Performance and Optimization of the Dodge City, Kansas WSR-88D Build 10.0 Tornado Detection Algorithm

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1. Introduction

After analyzing and optimizing the Build 10 Tornado Detection Algorithm (TDA) for the Goodland, KS (KGLD) radar (Thede, 1999), an effort was made to perform a similar analysis to the Dodge City, Kansas WSR-88D (KDDC) to optimize the TDA there. The goal of this study was to independently derive a set of TDA adaptable parameters for the Dodge City, Kansas WSR-88D and compare those results with the Radar Operations Center (ROC), formerly the Operational Support Facility (OSF), default sets. This derived parameter set maximizes the number of correct detections and, at the same time, minimizes the number of false alarms. This goal was achieved by evaluating algorithm performance on a large database of 54 confirmed tornadic events within the 230 km range of the TDA algorithm. Archive level II base data from the KDDC WSR-88D radar was processed using WATADS (WSR-88D Algorithm Testing and Display System) version 10.2 software. WATADS is a UNIX-based software tool that allows researchers to view recorded WSR-88D radar data (archived level II) and to test baseline WSR-88D and enhanced National Severe Storms Laboratory (NSSL) radar severe weather algorithms (WATADS, 1998).

As part of the WSR-88D Build 10 software release, the ROC authorized WSR-88D sites to modify several adaptable parameter sets which specify TDA processing characteristics. The ROC developed adaptable parameter sets for isolated supercells, squall lines, and combined supercell/squall line situations (the default set). An additional parameter set (minimized) allows the Build 10 TDA to perform similar to the Build 9 Tornado Vortex Signature (TVS) algorithm which often confirmed tornadic events that were already occurring (OSF, 1998). Adaptable parameter sets are defined by specific combinations of the following four algorithm parameters: minimum reflectivity threshold (dBZ), 3D feature depth (depth), minimum 3D feature low-level delta velocity (ladv), and minimum TVS delta velocity anywhere in a 3D feature (mxdv). Table 1 shows the ROC default adaptable parameter sets.

Table 1. OSF adaptable parameter sets.

	reflectivity(dBZ)	depth(km)	ladv(m s^{-1})	mxdv(m s^{-1})
default	**0**	**1.5**	**25**	**36**
squall line	**0**	**1.6**	**27**	**27**
supercell	**0**	**3.1**	**27**	**30**
minimized	**0**	**5.0**	**56**	**74**

2. Methodology

Fifty four tornadoes that occurred within the WFO Dodge City radar range (230 km) from 1995 to 1999 were examined using the KDDC radar. The KDDC radar range includes a large portion of western Kansas, southeast Colorado, the panhandle of Oklahoma, and northern Texas.

For the TDA analysis, algorithm performance was evaluated for each case (some containing multiple tornadic events) using WATADS software. The Witt (1998) time window scoring method was used: each tornadic time window included 20 minutes or four volume scans before the first reported tornado event, all volume scans while the tornado was on the ground, and one volume scan after the tornado dissipated. Hits (TVS icon associated with the tornadic cell) and misses were counted within the time window. False alarms were defined as any TVS detections not associated with a tornadic cell within the time window. Three indices were used to score the algorithm performance: Critical Success Index (CSI), Probability of Detection (POD), and False Alarm Rate (FAR)[Doswell et al. 1990].

The adaptable parameter sets listed in Table 1 were tested on the Dodge City tornadic data sets. To establish the optimized parameter set for Dodge City, various combinations of depth, ladv, and mxdv were tested. The minimum reflectivity threshold was set at zero. The minimum 3D feature depth (depth) was allowed to vary from 1.0 km to 5.0 km. The minimum 3D feature low-level delta velocity (ladv) was allowed to vary from 26 m s^{-1} to 56 m s^{-1}. The minimum TVS delta velocity anywhere within the 3D circulation (mxdv) was allowed to vary from 34 m s^{-1} to 74 m s^{-1}. All told, 100 different combinations were evaluated, not including the four ROC approved parameter sets.

3. Results

Table 2a shows TDA performance statistics (POD, FAR, CSI) for the ROC approved TDA parameter sets from 54 tornadoes.

Table 2a. POD, CSI, and FAR for various ROC approved TDA parameter sets from 54 tornadoes studied.

	reflectivity(dBZ)	depth(km)	ladv(m s^{-1})	mxdv(m s^{-1})	POD	FAR	CSI
default	**0**	**1.5**	**25**	**36**	**.385**	**.790**	**.157**
squall line	**0**	**1.6**	**27**	**27**	**.431**	**.800**	**.158**
supercell	**0**	**3.1**	**27**	**30**	**.407**	**.786**	**.163**
minimized	**0**	**5.0**	**56**	**74**	**.038**	**.659**	**.035**

Table 2b shows the top five optimized parameter sets (ranked by CSI) including the ROC approved parameters.

Table 2b. CSI for the top five optimized parameter sets including the ROC approved parameters.

	reflectivity(dBZ)	depth(km)	ladv(m s^{-1})	mxdv(m s^{-1})	POD	FAR	CSI
optimized 1	**0**	**2.0**	**46**	**34**	**.356**	**.757**	**.169**
optimized 2a	**0**	**2.0**	**56**	**34**	**.356**	**.758**	**.168**
optimized 2b	**0**	**1.0**	**46**	**34**	**.356**	**.758**	**.168**
optimized 4	**0**	**1.0**	**56**	**34**	**.356**	**.760**	**.168**
optimized 5	**0**	**1.0**	**36**	**34**	**.353**	**.759**	**.167**

Table 2c shows the top five optimized parameter sets (ranked by POD) including the ROC approved parameters.

Table 2c. POD for the top five optimized parameter sets including the ROC approved parameters.

	reflectivity(dBZ)	depth(km)	ladv(m s^{-1})	mxdv(m s^{-1})	POD	FAR	CSI
squall line	**0**	**1.6**	**27**	**27**	**.431**	**.800**	**.158**
supercell	**0**	**3.1**	**27**	**30**	**.407**	**.786**	**.163**
adaptable set 1	**0**	**1.0**	**26**	**34**	**.391**	**.788**	**.159**
adaptable set 2	**0**	**2.0**	**26**	**34**	**.391**	**.786**	**.161**
adaptable set 3	**0**	**2.0**	**26**	**34**	**.388**	**.786**	**.160**

4. Conclusion

These results demonstrate that selecting the best algorithm performance is not straightforward. The parameter set which optimized performance for the 54 tornadic cases based on CSI was the Optimized-1 parameter set. Interestingly, this data set produced a higher CSI by .006 and a lower FAR (.043) compared with the OSF approved supercell set. However, if only the POD is considered, the supercell parameter set had a .075 improvement over the Optimized-1 parameter set.

This study, which included nearly every archived tornado from 1995 to 1999 within the Dodge City, KS KDDC-88D 230 km range of detection, builds upon ROC's approved parameter set with additional parameter sets listed in Table 2b. Note that this data set will be run through the NSSL's recently released "Tornado Ground Truth Project" (http://www.nssl.noaa.gov/truth). Benefits of using the Tornado Ground Truth Project include: the use of software used by NSSL researchers to evaluate algorithm performance; developing local data sets for individual county warning areas; developing local adaptable parameter sets to tune algorithms for specific WSR-88D's; and, participating in the development of a nationwide repository at NSSL to aid researchers in understanding nationwide, regional, seasonal, and storm-type climatologies of severe storms and algorithm performance. The results will also assist in fulfilling the goals described in the 2000-2005 National Weather Service Strategic Plan (NWS,1999) of reducing the national average tornado warning false alarm rate from 0.80 (1998) to 0.40 or lower and increasing the probability of detection from 0.64 (1998) to 0.80 or higher and improving the lead times from 11 minutes (1998) to 15 minutes (2005).

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