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Numerical Weather Forecasting at the Savannah River Site

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by

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NUMERICAL WEATHER FORECASTING AT THE SAVANNAH RIVER SITE

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1. INTRODUCTION

Weather forecasts at the Savannah River Site (SRS) are important for applications to emergency response. The fate of accidentally-released radiological materials and toxic chemicals can be determined by providing wind and turbulence input to atmospheric transport models. This operation has been routinely performed at SRS using the WIND System[1], a system of computer models and monitors which collect data from towers situated throughout the SRS. However, the information provided to these models is spatially homogeneous (in one or two dimensions) with an elementary forecasting capability. This paper discusses the use of an advanced three-dimensional prognostic numerical model to provide space and time-dependent meteorological data for use in the WIND System dispersion models. The extensive meteorological data collection at SRS serves as a ground truth for further model development as well as for use in other applications.

A prognostic mesoscale model, the Regional Atmospheric Modeling System (RAMS)[2], is used to provide these forecasts. Use of RAMS allows for incorporation of mesoscale features such as the sea breeze, which has been shown to affect local weather conditions[3]. This paper discusses the mesoscale model and its configuration for the operational simulation, as well as an application using a dispersion model at the SRS.

2. OPERATIONAL DESIGN

Information regarding RAMS, a primitive-equation finite-difference model, is extensively available in the literature[2]. Three-dimensional initial conditions of meteorological fields are generated from large-scale Eta[4] analyses, a National Weather Service forecast model produced using weather conditions at 00 and 12 Greenwich Mean Time (GMT). Time-dependent lateral boundary conditions are also obtained from these fields (every 6 hours) by imposing the large-scale data at the RAMS boundary.

The operational scheme uses RAMS to generate meteorological fields at a mesoscale resolution (20 km). Model domain selection is important to ensure inclusion of topographic features relevant to the wind-field generation. The simulation region is centered about the SRS and includes parts of the Appalachians and Atlantic Ocean to allow for the development of mountain slope flow and sea breezes. Although the simulation time is 30 hours, only the final 24 hours are retained as a forecast product, allowing for a 6-hr "spinup" time in which the boundary layer and thermal structure within the atmosphere are developed.

Since large-scale data becomes available 4 to 6 hours after the analysis time, RAMS uses the 06 and 18 GMT Eta forecast for its initial conditions. The simulation takes ~3 hours to complete in its present configuration on the SRS Cray supercomputing system. Thus, the 24-hr forecast (beginning 12 hours after the Eta analysis) may become available several hours before needed. This allows for future refinement in grid size and spacing. Although numerous meteorological fields are generated by RAMS, variables needed for the dispersion model application discussed here are limited to horizontal wind speed components and turbulence, saved at hourly intervals. Automation of this procedure at regularly scheduled times is performed using a series of scripts involving an IBM workstation and the Cray.

3. APPLICATION

Forecast information is supplied to Puff-Plume[5], a dispersion model characterizing releases as Gaussian puffs or plumes simulated as a series of straight-line segments from the time of release. For this purpose, RAMS quantities were interpolated to the SRS geographical center at three different model levels. Before the existence of the RAMS forecast product, a Model Output Statistics (MOS) product (no longer available) or persistence was used if observational data did not exist. In the current configuration, the simulated data is utilized only when observations do not exist.

Plume transport is shown in Fig. 1 for a release at 12 LST, 20 May 1998. Three different footprints are illustrated, with solid circles denoting the use of observed data, and open circles denoting forecast data. The simulation is actually performed 4 hours after real-time (16 LST). Therefore, for two of the footprints, observed data is available for the first 4 hours only of the Puff-Plume 12-hr simulation. The use of persistence over the final 8 hours is clearly illustrated by the northern-most trajectory. Addition of the RAMS data results in a plume direction which shifts to easterly, slows down after 10 hours, then turns back to northeasterly for the final 2 hours. Use of observational data after it becomes available (simulation performed after 00 LST, 21 May) indicates a plume with variable movement lying between the two forecast trajectories.

4. SUMMARY

The operational predictive capabilities of the SRS dispersion codes benefit from use of data fields created with a mesoscale model. The mesoscale model provides both meteorological information in data-sparse regions, and forecast winds. While the local WINDS tower data is useful at SRS, diagnostic predictions of effluent releases or transport for a source many kilometers from the site will necessarily suffer as a result of assuming local winds for input into the dispersion models. The procedure described here is applied at SRS and surrounding regions, but is also adaptable to other regions.

Application of the forecast fields in a hypothetical release situation using a simple Gaussian dispersion model revealed differences in predicted plume location using the RAMS fields. Improvements in predicted plume location relative to calculations using persistence depend upon the accuracy of the input wind fields.

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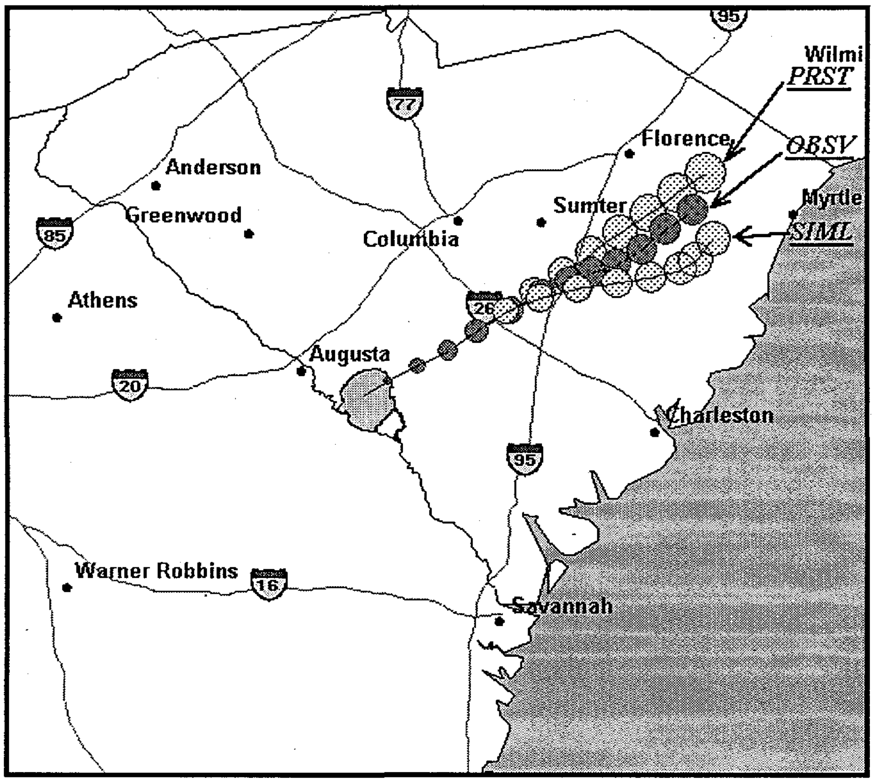

Figure 1: Sample output from Puff-Plume for a transport simulation beginning at 12:00 LST, 20 May 1998. An instantaneous 1.0 Ci release of Pu^{239} is assumed. Successive circles denote puff locations in hourly increments over a 12-hr period from the time of release. Circles with dark shading indicate times when observations are known, while the lighter shading denotes the use of forecast information. The three footprints (from north to south) represent the use of persistence after 4 hours of simulation (PRST), the use of observations at all times when they later became available (OBSV), and the use of RAMS-generated winds and turbulence at SRS after 4 hours of simulation (SIML).