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WARNING DECISION SUPPORT SYSTEM – INTEGRATED INFORMATION (WDSS-II). PART II: REAL-TIME TEST AT JACKSON MISSISSIPPI NWSFO

Gregory J. Stumpf[1,2,*], Travis M. Smith[1,2], Kevin L. Manross[1,2], Alan E. Gerard[3]

[1]Cooperative Institute for Mesoscale Meteorology Studies, University Of Oklahoma, Norman OK
[2]NOAA/National Severe Storms Laboratory, Norman OK
[3]NOAA/National Weather Service Forecast Office, Jackson MS

1. INTRODUCTION

The National Severe Storms Laboratory (NSSL) Warning Decision Support System – Integrated Information (WDSS-II) has provided an invaluable environment to facilitate the development of many new multiple-sensor severe weather applications for the National Weather Service (NWS). In just the past year (2002), NSSL has developed a variety of new algorithms (Smith et al. 2003). These include multiple-radar versions of the Storm Cell Identification and Tracking (SCIT) algorithm (Johnson, et al. 1998), the Hail Detection Algorithm (HAD; Witt et al. 1998), the Mesocyclone Detection Algorithm (MDA; Stumpf et al. 1998) and the Tornado Detection Algorithm (TDA; Mitchell et al. 1998). NSSL has also developed a variety of new severe weather applications including a two-dimensional hail swath algorithm. The display portion of the WDSSII has undergone some significant upgrades in the past year. The WDSSII displays multiple-source data in time-synchronized earth-centric three-dimensional coordinate system and is also user-configurable (Lakshman 2002).

The NSSL has played the primary role in the development and evaluation of severe weather applications for the Weather Surveillance Radar – 1988 Doppler (WSR-88D). NSSL developed many of the primary detection algorithms for the radar. These severe weather applications have included the SCIT algorithm, the HDA, the MDA, the TDA, and a Damaging Downburst Prediction and Detection Algorithm (DDPDA; Smith et al. 2002) and an Enhanced Hail Diagnosis Algorithm (EHDA; Witt and Marzban 2001).

These six algorithms comprised the Severe Storms Analysis Program (SSAP). Testing of the SSAP was done in offline mode with archived WSR-88D Level II data, or in real-time. Real-time testing was conducted using NSSL's Warning Decision Support System (WDSS; Eilts et al. 1996) at a variety of National Weather Service (NWS) Forecast Offices (NWSFO) nationwide between the period 1993 through the present year, 2002. Both of these legacy systems, the SSAP and the WDSS, were developed as single-radar software systems. All algorithm and radar products were keyed to the individual volume scans and individual radars. These restrictions were somewhat imposed upon by the primary funding institution for the development of these severe weather applications - the NEXRAD Radar Operations Center (ROC) – who is mandated to only support development and integration of single-radar data source meteorological applications for the WSR-88D.

Even with the limitations of single-source algorithms and systems, the WDSS proved valuable for warning improvements. Many of the then-experimental NSSL severe weather algorithms were integrated into the present-day WSR-88D system (including SCIT, HDA, TDA, soon MDA in the Fall 2003). This concept continues to be used to test improvements and additions to severe weather analysis applications at NSSL. We will briefly summarize the current improvements to the SSAP (more detail is

*Corresponding author's address: 1313 Halley Circle, Norman OK, 73069; (405) 366-0477; Greg.Stumpf@noaa.gov.

provided in the companion paper by Smith et al. 2003).

We will also describe the real-time testing proposed to evaluate these improved algorithms. The results of testing of the WDSS-II in an operational setting at the NWS Forecast Office at Jackson Mississippi, where four level-II WSR-88D data streams are available for operations, will be shown at the conference (publication of this manuscript occurred prior to the start of the operational test). We will have evaluated the operational utility of the new severe weather algorithms and the new display tools in a proof-of-concept test setting. These new concepts will continue to be tested to determine whether they will be included in future operational NWS systems that help guide and manage the severe weather warning decision making process.

2. MULTI-RADAR SEVERE WEATHER ALGORITHM IMPROVEMNTS

NSSL is currently developing major improvements to these severe weather algorithms as well as developing a variety of new applications to detect and diagnose severe weather. The traditional WSR-88D severe weather algorithms within the legacy SSAP have been designed for use with a single-radar data source. Although the algorithm guidance has led to an improvement of the National Weather Service (NWS) severe weather warning statistics, it is understood that effective warning decisions can only be made via the integration of information from many sources, including input from multiple remote sensors (multiple radars, mesoscale models, satellite, lightning, etc.) as well as input from other severe weather applications. Therefore, these traditional single-radar severe weather algorithms are being updated to take advantage of additional data sources, including input from multiple radars, in order to reduce the uncertainty of the measurements and increase the accuracy of the diagnoses of severe weather.

The Multiple-Radar Severe Storms Analysis Program (MR-SSAP) extends the concepts of all of the legacy algorithms into the multiple-radar (and multiple-sensor) realm. The present architecture of each algorithm is to detect two-dimensional (2D) features on radar elevation scans. At the end of each complete radar volume scan, the 2D features are vertically associated to create 3D detections. These 3D detections are also time-associated with 3D detections from a previous volume scan to produce tracks and trends. This method leads to a variety of disadvantages. First, algorithm products are only generated at the end of a volume scan, which is typically 5-6 minutes after the first elevation scan of the volume scan is collected. This has led to warning meteorologists placing less weight on the algorithm products for warning guidance and more weight on analysis of the more-timely radar data alone without the additional guidance. Second, storm and tornado evolution can typically be very rapid, and 5- or 6-minute algorithm update rates may be inadequate. Third, storms can be poorly sampled at very near ranges to the radar (cone-of-silence) and at far ranges (radar horizon, lower sampling resolution).

An early attempt at a multiple-radar SSAP compared the algorithm detections from the various single-radar sources and determined the “best” radar to use as the one sensing the storm or mesocyclone/TVS with the strongest intensity. This method, called the “County Warning Area (CWA) Table”, did not take advantage of combined information from multiple radars, and thus issues like poor sampling still plagued the system. It also did not synchronize for the time difference between the multiple radar scans through similar features.

The MR-SSAP instead *combines* the two-dimensional information from multiple radars and uses these data sets to produce 3D detections. This will allow for a more complete vertical sampling of storms and mesocyclones/TVSs where vertical sampling resolution is degraded. Signatures are now better sampled where adjacent radars are adding data to poorly sampled regions such as cones-of-silence (Fig. 1). Vertical and time association is then performed at regular intervals with the last several minutes of 2D features using a “virtual volume scan” concept (Lynn 2002) to enable rapidly-updating algorithm output and time-synchronization of the multiple-radar data. Our version presently updates the output at every 60 seconds. Faster updates are possible, but we feel that this update rate may initially overwhelm NWS warning forecasters. Real-time testing will be used to determine an optimal update rate. During the diagnosis phase of the 3D detections, range-dependent sampling differences are accounted for when combining both the reflectivity- and Doppler velocity-produced features. The MR-SSAP is also independent of radar volume coverage pattern and will operate in rapidly updating fashion with even just one radar source (if there are outages or regions of only single radar coverage).

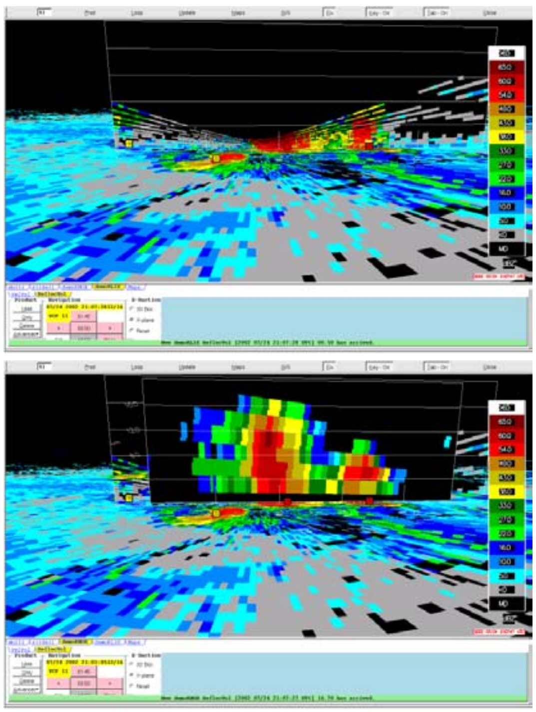

Figure 1. WSR-88D Slidell LA reflectivity data with horizontal and vertical planes as viewed in a three-dimensional "airplane viewpoint" from south of the storm (top). WSR-88D Slidell LA horizontal and WSR-88D Jackson MS vertical reflectivity planes of same data from same 3D viewpoint (bottom). Note that data from Jackson radar are used to fill the Slidell data-void cone-of-silence region.

In addition to the MR-SSAP products, we have developed a number of high-resolution two-dimensional multiple-sensor products for hail, hail swaths, rotation fields, and rotation tracks. Examples of the multiple-radar SSAP and these other two-dimensional products are shown and described in detail in the companion paper (Smith et al. 2003).

3. PROOF OF CONCEPT TEST AT THE JACKSON MS NWSFO

NSSL has provided an operational multiple-radar WDSS for the Jackson Mississippi NWSFO since 1998. The system operates using four independent legacy WDSS each running an independent set of single-radar algorithms (SSAP) for each radar (Fig. 2; KJAN – Jackson MS, KMOB – Mobile AL, KLIX – Slidell LA, and KGWX – Columbus MS) which serve the Jackson County Warning Area (CWA). The primary objective of the system was to mitigate a partial beam-blockage of the low-altitude elevation scans in a sector east of KJAN by integrating data from other radars scanning the same sector. A low-altitude reflectivity mosaic was developed that filled in the beam-blocked area east of KJAN. The CWA Table was also used to present information regarding the "best radar" to use when looking at individual storm and mesocyclone/TVS detections.

The NSSL and the Jackson NWSFO will jointly conduct a Proof-of-Concept Test (PoCT) to test the new experimental multiple-radar algorithms described in this manuscript. Jackson is the first NWSFO testbed of the MR-SSAP. We will be testing concepts in a "rapid-prototyping" mode; development and improvement of the algorithms and display systems is an on-going process and we will be updating the system as soon as new techniques are developed. At the time of this publication, NSSL has completed the installation the hardware and software for a Linux system to run the WDSSII and MR-SSAP. Installation of MR-SSAP Version 1.0 was made in mid-July. Early feedback from the users has been positive, and information from them is being used for the next software release (Version 2.0) scheduled for late October. An intensive operations period, which will be staffed by visiting NSSL scientists, will occur during Mississippi's autumn severe weather peak season in November 2002. Since this test has yet to start at the time of publication, the test results will be reported at the conference instead of in this manuscript.

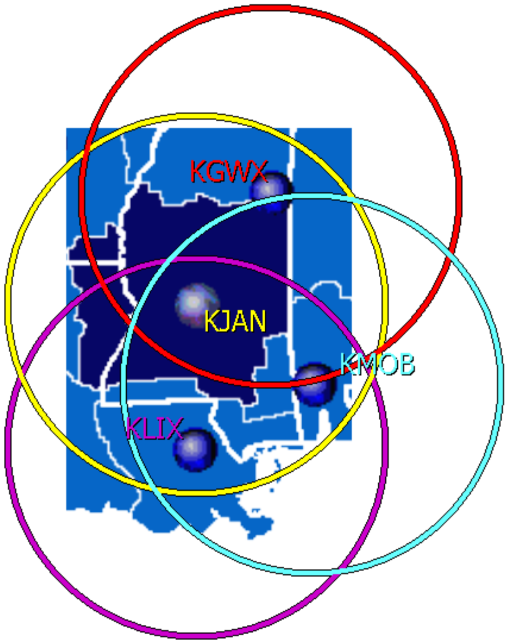

Figure 2. Four-radar coverage for the Jackson Mississippi NWSFO county warning area (dark blue). KJAN – Jackson MS (yellow); KLIX – Slidell LA (magenta); KMOB – Mobile AL (cyan); KGWX – Columbus MS (red).

We will evaluate the accuracy and the operational utility of NSSL's new enhanced severe and hazardous weather prediction multi-sensor algorithms during real-time operational warning situations. Proof-of-concept tests present opportunities to test the experimental algorithms during NWS severe-weather warning operational situations. This test will identify any special area of focus for additional algorithm and product display development prior to their inclusion into NWS systems. For example, the Southeastern U.S. climatology should allow NSSL to determine if the experimental algorithms are region-independent.

The PoCTs also provide operational experience to NSSL meteorologists and developers during real-time warning situations in order to better understand user requirements, and foster collaboration between NSSL scientists and operational meteorologists. The algorithms will each be evaluated qualitatively via feedback questionnaires from the NWS personnel. Scientific quantitative evaluation of cases will also be conducted after the test. Feedback on the utility of the WDSSII display and needed additions and enhancements will be acquired from the NWS meteorologists via post-shift questionnaires and by observations of operational use by NSSL staff. This feedback is very important to help NSSL determine how the algorithm output will be displayed on future operational systems.

4. FUTURE WORK

The Multiple-Radar SSAP and the two-dimensional high-resolution multiple-sensor hail and rotation products represent only the first phase of improvements for the NSSL experimental severe weather applications. We plan to expand the use of input from other sensors into the algorithms (including mesoscale model, lightning, surface, and satellite data) for a fully multiple-sensor suite of severe weather applications. An upgrade to our application and display systems will be tested during the Spring of 2003 at the NWSFO in Wichita Kansas. The results these tests will lead toward eventual improvement of the severe weather warning applications for the NWS systems nationwide.

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