Virginia, West Virginia and Maryland Early Action Compact Modeling Report

Virginia Department of Environmental Quality

March 31, 2004

Executive Summary

The purposes of this report are to document the CAMx modeling results for the Early Action Compact (EAC) projects of Virginia, West Virginia and Maryland and to present the calculation of relative reduction factors and future year 8-hour ozone design values associated with monitors in the concerned EAC areas. This modeling project covers five EAC areas in Virginia, West Virginia and Maryland. The Virginia Department of Environmental Quality is the lead agency in conducting this modeling study. The August 8-18, 1999 ozone episode was selected and used for the EAC modeling project. The Comprehensive Air quality Model with extensions version 4.02 (CAMx) model was selected and used for the modeling project. The National Center for Atmospheric Research (NCAR)/ Penn State Mesoscale Model, MM5, was employed to provide spatial and temporal distribution of meteorological fields to the CAMx air quality model. The MM5 simulation was performed with 3 nested domains, with respective grid resolution of 108 km, 36 km, and 12 km. The Sparse Matrix Operator Kernel Emissions (SMOKE) emissions model was used to process emission inventories into the formatted emission files required by the CAMx air quality model.

The CAMx base case model performance has been evaluated using statistical and graphical metrics for both 36 km and 12 km resolution modeling domains. The CAMx photochemical model meets or exceeds established U.S. EPA performance criteria for attainment demonstrations.

The 2007 future emission inventories were developed for the modeling domains. The future year CAMx runs were performed with the same model configuration and meteorological fields developed for the base case runs. Relative reduction factors and future year 8-hour ozone design values at four monitors were calculated in accordance with the U.S. EPA's *Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS (1999)* and the U.S. EPA's *Protocol for Early Action Compacts (2003)*. The results indicate that the attainment test is passed at all five monitors representing five EAC areas in three states during this modeling episode.

1. Introduction

In December of 2002, the Commonwealth of Virginia, the State of West Virginia, the State of Maryland, along with the local jurisdictions involved, signed and submitted ozone Early Action Compacts (EACs) to the U.S. EPA. The compacts were in turn signed by the EPA to complete the approval process. The purposes of the EACs are to defer the effective date of nonattainment designations for the involved local areas if violations of the 8-hour ozone NAAQS occur in the future. The EACs cover the following geographic areas:

The Roanoke, Virginia Metropolitan Statistical Area (Botetourt County, Roanoke County, Roanoke City, Salem City, and the Town of Vinton)
The Northern Shenandoah Valley Jurisdictions of Frederick County and Winchester City
Washington County, Maryland
Berkley County, West Virginia
Jefferson County, West Virginia

The EAC processes require photochemical dispersion modeling demonstrations to show attainment of the 8-hour ozone standard by December 2007.

The lead agency in the EAC modeling process for the above mentioned EAC areas is the Virginia Department of Environmental Quality (DEQ). Providing assistance to the DEQ are Roanoke/Alleghany Regional Commission (RVARC), local governments, the Maryland Department of Environment, the West Virginia Division of Air Quality, U.S. EPA and the University of North Carolina. The modeling study follows *Air Quality Modeling Analysis for Virginia, West Virginia and Maryland Early Action Ozone Compacts: Modeling Protocol, Episode Selection, and Domain Definition* prepared by Virginia Department of Environmental Quality.

This report documents photochemical modeling study results for 1999 base case and 2007 future case for the EAC areas and demonstrates attainment of the 8-hour ozone standards by all the above mentioned EAC areas by December 2007.

2. Episode Days for Modeling

DEQ recommended eleven episode days for simulations based on the observations of elevated 8-hour ozone concentrations. The episode days are from August 8 to August 18, 1999 wherein high ozone concentrations were measured in the six EAC areas. August 12 and August 13 are selected as primary episode days for 8-hour ozone attainment demonstration.

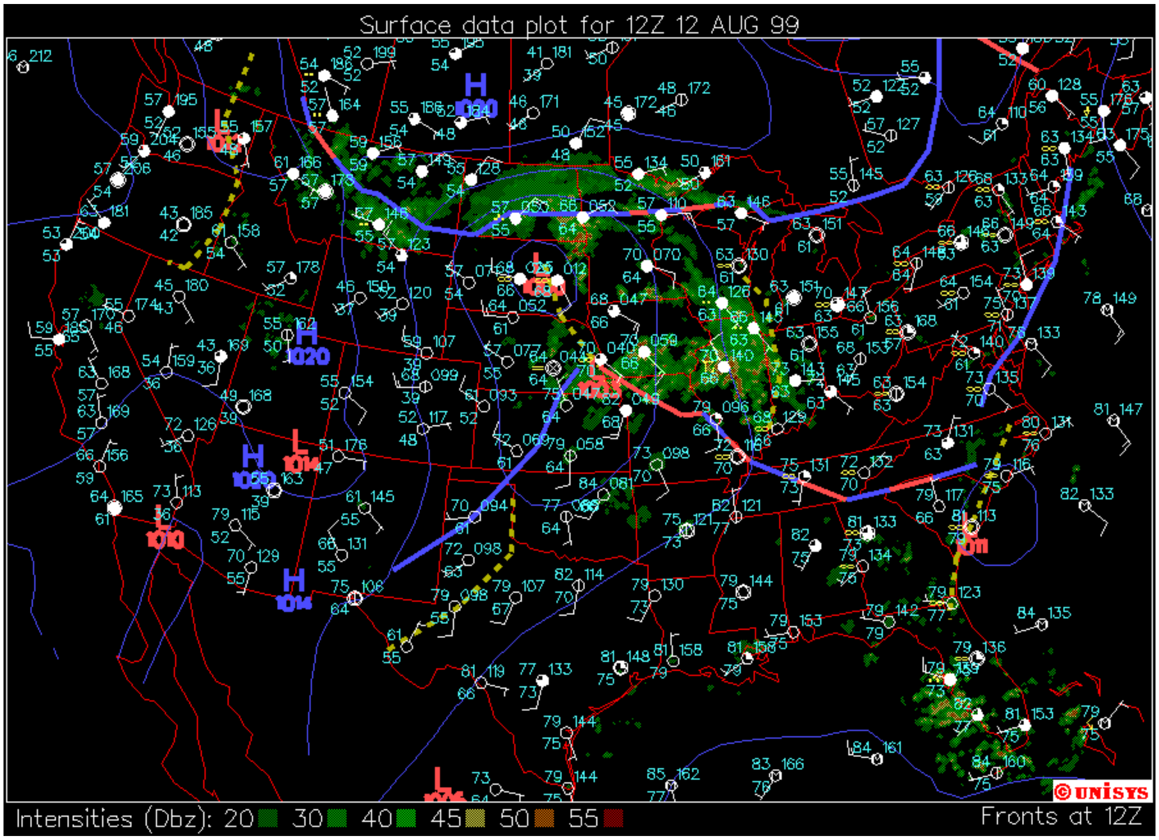
The ozone episode of August 12-13, 1999 was typical of a regional episode in the area. Eight-hour average ozone concentrations peaked at 85 ppb and 87 ppb at Frederick County and Vinton, Virginia, respectively on August 12th. The eight-hour average at Vinton reached 91 ppb on August 13th. Both concentrations were close to the 2001-2003

eight-hour average design values (85 ppb at both locations). Highest eight-hour averages occurred in Northern Virginia, peaking at 115 ppb on August 12th.
August 12th:

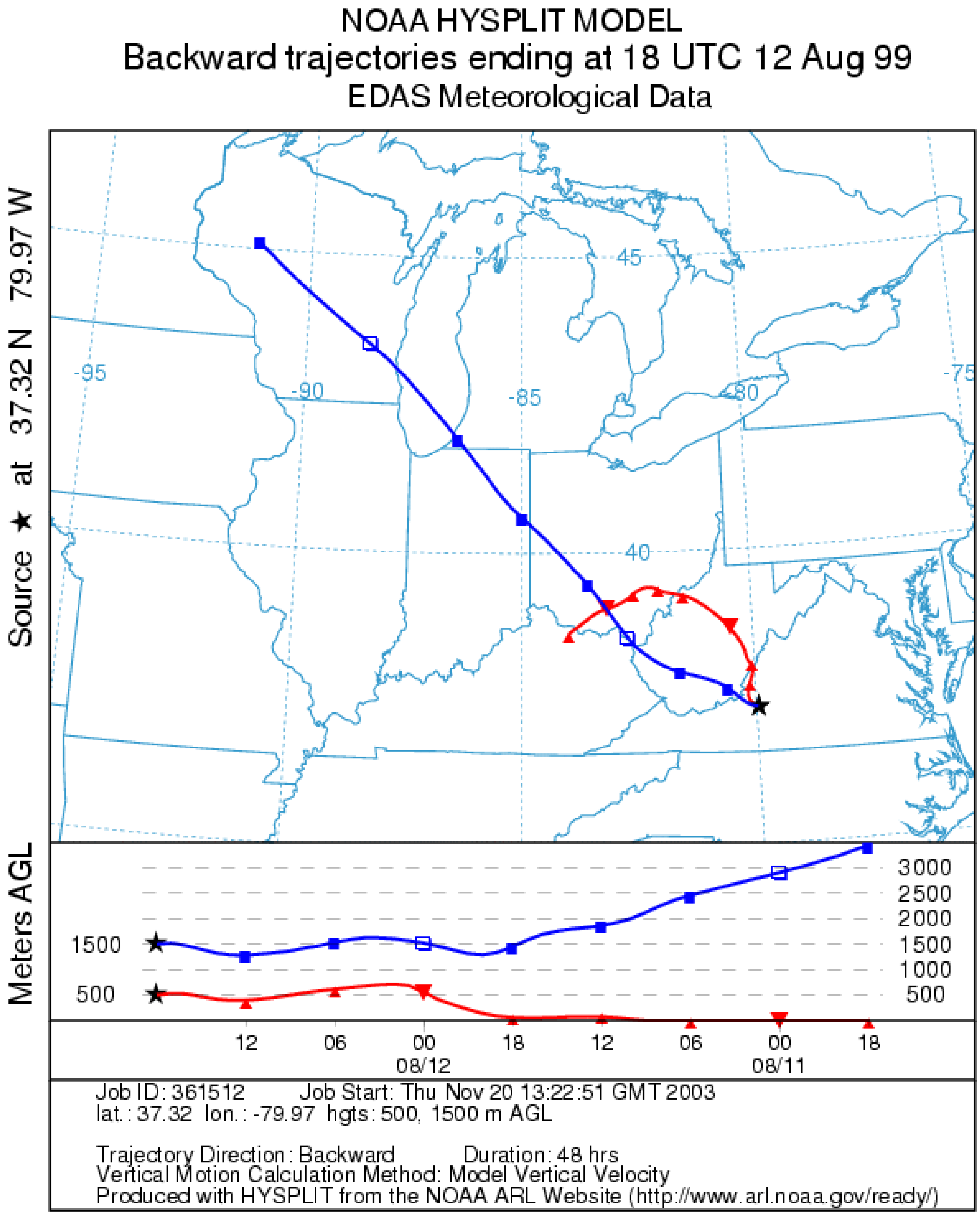
The surface weather map (Figure 2-1) on the morning of August 12th indicated a trough of low pressure extending from coastal New England, through the Delmarva region into central Virginia. South and east of the trough, surface winds were generally from the southeast and higher dew point temperatures, indicative of maritime air. West of the trough, surface winds were calm or light and variable with lower dew point temperatures, indicative of ozone-conducive continental air. Haze ("∞") was reported over a large area from Maine into Tennessee and Georgia. Surface winds remained light into the afternoon. Forty-eight hour 500 and 1500 meter back trajectories for Roanoke and Winchester (18z, 2:00 pm EDT; Figures 2-2 and 2-3) ending that afternoon indicated that air passed over the Ohio River Valley and West Virginia; a typical high ozone, regional air flow pattern. The evening (00z, August 13, 8:00 pm EDT, August 12) surface weather map (Figure 2-4) indicated the trough of low pressure separating maritime from continental air persisted from New England southwestward through Maryland and Richmond, extending into central North Carolina. Maximum temperatures east of the trough were around 90 degrees. West of the trough, high temperatures reached into the low to mid 90s.

August 13th:

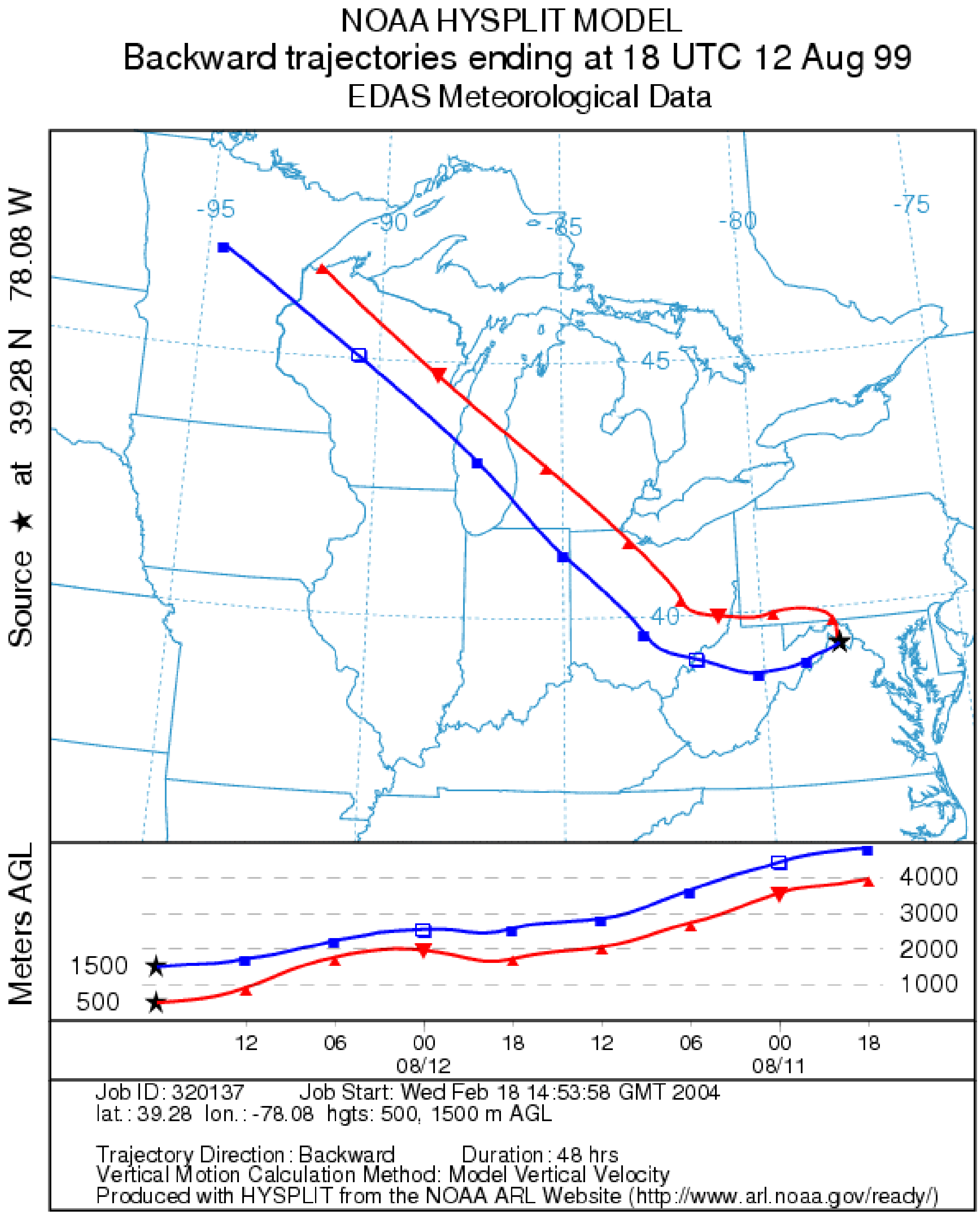
The surface weather map on the morning of August 13th (Figure 2-5) indicated the trough extended from Washington, DC through central Virginia into central North and South Carolina. Again, higher dew point temperatures and southerly winds east of the trough indicated maritime air. Lower dew points and calm winds west of the trough indicated the presence of a continental air mass. Forty-eight hour 500 and 1500 meter back trajectories for Roanoke (Figure 2-6) ending that afternoon originated from the Great Smokey Mountains region of northeastern Tennessee and north central Tennessee, respectively. Forty-eight hour 500 and 1500 meter back trajectories for Winchester ending that afternoon are shown in Figure 2-7. The 500 meter trajectory originated in West Virginia, stagnating and looping over west-central Virginia. The 1500 meter trajectory passed over the Ohio River Valley and West Virginia.. The surface trough separating the maritime air from the continental air persisted into the evening (Figure 2-8). High temperatures reached the mid-to-upper 90s in the region.



Surface data plot for 12z, August 12, 1999.
Figure 2-1.

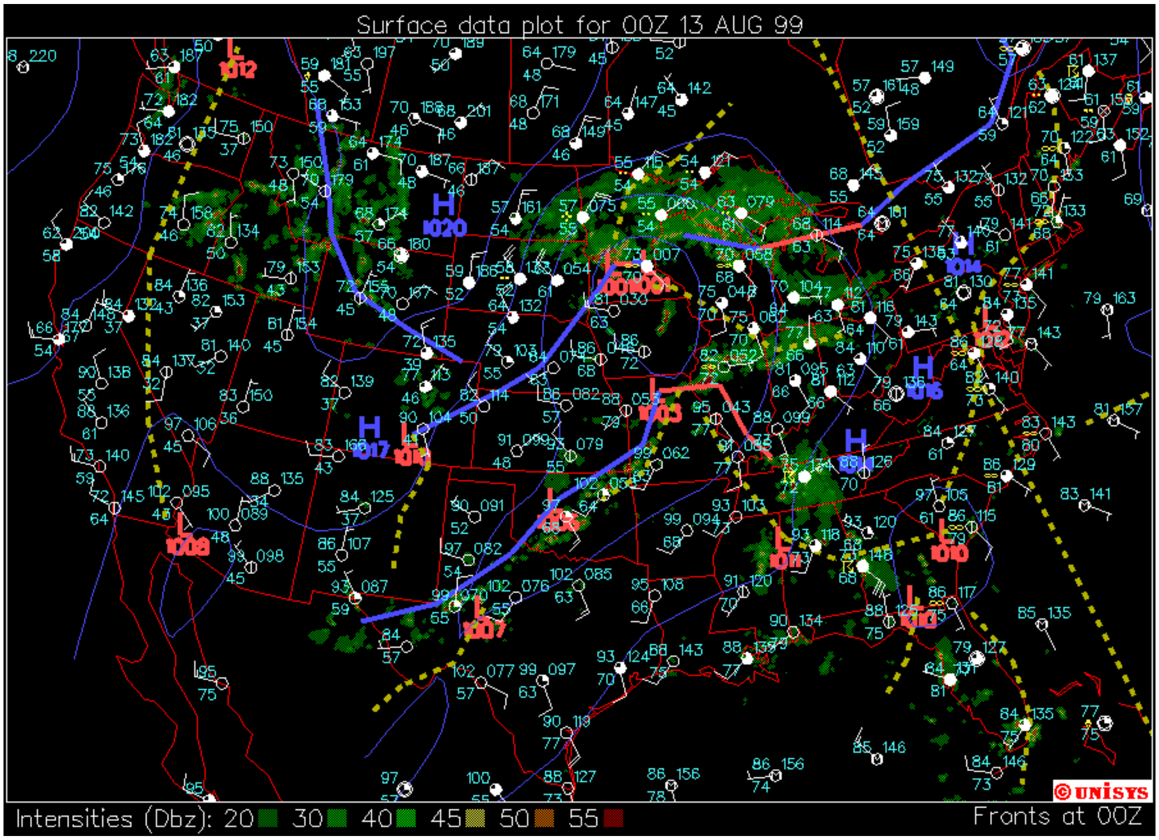


48-hour NOAA HYSPLIT model back trajectory for Roanoke, 18z, August 12, 1999.
Figure 2-2.

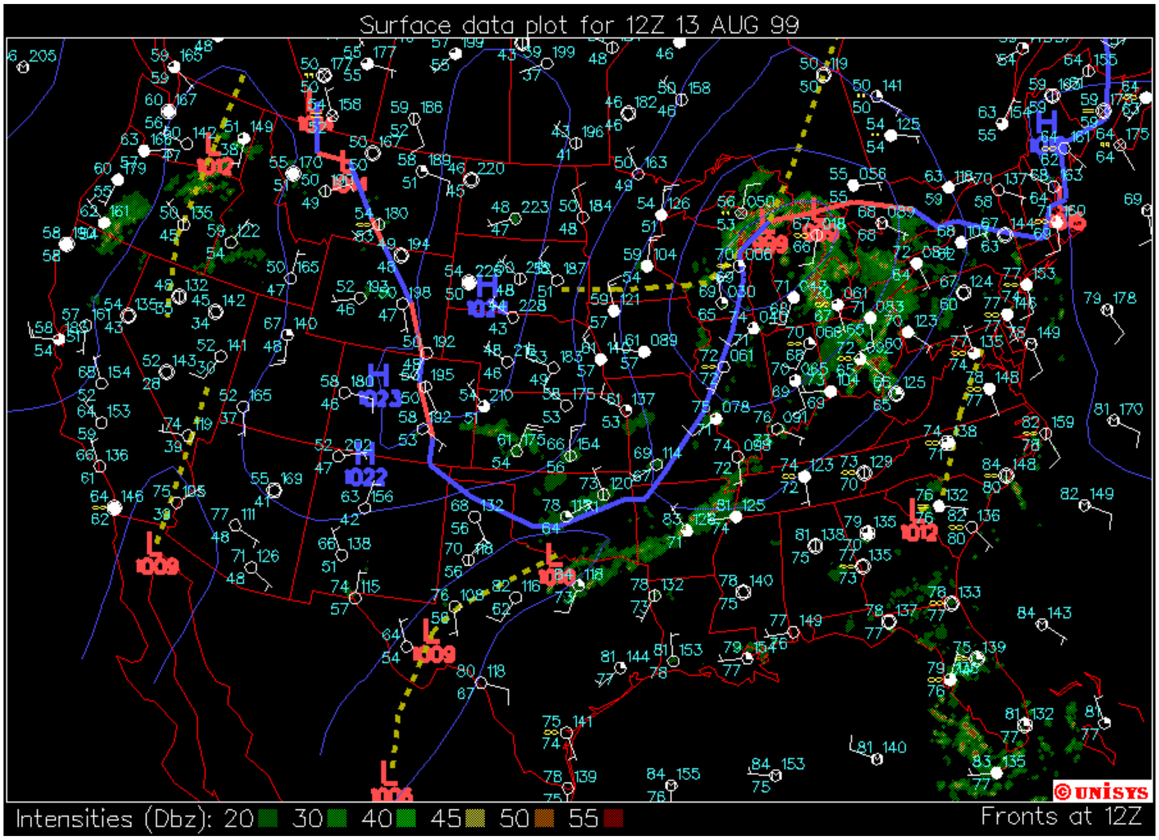


48-hour NOAA HYSPLIT model back trajectory for Winchester, 18z, August 12, 1999.

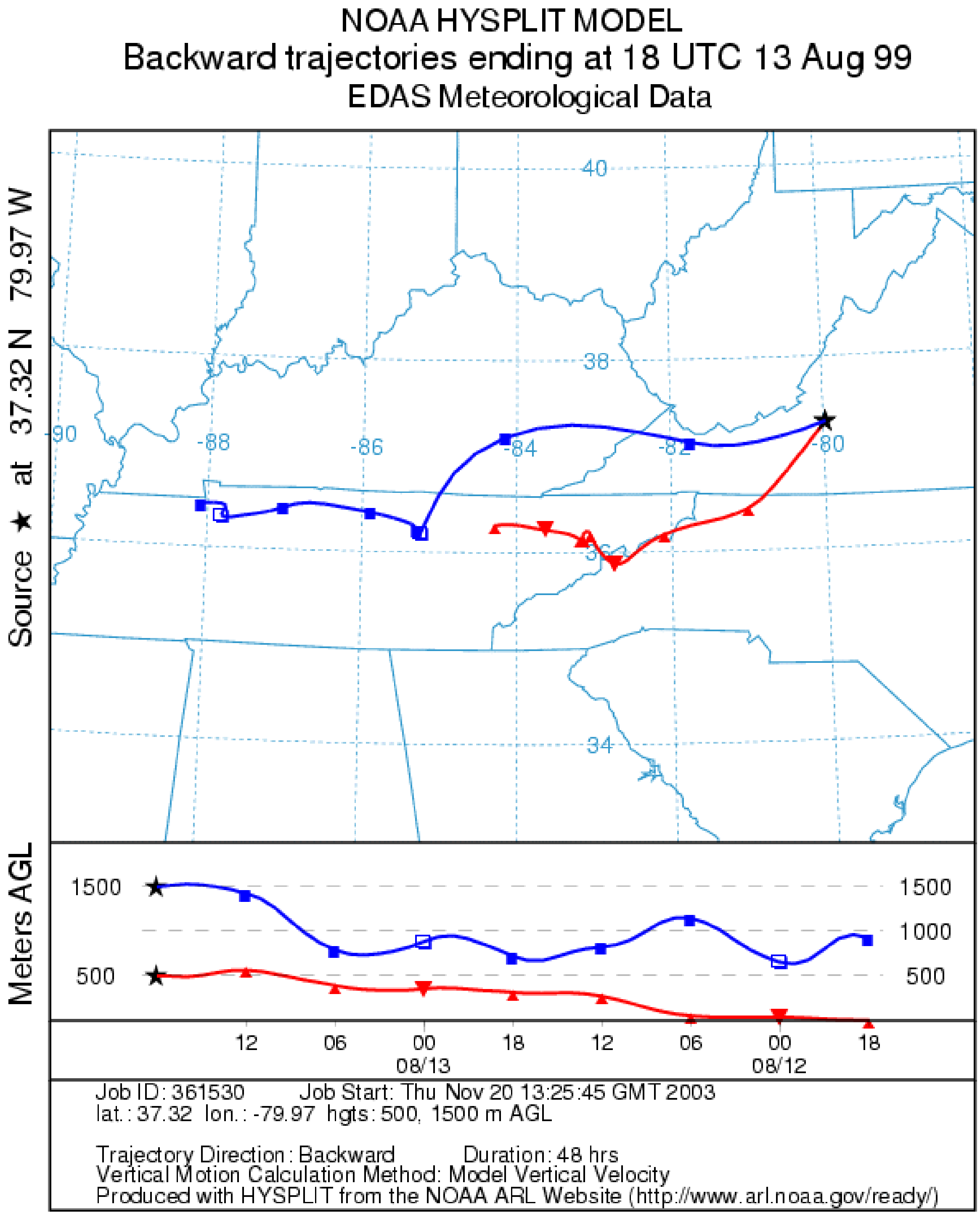
Figure 2-3.



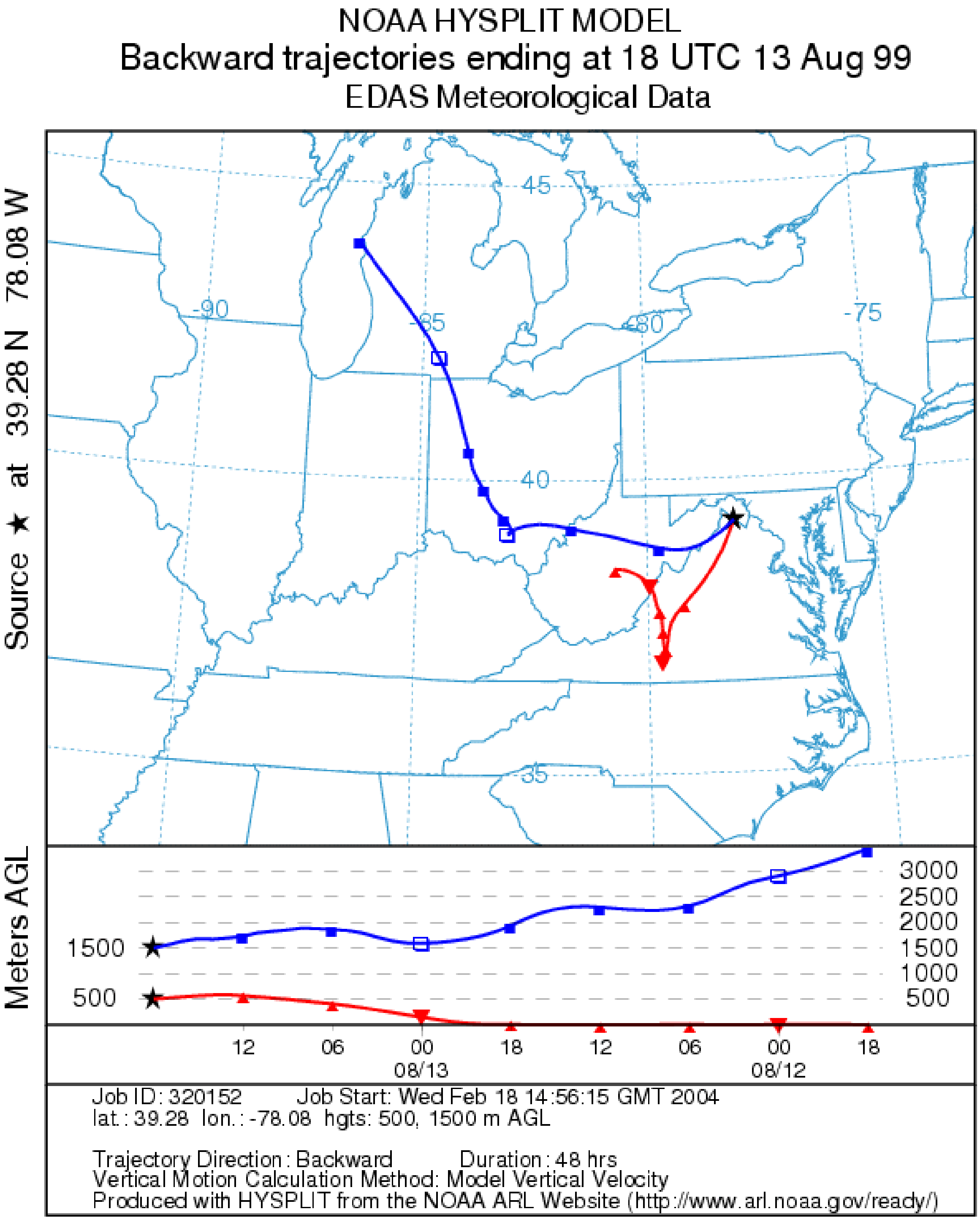
Surface data plot for 00z, August 13, 1999.
Figure 2-4.



Surface data plot for 12z, August 13, 1999.
Figure 2-5.

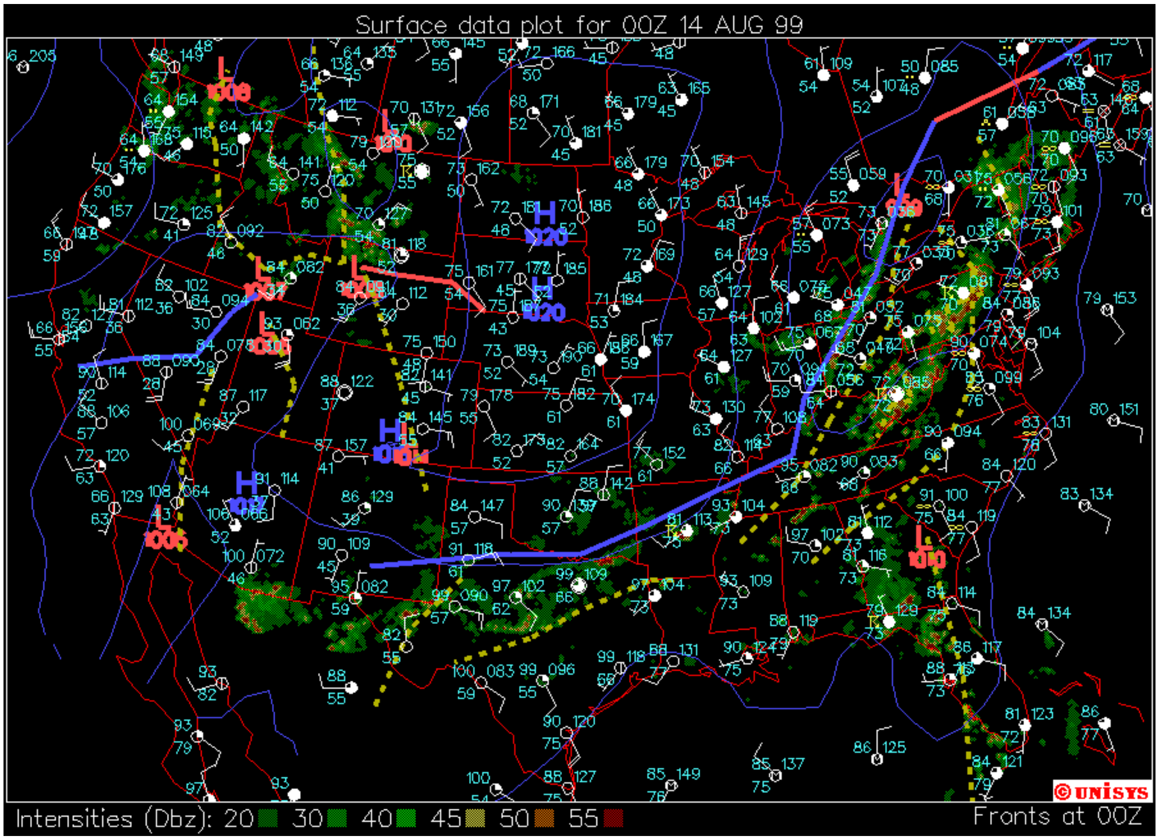


48-hour NOAA HYSPLIT model back trajectory for Roanoke, 18z, August 13, 1999.
Figure 2-6.



48-hour NOAA HYSPLIT model back trajectory for Winchester, 18z, August 13, 1999.

Figure 2-7.



Surface data plot for 00z, August 14, 1999.
Figure 2-8.

3. Emission Inventory and Processing

3.1 Emission Inventories

Emission inventories were required for both of the 36 km and the 12 km resolution modeling domains. Base case point source emissions including appropriate stack parameters (stack height, stack diameter, exit temperature and exit velocity), annual county-level area source emissions data including off-road sources, and on-road mobile sources were obtained from the EPA 1999 NEI Version 2 database. The 1999 NEI Version 2 data are in Microsoft Access database format. DEQ developed a converter and converted 1999 NEI Version 2 data into SMOKE IDA format. Biogenic emissions were prepared using SMOKE version 1.5 that includes a version of the Biogenic Emissions Inventory System. DEQ's MM5 meteorological modeling results and existing land use database from previous modeling studies were used for biogenic emissions calculation. The photochemical model ready emissions files were developed for the modeling domains for both the 1999 base year and the 2007 future year. The State of North Carolina provided 2007 future year 2007 emissions inventories. Updated 2007 future-year emission inventories for the EAC areas in Virginia and Maryland were developed by

DEQ and MDE.

3.2 Emissions Processing

The Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system was used to process the EAC emission inventories into the formatted emission files required by the CAMx air quality model. SMOKE supports area, mobile, and point source emission processing and biogenic emissions modeling. The emissions processing used in this EAC modeling study includes the steps of chemical speciation, temporal allocation and spatial allocation of emissions data. These steps are necessary so pollutant data can be converted to chemical model species needed for the CAMx model. These steps also involves converting the county based emissions information to the grid-cell based emissions information and the conversion of daily temporal emissions data to hourly data required by the CAMx model.

The SMOKE model was run for the episode from August 8 to August 18, 1999 using MM5 meteorological modeling results for the same time period. In addition to the temporal allocation of pollutant data, the hourly plume rise was calculated for the point source emissions for CAMx modeling. After the speciation, temporal allocation and spatial allocation processes were finished, emissions data of point, area, mobile and biogenic sources were merged into gridded hourly emissions. Figure 3-1 shows gridded maximum ground level NOx emissions in the 12 km resolution domain during the episode. Figure 3-2 shows gridded maximum NOx emissions at layer 5, which is roughly

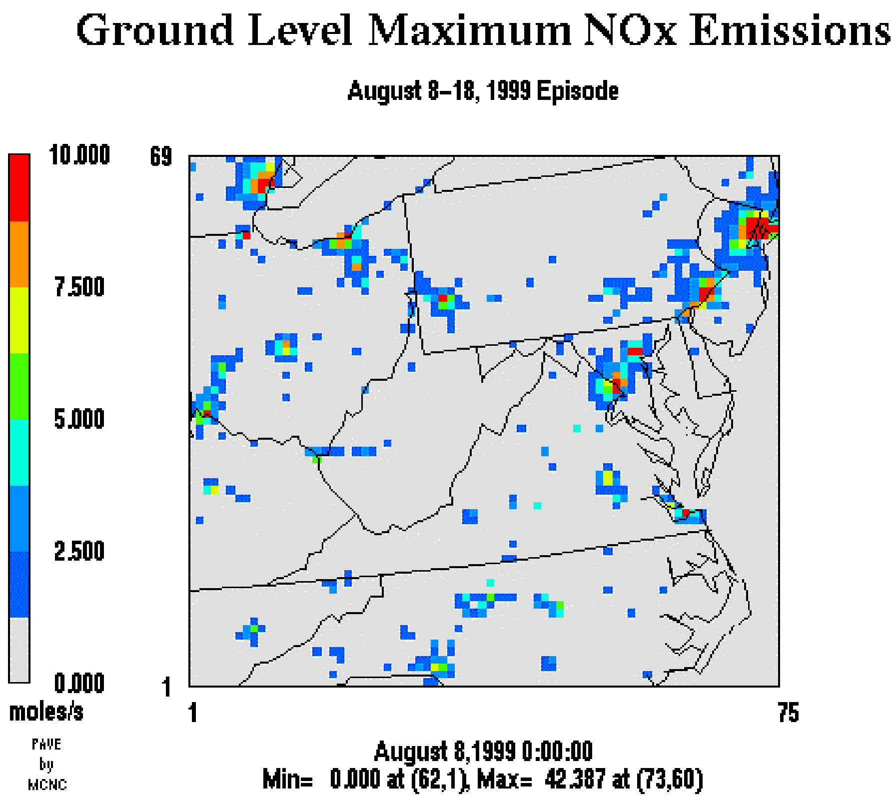


Figure 3-1. Gridded Maximum Ground Level NOx emissions as processed by SMOKE 300 meters above ground level.

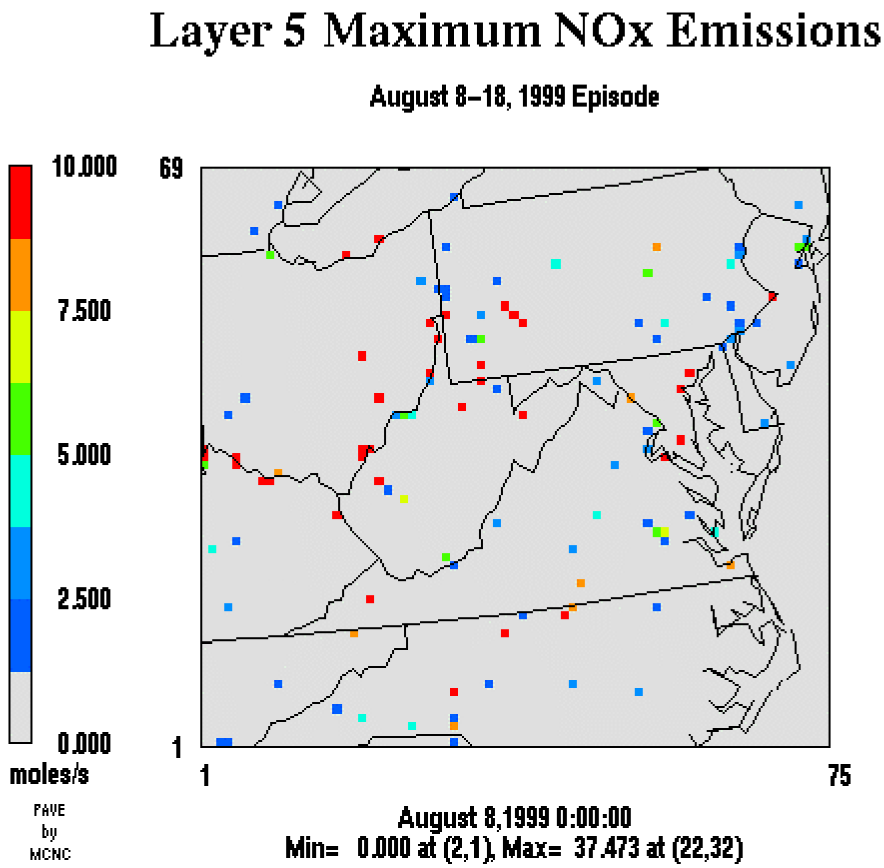


Figure 3-2. Gridded Maximum Layer 5 NOx Emissions

3.3 Biogenic Emissions Modeling

The biogenic emissions were modeled by using SMOKE, which includes a version of the Biogenic Emissions Inventory System 3 (BEIS3) that estimates VOC emissions from vegetation and nitric oxide emissions from soils. Apart from the land use data, the biogenic emissions depend on the meteorological conditions, in particular the air temperature, incoming solar radiation, wind speed and humidity. Those atmospheric variables were provided for each grid cell of the modeling domain by the MM5 simulation results. SMOKE BEIS3 was run for the entire episode from August 8 to August 18, 1999. Figure 3-3 shows gridded maximum biogenic VOC emissions in the 12 km resolution domain. Figure 3-4 shows gridded maximum biogenic NOx in the 12 km resolution domain.

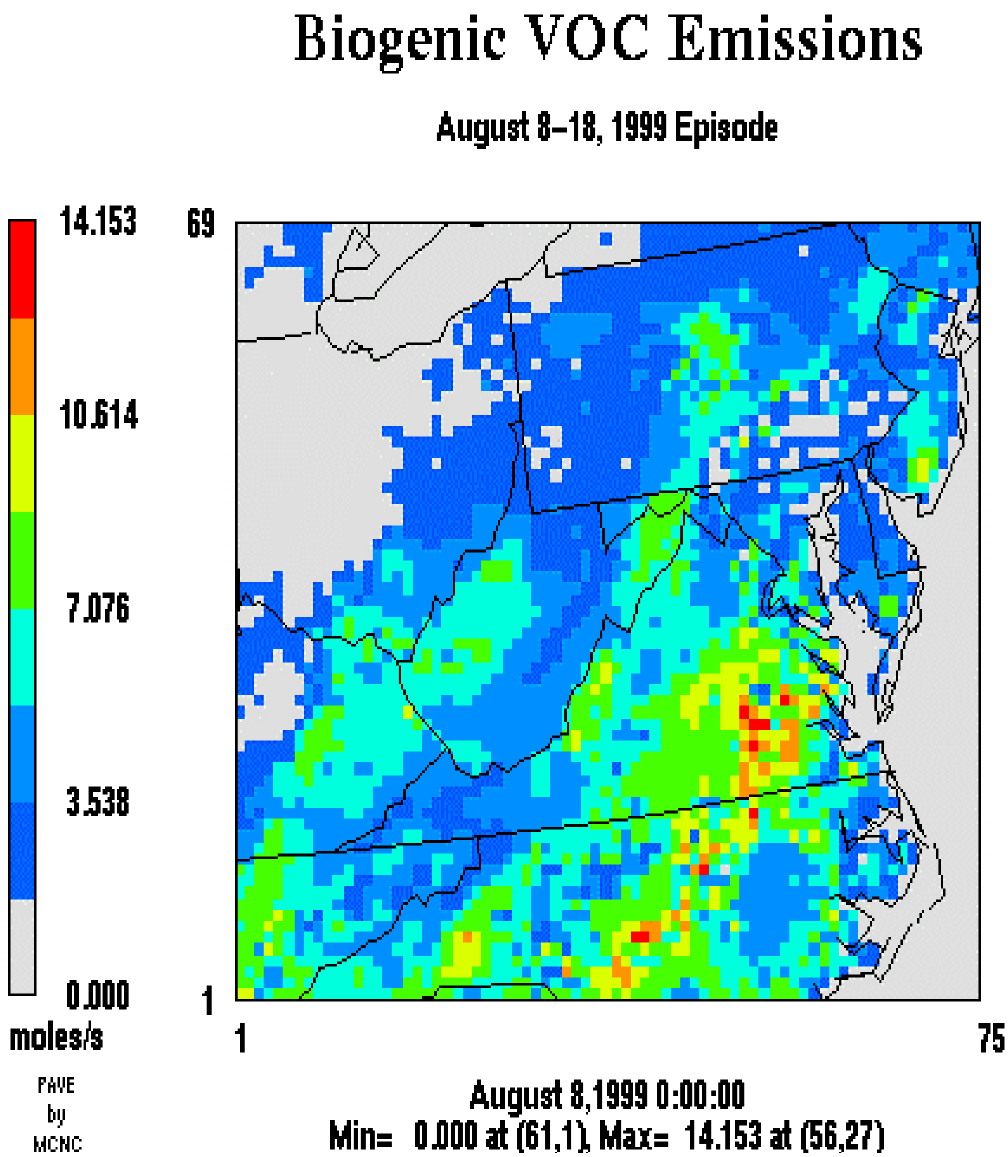


Figure 3-3. Gridded maximum biogenic VOC emissions as modeled by SMOKE

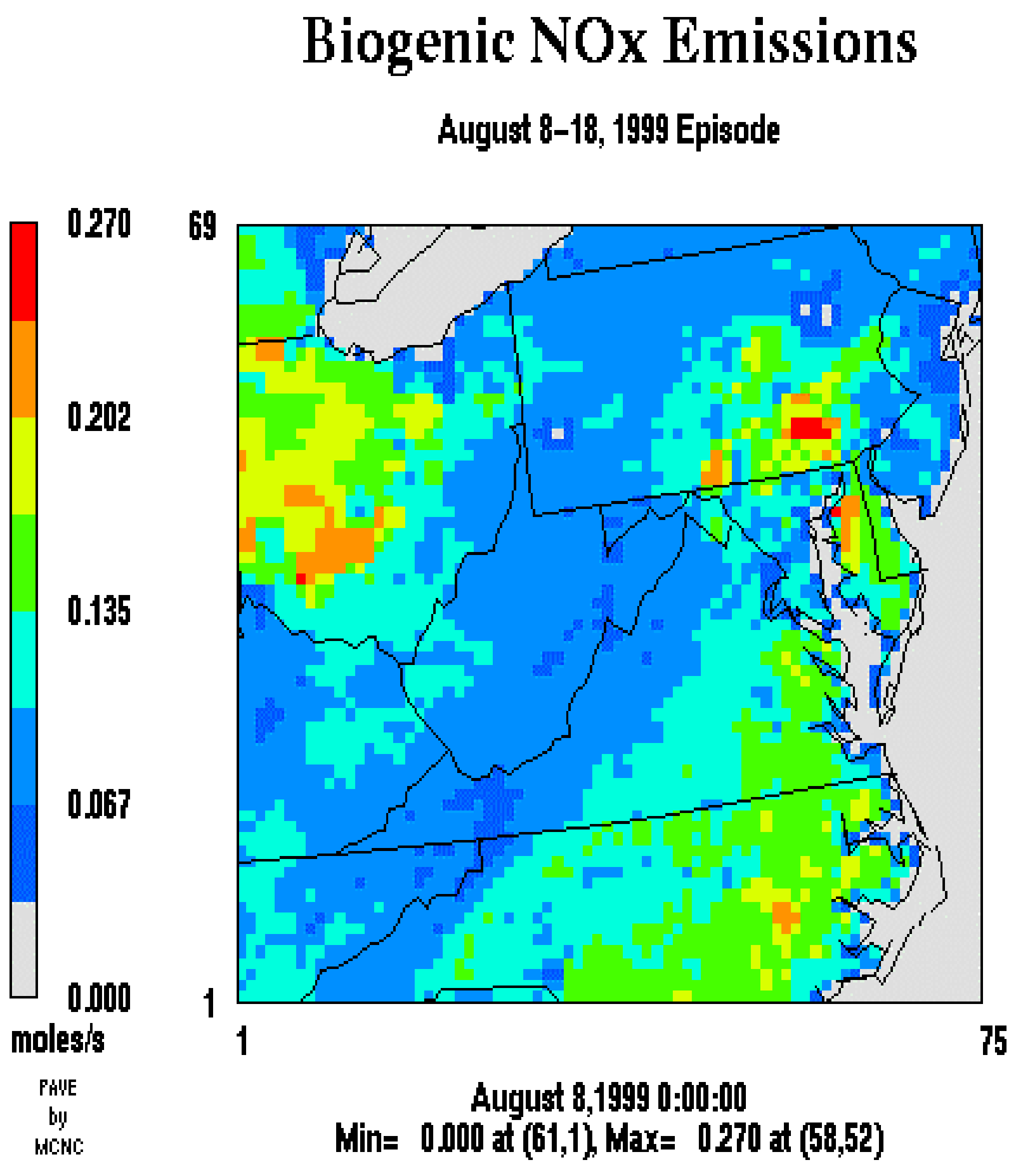


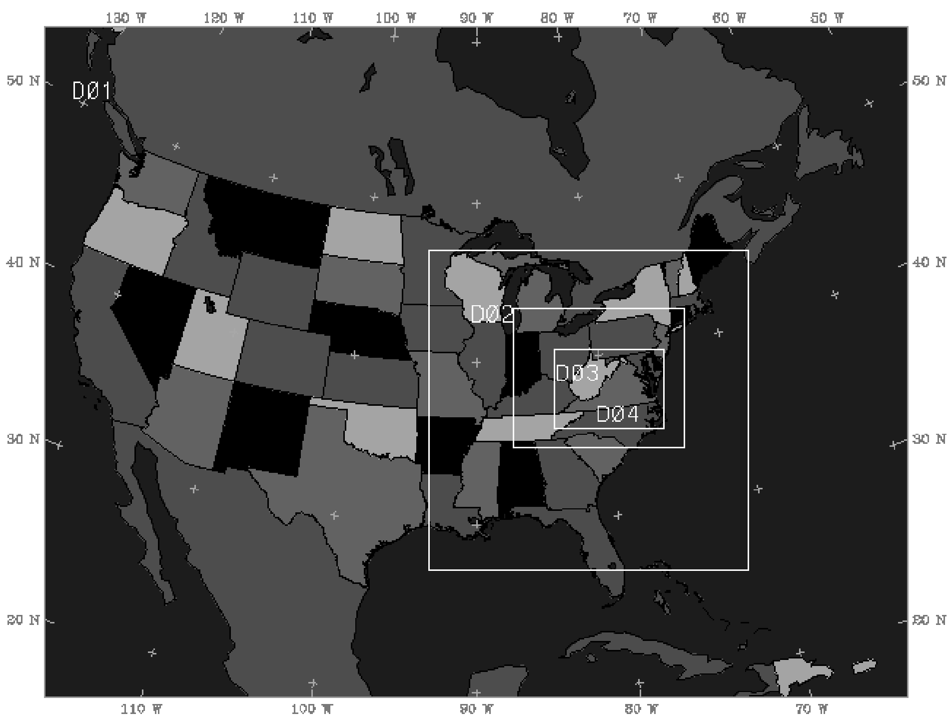
Figure 3-4. Gridded maximum biogenic NOx emissions as modeled by SMOKE

4 Meteorology Modeling

4.1 Numerical Configuration

The Penn State/NCAR Mesoscale Model, MM5, was employed to provide spatial and temporal distribution of meteorological fields to the CAMx air quality model. MM5 has been applied to a broad range of studies, including air quality simulations. The MM5 simulation was performed with 3 nested domains, with respective grid resolutions of 108 km, 36 km, and 12 km. Figure 4-1 shows the MM5 modeling domains for this EAC

Figure 4-1. DEQ MM5 MOdeling Domains



study. It can be seen that the 12 km resolution domain covers the entire state of Virginia and Mid-Atlantic states. The predominant types of meteorological data used in this study were surface and upper air meteorological measurements reported by the National Weather Service (NWS), and large-scale (i.e., regional/global) analysis databases developed by the National Center for Environmental Prediction (NCEP). Both types of data are archived by, and currently available from, the National Center for Atmospheric Research (NCAR). Measurement data include surface and aloft wind speed, wind direction, temperature, moisture, and pressure. Hourly surface data are usually available from many Class I airports, i.e., larger-volume civil and military airports operating 24-hour per day. The standard set of upper air data is provided by rawinsonde soundings launched every 12 hours from numerous sites across the continent. The typical spacing of rawinsonde site is approximately 300 km. The New York State Department of Environmental Conservation has kindly retrieved all necessary above-mentioned data from NCAR and sent the data to DEQ.

Table 4-1 shows the vertical grid structure of the MM5 model. The EAC MM5 simulations were conducted on DEQ's Linux Cluster system consisting of 6 computing nodes with 12 CPUs. The Distributed Memory Parallel Option was employed using the MPICH message-passing software to provide fast turnaround. The paralleling processing of MM5 has shortened run time by 10 times over previous MM5 executions on Sun Enterprise systems. A period of 240 hours was simulated for the EAC episode from August 8 to August 18, 1999. The first 12 hours were considered as the warm-up period, followed by 205 hours of prediction, which included the 48-hour ozone episode from August 12 to August 13, 1999.

4.2 MM5 Simulation Results and Statistical Evaluation

This section shows some MM5 predicted meteorological fields and statistical evaluation results. The METSTAT statistical evaluation package, developed by Environ, is used to compare the modeled temperature, humidity and wind fields with observed data.

METSTAT computes a set of statistical quantities, including bias, gross error, and root mean square error (RMSE, total, systematic, and unsystematic). Figure 4-3 shows the meteorological stations used by METSTAT statistical calculation.

4.2.1 Temperature

Figure 4-2 shows MM5 predicted 12 km domain temperature field on August 12, 1999 at 1900 hours GMT. In general, MM5 predicted temperature fields agree well with observed data at most meteorological

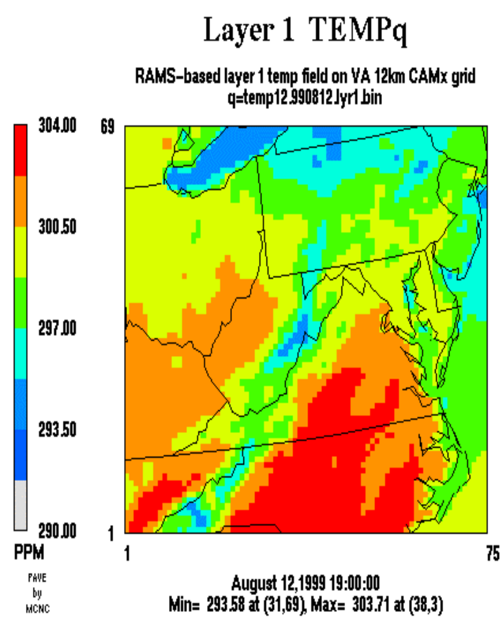


Figure 4-2. MM5 Temperature Field

Table 4-1 Vertical Grid Structures of MM5, CAMx and SMOKE

MM5 Layer K	Sigma	CAMx/SMOKE Layer	Interface Heights (m)
35	0.000	15	12821
34	0.050	15	
33	0.100	15	
32	0.150	15	
31	0.200	15	
30	0.250	15	
29	0.300	15	
28	0.350	15	
27	0.400	14	5812
26	0.440	14	
25	0.480	14	
24	0.520	14	
23	0.560	13	3874
22	0.600	13	
21	0.640	13	
20	0.670	12	2747
19	0.700	12	
18	0.730	11	2185
17	0.760	11	
16	0.785	10	1698
15	0.810	10	
14	0.835	9	1275
13	0.855	9	
12	0.875	8	950
11	0.895	8	
10	0.910	7	675
9	0.925	7	
8	0.940	6	444
7	0.950	6	
6	0.960	5	294
5	0.970	5	
4	0.980	4	146
3	0.086	3	102
2	0.992	2	58
1	0.996	1	29
0	1.000		

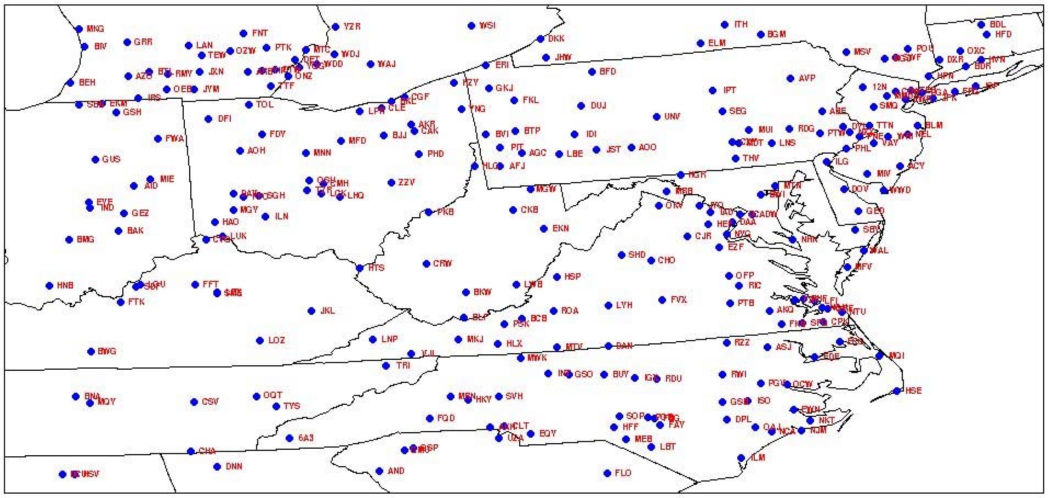


Figure 4-3. Meteorological observation stations

observation sites within the 12 km modeling domain during the episode .

Figure 4-4 shows METSTAT 12 km domain hourly temperature statistics for the August 8 to August 18, 1999 episode. The three RMSE legends in the second graph represent RMSE total, RMSE systematic and RMSE unsystematic.

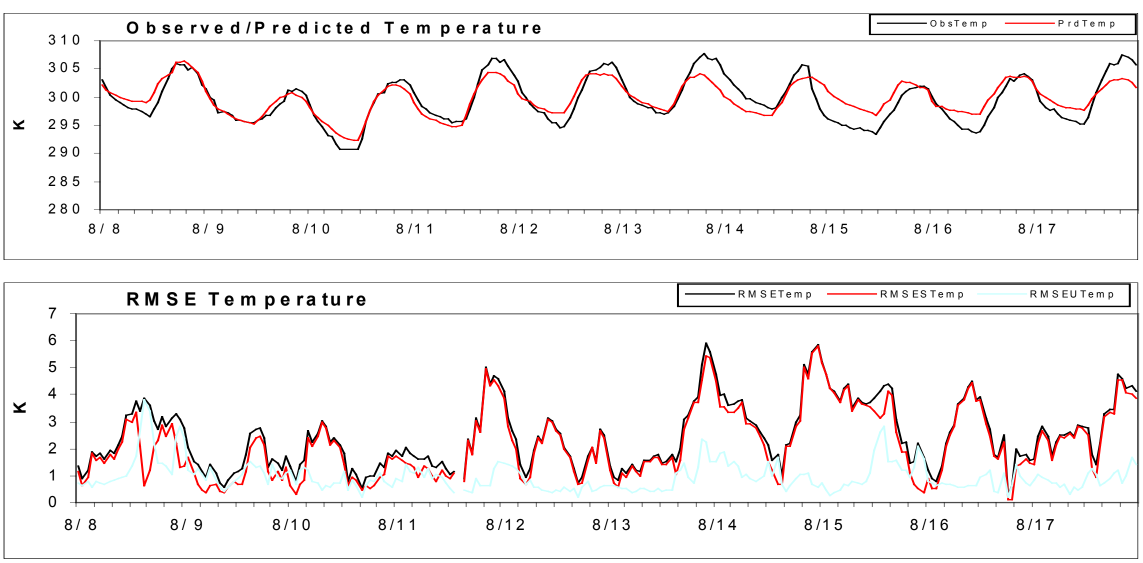


Figure 4-4. METSTAT hourly temperature statistics

4.2.2 Humidity

Figure 4-5 shows METSTAT 12 km domain hourly humidity statistics for the August 8 to August 18, 1999 episode. The predicted humidity fields agree reasonably well with observed humidity fields.

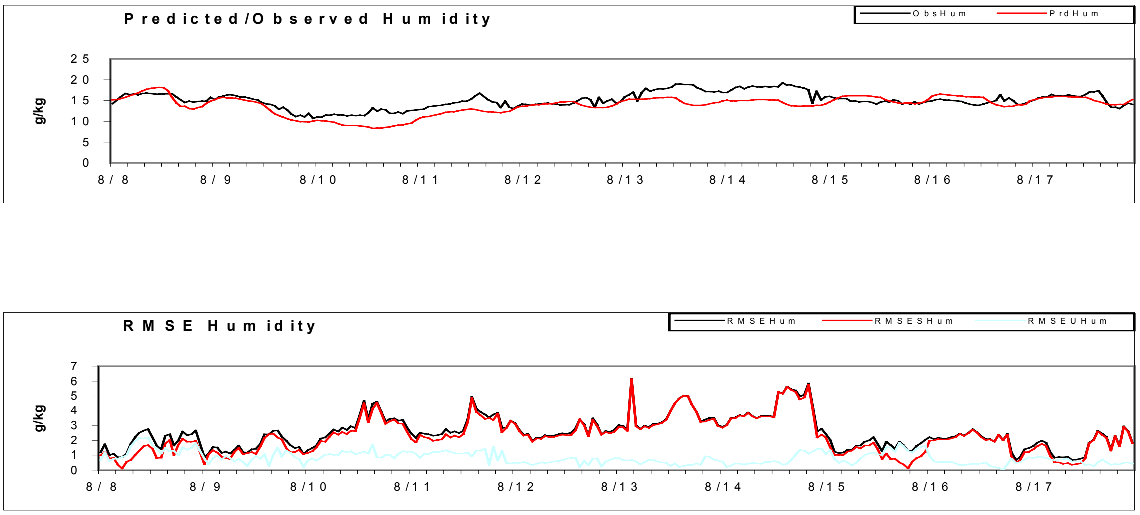


Figure 4-5 METSTAT 12 km domain hourly humidity statistics

4.2.3 Wind Fields

Figure 4-6 shows predicted surface wind on August 12, 1999 at 19:00 GMT. The wind field agrees reasonably well with observed wind field at that hour.

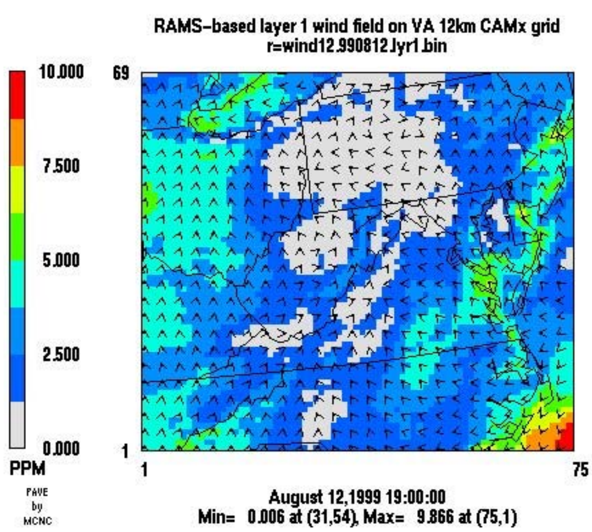


Figure 4-6 MM5 Predicted Surface Wind

Figure 4-7 shows METSTAT 12 km domain hourly wind statistics for the August 8 to August 18, 1999 episode.

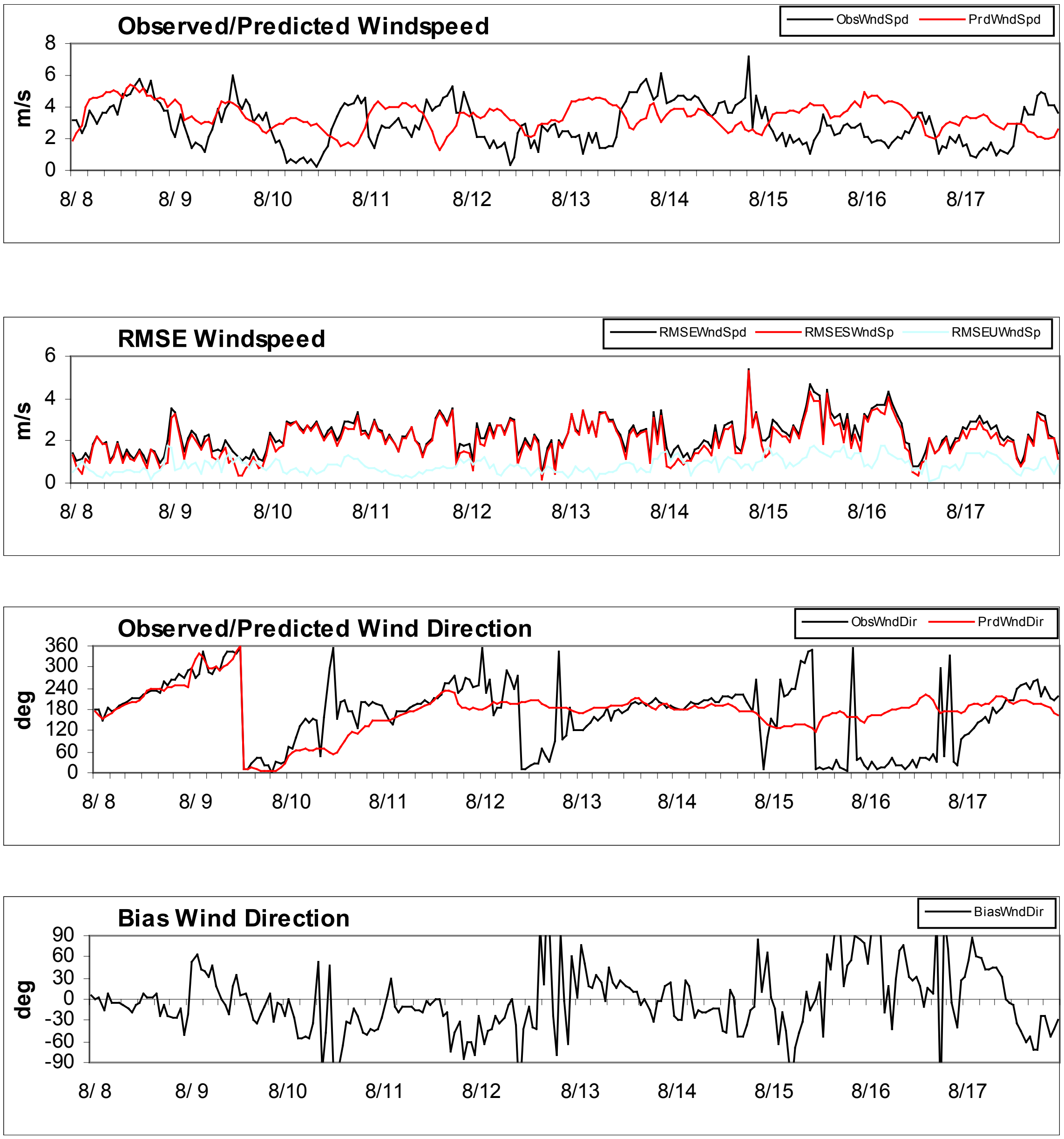


Figure 4-7. METSTAT 12 km domain wind statistics

During the episode, the simulated wind speed is in proper magnitude compare to the observed wind. Wind direction prediction performed fairly well from 8th to 15th even though abrupt wind direction changes were not captured during the 12th and 13th of the episode.

4.2.4 Planetary Boundary Layer Depth

Figure 4-9 through 4-11 shows Planetary Boundary Layer depth for August 12 and August 13, 1999 at 10AM and 2 PM hours. The PBL depth is also called mixing height. The mixing height values during the episode are in reasonable magnitude.

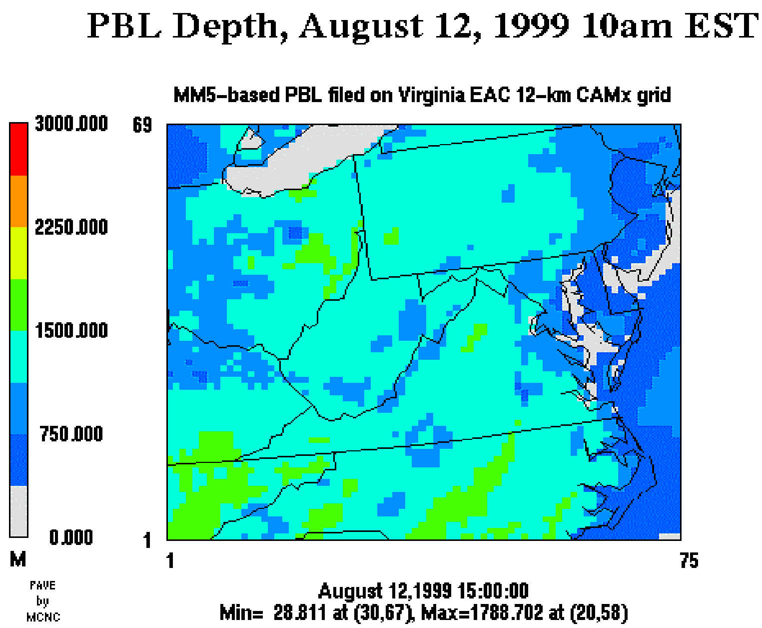


Figure 4-8 PBL Depth, August 12, 1999 10AM EST

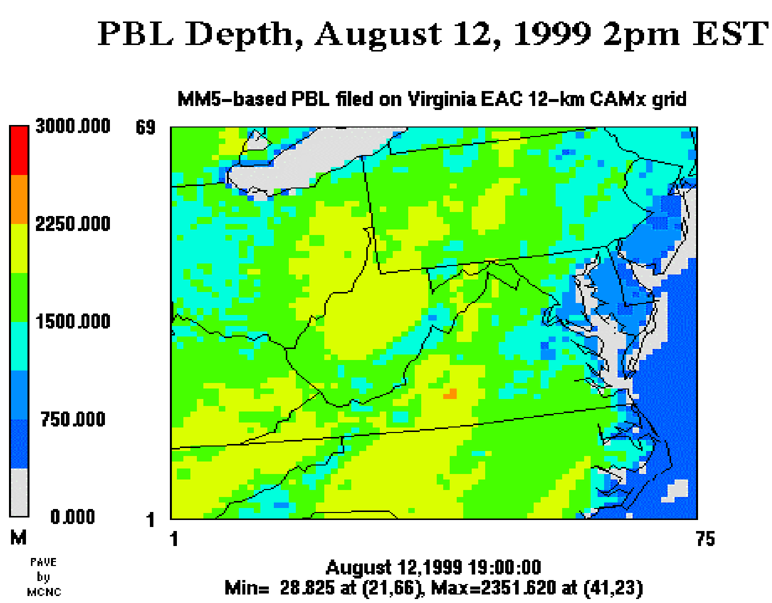


Figure 4-9 PBL Depth, August 12, 1999 2PM EST

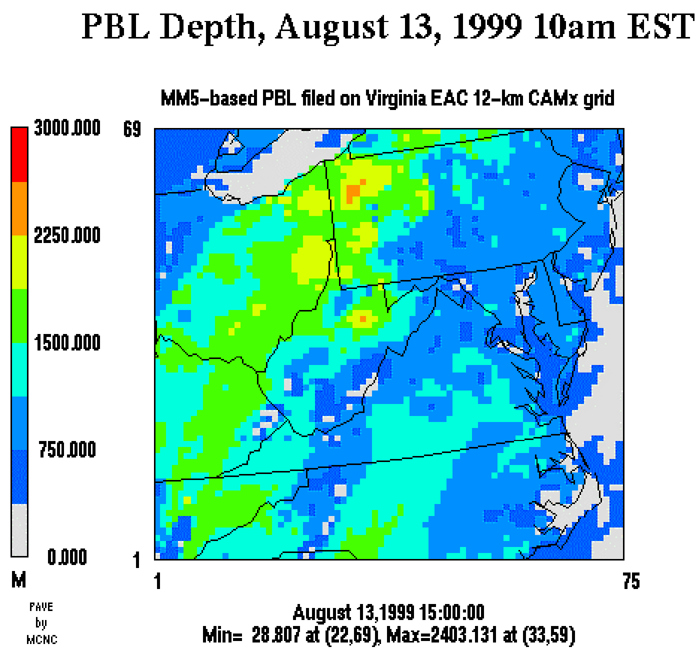


Figure 4-10. PBL Depth, August 13, 1999 10AM EST

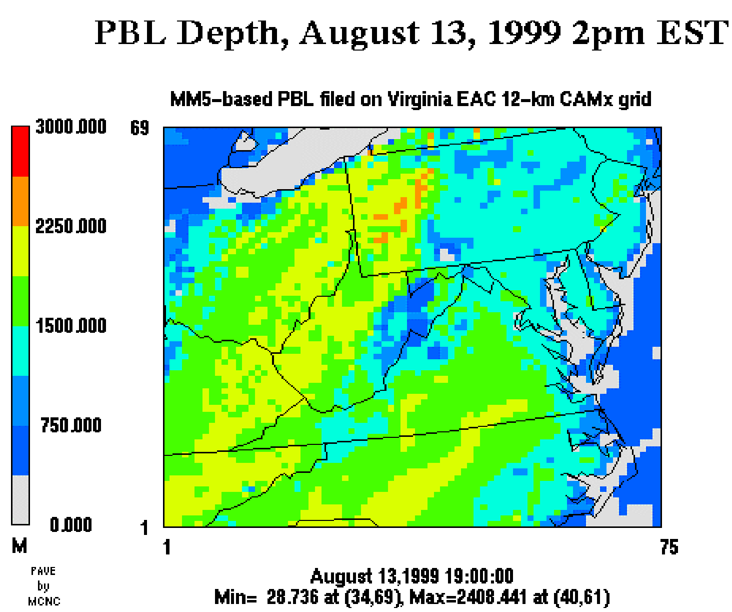


Figure 4-11. PBL Depth, August 13, 1999 2PM EST

5 Ozone Modeling

5.1 CAMx Model Configuration

The Eulerian photochemical model, CAMx modeling system was employed to simulate ozone concentration in the EAC modeling domains. The following is a list of model configuration parameters:

36/12 km grid August 8 – August 18, 1999 period
CB-IV chemistry with CMC fast solver
PPM advection solver
Wet and dry deposition
TUV photolysis rates
TOMS ozone column with default LULC albedo and haze

Figure 5-1 shows the AEC CAMx 36 km and 12 km modeling domains.

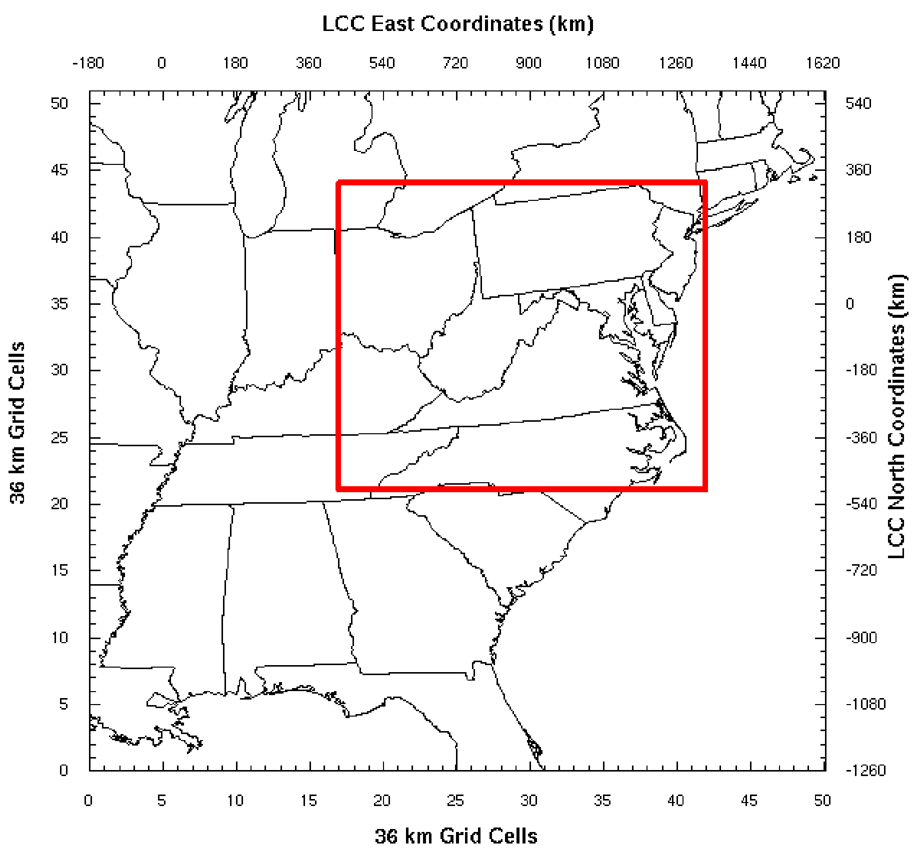


Figure 5-1. EAC CAMx 36 km and 12 km Modeling Domains

5.2 Model Performance Evaluation

Generally, predicted 8-hour ozone concentration agreed very well with observed values at most monitors in the 12 km domain. Figure 5-1 and Figure 5-2 show time series of observed and predicted 8-hour ozone concentrations from August 11 to August 14, 1999 at the Vinton (Roanoke County) and Frederick monitors. Daytime simulations showed good agreement with the observations. Night-time ozone concentrations were systematically over-predicted. However, night-time ozone concentration was not the main focus of this study. Figure 5-3 shows a scatter plot of predicted versus observed ozone concentration for all Virginia sites. Over 90% of predicted values fell within the ±50% bias lines. Most of the predicted values outside the ±50% region were due to night-time over-predictions.

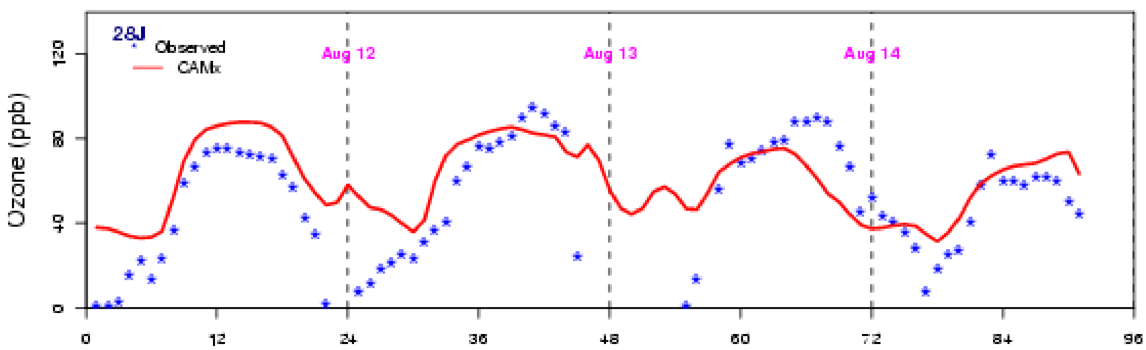


Figure 5-1. Time series of observed and simulated 8-hour ozone concentration at Frederick (Frederick/Winchester City)

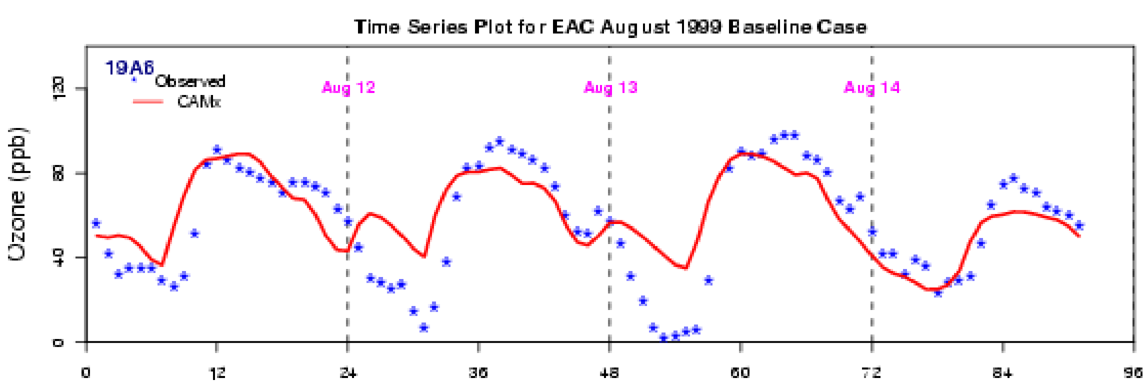


Figure 5-2. Time series of observed and simulated 8-hour ozone concentration at Vinton (Roanoke MSA)

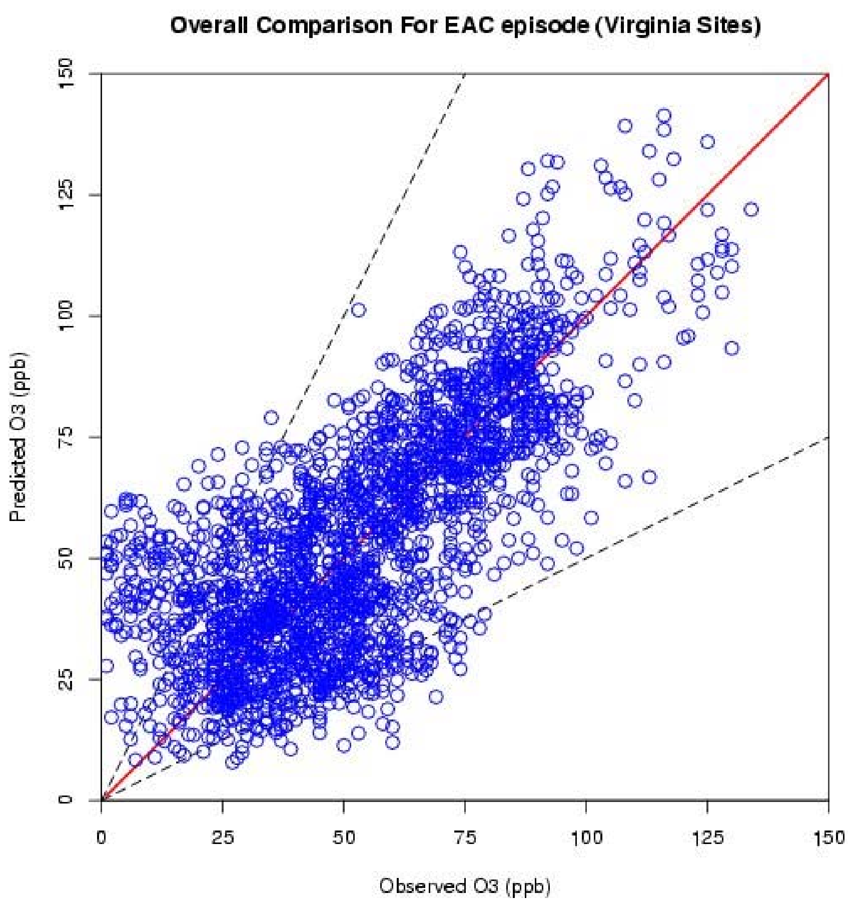


Figure 5-3. Scatter plot of observed and predicted ozone concentration for Virginia sites

Table 5-1 and Table 5-2 provides model performance metrics for August 12 and August 13, 1999 for major performance criteria. For Virginia sites, all performance goals were met for both episode days. For the entire 12 km domain, all performance goals were met for both episode days except the Normalized Bias for the 13th. It was decided based the performance metrics that the model is acceptable for future year modeling for the August 1999 episode.

Figure 5-4 and Figure 5-5 shows 12 km domain predicted base year daily maximum1-hour and 8-hour ozone concentrations, respectively, for the 12th and 13th of the episode.

Table 5-1. O3 performance statistics for August 12, 1999

	(a) 12km (VA Sites)	(b) 12km (Whole Domain)	(c) EPA Criteria
Overall Absolute Peak			
Predicted peak	153.9 ppb	153.9 ppb	
Observed peak	134.0 ppb	143.0 ppb	
Unpaired bias	14.9 %	7.7 %	20.0 %
Peak Prediction (Normalized Bias)			
Paired in space	1.7 %	-1.3 %	
Paired space/time	-4.2 %	-8.7 %	
Peak Prediction (Normalized Error)			
Paired in space	12.9 %	13.9 %	
Paired space/time	11.1 %	16.7 %	
Average Concentration Prediction			
Normalized bias	1.3 %	0.6 %	15.0 %
Normalized error	17.4 %	16.6 %	35.0 %
Mean bias	0.9 ppb	-0.6 ppb	
Mean error	14.1 ppb	13.0 ppb	

Table 5-2. O3 performance statistics for August 13, 1999

	(a) 12km (VA Sites)	(b) 12km (Whole Domain)	(c) EPA Criteria
Overall Absolute Peak			
predicted peak	116.4 ppb	116.4 ppb	
observed peak	113.0 ppb	164.0 ppb	
unpaired bias	3.0 %	-29.0 %	20.0 %
Peak Prediction (Normalized Bias)			
paired in space	-3.4 %	-0.5 %	
paired space/time	-11.6 %	-9.0 %	
Peak Prediction (Normalized Error)			
paired in space	16.9 %	14.2 %	
paired space/time	22.9 %	17.6 %	
Average Concentration Prediction			
normalized bias	-6.7 %	-2.4 %	15.0 %
normalized error	16.5 %	17.3 %	35.0 %
mean bias	-6.5 ppb	-2.9 ppb	
mean error	13.1 ppb	13.0 ppb	

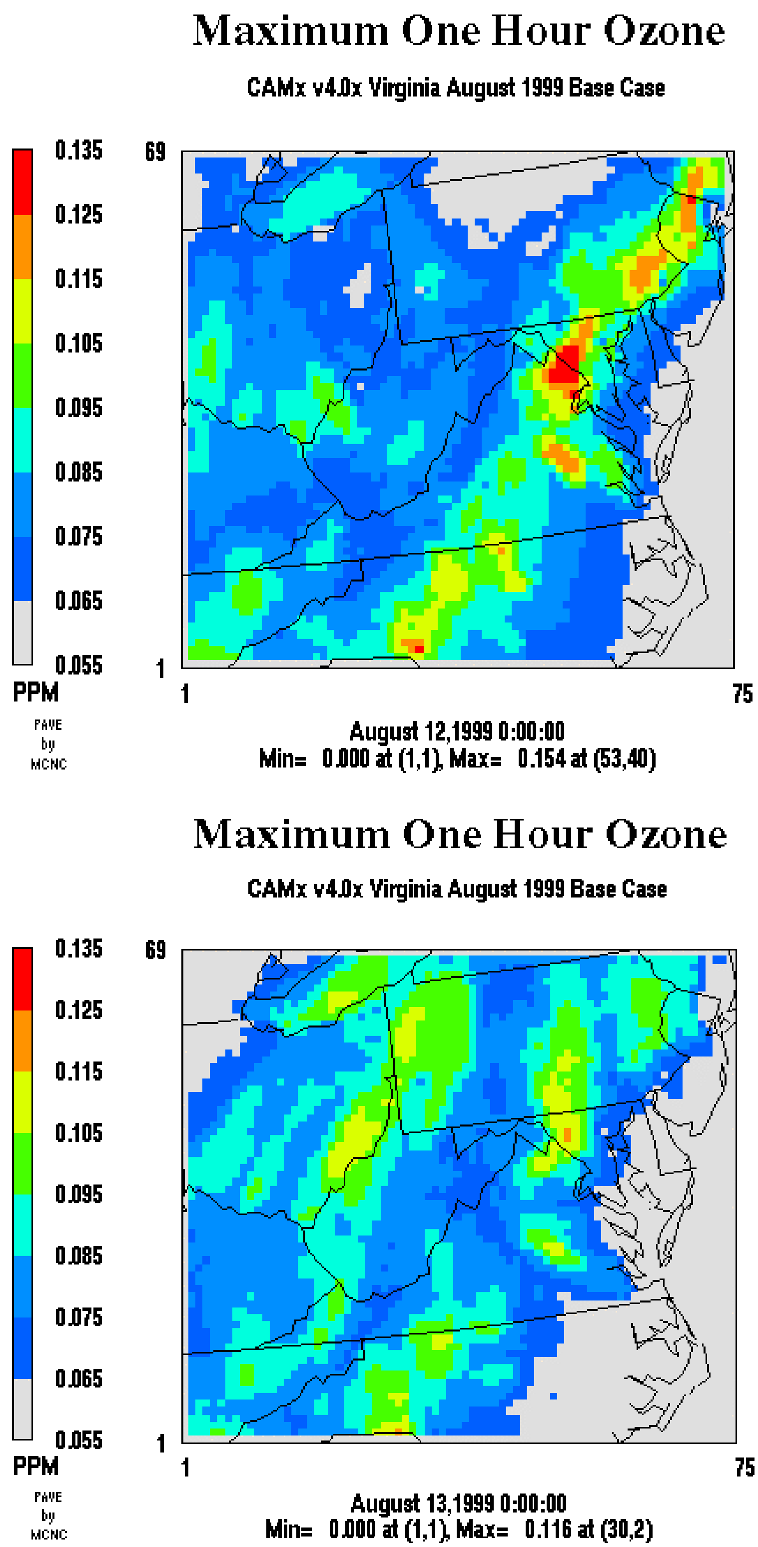


Figure 5-4. CAMx predicted 1-hour daily maximum ozone concentrations

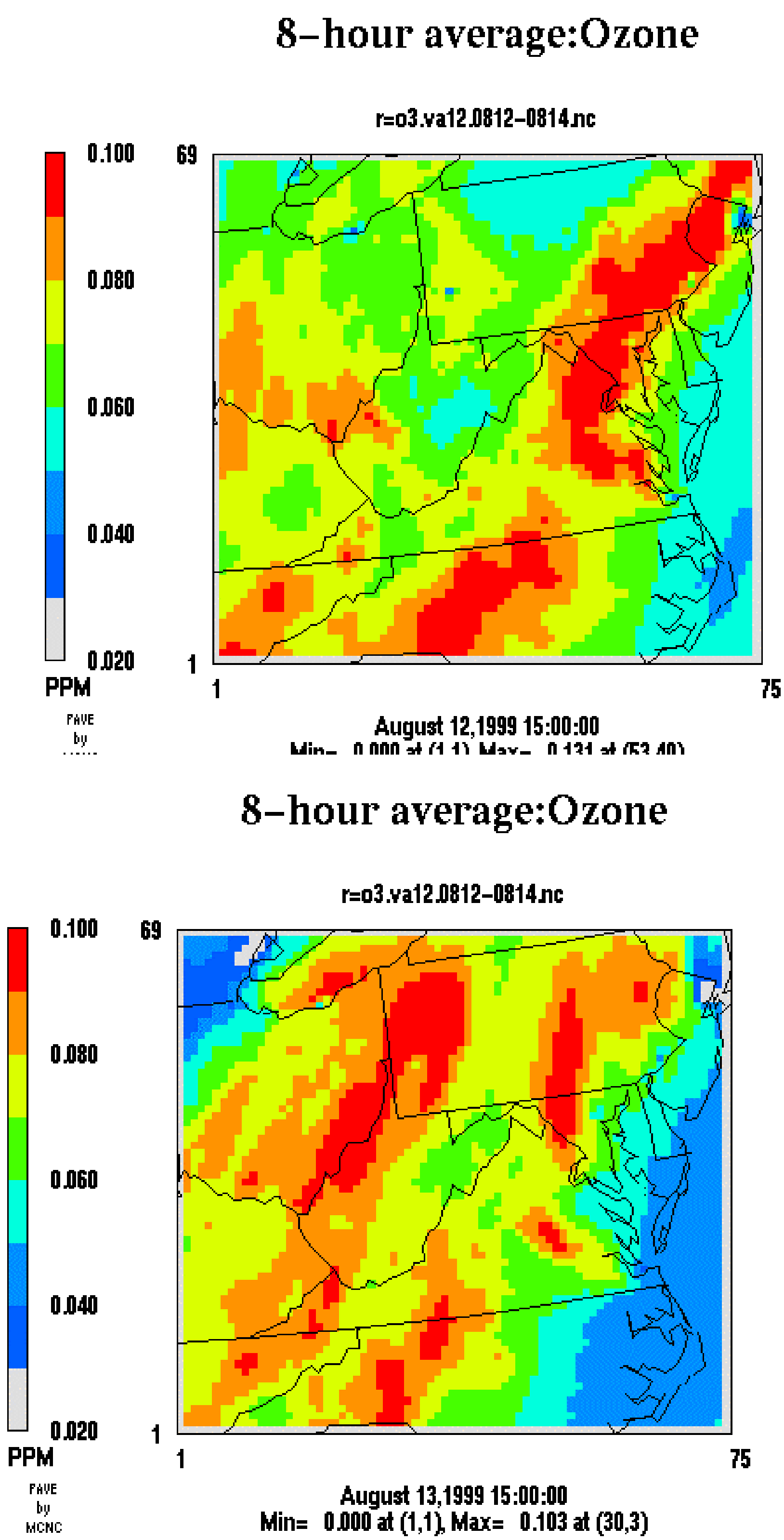


Figure 5-5. CAMx predicted 8-hour daily maximum ozone concentrations

Figure 5-6 and Figure 5-7 shows 12 km domain predicted future year daily maximum1-hour and 8-hour ozone concentrations, respectively, for the 12th and 13th of the episode. All EAC local control measures have been quantified and included in the future year emission inventories.

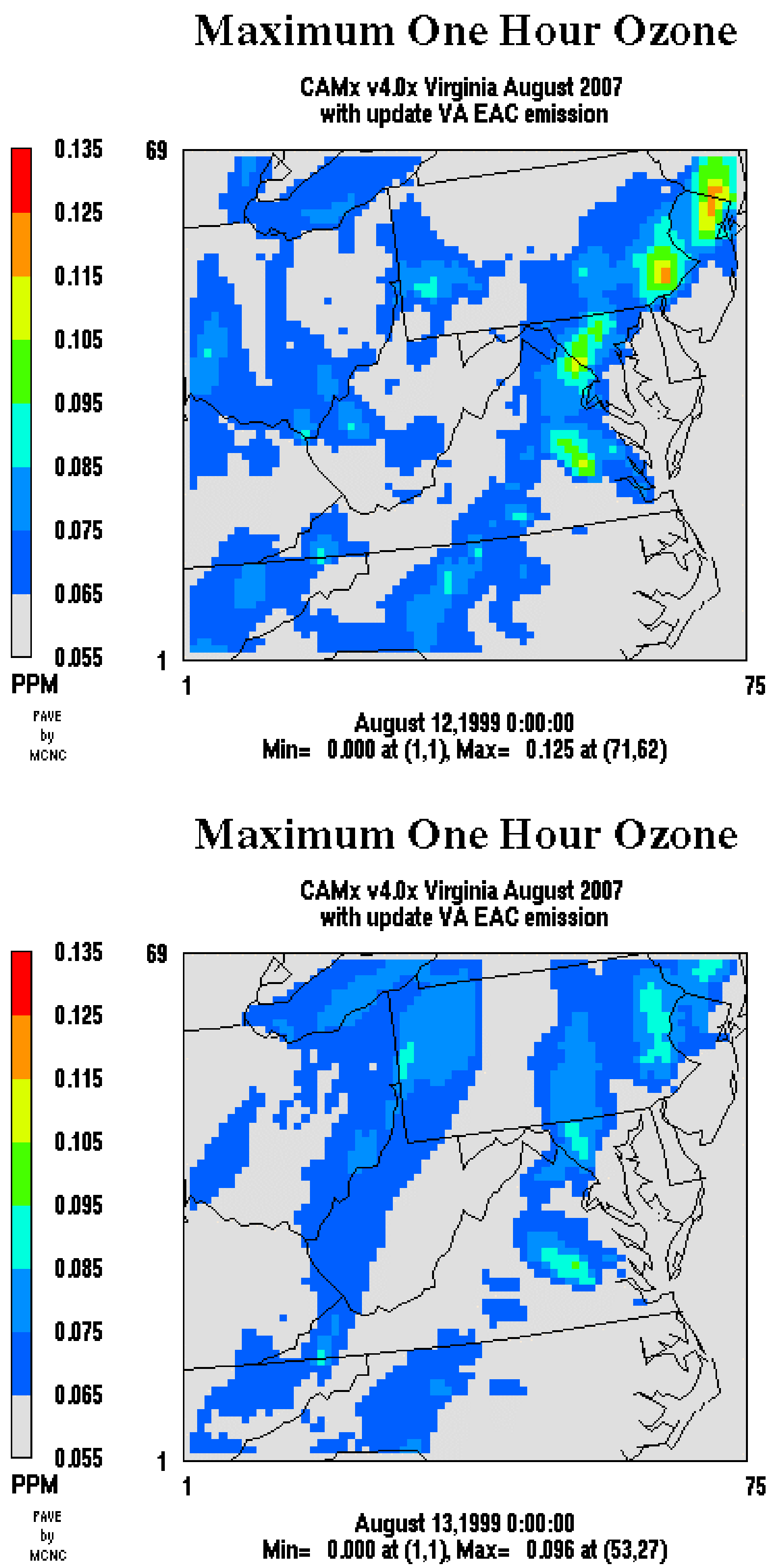
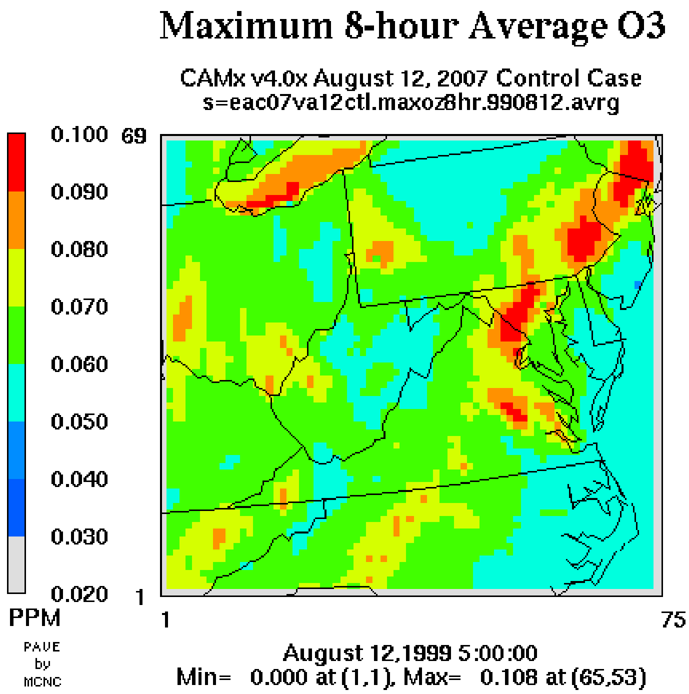


Figure 5-6. CAMx predicted future year 1-hour daily maximum ozone concentrations



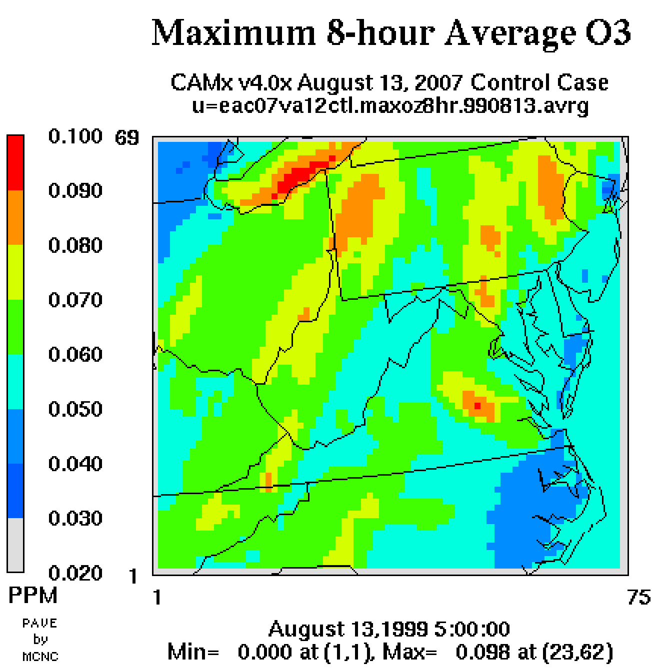


Figure 5-7. CAMx predicted future year 8-hour daily maximum ozone concentrations

6. Attainment Demonstration

Because EPA has not yet designated any region as non-attainment for 8-hour ozone, no formal requirement exists for an 8-hour attainment demonstration. However, EPA has developed draft procedures for using photochemical models to demonstrate attainment of the 8-hour ozone NAAQS. The critical elements in the demonstration of attainment under the 8-hour ozone NAAQS, established by the *Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS, U.S. EPA Office of Air Quality Planning and Standards, EPA-454/R-99-004, May 1999*, are the calculation of relative reduction factors (RRFs) and future design values (DVs). The RRFs and base-year Design Values are the basis for projecting future-year Design Values (DVF).

All episode days with modeled base year daily maximum 8-hour ozone concentration greater than or equal to 70 ppb will be use to calculate the RRF for the all monitors representing the five EAC areas in this study. Table 6-1 lists the monitors and their corresponding EAC areas.

Table 6-1. Monitors for calculating RRFs

Monitors and AIRS ID	EAC Areas
51-161-1004 Roanoke	Roanoke MSA, Virginia
51-069-0010 Frederick	Frederick/Winchester City, Virginia
51-069-0010 Frederick	Berkley County/Martinsburg City, West Virginia
51-069-0010 Frederick	Jefferson County, West Virginia
24-043-0009 Hagerstown	Washington County, Maryland

Figure 6-1 shows the spatial locations of the monitors listed in the above table.

6.1 Calculation Methodology for RRFs and DVs

The methodology calls for scaling base-year design values using RRFs from a photochemical model to future year design values. The calculation is carried out for each monitor. The attainment test is passed if all the future year scaled DVs are 84 ppb or less.

For each monitor (i) and modeling day (j) the maximum 8-hour ozone near the monitor is selected for the current ($O3C_{ij}$) and future-year ($O3F_{ij}$):

$$RRF_i = [\sum O3F_{ij}] / [\sum O3C_{ij}]$$

Attainment demonstration is done using monitor specific relative reduction factor (RRFi) that is the ration of the future-year to current-year 8-hour ozone estimates near the monitor:

$DVF_i = RRF_i \times DVC_i$

These current EPA procedures for using models to demonstrate attainment of the 8-hour ozone NAAQS will be in this study. In this chapter, the relative differences in the modeled 8-hour ozone estimates between 1999 base case simulation and 2007 control case simulation will be developed to scale their measured Design Value for comparison with the 84 ppb 8-hour ozone NAAQS. The attainment demonstration will be done using the above mentioned procedures for two EAC areas in Virginia, two EAC areas in West Virginia and one EAC area in Maryland.

Table 6-2. 8-Hour Ozone Design Values for Virginia and West Virginia EAC Areas

Virginia DEQ 1997-1999 4th Highest 8-hour Ozone Averages					
AIRS ID	County/City	1997	1998	1999	3 yr. Avg.
51-161-1004	Roanoke	84	99	89	**90**
51-069-0010	Frederick	88	98	85	**90**

Table 6-3. 8-Hour Ozone Design Values for Maryland EAC Areas

Virginia DEQ 1997-1999 4th Highest 8-hour Ozone Averages					
AIRS ID	County/City	1997	1998	1999	3 yr. Avg.
24-043-0009	Hagerstown	-	-	94	**94**

The following procedures are carried out in monitor design value scaling:

1. For each monitor, identify the monitor's corresponding cell.
2. For each cell representing a monitor, find daily maximum 8-hour ozone values greater or equal to 70 ppb for the entire episode for both the base case and future case.
3.Average the daily maximum 8-hour ozone values across days with daily maximum 8-hour ozone greater or equal to 70 ppb for the base case and future case.
4. Calculate the Relative Reduction Factors for each monitor
5.Calculate the future year Design Values for each monitor

Figure 6-1 shows the geophysical locations of the four monitors participating in RRF calculation and attainment test

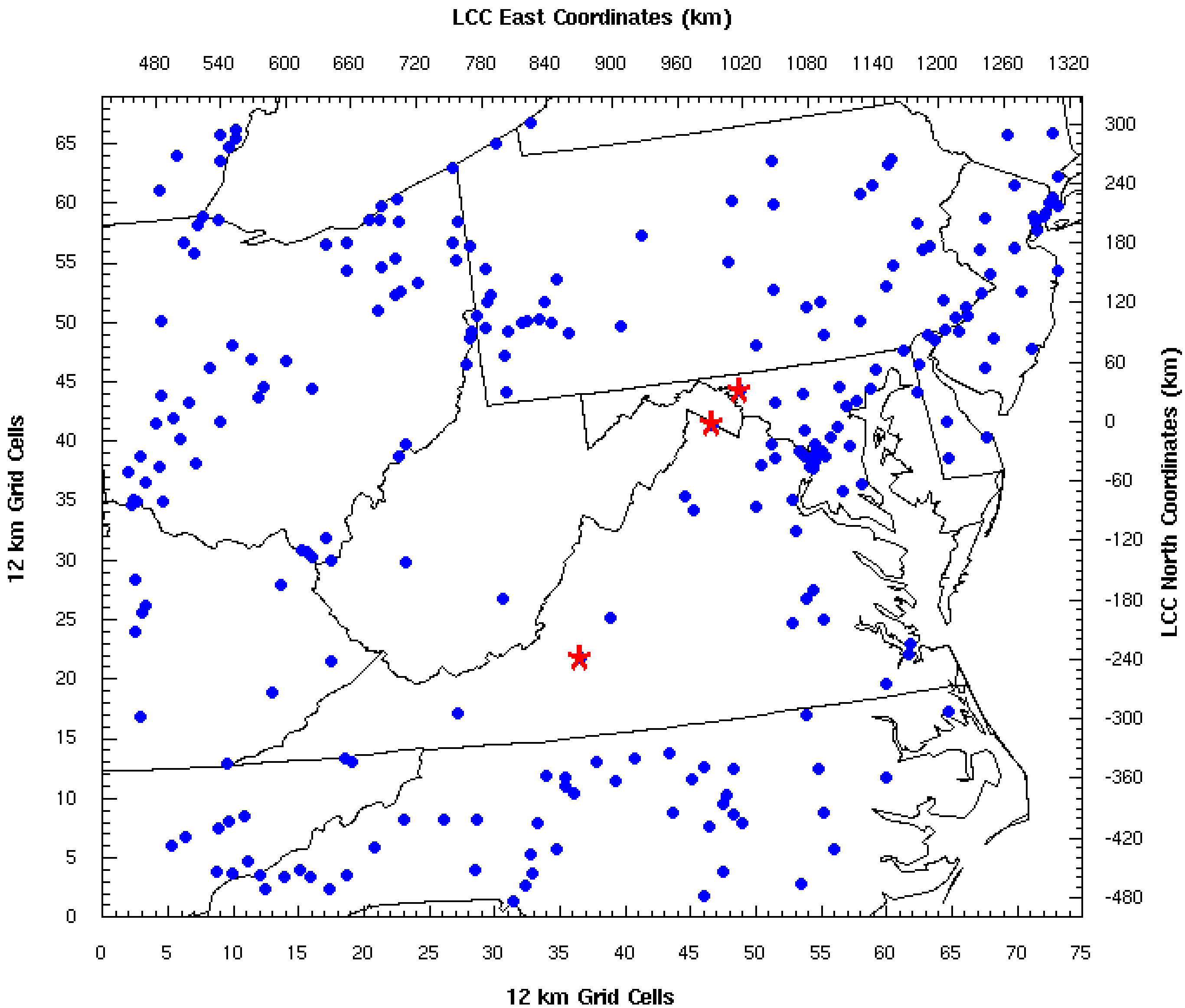


Figure 6-1. Spatial Locations of Monitors for RRFs Calculations and Attainment Demonstration of Virginia, West Virginia and Maryland EAC Areas.

6.1. 8-Hour Ozone Attainment Demonstration of Virginia and West Virginia EAC Areas

Table 6-4. Attainment Demonstration Results at Virginia Monitors

Monitors	Modeled Average Base-Year Daily Maximum Ozone Concentration (ppbv)	Modeled Average Future-Year Daily Maximum Ozone Concentration (ppbv)	RRF	Current DV (ppbv)	Future DV	Pass/Fail Status
Roanoke	79.95	62.24	0.778	90	70	Pass
Frederick	80.41	65.20	0.811	90	73	Pass

6.2. 8-Hour Ozone Attainment Demonstration of Maryland EAC Areas

Table 6-5. Attainment Demonstration Results at Maryland Monitors

Monitors	Modeled Average Base-Year Daily Maximum Ozone Concentration (ppbv)	Modeled Average Future-Year Daily Maximum Ozone Concentration (ppbv)	RRF	Current DV (ppbv)	Future DV	Pass/Fail Status
Hagerstown	86.88	69.70	0.802	94	75.4	Pass

6.3. Summary

Table 6-4 and Table 6-5 has demonstrated that all concerned EAC areas in this study will attain the 8-hour ozone standard by 2007.