Georgia Department of Natural Resources

Environmental Protection Division, Air Protection Branch

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Lonice C. Barrett, Commissioner

Harold F. Reheis, Director

March 31, 2004

Ms. Kay Prince
Chief, Air Planning Branch
U.S. EPA, Region IV
Air, Pesticides & Toxics Management Division
61 Forsyth Street, SW
Atlanta, Georgia 30303-8909

RE: March 31, 2004 Milestone Submittal for Augusta's Early Action Compact

Dear Ms. Prince:

With this letter, the Georgia Environmental Protection Division (EPD) is submitting the March 31, 2004 Early Action Plan (EAP) for Augusta's Early Action Compact (EAC). This fulfills the requirements of the June 30, 2003 milestone under the EAC agreement.

The attached June 30, 2003, EAP was developed by working very closely with stakeholders. We will continue with the stakeholder participation process for the EAC and are confident that our continued cooperation will be sufficient to ensure the successful development of an Early Action Plan for the Augusta Area that will achieve attainment of the 8-hour ozone standard by 2007.

Should you or your staff have any questions regarding our submittal, please contact Jimmy Johnson at (404) 363-7020.

Sincerely,

Ron Methier, Chief
Air Protection Branch

Enclosures

cc: James Joy
South Carolina Bureau of Air Quality

Honorable Bob Young
Mayor, City of Augusta

Honorable James Whitehead
Chairman, Board of Commissioners
Columbia County

Early Action Plan
for the
Augusta Early Action Compact

March 31, 2004

Prepared By:

Georgia Department of Natural Resources
Environmental Protection Division
Air Protection Branch

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1 Introduction

1.1 Background

This document satisfies the Early Action Plan (EAP) requirement for Augusta's agreement between the local governments representing the Augusta area, the Georgia Environmental Protection Division (EPD), and the United States Environmental Protection Agency (EPA). Its purpose is to proactively reduce ozone precursors and therefore ozone levels in the Augusta area sooner than expected under an expeditious timeline to attain and maintain compliance with the 8-hour ozone standard.

1.2 1-Hour Ozone Standard

National Ambient Air Quality Standards (NAAQS) are health-based standards set by EPA for six air pollutants that must be met in all areas of the United States. The NAAQS for ozone that is currently being implemented by the EPA is known as the 1-hour standard. This standard is based on the number of days per year during which the measured concentration of ozone in the air, averaged over one hour, is 0.12 parts per million (ppm) or greater. For an area to meet or attain the standard, the average number of days with one or more hourly observations about 0.12 ppm at each ozone monitor within that area must be equal to or less that one over a consecutive three-year period.[1]

1.3 8-Hour Ozone Standard

In 1997, the EPA set a new ozone NAAQS, called the 8-hour ozone standard. This standard is based on the measured concentration of ozone in the air, averaged over a consecutive 8-hour period. For an area to attain the standard, the three-year average of the annual fourth-highest daily maximum 8-hour average ozone concentration in the area must be less than or equal to 0.08 ppm.[2] The 8-hour ozone standard will be more difficult to attain than the 1-hour standard, but it will also provide a greater level of protection to the public against a wide range of ozone-related health effects. On June 2, 2003, EPA released the *Proposed Rule to Implement the 8-Hour Ozone National Ambient Air Quality Standard; Proposed Rule*, in the Federal Register.[3] The final implementation guidance for the 8-hour standard is anticipated to be released in the summer of 2004.

1.4 Early Action Compacts

On June 19, 2002, EPA released the *Protocol for Early Action Compacts Designed to Achieve and Maintain the 8-Hour Ozone Standard* (hereinafter referred to as the Protocol). Early Action Compacts (EACs) are contracts that can be signed between Local, State, and EPA officials for areas that are in attainment of the 1-hour ozone standard, but approach or monitor exceedances of the 8-hour ozone standard. EACs call for comprehensive air quality plans tailored to local

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1 40 Code of Federal Regulations (CFR) Part 50.9.
2 40 CFR Part 50.10.
3 Federal Register Vol. 68, No. 105, 32802.

needs that will develop and implement control strategies to achieve and maintain the 8-hour ozone standard. By signing an EAC, an area would be responsible for complying with a more expeditious timeline for achieving emissions reductions and would also be responsible for meeting many reporting milestones throughout the process. The benefit to working on the expedited timeline is that the area's official nonattainment designation would be postponed, and the area would achieve cleaner air sooner. Early Action Compact areas must show attainment by December 31, 2007.

The principles of the Early Action Compact (EAC) to be executed by Local, State, and the EPA officials are as follows:

- Early planning and implementation of emission reductions leading to expeditious attainment and maintenance of the 8-hour ozone standard;
- Local control of the measures to be employed with broad-based public input;
- State support to ensure technical integrity of the early action plan;
- Formal incorporation of the early action plan into the state implementation plan (SIP);
- Deferral of the effective date of nonattainment designation and related requirements[4] so long as all Compact terms and milestones are met; and
- Safeguards to return areas to traditional SIP requirements should EAC terms and/or milestones be unfulfilled, with appropriate credit given for emission reduction measures implemented.

EAC areas that fulfill milestone and reporting requirements will have the benefit of a deferred effective date of nonattainment designation. If at any time the EAC area does not meet the terms of its contract, then the area's nonattainment designation will become effective immediately and the compact will be dissolved.

EPA promulgated the proposed nonattainment designation effectiveness deferral in the December, 16, 2003, Federal Register, entitled *Deferral of Effective Date of Nonattainment Designations for 8-Hour Ozone National Ambient Air Quality Standards for Early Action Compact Areas; Proposed Rule*.[5] In this promulgation, EPA proposed an initial deferral date of September 30, 2005, provided EAC areas continue to meet their milestones and fulfill their EAC obligations. EPA will then promulgate a new deferral date before the expiration of the September 30, 2005, deferral date, and would then promulgate a third and final deferral date before the second deferral date expires.

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4 One nonattainment area requirement that will not apply for EAC areas meeting all their milestones is transportation conformity. Therefore, no motor vehicle emissions budgets for transportation conformity purposes are being established with this SIP revision.
5 Federal Register Vol. 68, No. 241, 70108.

1.5 Augusta Early Action Compact History

On December 31, 2002, the Georgia EPD submitted an 8-Hour Ozone EAC for the Augusta area to EPA. The EAC is a Memorandum of Agreement between the local governments representing the Augusta area (Local), the Georgia Environmental Protection Division (EPD), and the EPA. The local officials include the Augusta City Mayor who represents Richmond County and the Columbia County Commissioner. By signing the EAC, Georgia has agreed to assess progress towards developing and implementing the Early Action Plan (EAP).

1.6 Fall-line Air Quality Study

Research on air quality issues in the Augusta area actually began in the summer of 2000, with the kickoff of the Fall-line Air Quality Study[6] (FAQS). FAQS is a multi-year study commissioned to assess urban and regional air pollution, identify the sources of pollutants and pollutant precursors, and recommend solutions to the current and potential poor air quality in the "Fall-line" cities of Augusta, Macon, and Columbus. Researchers at the Georgia Institute of Technology (Georgia Tech) have directed the FAQS in cooperation with EPD, EPA, Georgia Regional Transportation Authority (GRTA), the U.S. Department of Defense (DOD), Georgia Department of Transportation (GDOT), the State of South Carolina, the State of Alabama, and all local stakeholders.

The FAQS has been implemented in 4 phases. Phase 1 was the preliminary assessment and pilot field study. Phase 2 was the emissions inventory development and inceptive field study. Phase 3 was the air quality modeling and corroborative field study. Finally, Phase 4, which is the current phase, is devoted to analysis, recommendations, and technology transfer. It is this FAQS research that has become the foundation of Augusta's EAC.

1.7 Augusta's Attainment Status

On July 15, 2003, EPD submitted a letter to EPA identifying its recommendations for potential 8-hour ozone nonattainment counties. In this letter, EPD identified Richmond County as a potential nonattainment county. After submitting this letter to EPA, the data for the 2003 ozone season went through the quality control and quality assurance process and was fully uploaded in the Air Quality Subsystem (AQS). According to the most recent three years of monitored data representing calendar years 2001-2003, the Augusta-Aiken CMSA has attained the 8-hour standard. EPD sent a letter dated November 14, 2003, to EPA indicating the new attainment status of the Augusta area, and EPA has recognized this status in its December 3, 2003, letter to EPD. Despite the fact that the Augusta area is now in attainment of the 8-hour standard, Augusta's Local officials and EPD have agreed to proceed with the EAC and plan proactively for Augusta's future. Stakeholders have continued to hold meetings in the Augusta area. EPD and Local officials will continue working together to develop and implement an EAP and continue to meet EAC milestones set by EPA.

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6 http://cure.eas.gatech.edu/faqs/index.html

1.8 Early Action Compact SIP Outline

This EAC SIP contains the following sections:

- Section 2, Data Analysis of monitoring data collected in the State of Georgia for calendar years 2001-2003;
- Section 3, Emissions Inventory Development, describing how inventories for the years 2000, 2007, and 2012 were developed;
- Section 4, Atmospheric Modeling and Data Analysis for Emissions Control Strategy Development and Attainment Demonstration;
- Section 5, Control Strategy and Emissions Budgets, which provides details on the control strategies to be implemented in the EAC area and the corresponding emissions budget; and
- Section 6, Rate of Progress Plan and Mid-Course Review, which will be developed in the future as necessary.

2. Conceptual Description of the Ozone Problem in Augusta

Results from the initial assessment of existing data and other studies, suggests that there are multiple temporal and spatial scales involved in the formation and accumulation of ground-level ozone in the three Fall Line Air Quality Study (FAQS) cities of Augusta, Macon, Columbus and across the state. All locations are affected by a regional tide of elevated ozone concentrations that extend across much of the southeast. Ozone concentrations in Augusta and Columbus in particular seem to be securely coupled to the region, experiencing ozone concentrations greater than the 8-hour ozone NAAQS only on days when ozone concentrations across the whole region are elevated. Ozone concentrations observed at the GA EPD site in Macon however also seem to have a strong statistical relationship with ozone concentrations observed in Atlanta. This may imply that, under certain conditions, Macon and Atlanta may share all or part of a small local airshed, thereby providing a mechanism for Macon to experience exceedance level ozone concentrations on any day that Atlanta has elevated ozone concentrations. The Fort Gordon monitoring site in Augusta does not appear to be influenced by nearby sources, and therefore this monitor may be more representative of the larger metropolitan area. Causality however, cannot be established through this statistical approach.

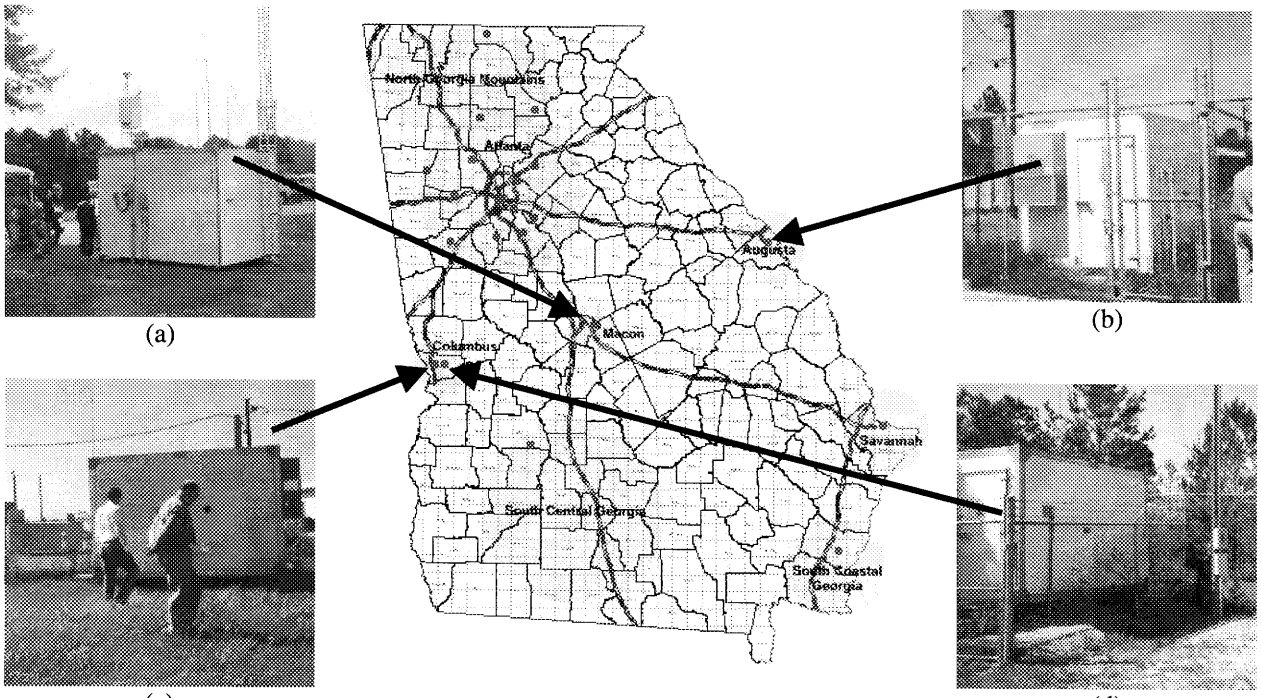
2.1 Past and Present Air Quality in the Fall Line Cities

The GA EPD has monitored concentrations of ozone in the Augusta metropolitan area continuously since 1989, in Macon since 1997, and in Columbus since 1981. See Table 2-1 and Figure 2.1. Data from the monitors that are still operating are the official determinants of air quality in the metropolitan areas and may be used to designate "nonattainment" areas.

Table 2-1: Location and Operational Status of the GA EPD Ozone Monitoring Network in the Fall Line Cities

City	Monitor	Latitude (degrees)	Longitude (degrees)	Elevation (masl)	Start Date	End Data
Augusta	Bayvale ES	33.43333	82.02194	46	4/27/89	Still Operating
Macon	GA Forestry	32.80306	83.54472	54	5/7/97	Still Operating
Columbus	Airport	32.52139	84.94361	101	4/1/83	Still Operating
	Crime Lab	32.53944	84.84333	122	1/1/81	Still Operating
	Columbus	32.50389	84.94028	NA	1/1/81	10/31/82

Figure 2-1: Currently Operating GA EPD Ozone Monitoring Stations At: (A) Macon - Georgia Forestry Service, (B) Augusta - Bayvale Es, (C) Columbus - Airport, And (D) Columbus - Crime Lab.



(a) (b) (c) (d)

2.2 The Spatial Scale of Ozone Air Quality

The preliminary study by Russell et al. suggested that there might be a connection between elevated ozone concentrations in Columbus, Augusta, and excessive pollutant concentrations in other parts of the state and region. This general phenomena was also one of the findings of the Ozone Transport Assessment Group (OTAG) study of the eastern US from the mid-1990's. Specifically, OTAG concluded that (ECOS, 1998 and summarized here from GA EPD, 1999):

- The southeast appears to be meteorologically decoupled from the Midwest and Northeast, indicating little transport either way to and from the Southeast.
- There does appear to be significant interstate transport, including within the southeast.
- Reductions of VOC and NOx in urban areas have an impact on ozone reduction within those areas.
- Reductions in NOx emissions in rural areas can have a significant impact on urban areas longer distances away.

2.3 Local

Figure 2-2 shows ozone concentrations in Augusta, Macon, and Columbus plotted as a function of wind direction and speed. In this analysis, peak daily 8-hour average ozone concentrations for the years 1997 – 1999 from the GA EPD's ozone monitoring network (see Table 2-12 and Figure 2-12) are combined with concurrent 24-hour resultant winds[7] from the nearest National Weather Service station (see Table 2) as reported in the *Local Climatological Data* reports from the NOAA, National Climatic Data Center. Ozone concentrations are classified by Air Quality Index categories for clean air: good, moderate, unhealthy for sensitive groups, and unhealthy. Any event with air quality classified as worse than moderate would fail to meet the 8-hour ozone NAAQS. In Figure 2-2, the daily peak 8-hour ozone concentration is plotted on the radial axis as the resultant wind speed and in the angular compass direction from which the resultant wind is blowing.

For the highest ozone concentrations, all four monitors appear to exhibit some unique directional characteristics. Disregarding wind speed, higher ozone concentrations at the Augusta monitor are observed most frequently when winds are blowing from the southeast. In Macon, the highest ozone concentrations are observed under a westerly wind flow pattern. In Columbus, both monitors show a tendency towards higher ozone concentrations with northwesterly winds. If wind speed is also considered however, the figures show that the highest ozone concentrations recorded at the monitors are most frequently associated with light or stagnant winds (less than 4 mph). Taken alone, this latter condition might indicate that transport of pollutants or pollutant precursors from other areas does not contribute significantly to elevated local concentrations of ozone. There are two primary caveats to this analysis however: space and time. First, the meteorological monitoring stations are not co-located with the ozone monitoring stations. It is possible therefore, that the winds are not representative of the air parcel sampled by the ozone monitoring station. Further, the winds are only representative of the surface winds and fail to characterize the winds aloft. It is these winds aloft, detached from the retarding frictional effects of the earth's surface, that are more likely involved in the long-range transport of pollutants and pollutant precursors. Second, it was assumed that ozone concentrations are affected primarily by concurrent winds. A viable scenario exists in which ozone or ozone precursors could have been deposited in the local area by winds during the previous or prior days. The analysis presented here does not account for this possibility.

Table 2-2: Local National Weather Service climatological monitoring stations near GA EPD ozone monitors.

City	Station	Latitude	Longitude	Elevation (masl)	~distance to O_3 monitor (km)
Augusta	Bush Field	33.3667	81.9500	41.5	10
Macon	Wilson Airport	32.6833	83.6500	107.9	17
Columbus	Metropolitan Airport	32.5000	84.9333	135.6	3 (Airport) 10 (Crime Lab)

7 Resultant wind is the vector sum of the wind speeds and directions divided by the number of observations for the 24 hour period beginning at 00 LDT.

Figure 2-2: Peak daily 8-hour average ozone concentrations as a function of local resultant wind.

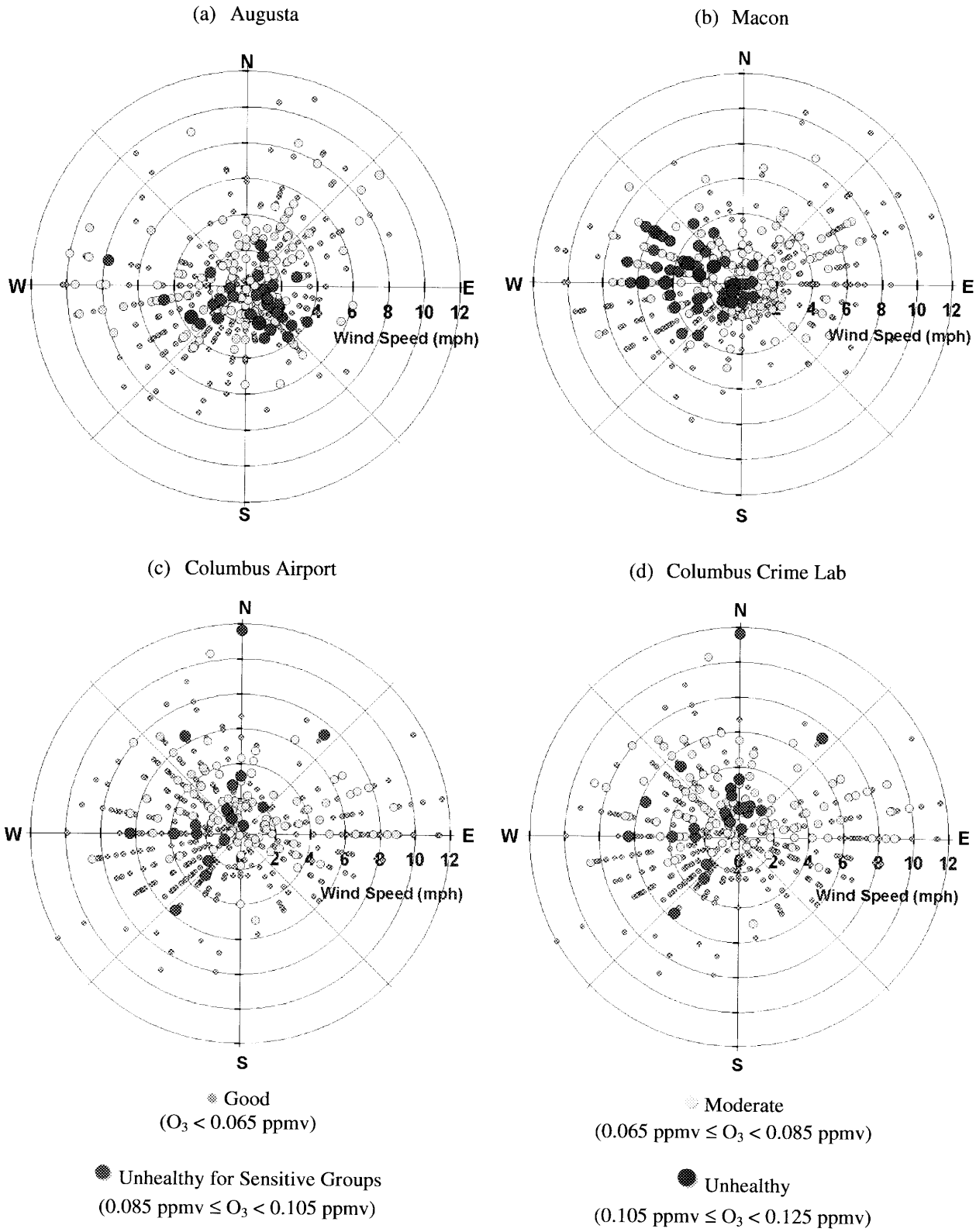
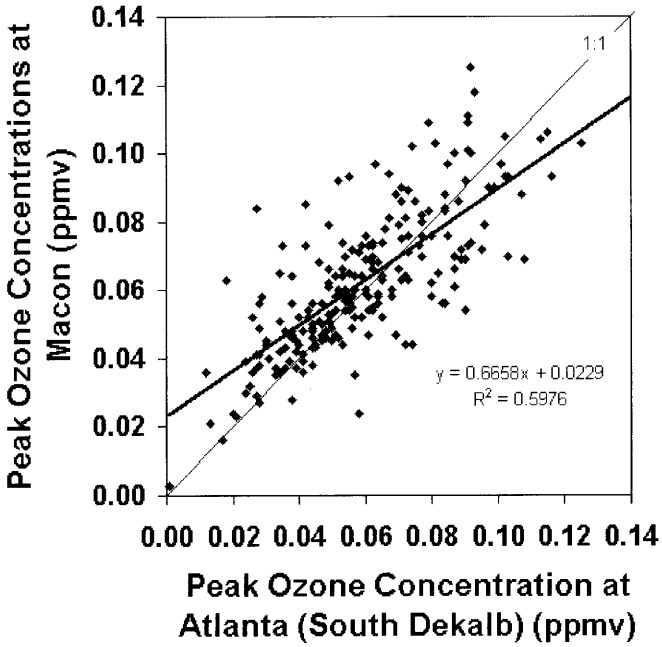


Figure 2-3 Year 2000 correlation between peak 1-hour ozone concentrations at Atlanta (South Dekalb) and Macon.



Statewide

An examination of ozone concentrations in Augusta, Macon, and Columbus relative to concurrent ozone concentrations at other monitors across the state reveals additional clues. Figure 2-3 is an example comparing peak daily 1-hour average ozone concentrations at the South Dekalb ozone monitoring site in metropolitan Atlanta, with concurrent peak daily 1-hour average ozone concentrations at the ozone monitoring site in Macon. The figure suggests that there is a fairly strong relationship between ozone concentrations observed in Atlanta with those observed in Macon. For the year 2000, when ozone concentrations were high in Atlanta, they also tended to be high in Macon. Likewise, when ozone concentrations were low in Atlanta, they also tended to be low in Macon. The R^2 value, also called the coefficient of understanding, is a statistical measure of the strength of this relationship. It may range from 0.0, no relationship, to 1.0, a perfect relationship. R, or the correlation coefficient and from which the coefficient of understanding is derived, is also a statistical measure of the strength of the relationship. It may range from -1.0, a perfect anti-relationship (i.e. when values are high at one station, they are low at the other and vice versa), to 0.0, no relationship, to 1.0, a perfect direct relationship. Table 2-3 shows the correlation coefficient of daily peak 1-hour average ozone concentrations from the 2000 ozone season among nine different stations in Georgia.

Table 2-3 Correlation of daily peak 1-hour average ozone concentrations among selected GA EPD ozone monitoring stations, 1 March – 16 October 2000.

	Augusta	Macon	Columbus Airport	Columbus Crime Lab	Atlanta South Dekalb	Leslie	Savannah	Brunswick	Ft. Mountain
Augusta	1.00	0.36	0.74	0.68	0.32	0.72	0.01	0.55	0.09
Macon	0.36	1.00	0.34	0.33	0.77	0.29	0.36	0.41	0.03
Columbus Airport	0.74	0.34	1.00	0.90	0.31	0.88	-0.04	0.54	-0.02
Columbus Crime Lab	0.68	0.33	0.90	1.00	0.28	0.81	-0.03	0.55	-0.09
Atlanta South Dekalb	0.32	0.77	0.31	0.28	1.00	0.27	0.25	0.31	0.03
Leslie	0.72	0.29	0.88	0.81	0.27	1.00	-0.08	0.62	-0.08
Savannah	0.01	0.36	-0.04	-0.03	0.25	-0.08	1.00	0.12	-0.03
Brunswick	0.55	0.41	0.54	0.55	0.31	0.62	0.12	1.00	-0.05
Ft. Mountain	0.09	0.03	-0.02	-0.09	0.03	-0.08	-0.03	-0.05	1.00

Referencing Table 2-3 and Figure 2-1, ozone concentrations in Augusta are most closely correlated (highest absolute correlation coefficient) with ozone concentrations at both monitors in Columbus and at another station in Leslie, about 75 miles southeast of Columbus in South Central Georgia. In reciprocal, the ozone concentrations observed at the Columbus monitors are most closely related to the values observed at Augusta and Leslie. The two monitors in Columbus are also highly correlated with each other, as one might expect. Somewhat unexpectedly given that Macon lies midway between Augusta and Columbus along the Fall Line, ozone concentrations in Macon more closely track those observed at the South Dekalb monitoring station in metropolitan Atlanta than they do either Augusta or Columbus. Rounding out the state, the Brunswick station in South Coastal Georgia seems to be moderately related to all the Fall Line stations, while the Savannah and Fort Mountain (in the North Georgia Mountains) sites do not appear to be correlated with any other site in Georgia.

2.4 Regional

Looking at the even larger region, there appears to be concurrence between high ozone concentrations in Georgia with high ozone concentrations in other states of the Southeast. Figure 2-4 shows the number of monitoring sites that recorded an exceedance of the 8-hour ozone NAAQS on each day between 1 May and 30 September 2000 in Georgia (source: GA EPD), South Carolina (SC Department of Health and Environmental Control), and Alabama (AL Department of Environmental Management). Events appear to occur nearly simultaneously across all three states. This result is consistent with the meteorological scale that largely controls the region's weather. It is this so called "synoptic" scale of approximately 1000 miles that characterizes the principal weather features of high and low pressure systems, the advance of warm and cold fronts, and the location and strength of jet streams. For example, the meteorological conditions present at 1600 EDT on 17 August 2000 are shown in Figure 5. On this date, many sites in Georgia, South Carolina, and Alabama exceeded the 8-hour ozone NAAQS. The whole Southeast was under the influence of the high-pressure dome centered over the Ohio Valley. This system substantially prevented the movement of air as evidenced by the stationary front extending across the region from Illinois to South Carolina. The apparent result was stagnation and a region-wide buildup of pollutants.

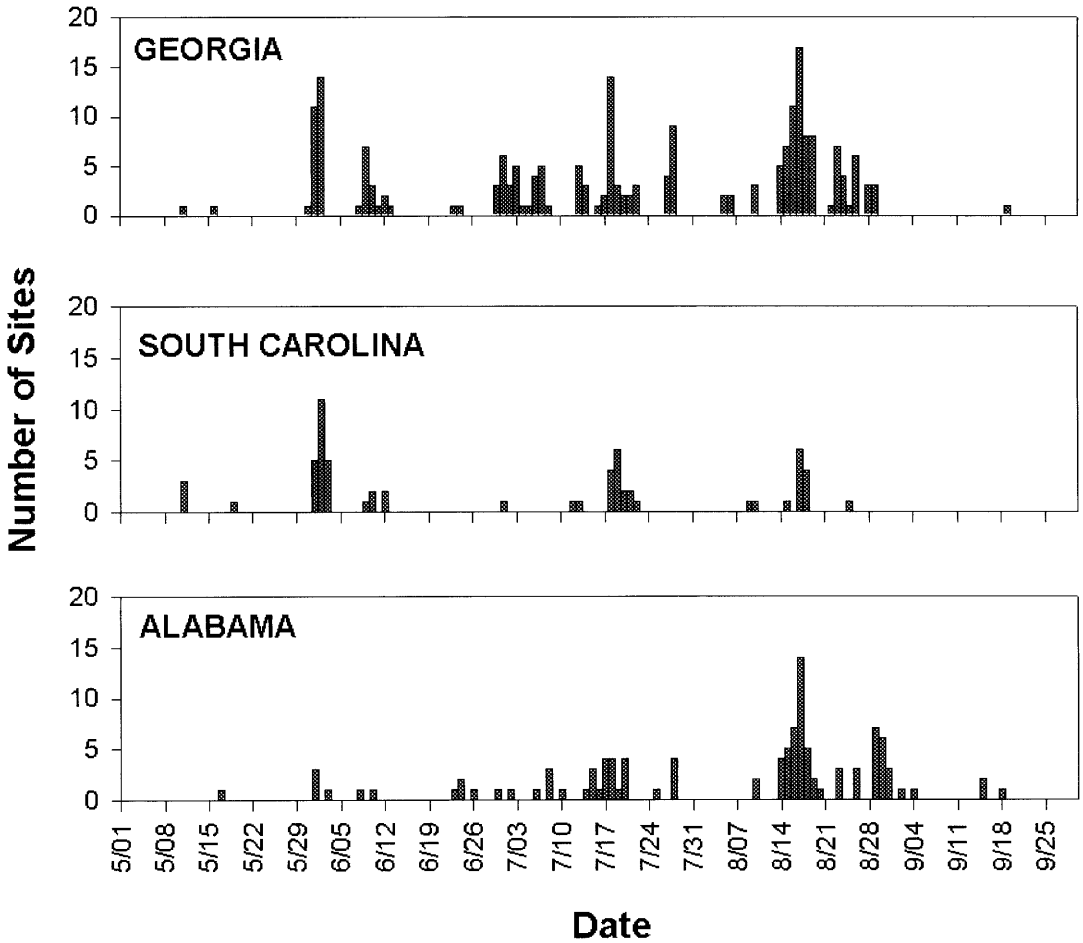
2.5 Forming a Spatial Hypothesis for Ozone

While the preceding analyses were simple and limited, they offer hints about the structure and organization of the regional, statewide, and local airsheds that collectively influence air quality in the Fall Line cities. Any proposed paradigm describing the air quality in the region must be consistent with this information (including the earlier report by Russell et al.). From this examination, one might hypothesize that a super-regional airshed exists across most of Georgia's piedmont and coastal plain and may extend into parts of Alabama and South Carolina. The super-regional airshed is primarily governed by the synoptic scale meteorology. When meteorological conditions are conducive to ozone formation and accumulation, all areas within the super-regional airshed may experience elevated ozone concentrations. This broad influence may be more significant for Augusta and Columbus than for Macon. The mountainous and extreme coastal regions of Georgia seem to be independent of this super-regional airshed

altogether however. This may be because the terrain in these areas is significantly different from the terrain of the piedmont and coastal plain. The specific types of terrain that are found in these areas can strongly influence local meteorological conditions. Meteorologists categorize these local influences that have sway over areas only a few miles to a few hundreds of miles in size as "mesoscale." Strong mesoscalic weather conditions can over-ride the synoptic scale influences.

In Macon, a strong influence on ozone concentrations beyond just the effects of the synoptic scale meteorology, may be found in another airshed that is nested within the super-regional airshed. This nested airshed is aligned roughly along I-75 and includes both metropolitan Atlanta and metropolitan Macon. Like the mountainous regions or coastal regions, this region may also have a unique mesoscale characteristic: urbanization. Augusta and Columbus may also have local airsheds nested within the larger regional airshed, but they do not appear as intense as the Atlanta-Macon airshed. The dominate influence on local air quality in these areas seems to be associated with the synoptic scale. This working spatial hypothesis for ozone is illustrated in Figure 6.

Figure 2-4 Number of monitoring sites observing[8] an exceedance of the 8-hr O3 NAAQS in 2000.



8 1 May – 30 September 2000. 22 sites reporting in GA; 24 sites reporting in SC; 16 sites reporting in AL. Exceedances in AL are estimated from daily peak 1-hour average ozone concentrations (exceedance is assumed if $O_3 > 0.096$ ppmv).

Figure 5 Meteorological conditions of 17 August 2000, 1600 EDT. Infrared imagery shows position of clouds and relative temperatures of cloud tops. Also shown are positions of surface high and low pressure systems, and locations of surface warm, cold, and stationary fronts.

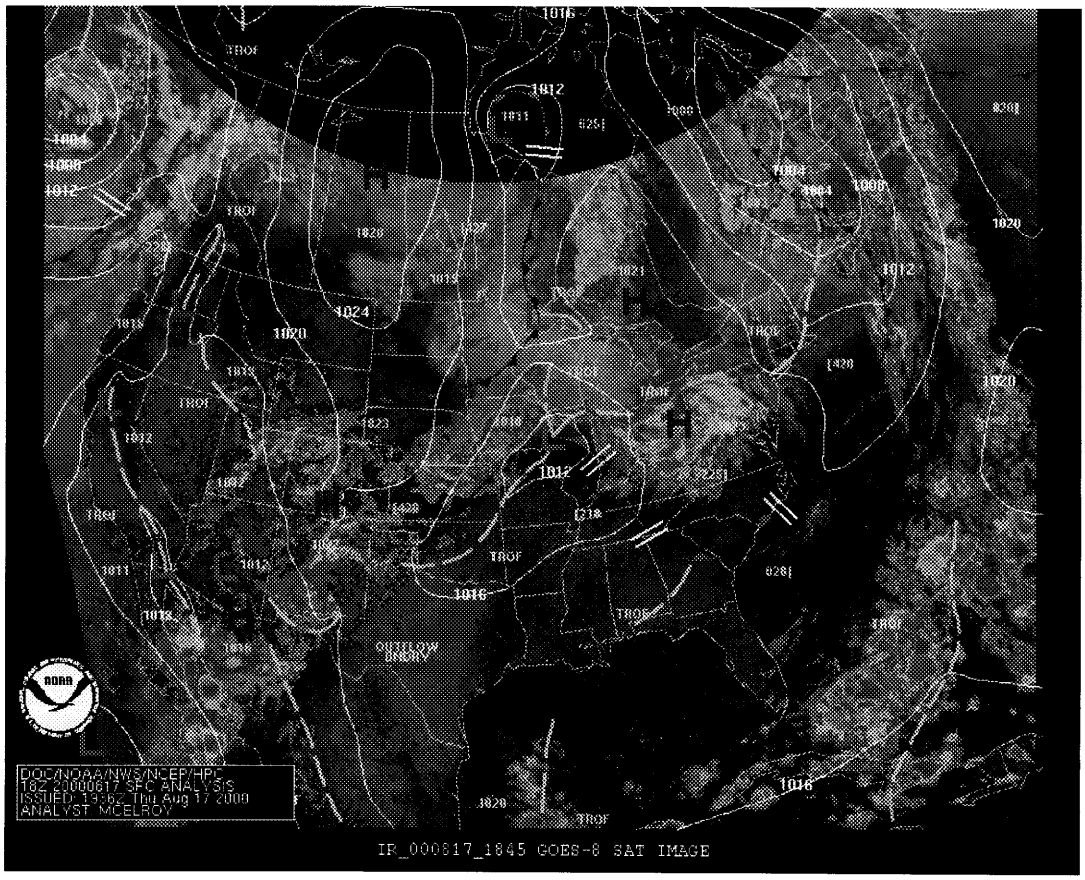
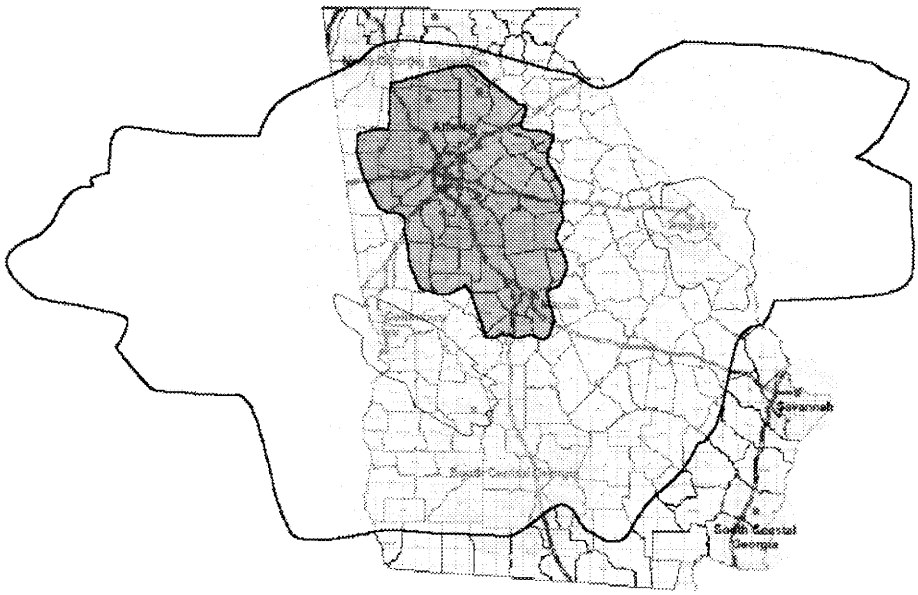


Figure 6 Diagram of proposed spatial ozone hypothesis: super-regional airshed with nested weak local airsheds in metropolitan Columbus and Augusta, and nested stonger inter-metropolitan Atlanta-Macon airshed.



References:

Environmental Council of the States, *Ozone Transport Assessment Group: Final Report*, http://www.epa.gov/ttn/rto/otag/finalrpt/; 1/8/98.

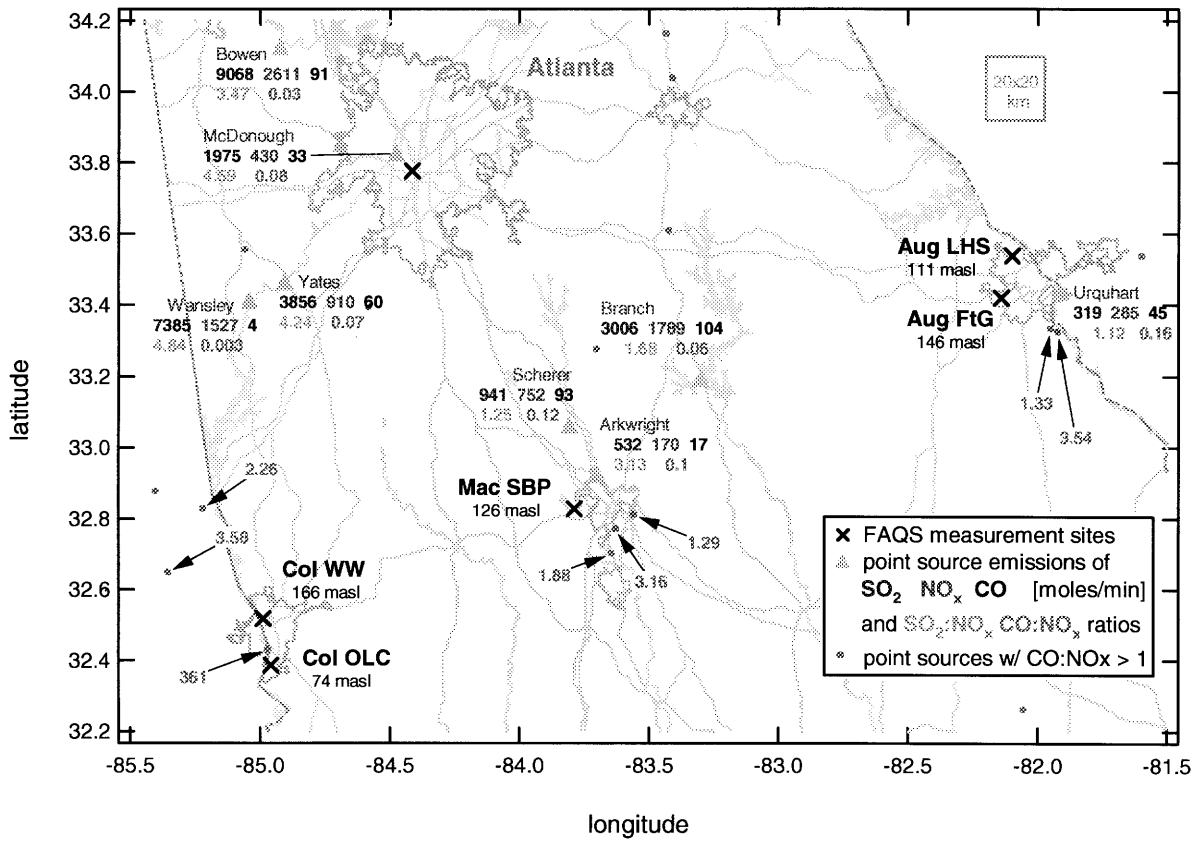
Georgia Environmental Protection Division (GA EPD), *State Implementation Plan for the Atlanta Ozone Non-attainment Area*, June 7, 1999.

Seabrook, C. *Atlanta Smog Rivals LA's*, Atlanta Journal and Constitution, 5/5/00.

Proximity of major emitters to selected sites

Figure 7 shows a map with the greater metropolitan Atlanta area to the north, the FAQS cities to the south, and the selected monitoring sites. This figure also shows the locations and emission strengths for SO_2, NO_x (as NO_2), and CO of major point sources based on 1990 EPA inventory data for GA, 1996 for SC, and 1997 for AL. The depicted sources are all steam generation plants run by electric utility companies. Also included are the locations of other point sources with $CO:NO_x$ emission ratios greater than 1. The biggest CO emitter with 47,660 tons/year (or 3237 moles/min) and a $CO:NO_x$ ratio of 361 is the Continental Carbon Black plant just inside AL, close to Columbus.

Figure 7 FAQS monitoring sites and major point sources across north-central Georgia.



Among all three primary pollutants, CO has the longest lifetime in the lower troposphere of almost 2 months, whereas NO_y lifetimes particularly in plumes are estimated to be less than 12 hours, chiefly due to removal of HNO_3. Since NO_y includes all NO_x (NO and NO_2) and its more photochemically stable oxidation products, NO_y measurements made at a nearby receptor location can be considered to represent the initially emitted NO_x after plume dispersion and dilution if the plume transport time is less than a few hours. Since the dispersion and dilution process acts equally on all three pollutants, the measured $SO_2:NO_y$ and $CO:NO_y$ ratios can be good tracers for nearby emission sources also.

Trace Gases

Table 4 statistically summarizes the trace gases observed at the AQR lab in each of the three FAQS cities. Ozone (O_3) concentrations in Macon were generally observed to be lower relative to the other two cities and periods. Midday ozone levels seemed to increase with time and season, and therefore were highest in Columbus both on average (66 ppbv) and maximum reported 1-min value (107 ppbv). At all three sites, the influence of the morning rush hour seems to cause the highest average carbon monoxide (CO), nitric oxide (NO), and total oxides of nitrogen (NO_y) levels, with absolute highest values reported at the North Columbus Water Works facility. Sulfur dioxide (SO_2) was lowest at Macon Sandy Beach Park and generally appeared on few occasions at higher levels without any noticeable diurnal dependence.

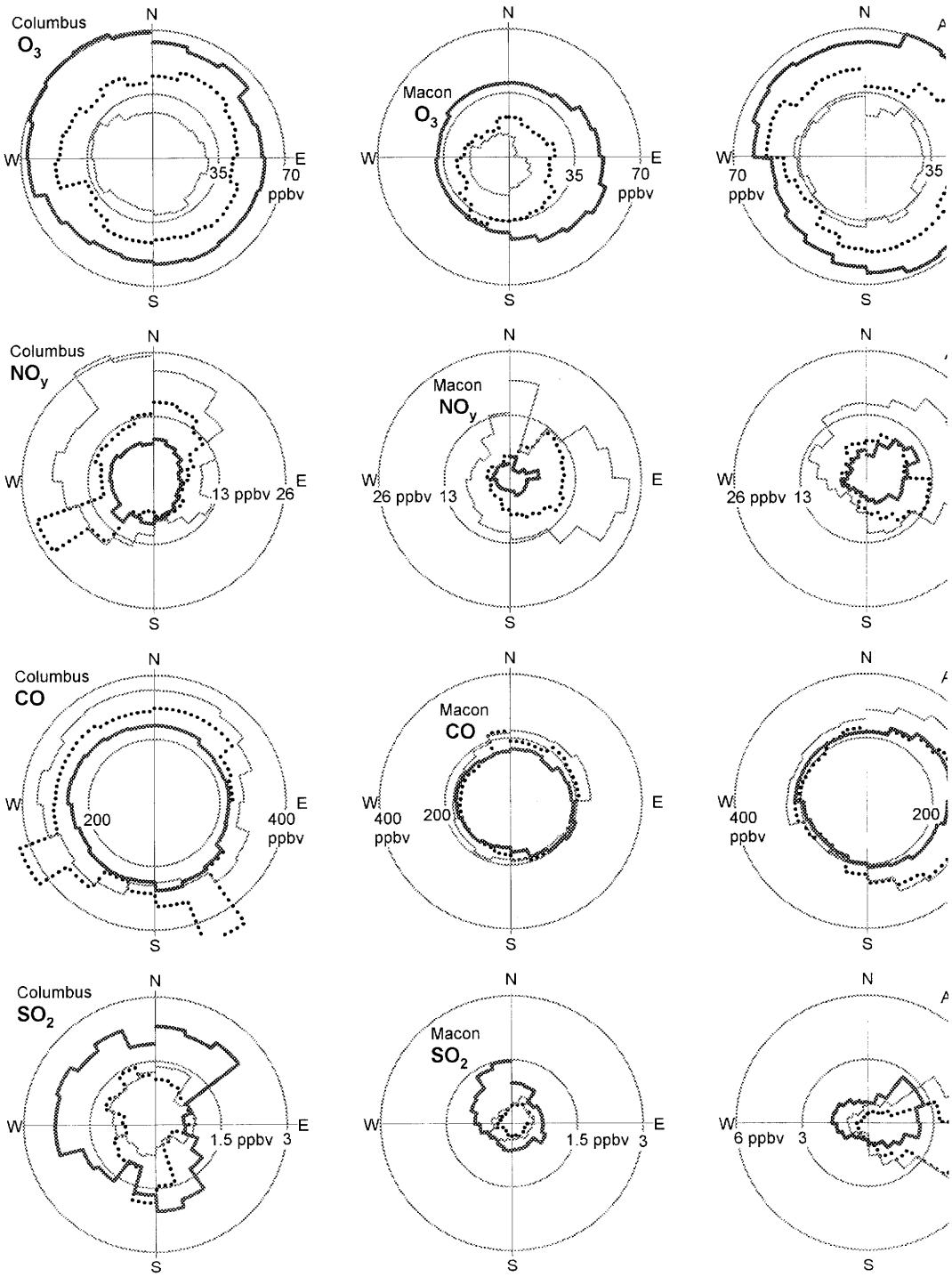
(a) Spatial Relationships

Based on the same daytime categories, correlations between the main trace gas species and wind direction resulted in the wind roses depicted in Figure 8. The polar graphs are again divided into 20 sectors of 18° each, whereas the scales are now in units of mixing ratio (ppbv). For visual comparison the scales on all wind roses are the same, except for SO_2 with Augusta's scale being twice that of the other two. Exceptional occurrences of easterly flow that brought in SO_2-rich air masses required this larger scale. In this respect, it is important to interpret Figure 8, the trace gas wind roses with the wind direction frequency, before general conclusions can be drawn. The averages based on the more frequent wind directions are statistically more significant and characterize more closely the general conditions at the site, whereas the values associated with less frequent directions may have more episodic character.

Table 4 Statistical summary of trace gas species measured via the AQR lab at Macon SBP, Augusta FtG, and Columbus WW separated for different periods of the day.

Parameter			**Macon**			**Augusta**			**Columbus**	
		AM	**midday**	**PM**	**AM**	**midday**	**PM**	**AM**	**midday**	**PM**
	EDT	5:00-10:00	10:00-18:00	18:00-5:00	5:00-10:00	10:00-18:00	18:00-5:00	5:00-10:00	10:00-18:00	18:00-5:00
O_3	coverage	85%	93%	84%	96%	94%	94%	91%	91%	89%
ppbv	**Avg**	**17**	**43**	**26**	**33**	**60**	**46**	**27**	**66**	**45**
	StD	9	11	14	11	14	13	11	13	15
	Min	1	18	0	11	14	17	1	19	2
	Max	43	86	58	63	103	92	60	107	114
CO	coverage	63%	68%	62%	72%	71%	70%	72%	68%	69%
ppbv	**Avg**	**190**	**168**	**183**	**239**	**208**	**230**	**331**	**248**	**291**
	StD	45	76	61	71	48	84	110	41	116
	Min	116	67	91	110	86	97	175	152	110
	Max	833	1984	1348	661	490	1622	1020	472	1838
SO_2	coverage	83%	82%	80%	81%	82%	83%	86%	83%	85%
ppbv	**Avg**	**0.4**	**0.7**	**0.3**	**1.6**	**1.3**	**1.2**	**1.1**	**2.0**	**1.1**
	StD	0.3	0.8	0.3	2.8	1.5	2.4	0.9	2.2	1.3
	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max	1.9	7.7	16.7	20.9	36.3	23.2	6.3	21.9	14.3
NO	coverage	33%	29%	32%	35%	33%	32%	36%	33%	34%
ppbv	**Avg**	**0.97**	**0.38**	**0.19**	**0.78**	**0.44**	**0.20**	**3.71**	**1.11**	**0.33**
	StD	1.19	2.31	0.75	1.01	0.92	1.91	7.14	0.96	1.02
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Max	8.42	85.20	16.74	6.87	36.34	57.23	58.25	14.75	26.27
NOy	coverage	34%	37%	32%	35%	33%	32%	35%	32%	34%
ppbv	**Avg**	**10.5**	**2.9**	**7.7**	**10.2**	**4.9**	**6.3**	**19.0**	**7.8**	**11.8**
	StD	6.9	4.4	6.2	9.4	4.5	6.8	15.3	3.6	9.8
	Min	1.4	0.0	0.7	0.8	0.0	0.5	2.6	1.1	1.2
	Max	42.9	143.9	45.4	88.5	59.9	132.2	102.3	30.4	111.8

Figure 8 Trace gas wind roses for same locations and time categories as zzz.



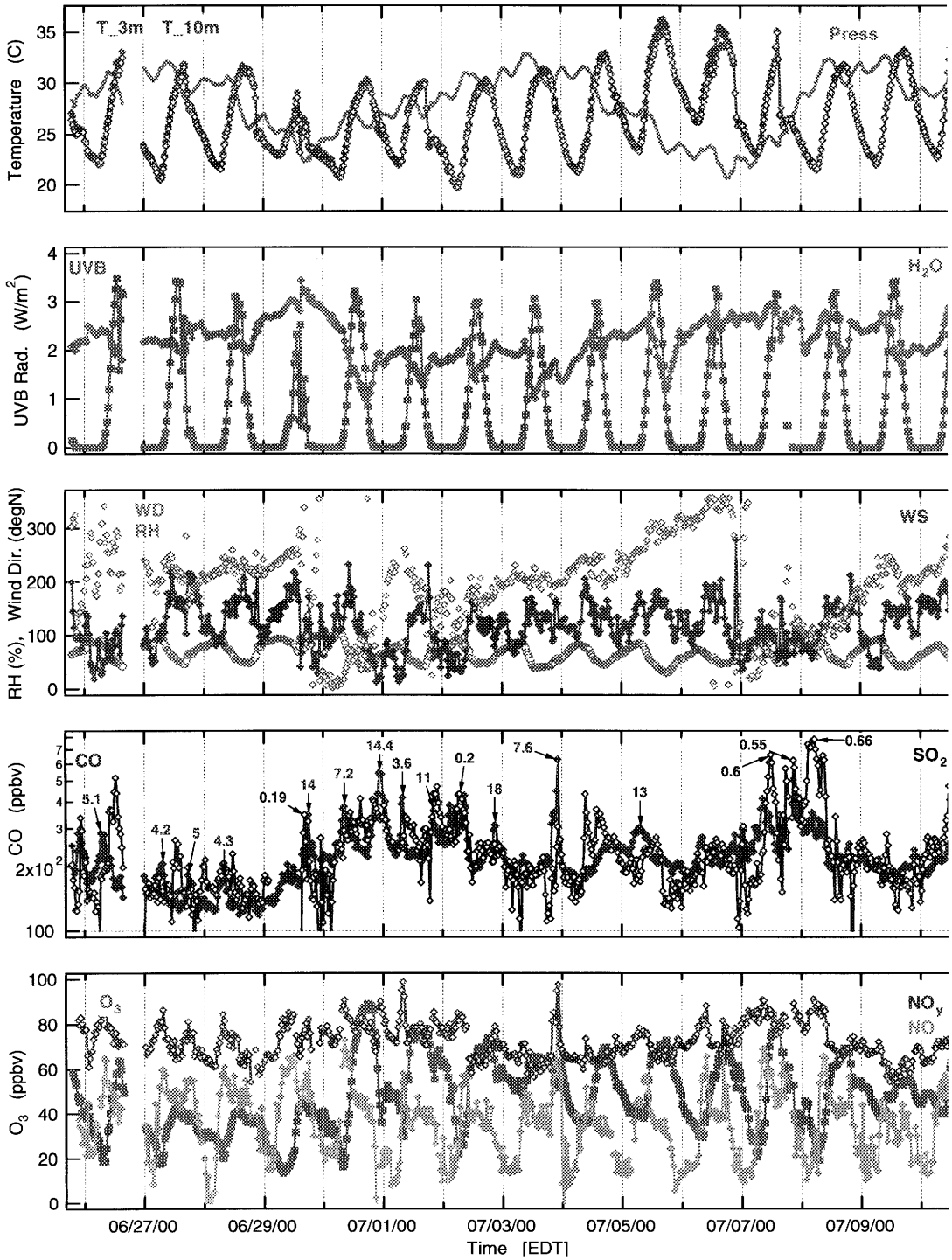
As expected, the average ozone levels are highest for the midday periods at all three sites indicative of a more regional character. Again considering the wind frequency distributions for all sites, the highest levels were observed at Columbus WW and the lowest at Macon SBP. Also, the ozone levels averaged for the three different time categories are clearly distinct from each other with the morning averages being the lowest. This is mainly due to the way "nighttime" was defined including the evening hours starting at 1800. As will be shown later, titration of ozone became more dominant late at night and early mornings. The titration effect, however, can be seen here from the anti-correlation between the average morning hours' [NO_y] and [O_3] at all three sites. For example, the most frequent northerly winds at Columbus WW carried the highest NO_y and the lowest ozone mixing ratios during the morning hours, a typical feature. This is also true for the most frequent southerly flows received at Macon SBP and Augusta FtG. The diurnal pattern of the NO_y wind roses therefore, shows NO_y features that are opposite to ozone.

The CO wind roses tend to correlate with NO_y and therefore anti-correlate with ozone for most times but this characteristic is not as clearly evident. The reason has to be seen mainly in the CO lifetime, which is ~2 months and by far the longest of all the species represented here. With that, it is less reactive and does not participate in ozone titration. The longer lifetime also causes a higher background level, i.e. the lowest level reported here is 110 ppbv, which might well represent the more regional CO background for southern GA. In contrast, minimum [NO_y] ranged much closer to zero at all three sites, which of course is affecting the visual appearance of the wind rose graphs where variations in [NO_y] are enhanced relative to [CO]. The lifetime of NO_y is governed by dry deposition with the loss of HNO_3 being the most efficient.

Time series and special occurrences

Figure 9, depicts the time series of the 30 min averaged data collected at Augusta FtG. The parameters shown in the five panels from top to bottom are: 1) the air temperatures from the 3 and 10 m above ground level and the barometric pressure; 2) the UV-B radiation of the photo-chemically important 280-320 nm wavelength range and the water vapor mixing ratio; 3) the wind direction, RH, and wind speed; 4) the CO and SO_2 mixing ratios on log scales; and 5) ozone mixing ratio on a linear scale, and NO and NO_y mixing ratios on log scales. The vertical lines mark midnight of each day. The numbers in the CO-SO_2 plots mark linear regression slopes of CO versus NO_y (brown) and SO_2 versus NO_y (blue) of certain plume encounters where $r^2 > 0.5$. By comparing the slopes with emission ratios of nearby sources, information can be gained regarding the air mass transport. Assuming constant emission rates, the relationship between the slopes and the absolute magnitudes of species' mixing ratios for re-occurring plumes of same origin provides insight on the mixing depth and stratification of the boundary layer.

Figure 9 Time series of main met parameters and trace gas species for Augusta FtG, 30 minute averages.



City Specific Observations

Augusta Fort Gordon, 25 June – 10 July 2000

Figure 9 shows that light winds prevailed on the first day of monitoring in Augusta, but that this was followed by a 3-day period of strong south-southwesterly flow and maximum ozone levels of 40 to 45 pbbv. Oscillating winds then caused concentrations of CO and NO_y to build from Friday 30 June through Sunday 2 July. The highest 8-hour ozone average of the Augusta period was 84 ppbv observed between 1230 and 2030 on 30 June. On top of the elevated CO "background" level of ~200 ppbv, the data show excursions of both [CO] and [NO_y] indicating emission ratios between 7.2 at midday and 14.4 at night on this day. The 3.6 CO:NO_y ratio on the next day (1 July) was registered under easterly flow, suggesting the same sources that caused the ratios between 4 and 5 during the first three days of the Augusta monitoring period.

An event of increased traffic amounts in the immediate vicinity of the AQR lab occurred on the eve of July 4th. This was similar to the Father's Day event in Macon. On 3 July, fireworks were displayed on the Parade Ground next to the AQR lab between 2100 and 2200 LT, and spectators parked cars in the vicinity. The regression of the CO versus NO_y correlation plot resulted in a slope of 7.6, while NO was ~14 ppbv and 30 % of NO_y. Since the emission source was so close, [NO] was expected to make up for most of [NO_y] but consistent winds with hourly averages of ~2 m/s caused rapid dilution and mixing, which also prevented ozone from being titrated out completely.

After the passage of a low-pressure front, the winds slowly veered from north over east to south on 7 and 8 July. This episode was accompanied by the absolute highest SO_2 mixing ratios of the entire measurement period being correlated with easterly wind directions as depicted in Figure 8. Interestingly, the largest SO_2 source in the region, with a 1996 SO_2:NO_x emission ratio of 1.12, is the Urquarth power plant east of Augusta and just across the state-line in SC. Thus, while this event was not related to a high ozone episode, there may be a chemical signal (e.g. SO_2:NO_x ratios of 0.5 to 0.7) indicating when emissions from the Urquarth power plant may be directly influencing local air quality. This needs to be examined in more detail once the FAQS regional emission inventory is completed.

Macon (Father's Day) and Augusta (3 July fireworks display) that allowed the measurement of nearby automotive exhausts. In both cases the emission ratio was determined to be between 7.2 and 7.6.

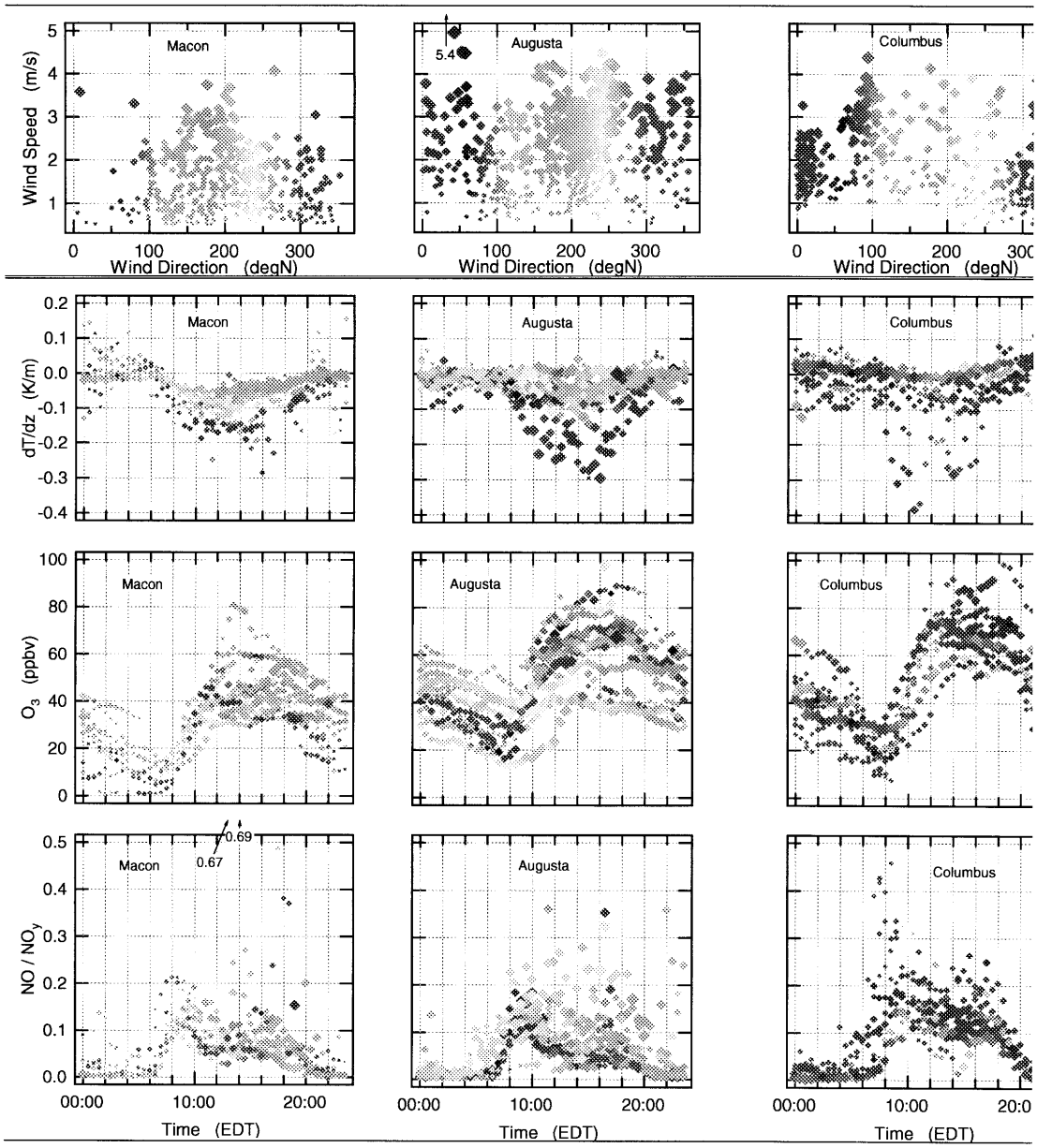
Interurban comparisons

The top panel of Figure 10 shows the correlation of wind speed versus wind direction providing the key for the three remaining panels, in that the size of the symbol increases with wind speed, and the color changes with direction: light blue and green signify southerly (from the south) winds, and red and purple denote northerly (from the north) winds. This key is then maintained for all the other graphs in Figure 10 that correlate the various parameters with the time of day, therefore revealing features that are re-occurring daily. One is the temperature "lapse" rate between 3 and 10 meters above ground (mag) indicating the diurnal variation of atmospheric stability within the surface layer, i.e. stably stratified conditions at night and convectively labile or neutral conditions during midday. Augusta was least stable at night probably due to the relatively strong winds that helped induce enough shear and mixing at night to prevent stable stratification.

Figure 10 also shows how the ozone levels increased as the summer season progressed from the earlier Macon period through Augusta to the Columbus period last. Due to the lack of NO_2 measurements, the photochemical age of the probed air masses has to be assessed by means of the $NO:NO_y$ ratio. The morning rush hour emissions affected the $NO:NO_y$ ratio at all threes sites, in that the almost negligible fraction of NO at night increased to 10 – 20 % between 0500 and 1000 LT. Low to medium strength northerly winds at Columbus caused more scatter and occasional NO fractions up to 45 % during these early morning periods. During the afternoons, the $NO:NO_y$ ratios were smallest at Macon, ranging between 5 and 12 % for most values (and close to 70 % during the Father's Day exception), while Augusta showed more scatter but with the bulk between 3 and 15 %. The afternoon ratios were highest at Columbus with a bulk 10 to 20 % range. It can also be seen that fresh NO was continuously fed into the sampled air masses, especially the ones coming from the nearby J.R. Allen Parkway to the north and west of the monitoring site.

At all three sites, the lowest O_3 concentrations occurred during relatively calm nightime hours due to the absence of photochemical production and titration effects from primary emissions. In contrast, clear sky daytime conditions were associated with the highest ozone levels. The ozone diurnal profile shows 'tight' transients during the morning hours, which can be explained by the recurring effect of downmixing from the nocturnal reservoir layers. As the rising sun induces surface heating, the stratified nocturnal boundary layer breaks up and mixing from aloft sets in. Several intensive measurement campaigns in the southeastern U.S. carried out as part of the Southern Oxidants Study (SOS) have revealed the fact that entrainment of O_3 from aloft can provide a large proportion of surface ozone. It was shown that O_3 produced throughout the CBL on the previous day (or days) contributes to the levels measured at the surface [Baumann et al., 2000], but since nocturnal boundary layers generally strongly decouple the surface from the free troposphere, movement of these layers at night around large regions must be taken into account. Therefore, high $[O_3]$ measured near the ground may not only be due to emissions being imported during the day that drive photochemical production but those high surface O_3 levels may also be due to O_3 being imported into the region during the night.

Figure 10 Diurnal variations of temperature lapse rate (dT/dz), ozone (O_3), and $NO:NO_y$ color coded according to wind direction, and size coded according to wind speed as presented for Macon, Augusta, and Columbus.



3. Emissions Inventory Development

This section identifies the 2000 base year, 2007 future year and the 2012 future year emission inventories for the EAC and details how the inventories were developed.

The 2000 base year EAC emissions inventory was developed from two inventories: (1) the 1999 EPA National Emissions Inventory (NEI) v2.3, and (2) the 2000 FAQS Emissions Inventory. Pollutants included in the inventory are CO, NOx, NH_3, SO_2, $PM_{2.5}$, PM_{10}, and VOCs. The inventories contain emissions from the following sectors and are described below: electric generating units (EGUs), non-EGU point sources, area, mobile, nonroad and biogenics.

The EGU inventory encompasses emissions from electric generating facilities located in the modeling domain. The SO_2 and NOx emissions are based on 2000 continuous emissions monitoring (CEM) data for utilities as reported to EPA's Clean Air Markets Division. EGU emissions for other pollutants were calculated by multiplying emission factors with the heat input data obtained from the Clean Air Markets Division.

The non-EGU inventory is a composite of the NEI and the FAQS inventories. The FAQS inventory was derived from surveying facilities that have annual emissions equal to or greater than 25 tons per year in 11 counties in and around Augusta, Columbus, and Macon. The FAQS inventory was for year 2000. Non-EGU facilities in the remaining area of the modeling domain came from the 1999 NEI and have annual emissions greater than equal to 100 tons per year. This 1999 NEI inventory was grown to 2000 using EPA's Economic Growth Analysis System[9] software, Version 4.0 (EGAS4.0).

The area source inventory consists of sources below the point source thresholds described above. The area source inventory is a composite of the 1999 NEI and the FAQS inventories. The FAQS inventory consists of 11 counties in and around Augusta, Columbus, and Macon. Area source emissions from the remaining portion of the modeling domain came from the 1999 NEI grown to 2000 using EGAS4.0.

EPA's MOBILE6 model was used to calculate on-road mobile source emission factors. Estimates of vehicle miles traveled (VMT) from GDOT and speeds from the Atlanta Regional Commission (ARC) were used. In addition to VMT and speeds, EPD provided inputs and supporting files containing other information needed to develop the mobile source emissions inventories.

With the exception of those from aircraft and locomotives, nonroad emissions for the modeling domain were calculated using EPA's NONROAD model. The 1999 NEI was used for aircraft and locomotive emission estimates. These 1999 nonroad estimates were grown to 2000 using EGAS4.0.

The Biogenic Emissions Inventory System (BEIS) was used to calculate biogenic emissions.

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9 http://www.epa.gov/ttnchie1/emch/projection/egas/index.html

Table 3-1 details the data sources of the 2000 base year EAC emissions inventory and the methods used to integrate each source into the inventory.

Table 3-1: Data sources of the Year 2000 Base Year EAC Emissions Inventory

Source category		Georgia		Other states
		FAQS Area[a]	Rest of the State	
Point	EGU	Continuous Emissions Monitoring (CEM) Datab for August 2000 and NET99c Emissions Inventory version 2.3		
	Non-EGU	FAQS Emissions Inventory[d]		NET99 EI version 2.3 projected to 2000 with EGAS4.0 growth factors
Area (NH_3)	All	Cardelino, 2003[e]		NET99 EI version 2.3 projected to 2000 with EGAS4.0 growth factors
Area	Forest wildfires, slash burning and prescribed burning, agricultural burning	FAQS Emissions Inventory		NET99 EI version 2.3 projected to 2000 with EGAS4.0 growth factors
	Others	NET99 EI version 3 projected to 2000 with EGAS4.0 growth factors		
Non-road	Aircraft, Railroad and Locomotives	FAQS Emissions Inventory	NET99 EI version 2.3 projected to 2000 with EGAS4.0 growth factors	
	Others	NET99 EI version 2.3 projected to 2000 with growth factors from EPA's NONROAD model[f]		
On-road (VMT and speeds)		GDOT[g] and ARC[h] respectively.		NET99 mobile source activity data[i] projected to 2000 using EGAS4.0

a. Includes the counties of Richmond, Columbia, McDuffie, Muscogee, Chattahoochee, Harris, Bibb, Houston, Jones, Peach and Twiggs.
b. Emissions from EGUs in the NET99 Emissions Inventory are replaced with CEM data available at http://cfpub.epa.gov/gdm using the air quality emissions processor.
c. Emissions Inventory is available at http://www.epa.gov/ttn/chief/net/index.html#1999.
d. FAQS Emissions Inventory Development report available at http://cure.eas.gatech.edu/faqs/models/index.html.
e. Developed by Dr. Carlos Cardelino (carlos.cardelino@eas.gatech.edu), School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia.
f. EPA's Non-road mobile model (June 2000) http://www.epa.gov/ttn/chief/emch/models/index.html.
g. Annual average daily VMT data for 2000 available at http://www.dot.state.ga.us/dot/plan-prog/transportation_data/400reports/index.shtml, with additional details provided in Appendix 3.
h. Speed data for the 13-county Atlanta nonattainment area is from Atlanta Regional Commission's travel demand model. Additional details are provided in Appendix 3.

Table: 3.2: Existing federal control strategies and projection methods used to generate the 2007 and 2012 EAC future base case emissions inventory from the 2000 base year inventory

Source category		Growth		Controls	
		Georgia	Other States	Georgia	Other State
Point	EGU	EGAS4.0		Plant specific control factors documented in Appendix 3	NOx SIP call and plant specific control factors documented in Appendix 3
	Non-EGU	EGAS4.0		VOC RACT controls, MACT controls, NOx SIP call control factors used in development of EPA's Emissions Inventory for HDDV Final Rulemaking provided in Appendix 3	
Area	All	EGAS4.0		STAGE-II controls, fuel efficiency, VOC controls, etc., used in EPA's HDDV Rule modeling documented in Appendix 3	
Non-road	All	EPA's NONROAD model (June, 2000)			
On-road VMT		VMT grown using the linear regression described in Appendix 3	EGAS4.0	Enhanced vehicle I/M, Stage II vapor recovery, Phase 1 Ga. Gasoline. Additional details are provided in Appendix 3	NET99 MOBILE input files

The following tables and figures detail the 2000 base year and the 2007 and 2012 future year statewide EAC emissions inventories. Only NOx and VOC emissions are detailed. NOx and VOC bar charts accompany each table. 2007 and 2012 statewide NOx emissions are 26% and 37% lower than 2000 statewide NOx emissions, respectively. Also, 2007 and 2012 statewide VOC emissions are 19% and 23% lower than 2000 statewide VOC emissions, respectively. These reductions are due to

national and state controls already required to be implemented between 2000 and 2012.

Table 3-3: 2000, 2007, and 2012 Emissions for the State of Georgia (tpd)

	2000		2007		2012	
	NOx	VOC	NOx	VOC	NOx	VOC
Point	760	104	497	78	456	74
Area	105	672	105	612	106	653
Mobile	923	570	679	389	463	288
Nonroad	304	197	287	177	288	179
Total	**2,092**	**1,542**	**1,568**	**1,256**	**1,314**	**1,195**

Figure 3-1: 2000, 2007, and 2012 NOx Emissions for the State of Georgia

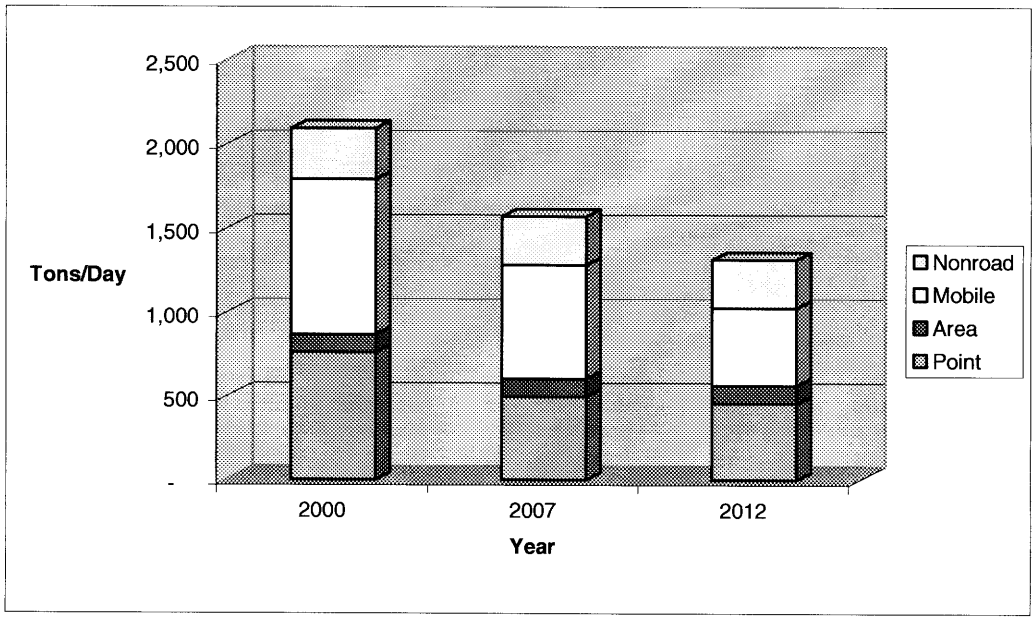
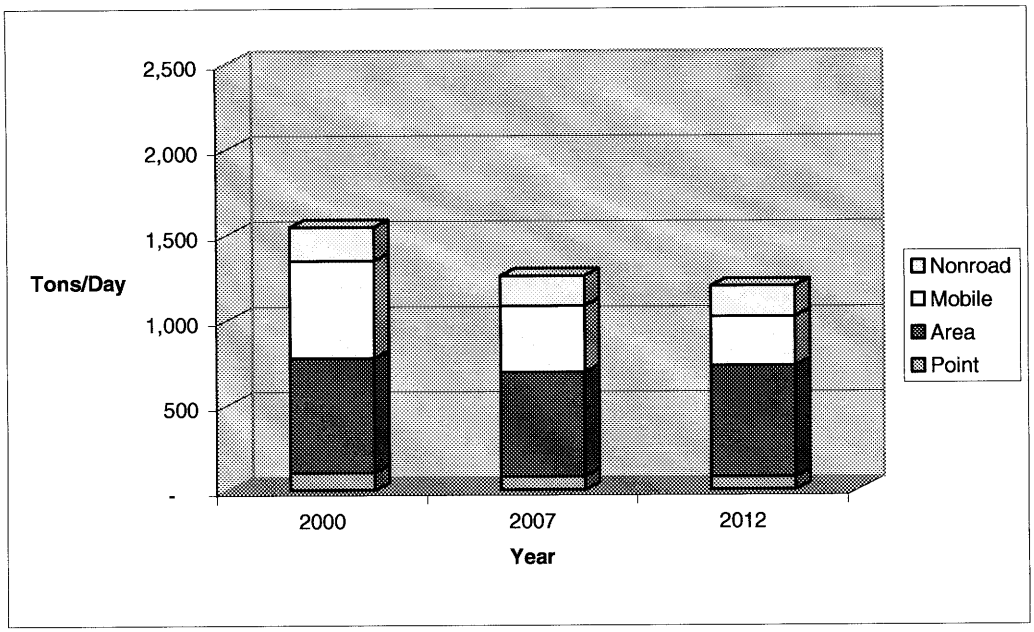


Figure 3-2: 2000, 2007, and 2012 VOC Emissions for the State of Georgia



The following table and figures detail the 2000 base year and the 2007 and 2012 future year Augusta-Richmond County MSA EAC emissions inventories. Only NOx and VOC emissions are detailed. NOx and VOC bar charts accompany each table. 2007 and 2012 Augusta-Richmond County MSA NOx emissions are 22% and 32% lower than 2000 NOx emissions, respectively. Also, 2007 and 2012 Augusta-Richmond County MSA VOC emissions are 20% and 24% lower than 2000 VOC emissions, respectively. These reductions are due to national and state controls already required to be implemented between 2000 and 2012.

Table 3-4: 2000, 2007, and 2012 Emissions for the Augusta-Richmond County MSA (tpd)

	2000		2007		2012	
	NOx	VOC	NOx	VOC	NOX	VOC
Point	19	5	15	3	15	3
Area	3	32	3	28	3	30
Mobile	30	21	22	14	15	11
Nonroad	8	5	7	4	7	4
Total	**59**	**63**	**46**	**50**	**40**	**48**

Figure 3-3: 2000, 2007, and 2012 NOx Emissions for the Augusta-Richmond County MSA

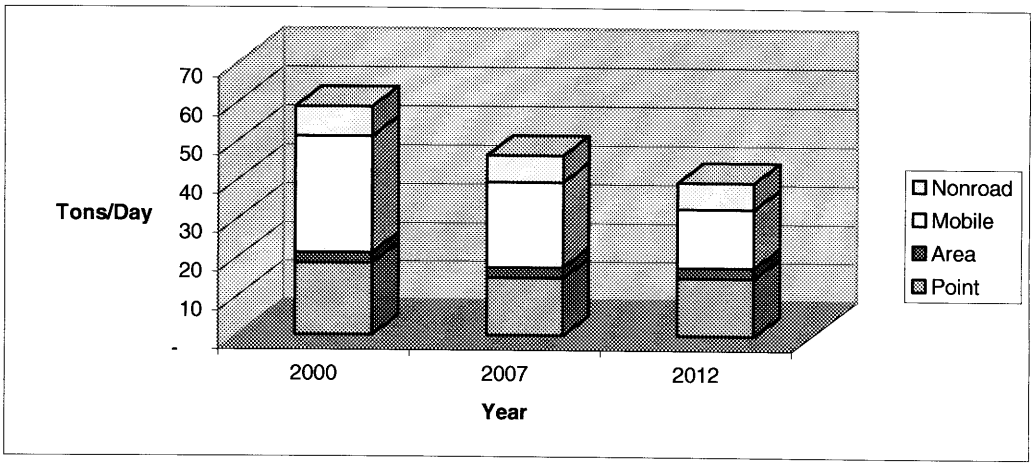
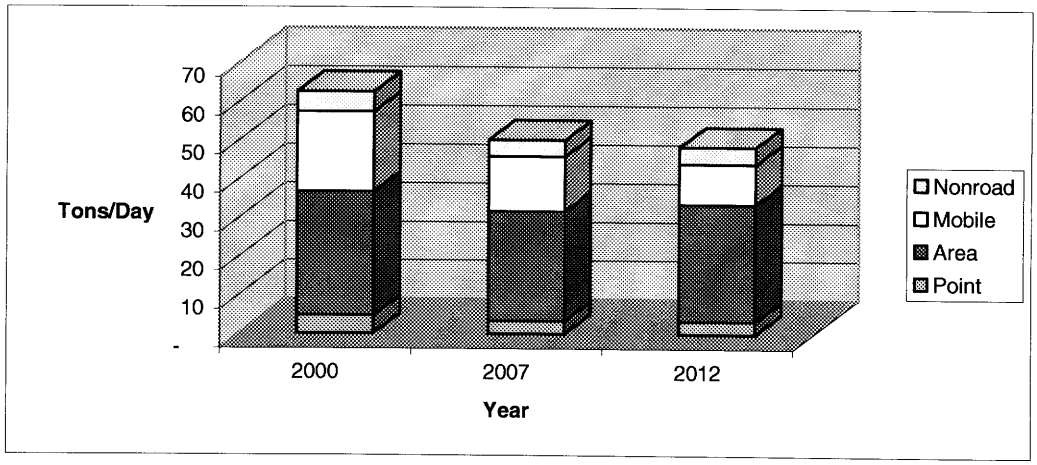


Figure 3-4: 2000, 2007, and 2012 VOC Emissions for the Augusta-Richmond County MSA



4. Atmospheric Modeling for Emissions Control Strategy Development and Attainment Demonstration

4.1 Background

This section provides details of atmospheric modeling conducted in support of the Augusta-Aiken Early Action Compact. The modeling effort utilizes the atmospheric modeling products (i.e., emission and air quality databases, modeling simulation results, software tools, etc.) developed during the Fall-line Air Quality Study (FAQS) (FAQS, 1999). Launched in 2000, FAQS is designed to investigate the level of air pollution in the cities of Augusta, Macon and Columbus and suggest control strategies for attainment of the NAAQS. With the expected completion date of June 2004, FAQS is one of the most comprehensive air quality studies conducted in Georgia and includes enhanced monitoring, emissions inventory development, and atmospheric modeling. Results of the modeling study are currently being documented and are expected to become available in June 2004.

4.2 Atmospheric Modeling System

Atmospheric modeling systems provide a scientific means of developing relationships between emissions, meteorology and air quality over a geographical region. Using spatially and temporally resolved meteorological, emission and air quality data; atmospheric models numerically solve mathematical equations that describe the physical and chemical processes that occur in the atmosphere. The complexity of these atmospheric processes, scarcity or total absence of quality input data at adequate spatial and temporal resolution, and computational limitations necessitate the use of simplifying assumptions that contribute to uncertainty in modeling results. In spite of these uncertainties, atmospheric models continue to play a central role in the development and analysis of emissions control strategies that are designed to improve local and regional air quality. The EPA recommends the use of photochemical models to demonstrate attainment and maintenance of the NAAQS. Guidance on the use of photochemical models to help demonstrate attainment and maintenance of the standard has been provided in EPA's guidance document (EPA, 1999). Atmospheric modeling in support of Augusta-Aiken Early Action Compact and described in this section was conducted pursuant to the recommendations provided in the guidance document.

The selection of an atmospheric modeling system that can be used for developing and evaluating emission control strategies is of critical importance for States and Local agencies that have multiple regions that exceed the NAAQS for one or more criteria pollutants. Although the guidance document does not specify a particular modeling system for use in a regulatory framework, it does provide a complete list of attributes that in large part ensure the adequacy of the modeling system for emissions control strategy development and evaluation. These include:

- The model has received a scientific peer review.
- Databases needed to perform the analysis are available and adequate.
- Available past appropriate performance has shown that the model is not biased towards underestimates.

• The model is available to users for free or at a reasonable cost, and is not proprietary.

The atmospheric modeling system selected by the GAEPD fulfills all of the above requirements. It is comprised of the Mesoscale Meteorological Model (MM5) developed by National Center of Atmospheric Research (NCAR); Community Multiscale Air Quality (CMAQ or Models3) developed by EPA; and Sparse Matrix Operator Kernel Emissions (SMOKE) processor developed by MCNC. This system has been used in a large number of research projects as well as regulatory applications in the last five years with satisfactory results. Details of these applications have been provided in Table 1, Appendix 4.

4.3 Atmospheric Modeling and Emissions Control Strategy Development Process

The task of simulating atmospheric processes over a region and assessing future changes in emissions and air quality is a complex one, requiring knowledge in various disciplines of mathematics and science. Selection of a geographical region and the historical meteorological episode to be simulated is the first step in the atmospheric modeling process. Both of these, selection of a geographical domain and the historical meteorological episode, are determined keeping in mind the objectives and the scope of the modeling study. The selected geographical region is divided into a three-dimensional grid. The available computational resources largely determine the resolution and size of the grid. Generally, atmospheric modeling grids extend thousands of square kilometers with a resolution that ranges from 4 to 100 kilometer in the horizontal, and 20 meters to several kilometer in the vertical direction. As for the length of modeling episode, a two to three week period is considered appropriate for most modeling studies in an effort to minimize the effect of initial conditions and capture full synoptic cycles associated with long-range transport of pollutants within the modeling domain.

Once the three-dimensional modeling grid is defined, emissions, meteorology and air quality databases are developed for the region of interest. These databases include information such as activity levels, emission rates, physical parameters of various sources, terrestrial, surface and upper level meteorological data, and gas and aqueous phase concentrations that are recorded at the monitoring stations located throughout the modeling domain. A prognostic meteorological model is generally used to simulate the dynamic physical processes over the domain. These models utilize meteorological databases to solve the coupled mass, energy and momentum equations and generate temporally and spatially resolved meteorological fields. The predicted meteorological fields are used, in part, to generate emissions fields using an emissions processor. An emissions processor performs spatial and temporal allocation; and chemical speciation of area, mobile, biogenic and point source emissions inventories. The output of emission processors is gridded, speciated and temporalized emission files for use in air quality modeling. Finally, the air quality database is used to generate initial conditions, boundary conditions and photolysis rates for the modeling grid. Utilizing all the processed data, the air quality model simulates the evolution of pollutant concentration in the modeling domain for the entire study period. The modeling results are compared with observations to assess the overall accuracy of the modeling effort.

Once the ability of the atmospheric modeling system to accurately simulate an historical air pollution event is established, changes in future emissions within the modeling domain are estimated. Modeling simulations are conducted with new emission fields and predicted air quality concentrations fields are used to assess the status of future air quality in the region with reference to a desired goal (e.g., NAAQS). If future air quality is determined to exceed permissible limits, an emission control strategy is developed for various sources within the modeling domain. This is followed by another round of modeling simulations to assess air quality improvement. The process continues until the desired level of future air quality is attained. The atmospheric modeling and emission control strategy development process is depicted in Figures 1 and 2 in Appendix 4.

The following sections describe atmospheric modeling and emission control strategy development tasks undertaken in support of Augusta-Aiken Early Action Compact. These include:

- Episode Selection
- Modeling domain and grid configuration
- Meteorological modeling
- Emissions modeling
- Air quality modeling
- Attainment demonstration

4.4 Episode Selection

In order to evaluate the suitability of selected episodes for photochemical modeling related to the 8-hour ozone standard, air quality and meteorological data was examined. Important considerations included: (1) a range of meteorological conditions that accompany air quality events, (2) pollutant concentration levels that characterize the air quality problem (e.g., nonattainment), and (3) the frequency of occurrence of the relevant meteorological/air quality events (to avoid using results from infrequent or extreme events to guide the assessment process).

The episode selection methodology is based on that developed by Deuel and Douglas (1998). It includes the classification of days within a multi-year period (e.g., 1995–2001) according to meteorological and air quality parameters using the Classification and Regression Tree (CART) analysis technique. The frequency of occurrence of ozone exceedances for each classification type is then determined for each area of interest. Days with maximum ozone concentrations within approximately 10 ppb of the respective design values can be identified. Also, an optimization procedure can be applied to select multi-day episodes for maximum achievement of specified episode selection criteria for various combinations of geographical areas and ozone metrics (e.g., 1-hour and 8-hour ozone). The episode selection methodology provides an objective approach to selecting modeling episodes that optimally represent typical meteorological conditions and relevant ozone concentration levels (per the ozone standard(s)). This methodology can also be used in reverse to evaluate the representativeness of predetermined episodes.

CART analysis (Douglas et al., 2002) was conducted to determine how representative the August 11-20, 2000 and August 1-20, 1999 air pollution episodes were of the meteorological conditions that caused exceedances in the Augusta-Aiken MSA during the 1995–2001 ozone seasons (May–October). The individual modeling days for these episodes are listed in Table 1. The observed maximum 8-hour ozone concentration, the number of monitoring sites within 10 ppb of Augusta's 2001 design value (87 ppb), and the CART classification bins are provided in this table. Episode days with maximum 8-hour ozone concentrations greater than or equal to 85 ppb are marked in bold. Also marked in bold are key exceedance regimes and episode days that contain at least one monitor with a maximum 8-hour ozone concentration within 10 ppb of the design value. Shading denotes primary episode days that exceed the 8-hour NAAQS, contain at least one monitor with a maximum 8-hour ozone concentrations within 10 ppb of the design value, and represent a key exceedance bin.

The key meteorological/air quality regimes for 8-hour ozone exceedances in Augusta corresponded to CART Bins 15 (25 days) and 21 (16 days). The total number of 8-hour exceedance days recorded during the 1995-2001 period was 80. Table 2 contains a summary of the exceedance bin classification splits for the 8-hour ozone analysis of Augusta (frequent bins).

Table 4-1. Modeling episodes for 8-hour ozone for Augusta. Exceedances of the 8-hour NAAQS, episode days with maximum 8-hour ozone concentrations within 10 ppb of the design value (87 ppb), and key exceedance regimes are marked in bold.

Shading denotes primary episode days that meet all three criteria listed above.

Year	Month	Day	Augusta 8-hr O3 max	Number of Sites w/in 10 ppb of the 8-hr site-specific DV	CART bin for Augusta
2000	8	10	68	0	25
2000	8	11	76	0	2
2000	8	12	71	0	13
2000	8	13	62	0	12
2000	8	14	72	0	2
2000	8	15	**89**	**2**	**15**
2000	8	16	81	**2**	25
2000	8	17	**111**	**2**	24
2000	8	18	80	**2**	25
2000	8	19	74	0	25
2000	8	20	58	0	17
1999	8	1	76	0	**21**
1999	8	2	73	0	**15**
1999	8	3	84	**3**	11
1999	8	4	82	**3**	**15**
1999	8	5	**93**	**3**	**15**
1999	8	6	**92**	**2**	**15**
1999	8	7	77	**1**	20
1999	8	8	**87**	**3**	**15**
1999	8	9	78	**1**	20
1999	8	10	77	**1**	**15**
1999	8	11	78	**1**	**21**
1999	8	12	**87**	**3**	**21**
1999	8	13	**101**	**1**	**21**
1999	8	14	76	0	**21**
1999	8	15	83	**2**	16
1999	8	16	69	0	25
1999	8	17	74	0	2
1999	8	18	**102**	**1**	**21**
1999	8	19	**87**	**1**	20
1999	8	20	61	0	16

Table 4-2 Summary of exceedance bin classification splits for 8-hour ozone analysis of Augusta.

Bin	15	21
# of exceedance days	25	16
Key classification parameters	yaugmax8 > 69.1 t85pma ≤ 20.3 yatlmax8 > 93.6 rh70pma ≤ 74.1 rh12au ≤ 50.5	yaugmax8 > 69.1 t85pma > 20.3 avg85a ≤ 1555 yatlmax8 ≤ 137.4 t85pmc > 20.7

yaugmax8	Yesterday's maximum 8-hour average ozone concentration (Augusta).
yatlmax8	Yesterday's maximum 8-hour average ozone concentration (Atlanta).
t85pma	Upper-air 850 mb temperature corresponding to the afternoon sounding on the current day (Atlanta).
t85pmc	Upper-air 850 mb temperature corresponding to the afternoon sounding on the current day (Charleston).
rh70pma	Upper-air 700 mb relative humidity corresponding to the afternoon sounding on the current day (Atlanta).
rh12au	Surface relative humidity at noon (Augusta).
avg85a	Average of the morning and afternoon sounding heights above sea level of the 850 mb surface (Atlanta).

Each episode period contains at least one episode day from the most critical bin (Bin 15), multiple exceedance days, and multiple days with a maximum 8-hour ozone concentration within approximately 10 ppb of the 1999-2001 design value for Augusta. With respect to the considerations listed above, the two multi-day episode periods (not considering the two start-up days assigned to each period) include:

- Nine 8-hour exceedance days with maximum ozone concentrations within 10 ppb of the 8-hour design value.
- Seven exceedance days meeting the 10 ppb criterion that represent both of the primary exceedance regimes (Bins 15 and 21).
- Exceedance days meeting the 10 ppb criterion that represent other exceedance regimes (Bins 20 and 24) and non-exceedance days meeting the 10 ppb criterion that represents other meteorological regimes (Bins 11, 16, and 25).
- A range of concentration values among the exceedance days meeting the 10 ppb criterion and the primary exceedance regime criterion from 87 to 102 ppb (with a mean of 93 ppb).
- Weekends and weekdays.

Based on the above CART analysis, the August 11-20, 2000, and August 1-20, 1999 episodes were deemed appropriate for characterizing 8-hour ozone in the Augusta-Aiken area.

4.5 Modeling Domain and Grid Configuration

Selection of a modeling domain (i.e., extent and resolution) is primarily driven by the nature of the problem and requires a balance between modeling accuracy and

computational efficiency. Limited computational resources require that the extent of the domain be large enough to fully capture the dynamics of pollutants species to and from the region of interest. In case the region is affected by long-range pollutant transport, a larger domain might be necessary. Size of the numerical grid is also of considerable importance. Finer resolution grids tend to capture the dynamics of plumes better than their coarse grid counterparts. Although large domains at fine grid resolutions are desirable, computational costs might be prohibitive.

A nested grid modeling approach has been employed with three grids at 36, 12 and 4-km grid resolution (Figure 1) overlaying the entire eastern United States and parts of Canada. The grid has a Lambert Conformal map projection with origin at 90W and true latitudes at 30 and 60N. The top of the modeling grid has been fixed at 70mb. Details of the MM5 and CMAQ modeling grids have been provided in Tables 4-3 and 4-4.

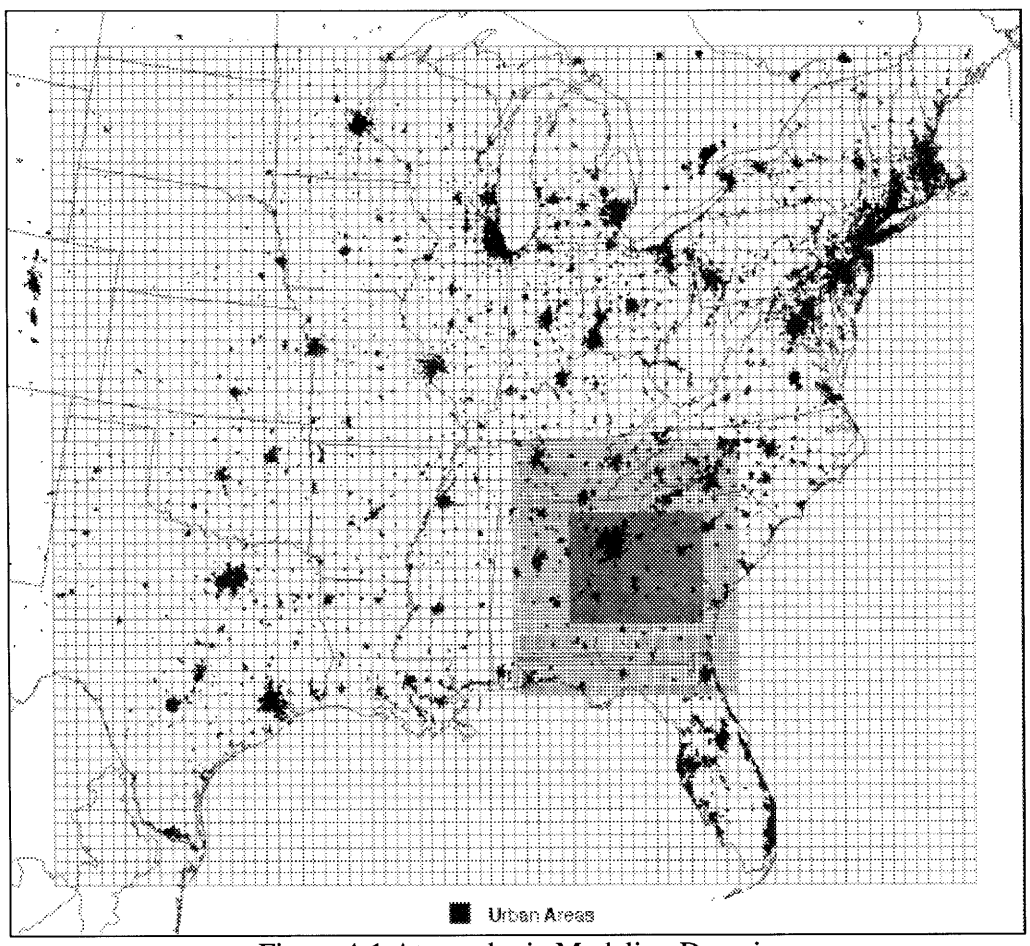


Figure 4-1 Atmospheric Modeling Domain

Table 4-3 MM5 and CMAQ Grid Configuration

Model	NLAYS	36-km resolution		12-km resolution		4-km resolution	
		NCOLS	NROWS	NCOLS	NROWS	NCOLS	NROWS
MM5	35	84	72	63	66	108	84
CMAQ	13	78	66	57	60	102	78

Table 4-4 MM5 and CMAQ Vertical Grid Structure

CMAQ Layer Number	MM5 Layer Number	Sigma level of Layer Top	Approximate height above Ground Level (meters)
Ground Surface	35	1.0	0.0
1	34	0.9975	18.0
2	33	0.9950	37.0
3	32	0.9900	74.0
4	31	0.9800	149.0
5	30	0.9700	225.0
	29	0.9600	301.0
6	28	0.9400	456.0
	27	0.9200	612.0
7	26	0.9000	772.0
	25	0.8750	975.0
8	24	0.8500	1182.0
	23	0.8200	1438.0
9	22	0.7900	1699.0
	21	0.7550	2014.0
	20	0.7200	2341.0
	19	0.6850	2677.0
	18	0.6500	3030.0
10	17	0.6150	3393.0
	16	0.5800	3772.0
	15	0.5450	4165.0
	14	0.5100	4582.0
	13	0.4750	5041.0
11	12	0.4400	5471.0
	11	0.4000	6023.0
	10	0.3600	6611.0
	9	0.3200	7243.0
12	8	0.2800	7930.0
	7	0.2400	8677.0
	6	0.2000	9498.0
	5	0.1600	10415.0
13	4	0.1200	11457.0
	3	0.0800	12656.0
	2	0.0400	14115.0
	1	0.0000	15952.0

4.6 Mesoscale Meteorological Modeling

4.6.1 Introduction

The fifth-Generation Penn State /NCAR Mesoscale Model (MM5) (Grell et al., 1994; Dudhia et al., 2002) was used to simulate local and synoptic scale meteorological conditions prevalent during the period of interest. MM5 is the latest in a series of models that were developed from a mesoscale model used at Penn State in the early 1970's (Anthes and Warner, 1978). Since that time, it has undergone many changes designed to broaden its usage. These include, (1) a multiple-nest capability; (2) non-hydrostatic dynamics that allow the model to be used at a few-kilometer scale; (3) multi-tasking capability on shared- and distributed-memory machines; (4) four-dimensional data-assimilation (FDDA) capability, and (5) multiple physics options (http://box.mmm.ucar.edu/mm5). It has been extensively used to develop meteorological fields for air quality models and its performance has been thoroughly evaluated and found adequate for air quality model applications. It requires a significant amount of data, most of which is available through the Data Support Section of Scientific Computing Division at NCAR. This includes:

- Topography and land use data;
- Gridded atmospheric data that has at least the following variables: sea-level pressure, wind, temperature, relative humidity and geopotential height at the following pressure levels: 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100 millibars;
- Observation data that contains soundings and surface reports.

It is important to point out that the predicted meteorological fields are used in emissions and air quality modeling and their accuracy is of considerable importance. A model performance evaluation procedure that is capable of appropriately quantifying the overall accuracy of the simulated meteorological fields is central to this effort.

4.6.2 Description of observed meteorological patterns during August 11-20, 2000

Before discussing the meteorological modeling results, it will be useful to describe the observed synoptic scale meteorological and air quality conditions prevalent during the period of interest. The following is a day-by-day account of observed regional meteorological conditions and air quality concentrations:

August 9, 2000: A strong upper level ridge whose center was positioned over southern Louisiana was the dominant synoptic feature. High pressure extended over the southeastern US and the flow aloft was predominantly zonal with the main jet over the US-Canadian border. The 12Z rawinsonde data for Peachtree City (FFC) indicated slightly unstable conditions with light winds aloft coupled with low-level instability and some moisture advection near 600 mb. These parameters were indicative of the potential for afternoon cumulus convection. Good warm air advection was apparent from the sounding upper level wind profile, and water vapor and satellite imagery indicated a good swath of Gulf moisture advection over the Southeast. Visible satellite imagery at 18Z showed a convective outflow boundary setting up and extending across northern Alabama through north Georgia into upstate South Carolina. With no major focus mechanism nearby, such as a front, and minimal upper

level support, cumulus convection was isolated in nature. With low level moisture and reduced photochemistry due to variable cloud cover, ozone levels across the state remained below the federal air quality standard.

August 10, 2000: The outflow boundary from 9 August was still an important feature to consider since synoptic conditions were similar to 9 August. However, an increase in downslope (NW) flow near 200 mb with additional mid-level drying above 600 mb was evident from the 12Z FFC rawinsonde data on 10 August. The ETA forecast model predicted lowering of geopotential heights with some minor cooling at 850 mb, which would only slightly enhance the convective potential across north Georgia. Upper level synoptic charts indicated that the upper level ridge was strengthening near the surface over the Southeastern US. An outflow boundary did develop just south of metro Atlanta; however, outflow from this convective activity could have enhanced subsidence north of that Atlanta metro area. An outflow boundary did develop just south of metro Atlanta; however, the resulting convective activity contributed to enhanced subsidence north of the area as indicated by elevated ozone concentrations in the region.

August 11–13, 2000: Synoptic conditions for the period involved a weak frontal passage on 12 August. Pre-frontal conditions existed on 11 August. The major synoptic features for 11 August were a weak trough digging from the north, a high amplitude ridge out west and a weak tropical disturbance off the Florida/Georgia coast. Mid-level moisture advection at 500 mb was evident from the 12Z FFC rawinsonde data along with minor cold air advection, which was indicative of the frontal passage. Post-frontal conditions existed on 12 August, with strong drying above 700 mb. With frontal conditions on the 11th and 12th, ozone levels remained within good air quality standards. Stable conditions existed with drying aloft, in response to the upper air anticyclone slowly drifting eastward and the front slipping southward of the Atlanta metro area. An upper level vorticity skirted across north Georgia following the passage of the front. On 13 August additional low and mid-level drying occurred in response to the surface ridge building across the Southeast. The strong upper level anticyclone responsible for this drying was centered over the north central plains. The strong upper level anticyclone responsible for drying was centered over the north central plains. The increased drying and subsidence from expanding ridge allowed for increased ozone production and accumulation in the region during this period.

August 14, 2000: A strong steep surface inversion indicated good residual buildup and the onset of a regional episode, as verified by the high nocturnal ozone readings at the Fort Mountain high elevation site (~865m ASL). Light wind speed, low relative humidity at 850 mb, a stable lapse, and good downslope flow gave stable conditions over north Georgia, in response to the strong surface ridge beginning to build over the Southeast. The strong upper level ridge drifted over the Central Plains.

August 15–18, 2000: A surface ridge axis extended southward towards the Gulf Coast, while the upper level ridge held firm over the Central Plains and upper Mississippi Valley on 15 August. On 16 August a regional buildup of ozone continued as an upper level ridge became firmly entrenched over the north central Gulf of Mexico, and the surface ridge intensified. Light northwesterly flow was indicated above 1200m agl at the FFC SODAR PA1-LR acoustic sounder during the

day on 16 August. Mixing heights extended up to 2500m according to the SODAR mixing height calculation, which was in agreement with the mixing height and stable conditions depicted by the FFC 12Z rawinsonde data. Split flow with light NNE winds aloft existed over north Georgia due to the center of the high being positioned slightly west of metro Atlanta. With plenty of subsidence and light NNE flow, the highest concentrations of surface ozone should have been on the south side of the metro area. On 17 August, continued subsident and stable conditions led to high ozone production over the Atlanta metro area. This production combined with high residual ozone and fumigation, helped enhance the regional episode. On 18 August, isentropic forward and back trajectory analysis indicated possible transport from Alabama. However, some ventilation did occur during the afternoon of 18 August to keep levels from really ramping, due to the passage of a weak 500 mb upper level trough.

August 19-20, 2000: Instability was on the rise on 19 August as the surface ridge weakened and a weak front approached north Georgia from the west. Some moisture advection was evident at 850 mb, due to a weak disturbance riding along the front. However, a definite air mass change did not occur until 20 August, when split flow and an increase in low-level wind speed "bumped" the residual ozone layer. The ETA forecast model depicted a weak Atlantic back-door cold front building in from the northeast. This front was accompanied by a slight increase in Atlantic moisture at 850 mb on 20 August, which gave a "cleaner" flow regime across north Georgia.

4.6.3 Application of Mesoscale Model

A number of meteorological modeling simulations aimed at evaluating strengths and weaknesses of various physics options available in MM5 version 3-5 and 3-6 were conducted. Operational details and results of these simulations are documented in Hu et al., (2003). The modeling simulation described below was determined to be of a quality that can be used for emissions and air quality modeling in support of the Augusta-Aiken Early Action Compact. The physics options and associated parameters used in the simulations are summarized in Table 5.

The following meteorological datasets were used in the modeling simulation:
• Surface elevation, land use/vegetation and soil temperature data from USGS at 30 second resolution available with MM5 installation package.
• NCEP ETA gridded analysis data available at 40-km resolution archived at 3-hour intervals was used for FDDA. The data is available at http://dss.ucar.edu/datasets/ds609.2.
• ADP observational data that consists of land and surface ship observations archived at 3-hour intervals and soundings data at 12-hour intervals available at http://dss.ucar.edu/datasets/ds353.4 and http://dss.ucar.edu/datasets/ds464.0.

Table 4-5 Meteorological model physics options and related modeling parameters

Physics options	Grid resolution		
	36-km	12-km	4-km
Nesting Type	One-way	One-way	One-way
Numerical Time Step	90 sec	30 sec	10 sec
Cumulus parameterization	Grell	Grell	None
PBL scheme	MRF	MRF	MRF
Moisture scheme	Mixed Phase	Mixed Phase	Mixed Phase
Radiation scheme	RRTM scheme	RRTM scheme	RRTM scheme
Land Surface scheme	OSU/Eta	OSU/Eta	OSU/Eta
Convection scheme	None	None	None
Observation nudging	None	None	None
3-D Grid analysis nudging	Yes	Yes	No
3-D Grid analysis nudging time interval	3-hour	3-hour	-
3-D Grid analysis nudging co-efficient	$GV=1x10^{-4}$ $GT=3x10^{-4}$ $GQ=1x10^{-6}$	$GV=1x10^{-6}$ $GT=3x10^{-4}$ $GQ=1x10^{-5}$	-
Surface Analysis nudging	Yes	Yes	No
Surface Analysis nudging time interval	3-hour	3-hour	-
Surface Analysis nudging co-efficient	$GV=1x10^{-4}$	$GV=1x10^{-6}$	No

4.6.4 Model Performance

4.6.4.1 Introduction

Model performance is the process of evaluating how accurately a modeling simulation estimates observed atmospheric properties. Once the simulation results are determined to be of acceptable accuracy, they can be used in a regulatory application. In the absence of regulatory guidance on adequate performance measures for prognostic meteorological models, statistical metrics proposed by Emery (2001) (Table 6) were computed, and evaluated against the benchmarks proposed in the referenced study (Table 7). The results are also compared with other peer-reviewed work.

Table 4-6 Mathematical formulation of statistical metrics used for evaluating mesoscale meteorological model performance

Metrics	Formulation
Bias	$B = \frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(P_j^i - O_j^i\right)$
Gross Error	$E = \frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left\|P_j^i - O_j^i\right\|$
Root Mean Square Error	$RMSE = \left[\frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(P_j^i - O_j^i\right)^2\right]^{1/2}$
Systematic Root Mean Square Error	$RMSE_S = \left[\frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(\hat{P}_j^i - O_j^i\right)^2\right]^{1/2}$
Unsystematic Root Mean Square Error	$RMSE_u = \left[\frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(P_j^i - \hat{P}_j^i\right)^2\right]^{1/2}$
Index of Agreement	$IOA = 1 - \left[\frac{IJ.RMSE^2}{\sum_{j=1}^{J}\sum_{i=1}^{I}\left\|P_j^i - M_o\right\| + \left\|O_j^i - M_o\right\|}\right]$

Table 4-7 Statistical benchmarks for Mesoscale Meteorological Models proposed by Emery (2001)

Statistical Measure	Benchmark
Wind Speed Bias (m/s)	<±0.5
Wind Speed Total RMSE (m/s)	2.0
Wind Speed Index of Agreement	0.6
Wind Direction Gross Error (degree)	30.0
Wind Direction Bias (degree)	<±10.0
Temperature Bias (Kelvin)	<±0.5
Temperature Gross Error (degree)	2.0
Temperature Index of Agreement	0.8
Humidity Bias (g/kg)	<±1.0
Humidity Gross Error (g/kg)	2.0
Humidity Index of Agreement	0.6

4.6.4.2 Methodology

Meteorological inputs required by CMAQ include three-dimensional distribution of winds, temperature, humidity, pressure, cloud cover, and other physical parameters in addition to diagnosed quantities such as turbulent mixing and planetary boundary layer heights. Given that the MM5 model code and algorithms have undergone significant peer review, operational evaluation of the model is sufficient to serve as the basis of evaluating if the model is operating with sufficient reliability to be used in support of SIP development. Thus, the prognostic meteorological model performance discussed here is limited to statistical analysis of the hourly-averaged modeled predictions and surface meteorological measurements that have been obtained from

http://dss.ucar.edu/datasets/ds472.0. The location of monitoring stations is provided in the Table 2, Appendix 4. Surface statistics for base meteorological variables, namely temperature, wind speed and direction, and humidity, have been computed. The metrics include: Bias Error (B), Gross Error (E) and Root Mean Square Error (RMSE), Systematic Root Mean Square Error ($RMSE_s$), Unsystematic Root Mean Square Error ($RMSE_u$) and Index Of Agreement (IOA).

A graphical summary of the daily and hourly mean performance statistics for the modeling simulations at 12- and 4-km grid resolution is provided in Figures 2 through 11. While reviewing these statistics, the reader is cautioned that summary statistics are useful in making only general assessment about the adequacy of meteorological fields. For example, daily-mean performance statistics are likely to conceal important hour-to-hour variations. Also note that the summary statistics depend upon the number of observation-prediction pairs and generally improve with larger sampling sizes and longer averaging periods. This is due to the fact that the probability of statistics being affected by extreme values is high in smaller sample sizes. With these caveats, we offer a summary of the modeling results for the base meteorological variable.

4.6.4.3 Results of modeling simulation at 12-km grid resolution

4.6.4.3.1 Temperature

The episode-average Bias (0.91 Kelvin) (Figures 4-2 and 4-3) fails to meet the benchmark with daily averages exhibiting over-prediction of the temperature on most days. Although the episode-average Gross Error (1.83 Kelvin) meets the benchmark, the daily-average Gross Error marginally exceeds it on August 19th and 20th. A high IOA (0.93) and low Systematic RMSE suggests that the temperature field simulated by the model is of satisfactory quality. The hourly statistical time series reveals a slight over prediction of peak temperature during the daytime hours. Also of note is the under prediction in nighttime temperatures on August 19th and 20th.

4.6.4.3.2 Wind speed and direction

The episode-average wind speed Bias (–0.27m/s) and total RMSE (systematic plus unsystematic) (1.94m/s) (Figure 4) meet the benchmark. However, the contribution of systematic RMSE towards the total is found to be higher. While ideally we want the episode-average IOA to be greater than 0.6, the computed IOA of 0.43 is not unusually poor. The episode-average wind direction Gross Error (50.2 degrees) fails to meet the benchmark.

4.6.4.3.3 Humidity

The episode-average statistics (Figures 5 and 6) indicate that the modeling simulation tends to under predict humidity throughout the episode. The average-daily Bias and Gross Error fail to meet the benchmark on most days. Bias and Gross Errors increase from –0.93 g/kg and 1.62 g/kg respectively on August 14th, to –2.6 g/kg and 2.82 g/kg on August 18th. Also of note is the larger contribution of the Systematic RMSE towards the total on August 16th, 17th and 18th.

4.6.4.4 Results of modeling simulation at 4-km grid resolution

4.6.4.4.1 Temperature

While the episode-average Bias (1.2 Kelvin) (Figures 7 and 8) fails to meet the benchmark, the episode-average Gross Error (1.94 Kelvin) meets it. A high IOA (0.9) and low Systematic RMSE suggests that the temperature field simulated by the model is of satisfactory quality.

4.6.4.4.2 Wind speed and direction

The episode-average Bias in wind speed (–0.035m/s) (Figure 9) is significantly better than the benchmark. The total RMSE is at the benchmark of 2.0 m/s, with greater contribution from the systematic component of the RMSE. The episode-average IOA (0.35) fails to meet the benchmark. Over all, the performance is viewed as satisfactory, having met most of the benchmarks.

4.6.4.4.3 Humidity

The episode-average statistics (Figures 10 and 11) indicate that the modeling simulation tends to under predict humidity throughout the episode. The average-daily Bias and Gross Errors increase from –1.03 g/kg and 1.55 g/kg respectively on August 14th, to –2.59 g/kg and 2.76 g/kg on August 18th. Also of note is the large contribution of the Systematic RMSE towards the total RMSE. The episode-average IOA (0.61) fails to meet the benchmark with fairly low daily-average IOA values throughout the simulation.

4.6.4.5 Summary

In addition to the model performance statistics described above, similar statistics were computed using ADP observational data (Hu et al., 2003). A literature review (Table 8) indicates that typical RMSE of hourly averaged surface wind speeds is 2-3 m/s for a wide range of wind speeds, models and geographic regions. For wind speeds in the range of 3-4 m/s, the RMSE in surface wind direction is around 50 degrees. The literature suggests that uncertainties in wind speeds and direction are primarily due to random turbulent processes and sub-grid variations in terrain and land use. It is therefore unlikely that the mesoscale models currently in use will be able to reduce these errors much further.

Overall, temperature and winds were simulated with good to satisfactory accuracy. Although humidity was less well modeled, it is of less importance in an air quality modeling effort that is aimed at developing an emission control strategy for attainment of the NAAQS for ozone. It should be pointed out that air quality performance serves as an additional check on how accurately a meteorological model was able to capture atmospheric dynamics during the episode. In the unlikely event of an unusually poor air quality model performance, it is reasonable to further investigate the performance of meteorological model.

Table 4-8 List of peer-reviewed journal articles related to mesoscale meteorological performance

	Emery et al., 2001	Rao et al., 2001		Zhong et al., 2003 (a) light winds, (b) strong winds						Castelli et al., 2004		Hanna et al., 2001. (c) 1995, OTAG. (d) 1991, Central California		
	Benchmark	RAMS3b	MM5	RAMS (a)	MM5 (a)	Meso-Eta (a)	RAMS (b)	MM5 (b)	Meso-Eta (b)	RAMS	Eta	RAMS (c)	MM5 (c)	MM5 (d)
Temperature Bias (degree C)	±0.5	1.38	-0.93	-0.74	-0.70	-1.77	-1.78	-0.74	-2.14	-	-	-	-	
Temperature Error (degree C)	2.0	2.29	2.22	-	-	-	-	-	-	-	-	-	-	-
Temperature RMSE (degree C)	-	3.03	2.89	2.50	2.17	2.57	2.62	1.97	2.99	3.40	3.37	-	-	-
Mixing Ratio Bias (g/kg)	±1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Mixing Ratio Error (g/kg)	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Mixing Ratio RMSE (g/kg)	-	-	-	-	-	-	-	-	-	1.70	1.76	-	-	-
Wind Speed Bias (m/s)	-	0.61	0.28	0.66	0.46	0.13	0.35	-0.26	1.64	-	-	-0.1	0.5	1.5
Wind Speed Error (m/s)	-	1.41	1.34	-	-	-	-	-	-	-	-	-	-	-
Wind Speed RMSE (m/s)	2.0	1.80	1.71	1.63	1.57	1.41	2.00	1.98	2.56	1.57*	2.21*	1.6	1.9	2.5
Wind Direction Bias (degree)	-	-	-	-0.43	9.91	0.85	-1.11	4.10	3.89	-	-	-12	14	-2
Wind Direction Error (degree)	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Wind Direction RMSE (degree)	-	-	-	68.37	66.66	69.49	64.58	72.98	61.02	-	-	76	51	66

*RMSVE

Castelli, S. T., S. Morelli, D. Anfossi, J. Carvalho, and S. Z. Sajani, 2004: Inter-comparison of two models, ETA and RAMS, with TRACT field campaign data. *Environmental Fluid Mechanics*, **4,** 157-196

Emery, C. et al., 2001: Enhanced meterological modeling and performance evaluation for two Texas ozone episodes. Prepared for the Texas Natural Resource Conservation Commission, Prepared by ENVIRON International Corporation, Novato, CA.

Hanna, S. R. and R. X. Yang, 2001: Evaluations of mesoscale models' simulations of near-surface winds, temperature gradients, and mixing depths. *Journal of Applied Meteorology*, **40,** 1095-1104

Hogrefe, C., S. T. Rao, P. Kasibhatla, G. Kallos, C. J. Tremback, W. Hao, D. Olerud, A. Xiu, J. McHenry, and K. Alapaty, 2001: Evaluating the performance of regional-scale photochemical modeling systems: Part I - meteorological predictions. *Atmospheric Environment*, **35,** 4159-4174

Zhong, S. Y. and J. Fast, 2003: An evaluation of the MM5, RAMS, and Meso-Eta models at sub-kilometer resolution using VTMX field campaign data in the Salt Lake Valley. *Monthly Weather Review*, **131,** 1301-1322

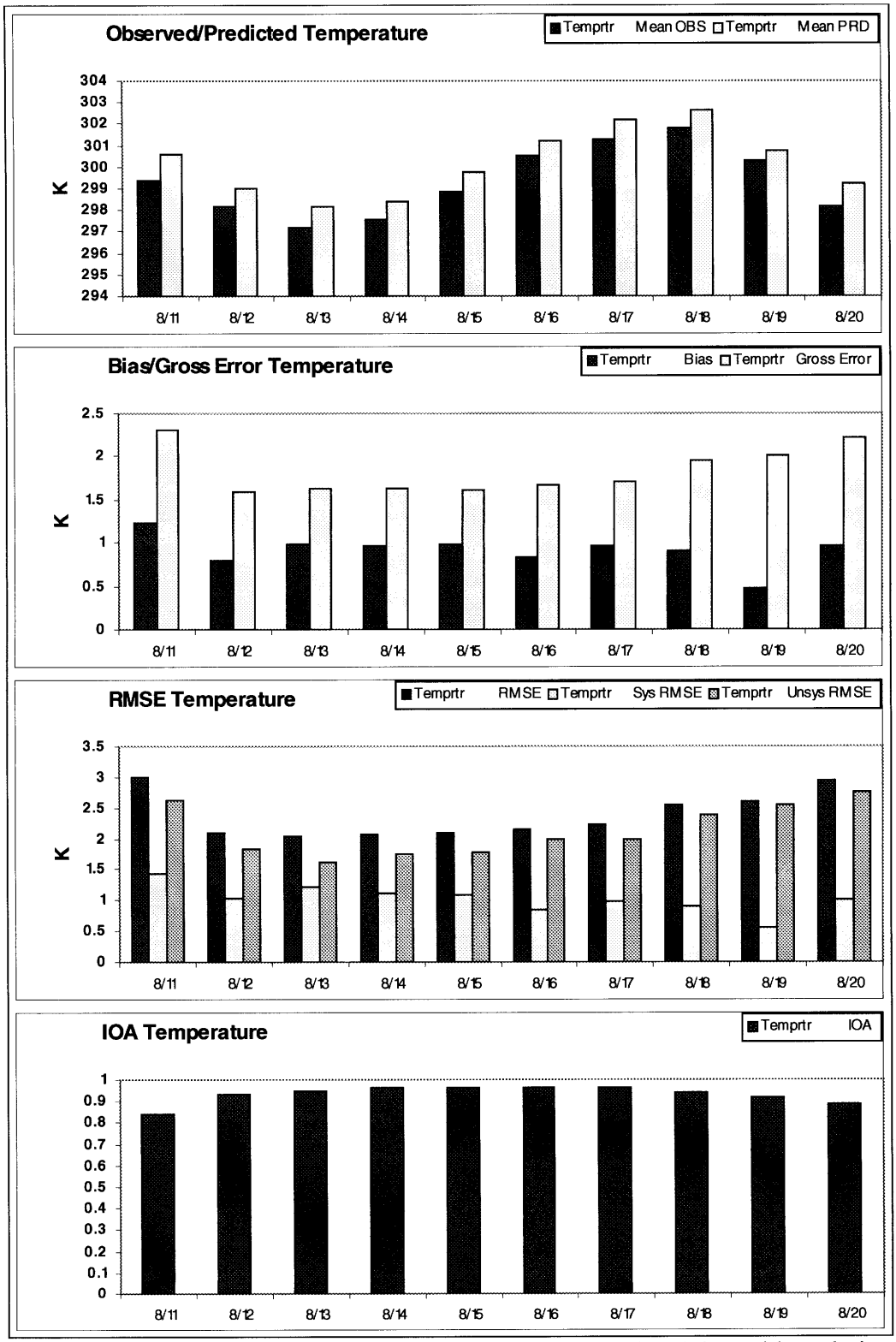


Figure 4-2 Daily statistical temperature time series plot for the 12-km grid resolution simulation.

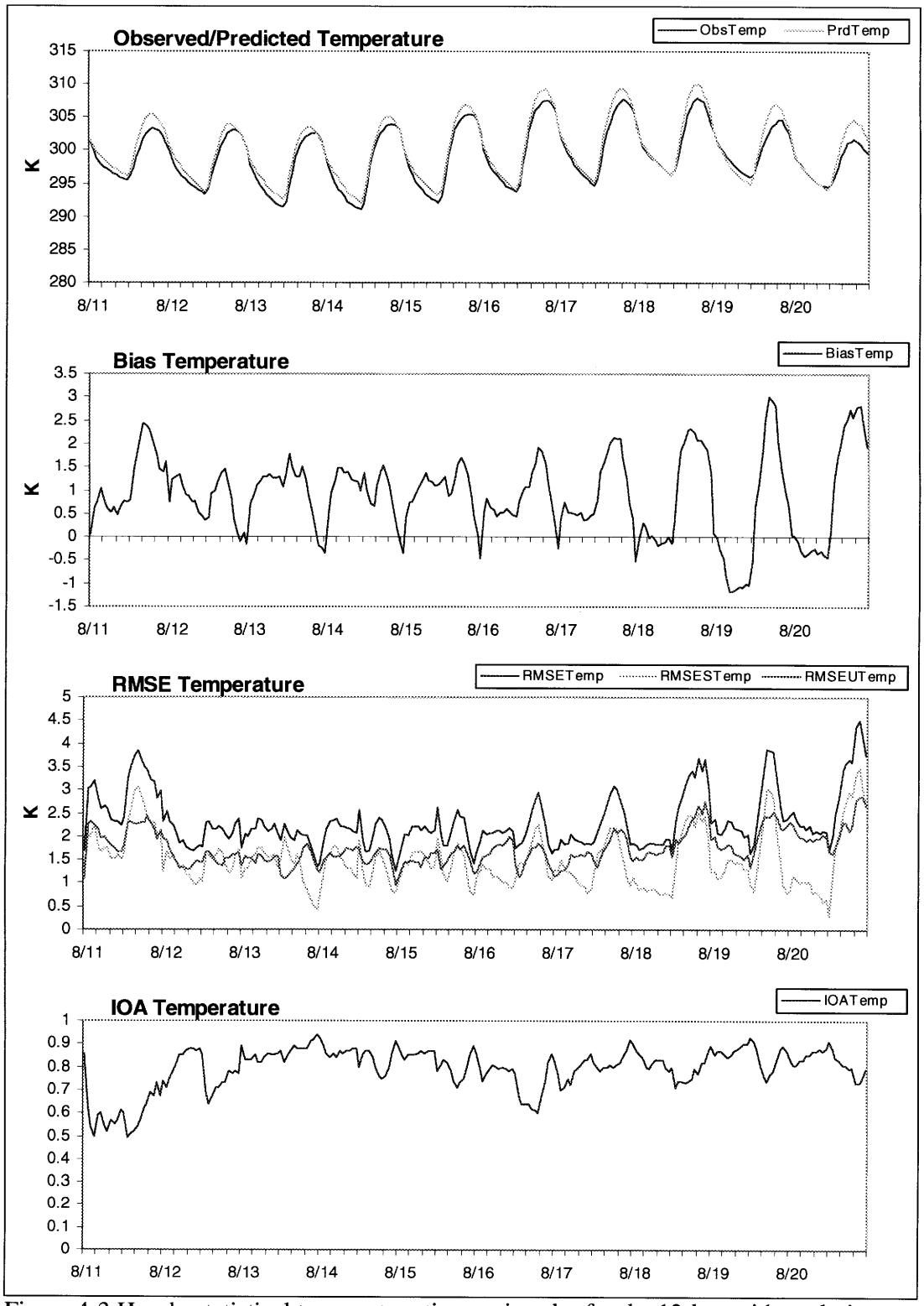


Figure 4-3 Hourly statistical temperature time series plot for the 12-km grid resolution simulation.

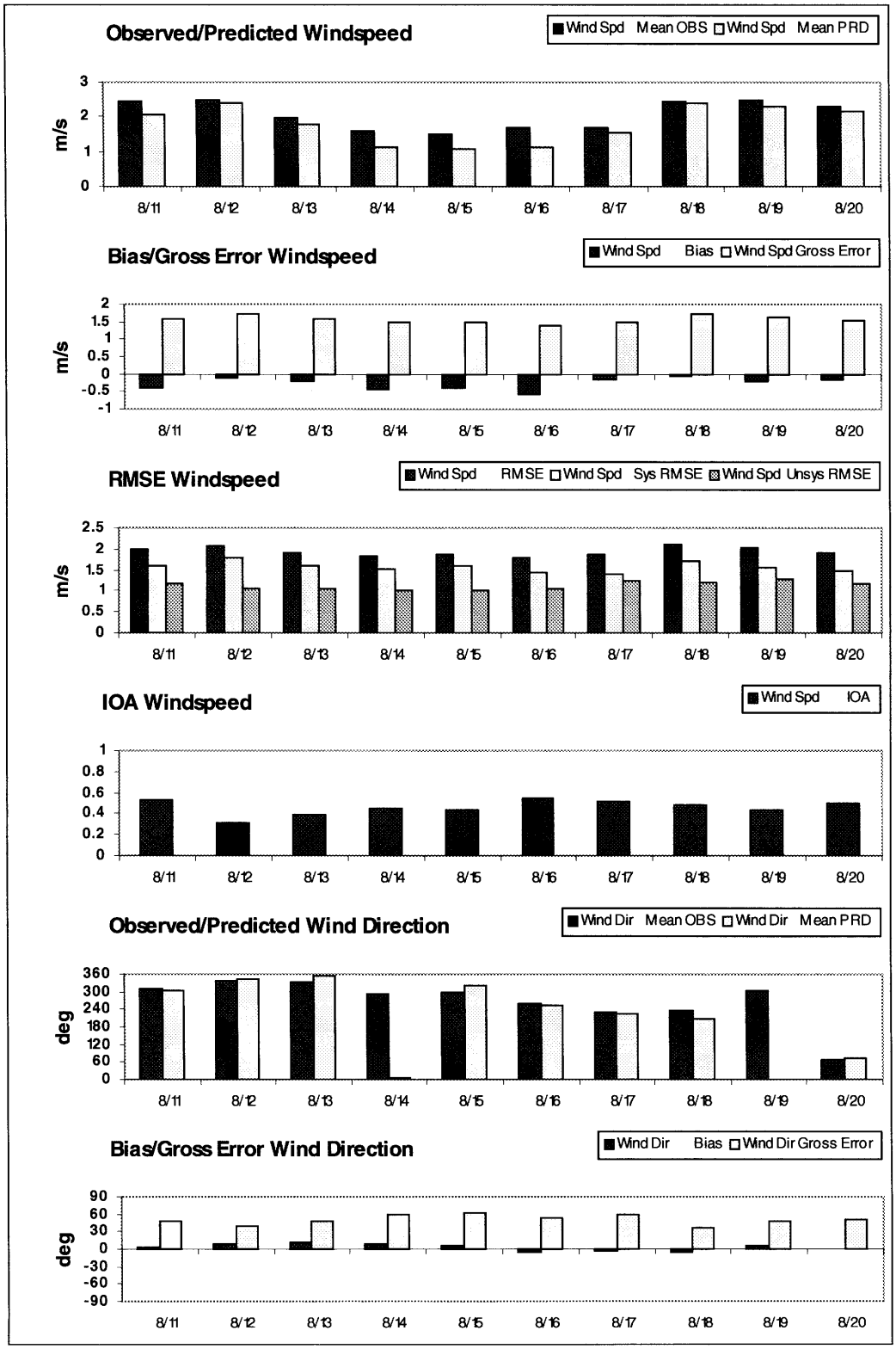


Figure 4-4: Daily statistical wind speed and direction time series plot for the 12-km grid resolution simulation.

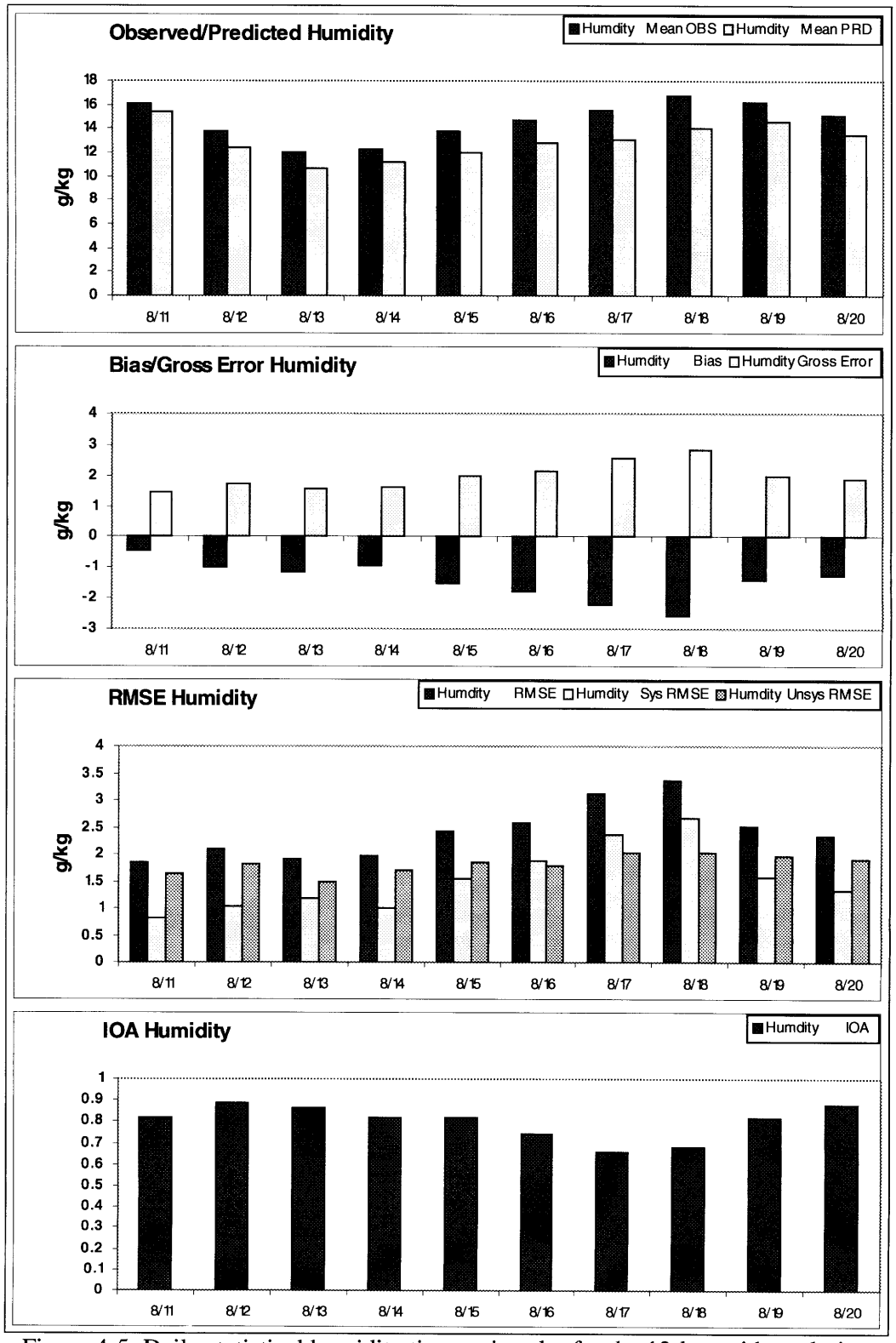


Figure 4-5: Daily statistical humidity time series plot for the 12-km grid resolution simulation.

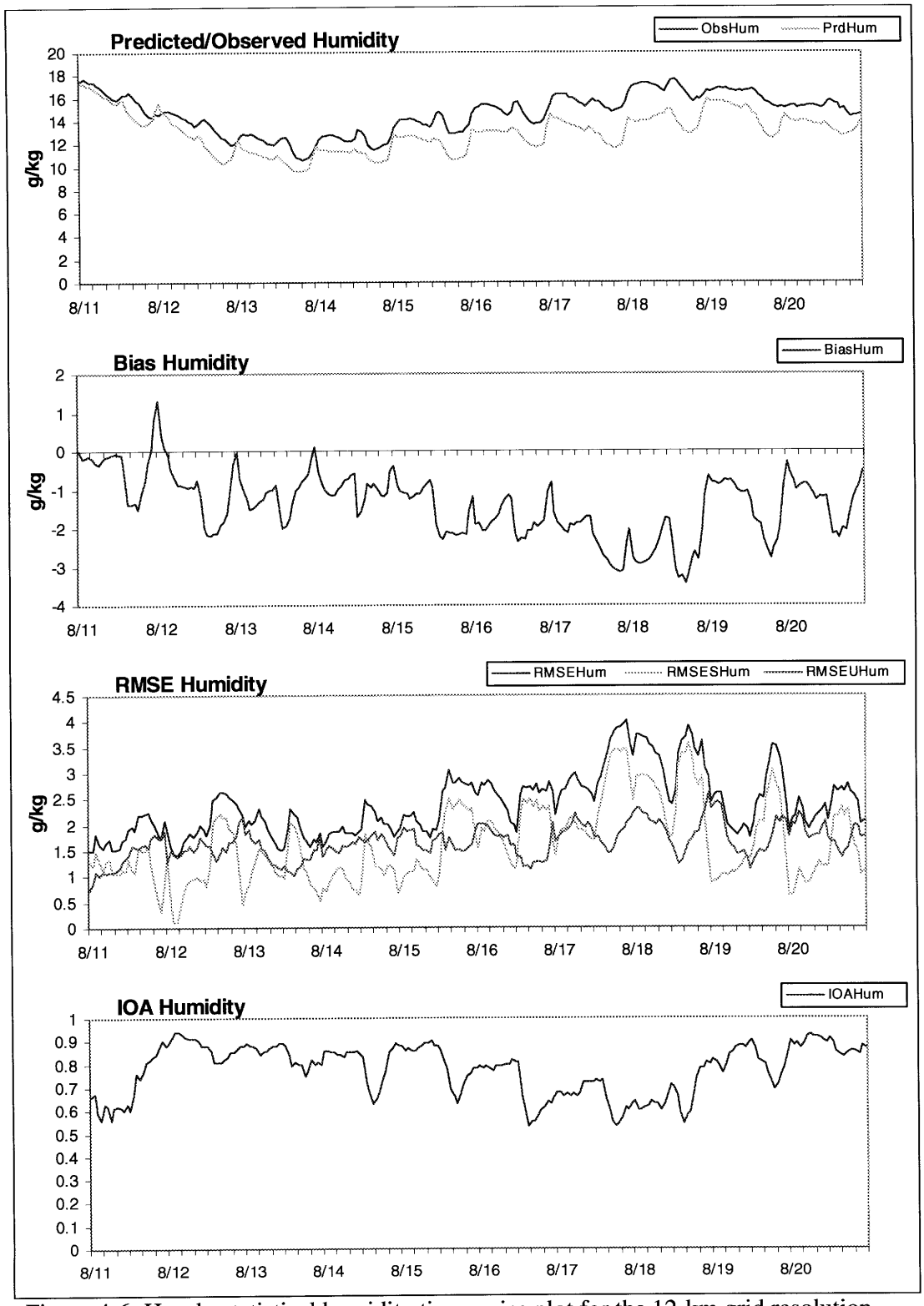


Figure 4-6: Hourly statistical humidity time series plot for the 12-km grid resolution simulation.

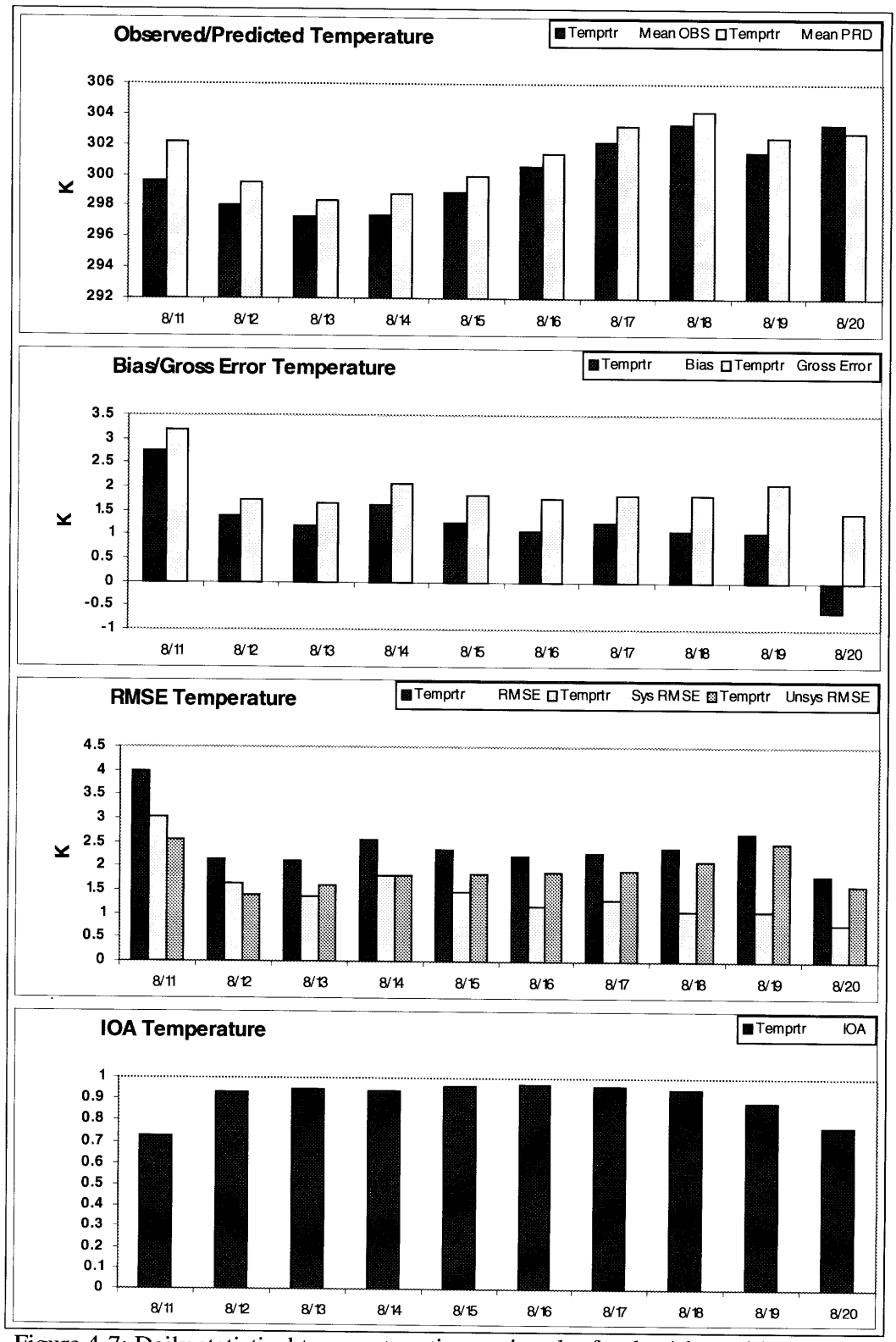


Figure 4-7: Daily statistical temperature time series plot for the 4-km grid resolution simulation.

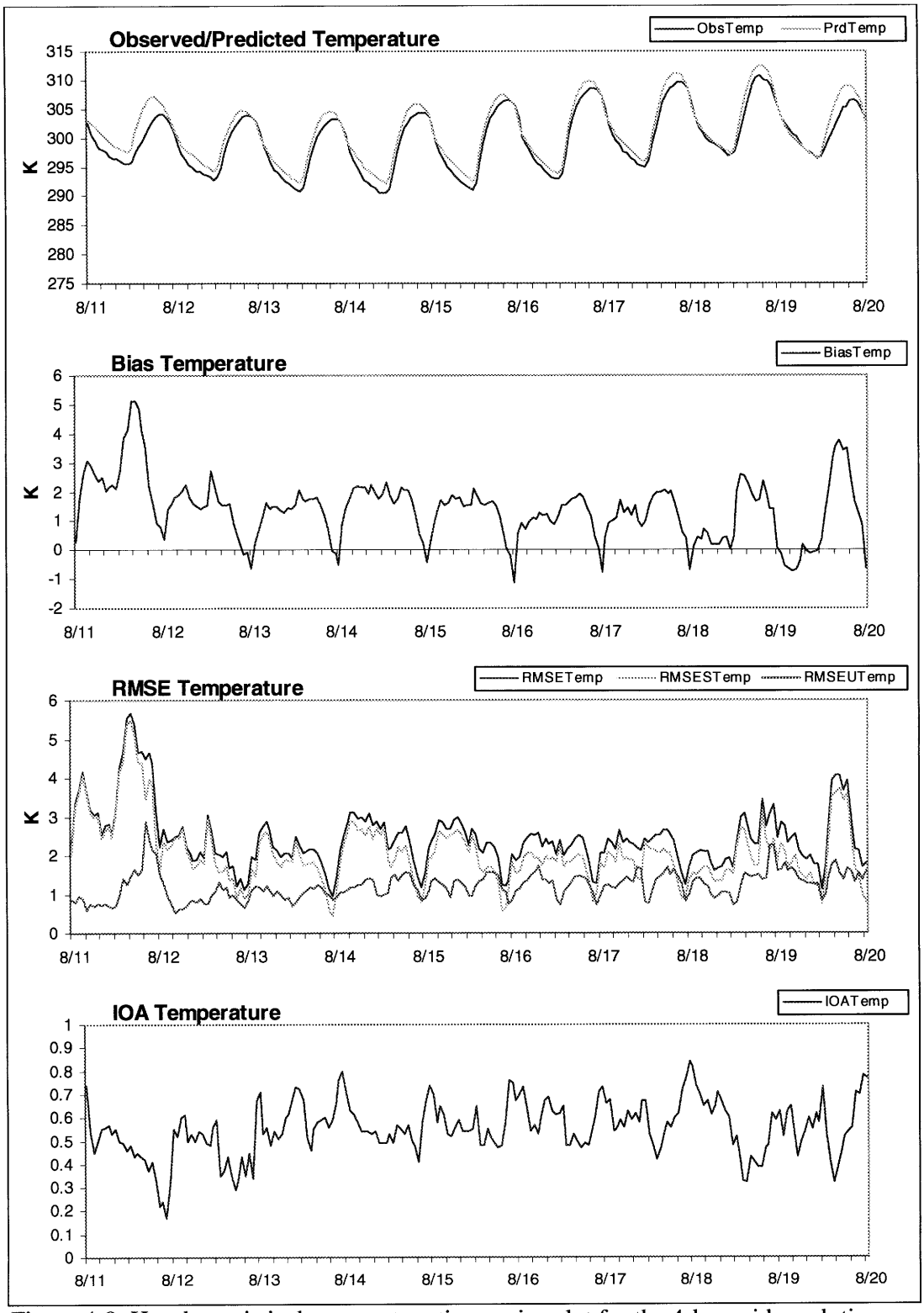


Figure 4-8: Hourly statistical temperature time series plot for the 4-km grid resolution simulation.

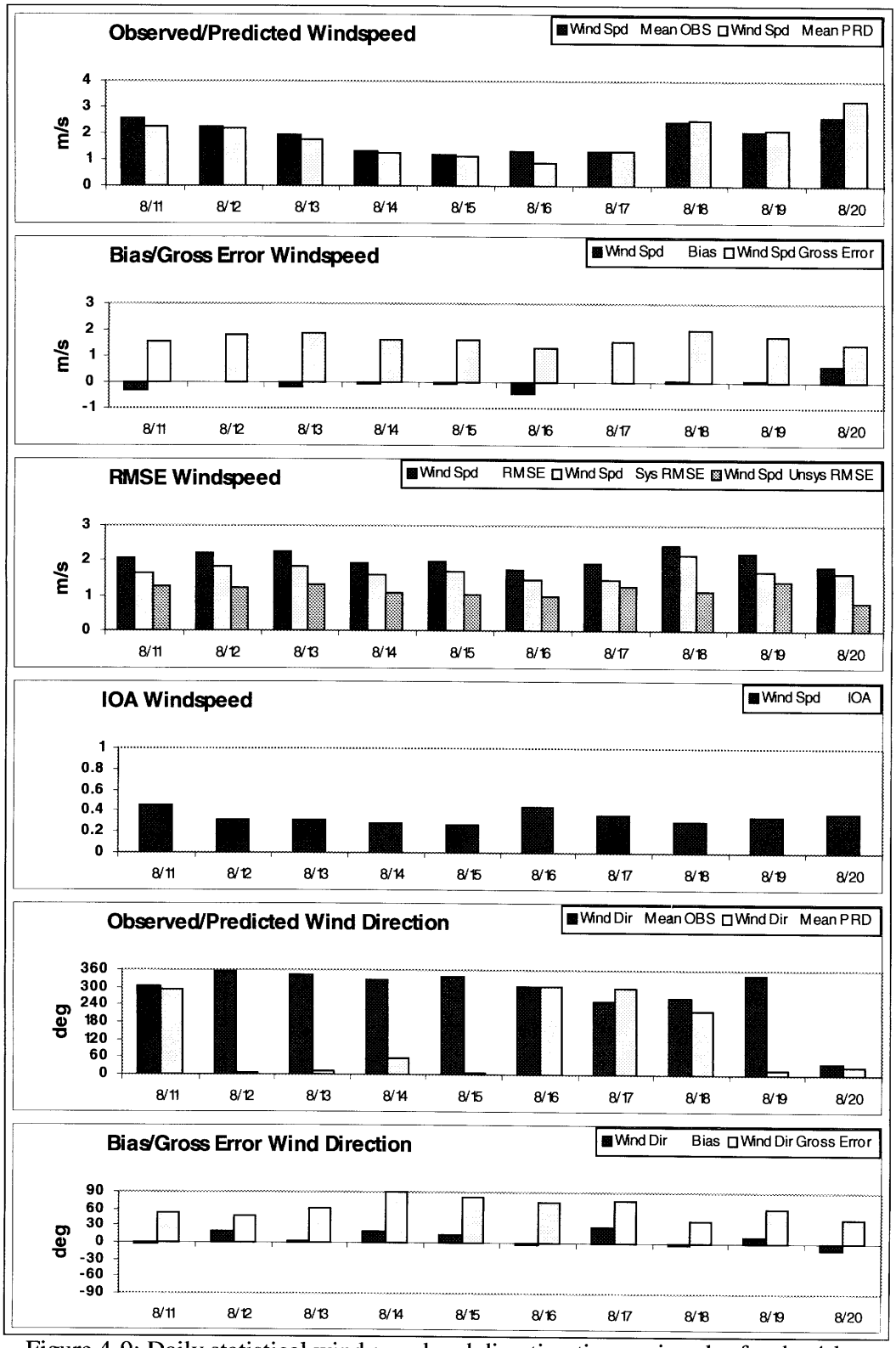


Figure 4-9: Daily statistical wind speed and direction time series plot for the 4-km grid resolution simulation.

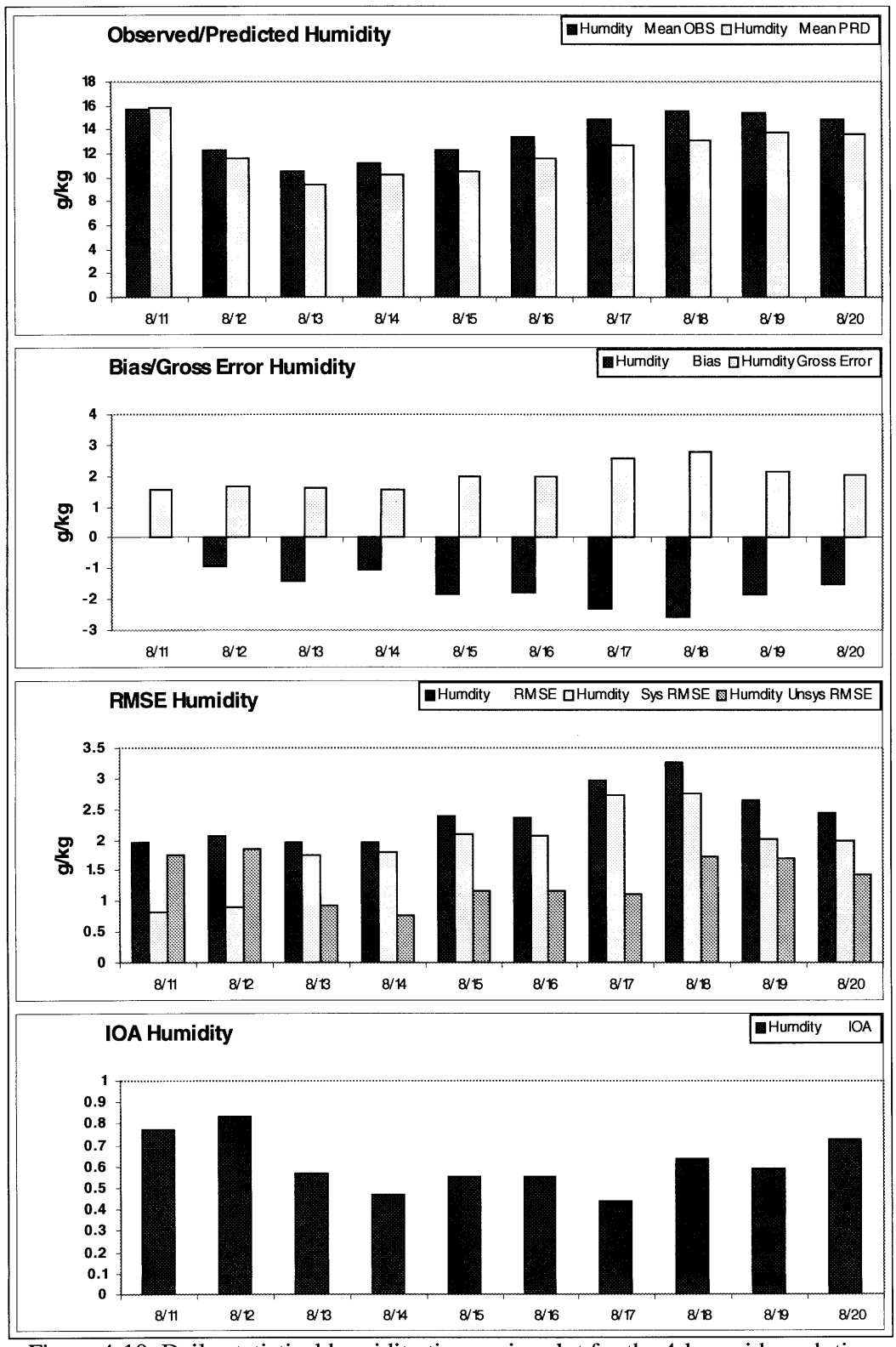


Figure 4-10: Daily statistical humidity time series plot for the 4-km grid resolution simulation.

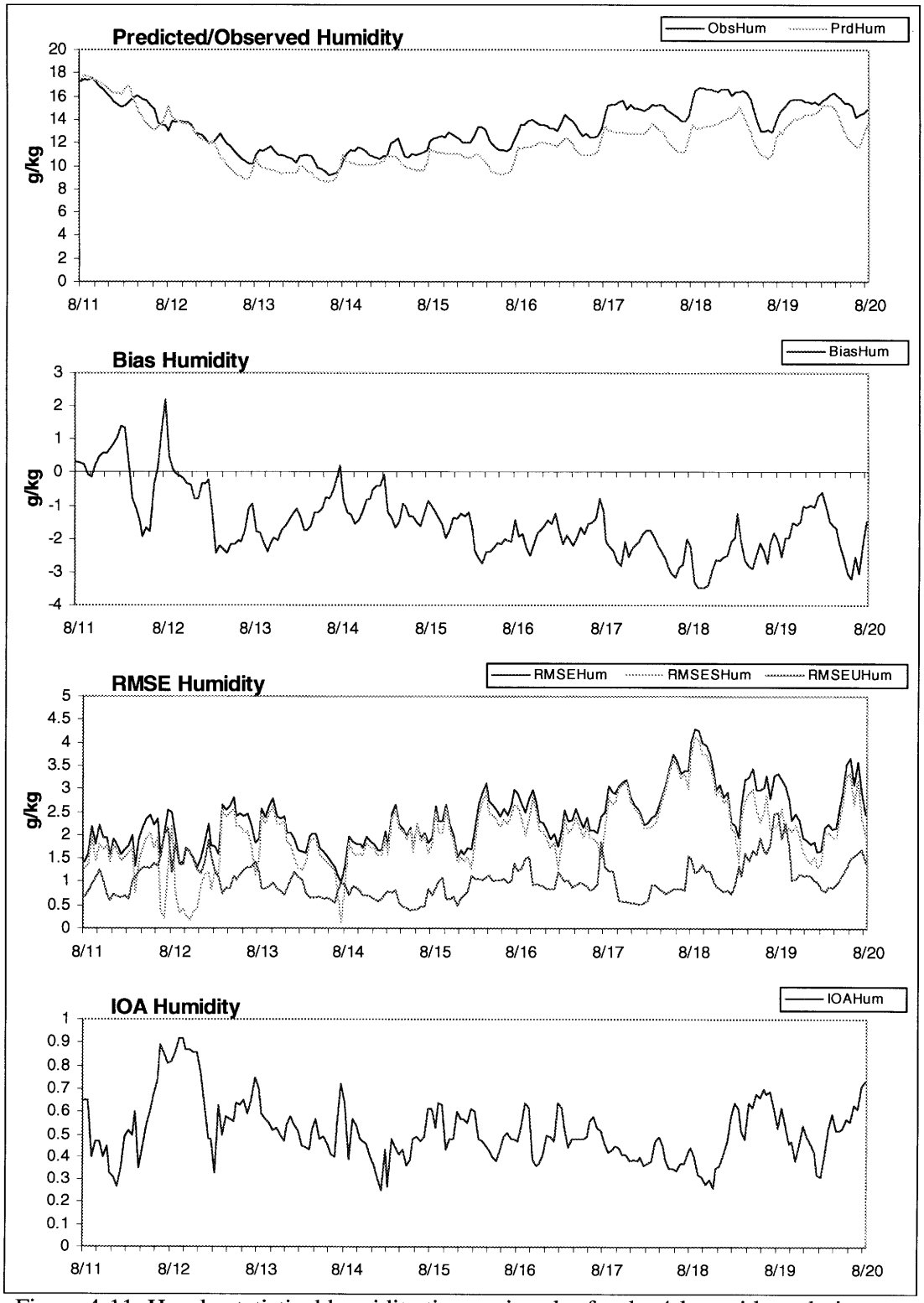


Figure 4-11: Hourly statistical humidity time series plot for the 4-km grid resolution simulation.

4.7 Emissions Processing

4.7.1 Introduction

Emission inventories are typically available with an annual or daily total emissions value for each emissions source. Air quality models such as CMAQ, however, require emissions data on an hourly basis, for each model grid cell and species. Consequently emission processing requires processing of the emission inventory through temporal allocation, chemical speciation, and spatial allocation, to achieve the input requirements of the air quality model. The Sparse Matrix Operator Kernel Emissions (SMOKE) processor (Coats, 1996; Houyoux, 1999) was used for creating gridded, temporalized and speciated emission files for use in CMAQ. SMOKE is capable of generating temperature sensitive mobile source emission factors using EPA's MOBILE6 model. It is also capable of generating a biogenic emissions inventory using the BEIS version 3. It requires a large amount of source specific emissions data. In addition, certain aspects of emissions processing require meteorological variables. These are provided by the meteorological model and include daily surface temperature for calculating mobile source emission factors; temperature and radiation field for calculating biogenic emissions; surface Planetary Boundary Layer (PBL) height, surface heat fluxes, wind speed, and temperature for estimating plume rise for point sources.

4.7.2 Emissions Inventory

Emission inventories for base and future years discussed in Section 3 were used to generate hourly, speciated and gridded emission files for air quality modeling. The list of SMOKE input files is provided in Table 3, Appendix 4. Following is a brief description of the data and methodology used in emissions processing for air quality modeling. Additional details about emission processing are provided in Hu et al., (2004).

4.7.3 Spatial Allocation

Emission models use spatial surrogates to allocate countywide emissions estimates of area, non-road and on-road mobile emissions to the modeling grid. The spatial surrogate database contains, for each modeling grid cell, fractions of demographic and/or geographic "features" of counties that fall within the grid cell. This fraction is usually referred to as the "spatial surrogate ratio". For simplicity, an integer code (i.e., Spatial Surrogate Code) is assigned to each feature. Each Source Classification Code (SCC) is assigned a Spatial Surrogate Code (SSC) through a cross-reference file and the countywide emissions are allocated to the grid cell based on the spatial surrogate ratio of the grid cell. A spatial surrogate dataset at 1-km resolution was developed from the geographic and demographic datasets available from various Federal agencies. Details of this processing are provided in Hu et al., (2004).

4.7.4 Temporal Allocation

The annual or daily emission estimates of area, non-road mobile, on-road mobile and non-EGU point source categories have been distributed using a set of monthly, weekly and diurnal weighting profiles developed by EPA and available at

http://www.epa.gov/ttn/chief/emch/temporal. For EGUs, CEM data available at http://cfpub.epa.gov/gdm/ has been used.

4.7.5 Chemical Speciation

Emissions inventories are generally built and reported for a variety of compounds such as Carbon Dioxide (CO), Nitrogen Oxides (NO_x), Volatile Organic Compounds (VOC) and Sulfur Oxides (SO_x). However, condensed chemical mechanisms used in air quality models contain a simplified set of equations that use representative "model species" to fully describe atmospheric chemistry. Source-specific factors are therefore required to convert the emissions from chemical classes in the emissions inventory to the species in the mechanism. Speciation profiles for the SAPRC99 chemical mechanism developed by EPA and information on how to assign them to individual sources is available at http://www.epa.gov/ttn/chief/emch/speciation

4.7.6 Quality Assurance

A three-step quality assurance procedure was adopted to identify any potential problems in emissions processing. It involved (1) examining the log files created by SMOKE during emissions processing for error messages, (2) comparing countywide emission totals generated by SMOKE with emission inventory totals, and (3) visual examination of emission fields using available graphics packages. Emission fields for all source categories were examined in order to make a qualitative assessment about the accuracy of spatial and temporal distribution of emissions. The visualization also provides a better understanding of the relative importance of various emission sources that contribute to poor air quality in the region of interest.

Daily average emission totals for Base (i.e., 2000) and Future years (i.e., 2007 and 2012) for all source categories for the 12 and 4-km modeling grids have been provided in Tables 9(a-d). As discussed in Section 3, emission reductions due to Federal, State and Local controls scheduled to go in place in the seven to twelve years following the base year will considerably lower the anthropogenic emission loading in Georgia and help greatly in continued improvement in air quality in the region.

Table 4-9a Daily average gridded emission totals for Base (i.e., 2000) and Future years (i.e., 2007 and 2012) simulations at 12-km resolution grid for area and non-road emission sources

	AREA											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	214.6	215.5	289.8	2951.9	2516.9	2074.0	5775.3	5417.6	6110.6	273.5	271.9	254.2
14th August	225.4	226.2	300.0	2952.3	2517.3	2074.0	5780.1	5422.3	6115.4	302.3	300.6	280.4
15th August	227.2	228.0	302.0	2952.4	2517.4	2075.0	5780.9	5423.2	6116.2	307.7	306.0	285.5
16th August	227.2	228.0	302.0	2952.4	2517.4	2075.0	5780.9	5423.2	6116.2	307.7	306.0	285.5
17th August	227.2	228.0	302.0	2952.4	2517.4	2075.0	5780.9	5423.2	6116.2	307.7	306.0	285.5
18th August	227.2	228.0	302.0	2952.4	2517.4	2075.0	5780.9	5423.2	6116.2	307.7	306.0	285.5
19th August	219.6	220.5	294.0	2952.1	2517.1	2074.0	5777.6	5419.8	6112.9	287.3	285.7	266.9

	NON-ROAD											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	574.6	535.9	614.0	451.1	439.8	444.0	5284.6	5879.2	5906.3	82.9	94.7	94.9
14th August	608.2	566.8	645.0	532.7	502.6	507.0	6944.4	7837.8	7864.9	88.2	100.9	101.2
15th August	613.2	571.3	650.0	543.5	510.5	514.0	7138.5	8061.1	8088.2	89.0	101.9	102.2
16th August	613.2	571.3	650.0	543.5	510.5	514.0	7138.5	8061.1	8088.2	89.0	101.9	102.2
17th August	613.2	571.3	650.0	543.5	510.5	514.0	7138.5	8061.1	8088.2	89.0	101.9	102.2
18th August	613.2	571.3	650.0	543.5	510.5	514.0	7138.5	8061.1	8088.2	89.0	101.9	102.2
19th August	579.7	540.5	619.0	461.9	447.6	452.0	5478.6	6102.5	6129.5	83.7	95.7	95.9

Table 4-9b Daily average gridded emission totals for Base (i.e., 2000) and Future years (i.e., 2007 and 2012) simulations at 12-km resolution grid for mobile and point emission sources

	MOBILE											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	1302.4	899.0	590.3	1221.3	805.1	612.0	12664.5	8503.3	7453.5	72.8	38.5	42.4
14th August	1628.6	1119.8	734.5	1555.4	1019.5	775.0	15994.9	10698.7	9371.4	91.0	47.4	52.1
15th August	1658.7	1140.1	747.4	1590.2	1041.6	789.0	16292.0	10890.8	9527.4	92.8	48.3	53.0
16th August	1643.6	1129.9	740.5	1570.0	1029.1	780.0	16093.2	10769.3	9425.7	92.0	47.9	52.6
17th August	1765.8	1214.2	796.3	1689.5	1107.2	840.0	17346.1	11598.7	10151.9	98.7	51.4	56.5
18th August	1765.7	1215.1	796.7	1678.4	1101.8	836.0	17255.6	11558.1	10121.6	98.8	51.7	56.7
19th August	1486.6	1023.9	671.5	1409.4	926.1	702.0	14506.0	9719.8	8507.2	83.1	43.6	47.9
	POINT											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	1545.1	984.0	931.0	849.1	630.3	567.0	1797.9	2234.6	1694.9	5203.0	5347.1	5232.3
14th August	1656.6	1049.5	988.0	878.4	651.0	587.0	1809.4	2246.9	1706.3	5564.8	5699.8	5683.4
15th August	1725.4	1086.6	1002.0	883.6	653.4	589.0	1812.0	2249.8	1708.9	5930.4	6064.0	5790.4
16th August	1752.9	1093.4	1002.0	883.6	653.4	589.0	1812.0	2249.8	1708.9	6170.4	6299.2	5790.4
17th August	1783.4	1108.6	1002.0	883.6	653.4	589.0	1812.0	2249.8	1708.9	6197.9	6331.1	5790.4
18th August	1810.2	1125.5	1002.0	883.6	653.4	589.0	1812.0	2249.8	1708.9	6210.8	6347.9	5790.4
19th August	1679.1	1053.6	962.0	882.7	652.4	588.0	1805.3	2242.6	1702.4	5910.1	6032.0	5467.6

Table 4-9c Daily average gridded emission totals for Base (i.e., 2000) and Future years (i.e., 2007 and 2012) simulations at 4-km resolution grid for area and non-road emission sources

	AREA											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	67.5	67.8	83.4	628.8	540.3	458.0	1408.9	1360.1	1646.0	42.6	43.1	23.0
14th August	71.4	71.6	87.6	629.0	540.4	459.0	1410.7	1361.9	1648.0	47.0	47.6	25.7
15th August	71.9	72.2	87.6	629.0	540.4	459.0	1411.0	1362.2	1648.0	47.7	48.3	26.1
16th August	71.9	72.2	87.6	629.0	540.4	459.0	1411.0	1362.2	1648.0	47.7	48.3	26.1
17th August	71.9	72.2	87.6	629.0	540.4	459.0	1411.0	1362.2	1648.0	47.7	48.3	26.1
18th August	71.9	72.2	87.6	629.0	540.4	459.0	1411.0	1362.2	1648.0	47.7	48.3	26.1
19th August	69.2	69.5	85.0	628.9	540.3	459.0	1409.7	1360.9	1648.0	44.6	45.2	26.1

	NON-ROAD											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	169.3	160.2	161.0	114.5	105.5	106.0	1560.5	1752.0	1754.0	23.7	27.3	26.3
14th August	179.1	169.3	163.0	141.1	126.0	126.0	2102.8	2392.9	2395.0	25.2	29.0	28.1
15th August	180.4	170.5	163.0	144.3	128.3	126.0	2160.5	2459.4	2462.0	25.4	29.3	28.3
16th August	180.4	170.5	163.0	144.3	128.3	129.0	2160.5	2459.4	2462.0	25.4	29.3	28.3
17th August	180.4	170.5	163.0	144.3	128.3	129.0	2160.5	2459.4	2462.0	25.4	29.3	28.3
18th August	180.4	170.5	163.0	144.3	128.3	129.0	2160.5	2459.4	2462.0	25.4	29.3	28.3
19th August	170.6	161.4	154.0	117.7	107.9	108.0	1618.2	1818.4	1821.0	23.9	27.5	26.6

Table 4-9d Daily average gridded emission totals for Base (i.e., 2000) and Future years (i.e., 2007 and 2012) simulations at 4-km resolution grid for mobile and point source emission sources

	MOBILE											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	408.3	303.9	208.0	350.9	247.6	194.5	3788.6	2705.4	2467.0	19.8	12.8	15.1
14th August	514.1	377.6	257.0	444.5	308.9	242.0	4780.0	3375.9	3073.0	24.7	15.9	18.7
15th August	522.2	383.1	261.0	451.8	313.5	245.0	4846.6	3419.5	3109.0	25.1	16.1	19.0
16th August	517.7	380.0	259.0	447.4	310.9	243.0	4797.0	3388.5	3082.0	24.9	16.0	19.0
17th August	556.1	408.6	278.0	481.0	334.3	261.0	5168.1	3650.0	3320.0	26.8	17.2	20.3
18th August	555.7	409.3	279.0	479.7	334.6	262.0	5151.3	3648.5	3321.0	26.8	17.2	20.3
19th August	466.4	344.6	235.0	402.0	281.3	220.0	4321.1	3067.4	2792.0	22.5	14.5	17.0

	POINT											
	NOX			VOC			CO			SO2		
DATE	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**	**2000**	**2007**	**2012**
13th August	423.4	231.5	224.0	89.7	69.3	68.1	209.8	276.9	274.8	1701.5	1725.3	1538.0
14th August	443.1	244.5	240.0	95.8	71.7	70.1	212.6	279.9	277.7	1695.7	1717.8	1690.0
15th August	466.5	258.0	244.4	96.1	71.9	70.3	213.2	280.5	278.8	1721.6	1742.6	1722.0
16th August	495.0	273.2	244.4	96.1	71.9	70.3	213.2	280.5	278.8	1911.6	1936.0	1722.0
17th August	512.1	281.5	244.4	96.1	71.9	70.3	213.2	280.5	278.8	1927.0	1953.6	1722.0
18th August	516.6	284.7	244.4	96.1	71.9	70.3	213.2	280.5	278.8	1968.3	1998.5	1722.0
19th August	464.6	255.8	232.0	95.9	71.6	70.1	211.3	278.5	278.8	1811.9	1830.9	1722.0

4.8 Air Quality Modeling

4.8.1 Introduction

Air quality modeling simulations were conducted using EPA's Community Multiscale Air Quality Chemistry Transport Model (CMAQ-CTM) or Models-3 (Dennis et al., 1996). The modeling system contains state-of-the-science parameterization of atmospheric processes affecting transport, transformation, and deposition of such pollutants as ozone, particulate matter, airborne toxics, and acidic and nutrient pollutant species. Thus, CMAQ has the "one atmosphere" modeling capability based mainly on the "first principal" description of the atmosphere. With the atmospheric science in a continuing state of advancement and review, the modeling structure of CMAQ is designed to integrate and test future formulations in an efficient manner, without requiring the development of a new modeling system. This fact alone makes CMAQ-CTM a suitable candidate for development and evaluation of emission control strategies.

4.8.2 Input data and model configuration

CMAQ incorporates output fields from the meteorological (e.g., MM5) and emissions (e.g., SMOKE) modeling systems and several other data sources through special processors into the CMAQ-CTM. The meteorological data is processed using Meteorology Chemistry Interface Processor (MCIP), initial and boundary conditions through ICON and BCON and clear sky photolysis rate using JPROC. Initial and boundary condition processors allow the use of a gridded concentration field as well as the species concentration profiles that are available with the installation. JPROC generates the photolysis rate lookup table under clear sky conditions. Data necessary for these computations is also available with the installation. Following is a brief description of the input data and model configuration used to conduct air quality modeling simulations in support of the Augusta-Aiken Early Action Compact.

4.8.2.1 Meteorology and Emissions

MCIP version 2 is used to create meteorological input files required by the air quality model. Most meteorological variables are passed through directly from the MM5 output fields. Others, such as dry deposition velocities, are computed by MCIP. MCIP also creates the horizontal and vertical grid structure for CMAQ by extracting data for the domain defined by the user. Since computational limitations prohibit the use of 34 vertical layers (MM5 default) in air quality modeling, the CMAQ modeling grid consisted of only 13 vertical layers.

Emissions processing required for generating speciated, temporalized and gridded emission input files for air quality modeling was discussed in the previous section.

4.8.2.2 Initial and Boundary Conditions

Initial and boundary conditions for the 36-km domain are generated from a set of predefined vertical profiles available with the CMAQ installation. For all nested domains (i.e., 12 and 4-km), air quality concentrations predicted on the "parent" domain are spatially interpolated onto the "daughter" domain. Thus for example,

boundary conditions for the 4-km domain (i.e., daughter domain) are obtained by spatially interpolating concentrations predicted at the 12-km resolution grid (i.e., parent domain).

4.8.2.3 Photolysis Rates

The photolysis rates processor JPROC was used to generate clear sky photolysis rates. The processing was performed using modified extraterrestrial radiation data from World Meteorological Organization (WMO) (Chang et al., 1994) and O_2 and O_3 absorption cross-section data from NASA (DeMore et al., 1994).

4.8.2.4 Model Configuration

CMAQ provides several scientific options for the most important atmospheric processes (i.e., gas-phase chemistry, advection). Since selection of a particular model configuration can have a significant effect on model performance and emission control strategy evaluation, several model configurations, parameters, and input datasets were evaluated. The simulations provided useful information about the inherent uncertainties in the modeling system and helped develop a more thoughtful approach towards the use of air quality models for regulatory proposes. CMAQ version 4.3 with modification to the vertical diffusion module was used in all simulations. Details of these simulations and the changes to the CMAQ source code are documented in Hu et al., (2004). The scientific options selected for these simulations are provided in Table 10.

Table 4-10 CMAQ and MCIP configuration

Physical Process	Module Name	Reference
Horizontal and vertical Advection	hppm and vppm	Piecewise Parabolic Method (PPM) (Colella and Woodward, 1994)
Horizontal Diffusion	multiscale	
Vertical Diffusion	eddy	Eddy diffusion formulation based on K-theory
Photolysis	phot	RADM photolysis module
Chemical mechanism and Solver	mebi_saprc	SAPRC-99 chemical mechanism with Modified Euler Backward Iterative (MEBI) solver
Aerosol Dynamics	aero3	Improved treatment for Secondary Organic Aerosol (SOA) and ISORROPIA for thermodynamics
Wet Deposition	aero_dpv2	
Cloud Dynamics	cloud_radm	RADM cloud module

4.8.3 Model Performance

4.8.3.1 Introduction

Model performance methodology outlined in EPA's draft 8-hour modeling guidance (EPA, 1999) is used as a guide for evaluating air quality model performance. The following sub-section describes the methodology used in evaluating the adequacy of air quality model results for regulatory proposes. It is important to point out that

model performance evaluated against observational data recorded at hourly intervals (i.e., finest temporal resolution at which air quality predictions are available) provides a more stringent test of the model's ability to replicate pollutant concentrations as compared to an evaluation that uses temporal averages (e.g., comparison of 8-hour average observation-prediction pairs). Similarly, comparison of observed and predicted concentration from a grid cell that "contains" the monitoring station is a more a rigorous test (i.e., finest spatial resolution at which air quality concentrations are available), compared to a test that utilizes predicted concentration from a "nearby" grid cell. The statistics described below use the above-mentioned approach and thus represent a more stringent test of the model and its ability to capture pollutant dynamics during the episode.

4.8.3.2 Methodology

The performance of the model at 12- and 4-km grid resolution is presented here. The statistical measures include the Mean Normalized Bias (MNB) and Mean Normalized Error (MNE) in hourly averaged O_3 concentrations predicted at the monitoring station. Mathematical formulation of these metrics is provided in Table 11. Since the normalized quantities can become large when observations are small, a cut-off value of 40 ppb is used in these computations. Thus, whenever the observation is smaller than the cut-off value, the prediction-observation pair is excluded from the calculation. The hourly normalized bias and error metrics are presented as daily averages over all monitoring stations. The normalized bias and error in peak O_3 concentration prediction at each monitoring station is also evaluated. The results from the analyses are compared with performance goals suggested in the guidance document (Table 11). Since an accurate prediction of O_3 precursor species is as important as ozone itself, model performance for Nitrogen Oxide (NO), Nitrogen Dioxide (NO_2), Isoprene and Non-Methane Hydro-carbon (NMHC) was also conducted. The results of this analysis have been documented in Hu et al., (2004).

Table 4-11 Performance statistics and EPA criteria

Metrics	Formulation	EPA criteria
Mean Normalized Bias	$\frac{1}{N}\sum_{i=1}^{N}\frac{\left(C_i^s - C_i^o\right)}{C_i^o}\times 100\%$	Less than ±15%
Mean Normalized Error	$\frac{1}{N}\sum_{i=1}^{N}\frac{\left\lvert C_i^s - C_i^o\right\rvert}{C_i^o}\times 100\%$	Less than 35%

The above-mentioned statistical analysis is followed by visual inspection of predicted concentrations fields. This helps in identifying dynamics of pollutant plumes in the region, and interpreting the performance issues related to individual monitors. For example, poor model performance at a monitoring station might be related to displacement of a plume due to error in wind direction. Finally, time series plots of predicted and observed hourly concentrations provide a stringent test of how well the model replicates the observed hourly concentration at the same time and location as the observed value. Problems with diurnal variation in predicted concentrations are readily apparent in a time series plot.

4.8.3.3 Modeling results at the 12-km grid resolution

A total of 106 monitoring stations are located within the 12-km modeling domain (Table 4, Appendix 4). Averaged over all monitoring stations, the Daily Mean Normalized Bias and Error in hourly O_3 predictions (Table 12) meets the EPA performance criteria on all episode days (i.e., August 13-19th 2000). Episode average MNB and MNE in hourly O_3 concentration at all monitoring stations located in the 12-km grid resolution domain are provided in Table 5, Appendix 4. The cumulative probability distribution curves (Figure 12) indicate that for 95 percent of all monitoring stations, the episode-average MNB is within ±15 percent. The MNE for almost all monitoring stations is less than 35 percent (Figure 4-13).

Table 4-12 Daily Mean Normalized Bias and Error in hourly O_3 concentration averaged over all monitoring stations

Date	Number of Observations greater than 40 ppb	Mean Normalized Bias (MNB)	Mean Normalized Error (MNE)
8/13/2000	1265	0.690	14.830
8/14/2000	1285	0.100	16.900
8/15/2000	1328	0.910	18.030
8/16/2000	1448	4.510	18.880
8/17/2000	1571	-3.290	19.680
8/18/2000	1583	-2.850	19.490
8/19/2000	1664	9.640	21.220

Figure 4-12 Cumulative probability distribution curves of episode-average Mean Normalized Bias in hourly O_3 concentration

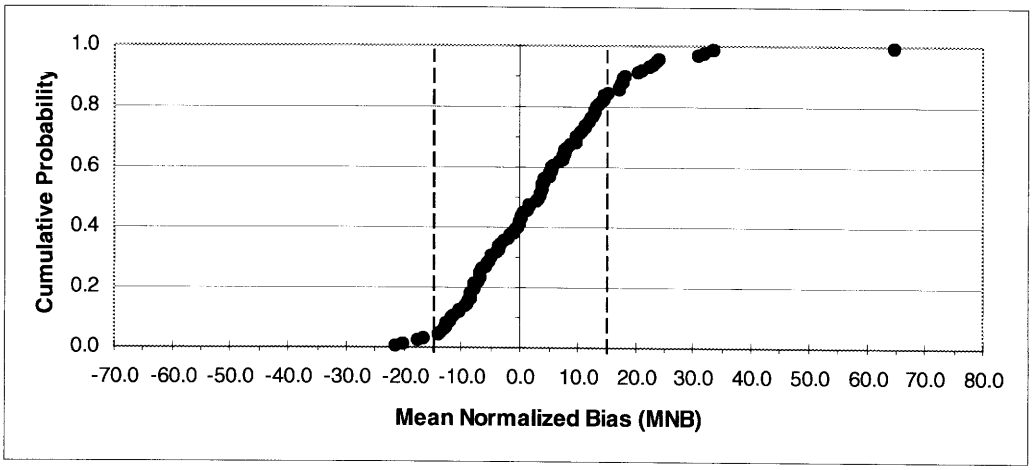
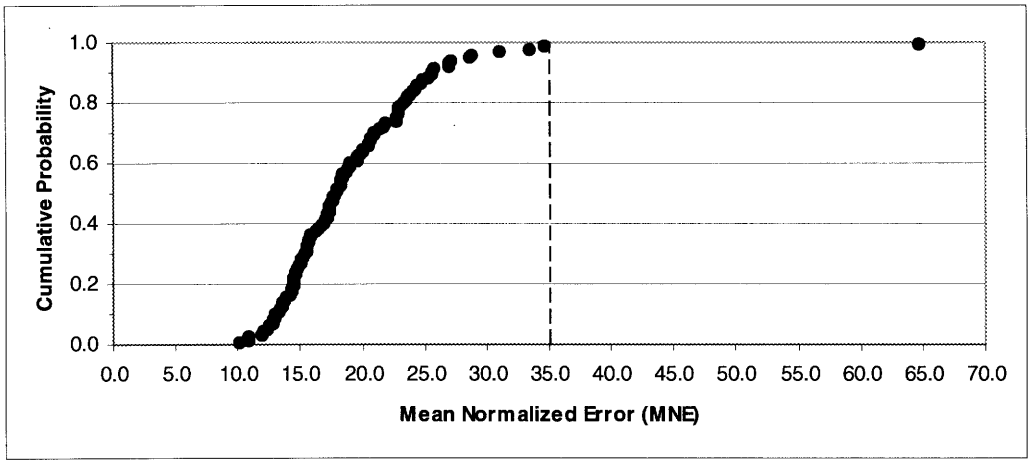


Figure 4-13 Cumulative probability distribution curves of episode-average Mean Normalized Error in hourly O_3 concentration



The daily Mean Normalized Bias and Error daily in peak O_3 concentration averaged over all monitoring station is provided in Table 4-13. The results meet the EPA criteria on all episode days. Episode average MNB and MNE in peak O_3 concentrations at all monitors located in the 12-km grid resolution domain are provided in Table 6, Appendix 4.

Table 4-13 Daily Mean Normalized Bias and Error in peak O_3 concentration averaged over all monitoring stations

Date	Number of stations	Mean Normalized Bias (MNB) in Peak O_3 Prediction	Mean Normalized Error (MNE) in Peak O_3 Prediction
8/13/2000	104	2.76	9.29
8/14/2000	104	-0.46	12.65
8/15/2000	104	1.03	12.54
8/16/2000	105	3.78	13.86
8/17/2000	105	-4.49	12.36
8/18/2000	105	1.16	15.22
8/19/2000	104	11.49	17.26

Time series plots of ozone concentrations observed at monitoring stations in the Augusta-Aiken and predicted by the model at 12-km grid resolution are provided in Figure 14 and 15. The 12-km grid resolution modeling simulation accurately predicts the diurnal variation in ozone concentration on all model days. Nighttime ozone concentrations at the Richmond County monitor are over-predicted on most days. At this station, observed ozone concentrations are very well simulated on all modeling days, except for August 17th, when the model under predicts the peak ozone concentration by 26ppb. The model under predicts of ozone at the Aiken County monitor on August 15th and over predicts on August 16th. Similar under prediction ozone can be seen on August 15th, 18th and 19th at the Barnwell County monitor in South Carolina.

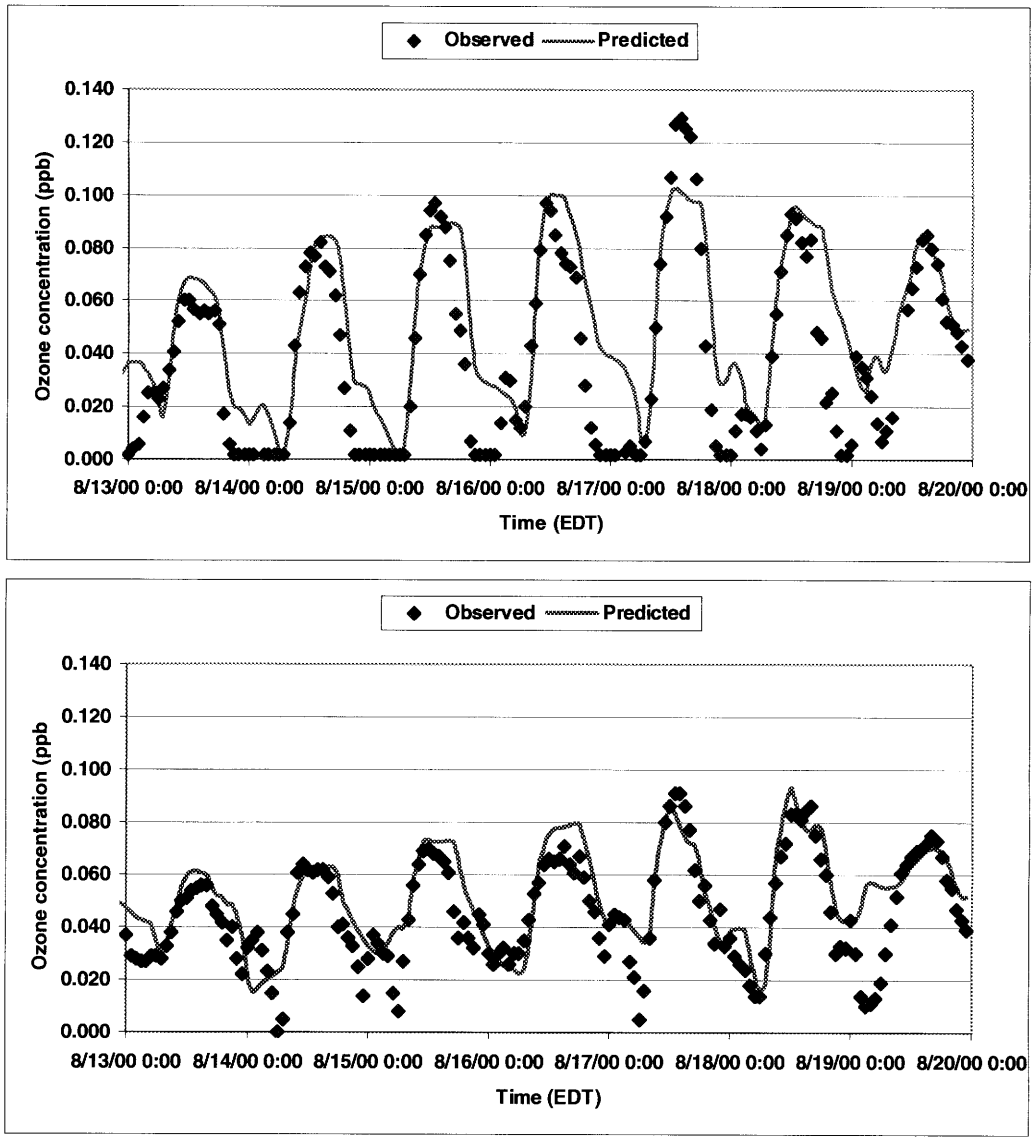


Figure 4-14 Predicted (at 12-km grid resolution) and observed hourly ozone concentration at monitoring stations in Richmond County, Georgia (top) and Edgefield County, South Carolina (bottom)

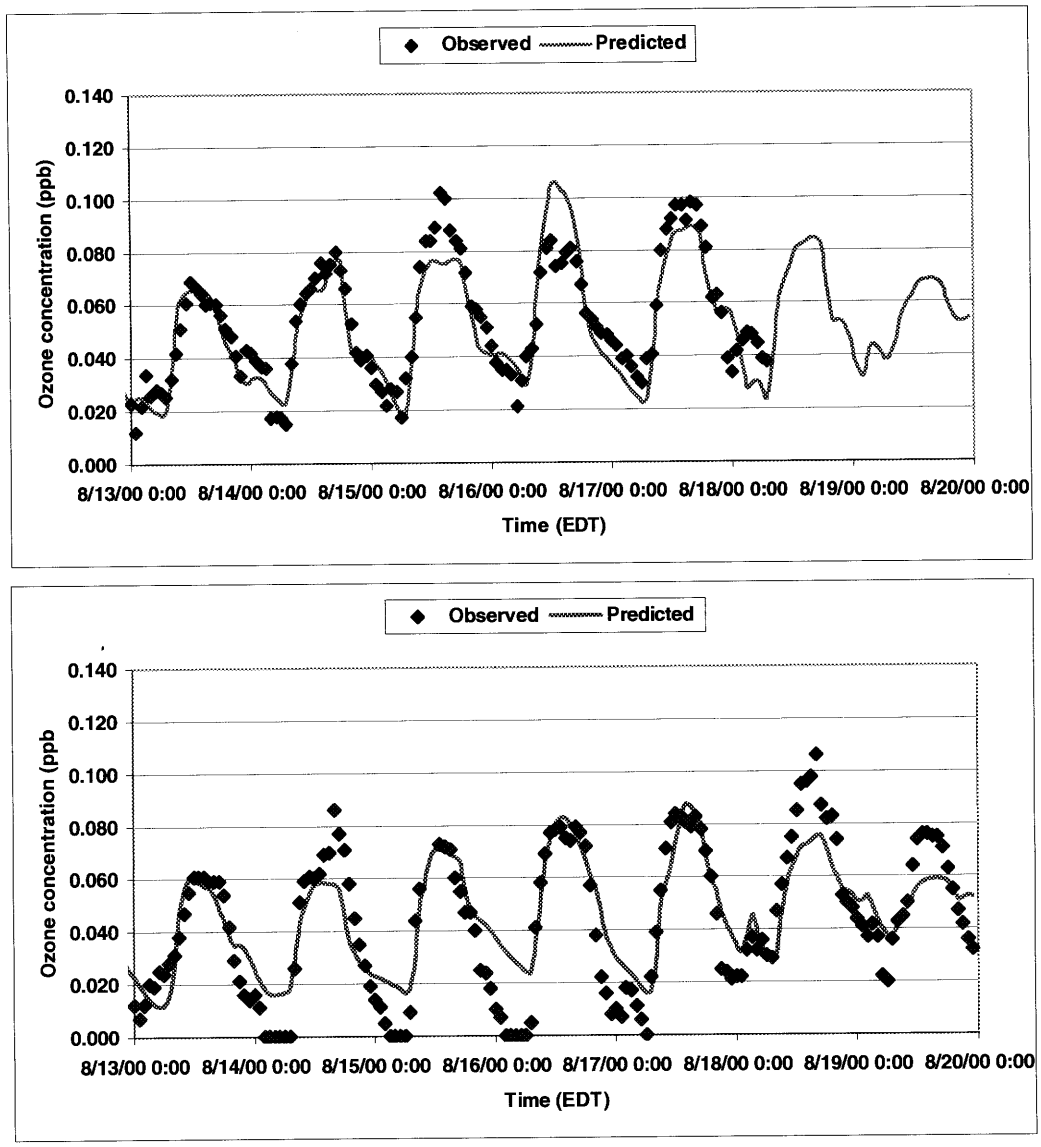


Figure 4-15 Predicted (at 12-km grid resolution) and observed hourly ozone concentration at monitoring stations in Aiken County (top) and Barnwell County, South Carolina (bottom)

4.8.3.4 Modeling results at the 4-km grid resolution

A total of 26 monitoring stations are located within the 4-km modeling domain (Table 7, Appendix 4). Averaged over all monitoring stations, the Mean Normalized Bias and Error in hourly O_3 predictions meets the EPA performance criteria (Table 14) on all episode days (i.e., August 13-19th 2000). Episode average MNB and MNE in hourly O_3 predictions at all monitors located in the 4-km grid resolution domain are provided in Table 8, Appendix 4. The cumulative probability distribution curves (Figure 16) indicate that for 98 percent of all monitoring stations, the episode-average MNB is within ±15 percent. The MNE for almost all monitoring stations is less than 35 percent (Figure 16).

Table 4-14 Daily Mean Normalized Bias and Error in hourly O_3 concentration averaged over all monitoring stations

Date	Number of Observations greater than 40 ppb	Mean Normalized Bias (MNB)	Mean Normalized Error (MNE)
8/13/2000	285	-4.02	13.17
8/14/2000	278	-3.12	18.49
8/15/2000	283	-2.87	20.02
8/16/2000	298	4.76	21.61
8/17/2000	339	-3.90	22.36
8/18/2000	376	-5.56	18.04
8/19/2000	391	-8.46	21.58

Figure 4-16 Cumulative probability distribution curves of episode-average Mean Normalized Bias in hourly O_3 concentration

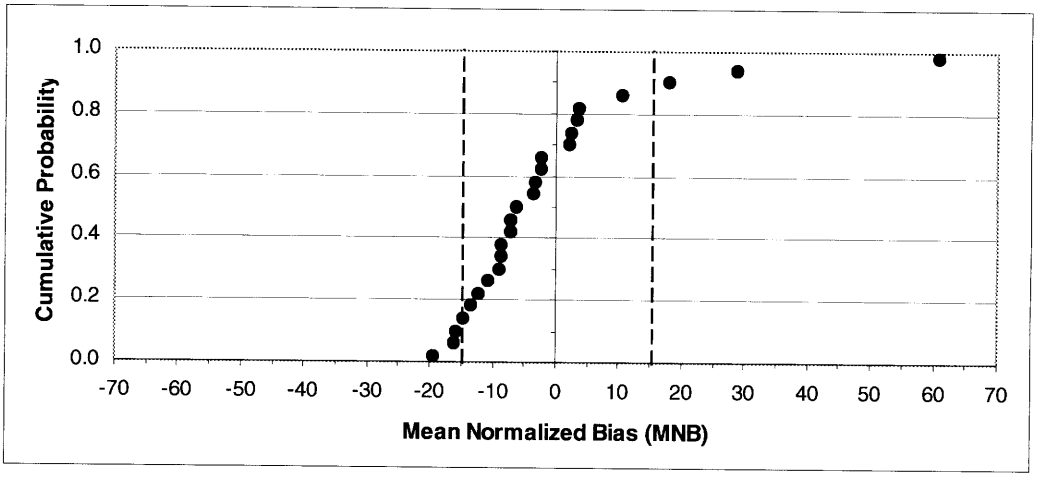
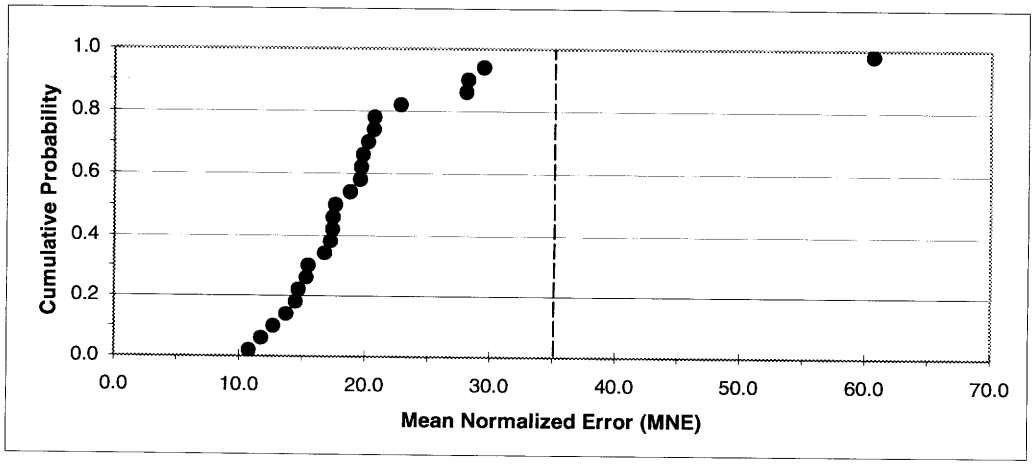


Figure 4-17 Cumulative probability distribution curves of episode-average Mean Normalized Error in hourly O_3 concentration



The daily Mean Normalized Bias and Error daily in peak O_3 concentration averaged over all monitoring station is provided in Table 15. The results meet the EPA criteria on all episode days. Episode average MNB and MNE in peak O_3 concentrations at all monitors located in the 4-km grid resolution domain are provided in Table 9, Appendix 4.

Table 4-15 Daily Mean Normalized Bias and Error in peak O_3 concentration averaged over all monitoring stations

Date	Number of Observations greater than 40 ppb	Mean Normalized Bias (MNB)	Mean Normalized Error (MNE)
8/13/2000	25	0.47	11.07
8/14/2000	24	-4.00	15.79
8/15/2000	24	0.78	15.20
8/16/2000	24	6.88	17.57
8/17/2000	24	-8.95	16.59
8/18/2000	24	-4.08	11.00
8/19/2000	23	-2.32	15.570

Time series plots of ozone concentrations observed at monitoring stations in the Augusta-Aiken and predicted by the model at 4-km grid resolution are provided in Figure 18 and 19. The 4-km grid resolution modeling simulation accurately predicts the diurnal variation in ozone concentration on all model days. Nighttime ozone concentrations at the Richmond County monitor are over-predicted on most days. Observed ozone concentrations at this station is very well simulated on all modeling days, except for August 17th and 19th when the model under predicts the peak ozone concentration by 28ppb and 20ppb and on August 19th when peak ozone concentration is under predicted by 10ppb at the monitor in Edgefield County on the same day. The model under predicts ozone at the Aiken County monitor on August 15th and 17th and over predicts on August 16th. Similar under prediction ozone can be seen on August 14th, 18th and 19th at the Barnwell monitor in South Carolina.

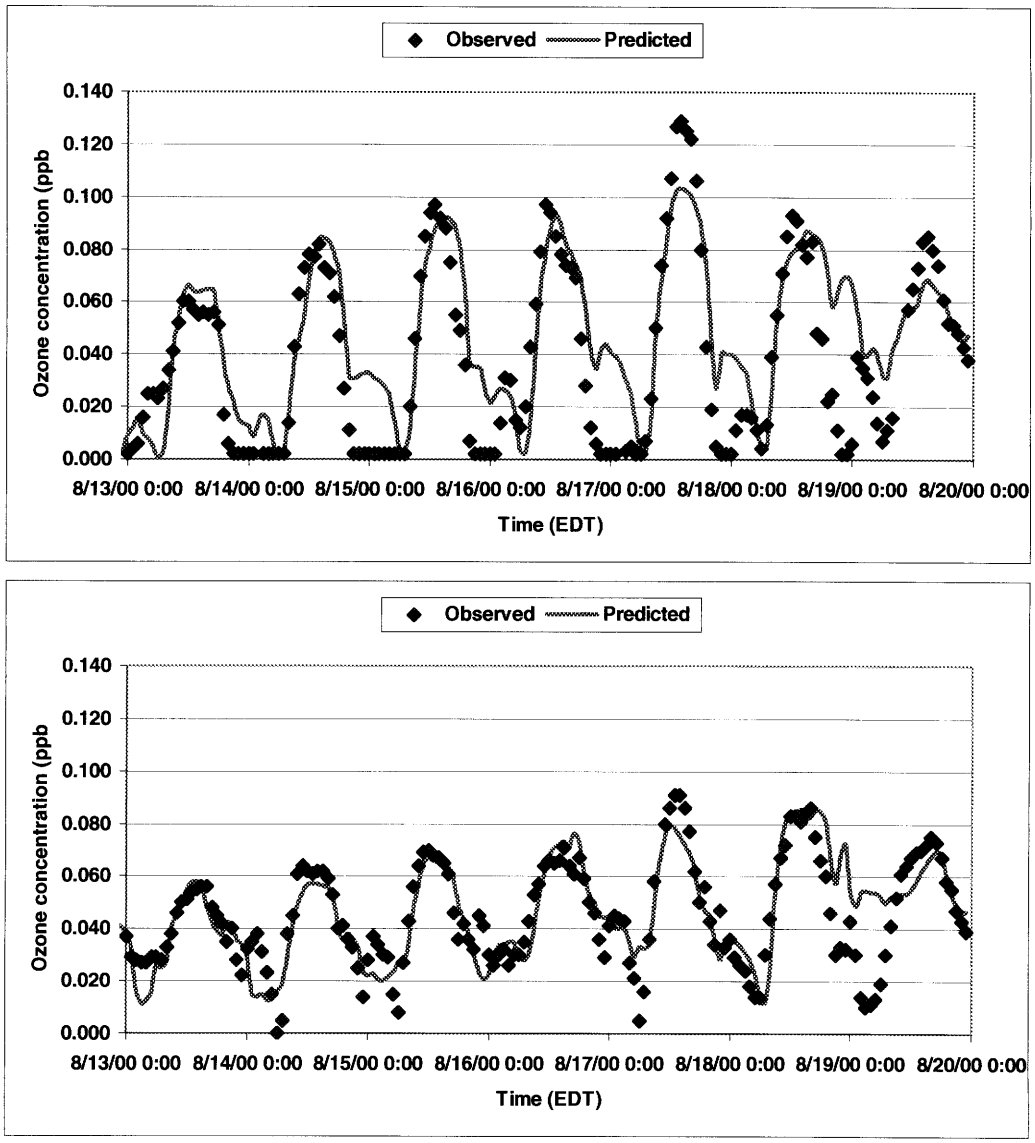


Figure 4-18 Predicted (at 4-km grid resolution) and observed hourly ozone concentration at monitoring stations in Richmond County, Georgia (top) and Edgefield County, South Carolina (bottom)

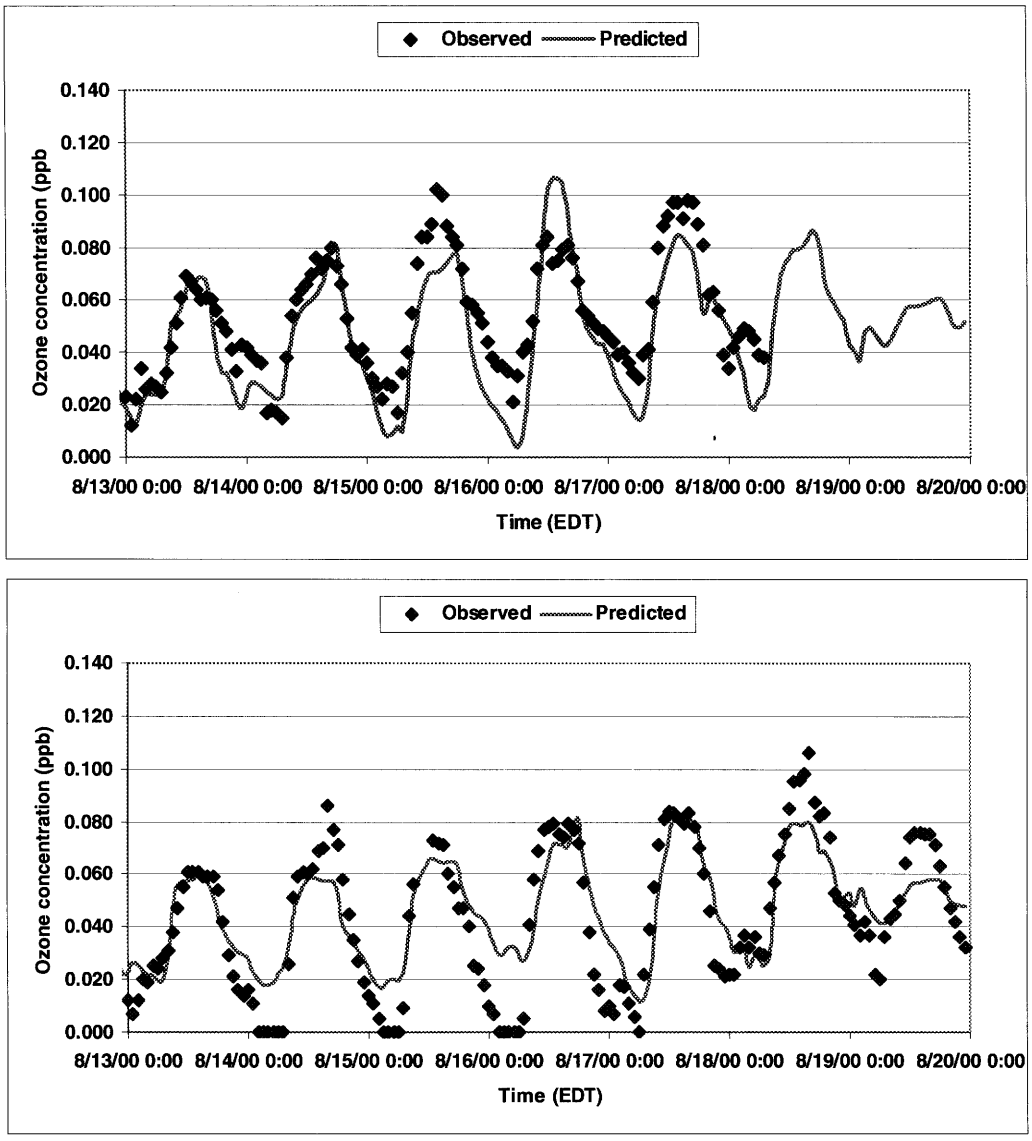


Figure 4-19 Predicted (at 4-km grid resolution) and observed hourly ozone concentration at monitoring stations in Aiken County (top) and Barnwell County, South Carolina (bottom)

4.9 Attainment Demonstration

4.9.1 Methodology

Attainment demonstration is a procedure laid down by EPA that assesses the attainment status of a region through analyses of air quality modeling results. The procedure is comprised of two sets of analyses. The first test, referred to in the guidance as the model attainment test, is an exercise in which a monitor-specific Future Design Value (FDV) is computed and compared with 84 ppb. If the FDV is less than or equal to 84 ppb, the monitor is in attainment. The FDV is computed by multiplying the ratio of future and current concentrations predicted "near" the monitor with the Base Design Value (BDV) of the monitor. The ratio is referred to as Relative Reduction Factor (RRF), and the BDV at the monitor is computed as the 3-year average of the 4th highest daily maximum 8-hour observed O_3 concentration. The term "near" refers to the "stencil" of grid-cells that are within a 15-km radius of the monitoring station. This corresponds to a 7x7 grid-cell stencil for a 4-km, and a 3x3 grid-cell stencil for a 12-km resolution grid. The guidance recommends that the highest predicted concentration in the stencil be selected for computing the RRF. It further suggests that CDV of the monitor include the episode year.

The second test, referred to in the guidance as the screening test, is intended to insure attainment of the standard at locations where there is currently no monitor. First, one or more locations with current predicted concentrations that consistently exceed those predicted near any monitor are selected. If the predicted 8-hour daily maximum is greater than 5 percent of the value observed at the monitoring location on 50 percent or more of the modeled days, a future design value is calculated following the procedure outlined in the guidance document.

Air quality model simulations for two future years (i.e., 2007 and 2012) were conducted in order to demonstrate attainment and maintenance of NAAQS in the Augusta-Aiken region. The BDV at monitoring stations is computed from observations recorded during the 1999 to 2001 ozone seasons.

Table 4-16 Base Design Value at monitoring stations in Augusta-Aiken

County Name	AIRS ID	8-hour O_3 Design Value
Richmond County, GA	132450091	0.087
Edgefield County, SC	450370001	0.081
Aiken County, SC	450030003	0.086
Barnwell County, SC	450110001	0.083

4.9.2 Attainment demonstration calculations for 2007 and 2012

Model attainment test calculations are shown in Table 17 and 18. The predicted concentrations from the modeling simulation at 12-km grid resolution have been used for these calculations. The results indicate that emission reductions from Federal and State emission controls reduce the daily maximum 8-hour O_3 concentration in the Augusta-Aiken by 12 ppb on average. The FDV for all monitoring stations are predicted to be well below 84 ppb. Similar results are obtained when predictions from

the 4-km grid resolution modeling results are used to calculate the monitor specific FDV.

Preliminary results indicate that "un-monitored" locations adjacent to the Augusta-Aiken will pass the screening test. A comprehensive analysis will be performed and submitted to EPA for review before the Early Action Compact is presented for public review.

Table 4-17 Attainment status of monitors in the Augusta-Aiken in 2007

Richmond							
Date	Observed (2001) Design Value	Max 8-hour Observed	Max 8-hour predicted 2000	Max 8-hour predicted 2007	If Max-8hr predicted > 70ppb	Relative Reduction Factor	Future (2007) Design Value
13th		0.0564	0.0694	0.0608	0		
14th		0.0724	0.0782	0.0685	1		
15th		0.0820	0.0874	0.0749	1		
16th		0.0811	0.1095	0.0961	1		
17th		0.1110	0.1011	0.0865	1		
18th		0.0796	0.0977	0.0841	1		
19th		0.0723	0.0803	0.0685	1		
	0.087		0.092	0.080		0.864	0.07516
Edgefield							
13th		0.0520	0.0656	0.0577	0		
14th		0.0605	0.0782	0.0685	1		
15th		0.0650	0.0874	0.0749	1		
16th		0.0655	0.1095	0.0961	1		
17th		0.0779	0.0988	0.0852	1		
18th		0.0789	0.0977	0.0841	1		
19th		0.0696	0.0803	0.0685	1		
	0.081		0.092	0.080		0.865	0.07007
Aiken							
13th		0.0623	0.0694	0.0608	0		
14th		0.0723	0.0782	0.0685	1		
15th		0.0890	0.0874	0.0749	1		
16th		0.0778	0.1095	0.0961	1		
17th		0.0936	0.1011	0.0865	1		
18th		0.0426	0.0977	0.0841	1		
19th		0.0000	0.0803	0.0685	1		
	0.086		0.092	0.080		0.864	0.07429
Barnwell							
13th		0.05863	0.06527	0.05614	0		
14th		0.0695	0.0707	0.05874	1		
15th		0.05812	0.07859	0.0674	1		
16th		0.07638	0.10073	0.08694	1		
17th		0.08	0.08818	0.0745	1		
18th		0.0915	0.09637	0.08305	1		

19th		0.07175	0.06611	0.05622	0		
	0.083		0.087	0.074		0.853	0.07079

Table 4-18 Attainment status of monitors in the Augusta-Aiken in 2012

Richmond							
Date	Observed (2001) Design Value	Max 8-hour Observed	Max 8-hour predicted 2000	Max 8-hour predicted 2007	If Max-8hr predicted > 70ppb	Relative Reduction Factor	Future (2012) Design Value
13th		0.0564	0.0694	0.05895	0		
14th		0.0724	0.0782	0.06629	1		
15th		0.0820	0.0874	0.07079	1		
16th		0.0811	0.1095	0.09228	1		
17th		0.1110	0.1011	0.08126	1		
18th		0.0796	0.0977	0.07949	1		
19th		0.0723	0.0803	0.06416	1		
	0.087		0.092	0.076		0.820	0.07131
Edgefield							
13th		0.0520	0.0656	0.05594	0		
14th		0.0605	0.0782	0.06629	1		
15th		0.0650	0.0874	0.07079	1		
16th		0.0655	0.1095	0.09228	1		
17th		0.0779	0.0988	0.08021	1		
18th		0.0789	0.0977	0.07949	1		
19th		0.0696	0.0803	0.06459	1		
	0.081		0.092	0.076		0.822	0.06658
Aiken							
13th		0.0623	0.0694	0.05895	0		
14th		0.0723	0.0782	0.06629	1		
15th		0.0890	0.0874	0.07079	1		
16th		0.0778	0.1095	0.09228	1		
17th		0.0936	0.1011	0.08126	1		
18th		0.0426	0.0977	0.07949	1		
19th		0.0000	0.0803	0.06416	1		
	0.086		0.092	0.076		0.820	0.07049
Barnwell							
13th		0.05863	0.06527	0.05465	0		
14th		0.0695	0.0707	0.05759	1		
15th		0.05812	0.07859	0.06435	1		
16th		0.07638	0.10073	0.0828	1		
17th		0.08	0.08818	0.07121	1		
18th		0.0915	0.09637	0.07842	1		
19th		0.07175	0.06611	0.05389	0		
	0.083		0.087	0.071		0.815	0.06768

4.10 Conclusions

In spite of rapid population and economic growth, Georgia and the surrounding states will witness a significant reduction in ozone and precursor emissions due to technological advancement and already legislated Federal, State and Local emission controls. These reductions will contribute significantly towards improvement in regional air quality. Atmospheric modeling conducted to-date, and described in this section demonstrates that the Augusta-Aiken will attain the 8-hour ozone standard in 2007 and maintain this classification till 2012.

References:

Coats, C. J., Jr. and Houyoux, M. R., 1996, "Fast Emissions Modeling with the Sparse Matrix Operator Kernel Emissions Modeling System", Presented at the Emissions Inventory: Key to planning, Permits, Compliance and Reporting, Air and Waste Management Association, New Orleans, Louisiana

Dennis, R. L., Byun, D. W., Novak, J. H., Galluppi, K. J., Coats, C. J., and Vouk, M. A., 1996, The next generation of integrated air quality modeling: EPA's Models-3, *Atmos. Environ.*, 20, 12, 1925-1936

Dudhia, J., 1993, A non-hydrostatic version of the Penn State / NCAR mesoscale model: Validation tests and simulation of an Atlantic cyclone and cold front. *Mon. Wea. Rev.,* 121, 1493-1513

Fall line Air Quality Study Alliance, 1999, Fall line Air Quality Study: An outline for assessing urban and regional air pollution, identifying the sources of pollutants and pollutant precursors, and recommending solutions to realized and potential poor air quality in the Augusta, Macon, and Columbus, Georgia metropolitan areas

Grell, G.A., Dudhia, J., and Stauffer, D.R., 1994, The Penn State/NCAR Mesoscale Model (MM5). NCAR Technical Note, NCAR/TN-398+STR, 138 pp

Deuel H.P., and Douglas S.G., 1998, Episode Selection for the Integrated Analysis of Ozone, Visibility, and Acid Deposition for the Southern Appalachian Mountains, SYSAPP_98/07r1, Systems Applications International, Inc., San Rafael, CA

Douglas S.G., Hudischewskyj A.B., Glass G.L., and Alvarez A.R. 2002, Ozone Episode Selection for Urban Areas in Northern Georgia and Northern Alabama (1995-2001), Systems Applications International, Inc., San Rafael, CA.

Hu et al., 2003, Meteorological modeling of the August 11-20 air pollution episode, *Report* to the Georgia Department of Natural Resources, Atlanta, Georgia

Hu et al., 2004, Air quality modeling of the August 11-20, 2000 air pollution episode, *Draft report* to the Georgia Department of Natural Resources, Atlanta, Georgia

EPA, 1999, Draft guidance on the use of models and other analyses in the attainment demonstrations for the 8-hour ozone NAAQS, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, EPA-454/R-99-004

5. Control Strategy and Emission Budgets

There are several state and local level controls that will be implemented in the Augusta-Richmond County MSA area that have not been accounted for in the modeling attainment demonstration. This section presents the controls that will be implemented at the state and local levels to help the area comply with the 8-hour ozone NAAQS.

5.1 State Level Controls

At the state level, two controls that will be implemented are an open burning ban during the ozone season and stage I vapor recovery.

5.1.1 Open Burning

An open burning ban will be implemented at the state level in the Augusta – Richmond County MSA in Richmond and Columbia Counties. The open burning ban will be in effect for the duration of the ozone season, which is May 1 through September 30. Some types of open burning have always been prohibited by the Georgia Rules for Air Quality Control. This will prohibit several additional types of open burning activities during the ozone season as follows:

- Burning of leaves, tree limbs, or other yard wastes.
- Burning of vegetative waste from land clearing (includes a ban on the use of air curtain destructors).
- Burning over of forest land by the owners of the land.

A few types of open fires are still allowed, provided there are no local ordinances that prohibit them. These include:

- Fires for carrying out recognized agricultural practices.
- Fires for recreational purposes or for cooking food.
- Fires for training fire-fighting personnel, except acquired structure burns are prohibited.

Emissions reductions estimates from open burning in the Augusta area, including Richmond and Columbia Counties, are estimated to be approximately 0.71 tpd of NOx and 1.75 tpd of VOC.

5.1.2 Stage I Vapor Recovery

Stage I vapor recovery will be implemented at the state level in the Augusta-Richmond County MSA in Richmond and Columbia Counties. Stage I vapor recovery is used during the refueling of gasoline storage tanks to reduce emissions of VOCs. Vapors in the storage tanks, which are displaced by the incoming gasoline, would be routed into the gasoline tank truck and therefore captured, instead of being vented to the atmosphere. Emissions reductions estimates from stage I vapor recovery in the Augusta area, including Richmond and Columbia Counties, are

estimated to be approximately 1.61 tpd of VOCs in 2007 and 1.81 tpd of VOCs in 2012.

5.2 Local Level Controls

In addition to the open burning bans and Stage I vapor recovery measures discussed above, Richmond County and the City of Augusta will be pursuing a number of local measures, such as truck stop electrification projects, school bus conversions and retrofits, and voluntary smog alert programs. A more detailed list of control measures under consideration was submitted with the December 2003 milestone report. Attachment B contains a copy of a draft resolution of support for the Augusta/Aiken Early Action Compact that the Augusta/Richmond Council will be adopting in April 2004.

ATTACHMENT A:

Supporting Information for Atmospheric Modeling

Table 1 MM5/SMOKE/CMAQ Modeling Applications

Figure 1 Atmospheric Modeling Process

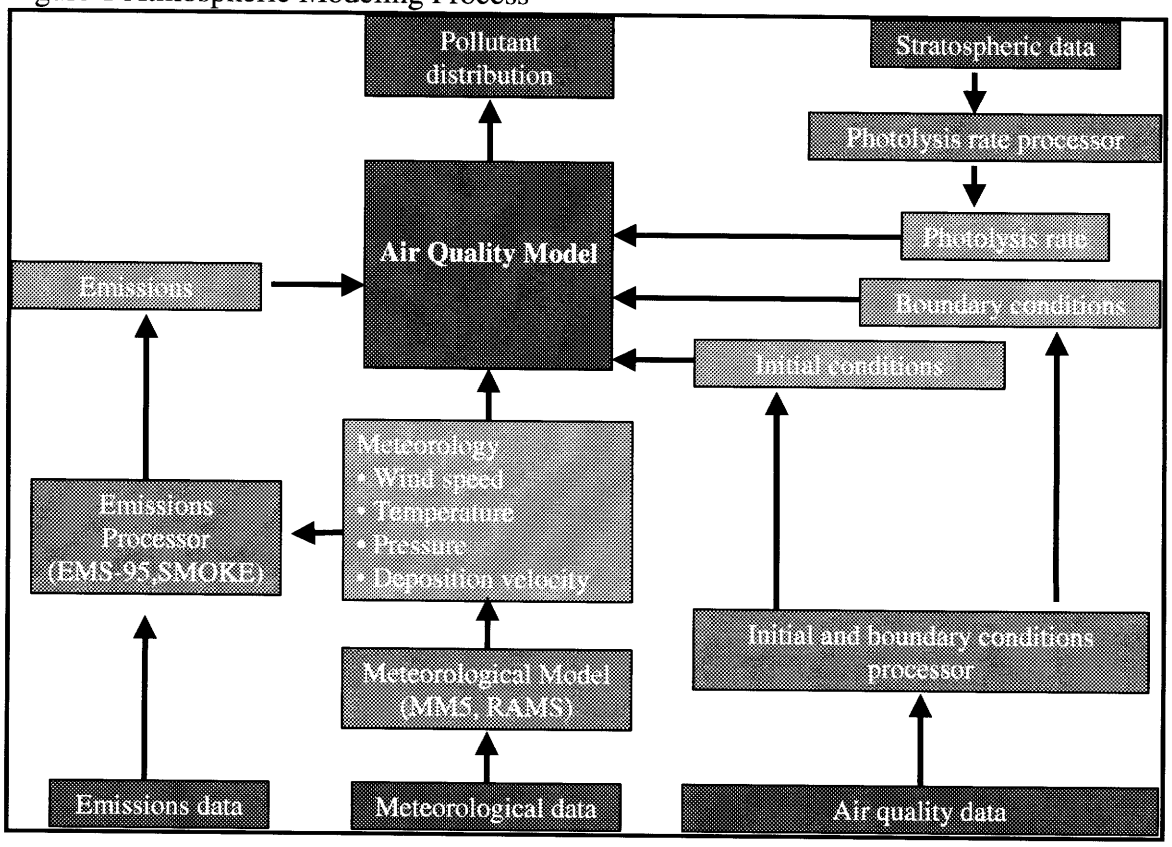


Figure 2 Atmospheric Modeling and Emissions ntrol Strategy Development Process

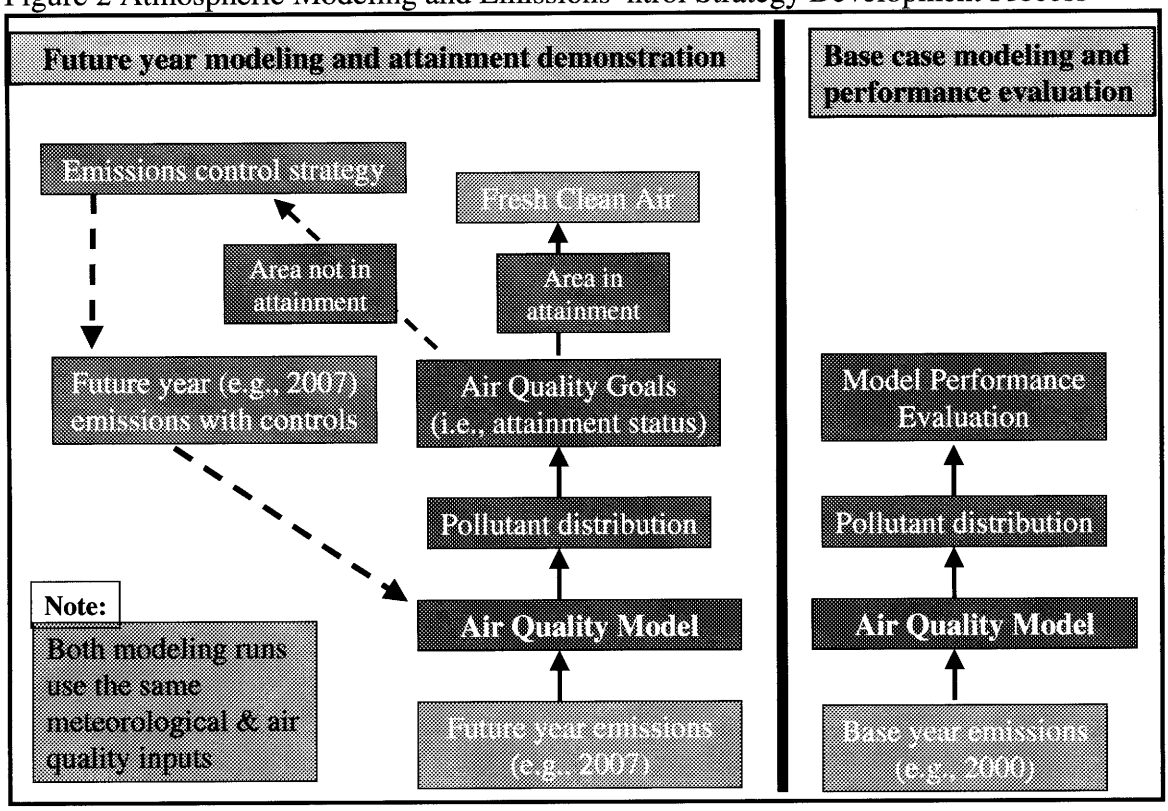


Table 2 Locations of Meteorological Modeling Stations

Table 3List of SMOKE input files for emissions processing

Category	SMOKE Logical name	Base year	Future year (i.e., 2007 & 2012)
Emissions inventory	PTINV	ptinv.faqs2000.ida.txt	ptinv.faqs2007.ida.txt, ptinv.faqs2012.ida.txt
	PTHOUR	cem.faqs.aug2000.txt	cem.faqs.aug2007.txt cem.faqs.aug2012.txt
	ARINV	arinv.faqs2000.ida.txt arinv.nonroad.faqs2000.ida.txt	arinv.faqs2007.ida.txt arinv.nonroad.faqs2012.ida.txt
	MBINV	mbinv.vmt.faqs2000.txt	mbinv.vmt.faqs2007.txt mbinv.vmt.faqs2012.txt
Spatial surrogates	AGPRO	agpro.36km.census2000.txt, agpro.12km. census2000.txt, agpro.4km. census2000.txt	
	MGPRO	mgpro.36km.census2000.txt, mgpro.12km.census2000.txt, mgpro.4km.census2000.txt	
	AGREF	agref.faqs2000.txt	
	MGREF	mgref.faqs2000.txt	
Temporal profiles	ATPRO/PTPRO	aptpro.faqs2000.txt	
	ATREF/PTREF	aptref.faqs2000.txt	
	MTPRO	mtpro.faqs2000.txt	
	MTREF	mtref.faqs2000.txt	
Speciation profiles	GSPRO	gspro.saprc99.faqs2000.txt	
	GSREF	gsref.sparc99.faqs2000.txt	
MOBILE6 inputs	M6LIST	m6list.faqs2000.2000.txt	m6list.faqs2007.txt m6list.faqs2012.txt
	MCREF	mcref.faqs2000.txt	mcref.faqs2007.txt mcref.faqs2007.txt
	MVREF	mvref.faqs2000.txt	mvref.faqs2007.txt mvref.faqs2007.txt
BEIS3 inputs	BELD3_A	LAND_A.faqs36, LAND_A.faqs12, LAND_A.faqs4	
	BELD3_B	LAND_B.faqs36, LAND_B.faqs12, LAND_B.faqs4	
	BELD3_TOT	LAND_T.faqs36, LAND_T.faqs12, LAND_T.faqs4	
Meteorological Inputs	GRID_CRO2D	GRIDCRO2D_faqs36.aug00, GRIDCRO2D_faqs12.aug00, GRIDCRO2D_faqs4.aug00	
	GRID_CRO3D	GRIDCRO3D_faqs36.aug00, GRIDCRO3D_faqs12.aug00, GRIDCRO3D_faqs4.aug00	
	MET_CRO2D	METCRO2D_faqs36.aug00, METCRO2D_faqs12.aug00, METCRO2D_faqs4.aug00	
	MET_CRO3D	METCRO3D_faqs36.aug00, METCRO3D_faqs12.aug00, METCRO3D_faqs4.aug00	
	MET_DOT3D	METDOT3D_faqs36.aug00, METDOT3D_faqs12.aug00, METDOT3D_faqs4.aug00	

Table 4 Locations of air quality monitoring stations on the 12 and 4-km resolution modeling grids used in performance evaluation

ID	AIRSID	State/County	12-km grid		4-km grid		Elevation (meters above sea-level)	Location Type
			COL	ROW	COL	ROW		
5	010270001	AL Clay	15	30	1	39	1063	RURAL
9	010510001	AL Elmore	12	23	-	-	156	RURAL
15	010731003	AL Jefferson	6	32	-	-	183	SUBURBAN
16	010731005	AL Jefferson	5	31	-	-	155	RURAL
18	010732006	AL Jefferson	7	31	-	-	170	SUBURBAN
19	010735002	AL Jefferson	8	34	-	-	201	RURAL
20	010736002	AL Jefferson	7	33	-	-	171	SUBURBAN
21	010790002	AL Lawrence	3	40	-	-	301	RURAL
23	010890014	AL Madison	8	43	-	-	183	SUBURBAN
36	011011002	AL Montgomery	11	22	-	-	220	SUBURBAN
39	011030011	AL Morgan	5	41	-	-	0	URBAN AND CENTER CITY
40	011170004	AL Shelby	7	30	-	-	600	RURAL
49	120030002	FL Baker	43	4	-	-	20	RURAL
50	120050006	FL Bay	17	3	-	-	4	RURAL
80	120310077	FL Duval	49	7	-	-	12	RURAL
81	120311003	FL Duval	49	5	-	-	3	SUBURBAN
82	120330004	FL Escambia	5	5	-	-	35	SUBURBAN
83	120330018	FL Escambia	4	3	-	-	3	SUBURBAN
84	120330024	FL Escambia	4	3	-	-	10	SUBURBAN
99	120590004	FL Holmes	17	8	-	-	25	RURAL
111	120730012	FL Leon	28	5	-	-	20	SUBURBAN
147	121130014	FL Santa Rosa	17	2	-	-	3	SUBURBAN
156	130210012	GA Bibb	32	27	53	30	54	RURAL
157	130219999*	GA Bibb	30	27	48	30	126	NA
158	130510021	GA Chatham	52	22	-	-	2	SUBURBAN
159	130570001	GA Cherokee	23	41	27	70	1194	RURAL
160	130670003	GA Cobb	23	38	27	61	0	SUBURBAN
161	130770002	GA Coweta	23	32	25	44	900	SUBURBAN
162	130850001	GA Dawson	27	41	39	72	372	RURAL
163	130890002	GA Dekalb	26	35	35	53	308	SUBURBAN
164	130893001	GA Dekalb	26	36	36	57	0	RURAL
166	130970004	GA Douglas	22	35	23	53	1145	SUBURBAN
168	131130001	GA Fayette	25	33	32	46	258	SUBURBAN
171	131210055	GA Fulton	25	35	33	53	292	SUBURBAN
174	131270006	GA Glynn	49	14	-	-	5	SUBURBAN
175	131350002	GA Gwinnett	27	38	39	61	290	SUBURBAN
176	131510002	GA Henry	27	33	38	46	900	RURAL
178	132130003	GA Murray	23	45	-	-	794	RURAL
181	132150008	GA Muscogee	22	24	22	20	101	SUBURBAN
183	132151003	GA Muscogee	22	24	24	20	122	RURAL

ID	AIRSID	State/County	12-km grid		4-km grid		Elevation (meters above sea-level)	Location Type
			COL	ROW	COL	ROW		
187	132230003	GA Paulding	20	37	17	58	417	RURAL
188	132450091	GA Richmond	43	34	87	50	46	SUBURBAN
189	132459999*	GA Richmond	43	35	85	53	111	NA
190	132470001	GA Rockdale	28	34	40	50	219	RURAL
192	132611001	GA Sumter	29	19	43	5	10	RURAL
193	370030003	NC Alexander	47	57	-	-	339	SUBURBAN
195	370110002	NC Avery	42	57	-	-	987	RURAL
199	370210030	NC Buncombe	37	52	-	-	675	SUBURBAN
201	370270003	NC Caldwell	45	57	-	-	366	URBAN AND CENTER CITY
211	370590002	NC Davie	52	57	-	-	219	SUBURBAN
221	370670022	NC Forsyth	54	60	-	-	287	URBAN AND CENTER CITY
225	370671008	NC Forsyth	55	59	-	-	285	RURAL
229	370870004	NC Haywood	34	52	-	-	805	SUBURBAN
231	370870035	NC Haywood	36	51	-	-	1585	RURAL
232	370870036	NC Haywood	34	53	-	-	1550	RURAL
233	370990005	NC Jackson	32	52	-	-	1433	RURAL
238	371090004	NC Lincoln	47	53	-	-	270	RURAL
251	371190041	NC Mecklenburg	51	51	-	-	232	URBAN AND CENTER CITY
252	371191005	NC Mecklenburg	50	50	-	-	195	RURAL
253	371191009	NC Mecklenburg	51	52	-	-	0	RURAL
265	371590021	NC Rowan	53	55	-	-	240	RURAL
266	371590022	NC Rowan	51	54	-	-	270	SUBURBAN
267	371730002	NC Swain	31	51	-	-	560	SUBURBAN
268	371790003	NC Union	53	49	-	-	200	SUBURBAN
274	371990003	NC Yancey	39	55	-	-	1982	RURAL
275	450010001	SC Abbeville	40	42	76	74	204	RURAL
276	450030003	SC Aiken	45	33	92	48	91	SUBURBAN
278	450070003	SC Anderson	39	46	-	-	300	SUBURBAN
279	450110001	SC Barnwell	48	33	100	48	91	RURAL
286	450210002	SC Cherokee	43	50	-	-	296	RURAL
287	450230002	SC Chester	48	47	-	-	201	RURAL
289	450290002	SC Colleton	52	31	-	-	11	RURAL
292	450370001	SC Edgefield	44	37	90	59	177	RURAL
294	450450009	SC Greenville	40	47	-	-	0	SUBURBAN
297	450730001	SC Oconee	33	46	-	-	658	RURAL
298	450770002	SC Pickens	36	45	-	-	216	RURAL
299	450790007	SC Richland	51	41	-	-	122	SUBURBAN
300	450790021	SC Richland	52	39	-	-	34	RURAL
302	450791002	SC Richland	51	41	-	-	134	RURAL
305	450791006	SC Richland	52	38	-	-	30	RURAL

ID	AIRSID	State/County	12-km grid		4-km grid		Elevation (meters above sea-level)	Location Type
			COL	ROW	COL	ROW		
306	450830009	SC Spartanburg	41	48	-	-	265	RURAL
307	450870001	SC Union	46	44	-	-	113	RURAL
311	450910006	SC York	48	48	-	-	222	SUBURBAN
313	470010101	TN Anderson	25	56	-	-	238	RURAL
317	470090102	TN Blount	28	53	-	-	564	RURAL
323	470370011	TN Davidson	6	57	-	-	165	URBAN AND CENTER CITY
325	470370026	TN Davidson	7	56	-	-	186	RURAL
337	470650028	TN Hamilton	19	47	-	-	62	RURAL
338	470651011	TN Hamilton	18	48	-	-	259	RURAL
345	470890002	TN Jefferson	29	57	-	-	310	RURAL
347	470930021	TN Knox	28	57	-	-	299	RURAL
350	470931020	TN Knox	27	56	-	-	322	SUBURBAN
351	470931030	TN Knox	27	55	-	-	265	SUBURBAN
352	470990002	TN Lawrence	1	47	-	-	252	RURAL
361	471210104	TN Meigs	20	49	-	-	244	RURAL
362	471251010	TN Montgomery	3	60	-	-	169	RURAL
365	471410004	TN Putnam	16	57	-	-	445	RURAL
368	471451020	TN Roane	24	55	-	-	304	RURAL
369	471490101	TN Rutherford	8	52	-	-	225	RURAL
370	471550101	TN Sevier	30	54	-	-	1243	RURAL
371	471550102	TN Sevier	30	52	-	-	2021	RURAL
385	471650007	TN Sumner	7	58	-	-	143	RURAL
386	471650101	TN Sumner	8	59	-	-	189	RURAL
389	471870106	TN Williamson	4	54	-	-	287	RURAL
390	471890103	TN Wilson	10	56	-	-	210	RURAL

Table 5 Episode Average Mean Normalized Bias and Error in hourly ozone concentration at monitoring stations located in the 12-km modeling domain

State/County	Monitor Type	AIRS ID	Number of Observations greater than 40 ppb	Mean Normalized Bias (MNB)	Mean Normalized Error (MNE)
AL Clay	RURAL	10270001	142	2.85	10.10
AL Elmore	RURAL	10510001	171	-17.67	25.60
AL Jefferson	SUBURBAN	10731003	114	17.73	28.75
AL Jefferson	RURAL	10731005	104	24.05	27.19
AL Jefferson	SUBURBAN	10732006	124	-5.05	22.91
AL Jefferson	RURAL	10735002	119	3.78	12.04
AL Jefferson	SUBURBAN	10736002	106	20.36	24.79
AL Lawrence	RURAL	10790002	177	-8.51	15.52
AL Madison	SUBURBAN	10890014	129	8.20	15.55
AL Montgomery	SUBURBAN	11011002	128	0.61	14.43
AL Morgan	URBAN	11030011	140	-11.43	17.65
AL Shelby	RURAL	11170004	134	-14.00	18.88
FL Baker	RURAL	120030002	115	12.88	16.48
FL Bay	RURAL	120050006	208	-20.32	24.08
FL Duval	RURAL	120310077	105	3.71	28.71
FL Duval	SUBURBAN	120311003	100	17.35	25.59
FL Escambia	SUBURBAN	120330004	117	-10.34	23.86
FL Escambia	SUBURBAN	120330018	182	-3.67	14.20
FL Escambia	SUBURBAN	120330024	158	-0.31	14.28
FL Holmes	RURAL	120590004	117	5.12	14.53
FL Leon	SUBURBAN	120730012	107	12.85	15.82
FL Santa Rosa	SUBURBAN	121130014	142	-11.75	15.29
GA Bibb	RURAL	130210012	142	-6.89	17.11
GA Bibb	NA	130219999	164	-6.94	18.34
GA Chatham	SUBURBAN	130510021	150	10.29	18.95
GA Cherokee	RURAL	130570001	43	64.74	64.74
GA Cobb	SUBURBAN	130670003	135	7.52	15.67
GA Coweta	SUBURBAN	130770002	147	-9.00	19.75
GA Dawson	RURAL	130850001	119	22.53	23.12
GA De Kalb	SUBURBAN	130890002	107	13.77	20.67
GA De Kalb	RURAL	130893001	131	3.46	20.99
GA Douglas	SUBURBAN	130970004	190	-2.64	18.66
GA Fayette	SUBURBAN	131130001	82	-3.27	19.01
GA Fulton	SUBURBAN	131210055	131	-7.94	25.86
GA Glynn	SUBURBAN	131270006	149	9.68	17.66
GA Gwinnett	SUBURBAN	131350002	128	-2.04	11.85
GA Henry	RURAL	131510002	128	-8.63	17.22
GA Murray	RURAL	132130003	229	-5.01	14.28
GA Muscogee	SUBURBAN	132150008	147	3.33	20.04

State/County	Monitor Type	AIRS ID	Number of Observations greater than 40 ppb	Mean Normalized Bias (MNB)	Mean Normalized Error (MNE)
GA Muscogee	RURAL	132151003	128	-0.75	16.76
GA Paulding	RURAL	132230003	183	0.11	15.11
GA Richmond	SUBURBAN	132450091	108	12.21	18.20
GA Richmond	NA	132459999	45	-0.87	12.79
GA Rockdale	RURAL	132470001	131	1.48	16.97
GA Sumter	RURAL	132611001	157	-16.64	19.59
NC Alexander	SUBURBAN	370030003	135	0.15	12.86
NC Avery	RURAL	370110002	106	14.52	17.54
NC Bunmbe	SUBURBAN	370210030	101	21.13	24.46
NC Caldwell	URBAN	370270003	114	4.20	13.21
NC Davie	SUBURBAN	370590002	115	-8.52	12.92
NC Forsyth	URBAN	370670022	109	11.22	21.82
NC Forsyth	RURAL	370671008	113	-1.54	21.37
NC Haywood	SUBURBAN	370870004	98	12.00	15.35
NC Haywood	RURAL	370870035	221	5.51	14.68
NC Haywood	RURAL	370870036	215	1.19	15.63
NC Jackson	RURAL	370990005	233	9.83	17.28
NC Lincoln	RURAL	371090004	120	-12.65	16.27
NC Mecklenburg	URBAN	371190041	118	5.54	22.80
NC Mecklenburg	RURAL	371191005	122	-5.10	27.06
NC Mecklenburg	RURAL	371191009	127	-13.08	25.35
NC Rowan	RURAL	371590021	131	-3.48	13.69
NC Rowan	SUBURBAN	371590022	137	-3.85	17.34
NC Swain	SUBURBAN	371730002	90	18.28	20.46
NC Union	SUBURBAN	371790003	113	12.65	21.01
NC Yancey	RURAL	371990003	222	7.64	18.27
SC Abbeville	RURAL	450010001	106	30.81	31.01
SC Aiken	SUBURBAN	450030003	116	-5.77	13.38
SC Anderson	SUBURBAN	450070003	170	-12.83	23.50
SC Barnwell	RURAL	450110001	122	-7.33	13.63
SC Cherokee	RURAL	450210002	153	-6.39	17.89
SC Chester	RURAL	450230002	122	15.10	18.02
SC Colleton	RURAL	450290002	111	10.67	14.78
SC Edgefield	RURAL	450370001	128	7.57	12.40
SC Greenville	SUBURBAN	450450009	153	-12.15	22.83
SC Oconee	RURAL	450730001	224	4.12	15.16
SC Pickens	RURAL	450770002	130	3.60	10.79
SC Richland	SUBURBAN	450790007	138	-9.32	20.46
SC Richland	RURAL	450790021	80	22.94	24.86
SC Richland	RURAL	450791002	159	-10.59	22.91

State/County	Monitor Type	AIRS ID	Number of Observations greater than 40 ppb	Mean Normalized Bias (MNB)	Mean Normalized Error (MNE)
SC Richland	RURAL	450791006	29	33.52	33.52
SC Spartanburg	RURAL	450830009	119	6.69	17.25
SC Union	RURAL	450870001	97	13.40	15.58
TN Blount	RURAL	470090101	227	-7.94	14.96
TN Blount	RURAL	470090102	84	17.84	19.54
TN Davidson	URBAN	470370011	83	31.90	34.72
TN Davidson	RURAL	470370026	111	11.30	22.86
TN Hamilton	RURAL	470650028	116	14.56	18.45
TN Hamilton	RURAL	470651011	140	8.80	17.79
TN Jefferson	RURAL	470890002	109	5.17	14.70
TN Knox	RURAL	470930021	115	-0.02	12.97
TN Knox	SUBURBAN	470931020	119	5.77	21.72
TN Knox	SUBURBAN	470931030	103	9.60	17.31
TN Lawrence	RURAL	470990002	124	1.49	10.82
TN Meigs	RURAL	471210104	116	7.86	14.45
TN Montgomery	RURAL	471251010	131	-5.50	18.19
TN Putnam	RURAL	471410004	218	-21.61	26.96
TN Roane	RURAL	471451020	94	23.57	24.33
TN Rutherford	RURAL	471490101	125	-7.75	13.87
TN Sevier	RURAL	471550101	234	-6.85	14.46
TN Sevier	RURAL	471550102	234	-8.98	13.65
TN Sumner	RURAL	471650007	113	3.88	12.45
TN Sumner	RURAL	471650101	96	14.29	20.09
TN Williamson	RURAL	471870106	163	-13.63	23.38
TN Wilson	RURAL	471890103	113	0.32	15.82

Table 6 Episode Average Mean Normalized Bias and Error in peak ozone concentration at monitoring stations located in the 12-km modeling domain

State/County	Monitor Type	AIRS ID	Mean Normalized Bias (MNB) in peak prediction	Mean Normalized Error (MNE) in peak prediction
AL Clay	RURAL	10270001	-3.850	4.440
AL Elmore	RURAL	10510001	-2.930	9.720
AL Jefferson	SUBURBAN	10731003	19.800	23.320
AL Jefferson	RURAL	10731005	12.780	14.500
AL Jefferson	SUBURBAN	10732006	4.910	11.750
AL Jefferson	RURAL	10735002	-2.370	11.730
AL Jefferson	SUBURBAN	10736002	14.380	19.600
AL Lawrence	RURAL	10790002	-12.680	15.420
AL Madison	SUBURBAN	10890014	2.410	7.440
AL Montgomery	SUBURBAN	11011002	-0.280	11.790
AL Morgan	URBAN	11030011	-7.920	12.420
AL Shelby	RURAL	11170004	-6.370	8.520
FL Baker	RURAL	120030002	-1.100	10.790
FL Bay	RURAL	120050006	-11.160	12.700
FL Duval	RURAL	120310077	8.910	20.110
FL Duval	SUBURBAN	120311003	6.980	11.450
FL Escambia	SUBURBAN	120330004	2.640	15.190
FL Escambia	SUBURBAN	120330018	-15.480	18.010
FL Escambia	SUBURBAN	120330024	-12.970	14.650
FL Holmes	RURAL	120590004	-4.800	8.170
FL Leon	SUBURBAN	120730012	3.090	6.440
FL Santa Rosa	SUBURBAN	121130014	-17.890	17.890
GA Bibb	RURAL	130210012	-15.820	15.820
GA Bibb	NA	130219999	-7.990	10.850
GA Chatham	SUBURBAN	130510021	19.120	19.850
GA Cherokee	RURAL	130570001	66.300	66.300
GA Cobb	SUBURBAN	130670003	-0.490	8.350
GA Coweta	SUBURBAN	130770002	-1.660	10.940
GA Dawson	RURAL	130850001	15.120	17.350
GA De Kalb	SUBURBAN	130890002	2.270	11.030
GA De Kalb	RURAL	130893001	5.130	9.400
GA Douglas	SUBURBAN	130970004	-7.330	17.600
GA Fayette	SUBURBAN	131130001	133.460	145.280
GA Fulton	SUBURBAN	131210055	-2.160	10.740
GA Glynn	SUBURBAN	131270006	6.770	14.840
GA Gwinnett	SUBURBAN	131350002	-5.030	7.600
GA Henry	RURAL	131510002	-14.880	16.560
GA Murray	RURAL	132130003	-3.720	8.450
GA Muscogee	SUBURBAN	132150008	5.950	15.290

State/County	Monitor Type	AIRS ID	Mean Normalized Bias (MNB) in peak prediction	Mean Normalized Error (MNE) in peak prediction
GA Muscogee	RURAL	132151003	-1.620	9.870
GA Paulding	RURAL	132230003	4.690	9.920
GA Richmond	SUBURBAN	132450091	-2.900	9.180
GA Richmond	NA	132459999	961.600	973.110
GA Rockdale	RURAL	132470001	-6.450	14.180
GA Sumter	RURAL	132611001	-12.810	13.420
NC Alexander	SUBURBAN	370030003	-6.420	12.400
NC Avery	RURAL	370110002	9.120	14.490
NC Bunmbe	SUBURBAN	370210030	12.480	15.600
NC Caldwell	URBAN	370270003	-3.470	9.200
NC Davie	SUBURBAN	370590002	-10.440	11.730
NC Forsyth	URBAN	370670022	13.310	20.190
NC Forsyth	RURAL	370671008	10.940	18.310
NC Haywood	SUBURBAN	370870004	8.260	9.250
NC Haywood	RURAL	370870035	-1.930	4.740
NC Haywood	RURAL	370870036	-3.490	4.840
NC Jackson	RURAL	370990005	-0.690	5.650
NC Lincoln	RURAL	371090004	-14.590	14.590
NC Mecklenburg	URBAN	371190041	7.960	15.410
NC Mecklenburg	RURAL	371191005	9.340	15.760
NC Mecklenburg	RURAL	371191009	-1.020	12.730
NC Rowan	RURAL	371590021	0.170	7.270
NC Rowan	SUBURBAN	371590022	0.770	12.440
NC Swain	SUBURBAN	371730002	8.390	9.640
NC Union	SUBURBAN	371790003	11.130	16.990
NC Yancey	RURAL	371990003	1.060	10.410
SC Abbeville	RURAL	450010001	29.700	29.700
SC Aiken	SUBURBAN	450030003	4.530	23.630
SC Anderson	SUBURBAN	450070003	2.550	9.550
SC Barnwell	RURAL	450110001	-13.750	15.970
SC Cherokee	RURAL	450210002	-0.760	8.840
SC Chester	RURAL	450230002	17.890	20.650
SC Colleton	RURAL	450290002	2.890	9.380
SC Edgefield	RURAL	450370001	1.310	7.290
SC Greenville	SUBURBAN	450450009	0.920	11.100
SC Oconee	RURAL	450730001	0.810	6.430
SC Pickens	RURAL	450770002	-0.050	5.100
SC Richland	SUBURBAN	450790007	-1.470	9.640
SC Richland	RURAL	450790021	15.880	20.580
SC Richland	RURAL	450791002	-3.240	9.980
SC Richland	RURAL	450791006	34.700	34.700

State/County	Monitor Type	AIRS ID	Mean Normalized Bias (MNB) in peak prediction	Mean Normalized Error (MNE) in peak prediction
SC Spartanburg	RURAL	450830009	2.350	13.600
SC Union	RURAL	450870001	7.090	11.230
SC York	SUBURBAN	450910006	10.720	11.940
TN Anderson	RURAL	470010101	4.550	14.500
TN Blount	RURAL	470090101	-4.550	7.120
TN Blount	RURAL	470090102	9.920	12.700
TN Davidson	URBAN	470370011	37.140	37.140
TN Davidson	RURAL	470370026	19.390	20.710
TN Hamilton	RURAL	470650028	4.550	9.980
TN Hamilton	RURAL	470651011	-3.740	6.940
TN Jefferson	RURAL	470890002	1.190	7.410
TN Knox	RURAL	470930021	0.400	6.620
TN Knox	SUBURBAN	470931020	12.330	17.070
TN Knox	SUBURBAN	470931030	10.320	12.790
TN Lawrence	RURAL	470990002	-4.530	7.710
TN Meigs	RURAL	471210104	-2.130	6.690
TN Montgomery	RURAL	471251010	4.380	10.390
TN Putnam	RURAL	471410004	-6.580	8.850
TN Roane	RURAL	471451020	13.660	16.860
TN Rutherford	RURAL	471490101	-6.110	8.800
TN Sevier	RURAL	471550101	-7.700	9.190
TN Sevier	RURAL	471550102	-14.540	16.570
TN Sumner	RURAL	471650007	9.500	12.800
TN Sumner	RURAL	471650101	37.100	43.900
TN Williamson	RURAL	471870106	-4.380	10.880
TN Wilson	RURAL	471890103	-1.270	8.110

Table 8 Episode Average Mean Normalized Bias and Error in hourly ozone concentration at monitoring stations located in the 4-km modeling domain

State/County	Monitor Type	AIRS ID	Number of Observations greater than 40 ppb	Mean Normalized Bias (MNB)	Mean Normalized Error (MNE)
AL Clay	RURAL	10270001	102	3.33	10.75
GA Bibb	RURAL	130210012	103	-10.87	19.59
GA Bibb	Not available	130219999	121	-12.18	17.40
GA Cherokee	RURAL	130570001	42	60.64	60.64
GA Cobb	SUBURBAN	130670003	91	-7.20	17.62
GA Coweta	SUBURBAN	130770002	106	-16.24	20.68
GA Dawson	RURAL	130850001	84	17.94	18.80
GA Dekalb	SUBURBAN	130890002	72	10.52	19.67
GA Dekalb	RURAL	130893001	91	2.27	20.72
GA Douglas	SUBURBAN	130970004	144	-8.81	19.80
GA Fayette	SUBURBAN	131130001	49	-8.68	14.49
GA Fulton	SUBURBAN	131210055	85	-2.30	28.20
GA Gwinnett	SUBURBAN	131350002	85	-8.97	15.33
GA Henry	RURAL	131510002	90	-13.57	16.77
GA Muscogee	SUBURBAN	132150008	109	-19.32	28.06
GA Muscogee	RURAL	132151003	92	-6.33	15.48
GA Paulding	RURAL	132230003	139	-2.42	14.71
GA Richmond	SUBURBAN	132450091	74	2.10	17.44
GA Richmond	Not available	132459999	18	-3.63	12.70
GA Rockdale	RURAL	132470001	89	3.62	17.23
GA Sumter	RURAL	132611001	121	-15.98	22.79
SC Abbeville	RURAL	450010001	74	28.80	29.46
SC Aiken	SUBURBAN	450030003	86	-14.71	20.23
SC Barnwell	RURAL	450110001	89	-7.23	13.75
SC Edgefield	RURAL	450370001	94	-3.36	11.75

Table 9 Episode Average Mean Normalized Bias and Error in peak ozone concentration at monitoring stations located in the 4-km modeling domain

State/County	Monitor Type	AIRS ID	Mean Normalized Bias (MNB) in peak prediction	Mean Normalized Error (MNE) in peak prediction
AL Clay	RURAL	10270001	-5.0700	5.0700
GA Bibb	RURAL	130210012	-16.1200	18.1000
GA Bibb	Not available	130219999	-9.5500	13.4000
GA Cherokee	RURAL	130570001	70.3000	70.3000
GA Cobb	SUBURBAN	130670003	-0.8100	13.5400
GA Coweta	SUBURBAN	130770002	-10.0500	10.8100
GA Dawson	RURAL	130850001	11.3300	13.4700
GA Dekalb	SUBURBAN	130890002	1.1500	10.3700
GA Dekalb	RURAL	130893001	2.5800	6.4300
GA Douglas	SUBURBAN	130970004	-8.1200	18.4400
GA Fayette	SUBURBAN	131130001	124.3000	140.7400
GA Fulton	SUBURBAN	131210055	1.1100	11.0400
GA Gwinnett	SUBURBAN	131350002	-4.5200	7.0400
GA Henry	RURAL	131510002	-16.4400	16.4400
GA Muscogee	SUBURBAN	132150008	-1.6700	12.0100
GA Muscogee	RURAL	132151003	-6.7500	11.3900
GA Paulding	RURAL	132230003	2.3000	9.2000
GA Richmond	SUBURBAN	132450091	-7.8300	11.1700
GA Richmond	Not available	132459999	885.0500	904.8400
GA Rockdale	RURAL	132470001	-5.2600	12.5100
GA Sumter	RURAL	132611001	-15.9700	20.1300
SC Abbeville	RURAL	450010001	27.1800	27.1800
SC Aiken	SUBURBAN	450030003	5.2600	24.6900
SC Barnwell	RURAL	450110001	-16.4300	17.0700
SC Edgefield	RURAL	450370001	-5.9900	8.7600

ATTACHMENT B:

Resolutions of Support from Richmond County / City of Augusta

A RESOLUTION

RESOLUTION ADOPTING LOCAL AIR QUALITY INITIATIVES

WHEREAS, on July 15, 2003, the Georgia EPD made recommendations to the United States EPA concerning county's in Georgia to be designated nonattainment for new ozone standards; and

WHEREAS, Richmond County was included in the EPD's recommendation to be designated nonattainment under the new ozone standards; and

WHEREAS, on November 14 2003, the Georgia EPD notified United States EPA of its rescission of Richmond County as a recommended nonattainment county under the new ozone standards due to newly available data showing the Augusta area in attainment of the 8-hour ozone standard; and

WHEREAS, the Augusta-Richmond County Commission commits to implementing the attached Local Air Quality Initiatives Plan; and

WHEREAS, the Augusta-Richmond County Commission pledges to work with and support the efforts of Georgia Tech and the Georgia EPD in crafting a coordinated response to address air quality problems related to ozone and particulate matter in Richmond County and the Augusta area that will be technically effective, accurate, timely, practical and implemented at the local level; and

WHEREAS, the Augusta-Richmond County Commission embraces the goals of the Clean Air Act, understands air quality is a regional issue and is committed to improving the air quality in Georgia.

NOW, THEREFORE, BE IT RESOLVED THAT THE AUGUSTA-RICHMOND COUNTY COMMISSION resolves to assist in the actions necessary to help Richmond County and the Augusta area maintain National Ambient Air Quality Standards.

Duly enacted this _____day of _____ 2004 by a vote of _____ yeas and _____ nays with _____ abstaining or absent

DRAFT

By: _____
Bob Young, Mayor

Attest: _____
Clerk of Commission

RICHMOND COUNTY EARLY ACTION COMPACT
LOCAL AIR QUALITY INITIATIVES PLAN
FINAL DRAFT IMPLEMENTATION SCHEDULE – MARCH 31, 2004

CONTROL MEASURE	IMPLEMENTATION DATE	COUNTY OF IMPLEMENTATION
Open Burning Ban During Ozone Season	May 2005	Richmond and Columbia
Truck Stop Electrification	May 2005	Richmond
Voluntary Smog Alerts	July 2004	Richmond and Columbia
Stage I Vapor Recovery	May 2005	Richmond
Reinforce existing policy ensuring that fleet vehicles and motorized equipment is maintained at peak efficiency and replaced at the end of its useful life with more efficient vehicles.	Ongoing	Richmond
Reinforce the existing city policy that prohibits the idling of vehicles when not in use.	Ongoing	Richmond
Conduct periodic energy audits to improve energy efficiency in county facilities.	Ongoing	Richmond
Promote the use of alternative modes of transportation (public transit, carpooling) by city employees. Currently, city employees can ride Augusta Public Transit at no cost with proper identification.	December 2004	Richmond

CONTROL MEASURE	IMPLEMENTATION DATE	COUNTY OF IMPLEMENTATION
Use the City's Greenspace Program to protect natural areas. Avoid or minimize the use of motorized vehicles and pesticides to maintain public parks and open space.	Ongoing	Richmond
Administer and enforce the existing Tree Ordinance to ensure that required landscaping and green space is a part of all new private development.	Ongoing	Richmond
Implement projects in the Augusta Regional Transportation Study Bicycle and Pedestrian Plan to increase and improve walking and cycling routes and reduce motor vehicle use.	Ongoing	Richmond
Encourage proper storage and disposal of household paints, solvents and pesticides.	Ongoing	Richmond
Promote community awareness and education though local media, distribution of educational materials, public speaking and through local businesses, industries and other organizations.	Ongoing	Richmond
Enforce existing restrictions on outdoor burning.	Ongoing	Richmond
Undertake activities as part of the Augusta Regional Transportation Study (ARTS), to raise public awareness about air pollution and quality.	Ongoing	Richmond

CONTROL MEASURE	IMPLEMENTATION DATE	COUNTY OF IMPLEMENTATION
Support the Augusta Region Transportation Study (ARTS) Long Range Transportation Plan Update	Ongoing – Study scheduled to be completed by October 31, 2004	Richmond
Support initiatives to provide public transportation for rural residents.	Ongoing	Richmond
Incorporate the Early Action Plan into municipal strategic plans.	Ongoing	Richmond