

**Ozone Modeling for the Columbus, Georgia, Region:  
Preliminary Analysis of the Impact of Local and Regional Emissions on  
Ozone in Columbus, and the Sensitivity to VOC and NO<sub>x</sub> Emissions  
Reductions.**

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## **Abstract**

A preliminary air quality modeling study has been conducted to provide a information about the extent and causes of elevated ozone levels in the Columbus area. Ozone production in Columbus from local emissions appears to be small in comparison to what occurs in other, larger urban areas. Results of the study suggest that transport of ozone from upwind areas plays a major, if not dominating, role in leading to high ozone in Columbus. While periods where Columbus appears to be significantly impacted from emissions from Atlanta and Birmingham were identified, no one area is overtly and singularly responsible for exceedance levels of ozone in the Columbus area. Indeed, based on this preliminary investigation, in some instances the elevated ozone levels in the Columbus area appear to be due to more or less similar contributions of transported emissions, transported ozone, and locally generated ozone on top of the regional ozone background. The modeling further suggests that regional controls, and controls in non-attainment areas in the region, will lead to significant ozone reductions in Columbus and result in ozone levels in the city below the remanded 8-hr standard.

The study does have limitations, and further studies, e.g., similar to what is being conducted as part of the Fall Line Air Quality Study, should provide an even stronger foundation for determining and better quantifying the sources of exceedance levels of ozone in Columbus. Such studies will also allow more detailed identification of how the current air quality controls will help lower ozone in Columbus.

## **Introduction**

In the last three years, Columbus, GA has experienced episodes of elevated ozone which exceed the 0.08 ppm, eight-hour average National Ambient Air Quality Standard (NAAQS). Of note, implementation of the eight hour ozone NAAQS is on hold pending the Supreme Court review of a lower court ruling suggesting that the US EPA did not have the authority to enforce such a standard (USDOJ, 2000). At present, the highest three-year average of the fourth highest eight-hour average ozone levels at any monitor in Columbus is 0.089 ppm which is slightly above the eight-hour average ozone NAAQS.

Columbus has two ozone monitors: Columbus Airport which has a three-year average of the fourth highest eight-hour average ozone levels of 0.087 ppm; and the Crime Lab which has the higher 0.089 ppm average (Table 1).

**Table 1. Fourth highest eight-hour average maximum ozone levels for 1997-1999 in Georgia. As seen, the years 1998 and 1999 are responsible for Columbus having a running three-year average over 0.085 ppm.**

FIPS County ID	AIRS Site ID	Station Name	Fourth Highest Eight-Hour Average Ozone		
			1997	1998	1999
021	0012	Macon SE	0.095	0.105	0.113
051	0021	Sav E Pres	0.071	0.077	0.083
085	0001	Dawsonville	0.079	0.096	0.089
089	0002	South DeKalb	0.092	0.111	0.112
089	3001	Tucker	0.085	0.111	0.111
097	9994	Douglasville	0.090	0.112	0.105
111	0094	Cohutta	0.075	0.081	0.081
113	0001	Fayetteville	-	0.111	0.113
121	0044	Confederate	0.104	0.125	0.124
127	0006	Brunswick	0.079	0.082	0.077
135	0002	Gwinnett	0.086	0.111	0.103
215	0008	Columbus Airport	0.080	0.091	0.089
215	1003	Columbus Crime Lab	0.081	0.090	0.097
223	0003	Yorkville	0.086	0.104	0.103
245	0091	Augusta Bungalow	0.087	0.099	0.090
247	0001	Conyers	0.110	0.112	0.123
261	1001	Sumter	0.081	0.085	0.082

Two questions arise: what is leading to the high ozone levels and what might be done to mitigate ozone formation on days when ozone is elevated? These are not easy questions to answer given the nature of ozone formation and the various processes involved in causing high ozone. Ozone is not directly emitted, but is formed from non-linear photochemical reactions of other compounds, most notably oxides of nitrogen (NO<sub>x</sub>) and volatile organic compounds (VOCs). Together, in the presence of sunlight, these two sets of compounds can react to form ozone and other photochemical oxidants. The relationship is not straightforward and reducing one of the two precursors (i.e., VOCs or NO<sub>x</sub>) does not necessarily result in a similar reduction in ozone levels (e.g. a ten percent reduction in VOCs does not necessarily result in a ten percent reduction in ozone). Instead, the relationship between VOCs, NO<sub>x</sub>, and ozone involves a large number of chemical reactions that, as a set, are highly non-linear. Indeed, reducing one

of the precursors may lead to very little change, or may even increase ozone, in some cases, and in others may lead to very substantial decreases. In addition, other processes, most notably transport, can be very important. Ozone and its precursors can be transported hundreds of kilometers causing high ozone levels downwind of the location where the majority of the emissions occur.

In designing an effective control program, it is necessary to understand how local ozone levels will respond to emissions changes, both locally and regionally. The most direct method for developing such relationships is through the use of air quality models that include the applicable physics and chemistry. One can exercise these models to determine how the air quality will likely respond to emissions changes. Here, one such model, the Urban-to-Regional Multiscale (URM) Model was used to assess the likely effectiveness of local control programs and to suggest the factors responsible for higher levels of ozone in the Columbus area. The intent of the study is to provide guidance on what type of programs may be useful for mitigating high ozone levels in the Columbus area. Given the limited resources that were available to conduct the preliminary study, the results are useful only for developing an initial understanding of the ozone problem in the Columbus area. Use of the results from the preliminary study in any regulatory framework is highly discouraged. Future studies of the ozone problem in the Columbus area must address the following issues:

- Lack of detailed air quality data for pollutants other than ozone in the Columbus area;
- Detailed quality assurance of emissions data and the emissions inventory;
- Selection of episodes which are representative of conditions conducive to ozone formation in Columbus; and
- Development of a finer resolution meteorological, emissions, and air quality modeling grid for the Columbus domain.

## Method

URM, an advanced photochemical oxidant model that has the ability to use multiple grid sizes, was applied to two historical periods, May 9-13, 1993 and July 11-15, 1995. The observed peak during the July period was moderately high, having a 113 ppb peak one-hour average and 92 ppb peak eight-hour average. The observed peak during the May period was low, having a 65 ppb peak one-hour average and 61 ppb peak eight-hour average. Using data sets adapted from the Southern Appalachian Mountains Initiative (SAMI) meteorological, emissions and air quality modeling data bases (Russell et al., 1998), URM was run for the following cases:

- the May 1993 base case;
- the July 1995 base case;
- a zero anthropogenic emissions sensitivity run for the May 1993 episode; and
- a zero anthropogenic emissions sensitivity run for the July 1995 episode.

Further, URM/DDM-3D was configured for the following experiments:

- Birmingham anthropogenic and biogenic VOC emissions sensitivity;
- Atlanta anthropogenic and biogenic VOC emissions sensitivity;
- Columbus anthropogenic and biogenic VOC emissions sensitivity;
- Birmingham anthropogenic NO<sub>x</sub> emissions sensitivity;
- Atlanta anthropogenic NO<sub>x</sub> emissions sensitivity; and
- Columbus anthropogenic NO<sub>x</sub> emissions sensitivity.

Shown in Figure 1 is the entire URM air quality modeling domain and the Columbus sub-

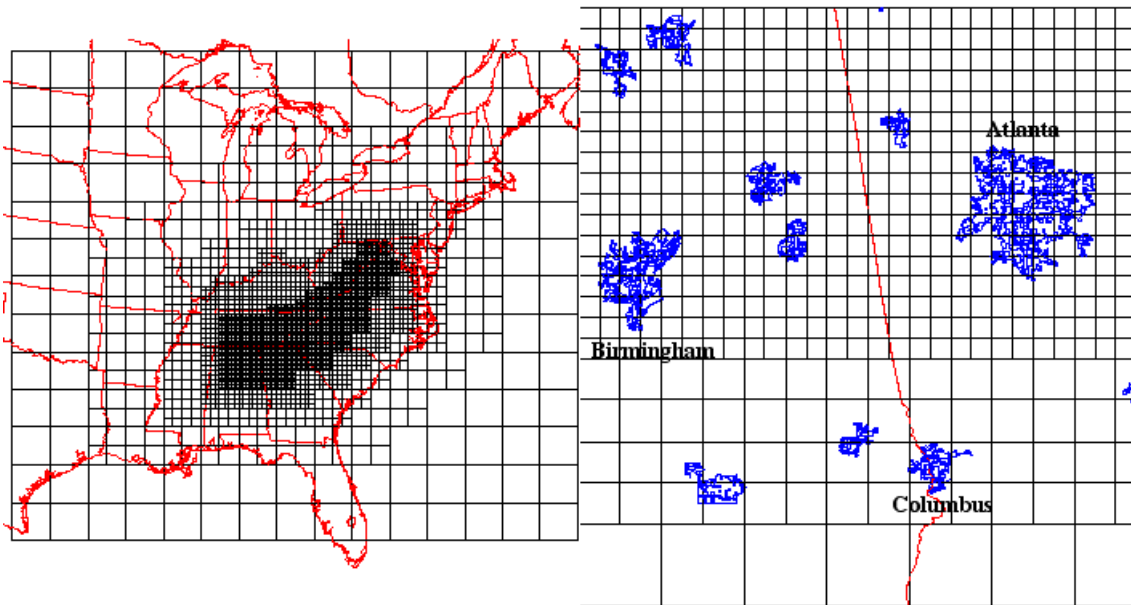


Figure 1. URM air quality modeling domain and Columbus sub-domain. Note that Atlanta and Birmingham are within the twelve kilometer domain while Columbus is in the twenty-four kilometer domain.

domain. The grid size in the Columbus area was twenty-four kilometers per side which is larger than is desirable for detailed urban-scale air quality model analyses, but due to project resource constraints, recasting the emissions, meteorological, and air quality modeling data for a finer grid resolution was not performed. However, the twenty-four kilometer grid size can be used to assess sensitivities to local and regional controls though with limitations. One such limitation is that finer scale responses are lost. That is, those physicochemical processes that function at scales finer than twenty-four kilometers (e.g. rapid, fine-scale photochemical production and accumulation of ozone) are masked in the air quality model due to the use of a coarse grid. However, the longer-range transport to the region will be captured, as well as the regional nature of the ozone in the Southeast.

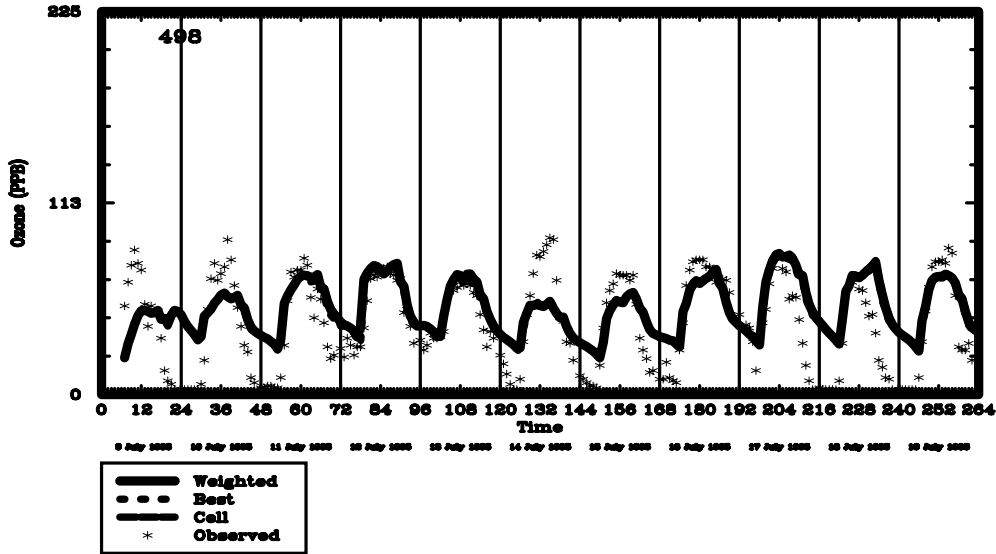


Figure 2. Comparison of observed and simulated ozone at Columbus, GA. While the peak ozone levels on most days is well reproduced, the day with the highest ozone finds somewhat lower simulated ozone. At night, the simulated ozone does not go to zero, but the observed ozone does on about half of the nights. The model is correctly reproducing nighttime ozone on those nights it does not go to zero, and suggests that sub-grid scale emissions are impacting the observations (e.g. excess sub-grid scale NO emissions which are carried over from the daytime hours are scavenging ozone during the nighttime hours). Note that the first two days are used to “spin-up” the model and remove the impacts of initial conditions.

## Results

July 1995 Base Case. The first step in analyzing the results was to compare the observed Columbus ozone to the simulated ozone. Results for the July episode are shown in Figure 2. While the performance is generally good, the peak ozone levels on the days with the highest ozone are underpredicted, and the simulated ozone generally does not go down as far at night. The predicted peak during the episode was about 80 ppb, somewhat less than the observed peak of 92 ppb on July 14<sup>th</sup>. The underestimate of the very highest levels can be due to inaccuracies in the meteorological fields or the lack of fine scale resolution, or both. For example, a peak resulting from the nearby point source in Alabama, will be lost, as would an intense local peak downwind from mobile source emissions in a more heavily-trafficked area. Also, the observed ozone sometimes goes to zero during the nights and early morning, but the simulated ozone does not. Both phenomena (i.e. day time underprediction of high ozone and nighttime overprediction of low ozone) are consistent with the emissions being underestimated, which is not surprising given recent evidence that in particular both mobile source VOC and NO<sub>x</sub>

emissions are underestimated by the MOBILE model used to generate those estimates, but the extent of this bias is not known (e.g. Brzezinski and Newell, 1998). Further evidence of the emissions being underestimated can be inferred from the results of the sensitivity runs which are described later. Also, the two Columbus sites, particularly the airport site, are located near roadways where NO<sub>x</sub> emissions from mobile sources scavenge ozone. However, since the proximity of the monitor to the road is below the resolution of the model as used here, the conclusion that underestimated mobile source NO<sub>x</sub> emissions are responsible for the lack of agreement in the predicted nighttime ozone to the observed nighttime ozone is only speculative. The underprediction of the daytime ozone peaks may also be, in part, an artifact of the larger grid sizes used here, but to a lesser extent than the overprediction at night. Air quality models tend to underpredict the peak ozone levels if their overall predictions are unbiased. The simulations also do well during the weekend period, which has proven difficult in the past. In summary, the good model results would suggest that the major processes impacting ozone in Columbus are being reproduced, though the relatively coarse grid, likely biased mobile source emissions estimates and underprediction of the peak ozone on some of the days suggest that there are some limitations in the use of the results.

The high levels of ozone in Columbus should be not be viewed as a purely local phenomena. One finding of the Southern Oxidants Study is the regional nature of ozone in the southeast United States (Chameides and Cowling, 1995). That is, periods of elevated ozone tend to coincide throughout the southeast. This is shown in Figure 3, which shows that much of the Southeast experienced elevated levels of ozone during the simulated period, particularly around, and immediately downwind of, the most densely populated areas. Also, examination of the observed ozone levels in Georgia confirms that high levels of ozone are not isolated at a few sites, but generally are experienced at many sites throughout the state. This suggests that ozone transport, as well as local generation of ozone from emissions, is important.

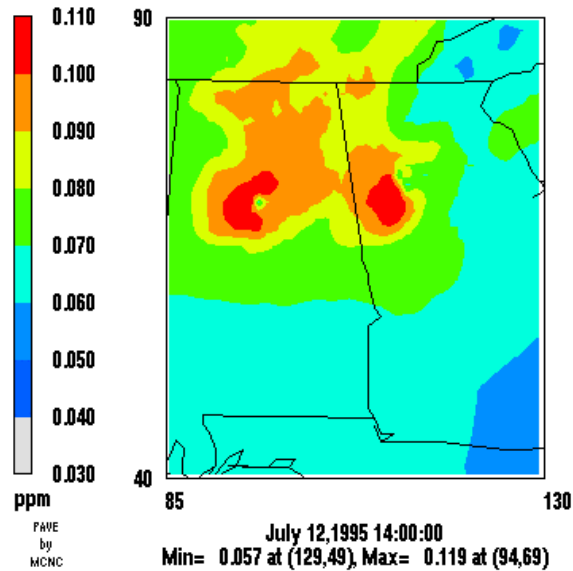


Figure 3. Modeled ozone levels in the southern Tennessee, Alabama, and Georgia region on July 12, 1995 at 2:00 pm CDT (i.e. the time of peak ozone in the area). The ozone is not limited to the major cities, but ozone is found throughout the region. This is corroborated by observations from remote sites, for example, Great Smoky Mountains, north Georgia mountains, and Leslie, Georgia.

July 1995, zero anthropogenic emissions in the Columbus area. The URM was run to show how predicted ozone levels in Columbus respond to the removal of the anthropogenic emissions in the Columbus area. This experiment was performed by removing the anthropogenic emissions for the Columbus area and running the URM with the modified emissions inventory. The effect of removing the anthropogenic emissions from the Columbus area is shown in Figure 4. As shown, the impact of removing the anthropogenic emissions was to reduce the predicted peak ozone in the Columbus area by 1 to 2 ppb.

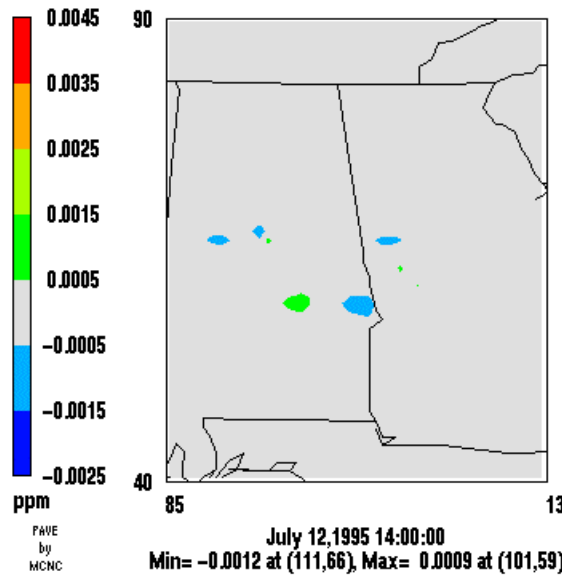


Figure 3. Deficit-enhancement plot of the simulated change in ozone from removing anthropogenic emissions in the Columbus area. The graphic was created by subtracting the URM ozone predictions which were based on the zero anthropogenic emissions from the base case URM ozone predictions. Areas with negative ozone values indicate that ozone is predicted to decrease if anthropogenic emissions are removed from the Columbus area, and positive ozone values indicate that ozone is predicted to increase if anthropogenic emissions are removed from the Columbus area.

A 1 to 2 ppb reduction in ozone is small given that all of the anthropogenic emissions associated with the Columbus area were removed. However, as stated previously, there are known or suspected limitations which impact the interpretation of the study results. Firstly, the mobile source emissions, if not other sources as well, are likely underestimated. An increase in the on-road mobile source emissions estimates will likely have the effect of increasing predicted ozone during the daytime, and subsequent removal of those emissions estimates will likely result in a larger (i.e. greater than 1 to 2 ppb) change in predicted ozone. Secondly, the period modeled is not as stagnant as some less frequent but very severe episodes that can lead to higher ozone levels and show greater local influence. Finally, the coarse grid size over the Columbus area that was used in this study (i.e. twenty-four kilometers) may not capture very local scale high ozone levels. Examination of the observed ozone record indicates significant ozone concentration gradients can exist in the Columbus area (i.e. high ozone levels in and around Columbus which rapidly transition to much lower ozone concentrations).

However, the results do strongly suggest that a significant fraction of the ozone in Columbus is from the regional background.

Birmingham, Atlanta, and Columbus URM/DDM-3D Sensitivities. A unique feature of URM not present in other air quality models is the capability to determine the impact of emissions (e.g. VOC, NO<sub>x</sub>, SO<sub>2</sub>, or speciated VOC such as benzene) from a source area (e.g. Atlanta) on a target area (e.g. Columbus). This feature is based on a technique known as the Decoupled Direct Method in Three Dimensions (DDM-3D) (Yang et al., 1999). The implementation of the DDM-3D in the URM allows for the efficient computation of sensitivity coefficients (e.g. change in ozone concentration per change in NO<sub>x</sub> emissions) at the same time that the state field (e.g. ozone concentration) is estimated. That is, in only one run of the URM, not only is the predicted ozone field computed, but also one or more sensitivity coefficients are computed. The sensitivity coefficients are used to predict the impact from an emissions source on a target area.

The URM was used to assess the sensitivity of ozone in Columbus to reductions of ozone precursors locally and in areas that, at times, may contribute to higher levels in the Columbus area. The precursors tested were anthropogenic VOCs and NO<sub>x</sub>, and biogenic VOCs. Birmingham and Atlanta were chosen as the source areas since their emissions are high and they experience periods of elevated ozone (i.e. greater than 90 ppb eight-hour average). Thus, if transport from the source area (e.g. Atlanta) to the target area (e.g. Columbus) is important, the impact on the concentrations due to the effects of transporting pollution from the source to the target will be exhibited in larger sensitivity coefficients along the axis of transport. Note that when transport is important, it is not only transport from a single source location, but also transport from the regionally high ozone levels. Hence, if the model results show that the plume from Atlanta impacts Columbus, the regional ozone and ozone precursors impacting Atlanta also contribute to the impact in Columbus, as do the sources along the axis of transport between Atlanta and Columbus.

In these tests, the sensitivities of emissions from the source areas (i.e. Birmingham, Atlanta, and Columbus) on ozone in the target area (i.e. Columbus) are presented as the change in predicted ozone in the target area due to a twenty-five percent reduction in the emissions from the source area. Thus, the size and magnitude of the plume will vary from city to city. For example, given the magnitude of emissions in Atlanta, one would expect to see a much larger region of influence than for emissions coming from Columbus. Also, the Atlanta region is larger, so there are more biogenic emissions as well.

As shown in Figure 5, the peak impact of anthropogenic VOCs on ozone in Columbus is small, less than 1 ppb, regardless of the source area for the period modeled. This is particularly true for the anthropogenic emissions in Columbus, where almost no impact on ozone in Columbus is found from a reduction of anthropogenic VOC emissions emitted from the Columbus area for the period modeled.

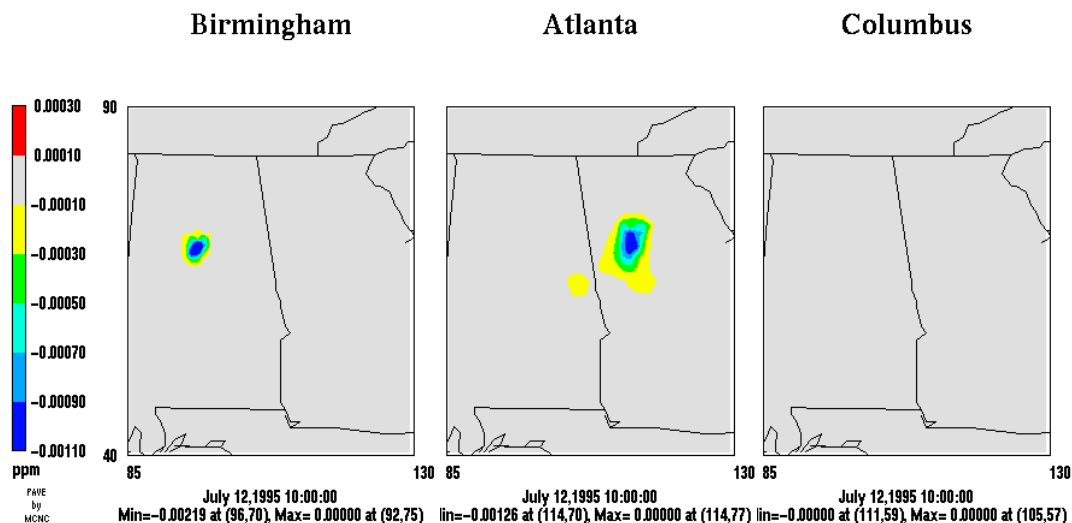


Figure 5. The predicted peak sensitivity of ozone in the Columbus area due to a twenty-five percent reduction in anthropogenic VOC emissions from Birmingham, Atlanta, and Columbus (12 July 1995, 10:00 am CDT).

However, there is a somewhat larger peak impact on ozone, still less than 1 ppb but greater than that predicted from anthropogenic VOCs, in Columbus from the Atlanta biogenic VOC emissions, as seen in Figure 6. This is likely due to the highly reactive isoprene emissions, which are ubiquitous to biogenic sources especially southeast

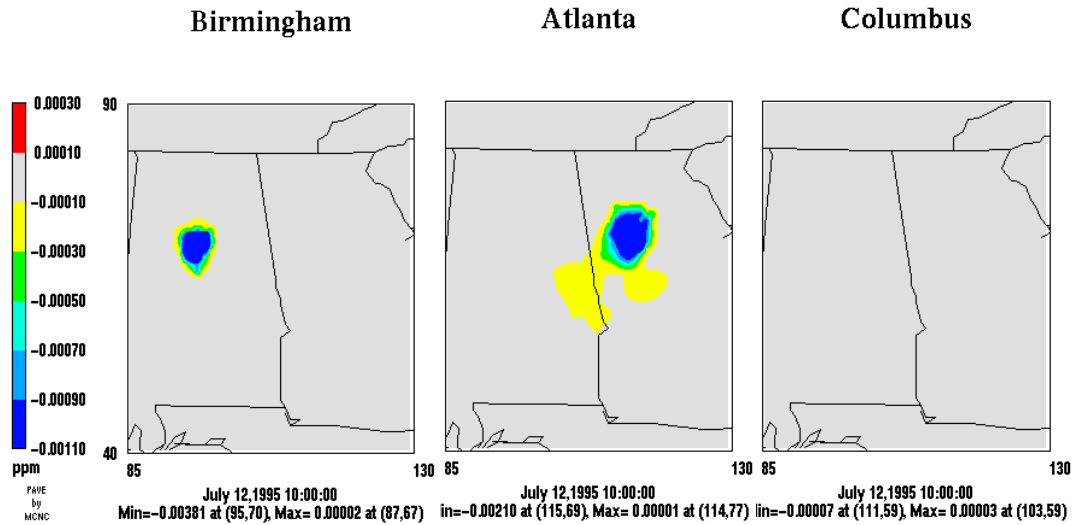


Figure 6. The predicted peak sensitivity of ozone in the Columbus area due to a twenty-five percent reduction in biogenic VOC emissions from Birmingham, Atlanta, and Columbus (12 July 1995, 10:00 am CDT).

deciduous forests, being transported from the Atlanta area which is well known to be a region rich in biogenic VOCs (e.g. Chang et al., 1996; Geron et al., 1995).

A slightly different result is found when considering  $\text{NO}_x$  emissions. As seen in Figures 7 and 8,  $\text{NO}_x$  emissions have a greater overall impact on predicted ozone both in magnitude and spatial extent than do VOC emissions. At 1:00 p.m. on July 10<sup>th</sup>, Figure 7,  $\text{NO}_x$  emissions from Birmingham are predicted to impact ozone in Columbus to an extent about equal to that of the locally generated  $\text{NO}_x$  emissions (i.e. on the order of about 1 ppb for a twenty-five percent change in  $\text{NO}_x$  emissions). Similarly though of larger magnitude and spatial extent,  $\text{NO}_x$  emissions from Atlanta at 10:00 am on July 12, Figure 8, are predicted to have a peak impact on Columbus area ozone greater than 1 ppb for a twenty-five percent reduction in  $\text{NO}_x$  emissions which is a larger impact on Columbus area ozone than that due to local  $\text{NO}_x$  emissions.

On the other hand, the May 1993 episode exhibited different results for the  $\text{NO}_x$  emissions sensitivities, Figure 9. For the May 1993 episode,  $\text{NO}_x$  emissions from Birmingham and Atlanta impact ozone generally to the north of those cities indicating that transport is generally from the south to the north. However, as can be observed in Figure 9, Columbus area  $\text{NO}_x$  emissions continue to impact only local ozone though in

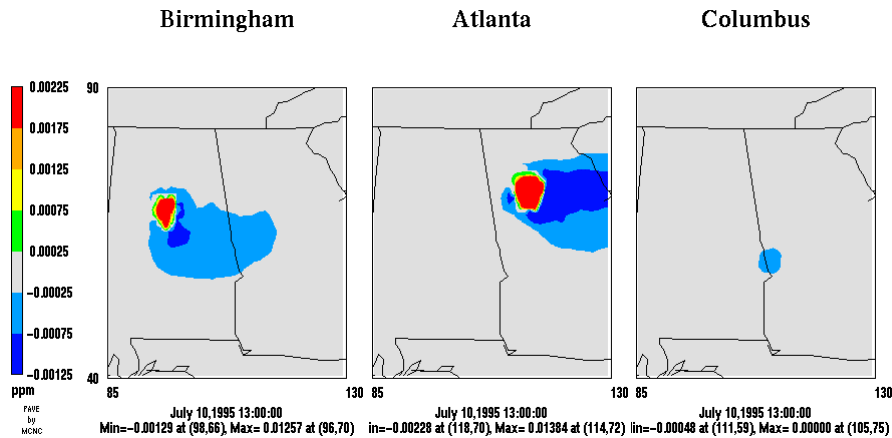


Figure 7. The predicted peak sensitivity of ozone in the Columbus area due to a twenty-five percent reduction in NO<sub>x</sub> emissions from Birmingham, Atlanta, and Columbus (10 July 1995, 1:00 pm CDT). Note that the predicted peak impact on Columbus area ozone due to Birmingham NO<sub>x</sub> emissions is about equal to that predicted for locally generated NO<sub>x</sub> emissions.

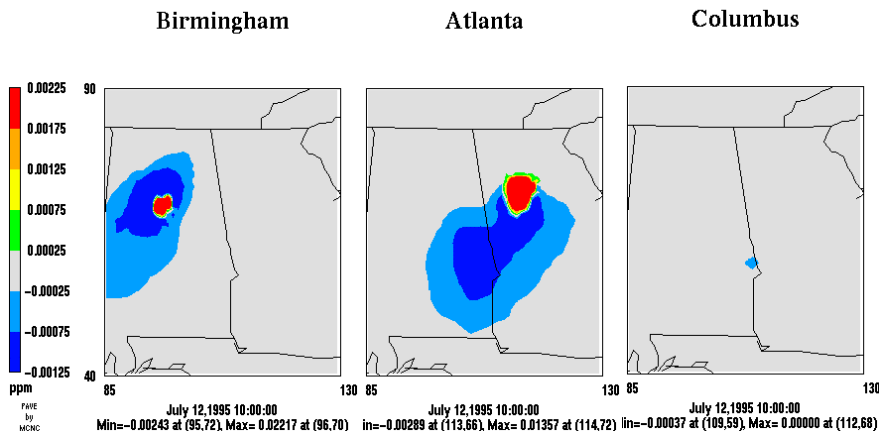


Figure 8. The predicted peak sensitivity of ozone in the Columbus area due to a twenty-five percent reduction in NO<sub>x</sub> emissions from Birmingham, Atlanta, and Columbus (12 July 1995, 10:00 am CDT). Note that the predicted peak impact on Columbus area ozone due to Atlanta NO<sub>x</sub> emissions is greater than that predicted for locally generated NO<sub>x</sub> emissions.

this case, removal of locally generated NO<sub>x</sub> emissions is predicted to slightly increase the Columbus area ozone.

These sensitivity results suggest a number of important features. Peak ozone in the Columbus region appears to be NO<sub>x</sub> limited. That is, decreasing NO<sub>x</sub> emissions locally, and from upwind areas such as Atlanta and Birmingham when Columbus is downwind, will generally decrease Columbus area peak ozone levels, and reducing VOC emissions, whether from upwind or local sources, will not impact Columbus area peak ozone levels significantly. However, reducing NO<sub>x</sub> emissions can lead to increases in ozone at night. In the cases when Atlanta and Birmingham NO<sub>x</sub> emissions impact Columbus area ozone, the impacts of NO<sub>x</sub> emissions reductions in those cities are

predicted to be similar to the impact from reductions in locally generated NO<sub>x</sub> emissions. However, Columbus is not always downwind of those cities, so while local reductions always impact air pollution to some extent, reductions in the other cities do not necessarily effect ozone in Columbus. That is, the impact on Columbus area ozone due to NO<sub>x</sub> emissions from Atlanta and Birmingham will depend on the wind direction and speed.

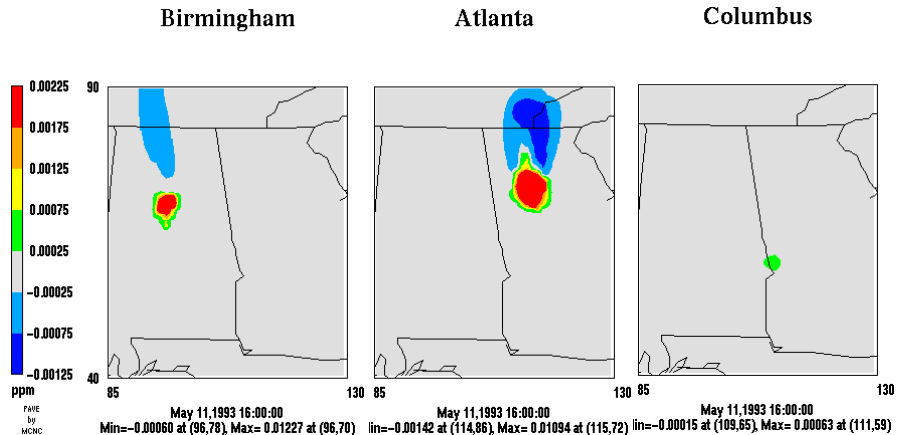


Figure 9. The predicted peak sensitivity of ozone in the Columbus area due to a twenty-five percent reduction in NO<sub>x</sub> emissions from Birmingham, Atlanta, and Columbus (11 May 1993, 2:00 pm CDT). Note the slight disbenefit on Columbus area ozone due to a twenty-five percent reduction in locally generated NO<sub>x</sub> emissions (i.e. ozone goes up when NO<sub>x</sub> emissions go down) attesting to the non-linear nature of ozone production.

The regional nature of the ozone is important in the context of Columbus and the results found here. Regional emissions controls will be effective in improving the air quality in Columbus, but without regional controls, significantly reducing ozone levels in Columbus, at least on days like those modeled here, will be difficult. Also, while the impact of local emissions on Columbus area ozone is small, emissions from Columbus contribute to the regional emissions load which in turn impacts the background and regional ozone levels. Further, though not exhibited in the episodes modeled in this study, Columbus emissions likely impact ozone levels in downwind areas, but the magnitude of this impact is unknown. Also, in areas that have a significant transport of ozone in to the city, local NO<sub>x</sub> emissions will often lead to local decreases in ozone (i.e. local NO<sub>x</sub> emissions scavenge the ozone when insufficient VOCs are present), but downwind increases in ozone (i.e. local NO<sub>x</sub> emissions are transported downwind to

areas where sufficient VOCs are present and photochemical production and accumulation of ozone can occur). This complicates identifying the most effective strategies to reduce ozone.

## **Discussion**

The recent decision to designate areas as non-attainment has brought added importance to the results found here. Thus, it is important to consider the limitations mentioned in the report. The conclusion that Columbus is subjected to very significant transport of ozone and ozone precursors, and that transport significantly contributes to the high ozone readings found at the two Columbus monitors is supported not only by the modeling but also consideration of the observations which shows a regional ozone cloud. The very highest readings are likely due to subgrid-scale variations in the ozone due to “local” emissions, such as the moderate point source in Alabama and strong traffic emissions, on top of this regional cloud. There is some evidence of this by examining the ozone observations at the two monitors in Columbus that sometimes show moderate differences. A more extensive study can address some of the issues that remain. Such a study would include additional episodes to look at the range of meteorologies leading to high ozone in the area and would use a finer grid resolution over the Columbus area. It would also be preferable to use more recent episodes, for example those occurring in August of 1999 that led to high ozone levels in Columbus. It would also be good to get a more detailed inventory of emissions in the nearby area, particularly of mobile sources which are suspected of being underestimated. A second type of study that could be useful is to diagnose the high ozone levels and link them to particular meteorological patterns, e.g., wind direction and speed, to demonstrate the importance of transport. Such a study would include analysis of ozone in the surrounding areas. The definitiveness of such an analysis is hindered by the lack of ozone data in the upwind counties in Georgia and Alabama.

## Conclusion

An air quality modeling study has been conducted to provide a preliminary evaluation of the extent and causes of elevated ozone levels in the Columbus area. Local ozone production from local emissions appears to be small in comparison to what occurs in other, larger urban areas, though some caveats are significant. Firstly, there is a very good chance that mobile source emissions are underestimated. The same may be true for emissions from other sources as well. Secondly, only two episodes were considered in this study. More extensive episode selection work is warranted for the work to be considered more definitive. In particular, episodes chosen for their representativeness to those conditions that most typically lead to ozone exceedences in the Columbus area must be elucidated. Thirdly, Columbus has only two ozone monitors, and no  $\text{NO}_x$  or VOC measurements. Such measurements are desirable for air quality model evaluation. Finally, the coarse scale grid that was used over the Columbus area (i.e. twenty-four kilometers) is likely to have masked some sub-grid scale (i.e. less than twenty-four kilometers) phenomena (e.g. proper capture of the nighttime scavenging of ozone by  $\text{NO}$ , and the impact of plumes from nearby sources causing locally high levels). Use of grid scales on the order of five or six kilometers should be considered in future studies in the Columbus area.

Further, the results of the study suggest that transport of ozone from upwind areas plays a major, if not dominating, role in leading to high ozone in Columbus. While periods where Columbus appears to be significantly impacted from emissions from Atlanta and Birmingham were identified, no one area is overtly responsible for exceedance level ozone in the Columbus area. Indeed, based on this preliminary investigation, in some instances the elevated ozone levels in the Columbus area appear to be due to more or less equal contributions of transported emissions, transported ozone, and locally generated ozone on top of the regional ozone background.

## Future Studies

A number of implied recommendations have been made throughout this report as to what should be considered in future air quality modeling studies of ozone in the Columbus area. These recommendations include:

- Additional episode selection work needs to be performed to choose episodes that are representative of the range of conditions conducive to high ozone levels in the Columbus area
- A finer scale grid mesh, on the order of five or six kilometers, should be used in future air quality modeling so that fine scale phenomena are better captured; and
- The emissions inventory should be further developed for the Columbus area. For one, recent studies suggest that mobile source emissions are underestimated.

Such actions will provide greater confidence to those reviewing such work that our results to date are applicable to the range of conditions found in the Columbus area.

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