8B.7 OVERVIEW OF SPRING 2004 WDSS-II DEMONSTRATION AT WFO NORMAN

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1. INTRODUCTION

The National Severe Storms Laboratory (NSSL) regularly develops new techniques to help forecasters make better and faster severe weather warning decisions. These techniques, often in the form of new radar applications and multiple-platform products, are evaluated in "proof-of-concept" tests at National Weather Service Weather Forecast Offices (WFOs).

The primary software platform at the NSSL for product research and development is the Warning Decision Support System – Integrated Information (WDSS-II; Lakshmanan 2002). WDSS-II allows NSSL scientists to rapidly develop, test, and implement into real-time data streams experimental products and applications.

Two Linux display workstations running WDSS-II were provided to WFO Norman during spring 2004, allowing forecasters to access and interrogate output from many experimental applications, products, and platforms during warning operations. NSSL meteorologists assisted the forecasters with interpretation during most severe weather events. WFO forecasters were asked to provide feedback and suggestions regarding the experimental products and applications.

2. LLSD SHEAR DIAGNOSTIC AND ROTATION TRACK PRODUCTS

Linear least squares derivative (LLSD) azimuthal and radial shear calculations have been found to provide a more accurate calculation of true vortex strength (Elmore et al. 1994). In practice, this technique removes many single-radar dependencies, provides smooth fields of shear, and better identifies the strength and location of shear features (Smith et al. 2003).

LLSD shear fields can be accumulated over time, providing "rotation track" maps. In 2004, the raw LLSD output, along with two rotation track products, were provided in real time to WFO Norman forecasters. One rotation track product mapped the maximum calculated LLSD shear value in the lowest 2 km above radar level (ARL) during the past 2 hours, while the other product mapped the maximum shear in the lowest 2 km ARL over the past 6 hours. Production of rotation track maps is also possible over different layers, such as 2-6 km, and over different time intervals.

An example of the output from the LLSD fields is shown in Fig. 1. At 2257 UTC on 9 June 2004, a "mini-supercell" thunderstorm was producing a tornado near Chandler, Oklahoma. The LLSD azimuthal shear product estimated nearly 0.01 s^{-1} shear in the mesocyclone about 700 m ARL (Fig. 1a). Meanwhile, the rotation track map (Fig. 1b) indicated a recent upward trend in mesocyclone intensity and a general north-northeastward motion.

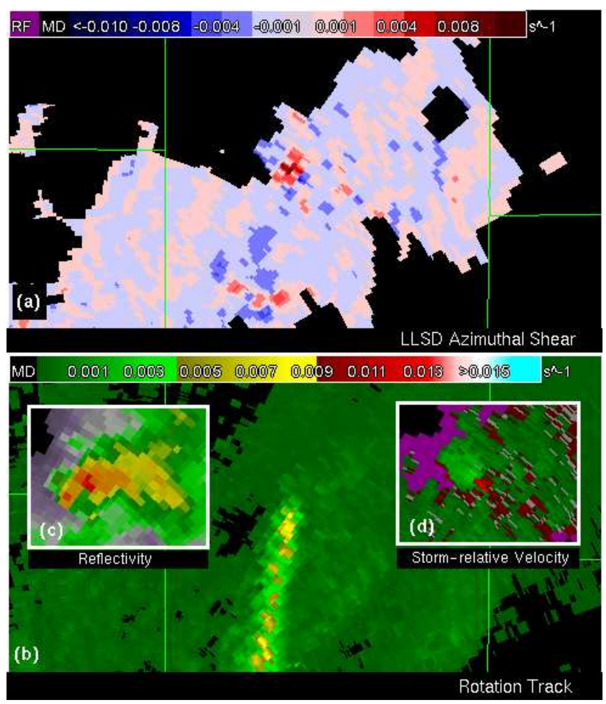

Figure 1. A tornadic "mini-supercell" thunderstorm observed by KTLX WSR-88D, 9 June 2004, 2257 UTC, at elevation angle 0.5 degrees (range 55 km and height 0.7 km above radar level near center of panels). **a)** Linear least squares derivative (LLSD) azimuthal shear. **b)** LLSD rotation tracks product. **c)** Reflectivity (same scale as panels a and b). **d)** Storm-relative velocity (same scale as panels a and b).

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When viewed in real-time, the rotation track maps can provide forecasters a quick summary of the changes in track and intensity of low-level mesocyclones, without the need to step back through multiple volume scans of velocity data over multiple elevation angles. At the end of a tornadic event, these maps are also frequently useful for storm damage surveys. WFO Norman used the rotation track maps to help identify several tornadoes from one supercell thunderstorm on 29-30 May 2004.

3. MULTIPLE-RADAR HAIL DIAGNOSTIC AND TRACK PRODUCTS

WDSS-II integrates reflectivity data onto a 3-dimensional grid from multiple radars, allowing the development of new hail diagnostic products. Single-radar algorithms derive 3-dimensional structures from a series of 2-dimensional detections at each individual elevation angle, at the end of each 4-6 minute volume scan. Prototype multiple-radar products from merged data combine 2-dimensional detections from all available radars to make 3-dimensional detections every 60 seconds (Stumpf et al. 2004a).

In addition to the more rapid update interval, the multiple-radar merger mitigates some range limitations associated with single-radar algorithm output. Storms near a radar are poorly sampled aloft due to the "cone-of-silence", and storms at long ranges are subject to lower sampling resolution and poor sampling at low altitude due to the "radar horizon". The merger of data from multiple radars can improve the vertical resolution of the data available to radar diagnostic applications (Zhang and Stumpf 2005).

Several multiple-radar hail diagnostic products (Stumpf et al. 2004b) were delivered to WFO Norman during spring 2004, including the maximum expected size of hail (MESH) product. Similar to the LLSD products, MESH grids may also be accumulated over time, helping forecasters more quickly identify storm trends. A "hail track" product was developed at NSSL and evaluated at WFO Norman for this purpose.

On 29-30 May 2004, a large, intense supercell produced a wide swath of significant hail across central Oklahoma. This swath was well-captured by the multiple-radar hail track product (Fig. 2). During real-time operations, this product can give forecasters a quick overview of how the hail swath is moving (showing both changes in direction and width) and changing in intensity. In addition, this product can assist in probing verification calls, helping the WFO staff "zero in" on spotters or towns likely to have been affected by large hail.

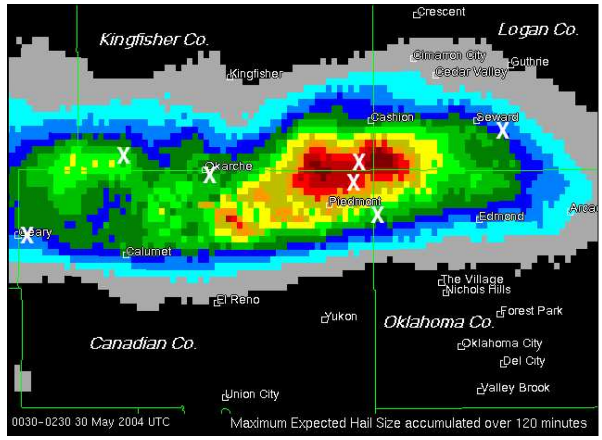

Figure 2. 120-minute multiple-radar accumulation of maximum expected hail size, from 0030 to 0230 UTC on 30 May 2004. Each "X" marks the location of a hail report during the time period.

4. NEAR-STORM ENVIRONMENT (NSE) AND OTHER APPLICATIONS

The use of "near-storm environment" (NSE) information can enhance the performance of radar algorithms by providing thermodynamic data with much higher temporal and spatial resolution than possible with rawinsonde data. NSE output is derived on an hourly basis from the output of the Rapid Update Cycle (RUC) model on a 20 km resolution grid.

NSE data can be used not only to improve the performance of hail diagnostic products, but can also be used to provide "intermediate" products to forecasters. One such product is the maximum reflectivity (from data provided by multiple radars) at the -20°C isotherm, where the height of the isotherm is determined from the NSE data. Through integration of RUC/NSE and data from multiple radars in WDSS-II, this field can be calculated and displayed automatically, much more quickly than a forecaster could interrogate the RUC data and reflectivity data from multiple elevation angles on multiple radars. Another example of an intermediate product provided to WFO Norman forecasters in 2004 is the maximum height of 50 dBZ echoes from the multiple-radar grid.

Fig. 3 shows an example of output from these new applications during the intense 29-30 May 2004 supercell. 50 dBZ echoes to over 16 km ARL (Fig. 3a) and 65 dBZ echoes extending as high as the -20°C isotherm (Fig. 3b) at 2317 UTC indicated the potential for signficant hail. Hail to the size of softballs was reported in the vicinity 8 minutes later. WFO Norman used these new applications during numerous events in 2004 to enhance their forecasts of maximum hail size potential.

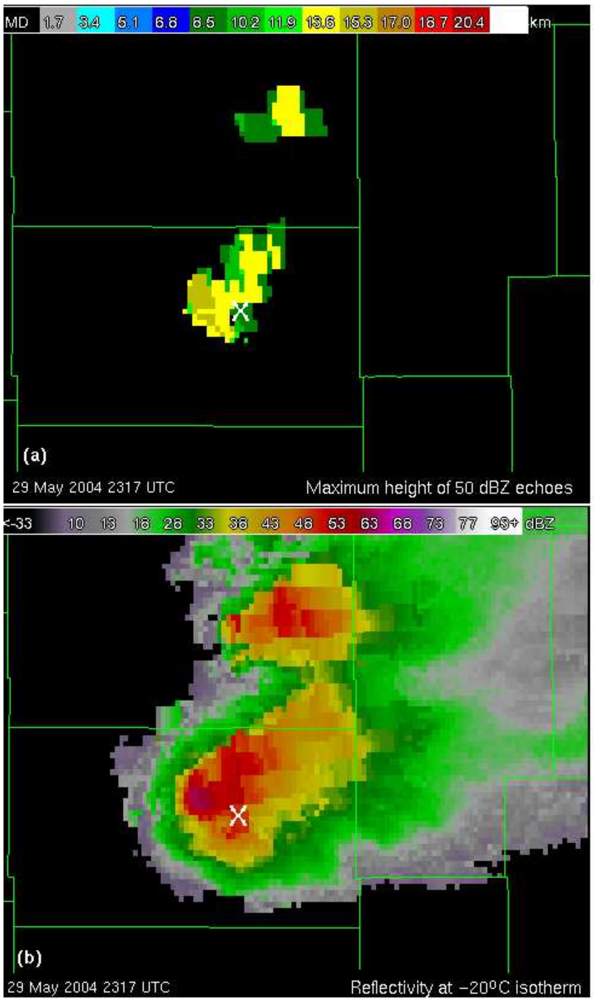

Figure 3. Multiple-radar **a)** Height of 50 dBZ echo top, and **b)** Reflectivity at the -20°C isotherm, 2317 UTC on 29 May 2004. The "X" marks the location of a report of hail more than 12 cm in diameter at 2325 UTC.

5. DISCUSSION AND CONCLUSIONS

Using WDSS-II to develop and display new applications, NSSL and WFO meteorologists worked together in the spring of 2004 to test and evaluate a number of new radar products and applications. All of these new products and applications were designed to help forecasters access data critical to making warning decisions more quickly and easily, helping them view combined data sets and radar data in a more compact format.

LLSD shear products, tracked over time, help forecasters quickly determine the changes in track and intensity of low-level mesocyclones. The MESH product, run on the merged reflectivity data from multiple radars, improves the spatial and temporal resolution of the MESH output available from single radars. In addition the LLSD rotation track and multiple-radar MESH hail tracks have been found to help in post-storm damage surveys and warning verification efforts.

Finally, "intermediate" products, many of which incorporate near-storm environment data from a numerical model, give forecasters quick access to other diagnostic tools, such as reflectivity values at environmental isotherms.

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