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Impact of Biodiesel Fuels on Air Quality and Human Health: Task 2 Report

The Impact of Biodiesel Fuels on Ozone Concentrations

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EXECUTIVE SUMMARY

This report evaluates the ozone air quality impacts from the use of biodiesel fuel in the South Coast (Los Angeles) Air Basin (SoCAB), lower Lake Michigan, Northeast Corridor, and other cities in the Eastern United States (US). The largest impacts on ambient ozone concentrations due to the use of biodiesel are expected to be due to changes in NOx emissions from diesel vehicles. Studies, such as the Ozone Transport Assessment Group (OTAG), have concluded that regional NOx controls are one of the most effective control strategies for reducing regional ozone concentrations in the eastern US. However, in some cases, NOx controls result in increased ozone levels, particularly in the urban cores of large cities. The assessment of ozone impacts due to biodiesel fuel use must therefore include the effects of the fuel on regional ozone and ozone transport as well as the effects within urban areas. The ozone air quality modeling conducted as part of this study therefore takes into account both urban-scale and regional-scale ozone formation through the use of high-resolution urban-scale modeling domains of the cities under study as well as coarser-scale regional-scale modeling.

This report documents Task 2 of the National Renewable Energy Laboratory (NREL) study "Impact of Biodiesel Fuels on Air Quality and Human Health". Under Task 1, engine test data using biodiesel and standard diesel fuels were analyzed to estimate the effects biodiesel fuel has on Heavy Duty Diesel Vehicle (HDDV) tailpipe NOx, VOC, CO, SO_2, and PM emissions and toxicity (Lindhjem and Pollack, 2000). The effects of biodiesel fuel use on Carbon Monoxide (CO) and Particulate Matter (PM) air quality and Exposure and Human Health Effects are addressed in the Task 3, 4, and 5 reports, respectively, of the NREL study.

The assessment of the impacts of biodiesel fuel use on ozone concentrations is made with respect to both 1-hour and 8-hour ozone concentrations. An analysis of daily peak ozone concentrations in each urban area is made along with displays of spatial distributions of daily maximum ozone concentrations. These results are used to evaluate the effects of biodiesel fuel use on the 1-hour and 8-hour ozone concentrations and attainment of the National Ambient Air Quality Standard (NAAQS). As part of the assessment, ozone exposure metrics are also calculated and evaluated as a measure of the impacts on ozone air quality and human health.

Model and Databases Used

The selection of the databases and models for the evaluation of biodiesel fuel effects focused on the SoCAB, Northeast Corridor cities, and Chicago. Several criteria were considered in the selection of the model and databases. These included the following

- access to the database and models;
- used recently in generating public policy;
- preference for a current baseline;
- databases most acceptable to regulatory agencies;
- best representation of current conditions;
- "good" model performance;
- high heavy-duty diesel vehicle (HDDV) emissions contribution; and
- both urban and regional representation.

Based on these selection criteria, database availability, and discussions with the NREL Technical Monitor, the following selections were made regarding the models and databases used in this study:

- The Comprehensive Air Quality Model with Extensions (CAMx) was selected to conduct the air quality modeling because it is state-of-science, publicly available, uses two-way grid nesting so that both urban- and region-scale issues can be addressed, availability of databases, and has been used recently for regulatory decision making (e.g., EPA NOx SIP Call Rule and Dallas-Fort Worth and Houston/Galveston SIPs).
- An enhanced July 1995 OTAG database was used to model the eastern US; – the July 1995 OTAG 36/12-km database was enhanced by adding two 4-km fine grids, one covering the lower Lake Michigan region and the other covering the Northeast Corridor, to better simulate urban ozone formation.
- The EPA 2007 SIP Call emissions inventory was used for the eastern US and the baseline (standard diesel) scenario with the MOBILE5 mobile source emissions updated to incorporate some of the MOBILE6 emission effects.
- A new South Coast Air Basin (SoCAB) database for the August 3-7, 1997 Southern California Ozone Study (SCOS) episode was used for ozone modeling of Southern California.
- The California Air Resources Board (ARB) latest emissions inventory for 1997 based on the EMFAC2000 mobile source emissions model was used for the baseline (standard diesel) emissions scenario.

Effects of Biodiesel Fuel Use

The incorporation of biodiesel fuel effects in the emission inventory used in this study was accomplished with the application of the 1995 version of the Emission Modeling System (EMS95) for the eastern US and the ARB's Gridded Emissions Model (GEM) for the SoCAB. Biodiesel effects were accounted for in the Heavy Duty Diesel Vehicle (HDDV) fleet only, and only the effects of a 20%/80% biodiesel/diesel fuel blend (B20) were considered. Under Task 1 of the NREL study, engine test data were analyzed and the average effects of the use of biodiesel fuel over a standard diesel fuel on HDDV tailpipe emissions of ozone precursors were estimated as shown in Table ES-1.

Table ES-1. Overall average change in mass emission effects due to use of biodiesel fuels in HDDVs over using a standard diesel fuel.

Biodiesel Fuel	NO_x	CO	VOC
B20	+2.4%	-13.1%	-17.9%
B100	+13.2%	-42.7%	-63.2%

Three emission scenarios were analyzed for 2007 in the eastern US and 1997 for the SoCAB:

- Standard diesel baseline scenario;
- 100% penetration in the HDDV fleet of a B20 biodiesel fuel scenario; and
- 50% penetration in the HDDV fleet of a B20 biodiesel fuel scenario.

Emission Summary Results

Table ES-2 summarizes the on-road mobile source NOx, VOC, and CO emission inventory in terms of the fractional contribution to the total inventory, the fractional contribution to the anthropogenic component, and the fraction of the on-road mobile inventory due to HDDV for the Lake Michigan and Northeast Corridor high-resolution (4-km) modeling domains, the 12-km eastern US OTAG domain, and the South Coast Air Basin (SoCAB) high-resolution (5-km) domain. While the on-road mobile component is a considerable percentage of the overall inventory, the HDDV contribution is relatively small, with the exception of the HDDV NOx emissions, which account for approximately one third of the on-road mobile inventory. Overall, the HDDV component is a small fraction of the entire emission inventory. However, it is also notable that emissions from on-road mobile sources in the SoCAB is relatively higher, especially the percentage of HDDV VOC to the total emission inventory that is higher in the SoCAB (1.9%) than in the Lake Michigan (0.3%) and North Corridor (0.2%) regions.

The resulting changes in the emission inventory for a representative episode weekday are presented in Table ES-3 for the two biodiesel emission scenarios and for the Lake Michigan, Northeast Corridor, eastern US, and SoCAB domains. The use of biodiesel fuel with the HDDV fleet is estimated to have a very small change (<1%) in all ozone precursor emissions.

Table ES-2. Summary of on-road mobile and HDDV emission contributions.

2007 SIP Call Base Case and Eastern US OTAG 12-km Domain			
	NOX	**VOC**	**CO**
Mobile % of Total Inv.	30.20%	2.16%	49.34%
Mobile % of Anthro.	37.36%	16.73%	49.34%
HDDV % of Mobile Inv.	35.10%	4.70%	4.50%
2007 SIP Call Base Case and Lake Michigan 4-km Domain			
	NOX	**VOC**	**CO**
Mobile % of Total Inv.	28.22%	7.36%	47.78%
Mobile % of Anthro.	40.07%	15.94%	47.78%
HDDV % of Mobile Inv.	32.60%	4.60%	4.70%
2007 SIP Call Base Case and Northeast Corridor 4-km Domain			
	NOX	**VOC**	**CO**
Mobile % of Total Inv.	42.03%	2.64%	42.05%
Mobile % of Anthro.	46.00%	14.12%	42.05%
HDDV % of Mobile Inv.	35.90%	7.30%	6.30%
1997 EMFAC2000 Base Case and South Coast Air Basin 5-km Domain			
	NOX	**VOC**	**CO**
Mobile % of Total Inv.	63.34	29.29	86.56
Mobile % of Anthro.	63.34	33.48	86.56
HDDV % of Mobile Inv.	41.26	6.50	8.26

Table ES-3. Summary of emission effects due to B20 biodiesel fuel use.

	100% B20 Biodiesel			**50% B20 Biodiesel**		
Emission Component	**2007 EUSA OTAG 12-km Domain**			**2007 EUSA OTAG 12-km Domain**		
	%Change NOX	**%Change VOC**	**%Change CO**	**%Change NOX**	**%Change VOC**	**%Change CO**
On-Road Mobile	0.841%	-0.851%	-0.593%	0.421%	-0.423%	-0.294%
Total Anthropogenic	0.315%	-0.142%	-0.293%	0.157%	-0.071%	-0.145%
Total	**0.254%**	**-0.018%**	**-0.293%**	**0.127%**	**-0.009%**	**-0.145%**
	2007 Lake Michigan 4-km Domain			**2007 Lake Michigan 4-km Domain**		
	%Change NOX	**%Change VOC**	**%Change CO**	**%Change NOX**	**%Change VOC**	**%Change CO**
On-Road Mobile	0.782%	-0.827%	-0.599%	0.391%	-0.411%	-0.297%
Total Anthropogenic	0.314%	-0.132%	-0.286%	0.157%	-0.066%	-0.142%
Total	**0.221%**	**-0.061%**	**-0.286%**	**0.111%**	**-0.030%**	**-0.142%**
	2007 Northeast Corridor 4-km Domain			**2007 Northeast Corridor 4-km Domain**		
	%Change NOX	**%Change VOC**	**%Change CO**	**%Change NOX**	**%Change VOC**	**%Change CO**
On-Road Mobile	0.863%	-1.312%	-0.820%	0.431%	-0.654%	-0.407%
Total Anthropogenic	0.397%	-0.185%	-0.345%	0.198%	-0.092%	-0.171%
Total	**0.363%**	**-0.035%**	**-0.345%**	**0.181%**	**-0.017%**	**-0.171%**
	1997 SoCAB 5-km Domain			**1997 SoCAB 5-km Domain**		
	%Change NOX	**%Change VOC**	**%Change CO**	**%Change NOX**	**%Change VOC**	**%Change CO**
On-Road Mobile	0.788%	-0.274%	-0.0749%	0.389%	-0.144%	-0.037%
Total Anthropogenic	0.499%	-0.092%	-0.065%	0.247%	-0.048%	-0.032%
Total	**0.499%**	**-0.080%**	**-0.065%**	**0.247%**	**-0.042%**	**-0.032%**

Ozone Modeling Results

The CAMx, version 3.02, air quality model was exercised for the 7-18 July, 1995 episode on the enhanced 36/12/4-km OTAG modeling domain for the 2007 SIP Call Base Case and the 100% and 50% B20 penetration into the HDDV fleet emission scenarios. Of the 12 episode days modeled, the July 11-15, 1995 period was analyzed in detail to evaluate the effects of biodiesel fuel use on urban and regional ozone air quality; the July 7-10, 1995 period is used to initialize the model and eliminate the influence of the initial concentrations, whereas the July 16-18, 1995 is a clean out period when ozone is relatively low so is not regulatory relevant. Modeling results were evaluated separately in the Lake Michigan and Northeast Corridor 4-km modeling domains and for selected urban areas in the eastern US within the 12-km OTAG modeling domain. The August 3-7, 1997 SCOS episode was simulated by CAMx version 3.10 for the three 1997 emissions scenarios in the South Coast Air Basin. Results for August 3, 1997 were not analyzed as it was used as an initialization day.

The use of a 100% or 50% penetration in the HDDV results in very small changes, both increases and decreases, in the peak daily maximum 1-hour and 8-hour ozone concentrations in the SoCAB and Northeast Corridor, lake Michigan, and other cities in the eastern US. The changes in 1-hour and 8-hour ozone peaks due to use of the biodiesel fuel are always < 1 ppb. Therefore, the biodiesel fuel use ozone impacts should not be considered significant.

Tables ES-4 and ES-5 summarizes the maximum increases and decreases in, respectively, daily maximum 1-hour and 8-hour ozone concentrations in each of the three regions due to use of biodiesel fuel in HDDVs. In the Lake Michigan region, the maximum increase and decrease in daily maximum ozone concentrations for the 100% B20 emissions scenario are +0.09 and –0.53 ppb, respectively. The maximum increases and decreases in daily maximum ozone concentrations in the Northeast Corridor are +0.20 and –0.25 ppb, respectively. Similar numbers for the SoCAB are +0.22 and –1.20 ppb. Thus, even the maximum changes in daily maximum ozone concentrations due to the introduction of biodiesel fuels in the HDDV fleet in the Lake Michigan, Northeast Corridor, and SoCAB regions are very small.

Table ES-4. Maximum increases and decreases in daily maximum 1-hour ozone concentrations (ppb) in the Lake Michigan, Northeast Corridor, and South Coast Air Basin regions.

Date	50% B20 Biodiesel (ppb)		100% B20 Biodiesel (ppb)	
	Max Increase	**Max Decrease**	**Max Increase**	**Max Decrease**
2007 Lake Michigan Domain				
July 11, 1995	+0.03	-0.16	+0.05	-0.33
July 12, 1995	+0.07	-0.10	+0.09	-0.19
July 13, 1995	+0.05	-0.12	+0.09	-0.24
July 14, 1995	+0.07	-0.09	+0.09	-0.18
July 15, 1995	+0.04	-0.26	+0.08	-0.53
2007 Northeast Corridor Domain				
July 11, 1995	+0.06	-0.08	+0.11	-0.14
July 12, 1995	+0.07	-0.12	+0.13	-0.25
July 13, 1995	+0.12	-0.06	+0.15	-0.07
July 14, 1995	+0.15	-0.04	+0.20	-0.09
July 15, 1995	+0.10	-0.10	+0.18	-0.20
1997 South Coast Air Basin Domain				
August 4, 1997	+0.09	-0.48	+0.17	-0.95
August 5, 1997	+0.10	-0.56	+0.19	-1.11
August 6, 1995	+0.11	-0.60	+0.22	-1.20
August 7, 1995	+0.13	-0.49	+0.26	-0.98

Table ES-5. Maximum increases and decreases in daily maximum 8-hour ozone concentrations (ppb) in the Lake Michigan, Northeast Corridor, and South Coast Air Basin regions.

Date	50% B20 Biodiesel (ppb)		100% B20 Biodiesel (ppb)	
	Max Increase	Max Decrease	Max Increase	Max Decrease
2007 Lake Michigan Domain				
July 11, 1995	+0.02	-0.14	+0.04	-0.28
July 12, 1995	+0.03	-0.09	+0.07	-0.17
July 13, 1995	+0.04	-0.11	+0.09	-0.21
July 14, 1995	+0.03	-0.09	+0.07	-0.18
July 15, 1995	+0.03	-0.20	+0.07	-0.40
2007 Northeast Corridor Domain				
July 11, 1995	+0.05	-0.07	+0.10	-0.13
July 12, 1995	+0.05	-0.10	+0.11	-0.20
July 13, 1995	+0.07	-0.04	+0.12	-0.07
July 14, 1995	+0.07	-0.04	+0.14	-0.07
July 15, 1995	+0.06	-0.04	+0.15	-0.08
1997 South Coast Air Basin Domain				
August 4, 1997	+0.06	-0.34	+0.12	-0.68
August 5, 1997	+0.07	-0.39	+0.15	-0.77
August 6, 1995	+0.08	-0.48	+0.15	-0.96
August 7, 1995	+0.08	-0.42	+0.15	-0.83

Conclusions

Measured ozone is typically reported to EPA's AIRS ozone compliance database to the nearest 1 ppb. The maximum estimated increase in daily maximum 1-hour or 8-hour ozone concentrations due to the use of either a 100% of 50% penetration of a B20 fuel in the HDDV fleet is 0.26 ppb for the 100% B20 fuel in the SoCAB region on August 7, 1997. As this maximum ozone increase is well below 1 ppb, then the use of biodiesel fuel is estimated to have no measurable adverse impact on 1-hour or 8-hour ozone attainment in Southern California and the Eastern United States. In the Lake Michigan and Northeast Corridor regions, the maximum ozone reduction benefit due to the biodiesel fuel use is also well below 1 ppb, thus biodiesel use in these two areas is estimated to have no measurable beneficial impact on ozone attainment. In the SoCAB, the modeling estimates there will be reductions in daily maximum ozone concentrations by as high as approximately 1 ppb, which is a small but potentially measurable beneficial impact on ozone attainment.

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1. INTRODUCTION

BACKGROUND

Biodiesel fuels have been investigated for a number of reasons, such as an extender for petroleum-based fuels derived from a domestic renewable energy source. But lately the primary interest is the potential for a more environmentally benign fuel. One potential benefit of biodiesel is that it can biologically degrade, making spills and leaks less of a concern. However, the potential for exhaust emission reductions and reductions in emissions toxicity are of the most interest. Several studies have shown that large reductions in hydrocarbon, particulate, and carbon monoxide emissions are expected from its use either as a neat fuel or as a blend with petroleum-derived fuels.

There have been several studies regarding the effects of biodiesel fuels on exhaust emissions of NOx, VOC, CO, and particulate matter (PM). Almost all of these studies have examined emissions from heavy-duty diesel vehicle (HDDV) engines. However, the effects of biodiesel use on ambient air quality have not been quantified. Thus, the National Renewable Energy Laboratory (NREL) has retained ENVIRON International Corporation to estimate the air quality and resultant and health effect toxic impacts from the use of biodiesel fuels in several cities in the U.S.

Ozone is formed in the atmosphere through complex reactions involving Volatile Organic Compounds (VOC) and oxides of Nitrogen (NOx) in the presence of sunlight. Reducing VOC emissions usually reduces ozone or has no effect. However, reducing NOx emissions may reduce or increase ozone concentrations. Currently there is a 1-hour ozone standard that is not to exceed 0.12 ppm (124 ppb) more than once per year averaged over 3 years. Thus, a violation of the 1-hour ozone standard occurs when the fourth highest values in 3-years at any monitor exceeds 0.12 ppm. More recently EPA has promulgated on 8-hour ozone standard that is expressed as the 3-year average of the fourth highest value with a threshold of 0.08 ppm (84 ppb).

Effects of Biodiesel Fuel on Ozone Concentrations

The introduction of biodiesel fuels can produce a small increase in NOx emissions from diesel vehicles that might, in turn, influence ozone concentrations. The Ozone Transport Assessment Group (OTAG) found that for the eastern U.S. regional NOx controls are the most effective control strategy for reducing regional ozone concentrations (OTAG, 1997). However, the OTAG study also found that, on occasion in some urban areas, NOx controls resulted in ozone increases. These NOx disbenefits occur in the very largest metropolitan areas, such as New York City and Chicago, or in areas with high NOx emissions, such as cities along the Ohio River (e.g., Louisville and Cincinnati). Even in areas where occasional NOx disbenefits do occur due to local NOx controls, further downwind benefits (i.e., ozone reductions) will likely be realized. OTAG concluded that the benefits of NOx control for reducing ozone transport into an urban area outweighed any potential disbenefits due to local controls in an urban area. Thus, any credible ozone assessment of the ozone benefits of biodiesel needs to include both the effects of the fuel on regional ozone and ozone transport as well as the effects within the urban area itself. This means that the ozone air quality modeling impact of biodiesel fuel use needs to account for both urban-scale and regional-scale ozone formation regimes. Thus, the air quality modeling needs to incorporate high-resolution (e.g., 4-5-km) urban-scale modeling as well as coarser (e.g., 10-20-km) regional-scale modeling.

Purpose

This document is the Task 2 Report for the NREL "Impacts of Biodiesel Fuels on Air Quality and Human Health study. The objective of Task 2 is to estimate the effects of the use of biodiesel fuels on elevated ozone concentrations in three cities that represent the range of ozone nonattainment areas in the U.S. The ozone air quality impacts of biodiesel fuel use are estimated using air quality modeling. The impacts of biodiesel fuel use on ozone concentrations are estimated for the South Coast (Los Angeles) Air Basin (SoCAB) region of Southern California, the Lake Michigan region (e.g. Chicago, Milwaukee, Gary, and Southwestern Michigan), and the Northeast Corridor region (e.g., New York City, Philadelphia, Baltimore, and Washington DC). Results also presented for other eastern US cities and for regional-scale ozone across the eastern US. Under Task 1 of the study, biodiesel test data were analyzed and recommendations for incorporating biodiesel effects on pollutant mass emissions for use in air quality modeling made (Lindhjem and Pollack, 2000). Other tasks of the study address the effects of biodiesel fuel use on Carbon Monoxide (CO, Task 3) and Particulate Matter (PM, Task 4) air quality, and on human health effects due to air toxics (risk and exposure, Task 5).

2. DATABASE AND MODEL SELECTION

The selection of the model and databases for evaluation of the effects of biodiesel fuel use on ozone concentrations focused on the following three “cities”: Los Angeles, the Northeast Corridor, and Chicago. An accurate evaluation of the effects of biodiesel use needs to adequately simulate urban photochemistry. Thus, a fine grid (4-5-km) was used in each city to properly simulate urban-scale ozone formation. The following criteria were considered in the selection of the model and database for use in this study:

- Access to database and models
- Used recently to generate public policy (e.g. SIP)
- Current baseline preferable to future-year baseline
- Database most acceptable to regulatory agencies
- Best representation of current conditions
- “Good” model performance
- High HDDV contribution
- Urban and regional representation

MODEL SELECTION

Currently there are several photochemical grid models available (e.g., UAM-IV, UAM-V, CAMx, CMAQ, etc.) that would likely be acceptable to the EPA and other regulatory agencies for use in ozone modeling. During the 1990’s, the UAM-IV was the preferred model in EPA’s Guidelines for Air Quality Modeling. However, more recently it has been removed from the list as EPA’s recommended model and currently EPA has no specific recommended air quality model for ozone. As the UAM-IV model does not support nested grids, it is an urban only model that can not treat regional issues so is not considered for this study. The UAM-V model does support nested grid applications and has also been used recently for generating public policy (OTAG, 1997; EPA, 1998a). However, the UAM-V is proprietary and not publicly available thus eliminating it from consideration.

EPA has recently released (June 1999) its models-3 Community Multi-Scale Air Quality (CMAQ) modeling system. CMAQ is designed to be a one-atmosphere model that treats all air pollution issues. It is designed to run using just output from the MM5 meteorological model. CMAQ does not support two-way grid nesting so the impacts of urban controls on regional air quality can not be assessed. Because it is fairly new, there are very few CMAQ databases available and it has not yet been used for any regulatory decisions.

The Comprehensive Air-quality Model with extensions (CAMx) is a three-dimensional two-way nested-grid photochemical grid model capable of treating both urban-scale and regional-scale ozone issues. CAMx was used by EPA in the recent NOx SIP Call technical analysis to evaluate the benefits and estimate the contributions of emissions from different States on downwind nonattainment (EPA, 1998a,b). CAMx is a nested-grid photochemical grid model with Plume in Grid (PiG) capability that is based on the latest (> 1995) science and coding practices. CAMx is also publicly available (available from www.camx.com) with no restrictions on its use. CAMx was used in the Dallas-Fort Worth and Houston/Galveston SIP modeling and is being used for public policy and potential SIP modeling for other Texas cities (e.g., Beaumont/Port Arthur, San

Antonio/Austin, and East Texas). In addition to Texas applications, the Lake Michigan States (LADCO, IL, IN, MI, and WI), Northeast States, and Midwest states are also using CAMx for their ozone air quality public policy decisions. CAMx is also one of the models being considered for use by the South Coast Air Quality Management District (SCAQMD) and the California Air Resources Board (ARB) for the 2002 AQMP/SIP for the South Coast Air Basin (SoCAB). Based on its public availability, technical attributes to treat both urban- as well as regional-scale ozone, and extensive use by EPA, States, and Stakeholders to generate public policy and SIP ozone control plans, CAMx was selected to evaluate the impacts of biodiesel fuels on ozone concentrations for this study.

MODELING DATABASES

High resolution (4 to 5-km) photochemical modeling databases are needed to simulate the effects of biodiesel fuel use. However, because transport is potentially an important component of ozone formation in the eastern US, the Northeast Corridor and Lake Michigan modeling databases should also be regional in nature so the effects of biodiesel fuel use can be assessed in both the urban and regional environments.

Southern California Databases

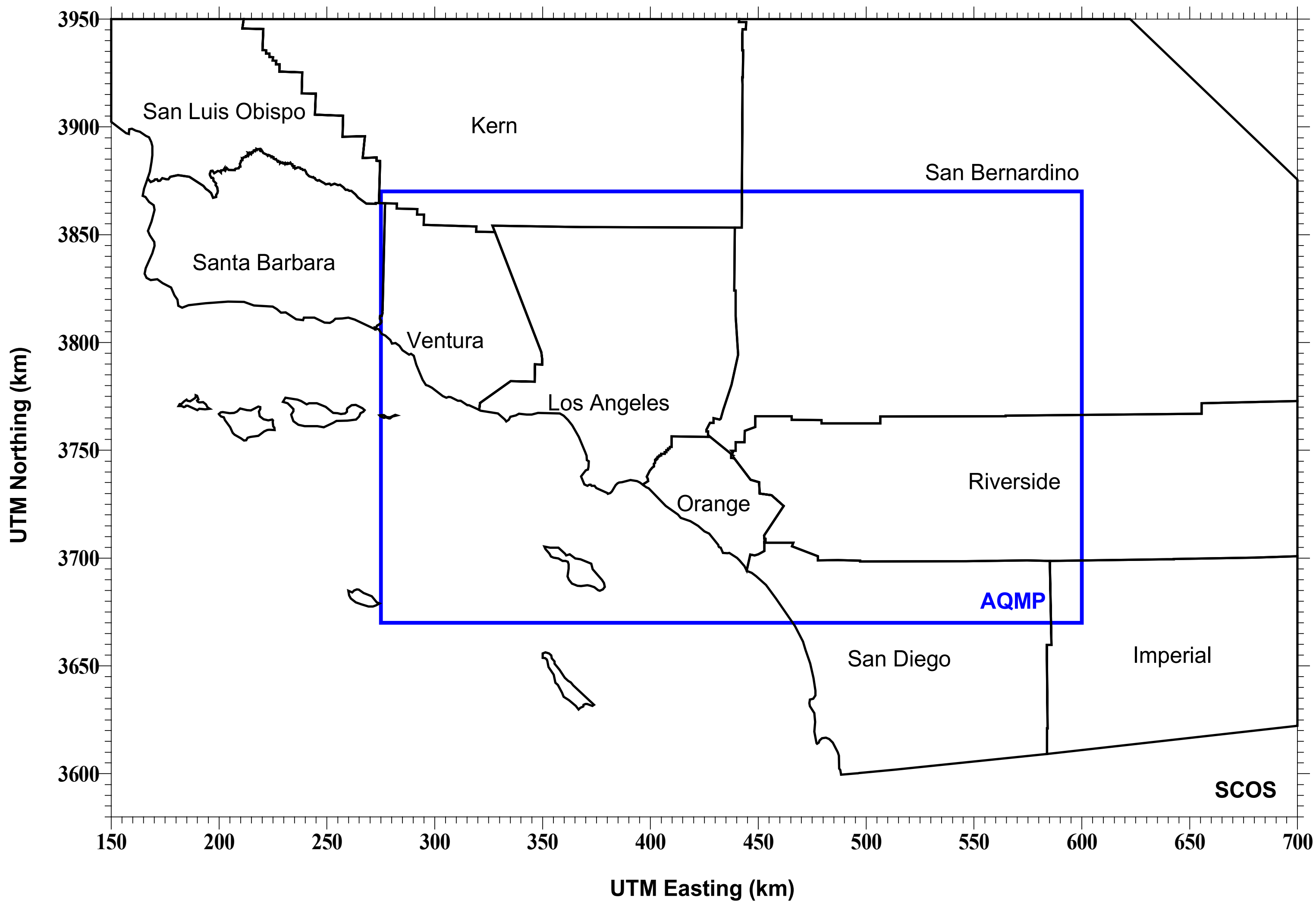
The 1997 Air Quality Management Plan (AQMP) and State Implementation Plan (SIP) and 1998 AQMP/SIP Revision for the South Coast Air Basin (SoCAB) used the UAM-IV photochemical grid model (Morris and Myers, 1990) and databases based on episodes from the 1987 Southern California Air Quality Study (SCAQS) (SCAQMD, 1997). Of these, the August 1987 SCAQS UAM-IV database is the best quality and most limiting (i.e., has the highest ozone). However, the 1987 SCAQS episodes and databases are now rather dated.

In 1997, the Southern California Ozone Study (SCOS) was conducted to collect ambient data for the development of new photochemical modeling databases for the SoCAB. The California Air Resources Board (ARB) and South Coast Air Quality Management District (SCAQMD) are using the SCOS data to develop new modeling databases to support the 2002 AQMP/SIP. The highest ozone during the SCOS field study occurred during the August 3-7, 1997 episode. A new modeling database has been developed for the SoCAB and the August 3-7, 1997 SCOS episode using the latest meteorological (MM5) and photochemical (CAMx) modeling technology (Yarwood et al., 2002; Morris et al., 2001; 2002). This database has been used by the National Academia of Sciences (NAS) to assess the effects new ozone standards may have on transportation planning (ENVIRON, 2002), to assess the causes of higher observed ozone on weekend days versus weekdays (Yarwood et al., 2002), and to assess the ozone impacts of advanced technology vehicles (Morris et al., 2001; 2002). The use of the more recent 1997 SCOS database is preferable and more acceptable to the regulatory agencies than the older 1987 SCAQS database. Thus the August 3-7, 1997 SCOS CAMx/MM5 database was selected in this study to assess the effects biodiesel fuel use would have on ozone formation in the SoCAB.

Figure 2-1 displays the southern California modeling domain used in the 1997/1999 Air Quality Management Plan (AQMP) for the new SCOS modeling domain that will be used for the 1997 SCOS episode databases under development. The ARB is developing new emissions for the enlarged SCOS domain. However, at the time this study was initiated, emissions were only available for the smaller AQMP domain, thus the August 3-7, 1997 CAMx/MM5 database only addresses the AQMP domain. As ozone formation in the SoCAB is completely contained within the AQMP domain, then use of the smaller AQMP domain will have no effect on the biodiesel fuel ozone assessment in the SoCAB. However, results for San Diego, Santa Barbara, Mojave Dessert, and Imperial County will not be available.

The August 3-7, 1997 CAMx/MM5 database was run using 1997 emissions for the AQMP domain and the model estimated ozone concentrations compared with the observed values in a model performance evaluation. The CAMx/MM5 modeling system reproduced the observed ozone concentrations in the SoCAB during August 4-7, 1997 quite well (Yarwood et al., 2002; Morris et al., 2001; 2002) meeting all of EPA's ozone modeling performance goals for SIP modeling (EPA, 1991). This is in contrast to the performance of the UAM-IV for the 1987 SCAQS episodes that was poor and exceeded EPA's performance goals (SCAQMD, 1997).

A new 1997 baseline emission inventory was developed by the California Air Resources Board (ARB) based on the EMFAC2000 mobile source emissions model. The EMFAC2000 produces more VOC, CO, and NOx emissions than its predecessor (EMFAC7G) that was used in the 1997/1999 SIP/AQMP modeling. For photochemical modeling, EMFAC2000 uses link-based vehicle miles traveled (VMT), speed, and starts data from the Direct Transportation Impact Model (DTIM4) travel demand model. The ARB EMFAC2000/DTIM4 mobile emissions model was used in this study.



CAMx Modeling Domains

Figure 2-1. AQMP modeling domain used in this study's modeling of the August 1997 SCOS episode and the SCOS modeling domain being used for databases under development.

Northeast Corridor Region Database

Since the 1994 SIP modeling of the Northeast Corridor urban cities, photochemical modeling of the Northeast Ozone Transport Region (OTR) has been performed mainly as part of OTAG and the EPA NOx SIP Call and related analysis. OTAG developed four regional-scale modeling databases for periods from July 1988, July 1991, July 1993, and July 1995. Of these, the July 1995 episode is the most recent and most appropriate for use in evaluating biodiesel fuel use in the Northeast Corridor region. The OTAG domain consists of a 36-km grid covering the entire eastern US and a 12-km nested grid covering the central portion of the domain, including the northeast corridor (see Figure 2-2). The EPA used the four OTAG databases and the UAM-V and CAMx photochemical models to provide the technical basis for the NOx SIP Call. However, numerous questions have been raised concerning the adequacy of 12-km grid resolution for simulating ozone concentrations, especially in the urban areas such as the Northeast Corridor and Lake Michigan areas (e.g., Tesche et al., 1998; Morris et al., 1998a,b). The Northeast States are in the process of developing new higher-resolution photochemical modeling databases that are not yet available

Chicago Area Databases

The OTAG/SIP Call databases discussed above also cover the Chicago and Lake Michigan area, albeit at fairly coarse (12-km) resolution. Thus, the same database and simulation could possibly be used to address both the Northeast Corridor and Chicago ozone issues. However, the adequacy of the 12-km grid resolution for simulating urban ozone formation is questionable.

The Lake Michigan Air Directors Consortium (LADCO) and four Lake Michigan States (IL, IN, MI, and WI) have developed more refined databases for the 4-km "Grid M" region displayed in Figure 2-3. Grid M databases have been developed for the June and July 1991 LMOS episodes and two 1995 databases. These databases were used by LADCO and the Lake Michigan States to develop comments on the EPA NOx SIP Call for local public ozone policy discussions and were also used for the St. Louis SIP modeling. All information generated by LADCO is publicly available and they have indicted that the revised updated emissions inventory would also be publicly available. LADCO is currently developing new databases for the region using MM5 and the CAMx models. Although the Grid M databases have been developed using 4-km resolution, almost all of the Grid M modeling analysis has been conducted at a 12-km resolution.

Selection of Ozone Modeling Databases for the Northeast Corridor and Lake Michigan Regions

The July 1995 OTAG database is an attractive photochemical modeling database for assessing the impacts of biodiesel fuel use on ozone formation because:

- It has been used in OTAG and EPA's NOx SIP Call and Tier 2/Low Sulfur Rulemakings so therefor has regulatory stature;
- Can address both the Northeast Corridor and Lake Michigan urban areas; and
- Would also provide a regional assessment of the impacts of biodiesel use on ozone concentrations in other cities across the eastern US.

However, the July 1995 OTAG database 36/12-km resolution is inadequate for properly simulating urban-scale ozone formation processes that may be important for the biodiesel fuel ozone impact assessment. Although the LADCO Grid M databases are routinely run at 12-km resolution, 4-km resolution versions of the database do exist. However, the Grid M databases cover just the Midwest so could not be used to assess ozone impacts in the Northeast Corridor.

Thus, to perform ozone modeling of the Northeast Corridor and Lake Michigan areas it was decided to enhance the July 7-15, 1995 OTAG episode database adding two high-resolution 4-km nested-grids as follows:

1. One for the Northeast Corridor stretching from Washington D.C. to Connecticut and including the urban cities of Washington DC, Baltimore, Philadelphia, and New York City; and
2. Another covering the Lower Lake Michigan region and including Chicago, Milwaukee, Gary, and Southwest Michigan.

Figure 2-4 displays the enhanced 36/12/4-km nested-grid domain for the July 1995 OTAG episode that includes high-resolution (4-km) grids for the Northeast Corridor and Lake Michigan regions. Although the focus on the biodiesel ozone impact assessment will be on ozone within the 4-km high-resolution Northeast Corridor and Lake Michigan areas, modeling results will also be obtained for other eastern US cities such as Atlanta, Birmingham, St. Louis, Memphis, Cincinnati, Pittsburgh, Detroit, etc., albeit using a lower grid resolution (12-km).

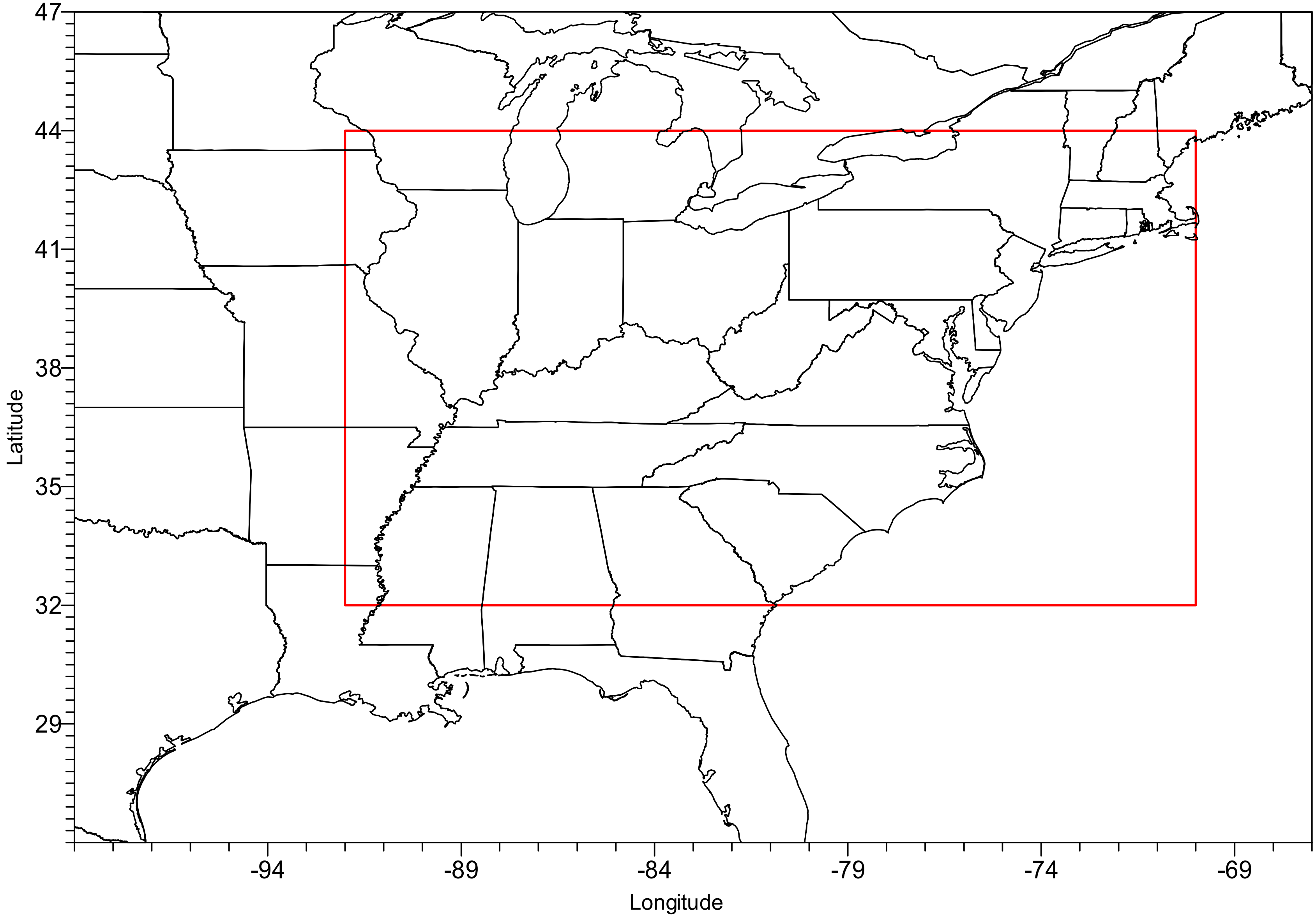


Figure 2-2. OTAG 36-km (outer) domain covering from Texas to Maine and 12-km (inner) nested-grid modeling domain that stretches from Arkansas/Mississippi to Massachusetts/New Hampshire.

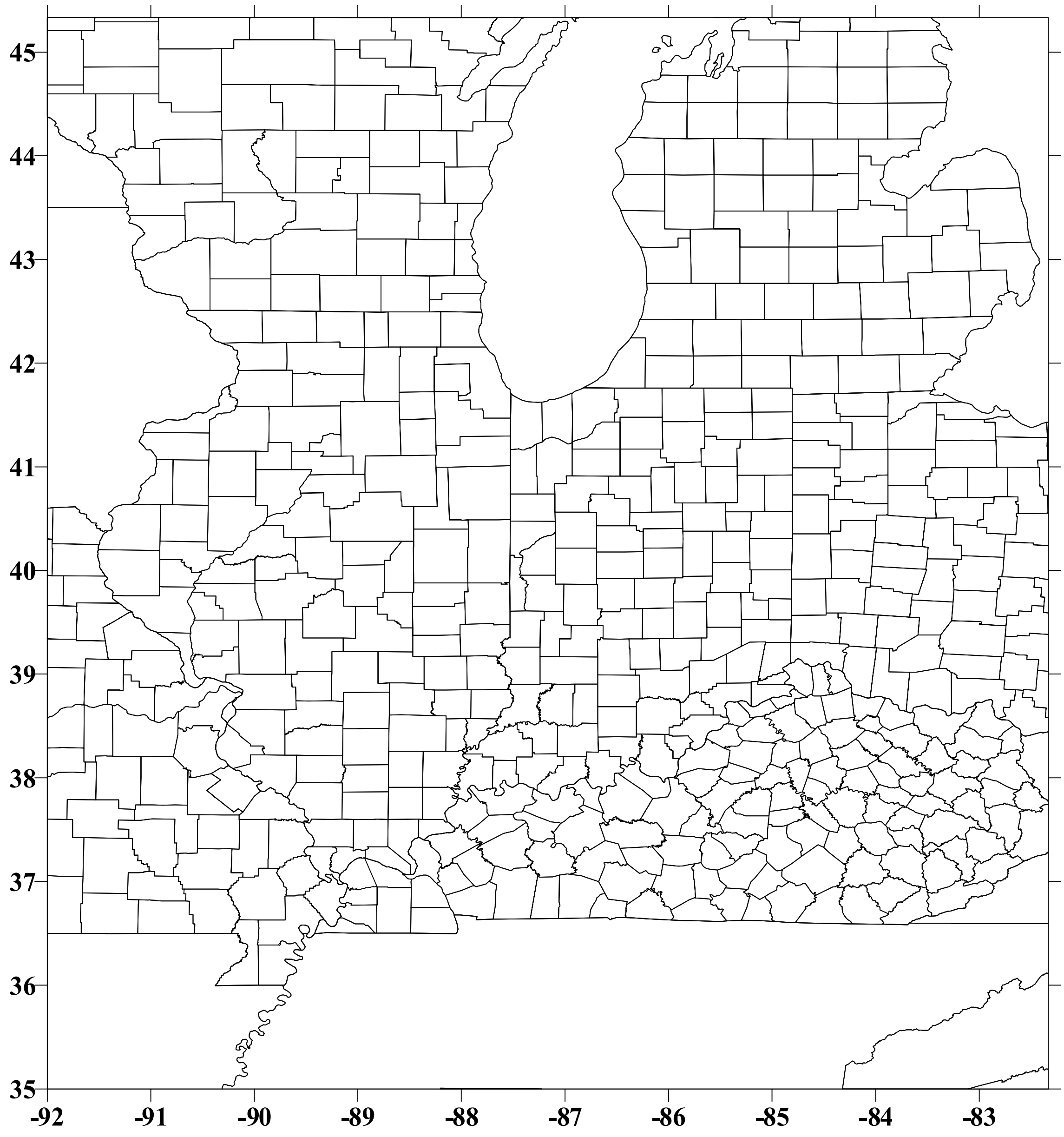
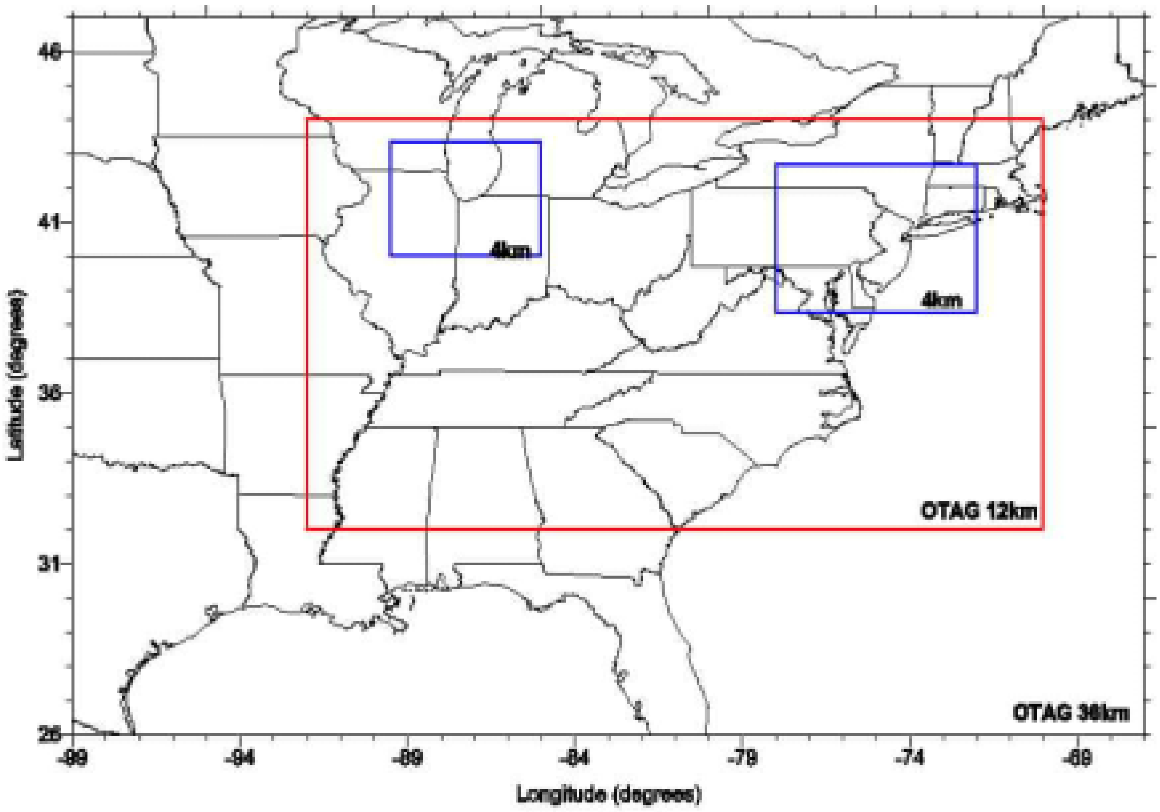


Figure 2-3. LADCO Grid M modeling domain used for the June 1991 and July 1995 episodes, both 4-km and 12-km versions of the databases are available.



DOMAINS WITH BUFFER CELLS

GRID	SW Corner	NE Corner
36km	(-99, 26)	(-67, 47)
12km	(-92.167, 31.889)	(-68.833, 44.111)
04km	(-78.056, 38.296)	(-71.944, 42.704)
04km	(-89.556,39.963)	(-84.944,43.378)

Figure 2-4. Enhanced OTAG modeling domain that includes two high-resolution 4-km nested-grids covering the Northeast Corridor and Lake Michigan regions within the standard OTAG 36/12-km grid.

SELECTION OF AN ASSESSMENT YEAR

Originally NREL preferred that the assessment of biodiesel fuel use on ozone formation use a current baseline year (e.g., 1995-2000) rather than a projected future-year baseline to reduce uncertainties associated with projecting emissions to future-years. It is recognized that there are numerous uncertainties associated with emissions, including projecting emissions to a future-year, so that use of a future-year projected inventory (e.g., 2005, 2007, or 2010) adds another potentially unnecessary layer of uncertainty to the modeling analysis. However, biodiesel fuel use will occur in a future, not historical year. As emissions have changed and will continue to change over the years, it makes more sense to make the biodiesel ozone impact assessment for a more current or future-year.

For the eastern US (including the Northeast Corridor and Lake Michigan) biodiesel fuel use ozone impact assessment, a future-year of 2007 was selected. This future-year was also used by OTAG and EPA in their various recent rulemakings. The growth and control projections for 2007 have been extensively reviewed and updated.

For the assessment of biodiesel fuel use in the SoCAB, it was originally intended to use the 2010 1-hour ozone attainment year. However, because the ARB/SCAQMD are in the process of developing a new SIP/AQMP, the latest 2010 emissions inventory is not available yet. Thus, the choice was to go back to the old 1997/1999 AQMP/SIP 2010 emission projections based on EMFAC7G or use the latest ARB 1997 emission inventories that are based on EMFAC2000. It was decided to proceed with the study using a 1997 assessment year for the following reasons:

- The 1997 year is based on the EMFAC2000, whereas the current 2010 inventory is based on EMFAC7G;
- There are numerous other emission updates in the current 1997 inventory not present in the currently available 2010 inventory (e.g., non-road, stationary sources, area sources, etc.);
- The 2010 emission projections for the SoCAB are even more uncertain than usual due to the inclusion of 182(e)(5) emission control measures in the 1-hour ozone SIP control plan that are based on no known control technology.

3. BIODIESEL EMISSIONS ASSESSMENT

Under Task 1 of the NREL Biodiesel Air Quality Impacts Study, engine dynamometer test data were reviewed and analyzed for a variety of engine types and model years for both a 20%/80% biodiesel/diesel fuel blend (B20) and a 100% biodiesel fuel (B100), as well as a standard diesel fuel. Table 3-1 summarizes the results of these analyses with respect to biodiesel fuel effects on heavy-duty diesel vehicle (HDDV) mass emissions for ozone precursors. A detailed discussion of the emission effects due to biodiesel fuels can be found in the Task 1 report (Lindhjem and Pollack, 2000). For the assessment of impacts of biodiesel fuel use on ozone concentrations for the future year scenarios, the effects of biodiesel fuels were accounted for only in the HDDV fleet. As it is unlikely to expect there will be sufficient biodiesel fuel produced to allow a significant penetration of B100 fuel in either the Lake Michigan, the Northeast Corridor, or the South Coast Air Basin (SoCAB), regions the assessment was made for just the B20 fuel only. A B20 fuel also has better biological stability and less water issues than a B100 fuel.

Table 3-1. Overall average change in mass emission effects due to biodiesel fuels in HDDVs over using a standard diesel fuel.

Biodiesel Fuel	NO_x	CO	VOC
B20	+2.4%	-13.1%	-17.9%
B100	+13.2%	-42.7%	-63.2%

EMISSION SCENARIOS

The biodiesel fuel effects on ambient ozone concentrations are assessed in the Northeast Corridor and Lake Michigan areas and the eastern U.S. for the following scenarios and the future year 2007:

- Future-year baseline diesel fuel (ARB standard diesel)
- 100% penetration of B20 fuel
- 50% penetration of B20 fuel

The gridded model-ready emission inventories for the Lake Michigan and Northeast Corridor modeling domains were prepared using the 1995 version of the Emission Modeling System (EMS95) and an enhanced version of the MOBILE5 emission factor model. The MOBILE5 model was modified to account for currently known changes to be implemented in MOBILE6. The EMS95 was configured for the OTAG 36-km and 12-km domains and for the two 4-km nested grids, as shown in Figure 2-4, and exercised for the July 7-18, 1995 episode. The baseline emissions scenario was developed for the year 2007 assuming implementation of both the Regional Ozone Transport (i.e., the NO_x SIP Call) Rule (ROTR) and the Tier 2/Low Sulfur Rule. The effects of B20 biodiesel fuels on NO_x, VOC and CO were accounted for only in HDDV portion of the inventory through modification of the on-road mobile emission factors in the EMS95 input data files using the adjustment factors in Table 3-1. EMS95 was then re-run for the 100% penetration level of B20 fuel and for the 50% penetration level (assumed adjustments of +1.2%, -8.95% and –6.55% for NO_x, VOC and CO, respectively) in order to provide the model-ready gridded emission inventories for the two future-year biodiesel emission scenarios.

The biodiesel fuel effects on ambient ozone concentrations are assessed in the South Coast Air Basin for the following scenarios and the base year 1997:

- 1997 baseline diesel fuel (CARB standard diesel)
- 100% penetration of B20 fuel
- 50% penetration of B20 fuel

The gridded model-ready emission inventories for the South Coast Air Basin (SoCAB) were prepared using EMFAC2000/DTIM4 on-road mobile source emissions models and the California Air Resources Board (ARB) Gridded Emissions Model (GEM) for the August 1997 Southern California Ozone Study (SCOS) episode. Currently only base year (1997) emissions are available using EMFAC2000/DTIM4. Therefore, the baseline diesel emissions scenario was developed for the year 1997. The effects of 100% and 50% penetration levels of B20 biodiesel fuels on NO_x, VOC and CO were accounted for only in HDDV portion of the inventory through source control modification in the GEM model.

EMISSION SUMMARIES

Emissions modeling was performed for the eastern US on a 36/12/4-km grid with 4-km domains covering the Northeast Corridor and Lake Michigan regions using EMS95 and for the SoCAB at 5-km resolution using GEM.

Lake Michigan and Northeast Corridor Emission Summaries

Table 3-2 summarizes the NO_x, VOC and CO emissions for the Lake Michigan and Northeast Corridor 4-km domains as well as the OTAG 12-km modeling domain by major emission source categories for July 14, 1995, a representative episode weekday. Table 3-3 provides a summary of the effects of biodiesel fuel on HDDV NO_x, VOC and CO emissions in terms fraction of on-road mobile emissions to the total inventory (anthropogenic plus biogenic), the fraction of on-road mobile emission to the total anthropogenic inventory, and the fraction of HDDV emissions to the total on-road mobile inventory. The resulting overall changes in emission inventories by major source category for each domain and for the two emissions scenarios are summarized in Table 3-4.

As a percentage of the total on-road mobile inventory (in the baseline scenario), the HDDV fraction of NO_x emissions varies from approximately 32% to 36%, depending on the domain, while the percentage of on-road mobile emissions in the total anthropogenic inventory is somewhat higher, varying from approximately 37% to 46%. As a percentage of the total inventory (anthropogenic plus biogenic), the on-road mobile NO_x emissions vary from approximately 28% to 42%. The variation seen across the domains is a result of the difference in fleet mix and amount of biogenic NO_x emissions, with the Northeast Corridor domain exhibiting a higher percentage of HDDV within the entire vehicle fleet as compared to the Lake Michigan domain. Note that in these summary tables, the OTAG 12-km domain also includes the contributions from both the Lake Michigan and the Northeast Corridor domains. The resulting overall impacts on the total NO_x emission inventory due to use of a B20 fuel is much less than 1%, as seen in Table 3-4, varying from only 0.22% to 0.36% for the 100% penetration level, and 0.11% to 0.18% for the 50% penetration level of B20 biodiesel fuel.

Similar results are seen for VOC and CO emission effects. The fraction of on-road mobile VOC emissions due to the HDDV contribution varies from 4.7% to 7.3%, with the largest percentage occurring in the Northeast Corridor domain. As a percentage of the anthropogenic emissions, on-road mobile VOC accounts for approximately 14% to 17% of the inventory, while the on-road mobile contribution ranges from approximately 2% to 7% of the total (anthropogenic plus biogenic) VOC emission inventory. For CO, the fraction of HDDV emissions vary from 4.5% to 6.3% of the on-road mobile component, while the on-road mobile CO emissions range from approximately 42% to 50% of the total emission inventory. As with the NO_x emission effects, the overall VOC and CO emission reductions due to biodiesel fuel use are very small. For the 100% penetration scenario, total VOC emission inventory reductions range from 0.018% to 0.06%, while the impacts due to the 50% penetration level are approximately 0.01% to 0.02%. For CO, reductions in the total emissions inventory range from 0.28% to 0.35% for the 100% B20 biodiesel scenario, and only 0.14% to 0.17% for the 50% penetration scenario.

Table 3-2. Future year baseline and biodiesel scenario emission summary for 14 July, 1995 for Lake Michigan and Northeast Corridor.

	2007 SIP CALL			**2007 100% B20 Biodiesel**			**2007 50% B20 Biodiesel**		
Emission Component	**OTAG 12km Domain**								
	NOX (tpd)	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**
Area	8113.01	15464.90	50618.14	8113.01	15464.90	50618.14	8113.01	15464.90	50618.14
Low Points	918.29	2874.23	3487.71	918.29	2874.23	3487.71	918.29	2874.23	3487.71
Elevated Points	1738.49	160.63	1661.42	1738.49	160.63	1661.42	1738.49	160.63	1661.42
On-Road Mobile	6435.27	3714.19	54237.05	6489.41	3682.57	53915.25	6462.34	3698.46	54077.38
Total Anthropogenic	17205.06	22213.94	110004.32	17259.20	22182.32	109682.52	17232.13	22198.22	109844.65
Biogenic	4081.86	149670.95	0.00	4081.86	149670.95	0.00	4081.86	149670.95	0.00
Total	**21286.92**	**171884.89**	**110004.32**	**21341.06**	**171853.27**	**109682.52**	**21313.99**	**171869.17**	**109844.65**
	Lake Michigan 4km Domain								
	NOX (tpd)	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**
Area	929.95	1701.96	5771.70	929.95	1701.96	5771.70	929.95	1701.96	5771.70
Low Points	82.80	418.82	422.85	82.80	418.82	422.85	82.80	418.82	422.85
Elevated Points	7.28	1.18	12.57	7.28	1.18	12.57	7.28	1.18	12.57
On-Road Mobile	684.15	402.41	5681.24	689.50	399.09	5647.19	686.82	400.76	5664.34
Total Anthropogenic	1704.18	2524.38	11888.36	1709.53	2521.05	11854.32	1706.86	2522.72	11871.47
Biogenic	714.96	2942.20	0.00	714.96	2942.20	0.00	714.96	2942.20	0.00
Total	**2419.14**	**5466.58**	**11888.36**	**2424.49**	**5463.25**	**11854.32**	**2421.82**	**5464.92**	**11871.47**
	Northeast Corridor 4km Domain								
	NOX (tpd)	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**
Area	1137.85	2641.74	11450.81	1137.85	2641.74	11450.81	1137.85	2641.74	11450.81
Low Points	182.54	554.27	279.02	182.54	554.27	279.02	182.54	554.27	279.02
Elevated Points	227.11	25.07	224.18	227.11	25.07	224.18	227.11	25.07	224.18
On-Road Mobile	1318.08	529.18	8667.11	1329.45	522.24	8596.02	1323.77	525.72	8631.83
Total Anthropogenic	2865.58	3750.26	20621.12	2876.95	3743.32	20550.03	2871.27	3746.80	20585.84
Biogenic	270.77	16282.81	0.00	270.77	16282.81	0.00	270.77	16282.81	0.00
Total	**3136.35**	**20033.07**	**20621.12**	**3147.72**	**20026.13**	**20550.03**	**3142.04**	**20029.61**	**20585.84**

Table 3-3. Summary of on-road mobile and HDDV emission contributions.

On-Road Mobile Emission Summary for 2007 SIP Call			
	OTAG 12km Domain		
	NOX	**VOC**	**CO**
Mobile % of Total Inv.	30.20%	2.16%	49.34%
Mobile % of Anthro.	37.36%	16.73%	49.34%
HDDV % of Mobile Inv.	35.10%	4.70%	4.50%
	Lake Michigan 4km Domain		
	NOX	**VOC**	**CO**
Mobile % of Total Inv.	28.22%	7.36%	47.78%
Mobile % of Anthro.	40.07%	15.94%	47.78%
HDDV % of Mobile Inv.	32.60%	4.60%	4.70%
	Northeast Corridor 4km Domain		
	NOX	**VOC**	**CO**
Mobile % of Total Inv.	42.03%	2.64%	42.05%
Mobile % of Anthro.	46.00%	14.12%	42.05%
HDDV % of Mobile Inv.	35.90%	7.30%	6.30%

Table 3-4. Summary of emission effects for B20 biodiesel fuel use.

	2007 100% B20 Biodiesel			2007 50% B20 Biodiesel		
Emission Component	**OTAG 12km Domain**			**OTAG 12km Domain**		
	%Change NOX	**%Change VOC**	**%Change CO**	**%Change NOX**	**%Change VOC**	**%Change CO**
Area	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Low Points	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Elevated Points	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
On-Road Mobile	0.841%	-0.851%	-0.593%	0.421%	-0.423%	-0.294%
Total Anthropogenic	0.315%	-0.142%	-0.293%	0.157%	-0.071%	-0.145%
Biogenic	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Total	**0.254%**	**-0.018%**	**-0.293%**	**0.127%**	**-0.009%**	**-0.145%**
	Lake Michigan 4km Domain			**Lake Michigan 4km Domain**		
	%Change NOX	**%Change VOC**	**%Change CO**	**%Change NOX**	**%Change VOC**	**%Change CO**
Area	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Low Points	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Elevated Points	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
On-Road Mobile	0.782%	-0.827%	-0.599%	0.391%	-0.411%	-0.297%
Total Anthropogenic	0.314%	-0.132%	-0.286%	0.157%	-0.066%	-0.142%
Biogenic	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Total	**0.221%**	**-0.061%**	**-0.286%**	**0.111%**	**-0.030%**	**-0.142%**
	Northeast Corridor 4km Domain			**Northeast Corridor 4km Domain**		
	%Change NOX	**%Change VOC**	**%Change CO**	**%Change NOX**	**%Change VOC**	**%Change CO**
Area	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Low Points	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Elevated Points	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
On-Road Mobile	0.863%	-1.312%	-0.820%	0.431%	-0.654%	-0.407%
Total Anthropogenic	0.397%	-0.185%	-0.345%	0.198%	-0.092%	-0.171%
Biogenic	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Total	**0.363%**	**-0.035%**	**-0.345%**	**0.181%**	**-0.017%**	**-0.171%**

The spatial distributions of the daily total NO_x, VOC and CO emissions and the impacts due to B20 biodiesel fuel use for a representative episode day (14 July, 1995) are displayed in Figures 3-1 through 3-6 for the two 4-km nested grid domains and for the 100% and 50% B20 penetration levels. Figures 3-1a and 3-1b display the spatial distributions of total surface NO_x emissions and on-road mobile source NO_x emissions in the Lake Michigan 4-km domain, respectively. The on-road mobile component accounts for approximately 28% of the total NO_x emissions and are primarily located within the major urban centers of Chicago and Milwaukee. The increases in total daily NO_x due to the introduction of B20 biodiesel fuel in the HDDV fleet are displayed in Figures 3-1c and 3-1d for the 100% and 50% penetration levels, respectively. As expected, the largest increases are seen within the urban areas of the domain with small differences distributed along the major transportation routes. In both biodiesel emission scenarios however, the increases are very small.

In Figures 3-2a and 3-2b the corresponding spatial distributions of NO_x emissions are displayed for the Northeast Corridor domain in terms of the daily total and on-road mobile source component, respectively. In the Northeast Corridor the mobile source component accounts for almost 45% of the daily total and, although the highest emissions on-road are generally confined to the urban centers, the emissions are seen to be more widely distributed across the domain due to the denser traffic networks linking Washington, DC, Baltimore, Philadelphia and New York City. While relatively small, the resulting increases in NO_x emissions under the 100% and 50% B20 biodiesel scenarios are correspondingly spread across the domain with the largest differences occurring within the major urban centers as shown in Figures 3-2c and 3-2d.

The daily total and on-road mobile VOC emissions and the corresponding reductions due to the B20 biodiesel emission scenarios are displayed in Figures 3-3 and 3-4 for the Lake Michigan and Northeast Corridor domains, respectively. As with the NO_x emissions, the spatial distribution of on-road mobile source VOC emissions are generally confined within the major urban centers. The percentage of total VOC emissions due to on-road mobile sources is approximately 7% in the Lake Michigan domain while within the Northeast Corridor domain, the on-road mobile component accounts for only approximately 2.5%, due to the higher percentage of biogenic VOCs within the domain. The spatial distribution of VOC emission reductions realized due to biodiesel fuel use are similar to those of $NO_{x,}$ with the largest differences generally within the urban areas of the domains and smaller emission reductions distributed along the major highways and transportation networks.

The spatial distribution of daily total and on-road mobile CO emissions, as well as the reductions resulting from the use of B20 biodiesel fuel, are presented in Figures 3-5 and 3-6 for the Lake Michigan and Northeast Corridor domains, respectively. For CO emissions the mobile source component accounts for approximately 42% to 48% of the total CO emissions in the Lake Michigan and Northeast Corridor domains. As such, the spatial distributions of the daily total and on-road mobile CO emissions are very similar, confined mainly to the urban centers and the transportation corridors of the domains. The reductions in CO emissions for the Lake Michigan and Northeast Corridor domains for each of the biodiesel emission scenarios are displayed in Figures 3-5c, 3-5d, 3-6c and 3-6d. As with the NO_x and VOC emissions, overall CO emission reductions for the 50% and 100% penetration level of a B20 fuel are small, ranging from approximately 0.14% to 0.35%, and are generally throughout the traffic networks and urban centers of the Lake Michigan and Northeast Corridor domains.

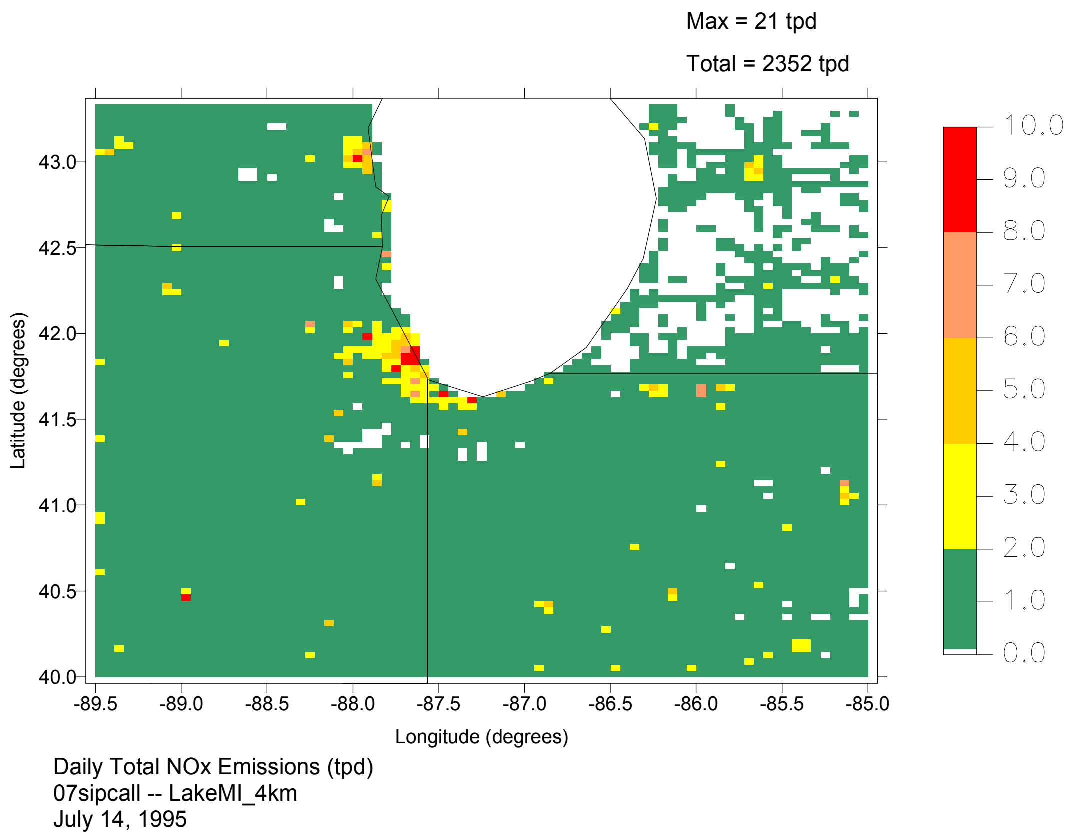


Figure 3-1a. Daily total NO_x emissions (tpd) for the 2007 SIP Call in the Lake Michigan domain on 14 July, 1995.

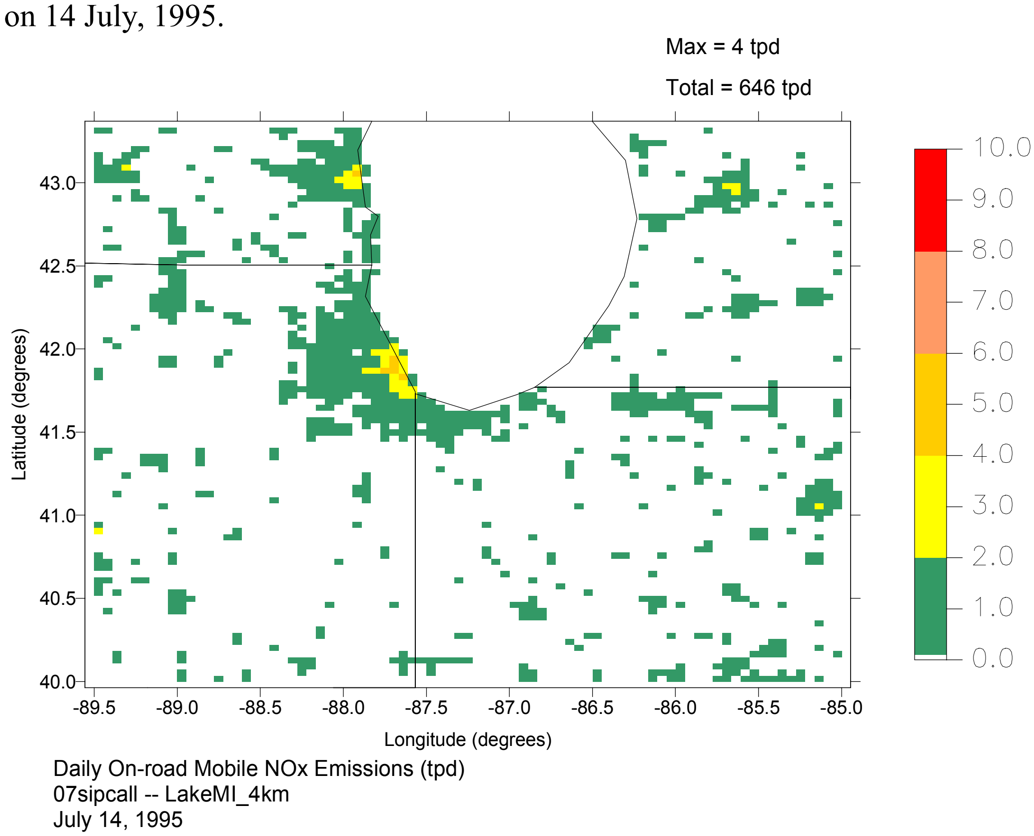


Figure 3-1b. Daily on-road mobile source NO_x emissions (tpd) for the 2007 SIP Call in the Lake Michigan domain on 14 July, 1995.

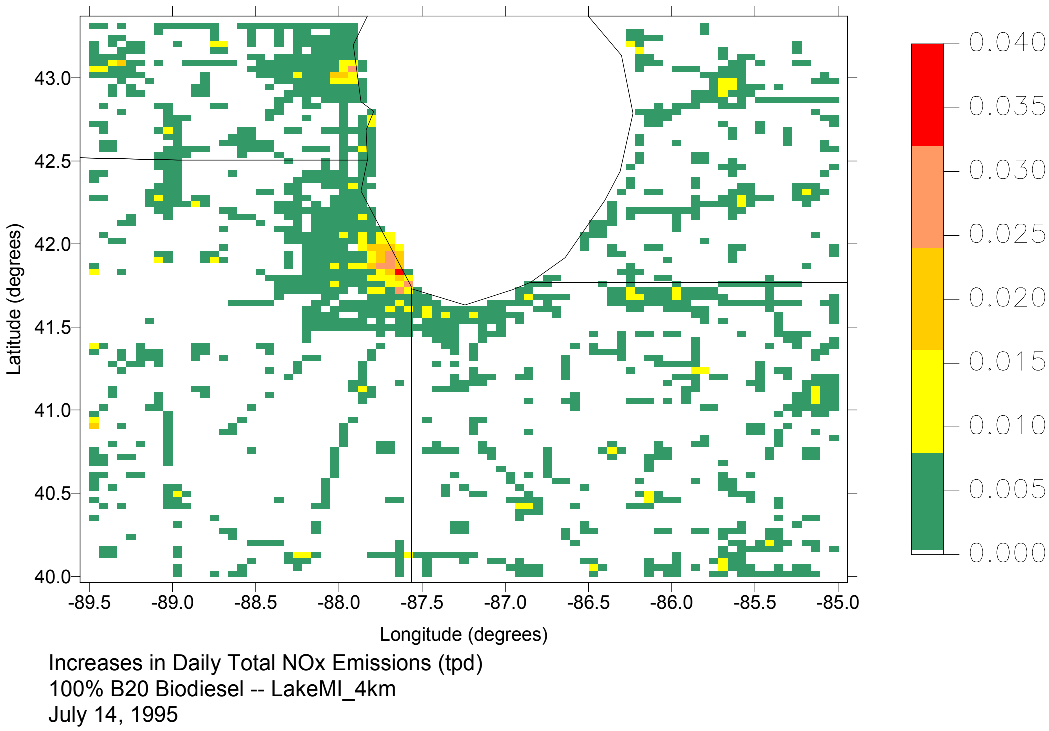


Figure 3-1c. Increases in daily total NO_x emissions (tpd) for the 2007 100% B20 biodiesel fuel scenario in the Lake Michigan domain on 14 July, 1995.

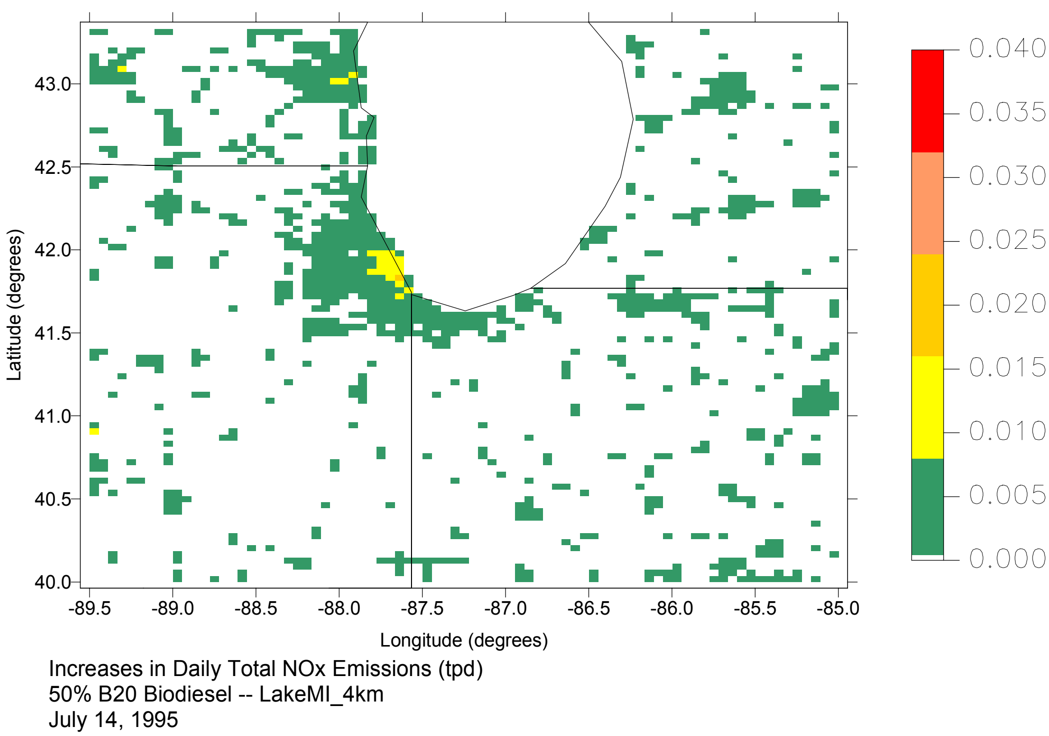


Figure 3-1.d. Increases in daily total NO_x emissions (tpd) for the 2007 50% B20 biodiesel fuel scenario in the Lake Michigan domain on 14 July, 1995.

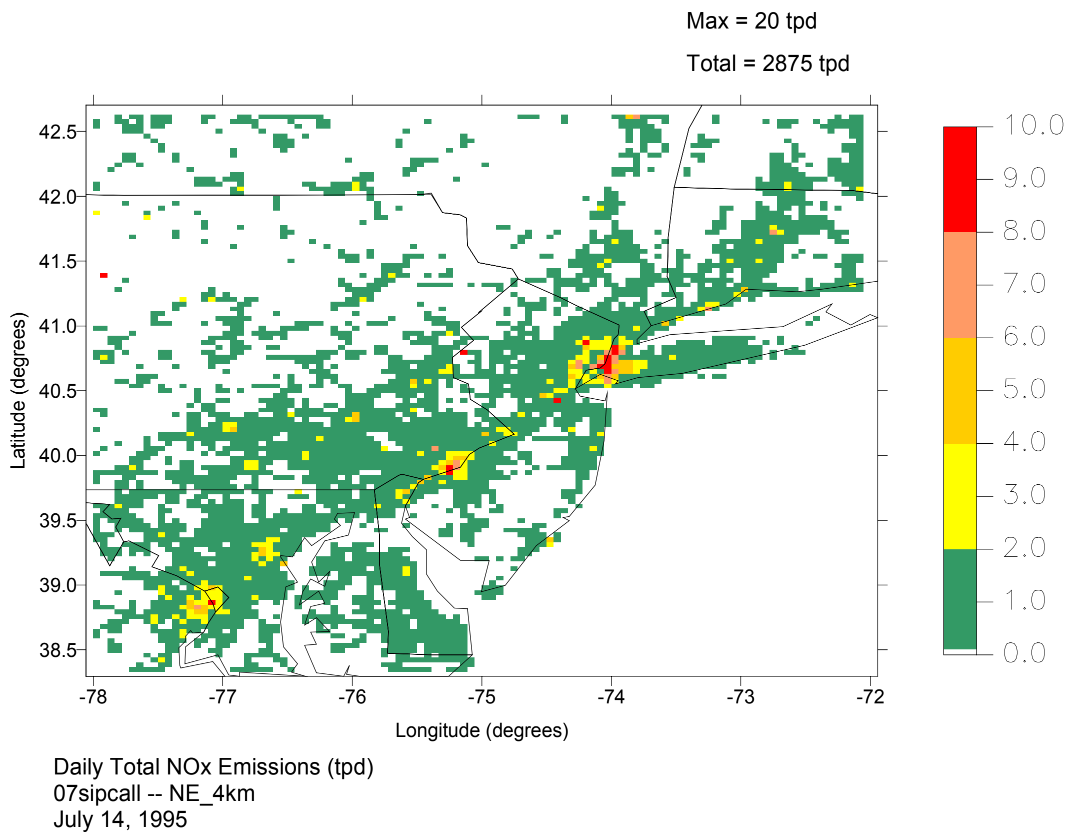


Figure 3-2a. Daily total NO_x emissions (tpd) for the 2007 SIP Call in the Northeast Corridor domain on 14 July, 1995.

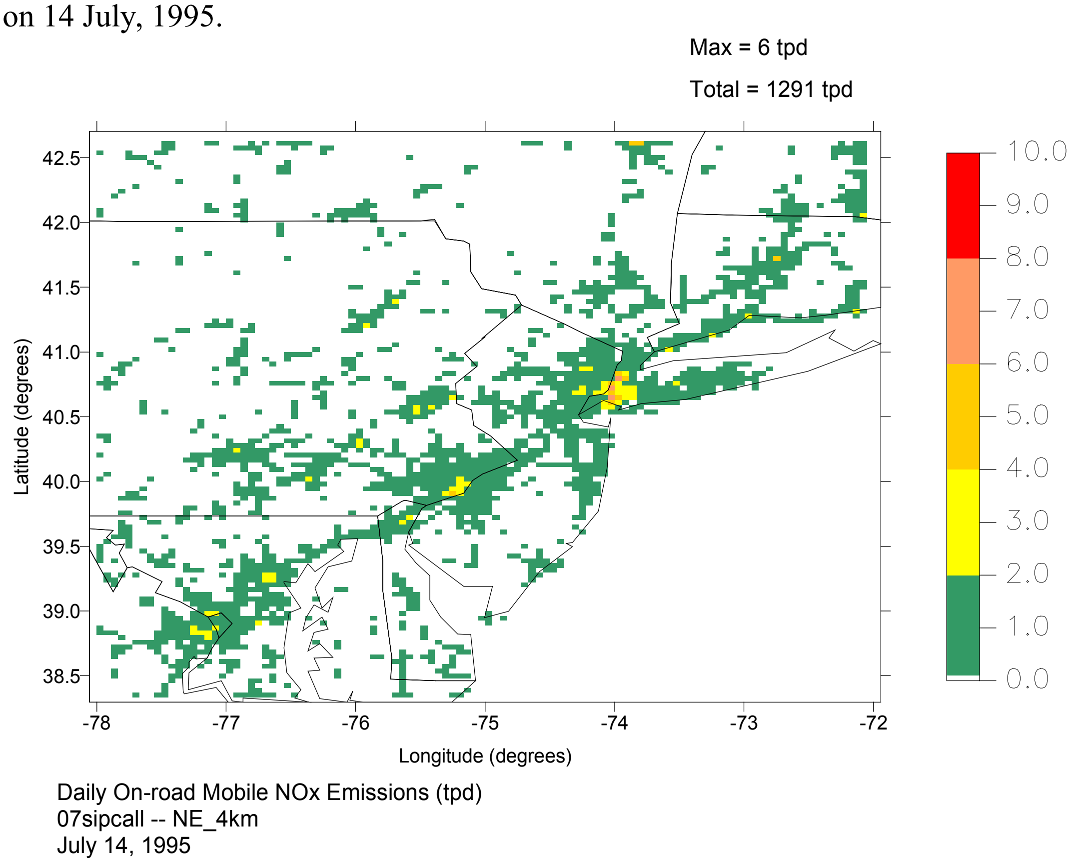


Figure 3-2b. Daily on-road mobile source NO_x emissions (tpd) for the 2007 SIP Call in the Northeast Corridor domain on 14 July, 1995.

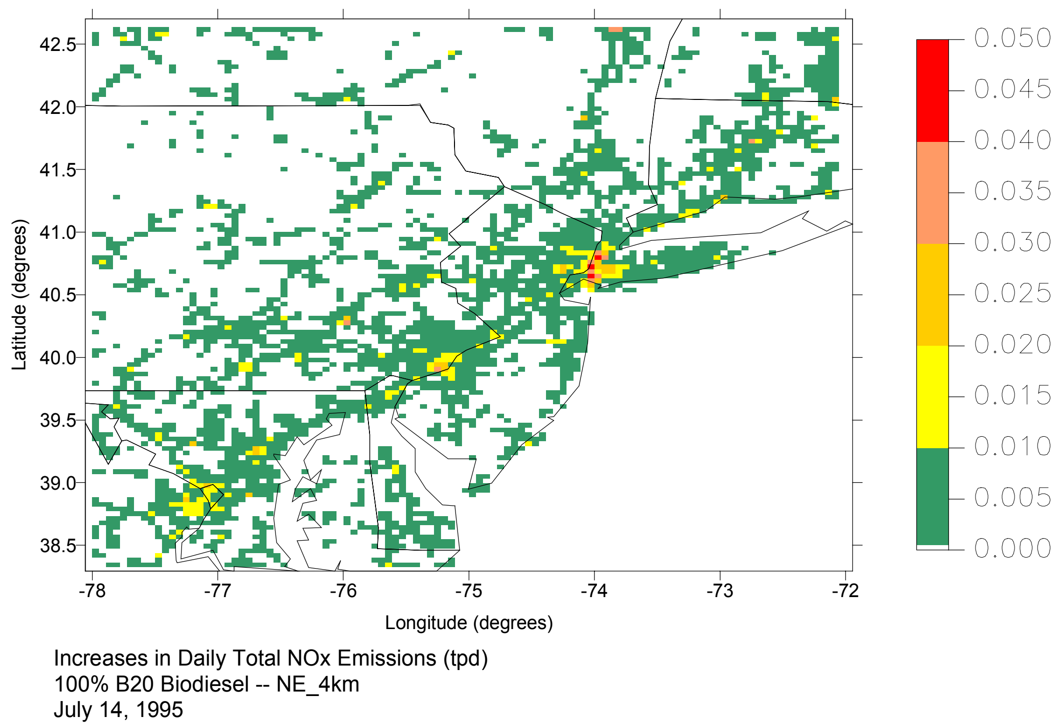


Figure 3-2c. Increases in daily total NO_x emissions (tpd) for the 2007 100% B20 biodiesel fuel scenario in the Northeast Corridor domain on 14 July, 1995.

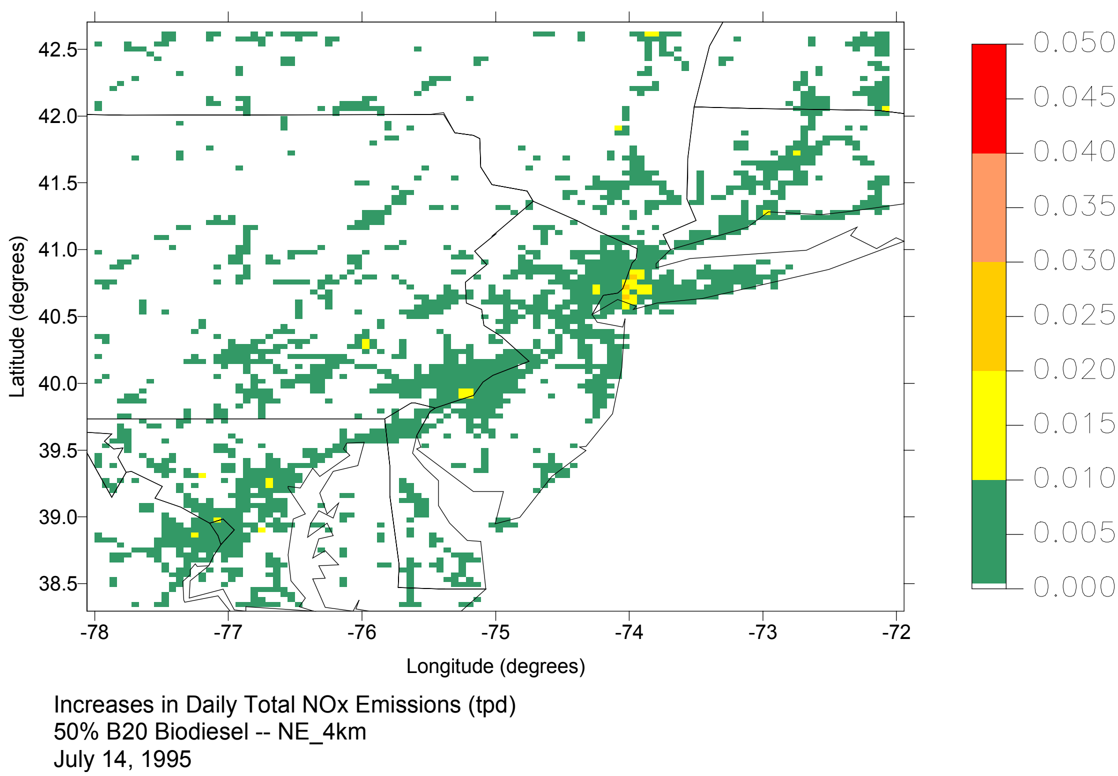


Figure 3-2d. Increases in daily total NO_x emissions (tpd) for the 2007 50% B20 biodiesel fuel scenario in the Northeast Corridor domain on 14 July, 1995.

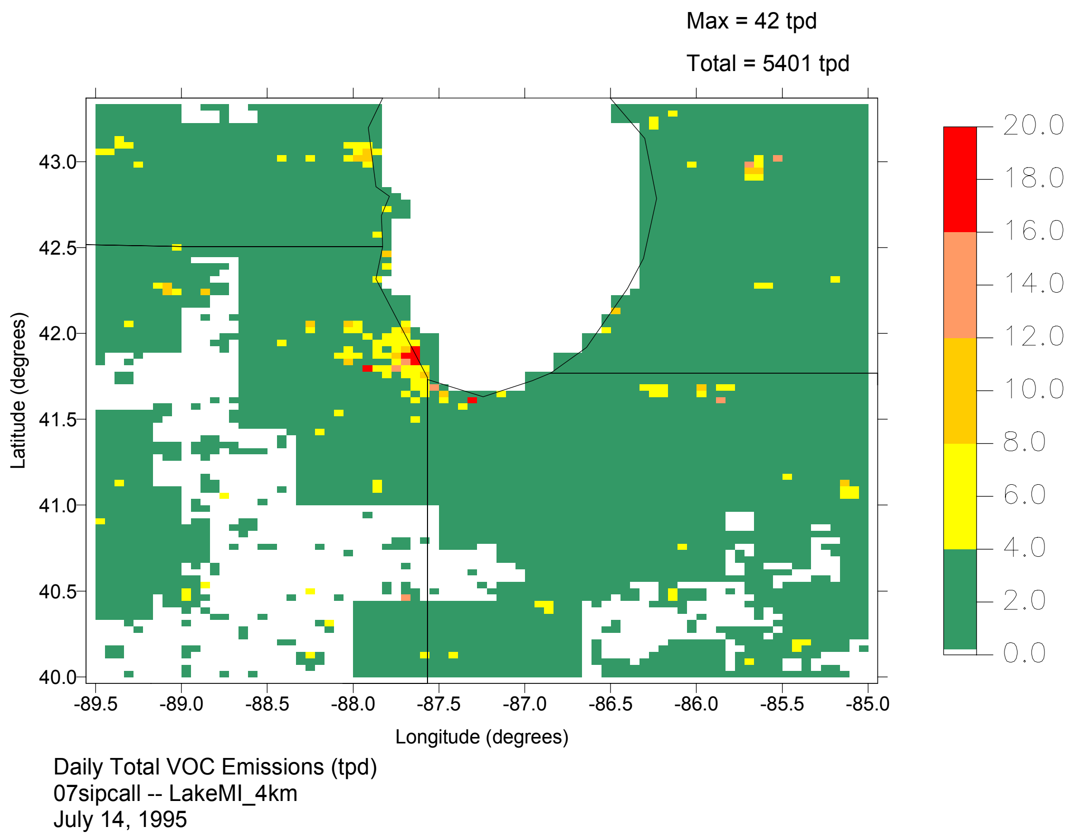


Figure 3-3a. Daily total VOC emissions (tpd) for the 2007 SIP Call in the Lake Michigan domain on 14 July, 1995.

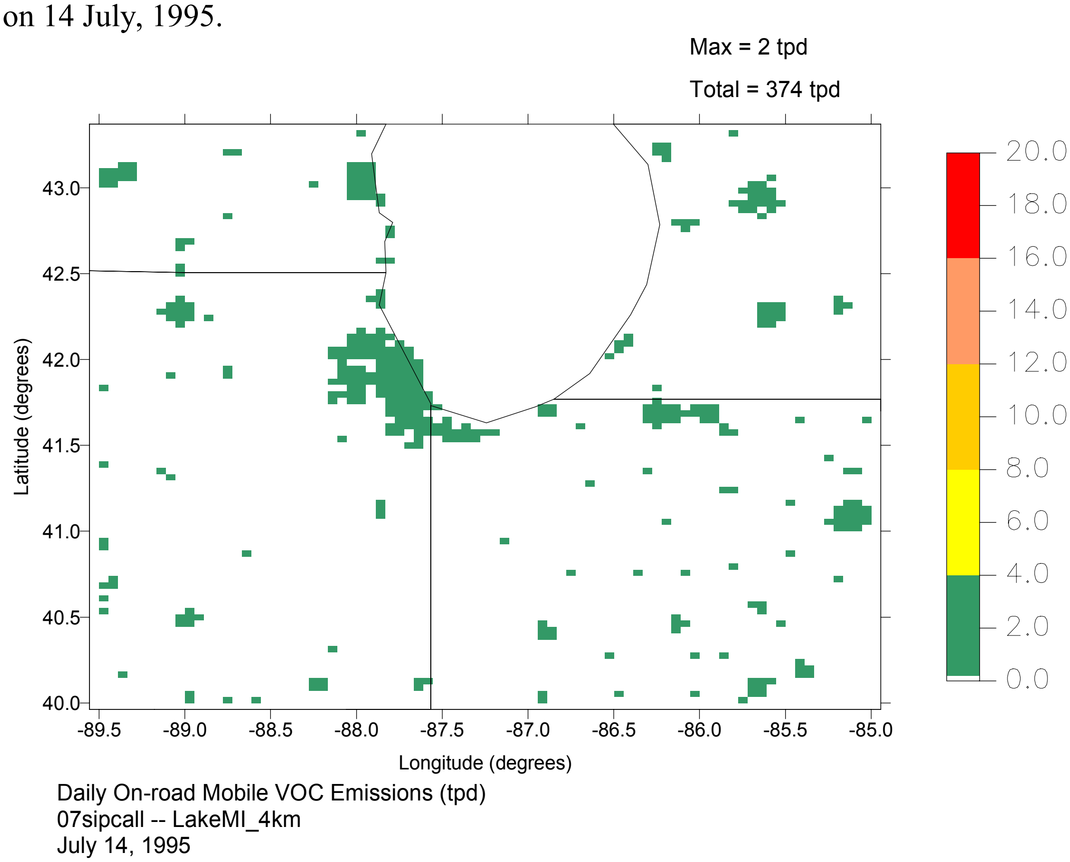
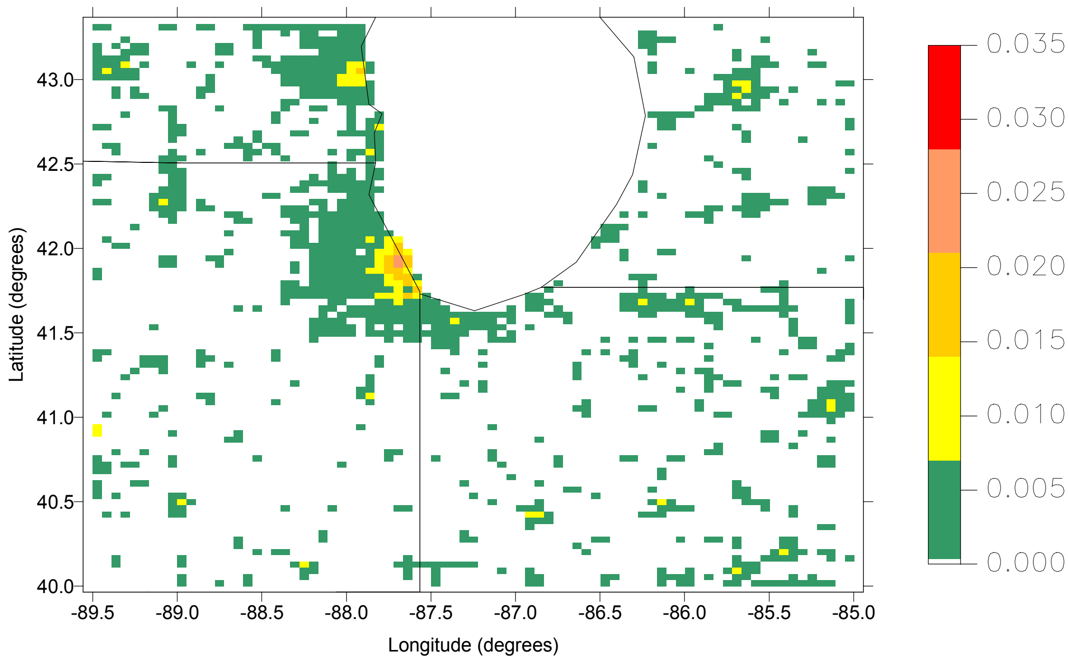
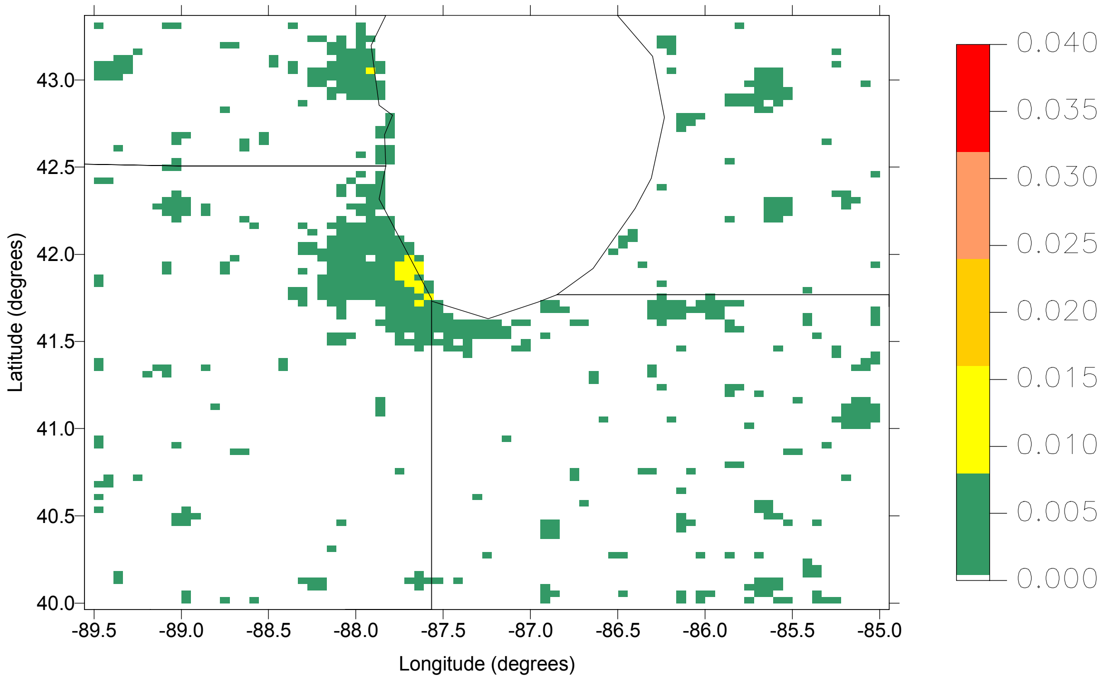


Figure 3-3b. Daily on-road mobile source VOC emissions (tpd) for the 2007 SIP Call in the Lake Michigan domain on 14 July, 1995.



Reductions in Daily Total VOC Emissions (tpd)
100% B20 Biodiesel -- LakeMI_4km
July 14, 1995

Figure 3-3c. Reductions in daily total VOC emissions (tpd) for the 2007 100% B20 biodiesel fuel scenario in the Lake Michigan domain on 14 July, 1995.



Reductions in Daily Total VOC Emissions (tpd)
50% B20 Biodiesel -- LakeMI_4km
July 14, 1995

Figure 3-3d. Reductions in daily total VOC emissions (tpd) for the 2007 50% B20 biodiesel fuel scenario in the Lake Michigan domain on 14 July, 1995.

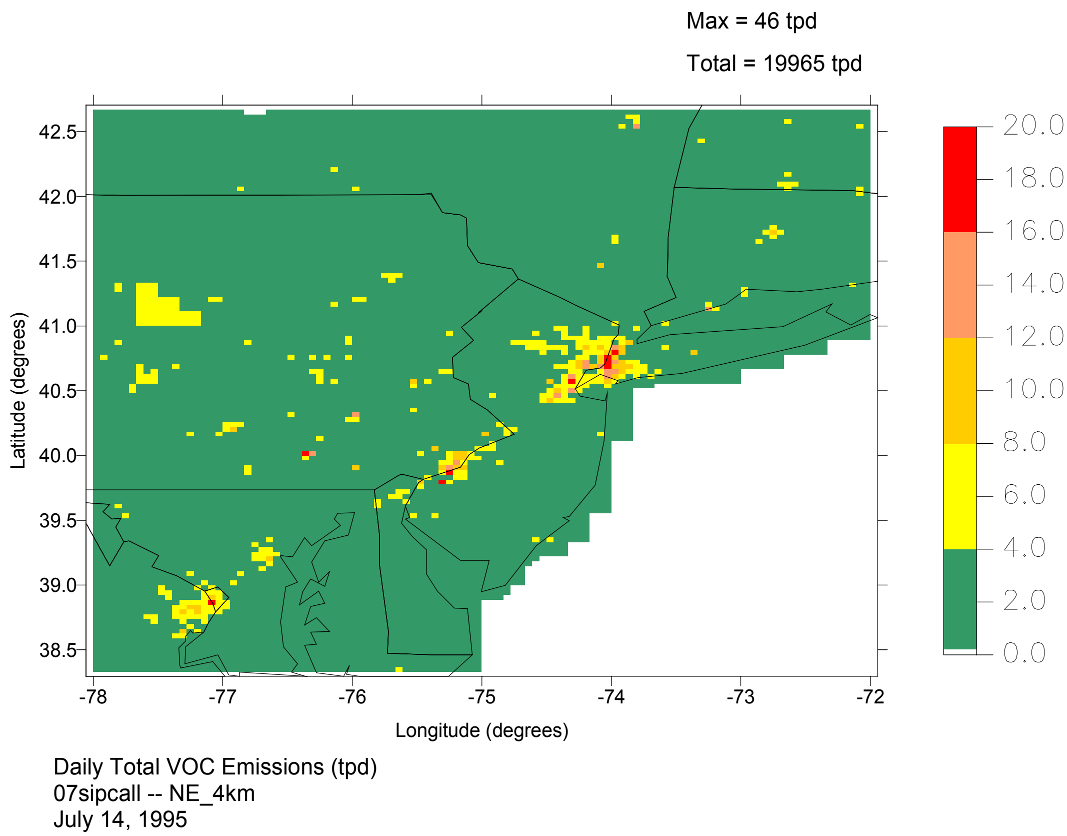


Figure 3-4a. Daily total VOC emissions (tpd) for the 2007 SIP Call in the Northeast Corridor domain on 14 July, 1995.

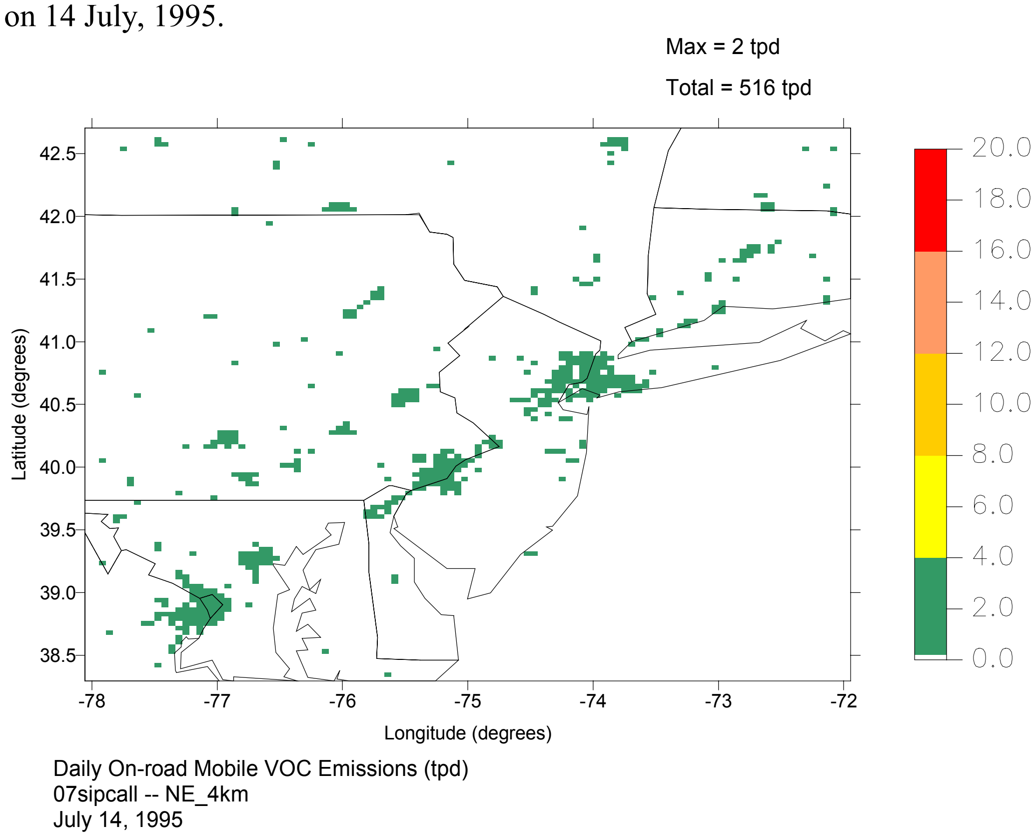


Figure 3-4b. Daily on-road mobile source VOC emissions (tpd) for the 2007 SIP Call in the Northeast Corridor domain on 14 July, 1995.

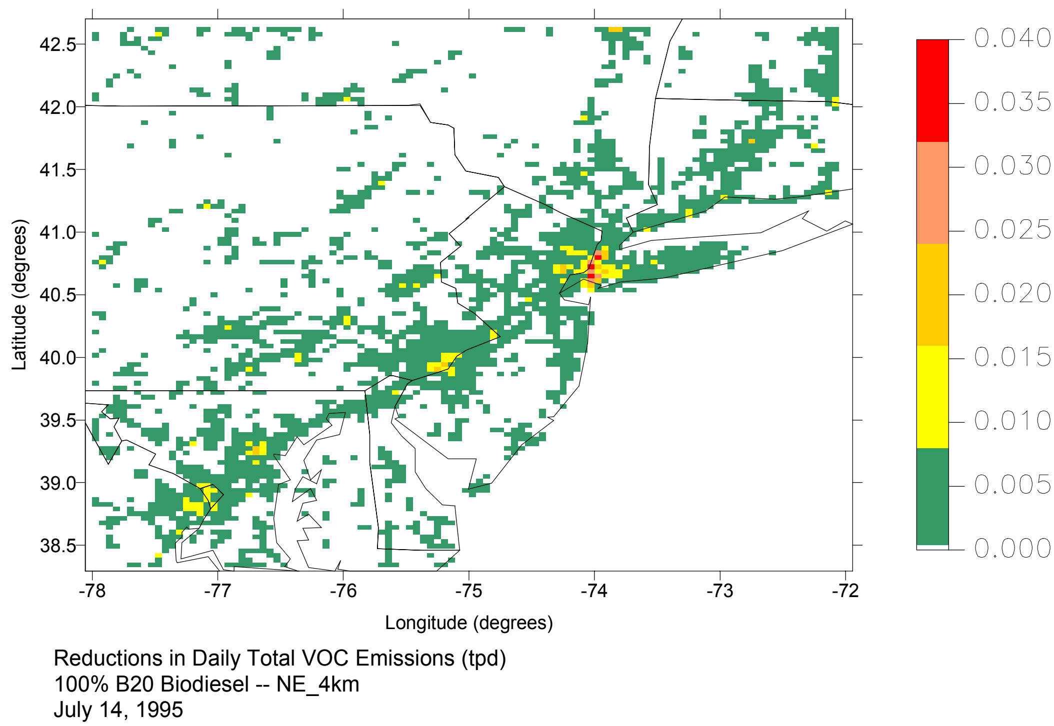


Figure 3-4c. Reductions in daily total VOC emissions (tpd) for the 2007 100% B20 biodiesel fuel scenario in the Northeast Corridor domain on 14 July, 1995.

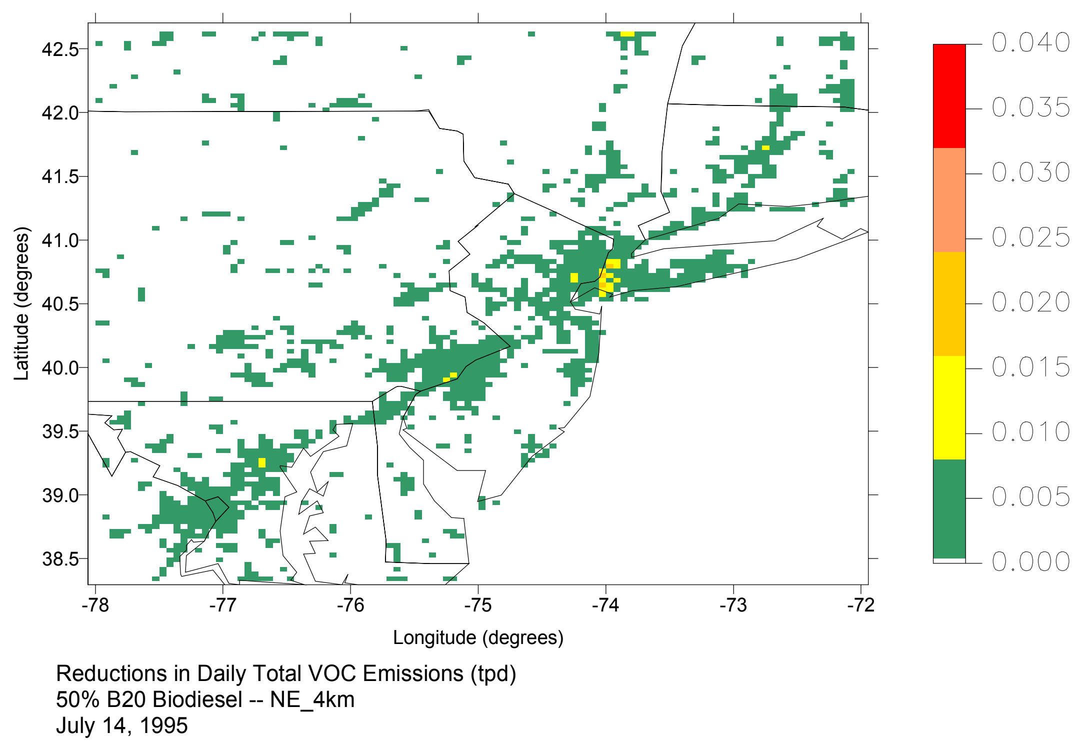


Figure 3-4d. Reductions in daily total VOC emissions (tpd) for the 2007 50% B20 biodiesel fuel scenario in the Northeast Corridor domain on 14 July, 1995.

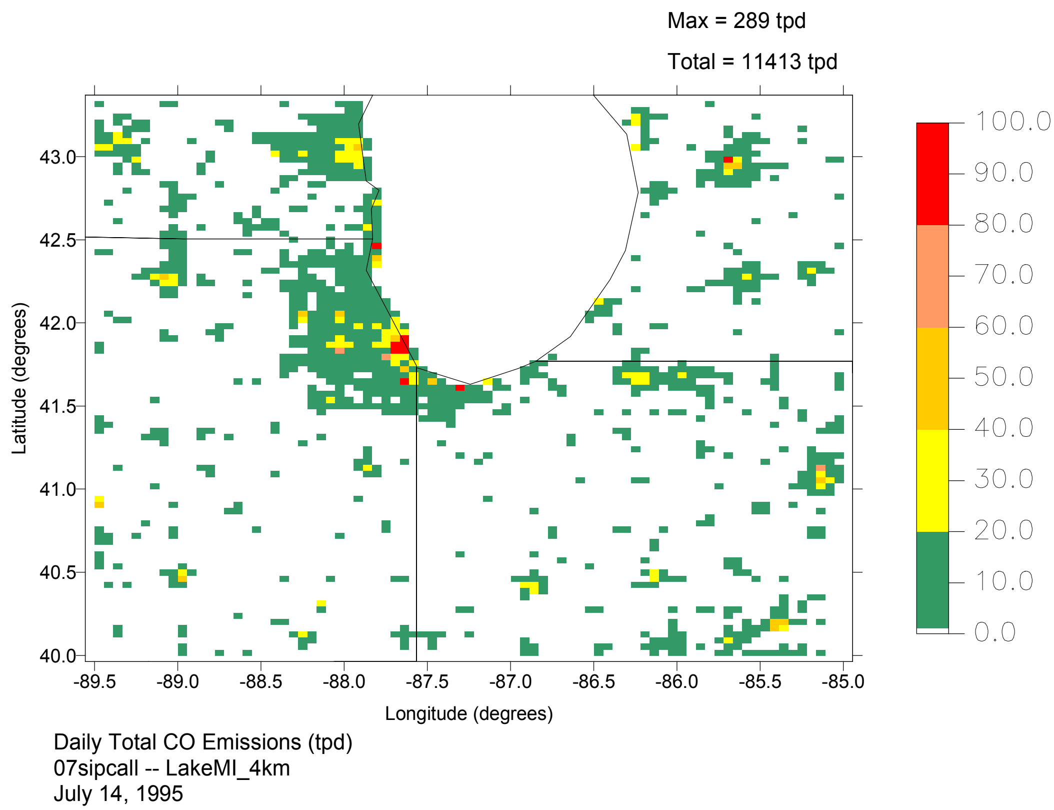


Figure 3-5a. Daily total CO emissions (tpd) for the 2007 SIP Call in the Lake Michigan domain on 14 July, 1995.

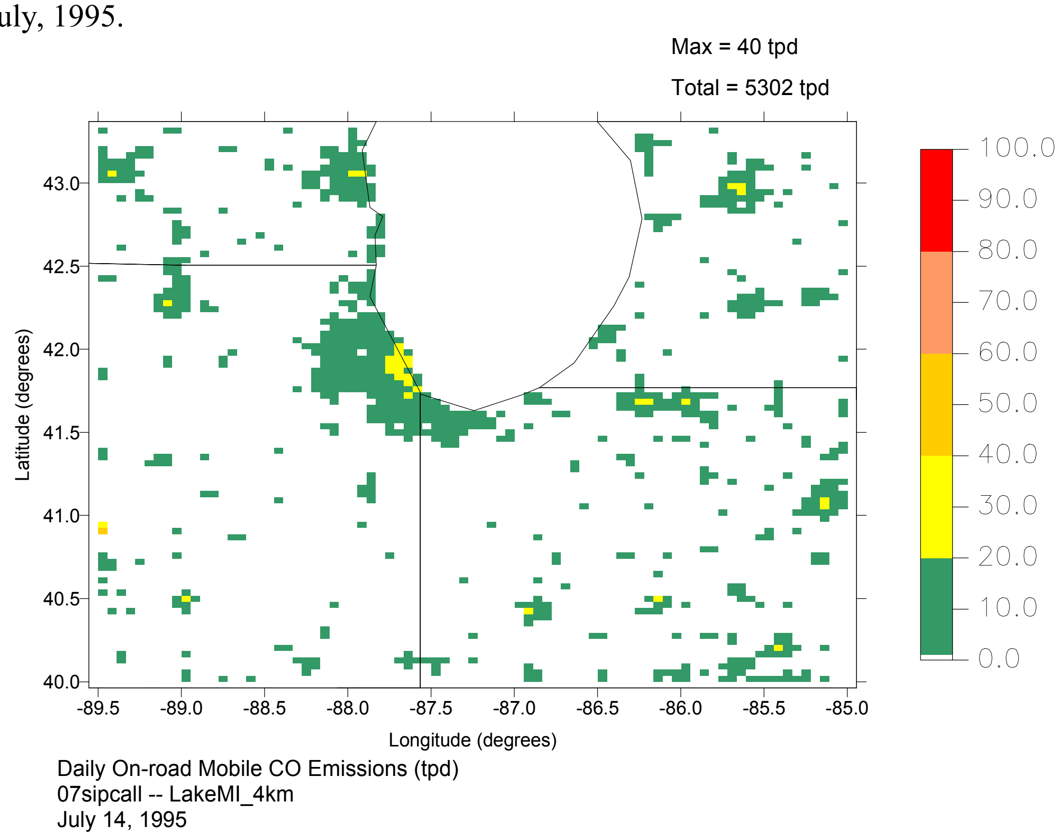


Figure 3-5b. Daily on-road mobile source CO emissions (tpd) for the 2007 SIP Call in the Lake Michigan domain on 14 July, 1995.

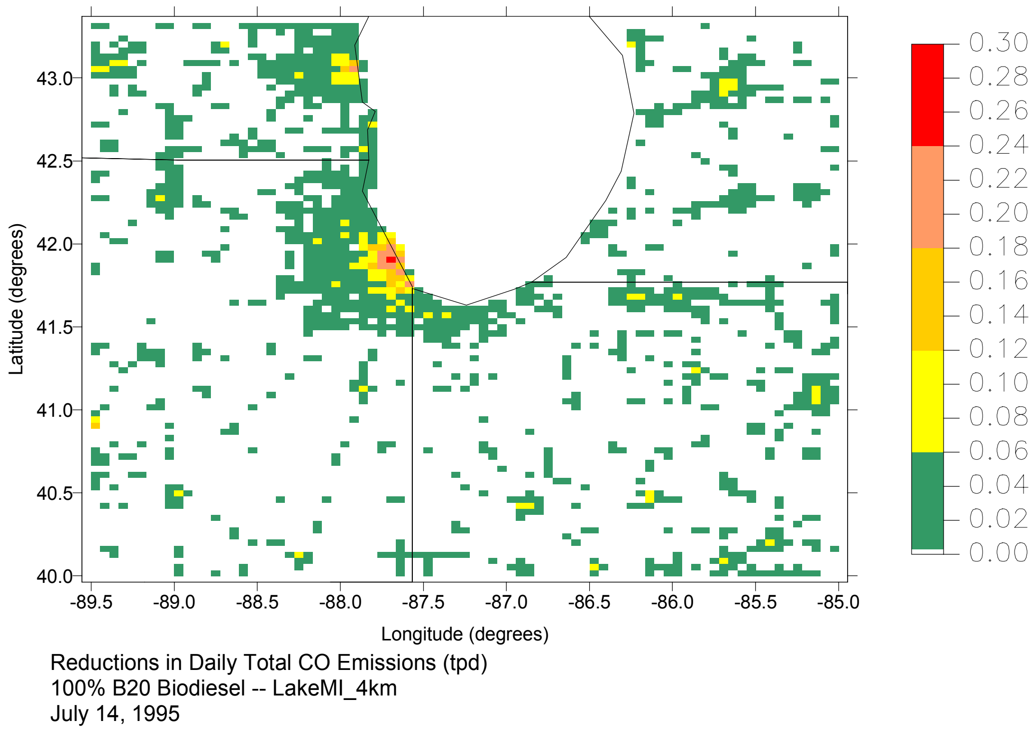


Figure 3-5c. Reductions in daily total CO emissions (tpd) for the 2007 100% B20 biodiesel fuel scenario in the Lake Michigan domain on 14 July, 1995.

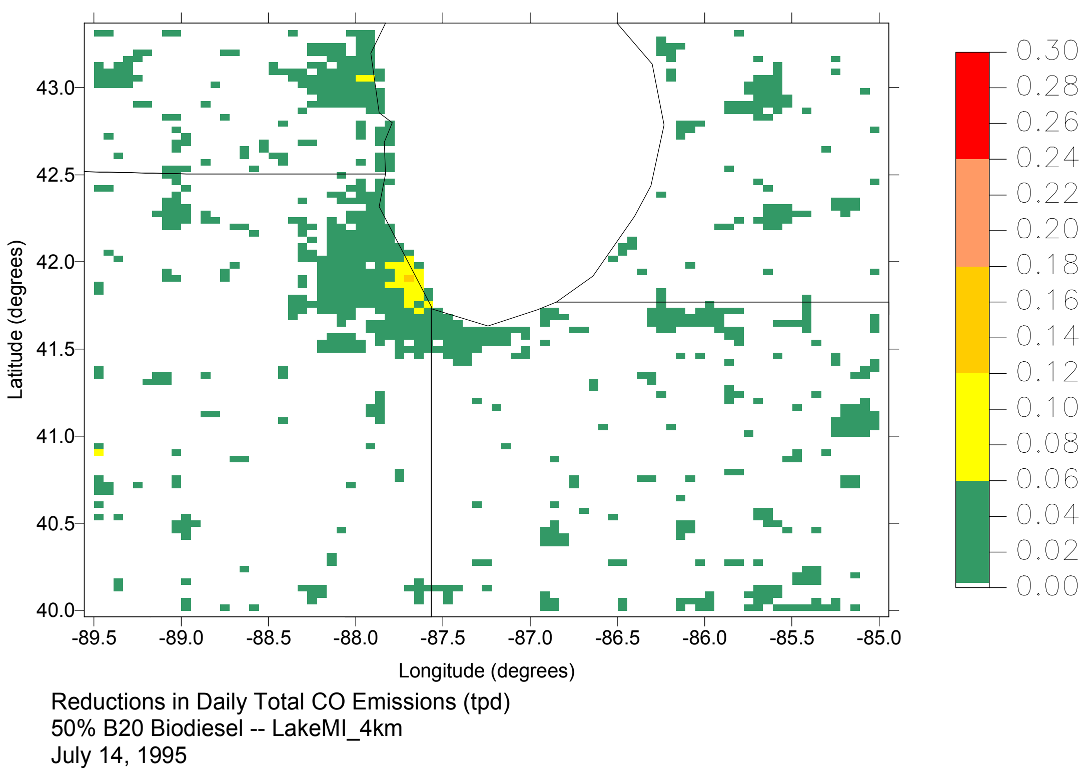


Figure 3-5d. Reductions in daily total CO emissions (tpd) for the 2007 50% B20 biodiesel fuel scenario in the Lake Michigan domain on 14 July, 1995.

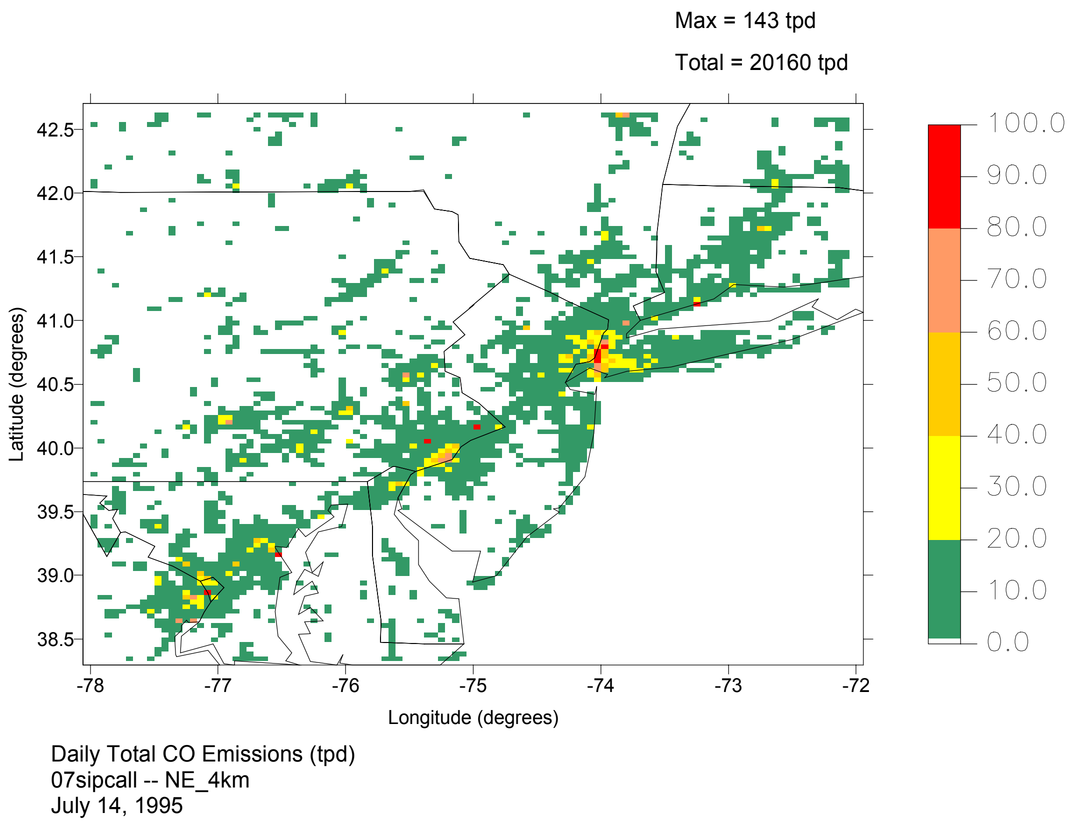


Figure 3-6a. Daily total CO emissions (tpd) for the 2007 SIP Call in the Northeast Corridor domain on 14 July, 1995.

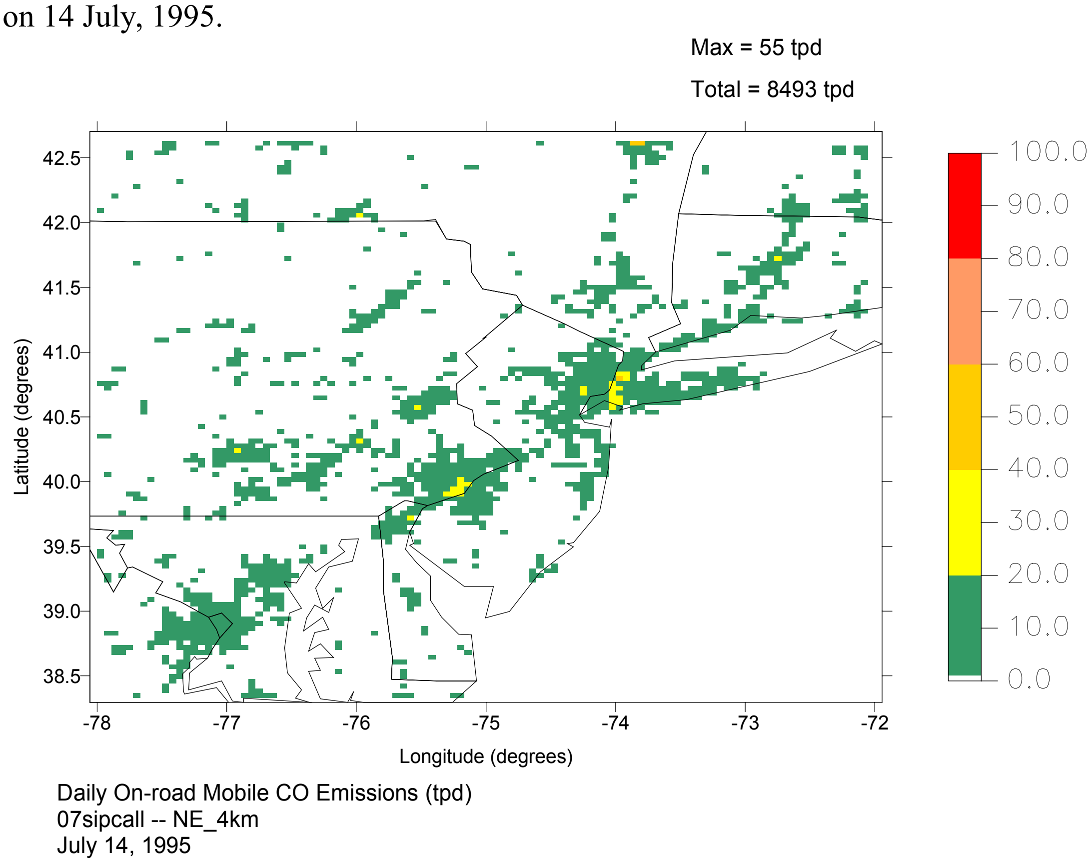
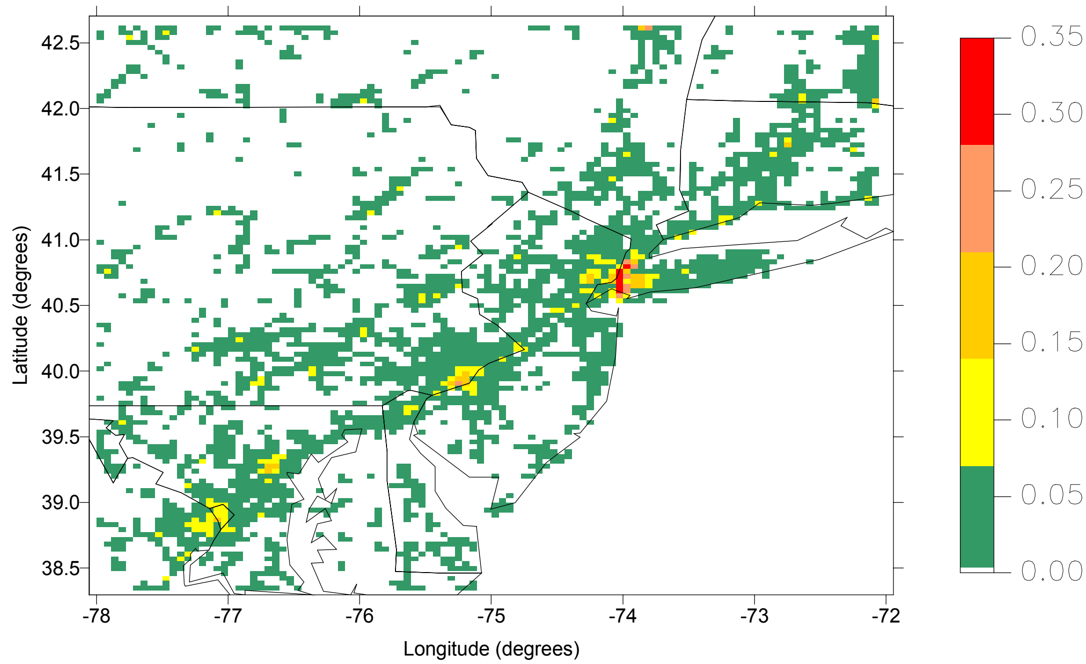
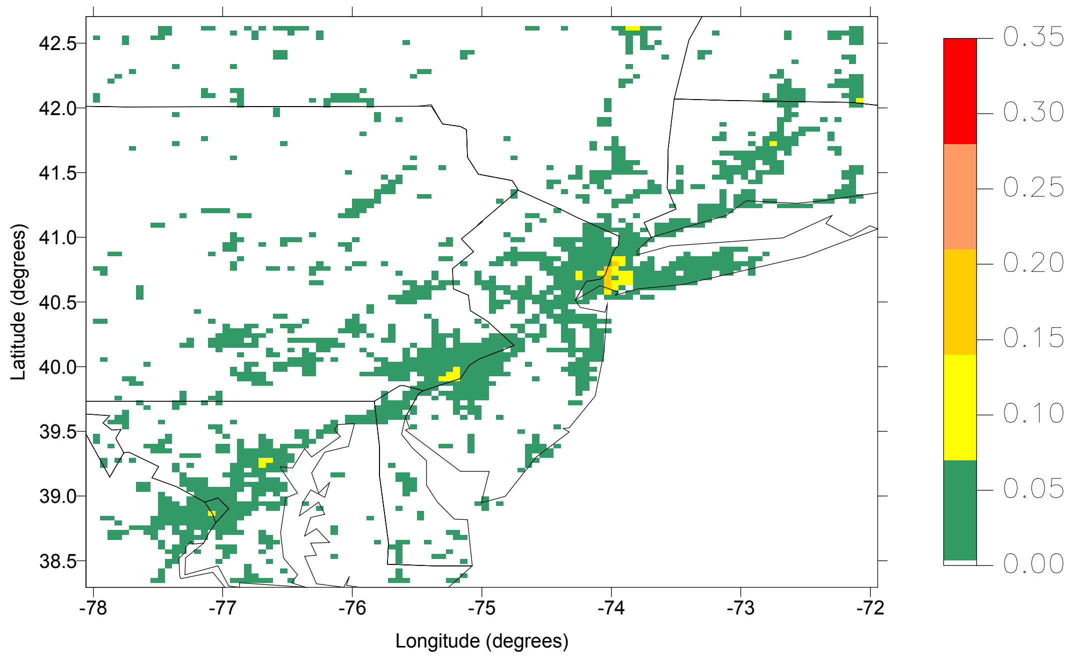


Figure 3-6b. Daily on-road mobile source CO emissions (tpd) for the 2007 SIP Call in the Northeast Corridor domain on 14 July, 1995.



Reductions in Daily Total CO Emissions (tpd)
100% B20 Biodiesel -- NE_4km
July 14, 1995

Figure 3-6c. Reductions in daily total CO emissions (tpd) for the 2007 100% B20 biodiesel fuel scenario in the Northeast Corridor domain on 14 July, 1995.



Reductions in Daily Total CO Emissions (tpd)
50% B20 Biodiesel -- NE_4km
July 14, 1995

Figure 3-6d. Reductions in daily total CO emissions (tpd) for the 2007 50% B20 biodiesel fuel scenario in the Northeast Corridor domain on 14 July, 1995.

South Coast Air Basin Emission Summary

Table 3-5 summarizes the effects of biodiesel fuel on HDDV NOx, VOC and CO emissions for the South Coast Air Basin 5-km AQMP modeling domain by major emissions source category and the August 3-7, 1997 episode days. Table 3-6 provides a summary of on-road mobile and HDDV emission contributions. The resulting overall changes in emission inventories by major source category and the two emission scenarios are summarized in Table 3-7.

As a percentage of the on-road mobile inventory (in the baseline scenario), the HDDV fraction of NOx emissions vary from approximately 26% to 42%, depending on which day, while the percentage of on-road mobile emissions in the total anthropogenic inventory is somewhat higher, varying from approximately 59% to 65%. The resulting overall impacts on the total NOx emission inventory due to use of a B20 fuel is much less than 1%, as seen in Table 3-7, varying from only 0.277% to 0.510% for the 100% penetration level, and 0.135% to 0.255% for the 50% penetration level of B20 biodiesel fuel.

Similar results are seen for VOC and CO emission effects. The fraction of on-road mobile VOC emissions due to the HDDV contribution varies from 4.6% to 6.8%, with the largest percentage occurring on August 7, 1997 (a Thursday). As a percentage of the anthropogenic emissions, on-road mobile VOC accounts for approximately 29.7% to 34.5% of the inventory, while the on-road mobile contribution ranges from approximately 26.2% to 29.4% of the total (anthropogenic plus biogenic) VOC emission inventory. For CO, the fraction of HDDV emissions vary from 4.3% to 8.6% of the on-road mobile component, while the on-road mobile CO emissions range from approximately 71.0% to 86.6% of the total emission inventory. It is noticed that there are no NOx and CO emission reported from biogenic sources in the ARB's emissions database.

As with the NOx emission effects, the overall VOC and CO emission reductions due to biodiesel fuel use are extremely small. For the 100% penetration B20 scenario, total VOC emission inventory reductions range from 0.031% to 0.082%, while the impacts due to the 50% penetration level are approximately 0.015% to 0.042%. For CO, reductions in the total emissions inventory range from 0.026% to 0.067% for the 100% B20 biodiesel scenario, and only 0.013% to 0.034% for the 50% penetration scenario.

Spatial distributions of the daily total NOx, VOC and CO emissions and the impacts due to 100% and 50% penetration of B20 biodiesel fuel for a representative episode day (August 4, 1997) are displayed in Figure 3-7 through Figure 3-9 for the 5-km nested grid domains.

Figures 3-7a and 3-7b display the spatial distributions of total surface NOx emissions and on-road mobile source NOx emissions in the South Coast Air Basin 5-km domain, respectively. The on-road mobile component are accounted for about 59% of the total NOx emissions and are primarily located within the major urban centers of the SoCAB. The increases in total daily NOx due to the introduction of B20 biodiesel fuel in the HDDV fleet are displayed in Figures 3-7c and 3-7d for the 100% and 50% penetration levels, respectively. As expected, the largest increases are seen within the urban areas of the domain with the largest differences distributed along the major transportation routes. In both biodiesel emission scenarios however, the increases are very small.

The daily total and on-road mobile VOC emissions and the corresponding reductions due to the B20 biodiesel emission scenarios are displayed in Figure 3-8 for the SoCAB 5-km modeling domain. As with the NOx emissions, the spatial distribution of on-road mobile source VOC emissions are generally confined within the major urban centers and major highways. The percentage of total VOC emissions due to on-road mobile sources is approximately 29%. The spatial distribution of VOC emission reductions realized due to biodiesel fuel use shows that the largest differences generally within the urban areas of the domains (e.g., downtown Los Angeles and Anaheim) and relatively smaller emission reductions distributed along the major highways and transportation networks. Different from the spatial distribution of NOx emission reductions, the VOC emission reductions along the major transportation networks is less obvious due to the lower percentage (only 6.5%) of HDDV source to the mobile inventory.

The spatial distributions of daily total and on-road mobile CO emissions, as well as the reductions resulting from the use of B20 biodiesel fuel, are presented in Figures 3-9 for the SoCAB 5-km modeling domain. For CO emissions, the mobile source component accounts for approximately 87% of the total CO emissions. As such, the spatial distributions of the daily total and on-road mobile CO emissions are very similar, confined mainly to the urban centers and the transportation corridors of the domains. The reductions in CO emissions for each of the biodiesel emission scenarios are displayed in Figures 3-9c and 3-9d. As with the NOx and VOC, overall CO emission reductions for the 50% and 100% penetration level of B20 fuel are small and generally throughout the traffic networks and urban centers of the SoCAB domain.

Table 3-5. Baseline and biodiesel scenario emissions summary for 3-7 August, 1997 for SoCAB domain

Emission Component	**1997 BASELINE**			**1997 100% B20 Biodiesel**			**1997 50% B20 Biodiesel**		
August 3	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**	**NOX (tpd)**	**VOC (tpd)**	**CO (tpd)**
Area	400.48	1591.14	2596.75	400.48	1591.14	2596.75	400.48	1591.14	2596.75
Points	120.69	35.85	49.73	120.69	35.85	49.73	120.69	35.85	49.73
On-Road Mobile	743.2	688.1	6487.4	746.7	687.3	6485	744.9	687.7	6486.2
Total Anthropogenic	1264.37	2315.09	9133.88	1267.87	2314.29	9131.48	1266.07	2314.69	9132.68
Biogenic	0	309.9	0	0	309.9	0	0	309.9	0
Total	**1264.37**	**2624.99**	**9133.88**	**1267.87**	**2624.19**	**9131.48**	**1266.07**	**2624.59**	**9132.68**
August 4									
Area	470.13	1487.22	1157.59	470.13	1487.22	1157.59	470.13	1487.22	1157.59
Points	124.71	35.83	46.49	124.71	35.83	46.49	124.71	35.83	46.49
On-Road Mobile	1027.4	766.4	7744.2	1035.5	764.3	7738.4	1031.4	765.3	7741.3
Total Anthropogenic	1622.24	2289.45	8948.28	1630.34	2287.35	8942.48	1626.24	2288.35	8945.38
Biogenic	0	327.6	0	0	327.6	0	0	327.6	0
Total	**1622.24**	**2617.05**	**8948.28**	**1630.34**	**2614.95**	**8942.48**	**1626.24**	**2615.95**	**8945.38**
August 5									
Area	471.08	1486.72	1156.91	471.08	1486.72	1156.91	471.08	1486.72	1156.91
Points	118.33	103.79	338.21	118.33	103.79	338.21	118.33	103.79	338.21
On-Road Mobile	1110.1	837.9	8361.9	1118.6	835.8	8355.9	1114.3	836.8	8358.9
Total Anthropogenic	1699.51	2428.41	9857.02	1708.01	2426.31	9851.02	1703.71	2427.31	9854.02
Biogenic	0	424.4	0	0	424.4	0	0	424.4	0
Total	**1699.51**	**2852.81**	**9857.02**	**1708.01**	**2850.71**	**9851.02**	**1703.71**	**2851.71**	**9854.02**
August 6									
Area	470.98	1486.81	1157.12	470.98	1486.81	1157.12	470.98	1486.81	1157.12
Points	124.35	122.78	419.93	124.35	122.78	419.93	124.35	122.78	419.93
On-Road Mobile	1069.4	794.7	8196.8	1077.8	792.5	8190.8	1073.6	793.6	8193.8
Total Anthropogenic	1664.73	2404.29	9773.85	1673.13	2402.09	9767.85	1668.93	2403.19	9770.85
Biogenic	0	360.5	0	0	360.5	0	0	360.5	0
Total	**1664.73**	**2764.79**	**9773.85**	**1673.13**	**2762.59**	**9767.85**	**1668.93**	**2763.69**	**9770.85**
August 7									
Area	470.98	1486.81	1157.12	470.98	1486.81	1157.12	470.98	1486.81	1157.12
Points	126.32	74.54	213.44	126.32	74.54	213.44	126.32	74.54	213.44
On-Road Mobile	1050.6	746.9	7744	1059	744.8	7737.9	1054.8	745.9	7740.9
Total Anthropogenic	1647.9	2308.25	9114.56	1656.3	2306.15	9108.46	1652.1	2307.25	9111.46
Biogenic	0	269.4	0	0	269.4	0	0	269.4	0
Total	**1647.9**	**2577.65**	**9114.56**	**1656.3**	**2575.55**	**9108.46**	**1652.1**	**2576.65**	**9111.46**

Table 3-6. Summary of on-road mobile and HDDV emission contributions for SoCAB

On-Road Mobile Emission Summary for 1997 Baseline			
	South Coast Air Basin 5-km Domain		
	NOX	**VOC**	**CO**
3-Aug			
Mobile % of Total Inv.	58.77	26.20	71.02
Mobile % of Anthro.	58.77	29.71	71.02
HDDV % of Mobile Inv.	25.75	4.55	4.26
4-Aug			
Mobile % of Total Inv.	63.34	29.29	86.56
Mobile % of Anthro.	63.34	33.48	86.56
HDDV % of Mobile Inv.	41.26	6.50	8.26
5-Aug			
Mobile % of Total Inv.	65.33	29.37	84.85
Mobile % of Anthro.	65.33	34.51	84.85
HDDV % of Mobile Inv.	40.90	6.18	8.18
6-Aug			
Mobile % of Total Inv.	64.25	28.75	83.88
Mobile % of Anthro.	64.25	33.06	83.88
HDDV % of Mobile Inv.	41.67	6.46	8.25
7-Aug			
Mobile % of Total Inv.	63.77	28.98	84.98
Mobile % of Anthro.	63.77	32.36	84.98
HDDV % of Mobile Inv.	42.25	6.75	8.58

Table 3-7. Summary of emission effects for B20 biodiesel fuel use in the SoCAB.

Emission Component	1997 100% Biodiesel			1997 50% Biodiesel		
3-Aug	**% Change NOX**	**% Change VOC**	**%Change CO**	**% Change NOX**	**% Change VOC**	**%Change CO**
Area	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Points	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
On-Road Mobile	0.4709	-0.1163	-0.0370	0.2287	-0.0581	-0.0185
Total Anthropogenic	0.2768	-0.0346	-0.0263	0.1345	-0.0173	-0.0131
Biogenic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.2768**	**-0.0305**	**-0.0263**	**0.1345**	**-0.0152**	**-0.0131**
4-Aug						
Area	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Points	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
On-Road Mobile	0.7884	-0.2740	-0.0749	0.3893	-0.1435	-0.0374
Total Anthropogenic	0.4993	-0.0917	-0.0648	0.2466	-0.0480	-0.0324
Biogenic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.4993**	**-0.0802**	**-0.0648**	**0.2466**	**-0.0420**	**-0.0324**
5-Aug						
Area	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Points	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
On-Road Mobile	0.7657	-0.2506	-0.0718	0.3783	-0.1313	-0.0359
Total Anthropogenic	0.5001	-0.0865	-0.0609	0.2471	-0.0453	-0.0304
Biogenic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.5001**	**-0.0736**	**-0.0609**	**0.2471**	**-0.0386**	**-0.0304**
6-Aug						
Area	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Points	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
On-Road Mobile	0.7855	-0.2768	-0.0732	0.3927	-0.1384	-0.0366
Total Anthropogenic	0.5046	-0.0915	-0.0614	0.2523	-0.0458	-0.0307
Biogenic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.5046**	**-0.0796**	**-0.0614**	**0.2523**	**-0.0398**	**-0.0307**
7-Aug						
Area	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Points	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
On-Road Mobile	0.7995	-0.2812	-0.0788	0.3998	-0.1339	-0.0400
Total Anthropogenic	0.5097	-0.0910	-0.0669	0.2549	-0.0433	-0.0340
Biogenic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.5097**	**-0.0815**	**-0.0669**	**0.2549**	**-0.0388**	**-0.0340**

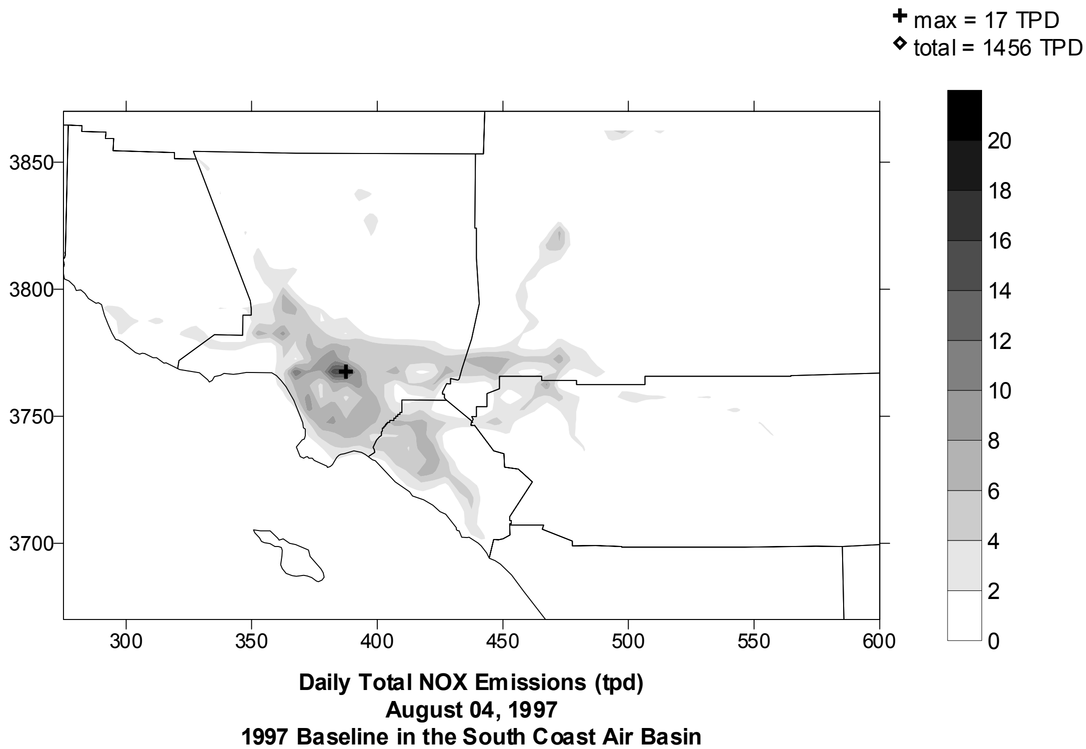


Figure 3-7a. Daily total NOx emissions (tpd) for the 1997 baseline in the South Coast Air Basin on August 4, 1997.

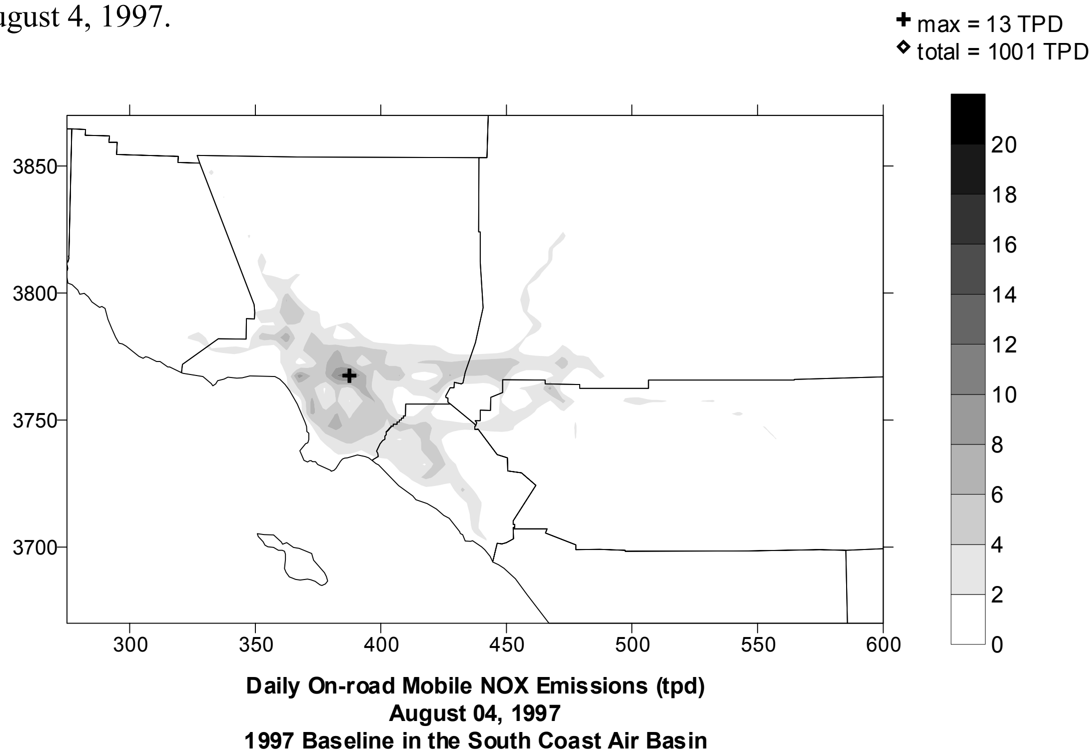


Figure 3-7b. Daily on-road mobile source NO_x emissions (tpd) for the 1997 baseline in the South Coast Air Basin on August 4, 1997

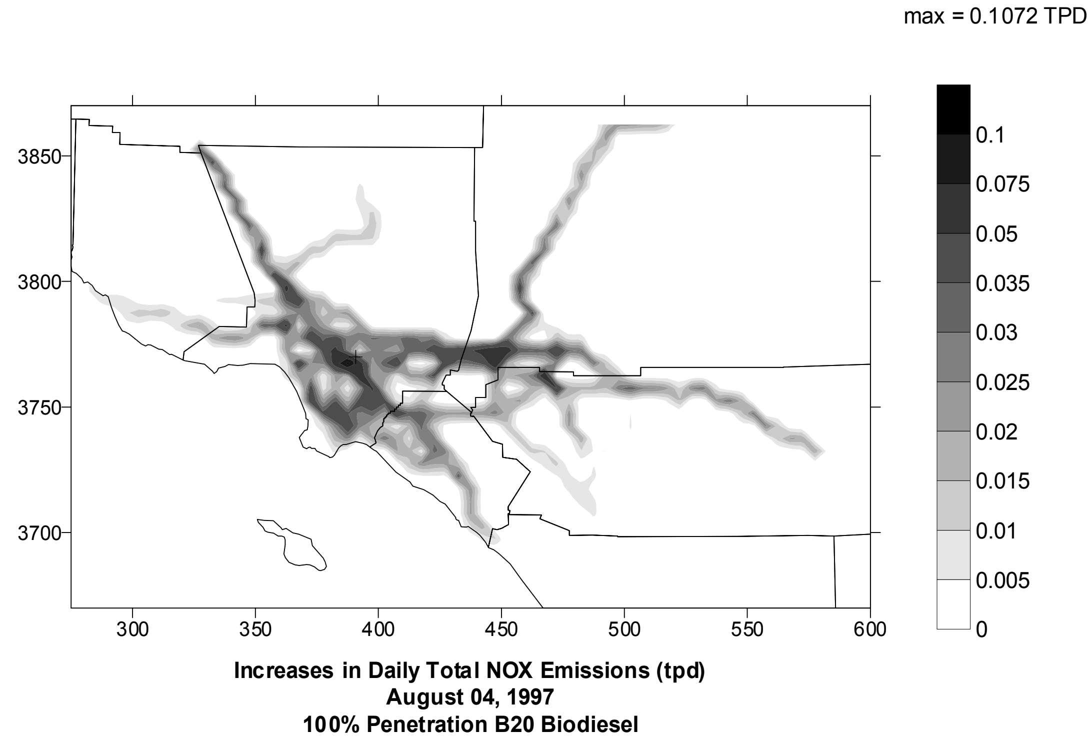


Figure 3-7c. Increases in daily total NO_x emissions (tpd) for the 1997 100% B20 biodiesel fuel scenario in the South Coast Air Basin on August 4, 1997.

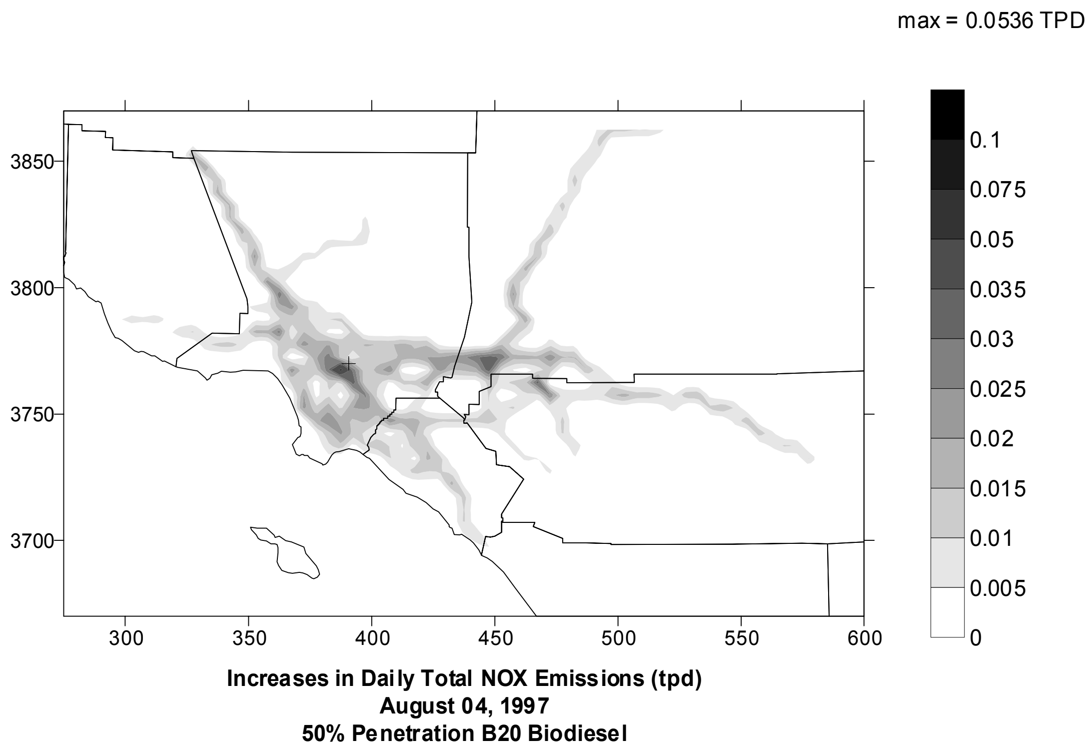


Figure 3-7d. Increases in daily total NO_x emissions (tpd) for the 1997 50% B20 biodiesel fuel scenario in the South Coast Air Basin on August 4, 1997

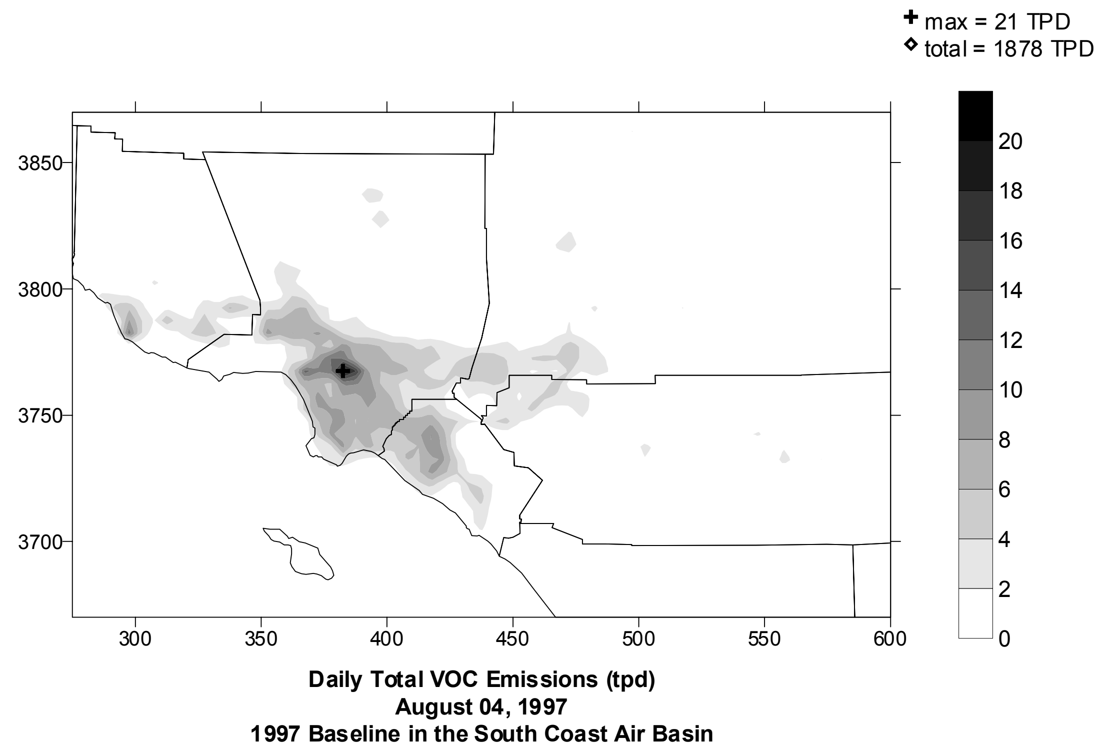


Figure 3-8a. Daily total VOC emissions (tpd) for the 1997 baseline in the South Coast Air Basin on August 4, 1997

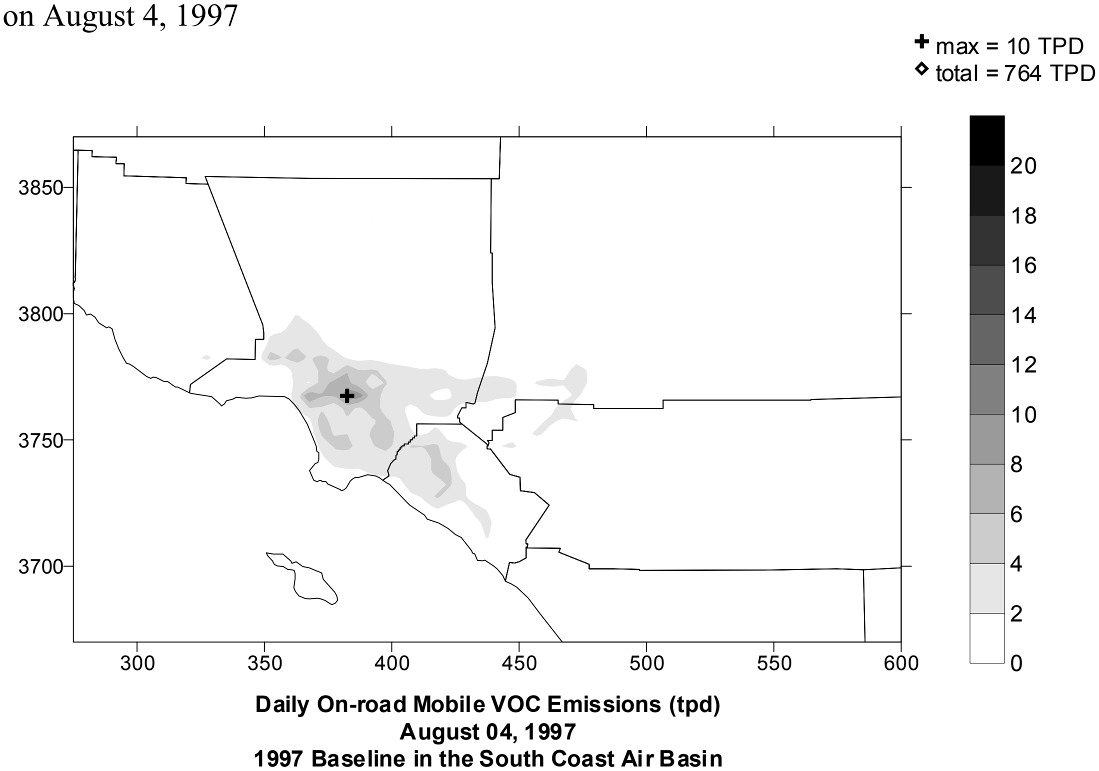


Figure 3-8b. Daily on-road mobile source VOC emissions (tpd) for the 1997 baseline in the South Coast Air Basin on August 4, 1997.

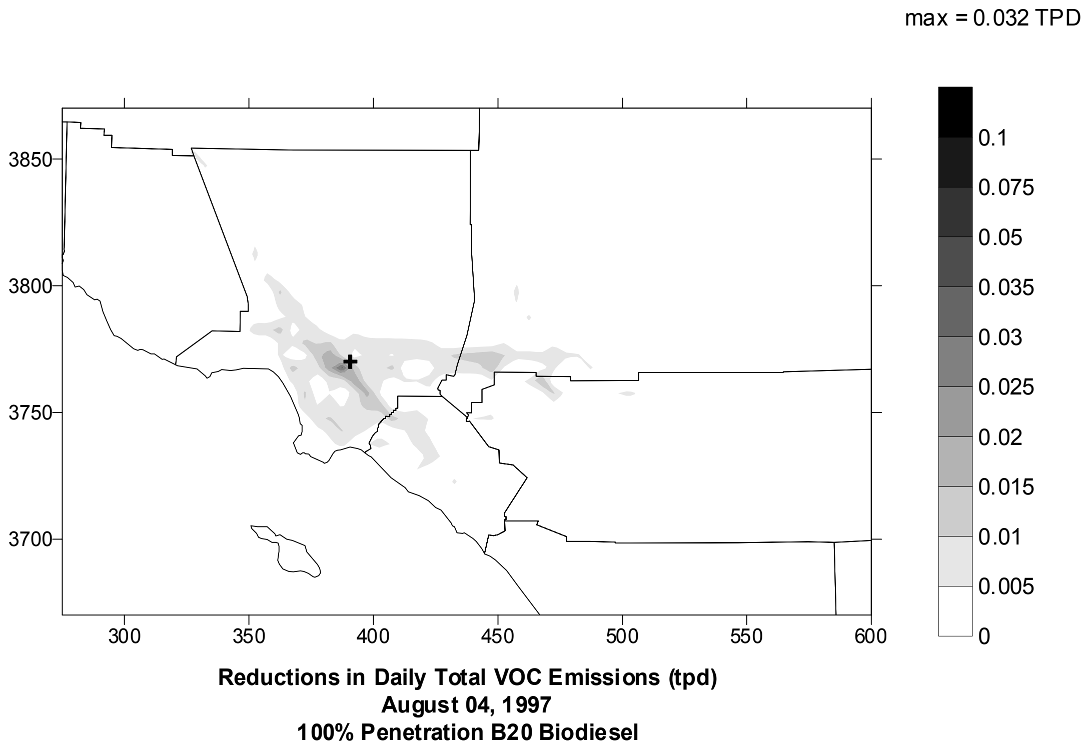


Figure 3-8c. Increases in daily total VOC emissions (tpd) for the 1997 100% B20 biodiesel fuel scenario in the South Coast Air Basin on August 4, 1997.

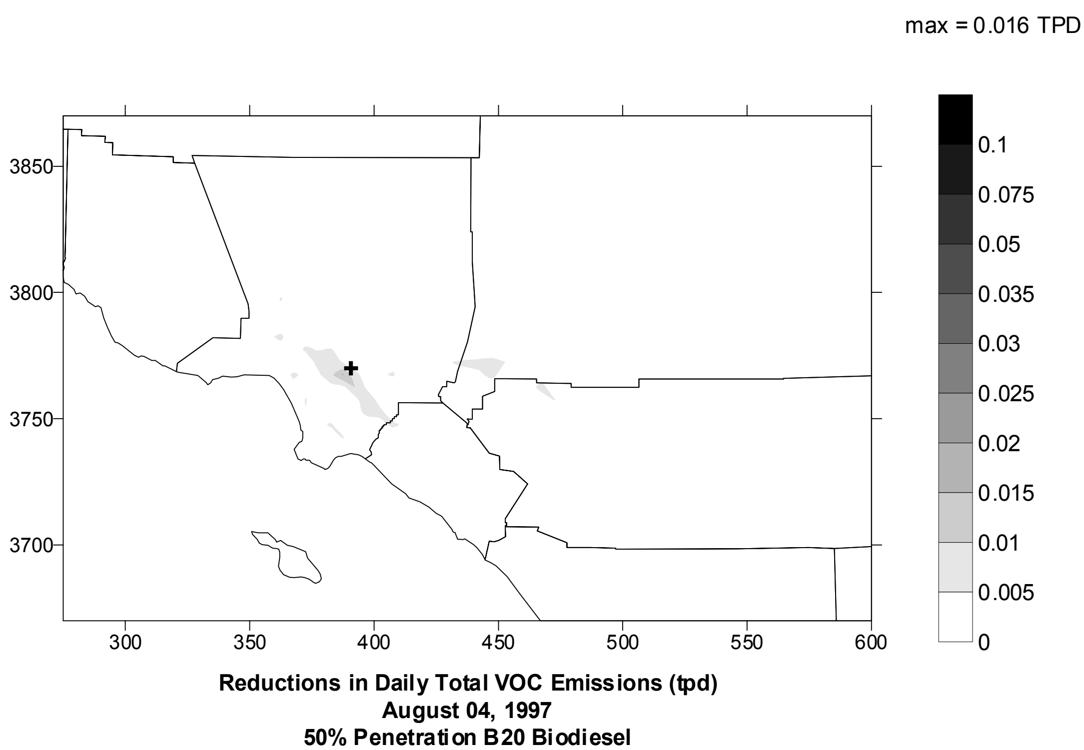


Figure 3-8d. Increases in daily total VOC emissions (tpd) for the 1997 50% B20 biodiesel fuel scenario in the South Coast Air Basin on August 4, 1997.

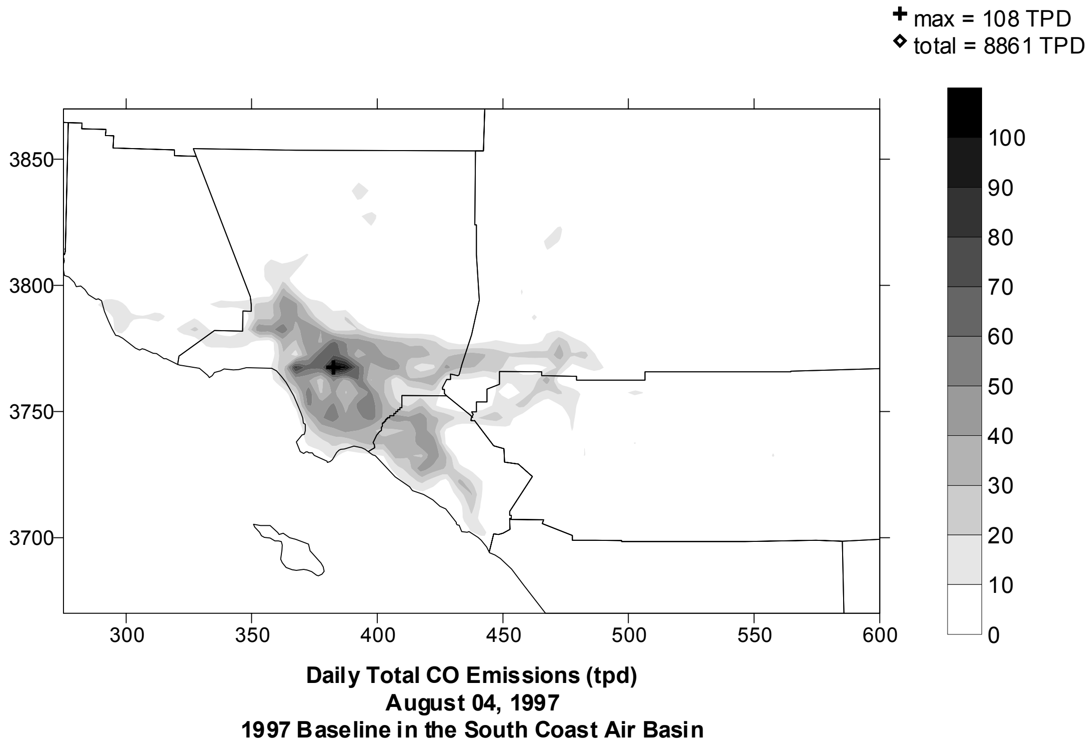


Figure 3-9a. Daily total CO emissions (tpd) for the 1997 baseline in the South Coast Air Basin on August 4, 1997.

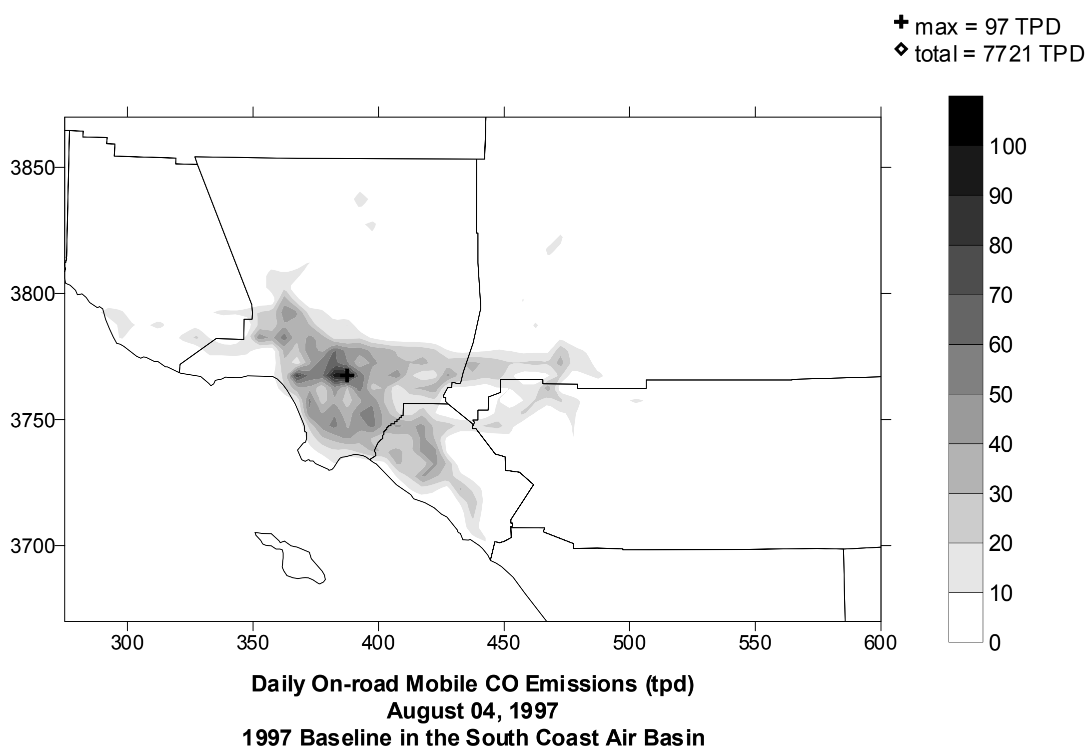


Figure 3-9b. Daily on-road mobile source CO emissions (tpd) for the 1997 baseline in the South Coast Air Basin on August 4, 1997.

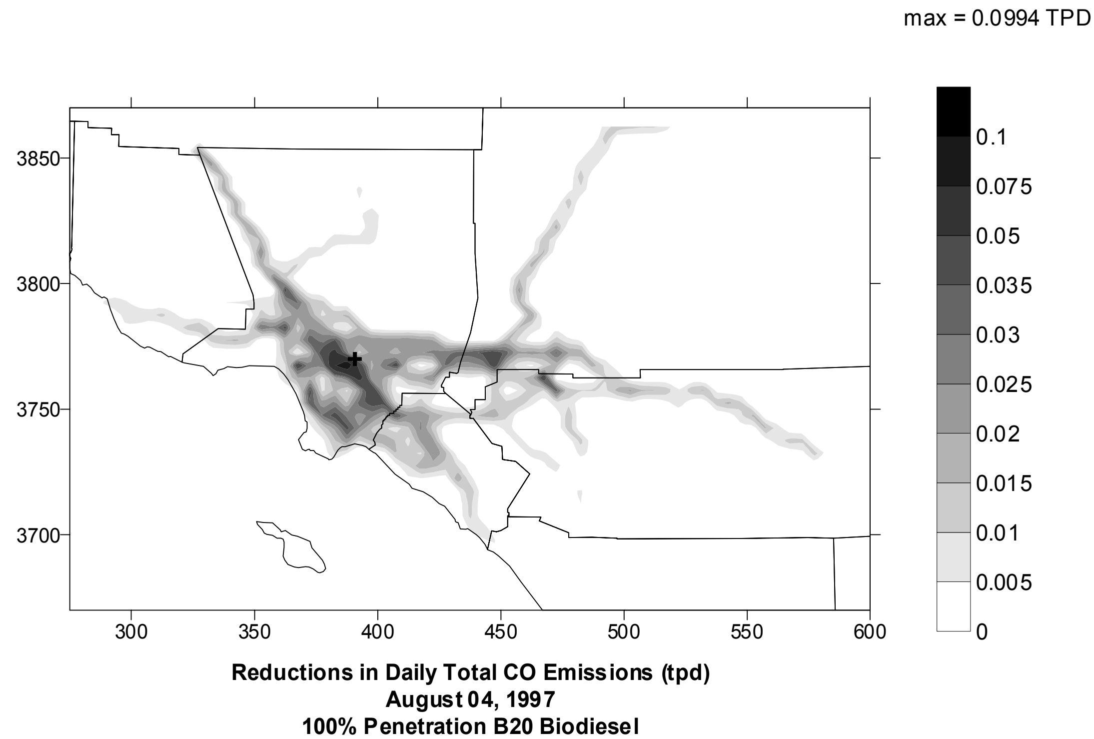


Figure 3-9c. Reductions in daily total CO emissions (tpd) for the 1997 100% B20 biodiesel fuel scenario in the South Coast Air Basin on August 4, 1997.

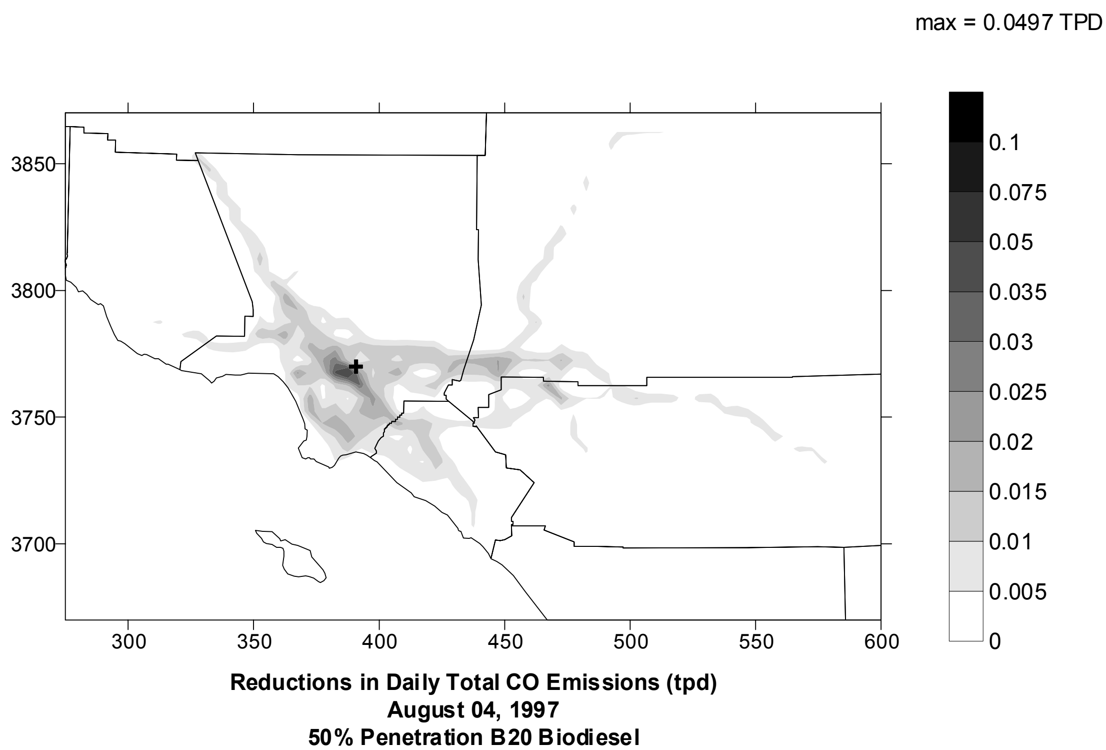


Figure 3-9d. Reductions in daily total CO emissions (tpd) for the 1997 50% B20 biodiesel fuel scenario in the South Coast Air Basin on August 4, 1997.

4. BIODIESEL OZONE ASSESSMENT

In this section, the impacts of biodiesel fuel use on ambient ozone concentrations are presented and discussed. The results of the CAMx high-resolution (4-km) modeling of the Lake Michigan and Northeast Corridor regions are presented first, followed by the lower resolution (12-km) modeling results for other eastern US cities. The section concludes with discussing the high-resolution (5-km) modeling results for the South Coast Air Basin (SoCAB). The impacts of biodiesel fuel use on air quality and human health are related through the evaluation of:

- Estimated peak 1-hour and 8-hour daily maximum ozone concentrations in each urban area are used to assess the effects biodiesel fuel would have on attainment;
- Effects of biodiesel fuel use are also assessed by examining the spatial distribution of daily maximum 1-hour and 8-hour ozone concentrations and their differences with the standard diesel base case; and
- Various air quality exposure metrics are used to assess the impacts of biodiesel fuel on population exposure to elevated ozone concentrations.

EASTERN US OZONE MODELING RESULTS

The Comprehensive Air Quality Model with Extensions (CAMx), version 3.02 (www.camx.com) was exercised for the 7-18 July, 1995 episode on the enhanced 36/12/4-km OTAG modeling domain shown in Figure 2-4. Meteorological input data files developed from the RAMS meteorological model for the 36-km and 12-km domains and the July 1995 OTAG modeling episode were used for each of the emission scenarios investigated. Note that separate high-resolution (4-km) meteorological data input files for the 4-km Northeast Corridor and Lake Michigan domains were not developed, instead CAMx interpolated the 4-km inputs from the 12-km resolution meteorological data. However, the emission inputs were developed separately for the two fine-grid domains at the 4-km high-resolution using the EMS95 emissions model. While the model was exercised for the entire July 7-18, 1995 period, only the results for 11-15, July 1995 are discussed here as the July 7-10 period is used for initialization and July 16-18 period are low ozone clean out days.

Biodiesel Ozone Impact Assessment for the Lake Michigan Region

The spatial distribution of estimated daily maximum 1-hour ozone concentrations are displayed in Figure 4-1 for the 2007 SIP Call Base Case in the Lake Michigan 4-km domain. Ozone concentration levels in the region for the first two days (July 11-12) are relatively low with daily peaks estimated to be below the 1-hour ozone standard (124 ppb) occurring northeast of the Chicago urban area. On July 13, the region of high ozone in excess of 124 ppb is estimated to occur along the western side of lower Lake Michigan with a peak of 166.6 ppb that occurs over Lake Michigan just off the shoreline from Racine, Wisconsin. The following day (July 14) the urban plume emanating from the Chicago area has shifted northeast and extends across the lower portion of the lake with exceedances of the 1-hour standard reaching southwestern Michigan. The daily peak ozone of 177.9 ppb occurs over the center of lower Lake Michigan. On July 15, the region of elevated ozone concentrations is considerably smaller and located just offshore from downtown Chicago with a daily peak value of 163.5 ppb. Small regions of ozone concentrations in excess of 124 ppb are estimated to occur along the lakeshore in Illinois and Indiana.

Predicted daily maximum 8-hour ozone concentrations for the 2007 SIP Call base case standard diesel scenario in the Lake Michigan 4-km domain are displayed in Figure 4-2 for the period of July 11-15, 1995. The spatial distribution of 8-hour ozone concentrations is similar to the 1-hour ozone distributions, although the extent of elevated ozone levels above the 8-hour ozone standard (84 ppb) is larger than the extent of 1-hour exceedances since the 8-hour standard is more stringent. As for the daily maximum 1-hour ozone concentrations, the predicted 8-hour ozone levels for the first two days (July 11-12) are relatively low, however on July 12 a small region of 8-hour ozone concentrations that exceed the standard are estimated to occur over the western portion of the lake northeast of Chicago with a peak of 87.7 ppb. On July 13 a broad region of 8-hour ozone in excess of 110 ppb is estimated to occur over the entire portion of lower Lake Michigan with exceedances of the standard predicted just west of Chicago as well as along the eastern shore of the lake in southwestern Michigan. By July 14, the estimated 8-hour peak of 157.9 ppb has shifted east occurring over the center of lower Lake Michigan with the region of 8-hour ozone exceedances spreading northeastward into Michigan. The spatial distribution of daily maximum 8-hour ozone concentrations on July 15 are similar to the 1-hour concentrations, although the area of estimated ozone concentrations that exceed the 8-hour ozone standard is considerably larger than the area of 1-hour ozone exceedances with ozone levels in excess of 84 ppb predicted to occur in northeastern Illinois as well as southeastern Wisconsin on the July 15.

Figures 4-3 and 4-4 display the impacts due to 100% penetration of B20 biodiesel fuel use on the daily maximum 1-hour and 8-hour ozone concentrations in the Lake Michigan 4-km domain, respectively. Since the 100% penetration level results in higher impacts compared to the 50% penetration scenario, only the results of the 100% penetration scenario are presented and discussed here. Although significantly smaller, the spatial distribution of impacts for the 50% penetration scenario is very similar to the 100% penetration scenario. Spatial displays of the 50% penetration of B20 biodiesel fuel emission scenarios are presented in Appendix A. In order that the impacts on reducing the exceedances of the 1-hour and 8-hour NAAQS can be assessed, the displays include hachured contours representing the regions of daily peak ozone concentrations (in the 2007 SIP Call baseline) above the 124 ppb and 84 ppb ozone standard thresholds for the 1-hour and 8-hour daily peaks, respectively. This allows us to assess whether any ozone increases or decreases due to biodiesel fuel use occurs in areas that are estimated to exceed the ozone standard.

An examination of Figure 4-3 reveals that for all episode days the impacts on the daily maximum 1-hour ozone concentrations are small and, except for July 11-12, are generally confined to a small region within and downwind of the Chicago urban area. Note that both benefits (ozone reductions) and disbenefits (ozone increases) are predicted. The disbenefits are highly localized having little or no impact on areas that exceed the 1-hour standard. The ozone reductions, while small (ranging from approximately 0.17-0.53 ppb) are seen in most cases to occur in areas of high ozone so would aide in reducing the ozone concentrations levels above the NAAQS in the 2007 SIP Call baseline simulation.

Figure 4-4 displays the impacts on the daily maximum 8-hour ozone concentration in the Lake Michigan domain due to the introduction of B20 biodiesel fuel at the 100% penetration level. The spatial distribution of impacts are very similar to those of the 1-hour concentrations. However in this case, the benefits due to biodiesel fuel use on reducing ozone occur in areas of NAAQS exceedances since the region exceeding the standard in the baseline are far more widespread than in the case of the daily maximum 1-hour ozone concentrations.

Table 4-1 summarizes the impacts due to B20 biodiesel fuel use on the daily 1-hour and 8-hour peak ozone concentrations in the Lake Michigan 4-km domain for both the 50% and 100% B20 penetration emission scenarios. Note that the differences in peak concentrations may not correspond to the maximum reductions seen in Figures 4-3 and 4-4 since these maximum ozone reductions do not necessarily occur at the same location as the ozone peaks.

Table 4-1. Summary of daily peak 1-hour and 8-hour ozone concentrations in the Lake Michigan 4-km domain for the 2007 standard diesel (SIP Call) and biodiesel emission scenarios.

Lake Michigan 1-Hour Ozone					
	2007 SIP Call	**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	(ppb)	**(ppb)**	**(% Difference)**	**(ppb)**	**(% Difference)**
July 11, 1995	88.60	88.51	-0.102%	88.42	-0.205%
July 12, 1995	103.41	103.36	-0.051%	103.31	-0.103%
July 13, 1995	166.80	166.77	-0.020%	166.74	-0.040%
July 14, 1995	177.98	177.98	0.002%	177.99	0.005%
July 15, 1995	163.54	163.48	-0.040%	163.41	-0.080%
Lake Michigan 8-Hour Ozone					
	2007 SIP Call	**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	(ppb)	**(ppb)**	**(% Difference)**	**(ppb)**	**(% Difference)**
July 11, 1995	80.46	80.43	-0.035%	80.40	-0.070%
July 12, 1995	87.80	87.80	0.000%	87.80	0.000%
July 13, 1995	148.24	148.21	-0.020%	148.18	-0.041%
July 14, 1995	157.93	157.93	-0.005%	157.92	-0.011%
July 15, 1995	146.78	146.75	-0.026%	146.71	-0.052%

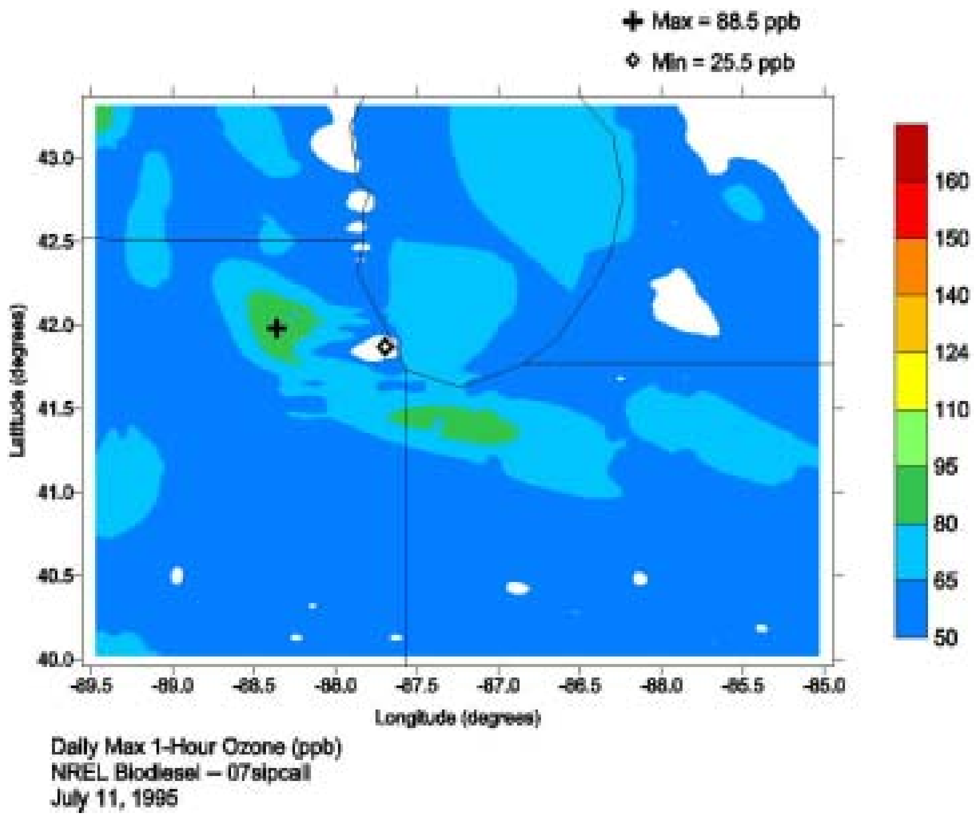


Figure 4-1a. Spatial distribution of daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 11, 1995 for the 2007 SIP Call scenario.

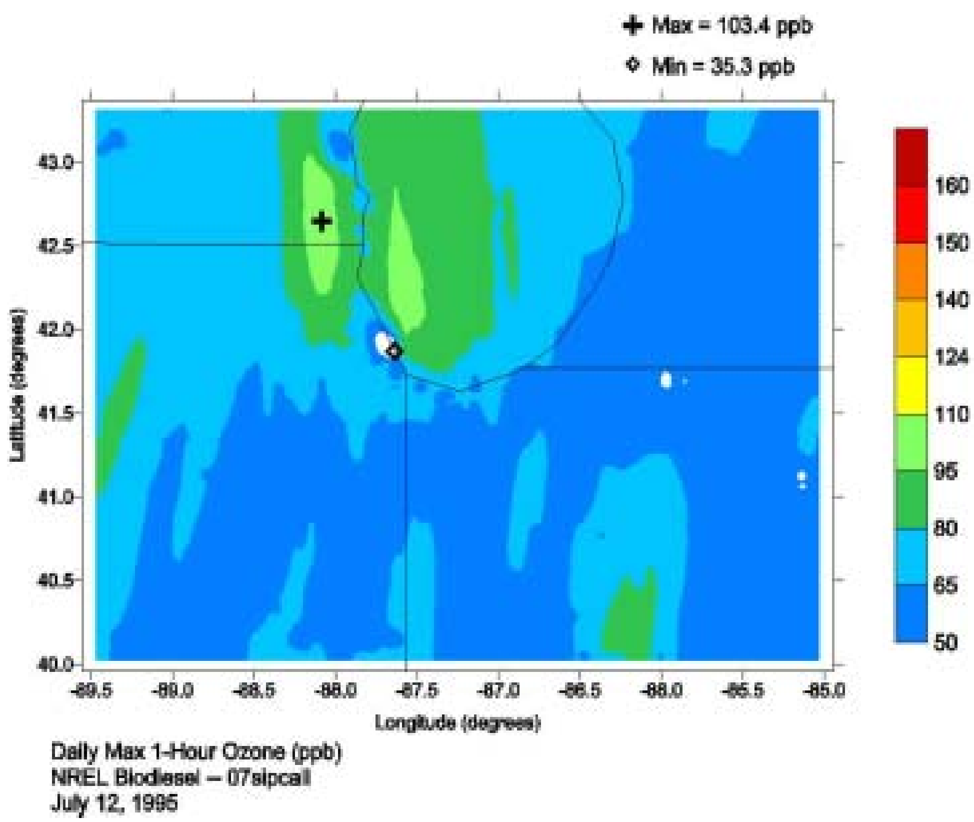


Figure 4-1b. Spatial distribution of daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 12, 1995 for the 2007 SIP Call scenario.

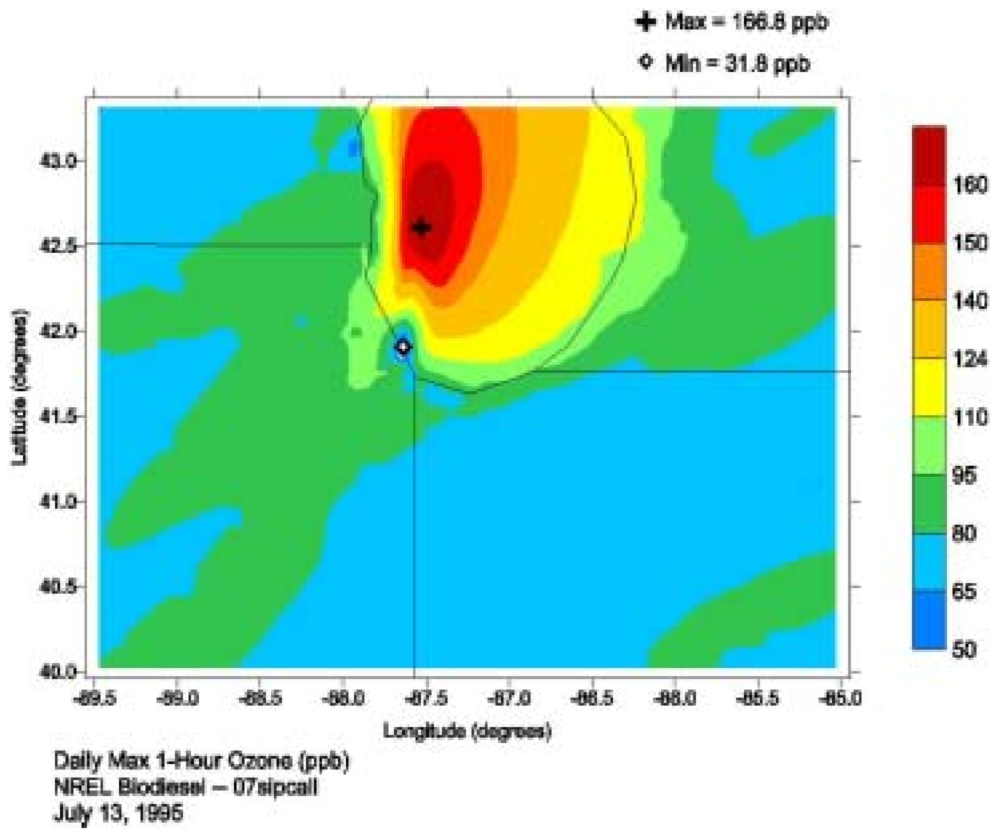


Figure 4-1c. Spatial distribution of daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 13, 1995 for the 2007 SIP Call scenario.

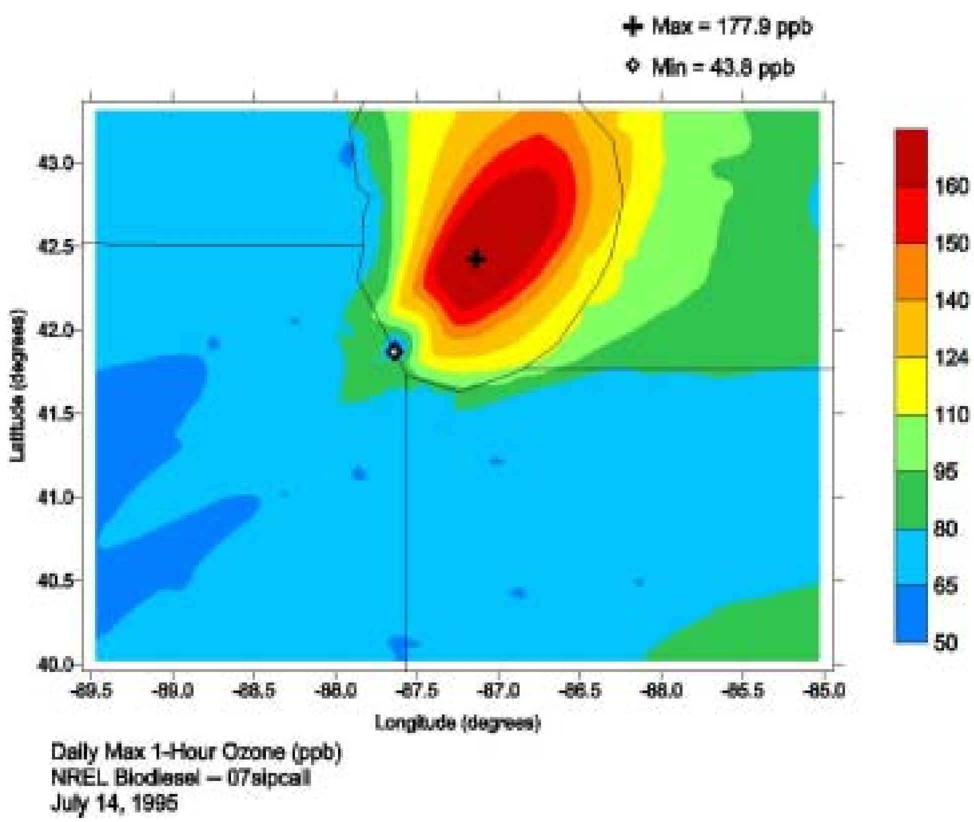


Figure 4-1d. Spatial distribution of daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 14, 1995 for the 2007 SIP Call scenario.

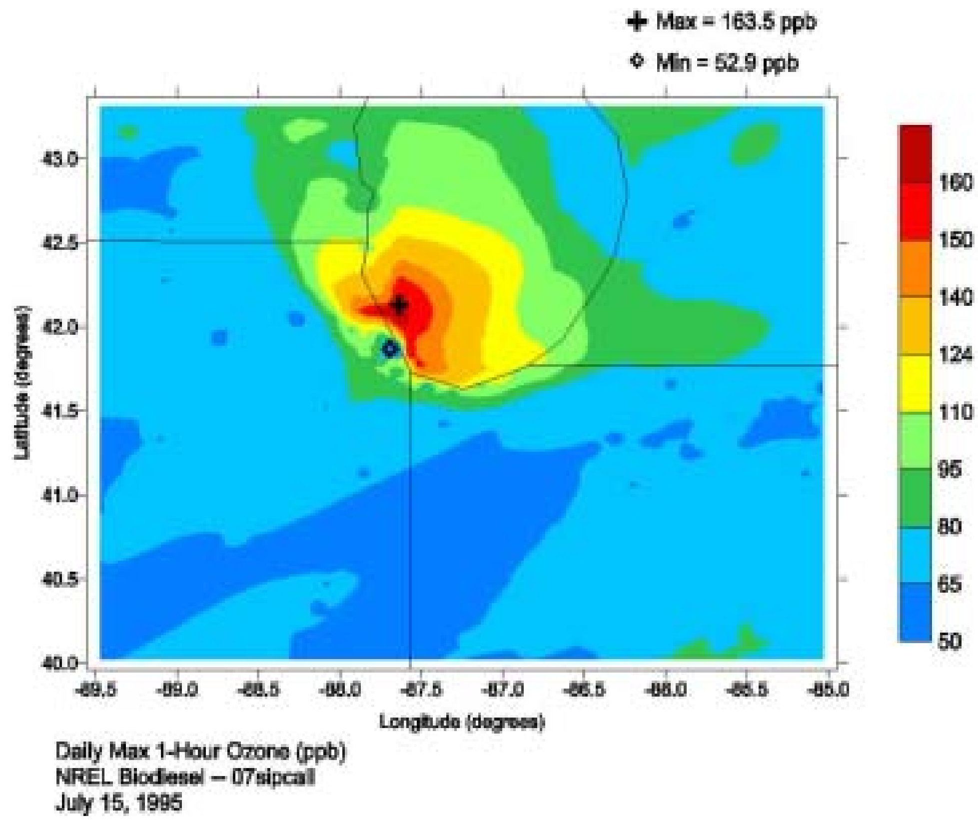


Figure 4-1e. Spatial distribution of daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 15, 1995 for the 2007 SIP Call scenario.

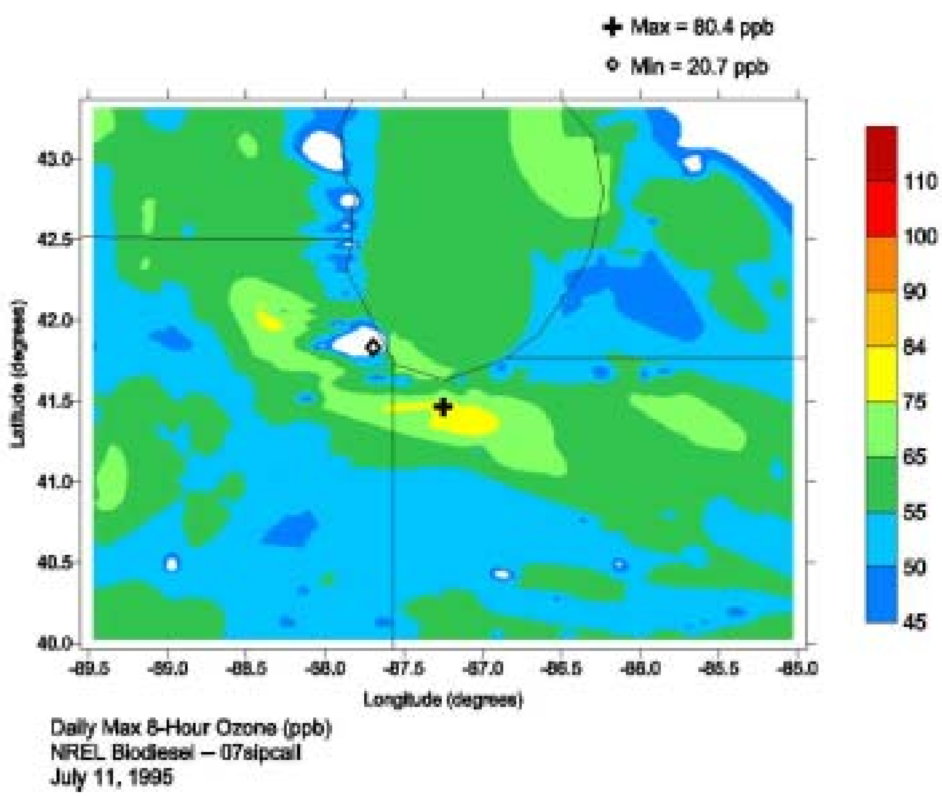


Figure 4-2a. Spatial distribution of daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 11, 1995 for the 2007 SIP Call scenario.

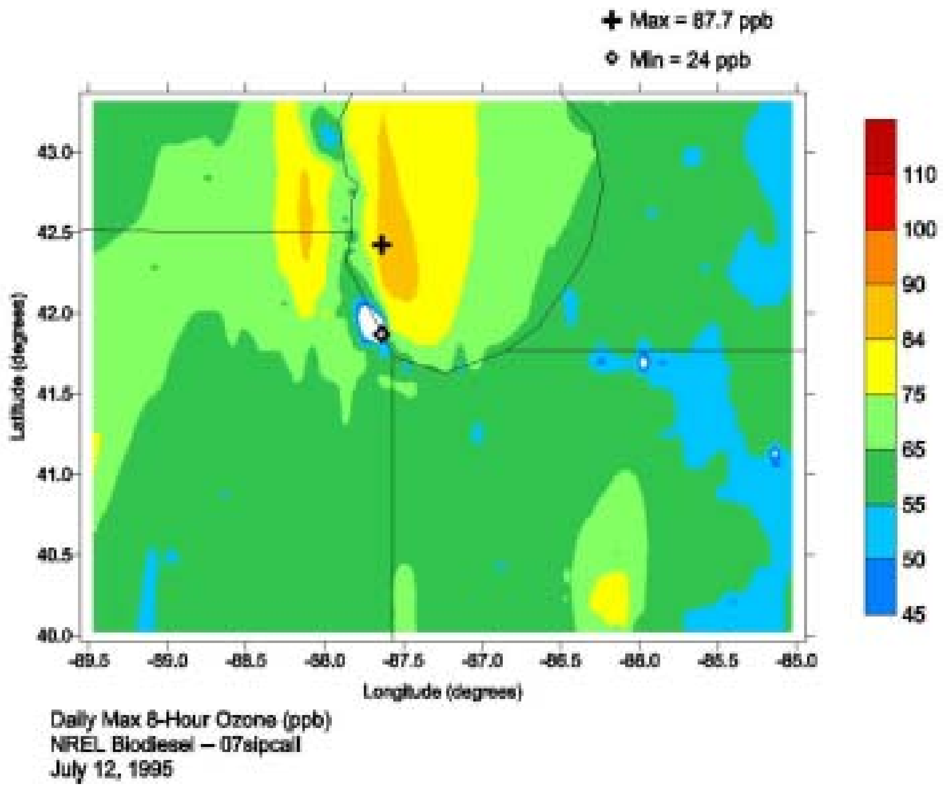


Figure 4-2b. Spatial distribution of daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 12, 1995 for the 2007 SIP Call scenario.

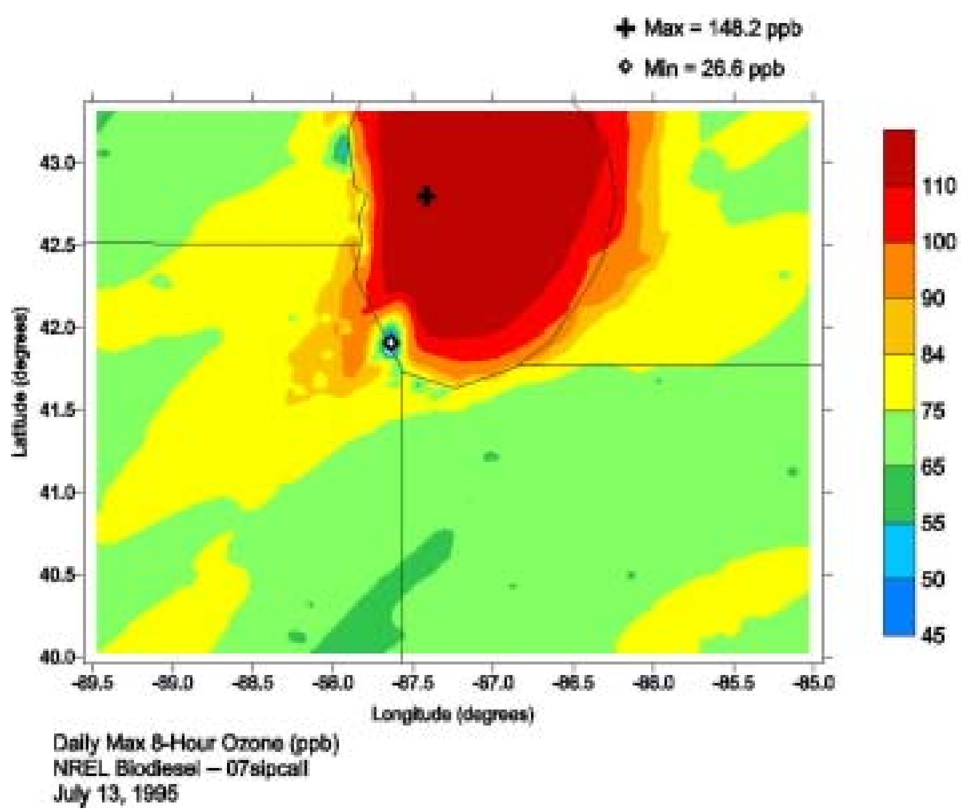


Figure 4-2c. Spatial distribution of daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 13, 1995 for the 2007 SIP Call scenario.

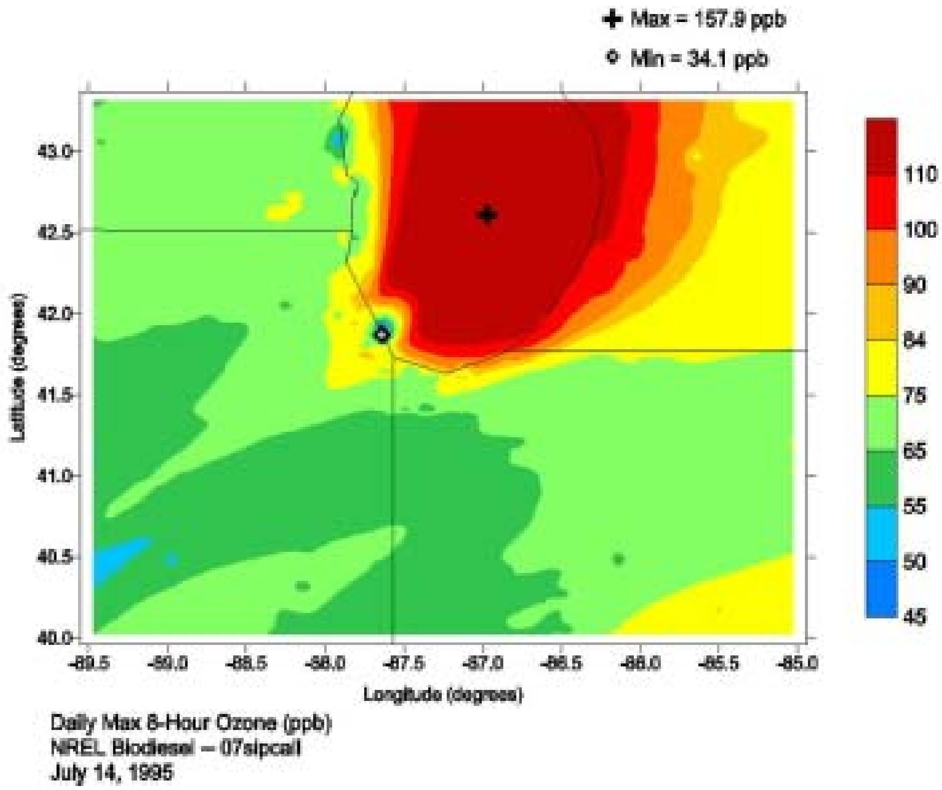


Figure 4-2d. Spatial distribution of daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 14, 1995 for the 2007 SIP Call scenario.

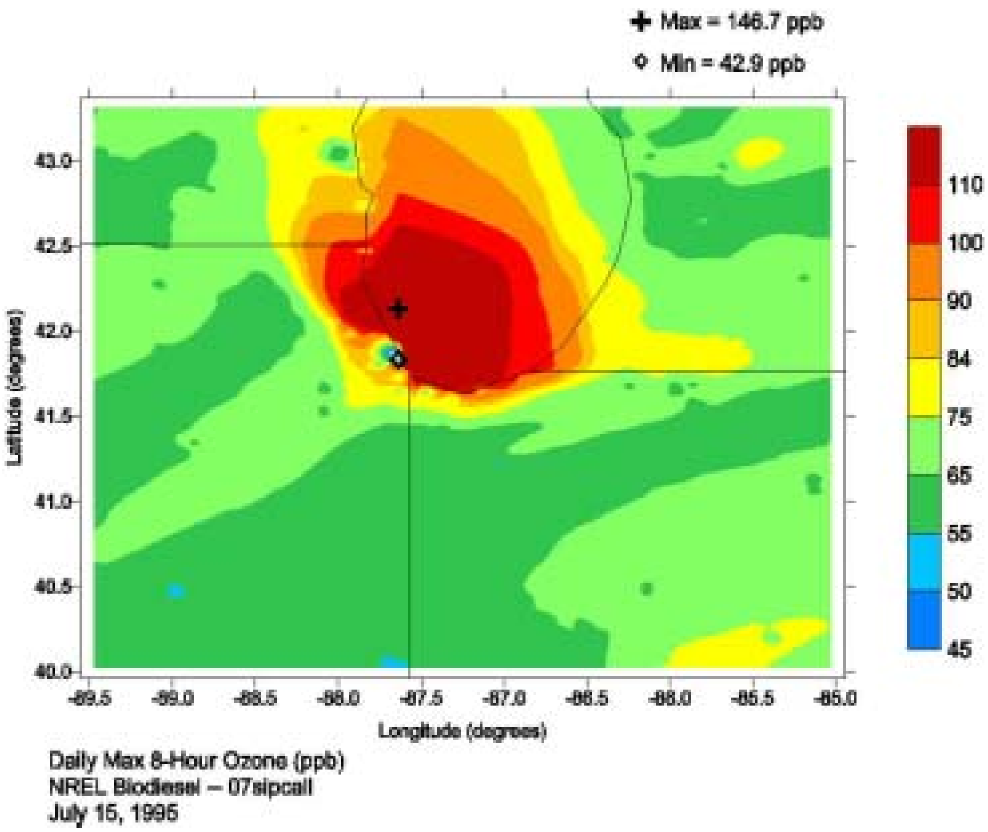


Figure 4-2e. Spatial distribution of daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 15, 1995 for the 2007 SIP Call scenario.

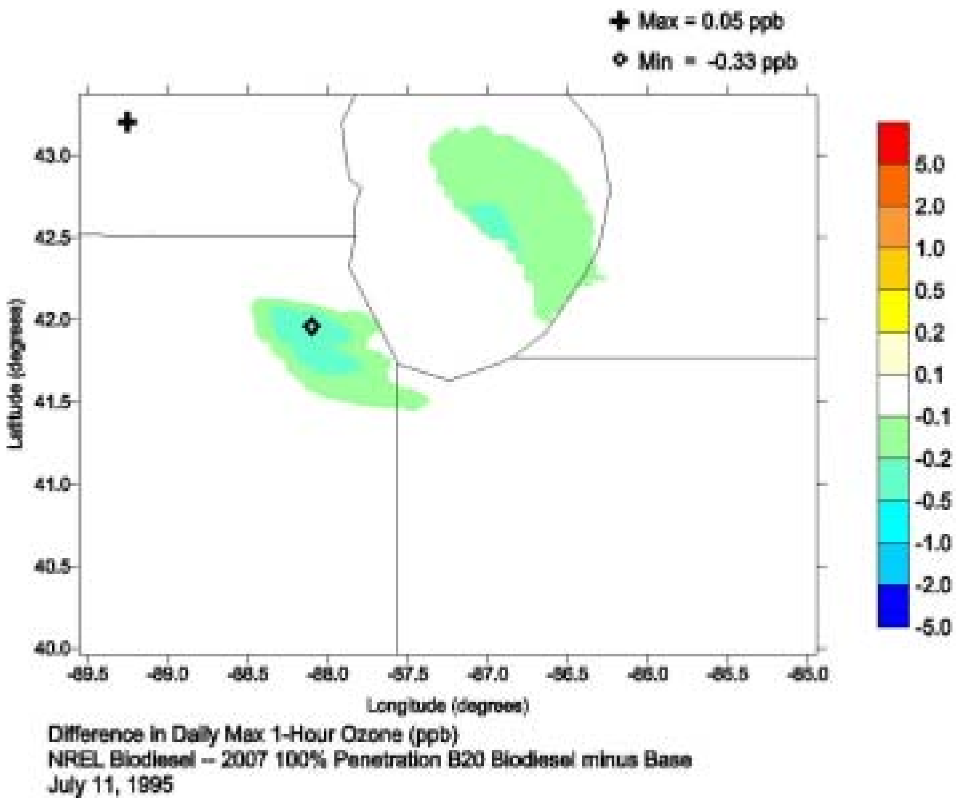


Figure 4-3a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan domain on July 11, 1995.

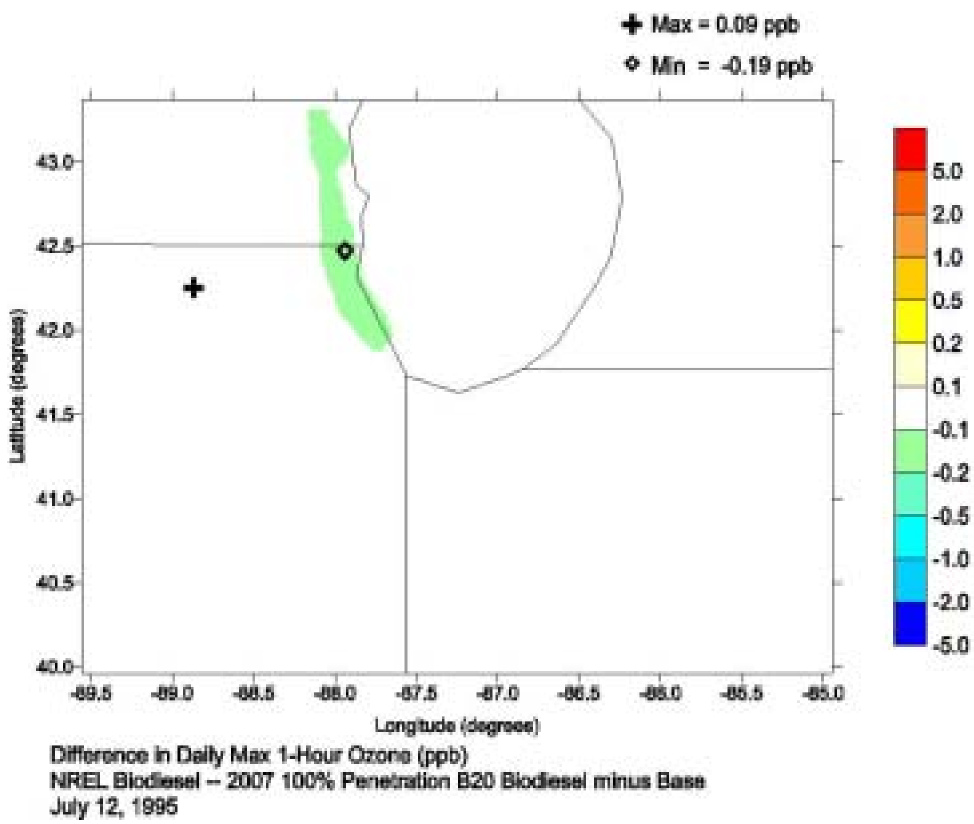


Figure 4-3b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan domain on July 12, 1995.

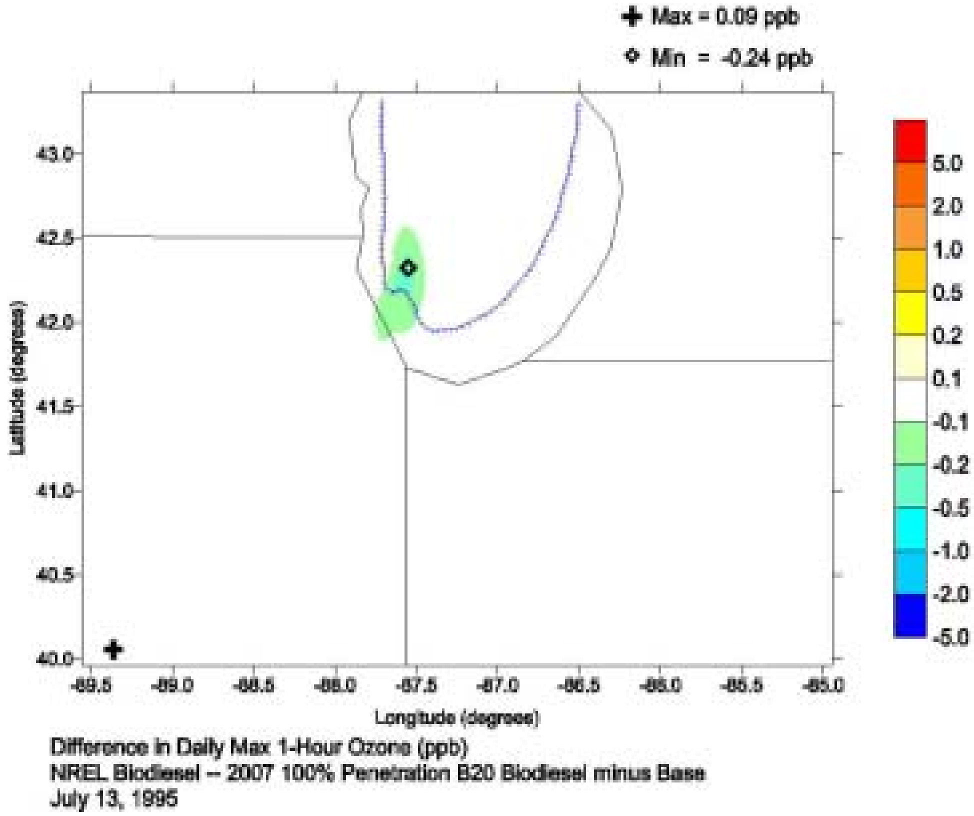


Figure 4-3c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan domain on July 13, 1995.

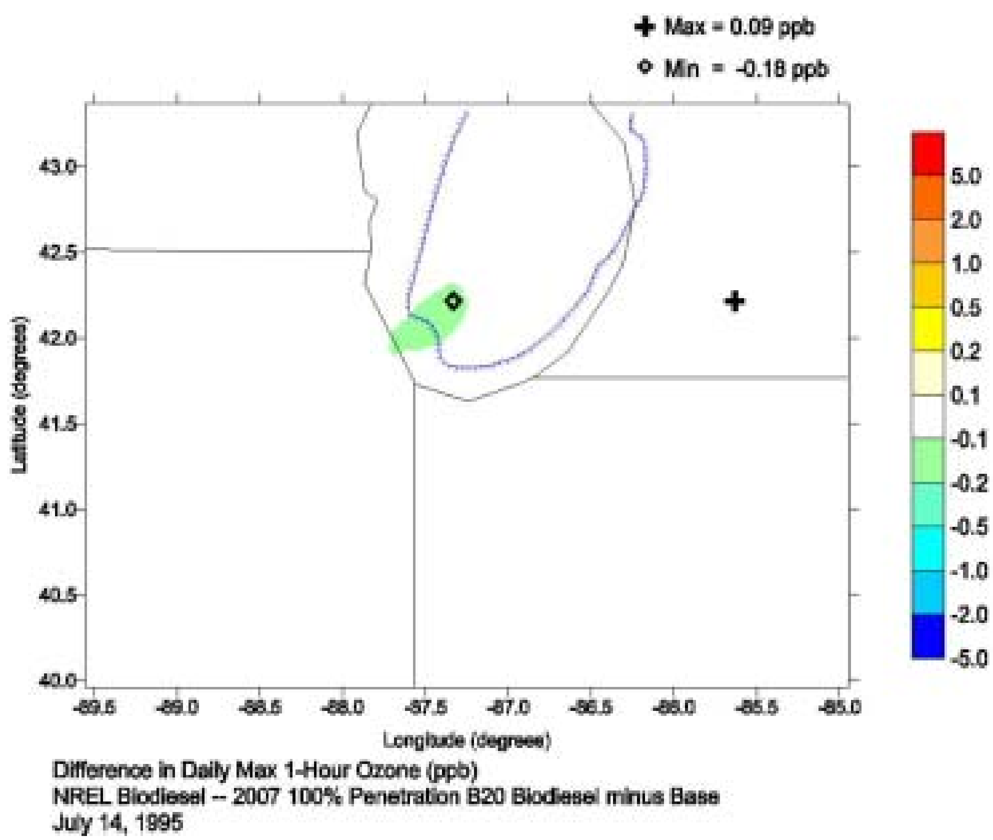


Figure 4-3d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan domain on July 14, 1995.

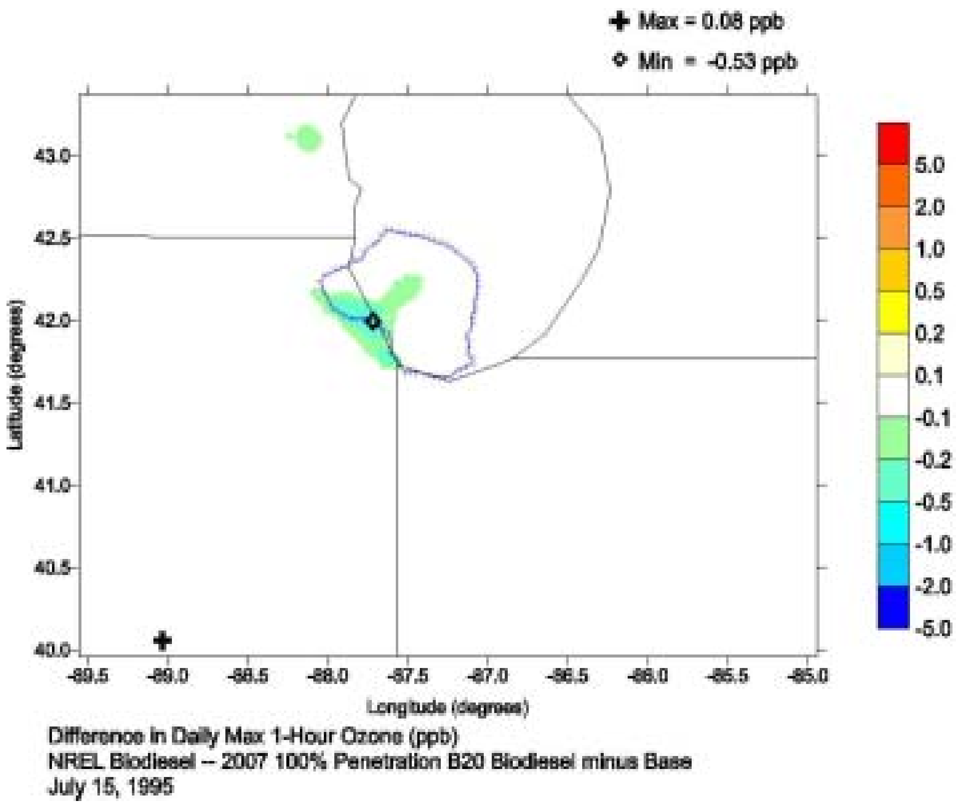


Figure 4-3e. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan domain on July 15, 1995.

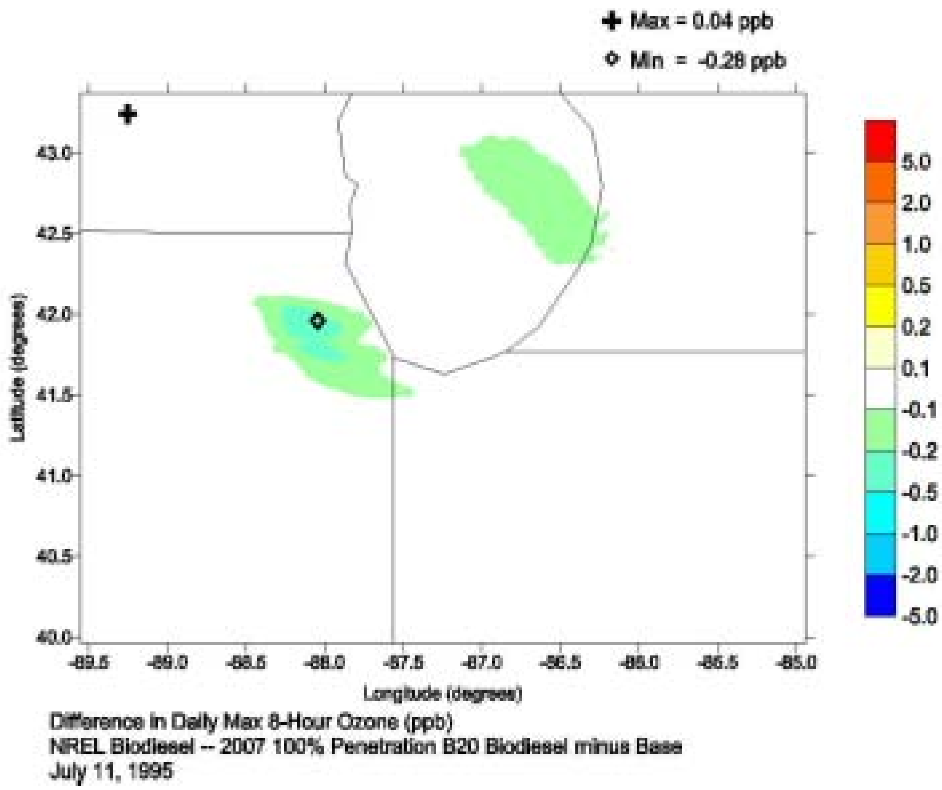


Figure 4-4a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan domain on July 11, 1995.

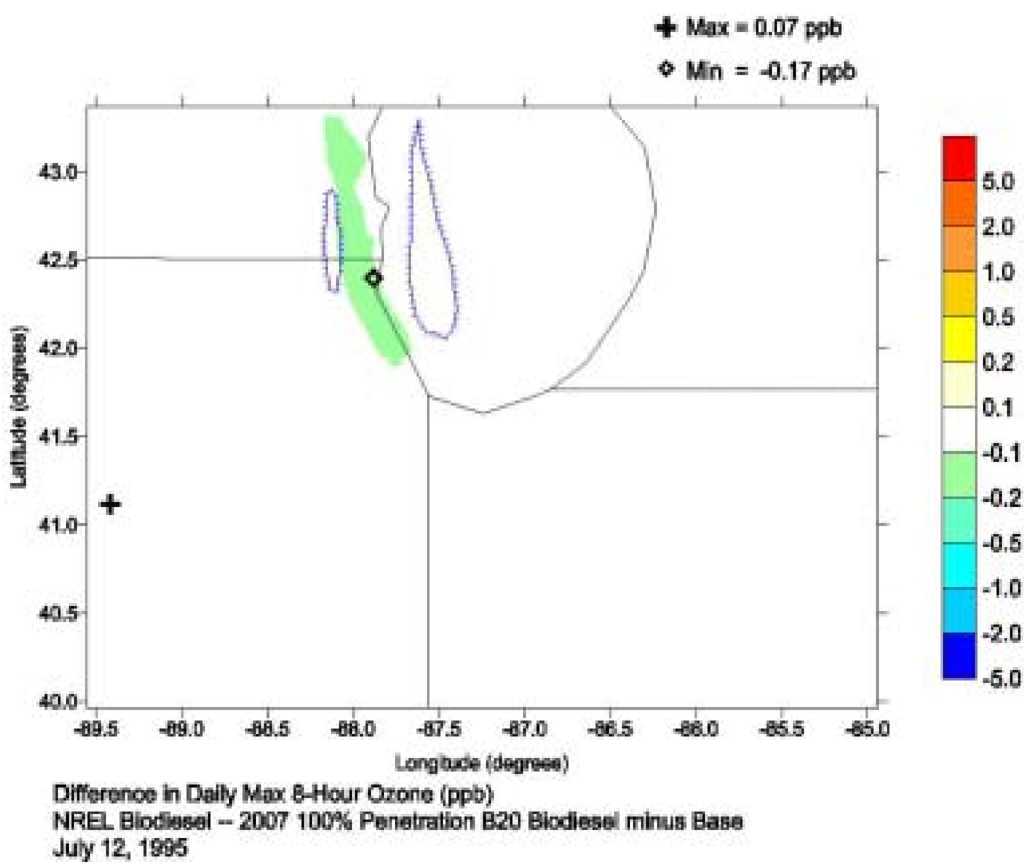


Figure 4-4b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan domain on July 12, 1995.

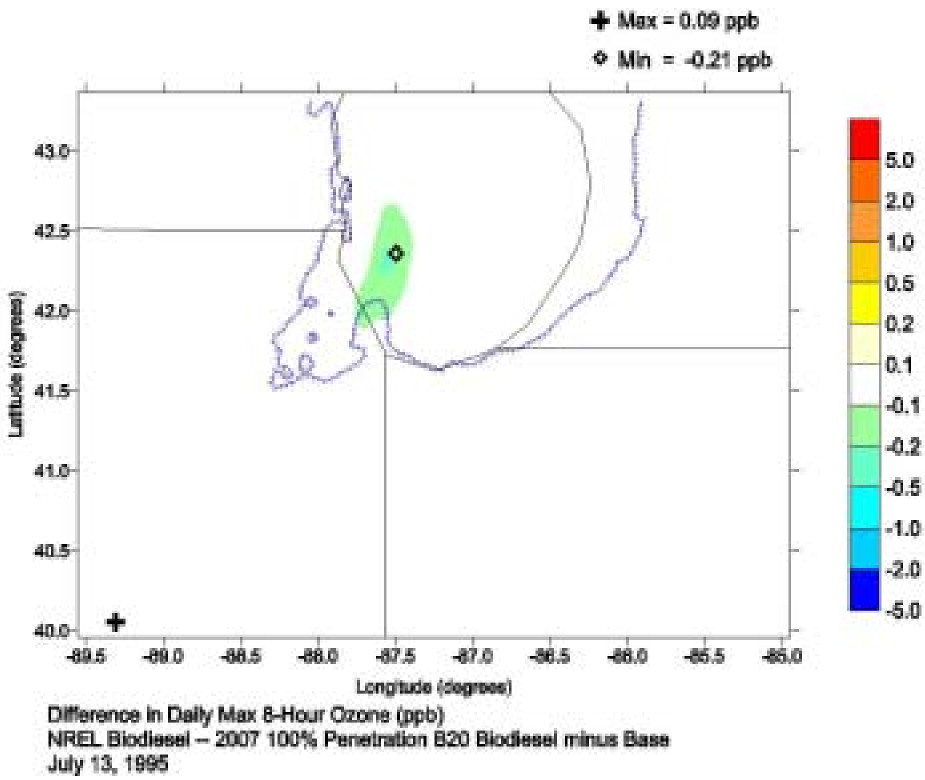


Figure 4-4c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan domain on July 13, 1995.

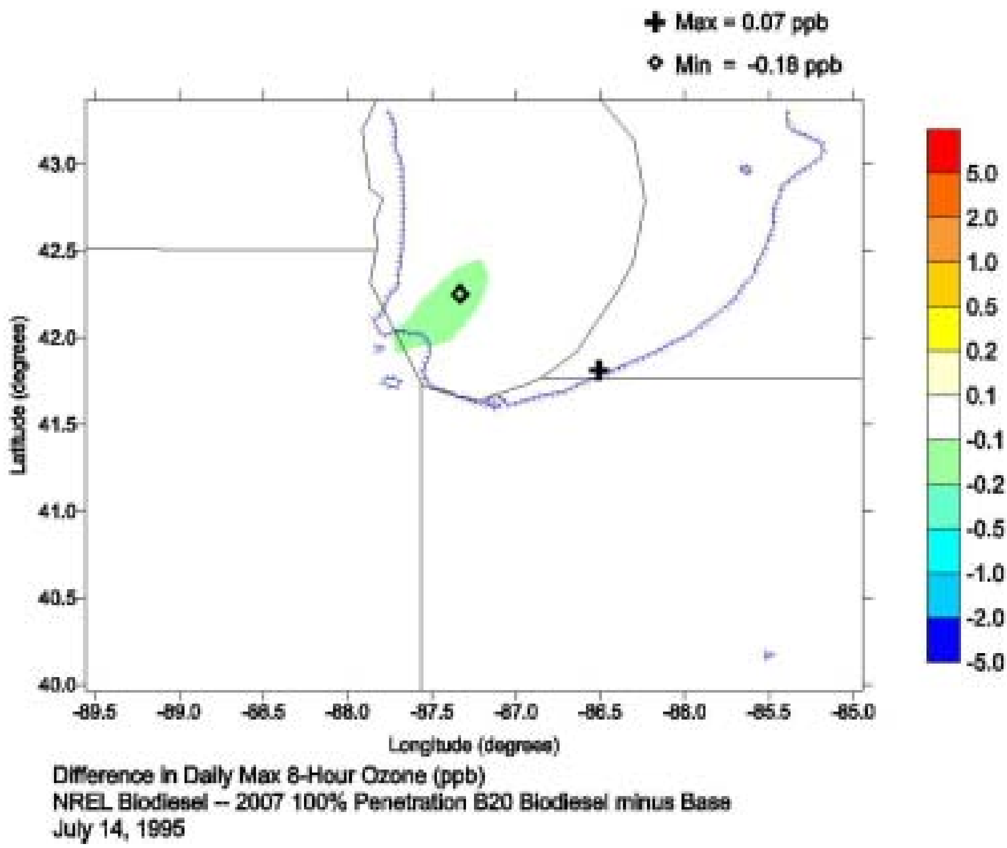


Figure 4-4d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan domain on July 14, 1995.

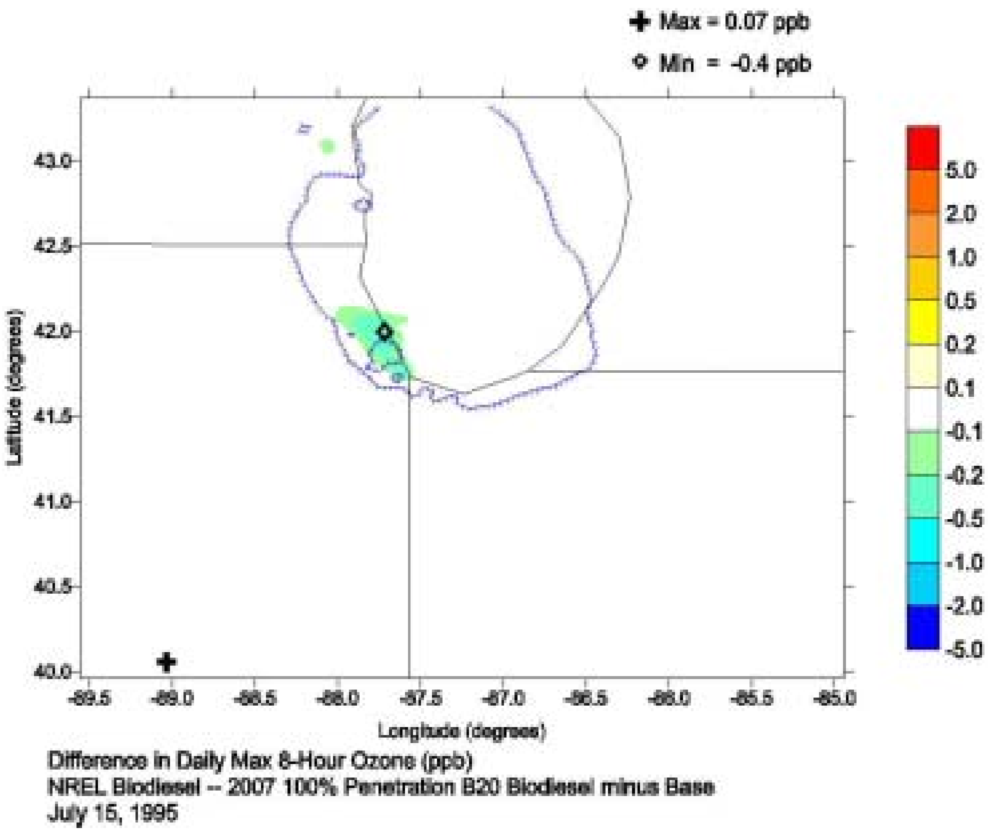


Figure 4-4e. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan domain on July 15, 1995.

Biodiesel Ozone Impact Assessment for the Northeast Corridor Region

The spatial distribution of the predicted daily maximum 1-hour ozone concentrations for the 2007 SIP Call baseline simulation in the Northeast Corridor 4-km domain are displayed in Figure 4-5. On the first day of the analysis period (July 11), predicted 1-hour ozone concentrations are relatively low with a peak of 109 ppb occurring just downwind of Washington D.C. High ozone levels are predicted on July 12 with a peak (145.6 ppb) again occurring downwind of Washington D.C. Small regions of 1-hour ozone exceedances are estimated for the Washington and Baltimore urban areas as well as in New Jersey east of Philadelphia. By July 13, the plume of elevated ozone concentrations extends the length of the Corridor from the Washington/Baltimore urban area through New Jersey and New York and into southern Connecticut, although no exceedances of the 1-hour NAAQS are predicted in the domain. The spatial distribution of estimated ozone concentrations on July 14 are similar to the previous day only with a large region of exceedances evident downwind of New York City over Long Island and Long Island Sound with a peak of 156.8 ppb predicted just north of Long Island over the sound. On July 15, the urban plume of elevated ozone concentrations moves east offshore from Long Island with a daily peak of 177 ppb and a broad region of ozone in excess of the standard east of New York City and confined mainly south of Long Island. In addition, a small region of ozone exceedances is predicted to occur near Washington D.C. and Baltimore spreading across the northern portion of Chesapeake Bay.

The spatial distributions of daily maximum 8-hour ozone concentrations in the Northeast Corridor domain, displayed in Figure 4-6, are quite similar to those of the daily peak 1-hour concentrations. However, as in the case of the Lake Michigan 4-km domain, the regions of exceedances of the 8-hour ozone standard are considerably larger than the regions exceeding the 1-hour ozone standard. The daily maximum 8-hour ozone concentrations are predicted to exceed the proposed standard of 84 ppb on all days during July 11-15 within Northern Corridor domain for the 2007 SIP Call baseline simulation.

The impacts on the daily maximum 1-hour and 8-hour ozone concentrations due to B20 biodiesel fuel use at a 100% penetration level in the Northeast Corridor domain are presented in Figures 4-7 and 4-8, respectively. The corresponding displays for the 50% penetration scenario are presented in Appendix B. While both benefits and disbenefits due to biodiesel fuel use are estimated throughout the domain, unlike in the Lake Michigan domain, the disbenefits in the Northeast Corridor domain tend to be equal to or out-weigh the benefits in terms of the magnitude of the peaks and are more widespread in terms of spatial extent.

On the first two days of the evaluation period, 1-hour ozone benefits are predicted for the New York City and Philadelphia urban areas, whereas slight disbenefits are estimated to occur in the region between Washington D.C. and Baltimore. On July 13, a localized reduction in 1-hour ozone is predicted in New York City with regions of ozone increases occurring downwind of Washington D.C. extending northeast. Impacts on July 14 are mainly disbenefits covering a broad region throughout the Corridor with a slight ozone reduction occurring downwind of New York City over Long Island. On July 15, the region of increases in 1-hour ozone concentrations has shifted east extending across Chesapeake Bay and Delaware and offshore south of Long Island. While this broad region of ozone increases adversely impacts the areas of ozone exceedances in the baseline simulation, a small region of benefits are also seen just south of Long Island.

In Figure 4-8 the impacts on the daily maximum 8-hour ozone concentrations are displayed and are seen to be very similar to the 1-hour impacts with respect to the spatial distribution. The impacts on the exceedances of the proposed 8-hour standard are more widespread since the regions of exceedances in the 2007 SIP Call baseline are likewise more broadly distributed throughout the Northeast Corridor domain.

The impacts due to B20 biodiesel fuel use on the daily 1-hour and 8-hour peak ozone concentrations in the Northeast Corridor 4-km domain for both the 50% and 100% penetration emission scenarios are summarized in Table 4-2. Except for July 14, slight increases in the daily peak 1-hour and 8-hour ozone concentrations are seen in the Northeast corridor due to use of biodiesel fuels. However, these increases in the ozone peaks are very small with maximum increases in 1-hour and 8-hour ozone peaks due to the biodiesel use of 0.09 ppb (0.051%) and 0.10 ppb (0.066%), respectively, occurring on July 15, 1995.

Table 4-2. Summary of daily peak 1-hour and 8-hour ozone concentrations in the Northeast Corridor 4-km domain for the 2007 standard diesel (SIP Call) and biodiesel emission scenarios.

Northeast Corridor 1-Hour Ozone					
	2007 SIP Call	**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	(ppb)	**(ppb)**	**(% Difference)**	**(ppb)**	**(% Difference)**
July 11, 1995	109.06	109.08	0.024%	109.11	0.049%
July 12, 1995	145.70	145.72	0.015%	145.74	0.028%
July 13, 1995	119.80	119.81	0.006%	119.82	0.017%
July 14, 1995	156.89	156.89	-0.003%	156.88	-0.007%
July 15, 1995	177.02	177.06	0.025%	177.11	0.051%
Northeast Corridor 8-Hour Ozone					
	2007 SIP Call	**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	(ppb)	**(ppb)**	**(% Difference)**	**(ppb)**	**(% Difference)**
July 11, 1995	102.40	102.42	0.021%	102.44	0.046%
July 12, 1995	123.95	123.98	0.023%	124.01	0.045%
July 13, 1995	108.44	108.48	0.035%	108.52	0.071%
July 14, 1995	142.03	142.05	0.018%	142.08	0.035%
July 15, 1995	155.26	155.31	0.033%	155.36	0.066%

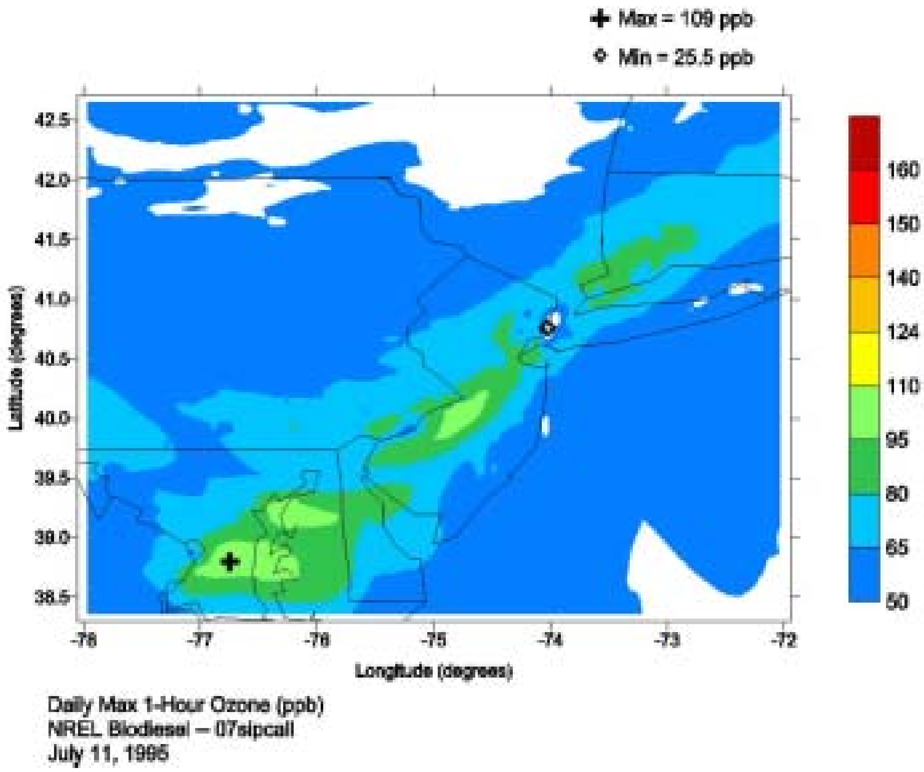


Figure 4-5a. Spatial distribution of daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 11, 1995 for the 2007 SIP Call scenario.

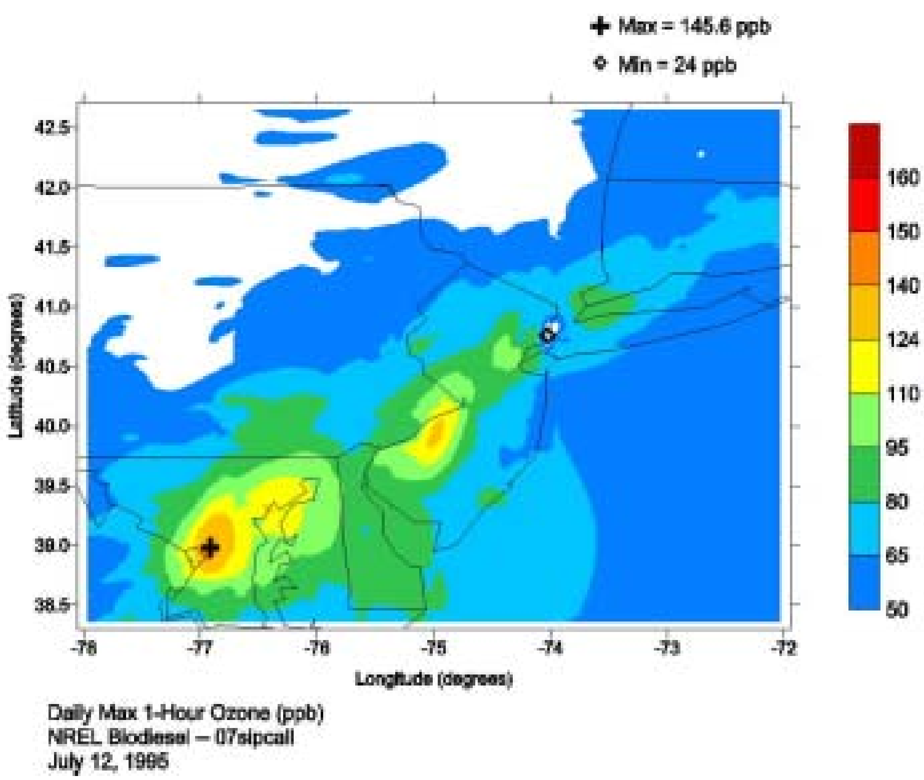


Figure 4-5b. Spatial distribution of daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 12, 1995 for the 2007 SIP Call scenario.

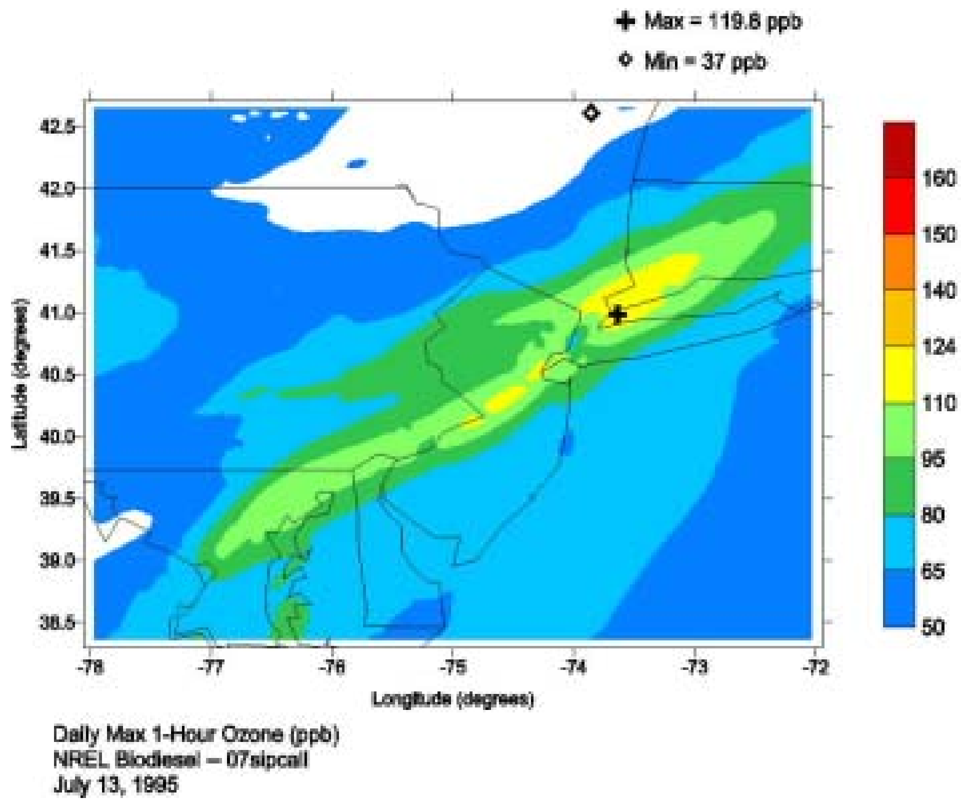


Figure 4-5c. Spatial distribution of daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 13, 1995 for the 2007 SIP Call scenario.

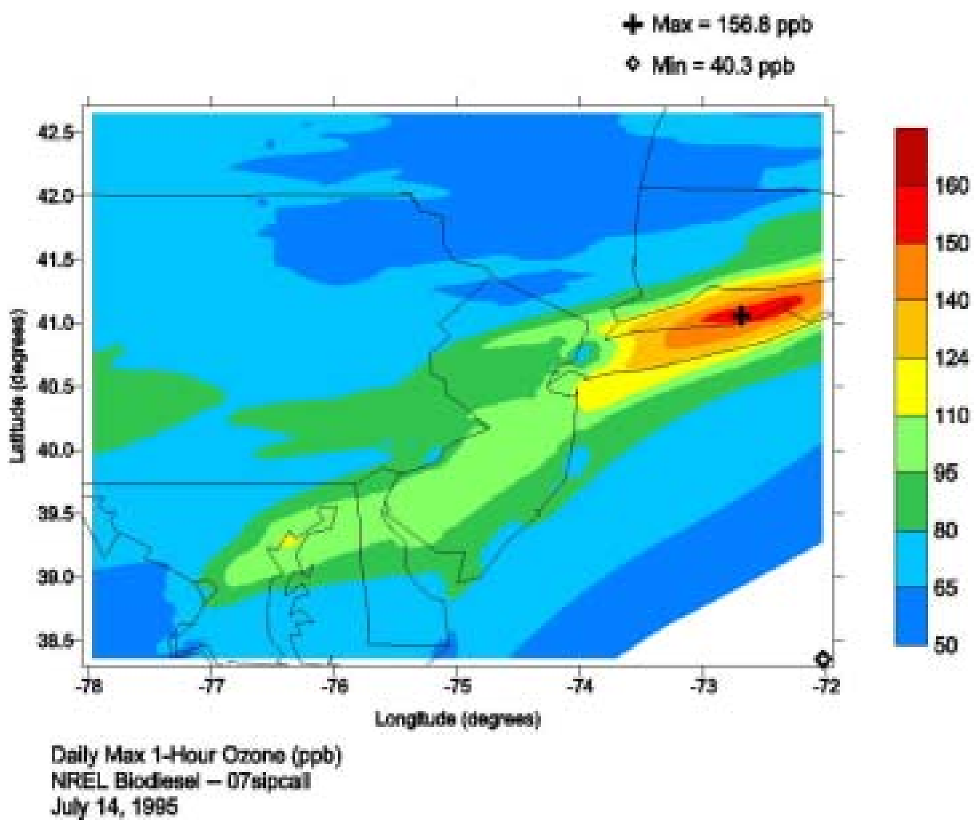


Figure 4-5d. Spatial distribution of daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 14, 1995 for the 2007 SIP Call scenario.

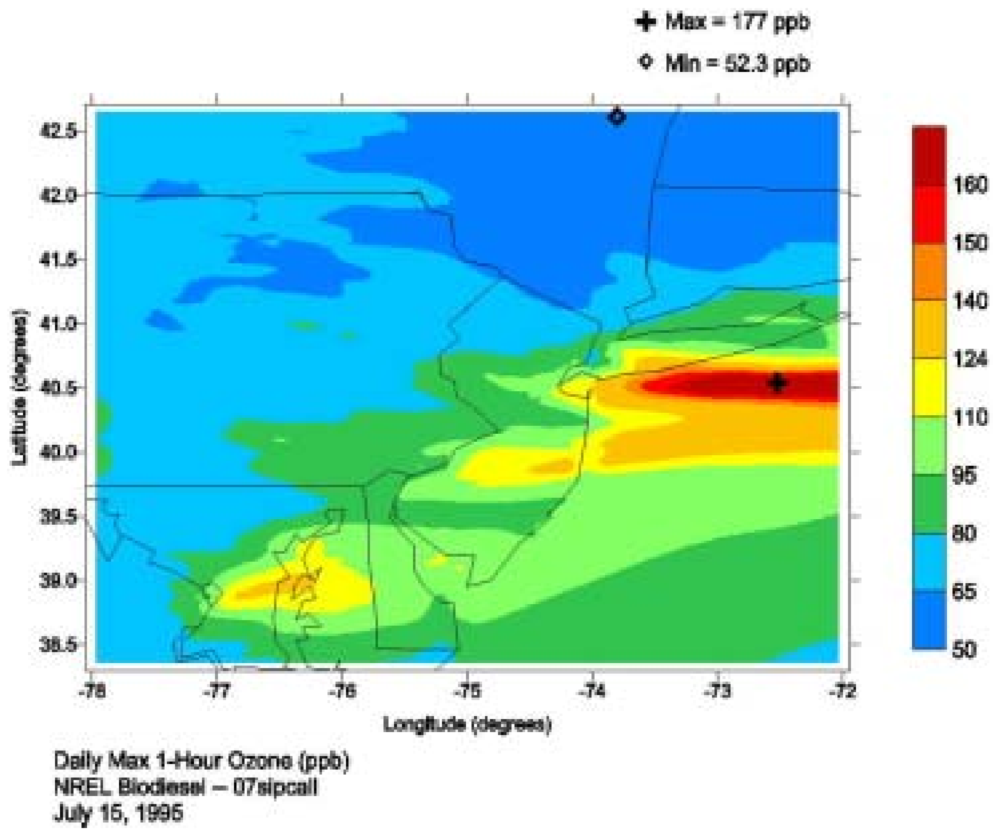


Figure 4-5e. Spatial distribution of daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 15, 1995 for the 2007 SIP Call scenario.

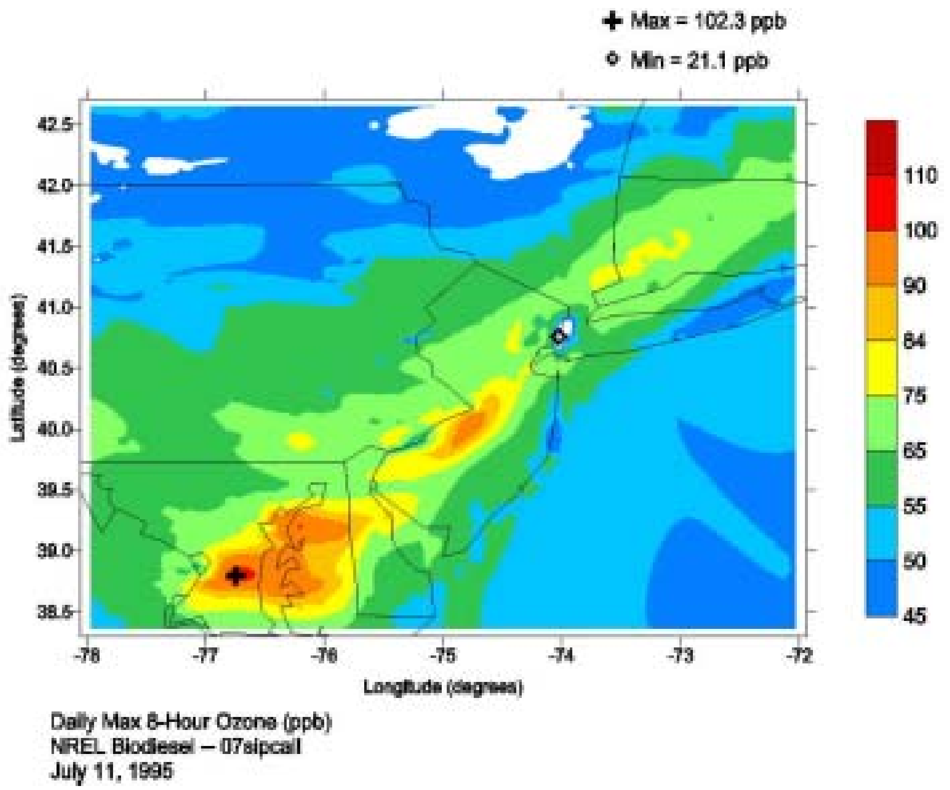


Figure 4-6a. Spatial distribution of daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 11, 1995 for the 2007 SIP Call scenario.

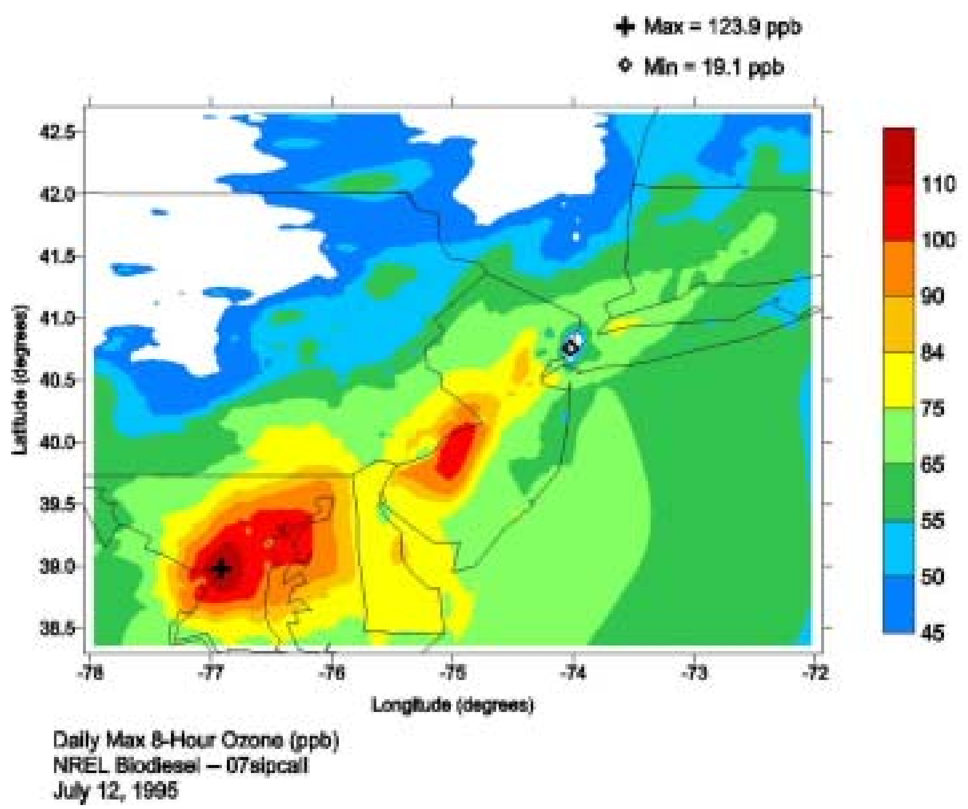


Figure 4-6b. Spatial distribution of daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 12, 1995 for the 2007 SIP Call scenario.

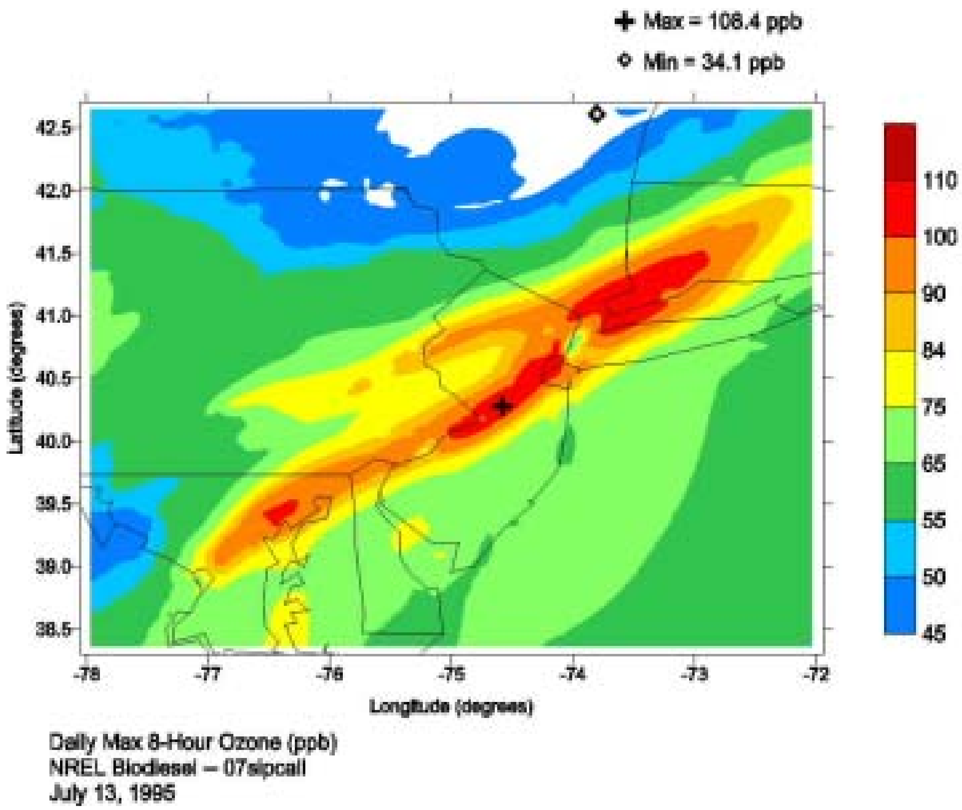


Figure 4-6c. Spatial distribution of daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 13, 1995 for the 2007 SIP Call scenario.

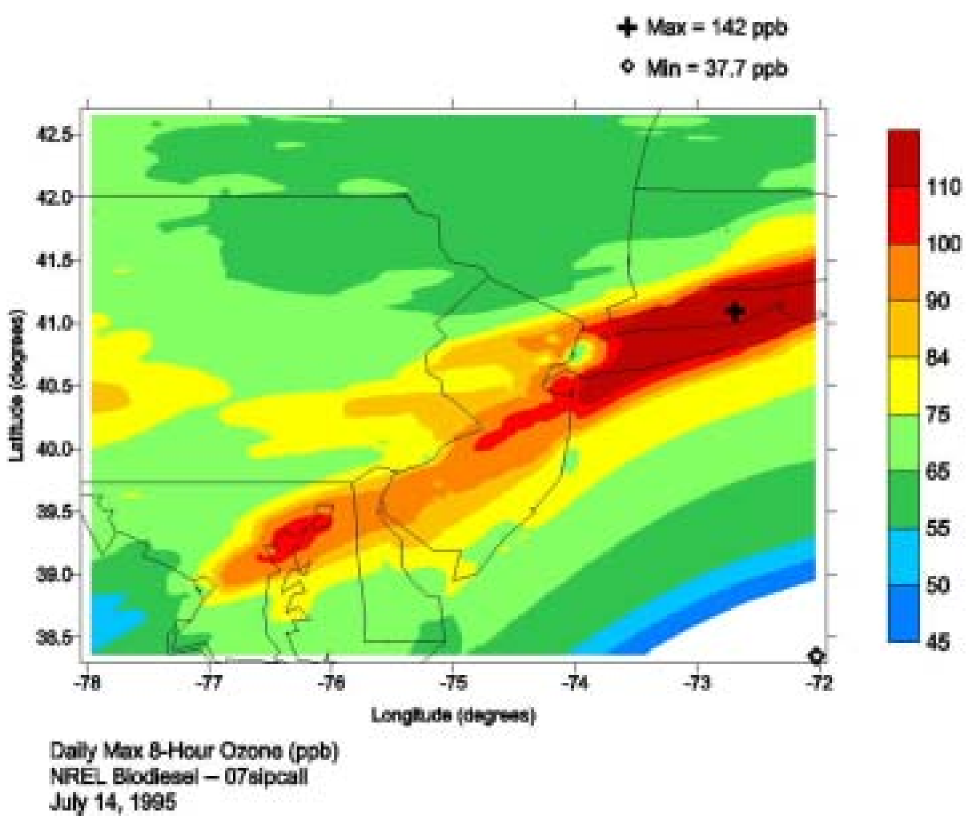


Figure 4-6d. Spatial distribution of daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 14, 1995 for the 2007 SIP Call scenario.

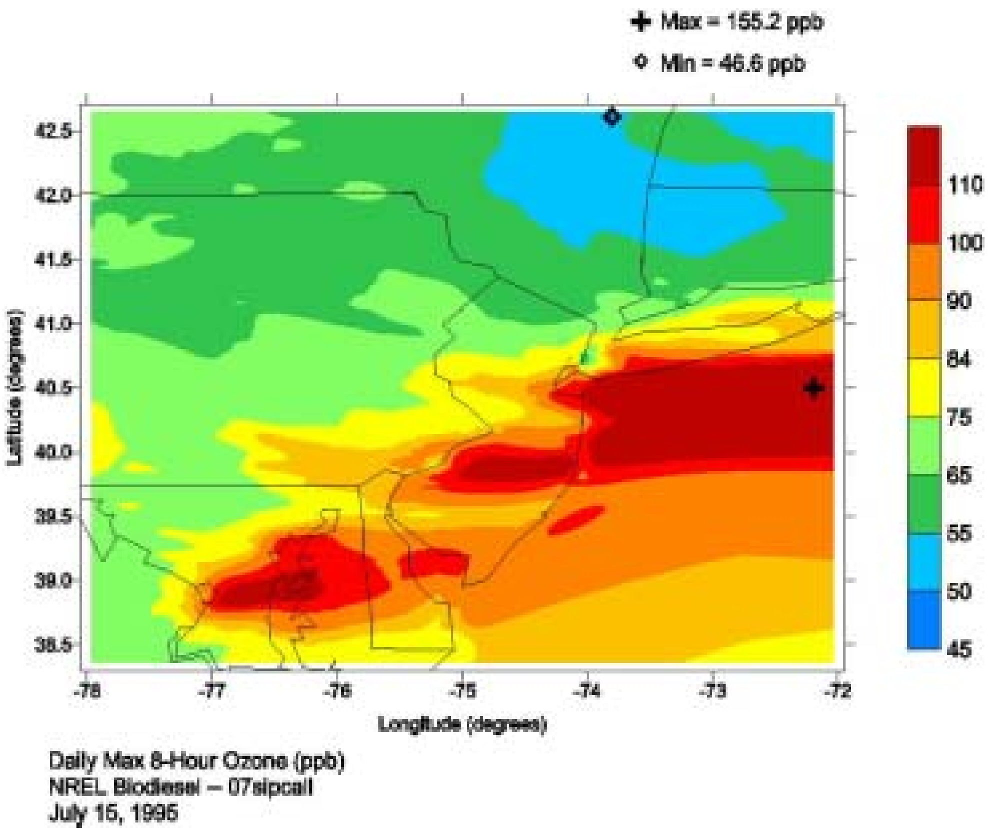


Figure 4-6e. Spatial distribution of daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 15, 1995 for the 2007 SIP Call scenario.

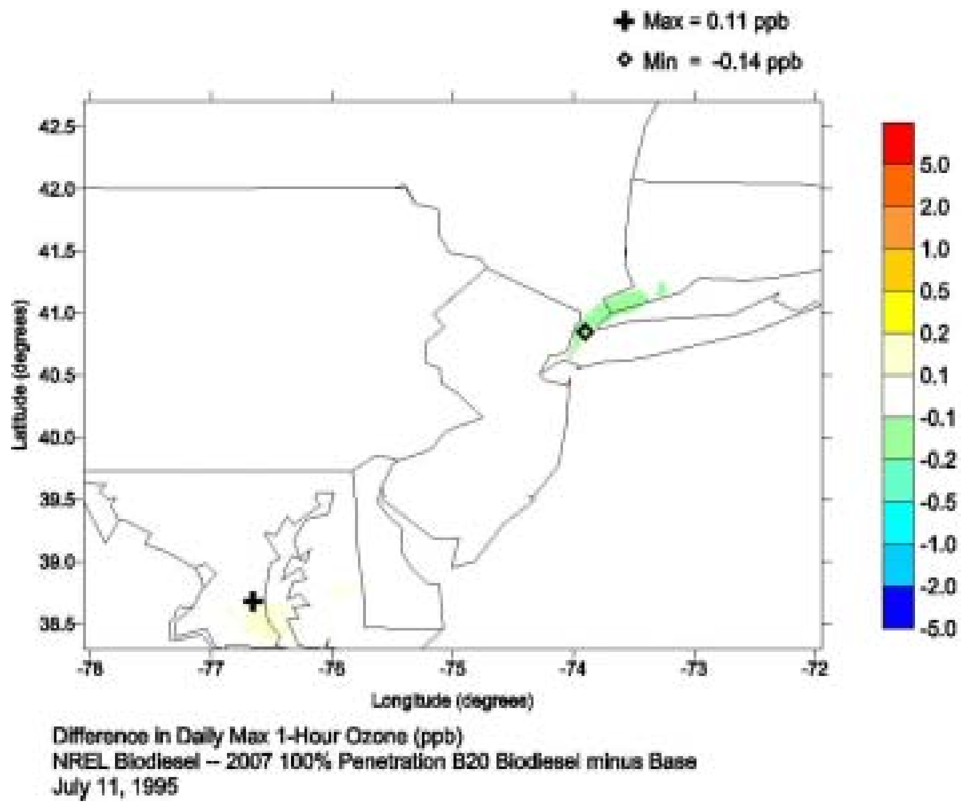


Figure 4-7a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor domain on July 11, 1995.

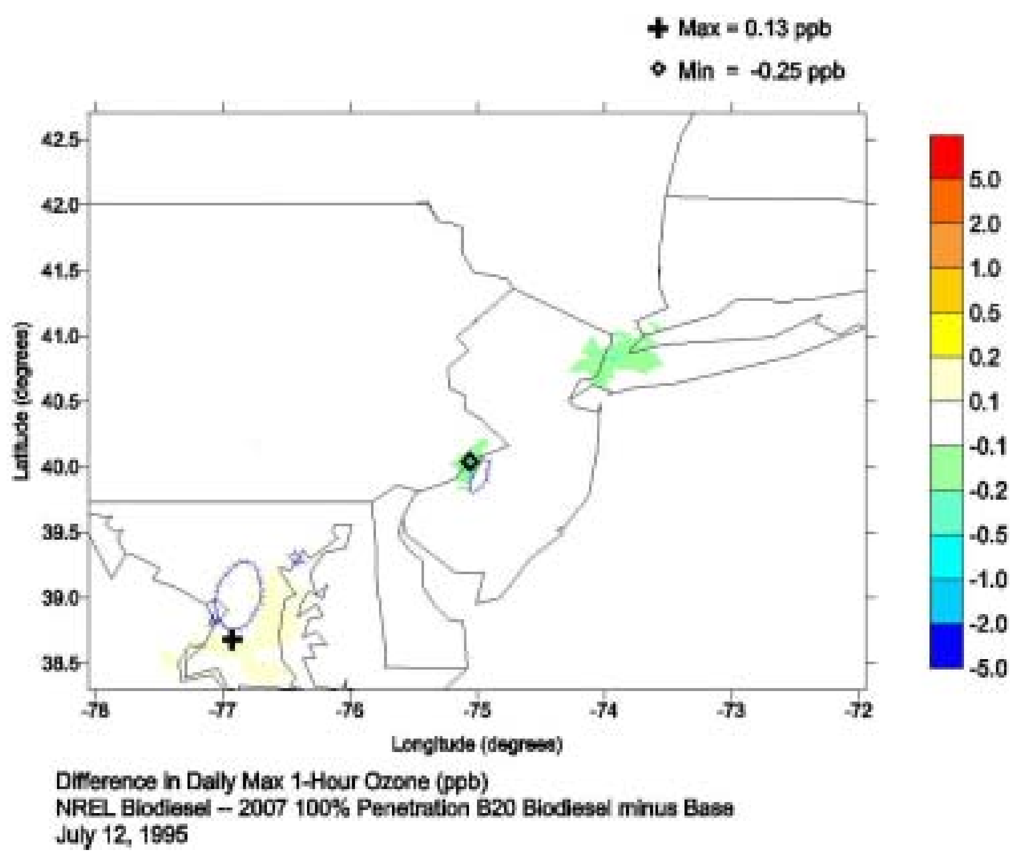


Figure 4-7b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor domain on July 12, 1995.

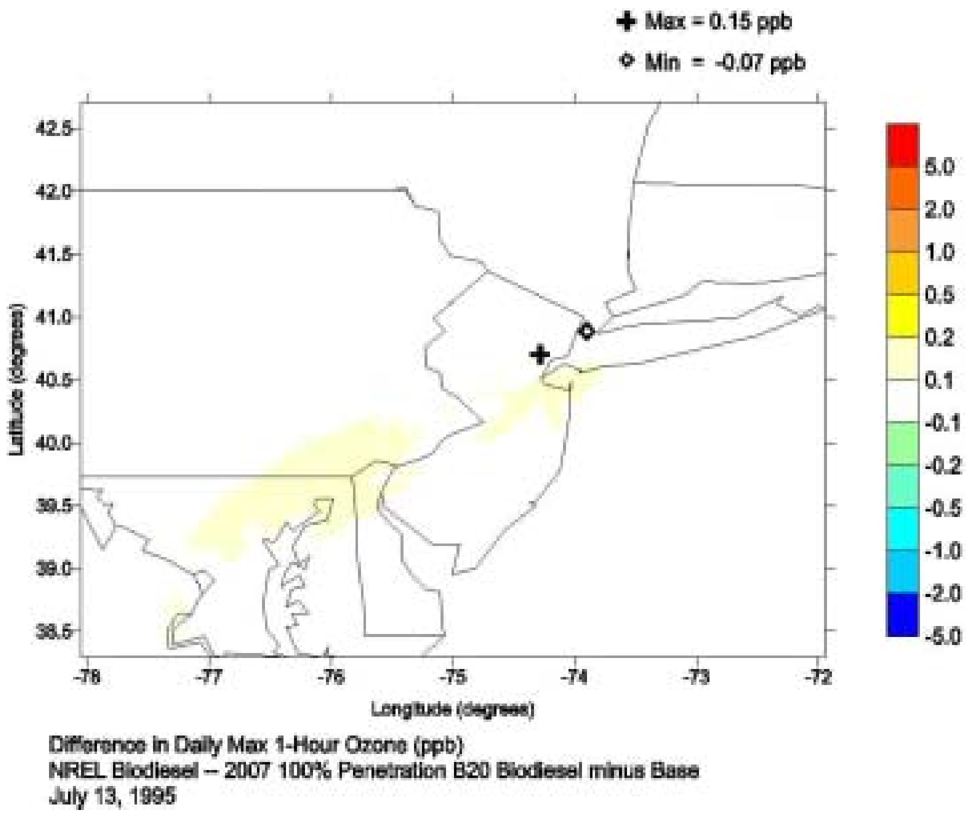


Figure 4-7c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor domain on July 13, 1995.

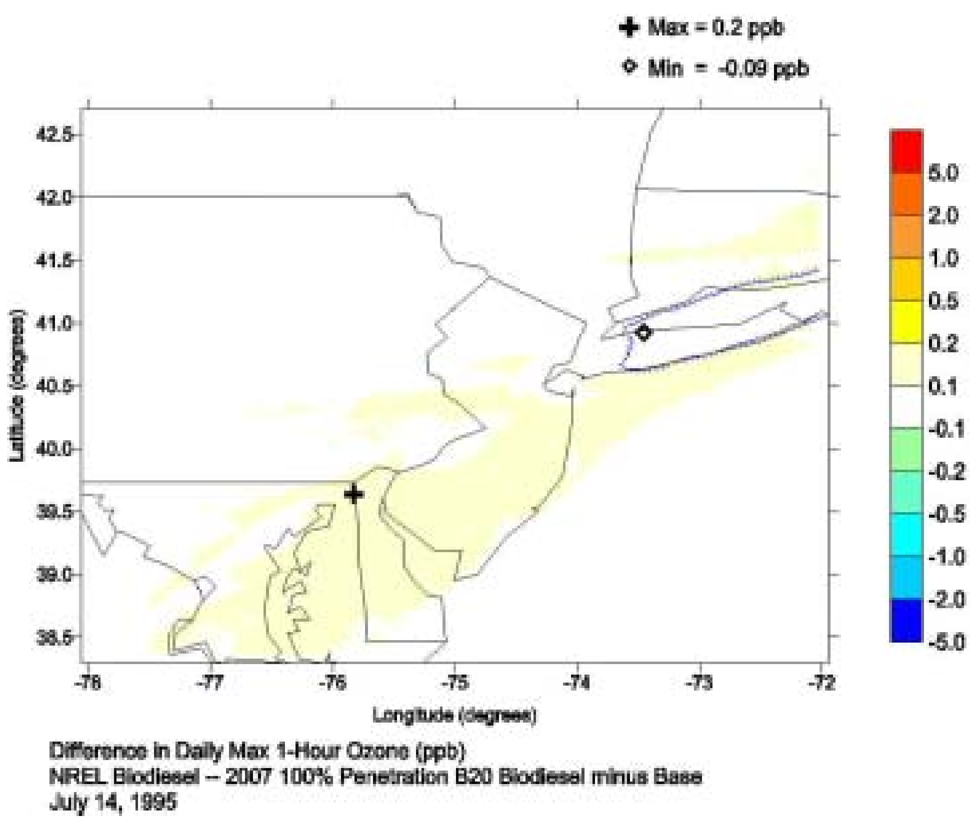


Figure 4-7d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor domain on July 14, 1995.

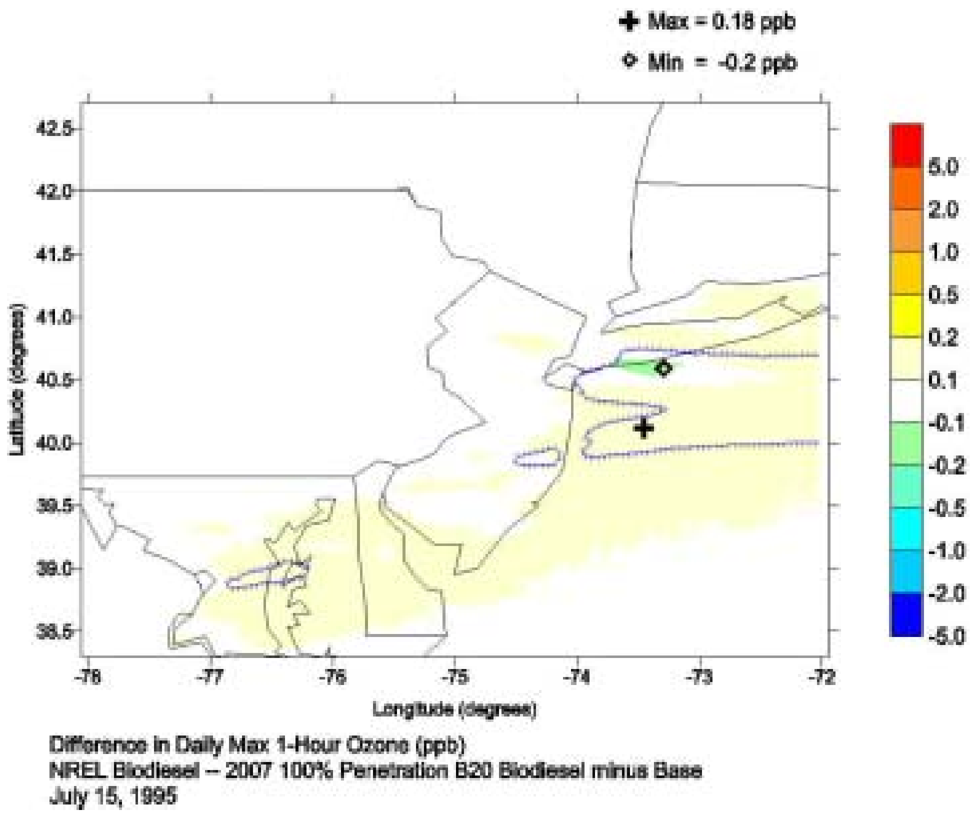


Figure 4-7e. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor domain on July 15, 1995.

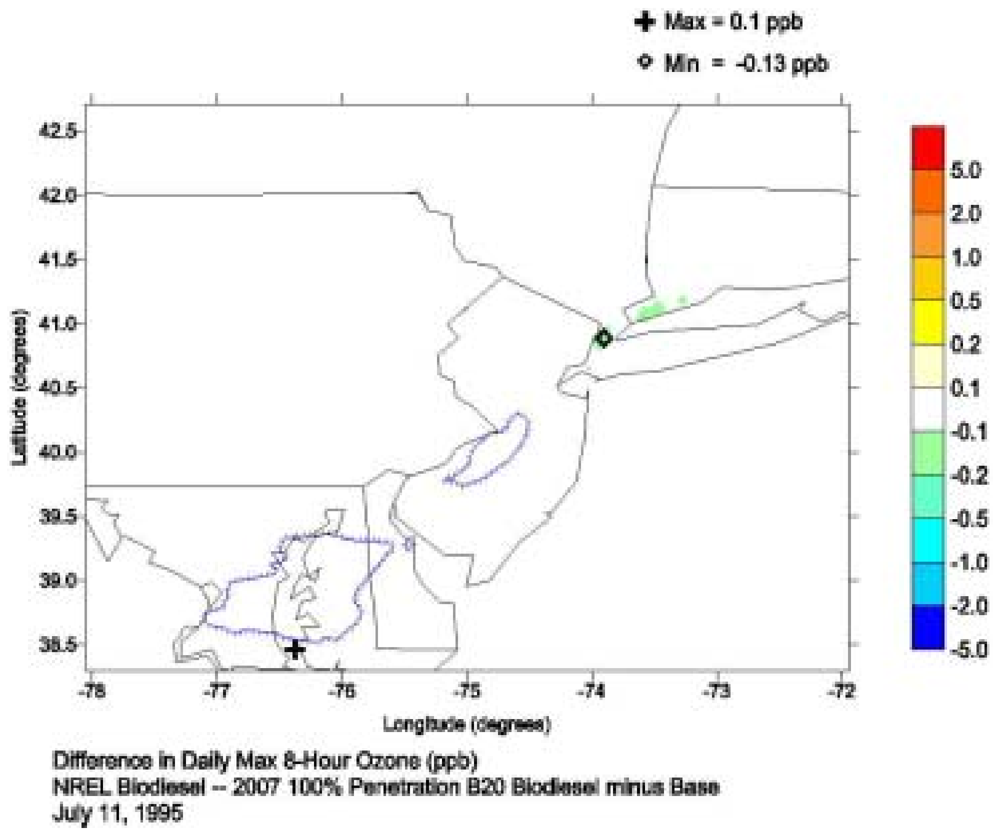


Figure 4-8a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor domain on July 11, 1995.

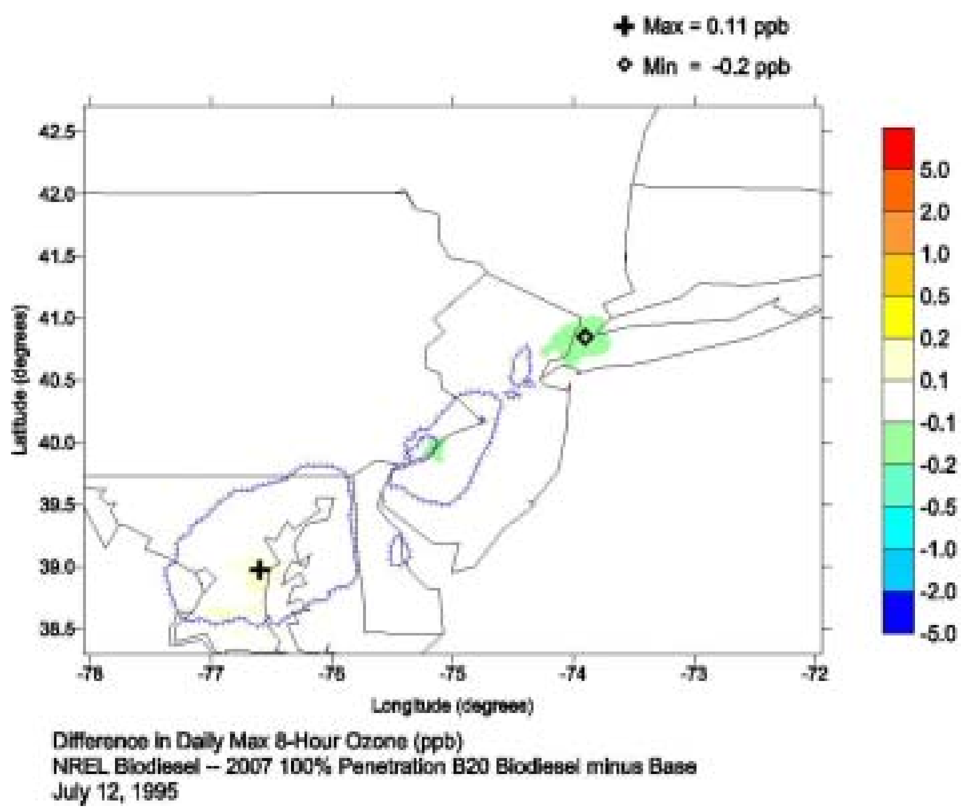


Figure 4-8b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor domain on July 12, 1995.

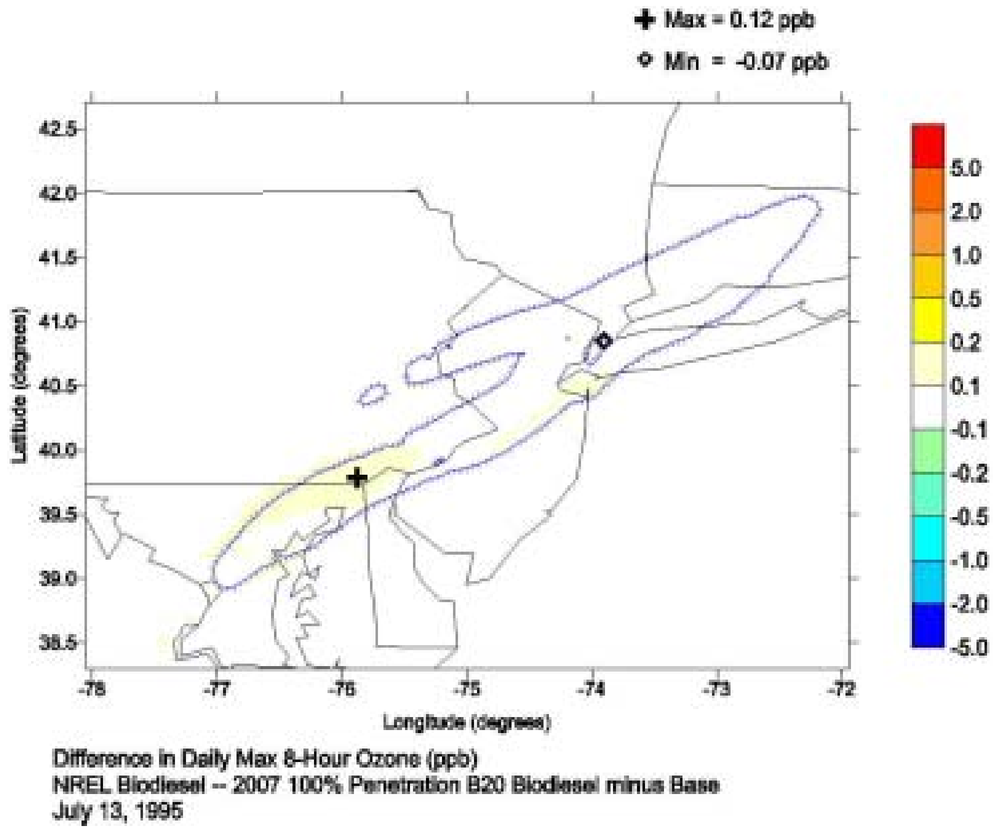


Figure 4-8c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor domain on July 13, 1995.

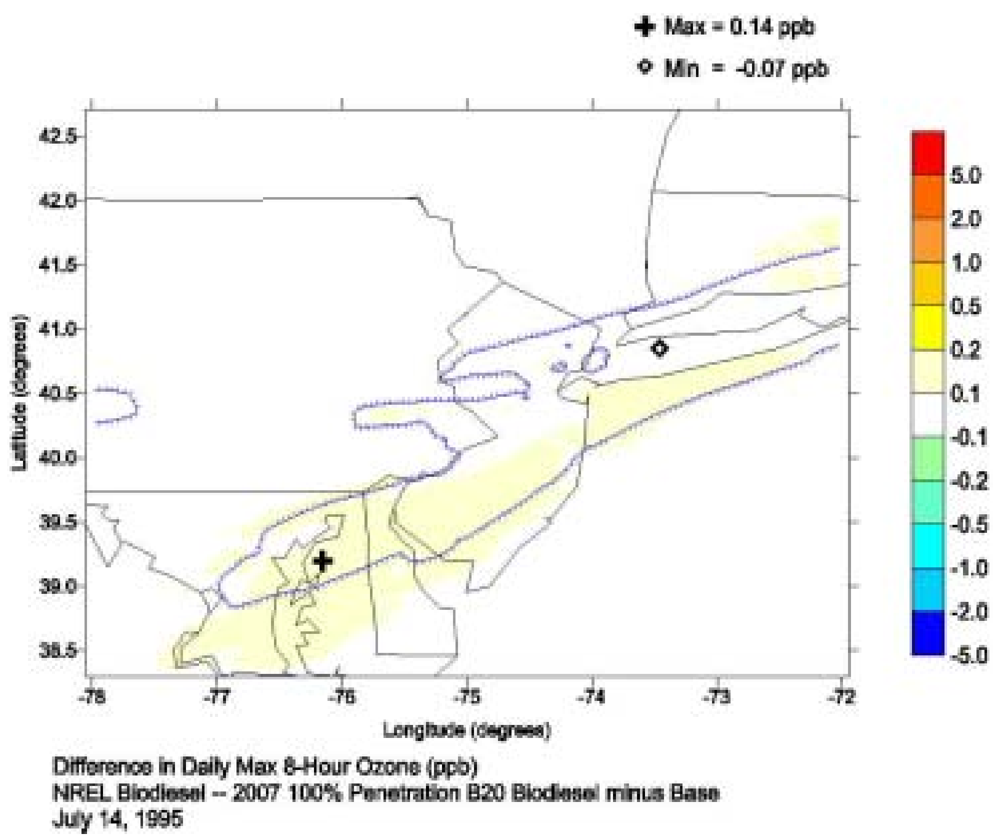


Figure 4-8d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor domain on July 14, 1995.

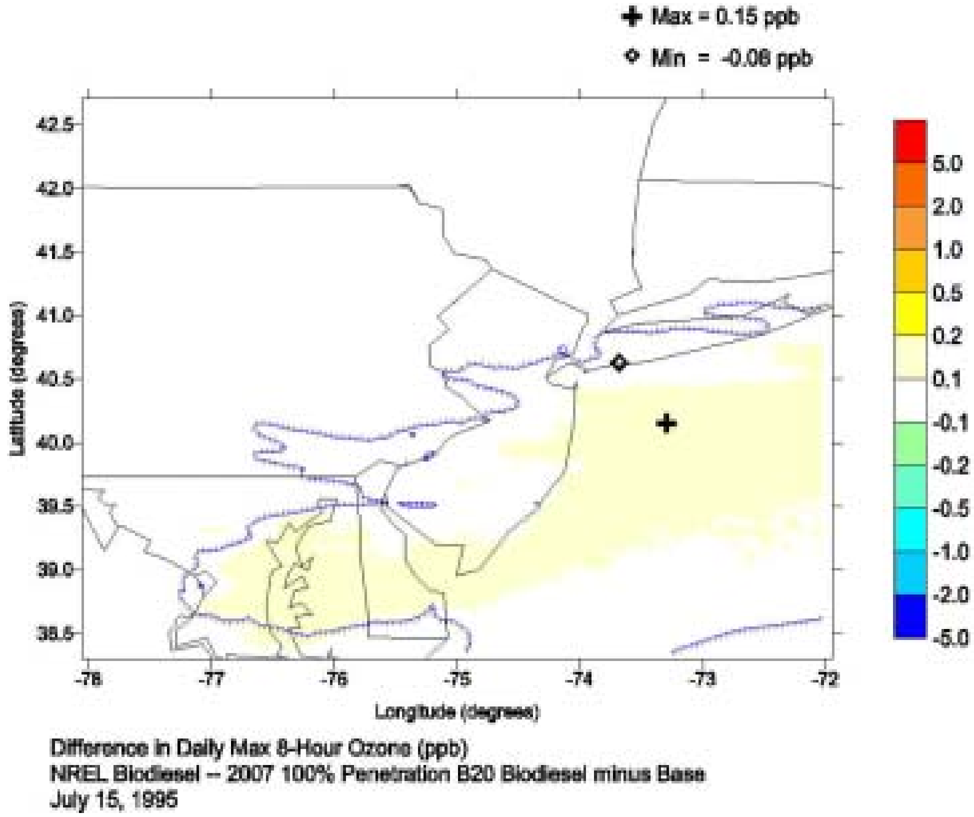


Figure 4-8e. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor domain on July 15, 1995.

Biodiesel Ozone Impact Assessment for Other Cities in the Eastern US

The CAMx ozone estimates on the OTAG 12-km eastern US domain are presented in Appendix C. An examination of Figures C-1 reveals that the highest daily maximum peak 1-hour ozone concentrations occur within the Lake Michigan and Northeast Corridor 4-km domains. Small regions of 1-hour NAAQS exceedances are estimated to occur in the Atlanta, Birmingham and Memphis urban areas as well as in eastern Virginia during July 11-15, 1995 period under the 2007 SIP Call baseline simulation. Spatial displays of the distribution of daily maximum 8-hour ozone concentrations in the OTAG 12-km domain for the 2007 SIP Call baseline simulation are presented in Figures C-2. In addition to the estimated exceedances of the proposed 8-hour standard occurring within the Lake Michigan and Northeast Corridor 4-km domains discussed previously, elevated 8-hour ozone concentrations are predicted in the urban areas of the Ohio River valley for most days. In addition, exceedances of the standard are predicted to occur for the Atlanta and Birmingham urban centers as well as for Detroit and the Lake Erie region and in southwestern Pennsylvania.

Similar to the results within the 4-km modeling domains, the impacts due to B20 biodiesel fuel use on both the daily maximum 1-hour and 8-hour ozone concentrations within the OTAG 12-km domain are relative minor. Displays of the impacts on the daily maximum 1-hour ozone for the 100% B20 emission scenario are presented in Figures C-3. For all days within the analysis period of July 11-15, 1995, the maximum impact on the 1-hour daily maximum ozone concentrations for the 100% penetration scenario occurs in Atlanta where the model predicts an ozone increase of approximately 0.2-0.25 ppb. The only reductions in 1-hour ozone are seen to occur within the regions of the two 4-km modeling domains. A broad region of small ozone increases are estimated to occur within the regions of northern Alabama and Georgia, stretching northeast from Atlanta along the Appalachian Mountain range. As expected, the impacts resulting from the 50% penetration scenario (displayed in Figures C-4) are similar although considerably smaller.

The impacts on the predicted daily maximum 8-hour ozone concentrations for both biodiesel emission scenarios, presented in Figures C-5 and Figures C-6 of Appendix C, are qualitatively similar to those of the 1-hour ozone impacts.

Ozone Exposure Estimates in the Eastern US

As an additional measure of the impacts of biodiesel fuel use on ozone air quality and human health, various exposure metrics are evaluated for each of the emission scenarios considered. Spatial coverage (exposure) of the hourly 1-hour and 8-hour ozone concentrations above thresholds of 124 ppb and 84 ppb, respectively, are calculated for each scenario in terms of the number of grid cell-hours above the standard. Also evaluated are the changes in the integrated concentrations of 1-hour and 8-hour ozone concentrations (dosage) above ozone thresholds of 124 ppb and 84 ppb, respectively. The dosage metric is expressed in terms of ppb-grid cell-hours above the ozone standard.

Table 4-3 summarizes the 1-hour and 8-hour exposure metrics for the Lake Michigan 4-km domain for each of the analysis days (July 11-15, 1995) for each scenario considered. Except for the July 15 episode day and dosage on July 13, the 1-hour exposure and dosage metrics remain the same or increase for both biodiesel emission scenarios. On July 15, a slight decrease is predicted for these exposure metrics. In all cases the impacts are seen to be minimal (much less than 1 percent). Similar results are predicted for the 8-hour exposure metrics. For the 8-hour metrics, the magnitude of the exposure and dosage are considerably larger than the corresponding 1-hour metrics, since the regions of exceedances of the 8-hour ozone standard are more widespread.

Table 4-3. Summary of exposure metrics for the Lake Michigan 4-km domain.

Lake Michigan 1-Hour Exposure Metrics						
	2007 SIP Call		50% B20 Biodiesel		100% B20 Biodiesel	
	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)
July 11, 1995	0	0.00	0	0.00	0	0.00
July 12, 1995	0	0.00	0	0.00	0	0.00
July 13, 1995	3557	53683.71	3557	53679.96	3558	53675.61
July 14, 1995	4603	85841.88	4605	85895.56	4606	85949.85
July 15, 1995	1225	14279.90	1225	14253.83	1224	14227.32
Lake Michigan 8-Hour Exposure Metrics						
	2007 SIP Call		50% B20 Biodiesel		100% B20 Biodiesel	
	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)
July 11, 1995	0	0.00	0	0.00	0	0.00
July 12, 1995	226	275.63	228	275.27	226	274.84
July 13, 1995	13196	277238.84	13205	277244.34	13211	277250.59
July 14, 1995	15526	360967.72	15535	361107.22	15542	361249.53
July 15, 1995	10572	157262.58	10573	157287.34	10578	157311.08

Table 4-4 summarizes the corresponding exposure results for the Northeast Corridor 4-km domain. Unlike the results for the Lake Michigan domain, all analysis days show an increase in both exposure and dosage for the Northeast Corridor for both the 1-hour and 8-hour metrics. While the impacts due to the use of biodiesel fuel are such to increase both ozone exposure and dosage, the changes are extremely small, less than 1%.

Table 4-4. Summary of exposure metrics for the Northeast Corridor 4-km domain.

Northeast Corridor 1-Hour Exposure Metrics						
	2007 SIP Call		50% B20 Biodiesel		100% B20 Biodiesel	
	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)
July 11, 1995	0	0.00	0	0.00	0	0.00
July 12, 1995	186	1307.59	187	1311.54	188	1315.56
July 13, 1995	0	0.00	0	0.00	0	0.00
July 14, 1995	1582	17513.87	1583	17556.69	1587	17599.14
July 15, 1995	2932	35904.80	2943	36069.84	2949	36234.43
Northeast Corridor 8-Hour Exposure Metrics						
	2007 SIP Call		50% B20 Biodiesel		100% B20 Biodiesel	
	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)
July 11, 1995	2659	15252.60	2665	15337.75	2672	15422.56
July 12, 1995	5786	54222.26	5803	54374.32	5812	54526.00
July 13, 1995	8351	61252.63	8382	61517.29	8412	61781.13
July 14, 1995	14312	187447.50	14356	187993.91	14407	188541.19
July 15, 1995	41985	495718.72	42120	497721.72	42263	499731.53

The exposure assessment for cities within the OTAG 12-km domain was conducted based on the attainment status of the surrounding counties. Each "city" was defined by the 12-km modeling grid cells within each of the surrounding counties. Table 4-5 displays the definition of the counties used for each urban center. The exposure metrics (exposure and dosage) were evaluated for the following cities: Atlanta, GA; Birmingham, AL; Cincinnati, OH; Detroit, MI, Louisville, KY; Memphis, TN; Pittsburgh, PA; and St. Louis, MO.

Table 4-5. Counties included in each "City" for exposure assessment.

City	Counties
Atlanta	Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinett, Henry, Paulding, Rockdale
Birmingham	Jefferson, Shelby
Cincinnati	Butler, Clermont, Hamilton (OH) Boone, Campbell, Kenton (KY)
Detroit	Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, Wayne
Louisville	Jefferson, Oldham, Bullitt (KY) Clark, Floyd (IN)
Memphis	Shelby
Pittsburgh	Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland
St. Louis	Franklin, Jefferson, St. Charles, St. Louis (MO) Madison, Monroe, St. Clair (IL)

Tables 4–6 and 4-7 summarize the 1-hour and 8-hour exposure metrics for the cities within the OTAG 12-km domain, respectively. For the 1-hour metrics, only Atlanta and Birmingham show any impacts due to the use of biodiesel fuels, as these are the only areas that were predicted to exceed the standard in any of the scenarios considered. As expected, the changes in both the exposure and dosage metrics are minimal. The impacts on the 8-hour metrics, presented in Table 4-7, show that although all urban centers considered are affected with respect to the ozone exposure metrics, the impacts are relatively minor.

Table 4-6. Summary of 1-hour ozone exposure metrics in OTAG 12-km domain.

1-Hour Exposure Metrics									
	2007 SIP Call			2007 50% B20 Biodiesel			2007 100% B20 Biodiesel		
	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)
Atlanta									
July 11, 1995	165.07	128	1629.37	165.19	128	1641.93	165.31	128	1654.49
July 12, 1995	136.16	20	110.79	136.27	20	112.65	136.38	20	114.68
July 13, 1995	118.43	0	0	118.52	0	0	118.62	0	0
July 14, 1995	137.31	26	136.83	137.4	26	139.07	137.49	27	141.3
July 15, 1995	171.55	71	1289.31	171.64	71	1296.16	171.74	71	1302.97
Birmingham									
July 11, 1995	118.07	0	0	118.14	0	0	118.21	0	0
July 12, 1995	139.38	14	119.07	139.47	14	120.16	139.55	14	121.25
July 13, 1995	107.21	0	0	107.26	0	0	107.31	0	0
July 14, 1995	128.24	4	9.39	128.3	4	9.64	128.37	4	9.88
July 15, 1995	142.57	15	166.88	142.6	15	167.69	142.62	15	168.5
Cincinnati									
July 11, 1995	77.66	0	0	77.65	0	0	77.64	0	0
July 12, 1995	101.23	0	0	101.23	0	0	101.23	0	0
July 13, 1995	87.85	0	0	87.88	0	0	87.9	0	0
July 14, 1995	103.65	0	0	103.68	0	0	103.71	0	0
July 15, 1995	103.63	0	0	103.66	0	0	103.68	0	0
Detroit									
July 11, 1995	66.78	0	0	66.78	0	0	66.78	0	0
July 12, 1995	78.79	0	0	78.78	0	0	78.77	0	0
July 13, 1995	92.99	0	0	92.99	0	0	92.98	0	0
July 14, 1995	111.09	0	0	111.11	0	0	111.13	0	0
July 15, 1995	113.7	0	0	113.74	0	0	113.77	0	0
Louisville									
July 11, 1995	98.77	0	0	98.76	0	0	98.75	0	0
July 12, 1995	109.94	0	0	109.93	0	0	109.92	0	0
July 13, 1995	98.36	0	0	98.39	0	0	98.41	0	0
July 14, 1995	119.12	0	0	119.14	0	0	119.16	0	0
July 15, 1995	114.9	0	0	114.93	0	0	114.96	0	0

1-Hour Exposure Metrics									
	2007 SIP Call			**2007 50% B20 Biodiesel**			**2007 100% B20 Biodiesel**		
	Peak (ppb)	**Exposure (grid cell-hrs)**	**Dosage (ppb-grid cell-hrs)**	**Peak (ppb)**	**Exposure (grid cell-hrs)**	**Dosage (ppb-grid cell-hrs)**	**Peak (ppb)**	**Exposure (grid cell-hrs)**	**Dosage (ppb-grid cell-hrs)**
Memphis									
July 11, 1995	104.49	0	0	104.5	0	0	104.51	0	0
July 12, 1995	113.69	0	0	113.69	0	0	113.68	0	0
July 13, 1995	101.46	0	0	101.47	0	0	101.48	0	0
July 14, 1995	108.16	0	0	108.19	0	0	108.22	0	0
July 15, 1995	110.67	0	0	110.68	0	0	110.69	0	0
Pittsburgh									
July 11, 1995	76.96	0	0	76.97	0	0	76.99	0	0
July 12, 1995	99.5	0	0	99.47	0	0	99.44	0	0
July 13, 1995	90.23	0	0	90.25	0	0	90.27	0	0
July 14, 1995	99.88	0	0	99.9	0	0	99.93	0	0
July 15, 1995	108.92	0	0	108.95	0	0	108.99	0	0
St. Louis									
July 11, 1995	102.74	0	0	102.78	0	0	102.82	0	0
July 12, 1995	98.14	0	0	98.2	0	0	98.27	0	0
July 13, 1995	93.86	0	0	93.92	0	0	93.98	0	0
July 14, 1995	100.41	0	0	100.46	0	0	100.51	0	0
July 15, 1995	94.23	0	0	94.28	0	0	94.34	0	0

Table 4-7. Summary of 8-hour ozone exposure metrics in OTAG 12-km domain.

8-Hour Exposure Metrics									
	2007 SIP Call			2007 50% B20 Biodiesel			2007 100% B20 Biodiesel		
	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)
Atlanta									
July 11, 1995	152	459	10285.71	152.11	461	10322.01	152.22	461	10358.46
July 12, 1995	121.26	221	3116.92	121.35	221	3132.87	121.43	221	3148.95
July 13, 1995	110.54	155	1766.58	110.63	155	1776.77	110.71	156	1786.87
July 14, 1995	122.77	204	2987.95	122.85	205	3001.82	122.93	205	3015.71
July 15, 1995	153.45	262	5280.56	153.53	262	5299.63	153.62	263	5318.54
Birmingham									
July 11, 1995	112.2	169	1662.16	112.26	170	1669.54	112.32	171	1677.01
July 12, 1995	127.21	264	3048.26	127.29	265	3064.16	127.36	265	3080.32
July 13, 1995	104.18	64	546.9	104.23	64	550.04	104.28	64	553.11
July 14, 1995	118.98	112	1550.98	119.04	112	1555.47	119.1	112	1560.1
July 15, 1995	137.78	84	1574.92	137.84	84	1578.58	137.91	86	1582.24
Cincinnati									
July 11, 1995	71.98	0	0	71.97	0	0	71.95	0	0
July 12, 1995	91.94	32	119.09	91.93	32	118.91	91.92	32	118.71
July 13, 1995	84.27	2	0.33	84.3	2	0.37	84.32	2	0.42
July 14, 1995	98.4	79	358.58	98.42	79	360.33	98.45	79	362.1
July 15, 1995	99.11	57	297.27	99.13	57	298.34	99.15	57	299.43
Detroit									
July 11, 1995	62.24	0	0	62.24	0	0	62.23	0	0
July 12, 1995	68.11	0	0	68.09	0	0	68.07	0	0
July 13, 1995	86.46	8	7.51	86.44	8	7.44	86.43	8	7.36
July 14, 1995	105.78	108	680.81	105.8	108	682.19	105.81	108	683.51
July 15, 1995	107.26	107	939.95	107.29	108	941.7	107.32	108	943.45
Louisville									
July 11, 1995	90.64	10	31.92	90.63	10	31.89	90.61	10	31.84
July 12, 1995	99.35	34	253.38	99.34	34	253.06	99.33	34	252.73
July 13, 1995	90.43	13	36.46	90.45	13	36.66	90.47	13	36.86
July 14, 1995	111.07	70	631.63	111.09	70	632.88	111.11	70	634.14

8-Hour Exposure Metrics									
	2007 SIP Call			2007 50% B20 Biodiesel			2007 100% B20 Biodiesel		
	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)	Peak (ppb)	Exposure (grid cell-hrs)	Dosage (ppb-grid cell-hrs)
July 15, 1995	107.28	84	727.13	107.3	84	728.58	107.33	84	729.99
Memphis									
July 11, 1995	95.75	22	125.27	95.75	22	125.29	95.76	22	125.29
July 12, 1995	101.56	6	66.3	101.56	6	66.29	101.56	6	66.28
July 13, 1995	91.25	6	22.48	91.26	6	22.61	91.27	6	22.74
July 14, 1995	100.48	20	183.94	100.53	20	184.62	100.57	20	185.31
July 15, 1995	99.6	6	56.86	99.6	6	56.88	99.61	6	56.89
Pittsburgh									
July 11, 1995	72.79	0	0	72.81	0	0	72.82	0	0
July 12, 1995	92.25	24	69.05	92.22	24	68.63	92.19	24	68.21
July 13, 1995	84.48	5	1.59	84.5	5	1.67	84.51	5	1.75
July 14, 1995	95.66	120	440.9	95.68	120	443.77	95.71	120	446.63
July 15, 1995	103.35	174	1123.27	103.38	174	1128.18	103.41	174	1133.13
St. Louis									
July 11, 1995	94.99	19	106.35	95.02	19	106.97	95.06	19	107.57
July 12, 1995	90.97	9	36.16	91.03	9	36.61	91.09	9	37.07
July 13, 1995	89.15	10	26.04	89.2	10	26.53	89.25	10	27.02
July 14, 1995	93.75	24	97.6	93.79	24	98.55	93.84	24	99.51
July 15, 1995	90.76	17	47.41	90.81	17	48.27	90.86	17	49.12

SOUTH COAST AIR BASIN OZONE MODELING RESULTS

The spatial distribution of the predicted daily maximum 1-hour ozone concentrations for the 1997 baseline simulation in the South Coast Air Basin (SoCAB) 5-km domain are displayed in Figure 4-9. On the first day of the analysis period (August 4), predicted 1-hour ozone concentrations are relatively high with a peak of 163 ppb occurring just east of San Bernardino along the county line of Riverside and San Bernardino. A broad area of high ozone levels (>124 ppb) are predicted north and northeast of Los Angeles. Compared to the observations, the model overpredicts the ozone concentration a little bit but catches the overall distribution pattern very well, especially the observed maximum areas. Two estimated high ozone areas predicted on August 5 with one peak (167 ppb) occurring north of Los Angles and another peak occurring east of Riverside. Several exceedances with a maximum of 187 ppb are observed in Riverside and its downwind area where the ozone concentrations are underestimated by the model. The ozone levels are slightly overpredicted by the model in another maximum area north of Los Angeles where the observed 1-hour ozone levels are below the standard. The model performs very well on August 6. Two ozone exceedance areas occur, again one in the east of Riverside along the county boundary and another north and northwest of Los Angeles, are observed and predicted well by the model. The spatial distribution of estimated ozone concentrations on August 7 is similar to the previous day, but the ozone levels are lower in most of the region with only two observed exceedance sites.

The spatial distributions of daily maximum 8-hour ozone concentrations in the South Coast Air Basin, displayed in Figure 4-10, are quite similar to those of the daily peak 1-hour concentrations. The predicted high 8-hour ozone level area is quite consistent with observations. However, the peak 8-hour ozone concentrations are overestimated during the whole episode compared to the observations. And as in the case of the Lake Michigan and Northeast Corridor, the regions of exceedances of the proposed 8-hour ozone standard are relatively larger than the region exceeding the 1-hour ozone standard.

The impacts on the daily maximum 1-hour and 8-hour ozone concentrations due to B20 biodiesel fuel use at a 100% penetration level in the South Coast Air Basin domain are presented in Figures 4-11 and 4-12, respectively. The corresponding displays for the 50% penetration scenario are presented in Appendix D. Though increases of ozone concentrations (disbenefits) due to the B20 fuel are predicted in the SoCAB domain, however, unlike in the Lake Michigan and Northeast Corridor domains, the ozone benefits (reductions) are obvious and out-weigh the disbenefits in terms of the magnitude of the peaks and are far more widespread in terms of spatial extent. The maximum benefits occur coincidentally in the regions of predicted exceedances (of both the 1-hour and 8-hour standards) in the baseline scenario during most days of the episode. The benefits due to 100% penetration of B20 biodiesel fuel use range from 0.95 ppb to 1.2 ppb for daily maximum 1-hour ozone concentrations and 0.68 ppb to 0.96 ppb for daily maximum 8-hour ozone concentrations. The increases of ozone concentration due to 100% penetration of B20 biodiesel fuel use are overall small, ranging from 0.17 ppb to 0.26 ppb for daily maximum 1-hour ozone concentrations and 0.12 ppb to 0.15 ppb for daily maximum 8-hour ozone concentrations.

On August 4 (Figure 4-11a), a broad area of 1-hour ozone benefits is predicted from the Los Angeles metropolitan area all the way east to the San Bernardino National Forest while trivial magnitudes (<0.17ppb) of disbenefits are estimated to occur in the rest of the domain. The maximum benefits occur around the city of San Bernardino with a peak ozone reduction value of 0.95 ppb. On the rest of the episode days, the distribution patterns of the benefits and disbenefits are similar to that of August 4, except that the maximum benefits center shifts westward to the southeast of Los Angeles on August 5, where relative lower ozone levels are predicted. It is also noticeable that some benefits areas agree well with the highway system (e.g., highway 10 on August 4 and highway 15 on August 7).

In Figure 4-12 the impacts on the daily maximum 8-hour ozone concentrations are displayed and are seen to be very similar to the 1-hour impacts with respect to the spatial distribution. The disbenefits are even more trivial (less than 0.15 ppb during the whole episode) than seen for 1-hour ozone.

The impacts due to B20 biodiesel fuel use on the daily 1-hour and 8-hour peak ozone concentrations in the South Coast Air Basin 5-km domain for both the 50% and 100% penetration emission scenarios are summarized in Table 4-8. On all episode days and for both 1-hour and 8-hour ozone concentrations, the use of biodiesel fuel in the SoCAB is estimated to reduce the peak estimated ozone concentrations. However, these reductions in peak ozone concentrations are small with the maximum reduction being approximately 1 ppb.

Table 4-8. Summary of daily peak 1-hour and 8-hour ozone concentrations in the South Coast Air Basin 5-km domain for the 1997 standard diesel (Baseline) and biodiesel emission scenarios.

South Coast Air Basin 1-Hour Ozone					
	1997 Baseline	**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	(ppb)	**(ppb)**	**(% Difference)**	**(ppb)**	**(% Difference)**
4-Aug-97	163.236	162.871	-0.224	162.501	-0.450
5-Aug-97	167.000	166.772	-0.137	166.564	-0.261
6-Aug-97	176.423	175.943	-0.272	175.458	-0.547
7-Aug-97	160.567	160.442	-0.078	160.383	-0.115
South Coast Air Basin 8-Hour Ozone					
	1997 Baseline	**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	(ppb)	**(ppb)**	**(% Difference)**	**(ppb)**	**(% Difference)**
4-Aug-97	144.482	144.233	-0.172	143.983	-0.345
5-Aug-97	126.084	125.852	-0.184	125.618	-0.370
6-Aug-97	140.309	140.037	-0.194	139.762	-0.390
7-Aug-97	143.504	143.376	-0.089	143.244	-0.181

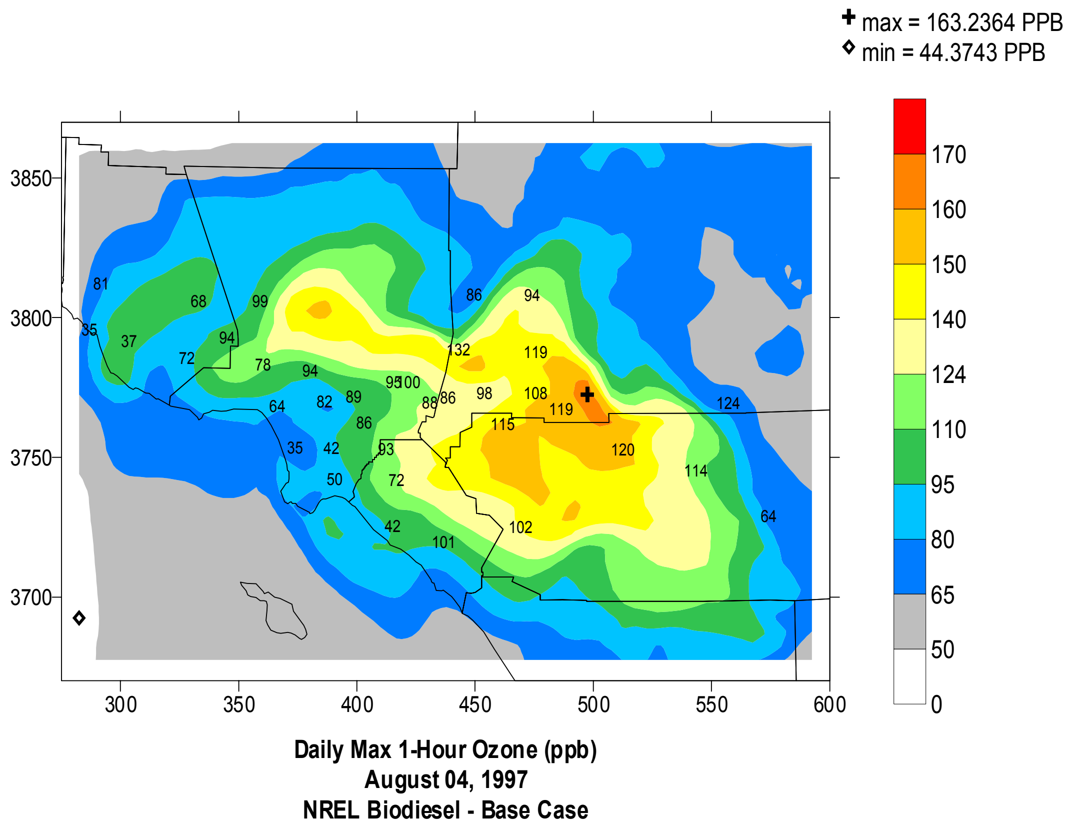


Figure 4-9a. Spatial distribution of daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 4, 1997 for the baseline scenario

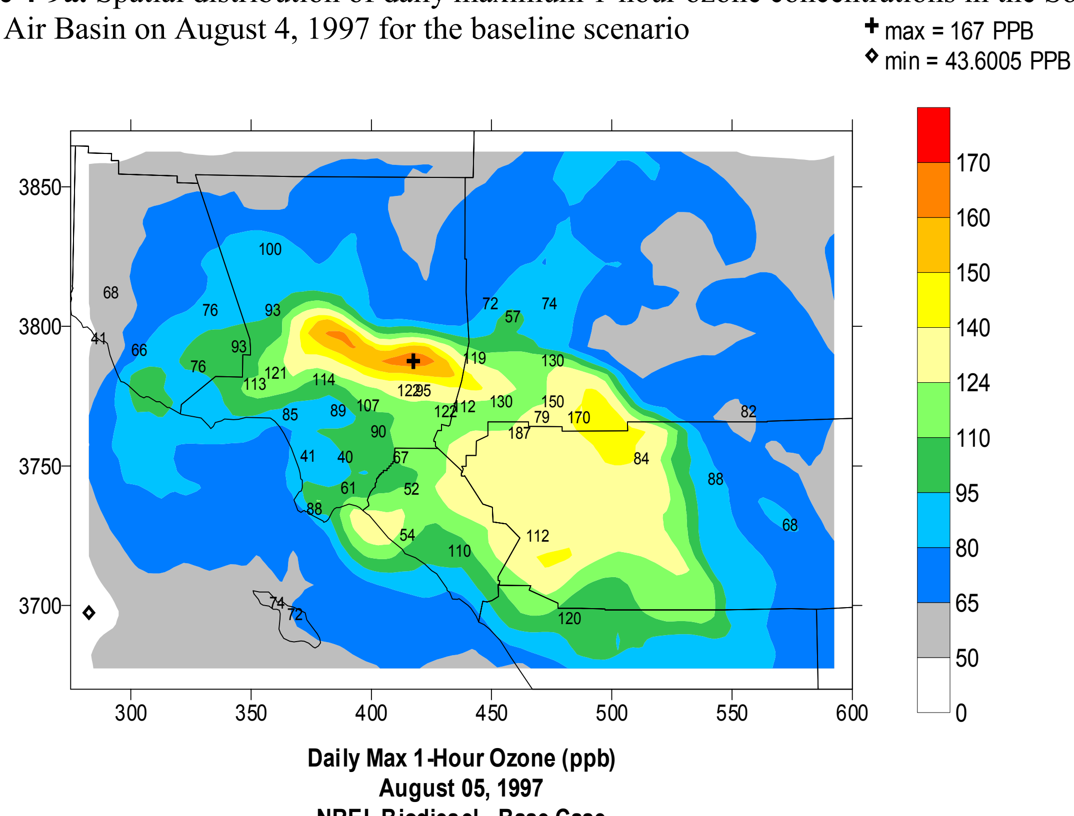


Figure 4-9b. Spatial distribution of daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 5, 1997 for the baseline scenario

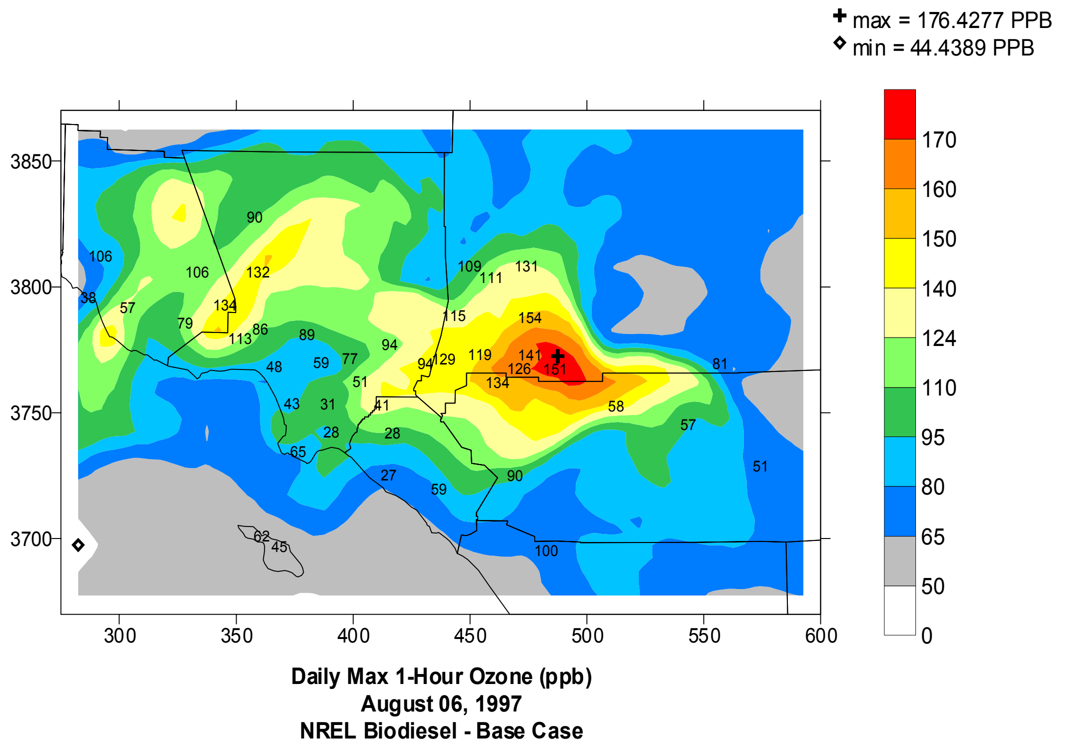


Figure 4-9c. Spatial distribution of daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 6, 1997 for the baseline scenario

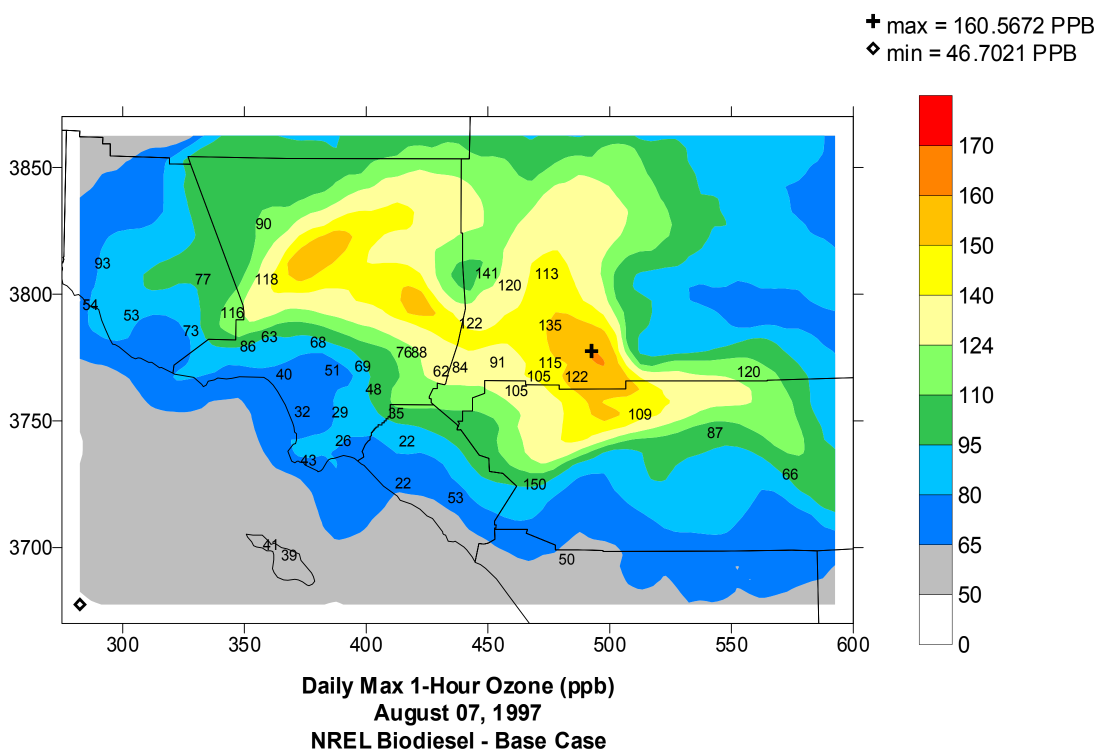


Figure 4-9d. Spatial distribution of daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 7, 1997 for the baseline scenario

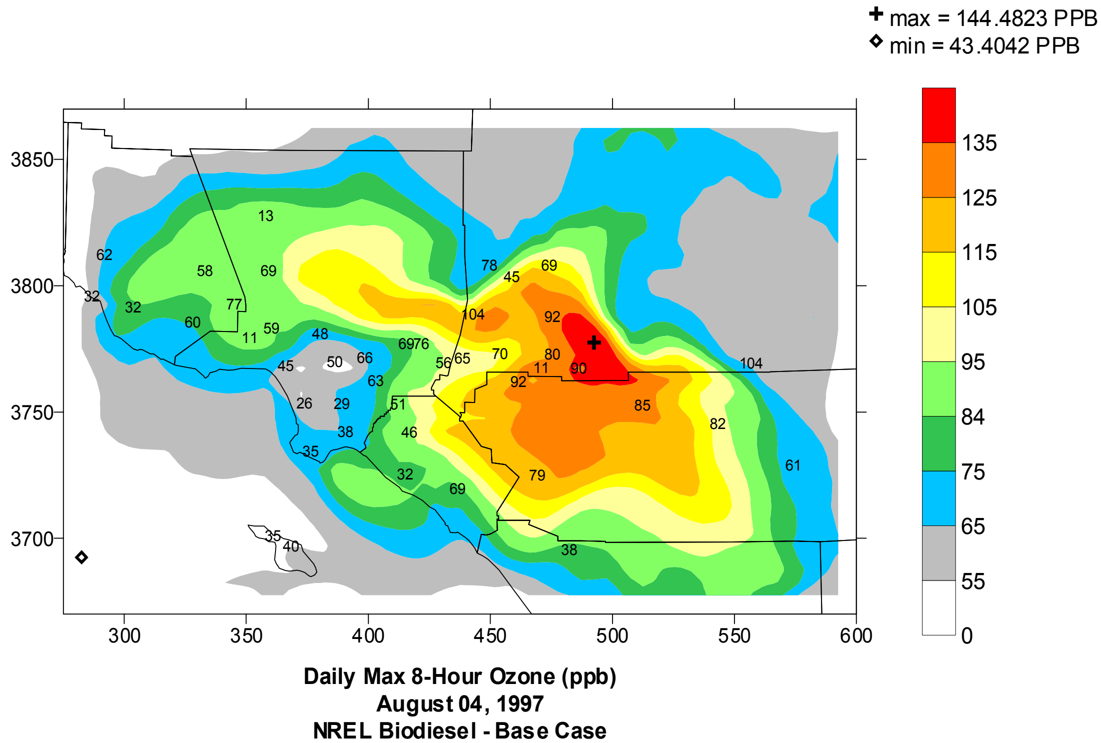


Figure 4-10a. Spatial distribution of daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 4, 1997 for the baseline scenario

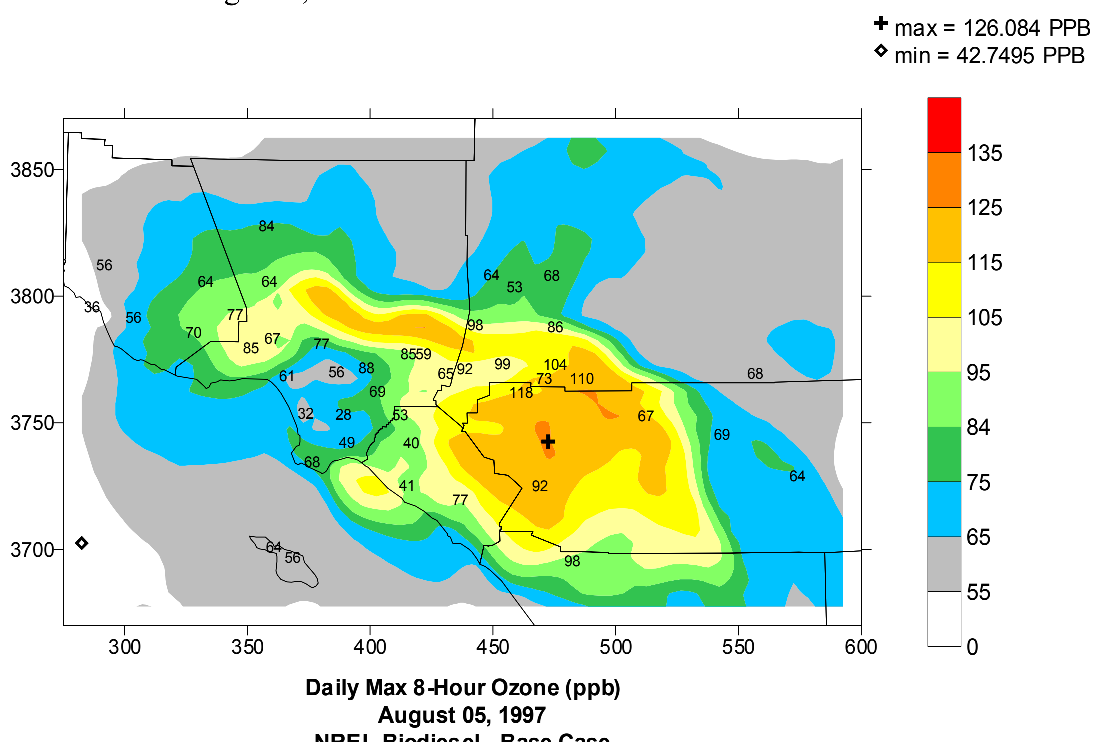


Figure 4-10b. Spatial distribution of daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 5, 1997 for the baseline scenario

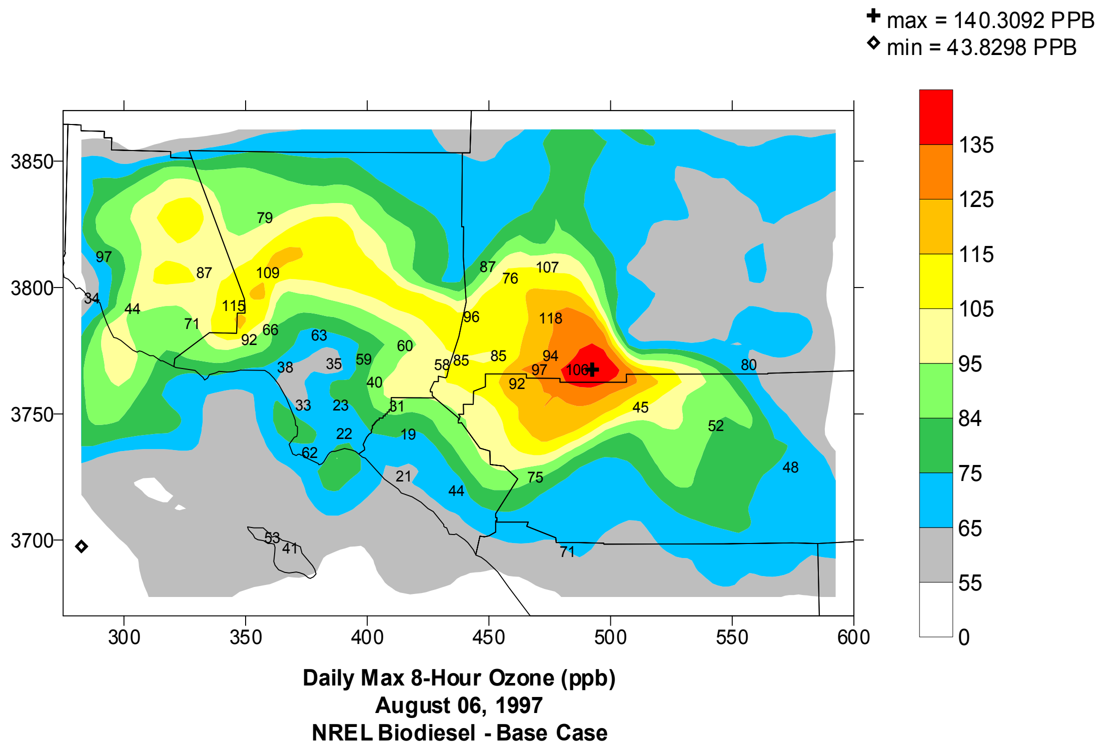


Figure 4-10c. Spatial distribution of daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 6, 1997 for the baseline scenario

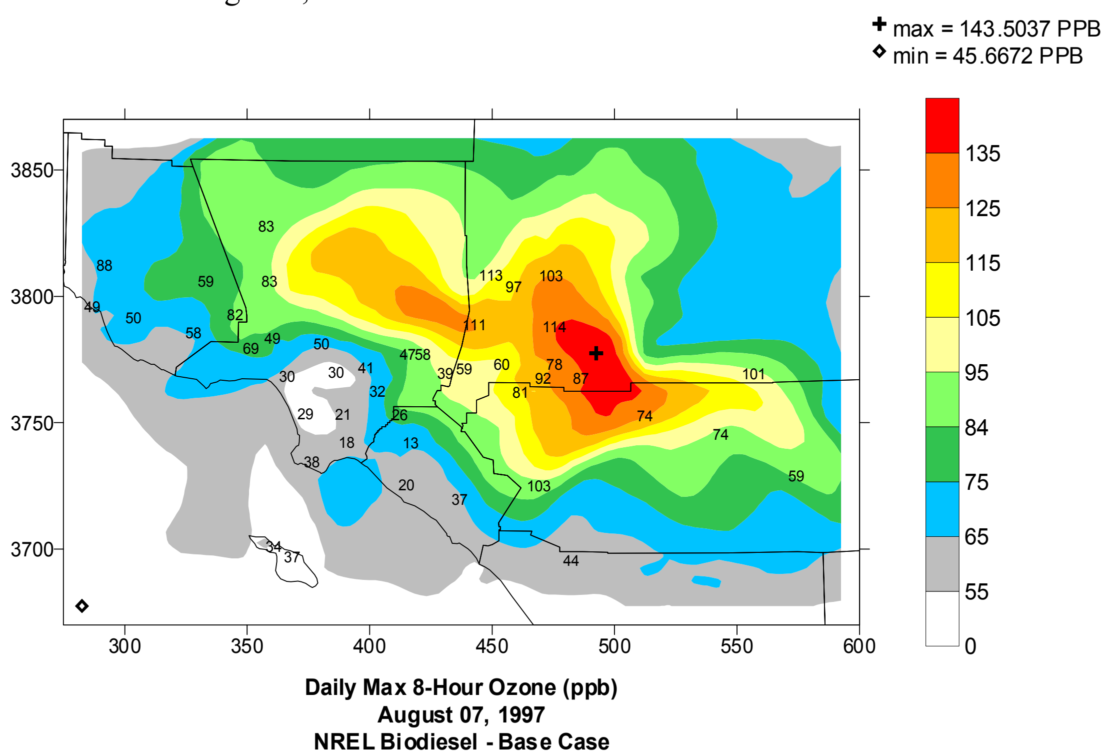


Figure 4-10d. Spatial distribution of daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 7, 1997 for the baseline scenario

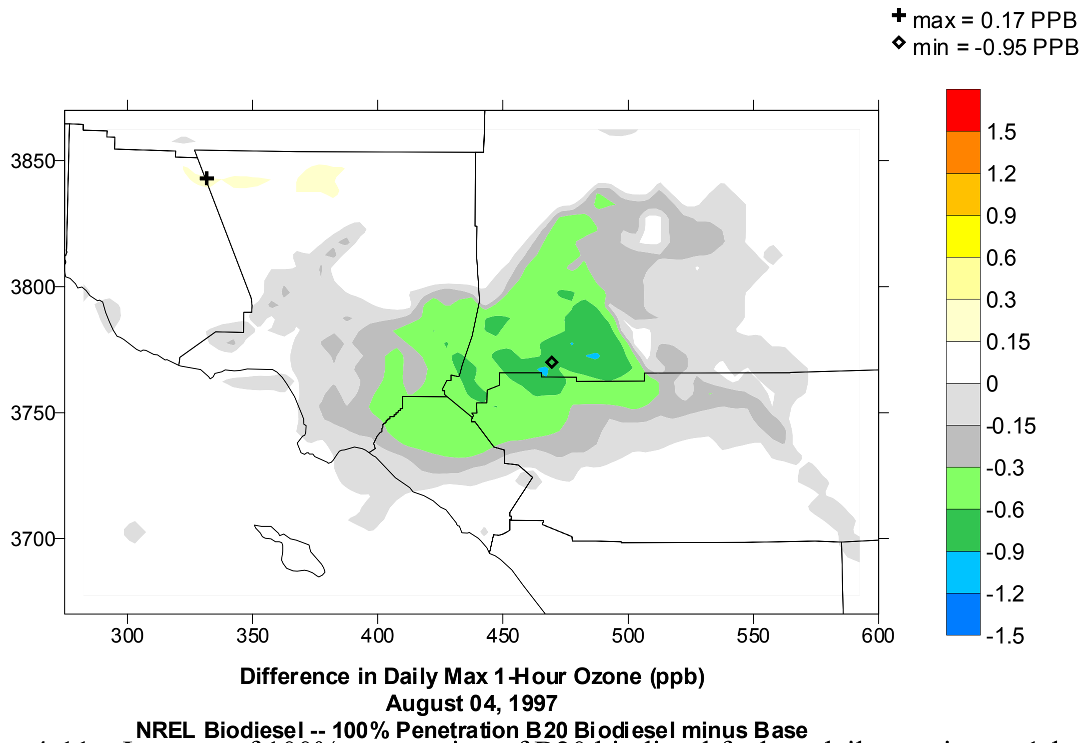


Figure 4-11a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 4, 1997 for the baseline scenario

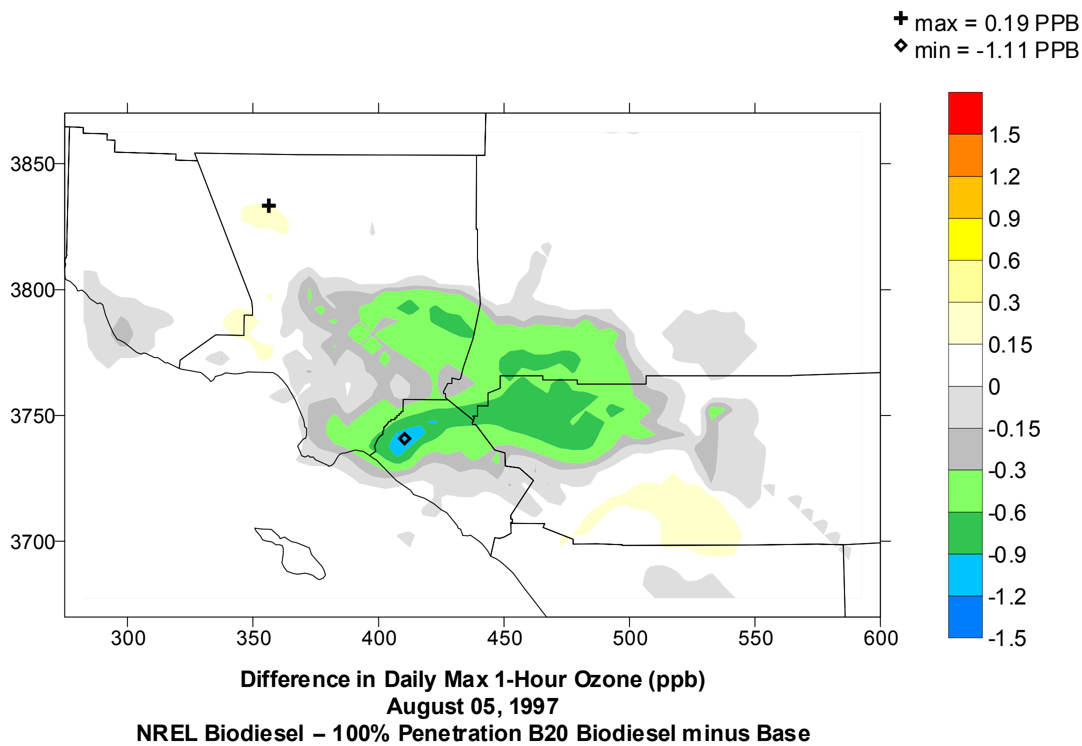


Figure 4-11b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 5, 1997 for the baseline scenario

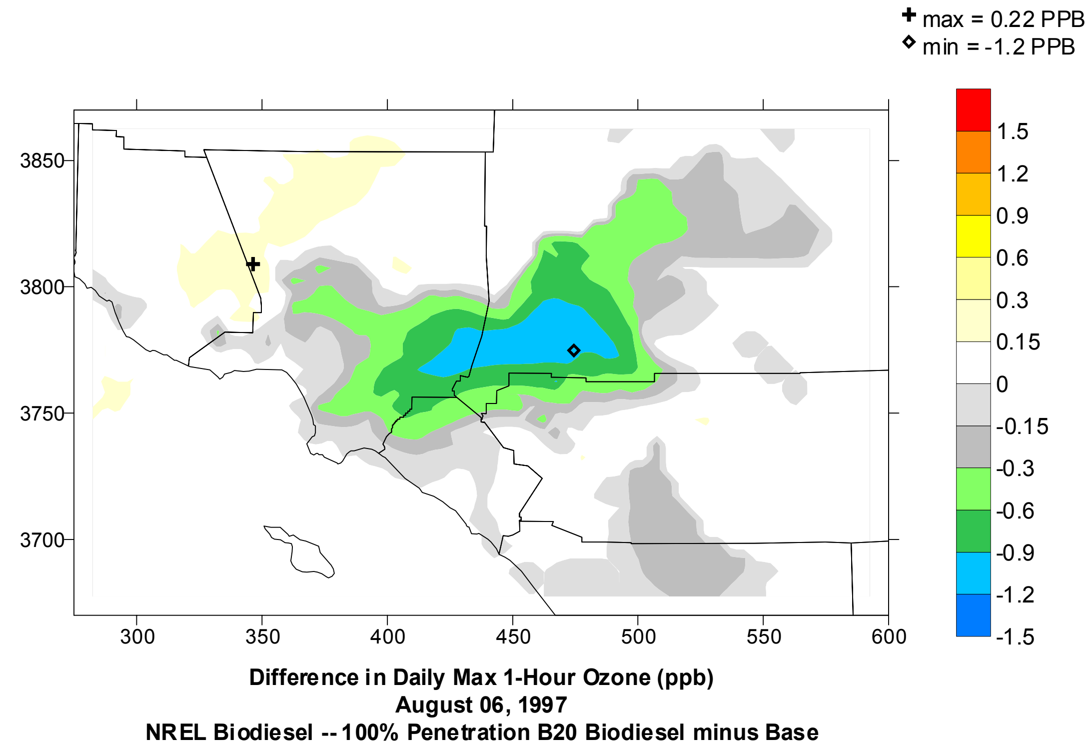


Figure 4-11c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 6, 1997 for the baseline scenario

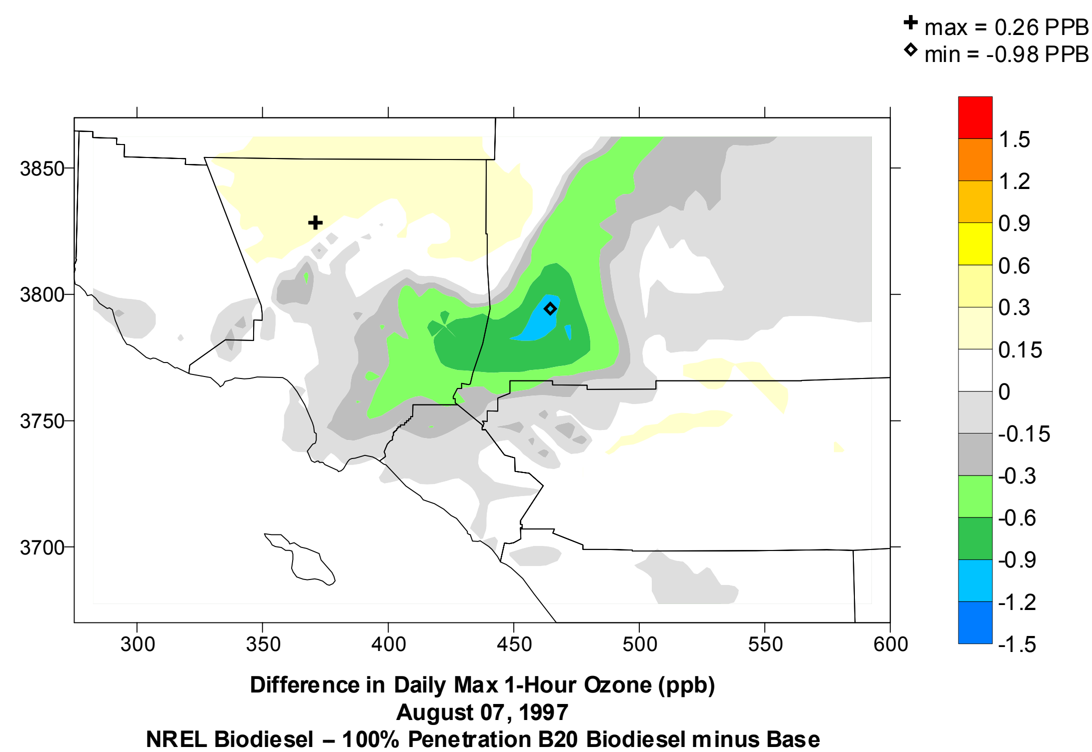


Figure 4-11d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin on August 7, 1997 for the baseline scenario

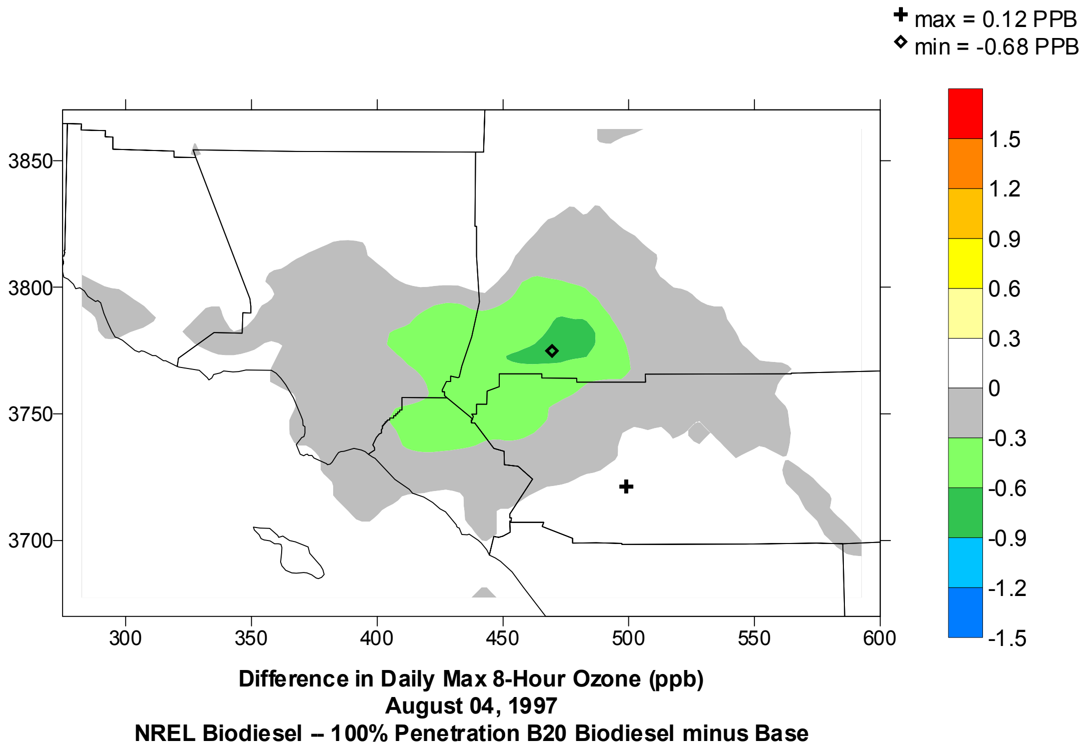


Figure 4-12a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 4, 1997 for the baseline scenario

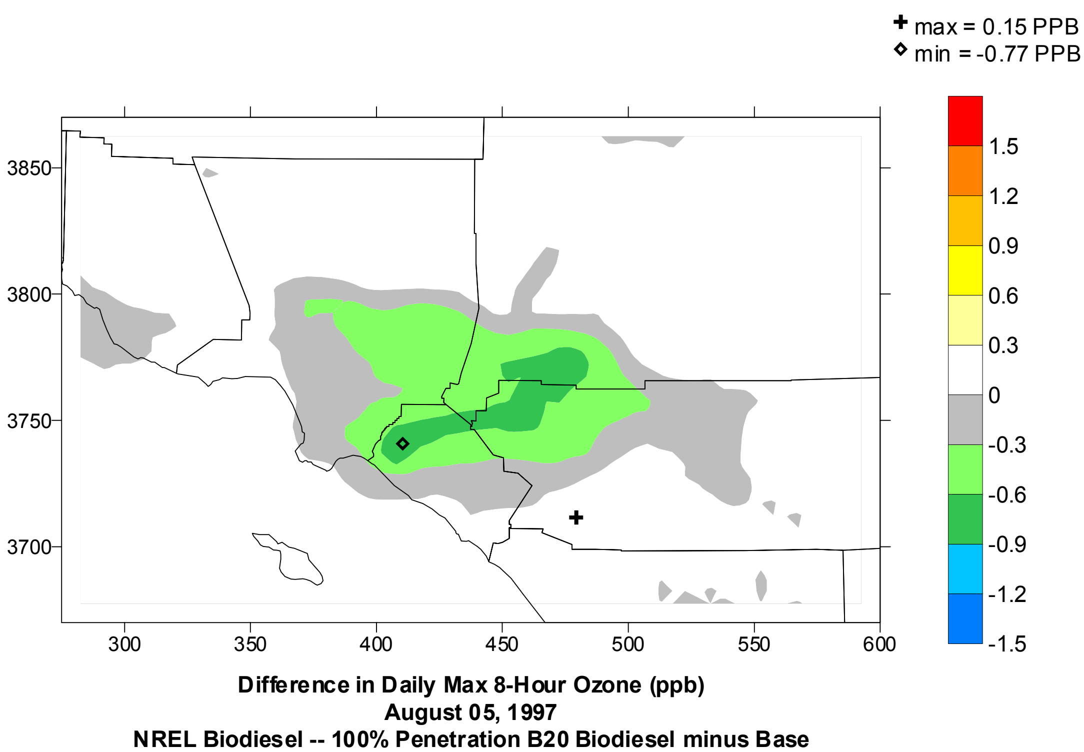


Figure 4-12b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 5, 1997 for the baseline scenario

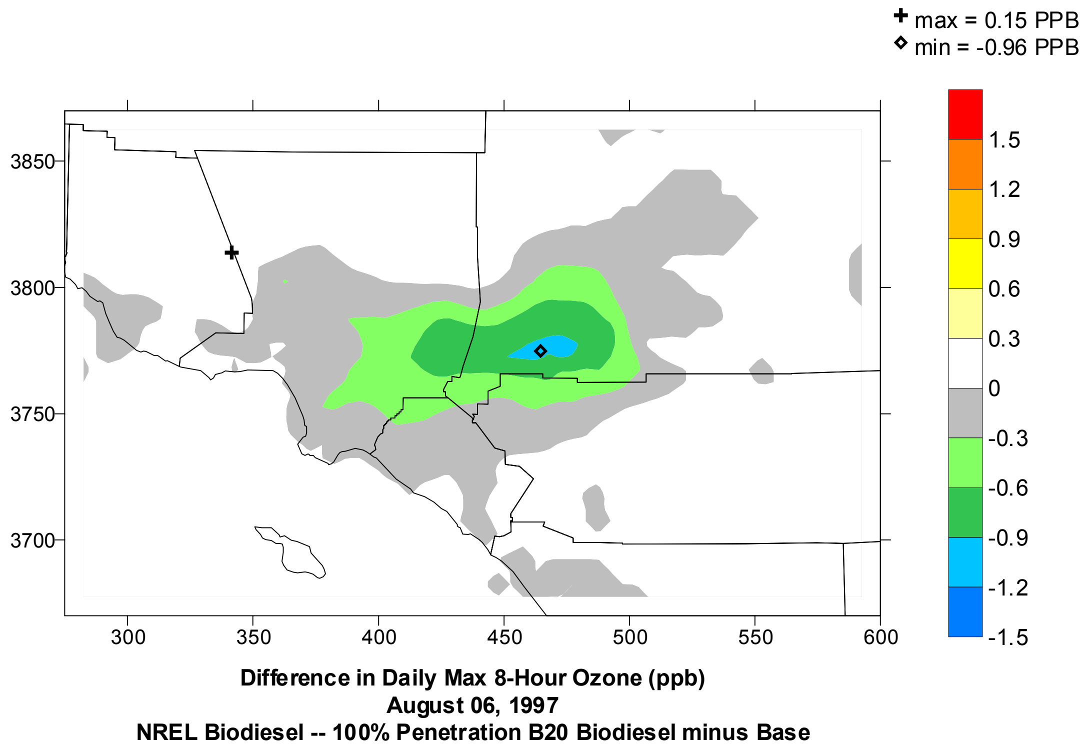


Figure 4-12c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 6, 1997 for the baseline scenario.

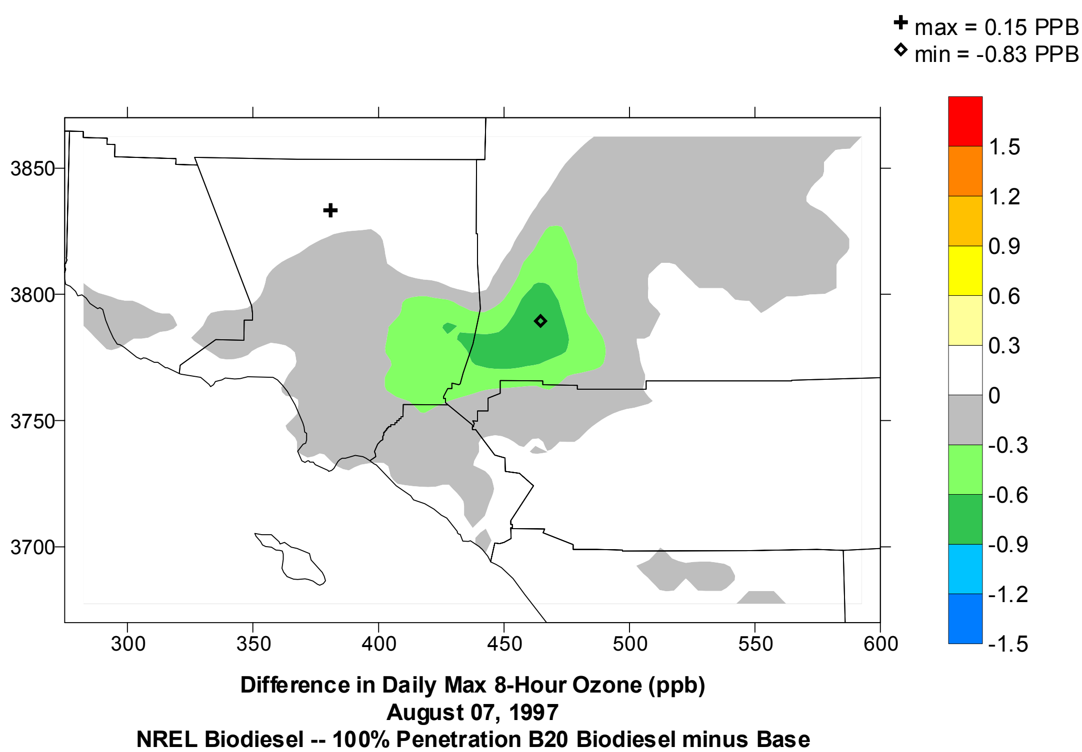


Figure 4-12d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin on August 7, 1997 for the baseline scenario.

Ozone Exposure Estimates in the South Coast Air Basin

The effects of biodiesel fuel use in the South Coast Air Basin (SoCAB) on exposure to 1-hour and 8-hour ozone concentrations was estimated using the same exposure and dosage metrics as used for the Lake Michigan and Northeast Corridor regions discussed earlier and are shown in Table 4-9. The effects of biodiesel fuel use in the SoCAB is to have small reductions in both the area exposed to elevated 1-hour and 8-hour ozone concentrations above the standard as well as the dosage of the exposure. On most days the ozone exposure/dosage reduction due to the biodiesel fuel use is less than 1 percent. However, on August 5, 1997 the 1-hour ozone exposure reduction in the 100% B20 scenario approaches 5 percent.

Table 4-9. Summary of ozone exposure metrics for the South Coast Air Basin.

South Coast Air Basin 1-Hour Exposure Metrics						
Date	**1997 Baseline**		**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	Exposure (grid cell-hrs)	**Dosage (ppb-grid cell-hrs)**	**Exposure (grid cell-hrs)**	**Dosage (ppb-grid cell-hrs)**	**Exposure (grid cell-hrs)**	**Dosage (ppb-grid cell-hrs)**
August 3, 1997	6	4.24	6	4.26	7	4.29
August 4, 1997	1392	18684.12	1387	18489.31	1381	18294.22
August 5, 1997	847	7087.28	834	6941.57	826	6798.25
August 6, 1997	963	14133.96	960	13942.56	958	13752.77
August 7, 1997	1396	16953.88	1395	16804.77	1388	16655.23
South Coast Air Basin 8-Hour Exposure Metrics						
Date	**1997 Baseline**		**50% B20 Biodiesel**		**100% B20 Biodiesel**	
	Exposure (grid cell-hrs)	**Dosage (ppb-grid cell-hrs)**	**Exposure (grid cell-hrs)**	**Dosage (ppb-grid cell-hrs)**	**Exposure (grid cell-hrs)**	**Dosage (ppb-grid cell-hrs)**
August 3, 1997	1254	9335.72	1255	9343.89	1256	9352.00
August 4, 1997	5763	98219.91	5761	97898.80	5753	97575.40
August 5, 1997	4378	68444.44	4370	68089.29	4362	67733.53
August 6, 1997	4233	60373.43	4223	60035.98	4216	59702.98
August 7, 1997	4987	86027.52	4988	85781.70	4985	85532.16

5. CONCLUSIONS

The 100% and 50% penetration of a B20 biodiesel fuel is estimated to have very small effects (increases and decreases) in ozone concentrations in the Northeast Corridor, Lake Michigan, and Southern California regions. For the most part the changes in ozone due to the biodiesel fuel use are so small that they would not be measurable. Therefore, the main conclusion of the analysis is that the use of a B20 biodiesel in the HDDV fleet would have no significant ozone impact.

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Appendix A

Impacts on Daily Maximum
1-Hour and 8-Hour Ozone Concentrations
Due to 50% Penetration of B20 Biodiesel Fuel Use
in the Lake Michigan 4-km Domain

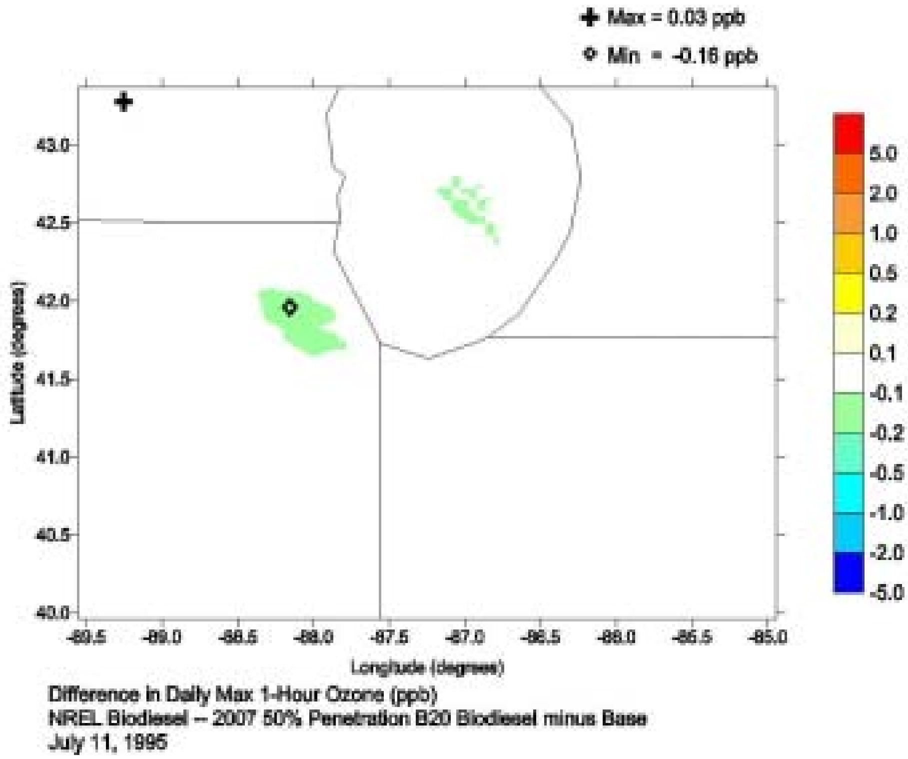

Figure A-1a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 11, 1995.

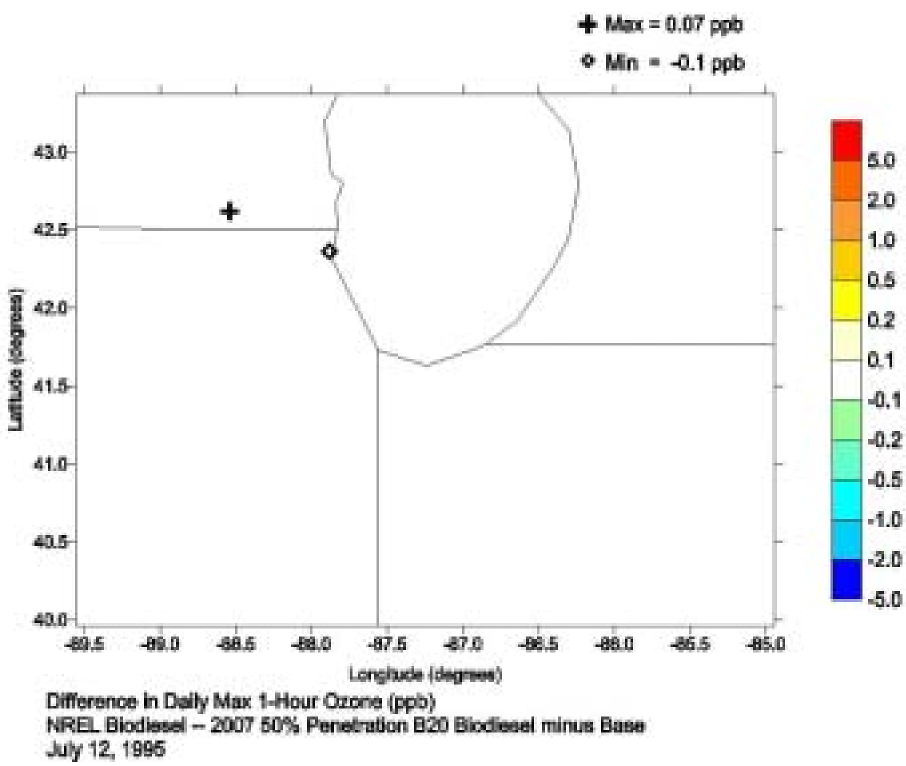

Figure A-1b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 12, 1995.

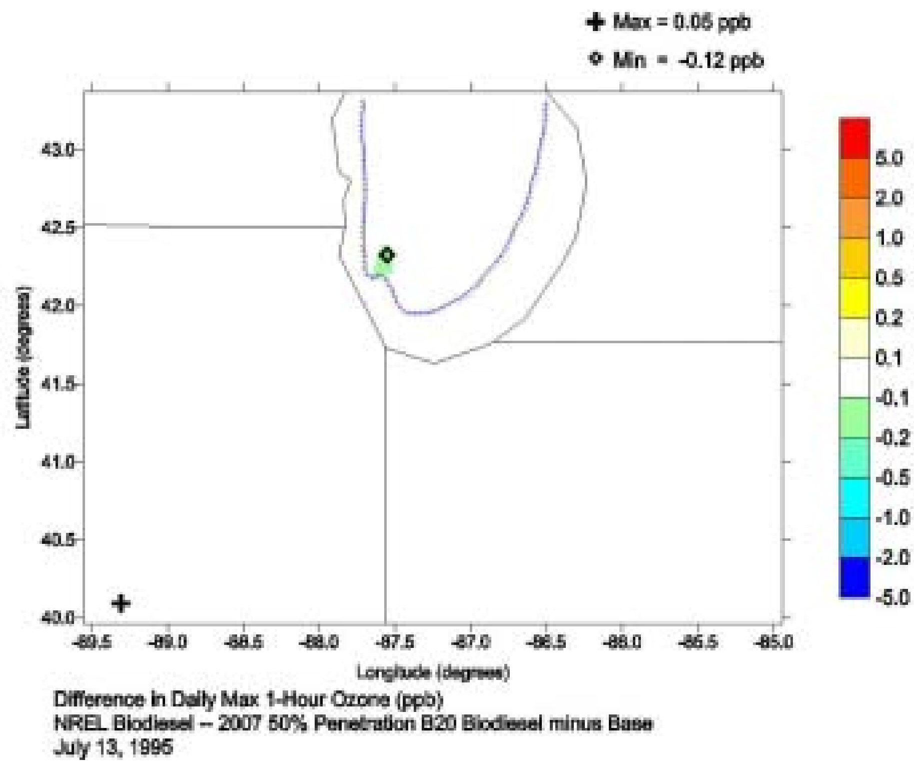

Figure A-1c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 13, 1995.

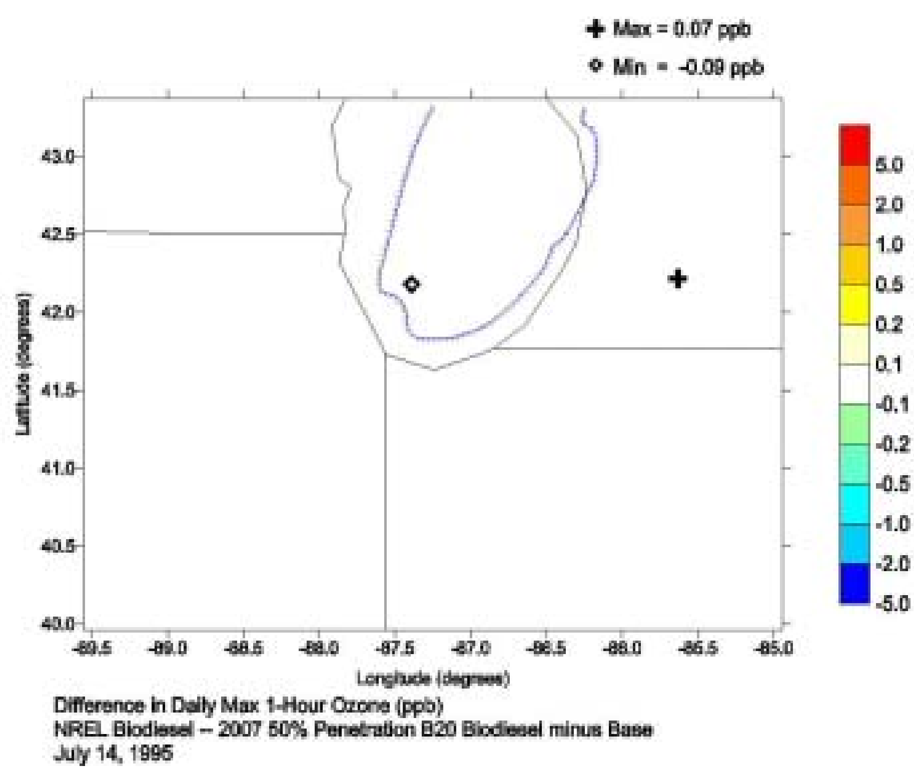

Figure A-1d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 14, 1995.

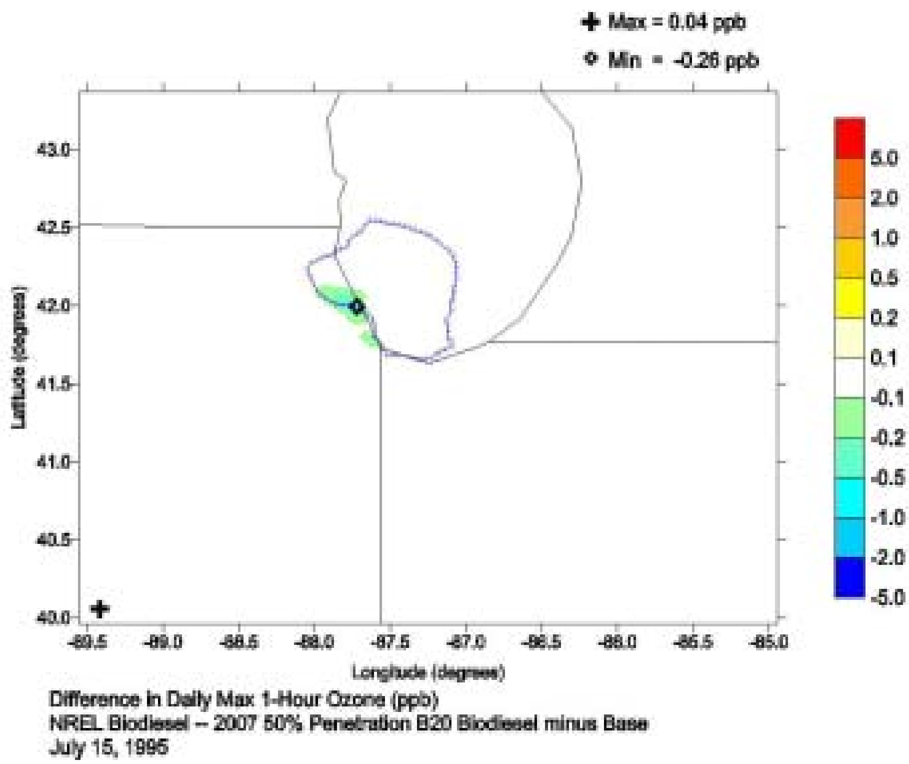

Figure A-1e. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 15, 1995.

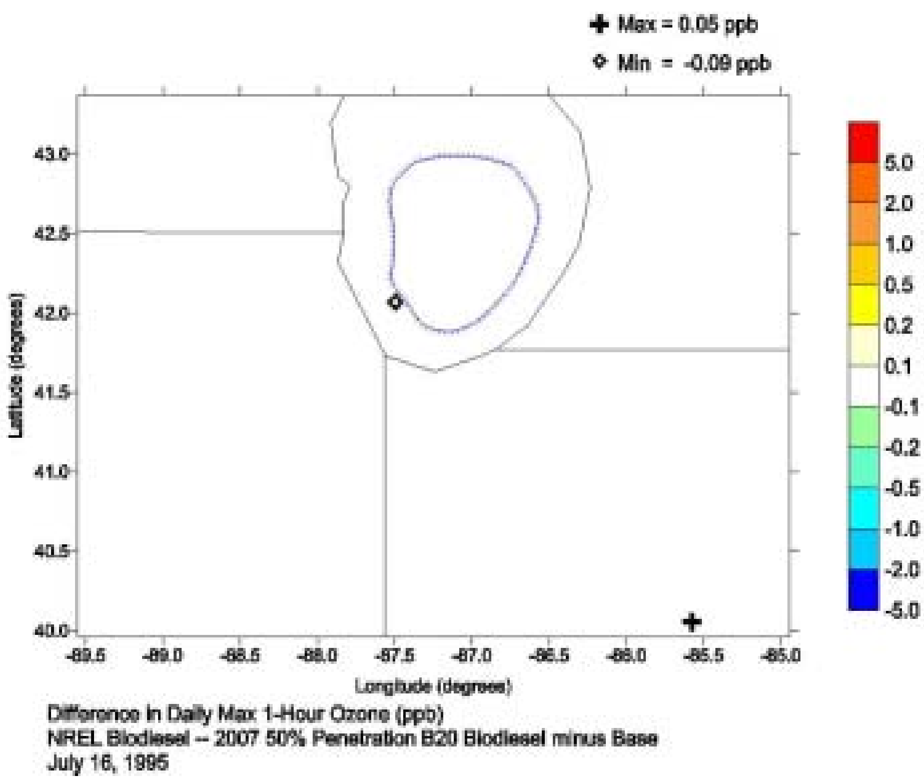

Figure A-1f. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Lake Michigan 4-km domain on July 16, 1995.

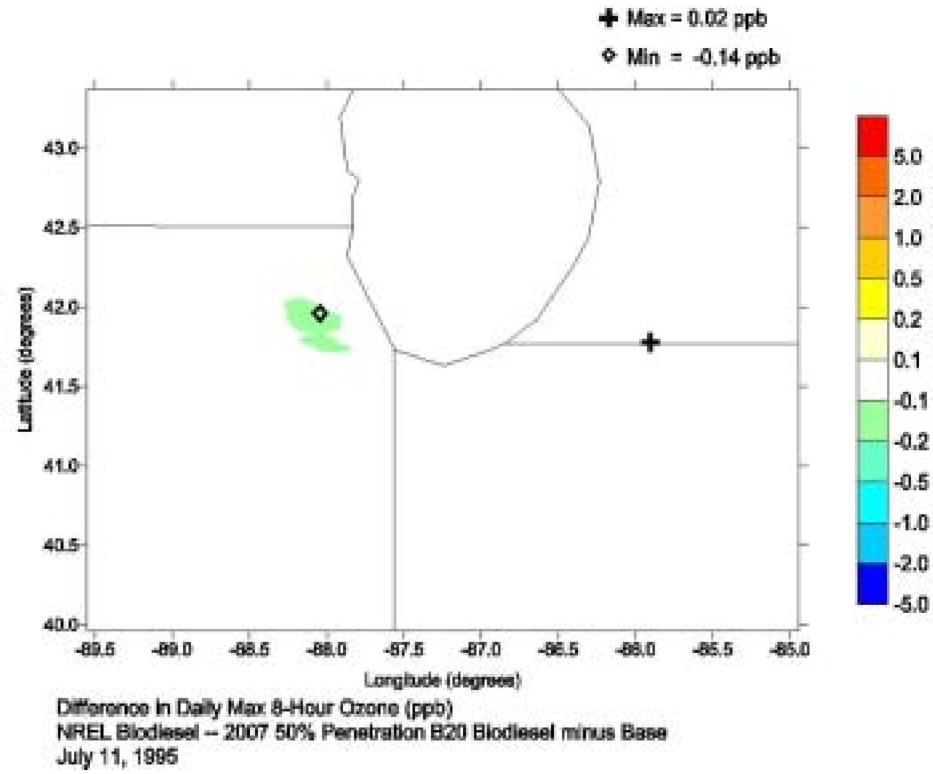

Figure A-2a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 11, 1995.

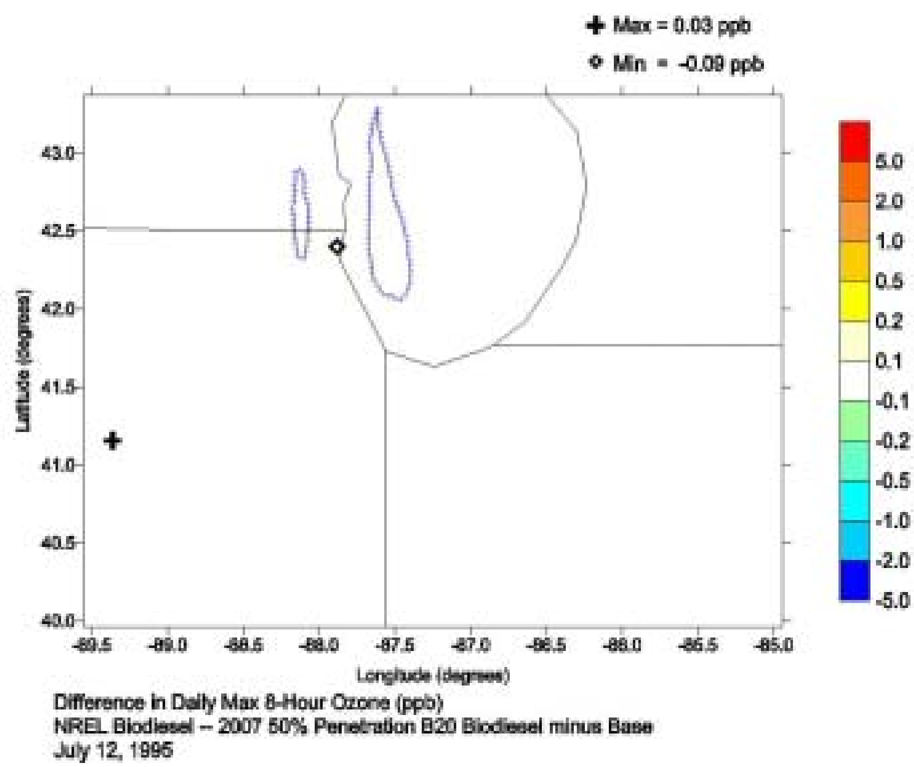

Figure A-2b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 12, 1995.

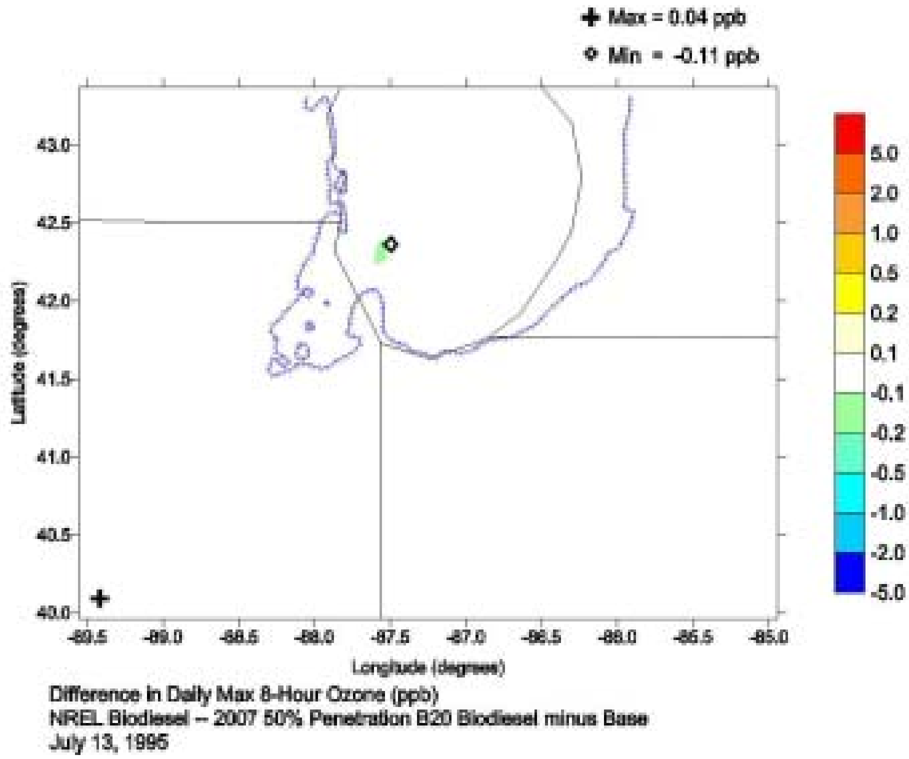

Figure A-2c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 13, 1995.

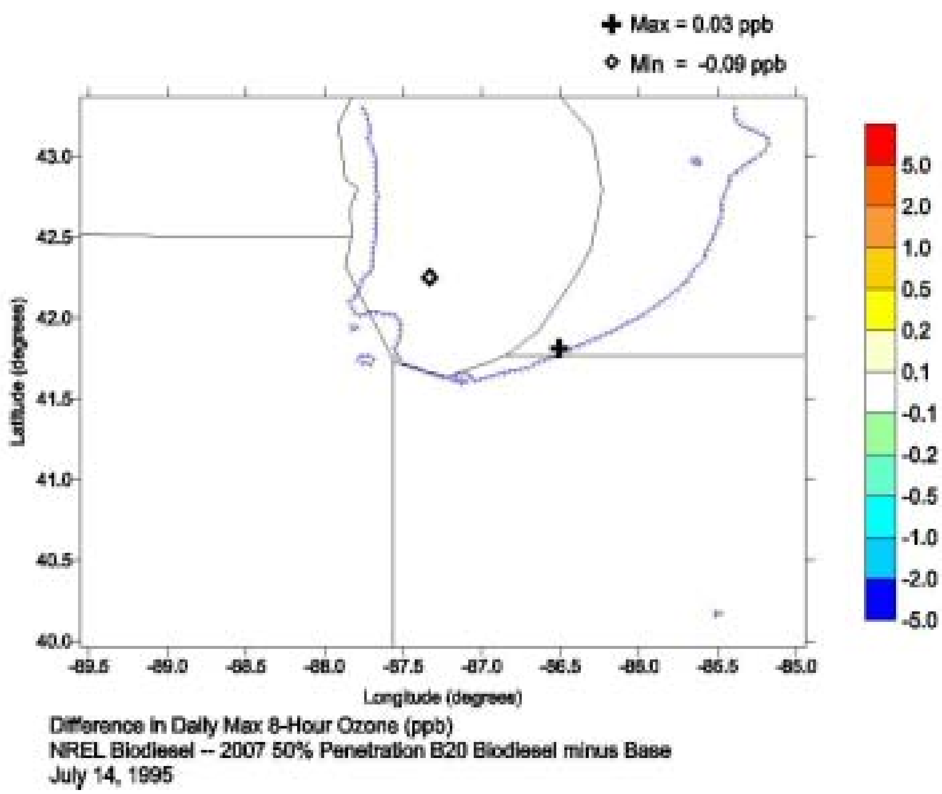

Figure A-2d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 14, 1995.

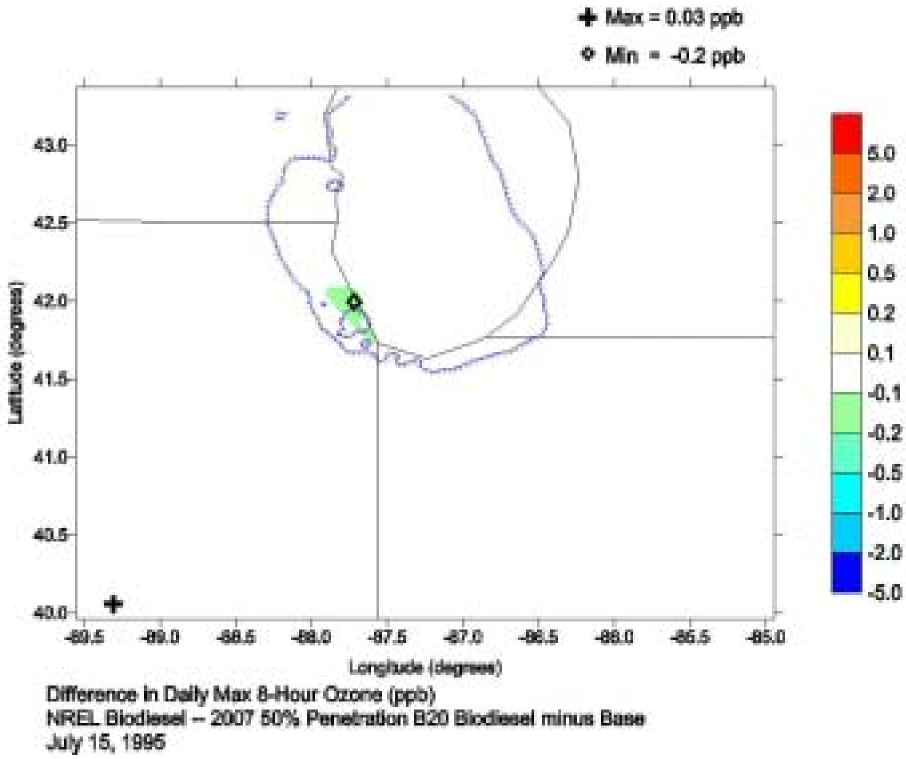

Figure A-2e. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 15, 1995.

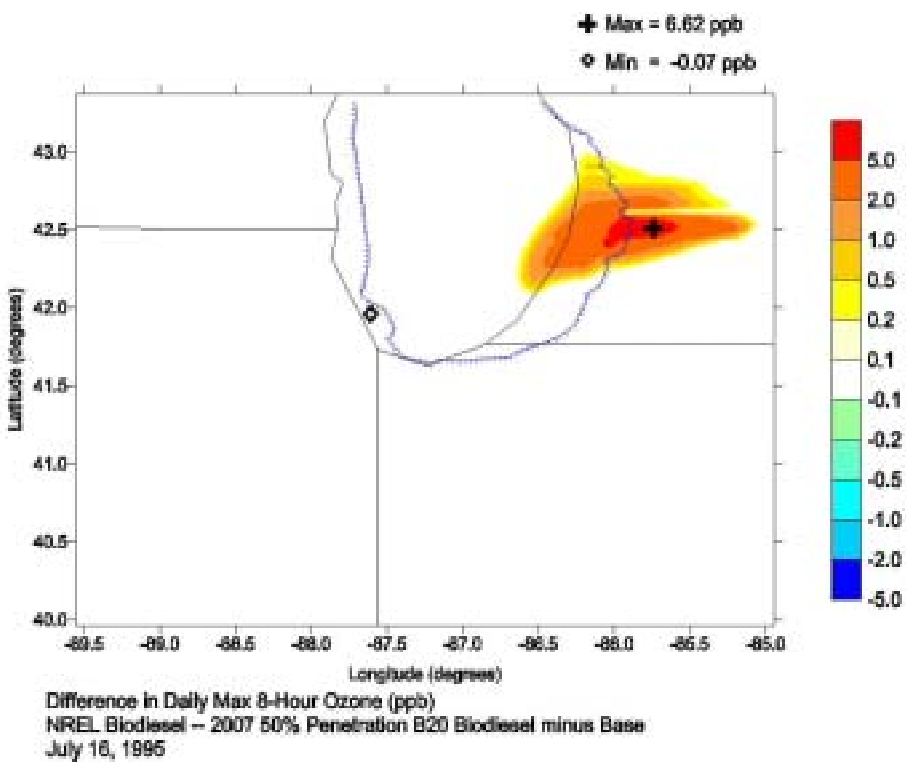

Figure A-2f. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Lake Michigan 4-km domain on July 16, 1995.

Appendix B

Impacts on Daily Maximum
1-Hour and 8-Hour Ozone Concentrations
Due to 50% Penetration of B20 Biodiesel Fuel Use
in the Northeast Corridor 4-km Domain

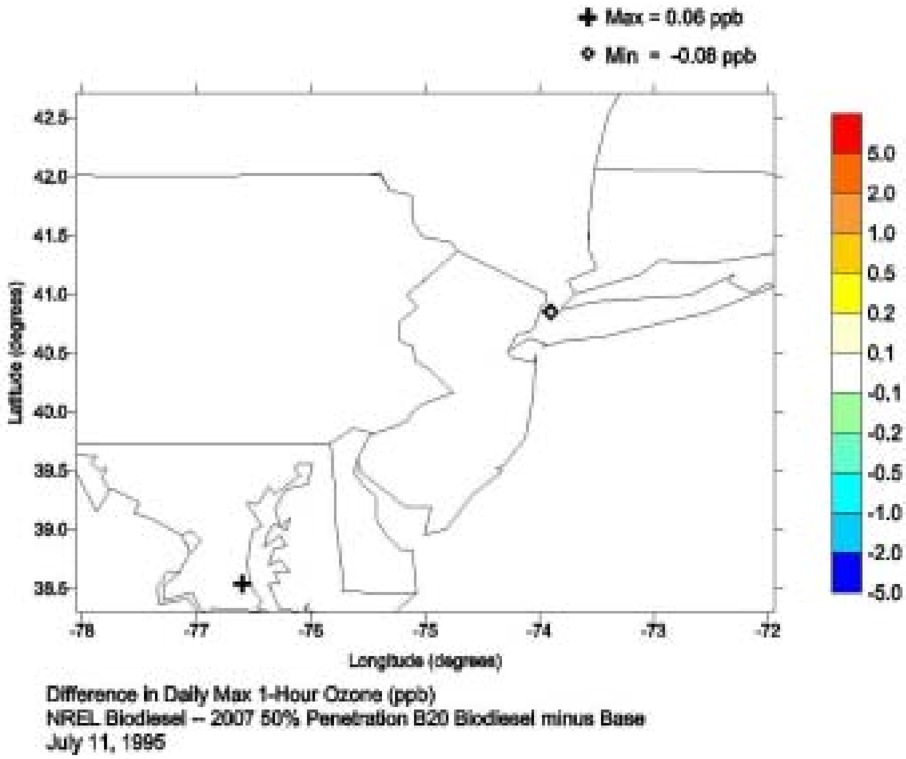

Figure B-1a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 11, 1995.

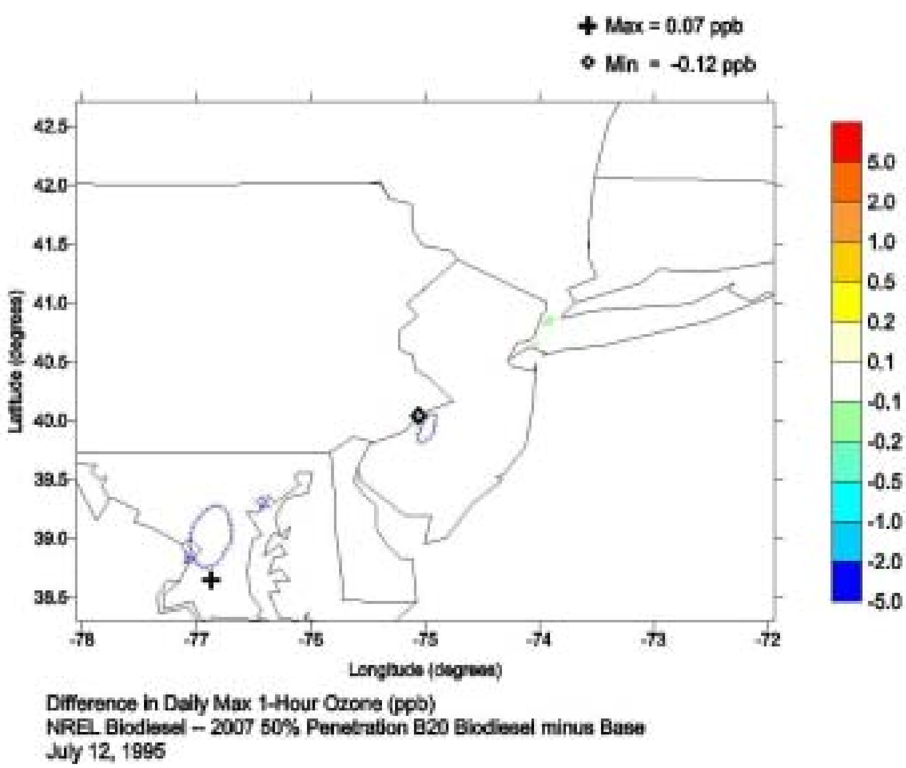

Figure B-1b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 12, 1995.

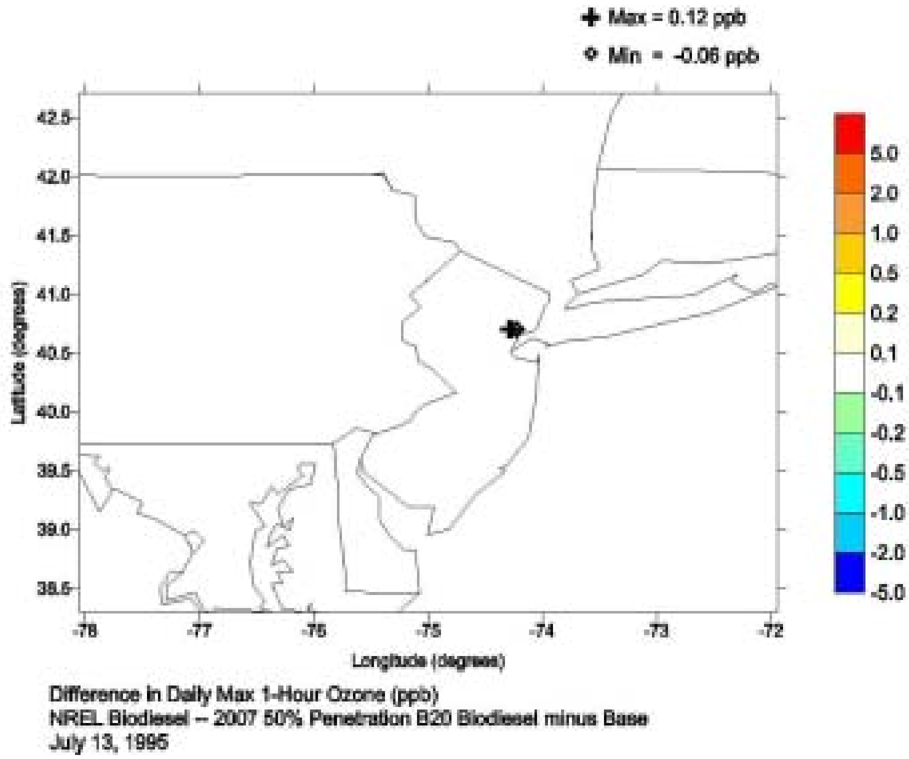

Figure B-1c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 13, 1995.

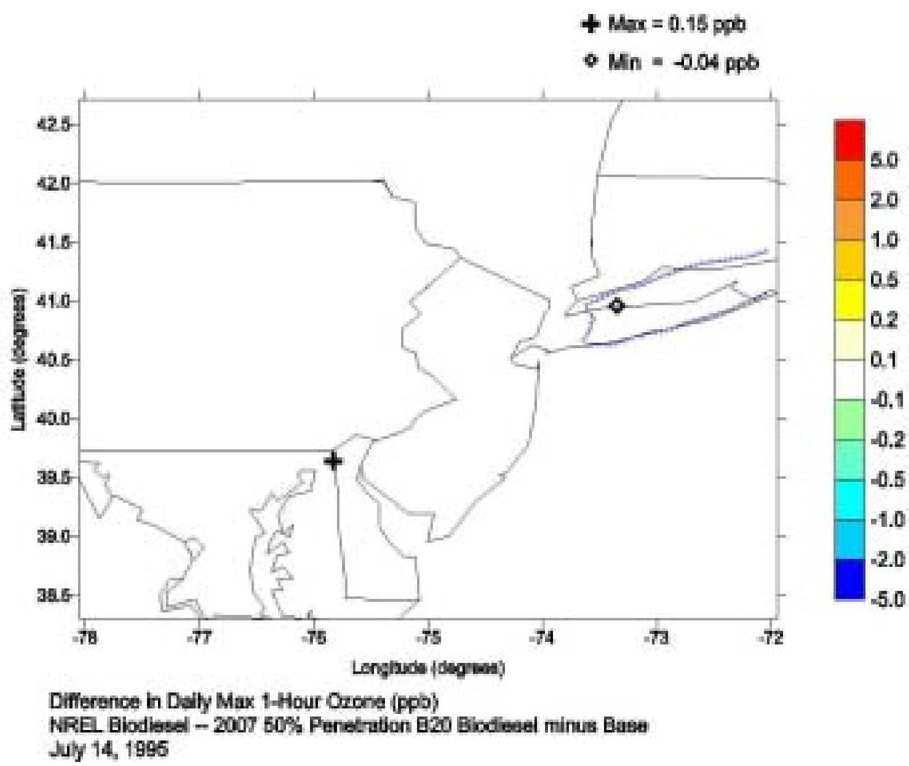

Figure B-1d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 14, 1995.

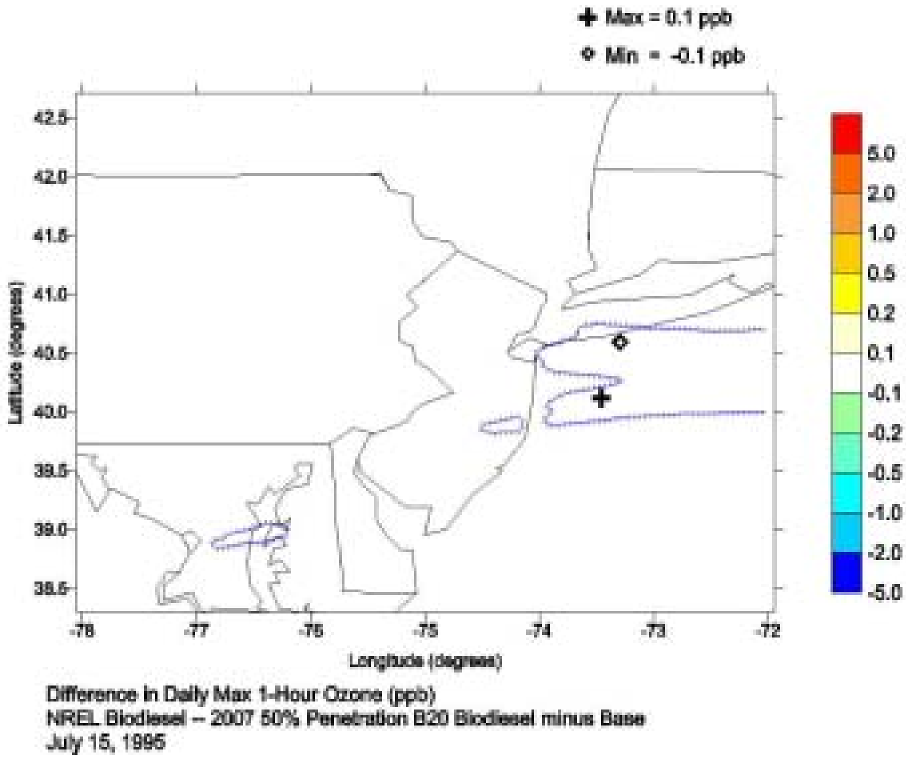

Figure B-1e. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 15, 1995.

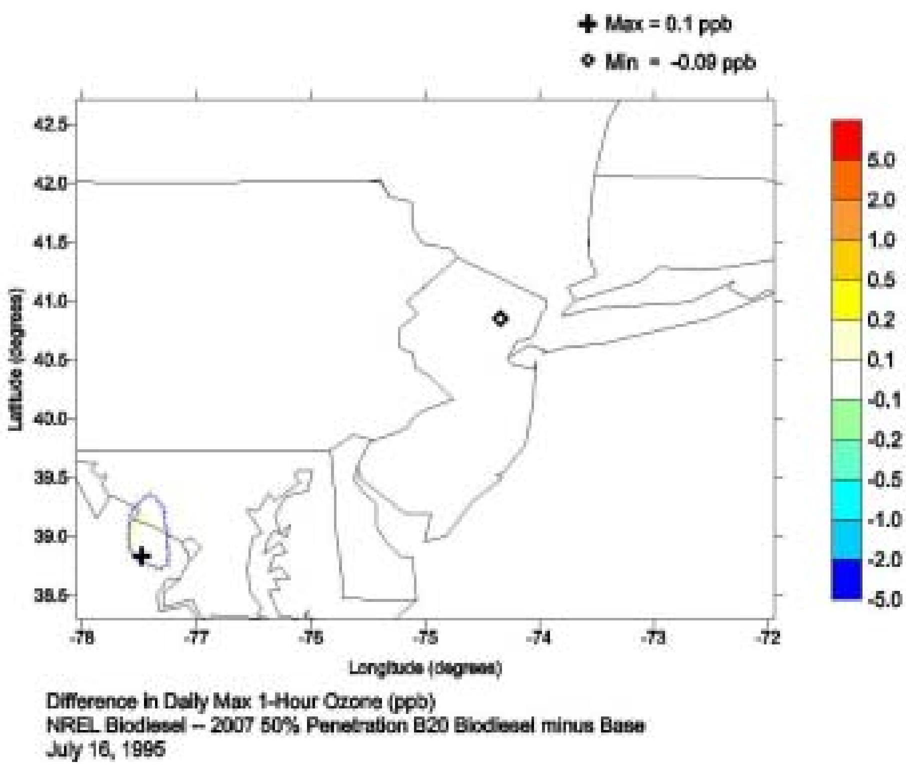

Figure B-1f. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the Northeast Corridor 4-km domain on July 16, 1995.

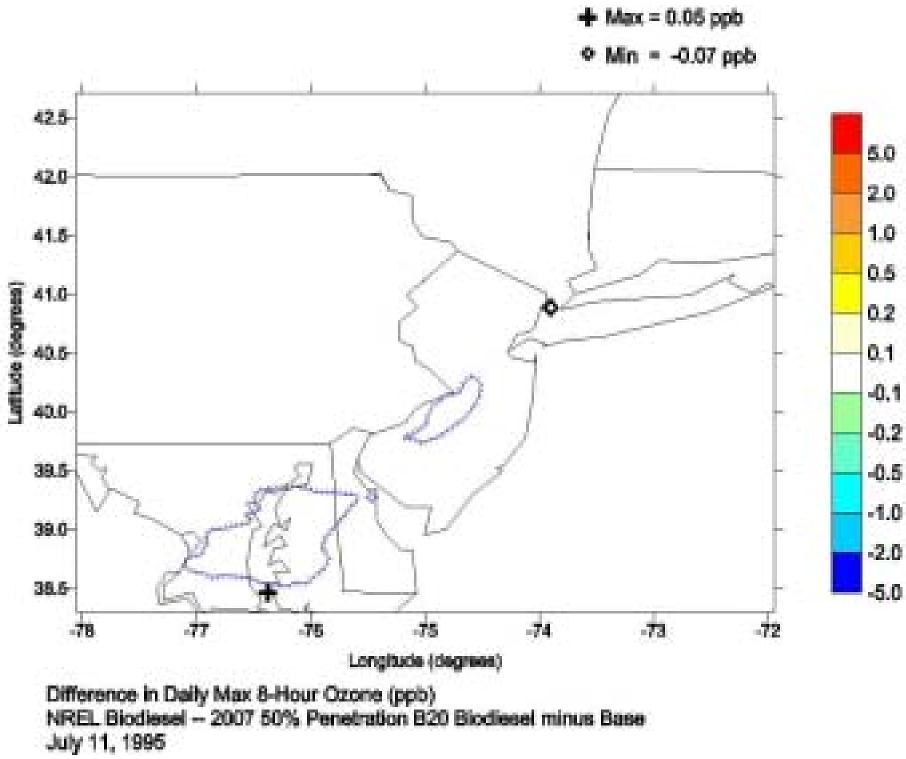

Figure B-2a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 11, 1995.

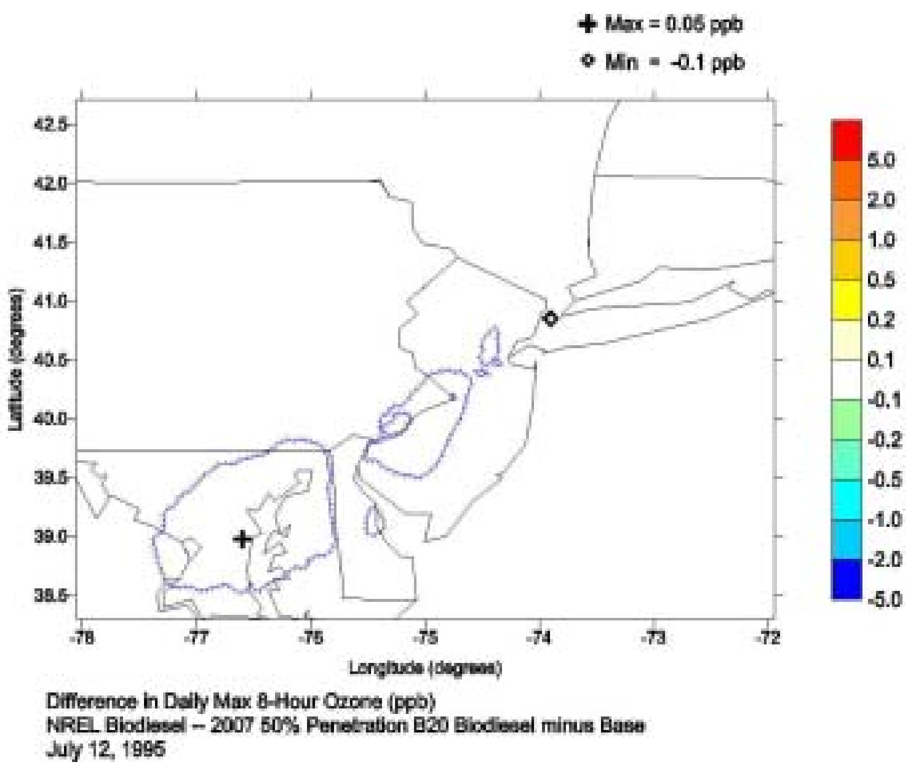

Figure B-2b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 12, 1995.

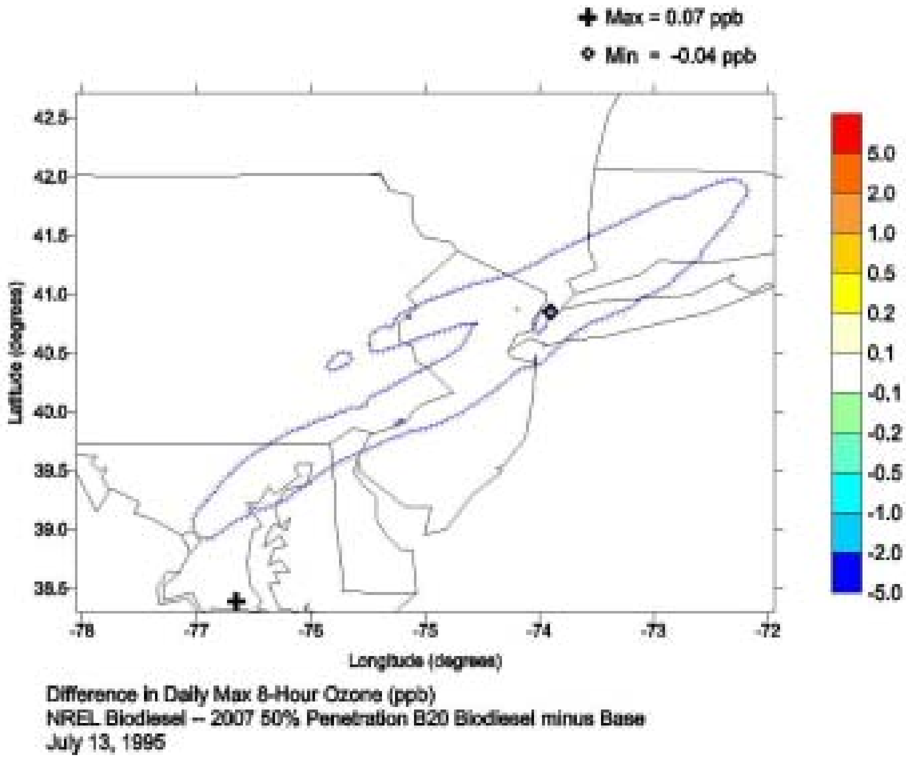

Figure B-2c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 13, 1995.

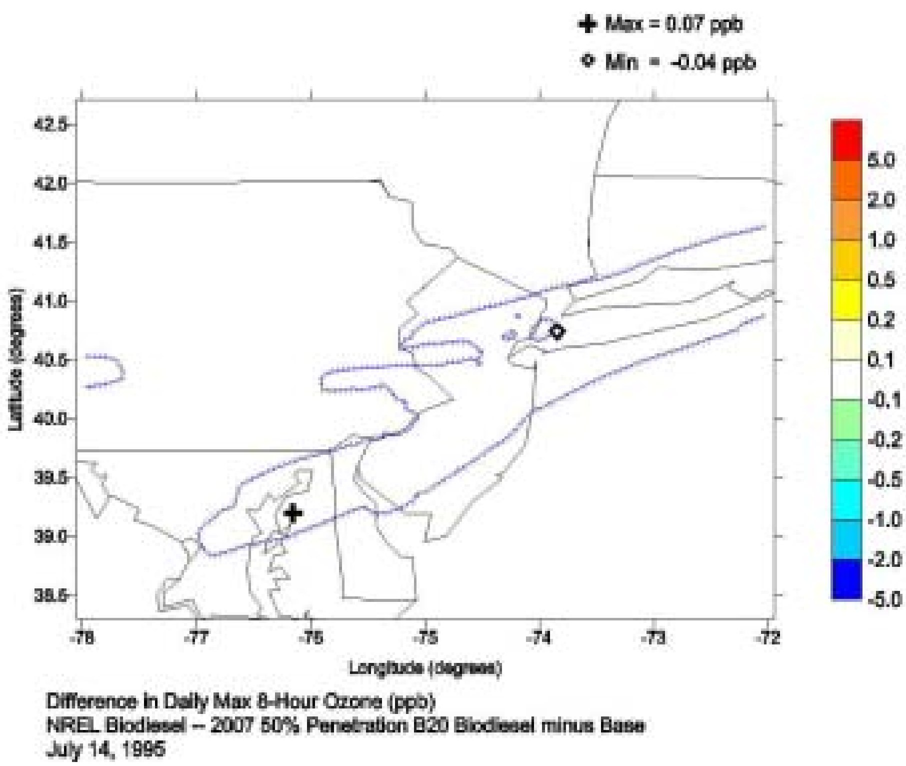

Figure B-2d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 14, 1995.

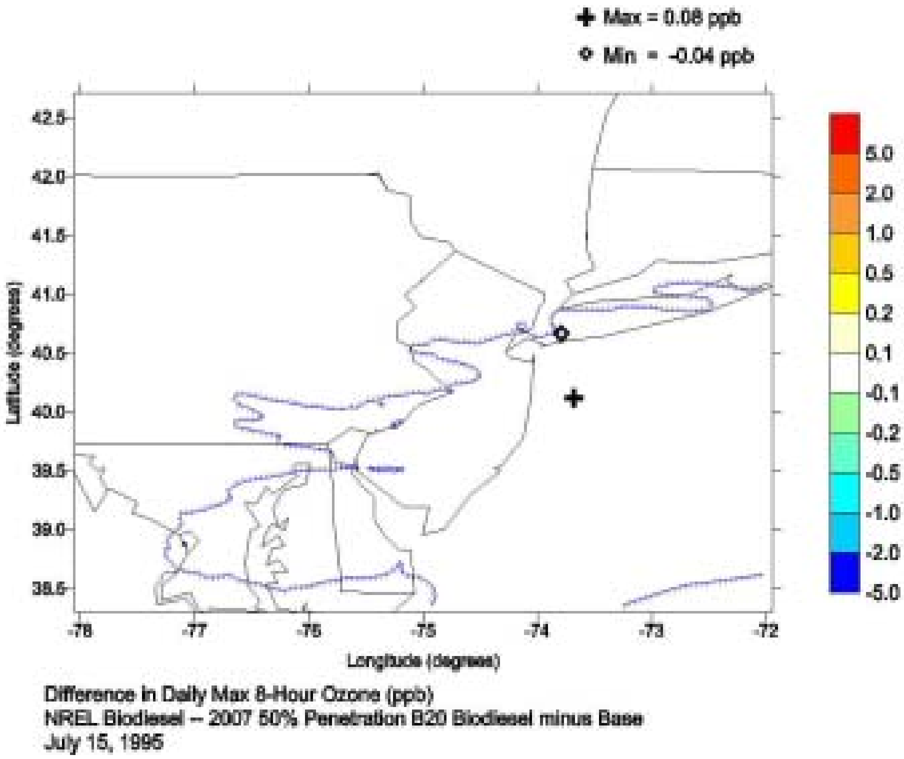

Figure B-2e. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 15, 1995.

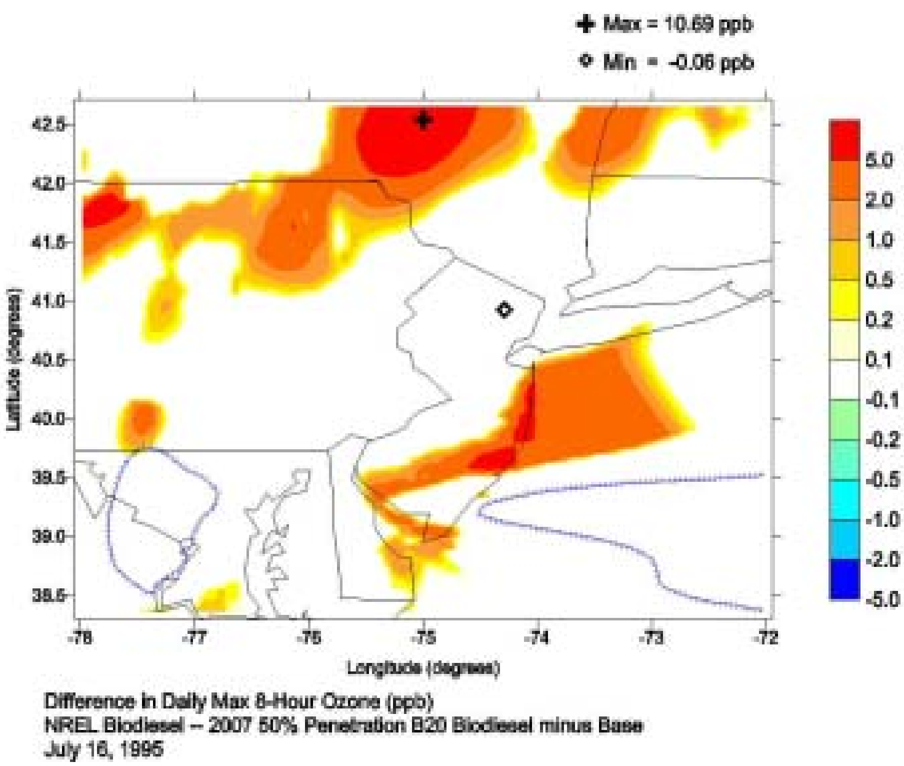

Figure B-2f. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the Northeast Corridor 4-km domain on July 16, 1995.

Appendix C

Spatial Displays of CAMx Modeling Results
For the OTAG 12-km Domain

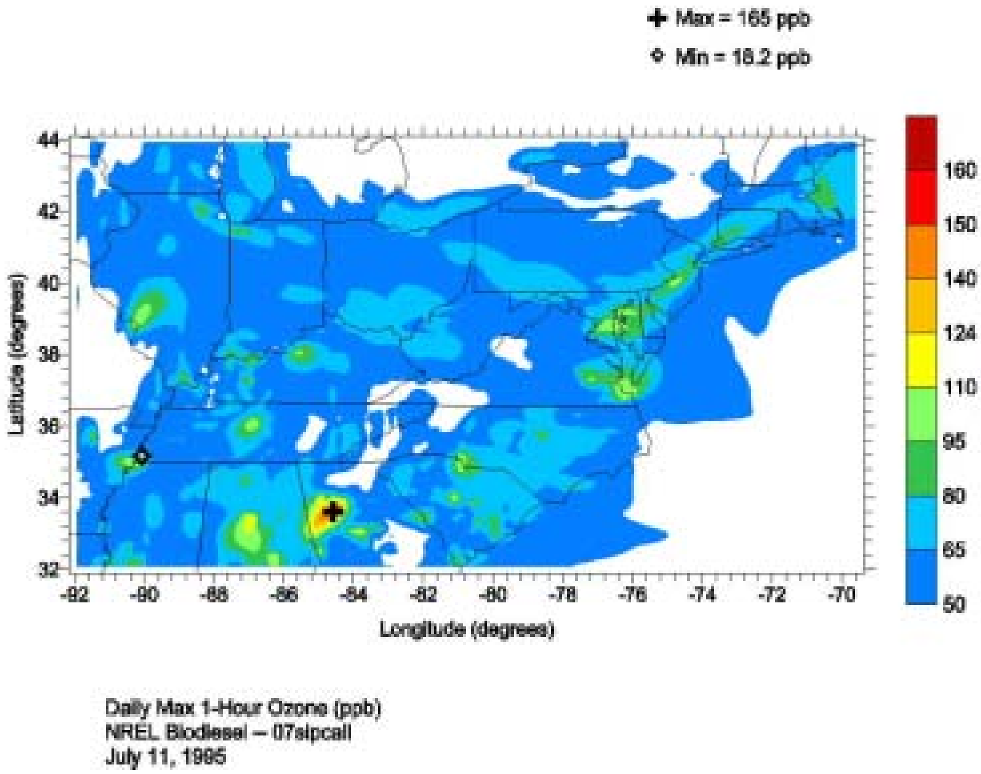

Figure C-1a. Spatial distribution of daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 11, 1995 for the 2007 SIP Call scenario.

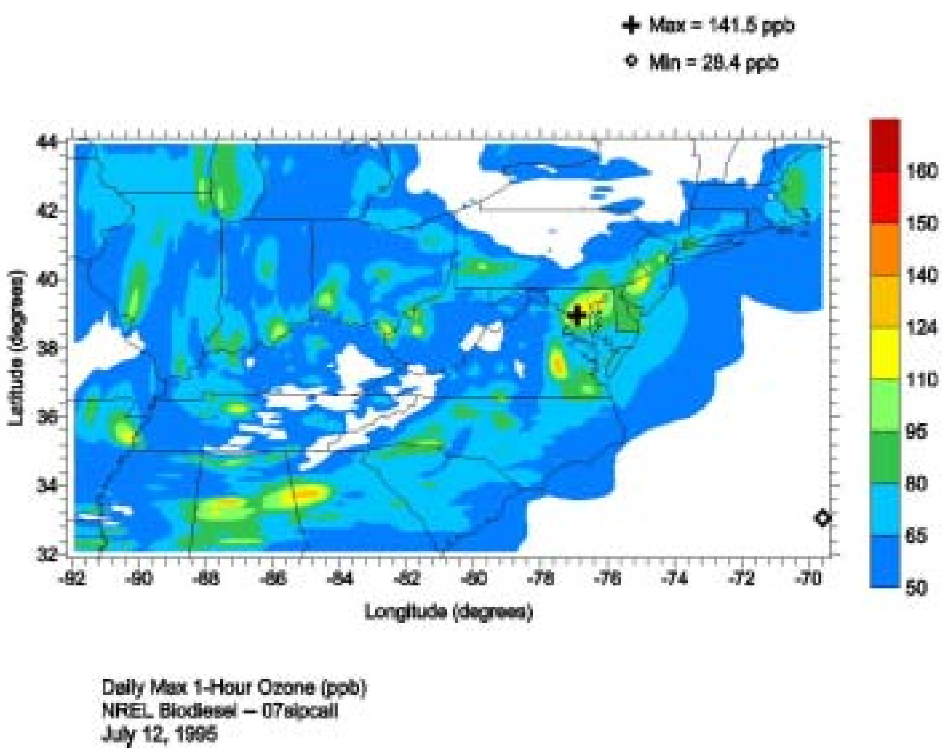

Figure C-1b. Spatial distribution of daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 12, 1995 for the 2007 SIP Call scenario.

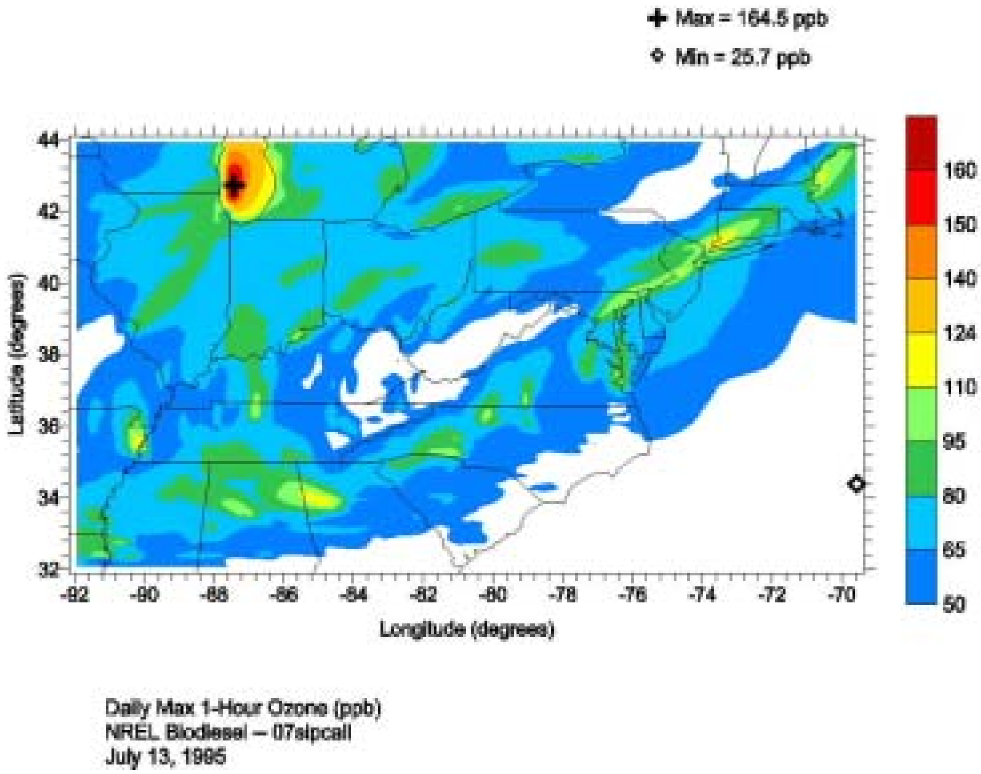

Figure C-1c. Spatial distribution of daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 13, 1995 for the 2007 SIP Call scenario.

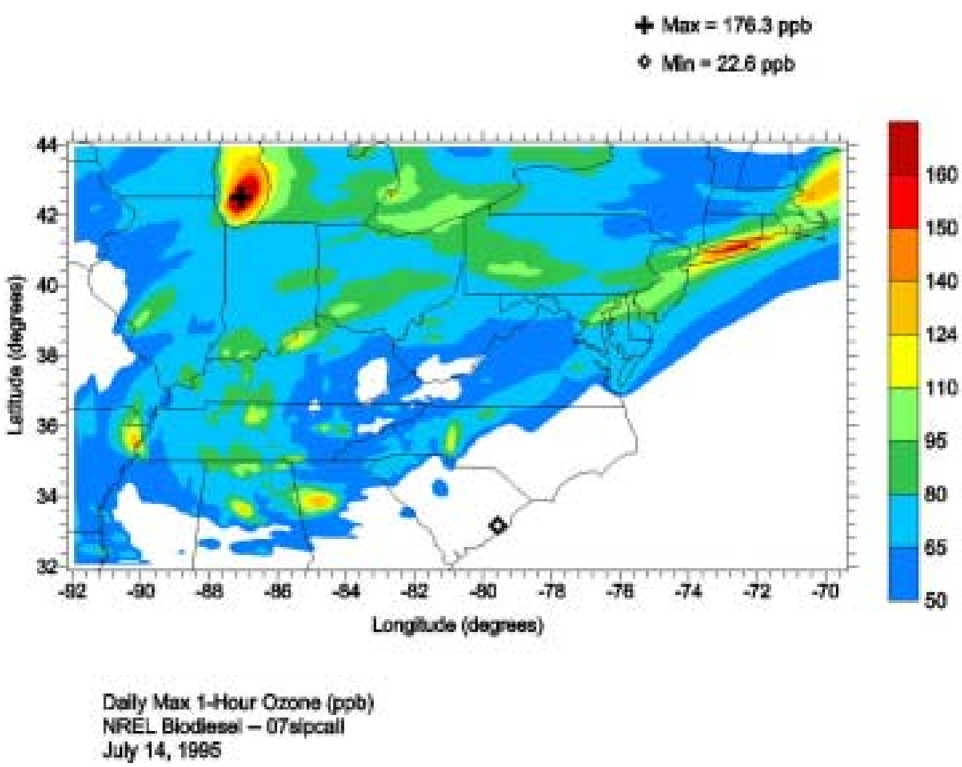

Figure C-1d. Spatial distribution of daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 14, 1995 for the 2007 SIP Call scenario.

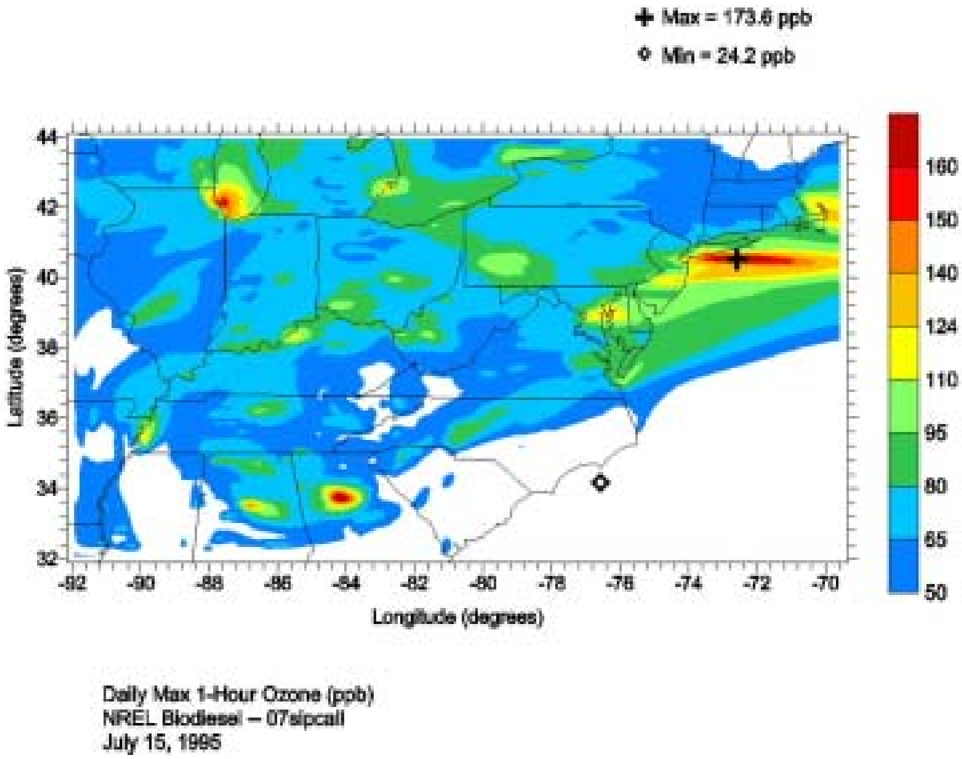

Figure C-1e. Spatial distribution of daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 15, 1995 for the 2007 SIP Call scenario.

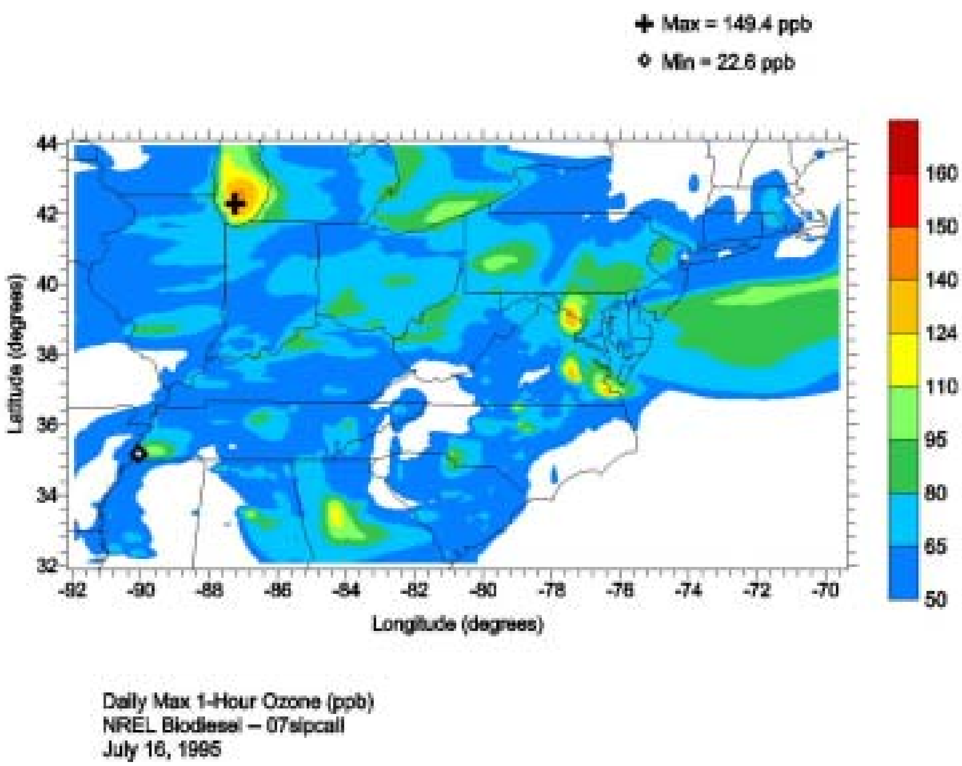

Figure C-1f. Spatial distribution of daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 16, 1995 for the 2007 SIP Call scenario.

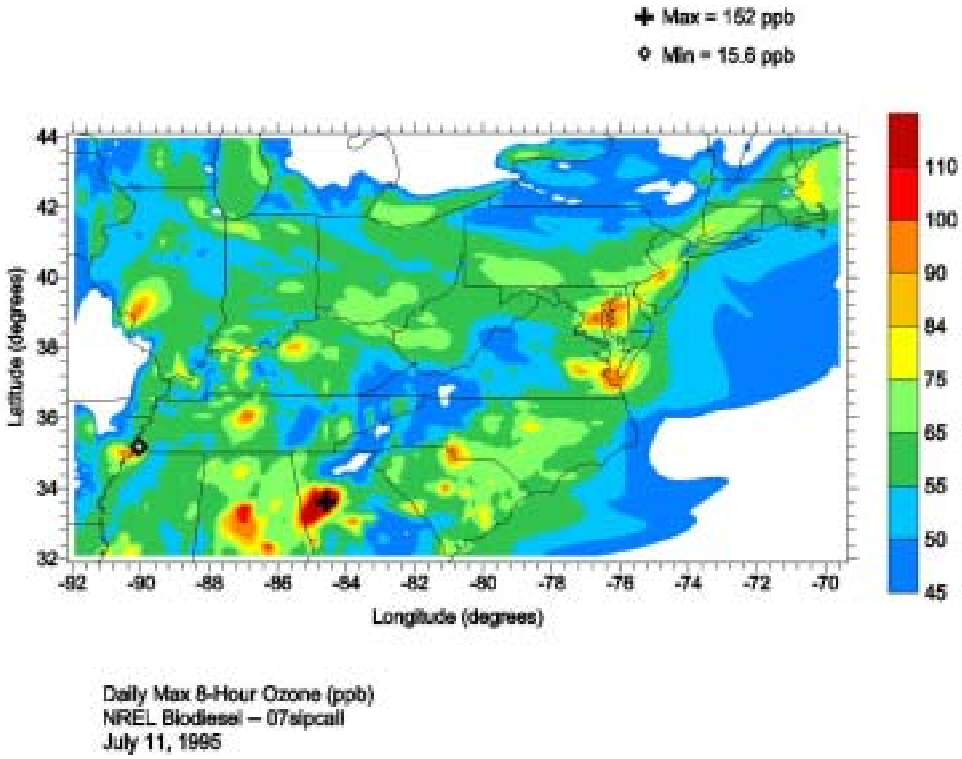

Figure C-2a. Spatial distribution of daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 11, 1995 for the 2007 SIP Call scenario.

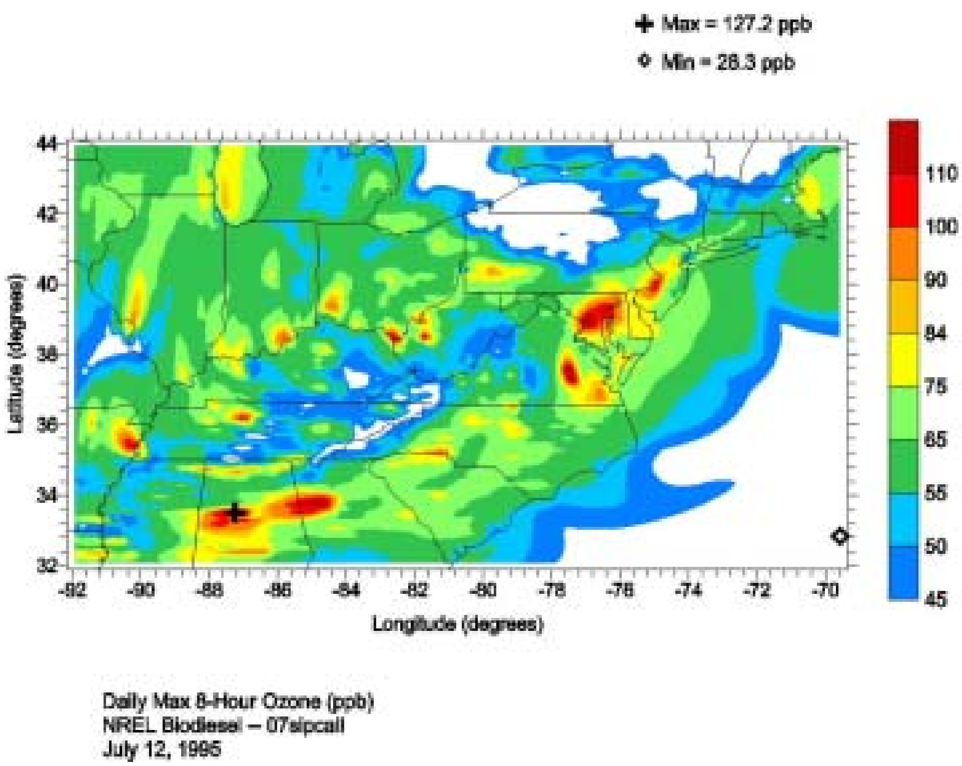

Figure C-2b. Spatial distribution of daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 12, 1995 for the 2007 SIP Call scenario.

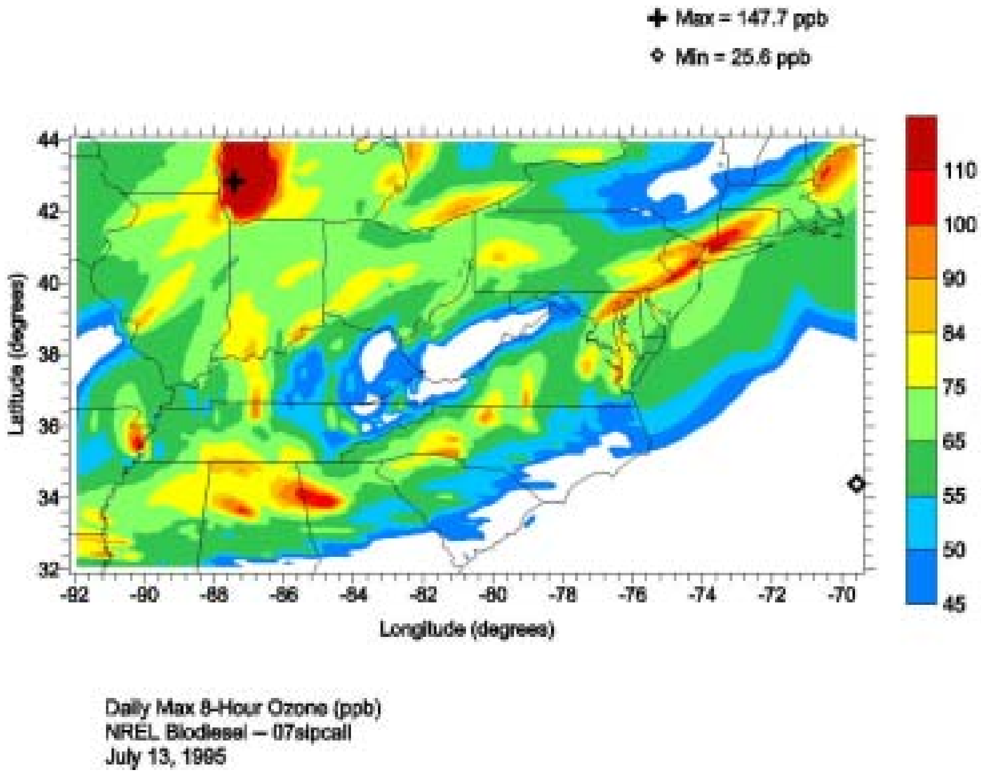

Figure C-2c. Spatial distribution of daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 13, 1995 for the 2007 SIP Call scenario.

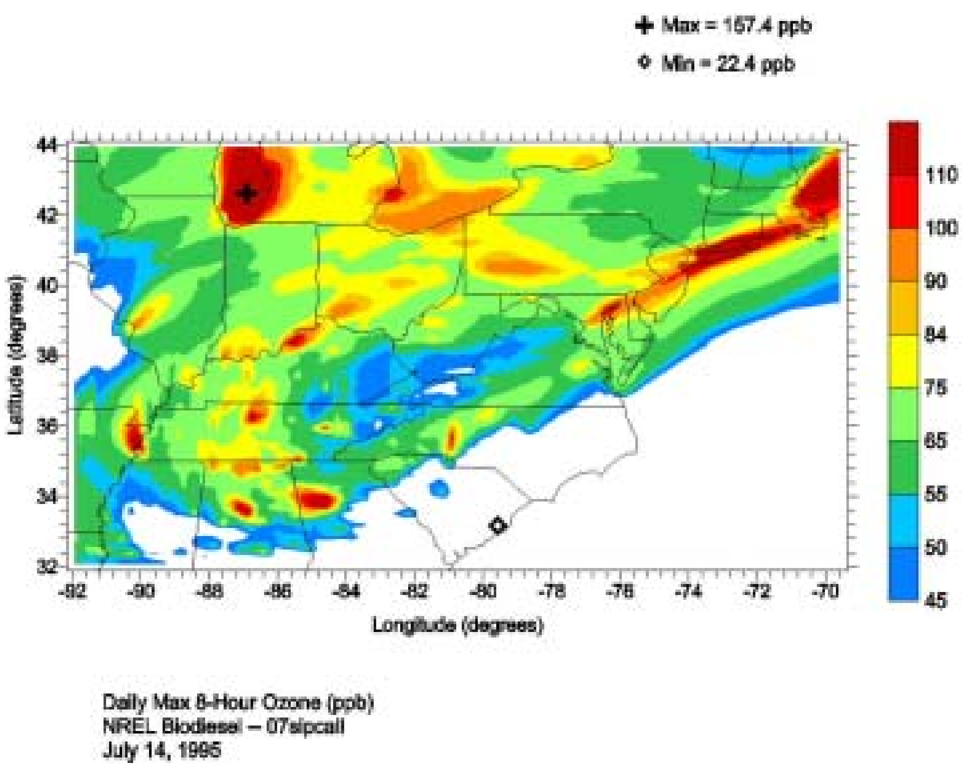

Figure C-2d. Spatial distribution of daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 14, 1995 for the 2007 SIP Call scenario.

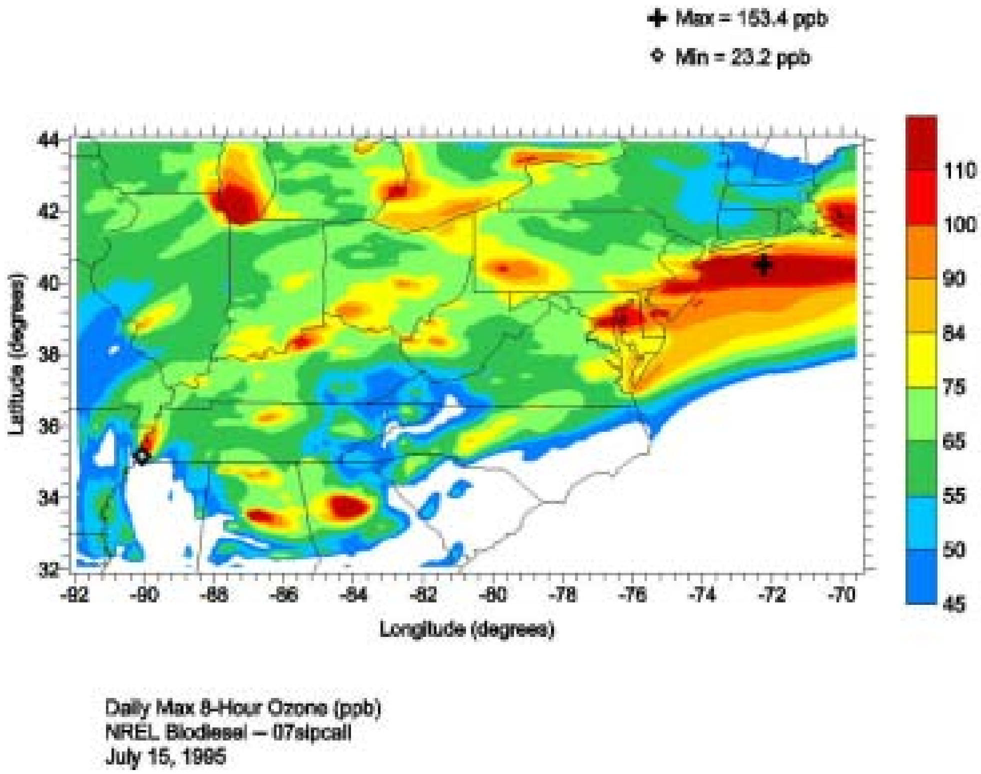

Figure C-2e. Spatial distribution of daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 15, 1995 for the 2007 SIP Call scenario.

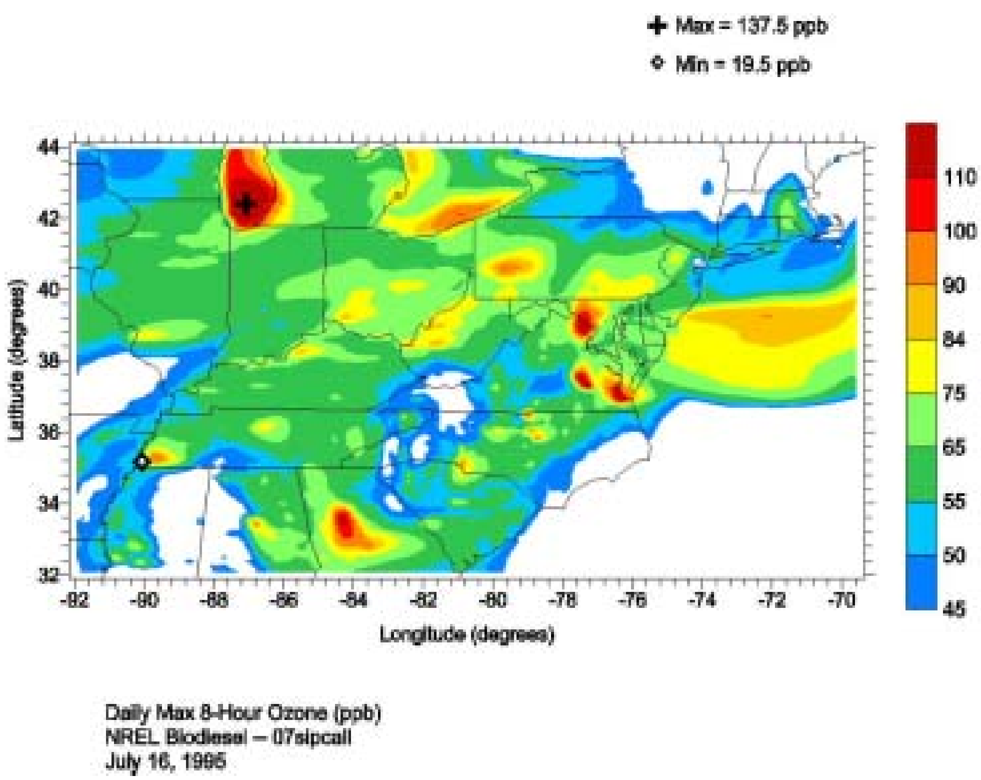

Figure C-2f. Spatial distribution of daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 16, 1995 for the 2007 SIP Call scenario.

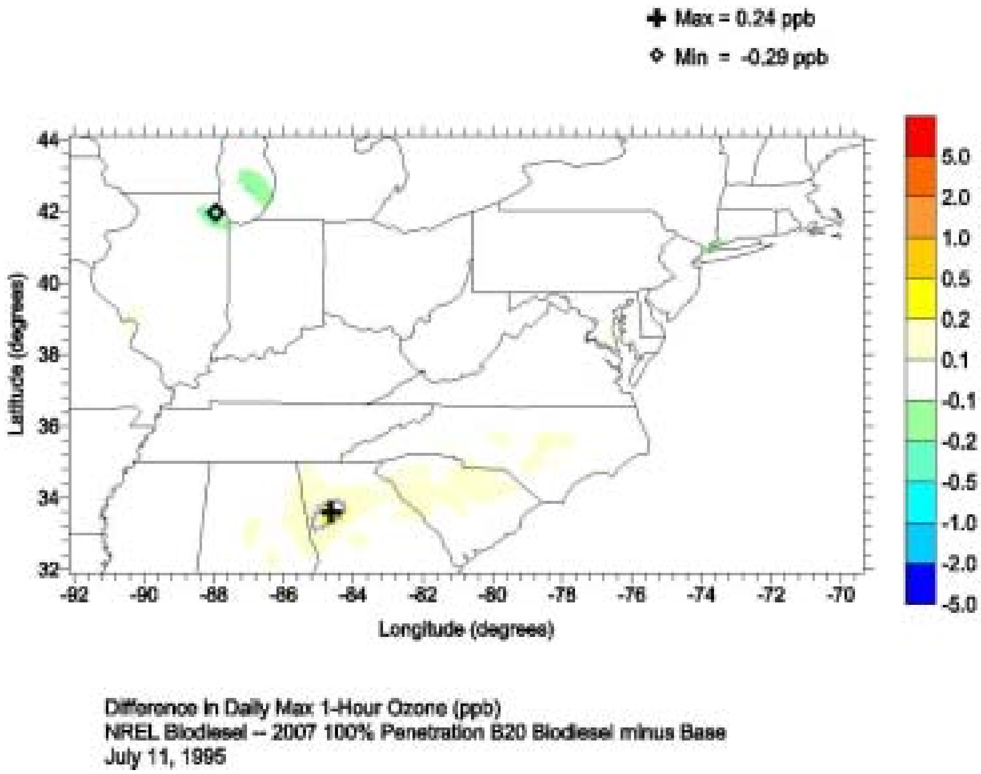

Figure C-3a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 11, 1995.

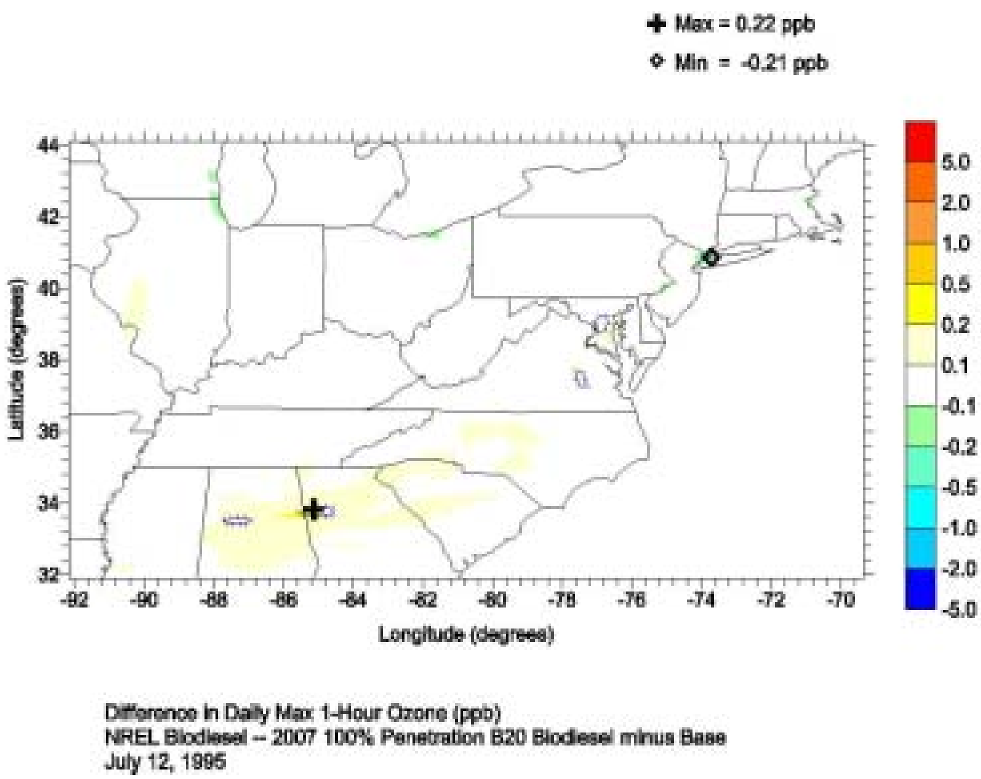

Figure C-3b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 12, 1995.

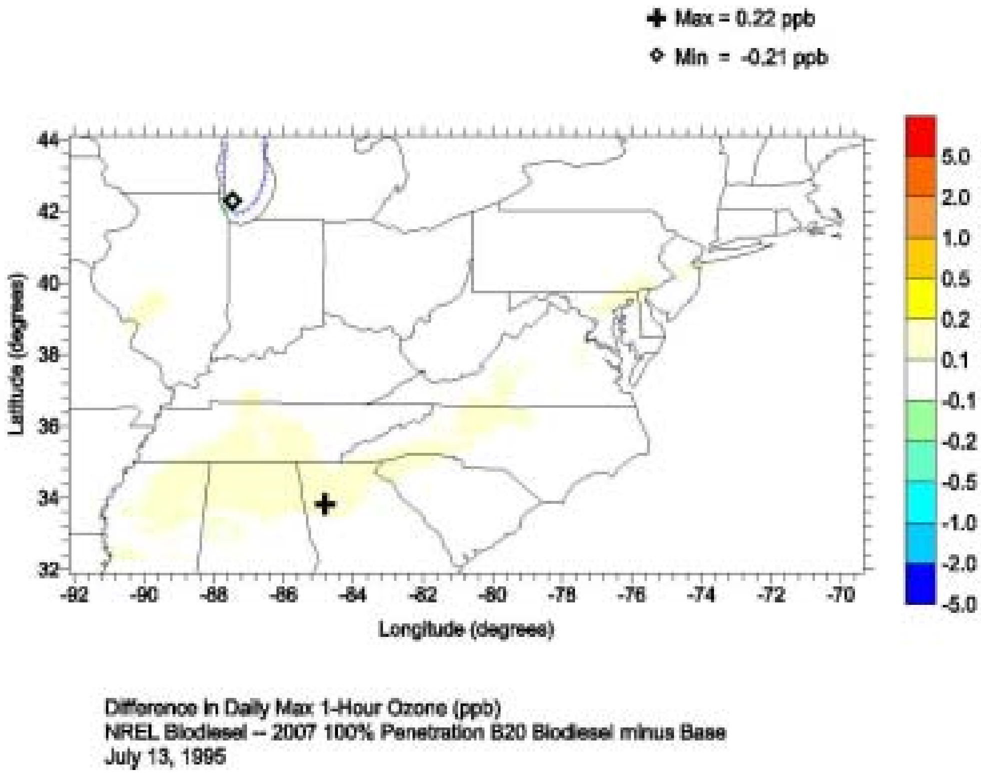

Figure C-3c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 13, 1995.

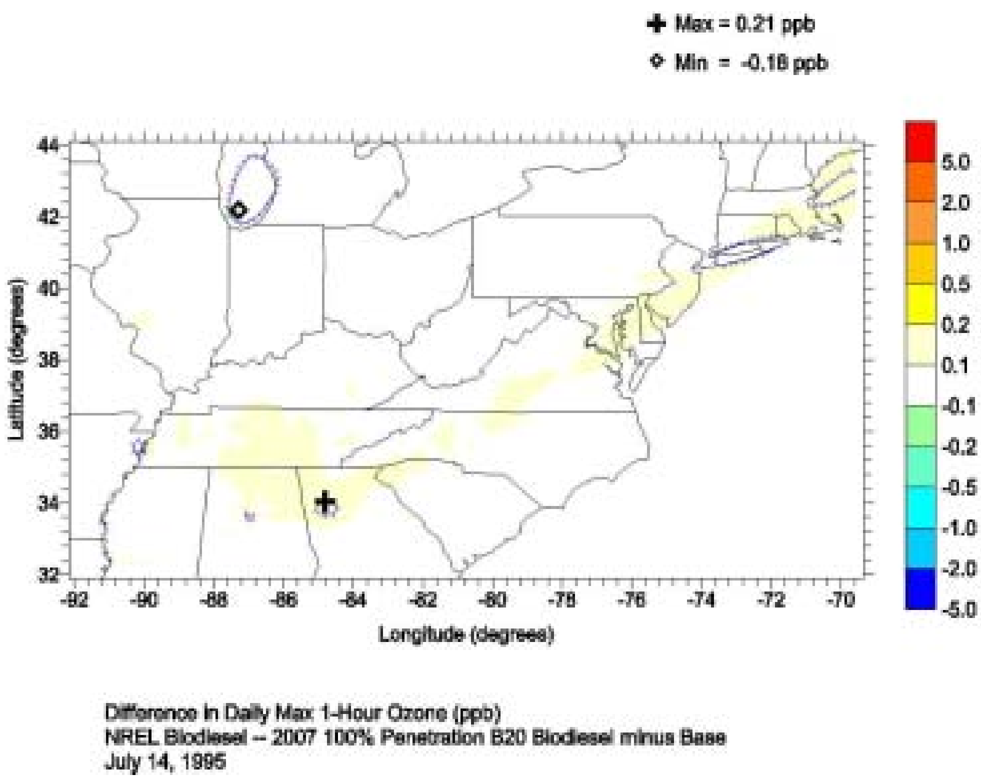

Figure C-3d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 14, 1995.

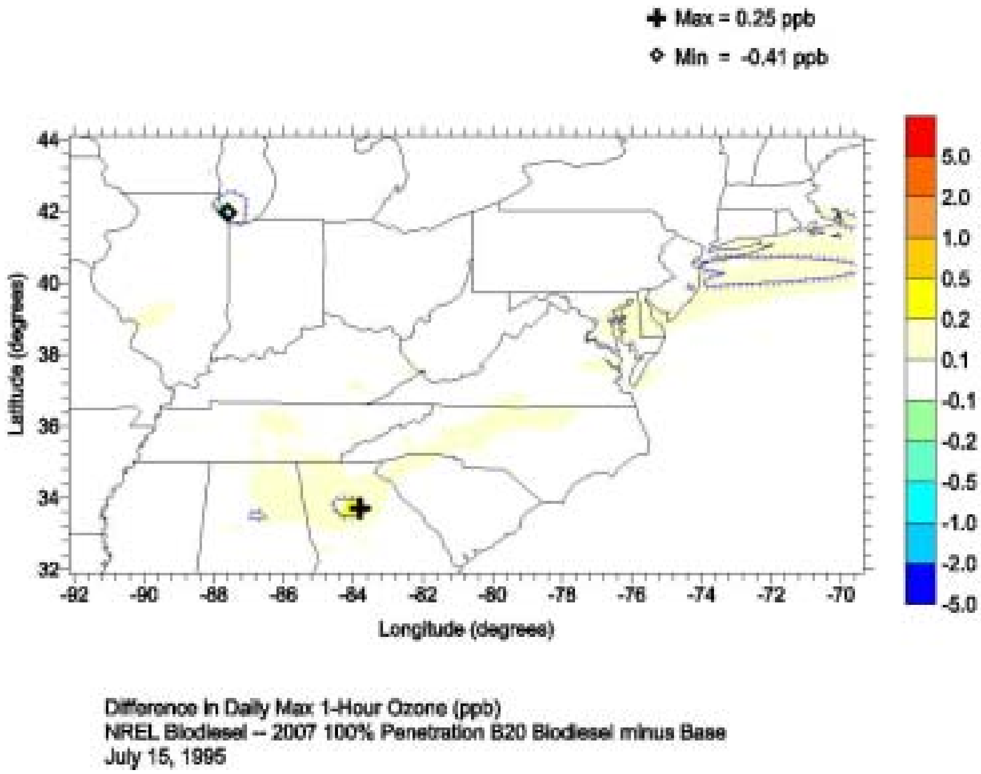

Figure C-3e. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 15, 1995.

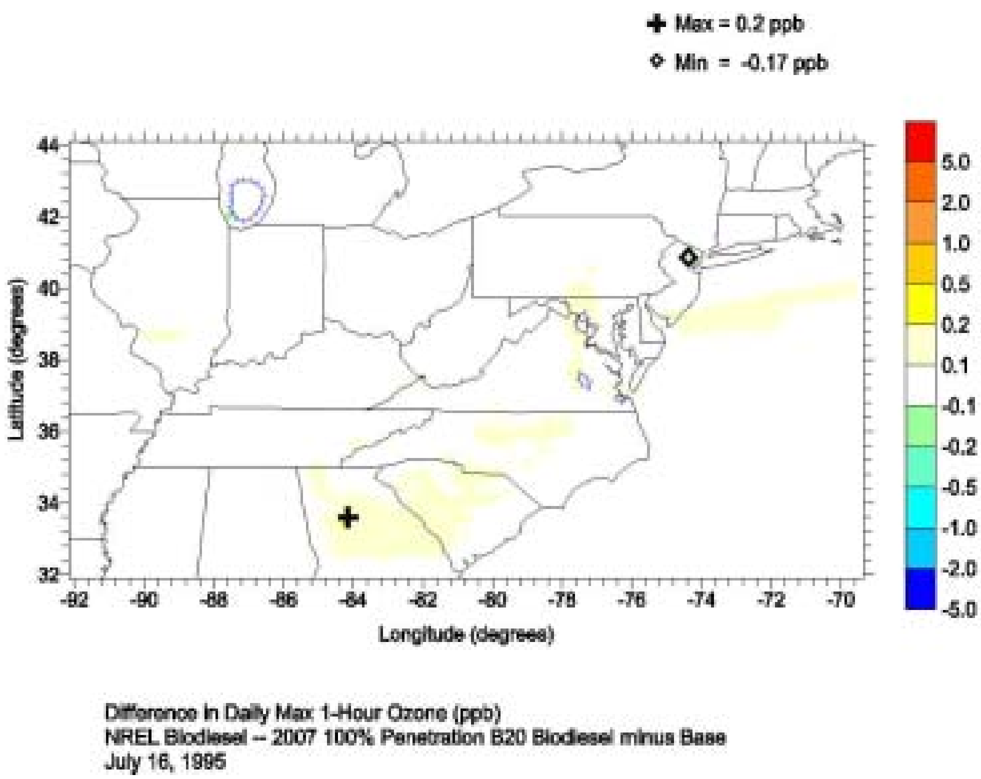

Figure C-3f. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 16, 1995.

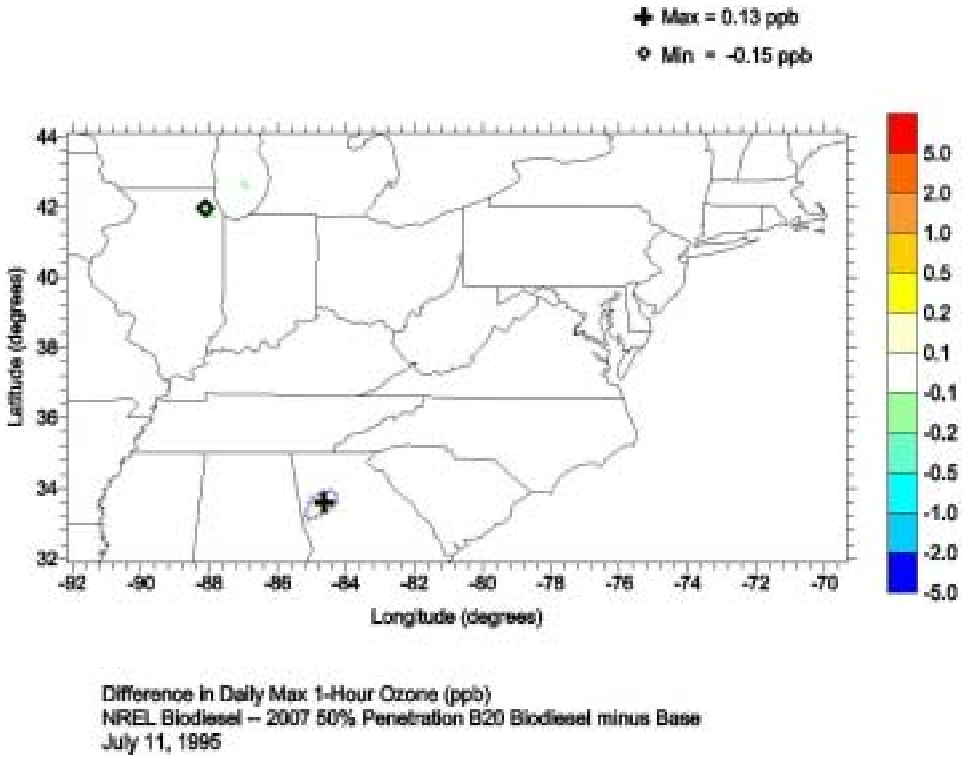

Figure C-4a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 11, 1995.

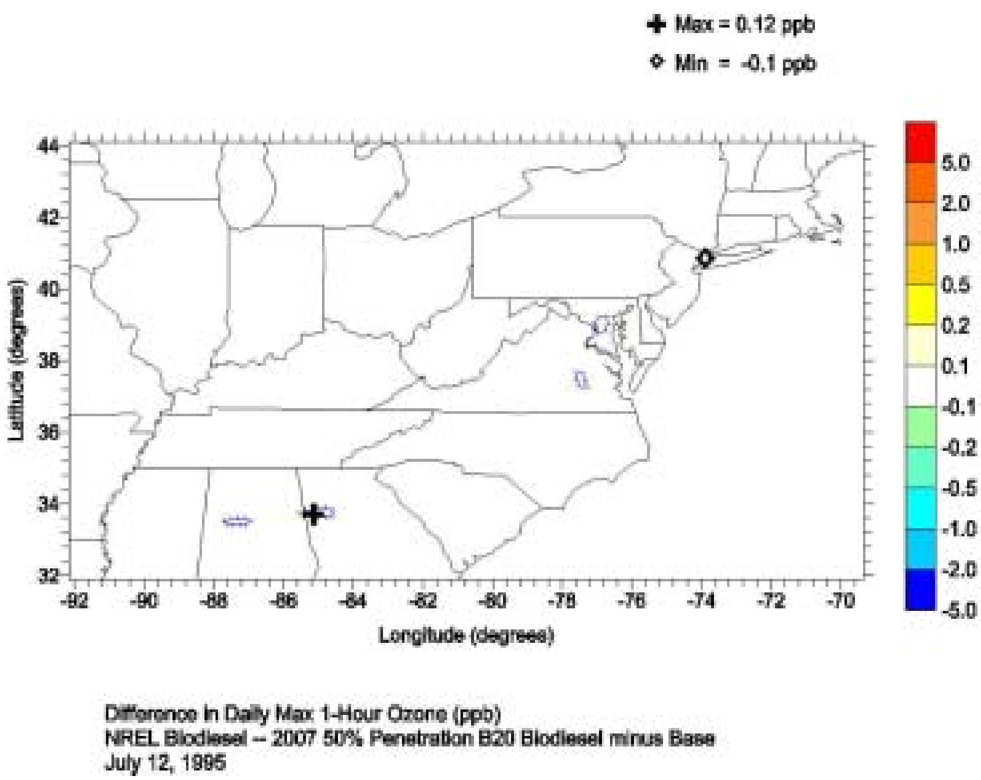

Figure C-4b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 12, 1995.

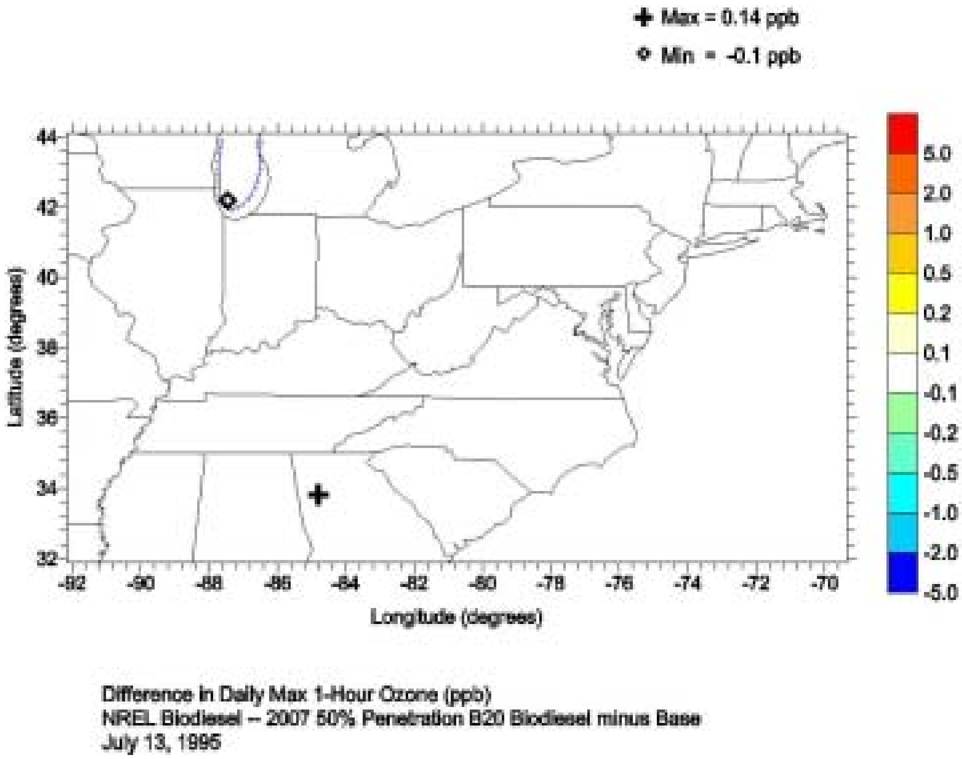

Figure C-4c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 13, 1995.

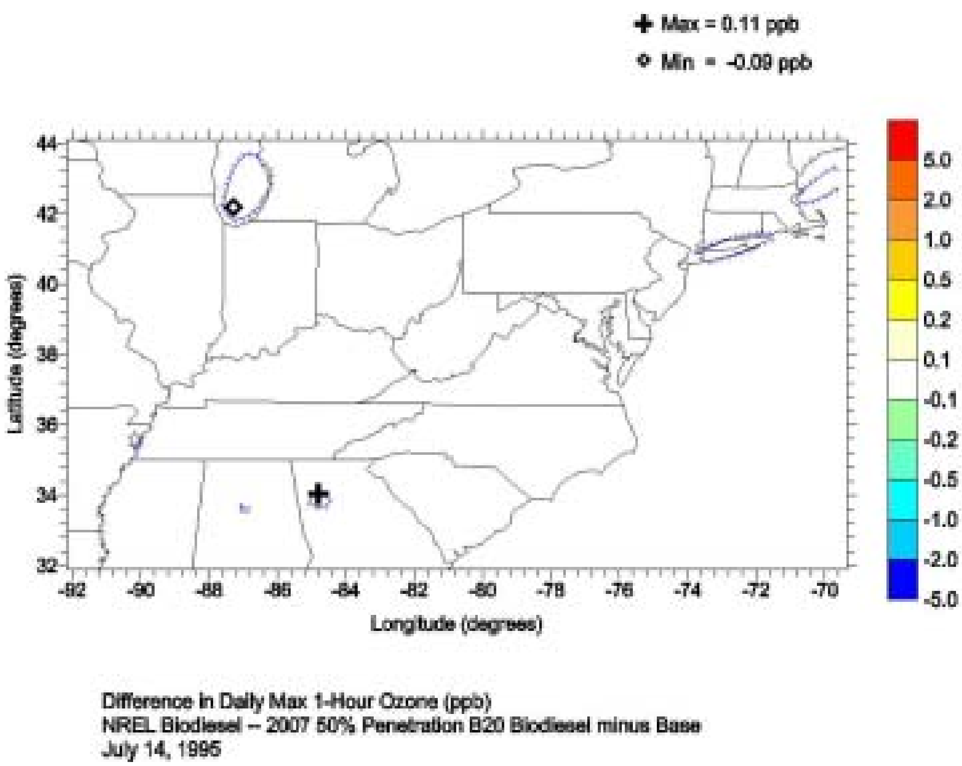

Figure C-4d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 14, 1995.

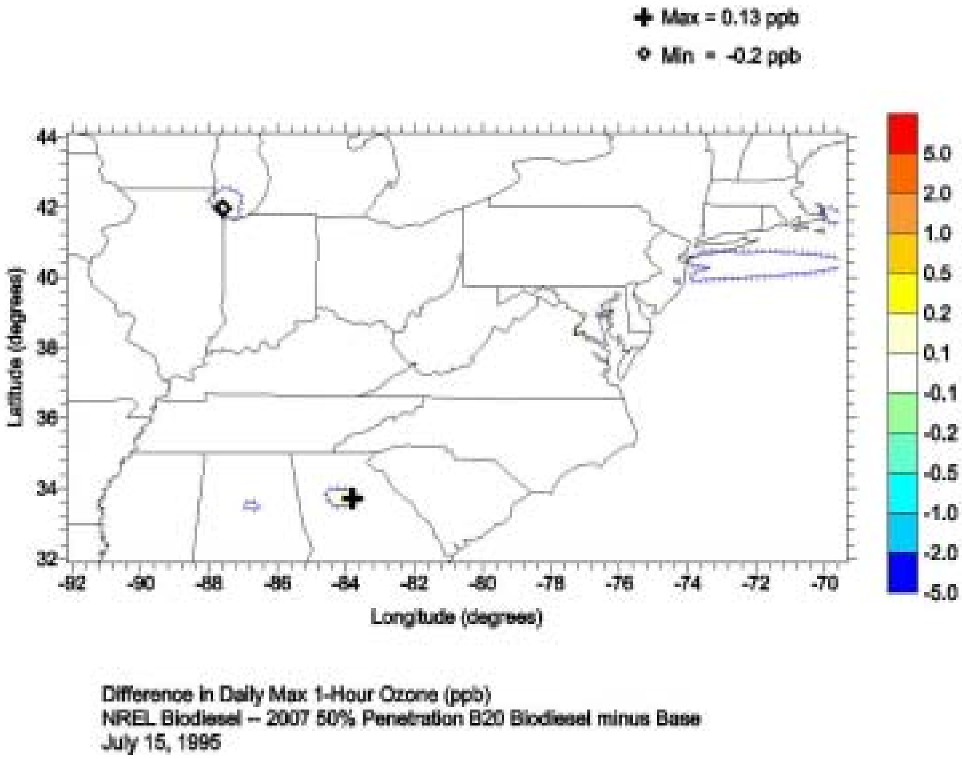

Figure C-4e. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 15, 1995.

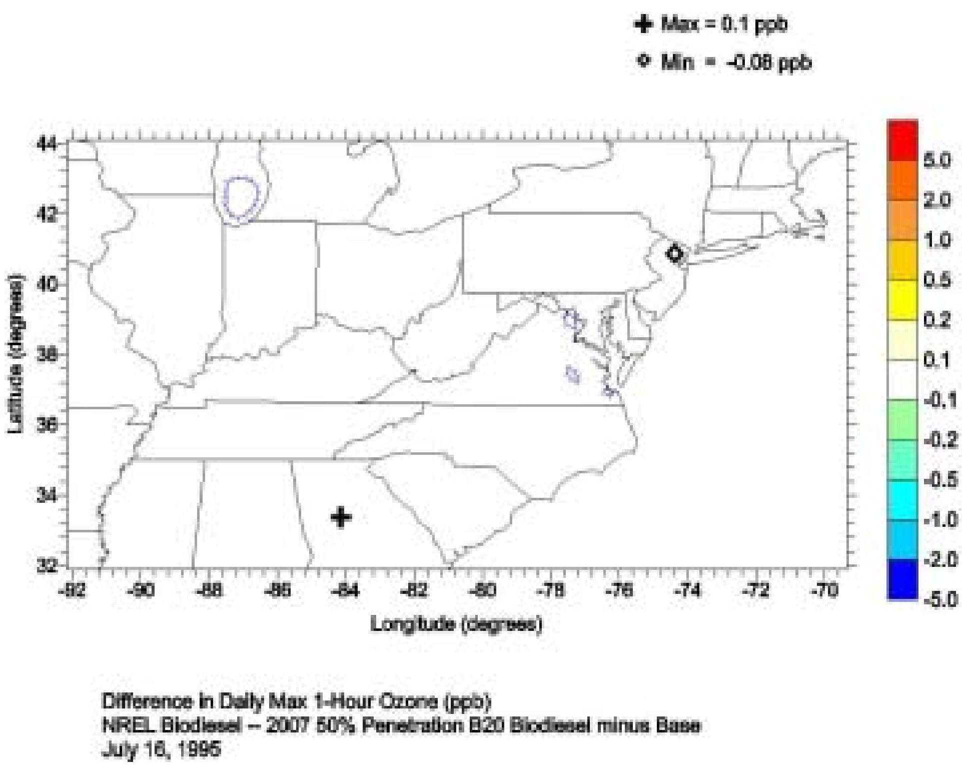

Figure C-4f. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the OTAG 12-km domain on July 16, 1995.

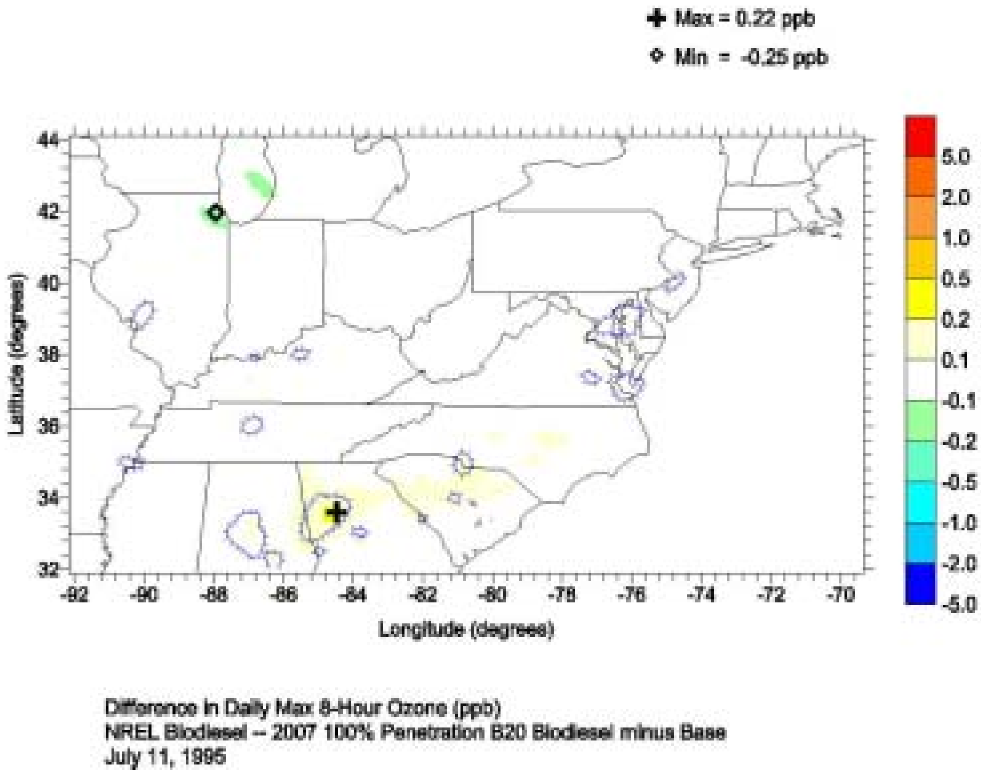

Figure C-5a. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 11, 1995.

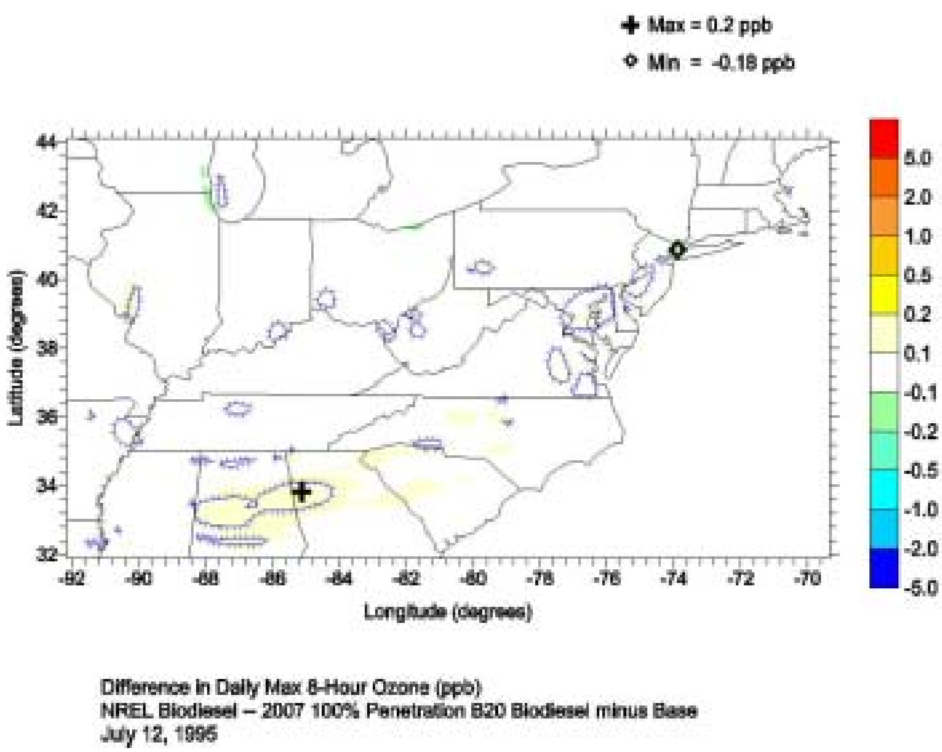

Figure C-5b. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 12, 1995.

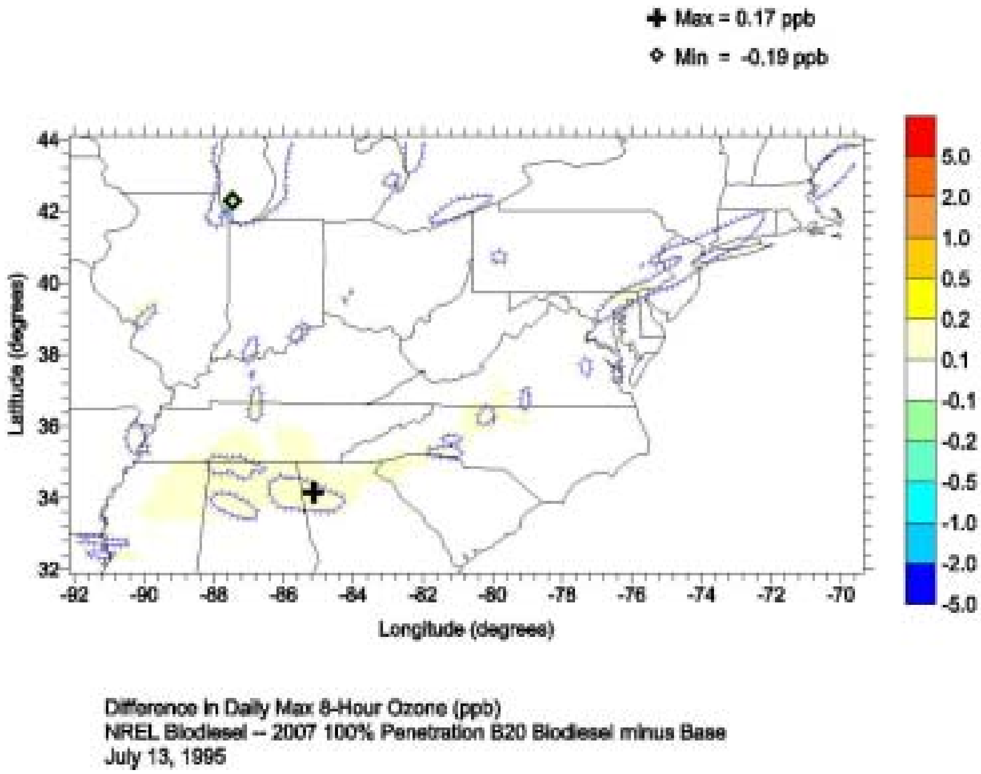

Figure C-5c. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 13, 1995.

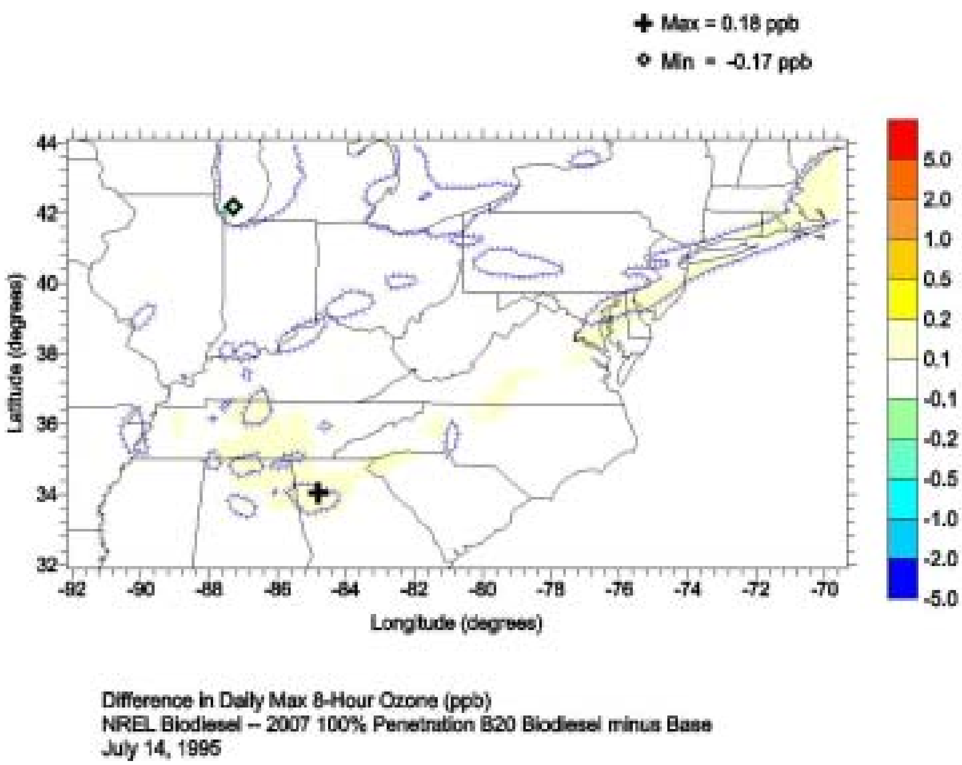

Figure C-5d. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 14, 1995.

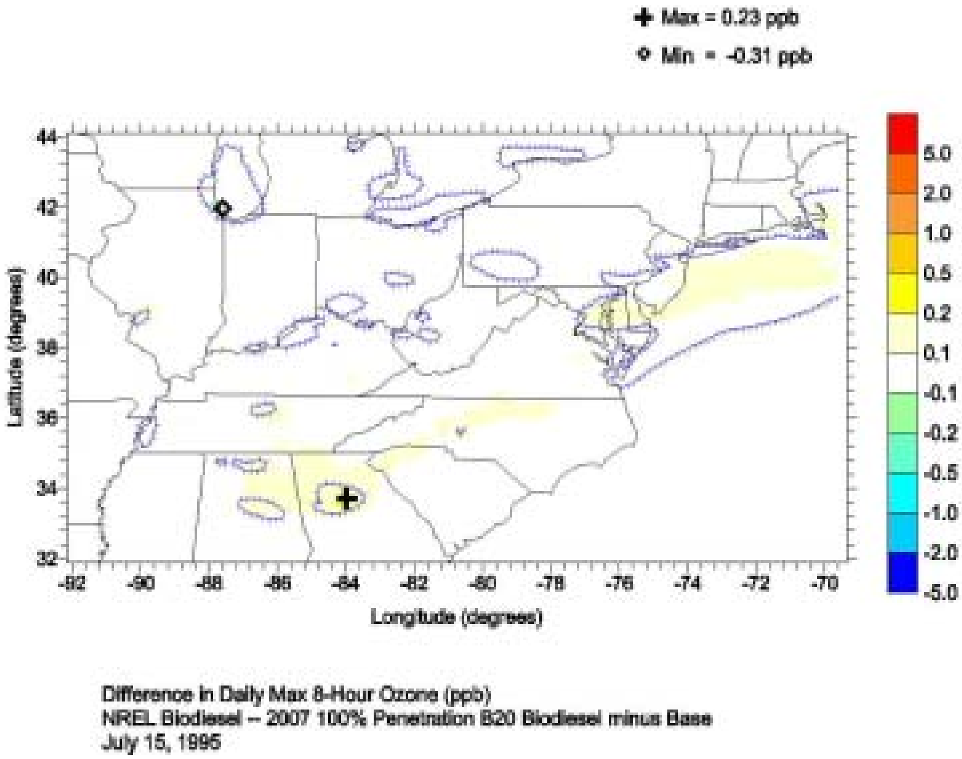

Figure C-5e. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 15, 1995.

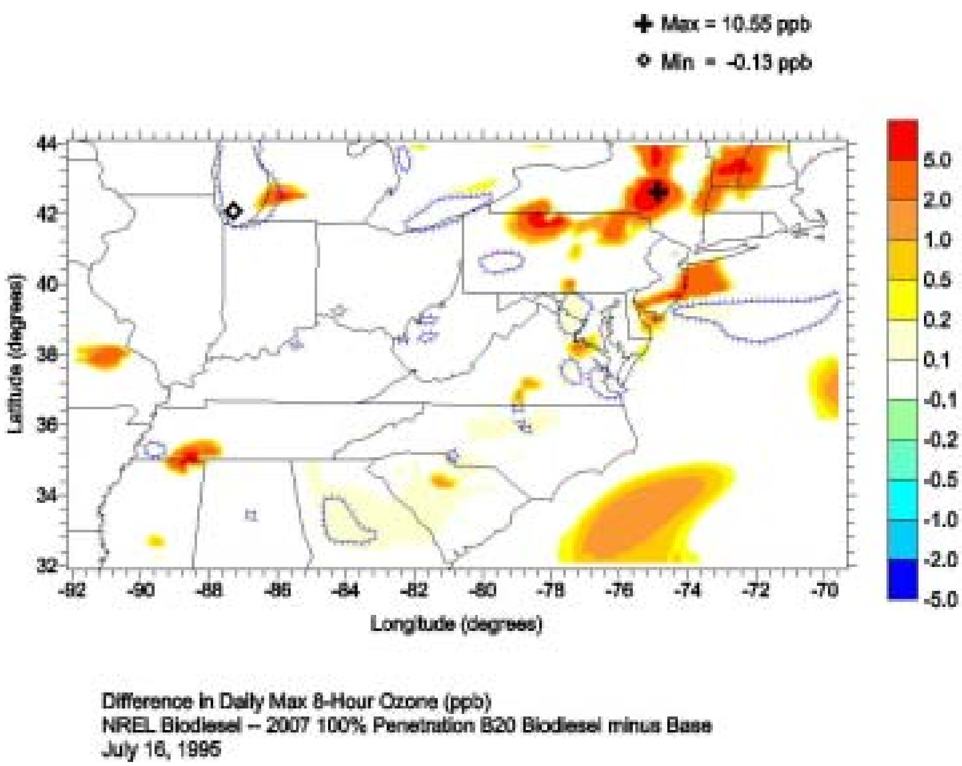

Figure C-5f. Impacts of 100% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 16, 1995.

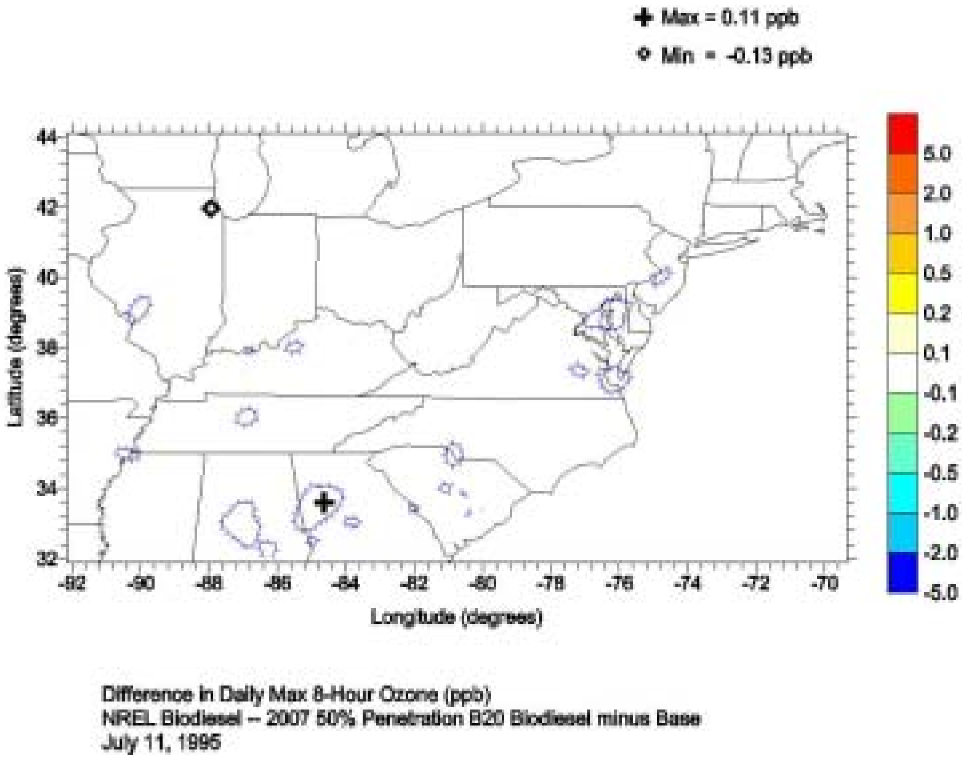

Figure C-6a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 11, 1995.

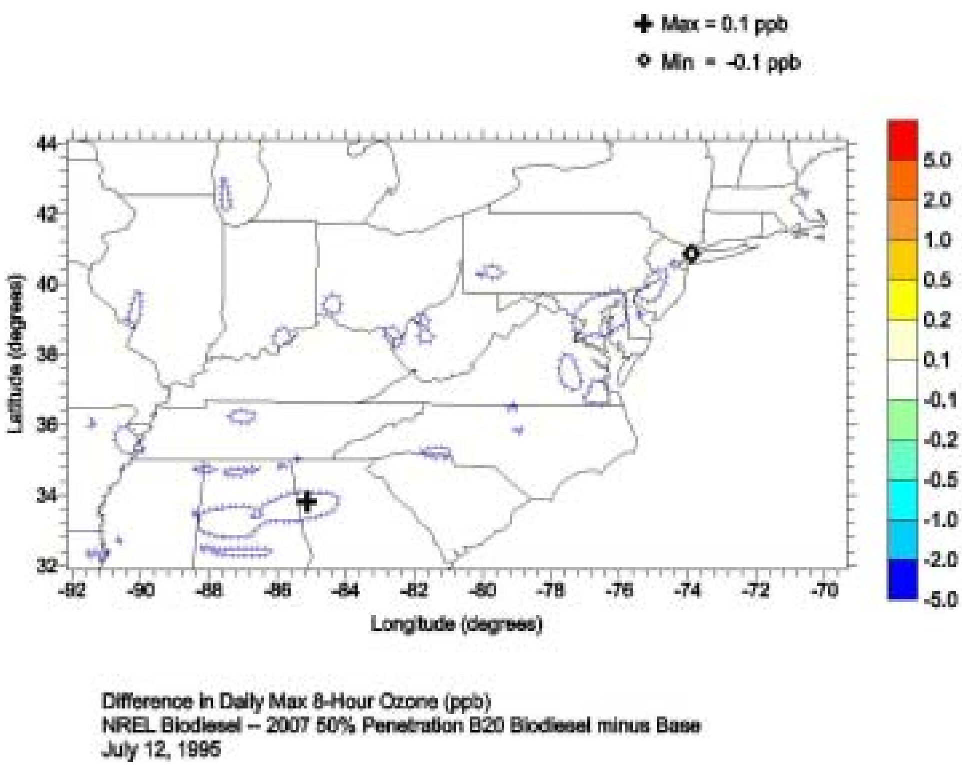

Figure C-6b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 12, 1995.

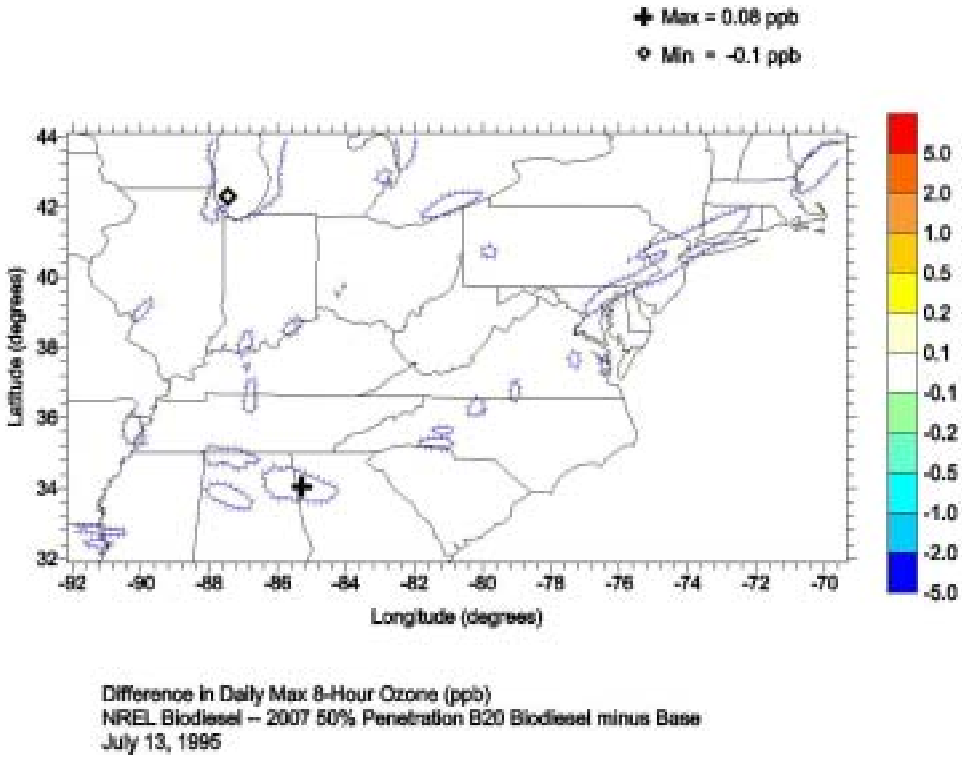

Figure C-6c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 13, 1995.

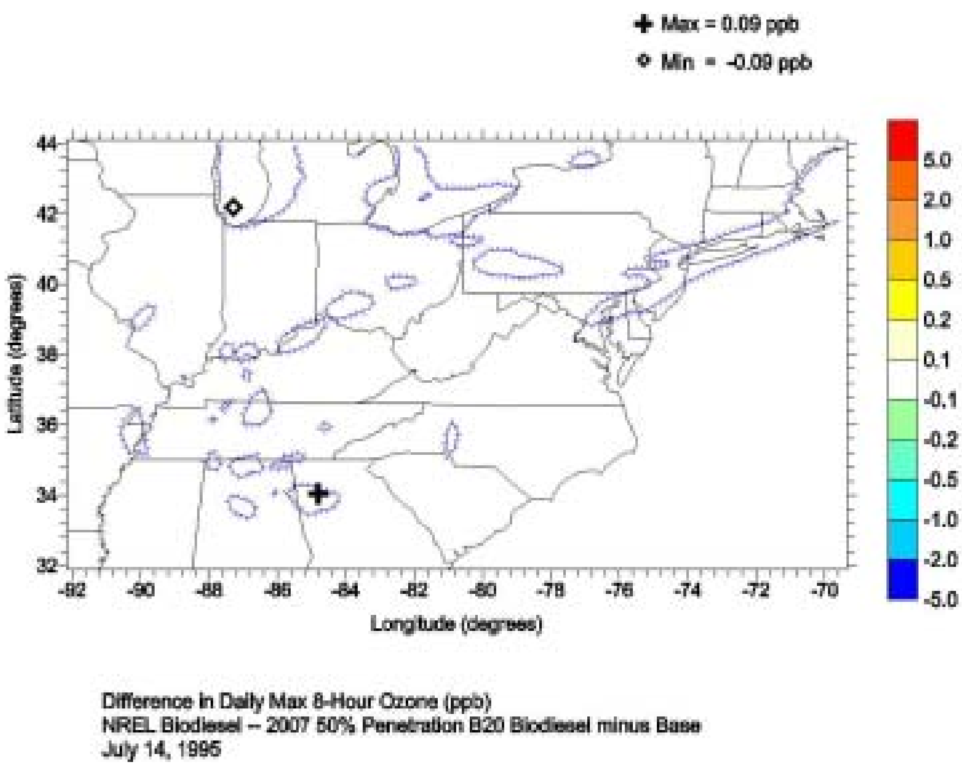

Figure C-6d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 14, 1995.

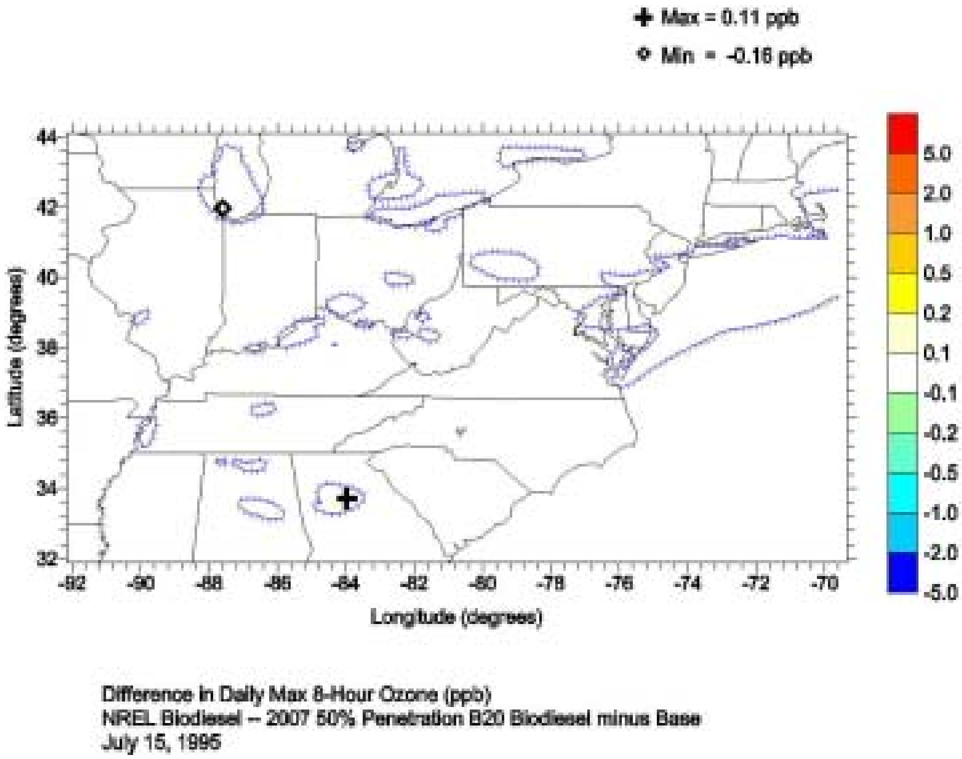

Figure C-6e. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 15, 1995.

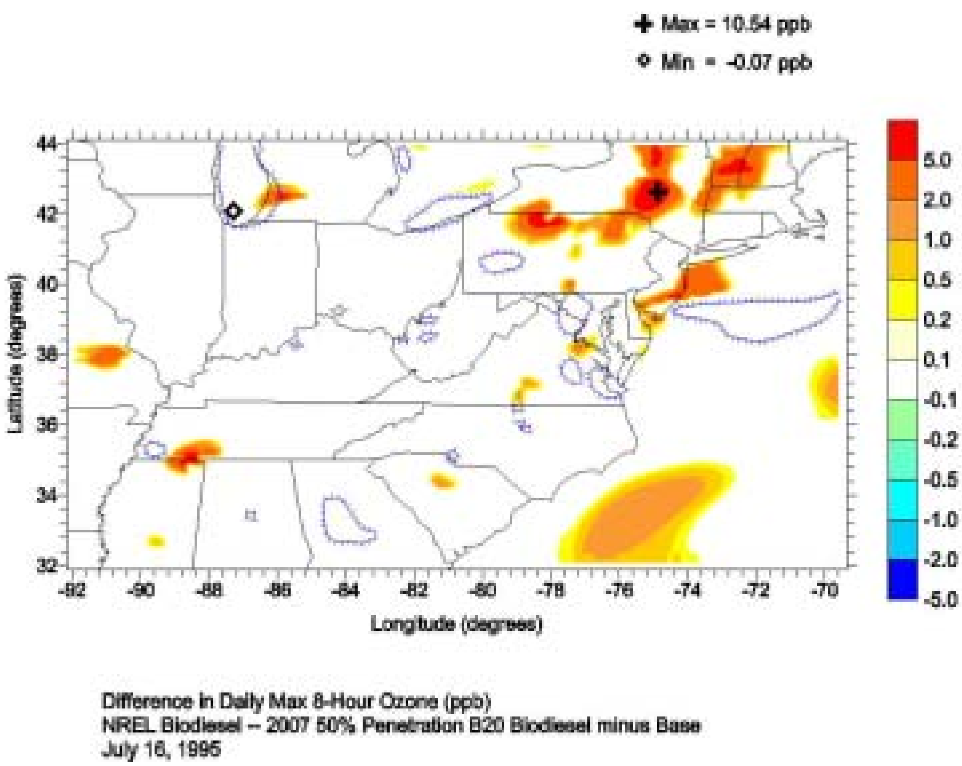

Figure C-6f. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the OTAG 12-km domain on July 16, 1995.

Appendix D

Impacts on Daily Maximum 1-Hour and
8-Hour Ozone Concentrations Due to
50% Penetration of B20 Biodiesel Fuel Use
in the South Coast Air Basin 5-km Domain

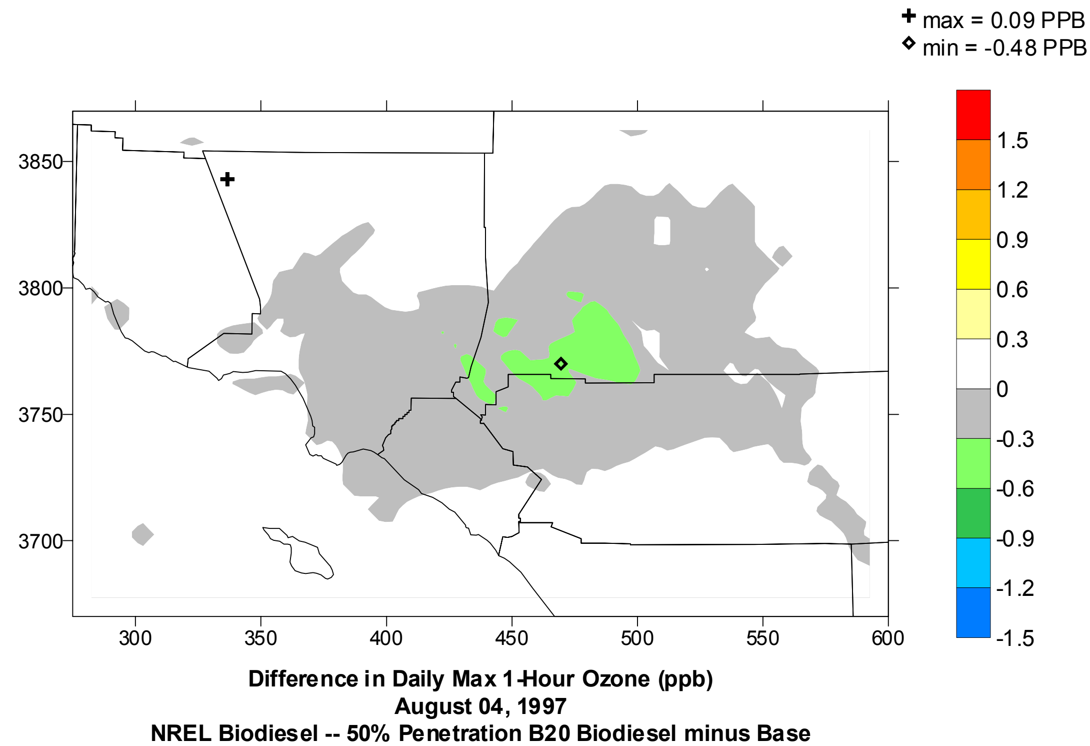

Figure D-1a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 4, 1997.

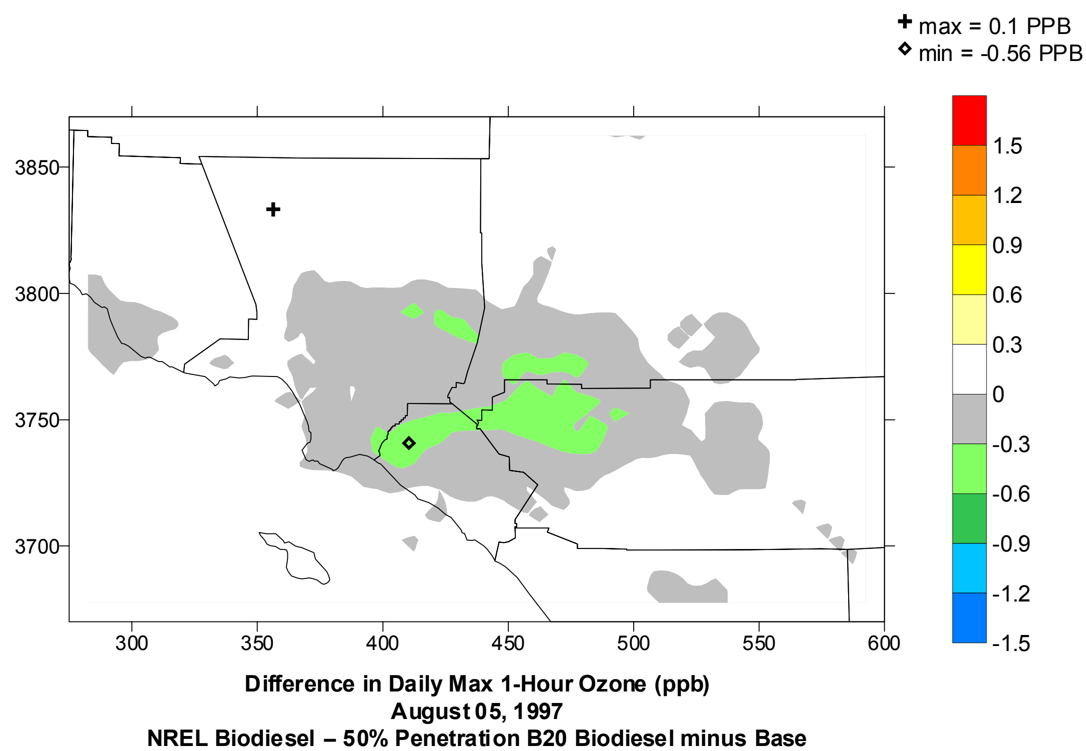

Figure D-1b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 5, 1997.

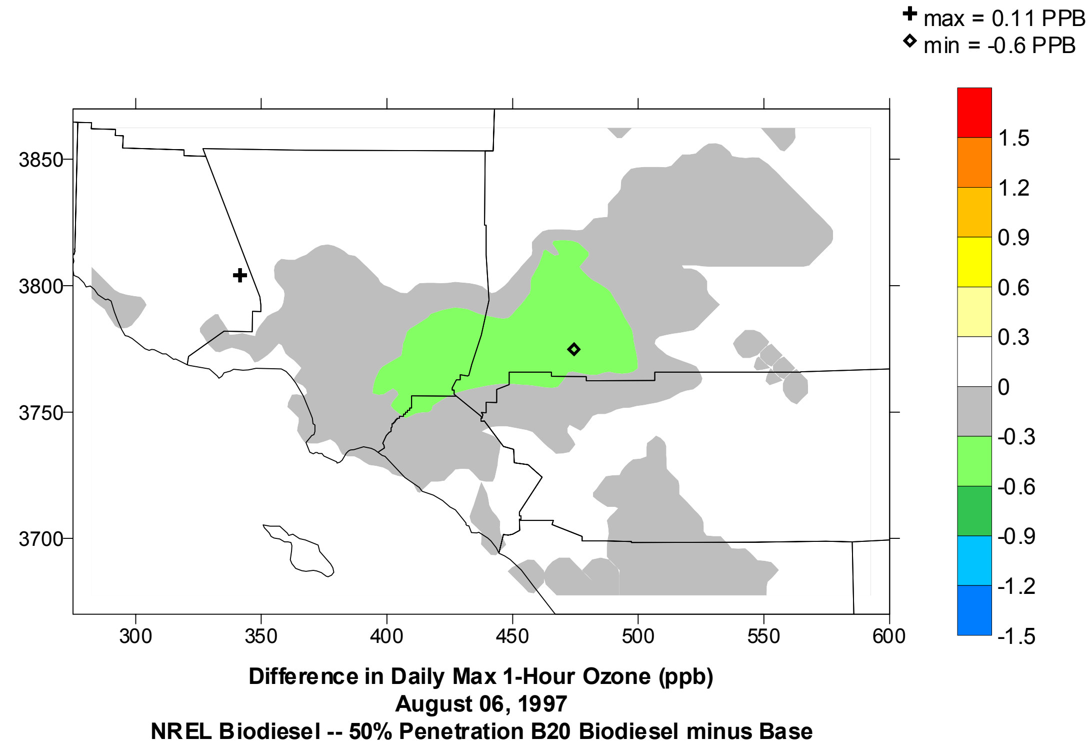

Figure D-1c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 6, 1997.

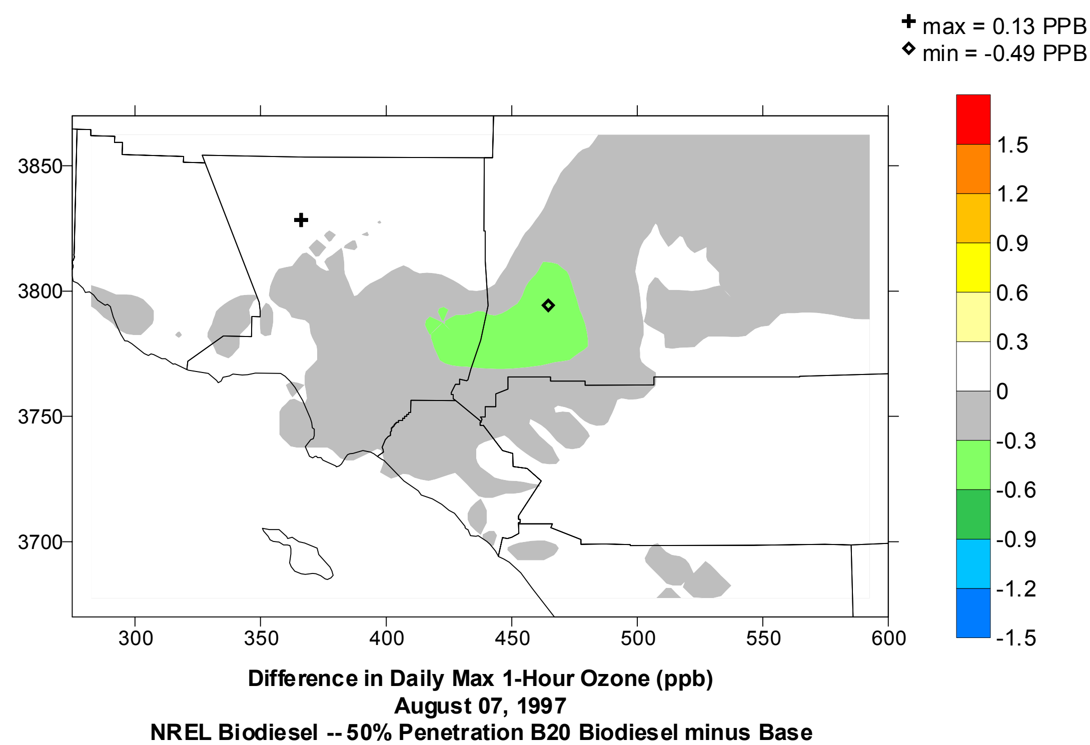

Figure D-1d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 1-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 7, 1997.

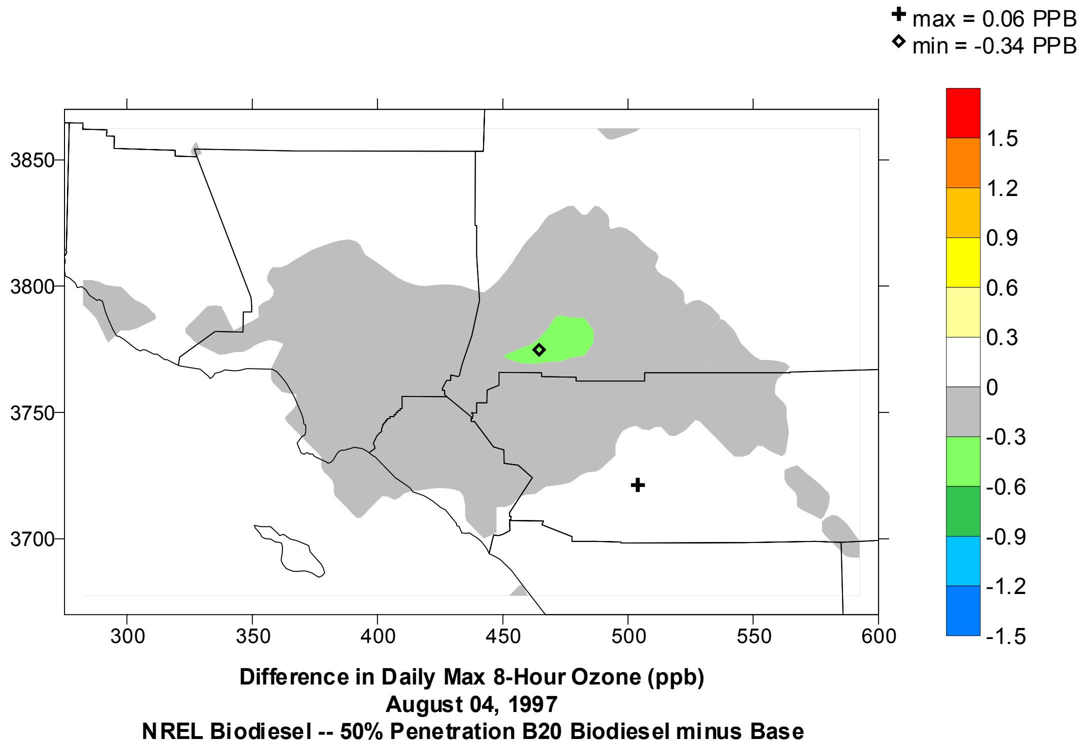

Figure D-2a. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 4, 1997.

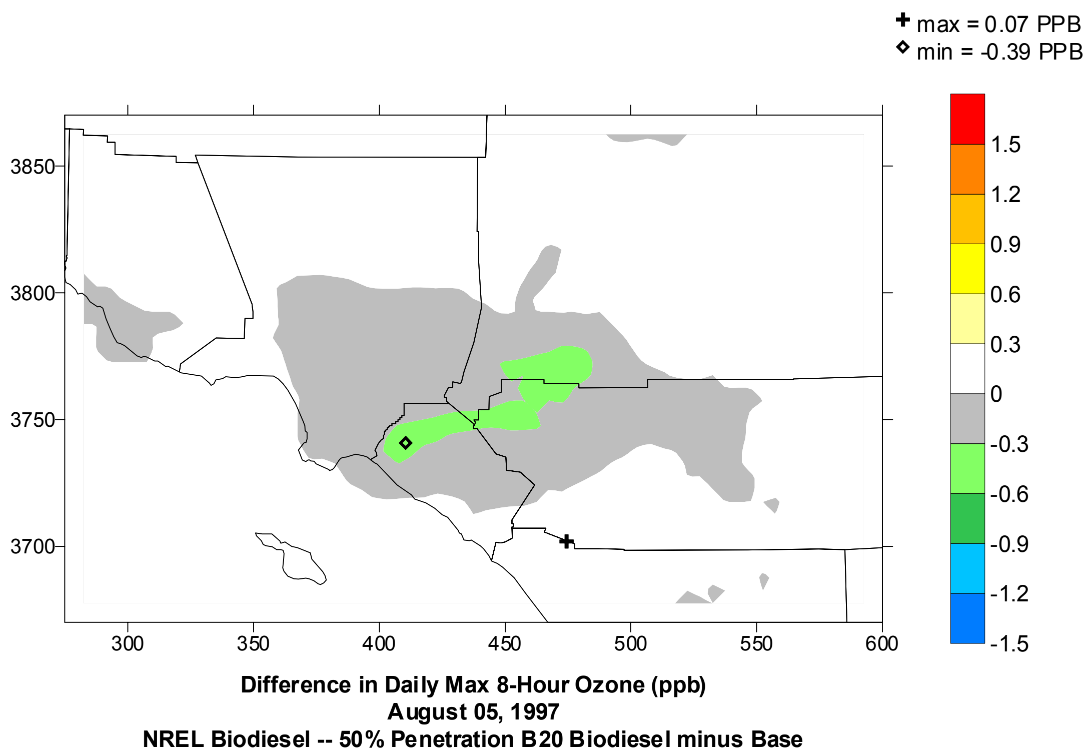

Figure D-2b. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 5, 1997.

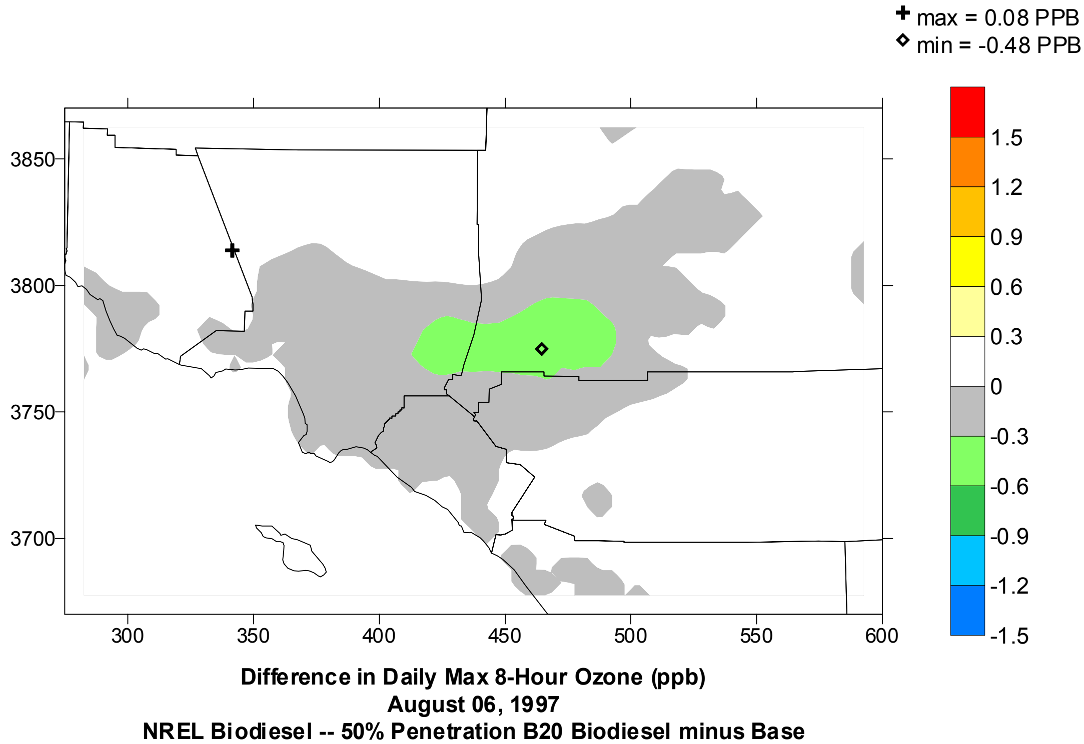

Figure D-2c. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 6, 1997.

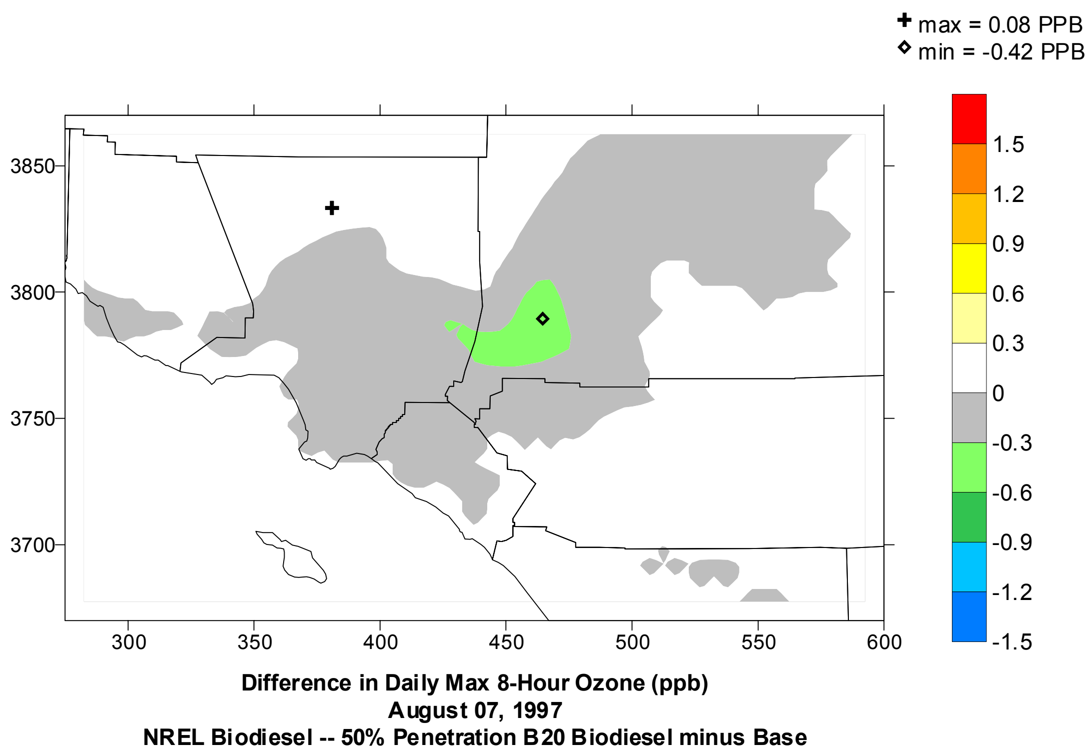

Figure D-2d. Impacts of 50% penetration of B20 biodiesel fuel on daily maximum 8-hour ozone concentrations in the South Coast Air Basin 5-km domain on August 7, 1997.

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This report documents Task 2 of the NREL study “Impact of Biodiesel Fuels on Air Quality and Hyman Health”. Under Task 1, engine test data using biodiesel and standard diesel fuels were analyzed to estimate the effects biodiesel fuel has on heavy duty diesel vehicle tailpipe emissions.

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