# PRELIMINARY EVALUATION OF THE JUNE 2002 VERSION OF CMAQ

Brian Eder*, Shaocai Yu*, Robin Dennis*, Jonathan Pleim* and Kenneth Schere *
Atmospheric Modeling Division
National Exposure Research Laboratory
U.S. EPA, NC  27711
e-mail: **eder@hpcc.epa.gov**
Voice (919) 541-3994    Fax (919) 541-137

## 1.  INTRODUCTION

The latest version of EPA's Community Multiscale Air Quality model was released during June of this year.  As part of this release, a preliminary evaluation was performed involving numerous model configurations, resolutions and domains.  For the sake of brevity only the "base" configuration (defined below) will be presented. The evaluation, which covered a two week period (1–14 July) during 1999, utilized ambient air concentration data of nine species ($O_3$, $SO_2$, $NO_3^-$, $HNO_3$, $PM_{2.5}$, EC, OC, $SO_4^-$, and $NH_4^+$) obtained from three nationwide networks: AIRS, CASTNet and IMPROVE.   A suite of metrics was used in the evaluation, including summary statistics and numerous measures of bias and error.

## 2.0  CMAQ CONFIGURATION

The CMAQ "base" configuration examined in this abstract uses the SAPRC99 gas-phase chemistry mechanism with the AE3 aerosol module and BEIS 3.09 biogenic emissions. The simulation was performed using a 32 km resolution for the U.S. domain.
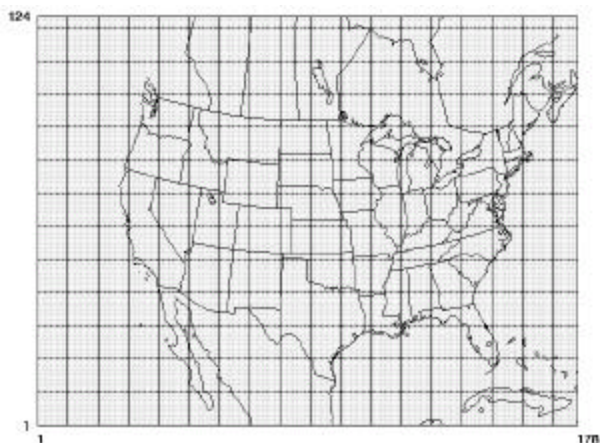


Fig. 1  32 km domain

## 3.0  EVALUATION DATA SETS

### 3.1  AIRS

Hourly $O_3$ (ppb) data obtained from EPA's Aerometric Information Retrieval System (AIRS) were used in the evaluation.  Over 1000 stations were available, mostly in urban areas, resulting in over 300,000 observations.  In addition to the hourly data, both  the maximum   1-hr and maximum  8-hr concentrations were calculated for each station and each day over the two week evaluation period.

### 3.2  CASTNet

Weekly average concentrations of $SO_2$, $SO_4^{2-}$, $NO_3$, $HNO_3$ and $NH_4^+$ ($\mu g\ m^{-3}$) obtained from  the Clean Air Status and Trends Network (CASTNet) were also available for 60, mostly rural stations Unfortunately, only one collection period (6-13 July) coincided with the simulation period.

### 3.3  IMPROVE

Daily average concentrations of $SO_4^{2-}$, $NO_3$, $PM_{2.5}$, OC and EC ($\mu g\ m^{-3}$) from 50 rural IMPROVE (Interagency Monitoring of PROtected Visual Environments)  sites were also used. These data are collected on every third day, (midnight to midnight, local time), limiting the number of  days available for comparison  to 4 (July 3, 7, 10, 14).

## 4.0  STATISTICS

Numerous measures of both bias and error were calculated for each species.  For bias, Mean Bias (MB), Mean Normalized Bias (MNB), Normalized Mean Bias (NMB) and Mean Fractional Bias (MFB) were calculated.  For error, we examined Normalized Mean Error (NME),Mean Absolute Gross Error (MAGE), Mean Normalized Gross Error (MNGE) and Root Mean Square Error (RMSE).

## 5.0 RESULTS

Examination of Table 1 reveals that CMAQ exhibits varied levels of skill in its ability to simulated ambient air concentrations of the nine species. Correlations range from 0.31 for $NO_3$ (CASTNet) to 0.92 for $SO_4$ (IMPROVE). Most correlations are between 0.60 – 0.90. With the exception of EC, simulations are consistently biased high across all species. The Mean Normalized Biases (which are sensitive to small observed concentrations) range from –15.0% for EC to 246.0% for $HNO_3$. Mean Fractional Biases are smaller, ranging from -46.0%, again for EC, to 80.5% for $SO_2$. Normalized Mean Biases range from –20.7% (EC) to 157.0% ($SO_2$).

Errors associated with CMAQ simulations are also varied, depending upon specie. The Mean Normalized Gross Errors (which like the MNB is sensitive to small observed concentrations) are generally large, ranging from 31.1% for $O_3$ (max 1-hr) to 259.2 for $HNO_3$. The Normalized Mean Errors are somewhat smaller, ranging from 26.2% for $O_3$ (max 1-hr) to 167.3 for $NO_3$.

Table 1.  Evaluation statistics

| Species | $O_3$ Hourly | $O_3$ Max-1 | $O_3$ Max-8 | $SO_4$ | | $NO_3$ | | $PM_{25}$ | $NH_4$ | $SO_2$ | $HNO_3$ | OC | EC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Network | AIRS | AIRS | AIRS | CAS | IMP | CAS | IMP | IMP | CAS | CAS | CAS | IMP | IMP |
| n | 346,824 | 14,481 | 14,481 | 60 | 174 | 60 | 147 | 164 | 60 | 60 | 60 | 138 | 136 |
| r | 0.68 | 0.68 | 0.69 | 0.88 | 0.92 | 0.31 | 0.63 | 0.73 | 0.82 | 0.84 | 0.71 | 0.6 | 0.6 |
| MB | 9.4 | 10.7 | 10.8 | 0.7 | 0.3 | 0.6 | 0.0 | 1.3 | 0.6 | 1.5 | 2.0 | 1.7 | -0.16 |
| MNB % | 90.8 | 24.9 | 29.0 | 21.3 | 30.0 | 158.3 | 16.2 | 41.0 | 114.1 | 245.8 | 246.0 | 123.0 | -15.0 |
| MFB % | 22.1 | 18.0 | 20.9 | 6.2 | 4.7 | 22.2 | 79.0 | 15.0 | 28.7 | 80.5 | 49.7 | 50.0 | -46.0 |
| MAGE | 15.2 | 15.4 | 14.0 | 1.2 | 0.8 | 0.8 | 0.3 | 3.6 | 0.6 | 1.5 | 2.3 | 2.0 | 0.2 |
| MNGE % | 109.2 | 31.1 | 34.4 | 42.3 | 61.0 | 204.8 | 128.2 | 64.0 | 124.1 | 254.6 | 259.2 | 131.0 | 66.0 |
| NME % | 44.4 | 26.2 | 28.4 | 32.1 | 38.2 | 167.3 | 102.5 | 45.8 | 56.3 | 161.3 | 116.5 | 86.9 | 58.6 |
| NMB % | 27.5 | 18.3 | 21.8 | 19.2 | 13.1 | 112.3 | 4.3 | 16.6 | 50.9 | 157.0 | 105.2 | 76.4 | -20.7 |
| RMSE | 19.5 | 19.8 | 17.6 | 1.7 | 1.4 | 1.3 | 0.6 | 5.4 | 0.9 | 2.0 | 3.2 | 3.1 | 0.0 |