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CURRENT AND PLANNED ACTIVITIES FOR THE WARNING DECISION SUPPORT SYSTEM – INTEGRATED INFORMATION (WDSS-II)

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INTRODUCTION

The Warning Decision Support System (WDSS) was developed by NSSL in the early 1990's in order to test newly developed severe weather detection algorithms on data from the WSR-88D (Eilts, 1997). This endeavor was undertaken as part of NSSL's mission to enhance the National Oceanic and Atmospheric Administration's (NOAA) capabilities to provide accurate and timely forecasts and warnings of hazardous weather events. The first operational test of the WDSS was conducted in the Phoenix, AZ National Weather Service forecast office in 1994.

Several severe weather detection algorithms, based primarily on WSR-88D data, were tested during the initial years. Rudimentary data integration algorithms were also added to provide Near Storm Environment (NSE) data from the RUC model and a National Lightning Detection Network system to provide cloud-to-ground lightning strike data. The WDSS provided tools to ingest and display the raw data and algorithm products for operational forecasters during the test period. The efforts undertaken with WDSS were very effective in enhancing the capabilities of algorithms and applications developed at NSSL and elsewhere. Some WDSS capabilities were implemented in operational systems of the NWS (most notably algorithm enhancements to the WSR-88D RPG).

It became evident early in the development of WDSS that the system was unable to accommodate the true integration of other data sources. The design of the early WDSS was intended for the development of Doppler radar severe weather algorithms. The implementation of the system made the integration of other data sources very difficult. The development of a "Next Generation WDSS" (Hondl, 1997) was planned to fully integrate and handle all available observational data streams and support multiple sensor application development (i.e. algorithms) to further improve forecasts and warnings of hazardous weather events.

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DESIGN REQUIREMENTS FOR WDSS-II

A team of WDSS development meteorologists and programmers was put together to define the requirements and attributes of a new system. This new system was called the Warning Decision Support System – Integrated Information (or WDSS-II).

The application developers identified the following primary attributes for the system: 1) that the system be easy to make changes and add new products and concepts; 2) that the development process be simple enough for algorithm developers of varying experience to work with; 3) that the system support data integration from multiple observational sensors/systems with relative ease; and 4) that the system provide a seamless path from data ingest, to data processing, to data output and display.

Another desired attribute was to improve the pace of technology transfer from research to operational systems (Hondl, 1997; Eilts and Saffle, 1998). The algorithm or applications developed in WDSS-II could eventually be deployed on operational systems of the NWS (AWIPS) or FAA (WARP, ITWS) or the tri-agency NEXRAD (ORPG). NSSL's application developers have been enhancing and developing new algorithms for each of these partners, as well as for many internal NSSL research projects.

The system design and desired functionality required the development of several prototype applications and Application Programmer Interface (API) specifications. An early effort to combine the WDSS-II and the Common Operations and Development Environment (CODE; Johnson, 1999, and Ganger, 2002) was not completed. The multi-sensor, data integration components of WDSS-II were beyond the scope of CODE as developed for the Open Radar Product Generator (ORPG). In addition, some of the applications developed using WDSS-II may be better suited for implementation in other operational systems. A goal is for some of the convenience functions developed for radar data in WDSS-II to be reused by the CODE project (and that other multi-sensor applications developed in WDSS-II be made available to other operational systems).

CURRENT WDSS-II DESCRIPTION

Currently, the WDSS-II system is composed of LINUX-based applications that ingest multiple data streams and process the data using NSSL's enhanced severe weather detection algorithms. Several new algorithms currently under development integrate multiple radars or other sensor data sets for display. Data sets currently ingested and displayed by WDSS-II and available for development include WSR-88D Level II, Terminal Doppler Weather Radar, NLDN lightning strike, Oklahoma Mesonet surface observation, and the KOUN Dual-Polarization WSR-88D data.

The WDSS-II infrastructure allows developers to access data from other network computers. This is beneficial to the algorithm developer since the system can be run on another computer and maintained by another person, but the developer has access to all the available data. The developer may run their algorithm and view output on their individual workstation. This significantly cuts down the resources required by the developer and still provides access to the full breadth of the data and other algorithm output.

The WDSS-II API supports the input/output of data in NetCDF and XML formats (Lakshmanan, 2002). These standard data formats provide a user-friendly format specification. The WDSS-II API provides convenience functions to read, process, and output data in these formats. This API is shared by the WDSS-II display such that algorithm developers may generate intermediate products and view these products with nothing more than some configuration file additions.

WDSS-II DISPLAY

The WDSS-II display was implemented using the OpenGL graphics library. It provides an earth-centric, 3-D display capable of displaying data from multiple sources/sensors and processing algorithms. Geographical data and information (e.g. maps) are stored as standard shapefiles. The WDSS-II display handles the synchronization of multiple sources by keying off the data time.

In the display, each data source is unique and handled separately from other sources. (A source may be a particular radar, other observational system, or output from the developer's own algorithm.) All data from multiple sources may be viewed simultaneously in the display. The user may elect to hide individual sources or only display one source at a time. The system infrastructure notifies the display when new products are generated so that it may update.

The WDSS-II infrastructure currently supports several types of meteorological data including polar format radar data, Cartesian 2-D and 3-D grids, and a latitude/longitude –based grid. In addition, the display handles data in tabular text format (using XML) and icon overlays (with user configurable icon descriptions). The display utilizes a unique virtual volume of radar data (Lynn and Lakshmanan, 2002) such that the user may navigate through a radar volume and display data from any elevation angle.

The virtual volumes and 3-D grids allow the generation of cross sections from the radar volume. Then, using the 3-D, earth-relative display the user can fly through/around the radar cross section.

While the data is maintained in 3-D space, the WDSS-II display in not yet a fully functional 3-D graphics display. Additional capabilities to display iso-surfaces and other 3-D graphics are being investigated.

WDSS-II VISUAL PROGRAMMING CAPABILITY

The WDSS-II development system also allows users to apply algorithms to the data (once or multiple algorithms in succession) and visualize the algorithm's effect on the data. The performance characteristics of these processing methods may be modified simply by changing a configuration file. Once the developer is satisfied with the look of the data, the specific algorithm processing method may be implemented in source code.

Virtually any WDSS-II algorithm can be run as a visual programming tool. Several processing methods have been developed to filter the data using Cressman or Gaussian templates, to compute shear and rotation, or to contour the data.

CURRENT WDSS-II DEVELOPMENT PROJECTS

There are several projects currently underway to integrate other meteorological data into WDSS-II. The overall goal is to provide the infrastructure to access and display multi-sensor data or computer simulations. In turn, it is hoped that this capability will lead to greater understanding of the severe weather processes and improvements to the algorithms.

The NSSL algorithm developers are currently developing a multi-radar version of the Severe Storms Analysis Program (SSAP, Stumpf, 2002). The SSAP contains the severe weather detection algorithms that identify and track storm cells, mesocyclones and tornado signatures. The SSAP then quantifies the characteristics of the signatures and provides guidance to the forecaster. Instead of running the algorithms on each individual radar, the multi-radar SSAP combines the intermediate algorithm output from each radar into a single algorithm to identify storm cells and other severe weather signatures.

A project is also under development to ingest and display satellite data using WDSS-II. Severe weather algorithms will then be able to access cloud-top temperatures (or other satellite variables) and use that information in the decision-making process. Other algorithms could be run on the satellite data itself and provide data to applications used by the forecaster.

Another project involves ingesting computer model information. The current NSSL severe weather detection algorithms use NSE data from the RUC model to provide environmental information to the algorithms. At the current time, the NSE data is a blackbox to the algorithm developer. The environmental information affects the algorithm output, but the developer is unable to see the NSE data. Being able to visualize the NSE data would allow the developer to better understand its effect on the algorithm output. Likewise, forecasters would be better prepared to understand how the data affected the decision support output.

NSSL is also deploying a Lightning Mapper Array (LMA) to provide lightning channel information for all lightning (not just cloud-to-ground strikes). These data will be ingested and supported by the WDSS-II infrastructure. Researchers will be able to overlay LMA data with computer model simulations and observational radar data. If the processing speed is sufficient, these data may even be available in realtime.

In addition, the WDSS-II will be used to display Phased Array Radar (PAR) data. The PAR is being built at the National Weather Radar Testbed in Norman, OK. These data will have significantly different characteristics than the WSR-88D Level II data. Tools and analysis methods for the handling, processing and display of the PAR data will require WDSS-II API extensions and modifications.

OPERATIONAL TESTS INVOLVING WDSS-II

Currently, the WDSS-II system is deployed at NSSL and data from the system is available to the Norman, OK NWS forecast office. The Norman NWS forecast office is also using WDSS-II to display base products and algorithm output from the KOUN Dual-Polarization WSR-88D.

Additional plans include a WDSS-II deployment at the Jackson, MS NWS forecast office. The Jackson NWS forecast office has been using an older WDSS version and receiving data from five WSR-88D radars. The initial version of the multi-radar SSAP will be tested on the Jackson WDSS-II system.

CONCLUSIONS

NSSL has developed a very robust and extremely powerful tool for multi-radar and multi-sensor algorithm development. Considerable effort was expended to develop the capabilities of WDSS-II based on earlier algorithm development needs and requirements as evidenced by NSSL researchers.

The NSSL algorithm developers and researchers have been using the WDSS-II for algorithm development and display for about the last six months. The tools and data access APIs have greatly enhanced the development capability over what was available with the earlier version of WDSS and are more extensive than the APIs of operational systems. Algorithm developers have been able to quickly and easily generate source code to test new analysis tools and have greatly increased their productivity.

The WDSS-II system has proven to be a very user-friendly development environment and suitable for realtime algorithm testing and display. WDSS-II should be considered as a development environment for multi-sensor applications and the WDSS-II tools should migrate to operational systems with multi-sensor processing requirements.

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