UCRL-JC-146205

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Advancement of a Real-Time Atmospheric Dispersion Modeling System

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Submitted to the American Meteorological Society's 12th Joint Conference on the Applications of Air Pollution Meteorology, Norfolk, VA, May 20–24, 2002

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UCRL-JC-146205-EXT-ABS

1.1 Advancement of a Real-Time Atmospheric Dispersion Modeling System

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1. INTRODUCTION

This paper describes new capabilities which are being incorporated into the Department of Energy's operational National Atmospheric Release Advisory Center (NARAC) at Lawrence Livermore National Laboratory (LLNL). The NARAC system is used to provide detailed assessments of the consequences of atmospheric releases of hazardous materials for real-time emergency response, pre-planning and post-incident assessments, and research.

At the core of the NARAC system are the coupled atmospheric data assimilation and dispersion models ADAPT/LODI (Sugiyama and Chan, 1998; Nasstrom et al., 2000) and an in-house version of the Naval Research Laboratory's COAMPS weather forecast model (Hodur, 1997).

The NARAC models are supported by a real-time meteorological data acquisition system and extensive databases of geography, terrain, maps, population, source terms (radiological, chemical, biological), material properties, health-risk levels, and protective action guidelines. Internet- and Web-based software tools provide remote access to NARAC (C. Foster, et al., 2000) to request and display plume predictions as shown in Figure 1.

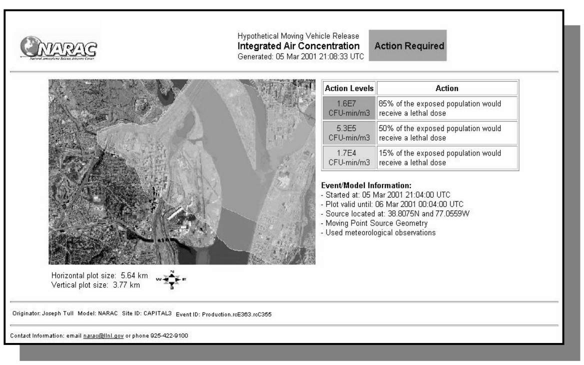

Figure 1. NARAC plot including plume, geographic data layers, and health risk level information.

2. PHYSICAL PROCESSES

New capabilities are being added to the core ADAPT/LODI models, with a focus on the incorporation of spatially inhomogeneous physics. This includes the development of turbulence parameterizations derived from surface-energy budget methods (van Ulden and Holtslag, 1985), which utilize standard meteorological observations, land-use data, and/or weather prediction model output. Velocity variance data are incorporated when available.

Ultraviolet decay of biological agents has been added to the models, coupled to biological and chemical material-property and health-risk level databases. A particle-size and rain-rate dependent precipitation-scavenging algorithm is being tested and a new resuspension capability is under current development (Loosmore, 2002).

NARAC also continues to evaluate and refine the ADAPT/LODI models using its extensive archive of tracer experiment data (K. Foster et al., 2000), as shown in the complex terrain example in Figure 2.

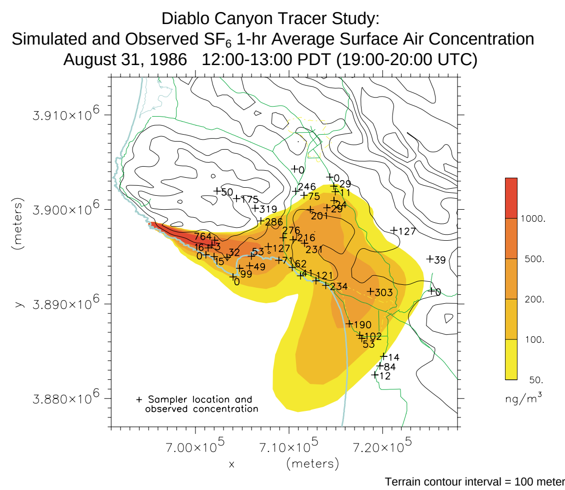

Figure 2. ADAPT/LODI simulations compared with Diablo Canyon Power Plant tracer experiment (DOPPTEX) data

3. URBAN MODELS

Urban parameterizations have been developed, which simulate the area-averaged effects of metropolitan areas on flow and dispersion. ADAPT contains an urban model, which parameterizes the reduction of the mean velocity and the increased turbulence in the urban roughness sublayer (Leone et al., 2001). An urban canopy model has been incorporated into COAMPS (Chin et al., 2000), which includes drag, turbulent production, anthropogenic and rooftop heating, and radiation balance terms. These urban models are being evaluated using DOE's URBAN 2000 field experiment (see Urban Symposium papers).

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USGS land-use/land-cover databases and sampling tools have been developed in the NARAC system to provide the input required to drive the urban models.

4. PERFORMANCE AND PARALLELIZATION

Parallelization of the models is used to improve computational performance for high-resolution simulations or complex source applications. Parallel implementation is based on a combination of MPI and OpenMP, in order to support both multi-processor and massively-parallel computing platforms.

LODI has been parallelized by taking advantage of the inherently parallel nature of Lagrangian random-walk dispersion models (Larson and Nasstrom, 2001).

A parallel version of the COAMPS model was developed in a joint LLNL and Naval Research Laboratory collaboration (Mirin et al., 2001), based on a horizontal domain decomposition. This version is being used operationally by the Navy and will be integrated into the NARAC system.

5. RAPID-RESPONSE MODELS

NARAC is incorporating rapid-response models as part of its deployable system. These models are intended to be used for scenario planning, initial response, or when a connection to the NARAC central system is not available. Integration of the HOTSPOT radiological modeling capability (Homann, 1994) has been completed and work has begun on incorporating an industrial chemical model and a two-dimensional puff model.

6. ONGOING DEVELOPMENT EFFORTS

NARAC is currently working on extending its multi-scale modeling capability. An LLNL-developed computational fluid dynamics (CFD) model FEM3MP (Chan and Stevens, 2000), which explicitly models buildings, has been used by NARAC for special event planning and site vulnerability analysis. In demonstration simulations, ADAPT and COAMPS output fields have been used to drive FEM3MP simulations.

Another topic of great interest is the investigation and development of approaches to incorporate sensor data into situation awareness displays and dispersion calculations. The long-term goal is to develop tools which use this data for source characterization and optimization plume prediction.

NARAC is also developing approaches for linking its outdoor modeling capabilities with other systems. A demonstration capability was recently built to couple to a subway emergency response system, which provides NARAC with source terms of the release rates from subway vents and exits.

This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

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