WSRC-MS-96-0766

CONF-970419--9

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A document prepared for SIXTH TOPICAL MEETING ON EMERGENCY PREPAREDNESS AND RESPONSE, AMERICAN NUCLEAR SOCIETY at San Francisco, CA, USA from 4/22/97 - 4/25/97.

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APPLICATION OF A THREE-DIMENSIONAL PROGNOSTIC MODEL DURING THE ETEX REAL-TIME MODELING EXERCISE: EVALUATION OF RESULTS

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SUMMARY

Increases in computing capabilities and ready access to large-scale model output make it possible to employ advanced three-dimensional prognostic models to forecast the long-range transport of toxic or radioactive gases for emergency response. The Savannah River Technology Center (SRTC) of the U.S. Department of Energy's Savannah River Site demonstrated this during the European Tracer EXperiment[1,2] (ETEX). ETEX, conducted in the Fall of 1994, provided an opportunity to evaluate the performance of models for long-range atmospheric pollutant transport and dispersion. A comparison of SRTC forecast results for the first ETEX experiment with measured surface tracer gas concentrations shows that the predicted plume is transported too quickly and surface concentrations are low. However, modeling studies show that the forecast performance is significantly improved if convective parameterization is not employed.

MODELING APPROACHES

The SRTC employs the Colorado State University Regional Atmospheric Modeling System (RAMS)[3] and a Lagrangian Particle Dispersion Model (LPDM).[4] RAMS is a primitive equation three-dimensional atmospheric model with a terrain-following vertical coordinate system. LPDM simulates dispersion based upon the flow and turbulence fields calculated by RAMS.

The ETEX model domain encompasses most of Western Europe (see Figure 1). For the ETEX real-time modeling exercise, the US National Weather Service Aviation Model (AVN) 72-hour forecast was used to produce the initial and boundary conditions for RAMS. Some of these SRTC results have been reported previously[5,6,7]. The current model evaluation effort involves the use of model output data from the European Centre for Medium Range Weather Forecasts (ECMWF). The RAMS model involves a single grid with uniform 75 km horizontal mesh spacing and a stretched vertical mesh spacing with the first grid point at 50 m above ground level (AGL) and a maximum grid spacing of 1250 m near the model top at approximately 19.7 km AGL. A time step of 60 s was employed. RAMS was run in the nonhydrostatic mode with second-order turbulence parameterization, both with and without convective parameterization.

RESULTS

The initial step in the SRTC model evaluation was to rerun the forecast for the ETEX release of 10-23-94 using the ECMWF analyses as initial and boundary conditions for RAMS. As required by the ETEX model evaluation protocol, the forecast was executed for 90 hours following the release time of 16 UTC. The wind field from RAMS was then used in the LPDM particle dispersion model to simulate the transport and diffusion of the tracer gas. Figure 1 shows contours of the predicted tracer surface concentrations at 16 UTC, 48 hours after the beginning of the release. Also shown are measured surface concentrations (etex v1.1.960505) at approximately 135 sampling stations; these concentrations are three-hour averages over the period from 15 to 18 UTC. The contours show the plume located over southern Norway and Sweden and over the Baltic Sea just north of Poland. Additional low concentration contours are seen in southern Poland, western Slovenia, and central Hungary. The sampler measurements, indicated by the shaded boxes in Figure 1, show the main part of the plume to be located over Denmark, western Germany, western Poland, the Czech Republic, Slovenia, and Hungary. In general, the predicted plume is too far to the north and west and the surface concentrations are too low. This result is consistent with that obtained during ETEX in 1994 using the analyses from AVN.[5] Thus, the replacement of AVN model output with ECMWF model output for initial and boundary conditions did not result in a significant change in the RAMS/LPDM analyses. This suggests that the differences between the model predictions and the measured data are more likely the fault of the model than the boundary conditions.

One possible explanation for the results shown in Figure 1 is that the particles are lifted too much as they are transported across the domain. This could account for the low concentrations predicted at the surface; it could also explain the too rapid movement of the plume, owing to the particles being carried by higher wind speeds aloft. To test this hypothesis, a modeling study was performed in which the RAMS option for employing a parameterized convection model was turned off and the forecast rerun. The convective parameterization model in RAMS is used to help the model develop vertical motion when the horizontal grid spacing is too coarse for the model to develop its own convective circulation. This model redistributes heat and moisture vertically when the model produces a region that is superadiabatic or convectively unstable. The 75 km grid spacing of the ETEX model should benefit from using this convective parameterization; omitting it should reduce the predicted vertical motion. The results of the RAMS/LPDM forecast without convective parameterization are shown in Figure 2 for the same time as Figure 1. These results are an improvement over Figure 1. The predicted plume is closer to the measured plume and the surface concentrations are higher. The lateral spread of the predicted plume corresponds well to the measurements, though the position is still somewhat to the west and the longitudinal spread is too narrow. Nevertheless, the results are qualitatively improved when convective parameterization is not invoked. Though not shown, this conclusion also holds at 24, 36, and 60 h following the release.

To further support the qualitative comparison illustrated in Figures 1 and 2, a quantitative assessment was performed of the RAMS/LPDM results with and without convective parameterization using ECMWF model output as initial and boundary conditions. The Normalized Mean Square Error (NMSE) was calculated for both cases using measured concentration data from 20 of the 160 sampling stations. The NMSE is the sum of the squares of the concentration errors divided by the number of observations and normalized by the overall averages of the measured and predicted concentrations. For the "convective" case shown in Figure 1, the NMSE is 16.7. The NMSE for the "non-convective" case shown in Figure 2 is 8.7, almost a factor of two lower. This underscores the observation that, for the conditions of the first ETEX release, a better simulation is obtained when convective parameterization is not used. Further evaluation is required to develop a complete explanation for this observation; this will be discussed at the conference.

ACKNOWLEDGMENT

The information contained in this document was developed during the course of work conducted under contract No. DE-AC09-89SR18035 with the U.S. Department of Energy.

REFERENCES

1. W. Klug, F. Girardi, G. Graziani, and K. Nodop, "ETEX, A European Atmospheric Tracer Experiment," *Proceedings of the American Nuclear Society Topical Meeting on Environmental Transport and Dosimetry* , Charleston, SC (1993).

2. F. Girardi, "ETEX: The European Tracer Experiment: The Achievement of the In-Field Campaign," *Proceedings of the American Nuclear Society Fifth Topical Meeting on Emergency Preparedness and Response,* Savannah, GA (1995).

3. R.A. Pielke, W.R. Cotton, R.L. Walko, C.J. Tremback, W.A. Lyons, L.D. Grasso, M.E. Nichols, M.D. Moran, D.A. Wesley, J.T. Lee, and J.H. Copeland, "A comprehensive meteorological monitoring system - RAMS," *Meteorology and Atmospheric Physics*, **49**, 69-91 (1992).

4. R.T. McNider, M.D. Moran, and R.A. Pielke, "Influence of Diurnal and Inertial Boundary Layer Oscillations On Long Range Dispersion," *Atmos. Environ.*, **22**, 2445-2462 (1988).

5. R.P. Addis, D.P. Griggs, and J.D. Fast, "Prognostic Modeling of Atmospheric Pollutant Transport in Europe," *Proceedings of the American Nuclear Society Fifth Topical Meeting on Emergency Preparedness and Response*," Savannah GA (1995).

6. D.P. Griggs, "Prognostic Modeling of Long-Range Atmospheric Pollutant Transport for ETEX," *Preprints, American Meteorological Society Ninth Joint Conference on the Applications of Air Pollution Meteorology*, Atlanta GA (1996).

7. D.P. Griggs and R.P. Addis, "Forecasting Long-Range Atmospheric Pollutant Transport and Diffusion: Approaches and Issues," *Trans. Am. Nucl. Soc.*, 74, 55-58 (1996).

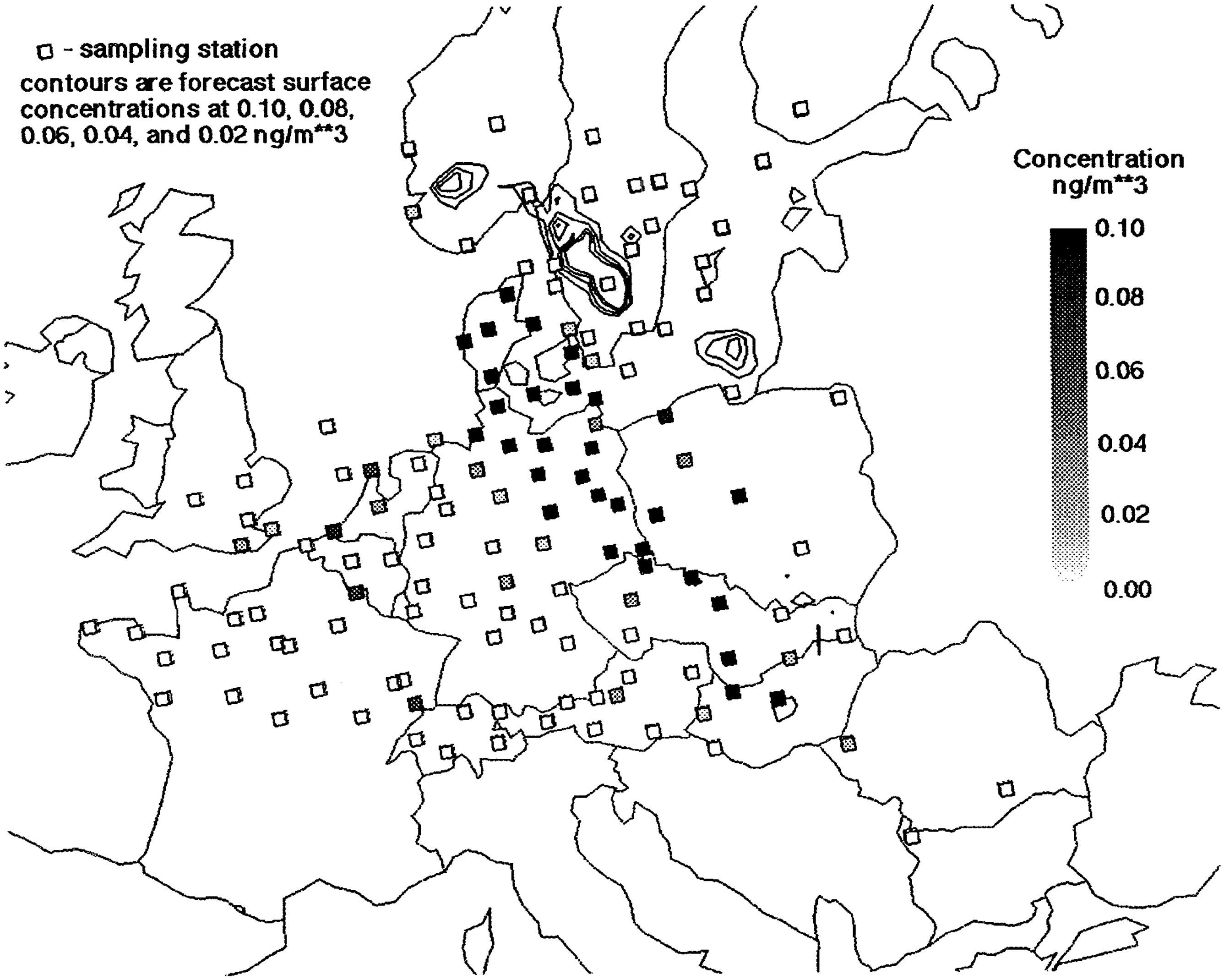

Figure 1. Comparison of measured tracer gas surface concentrations from the first ETEX release (etex v1.1.960505; 3-hour averages for 15-18 UTC, 10/25/94) and predicted concentration contours (RAMS/LPDM with convective parameterization) at 16 UTC, 10/25/94 (48 h after the release).

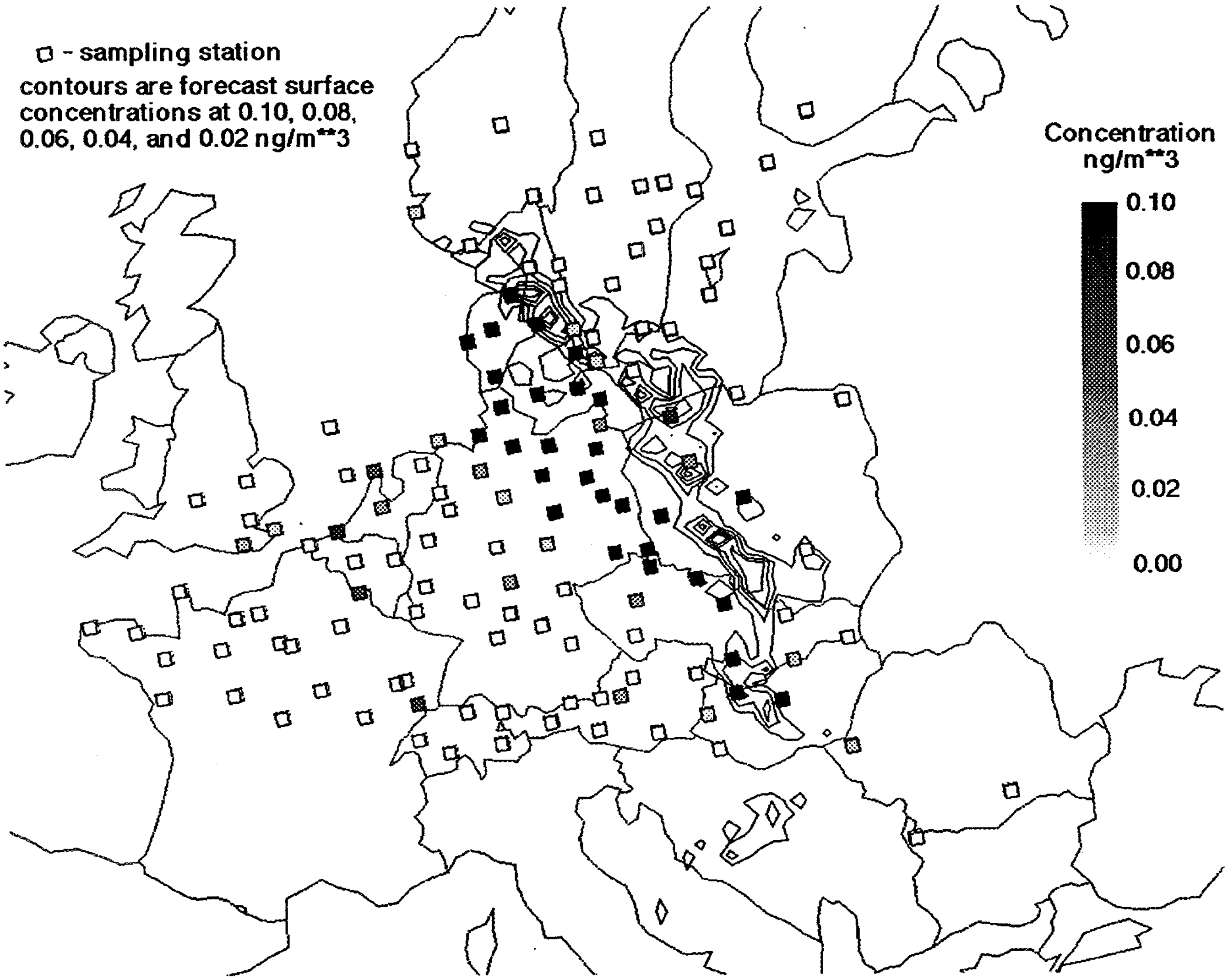

Figure 2. Comparison of measured tracer gas surface concentrations from the first ETEX release (etex v1.1.960505; 3-hour averages for 15-18 UTC, 10/25/94) and predicted concentration contours (RAMS/LPDM <u>without</u> convective parameterization) at 16 UTC, 10/25/94 (48 h after the release).