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A REAL-TIME MONITORING/EMERGENCY RESPONSE WORKSTATION USING A 3-D NUMERICAL MODEL INITIALIZED WITH SODAR

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ABSTRACT

Many workstation based emergency response dispersion modeling systems provide simple Gaussian models driven by single meteorological tower inputs to estimate the downwind consequences from accidental spills or stack releases. Complex meteorological or terrain settings demand more sophisticated resolution of the three-dimensional structure of the atmosphere to reliably calculate plume dispersion. Mountain valleys and sea breeze flows are two common examples of such settings. To address these complexities, we have implemented the three-dimensional diagnostic MATHEW mass-adjusted wind field and ADPIC particle-in-cell dispersion models on a workstation for use in real-time emergency response modeling. Both MATHEW and ADPIC have shown their utility in a variety of complex settings over the last 15 years within the Department of Energy's Atmospheric Release Advisory Capability (ARAC[1]) project.

INTRODUCTION

Faster workstations allow utilization of more complex models. Complex models require more data especially three dimensional data. SODAR provides a low cost automated method for obtaining a vertical wind profile. All of these technology improvements provide a foundation for building a real-time monitoring and emergency response workstation.

We chose ARAC's regional scale model which run on large multi-user computers. This model requires an experienced user who understands all of the features of the models. By fixing several of the input parameters, the model is suitable as a workstation based real-time emergency response tool. Many parameters are computed or extrapolated from the input data leaving a "knobless and buttonless" control of the models. This constrained use of the ARAC models allows personnel with limited modeling experience to obtain better and more accurate predictions than the simpler Gaussian models.

This specialized emergency response workstation could support a simple site where only one or two possible release products such as a stack on a tritium handling facility or a soil remediation site with resuspension of known products as the only pathway. The addition of a more complex user interface would allow the workstation to become a training and planning tool similar to a future planned ARAC site workstation.

SYSTEM COMPONENTS

Figure 1 illustrates the essential components of the system. Surface and upper air meteorological measurements are needed to specify the wind field in the vicinity of the facility. Conventional meteorological towers are used to measure the lowest layer near the ground. Each tower has a programmable data logger which formats and transmits data to the workstation once every 15 minutes over dial-up or leased line modems. Most facilities with hazardous material already have real-time meteorological systems in place which could be interfaced with the stand-alone workstation.

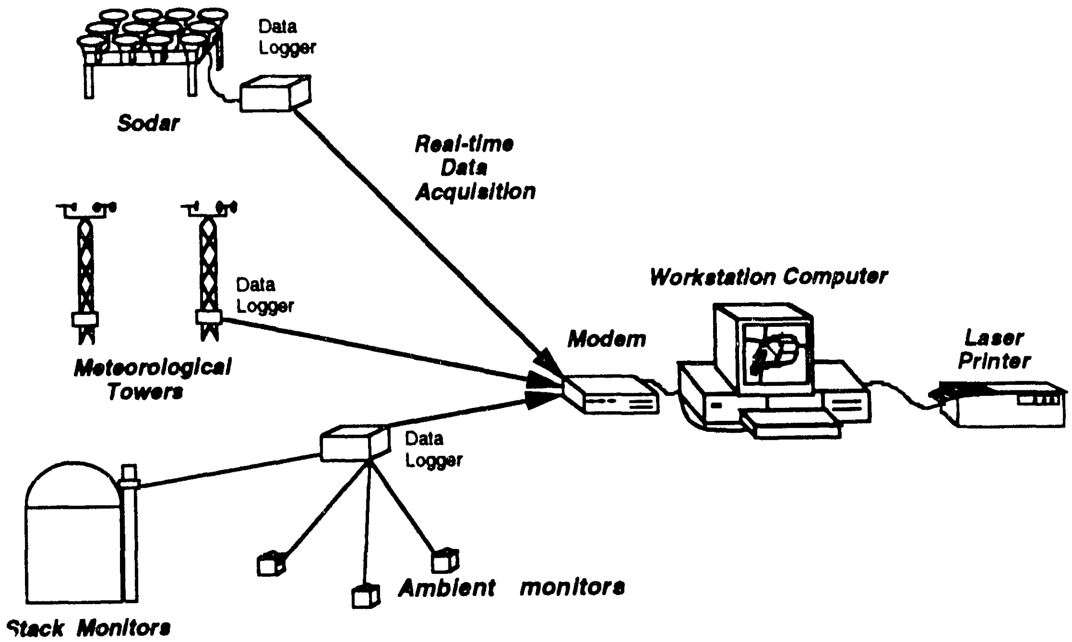

Figure 1. Stand-Alone Monitoring/Emergency Response System

A sound detection and ranging system or SODAR is used to initialize the vertical profile of winds in the model. SODARs emit pulses of sound upward into the atmosphere from a phased-array of speakers. The speakers are then used to measure the faint return sound waves which are reflected downward from the turbulent structure of the atmosphere. The Doppler shift in the frequency of the return signals is used to determine wind speed and direction at several layers in the atmosphere up to 1 km above ground. In addition, the mixing height is derived from the intensity of the return signal. Wind profile data are collected on a local data logger and transmitted to the workstation once every 15 minutes over dial-up modem lines. During heavy rain or high winds when the background noise masks the return sound, the workstation system derives an atmospheric wind profile from a power aw profile projection of a surface towers. Stack and ambient monitors collect real-time measurements of toxic and radiological hazardous materials.

These monitors are networked to a single computer-controlled data logger which would transmit periodically to the workstation. The monitoring data logger can be programmed to send high readings immediately and transmit routine background concentrations at a lower priority. The data logger is a personal computer which runs a laboratory automation package with hundreds of interface modules for most laboratory instruments.

The workstation computer uses a RISC-class UNIX-based platform with color graphics monitor, disk, modems and laser printer. This configuration is common in engineering offices which use complex Fortran applications. The fast personal computers do not calculate fast enough to support our real-time 3-d dispersion models. The multitasking capability of UNIX is essential for the concurrent data collection effort, the dispersion modeling and producing graphical output on the laser printer.

DISPERSION MODEL

A three-dimensional, diagnostic numerical model, employs the following series of three codes (figure 2)

MEDIC - Meteorological data interpolation code
MATHEW - Mass-adjusted three-dimensional wind field
ADPIC - Atmospheric dispersion by particle-in-cell

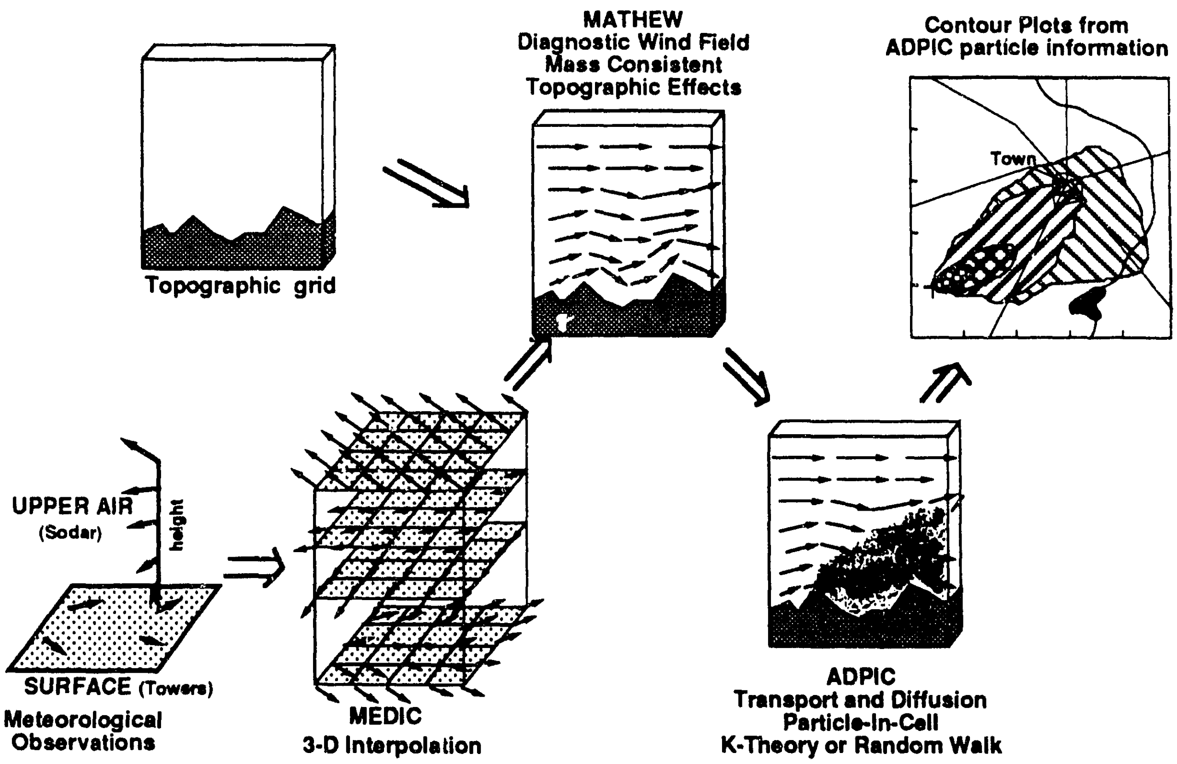

Figure 2. MATHEW / ADPIC Modeling System

Input for the models come from surface meteorological towers, sodar and radiological monitors. Rawinsonde upper air data are not as easily integrated into a workstation system where as SODAR data can be quickly obtained to initialize MEDIC's vertical wind profile. MEDIC uses an inverse-distance-squared (1/R2) weighting of the wind speed and direction measurements in combination with boundary layer power laws to initialize the horizontal wind field for MATHEW. MATHEW minimizes the divergence in the initial wind field by adjusting the horizontal vectors and generating vertical winds according to mass consistency.

The stack monitor's data logger provides source rates for the dispersion model, ADPIC. ADPIC uses this wind field to transport the release from single or multiple sources over the grid. Diffusion is accomplished by either gradient (K-theory) or Monte Carlo schemes using thousands of Lagrangian marker particles. Sources may be either puffs or plumes with time-varying release rates. Half-life decay, particle-size-dependent settling, dry deposition and rainout are computed for each time step for each source. Post processing graphics routines draw the contours of interest, such as dose, air concentration or deposition over maps which are digitized for the region.

Model outputs include contoured isopleths displayed on site geography or plume densities shown over 3-D color shaded terrain. The models are automatically updated every 5-minutes to provide the emergency response manager with a continuous display of potentially hazardous ground-level conditions if an actual release were to occur. Model run time is typically less than 2 minute on 6 megaflop (~30 MIPS) workstations. Data acquisition, limited by dial-up modem communications, requires 3 to 5 minutes.

CONCLUSIONS

The cost, reliability and performance of workstations provide an opportunity to utilize advanced real-time dispersion modeling for facility monitoring and emergency accident assessment. Near continuous (15 minute update resolution) displays of real-time assessments for ambient facility effluent dispersion conditions can reside on workstation displays in facility control rooms and emergency coordination centers. The workstation in the emergency response center now can perform tasks which previously required very large computers and the results were available only in a post accident evaluation phase.

REFERENCES

1. T.J. Sullivan, ARAC: Evolution by accident, in Topical Meeting on Emergency Response Modeling, Chicago, 1988, American Nuclear Society.

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