15.2 EVALUATION OF THE IMPACT OF EMISSION SOURCES IN CORPUS CHRISTI ON THE REGIONAL AIR QUALITY

Sunil Kumar and Kuruvilla John *
Texas A&M University-Kingsville, Kingsville, Texas

1. INTRODUCTION

Tropospheric ozone is a serious air pollution problem currently affecting many parts of the world including the United States as high ozone concentration damages human health, vegetation and also many common materials we use. Ozone is produced in the atmosphere through a series of reactions involving precursors of ozone namely, oxides of nitrogen and volatile organic compounds (VOCs), which are emitted from various sources, such as, industries, motor vehicles, etc. Since the formation of ozone requires some time, very often high levels of ozone are formed at a place far-off from the source of emissions of ozone precursors, where they have been transported by wind. Corpus Christi is an industrialized urban area located in the semi-arid coastal region of South Texas. There is a concern in the neighboring areas of San Antonio and Austin that the emissions from Corpus Christi might be impacting the observed ozone levels in these areas adversely. Therefore, a photochemical modeling study was undertaken to evaluate the impact of Corpus Christi emission sources on the nearby areas of San Antonio and Austin. CAMx ver. 3.01, a photochemical model developed by ENVIRON (2000) was used for this purpose. We have selected the period of July 7-12, 1995 for this modeling study as high ozone levels were observed in San Antonio and Austin during this period and though Corpus Christi didn't observe high levels this episode was considered to be a good one from the point of view of evaluating ozone and precursor transport from Corpus Christi to San Antonio and Austin.

2. METHODOLOGY

The CAMx photochemical model was used for this study to simulate a high ozone episode of July 7-12, 1995. The CAMX simulates ozone levels on many scales, and includes treatments for Plume-in-Grid, ozone source apportionment, and options for chemical mechanism and horizontal advection solver. Details of this model are available in its user guide (ENVIRON, 2000).

Three-dimensional meteorological fields required to drive CAMx in this study were acquired from the Alamo Area Council of Governments (AACOG), San Antonio, Texas. These meteorological fields were initially produced by the Wisconsin Department of Natural Resources using the Regional Scale Atmospheric Modeling System (RAMS, version 3a) during the Ozone modeling program for the July 1995 episode. Details of the RAMS are available in its user guide (Walko et. al., 2002). Since RAMS generated meteorological fields were produced for a different grid system and resolution and were not compatible with the formats of CAMx, additional modifications were made by ENVIRON to make them suitable for their use in this particular study (Emery et. al., 1999).

In addition to meteorological fields, other required data such as, land use/land cover, chemical mechanism parameters, photolysis rates, vertical diffusivity, initial, top, boundary conditions, and emissions processed by Emissions Processing System (EPS2) were also acquired from the AACOG. EPS2 allocates emissions temporally, spatially, and chemically as required by the CAMx photochemical model and its details are available in its user guide (Systems Applications International, 1992).

Figure 1 shows the 32/16/4-km nested-grid CAMX modeling domain. Corpus Christi, San Antonio, and Austin are located inside the 4-km grid-system.

The following options were selected in CAMx for this particular study:

- Advection scheme – Piecewise parabolic method (PPM);
- Chemical mechanism parameters – CB-IV mechanism
- Plume-in-Grid (PiG) treatment – Sources within 4-km grid having NOx emissions greater than one ton per day, and all other NOx sources greater than 20 tons per day in other grids, were flagged for PiG treatment;
- PiG parameters – Maximum PiG puff length and Maximum PiG puff age were selected to be 2000 m and 24 hours respectively;
- Dry deposition option selected.

The base case modeling run using CAMx was evaluated for its ability to capture both the 1-hour and 8-hour ozone levels in San Antonio, Austin, and Corpus Christi during selected episode days (July 7-12, 1995) using the US EPA approved statistical evaluation parameters namely, unpaired peak accuracy, averaged peak accuracy, peak timing bias, overall bias, and overall gross error. Time-series analyses were also undertaken for graphical comparison of the observed and modeled ozone concentrations. After finding the model performance to be satisfactory, it was then used for two emissions control scenarios to judge the effects of anthropogenic emissions in Corpus Christi on the regional air quality, especially the metropolitan areas of San Antonio and Austin. In the first case, all major point source emissions were taken out from Corpus Christi,

* *Corresponding author address*: Kuruvilla John, Dept. of Environmental Engineering, Texas A&M University-Kingsville, Kingsville, TX 786363;
e-mail: k-john@tamuk.edu

while the second scenario involved zeroing out of all emissions from there. EPS2 was used to take out emissions from Corpus Christi in both the cases.

3. RESULTS AND DISCUSSION

For the base case, the unpaired peak accuracy, average paired peak accuracy, and normalized bias values overall show overpredictions in San Antonio and Austin. For Corpus Christi, these values initially show underpredictions but later on turn to overpredictions on July 10. Interestingly, the unpaired peak accuracy and average paired peak accuracy overall show similar patterns. The normalized bias is under the EPA criteria levels for the entire study period in Corpus Christi. However, for San Antonio and Austin, it is above the levels except on July 11. The estimated peak of ozone in San Antonio occurs about 2 hours earlier than the observed peak. For Corpus Christi, this occurs at about the same time. The normalized gross error is under the EPA criteria levels for all areas except for San Antonio on July 9. Daily statistics for 8-hour average ozone showed similar pattern as 1-hour average ozone discussed above but with reduced values.

Results from the first control case indicate that the major point sources in Corpus Christi usually contribute 3 to 4 ppb during the nighttime hours (10 PM-Midnight) towards the 1-hour ozone levels in San Antonio and about 1 ppb in Austin. Maximum 8-hour contributions were less than 1 ppb at both the sites. All sources together from Corpus Christi usually contributed 10 to 20 ppb and 1 to 3 ppb towards the 1-hour ozone levels in San Antonio and Austin respectively during this episode. Maximum contributions to the 8-hour averaged ozone levels were approximately 8 to 9 ppb and 1 ppb in San Antonio and Austin respectively. Maximum impact of Corpus Christi point sources alone and point and area sources combined together on the 1-hour ozone levels of downwind areas including San Antonio and Austin are shown in Figure 2. Maximum impact due to point sources alone on San Antonio and Austin was 7 ppb (10 PM) and 3 ppb (10 AM) respectively. Maximum impact due to point and area sources combined together on San Antonio and Austin was 21 ppb (10-11 PM) and 6 ppb (11 AM) respectively. Though the benefits of emissions reduction in Corpus Christi were observed immediately downwind during the daytime hours, this reduction showed an increase in the local ozone levels during the late evening and early morning hours.

4. REFERENCES

ENVIRON International Corporation, 2000: User's Guide to the Comprehensive Air Quality Model with Extensions (CAMx) Version 3.01, 159 pp.

Systems Applications International, 1992: User's Guide for the Urban Airshed Model, Vol. IV, Part A, Emissions Preprocessor System (Ver. 2): Core FORTRAN System. EPA Tech. Rep. EPA-450/4-90-007D (R), 227 pp.

Emery, C. A., Morris, R. E., Jimenez, M. M., Wilson, G. M., and Tai, E, 1999: Conversion and Enhancement of the San Antonio/Austin UAM IV Photochemical Modeling Database to CAMx. ENVIRON International Corp. Rep. prepared for AACOG and TNRCC, 34 pp.

Walko, R. L., and Tremback C. J., 2002: Regional Atmospheric Modeling System Version 4.3/4.4, [Available on-line from http:// www.atmet.com/html/ docs/rams/ug44-rams-intro.pdf.]

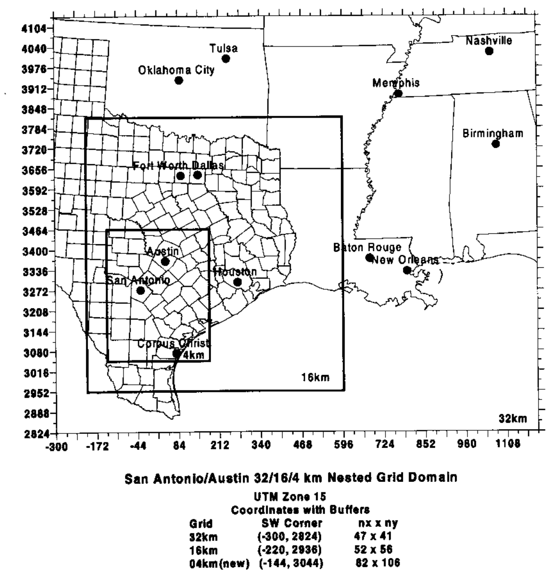

Figure 1: The nested-grid 32/16/4-km CAMx modeling domain (Source: Emery et. al., 1999).

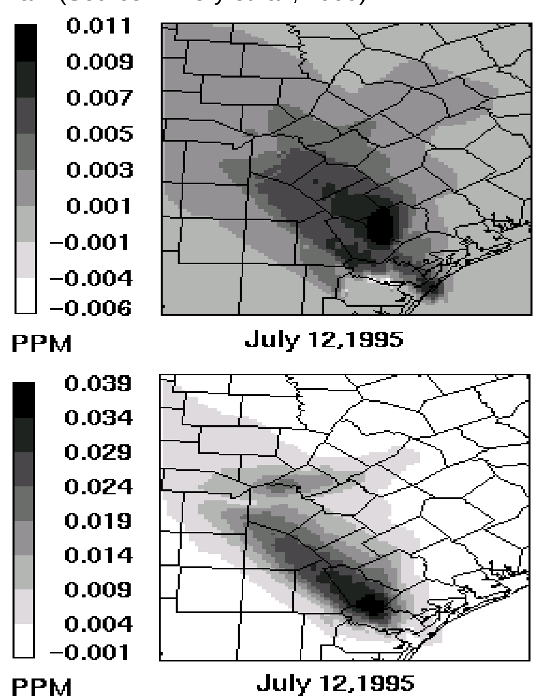

Figure 2: Maximum 1-hour ozone contribution from Corpus Christi sources – Point sources only (Top), Point & area sources combined together (Bottom).