JP1.12. USES OF HIGH-RESOLUTION MESOSCALE MODELING TO SUPPORT ARMY RESEARCH AND DEVELOPMENT, TESTING, AND EVALUATION

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1. INTRODUCTION

The U.S. Army Test and Evaluation Command (ATEC) Four-Dimensional Weather (4DWX) System is a next-generation meteorological support system that was developed to support Army research, development, test and evaluation in general and ATEC developmental and operational tests in particular. A key component of the 4DWX systems at Aberdeen Proving Ground's Aberdeen Test Center (ATC), Dugway Proving Ground's West Desert Test Center (WDTC), White Sands Missile Range (WSMR), and Yuma Proving Ground (YPG) is the Penn State/National Center for Atmospheric Research (NCAR) Mesoscale Model Version 5 (MM5). Depending on the range, MM5 is used with three or four nested computational domains to achieve the high resolution needed to resolve the local effects of complex terrain and other variations in land-surface characteristics. The 4DWX systems use MM5 in both analysis and forecast modes. Depending on the typical operational needs of the test center, MM5 is executed once or twice per day to generate 24- to 36-hour forecasts to assist in test planning and conduct. Following each 24-hour period, MM5 is run in an analysis mode in which the model solution is nudged toward the observed conditions. The result is a physics-based analysis of the three-dimensional structure of the atmosphere as it evolved throughout the period, which is archived for climatological and forensic purposes. The most recent 4DWX analysis capability is an MM5 analysis of existing conditions every 3 hours coupled with a short-term forecast, which supports real-time test go/no-go decisions. This system, referred to as real-time four-dimensional data assimilation (RT-FDDA), has been prototypes and tested at WDTC, and is on the verge of becoming part of WDTC's suite of operational 4DWX products. RT-FDDA will be implemented at the other Army test ranges over the next 18 months.

Whether used in the forecast or analysis mode, MM5 output is used to drive applications models such as a noise propagation model for ATC artillery tests, a dispersion model for WDTC smoke/obscurants and chemical/biological agent simulant tests, and an air drop model which predicts the impact point for an object released at a time and location from an airplane. MM5 output also provides realistic synthetic atmospheres to support ATEC Virtual Proving Ground (VPG) modeling and simulation.

2. 4DWX SYSTEM CONCEPT

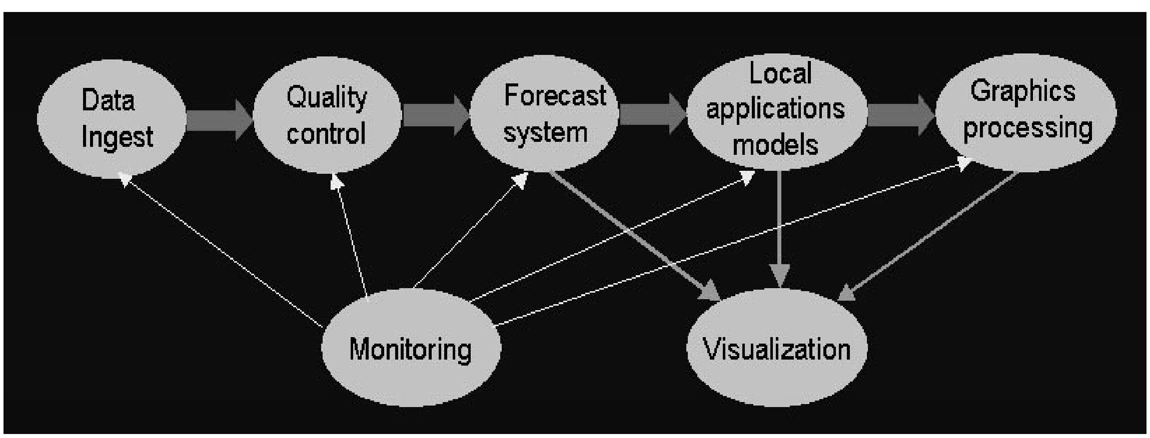

Fig.1 ATEC 4DWX operational system.

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Figure 1 schematically illustrates the operation of the ATEC 4DWX systems. While the system at each test range has some degree of uniqueness in terms of the specific MM5 model forecast cycles, underlying data infrastructure, and types of output products, the overall functionality is as shown in the figure. Meteorological and model data from numerous sources (NOAA Port, local test range, select ftp sites) are automatically ingested into the local 4DWX database. These data are used to initialize MM5 forecasts and to nudge MM5 analyses (continuously in the case of RT-FDDA), and output products are then created for viewing in user-configurable integrated displays and on the web browser. A system monitor tracks all data sources, host and applications processes, network connections, and output product creation and selectively notifies users and system administrators in the event of developing system problems.

Figure 2 provides a more detailed depiction of MM5 operation and coupling with applications models in the 4DWX systems. Meteorological and model data, which are ingested as flat files or in (MySQL) database format, serve a number of applications, including MM5 input. As MM5 runs are executed, an output data conversion and reformatting process is applied dynamically to each completed model output interval (currently set to one hour for all of the ranges). Each output conversion is tailored to the specific requirements of the local applications models. Currently, there are three applications models for which specialized MM5-derived datasets are created: SCIPUFF (Defense Threat Reduction Agency's transport and dispersion model - part of the HPAC suite of models, which uses gridded 3D meteorological fields as input); NAPS (Army Research Laboratory's 2D sound propagation model, which uses a sounding as its meteorological data input); and WindPADS (airdrop model created by Planning Systems Incorporated, which uses GRIB-formatted model data as its meteorological input). NCAR also is currently developing an interface to the ballistic trajectory model (GTRAJ).

3. EXAMPLES OF COUPLED APPLICATIONS

SCIPUFF was the first range applications model coupled with 4DWX MM5 output. The linked MM5/ SCIPUFF modeling capability was required to support WDTC field tests in which military smokes and obscurants or simulants for chemical or biological agents are released to the atmosphere. An output processing routine automatically converts native MM5 binary output to a format suitable for input to the SCIPUFF transport and dispersion model. This conversion occurs each time the operational 00Z and 12Z forecast runs complete. While the WDTC MM5 simulation is nested down to 1.1-km (Domain 4), the SCIPUFF-ready format is created only for the 3.3-km Domain 3, which covers an area of approximately 200 x 200 km. The newly developed RT-FDDA system running at WDTC also produces SCIPUFF-ready data. Figure 3 compares a SCIPUFF run

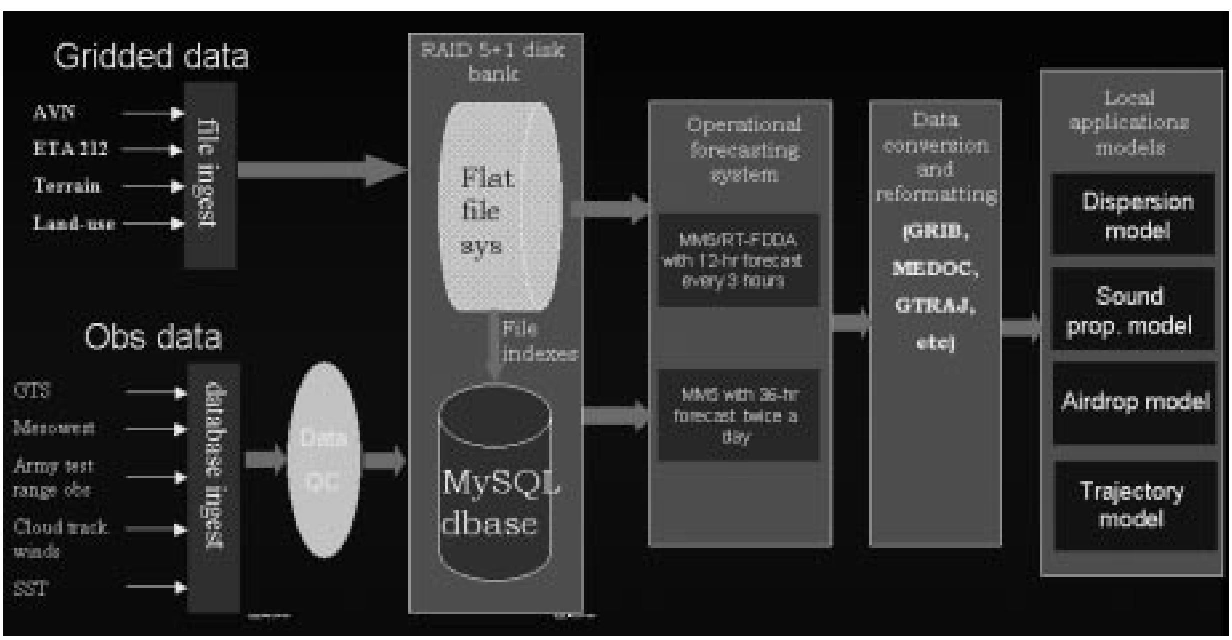

Fig.2 Coupling of MM5 output with local application models.

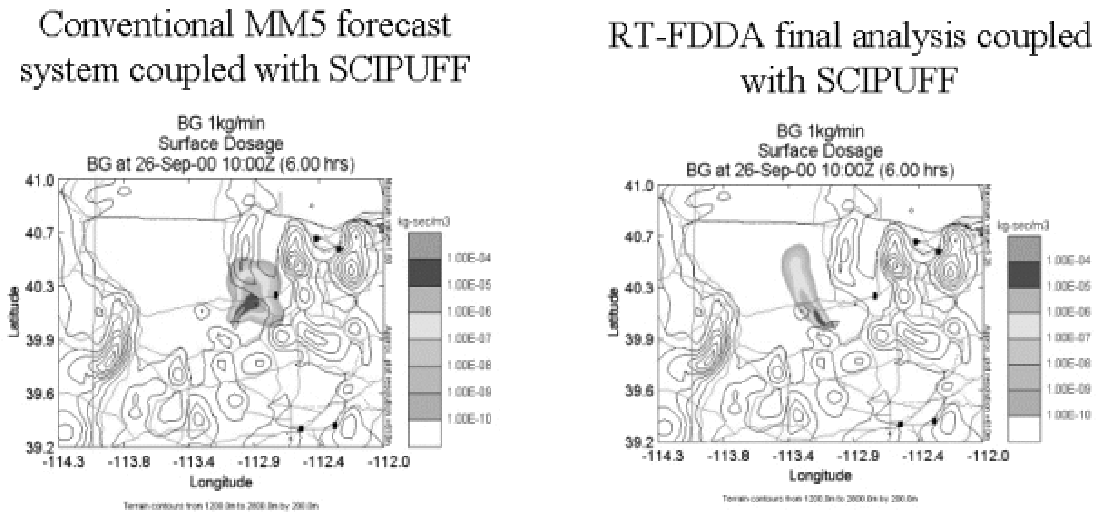

Fig.3 Surface dosage patterns predicted by SCIPUFF using MM5 forecast (left side) and RT-FDDA analysis (right side) as input.oupling of MM5 output.

made using an MM5 forecast by the WDTC 4DWX system as input (left-side of figure) with a SCIPUFF run made using a final RT-FDDA analysis as input (right-side of figure). On the evening of 25 September 2000, a small quantity of BG (a biological agent simulant) was released at the WDTC Target S Grid during a biological agent detector test. The duty forecaster at the time of the release noted that readings from the local mesonet showed that the winds were steady and out of the southeast. The time-integrated simulant concentration (dosage) pattern predicted by SCIPUFF using the RT-FDDA input was consistent with the observed wind pattern and the test director's subjective estimate of the cloud track.

Another coupled application developed for 4DWX consists of using MM5 output to provide the meteorological input for the ARL Noise Assessment and Prediction System (NAPS). In order to make its sound intensity prediction, NAPS requires a single vertical sounding and information about the noise source. NAPS provides range forecasters and test directors with a visual display of noise levels in the surrounding community. Because sound levels resulting from range testing operations such as artillery firings and detonations can have a negative impact on populations surrounding ATC, NAPS is used to identify test periods when sound propagation intensities are likely to fall below critical levels. Prior to 4DWX implementation at ATC, data from a single balloon sounding taken early each morning were used as meteorological input to NAPS. This approach was not very satisfactory because the sounding could be many hours old by the time that testing occurred and/or could be spatially separated by a considerable distance from the test location. The 4DWX MM5-NAPS application overcomes this problem by providing the user with a sounding derived from the MM5 output for both the time and location of the test. Sound intensity footprints may

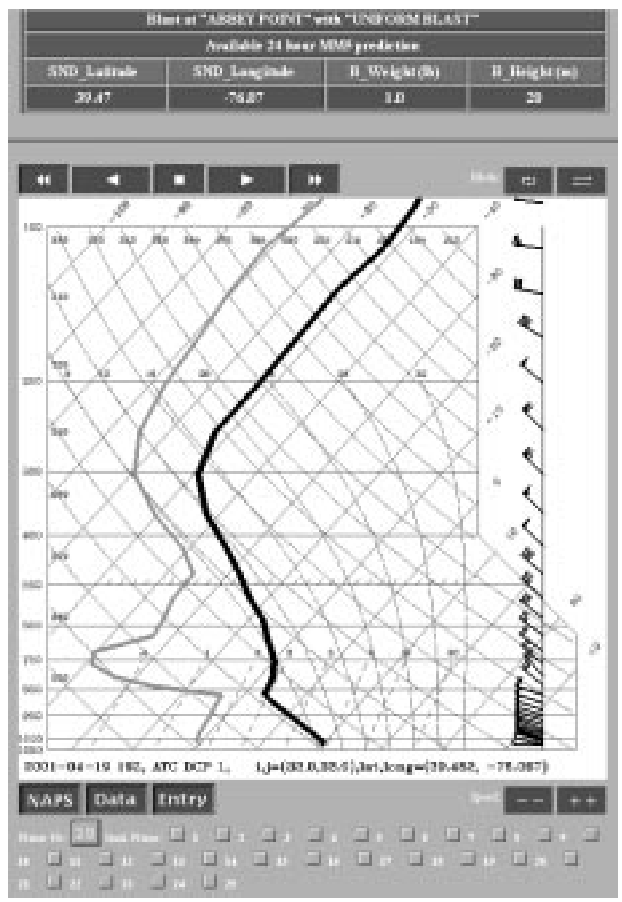

Fig.4 MM5 model derived sounding input to (2D) NAPS sound propagation model.

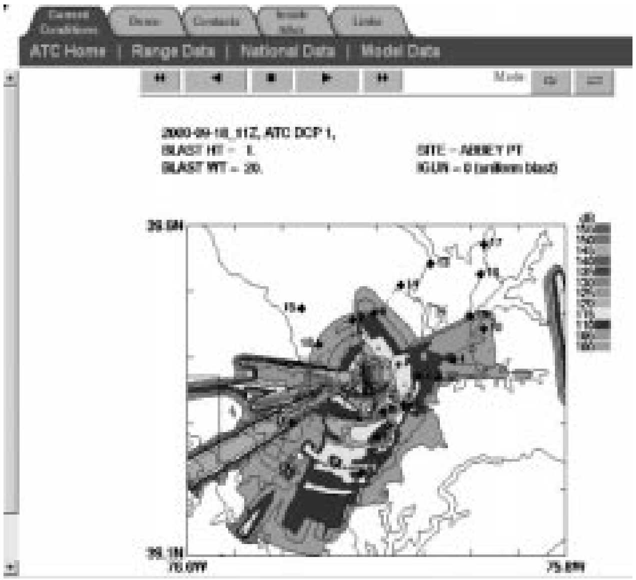

Fig.5 Sound intensity footprint generated from MM5 sounding input to NAPS.

now be forecasted a day in advance, providing valuable guidance to test directors who sometimes must expend considerable resources to set up a test. Figure 4 is an example of an MM5 derived sounding for input to NAPS. As the MM5 forecast for each hour is completed, a derived sounding is created for a pre-defined ATC test location. The user can view a movie loop of these soundings using the movie controls shown in the figure.

In addition to creating derived soundings, the ATC 4DWX system automatically runs the NAPS model with each virtual sounding to produce a sound intensity footprint corresponding to each MM5 forecast hour for pre-defined blast parameters. Figure 5 is an example of NAPS sound intensity output corresponding to the sounding in Figure 4 for a 20-lb charge detonation at Abbey Point. The color-coded legend identifies the sound level in decibels. These sound footprints can be looped over the forecast hours using the indicated movie loop controls.

The sound intensity forecasts generated by NAPS for a pre-determined source at a pre-determined location satisfy most, but not all of the ATC's operational requirements. Consequently, a web-based graphical interface permits the 4DWX system user to generate similar output on the fly for any of the standard test locations on the range or for an arbitrary location. Figure 6 shows how the user may specify blast location, blast materiel specifications, and range of time over which to run the NAPS simulation.

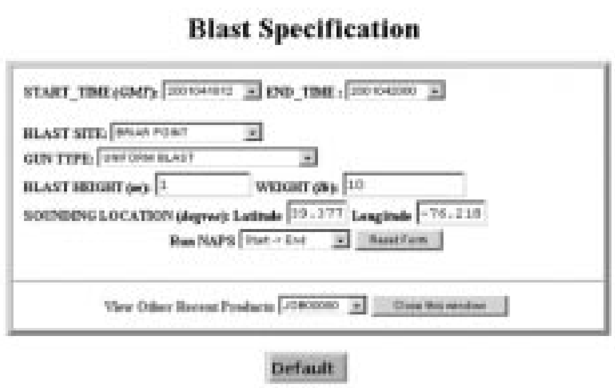

Fig.6 NAPS-MM5 control graphical user interface (GUI).

4. CONCLUSION

The use of 4DWX system MM5 output to drive specific application models is proving to be highly useful at the major Army test ranges. This usefulness is expected to be enhanced as the new RT-FDDA capability is implemented at all ranges because of the improved accuracy of RT-FDDA analyses and near-term forecasts over more traditional MM5 forecasts. Although not discussed in this paper, a newly created MM5 interface to the WindPADS model currently is undergoing testing with live parachute jumping, and an interface to the GTRAJ trajectory model is in the design phase. These coupled applications will not only provide superior guidance to range test operations, but also will allow improved analyses of meteorological effects on test results. For example, the flight of artillery projectiles, which is thought to be highly influenced by the integrated effects of winds along the ballistic path, may be better analyzed with such a coupled system.

While the preliminary results linking high-resolution MM5 forecast and RT-FDDA output with Army range applications models are highly promising, a good deal of effort must go into verifying the accuracy of the MM5 simulations as well as the applications models themselves. To the extent possible, the sensitivity of applications model output to meteorological errors must be determined and translated into uncertainties in the application model estimates. NCAR and ATEC are currently collaborating on a substantial verification and validation effort, which serves both to accredit these systems operationally and to provide objective feedback for evolving system enhancements.