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THE FIRST WORKSHOP ON SEVERE WEATHER TECHNOLOGY FOR NWS WARNING DECISION MAKING

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1. Introduction

In July 2005, the Meteorological Development Laboratory (MDL) and the Warning Decision Training Branch (WDTB) started a series of workshops aimed at improving severe weather technology for National Weather Service (NWS) warning decision making. This initial workshop was called "The First Workshop on Severe Weather Technology for NWS Warning Decision Making". The structure of the workshop was based off of a series of successful development workshops for the National Severe Storms Laboratory (NSSL) Warning Decision Support Software (WDSS; Eilts et al. 1996) in the 1990s. The previous WDSS workshops provided a fertile environment for researchers, developers, and forecasters to work together to develop and test the next generation of 0-2 hour convective severe weather warning decision making technologies.

The current workshops seek to revive this successful relationship and more heavily integrate the technology development into the existing NWS requirements generation process. The workshop brought together NWS forecasters, software developers, NWS headquarters requirements group representatives, and researchers to identify new technologies and ideas to improve NWS severe weather warning decision making. It also addressed two main areas:

1. Establishing the current state of forecaster needs for improvement in warning decision making, and
2. Evaluating new technologies in the context of these needs.

The needs assessment review utilized 1) an online survey form publicized to the NWS through Regional headquarters, 2) presentations from forecast offices at the workshop ("Stories From the Field"), and 3) structured breakout groups during the workshop. In addition to the NWS forecaster participation, other subject matter experts were invited to give talks and demonstrations of new and relatively mature warning decision making technologies at the workshop.

The structure and latest results from the workshop are extensively documented online at:

http://www.nws.noaa.gov/mdl/dab/workshop/Meteorological_Development_Laboratory_Workshop.htm

Raw inputs and summaries are provided for the survey forms and breakout group discussions along with copies and summaries of the presentations given at the workshop.

Results of the workshop are useful to illustrate the state of current warning decision making in the NWS. The results also provide insight into some of the potential directions for future NWS products and services. The ultimate goal of the workshops is to develop an open, innovative, and regularly meeting group that aggressively evaluates new technologies and ideas to improve all facets of NWS warning decision making and significant weather-impacted event operations. One intended benefit of the workshops is to help requirements groups with understanding the latest technologies that can be used in addressing strategic planning for the NWS and the National Oceanic and Atmospheric Administration (NOAA).

It should be noted that the views expressed in this paper and those discussed in the workshop are those of the author(s) and workshop participants and do not necessarily represent those of the NWS or NOAA.

2. Needs Assessment

To begin evaluating the current needs in warning decision making, a three question online survey was posted shortly before the workshop. The survey was also an opportunity to solicit input for the workshop from those who could not attend. The online survey was announced to all of NWS through NWS Regional Headquarters, and anyone with a noaa.gov email and password could contribute to the survey. A second announcement was made after the workshop in conjunction with the 2005 Workshop on Great Lakes Operational Meteorology. The three questions asked in the survey are listed below:

1. What are your current needs in NWS warning decision making?
2. What current needs are not being met?
3. In five years, what improvements would you like to see in NWS warning decision making?

Forty-three detailed and widely varying responses were gathered to each of these questions. To view the raw survey results online (if you have a noaa.gov email and password), please see the "Pre-Workshop Survey RESULTS" on the workshop website. Many forecasters had a difficult time understanding the subtleties between questions, so considerable overlap exists between answers to the three questions. When taken together, the input suggests a desire to improve upon nearly all facets of warning decision making. Areas of desired improvement include:

- higher resolution observational data on the temporal and spatial scale of severe convection
- more dedicated time, resources, and infrastructure for improved training
- improvements in base data displays that allow more effective navigation in both space (2D and 3D) and time (4D)
- faster and more dependable software and hardware
- improved algorithm guidance information
- better decision support tools
- improved software interface design
- new tools to monitor situation awareness
- new product formats that allow for better conveying certainty in warning decisions
- more effective warning communication
- better measures of public service and verification improvements
- improved leadership skills and workload management
- more research into forecast problems and better guidance
- better capabilities to merge geographic information into operations
- faster implementation of technological improvement

The most often mentioned areas of need were improving observational data, technologies, and training. Although this workshop was geared more toward technology, the responses to the survey indicate how human factors are interconnected to technology.

3. Stories From the Field

Eight presentations from NWS forecasters were given over the current state of operations and relevant significant issues at each forecast office. Also, a presentation was given detailing the NASA Short-term Prediction Research and Transition (SPoRT) testbed at the Huntsville, AL, WFO (Goodman et al. 2004). To view the presentations and summaries, please see Sessions 2 and 5 of the agenda:

http://www.nws.noaa.gov/mdl/dab/workshop/agenda.htm

The presentations illustrate the many facets of current warning decision making. Common operational threads include a focus on a wholistic approach to warning decision making with a particular focus on base data analysis. Workload management and maintaining a high state of situation awareness for significant events are also common important themes.

4. Future Technologies and Operations

Warning decision-making technology experts, severe weather researchers, and NWS program managers gave presentations on the following topics:

- The future of public weather services
- The future of severe weather warning operations and public services
- Bridging the gap between watches and warnings
- The future of gridded verification
- Warnings and GIS improvements
- The NEXRAD product improvement plan
- The future of GOES-R (Gurka and Dittberner 2001)
- Total lightning mapping improvements
- The future of the Advanced Weather Information Processing System (AWIPS; Wakefield 1998)
- The future of the System for Convection Analysis and Nowcasting (SCAN; Smith et al. 1999)

- Integration of NSSL's Four Dimensional Storm-cell Investigator (FSI; Stumpf et al. 2005) into SCAN
- Future of multi-radar algorithms, multi-sensor approaches, and rapid update processing
- NSSL's Warning Decision Support System II (WDSSII; Lakshmanan et al. 2004) development and application improvements
- Improved convective initiation using the National Center for Atmospheric Research (NCAR) Auto-Nowcaster (Meuller et al. 2003)
- The future of NOAA's NWS Weather Event Simulator (Magsig et al. 2006)

To review each of the presentations and summaries, refer to Sessions 1, 4, 5, and 7 of the agenda:

http://www.nws.noaa.gov/mdl/dab/workshop/agenda.htm

A number of planning processes and programs related to future technologies and operations were discussed during the workshop. One of these is the NOAA Planning Programming Budgeting and Execution System (PPBES; for more information see http://www.ppi.noaa.gov/). According to the PPBES website, "The PPBES ties strategy, planning, program, and budget together". One need discussed at the workshop is the improved integration of NWS services with other NOAA products to form a one stop shop for NOAA products and information.

At the NWS level, a planning process exists called the Operations and Services Improvement Process (OSIP; those with noaa.gov accounts can access https://osip.weather.gov). According to the OSIP website, "OSIP provides a means for NOAA's National Weather Service to collect needs and opportunities, validate the requirement, identify and document solution(s), and assist in prioritizations and resource allocation". In the workshop, it was briefed that some of the future technologies in AWIPS have already started the OSIP process. OSIP is one opportunity for new ideas and technologies, such as those discussed in this workshop, to be brought into the requirements process.

On the WSR-88D radar level, a process exists called the Technical Advisory Council (TAC). The TAC scientifically evaluates potential radar improvements for the WSR-88D program. The TAC is comprised of members from the three agencies representing the WSR-88D Radar Operations Center (namely, the NWS, the Federal Aviation Administration, and the Department of Defense). In the workshop, numerous planned radar improvements were briefed that have been approved by the TAC and are now passing through OSIP.

One theme discussed in the future technologies and operations part of the workshop was the potential for changes in the concept of NWS operations. The potential benefits discussed include providing more and improved science-based support for emergency decision making associated with high impact events such as severe weather, homeland security, and natural and man-made disasters. Some of the key ingredients that could support improving existing services include improved situation awareness (internal and external), coordination (internal and external), data integration [geographic information systems (GIS), visualization, multi-sensor algorithms], the exploitation of new technology (internet, mobile cellular) and techniques (geo-referenced/graphical, probabilistic threat). Improvements in creating meaningful and informative new metrics, such as public impact evaluations and gridded warning verification, would also be an important component of improving high impact event support.

The status of many observational systems was also discussed in the workshop. In the radar program the top three priorities, based off of field input, are dual polarization, super resolution, and Terminal Doppler Weather Radar (TDWR). TDWR integration into NWS operations is planned to continue to expand in 2006. Super resolution radar data are planned for 2007. Dual polarization radar is being planned for 2009.

In the satellite program, GOES-R is one of the significant future improvements that is planned to be launched in 2012. Some of the improvements planned for GOES-R include increases in spatial and temporal resolution, improved spectral observations, a total lightning mapper, and a space weather instrument.

Another remote sensing platform discussed in the workshop is the surface based total lightning diagnosing Lightning Mapping Array (LMA; Krehbiel et al. 2000). LMAs have demonstrated significant improvement in advancing lightning prediction and warning decision making, but no timetable has been set for integration into NWS operations.

The primary technology for future NWS warning decision making will likely continue to be AWIPS. The AWIPS program, however, is currently in the midst of major changes. A new contractor has been awarded the AWIPS contract, and they will assume control of AWIPS maintenance and development in stages starting in Fiscal Year (FY) 2006.

There are extensive opportunities to enhance warning decision making performance with improvements in AWIPS software. To address this, a fiscal year 2008-2013 plan has been submitted in the PPBES to support increases for research and new software for the Local Forecast and Warnings (LFW) program. Some of the areas of AWIPS prototype development preparing for FY2008 include data management (pull versus push), visualization tools, collaboration tools, and geographic information generation.

In the shorter term, the System for Convective Analysis and Nowcasting (SCAN) program is one component of AWIPS that is proactively incorporating new decision support systems and tools. Some of the more significant future SCAN improvements being considered include 1) warning decision making enhancements from NSSL's WDSS II, and 2) convective initiation and short term forecasting using NCAR's Auto-Nowcaster. The first major SCAN improvement currently planned to start development in 2005 is the WDSSII 3D and 4D visualization capability termed the Four-dimensional Storm-cell Investigator (FSI). More WDSSII technology is being considered for future versions of SCAN, including decision-assistance applications that integrate data from multiple radars and multiple sensors, and rapid update processing.

Any new technology incorporated into warning operations would greatly benefit from simulation and training capability like the AWIPS-based NOAA's NWS Weather Event Simulator (WES). The short term plan for the WES is for the WDTB and the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) to continue developing and supporting the WES outside of the AWIPS baseline software development process. The long term goal of the WES is for the AWIPS training functionality to be developed into the AWIPS baseline to support expanded AWIPS functionality, including future technologies.

5. Breakout Groups

To allow for more in depth discussion of topics, the participants were assigned to breakout groups (A-F) with at least one field forecaster in each group. Groups A-C covered weather threat interrogation, and groups D-F covered warning dissemination and management. Multiple groups were assigned the same questions in order to provide some diversity in the answers. The first day's breakout session focused on outlining and ranking the most important shortcomings of the group's topics (after having heard presentations on the "State of the NWS" as well as "Stories from the Field".) The second day's breakout session focused on outlining and ranking ideas for critical future improvements of the group's topics (after hearing presentations on future technologies). The final day provided an opportunity for all participants to contribute to the topical areas covered by the other groups.

These discussions allowed sharing of a wide variety of perspectives in synthesizing the important elements of the workshop. For a complete detail of the breakout group notes with summaries see:

http://www.nws.noaa.gov/mdl/dab/workshop/Breakout_Group_Notes.pdf

The breakout sessions confirm that many of the technologies and ideas discussed at the workshop address current needs. The results also augment the original needs assessment by providing more detailed suggestions for improvements.

6. Cataloging the Ideas

The next step is to enter all the unique ideas from the surveys and breakout sessions into a database and succinctly explain the scope and expected benefit from the ideas. Once the ideas are sufficiently documented, selected components are going to be briefed to relevant requirements, development, and training groups. The ideas will also be updated on the website for anyone to access or add to. Future workshops will use these ideas as a starting point to further evaluate new technologies and ideas for improving NWS warning decision making. Requirements status will be monitored in future workshops to ensure the "lowest hanging fruit" are being appropriately recognized.

7. Conclusions

The NWS warning decision making needs assessment and future solutions brainstorming components of this workshop suggests three main areas are perceived by those forecasters surveyed as being critical to the future improvement in warning for severe convective storms: observational data, technology, and training. Detection and prediction of severe weather will improve with observational data collected closer to the time and space scale of severe weather.

Highly reliable and intuitive software will allow forecasters to utilize new technology effectively. Finally, robust training (including technology for training) will ensure warning decision makers are adequately trained to apply new technologies effectively. The mix of technology and human factors deemed critical underscores the importance of a blended approach to implementing future technologies.

This workshop has identified numerous innovative ideas that could improve warning decision making effectiveness. These ideas will be documented and presented to requirements, development, and training groups for consideration of improvement to NWS OSIP projects and NOAA PPBES plans. Future workshops will regularly meet to continuously evaluate new technologies and ideas, and to raise awareness of potential improvements to NWS warning decision making and significant weather-impacted event operations.

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