P5.18 STORM CHARACTERIZATION AND SHORT TERM FORECASTING USING A PHASED ARRAY RADAR

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1. INTRODUCTION

The National Weather Radar Testbed (NWRT) in Norman, Oklahoma is a multi-agency facility and partnership that began testing a US Navy Phased Array Radar (PAR) in 2003 for severe weather applications. The rapid scanning capability of the PAR provides a volume update rate of 58 seconds compared to a minimum of 240 seconds for the conventional WSR-88D radar (Klazura and Imy 1993). The PAR is also highly adaptable allowing for rapid volume scans of severe weather in a sector while concurrent full azimuth surveillance scans may be continued at a lower update rate. This rapid volume-scanning capability allows for characterization of the meso-gamma-scale (2-20 km, 3-30 min) evolution of storm structure (as indicated by reflectivity) and storm-scale dynamics (radial and perhaps cross beam velocities as new retrievals techniques emerge).

This high rate radar data can be interpreted by nowcasting tools such as TITAN (Thunderstorm Identification Tracking Analysis and Nowcasting, Dixon and Weiner 1993) to quantify storm characteristics (including trends in storm intensity and tracks), determine storm motion and produce very rapidly updating nowcasts (0-60 min forecasts) of storm location and evolution. In this study we explore the utility of combining the rapid scanning capability of the PAR and the TITAN nowcasting software to characterize the 3D evolution of an evolving squall line that propagated through central Oklahoma on 16-17 June 2005 causing significant hail and wind damage (Storm Prediction Center Report, NOAA).

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2. METHODOLOGY

Rapid scan reflectivity data from the PAR are analyzed using TITAN to determine the time and space evolution of the leading edge of a strong squall line that approached Norman from the NW as indicated in the two WSI images shown in Figure 1. The squall line (which was classified as a derecho by the Storm Prediction Center) cut a swath of hail and strong straight-line wind damage from SW Kansas to Central Oklahoma. Note that a derecho is defined as a widespread and long-lived windstorm (with winds > 57 mph) that is associated with a band of rapidly moving showers or thunderstorms often associated with bow echoes.

TITAN is used to analyze the rapid-scan PAR data to (a) generate statistics of the storm

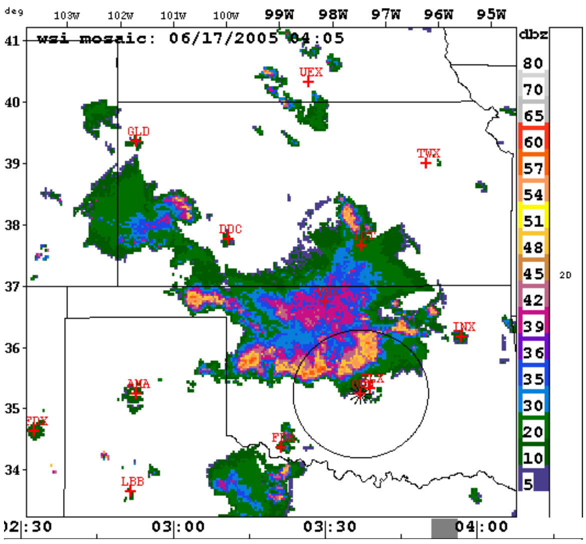

Fig. 1. Mosaic of WSR-88D radar data at 0355 UTC 17 June 2005 provided by WSI. The range ring indicates the maximum range of the PAR which was performing rapid volume scans in the NW quadrant during this event.

properties and their evolution; (b) track storm cells evident in the radar reflectivity and (c) produce forecasts of storm location and sizes. TITAN is also applied to the commercially available WSI radar mosaic produce from the national network of WSR-88D.

There are a number of parameters that can be adjusted both in data preprocessing and in the TITAN software itself. In this study TITAN was used to track the areas of PAR reflectivity exceeding 50 and 60 dBZ. A minimum area threshold of 50 km^2 was used as limiting criteria for defining a storm cell. The forecasts are evaluated by comparing the predicted and observed tracks of the storm centroids as they propagate across the domain. In addition, TITAN is used to determine the 3D evolution of the squall line as it approaches the NWRT. Results including tracking height of echo returns exceeding 30, 40, 50; trends in storm cell area – growth/decay; max intensity – increase/ decrease; evolution of hail shaft will be presented in detail in the poster.

3. PHASED ARRAY RADAR

The Phased array radar can complete a full volume scan in 58 sec. It also has the following features: (wavelength 9.38 cm, 500 kW peak power 1.57 micro-sec pulse rate). During this observational period the PAR was configured to have a range resolution of 60 m with maximum range of 140 km and 13 elevation angles. The resulting 3D mosaic has a horizontal resolution of 250 m and vertical resolution of 800 m with an update rate of 1 min (see Heinselman et al. 2006 for a more complete description of the PAR).

Figure 2 gives a plan-view and two cross sectional views of the full volume sector scan completed at 0357 UTC. At this time the squall line has a classic bow echo signature with multi-cellular convection along the leading edge (Figure 2a,b) of the squall line. These cells appear to be in a decaying stages while the cell depicted in the NW-SE cross section has the characteristic structure of a mature supercell with large hail indicated (dBZ > 65 dBZ) at the surface and aloft. Also note the consistent vertical structure of these cells afforded by the rapid scanning capability of the PAR. As will be demonstrated in the following section, the rapid scanning high resolution PAR data combined with TITAN to produce increased lead times in forecasting large hail.

4. TITAN ANALYSIS

TITAN is used for storm tracking and forecasting throughout the world (e.g., Fox et al. 2000; Megenhardt et al. 2000; Wang et al. 2005). It is an object based tracker, meaning that it detects storm objects using a set of criteria (e.g., reflectivity threshold, area threshold) and tracks these objects using pattern recognition software (e.g., shape, area, convex hull pattern, etc). In this study we use TITAN to detect and track varying scales of the storm ranging from the entire squall line (not shown) to individual storm cells and hail-producing supercells embedded in the squall line. This is done by adjusting the storm detection parameters (dBZ threshold and the minimum storm size area).

Using a dBZ threshold of 60 dBZ and a minimum storm area of 50 km^2, TITAN tracked to hail-producing cells embedded in the squall line, one of which appeared to be a supercell (Figure 2b).

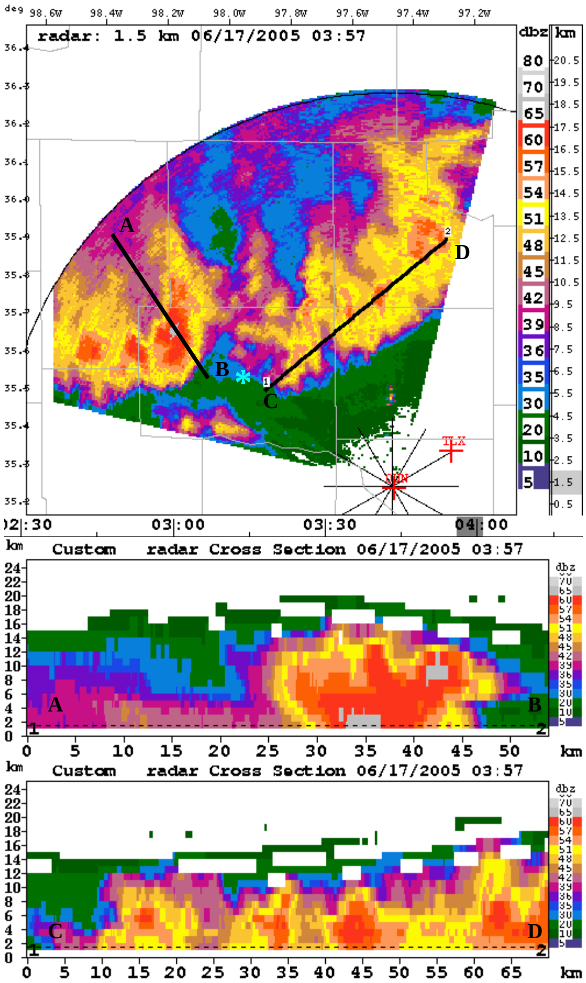

Fig. 2. Reflectivity data from the PAR in (a) plan-view at an altitude of 1.5 km and (b,c) cross sections (A-B,C-D) of the reflectivity data obtained with the PAR at 0357 UTC on 17 June 2005. The cyan asterisk in (a) denotes the location of 2.5 cm diameter hail observed at 0425 UTC in Canadian County, OK.

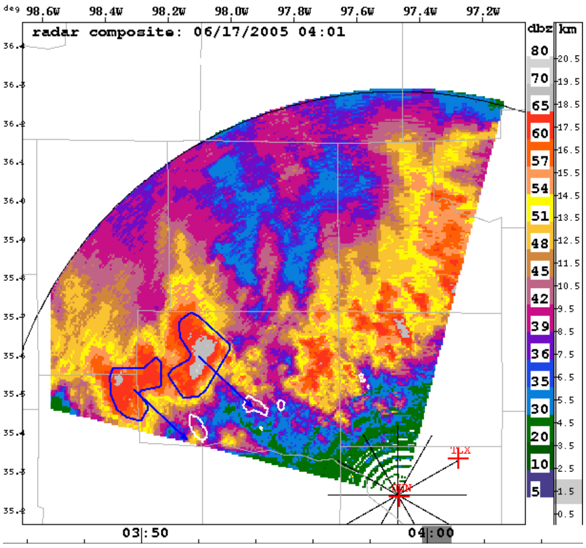

Fig. 3. Plan-view of the PAR radar at an elevation of 1.5 km. The blue polygons depict TITAN detections for a threshold reflectivity of 60 dBZ. The blue arrows indicate the 30 min forecast center positions and the white contours correspond with the verifying 60 dBZ locations at 0430 UTC.

The supercell has a large area of reflectivity exceeding 65 dBZ. This storm had a history of producing hail greater than 2.5 cm (Storm Prediction Center Reports). Figure 3 indicates the quality of the 30 min forecasts for the center of the hail shaft. These forecasts were made using the previous 5 min of storm history (which would not be possible using WSR-88D data) and could be updated as often as every 2 min. Thus, operational implementation of the PAR has the potential for improved warning lead times for severe weather.

TITAN also gives information on storm characteristics and trends (storm area and volume, top heights, storm intensity, etc). The characteristics of the squall line and embedded cells and their evolution will be presented in detail in the poster.

5. SUMMARY AND FUTURE WORK

The entire squall line, individual cells and hail shafts (> 60 dBZ) are tracked separately in three-dimensions across the PAR field of view using TITAN. The skill of TITAN nowcasts was very good, but decreased with decreasing storm scale as expected (Wilson 1987). Skill statistics such as POD, FAR, CSI will be given in the poster. Depending on the reflectivity threshold chosen, TITAN can be configured to track the entire squall line, individual cells, or even individual hail cores (Figure 3) and produce forecasts on each in a fraction of the time (~2-3 min vs 10 min) needed when using the slower-scanning WSR-88D radars. These more timely forecasts should increase the warning lead time for severe thunderstorms.

6. ACKNOWLEDGEMENTS

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