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Ozone Transport Assessment Group: Ozone Modeling

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ABSTRACT

The Environmental Council of the States, in conjunction with the U.S. Environmental Protection Agency, established the Ozone Transport Assessment Group (OTAG). The goal of OTAG is to identify and recommend a strategy to reduce transported ozone and its precursors which, in combination with other measures, will enable attainment and maintenance of the ozone NAAQS in the eastern U.S. Ozone modeling will be performed as part of OTAG to assess the air quality impact of possible control strategies. The purpose of this paper is to describe the OTAG modeling activities.

INTRODUCTION

Summertime weather conditions can lead to elevated ozone concentrations which approach or exceed the National Ambient Air Quality Standards (NAAQS) for ozone across a large portion of the eastern U.S.[1,2,3] These elevated concentrations, through transport, make it difficult for individual urban areas to demonstrate attainment of the ozone NAAQS. These urban areas have found that it will take significant reductions in both local ozone precursor emissions and incoming (transported) ozone and ozone precursor concentrations in order to show attainment.

In recognition of the transport problem, the U.S. Environmental Protection Agency (USEPA) established a two-phase program for states to develop approvable ozone State Implementation Plans (SIPs). In a policy memorandum dated March 2, 1995, USEPA outlined the major elements of this program.[4] Phase I requires states to complete pre-November 1994 SIP requirements, submit regulations sufficient to meet the initial Rate of Progress requirements, and submit modeling analyses. Phase II calls for a two-year (1995-1996) consultative process to assess national and regional strategies to deal with ozone transport in the eastern U.S., and subsequent revisions of local control plans, as necessary, based on any new national or regional strategies.

To accomplish the Phase II consultative process, the Environmental Council of the States (ECOS), in conjunction with USEPA, established the Ozone Transport Assessment Group (OTAG). The goal of OTAG is to identify and recommend a strategy to reduce transported ozone and its precursors which, in combination

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with other measures, will enable attainment and maintenance of the ozone NAAQS in the eastern U.S. A number of criteria will be used to select the strategy including, but not limited to, cost-effectiveness, feasibility, and impacts on ozone levels. A modeling study will be performed to quantify the ozone impacts. This study consists of the following five tasks:

* prepare appropriate photochemical model inputs for several periods of elevated ozone concentrations (i.e., ozone episodes);
* perform basecase photochemical model simulations for these episodes;
* perform an operational evaluation of the basecase simulation to assess model performance;
* perform sensitivity tests to examine the response of the model to changes in certain model inputs; and
* apply the model to examine the effect of current, expected, and possible additional national and regional control strategies on the transport of ozone and ozone precursors in the eastern U.S.

OVERVIEW OF MODELING SYSTEM

The modeling study will employ the following models:

EMS-95: The EMS-95 emissions model will be used to provide emissions inputs for the photochemical models.[5] EMS-95 spatially distributes, temporally allocates, and chemically speciates user-supplied emissions for point and anthropogenic area sources; and calculates emissions for motor vehicles for each grid cell and each hour, and then chemically speciates them.

The primary emissions database is USEPA's new National Inventory, which is the product of a recent effort initiated by ECOS and USEPA. BEIS2 biogenic emissions will be used. Base year inventories for each episode year (for basecase modeling) and future year inventories for 1999 and 2007 (for strategy modeling) will be derived from the National Inventory, which reflects 1990 conditions.

RAMS: The RAMS prognostic meteorological model will be used to provide meteorological inputs for the photochemical models.[6] Observed meteorological data will be incorporated into the RAMS predictions using a four-dimensional data assimilation (FDDA) procedure.

Another prognostic meteorological model, SAIMM (which is derived from an earlier version of RAMS), has already been used to prepare meteorological fields for the July 1988 episode. Given the similar lineage of RAMS and SAIMM and the limited resources of this project, the existing SAIMM fields will be used for this episode.

UAM-V: Version 1.23 of the UAM-V photochemical grid model will be used to predict ozone and ozone precursor concentrations.[7] UAM-V is an enhanced version of the current USEPA guideline version of the UAM model. It incorporates many new features including variable nested-grids, a user-defined vertical grid structure, updated dry deposition, updated photolysis rates, a Plume-in-Grid (PiG) algorithm for treating point source plumes, and use of three-dimensional inputs for meteorological variables, such as, temperature, water, vapor, and pressure.

A select number of simulations will also be performed with ROM to confirm the UAM-V results and to provide a "bridge" to the extensive set of ROM results which have been used by a number of states for their current SIP development efforts.

EPISODES

The OTAG modeling will examine transport during periods of elevated ozone concentrations in the eastern U.S. Due to time constraints and the limited level of resources currently identified, the modeling will only be able to consider four episodes. The primary criteria for selecting these episodes are consistency with current SIP modeling and existence of interregional transport. The following four episodes have been selected for modeling:

July 1 - 15, 1988
July 13 - 21, 1991
July 20 - 30, 1993
July 7 - 18, 1995

Examination of surface ozone concentration maps, synoptic weather maps, and trajectory analyses show that these episodes all involve intraregional and interregional transport.

MODELING DOMAIN AND GRID CONFIGURATION

An initial consideration in setting-up a photochemical grid model is to define the spatial extent of the modeling region, the coordinate system, and the horizontal and vertical grid resolution. The grid structure for UAM-V in the OTAG modeling is as follows:

Domain: SUPROXA domain (see Fig. 1)

Coordinate System: latitude/longitude

Horizontal Resolution: 12 km (Grid A) / 36 km (Grid B)

Vertical Resolution: 7 layers (Grid A) / 5 layers (Grid B)

This grid configuration will result in 19,102 grid cells in the surface layer and 125,650 grid cells in total. (Note: even though a latitude/longitude coordinate system is used, the horizontal grid resolution is expressed in terms of the UTM equivalents because it is easier to comprehend.)

MODEL APPLICATION

Three types of modeling analyses will be conducted. First, basecase simulations will be performed and compared to ambient measurements for the purpose of evaluating model performance. A number of numerical and graphical performance measures will be considered. The performance evaluation will focus on the model's ability to reproduce the magnitude, spatial pattern, and temporal profile of observed ozone and ozone precursor concentrations.

Second, several sensitivity tests will be performed to provide some general information to guide the development of control strategies. A desirable feature of these tests is that the model inputs can usually be prepared quickly and easily; thereby, allowing many model simulations to be conducted.

Third, actual control strategies will be modeled. Two sets of strategies will be identified: Phase I and post-Phase I. The Phase I strategy includes all existing (or expected) national, regional, and nonattainment area control measures. Examples of these measures are national programs for motor vehicles, commercial and consumer solvents, architectural coatings, and small engines; the low emission vehicle and NOx control initiatives in the Ozone Transport Region; and individual state 15% plans. The post-Phase I strategies include possible additional national and regional control measures.

CONCLUSIONS

The OTAG modeling study will provide information to help answer questions about the significance of ozone and ozone precursor transport, and the relative effectiveness of controls (on both a pollutant and geographic basis) in reducing transported ozone and ozone precursor concentrations in the eastern U.S. based on present understanding of the science. The study is unique in its attempt to both bring together the numerous stakeholders and employ state-of-the-art models and up-to-date data bases, which should enhance the political and technical acceptability of the modeling results.

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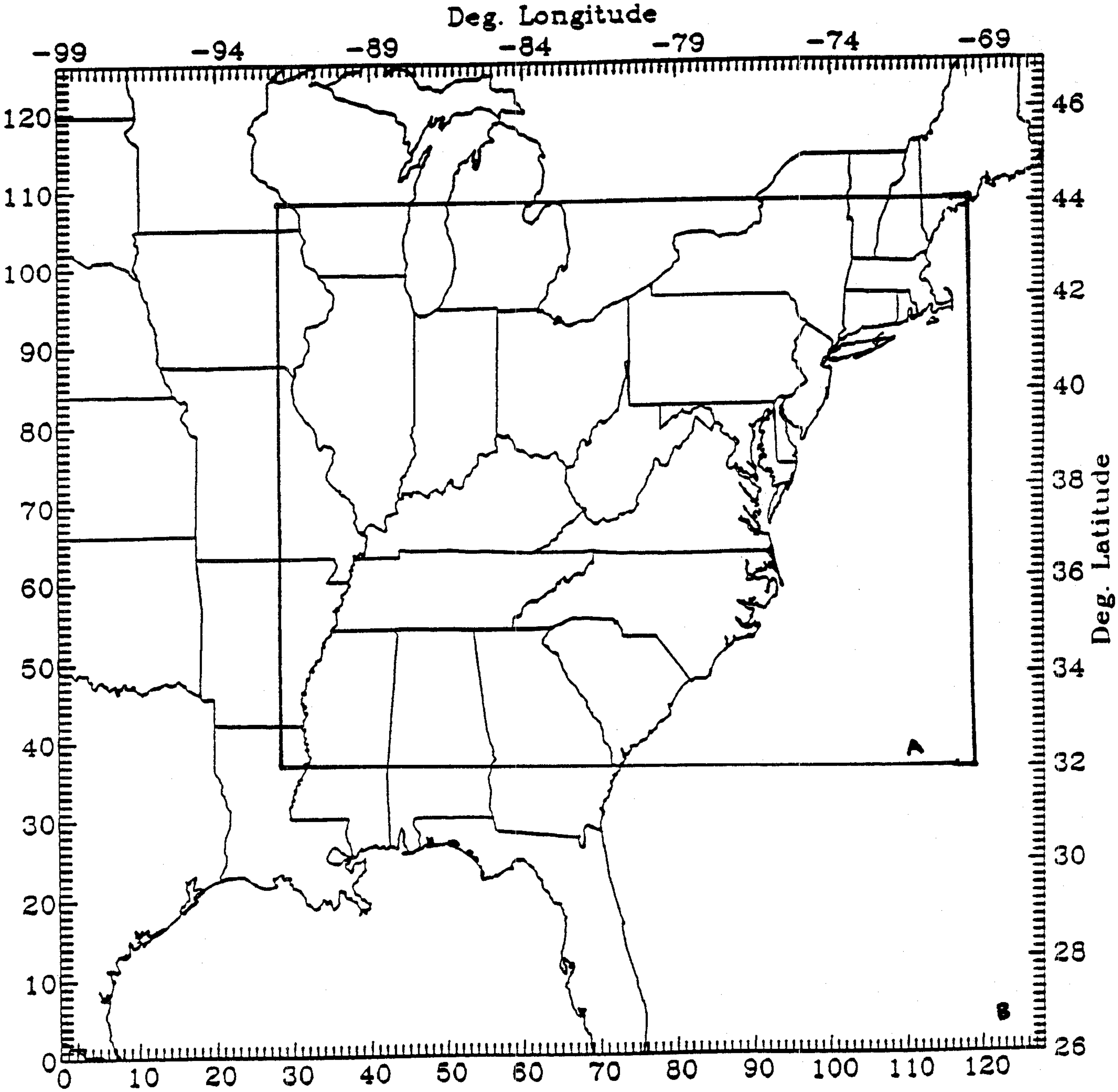

Figure 1. UAM-V Modeling Grid Configuration