

8-Hour Ozone and PM_{2.5} Modeling to Support the Georgia SIP

Extended Abstract #509

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INTRODUCTION

Recently, EPA designated multiple areas in Georgia as non-attainment for 8-hour ozone (Atlanta and Macon) and PM_{2.5} (Atlanta, Macon, Floyd County, and two counties adjacent to Chattanooga, TN). Attainment status was determined by calculating “design values” for ozone and PM_{2.5} and comparing these values to the National Ambient Air Quality Standards (NAAQS) for 8-hour ozone (85 ppb) and annual PM_{2.5} (15 µg/m³). The ozone design value is the three year average of the measured fourth high daily maximum ozone value from each of the three years. Similarly, the PM_{2.5} design value is the three year average of the measured annual average PM_{2.5} concentrations from each of the three years. In order to develop efficient emission control strategies and demonstrate future attainment with the NAAQS, the Georgia Environmental Protection Division (GA EPD) is using the MM5/SMOKE/CMAQ modeling system to perform episodic emission sensitivities. Regional sensitivities evaluate the response of ozone and PM_{2.5} to emission reductions of NO_x, VOCs, SO₂, NH₃, and primary organic and elemental carbon (PC) in Atlanta. Point source sensitivities simulate the installation of SCRs for NO_x and scrubbers for SO₂ at a number of large coal-fired power plants in Georgia.

MODELING APPROACH

The modeling used in GA EPD’s SIP attainment demonstrations will be based on the VISTAS regional haze modeling¹ which includes annual simulations of 2002, 2009, and 2018 at 36 km (continental U.S.) and 12 km (Eastern U.S.) grid resolutions. The primary modeling system consists of the NCAR/PSU Meso-scale Modeling System² (MM5) meteorological model, the Sparse Matrix Operator Kernel Emissions^{3,4} (SMOKE) emissions model, and the Models-3 Community Multiscale Air Quality⁵ (CMAQ) air quality model. This grid-based modeling system simulates hourly concentrations of ozone, PM, and gaseous precursors throughout the modeling domain. Details on VISTAS specific model set-up and execution is documented elsewhere^{6,7,8}.

Future Attainment Status

The base case modeling utilized the VISTAS BaseF4 emissions for 2002. Model estimates for ozone, PM, and gaseous precursors were compared against observations from various monitoring networks in order to assess model performance^{7,8}. Once satisfactory model performance was achieved, future emission estimated were estimated for 2009 using growth and control factors in addition to the Integrated Planning Model (IPM) to predict emission rates and controls at all electric generating units (EGUs). These 2009 emissions were input into the modeling system (with 2002 meteorological fields) to produce 2009 modeled pollutant distributions. In Georgia, it was estimated that there would be a 34.1% reduction in SO₂ emissions (mostly due to EGU point sources), 23.5% reduction in NO_x emissions (mostly due to on-road mobile and EGU point source reductions), and 14.1% reduction in anthropogenic VOC emissions (mostly from on-road and non-road mobile sources). Model attainment demonstrations use a 5-year weighted design

value as a starting point. The 5-year weighted design value is defined as the average of the three design values straddling the year being modeled to reduce fluctuations due to meteorology. For example, the 5-year design value for 2002 modeling will be the average the 2000-2002, 2001-2003, and 2002-2004 design values. According to EPA guidance^{9,10}, modeling results should be used in a relative sense rather than looking at the absolute change in concentrations. Therefore, future design values are calculated by multiplying the 2002 5-year design value by a Relative Reduction Factor (RRF) where the RRF is the ratio of future modeled mean concentrations to base year modeled mean concentrations. For ozone, only days when the modeled base year ozone concentrations exceeded 85 ppb were included in the RRF calculation.

Twelve ozone monitoring sites in Atlanta and one in Macon have 5-year design values above the NAAQS. Of particular concern is the Confederate Avenue site in downtown Atlanta that has a 5-year 8-hour ozone design value of 94.8 ppb while the other violating monitors have values that range from 85.6 to 92.1 ppb. The predicted future design value for these sites are all below 85 ppb except for Confederate Avenue which has a value of 87. The work of Marmur¹¹ has shown that due to favorable meteorological conditions in recent years, an additional ozone “safety buffer” of between 3 – 7 ppb may be required to ensure attainment if meteorological conditions were more ozone conducive in future years. This may result in an additional one (3 ppb buffer) to eight (7 ppb buffer) monitoring sites violating the ozone NAAQS in 2009 if additional emission reductions are not achieved.

For PM_{2.5}, Georgia has eleven monitoring sites in Atlanta and one site in Macon, Floyd County, and Chattanooga that have 5-year design values above the NAAQS. Of particular concern is the Fire Station #8 site in downtown Atlanta that has a 5-year annual PM_{2.5} design value of 18.3 µg/m³ while the other violating monitors have values that range from 15.1 to 16.5 µg/m³. Measured PM_{2.5} at Fire Station #8 is consistently higher than surrounding monitors (i.e., 1.8 µg/m³ higher than another monitor two miles away) and indicates the presence of a strong local source of PM_{2.5}. The predicted future design values for these sites are all below 15 µg/m³ except for Fire Station #8 which has a value of 17.1 µg/m³ and two other Atlanta sites with values of 15.6 and 15.3 µg/m³.

EMISSION SENSITIVITIES

Since Atlanta will likely not be in attainment with the ozone and PM_{2.5} NAAQS based on 2009 projected emissions, additional emission reductions beyond those already planned will be required. In order to most efficiently design emission control strategies to reduce PM_{2.5} and ozone, GA EPD is performing episodic emission sensitivities on a winter (November 19, 2002 – December 19, 2002) and a summer episode (May 25, 2002 – June 25, 2002). These episodes were chosen using a Classification and Regression Tree (CART) analysis for ozone¹² and PM_{2.5}¹³ and can be used to represent longer periods of time (e.g., entire ozone season or annual averages). The emission sensitivities were performed on a sub-12 km grid developed by GA EPD that covers Alabama and Georgia (and adjacent states). Regional sensitivities (i.e., mobile, area, and non-EGU point sources) of ozone and PM_{2.5} include responsiveness to 10% emission reductions in NO_x, VOCs, SO₂, NH₃, and PC in Atlanta (20 county non-attainment area). Point source sensitivities simulate the installation of SCRs for NO_x and scrubbers for SO₂ at a number of large coal-fired power plants in Georgia. These emission sensitivities were based on the VISTAS 2009 BaseD emissions which already included 4 SCRs and 2 scrubbers at Plant Bowen, 2 SCRs and 1 scrubber at Plant Wansley, 1 SCR at Plant Hammond, and 1 scrubber at Plant Yates. Table 1 contains the average modeled response of ozone at the Confederate Avenue monitoring station and Table 2 contains the average modeled response of PM_{2.5} at the Fire

Station #8 monitoring station. These sensitivities are presented as an absolute change (ppb or $\mu\text{g}/\text{m}^3$) and as a relative change on a tons per day basis (ppt/TPD or $\text{ng}/\text{m}^3/\text{TPD}$).

Table 1: Average ozone response at the Confederate Avenue monitoring station in Atlanta, GA based on 7 days in which the 2002 base case modeled 8-hour ozone concentration was above 85 ppb.

Ozone Sensitivity	Avg. Response (ppb)	Avg. Response (ppt/TPD)
10% Atlanta NO _x	1.36	35.7
10% Atlanta VOC	0.08	1.5
2 SCRs at Plant McDonough	0.42	60.4
4 SCRs at Plant Scherer	0.41	13.7
2 SCRs at Plant Branch	0.07	4.6
3 SCRs at Plant Hammond	0.03	2.2
2 SCRs at Plant Yates	0.11	9.9

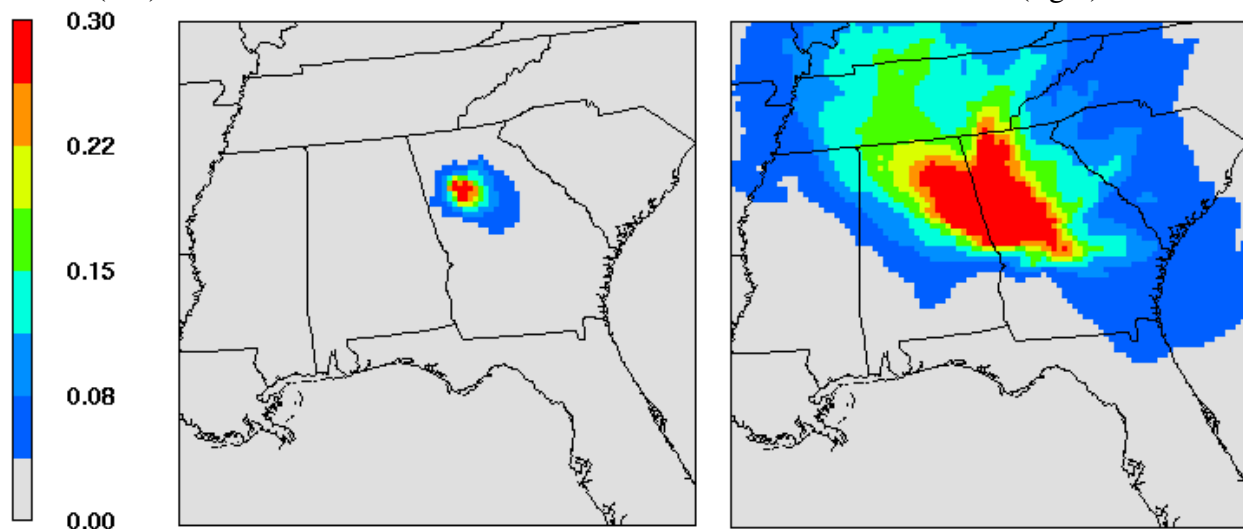
Table 2: Average PM_{2.5} response at Fire Station #8 monitoring station in Atlanta, GA.

PM2.5 Sensitivity	Summer ($\mu\text{g}/\text{m}^3$)	Winter ($\mu\text{g}/\text{m}^3$)	Annual ($\mu\text{g}/\text{m}^3$)	Annual ($\text{ng}/\text{m}^3/\text{TPD}$)
10% Atlanta PC	0.19	0.36	0.25	85.7
10% Atlanta SO ₂	0.02	0.01	0.01	1.9
10% Atlanta NO _x	0.03	-0.02	0.00	-0.09
10% Atlanta NH ₃	0.06	0.15	0.09	22.5
10% Atlanta VOCs	0.00	0.01	0.01	0.11
2 Scrubbers at Bowen	0.19	0.07	0.091	0.50
4 Scrubbers at Branch	0.15	0.03	0.098	0.63
4 Scrubbers at Hammond	0.05	0.04	0.030	0.42
2 Scrubbers at McDonough	0.11	0.07	0.070	1.39
4 Scrubbers at Scherer	0.38	0.04	0.150	0.56
1 Scrubbers at Wansley	0.09	0.06	0.044	0.44
2 Scrubbers at Yates	0.05	0.06	0.037	0.71

Ozone is far more responsive to reduction of NO_x than VOCs, indicating Atlanta is in a NO_x limited regime. Large benefits would be realized if additional reductions of regional NO_x in Atlanta could be achieved. Also, the installation of SCRs at Plant McDonough and Plant Scherer would be of most benefit when compared to controls at the other large EGU facilities in Georgia. Seasonal average PM_{2.5} sensitivities were calculated for the summer and winter episodes. In addition, “annual” sensitivities were calculated by assigning different weighting factors to each episode day based on how important that day was to the annual average. For PM_{2.5} controls, the largest benefits are achieved from additional controls of regional PC from Atlanta. The benefits in the winter are almost double those of the summer due to higher PC emissions and lower mixing heights in the winter. Controls of regional SO₂, NO_x, NH₃, and VOCs have a much smaller benefit. In fact, regional NO_x controls in the wintertime show a slight disbenefit (increased PM_{2.5} due to reductions in NO_x). Additionally, the installation of scrubbers at Plant Scherer, Plant Bowen, Plant Branch, and Plant McDonough would be of most benefit when compared to controls at the other facilities. The benefits of adding scrubbers are much more

pronounced in the summertime when warmer temperatures foster photochemical formation of secondary sulfate. Figure 1 compares the episode average $PM_{2.5}$ response due to a 10% reduction in Atlanta PC (winter) to that due to the installation of four scrubbers at Plant Scherer (summer). PC reductions show more local benefits while the SO_2 reductions are more regional. Unfortunately, the implementation of scrubbers and a realistic regional reduction in PC emissions across Atlanta likely will not be sufficient to bring Fire Station #8 into attainment. This is primarily due to the impact of significant local sources such as a large railyard and a couple of cement/asphalt recycling facilities in the immediate vicinity that need to be addressed. The impact of these local sources will be evaluated outside the CMAQ model through dispersion and observational-based models.

Figure 1: Episode average $PM_{2.5}$ response ($\mu g/m^3$) due to a 10% reduction in Atlanta PC in the winter (left) and to the installation of scrubbers at Plant Scherer in the summer (right).



Additional emission sensitivities will be performed to help develop a number of different control strategies ranging from moderate controls to more extensive controls. These control strategies will be evaluated by running them through a 2002 annual simulations for $PM_{2.5}$ (12 km grid resolution) and through the 2002 ozone season for ozone (4 km grid resolution).

SUMMARY

GA EPD is working to bring ozone and $PM_{2.5}$ non-attainment areas in Georgia into attainment by 2009. With the implementation of emission reductions already planned, it has been shown that Macon should attain the ozone standard by 2009. In addition, Macon, Floyd County, and Chattanooga will attain the $PM_{2.5}$ standard by 2009. However, additional emission reductions will be required to bring Atlanta into attainment. For ozone, additional reductions from mobile-source NO_x and EGU NO_x (especially Plants McDonough and Scherer) will be of greatest benefit. For $PM_{2.5}$, Atlanta will need additional emission reductions of regional PC emissions and EGU SO_2 (e.g., Plant Scherer, Plant Bowen, Plant Branch, and Plant McDonough) as well as reductions from local sources of $PM_{2.5}$ in the vicinity of the Fire Station #8 monitor.

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