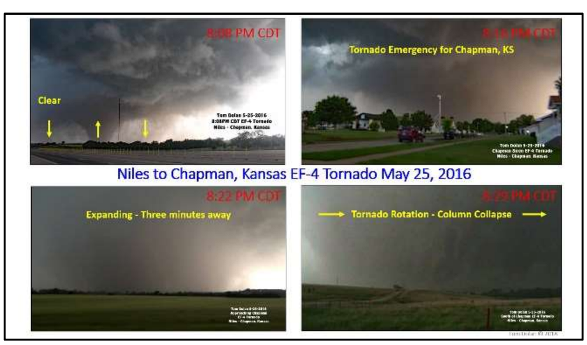

Fig 19 Niles-Chapman Tornado Photos

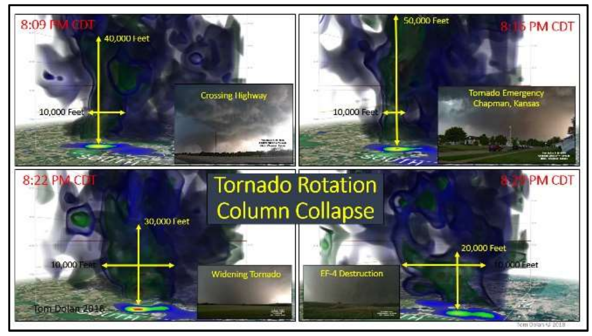

Fig 20 Rotation sequence with Column Collapse

Fig 21 Tornado Damage Indicators

Fig 22 Tornado Collapse Area

Damage photos taken following the tornado are used to compare with the 3D radar data and the observed tornado phases. The photos and Doppler radar data are assembled to demonstrate the life cycle morphology of this tornadic event from pre-initiation, intensification, and collapse.

Greensburg, KS was hit by an EF-5 on May 3, 2007. Figures 23-25 display volume scan images that start with a blend of Base Reflectivity and Rotation and then have images of Base Reflectivity, Rotation, and Base Velocity. These 3 Figures are as the EF-5 tornado is approaching, going through, and passing the town. A new rotation is commencing just to the east of town in Figure 25 which will become the next tornado in the sequence.

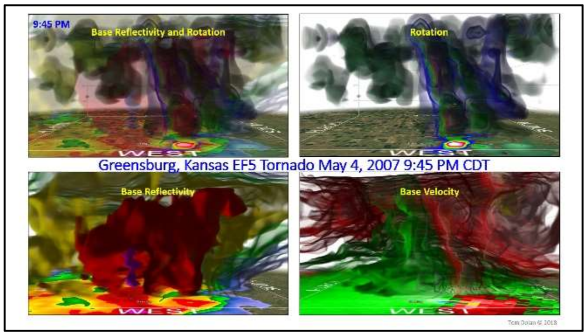

Fig 23 Greensburg EF-5 9:45 PM

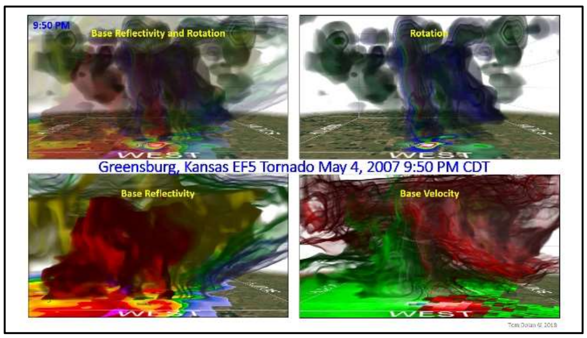

Fig 24 Greensburg EF-5 9:50 PM

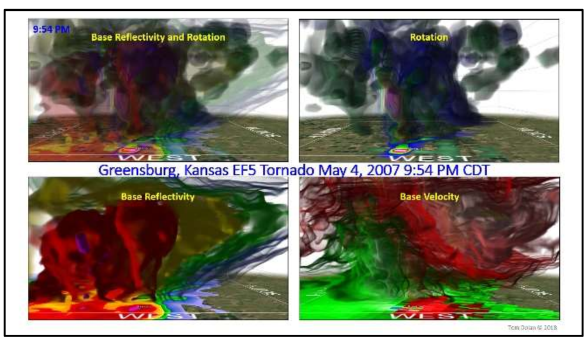

Fig 25 Greensburg EF-5 9:54 PM

El Reno, OK was hit by an EF-3 tornado on May 31, 2013. As the event was unfolding there was an 8-mile-long and 40,000-foot hail core that commenced to collapse over a few volume scans. The hail core can be seen in Figure 26. This event would be difficult to see in 2D radar and the tornado initially went south then south east before turning back north and rapidly strengthening as seen in Figure 27 to the point of creating a significant vortex hole as seen in the correlation coefficient data as well as velocity data absent in vortex other volume scans.

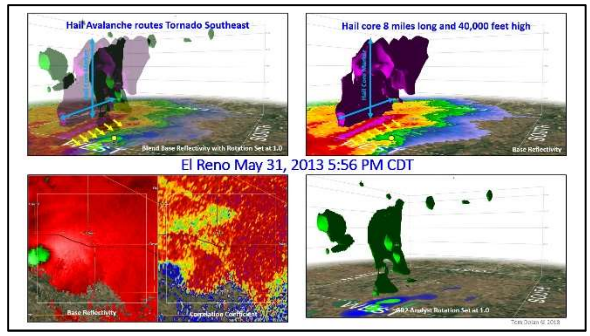

Fig 26 El Reno EF-5 Hail Core Collapses

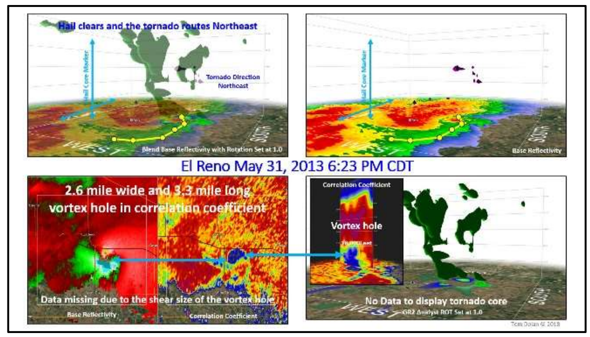

Fig 27 El Reno EF-5 Vortex Hole

5. CONCLUSIONS

The techniques used in this Doppler Radar Analysis as shown from the project example can be used to assist with monitoring tornadic thunderstorms for tornado development. Archive data allows for reconstruction of tornado events to better understand the tornado life. Obstruction of wind going past the blocking effect of higher Base Reflectivity such as 50 dBZ plays a role in tornado formation and cycling as it dissipates.

6. TOOLS AND DATA SOURCES

GR2Analyst by Gibson Ridge Software, FantaMorph by Abrosoft, Snagit by TechSmith, Weather Data feeds from Allisonhouse.com, NEXRAD archive data from ncdc.noaa.gov, Weather forecast and monitoring and tools from weather.gov and spc.noaa.gov. Photos and Images by Tom Dolan unless otherwise noted.

7. Research Participants

Tom Dolan – 2009 through 2018
Don Dolan – 2013 through 2018
Kathy Dolan – 2010 and 2011
Randy Ryan – 2009 and 2011
Matt Dolan – 2010
Bill Kirkpatrick and Jamie Allen – Single Storms