P2.38   BUILD FOUR OF NOAA'S NWS WEATHER EVENT SIMULATOR

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1. Introduction

The Weather Event Simulator (WES) is a Linux-based software package that allows the playback and simulation of weather events using NOAA's NWS operational software and archived data sets (Magsig and Page 2002). The WES contains an operational build of the Advanced Weather Interactive Processing System (AWIPS) software along with WES software to facilitate data processing and display (Fig. 1).

The first version of WES (WES1.0) was released in 2001 (Magsig and Page 2002), and it was utilized primarily by the NWS and training-related organizations. By 2003, a cost-free version of the WES (WES1.3) was developed (Magsig 2004), and Universities and other NWS collaborators began to use the WES (Magsig et al. 2004).

Since the release of WES1.3, the WES has continued to keep pace with the frequent AWIPS software builds, and new AWIPS functionality has been added. WES2.0, released in March 2004, featured the AWIPS Flash Flood Monitoring Prediction System (FFMP) (Smith et al. 2000). WES3.3, released in Oct. 2004, featured a major AWIPS build upgrade to OB3.3 in addition to some coding improvements to improve performance. WES4.0 is currently being worked on at the time of this paper submission, and it is planned to include AWIPS Build4.0, with new functionality to support the Digital Mesocyclone Detection product, the Tornado Rapid Update product, and the System for Convection Analysis and Nowcasting (SCAN) storm cells table.

This paper will review the significant changes to the WES program since WES1.3, and it will discuss the development of WES4.0 ongoing at the time of this paper submission.

2. WES2.0

The primary improvement in WES2.0 was the

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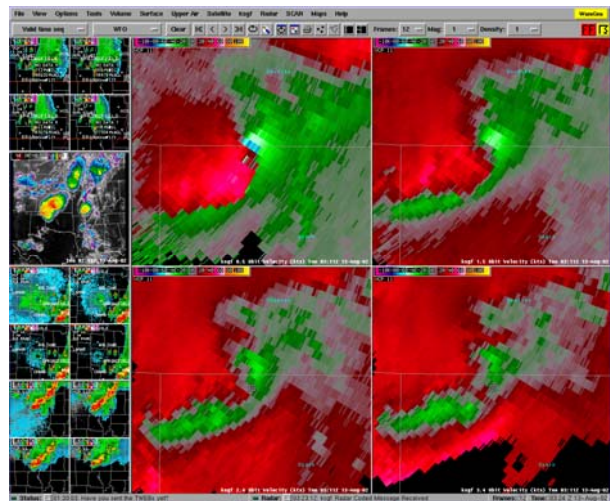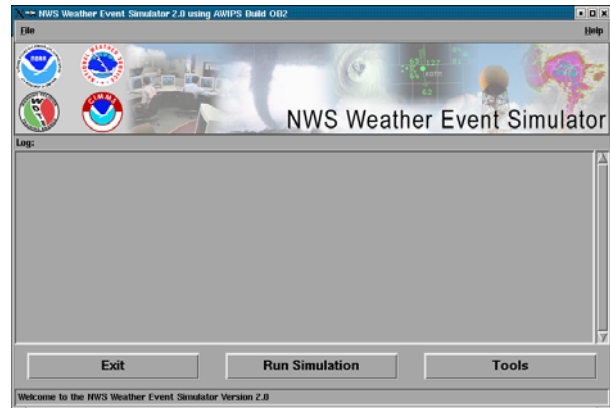
Fig 1. WES graphical user interface (top) and AWIPS D2D bottom.

inclusion of support for the AWIPS FFMP application (Fig. 2). Development of FFMP functionality for WES was made possible by a special project funded by the Warning Decision Training Branch for the Forecast Systems Laboratory (FSL) to port the necessary processors over to Linux, with assistance from the Meteorogical Development Laboratory (MDL).

FFMP uses digital flash flood guidance, released from the River Forecast Centers, along with radar estimates from the Digital Hybrid Scan
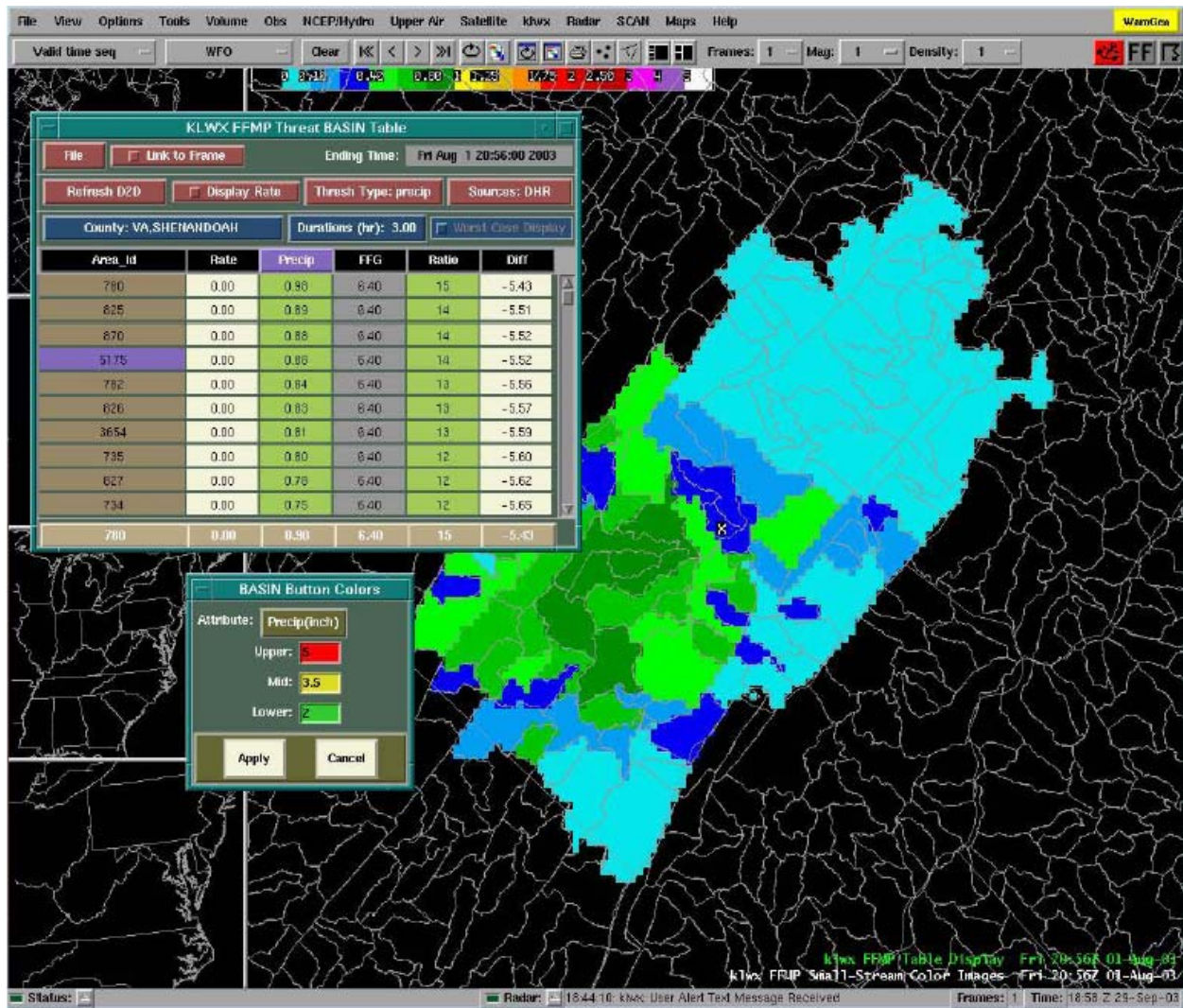
Fig 2. FFMP table and basin level precipitation display in D2D.

reflectivity data and high-resolution watershed basins maps to provide forecasters with county-level and basin-level precipitation estimation at multiple time scales. Graphics and tabular output are accessed by an FFMP table (Fig. 2), which utilizes the AWIPS Display in Two Dimensions (D2D) software for primary display of hydrometeorological fields. In FFMP, forecasters can monitor the county level precipitation, and they can zoom in to evaluate the threat on the watershed basin level. FFMP provides maps of precipitation, precipitation rate, ratio of precipitation to flash flood guidance, and difference between precipitation and flash flood guidance. The unique data structures, display design, and processing design in FFMP do not easily lend themselves to the type of archive playback and simulation techniques used by the

WES. Therefore, the details and limitations of the WES FFMP solutions will be discussed below.

2.1   WES2.0: FFMP Data Creation

The FFMP data used for display is created by the FFMPprocessor program. Accumulations covering the last six hours for each radar are stored in binary format files in the "ffmp" subdirectory under each radar name. The accumulations-based product storage, rather than volume scan storage, coupled with the differences in filenames preclude the type of easy archiving and data processing in the WES. The accumulation files in FFMP are stored in an accumulations.dat file, whereas most AWIPS data products are stored in yyyymmdd_hhmm format (e.g. 20040701_1435). In order for FFMP data to
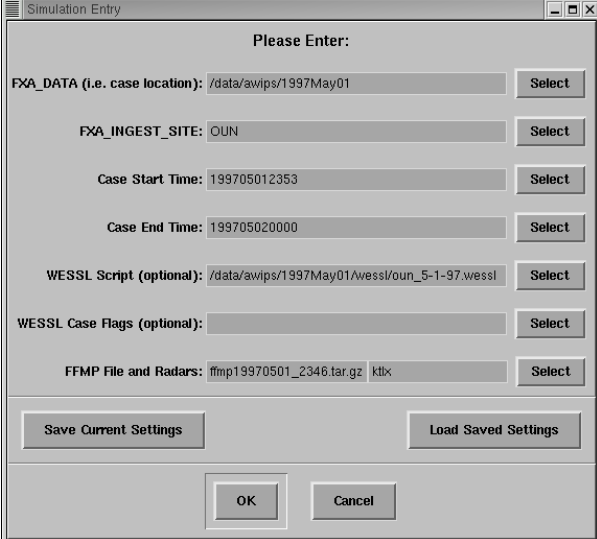
be created for research and training, a data generation tool was developed using the DRT mode of the FFMPprocessor. The DRT mode of the FFMP processor allows for FFMP processing on archived data sets.

To create an FFMP dataset in WES, the user must configure the AWIPS with WES to include DHR files, basin files, and digital flash flood guidance (for instruction on creating FFMP data, see the WES installation instructions on the installation CD). Once the input data is available, the user enters the case name and the *end time* of the desired FFMP dataset. If the user desires to review a data set in a static mode, the end time should represent the end of the six hour time period of interest. If the user intends to run a simulation as if in real time, the end time should represent the start time of the simulation. During simulation mode, the FFMP data is created on the fly during a simulation as if in real time.

In creating FFMP datasets with WES, some of the necessary AWIPS processors are started (including the FFMP processor), to process the Digital Hybrid Reflectivity (DHR) files in a batch mode. As of WES3.3, the previous 84 files relative to the start time are processed to fill the accumulations used in FFMP (in WES4.0 this will be changed to 92 files to support VCP12 inventories). Each DHR file takes ~ 5 seconds to process, which can yield a significant amount of time for processing a large case with multiple radars. A six hour accumulation dataset is generated in the "ffmp" data subdirectory upon successful completion of the FFMP data generation routine. The "ffmp" directory is tarred, gzipped, and stored in a neighboring "ffmptars" directory for later use by the WES data preparation software (Fig.3) during simulation mode.

2.2   WES2.0: FFMP Case Review Mode

The AWIPS D2D has a stand-alone data review mode that is controlled by a user-controlled clock widget. The user enters the end time of desired data period, and up to 32 frames of data can be accessed from the standard data menus. FFMP, however, was not designed to utilize the standard AWIPS clock widget. The last 32 frames of the ffmp dataset can be partially analyzed, but the FFMP display table requires the AWIPS notificationServer to be running, in addition to the D2D, in order to change the FFMP graphics fields. Therefore, attempting to run FFMP in case review mode is not recommended.

Fig 3. WES software simulation entry window including an entry for the FFMP tar file and the list of valid radars.

2.3   WES2.0: FFMP Simulation Mode

To be able to review FFMP datasets with full functionality, the user must enter simulation mode. In simulation mode, all the AWIPS processors needed for FFMP display are started. The gzipped FFMP tar file is untarred and gunzipped in the simulation preparation stage. During the simulation, the WES issues a special FFMP trigger when every DHR file is processed to initiate the FFMPprocessor to create FFMP data as if in real time. If the user wishes to review a dataset and not have data continually feeding in during a simulation, the WES pause function can be invoked. When the simulation is paused, the AWIPS processes needed for FFMP display are running, so FFMP datasets can be explored. Thus, in simulation mode, FFMP data for a case can be reviewed, and FFMP behaves as if in real time during the simulation.

3.   WES3.3

Beginning with WES3.3, the version number has been changed to reflect the version of AWIPS included with the WES release. The primary improvements in WES3.3 included a major upgrade to the AWIPS in WES to Build 3.3 and improvements to speed up the simulation preparation and WES data processing. A delay in the release of the WES occurred during OB3 due to major changes in OB3 AWIPS radar data structures significantly impacting the WES.

Workarounds for the problems have been developed, and the WES has been configured to automatically detect and fix any pre-OB3 cases to work with the OB3.3 AWIPS in WES3.3. In addition to the major additions to WES3.3, the WES Scripting Language was updated to include a new station log to facilitate easy perusal of pre-configured supplemental imagery during a simulation.

4. WES4.0

At the time of this paper submission, WES4.0 development is ongoing. Some of the new features planned for WES4.0 include utilizing AWIPS Build4.0 and developing new functionality to support the Digital Mesocyclone Detection product, the System for Convection Analysis and Nowcasting (SCAN) storm cells table, and the Tornado Rapid Update product. In addition to the planned AWIPS improvements in WES, the WES Scripting Language map generation tool is planned to support sites outside the continental US.

4.1 WES4.0: DMD Support

The Digital Mesocyclone Detection (DMD) product is one of the new additions to AWIPS in OB4. The DMD is based off of 1990's research at the National Severe Storms Laboratory (NSSL) on better tracking and diagnosing a robust range of radar vortices for warning operations (Stumpf et al. 1998). The DMD is a rapid update product, and the data arrays arrive after every radar tilt, where they are appended to a volume scan-based netcdf file storage convention. The netcdf files are accessed by a SCAN DMD table to assist forecasters in analyzing the rotation in severe convective weather. Because the netcdf files needed to display the SCAN DMD are not stored for each tilt, there is no easy way to extract the single tilt information from the netcdf files needed to simulate the real-time processing of the DMD. The preexisting netcdf files are still used, however, to set the start time of the simulation. Fortunately, the raw DMD files are stored for each radar tilt in another location.

Inside the DMD product directories the decompressed raw files are stored in a directory for each elevation angle. These raw files are used in WES to simulate processing of the DMD. Each minute the files are processed using the "radar/generic" directory and a special AWIPS decoder notification. During a simulation, the data is created on the fly, where it is added to the existing volume scan files.

4.3 WES4.0: SCANprocessor Support

Another planned addition to WES4.0 is support for the SCAN storm cells table. The SCAN storm cells table organizes cell output derived from the combined attribute table found in the 1 km composite reflectivity product, along with other radar product inputs such as Vertically Integrated Liquid (VIL), Storm Tracking Information (STI), Mesocyclone (M), and Tornado Vortex Signature (TVS). The SCANprocessor creates SCAN output files in a volume scan storage convention in each radar's "tstorm" directory at the end of each volume scan. The data storage supports WES archiving for case review mode, though the file formats do not easily support the simulation mode in WES.

In order to simulate the arrival of the SCAN storm cells files, the SCANprocessor is initiated using a special SCANprocessor trigger each time a composite reflectivity product is processed. At the end of each volume scan, a new file is created and the SCAN storm cells table updates.

4.4 WES4.0: TRU Support

Another planned addition to WES4.0 is support for the Tornado Rapid Update (TRU) product. The TRU product arrives after every radar tilt, and it provides intermediate Tornado Detection Algorithm output before the end of the volume scan. The TRU products support archival, playback, and simulation in WES, but the directory structures requires the WES code to be modified to properly handle the raw files as well as the unique TRU links in the "current" directory.

5 Conclusions

The Weather Event Simulator project was meant as an interim step toward full simulation and playback capabilities for training and research. WES continues to keep pace with rapid AWIPS development, and new functionality is constantly being added for warning-related training and research, such as FFMP.

The plans for the latest version of WES under development, WES4.0, include updating the AWIPS with WES to OB4.0, as well as including support for the new DMD, SCAN, and TRU products. Following the release of WES4.0, the next major release of WES is planned after the release of AWIPS OB5. In addition to including the

latest AWIPS build, enhance training functionality is planned. Until the AWIPS program develops training and research capability into the AWIPS baseline, CIMMS and WDTB will continue developing future versions of the Weather Event Simulator.

6   Acknowledgements

WES is available cost from by emailing rozumal@ucar.edu.

7   References

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