17.4 SHOULD GEOGRAPHIC REGION OR NEAR-STORM ENVIRONMENT DICTATE WSR-88D ALGORITHM ADAPTABLE PARAMETER SETTINGS?

Robert R. Lee*[1], Gregory J. Stumpf [2,3], and Phillip L. Spencer[2,3]

[1] NEXRAD Operational Support Facility, Norman, Oklahoma
[2] National Severe Storms Laboratory, Norman, Oklahoma
[3] Cooperative Institute for Mesoscale Meteorology Studies, Norman, Oklahoma

1. **THE FIRST APPROXIMATION**

The Weather Surveillance Radar - 1988, Doppler (WSR-88D) severe storm detection algorithms were designed in the late 1970's to early 1980's with the ability to be fine tuned for different geographic areas, climate regimes, and weather phenomena. For example, algorithm developers designed the mesocyclone algorithm with adjustable parameters to specify size, shape, momentum, and shear of atmospheric circulations to be detected.

After the WSR-88D network was installed, field reports and other investigations led algorithm developers to believe default algorithm adaptable parameter values were too strict for optimal performance in severe weather events such as bow echos, comma heads, gust fronts, squall lines, and mini-supercells (Burgess *et al.* 1995, Grant and Prentice 1996). Vandersip and Koch (1998) showed mean values of depth, diameter, and rotational velocity, of Great Plains supercells were significantly larger, at a 1% significance level, than southeast United States supercells.

Original WSR-88D algorithms were calibrated for the Great Plains and research has shown severe storm characteristics varies between the Great Plains and southeast United States, therefore algorithms have been adapted to different regions. Lee (1997), Lee and White (1998), and Tipton *et al.* (1998) document efforts to analyze Level II data collected from various sites around the country and calculate Mesocyclone and Tornado Vortex Signature Algorithm (MTA) performance using different adaptable parameter combinations. Lowering values of several algorithm adaptable parameters caused MTA to identify more tornadoes at non-Great Plains locations by recognizing smaller two-dimensional features and detecting circulations containing smaller shear values. In 1995 and 1996 the NEXRAD Operational Support Facility (OSF) authorized forecasters to lower several MTA adaptable parameters from their default values under the unit radar committee (URC) level of change authority (*Federal Meteorological Handbook* No. 11, Part A 1991).

Forecasters were encouraged to optimize algorithm performance for their specific regions using the WSR-88D Algorithm Testing and Display System (WATADS), a WSR-88D emulation software package (McKibben 1996). The results of optimizing algorithm performance were lower MTA adaptable parameter values and additional detections of non tornadic circulations.

Past efforts to adapt radar algorithms to local conditions were directed to climate and weather regimes, not near storm environments. The WSR-88D velocity dealiasing algorithm requires environmental data in the form of a vertical wind profile. The WSR-88D build 9 Hail Detection Algorithm (HDA) requires as input the height of the 0°C and -20°C isotherms. There are at least three problems associated with radar algorithms that require local environmental data. First, there is no automated source for such data in the current WSR-88D. Forecasters must manually supply and constantly update environmental variables while many other duties demand their attention especially during severe weather events. Second, programmers have to assume one set of manually entered environmental data is equally appropriate over the entire radar coverage area. Third, the source for current environmental data is typically rawinsonde data which only has a resolution of 12 h and 300 km.

2. **A BETTER WAY**

2.1 *Description of the Near Storm Environment Algorithm*

Large, Great Plains-like storms have been observed in the southeast United States and small mini-supercell storms have been observed in the Great Plains. Are physical characteristics of severe thunderstorms controlled by geographic region or meteorological environment? Ultimately, the near storm environment (NSE) dictates the physical characteristics (horizontal and vertical size, shear, updraft strength, precipitation production) of a storm (Galway 1956, Miller 1967, Davies-Jones *et al.* 1990, Johns and Doswell 1992, Davies 1993, Johns *et al.* 1993, Droegemeier *et al.* 1993, Brooks *et al.* 1993, Brooks *et al.* 1994a, Brooks *et al.* 1994b, Stensrud et al. 1996).

Presently, algorithm developers are attempting to identify differences in the NSE which helps define regional differences. If the NSE dictates a Great Plains environment, then a Great Plains-like hail storm can occur anywhere. There is no such thing as a “typical” East Coast type hail storm for which algorithms should be tuned.

In the future, NSE data will be available from the Advanced Weather Interactive Processing System

---

* *Corresponding author address:* Robert R. Lee, NEXRAD Operational Support Facility, 1200 Westheimer Drive Norman, OK 73069; e-mail: rlee@osf.noaa.gov

(AWIPS). Today, developmental algorithms in the National Severe Storms Laboratory (NSSL) Warning Decision Support System (WDSS) (Johnson *et al*. 1996, Johnson *et al.* 1998) use NSE data.

Forecasters do not have time or sufficient data manually to assign environmental variables to every storm cell observed by the radar; therefore, NSSL scientists developed an NSE algorithm to accomplish this task using the WDSS. Rapid Update Cycle (RUC-2) model (Benjamin *et al.* 1998) grid files containing wind, temperature, moisture, and pressure information are obtained hourly. From these, stability, shear, and other variables, some of which are listed in Table 1, are computed at NSSL in real-time for regions surrounding the 11 sites which currently operate a WDSS system. Files containing NSE variables are transferred hourly via file transfer protocol (ftp) to each WDSS site. Software within each WDSS system finds the RUC-2 gridpoint (40 km resolution) nearest each storm cell identification and tracking algorithm identified cell, and the NSE variables at that particular gridpoint are associated with the cell.

The NSE algorithm provides the following advantages: 1) automation for assigning NSE variables to storm cells; 2) timely updates; and, 3) high spacial resolution to assign different NSE variables to different storms (important when two or more different air masses are within range of a single radar).

2.2 *Applying the Near Storm Environment Algorithm*

Only three algorithms in the current version of WDSS use NSE variables. HDA uses RUC-2 information to determine the heights of the 0°C and -20°C isotherms. The Mesocyclone Detection Algorithm (MDA) uses the estimated storm motion as a first guess mesocyclone motion in its tracking function. The MDA also uses NSE information to determine maximum storm top height (maximum parcel level) for calculating storm-relative depths in a scheme to classify low topped mesocyclones. Several NSE variables will also be tested in the Damaging Downburst Prediction Algorithm (DDPDA), currently under development.

Research, referenced in section 2.1, suggests forecasters and radar algorithms can use information gained from the use of NSE variables, listed in Table 1, to assess the likelihood that an environment can support severe storms. In the future, NSSL scientists will be attempting to use NSE variables, from operational numerical model output, to improve storm severity predictions in radar algorithms. The NSE algorithm will generate environmental variables which will be associated with radar detected storm cells and vortices. Rule bases and neural networks will be developed to assess storm severity using algorithm detections and NSE variables.

3. SUMMARY AND CONCLUSIONS

Soon after the WSR-88D network was installed, algorithm performance was optimized based on the theory that different geographic regions have storms with different characteristics (depth, diameter, rotational velocity, updraft speed, etc.) Vandersip and Koch (1988) showed this is true at a 1% significance level when comparing Great Plains supercells to smaller scale storms typical of the southeast United States; however, optimizing radar algorithm performance based on geographic region does not account for events during which the environment supports storm scale processes atypical of that geographic region. *At this time, the authors propose the NSE dictates differences in regional storm climatology, and radar algorithms should use NSE data to help forecasters detect and diagnose severe storms.*

In the near future, NSSL scientists will be testing NSE variables listed in Table 1 to see if research results referenced in section 2.1 can be used operationally to improve radar algorithm assessments of storm severity. Environmental variables will be used in future radar algorithms to improve predictions of hail size and amount, damaging downburst winds, detection and diagnosis of atmospheric vortices, and many other severe weather hazards. Results, including examples, will be available at the time of the conference and at the following Web site:

http://www.nssl.noaa.gov/swat/sevcon98_nse.html.

4. ACKNOWLEDGMENT

The authors thank Andy White and Mike Eilts for reviewing the manuscript.

5. REFERENCES

Benjamin, S.G., J.M. Brown, K.J. Brundage, B. Schwartz, T. Smirnova, and T.L. Smith, 1998: The operational RUC-2. Preprints, *16th Conf. on Weather Analysis and Forecasting*, Phoenix, Amer. Meteor. Soc., 249-252.

Brooks, H.E., C.A. Doswell III, and R. Davies-Jones, 1993: Environmental helicity and the maintenance and evolution of low-level mesocyclones. *The Tornado: Its Structure, Dynamics, Prediction and Hazards, Geophys. Monogr.*, C. Church, Ed., No. 79. Amer. Geophys. Union, 97-104.

———, C.A. Doswell III, and J. Cooper, 1994a: On the environments of tornadic and nontornadic mesocyclones. *Wea. Forecasting*, **9**, 606-618.

———, C.A. Doswell III, and R.B. Wilhelmson, 1994b: The role of midtropospheric winds in the evolution and maintenance of low-level mesocyclones. *Mon. Wea. Rev.*, **122**, 126-136.

Burgess, D. W., R.R. Lee, S.S. Parker, D.L. Floyd, D.L. Andra Jr. 1995: A study of mini supercells observed by WSR-88D radars. Preprints, *27th Conf. on Radar Meteorology*, Vale, Amer. Meteor.

Soc., 4-6.

Davies, J.M., 1993: Hourly helicity, instability, and EHI in forecasting supercell tornadoes. Preprints, *17th Conf. on Severe Local Storms*, Chicago, Amer. Meteor. Soc., 107-111.

Davies-Jones, R., D. Burgess, and M. Foster, 1990: Test of helicity as a tornado forecast parameter. Preprints, *16th Conf. on Severe Local Storms*, Kananaskis Park, Alberta, Canada, Amer. Meteor. Soc., 588-592.

Droegemeier, K.K., S.M. Lazarus, and R. Davies-Jones, 1993: The influence of helicity on numerically simulated convective storms. *Mon. Wea. Rev.*, 121, 2005-2029.

Federal Meteorological Handbook, No. 11 (Interim Version One), 1991a: *Doppler Radar Meteorological Observations*. Part A, System concepts, responsibilities, and procedures. FCM-H11A-1991, Office of the Federal Coordinator for Meteorological Services and Supporting Research, Rockville, Maryland, 58 pp.

Galway, J.G., 1956: The lifted index as a predictor of latent instability. *Bull. Amer. Meteor. Soc.*, *37*, 528-529.

Grant, B., R. Prentice, 1996: Mesocyclone characteristics of mini-supercell thunderstorms. Preprints, *15th Conference on Weather and Forecasting*, Norfolk, Amer. Meteor. Soc., 362-365.

Johns, R.H and C.A. Doswell III, 1992: Severe local storms forecasting. *Wea. Forecasting*, **7**, 588-612.

———, J.M. Davies, and P.W. Leftwich, 1993: Some wind and instability parameters associated with strong and violent tornadoes, 2. Variations in the combinations of wind and instability parameters. *The Tornado: Its Structure, Dynamics, Prediction and Hazards, Geophys. Monogr.*, C. Church, Ed., No. 79. Amer. Geophys. Union, 583-590.

Johnson, J.T., M.D. Eilts, and L.P. Rothfusz, 1996: weather information display, analysis and product generation tools used for support of the 1996 Summer Olympic Games: warning tools. Preprints, 12th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, Atlanta, Amer. Meteor. Soc., 17-21.

———, K. Hondl, M.D. Eilts, M. Benner, J.W. Conway, V. Farmer, V. Ganti, M. Jain, Z. Jing, A. Jones, V. Lakshmanan, M. Lehman, R.J. Lynn, P.L McKeen, E.D. Mitchell, R. Rabin, T.M. Smith, P.L. Spencer, G.J. Stumpf, K. Thomas, M. Wee, A.Witt, A. Wyatt, D.S. Zaras, 1998: Warning decision support system: the next generation. Preprints, 14th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, Phoenix, Amer. Meteor. Soc., J25-J28.

Lee, R. R., 1997: Regional adaptation of NEXRAD mesocyclone and TVS algorithms. Preprints 28 Intl. Conf. On Radar Meteorology, Austin, Amer. Meteor. Soc., 347-348.

———, and A. White, 1998: Improvement of the WSR-88D mesocyclone algorithm, *Wea. Forecasting*, In press.

McKibben, Loretta, 1996: WATADS (WSR-88D Algorithm testing and display system) reference guide for version 8.0. [Available from Storm Scale Research and Applications Division, National Severe Storms Laboratory, 1313 Halley Circle Norman, OK 73069.]

Miller, Robert C., 1967: Notes on analysis and severe-storm forecasting procedures of the military weather warning center. Tech. Rep 200, AWS (MAC), USAF, 139 pp.

Stensrud, D.J., J.V. Cortinas Jr., and H.E. Brooks, 1997: Discriminating between tornadic and nontornadic thunderstorms using mesoscale model output. *Wea. Forecasting*, **12**, 613-632.

Tipton, G. A, E. D. Howieson, J. M. Margraf, and R.R. Lee, 1998: Optimizing the WSR-88D MESO/TVS algorithm using (WATADS) - a case study. *Wea. Forecasting*, In press.

Vandersip, C. and S. E. Koch, 1998: Results from a single-Doppler radar study of kinematic and structural characteristics of mesocyclones in the southeastern and Great Plains regions of the United States. Preprints, *16th Conf. Wea. and Forecasting*, Phoenix, Amer. Meteor. Soc., 205-207.

Table 1. Near storm environment variables derived from RUC II model grids which may be used by severe storm radar algorithms to diagnose storm severity.

CAPE	Convective Available Potential Energy
CIN	Convective Inhibition
LFC	Level of Free Convection
EL	Equilibrium Level
LI	Lifted Index
EHI	Energy Helicity Index
MPL	Maximum Parcel Level (most unstable parcel)
Avg RH below LCL	Average Relative Humidity below Lifted Condensation Level
dCAPE	downdraft CAPE(1,3,1-3 km)
Stm Rel Flow	Storm-relative flow (0-2, 4-6, 9-11 km AGL
BRN	Bulk Richardson Number
BRNshear	Bulk Richardson Number shear
Shear	Shear Magnitude (0-3, 0-6, 0-11 km)
SRH	Storm-Relative Helicity
Sfc Moisture Conv	Surface moisture convergence
Isotherm Heights	- 0°C and -20°C Isotherm heights
delta-Temp 700-500 mb	Temperature difference between 700 mb and 500 mb
Avg wind 500 - 300 mb	Average Wind Speed between 500 mb and 300 mb
lapse rate 850 - 500 mb	Lapse rate between 850 and 500 mb