Appendix C

Diagnostic Wind Model (DWM) Parameters

```
Balt/Wash7/5/88-7/7/88
NX        :48
NY        :50
NZ        :14
DXK       :  5.0
DYK       :  5.0
CELLZB    :    0.0   50.0 100.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0
            1000.01500.02000.02500.03000.0
UTMXOR    :240.0
UTMYOR    :4235.0
TSTART    :     0
TEND      :  2300
TINC      :1.
NWIND     :35
NUPPER    :5
ZSWIND    :10.
RMIN      :20.
RMAX1     :500.
RMAX2     :500.
RMAX3     :500.
R1        :25.
R2        :300.
NINTRP    :     6     4     4     4     4     4     4     4     4     4
                4     4     4
NZPRNT    :1
IPR0      :-1
IPR1      :-1
IPR2      :-1
IPR3      :-1
IPR4      :-1
IPR5      :-1
IPR6      :-1
IPR7      :-1
ICALC     :1
IOUTD     :1
HTFAC     :1.
NITER     :50
DIVLIM    :1.0E-6
IOBR      :0
NUMBAR    :0
I3DCTW    :0
NSMTH     :1
IEXTRP    :1
FEXTRP    :     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                0.0     0.0     0.0
```

Appendix D

UAMWND Parameters

Appendix D contains the input parameters for the UAM/DWM interface. The day-specific entry is the ISTAB parameter that sets the stability parameter.

```
DWMWINDFIELDS-Balto/Wash
TOP       :3000.03000.03000.03000.03000.03000.03000.03000.03000.03000.0
           3000.03000.03000.03000.03000.03000.03000.03000.03000.03000.0
           3000.03000.03000.03000.0
NZD       :14
HGT       :    0.0   50.0  100.0  200.0  300.0  400.0  500.0  600.0  700.0  800.0
           1000.01500.02000.02500.03000.0
NSMTH     :2
IDATEW    :91201
BEGTIW    :    0.0
JDATEW    :91201
ENDTIW    :   24.0
ISTAB     :    5    5    6    6    5    5    4    3    2    2
               1    2    2    1    2    2    2    3    4    4
               5    6    6    6
Z0        :1.20
NXT       :23
NYT       :25
```

Appendix E

Wind Data for DWM
Episode 3

Appendix F provides the wind data input to the DWM for Episode 3. The location of each station is given in UTM (km) coordinates. More information about each station is given in Appendix A.

```
NSTA     :30
NSTRHR   :0
NENDHR   :24
TDIF     :1.0
KYEAR    :91
KMONTH   :07
KDAY     :20
 BWI    356.0 4338.3  Balto.Wash.Intl
 DCA    325.0 4301.9  Wash.Natl
 IAD    287.7 4313.9  Wash.Dulles
 ILG    448.5 4390.8  Wilmington
 NHK    376.1 4239.9  Patuxent NAS
 PHI    478.6 4414.7  Phil.Int
 ACS    528.6 4399.9  Atl City Surf
 ADW    338.1 4296.8  Andrews
 ABE    404.9 4376.5  Aberdeen
 CXY    342.6 4453.3  Capitol City Arprt
 DAA    310.0 4287.5  Fort Belvior
 DOV    459.7 4331.5  Dover AFB
 HGR    266.1 4398.6  Hagerstown
 LNS    389.6 4449.0  Lancaster
 MDT    349.9 4450.5  Harrisburg
 MIV    491.4 4349.9  Millville
 NXX    487.5 4449.0  Willow Grove
 NYG    298.7 4263.2  Quantico MAS
 PNE    498.6 4436.8  Philadelphia NE
 RDG    417.9 4468.7  Reading
 SBY    456.3 4242.7  Salisbury
 SPE    408.0 4372.6  Spesutie, apg
 TPT    378.6 4306.4  Thomas Point
 TRE    402.8 4369.6  Trench Warefare, apg
 WOR    397.9 4350.6  Worton Pt, apg
 CKY    359.7 4369.0  Cockeysville,240051007
 DAV    356.7 4307.1  Davidsonville,240030014
 ROC    317.8 4331.3  Rockville,240313001
 EDG    388.3 4362.8  Edgewood,240251001
 ESX    372.4 4356.8  Essex,240053001
```

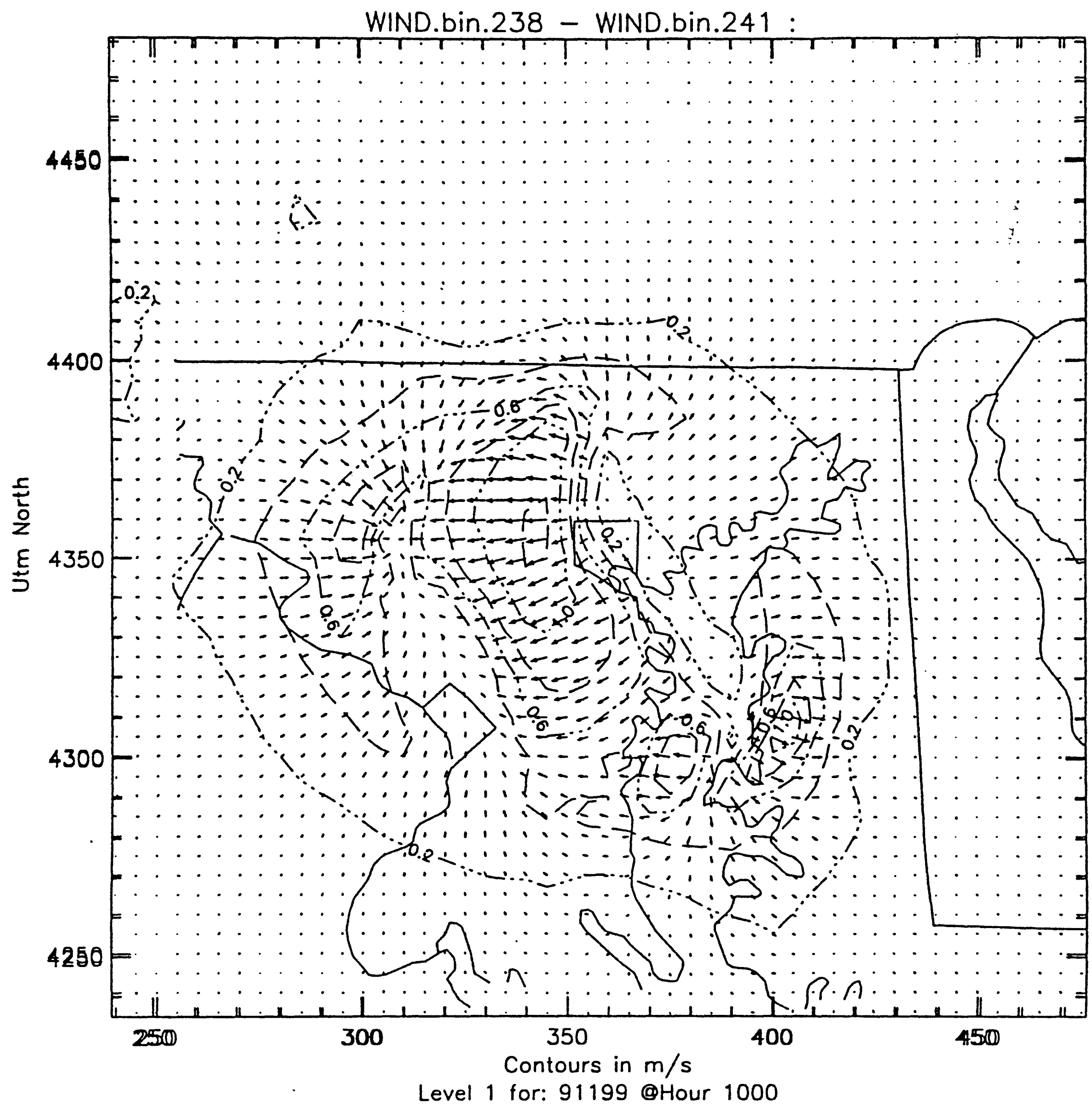


Figure 1. Difference in wind fields (units of ms^{-1}) between Diagnostic Wind Model (DWM) runs for Hour 1000 on July 18, 1991 using corrected morning BWI mixing heights (WIND.bin.241) and uncorrected - much higher - BWI mixing heights (WIND.bin.238).

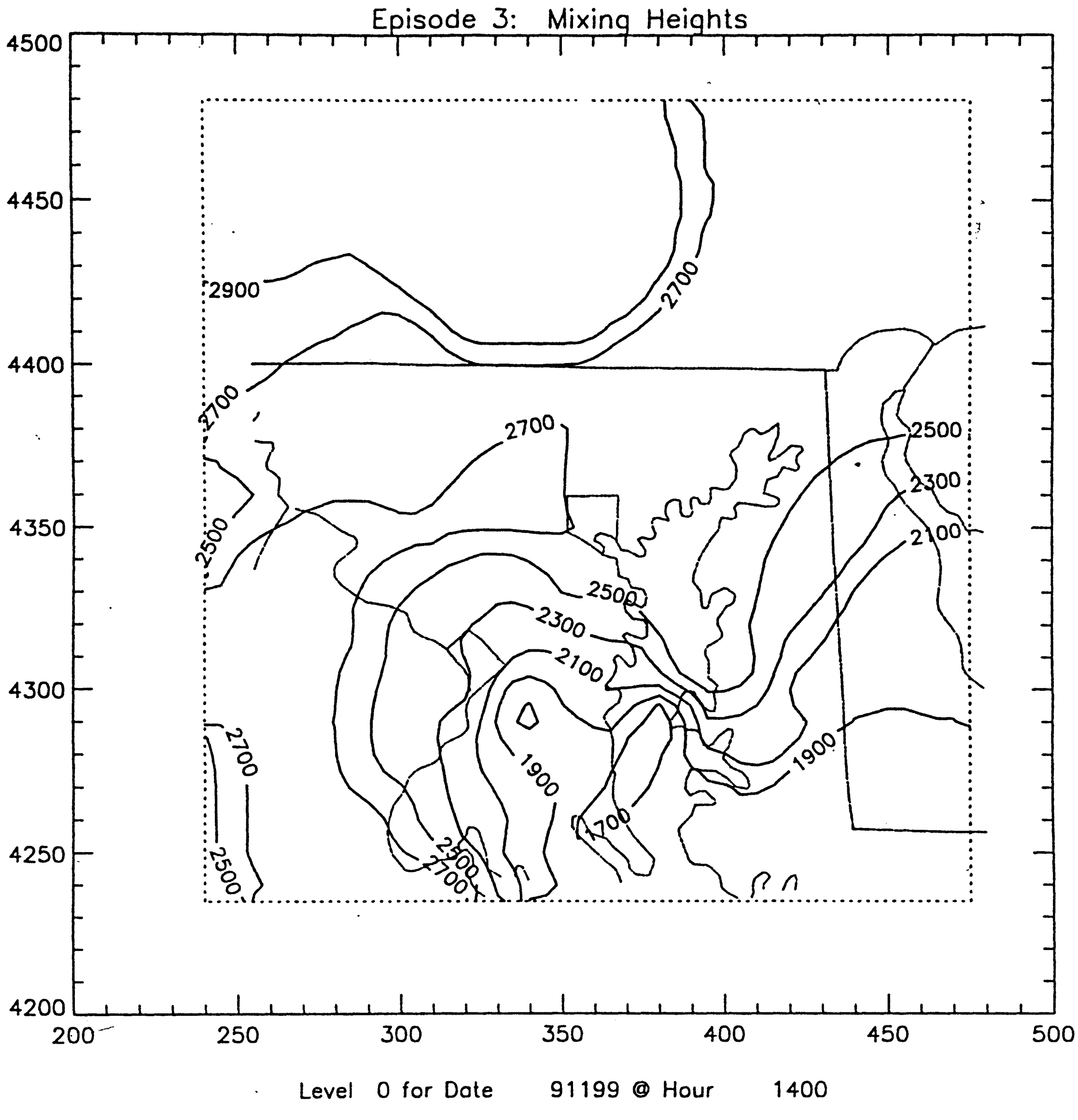


Figure 2. Mixing height field (in m) for Hour 1400 on July 18, 1991 prepared by MIXEMUP preprocessors.

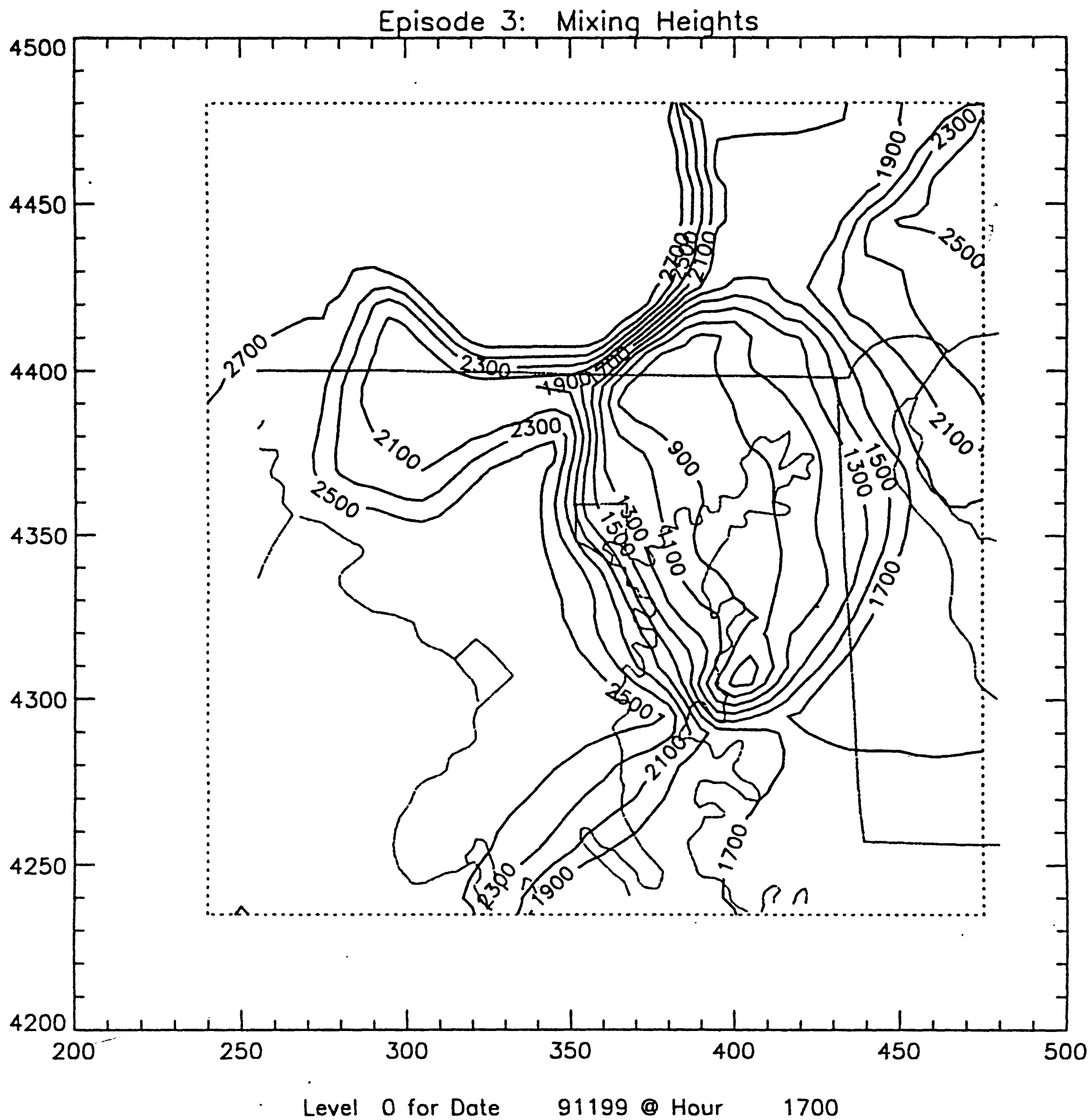


Figure 3. As in Figure 2 but for Hour 1700. Note lower mixing heights due to influence of cooler conditions at Aberdeen sites.

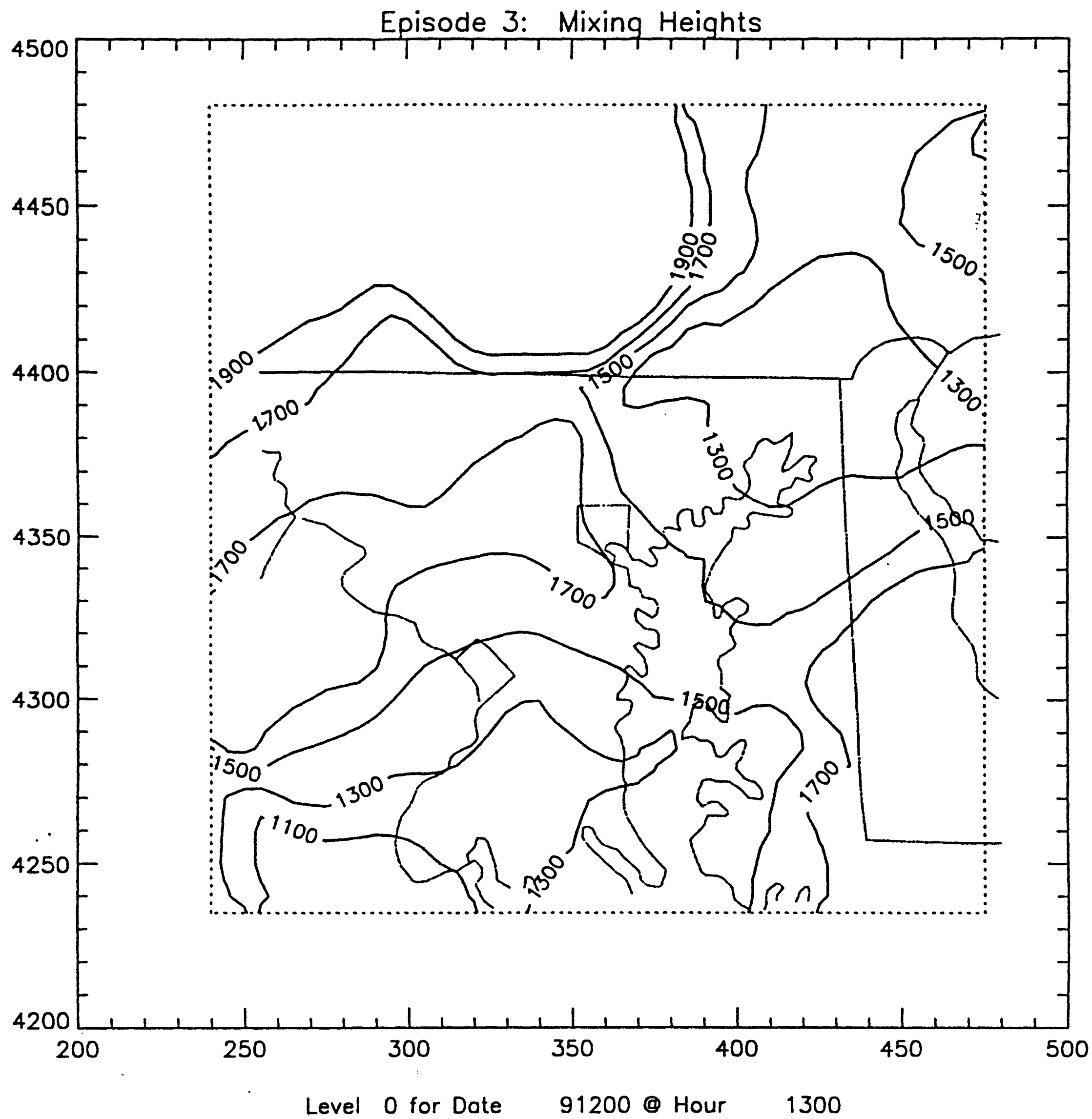


Figure 4. As in Figure 2 but for Hour 1300 on July 19, 1991.

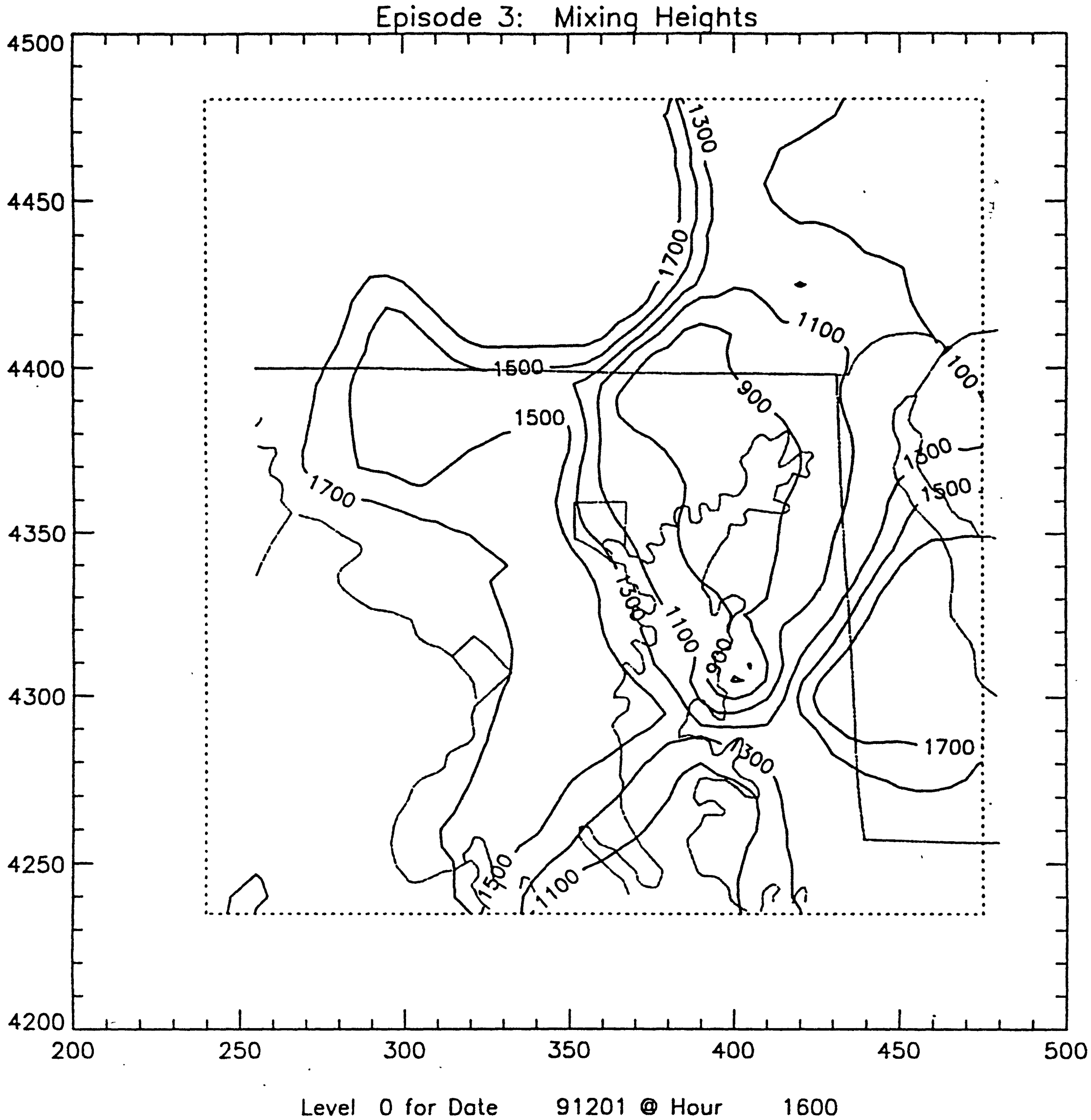


Figure 5. As in Figure 2 but for Hour 1600 on July 20, 1991.

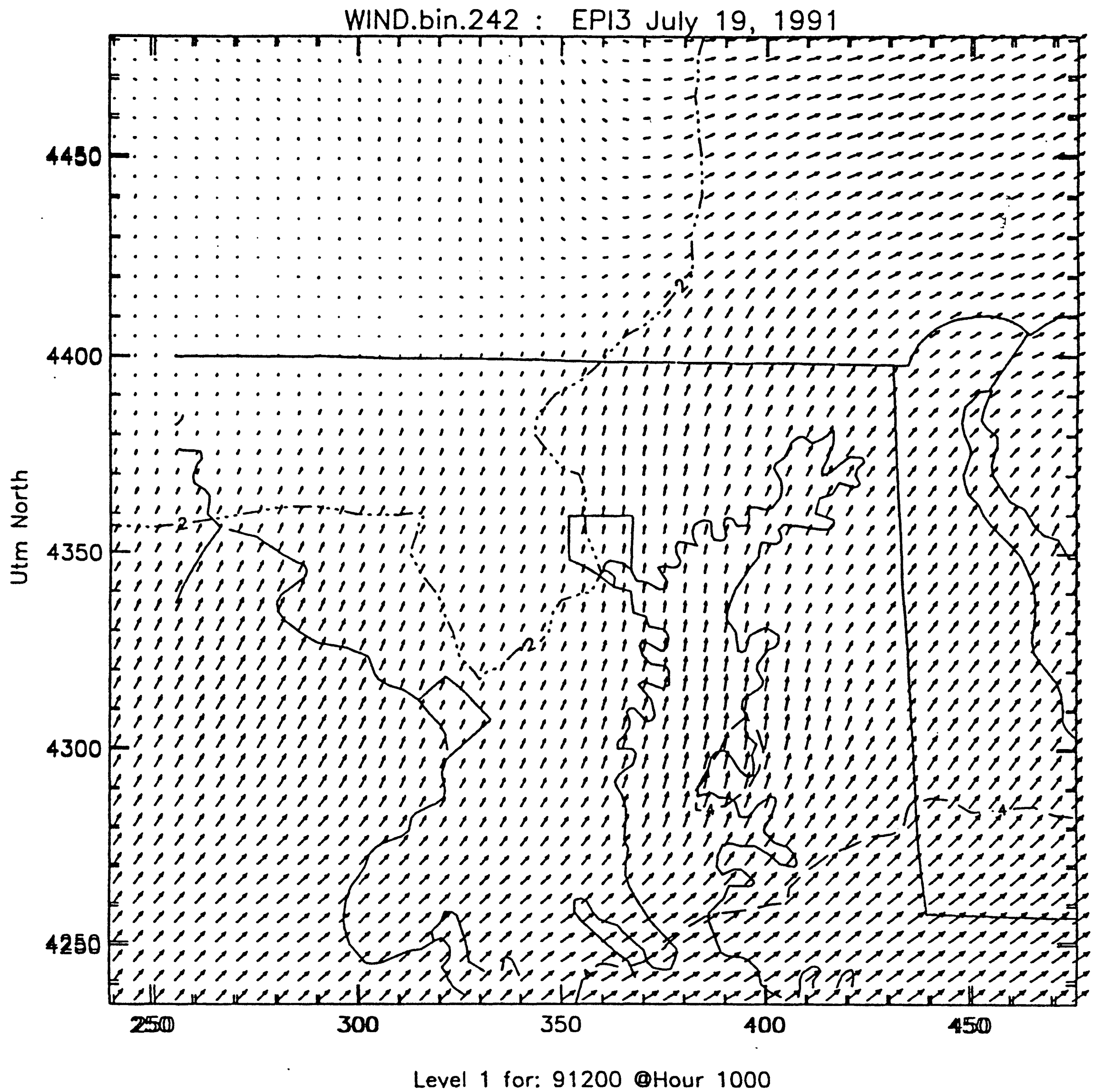


Figure 6. DWM wind fields (in ms^{-1}) for the lowest UAM layer (Layer 1, approximately surface to 400 m) for July 19, 1991.

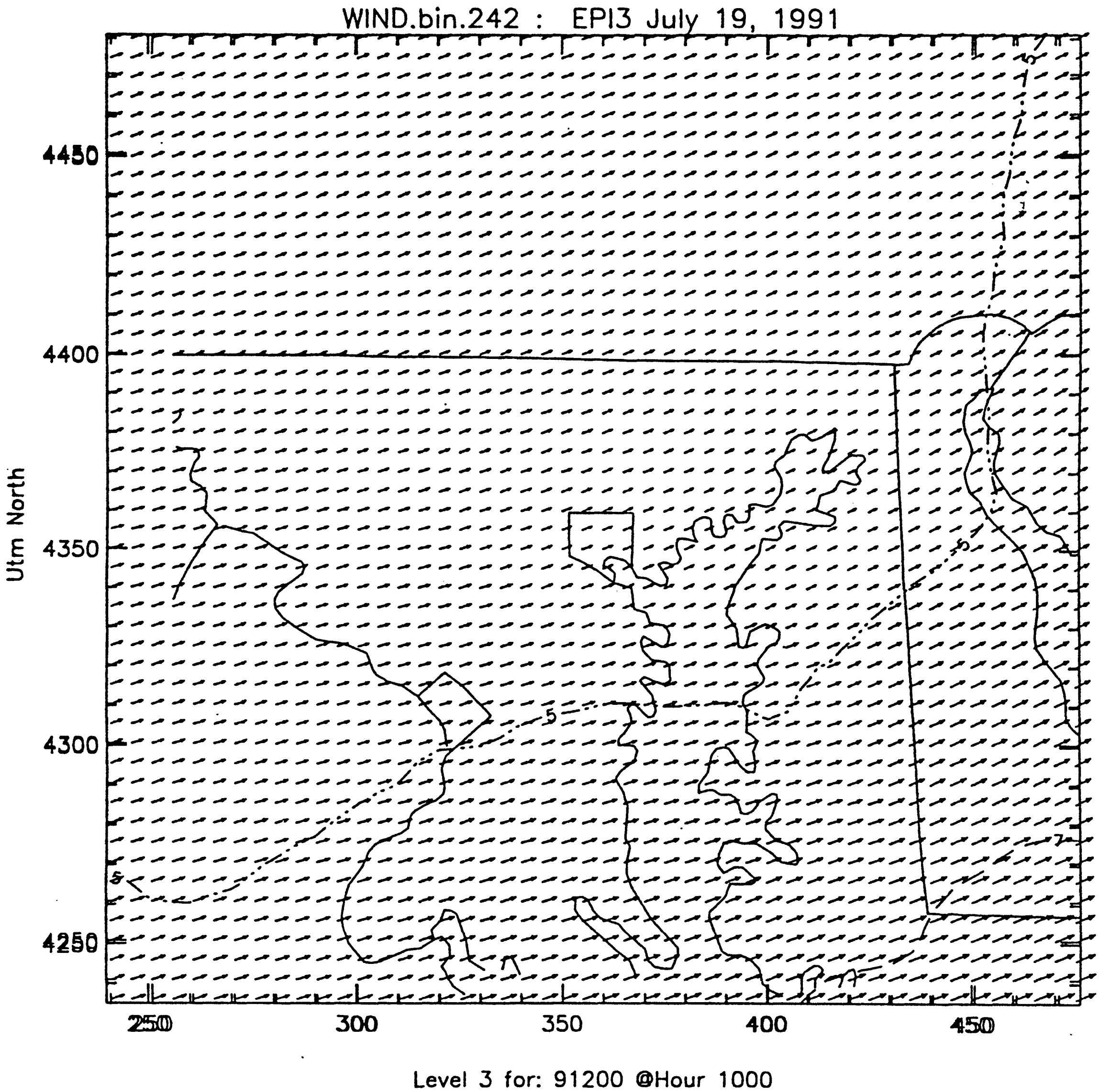


Figure 7. As in Figure 6 but for Layer 3 of the UAM (approximately 800 m).

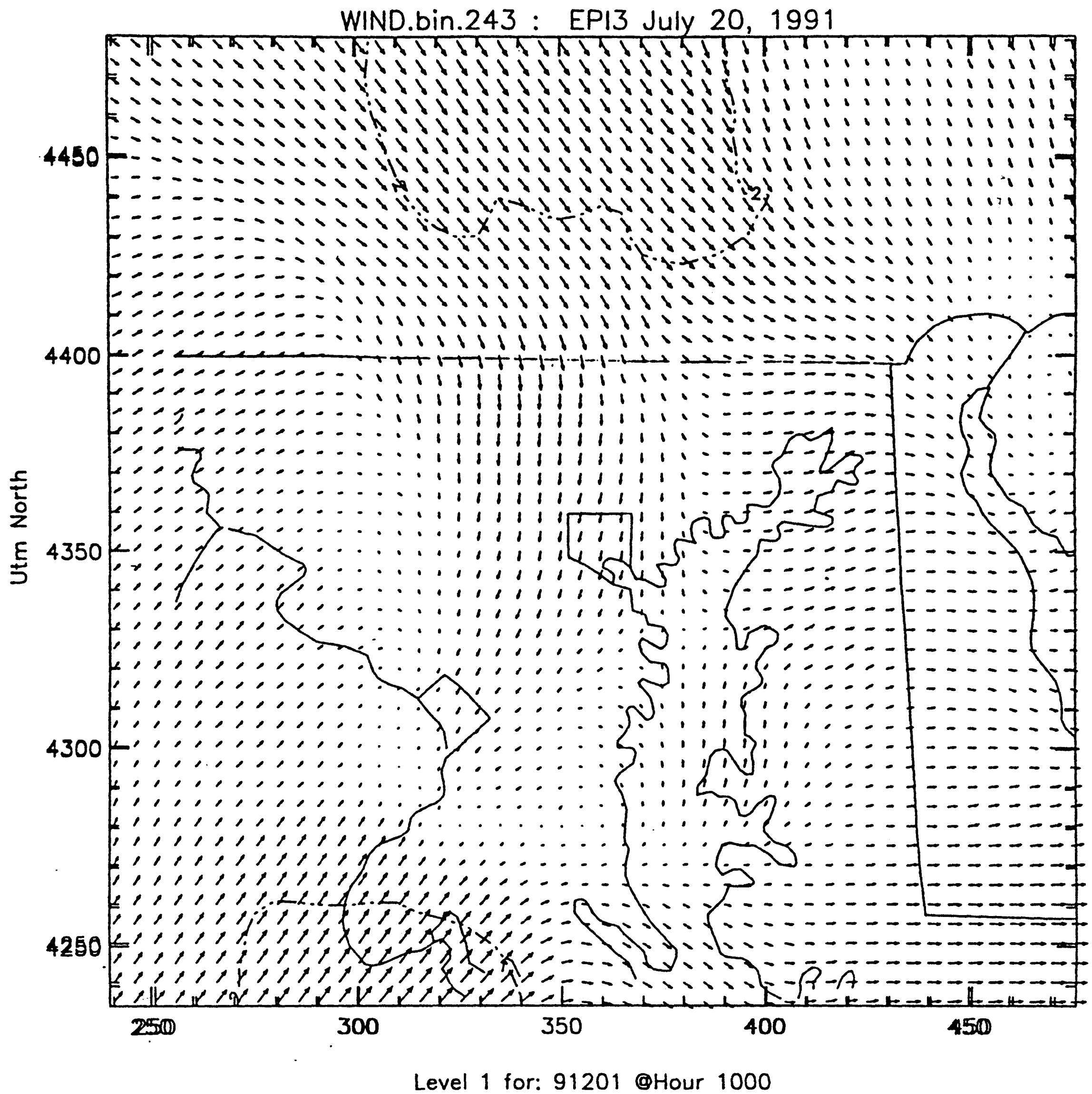


Figure 8. As in Figure 6 but for July 20, 1991. Layer 1 is approximately surface to 400 m).

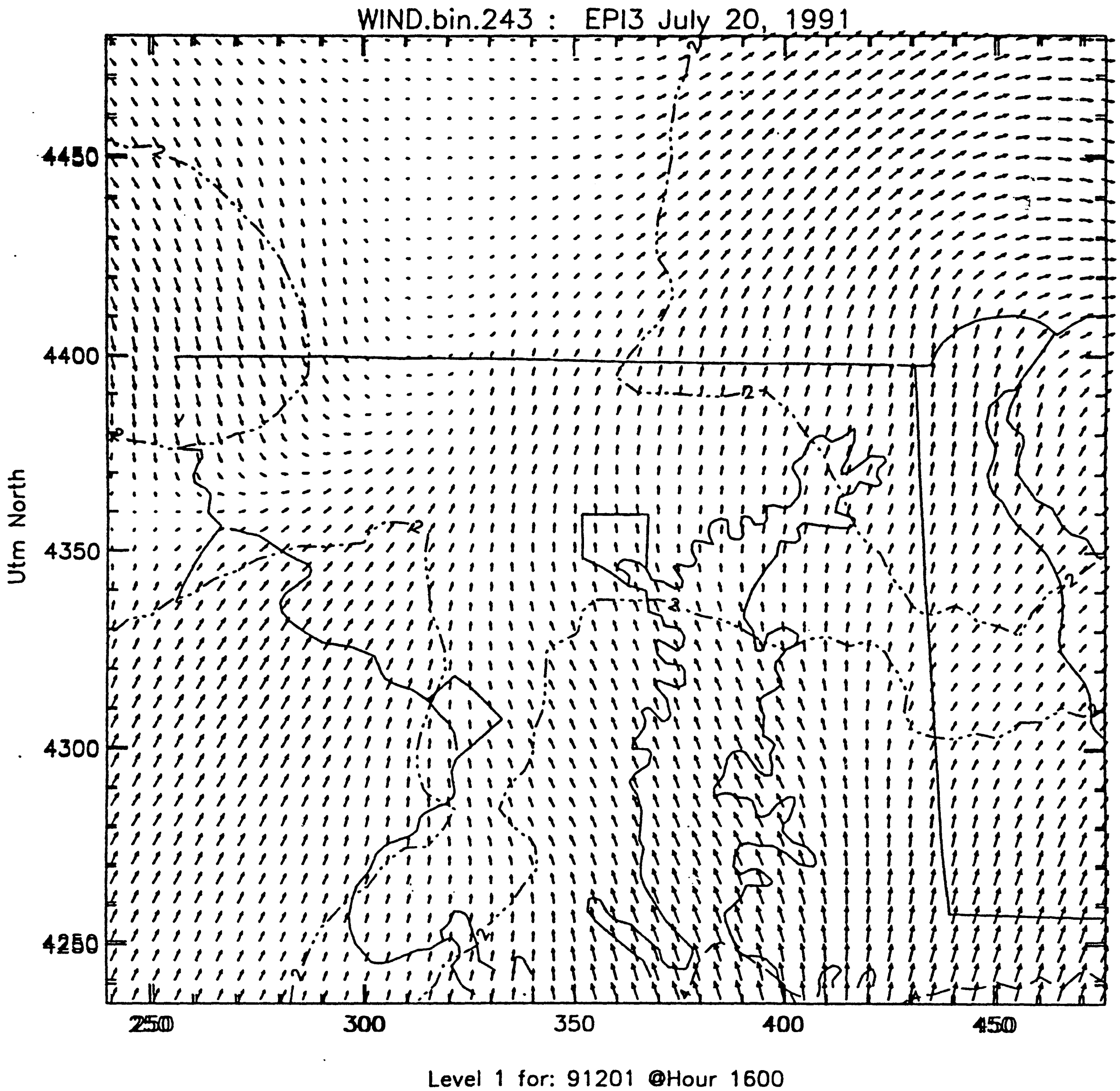


Figure 9. As in Figure 6 but for Hour 1600 on July 20, 1991. Layer 1 at this time is approximately surface to 700 m with higher heights in the NW quadrant.

Model Performance Evaluation for Baltimore-Washington UAM-IV Modeling Domain

1. Introduction

This document presents the findings of the Urban Airshed Model (UAM-IV) runs for the two 1991 base case episodes to show acceptable performance within the accuracy constraints of the model as applied to the Baltimore-Washington UAM-IV modeling domain. The two episodes evaluated here are Episode 3 (July 18-20, 1991), and Episode 3b (July 14-16, 1991).

The document includes a brief discussion of UAM-IV input files used for the evaluation of model performance, followed by a presentation of the graphical and statistical results for each individual episode. Finally, a conclusion statement regarding the usefulness of each episode for regulatory purposes is made to meet the SIP modeling documentation requirement.

The performance measures used in this document include both graphical and statistical analyses as recommended in the EPA photochemical modeling guidelines (EPA, 1991). The following graphical displays were generated for graphical analyses:

Time-series plots - The time-series plot, developed for each monitoring station in the modeling domain, depicts the hourly predicted and observed concentrations for the simulation period. The time-series reveals the model's ability to reproduce the peak prediction, the presence of any significant bias within the diurnal cycle, and a comparison of the timing of the predicted and observed ozone maxima.

Ground-level isopleths - Ground-level isopleths display the spatial distribution of predicted concentrations at each hour. Isopleths of predicted daily maxima provide information on the magnitude and location of predicted domain peak ozone concentrations.

Scatterplots of predictions and observations - Scatterplots depict the extent of bias and error in the ensemble of hourly prediction-observation pairs. Bias is indicated by the systematic positioning of data points above or below the perfect correlation line. The dispersion of points is a measure of the error in the simulation. The scatterplots also reveals outlier prediction-observation pairs.

The following mathematical formulations were applied as statistical measures for model performance evaluation. These formulations are detailed in Appendix C. of the EPA photochemical modeling guidelines (EPA, 1991).

Unpaired highest-prediction accuracy - This measure quantifies the difference between the highest observed value and highest predicted value over all hours and monitoring stations. The EPA's guideline document describes unpaired peak accuracy as comparing predicted peak ozone and observed peak ozone across the entire domain. However, the predicted ozone maximum may occur near the domain boundary due to high ozone concentrations transported across the domain boundary. It is inappropriate to compare predicted ozone values at boundary and observed values near the interested urban area. Therefore, the unpaired peak accuracy is determined with the predicted values within the area affected by Baltimore-Washington urban plumes.

Normalized bias test - This test measures the model's ability to replicate observed patterns during the times of day when available monitoring and modeled data are most likely to represent similar spatial scales.

Gross error of all pairs above 60 ppb - In conjunction with bias measurements, this metric provides an overall assessment of base case performance.

The EPA recommended that the model performance should fall between the following values to be judged acceptable:

- Unpaired highest prediction accuracy: ±15-20 %
- Normalized bias - pairs >60 ppb: ± 5-15 %
- Gross error of all pairs >60 ppb: 30-35 %

For the three statistical measures, numbers less than the lower range or closer to zero are better.

The following additional measures were also included:

Average station peak prediction accuracy - This is a measure of peak performance at all monitor sites, using pairings in time and space.

Bias of all pairs above 60 ppb - This bias metric measures the overall degree to which model predictions overestimate or underestimate observed values.

Bias of all station peaks - For this metric, bias calculations are performed on observation-prediction pairs associated with peak ozone values for each monitoring station. This metric provides information on the model's ability to replicate peak ozone observations.

Observed ozone data from 38 ozone monitoring sites within the modeling domain were used for the statistical and graphical analyses as part of the model performance evaluation. The modeling domain and the locations of the monitors are shown in Figure 1.

Predictions can be generated at monitoring sites using different cell-aggregation methods. Cell aggregation addresses the problem of comparing UAM predictions with observed data. UAM grid cells in this case are 5 x 5 km. The air quality data at monitors are for specific point locations, which may not be representative of a single cell or area-wide concentrations. Cell-aggregation provides a means of comparing estimates from one or more cells for an area including a monitoring site. Detailed description of the cell aggregation methods can be found in the User's Guide for the Urban Airshed Model, Volume VII: User's Manual for the Performance Evaluation System (EPA-450/4-90-007G, June, 1992). The EPA's guideline document recommends the use of a four-cell bilinear interpolation average to determine the predicted concentration to be used in comparison with observed values (EPA, 1992). Thus, this bilinear interpolation cell aggregation method was used for the performance evaluation for Baltimore-Washington modeling domain.

2. Model Input Data

This section briefly reviews UAM input files used for the model performance evaluation runs for the two 1991 episodes. The UAM-IV requires input files containing three types of data: meteorological data; emissions data; and initial and boundary concentration data. The detailed discussion of the preparation of the emission and meteorological files can be found in Appendix C: Modeling Inventory Preparation and Quality Assurance and Appendix D: Air Quality Data and Meteorological Input Preparation.

Emissions

Emission inventories data used for the model performance evaluation are based on 1990 baseline inventories. The emission data for Virginia, District of Columbia, and Maryland potion of the domain were obtained by extracting the 1990 SIP emissions from the USEPA Aerometric Information Retrieval System (AIRS). The emission data for the remainder of the modeling domain were extracted from OTAG emission database. All 1990 emission data were first adjusted to 1991 using growth rates from the Bureau of Economic Analysis (BEA) database. 1991 data were then processed through EPS2.0 system to generate the UAM-IV input.

Both Biogenic Emission Inventory System version 1 (BEIS1) and Version 2 (BEIS2) were used for the model performance evaluation for the two 1991 episodes. The BEIS1 inventory was derived from ROM-UAM Interface Program System, while the BEIS2 inventory was derived from UAM-BEIS2 program for the analysis.

Boundary and Initial Conditions

Output from regional models, such as UAM-V and Regional Oxidant Model (ROM), were used to derive the boundary and initial conditions for the Baltimore-Washington UAM-IV domain. For the BEIS2 base case simulations, the boundary and initial conditions were generated from OTAG UAM-V/BEIS2 1991 base case run by executing the EXTRACT_BC program. For the BEIS1 base case runs, the output from the EPA's ROM/BEIS1 run was used to generate the initial and boundary condition files for the domain.

Mixing Heights

The Mixing-Height Estimation Methodology for UAM Purposes (MIXEMUP) procedure was selected for mixing heights estimation. The MIXEMUP scheme and application for the Baltimore-Washington UAM modeling are discussed in detail in Appendix B4: Air Quality and Meteorological Data Preparation.

Wind Field

The winds used for model performance evaluation were generated using the Diagnostic Wind

Model (DWM). Detailed discussion on the wind fields preparation can be found in Appendix D: Air Quality and Meteorological Data Preparation.

Temperature field

The temperature preprocessor (TEMPERATUR) GMISS was used to process surface hourly observed temperature data and covert the 2D temperature field into UAM format.

Meteorological Scalars Files

GMISS was used to extracts hourly gridded ROM meteorological scalars files. The ROM-UAM Interface IMETSCL program was used to process ROM meteorological scarlars files for UAM input.

3. Model Results

July 18-20, 1991 Episode (Episode 3)

The model performance evaluation was conducted with both BEIS1 and BEIS2 for this episode. Table 1 lists statistical model performance measures for the episode for the entire domain. The peak observed hourly-averaged ozone concentrations were 132 ppb at the Ft. Meade(FTMDE) and Greenbelt(GRNBT) Sites on July 19 (day 2) and 178 ppb at the Seven Corners(7CRNR) Site on July 20 (day 3). The peak predicted daily ozone maximum values in the domain were 151 ppb with BEIS1 and 168 ppb with BEIS2 on July 19, and 168 ppb with BEIS1 and 210 ppb with BEIS2 on July 20. The simulations overpredict the domain peak ozone with both BEIS1 (14.5%) and BEIS2 (27.6%) on July 19. However, the simulations underpredict the domain peak with BEIS1 (-5.6%) and overpredict with BEIS2 (18.2%) on July 20. Those simulations meet or nearly meet the EPA's performance goals for the unpaired peak accuracy (15-20%) for both days.

The acceptable performance (15%) for normalized bias was achieved for the simulations with both BEIS1 and BEIS2 on both July 19 and July 20. The normalized bias is a measure of the tendency to over- or under-predict hourly ozone concentrations. The positive values of the normalized bias on July 19 indicated the model systematically overpredicts hourly ozone concentrations during the daytime hours on this day. However, the normalized bias values indicate that the model tends to underpredict the hourly ozone with BEIS1 (-10.4%) and may slightly overpredict the hourly ozone with BEIS2 (0.6%) on July 20. The overall gross error on both July 19 and July 20 are within the EPA recommended range. While the gross error with BEIS2 is slightly higher than that with BEIS1 on July 19, the performance statistic with BEIS2 is comparable to that with BEIS1 on July 20.

Other suggested performance measures were also computed and listed in Table 1, but there are no acceptable ranges established by EPA. The unsigned average station peak accuracy with BEIS2 is also comparable to that with BEIS1 on July 20. The values of bias of all pairs of ozone concentration > 60 ppb (in time and space) indicate that hourly ozone were overpredicted on an average of 2.3 ppb with BEIS1 and 5.6 ppb with BEIS2 on July 19, and underpredicted on an average of 12.4 ppb with BEIS1 and 1.1 ppb with BEIS2 on July 20.

The scatter plots of hourly simulation-observation pairs with BEIS1 (on the left) and BEIS2 (on the right) for the episode are displayed in Figure 2. The plots show that the majority of data points for the observed ozone greater than approximately 120 ppb lie below the perfect correlation line with both BEIS1 and BEIS2, which indicates that the simulations tend to underpredict the higher observed concentrations. However, The tendency of the underprediction of the elevated ozone values appears to be slightly improved if BEIS2 biogenic inventory is used. Figure 2 also shows that the predicted ozone concentrations with BEIS2 seem comparable to those with BEIS1 simulation.

Figures 3 and 4 show the UAM-IV layer one isopleth plots of predicted daily maximum ozone concentrations with superimposed observed daily maximum ozone (numbers in the plots) for July 19 and 20, respectively. The isopleths display the spatial distributions of the predicted ozone values. On July 19, the daily maximum ozone concentrations were significantly overpredicted throughout the Baltimore-Washington area. The overpredictions of the daily maximum ozone concentrations were more apparent with the BEIS2 simulation. The elevated ozone plume appeared to be from Washington to Baltimore into southern Pennsylvania. The predicted ozone peak of 151 ppb with BEIS1 and 168 ppb with BEIS2 occurred north of Baltimore City, close to the Maryland and Pennsylvania border. It is impossible to know whether the ozone peak actually occurred over this area or not since there were no ozone monitors in the vicinity of the predicted peak ozone concentrations. However, the daily maximum ozone were overpredicted at the two monitors just north of the Baltimore. The measured peak ozone was 132 ppb observed between Washington D.C. and Baltimore City, where the predicted ozone concentrations were much lower (100 - 120 ppb). Although the UAM-IV simulations overpredicted the daily maximum ozone for the Baltimore-Washington area, the model performance statistics show that the predicted hourly ozone are acceptable as discussed earlier.

On July 20, the model reproduced the spatial pattern of the elevated ozone fairly well for the domain. The locations of the ozone plumes were predicted correctly downwind of Baltimore area. The predicted ozone plume out of Washington D.C. appeared to be too far west. It is believed that the overextension of the bay breeze farther inland due to the lack of meteorological observations away from the Chesapeake bay may have pushed the ozone plume farther west. The hourly wind field indicated that the surface wind shifted directions from north or northeast to southwest in the afternoon. As the result, the pollutants emitted in the morning were recycled back into the cities. This emission recycling effect may have resulted in the high ozone concentrations in Baltimore-Washington area for this episode day. The peak observed ozone concentration in Washington D.C. area was 178 ppb at the Seven Corners site (7CRNR) located southwest of the city, while the predicted ozone peak was 168 ppb with BEIS1 and 198 ppb with BEIS2 occurred 10 - 20 km north of the city. It appears that the BEIS2 simulation overpredicted peak ozone in both Washington and Baltimore areas. The observed peak ozone at McMillan (MCLEN) site was only 69 ppb, much lower than the peak ozone recorded at surrounding sites few grid cells away. The predicted peak ozone at this site was 168 ppb (with BEIS2 simulation). It is clear that the model cannot resolve such sharp spatial concentration gradients with a 5km grid spacing. The daily maximum ozone concentrations were underpredicted in most Virginia portion of the domain. This may be due to the underpredictions of boundary ozone by both ROM/BEIS1 and UAM-V/BEIS2 simulations. The measured ozone data at Fauquier County located just inside the southwest corner of the domain also indicated that the boundary conditions for ozone may be underestimated. The preliminary sensitivity study demonstrated that adjusted boundary conditions for ozone would improve the model performance in Virginia portion of the domain.

Time series plots of predicted (four cell bilinear interpolation, with BEIS1 and BEIS2) versus observed hourly ozone concentrations for all monitoring sites are presented in Figure 5 for the episode. The model reproduces reasonable diurnal variations in hourly ozone concentrations, as well as day-to-day variations in ozone levels, but the model overpredicts at some sites (RCKVL and MCLEN) and underpredicts at others (DAVSL, FTMDE, GRNBT, ARLTN, MCLEN, ALEXA and FAQUR etc.). The underprediction of afternoon ozone concentrations at Fauquier (FAQUR) and some other sites in the Virginia portion of the domain are probably influenced by the underestimated boundary conditions southwest of the domain. The underpredictions of the afternoon ozone concentrations at the Alexandria (ALEXA) and Arlington (ARLTN) may be due to the proximity of these sites to major NOx sources. The predicted hourly ozone concentrations are in fairly good agreement with the observed values at some sites (YORK and REDNG) in Pennsylvania. The simulation with BEIS2 does much better job than the simulations with BEIS1 at some sites (7CRNR, ARLIN and WDC24) in Washington area. However, the BEIS2 simulation overpredicts the afternoon ozone in Baltimore area.

July 14-16, 1991 Episode (Episode 3b)

The model performance evaluation was also conducted with both BEIS1 and BEIS2 for this episode. The model performance statistical measures for the episode for the entire domain are presented in Table 2. The peak observed ozone concentrations were 102 ppb on July 15 (day 2) and 137 ppb on July 16 (day 3). The unpaired ozone peaks are overpredicted by 12.7 % with BEIS1 and 23.5% with BEIS2 on July 15, and overpredicted by 12.6% with BEIS1 and 22% with BEIS2 on July 16. Note that the location of the predicted peak ozone was just one cell away from observed peak ozone near the Rockville site on July 16. The performance measure of unpaired peak accuracy satisfies EPA's recommendation with BEIS1 simulations, and nearly meets the performance goal with BEIS2 simulations.

The normalized bias statistic, the measure of the tendency to over or under predict hourly ozone concentrations, ranges from -4.5% to 5.1% for day 2 and day 3 of the episode. The acceptable performance for bias of plus or minus 15% has been met for both days for both BEIS1 and BEIS2 simulations. The positive and negative signs of the bias measure also indicate that hourly ozone concentrations were overpredicted for July 15, and underpredicted for July 16. The gross errors have also met the performance goal, with the values from 13.8% to 23.4% for both days. The gross errors of BEIS2 simulations are approximately 5% different from that of BEIS1 simulations for both July 15 and 16, indicating that there are no significant differences in the model performances between BEIS1 and BEIS2 simulations.

Other suggested performance measures also show that average station peaks are underpredicted by approximately 10 - 11 ppb on July 16. The average bias of all hourly prediction-observation pairs > 60 ppb are underpredicted by 5 and 4 ppb on July 16 with BEIS1 and BEIS2, respectively.

The scatter plots of simulation-observation pairs (Figure 6) show both overpredictions and underpredictions of the hourly ozone. The ozone concentrations were mostly underpredicted when observed ozone concentrations were higher than 120 ppb with BEIS1. However, the ozone concentrations were mostly overpredicted when observed ozone concentrations were higher than 120 ppb if BEIS2 biogenic emission was used.

The spacial distributions of predicted daily maximum ozone as well as observed daily maximum ozone for each monitoring station are shown in Figure 7 for July 15, and Figure 8 for July 16. On July 15 (day 2), the observed daily maximum ozone concentrations were relatively low in the domain with peak ozone of 102 ppb recorded at Mount Vernon site (MTVRN). The predicted ozone at this site was lower than observed, which may be due to the titration of ozone from major NOx sources just few cells upwind. The predicted peak ozone were 115 ppb with BEIS1 and 126 ppb with BEIS2 at south or southeast of the Washington D.C. area. The model appears to perform very well in simulating the spatial distribution of the observed daily maximum ozone on this day.

On July 16 (day 3), unlike other modeled episode days, the predominate wind direction was from southeast in the afternoon in Baltimore-Washington area. The Figure 8 has shown that two predicted elevated ozone plumes were located northwest of the Washington D.C. and Baltimore City. The observed peak ozone was 137 ppb at both McMillan (MCLEN) and Rockville (RCKVL) sites, downwind of Washington D.C. for this episode day, while the predicted peak ozone was 154 ppb with BEIS1 and 167 ppb with BEIS2 simulations located only one cell away from the RCKVL monitor where the observed ozone peak recorded. The BEIS1 simulation seemed to overpredict the peak ozone in Washington area, while the BEIS2 simulation seemed to overpredict the peak ozone in both Washington and Baltimore areas, and produce much larger ozone plumes in both cities compared to the BEIS1 simulation. The spatial extent of the ozone plumes extends much farther downwind to areas northwest of the Washington D.C. and Baltimore. The location of the elevated ozone plumes produced by the model may be reasonable since the predominate wind direction was from southeast. However, the spatial extent and the magnitude of the elevated ozone plumes can not be verified by the observed data due to the lack of ozone monitors in the southeast to northwest direction (across Corridor) of the cities in 1991. It is noticeable that there were two large areas across the two urban centers where ozone was titrated by incoming NOx from south or southeast of the cities.

Time series plots (Figure 9) show that the model replicates the diurnal pattern of the hourly observed ozone concentrations reasonably well at most monitor sites, except for some sites (LBUFF and FAQUR) where the ozone concentrations were mostly influenced by the boundary conditions.

These plots also confirmed that the model with BEIS2 tends to overpredict afternoon maximum ozone concentrations at the sites (CKYVL and GARSN) downwind of the Baltimore area as seen from the isopleth plot.

4. Summary

In general, the model performance evaluation statistical measures and graphical displays indicate that the model performances were acceptable for the two 1991 episodes with both BEIS1 and BEIS2 simulations. The model replicates the diurnal patterns of the hourly observed ozone reasonably well at most sites. The model performances with BEIS2 are comparable to those with BEIS1 biogenic emissions, although the BEIS2 simulations tend to overpredict the peak ozone concentrations, especially in the Baltimore area. Model performance may be improved with more representative wind fields, emission data and boundary conditions for the episodes. Nevertheless, based on the acceptable performance (even with BEIS2), the two episodes can be used for the future year control strategy evaluations.

5. Reference

EPA, 1991. Guideline for regulatory application of the Urban Airshed Model, EPA-450/4-91-013.

EPA, 1992. User's Guide for the Urban Airshed Model, Volume VII: User's Manual for the Performance Evaluation System, EPA-450/4-90-007G.

Table 1 : UAM-IV Model Performence Statistic

Baltimore/Washington Domain

Episode 3 (July 18 - 20, 1991)

Statistical Measure	7/18/91		7/19/91		7/20/91		EPA Criteria
	BEIS1	BEIS2	BEIS1	BEIS2	BEIS1	BEIS2	
Predicted Peak (ppb)	132.65	150.46	151.16	168.36	168.08	210.40	
Observed Peak (ppb)	127.00	127.00	132.00	132.00	178.00	178.00	
N. of Cells >=125 ppb	24	111	100	203	213	394	
Recommended Performence Measures							
Unpaired Peak Accuracy (%)	4.45	18.47	14.51	27.55	-5.57	18.2	± 20%
Normalized Bias > 60 ppb (%)	-7.78	-9.97	4.18	8.29	-10.37	0.62	± 15%
Gross Error > 60 ppb (%)	22.05	22.1	17.67	24.24	24.03	24.1	35%
Additional Performence Measures							
Ave. Station Peak Accuracy (%)	20.86	21.97	14.1	22.32	22.97	21.34	
Bias of All Pairs > 60 ppb (ppb)	-8.64	-10.55	2.29	5.58	-12.41	-1.14	
Bias of All Station Peak (ppb)	-17.52	-16.62	-2.02	0.83	-19.01	-5.72	

Note: A negative sign indicates under-prediction

Analysis Conducted by Virginia Department of Environmental Quality

Table 2 : UAM-IV Model Performence Statistic
Baltimore/Washington Domain
Episode 3b (July 14 - 16, 1991)

Statistical Measure	7/14/91		7/15/91		7/16/91		EPA Criteria
	BEIS1	BEIS2	BEIS1	BEIS2	BEIS1	BEIS2	
Predicted Peak (ppb)	108.80	122.79	114.96	125.94	154.25	167.17	
Observed Peak (ppb)	82.00	82.00	102.00	102.00	137.00	137.00	
N. of Cells >=125 ppb	0	0	0	1	113	245	
Recommended Performence Measures							
Unpaired Peak Accuracy (%)	32.69	49.75	12.71	23.47	12.59	22.02	± 20%
Normalized Bias > 60 ppb (%)	-0.65	-11.91	5.09	0.11	-5.25	-4.5	± 15%
Gross Error > 60 ppb (%)	12.75	16.66	13.82	18.99	18.15	23.35	35%
Additional Performence Measures							
Ave. Station Peak Accuracy (%)	15.21	16.94	15.04	20.59	15.25	20.99	
Bias of All Pairs > 60 ppb (ppb)	-0.6	-7.99	3.13	0.13	-4.65	-3.65	
Bias of All Station Peak (ppb)	1.48	-7.06	2.01	-2.67	-10.86	-10.36	

Note: A negative sign indicates under-prediction

Analysis Conducted by Virginia Department of Environmental Quality

Figure 1

Baltimore-Washington UAM-IV Domain

With Ozone Monitoring Sites

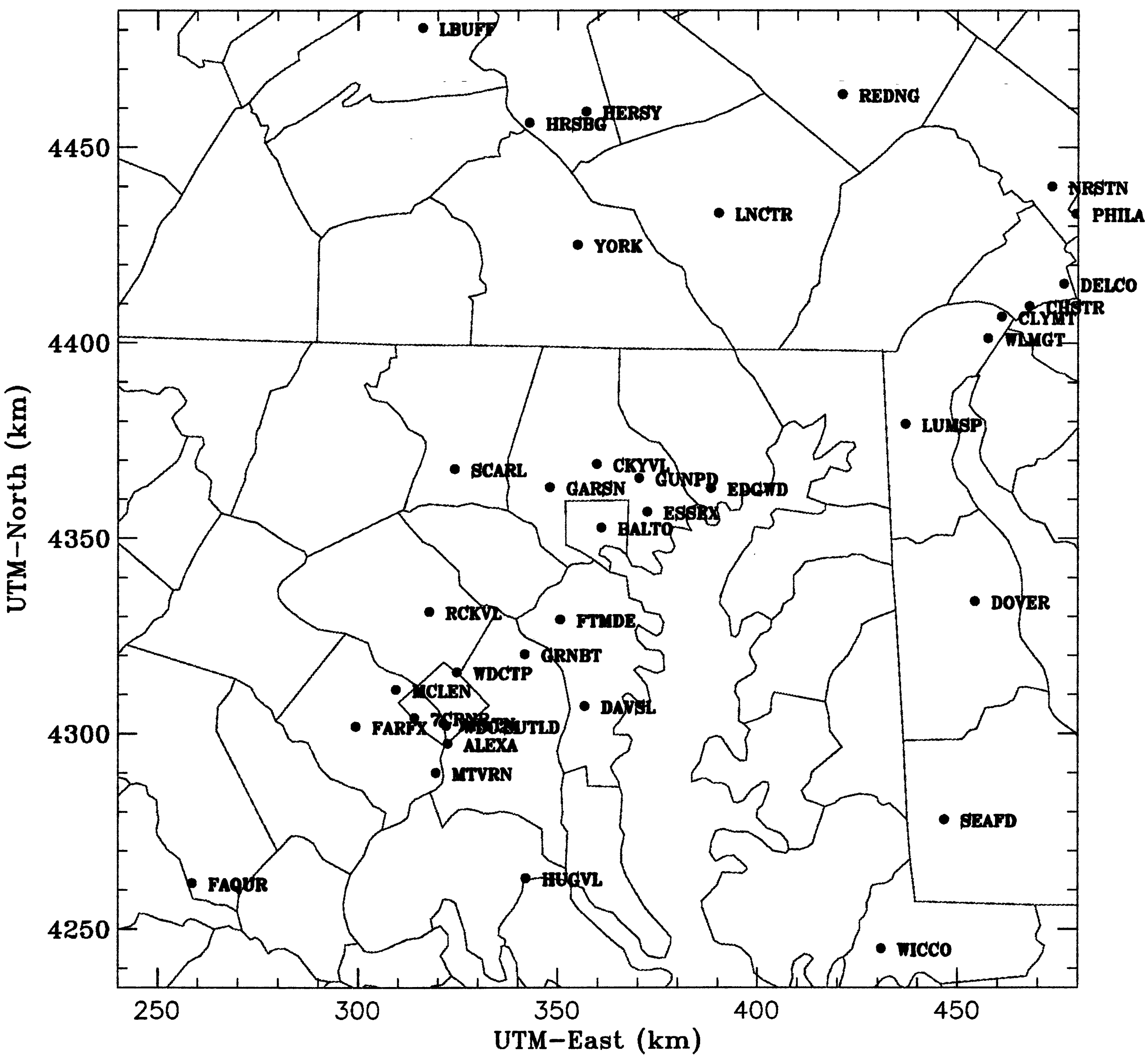


Figure 2: ***Scatter Plot of Hourly Ozone: Simulated vs Observed***
UAM-IV Layer 1, Base Case, -- B/W Domain

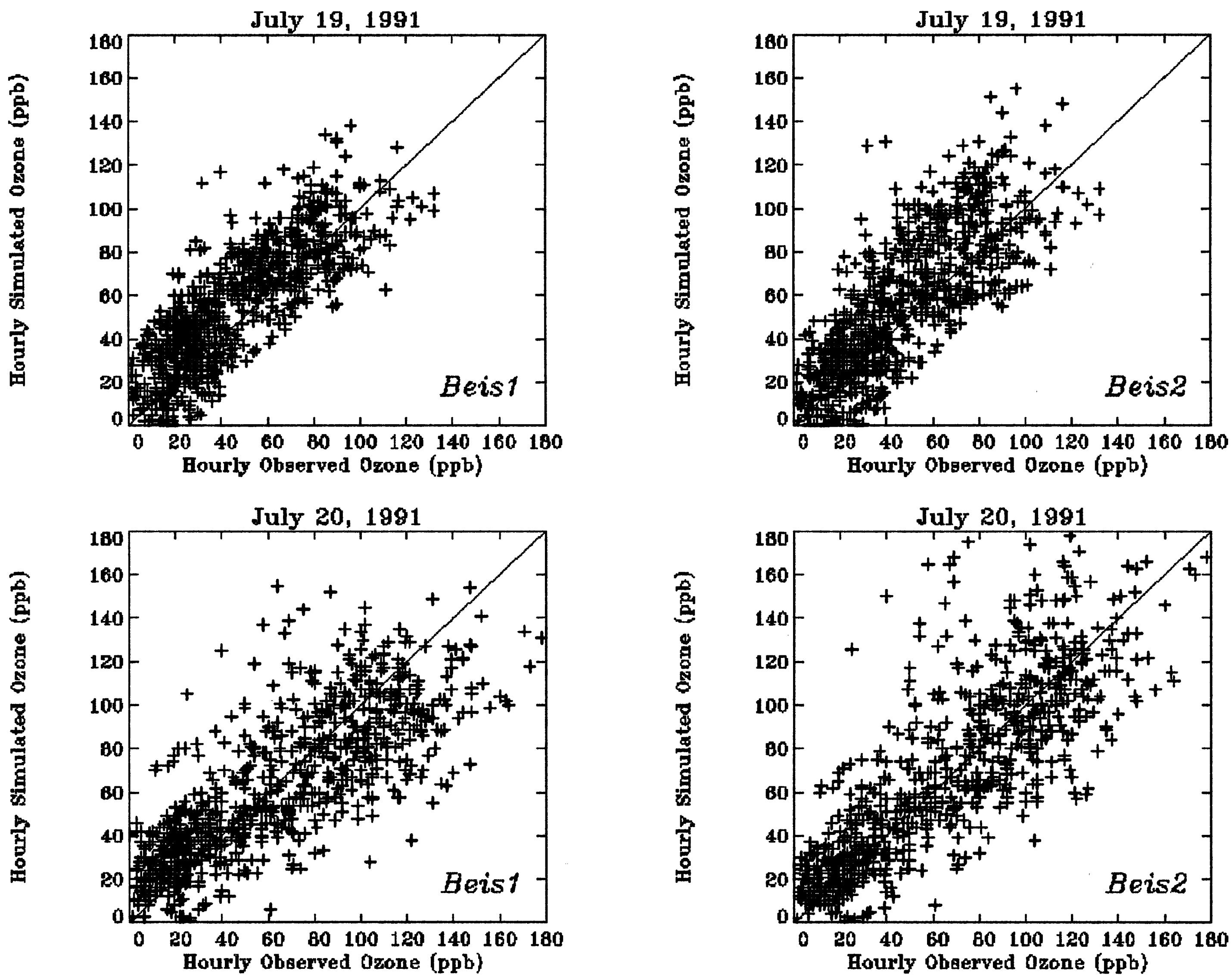


Figure 3(a)

Predicted Daily Max Ozone – 1991 Base Case
UAM–IV Layer 1, Beis1, B/W Domain

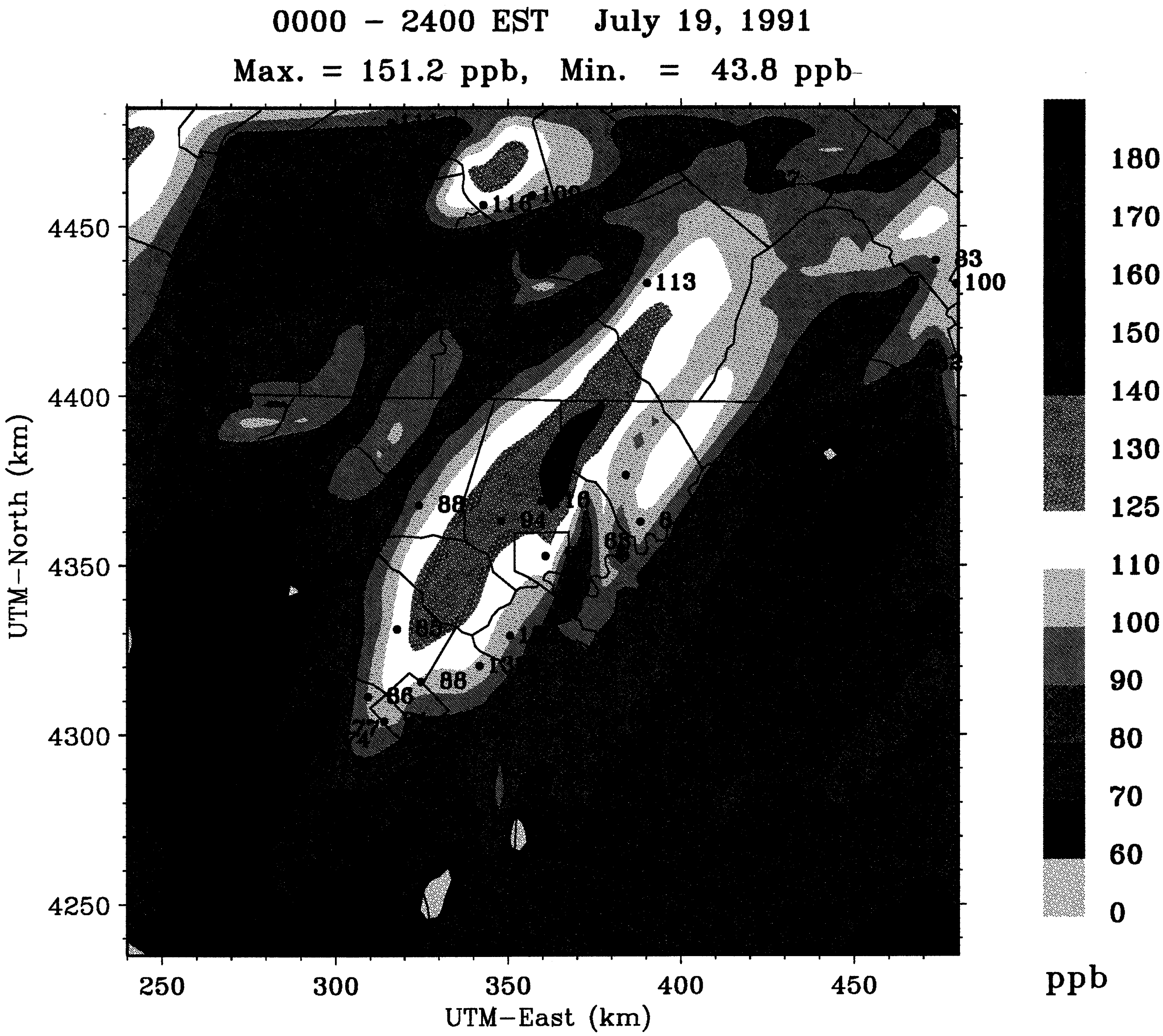
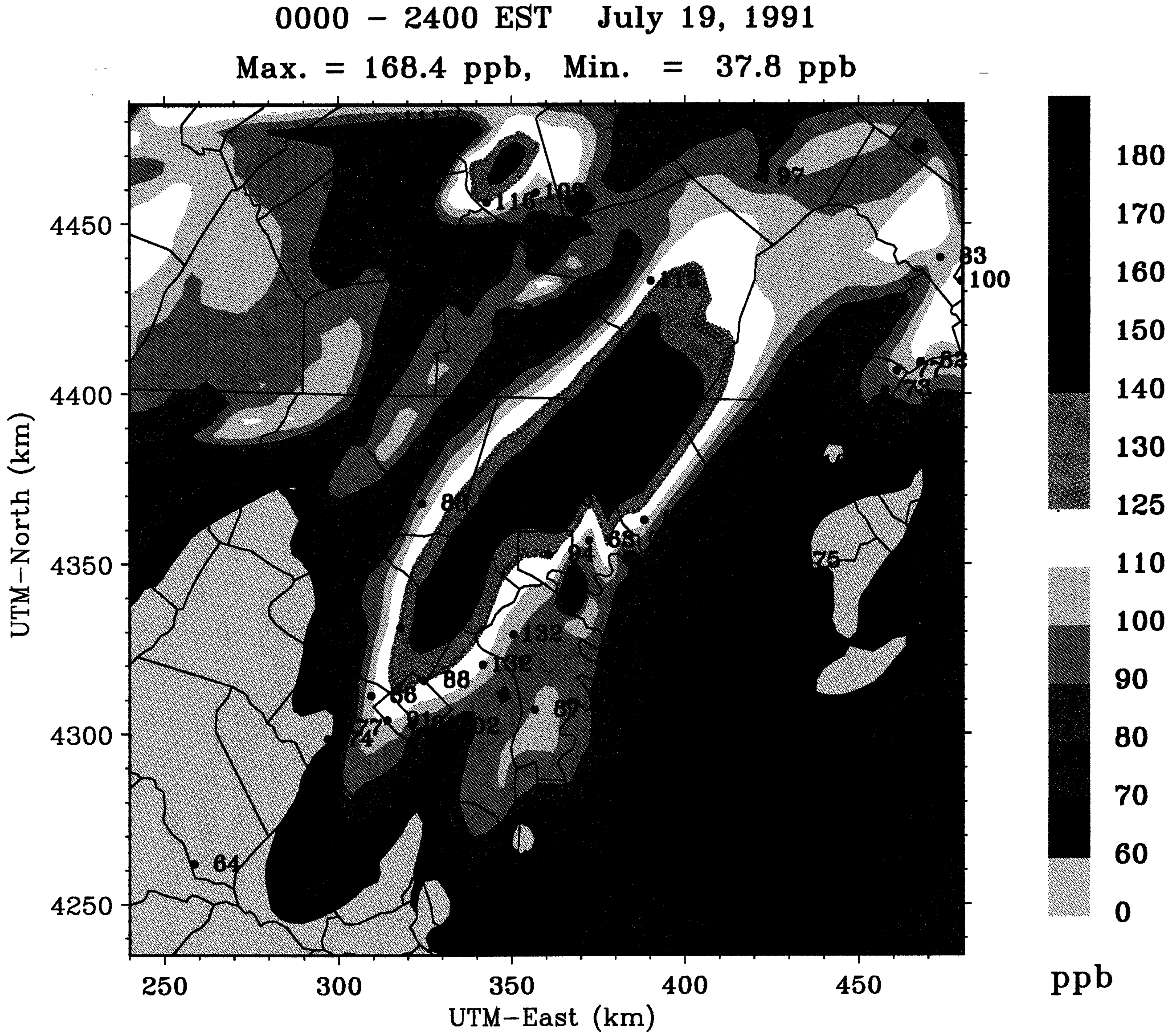


Figure 3(b)

Predicted Daily Max Ozone - 1991 Base Case
UAM-IV Layer 1, Beis2, B/W Domain



Anthro. emission : 1991 Base case (basA2D2)
Biogenic emission : UAM-BEIS2
Boundary condition : OTAG 1991 Base D2

Figure 4(a)

Predicted Daily Max Ozone – 1991 Base Case
UAM–IV Layer 1, Beis1, B/W Domain

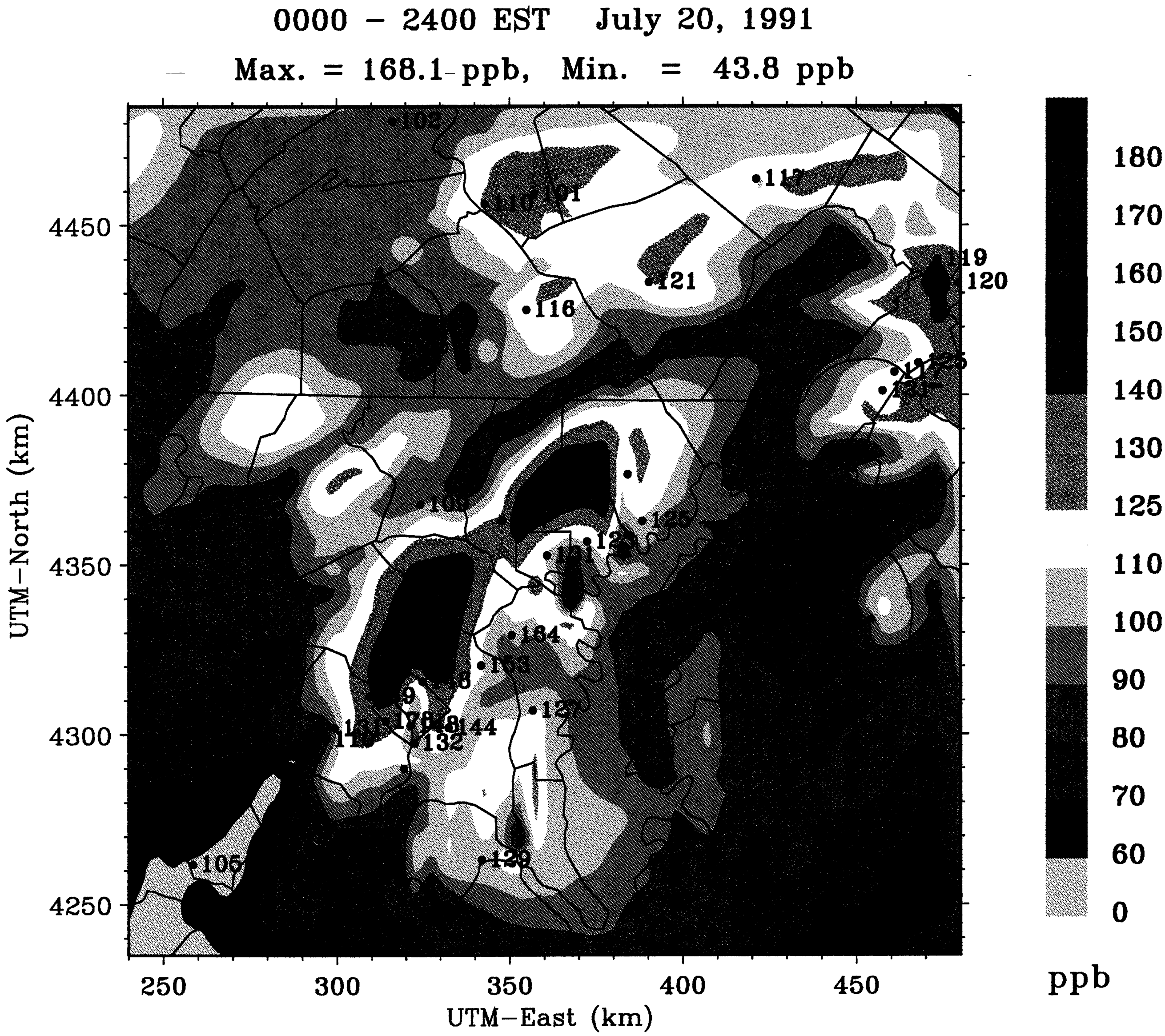
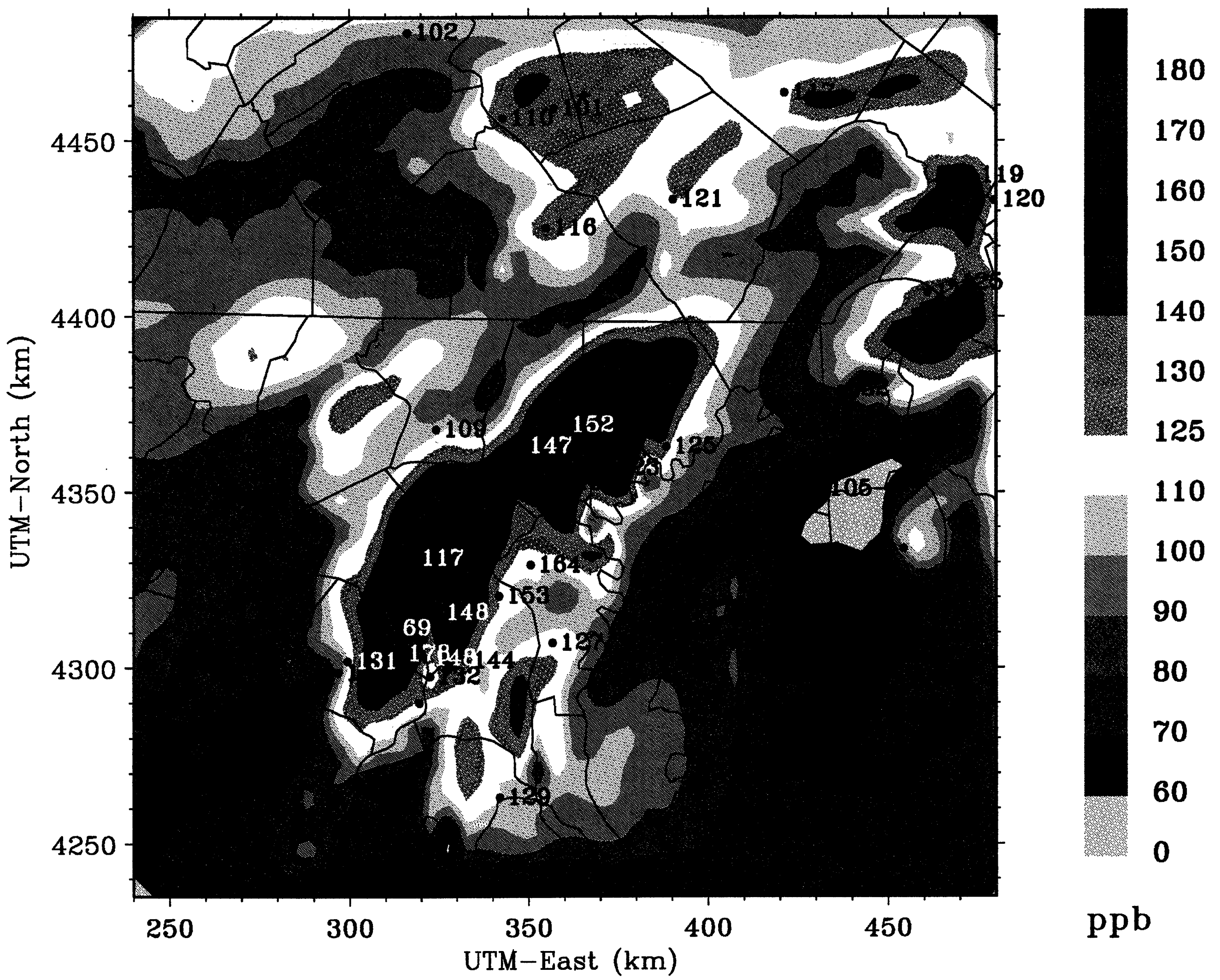


Figure 4(b)

Predicted Daily Max Ozone – 1991 Base Case
UAM–IV Layer 1, Beis2, B/W Domain

0000 – 2400 EST   July 20, 1991

Max. = 210.4 ppb, Min. = 37.8 ppb



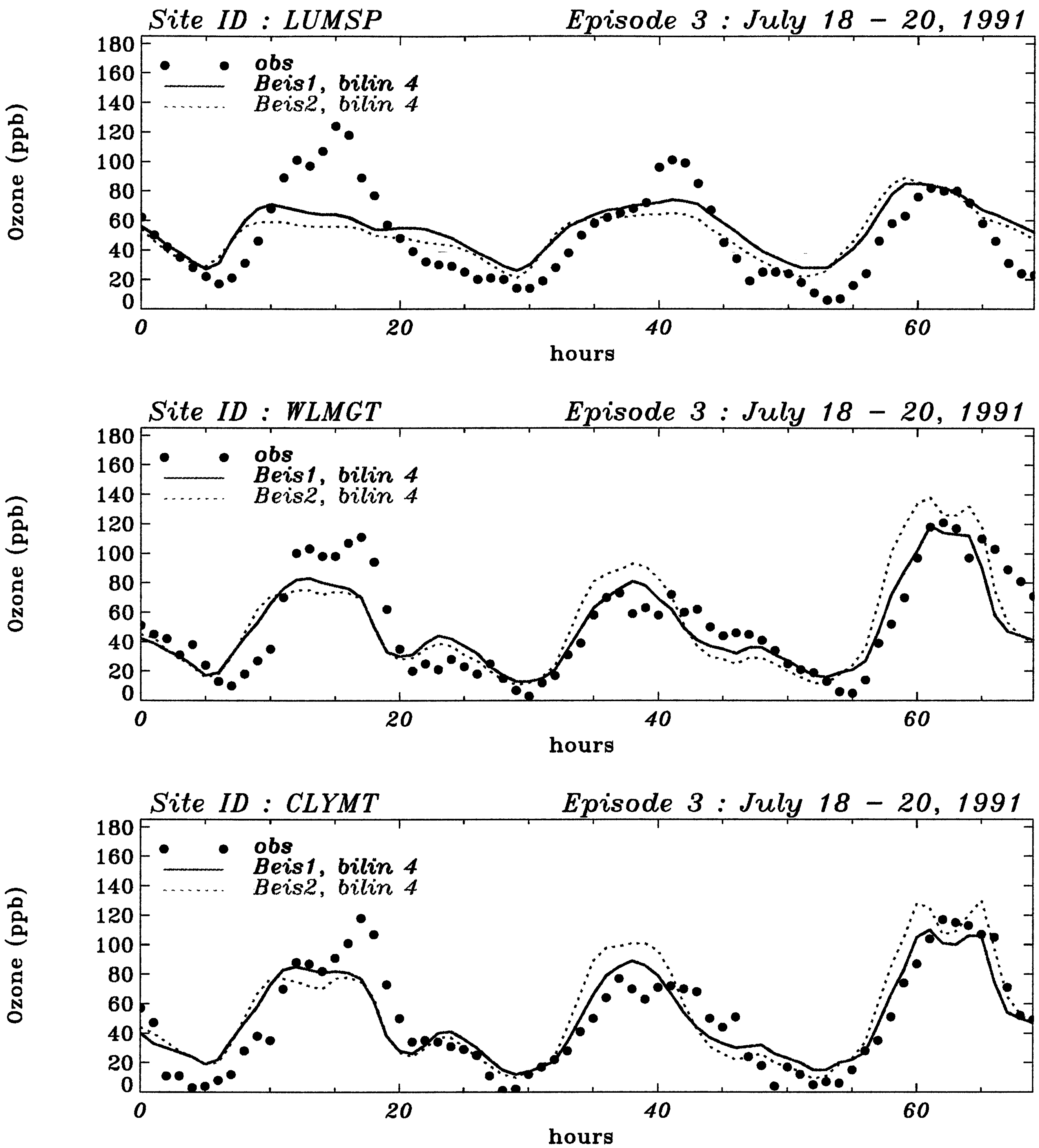
Anthro. emission : 1991 Base case (basA2D2)
Biogenic emission : UAM–BEIS2
Boundary condition : OTAG 1991 Base D2

Figure 5

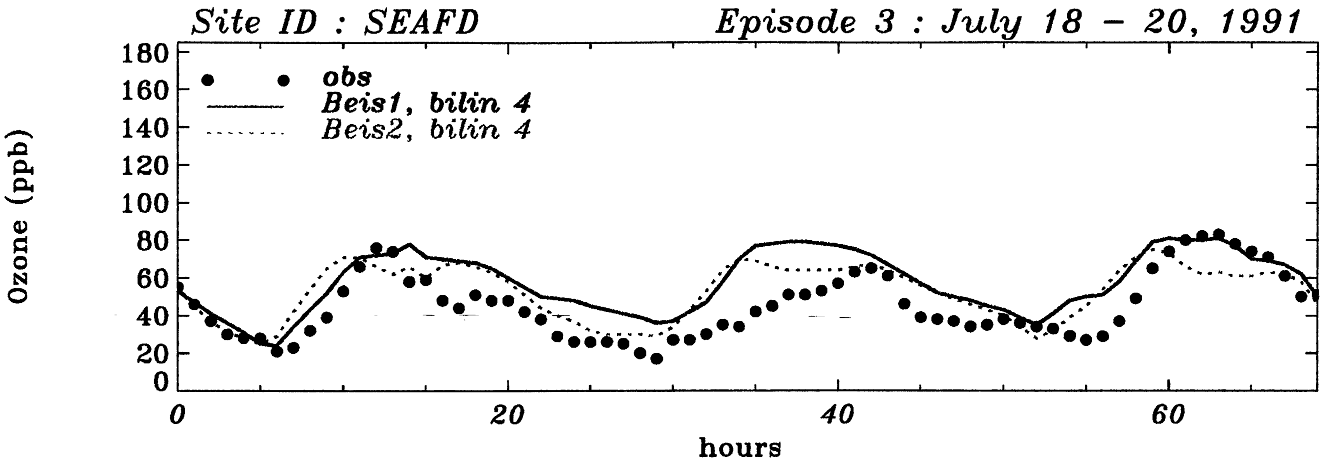
Time Series Plots of Ozone

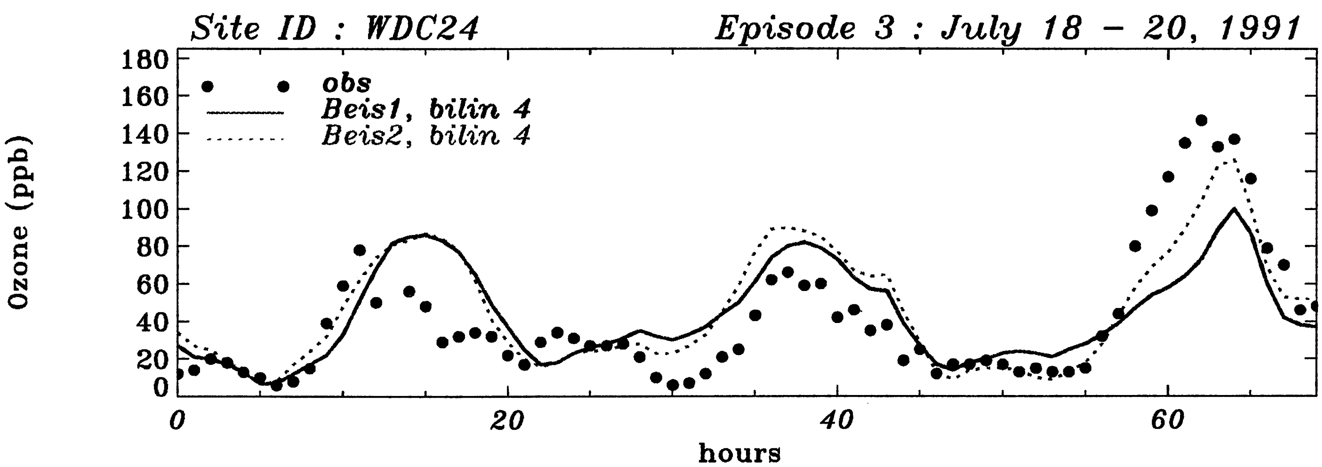
Simulated vs Observed

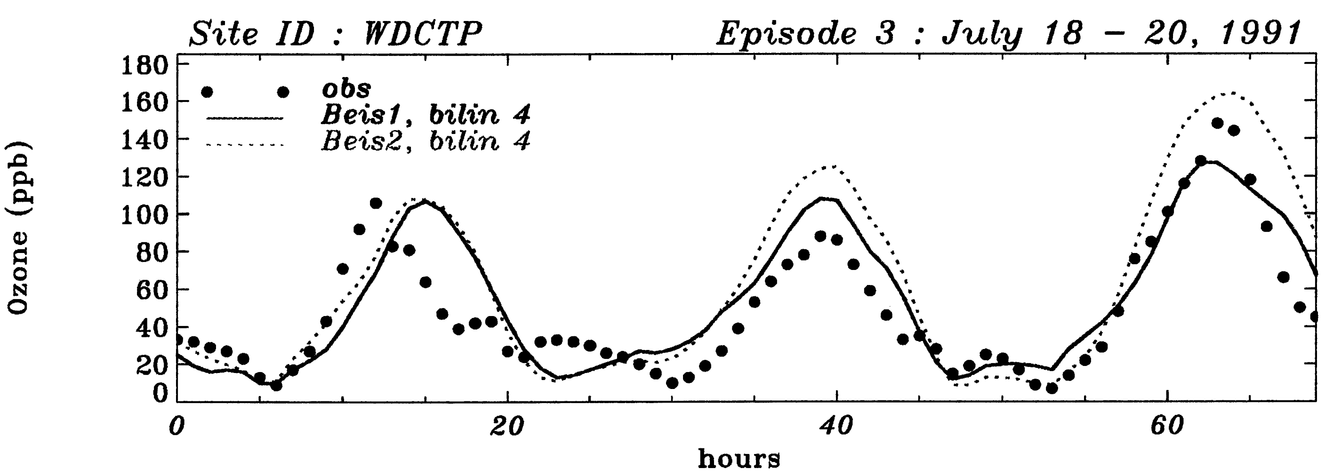
July 18-20, 1991 (Episode 3)



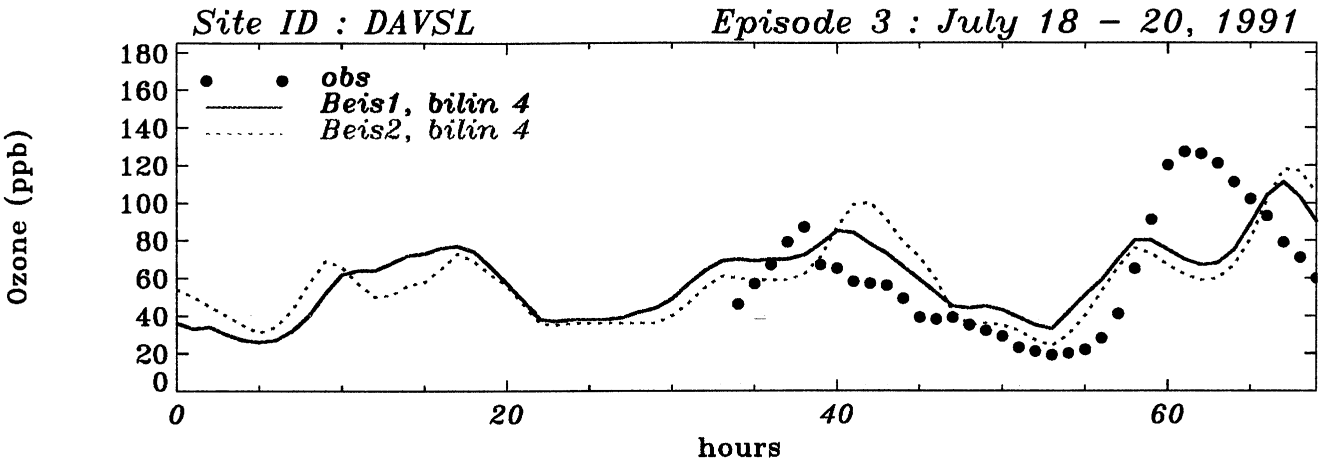
Time Series Plot of Ozone: Simulated vs. Observed
UAM–IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain

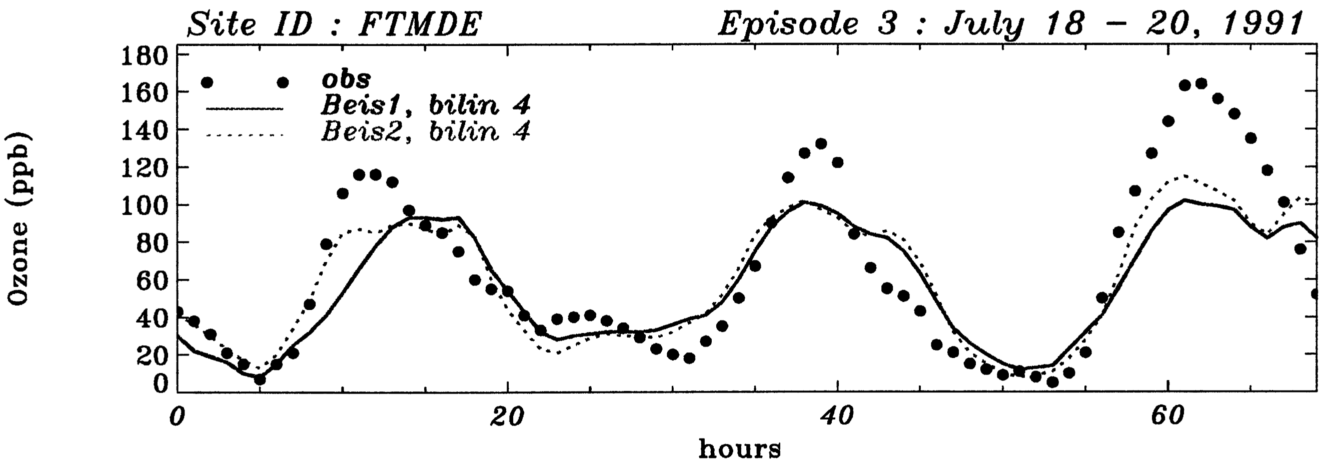


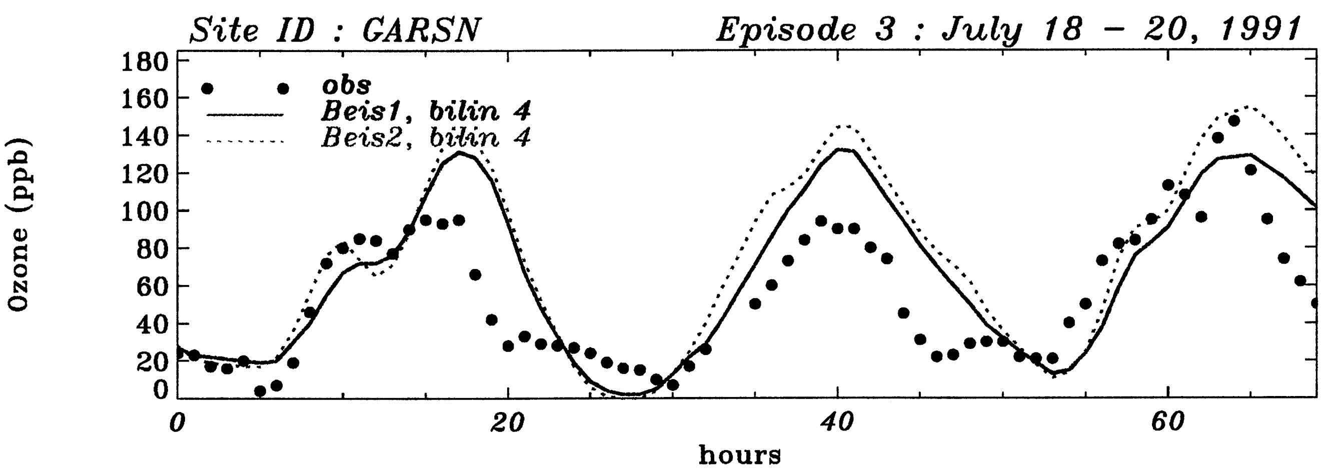




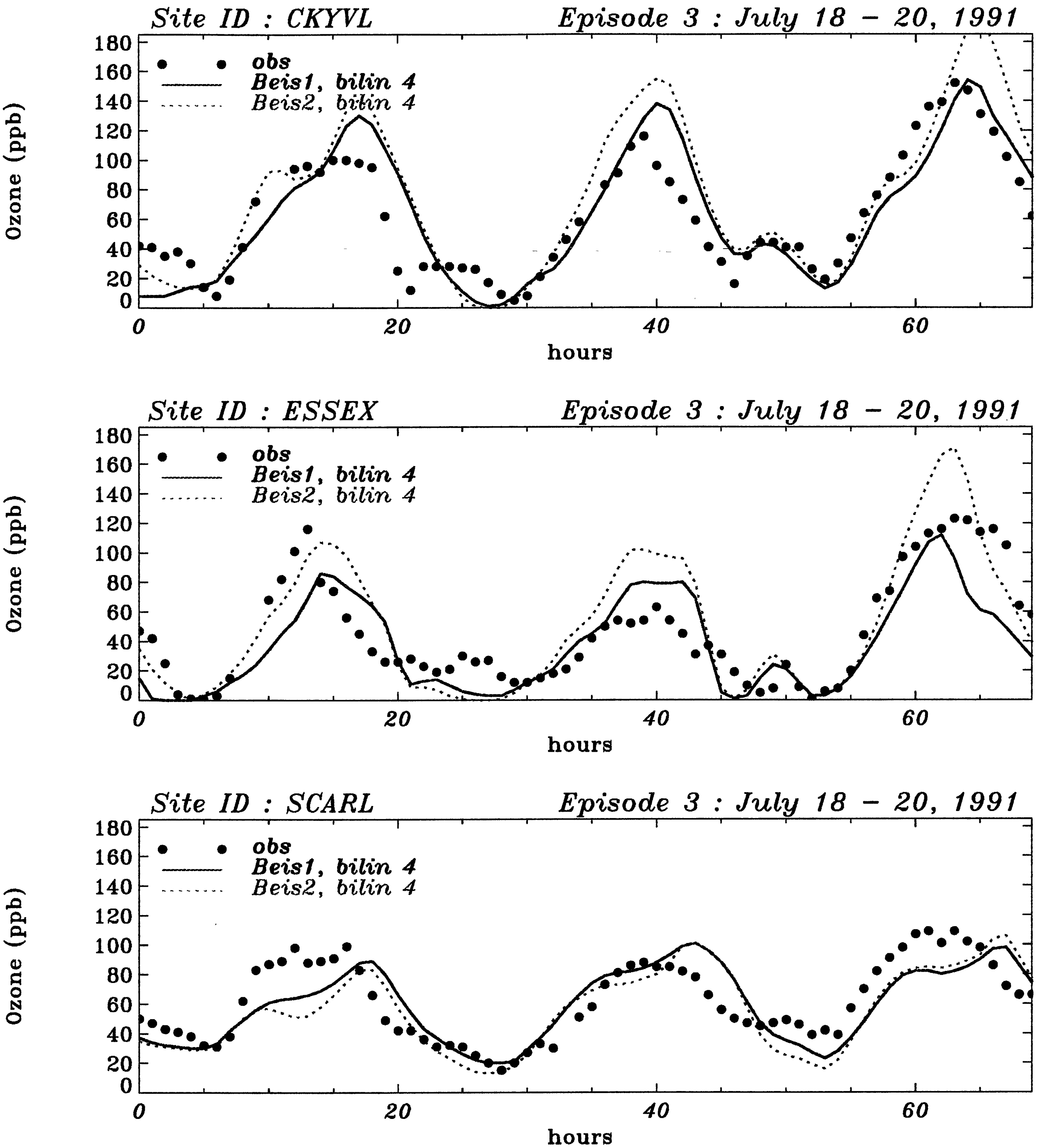
Time Series Plot of Ozone: Simulated vs. Observed
UAM–IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain



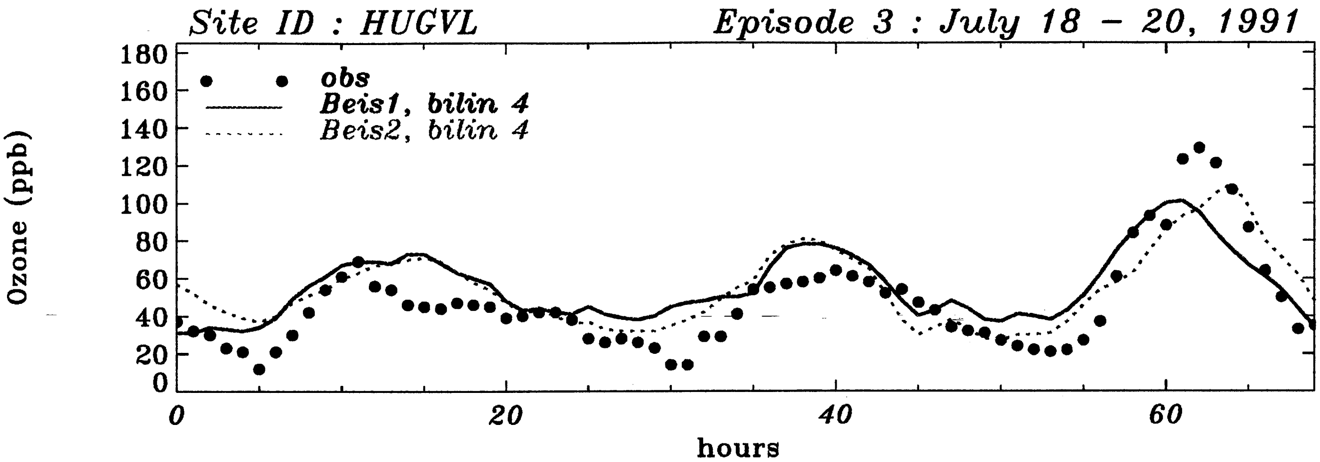


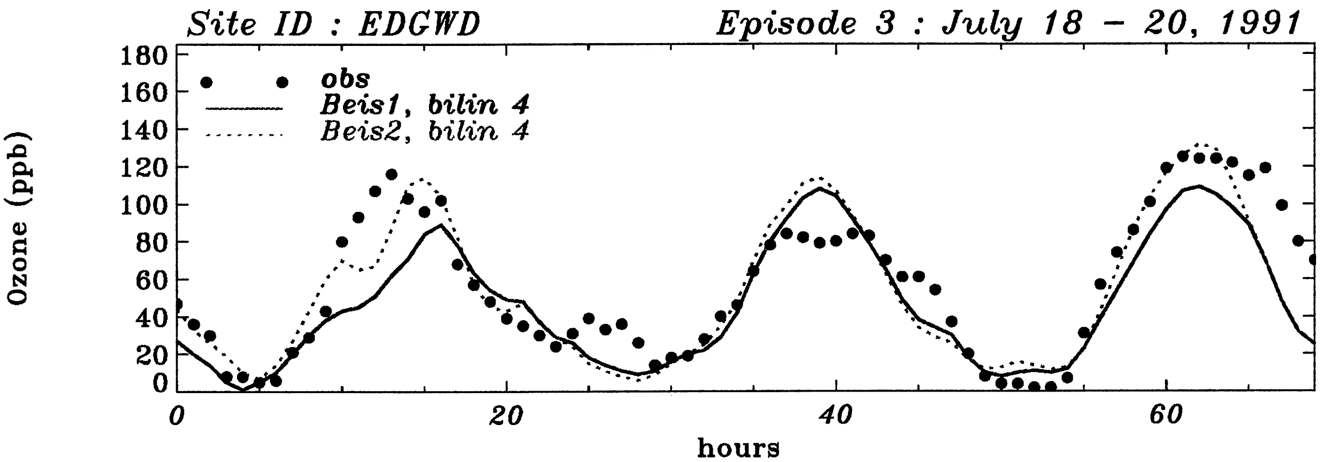


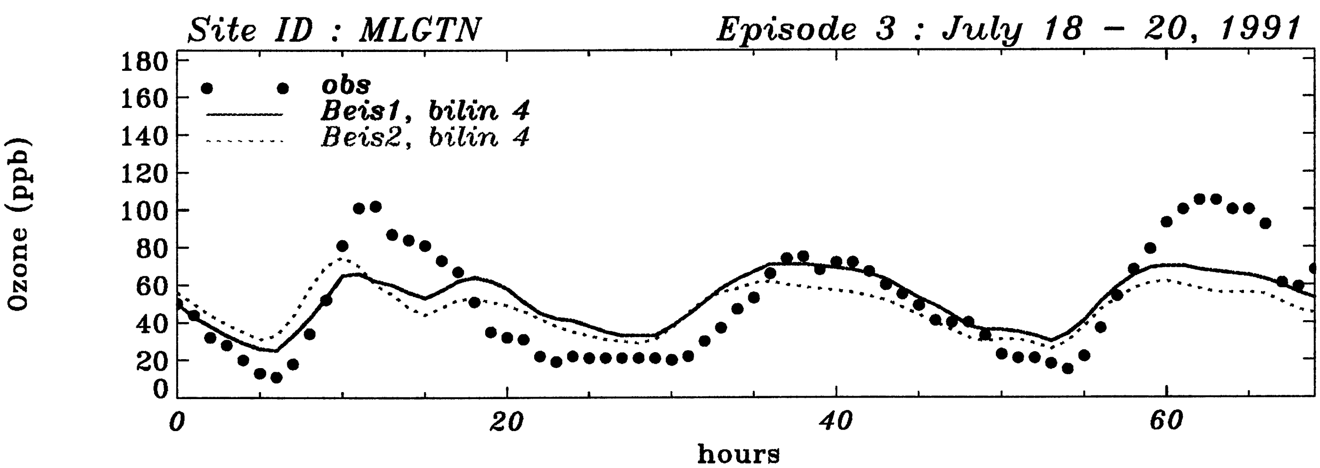
Time Series Plot of Ozone: Simulated vs. Observed
UAM-IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain



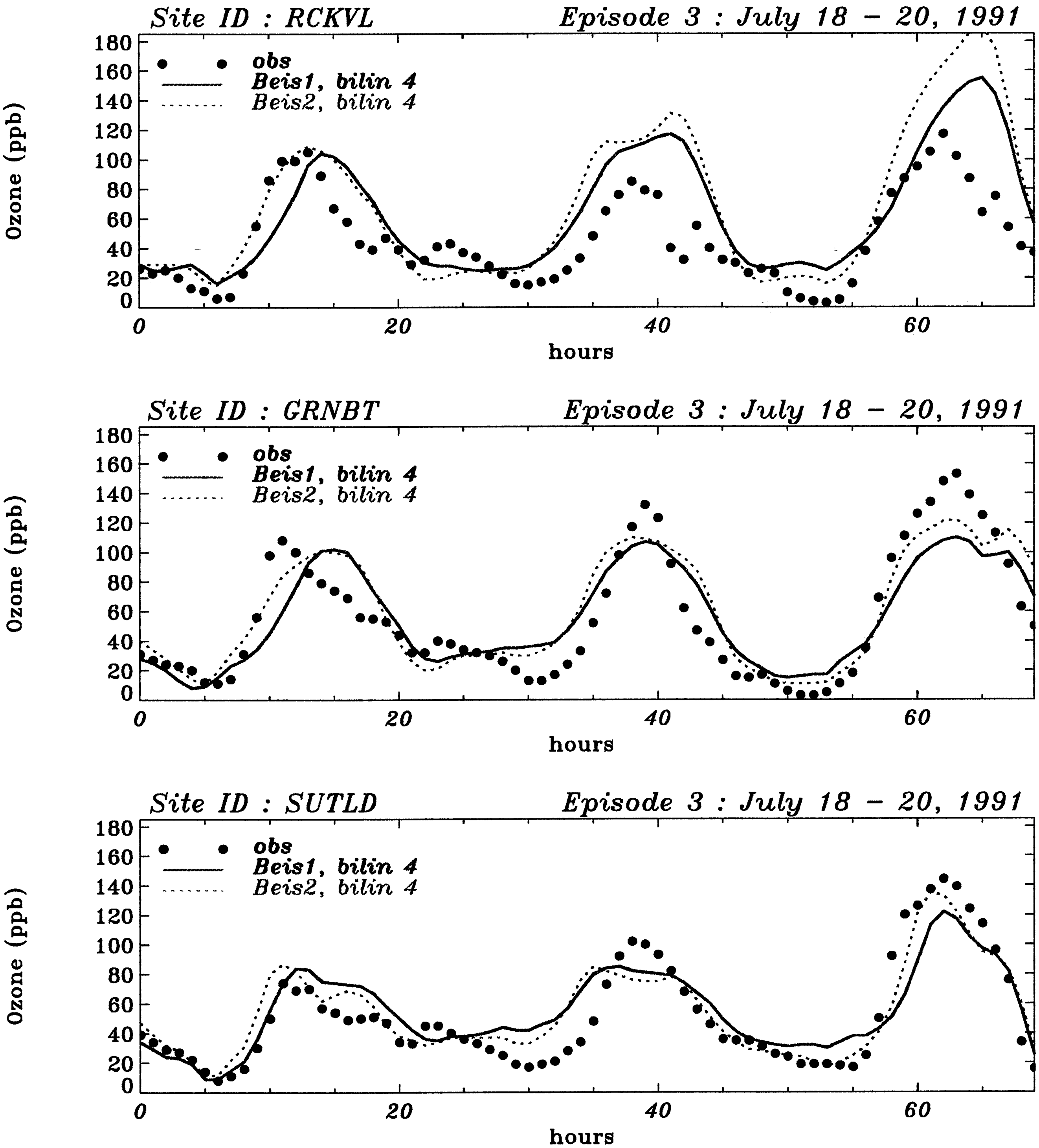
Time Series Plot of Ozone: Simulated vs. Observed
UAM–IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain



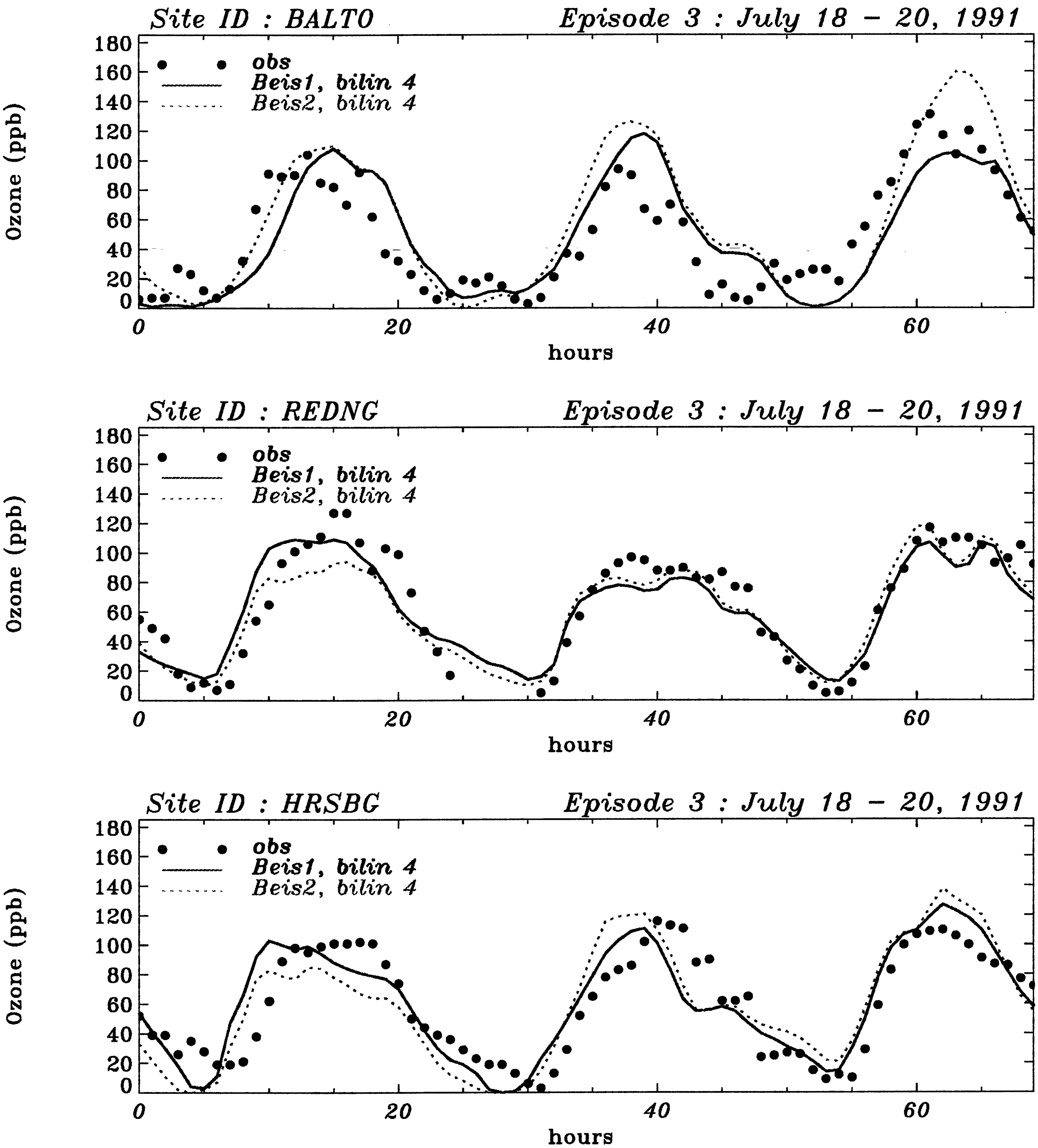




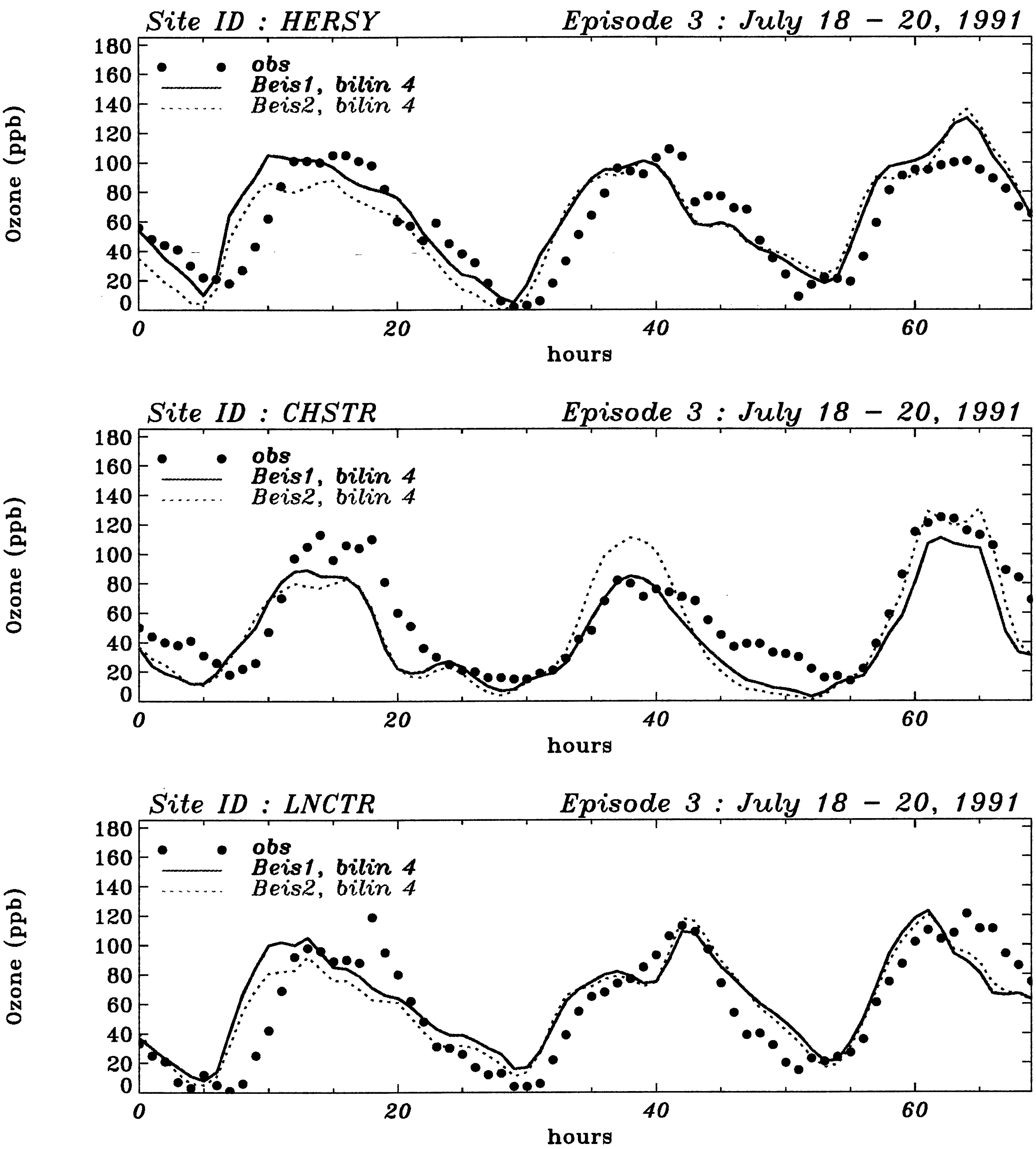
Time Series Plot of Ozone: Simulated vs. Observed
UAM-IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain



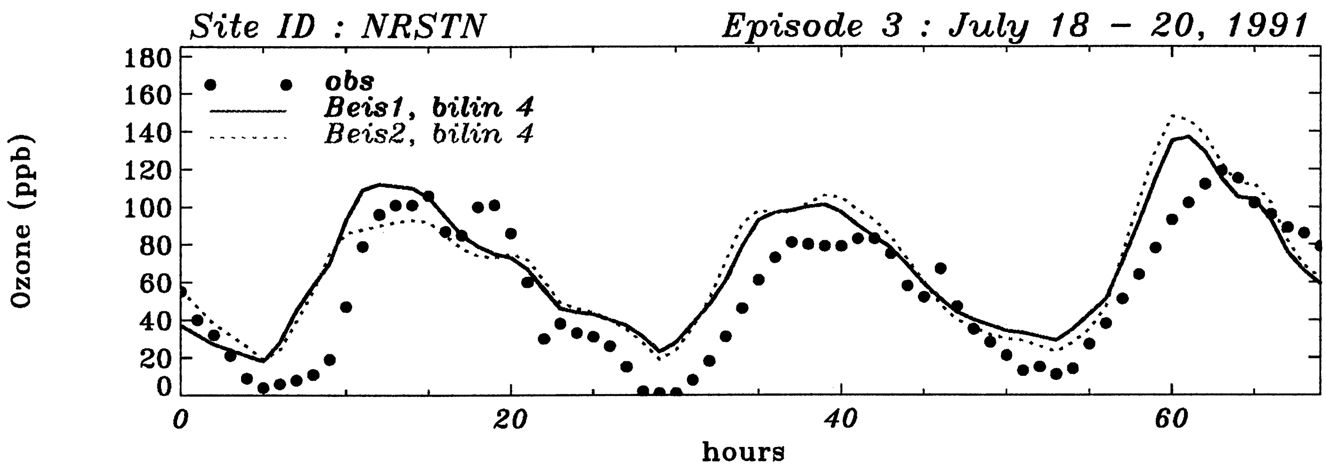
Time Series Plot of Ozone: Simulated vs. Observed
UAM–IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain

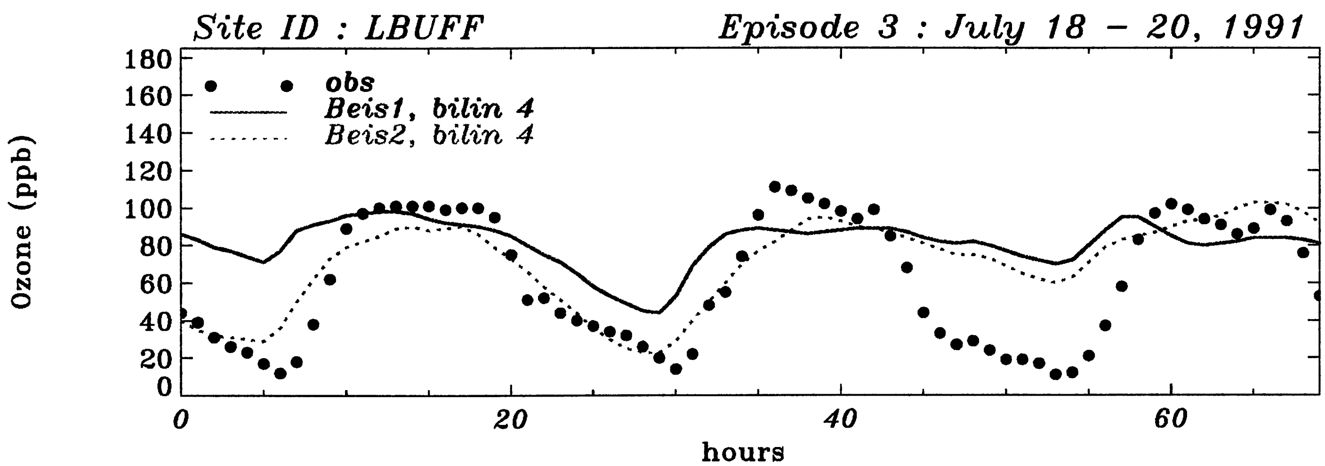


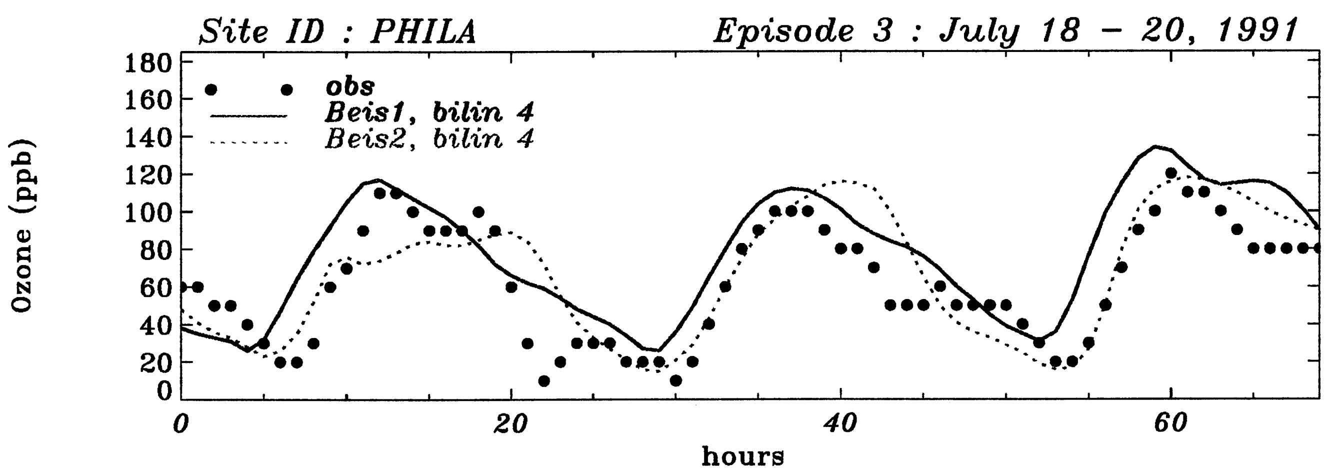
Time Series Plot of Ozone: Simulated vs. Observed
UAM-IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain



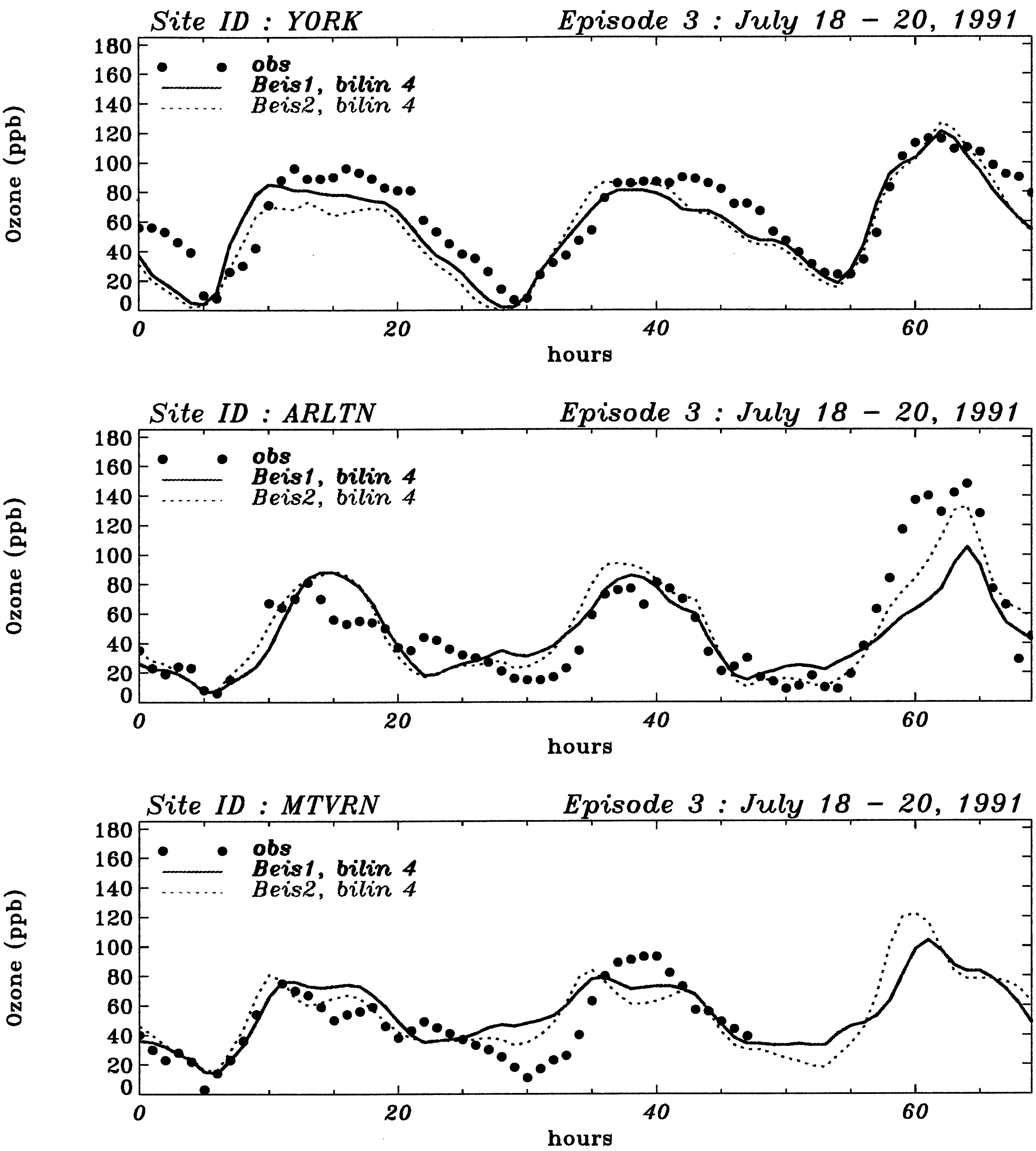
Time Series Plot of Ozone: Simulated vs. Observed
UAM-IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain



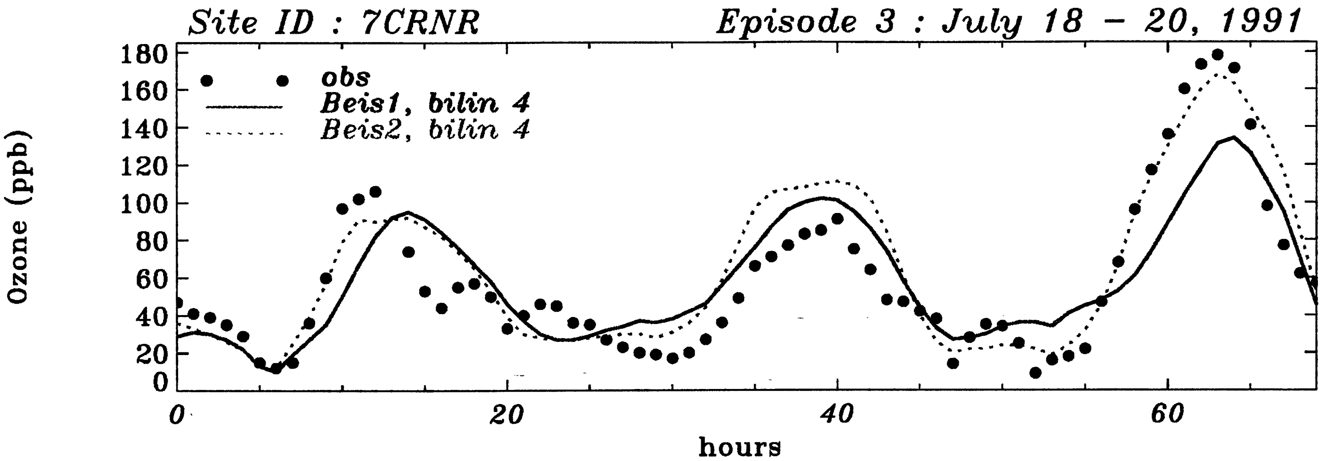


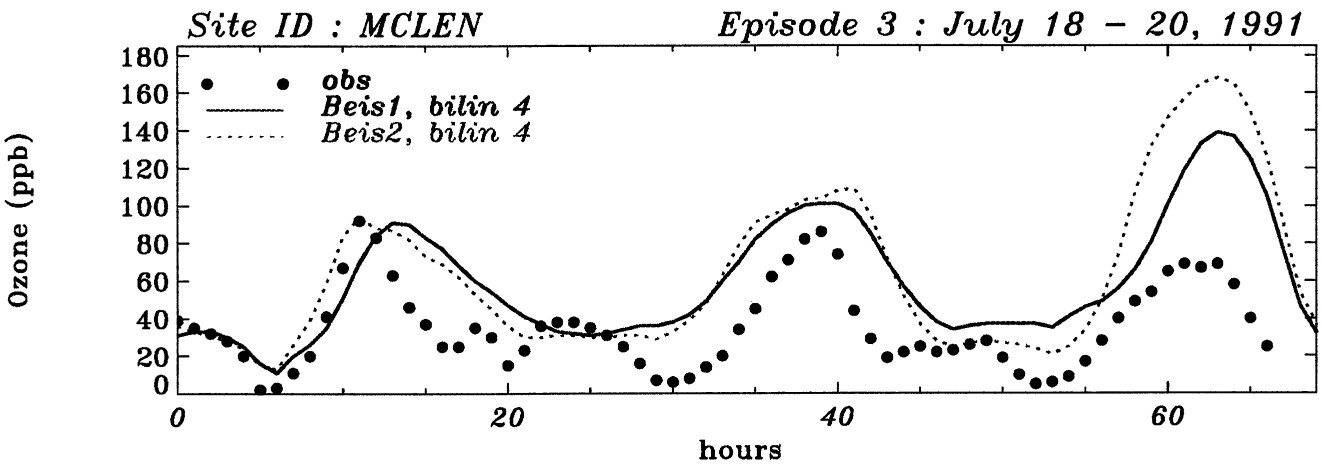


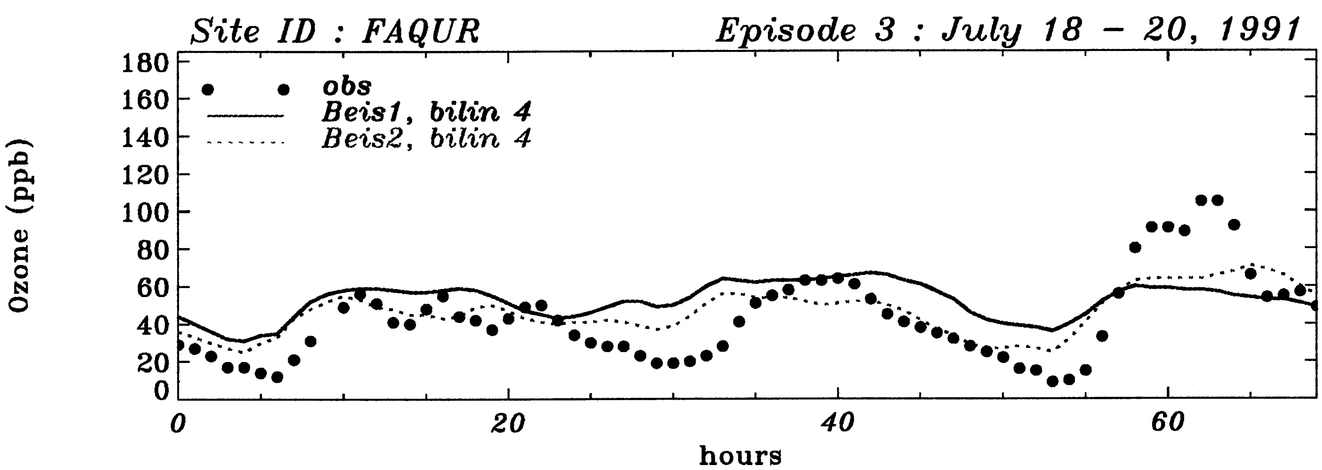
Time Series Plot of Ozone: Simulated vs. Observed
UAM–IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain



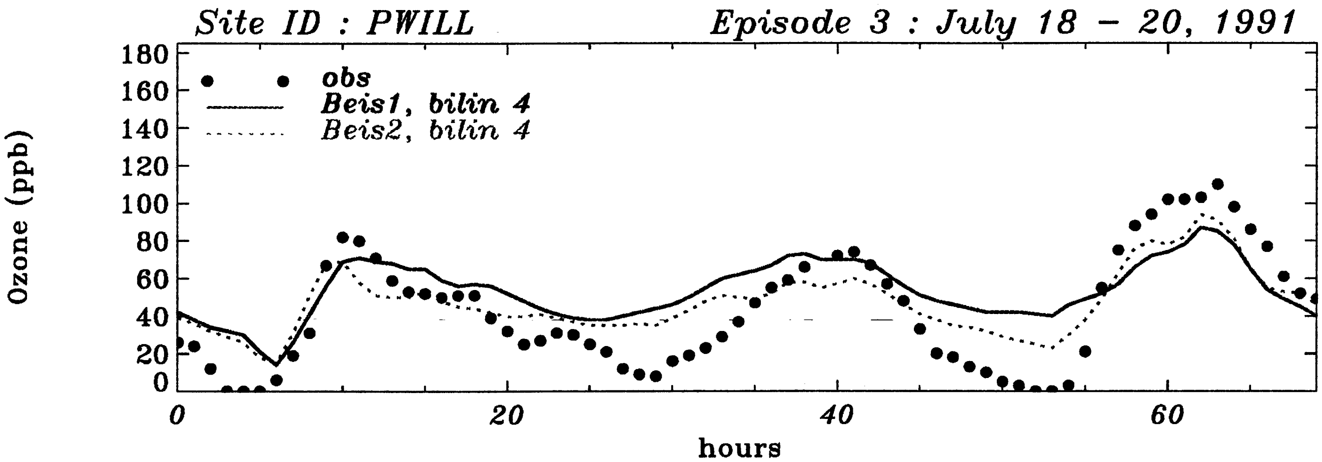
Time Series Plot of Ozone: Simulated vs. Observed
UAM-IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain

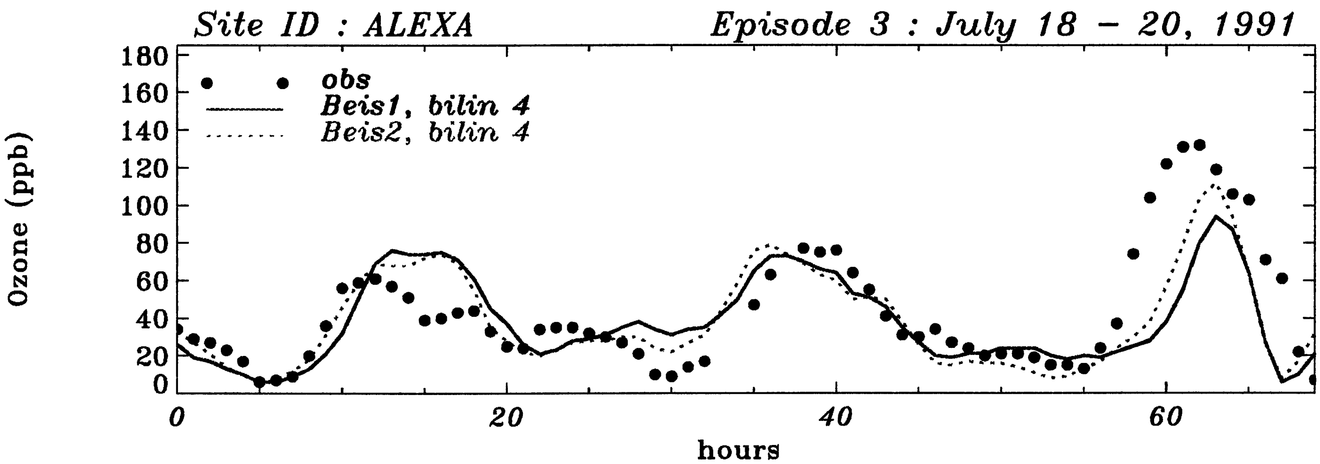


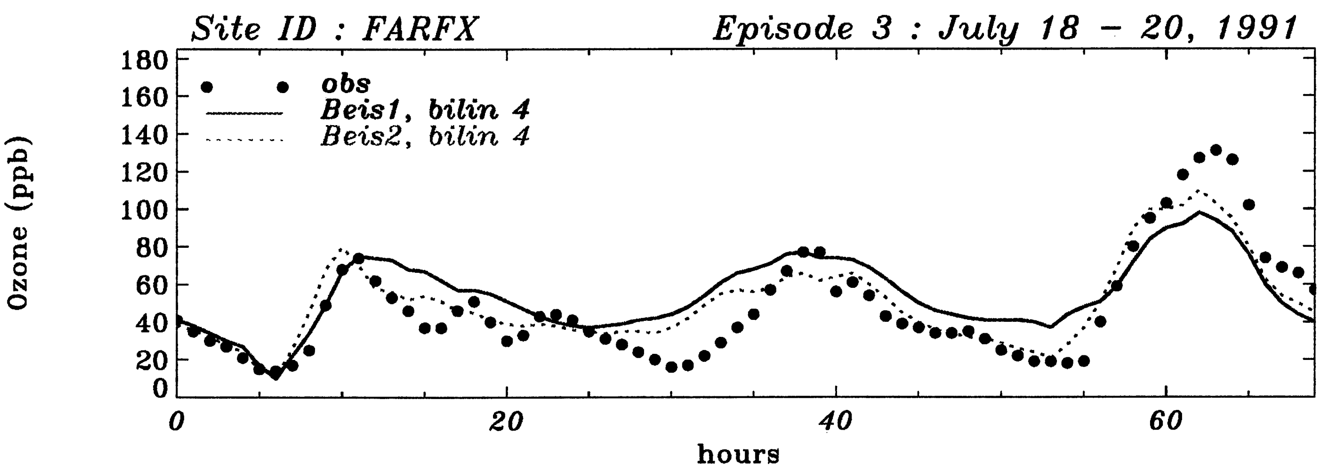




Time Series Plot of Ozone: Simulated vs. Observed
UAM–IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain







Time Series Plot of Ozone: Simulated vs. Observed
UAM–IV Layer 1, 91base, Beis1/Beis2 -- B/W Domain

Figure 6 : *Scatter Plot of Hourly Ozone: Simulated vs Observed*
UAM-IV Layer 1, Base Case, -- B/W Domain

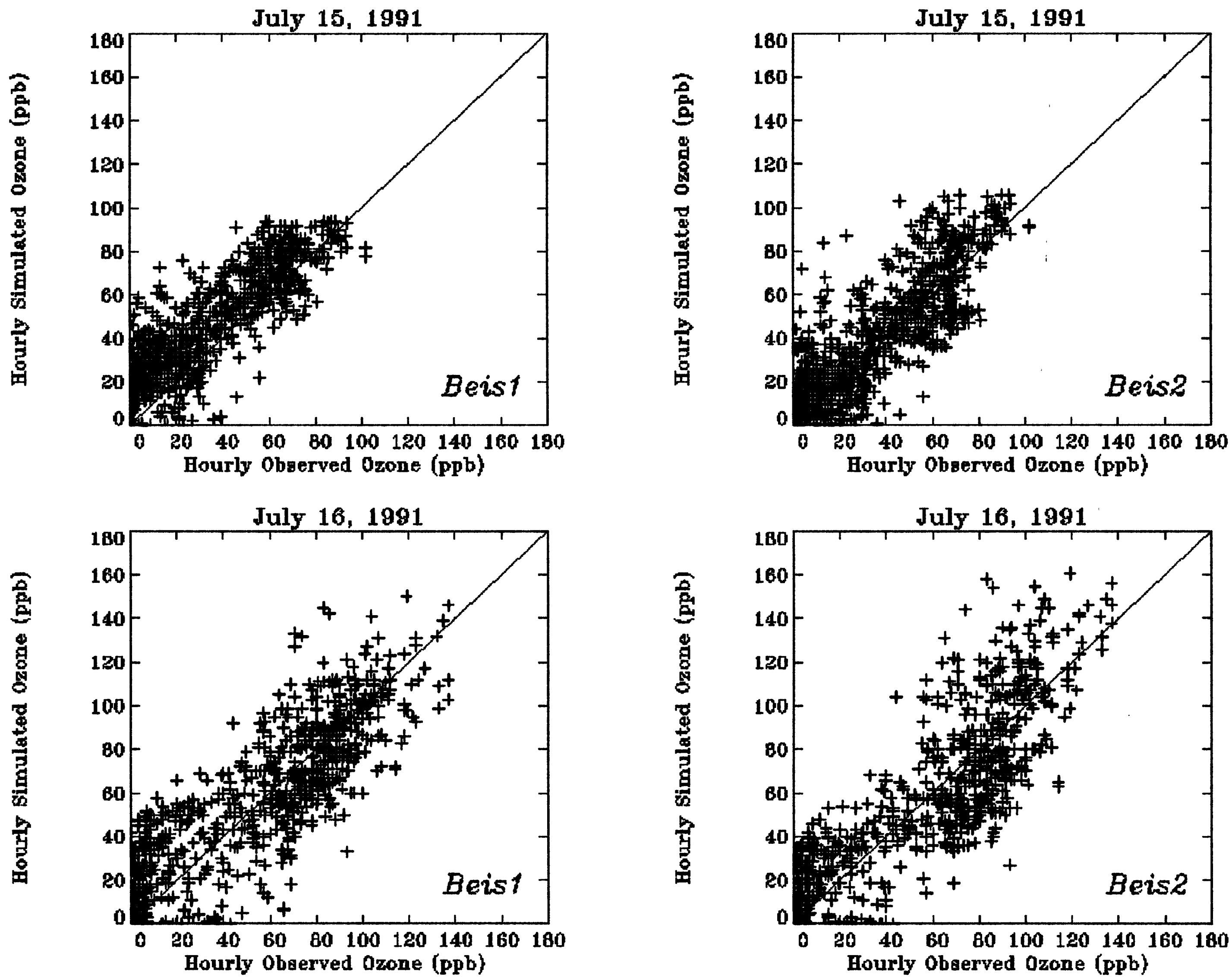


Figure 7(a)

Predicted Daily Max Ozone - 1991 Base Case UAM-IV Layer 1, Beis1, B/W Domain

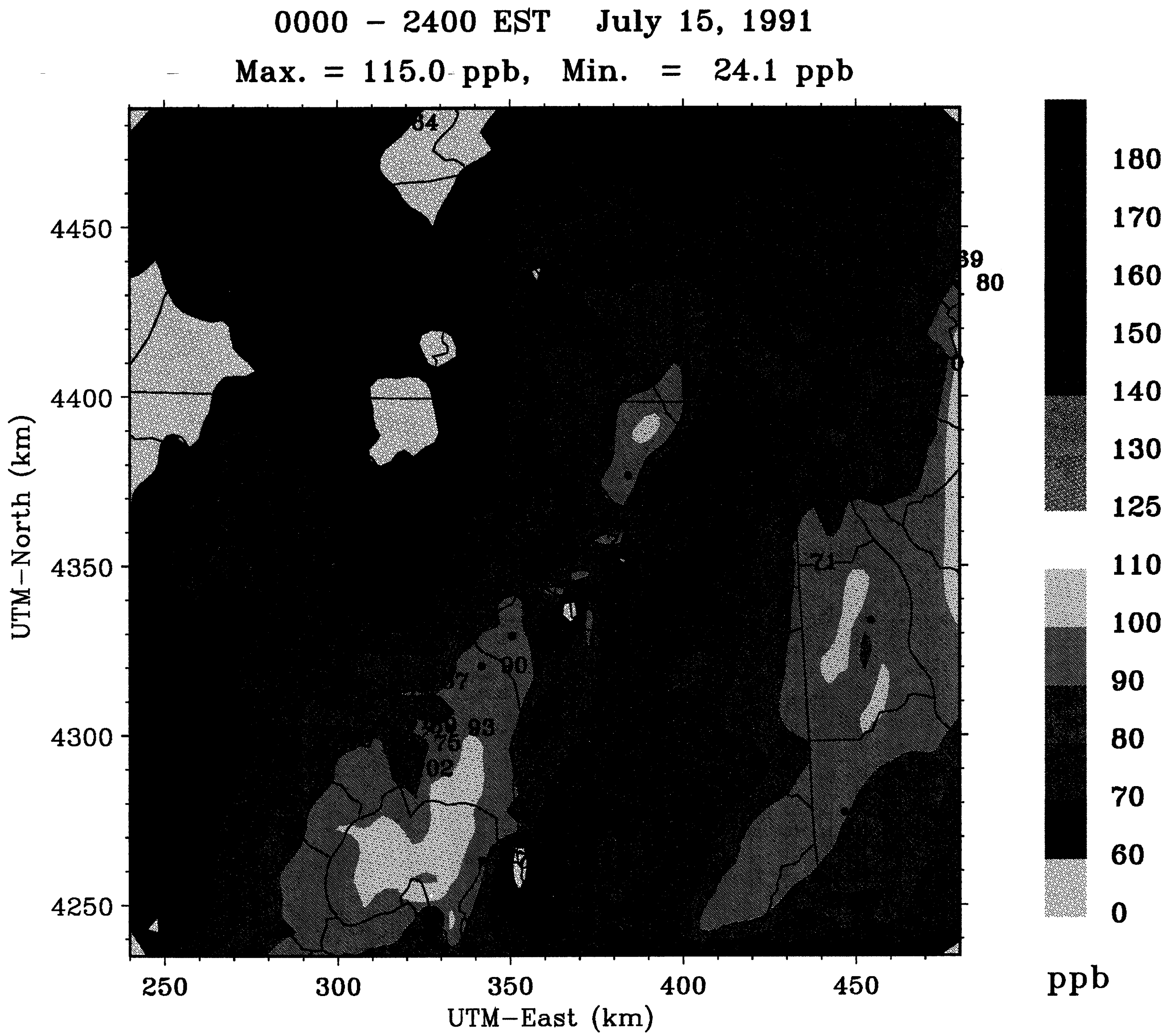
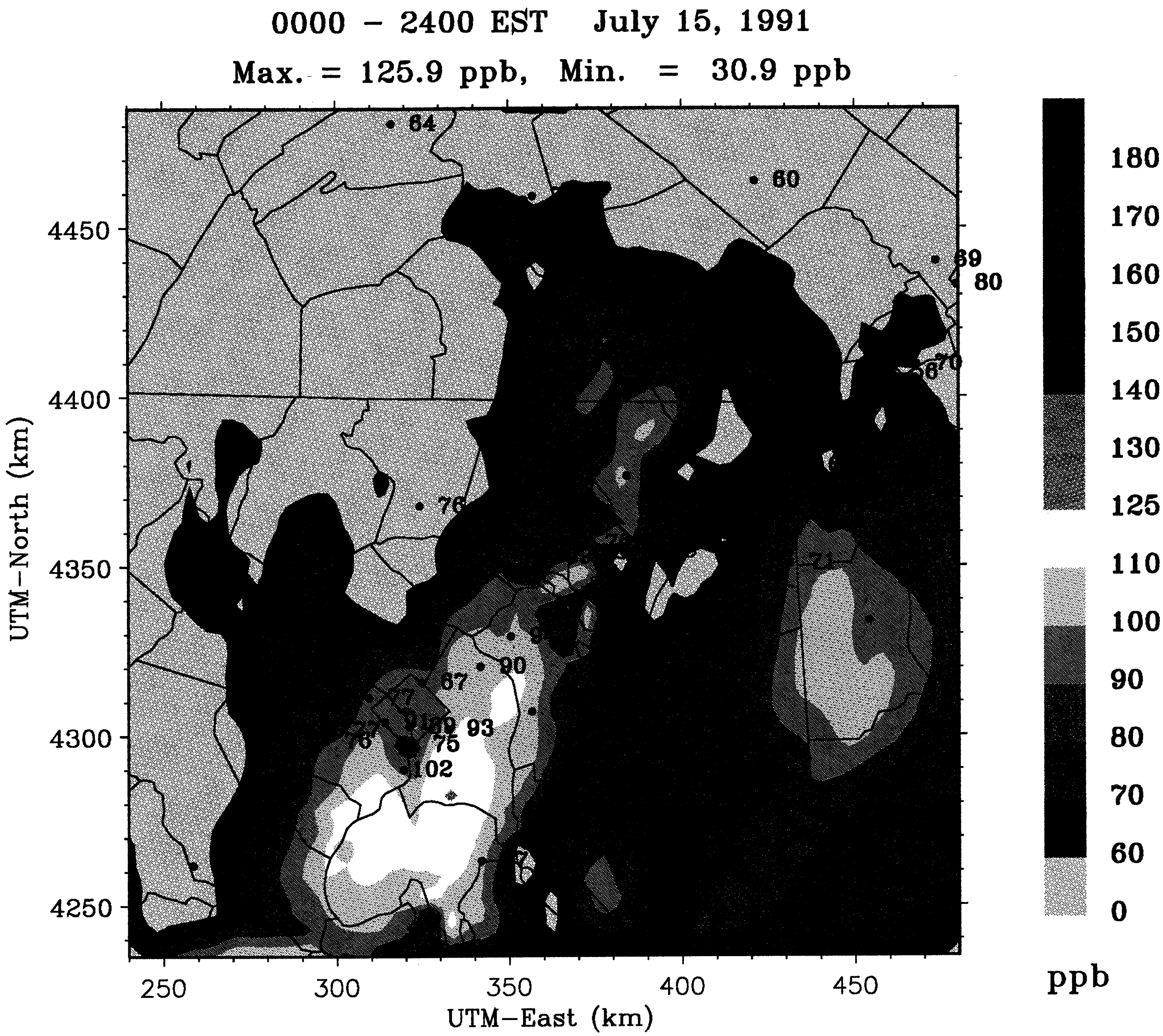


Figure 7(b)

Predicted Daily Max Ozone - 1991 Base Case
UAM-IV Layer 1, Beis2, B/W Domain



Anthro. emission : 1991 Base case (basA2D2)
Biogenic emission : UAM-BEIS2
Boundary condition : OTAG 1991 Base D2

Figure 8(a)

Predicted Daily Max Ozone – 1991 Base Case
UAM–IV Layer 1, Beis1, B/W Domain