COMPARISON OF SPATIAL PATTERNS OF POLLUTANT DISTRIBUTION WITH CMAQ PREDICTIONS

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1.0 INTRODUCTION

One indication of model performance is the comparison of spatial patterns of pollutants, either as concentration or deposition, predicted by the model with spatial patterns derived from measurements. If the spatial patterns produced by the model are similar to the observations in shape, location, and magnitude it can add to our confidence that the model is performing well. However, deriving spatial patterns from measured pollutant data is not always trivial. Modeling networks are spatially sparse, and frequently biased toward certain types of land use. Likewise, frequently there is measurement bias between monitoring networks. This study will compare the observed spatial patterns with those predicted by EPA's Community Multiscale Air Quality (CMAQ) model, noting any similarities and differences. We will consider sulfate (SO_4), nitrate (NO_3), ammonium aerosols (NH_4), and ozone (O_3).

2.0 CMAQ CONFIGURATION

An annual 2001 simulation consisting of a 36x36 km model resolution Lambert conformal horizontal domain with 14 vertical layers was conducted over the continental U.S. utilizing CMAQ. Initial and boundary conditions were provided by the GEOS-CHEM, a global 3-D chemistry/transport model. Year-specific 2001 meteorological data provided by Mesoscale Model (MM5) version 3.6.1 were used and processed by MCIP v2.3 for model-ready inputs. Anthropogenic emissions were provided by the 1999 National Emissions Inventory (NEI). Biogenic emissions were obtained from BEIS 3.12.

3.0 OBSERVATIONAL DATA

After exploring the development of reliable spatial models for the monitoring data using a variety of approaches, we chose the radial basis functions interpolation procedure for the SO_4, NH_4, NO_3 fields. Natural neighbor interpolation was used for O_3 because it handles dense, irregular networks better. Data from the CASTNet and STN monitoring networks were combined because their measurement techniques for SO_4 and NH_4 are similar. Because no two networks measure nitrogen aerosols in the same way, we chose to use total nitrate (NO_3 + HNO_3) reported by CASTNet for the spatial analysis of nitrogen. Ozone data were taken from the state and local air monitoring networks (AIRS) and CASTNet.

STN data are collected 1 day in 3 or 6, depending on the site. CASTNet data are collected as weekly integrated samples. To overcome this difference, 28 day averages (lunar months) were constructed from all networks, with the start date corresponding to the CASTNet sampling schedule. Ozone comparisons were made based upon the maximum hourly average observed each lunar month. Annual 2001 average spatial plots of observed and predicted SO_4, NH_4, and NO_3 are considered here.

4.0 RESULTS

4.1 Sulfate

Examinations of observed and predicted sulfate spatial patterns reflect CMAQ's predictive skill in simulating SO_4 spatial patterns (Figures 1 and 2). The pattern of maximum concentration predicted by the model is similar to the

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interpolated pattern from the data both in location and in magnitude. The East to West gradient is similar within the limited resolution of the data. The only difference seems to be a bit higher observed concentration in Southern California and the Pacific Coast.

4.2 Nitrate

Annual averages of total nitrate (NO3 + HNO3) observed in CASTNet and predicted by CMAQ are given in Figures 3 and 4. The patterns are very similar, with maxima of the same magnitude in Indiana and Ohio, and secondary maxima in Southeastern Pennsylvania and Southern California. The East-West gradients are also quite similar.

4.3 Ammonium

Predicted and observed patterns of NH4 are given in Figures 5 and 6. They are remarkably similar, with maxima in the upper mid-west, in southern Pennsylvania, and in Northern Georgia. They differ in that CMAQ also predicts a secondary maxima in Eastern North Carolina that is not observed by the stations in the area. Patterns in the West are quite similar, although one observing station measured high levels in Salt Lake City that aren't predicted by the model.

4.4 Ozone

Maximum observed and predicted hourly level of ozone during lunar month 8, the highest month for ozone, are shown in Figures 7 and 8. The distinct spatial patterns that are seen in other pollutants are not present in ozone; however there are similarities between the model forecasts and observations. Both have maxima along the Northeast coast between Washington DC and Boston as well as along the Southern California Coast. They also agree in showing few major maxima, but scattered values between .08 and .1 ppm throughout the rest of the country.

5.0 SUMMARY

Spatial patterns predicted by CMAQ are very similar to those interpolated from observations in both location and magnitude. These similarities suggest that CMAQ is doing a credible job of predicting air pollutant concentrations on this scale.

6.0 Disclaimer

The research presented here was partially performed under the Memorandum of Understanding between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and under agreement number DW13921548*. Although it has been reviewed by EPA and NOAA and approved for publication, it does not necessarily reflect their policies or views.*

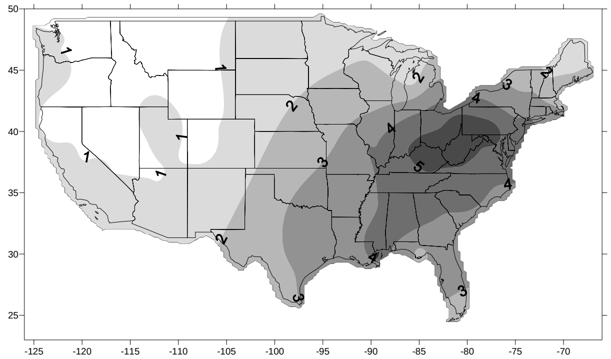

Fig. 1 Spatial plot of Observed 2001 Annual Sulfate from STN and CASTNet.

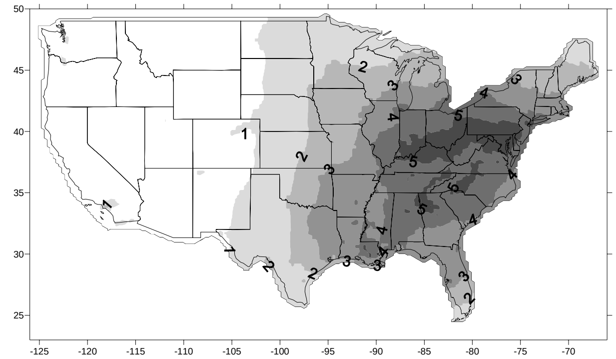

Fig. 2 Spatial plot of Predicted 2001 Annual Sulfate from CMAQ.

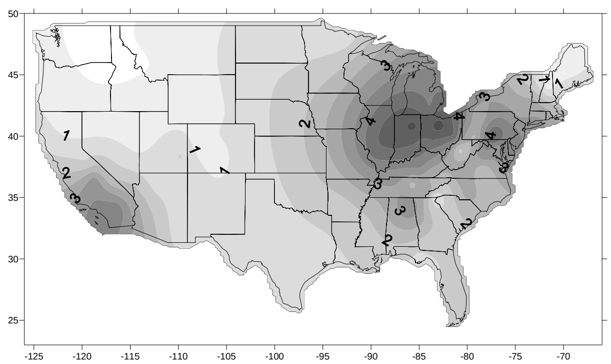

Fig. 3 Spatial plot of Observed 2001 Annual Total Nitrate (NO_3 + HNO_3) from CASTNet.

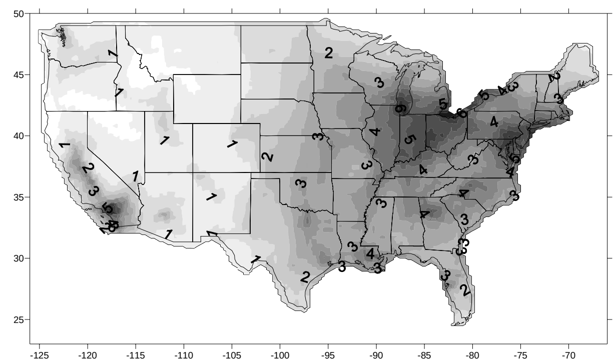

Fig. 4 Spatial plot of Predicted 2001 Annual Total Nitrate (NO_3 + HNO_3) from CMAQ.

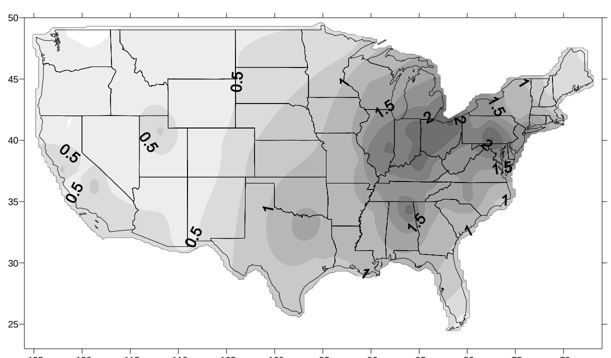

Fig. 5 Spatial plot of Observed 2001 Annual Ammonium from STN and CASTNet.

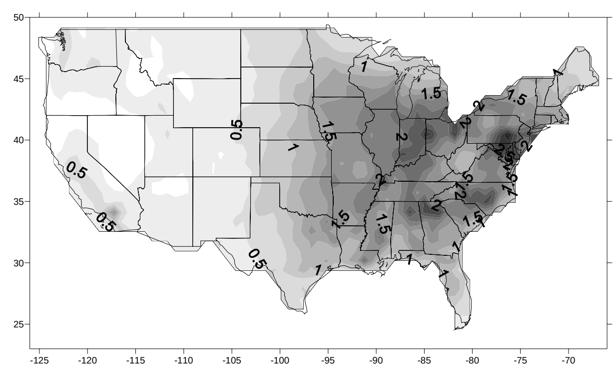

Fig. 6 Spatial plot of Predicted 2001 Annual Ammonium from CMAQ.

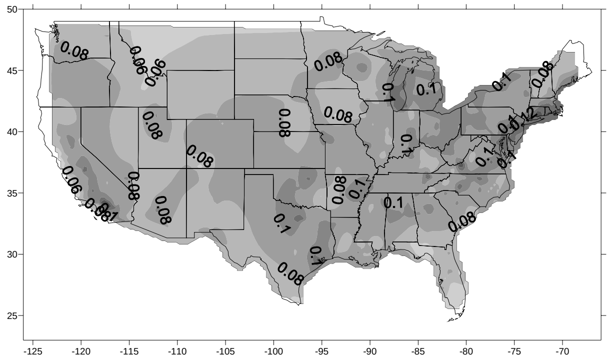

Fig. 7 Spatial plot of Observed Maximum hour Ozone during LM 8 (July 17 - August 13, 2001) from CASTNet and AIRS.

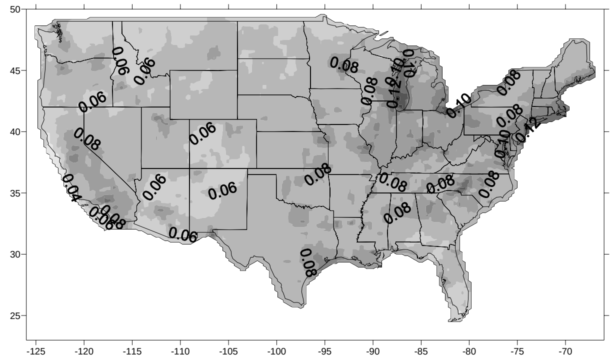

Fig. 8 Spatial plot of Predicted Maximum hour Ozone during LM 8 (July 17 - August 13, 2001) from CMAQ.