



west virginia department of environmental protection

Appendix D

LADCO

Documentation

Promoting a healthy environment.

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Table of Contents

Appendix D1: Regional Air Quality Analyses for Ozone, PM_{2.5}, and Regional Haze:
Final Technical Support Document. Page 5

Appendix D2: Development of 2005 Base Year Growth and Control Factor for
Lake Michigan Air Directors Consortium (LADCO) Final Report. Page 177

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Appendix D1:
Regional Air Quality Analyses for Ozone, PM_{2.5}, and
Regional Haze: Final Technical Support Document

http://www.ladco.org/reports/technical_support_document/tsd/tsd_version_iv_april_25_2008_final.pdf

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Regional Air Quality Analyses for Ozone, PM_{2.5}, and Regional Haze: Final Technical Support Document



April 25, 2008

States of Illinois, Indiana, Michigan, Ohio, and Wisconsin

Table of Contents

Section-Title	Page
Executive Summary	iii
1.0 Introduction	1
1.1 SIP Requirements	1
1.2 Organization	2
1.3 Technical Work: Overview	3
2.0 Ambient Data Analyses	4
2.1 Ozone	4
2.2 PM _{2.5}	21
2.3 Regional Haze	35
3.0 Air Quality Modeling	46
3.1 Selection of Base Year	46
3.2 Future Years of Interest	46
3.3 Modeling System	47
3.4 Domain/Grid Resolution	47
3.5 Model Inputs: Meteorology	48
3.6 Model Inputs: Emissions	51
3.7 Base Year Modeling Results	60
4.0 Attainment Demonstration for Ozone and PM_{2.5}	71
4.1 Future Year Modeling Results	71
4.2 Supplemental Analyses	82
4.3 Weight of Evidence Determination for Ozone	82
4.4 Weight of Evidence Determination for PM _{2.5}	90
5.0 Reasonable Progress Assessment for Regional Haze	93
5.1 Class I Areas Impacted	93
5.2 Future Year Modeling Results	96
5.3 Weight of Evidence Determination for Regional Haze	104
6.0 Summary	111
7.0 References	114
Appendix I Ozone and PM_{2.5} Modeling Results	
Appendix II Ozone Source Apportionment Modeling Results	
Appendix III PM_{2.5} Source Apportionment Modeling Results	
Appendix IV Haze Source Apportionment Modeling Results	

EXECUTIVE SUMMARY

States in the upper Midwest face a number of air quality challenges. More than 50 counties are currently classified as nonattainment for the 8-hour ozone standard and 60 for the fine particle ($PM_{2.5}$) standard (1997 versions). A map of these nonattainment areas is provided in the figure below. In addition, visibility impairment due to regional haze is a problem in the larger national parks and wilderness areas (i.e., Class I areas). There are 156 Class I areas in the U.S., including two in northern Michigan.

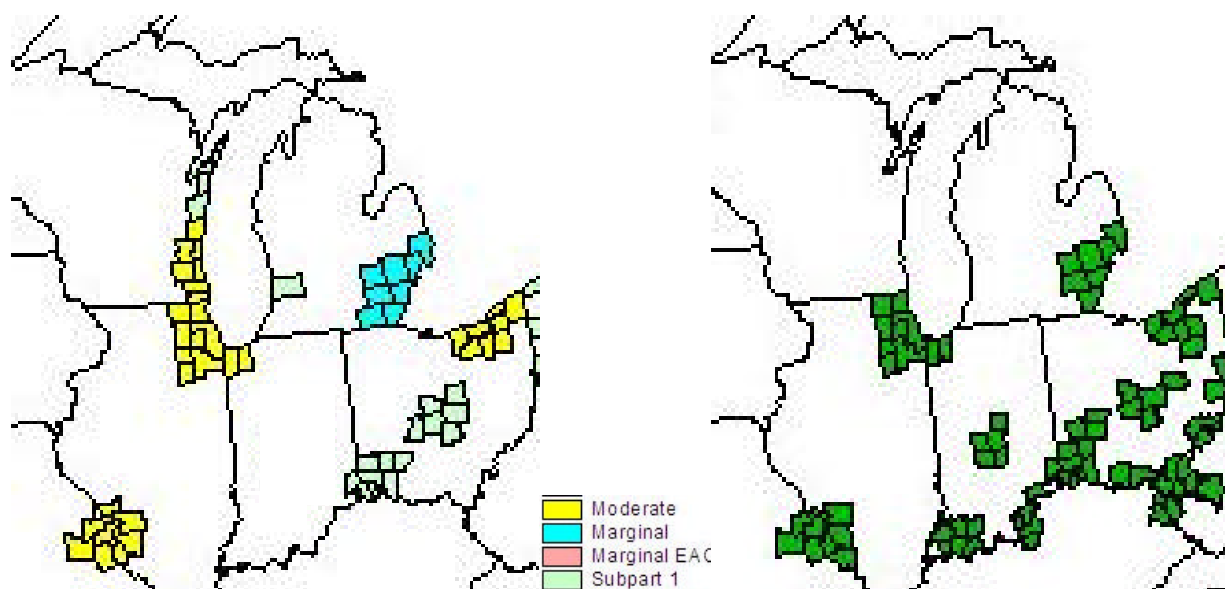


Figure i. Current nonattainment counties for ozone (left) and $PM_{2.5}$ (right)

To support the development of State Implementation Plans (SIPs) for ozone, $PM_{2.5}$, and regional haze in the States of Illinois, Indiana, Michigan, Ohio, and Wisconsin, technical analyses were conducted by the Lake Michigan Air Directors Consortium (LADCO), its member states, and various contractors. The analyses include preparation of regional emissions inventories and meteorological data, evaluation and application of regional chemical transport models, and collection and analysis of ambient monitoring data.

Monitoring data were analyzed to produce a conceptual understanding of the air quality problems. Key findings of the analyses include:

Ozone

- Current monitoring data (2005-2007) show about 20 sites in violation of the 8-hour ozone standard of 85 parts per billion (ppb). Historical ozone data show a steady downward trend over the past 15 years, especially since 2001-2003, due likely to federal and state emission control programs.
- Ozone concentrations are strongly influenced by meteorological conditions, with more high ozone days and higher ozone levels during summers with above normal temperatures.

- Inter- and intra-regional transport of ozone and ozone precursors affects many portions of the five states, and is the principal cause of nonattainment in some areas far from population or industrial centers.

PM_{2.5}

- Current monitoring data (2005-2007) show 30 sites in violation of the annual PM_{2.5} standard of 15 ug/m³. Nonattainment sites are characterized by an elevated regional background (about 12 – 14 ug/m³) and a significant local (urban) increment (about 2 – 3 ug/m³). Historical PM_{2.5} data show a slight downward trend since deployment of the PM_{2.5} monitoring network in 1999.
- PM_{2.5} concentrations are also influenced by meteorology, but the relationship is more complex and less well understood compared to ozone.
- On an annual average basis, PM_{2.5} chemical composition consists mostly of sulfate, nitrate, and organic carbon in similar proportions.

Haze

- Current monitoring data (2000-2004) show visibility levels in the Class I areas in northern Michigan are on the order of 22 – 24 deciviews. The goal of EPA's visibility program is to achieve natural conditions, which is about 12 deciviews for these Class I areas, by the year 2064.
- Visibility impairment is dominated by sulfate and nitrate.

Air quality models were applied to support the regional planning efforts. Two base years were used in the modeling analyses: 2002 and 2005. Basecase modeling was conducted to evaluate model performance (i.e., assess the model's ability to reproduce observed concentrations). This exercise was intended to build confidence in the model prior to its use in examining control strategies. Model performance for ozone and PM_{2.5} was found to be generally acceptable.

Future year strategy modeling was conducted to determine whether existing ("on the books") controls would be sufficient to provide for attainment of the standards for ozone and PM_{2.5} and if not, then what additional emission reductions would be necessary for attainment. Based on the modeling and other supplemental analyses, the following general conclusions can be made:

- Existing controls are expected to produce significant improvement in ozone and PM_{2.5} concentrations and visibility levels.
- The choice of the base year affects the future year model projections. A key difference between the base years of 2002 and 2005 is meteorology. 2002 was more ozone conducive than 2005. The choice of which base year to use as the basis for the SIP is a policy decision (i.e., how much safeguard to incorporate).
- Modeling suggests that most sites are expected to meet the current 8-hour ozone standard by the applicable attainment date, except for sites in western Michigan and, possibly, in eastern Wisconsin and northeastern Ohio.

- Modeling suggests that most sites are expected to meet the current PM_{2.5} standard by the applicable attainment date, except for sites in Detroit, Cleveland, and Granite City.

The regional modeling for PM_{2.5} does not include air quality benefits expected from local controls. States are conducting local-scale analyses and will use these results, in conjunction with the regional-scale modeling, to support their attainment demonstrations for PM_{2.5}.

- These findings of residual nonattainment for ozone and PM_{2.5} are supported by current (2005 – 2007) monitoring data which show significant nonattainment in the region (e.g., peak ozone design values on the order of 90 – 93 ppb, and peak PM_{2.5} design values on the order of 16 - 17 ug/m³). It is unlikely that sufficient emission reductions will occur in the next couple of years to provide for attainment at all sites.
- Attainment at most sites by the applicable attainment date is dependent on actual future year meteorology (e.g., if the weather conditions are consistent with [or less severe than] 2005, then attainment is likely) and actual future year emissions (e.g., if the emission reductions associated with the existing controls are achieved, then attainment is likely). If either of these conditions is not met, then attainment may be less likely.
- Modeling suggests that the new PM_{2.5} 24-hour standard and the new lower ozone standard will not be met at several sites, even by 2018, with existing controls.
- Visibility levels in a few Class I areas in the eastern U.S. are expected to be greater than (less improved than) the uniform rate of visibility improvement values in 2018 based on existing controls, including those in northern Michigan and some in the northeastern U.S. Visibility levels in many other Class I areas in the eastern U.S. are expected to be less than (more improved than) the uniform rate of visibility improvement values in 2018. These results, along with information on the costs of compliance, time necessary for compliance, energy and non air quality environmental impacts of compliance, and remaining useful life of existing sources, should be considered by the states in setting reasonable progress goals for regional haze.

Section 1.0 Introduction

This Technical Support Document summarizes the final air quality analyses conducted by the Lake Michigan Directors Consortium (LADCO)¹ and its contractors to support the development of State Implementation Plans (SIPs) for ozone, fine particles (PM_{2.5}), and regional haze in the States of Illinois, Indiana, Michigan, Ohio, and Wisconsin. The analyses include preparation of regional emissions inventories and meteorological modeling data for two base years (2002 and 2005), evaluation and application of regional chemical transport models, and analysis of ambient monitoring data.

Two aspects of the analyses should be emphasized. First, a regional, multi-pollutant approach was taken in addressing ozone, PM_{2.5}, and haze for technical reasons (e.g., commonality in precursors, emission sources, atmospheric processes, transport influences, and geographic areas of concern), and practical reasons (e.g., more efficient use of program resources). Furthermore, EPA has consistently encouraged multi-pollutant planning in its rule for the haze program (64 FR 35719), and its implementation guidance for ozone (70 FR 71663) and PM_{2.5} (72 FR 20609). Second, a weight-of-evidence approach was taken in considering the results of the various analyses (i.e., two sets of modeling results -- one for a 2002 base year and one for a 2005 base year -- and ambient data analyses) in order to provide a more robust assessment of expected future year air quality.

The report is organized in the following sections. This Introduction provides an overview of regulatory requirements and background information on regional planning. Section 2 reviews the ambient monitoring data and presents a conceptual model of ozone, PM_{2.5}, and haze for the region. Section 3 discusses the air quality modeling analyses, including development of the key model inputs (emissions inventory and meteorological data), and basecase model performance evaluation. A modeled attainment demonstration for ozone and PM_{2.5} is presented in Section 4, along with relevant data analyses considered as part of the weight-of-evidence determination. Section 5 documents the reasonable progress assessment for regional haze, along with relevant data analyses considered as part of the weight-of-evidence determination. Finally, key study findings are reviewed and summarized in Section 6.

1.1 SIP Requirements

For ozone, EPA promulgated designations on April 15, 2004 (69 FR 23858, April 30, 2004). In the 5-state region, more than 100 counties were designated as nonattainment.² The designations became effective on June 15, 2004. SIPs for ozone were due no later than three years from the effective date of the nonattainment designations (i.e., by June 2007). The attainment date for ozone varies as a function of nonattainment classification. For the region, the attainment dates are either June 2007 (marginal nonattainment areas), June 2009 (basic nonattainment areas), or June 2010 (moderate nonattainment areas).

¹ A sub-entity of LADCO, known as the Midwest Regional Planning Organization (MRPO), is responsible for the regional haze activities of the multi-state organization.

² Based on more recent air quality data, many counties in Indiana, Michigan, and Ohio were subsequently redesignated as attainment. As of December 31, 2007, there are 53 counties designated as nonattainment in the region.

For PM_{2.5}, EPA promulgated designations on December 17, 2004 (70 FR 944, January 5, 2005). In the 5-state region, 70 counties were designated as nonattainment.³ The designations became effective on April 5, 2005. SIPs for PM_{2.5} are due no later than three years from the effective date of the nonattainment designations (per section 172(b) of the Clean Air Act) (i.e., by April 2008) and for haze no later than three years after the date on which the Administrator promulgated the PM_{2.5} designations (per the Omnibus Appropriations Act of 2004) (i.e., by December 2007). The applicable attainment date for PM_{2.5} nonattainment areas is five years from the date of the nonattainment designation (i.e., by April 2010).

For haze, the Clean Air Act sets “as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in Class I areas which impairment results from manmade air pollution.” There are 156 Class I areas, including two in northern Michigan: Isle Royale National Park and Seney National Wildlife Refuge⁴. EPA’s visibility rule (64 FR 35714, July 1, 1999) requires reasonable progress in achieving “natural conditions” by the year 2064. As noted above, the first regional haze SIP was due in December 2007 and must address the initial 10-year implementation period (i.e., reasonable progress by the year 2018). SIP requirements (pursuant to 40 CFR 51.308(d)) include setting reasonable progress goals, determining baseline conditions, determining natural conditions, providing a long-term control strategy, providing a monitoring strategy (air quality and emissions), and establishing BART emissions limitations and associated compliance schedule.

1.2 Organization

LADCO was established by the States of Illinois, Indiana, Michigan, and Wisconsin in 1989. The four states and EPA signed a Memorandum of Agreement (MOA) that initiated the Lake Michigan Ozone Study (LMOS) and identified LADCO as the organization to oversee the study. Additional MOAs were signed by the States in 1991 (to establish the Lake Michigan Ozone Control Program), January 2000 (to broaden LADCO’s responsibilities), and June 2004 (to update LADCO’s mission and reaffirm the commitment to regional planning). In March 2004, Ohio joined LADCO. LADCO consists of a Board of Directors (i.e., the State Air Directors), a technical staff, and various workgroups. The main purposes of LADCO are to provide technical assessments for and assistance to its member states, and to provide a forum for its member states to discuss regional air quality issues.

MRPO is a similar entity led by the five LADCO States and involves the federally recognized tribes in Michigan and Wisconsin, EPA, and Federal Land Managers (i.e., National Park Service, U.S. Fish & Wildlife Agency, and U.S. Forest Service). In October 2000, the States of Illinois, Indiana, Michigan, Ohio, and Wisconsin signed an MOA that established the MRPO. An operating principles document for MRPO, which describe the roles and responsibilities of states, tribes, federal agencies, and stakeholders, was issued in March 2001. MRPO has a similar purpose as LADCO, but is focused on visibility impairment due to regional haze in the Federal Class I areas located inside the borders of the five states, and the impact of emissions from the five states on visibility impairment due to regional haze in the Federal Class I areas located outside the borders of the five states. MRPO works cooperatively with the Regional Planning Organizations (RPOs) representing other parts of the country. The RPOs sponsored several

³ USEPA subsequently adjusted the final designations, which resulted in 63 counties in the region being designated as nonattainment (70 FR 19844, April 15, 2005).

⁴ Although Rainbow Lake in northern Wisconsin is also a Class I area, the visibility rule does not apply because the Federal Land Manager determined that visibility is not an air quality related value there.

joint projects and, with assistance by EPA, maintain regular contact on technical and policy matters.

1.3 Technical Work: Overview

To ensure the reliability and effectiveness of its planning process, LADCO has made data collection and analysis a priority. More than \$7M in RPO grant funds were used for special purpose monitoring, preparing and improving emissions inventories, and conducting air quality analyses⁵. An overview of the technical work is provided below.

Monitoring: Numerous monitoring projects were conducted to supplement on-going state and local air pollution monitoring. These projects include rural monitoring (e.g., comprehensive sampling in the Seney National Wildlife Refuge and in Bondville, IL); urban monitoring (e.g., continuation of the St. Louis Supersite); aloft (aircraft) measurements; regional ammonia monitoring; and organic speciation sampling in Seney, Bondville, and five urban areas.

Emissions: Baseyear emissions inventories were prepared for 2002 and 2005. States provided point source and area source emissions data, and MOBILE6 input files and mobile source activity data. LADCO and its contractors developed the emissions data for other source categories (e.g., select nonroad sources, ammonia, fires, and biogenics) and processed the data for input into an air quality model. To support control strategy modeling, future year inventories were prepared. The future years of interest include 2008 (planning year to address the 2009 attainment year for basic ozone nonattainment areas), 2009 (planning year to address the 2010 attainment year for PM_{2.5} and moderate ozone nonattainment areas), 2012 (planning to address a 2013 alternative attainment date), and 2018 (first milestone year for regional haze).

Air Quality Analyses: The weight-of-evidence approach relies on data analysis and modeling. Air quality data analyses were used to provide both a conceptual model (i.e., a qualitative description of the ozone, PM_{2.5}, and regional haze problems) and supplemental information for the attainment demonstration. Given uncertainties in emissions inventories and modeling, especially for PM_{2.5}, these data analyses are a necessary part of the overall technical support.

Modeling includes baseyear analyses for 2002 and 2005 to evaluate model performance and future year strategy analyses to assess candidate control strategies. The analyses were conducted in accordance with EPA's modeling guidelines (EPA, 2007a). The PM/haze modeling covers the full calendar year (2002 and 2005) for an eastern U.S. 36 km domain, while the ozone modeling focuses on the summer period (2002 and 2005) for a Midwest 12 km subdomain. The same model (CAMx) was used for ozone, PM_{2.5}, and regional haze.

⁵ Since 1999, MRPO has received almost \$10M in RPO grant funds from USEPA.

Section 2.0 Ambient Data Analyses

An extensive network of air quality monitors in the 5-state region provides data for ozone (and its precursors), PM_{2.5} (both total mass and individual chemical species), and visibility. These data are used to determine attainment/nonattainment designations, support SIP development, and provide air quality information to public (see, for example, www.airnow.gov).

Analyses of the data were conducted to produce a conceptual model, which is a qualitative summary of the physical, chemical, and meteorological processes that control the formation and distribution of pollutants in a given region. This section reviews the relevant data analyses and describes our understanding of ozone, PM_{2.5}, and regional haze with respect to current conditions, data variability (spatial, temporal, and chemical), influence of meteorology (including transport patterns), precursor sensitivity, and source culpability.

2.1 Ozone

In 1979, EPA adopted an ozone standard of 0.12 ppm, averaged over a 1-hour period. This standard is attained when the number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than 1.0, averaged over a 3-year period, which generally reflects a design value (i.e., the 4th highest daily 1-hour value over a 3-year period) less than 0.12 ppm.

In 1997, EPA tightened the ozone standard to 0.08 ppm, averaged over an 8-hour period⁶. The standard is attained if the 3-year average of the 4th-highest daily maximum 8-hour average ozone concentrations (i.e., the design value) measured at each monitor within an area is less than 0.08 ppm (or 85 ppb).

Current Conditions: A map of the 8-hour ozone design values at each monitoring site in the region for the 3-year period 2005-2007 is shown in Figure 1. The “hotter” colors represent higher concentrations, where yellow and orange dots represent sites with design values above the standard. Currently, there are 19 sites in violation of the 8-hour ozone NAAQS in the 5-state region, including sites in the Lake Michigan area, Detroit, Cleveland, Cincinnati, and Columbus.

Table 1 provides the 4th-highest daily 8-hour ozone values and the associated design values since 2001 for several high monitoring sites throughout the region.

⁶ On March 12, 2008, USEPA further tightened the 8-hour ozone standard to increase public health protection and prevent environmental damage from ground-level ozone. USEPA set the primary (health) standard and secondary (welfare) standard at the same level: 0.075 ppm (75 ppb), averaged over an 8-hour period.

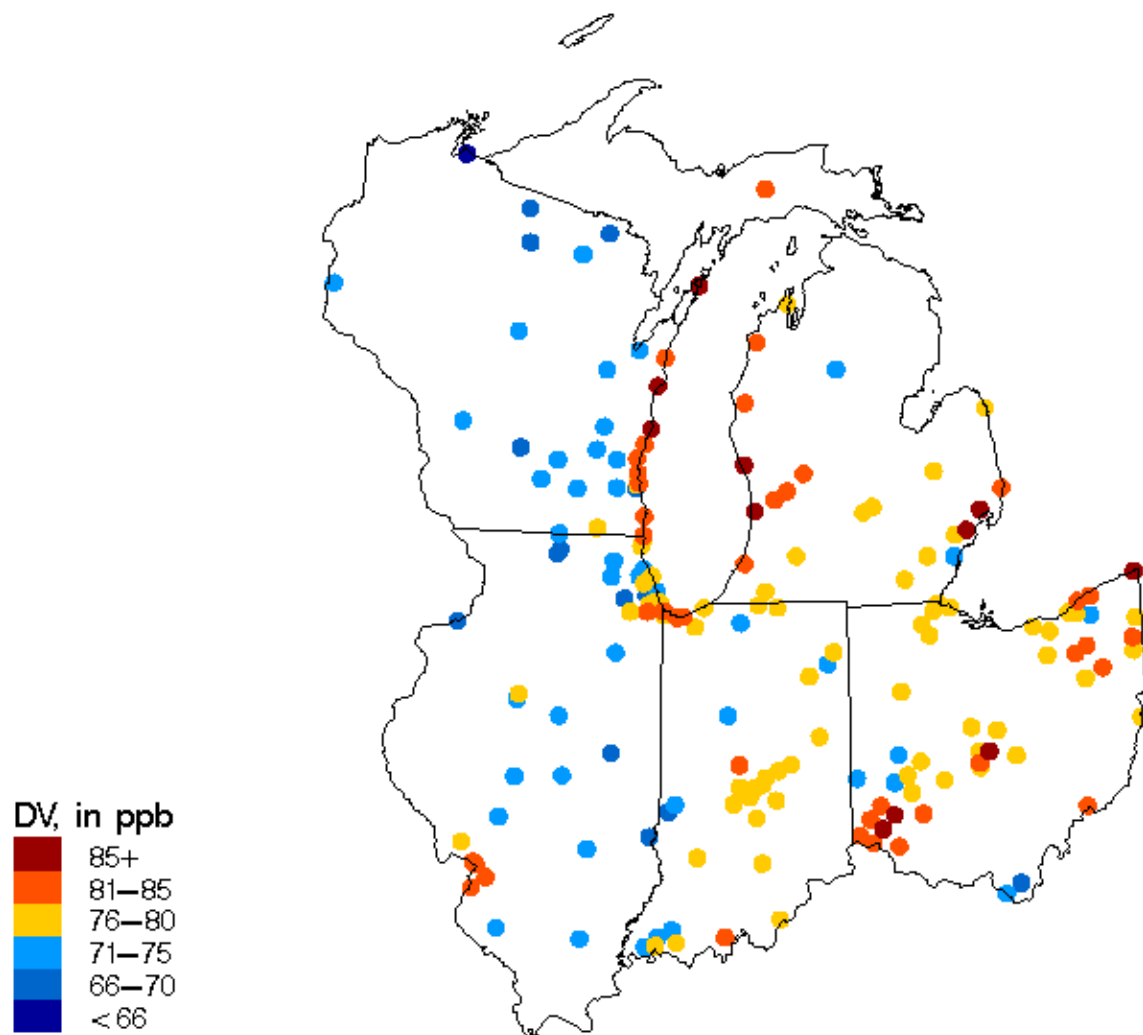


Figure 1. 8-hour ozone design values (2005-2007)

Table 1. Ozone Data for Select Sites in 5-State Region

Key Sites	4th High 8-hour Value							Design Values				
	'01	'02	'03	'04	'05	'06	'07	'01-'03	'02-'04	'03-'05	'04-'06	'05-'07
Lake Michigan Area												
Chiwaukee	99	116	88	78	93	79	85	101	94	86	83	85
Racine	92	111	82	69	95	71	77	95	87	82	78	81
Milwaukee-Bayside	93	99	92	73	93	73	83	94	88	86	79	83
Harrington Beach	102	93	99	72	94	72	84	98	88	88	79	83
Manitowoc	97	83	92	74	95	78	85	90	83	87	82	86
Sheboygan	102	105	93	78	97	83	88	100	92	89	86	89
Kewaunee	90	92	97	73	88	76	85	93	87	86	79	83
Door County	95	95	93	78	101	79	92	94	88	90	86	90
Hammond	90	101	81	67	87	75	77	90	83	78	76	79
Whiting				64	88	81	88				77	85
Michigan City	90	107	82	70	84	75	73	93	86	78	76	77
Ogden Dunes	85	101	77	69	90	70	84	87	82	78	76	81
Holland	92	105	96	79	94	91	94	97	93	89	88	93
Jenison	86	93	91	69	86	83	88	90	84	82	79	85
Muskegon	95	96	94	70	90	90	86	95	86	84	83	88
Indianapolis Area												
Noblesville	88	101	101	75	87	77	84	96	92	87	79	82
Fortville	89	101	92	72	80	75	81	94	88	81	75	78
Fort B. Harrison	87	100	91	73	80	76	83	92	88	81	76	79
Detroit Area												
New Haven	95	95	102	81	88	78	93	97	92	90	82	86
Warren	94	92	101	71	89	78	91	95	88	87	79	86
Port Huron	84	100	87	74	88	78	89	90	87	83	80	85
Cleveland Area												
Ashtabula (Conneaut)	97	103	99	81	93	86	92	99	94	91	86	90
Notre Dame (Geauga)	99	115	97	75	88	70	68	103	95	86	77	75
Eastlake (Lake)	89	104	92	79	97	83	74	95	91	89	86	84
Akron (Summit)	98	103	89	77	89	77	91	96	89	85	81	85
Cincinnati Area												
Wilmington (Clinton)	93	99	96	78	83	81	82	96	91	85	80	82
Sycamore (Hamilton)	88	100	93	76	89	81	90	93	89	86	82	86
Hamilton (Butler)	83	100	94	75	86	79	91	92	89	85	80	85
Middleton (Butler)	87	98	83	76	88	76	91	89	85	82	80	85
Lebanon (Warren)	85	98	95	81	92	86	88	92	91	89	86	88
Columbus Area												
London (Madison)	84	97	90	75	81	76	83	90	87	82	77	80
New Albany (Franklin)	90	103	94	78	92	82	87	95	91	88	84	87
Franklin (Franklin)	83	99	84	73	86	79	79	88	85	81	79	81
Ohio Other Areas												
Marietta (Washington)	85	95	80	77	88	81	86	86	84	81	82	85
St. Louis Area												
W. Alton (MO)	85	99	91	77	89	91	89	91	89	85	85	89
Orchard (MO)	88	98	90	76	92	92	83	92	88	86	86	89
Sunset Hills (MO)	88	98	88	70	89	80	89	91	85	82	79	86
Arnold (MO)	86	93	82	70	92	79	87	87	81	81	80	86
Margaretta (MO)	80	98	90	72	91	76	91	89	86	84	79	86
Maryland Heights (MO)					88	84	94					88

Meteorology and Transport: Most pollutants exhibit some dependence on meteorological factors, especially wind direction, because that governs which sources are upwind and thus most influential on a given sample. Ozone is even more dependent, since its production is driven by high temperatures and sunlight, as well as precursor concentrations (see, for example, Figure 2).

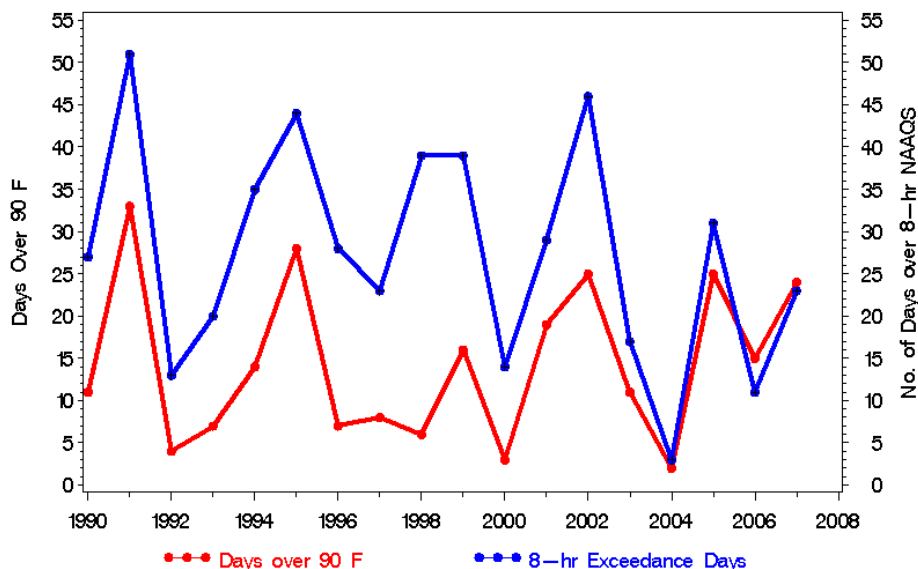


Figure 2. Number of hot days and 8-hour “exceedance” days in 5-state region

Qualitatively, ozone episodes in the region are associated with hot weather, clear skies (sometimes hazy), low wind speeds, high solar radiation, and southerly to southwesterly winds. These conditions are often a result of a slow-moving high pressure system to the east of the region. The relative importance of various meteorological factors is discussed later in this section.

Transport of ozone (and its precursors) is a significant factor and occurs on several spatial scales. Regionally, over a multi-day period, somewhat stagnant summertime conditions can lead to the build-up in ozone and ozone precursor concentrations over a large spatial area. This pollutant air mass can be advected long distances, resulting in elevated ozone levels in locations far downwind. An example of such an episode is shown in Figure 3.

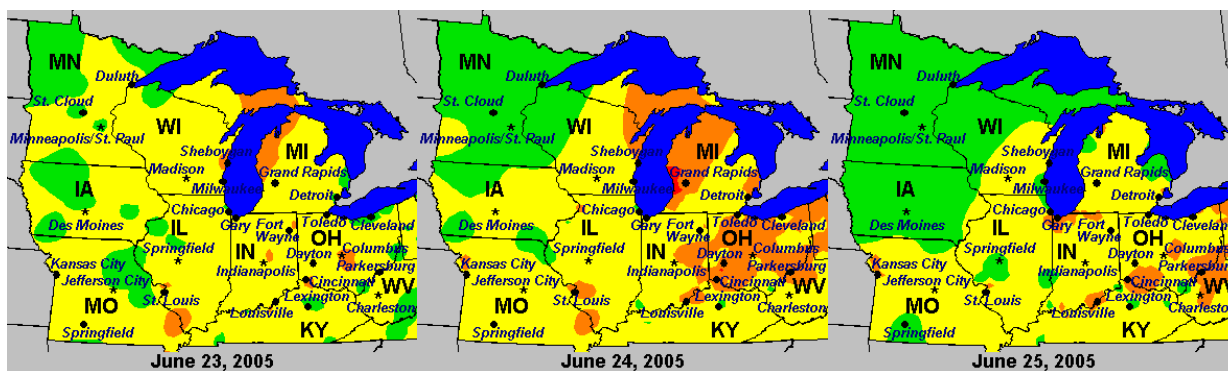


Figure 3. Example of elevated regional ozone concentrations (June 23 – 25, 2005)

Note: hotter colors represent higher concentrations, with orange representing concentrations above the 8-hour standard

Locally, emissions from urban areas add to the regional background leading to ozone concentration hot spots downwind. Depending on the synoptic wind patterns (and local land-lake breezes), different downwind areas are affected (see, for example, Figure 4).

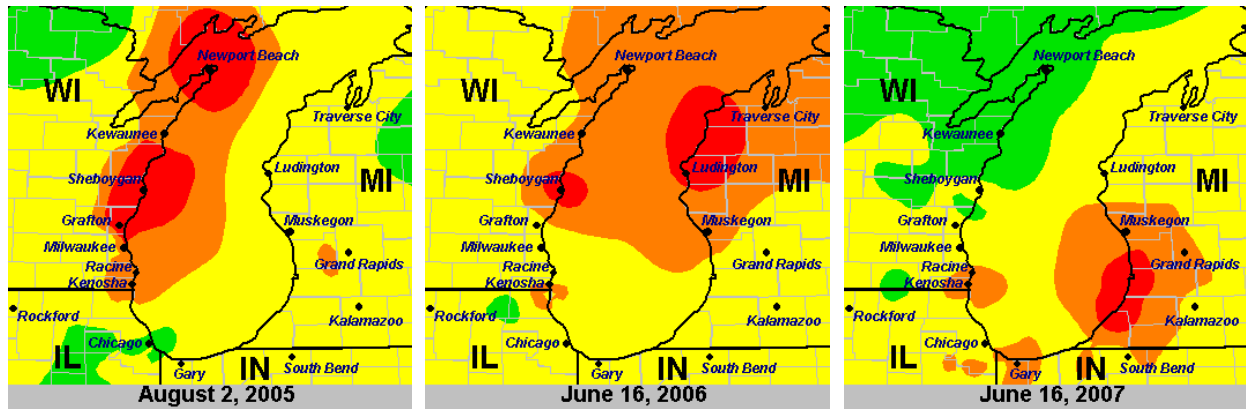


Figure 4. Examples of recent high ozone days in the Lake Michigan area

Note: hotter colors represent higher concentrations, with orange representing concentrations above the 8-hour standard

Aloft (aircraft) measurements in the Lake Michigan area also provide evidence of elevated regional background concentrations and “plumes” from urban areas. For one example summer day (August 20, 2003 – see Figure 5), the incoming background ozone levels were on the order of 80 – 100 ppb and the downwind ozone levels over Lake Michigan were on the order of 100 - 150 ppb (STI, 2004).

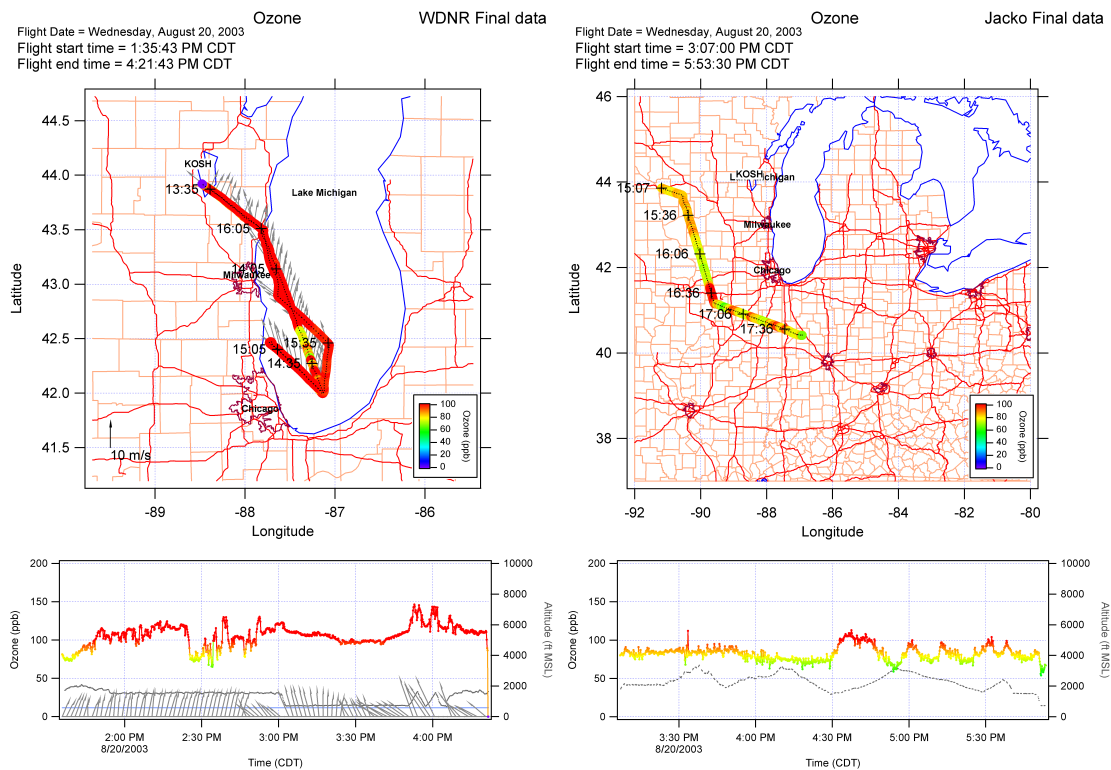


Figure 5. Aircraft ozone measurements over Lake Michigan (left) and along upwind boundary (right) – August 20, 2003 (Note: aircraft measurements reflect instantaneous values)

As discussed in Section 4, residual nonattainment is projected in at least one area in the 5-state region –i.e., western Michigan. To understand the source regions likely impacting high ozone concentrations in western Michigan and estimate the impact of these source regions, two simple transport-related analyses were performed.

First, back trajectories were constructed using the HYSPLIT model for high ozone days (8-hour peak > 80 ppb) during the period 2002-2006 in western Michigan to characterize general transport patterns. Composite trajectory plots for all high ozone days based on data from three sites (Cass County, Holland, and Muskegon) are provided in Figure 6. The plots point back to areas located to the south-southwest (especially, northeastern Illinois and northwestern Indiana) as being upwind on these high ozone days.

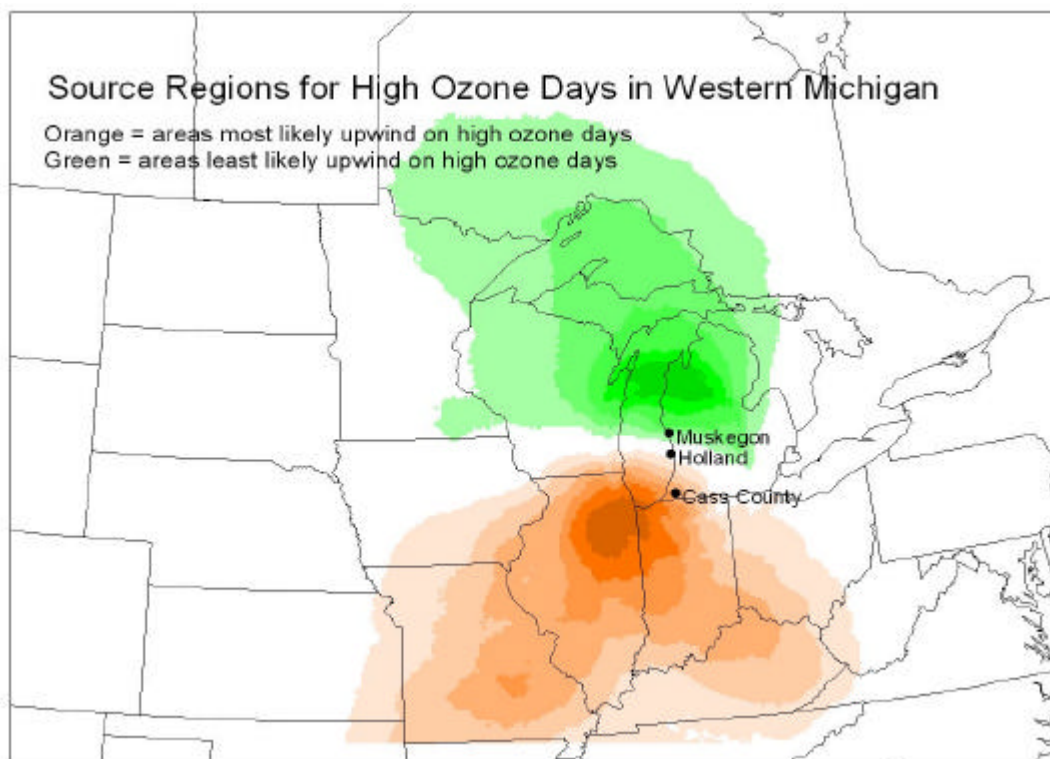


Figure 6 Back trajectory analysis showing upwind areas associated with high ozone concentrations

Second, to assess the impact from Chicago/NW Indiana, Blanchard (2005a) compared ozone concentrations upwind (Braidwood, IL), within Chicago (ten sites in the City), and downwind (Holland and Muskegon) for days in 1999 – 2002 with southwesterly winds - i.e., transport towards western Michigan. Figure 7 shows the distribution of daily peak 8-hour ozone concentrations by day-of-week, with a line connecting the mean values. The difference between day-of-week mean values at downwind and upwind sites indicates that Chicago/NW Indiana contributes about 10-15 ppb to downwind ozone levels.

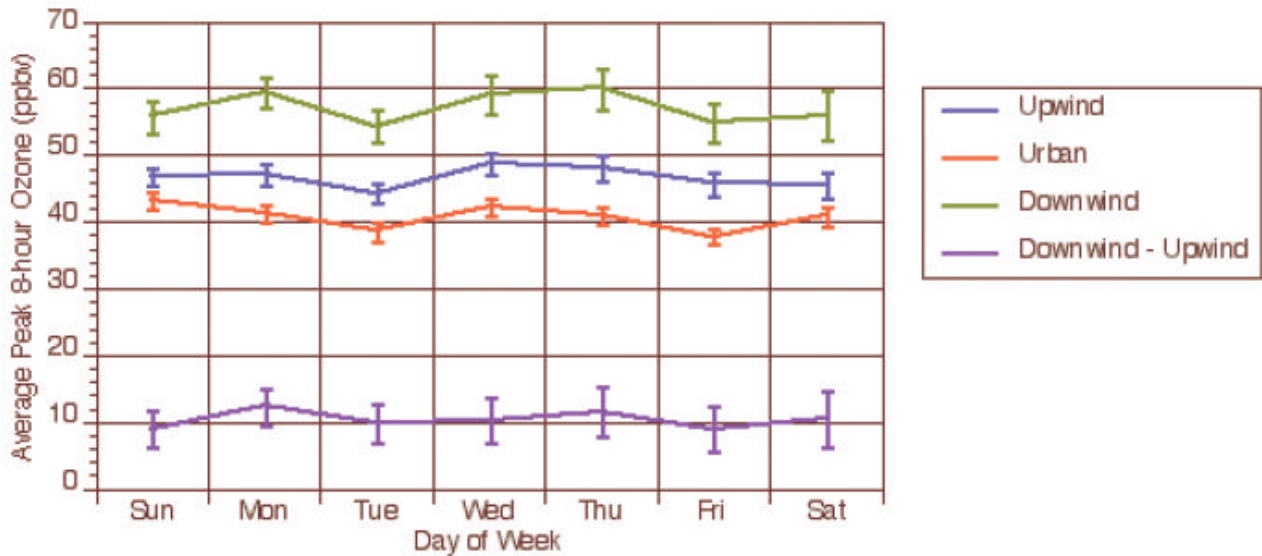


Figure 7. Mean day-of-week peak 8-hour ozone concentrations at sites upwind, within, and downwind of Chicago, 1999 – 2002 (southwesterly wind days)

Based on this information, the following key findings related to transport can be made:

- Ozone transport is a problem affecting many portions of the eastern U.S. The Lake Michigan area (and other areas in the LADCO region) both receive high levels of incoming (transported) ozone and ozone precursors from upwind source areas on many hot summer days, and contribute to the high levels of ozone and ozone precursors affecting downwind receptor areas.
- The presence of a large body of water (i.e., Lake Michigan) influences for the formation and transport of ozone in the Lake Michigan area. Depending on large-scale synoptic winds and local-scale lake breezes, different parts of the area experience high ozone concentrations. For example, under southerly flow, high ozone can occur in eastern Wisconsin, and under southwesterly flow, high ozone can occur in western Michigan.
- Downwind shoreline areas around Lake Michigan are affected by both regional transport of ozone and subregional transport from major cities in the Lake Michigan area. Counties along the western shore of Michigan (from Benton Harbor to Traverse City, and even as far north as the Upper Peninsula) are impacted by high levels of incoming (transported) ozone.

Data Variability: Since 1980, considerable progress has been made to meet the previous 1-hour ozone standard. Figure 8 shows the decline in both the 1-hour and 8-hour design values for the 5-state LADCO region over the last 25 years.

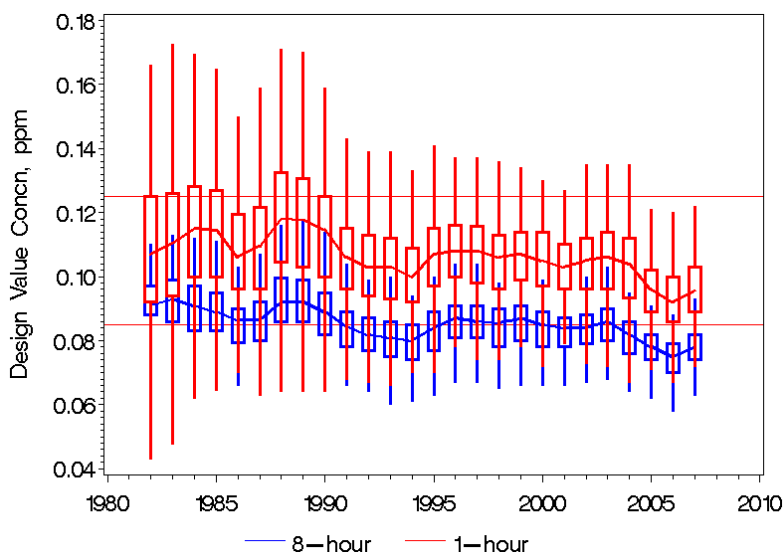


Figure 8 Ozone design value trends in 5-State region

The trend is more dramatic for the higher ozone sites in the 5-state region (see Figure 9). This plot shows a pronounced downward trend in the design value since the 2001-2003 period, due, in part, to the very low 4th high values in 2004.

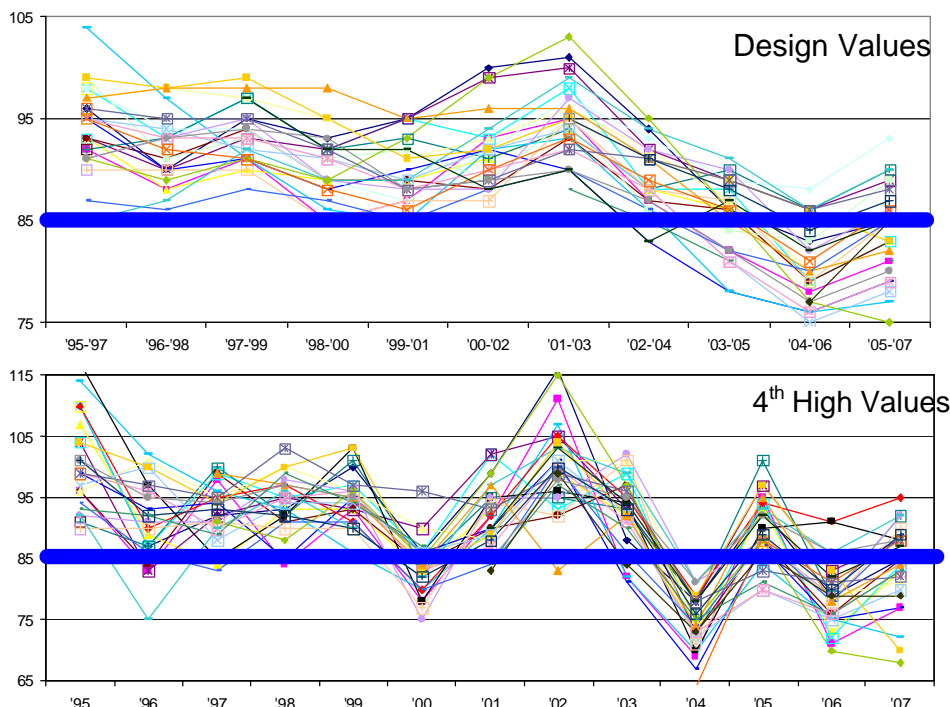


Figure 9. Trend in ozone design values and 4th high values for higher ozone sites in region

The improvement in ozone concentrations is also seen in the decrease in the number of sites measuring nonattainment over the past 15 years in the Lake Michigan area (see Figure 10).

Ozone Design Values, 1995_1997

Ozone Design Values, 2000_2002

Ozone Design Values, 2005_2007

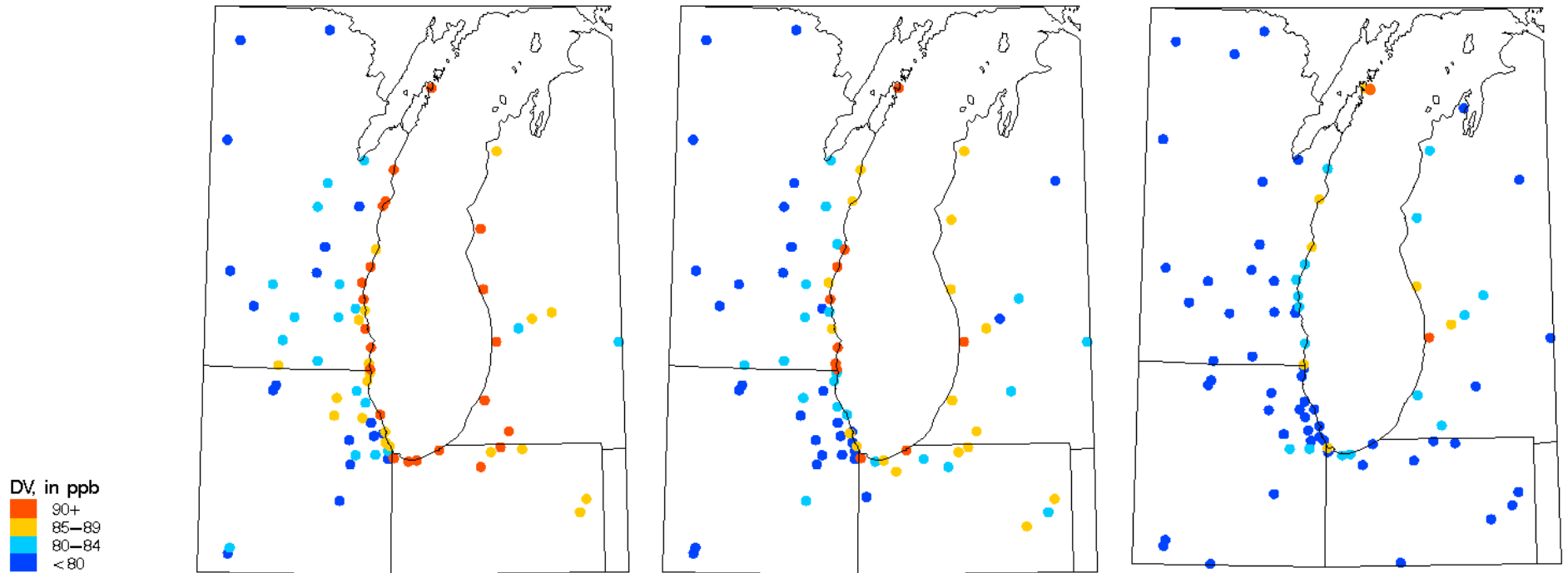


Figure 10. Ozone design value maps for 1995-1997, 2000-2002, and 2005-2007

Given the effect of meteorology on ambient ozone levels, year-to-year variations in meteorology can make it difficult to assess trends in ozone air quality. Two approaches were considered to adjust ozone trends for meteorological influences: an air quality-meteorology statistical model developed by EPA (i.e., Cox method), and statistical grouping of meteorological variables performed by LADCO (i.e., Classification and Regression Trees, or CART).

Cox Method: This method uses a statistical model to ‘remove’ the annual effect of meteorology on ozone (Cox and Chu, 1993). A regression model was fit to the 1997-2007 data to relate daily peak 8-hour ozone concentrations to six daily meteorological variables plus seasonal and annual factors (Kenski, 2008a). Meteorological variables included were daily maximum temperature, mid-day average relative humidity, morning and afternoon wind speed and wind direction. The model is then used to predict 4th high ozone values. By holding the meteorological effects constant, the long term trend can be examined independently of meteorology. Presumably, any trend reflects changes in emissions of ozone precursors.

Figure 11a shows the meteorologically-adjusted 4th high ozone concentrations for several monitors near major urban areas in the region. The plots indicate a general downward trend since the late 1990s for most cities, indicating that recent emission reductions have had a positive effect in improving ozone air quality.

A similar model was run to examine meteorologically adjusted trends in seasonal average ozone. This model incorporates more meteorological variables, including rain and long-distance transport (direction and distance). Model development was documented in Camalier et al., 2007. The seasonal average trends are shown in Figure 11b. Trends determined by seasonal model for the same set of sites examined above are consistent with those developed by the 4th high model.

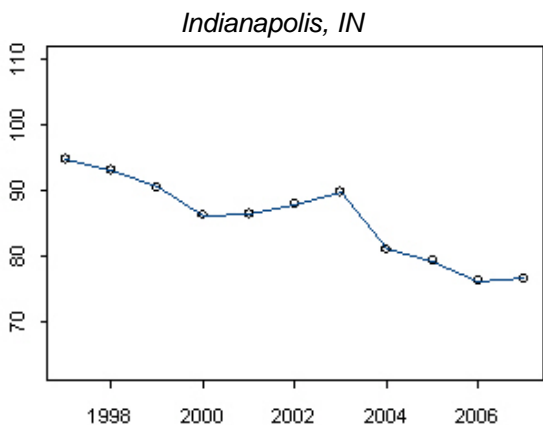
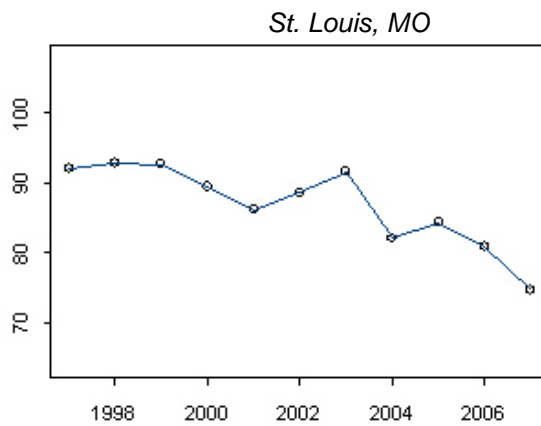
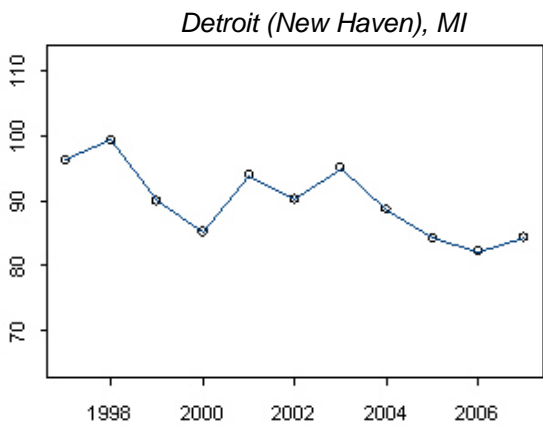
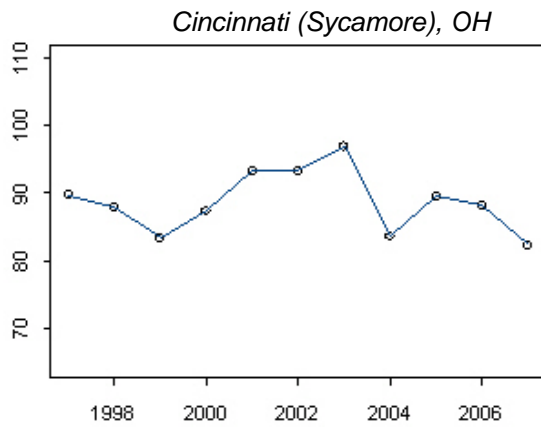
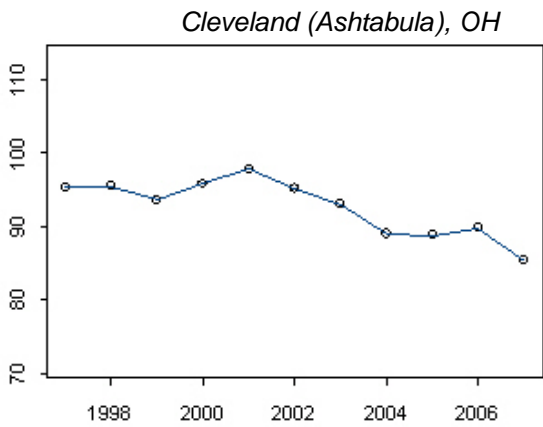
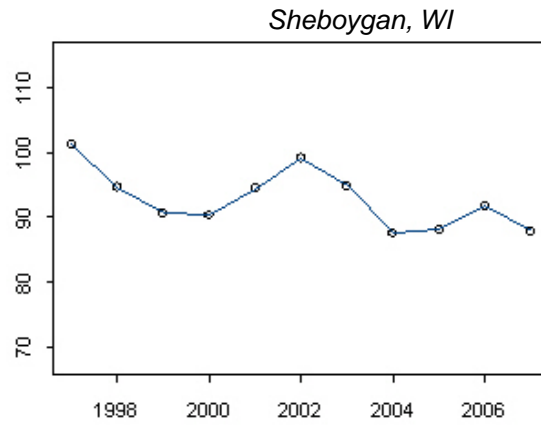
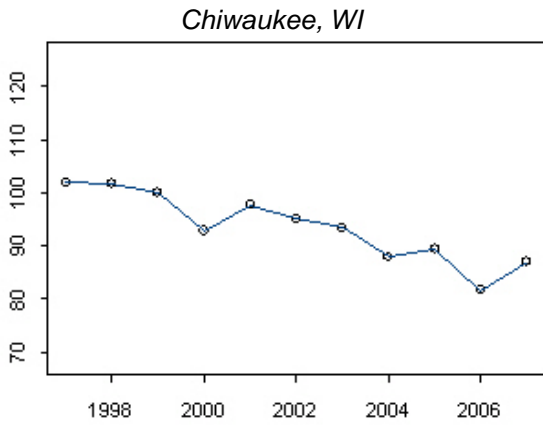


Figure 11a. Trends in meteorologically adjusted 4th high 8-hour ozone concentrations for seven Midwestern sites (1997 – 2007)

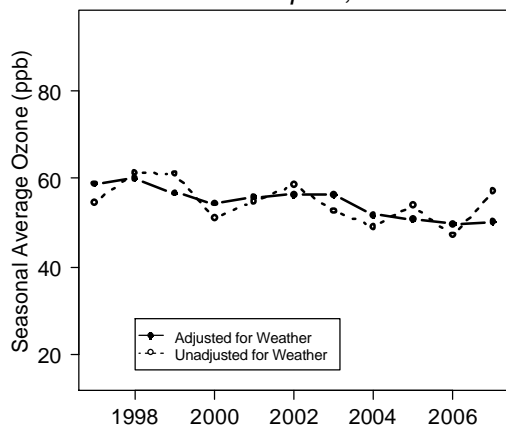
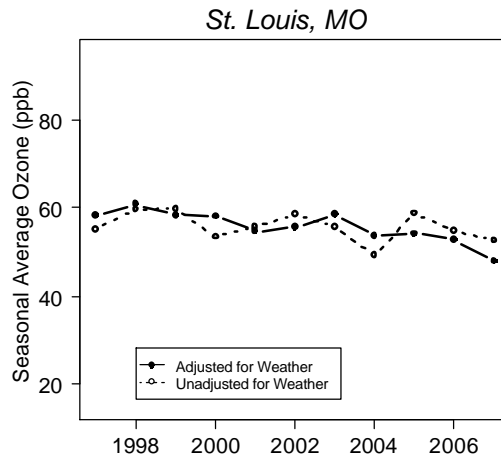
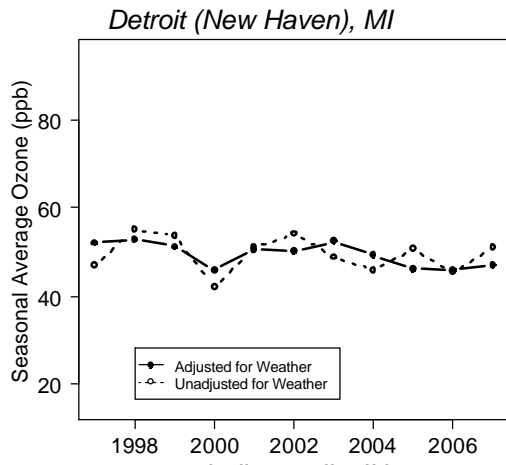
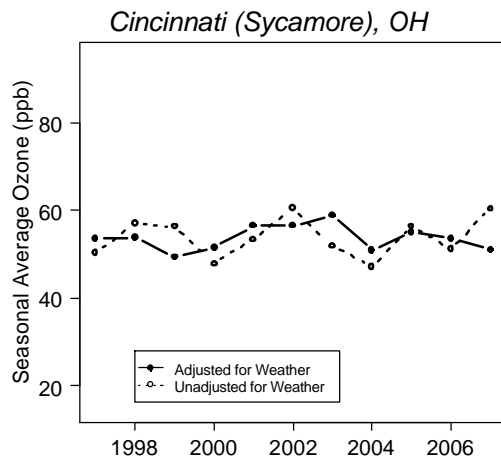
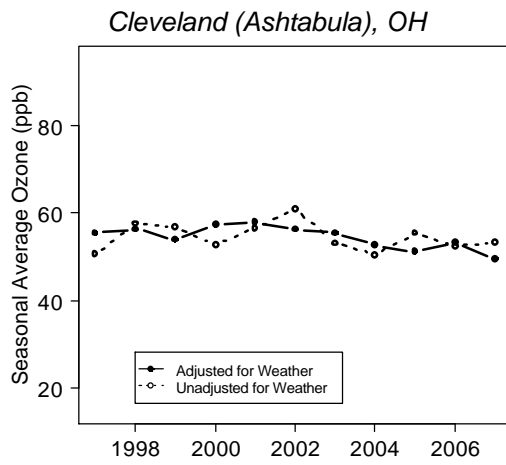
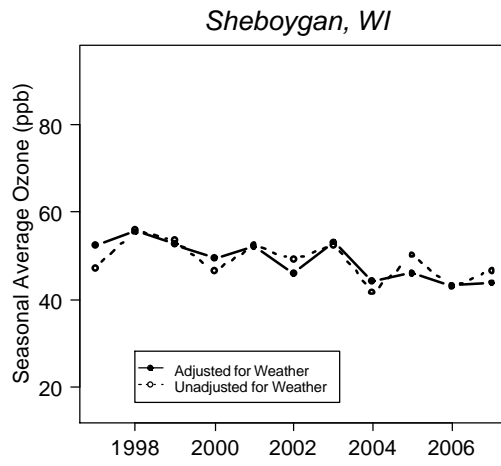
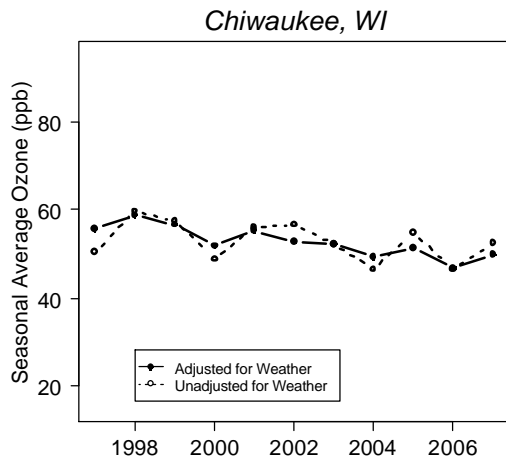


Figure 11b. Trends in seasonal 8-hour ozone concentrations for seven Midwestern sites (1997 – 2007)

CART: Classification and Regression Tree (*CART*) analysis is another statistical technique which partitions data sets into similar groups (Breiman et al., 1984). *CART* analysis was performed using data for the period 1995-2007 for 22 selected ozone monitors with current 8-hour design values close to or above the standard (Kenski, 2008b). The *CART* model searches through 60 meteorological variables to determine which are most efficient in predicting ozone. Although the exact selection of predictive variables changes from site to site, the most common predictors were temperature, wind direction, and relative humidity. Only occasionally were upper air variables, transport time or distance, lake breeze, or other variables significant. (Note, the ozone and meteorological data for the *CART* analysis are the same as used in the EPA/Cox analysis.)

For each monitor, regression trees were developed that classify each summer day (May-September) by its meteorological conditions. Similar days are assigned to nodes, which are equivalent to branches of the regression tree. Ozone time series for the higher concentration nodes are plotted for select sites in Figure 12. By grouping days with similar meteorology, the influence of meteorological variability on the trend in ozone concentrations is partially removed; the remaining trend is presumed to be due to trends in precursor emissions or other non-meteorological influences. Trends over the 13-year period at most sites were found to be declining, with the exception of Detroit which showed fairly flat trends. Comparison of the average of the high concentration node values for 2001-2003 v. 2005-2007 showed an improvement of about 5 ppb across all sites (even Detroit).

The effect of meteorology was further examined by using an ozone conduciveness index (Kenski, 2008b). This metric reflects the variability from the 13-year average in the number of days in the higher ozone concentration nodes (see Figure 13). Examination of these plots indicates:

- 2002 and 2005 were both above normal, with 2002 tending to be more severe; and
- 2001-2003 and 2005-2007 were both above normal, with no clear pattern in which period was more severe (i.e., ozone conduciveness values were similar at most sites, 2001-2003 values were higher at a few sites, and 2005-2007 values were higher at a few sites).

Given the similarity in ozone conduciveness between 2001-2003 and 2005-2007, the improvement in ozone levels noted above is presumed to be due to non-meteorological factors (i.e., emission reductions).

In conclusion, all three statistical approaches (*CART* and the two nonlinear regression models) show a similar result; ozone in the urban areas of the LADCO region has declined during the 1997-2007 period, even when meteorological variability is accounted for. The decreases are present whether seasonal average ozone, peak values (annual 4th highs), or a subset of high days with similar meteorology are considered. The consistency in results across models is a good indication that these trends reflect impacts of emission control programs.

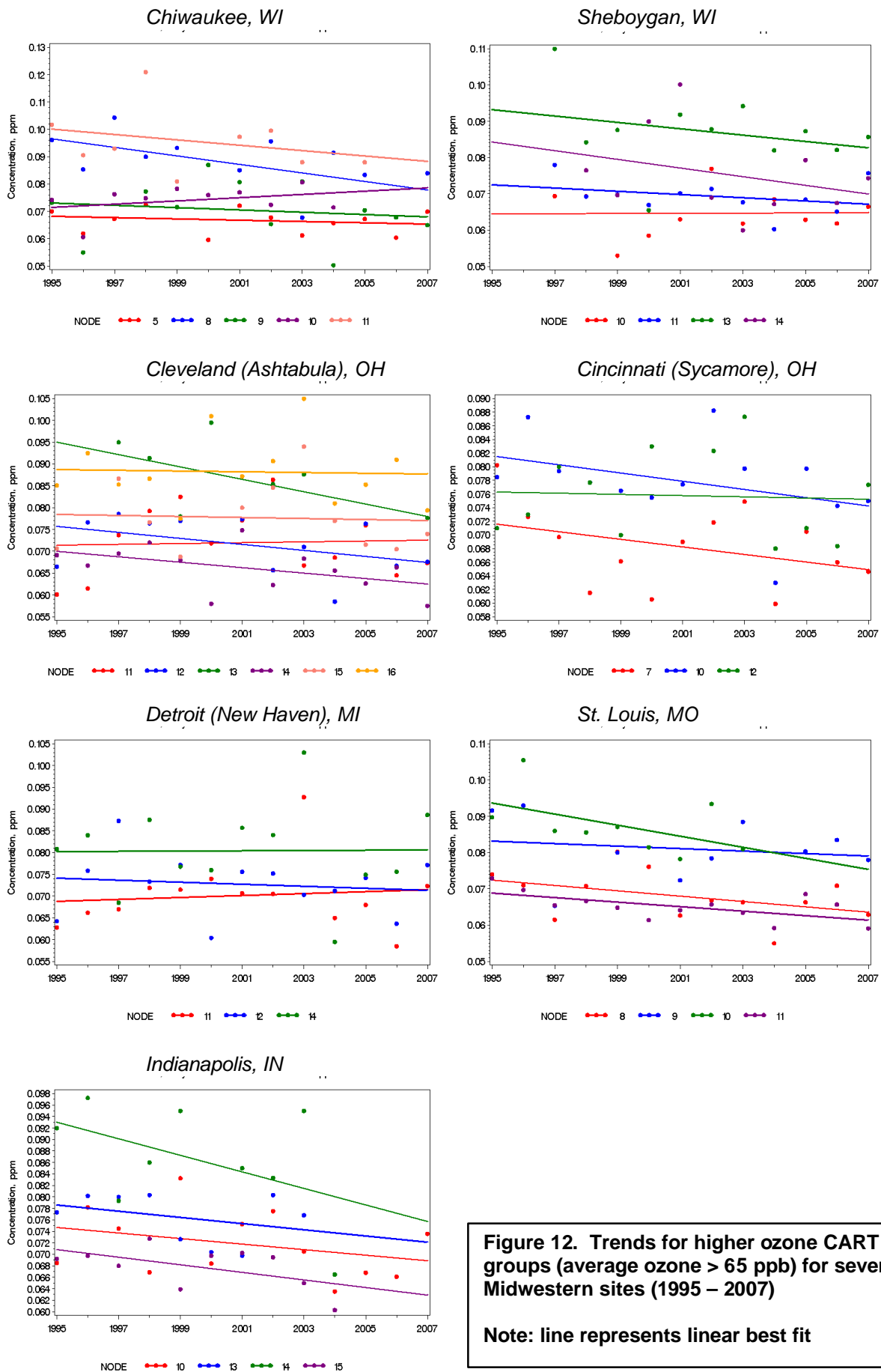


Figure 12. Trends for higher ozone CART groups (average ozone > 65 ppb) for seven Midwestern sites (1995 – 2007)

Note: line represents linear best fit

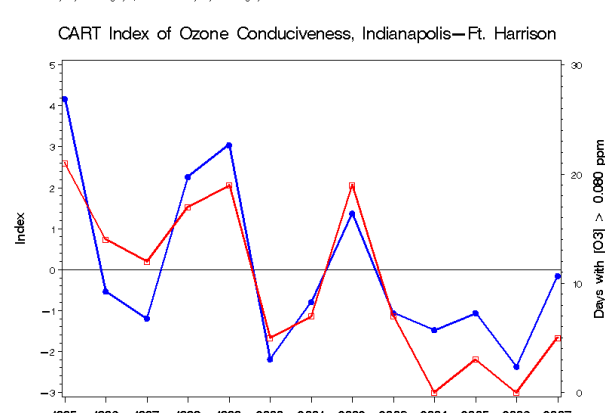
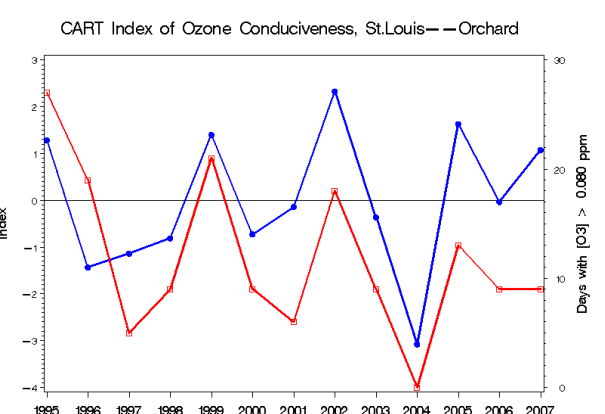
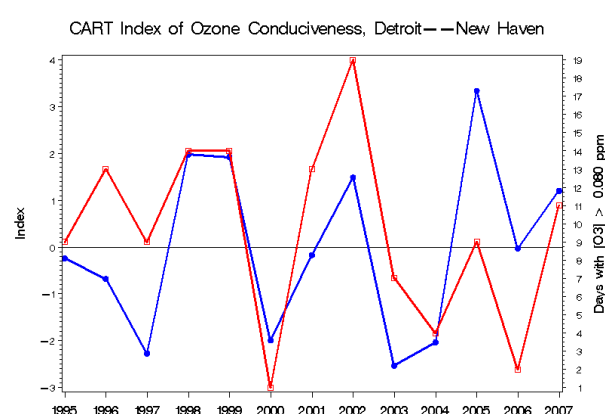
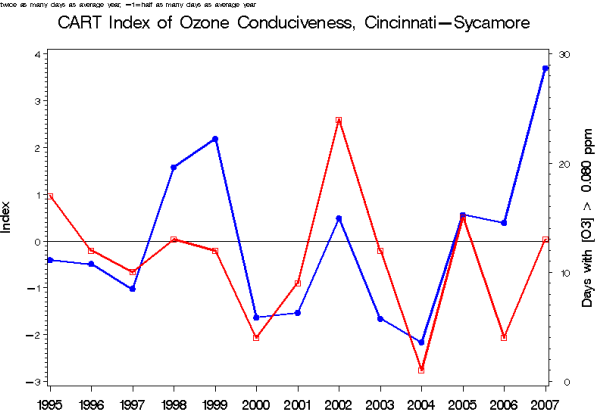
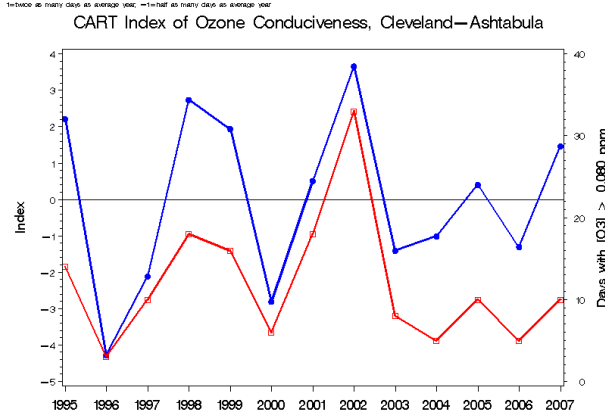
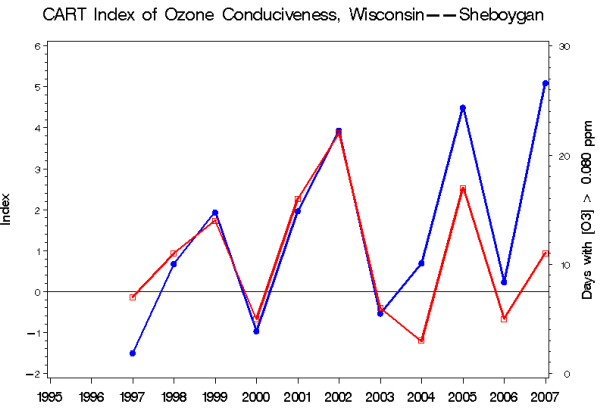
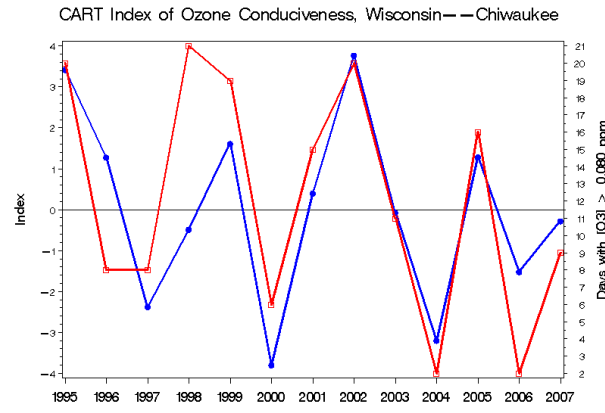


Figure 13. Ozone conduciveness index (and number of high ozone days) for seven Midwestern site (1995 – 2007)

Precursor Sensitivity: Ozone is formed from the reactions of hydrocarbons and nitrogen oxides under meteorological conditions that are conducive to such reactions (i.e., warm temperatures and strong sunlight). In areas with high VOC/NO_x ratios, typical of rural environments (with low NO_x), ozone tends to be more responsive to reductions in NO_x. Conversely, in areas with low VOC/NO_x ratios, typical of urban environments (with high NO_x), ozone tends to be more responsive to VOC reductions.

An analysis of VOC and NO_x-limitation was conducted with the ozone MAPPER program, which is based on the Smog Production (SP) algorithm (Blanchard, et al., 2003). The “Extent of Reaction” parameter in the SP algorithm provides an indication of VOC and NO_x sensitivity:

Extent Range	Precursor Sensitivity
< 0.6	VOC-sensitive
0.6 – 0.8	Transitional
> 0.8	NO _x -sensitive

A map of the Extent of Reaction values for high ozone days is provided in Figure 14. As can be seen, ozone is usually VOC-limited in cities and NO_x-limited in rural areas. (Data from aircraft measurements suggest that ozone is usually NO_x-limited over Lake Michigan and away from urban centers on days when ozone in the urban centers is VOC-limited.) The highest ozone days were found to be NO_x-limited. This analysis suggests that a NO_x reduction strategy would be effective in reducing ozone levels. Examination of day-of-week concentrations, however, raises some question about the effectiveness of NO_x reductions.

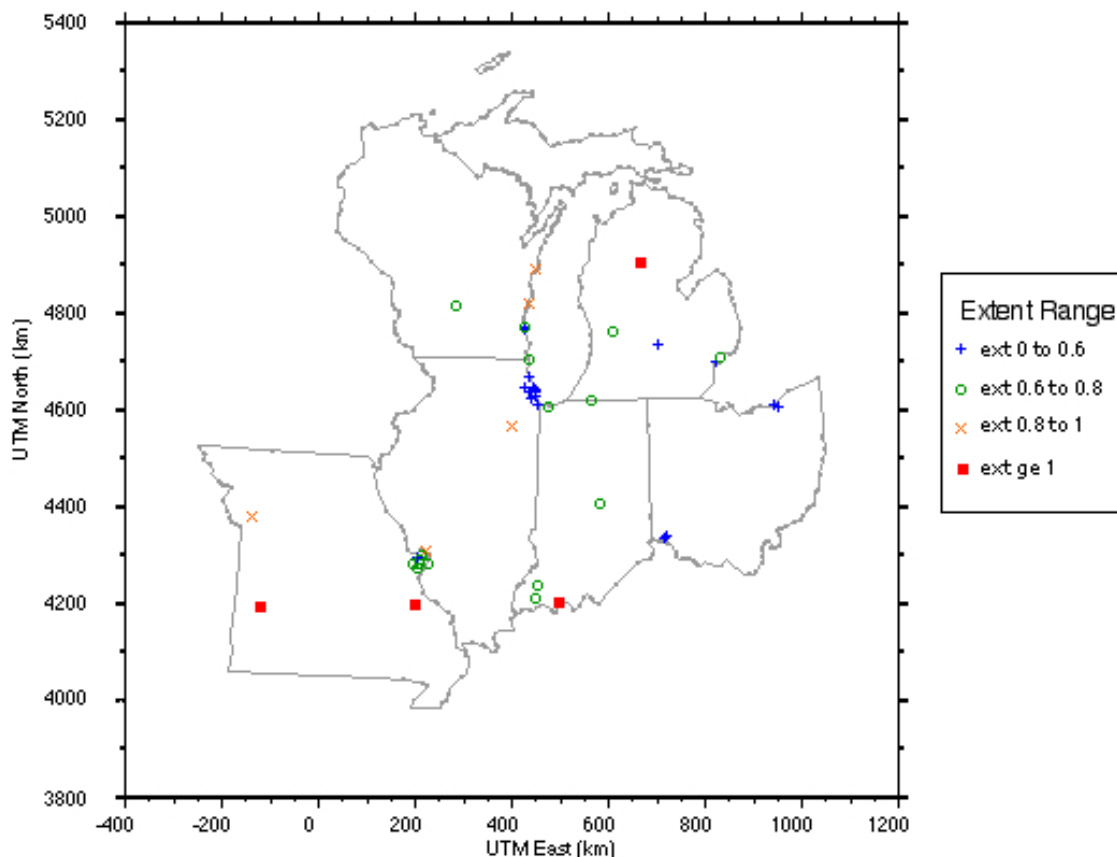


Figure 14. Mean afternoon extent of reaction (1998 – 2002)

Blanchard (2004 and 2005a) examined weekend-weekday differences in ozone and NO_x in the Midwest. All urban areas in these two studies exhibited substantially lower (40-60%) weekend concentrations of NO_x compared to weekday concentrations. Despite lower weekend NO_x concentrations, weekend ozone concentrations were not lower; in fact, most urban sites had higher concentrations of ozone, although the increase was generally not statistically significant (see Figure 15). This small but counterproductive change in **local** ozone concentrations suggests that **local** urban-scale NO_x reductions alone may not be very effective.

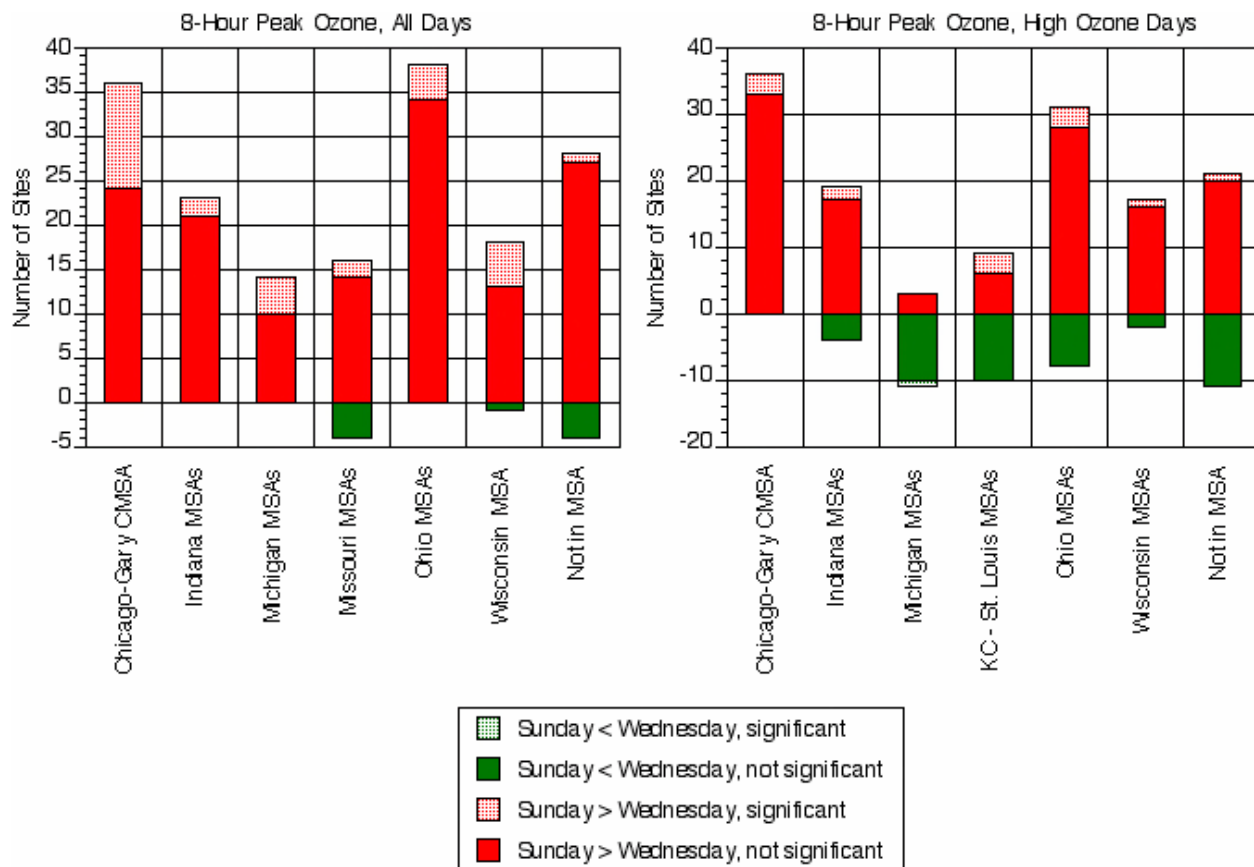


Figure 15. Weekday/weekend differences in 8-hour ozone – number of sites with weekend increase (positive values) v. number of sites with weekend decreases (negative values)

Two additional analyses, however, demonstrate the positive effect of NO_x emission reductions on downwind ozone concentrations. First, Blanchard (2005a) looked at the effect of changes in precursor emissions in Chicago on downwind ozone levels in western Michigan. For the transport days of interest (i.e., southwesterly flow during the summers of 1999 – 2002), mean NO_x concentrations in Chicago are about 50% lower and mean ozone concentrations at the (downwind) western Michigan sites are about 1.5 – 5.2 ppb (3 – 8 %) lower on Sunday compared to Wednesday. This degree of change in downwind ozone levels suggests a positive, albeit non-linear response to urban area emission reductions.

Second, Environ (2007a) examined the effect of differences in day-of-week emissions in southeastern Michigan on downwind ozone levels. This modeling study found that weekend changes in ozone precursor emissions cause both increases and decreases in Southeast Michigan ozone, depending upon location and time:

- Weekend increases in 8-hour maximum ozone occur in and immediately downwind of the Detroit urban area (i.e., in VOC-sensitive areas).
- Weekend decreases in 8-hour maximum ozone occur outside and downwind of the Detroit urban area (i.e., in NOx-sensitive areas).
- At the location of the peak 8-hour ozone downwind of Detroit, ozone was lower on weekends than weekdays.
- Ozone benefits (reductions) due to weekend emission changes in Southeast Michigan can be transported downwind for hundreds of miles.
- Southeast Michigan benefits from lower ozone transported into the region on Saturday through Monday because of weekend emission changes in upwind areas.

In summary, these analyses suggest that urban VOC reductions and regional (urban and rural) NOx reductions will be effective in lowering ozone concentrations. Local NOx reductions can lead to local ozone increases (i.e., NOx disbenefits), but this effect does not appear to pose a problem with respect to attainment of the standard. It should also be noted that urban VOC and regional NOx reductions are likely to have multi-pollutant benefits (e.g., both lower ozone and PM_{2.5} impacts).

2.2 PM_{2.5}

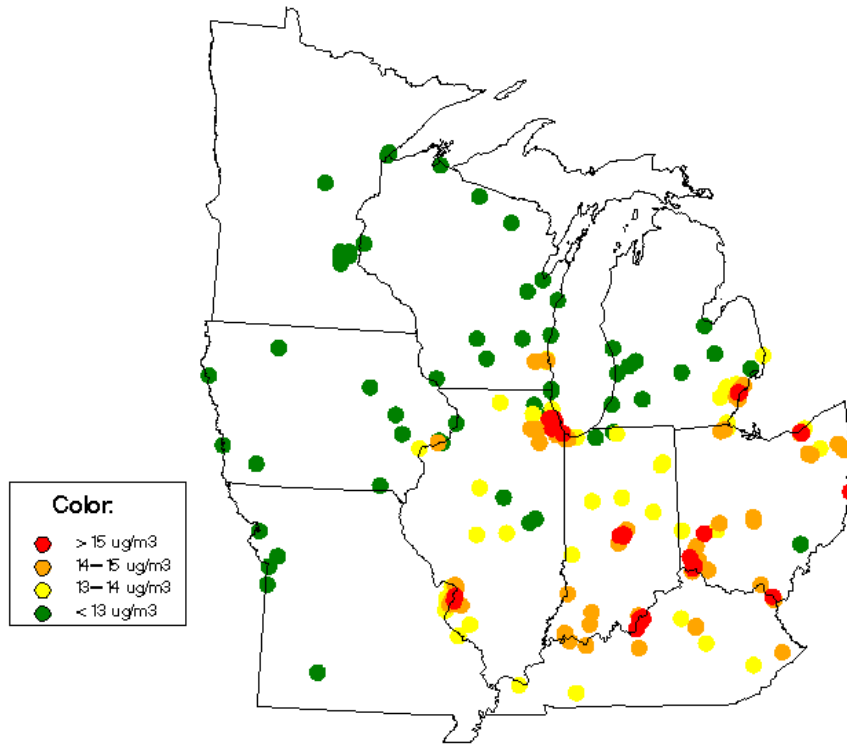
In 1997, EPA adopted the PM_{2.5} standards of 15 ug/m³ (annual average) and 65 ug/m³ (24-hour average). The annual standard is attained if the 3-year average of the annual average PM_{2.5} concentration is less than or equal to the level of the standard. The daily standard is attained if the 98th percentile of 24-hour PM_{2.5} concentrations in a year, averaged over three years, is less than or equal to the level of the standard.

In 2006, EPA revised the PM_{2.5} standards to 15 ug/m³ (annual average) and 35 ug/m³ (24-hour average).

Current Conditions: Maps of annual and 24-hour PM_{2.5} design values for the 3-year period 2005-2007 are shown in Figure 16. The “hotter” colors represent higher concentrations, where red dots represent sites with design values above the annual standard. Currently, there are 30 sites in violation of the annual PM_{2.5} standard.

Table 2 provides the annual PM_{2.5} concentrations and associated design values since 2003 for several high monitoring sites throughout the region.

PM_{2.5} FRM Annual Design Values, 2005–2007



PM_{2.5} FRM 98th Percentile Concentration, 2005–2007

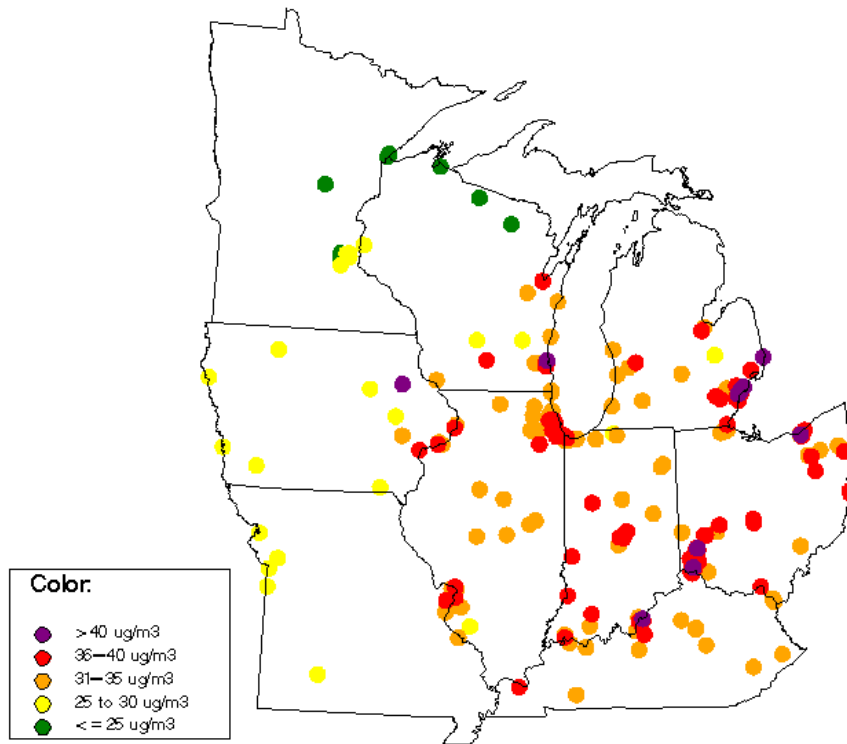


Figure 16. PM_{2.5} design values - annual average (top) and 24-hour average (bottom) (2005-2007)

Table 2. PM2.5 Data for Select Sites in 5-State Region

Key Site	County	Site ID	Annual Average Conc.					Design Values			2005 BY	2002 BY
			'03	'04	'05	'06	'07	'03 - '05	'04 - '06	'05 - '07	Average w/ 2007	Average
Chicago - Washington HS	Cook	170310022	15.6	14.2	16.9	13.2	15.7	15.6	14.8	15.3	15.2	15.9
Chicago - Mayfair	Cook	170310052	15.9	15.3	17.0	14.5	15.5	16.1	15.6	15.7	15.8	17.1
Chicago - Springfield	Cook	170310057	15.6	13.8	16.7	13.5	15.1	15.4	14.7	15.1	15.0	15.6
Chicago - Lawndale	Cook	170310076	14.8	14.2	16.6	13.5	14.3	15.2	14.8	14.8	14.9	15.6
Blue Island	Cook	170312001	14.9	14.1	16.4	13.2	14.3	15.1	14.6	14.6	14.8	15.6
Summit	Cook	170313301	15.6	14.2	16.9	13.8	14.8	15.6	15.0	15.2	15.2	16.0
Cicero	Cook	170316005	16.8	15.2	16.3	14.3	14.8	16.1	15.3	15.1	15.5	16.4
Granite City	Madison	171191007	17.5	15.4	18.2	16.3	15.1	17.0	16.6	16.5	16.7	17.3
E. St. Louis	St. Clair	171630010	14.9	14.7	17.1	14.5	15.6	15.6	15.4	15.7	15.6	16.2
Jeffersonville	Clark	180190005	15.8	15.1	18.5	15.0	16.5	16.5	16.2	16.7	16.4	17.2
Jasper	Dubois	180372001	15.7	14.4	16.9	13.5	14.4	15.7	14.9	14.9	15.2	15.5
Gary	Lake	180890031			16.8	13.3	14.5	16.8	15.1	14.9	15.6	
Indy - Washington Park	Marion	180970078	15.5	14.3	16.4	14.1	15.8	15.4	14.9	15.4	15.3	16.2
Indy - W 18th Street	Marion	180970081	16.2	15.0	17.9	14.2	16.1	16.4	15.7	16.1	16.0	
Indy - Michigan Street	Marion	180970083	16.3	15.0	17.5	14.1	15.9	16.3	15.5	15.8	15.9	16.6
Allen Park	Wayne	261630001	15.2	14.2	15.9	13.2	12.8	15.1	14.4	14.0	14.5	15.8
Southwest HS	Wayne	261630015	16.6	15.4	17.2	14.7	14.5	16.4	15.8	15.5	15.9	17.3
Linwood	Wayne	261630016	15.8	13.7	16.0	13.0	13.9	15.2	14.2	14.3	14.6	15.5
Dearborn	Wayne	261630033	19.2	16.8	18.6	16.1	16.9	18.2	17.2	17.2	17.5	19.3
Wyandotte	Wayne	261630036	16.3	13.7	16.4	12.9	13.4	15.5	14.3	14.2	14.7	16.6
Middleton	Butler	390170003	17.2	14.1	19.0	14.1	15.4	16.8	15.7	16.2	16.2	16.5
Fairfield	Butler	390170016	15.8	14.7	17.9	14.0	14.9	16.1	15.5	15.6	15.8	15.9
Cleveland-28th Street	Cuyahoga	390350027	15.4	15.6	17.3	13.0	14.5	16.1	15.3	14.9	15.4	16.5
Cleveland-St. Tikhon	Cuyahoga	390350038	17.6	17.5	19.2	14.9	16.2	18.1	17.2	16.8	17.4	18.4
Cleveland-Broadway	Cuyahoga	390350045	16.4	15.3	19.3	14.0	15.3	17.0	16.2	16.2	16.5	16.7
Cleveland-E14 & Orange	Cuyahoga	390350060	17.2	16.4	19.4	15.0	15.9	17.7	16.9	16.8	17.1	17.6
Newburg Hts - Harvard Ave	Cuyahoga	390350065	15.6	15.2	18.6	13.1	15.8	16.5	15.6	15.8	16.0	16.2
Columbus - Fairgrounds	Franklin	390490024	16.4	15.0	16.4	13.6	14.6	15.9	15.0	14.9	15.3	16.5
Columbus - Ann Street	Franklin	390490025	15.3	14.6	16.4	13.6	14.7	15.4	14.9	14.9	15.1	16.0
Columbus - Maple Canyon	Franklin	390490081	14.9	13.6	14.6	12.9	13.1	14.4	13.7	13.5	13.9	16.0
Cincinnati - Seymour	Hamilton	390610014	17.0	15.9	19.8	15.5	16.5	17.6	17.1	17.3	17.3	17.7
Cincinnati - Taft Ave	Hamilton	390610040	15.5	14.6	17.5	13.6	15.1	15.9	15.2	15.4	15.5	15.7
Cincinnati - 8th Ave	Hamilton	390610042	16.7	16.0	19.1	14.9	15.9	17.3	16.7	16.6	16.9	17.3
Sharonville	Hamilton	390610043	15.7	14.9	16.9	14.5	14.8	15.8	15.4	15.4	15.6	16.0
Norwood	Hamilton	390617001	16.0	15.3	18.4	14.4	15.1	16.6	16.0	15.9	16.2	16.3
St. Bernard	Hamilton	390618001	17.3	16.4	20.0	15.9	16.1	17.9	17.4	17.3	17.6	17.3
Steubenville	Jefferson	390810016	17.7	15.9	16.4	13.8	16.2	16.7	15.4	15.5	15.8	17.7
Mingo Junction	Jefferson	390811001	17.3	16.2	18.1	14.6	15.6	17.2	16.3	16.1	16.5	17.5
Ironton	Lawrence	390870010	14.3	13.7	17.0	14.4	15.0	15.0	15.0	15.4	15.2	15.7
Dayton	Montgomery	391130032	15.9	14.5	17.4	13.6	15.6	15.9	15.2	15.5	15.5	15.9
New Boston	Scioto	391450013	14.7	13.0	16.2	14.3	14.0	14.6	14.5	14.8	14.7	17.1
Canton - Dueber	Stark	391510017	16.8	15.6	17.8	14.6	15.9	16.7	16.0	16.1	16.3	17.3
Canton - Market	Stark	391510020	15.0	14.1	16.6	11.9	14.4	15.2	14.2	14.3	14.6	15.7
Akron - Brittain	Summit	391530017	15.4	15.0	16.4	13.5	14.4	15.6	15.0	14.8	15.1	16.4
Akron - W. Exchange	Summit	391530023	14.2	13.9	15.7	12.8	13.7	14.6	14.1	14.1	14.3	15.6

When EPA initially set the 24-hour standard at $65 \mu\text{g}/\text{m}^3$, it also adopted the following concentration ranges for its Air Quality Index (AQI) scale:

Good	$< 15 \mu\text{g}/\text{m}^3$
Moderate	$15\text{-}40 \mu\text{g}/\text{m}^3$
Unhealthy for Sensitive Groups (USG)	$40\text{-}65 \mu\text{g}/\text{m}^3$
Unhealthy	$65\text{-}150 \mu\text{g}/\text{m}^3$

Figure 17 shows the frequency of these AQI categories for major metropolitan areas in the region. Daily average concentrations are often in the moderate range and occasionally in the USG range. Moderate and USG levels can occur any time of the year.

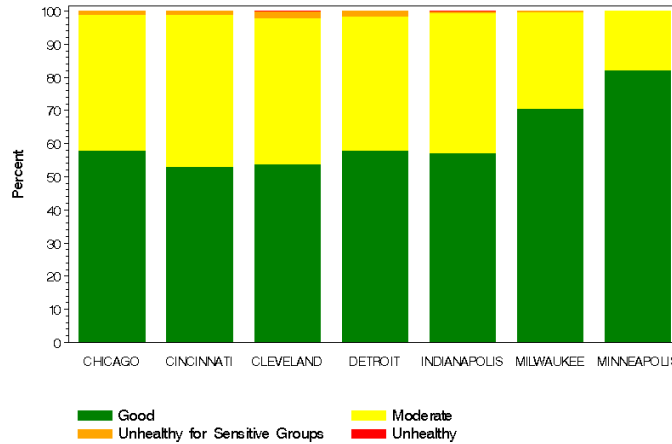


Figure 17. Percent of days in AQI categories for PM_{2.5} (2002-2004)

Data Variability: PM_{2.5} concentrations vary spatially, temporally, and chemically in the region. This variability is discussed further below.

On an annual basis, PM_{2.5} exhibits a distinct and consistent spatial pattern. As seen in Figure 16, across the Midwest, annual concentrations follow a gradient from low values ($5\text{-}6 \mu\text{g}/\text{m}^3$) in northern and western areas (Minnesota and northern Wisconsin) to high values ($17\text{-}18 \mu\text{g}/\text{m}^3$) in Ohio and along the Ohio River. In addition, concentrations in urban areas are higher than in upwind rural areas, indicating that local urban sources add a significant increment of $2\text{-}3 \mu\text{g}/\text{m}^3$ to the regional background of $12\text{-}14 \mu\text{g}/\text{m}^3$ (see Figure 18).

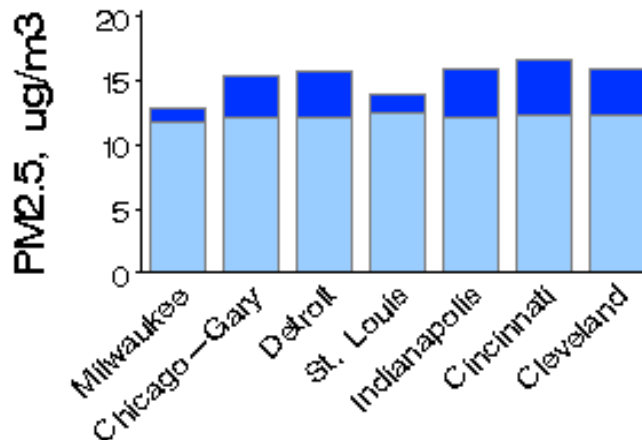


Figure 18. Regional (lighter shading) v. local components (darker shading) of annual average PM_{2.5} concentrations

Because monitoring for PM_{2.5} only began in earnest in 1999, after promulgation of the PM_{2.5} standard, limited data are available to assess trends. Time series based on federal reference method (FRM) PM_{2.5}-mass data show a downward trend in each state (see Figure 19)⁷.

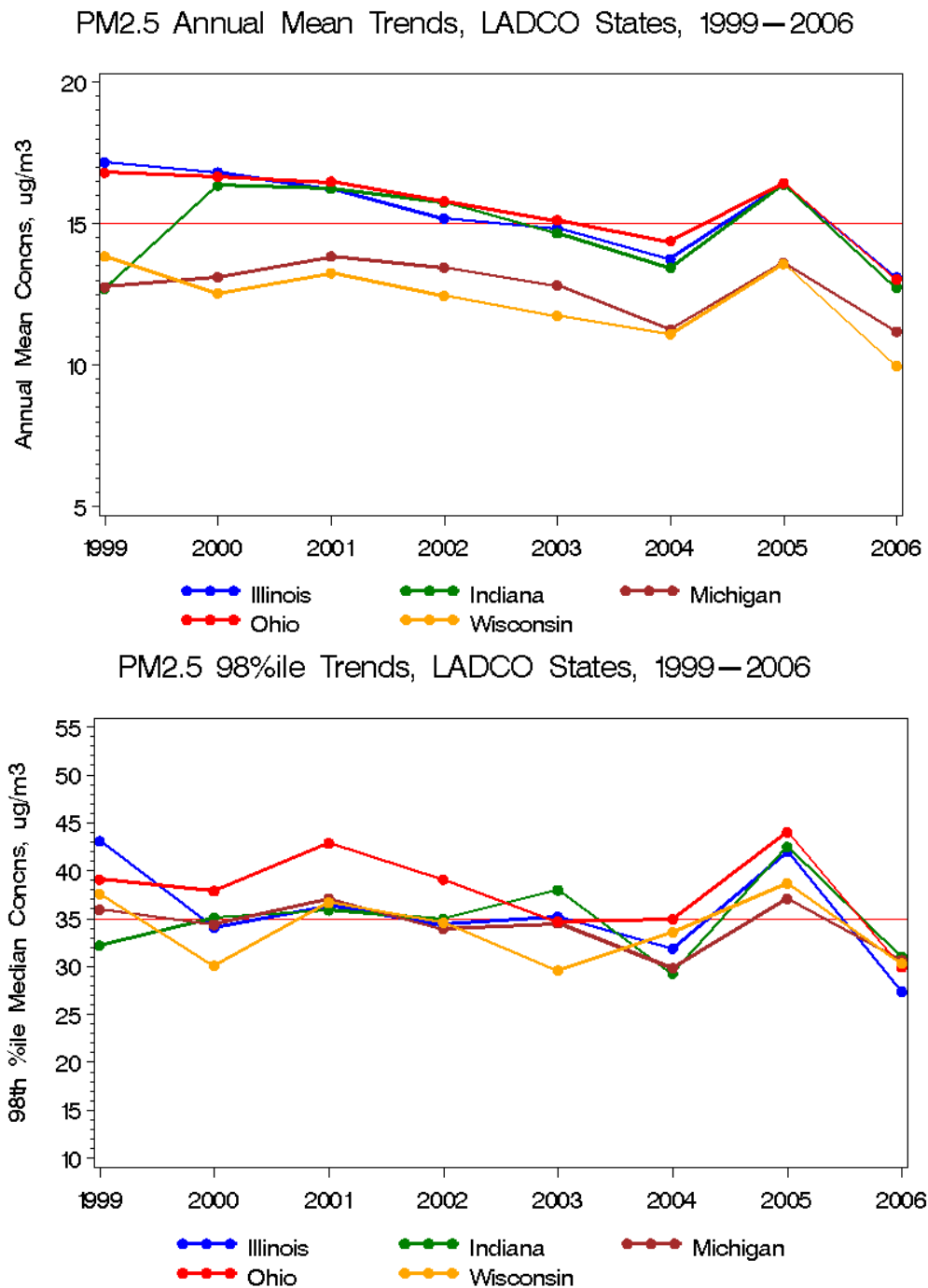


Figure 19. PM_{2.5} trends in annual average (top) and daily concentrations (bottom)

⁷ Despite the general downward trend since 1999, all states experienced an increase during 2005. Further analyses are underway to understand this increase (e.g., examination of meteorological and emissions effects).

A statistical analysis of PM_{2.5} trends was performed using the nonparametric Theil test for slope (Hollander and Wolfe, 1973). Trends were generally consistent around the region, for both PM mass and for the individual components of mass. Figure 20 shows trends for PM_{2.5} based on FRM data at sites with six or more years of data since 1999. The size and direction of each arrow shows the size and direction of the trend for each site; solid arrows show statistically significant trends and open arrows show trends that are not significant. Region-wide decreases are widespread and consistent; all sites had decreasing concentration trends (13 of the 38 were statistically significant). The average decrease for this set of sites is -0.24 ug/m³/year.

Theil Trends for FRM PM_{2.5}, 1999—2006

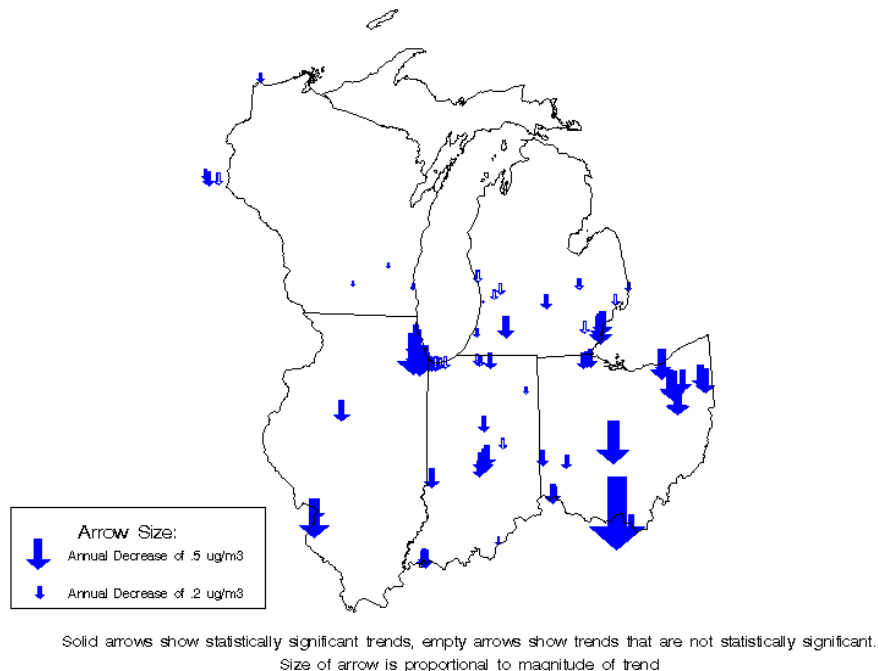


Figure 20. Annual trends in PM_{2.5} mass (1999 – 2006)

Seasonal trends show mostly similar patterns (Figure 21). Trends were downward at most sites and seasons, with overall seasonal averages varying between -0.15 to -0.56 ug/m³/year. The strongest and most significant decreases took place during the winter quarter (January - March). No statistically significant increasing trends were observed.

Seasonal Trends for FRM PM_{2.5}, 1999–2006

Based on Seasonal Daily Data

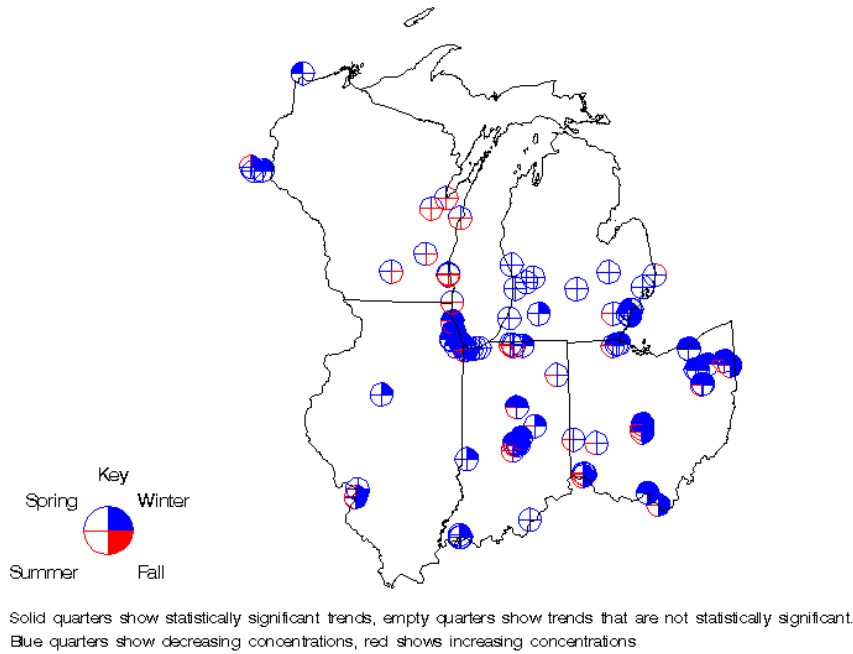


Figure 21. Seasonal trends in PM_{2.5} mass (1999 – 2006)

PM_{2.5} shows a slight variation from weekday to weekend, as seen in Figure 22. Although most cities have slightly lower concentrations on the weekend, the difference is usually less than 1 $\mu\text{g}/\text{m}^3$. There is a more pronounced weekday/weekend difference at monitoring sites that are strongly source-influenced. Rural monitors tend to show less of a weekday/weekend pattern than urban monitors.

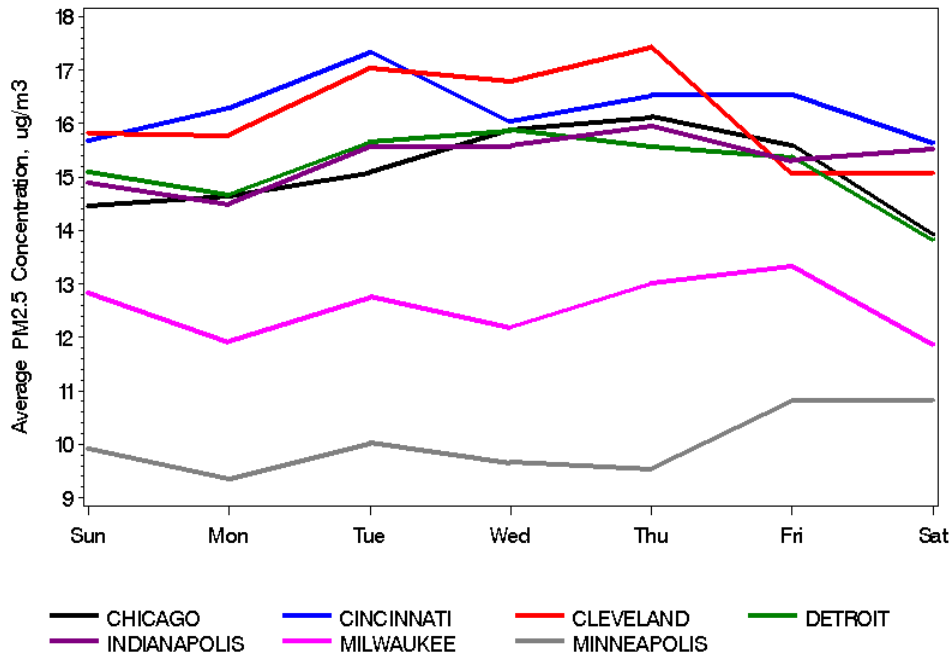


Figure 22 Day-of-week variability in PM_{2.5} (2002-2004)

In the Midwest, PM_{2.5} is made up of mostly ammonium sulfate, ammonium nitrate, and organic carbon in approximately equal proportions on an annual average basis. Elemental carbon and crustal matter (also referred to as soil) contribute less than 5% each.

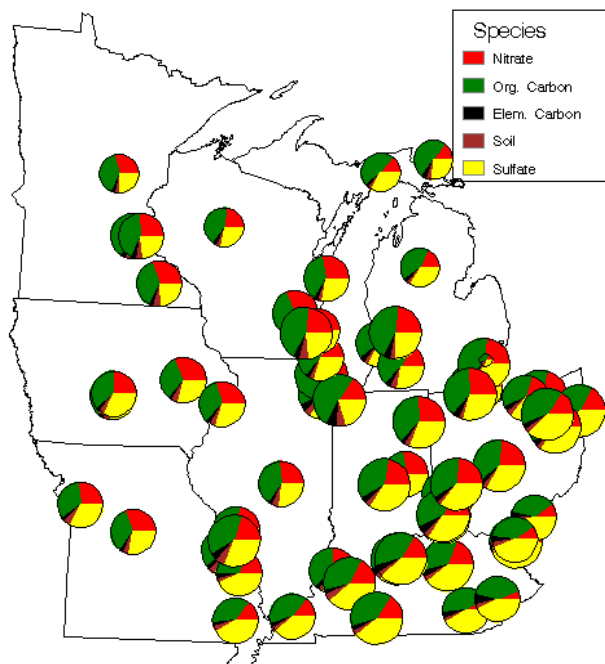


Figure 23. Spatial map of PM_{2.5} chemical composition in the Midwest (2002-2003)

The three major components vary spatially (Figure 23), including notable urban and rural differences (Figure 24). The components also vary seasonally (Figure 25). These patterns account for much of the annual variability in PM_{2.5} mass noted above.

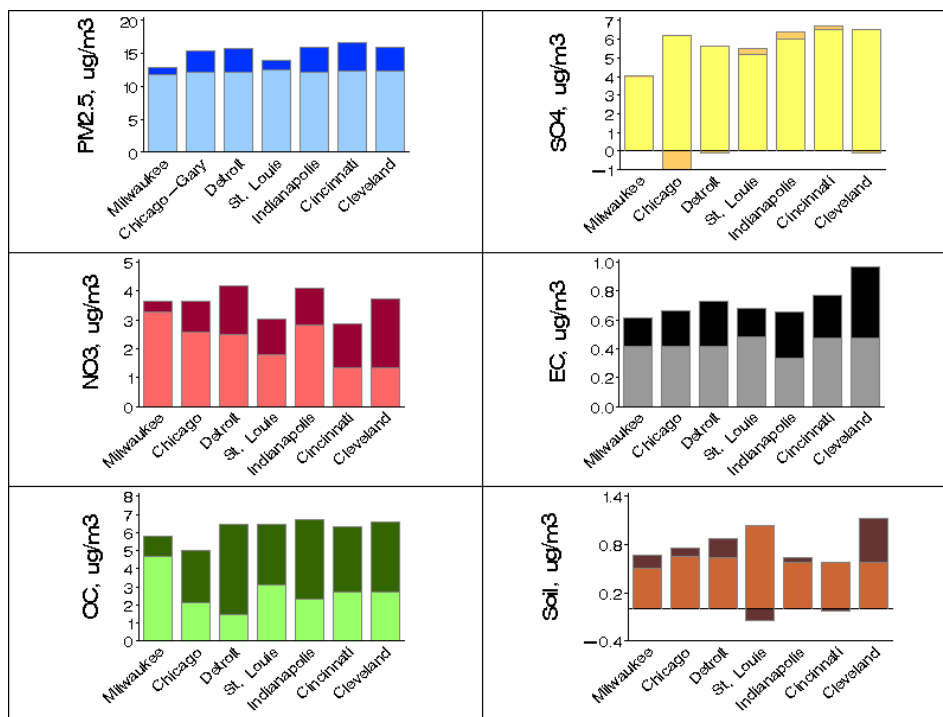


Figure 24. Average regional (lighter shading) v. local (darker shading) of PM_{2.5} chemical species

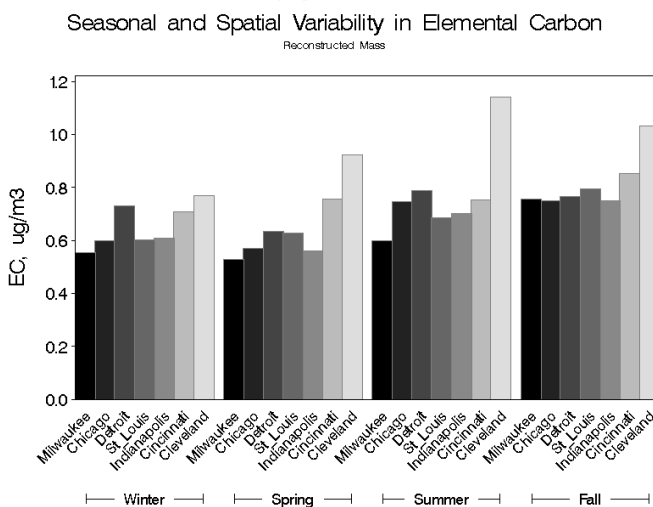
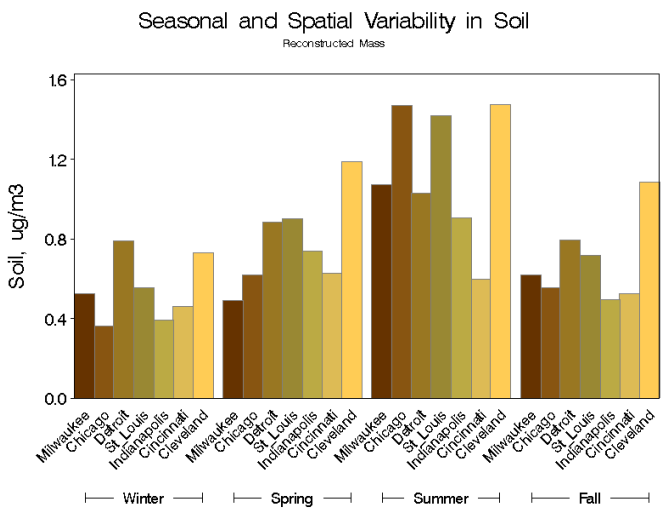
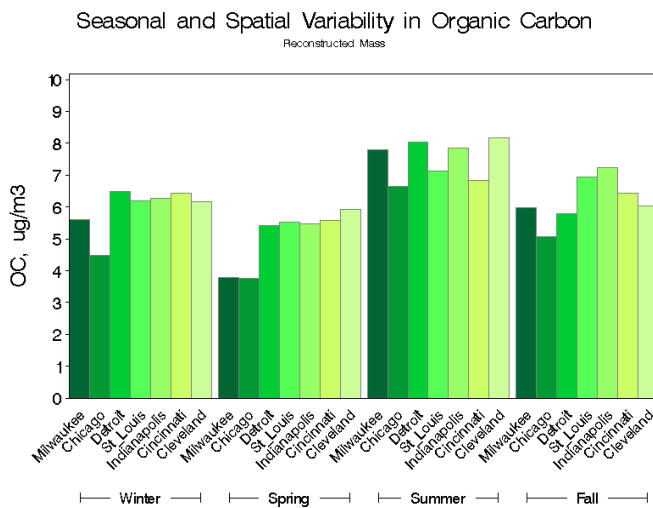
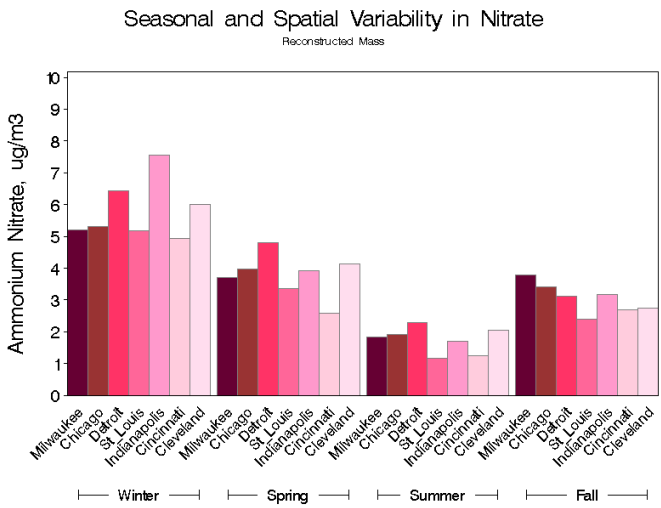
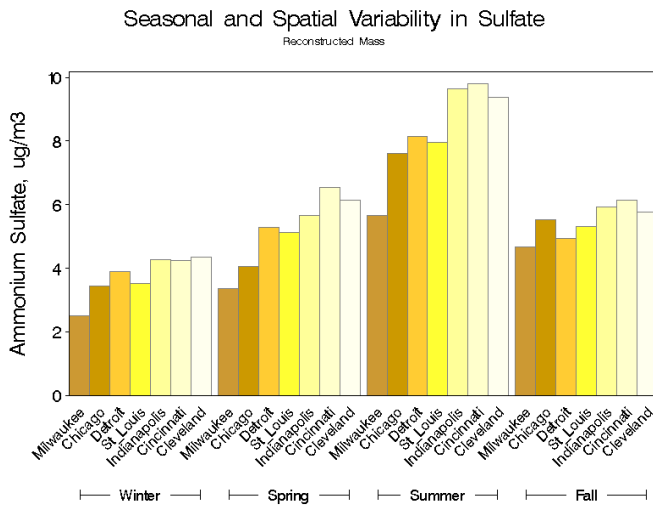


Figure 25 Seasonal and spatial variability in PM_{2.5} components

Ammonium sulfate peaks in the summer and is highest in the southern and eastern parts of the Midwest, closest to the Ohio River Valley. Sulfate is primarily a regional pollutant; concentrations are similar in rural and urban areas and highly correlated over large distances. It is formed when sulfuric acid (an oxidation product of sulfur dioxide) and ammonia react in the atmosphere, especially in cloud droplets. Coal combustion is the primary source of sulfur dioxide; ammonia is emitted primarily from animal husbandry operations and fertilizer use.

Ammonium nitrate has almost the opposite spatial and seasonal pattern, with the highest concentrations occurring in the winter and in the northern parts of the region. Nitrate seems to have both regional and local sources, because urban concentrations are higher than rural upwind concentrations. Ammonium nitrate forms when nitric acid reacts with ammonia, a process that is enhanced when temperatures are low and humidity is high. Nitric acid is a product of the oxidation of nitric oxide, a pollutant that is emitted by combustion processes.

Organic carbon is more consistent from season to season and city to city, although concentrations are generally slightly higher in the summer. Like nitrate, organic carbon has both regional and local components. Particulate organic carbon can be emitted directly from cars and other fuel combustion sources or formed in a secondary process as volatile organic gases react and condense. In rural areas, summer organic carbon has significant contributions from biogenic sources.

Precursor Sensitivity: Data from the Midwest ammonia monitoring network were analyzed with thermodynamic equilibrium models to assess the effect of changes in precursor gas concentrations on PM_{2.5} concentrations (Blanchard, 2005b). These analyses indicate that particle formation responds in varying degrees to reductions in sulfate, nitric acid, and ammonia. Based on Figure 26, which shows PM_{2.5} concentrations as a function of sulfate, nitric acid (HNO₃), and ammonia (NH₃), several key findings should be noted:

- PM_{2.5} mass is sensitive to reductions in sulfate at all times of the year and all parts of the region. Even though sulfate reductions cause more ammonia to be available to form ammonium nitrate (PM-nitrate increases slightly when sulfate is reduced), this increase is generally offset by the sulfate reductions, such that PM_{2.5} mass decreases.
- PM_{2.5} mass is also sensitive to reductions in nitric acid and ammonia. The greatest PM_{2.5} decrease in response to nitric acid reductions occurs during the winter, when nitrate is a significant fraction of PM_{2.5}.
- Under conditions with lower sulfate levels (i.e., proxy of future year conditions), PM_{2.5} is more sensitive to reductions in nitric acid compared to reductions in ammonia.
- Ammonia becomes more limiting as one moves from west to east across the region.

Examination of weekend/weekday difference in PM-nitrate and NO_x concentrations in the Midwest demonstrate that reductions in local (urban) NO_x lead to reductions, albeit non-proportional reductions, in PM-nitrate (Blanchard, 2004). This result is consistent with analyses of continuous PM-nitrate from several US cities, including St. Louis (Millstein, et al, 2007).

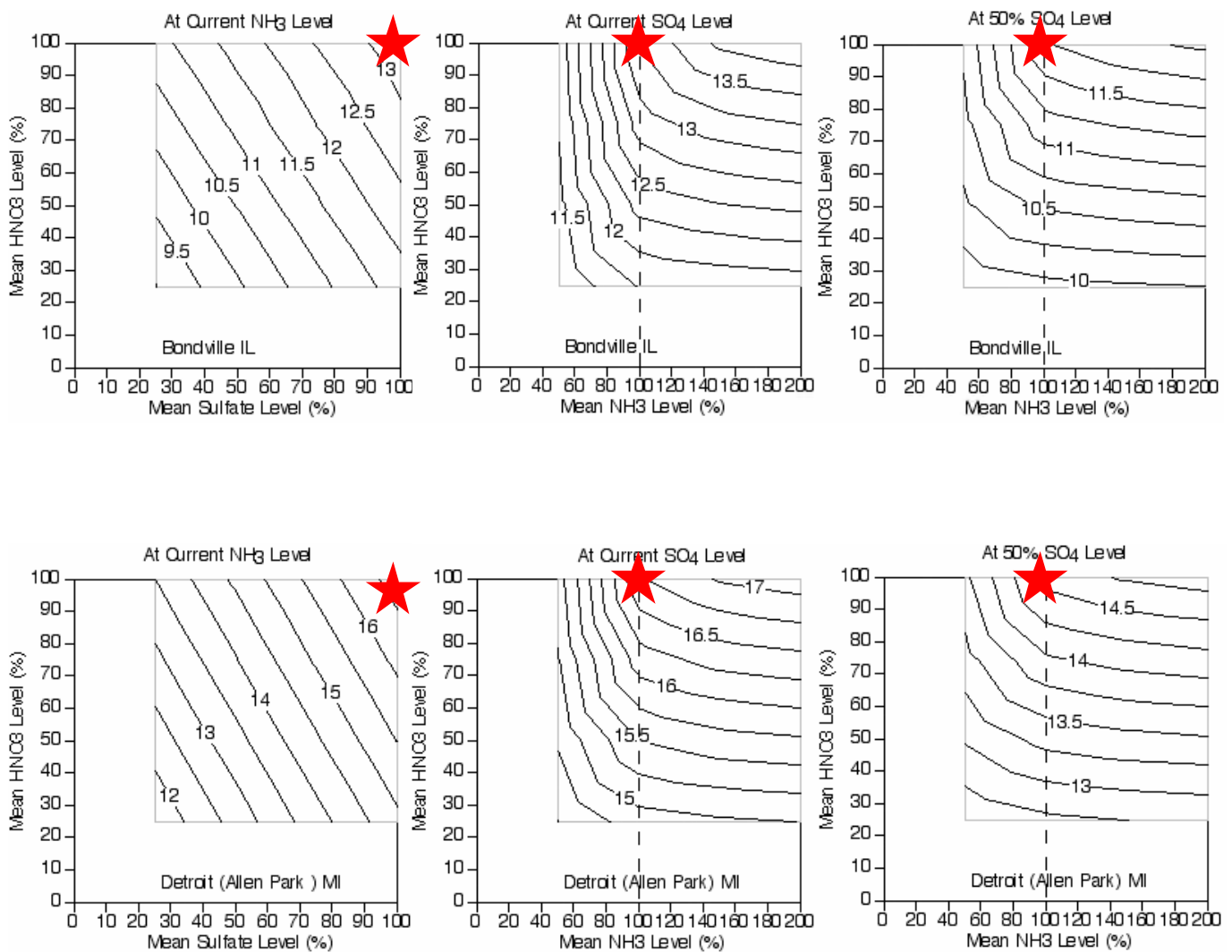


Figure 26. Predicted mean PM fine mass concentrations at Bondville, IL (top) and Detroit (Allen Park), MI (bottom) as functions of changes in sulfate, nitric acid (HNO₃), and ammonia (NH₃)

Note: starting at the baseline values (represented by the red star), either moving downward (reductions in nitric acid) or moving leftward (reductions in sulfate or ammonia) results in lower PM_{2.5} values

Meteorology: PM_{2.5} concentrations are not as strongly influenced by meteorology as ozone, but the two pollutants share some similar meteorological dependencies. In the summer, conditions that are conducive to ozone (hot temperatures, stagnant air masses, and low wind speeds due to stationary high pressure systems) also frequently give rise to high PM_{2.5}. In the case of PM, the reason is two-fold: (1) stagnation and limited mixing under these conditions cause PM_{2.5} to build up, usually over several days, and (2) these conditions generally promote higher conversion of important precursors (SO₂ to SO₄) and higher emissions of some precursors, especially biogenic carbon. Wind direction is another strong determinant of PM_{2.5}; air transported from polluted source regions has higher concentrations.

Unlike ozone, PM_{2.5} has occasional winter episodes. Conditions are similar to those for summer episodes, in that stationary high pressure and (seasonally) warm temperatures are usually factors. Winter episodes are also fueled by high humidity and low mixing heights.

PM_{2.5} chemical species show noticeable transport influences. Trajectory analyses have demonstrated that high PM-sulfate is associated with air masses that traveled through the sulfate-rich Ohio River Valley (Poirot, et al, 2002 and Kenski, 2004). Likewise, high PM-nitrate is associated with air masses that traveled through the ammonia-rich Midwest. Figure 27 shows results from an ensemble trajectory analysis of 17 rural eastern IMPROVE sites.

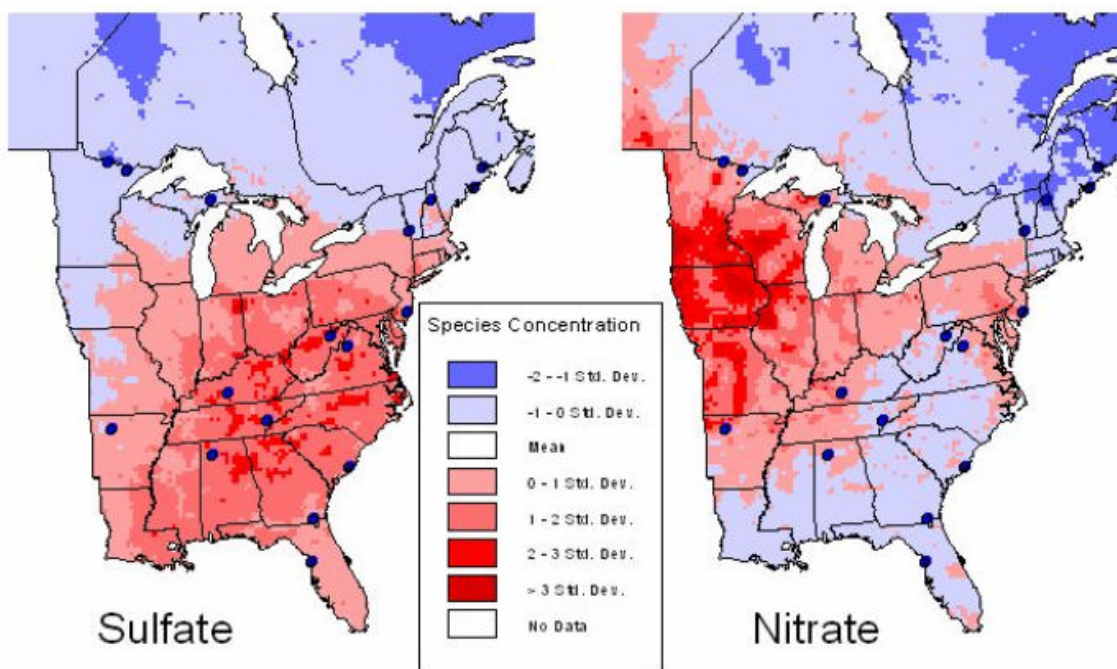


Figure 27. Sulfate and nitrate source regions based on ensemble trajectory analysis

When these results are considered together with analyses of precursor sensitivity (e.g., Figure 26), one possible conclusion is that ammonia control in the Midwest could be effective at reducing nitrate concentrations. The thermodynamic equilibrium modeling shows that ammonia reductions would reduce PM concentrations in the Midwest, but that nitric acid reductions are more effective when the probable reductions in future sulfate levels are considered.

Source Culpability: Three source apportionment studies were performed using speciated PM_{2.5} monitoring data and statistical analysis methods (Hopke, 2005, STI, 2006, and STI, 2008). Figure 28 summarizes the source contributions from these studies. The studies show that a large portion of PM_{2.5} mass consists of secondary, regional impacts, which cannot be attributed to individual facilities or sources (e.g., secondary sulfate, secondary nitrate, and secondary organic aerosols). Nevertheless, wind analyses (e.g., Figure 27) provide information on likely source regions. Regional- or national-scale control programs may be the most effective way to deal with these impacts. EPA's CAIR, for example, will provide for substantial reductions in SO₂ emissions over the eastern half of the U.S., which will reduce sulfate (and PM_{2.5}) concentrations and improve visibility levels.

The studies also show that a smaller, yet significant portion of PM_{2.5} mass is due to emissions from nearby (local) sources. Local (urban) excesses occur in many urban areas for organic and elemental carbon, crustal matter, and, in some cases, sulfate. The statistical analysis methods help to identify local sources and quantify their impact. This information is valuable to states wishing to develop control programs to address local impacts. A combination of national/regional-scale and local-scale emission reductions may be necessary to provide for attainment.

The carbon sources are not easily identified in complex urban environments. LADCO's Urban Organics Study (STI, 2006) identified four major sources of organic carbon: mobile sources, burning, industrial sources, and secondary organic aerosols. Additional sampling and analysis is underway in Cleveland and Detroit to provide further information on sources of organic carbon.

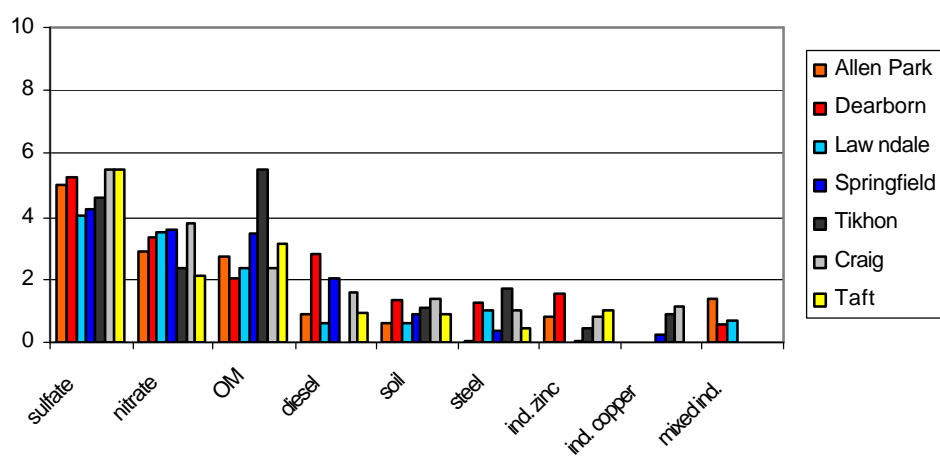
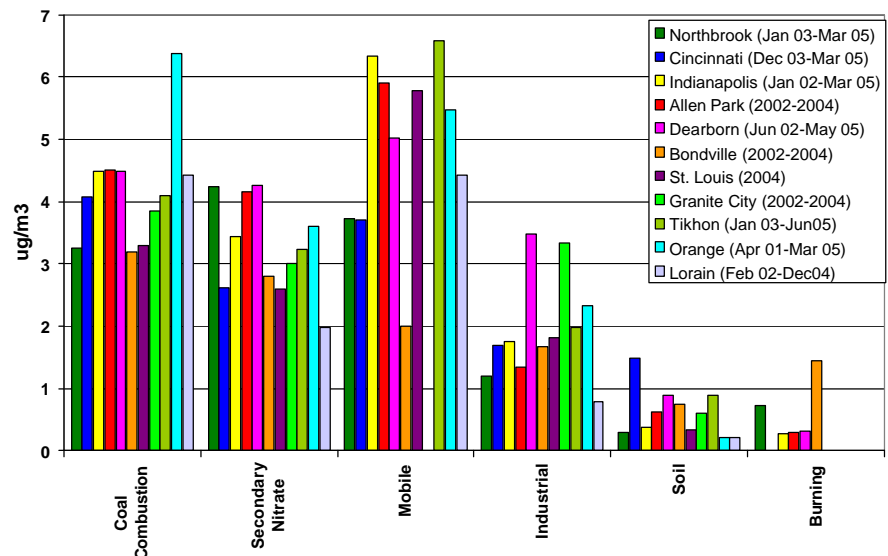
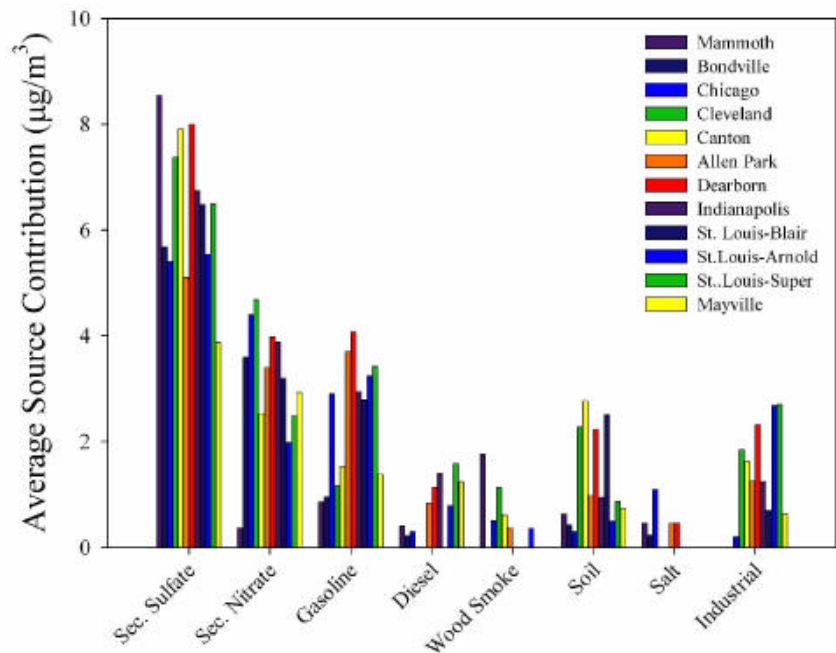


Figure 28. Major Source Contributions in the Midwest based on Hopke, 2005 (upper left), STI, 2006 (upper right), and STI, 2008 (lower left) (Note: the labeling of similar source types varies between studies – e.g., organic carbon/mobile sources are named gasoline and diesel by Hopke, mobile by STI 2006, and OM and diesel by STI 2008)

2.3 Haze

Section 169A of the Clean Air Act sets as a national goal “the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution”. To implement this provision, in 1999, EPA adopted regulations to address regional haze visibility impairment (USEPA, 1999). EPA’s rule requires states to “make reasonable progress toward meeting the national goal”. Specifically, states must establish reasonable progress goals, which provide for improved visibility on the most impaired (20% worst) days sufficient to achieve natural conditions by the year 2064, and for no degradation on the least impaired (20% best) days.

The primary cause of impaired visibility in the Class I areas is pollution by fine particles that scatter light. The degree of impairment, which is expressed in terms of visual range, light extinction (1/Mm), or deciviews (dv), depends not just on the total PM_{2.5} mass concentration, but also on the chemical composition of the particles and meteorological conditions.

Current Conditions: A map of the average light extinction values for the most impaired (20% worst) visibility days for the 5-year baseline period (2000-2004) is shown in Figure 29.

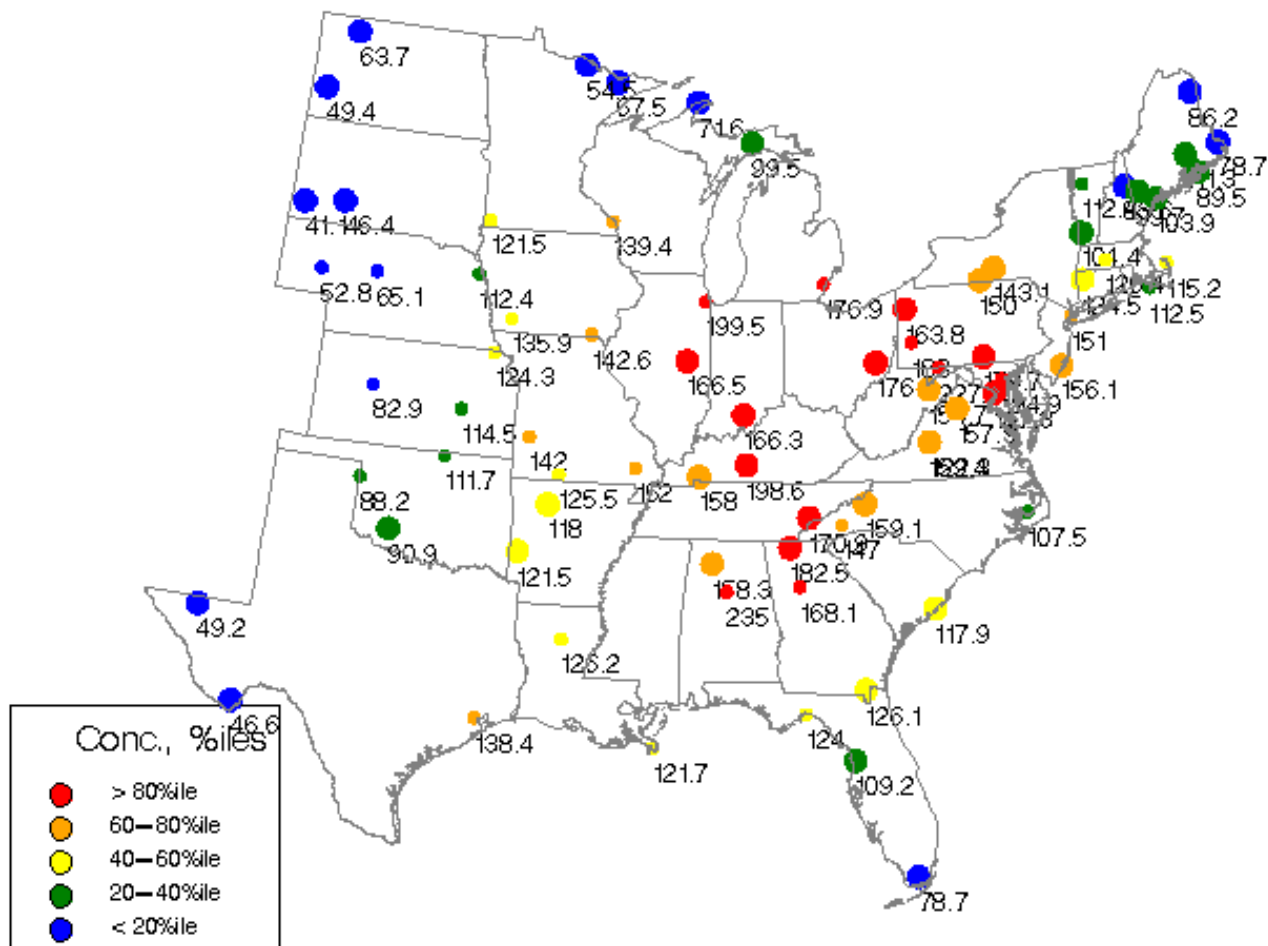


Figure 29. Baseline Visibility Levels for 20% Worst Days (2000 – 2004), units: Mm⁻¹

Initially, the baseline (2000 – 2004) visibility condition values were derived using the average for the 20% worst and 20% best days for each year, as reported on the VIEWS website: <http://vista.cira.colostate.edu/views/Web/IMPROVE/SummaryData.aspx> . These values were calculated using the original IMPROVE equation for reconstructed light extinction.

Three changes were made to the baseline calculations to produce a new set of values. First, the reconstructed light extinction equation was revised by the IMPROVE Steering Committee in 2005. The new IMPROVE equation was used to calculate updated baseline values.

Second, due to sampler problems, the 2002-2004 data for Boundary Waters were invalid for certain chemical species. (Note, sulfate and nitrate data were valid.) A “substituted” data set was developed by using values from Voyageurs for the invalid species.

Third, LADCO identified a number of days during 2000-2004 where data capture at the Class I monitors was incomplete (Kenski, 2007b). The missing data cause these days to be excluded from the baseline calculations. However, the light extinction due to the remaining measured species is significant (i.e., above the 80th percentile). It makes sense to include these days in the baseline calculations, because they are largely dominated by anthropogenic sources. (Only one of these days is driven by high organic carbon, which might indicate non-anthropogenic aerosol from wildfires.) As seen in Table 3, inclusion of these days in the baseline calculation results in a small, but measurable, effect on the baseline values (i.e., values increase from 0.2 to 0.8 dv).

Table 3. Average of 20% worst days, with and without missing data days

	Average Worst Day DV, per RHR	Average Worst Day DV, with Missing Data Days	Difference
BOWA	19.59	19.86	0.27
ISLE	20.74	21.59	0.85
SENE	24.16	24.38	0.22
VOYA	19.27	19.48	0.21

A summary of the initial and updated baseline values for the Class I areas in northern Michigan and northern Minnesota are presented in Table 4. The updated baseline values reflect the most current, complete understanding of visibility impairing effects and, as such, will be used for SIP planning purposes.

Table 4. Summary of visibility metrics (deciviews) for northern Class I areas

Old IMPROVE Equation (Cite: VIEWS, November 2005)									
20% Worst Days									
	2000	2001	2002	2003	2004	Baseline Value	2018 URI Value	Natural Conditions	
Voyageurs	18.50	18.00	19.00	19.20	17.60	18.46	16.74	11.09	
BWCA	19.85	19.99	19.68	19.73	17.65	19.38	17.47	11.21	
Isle Royale	20.00	22.00	20.80	19.50	19.10	20.28	18.17	11.22	
Seney	22.60	24.90	24.00	23.80	22.60	23.58	20.73	11.37	
20% Best Days									
	2000	2001	2002	2003	2004	Baseline Value		Natural Conditions	
Voyageurs	6.30	6.20	6.70	7.00	5.40	6.32		3.41	
BWCA	5.90	6.52	6.93	6.67	5.61	6.33		3.53	
Isle Royale	5.70	6.40	6.40	6.30	5.30	6.02		3.54	
Seney	5.80	6.10	7.30	7.50	5.80	6.50		3.69	
New IMPROVE Equation (Cite: VIEWS, March 2006)									
20% Worst Days									
	2000	2001	2002	2003	2004	Baseline Value	2018 URI Value	Natural Conditions	
Voyageurs	19.55	18.57	20.14	20.25	18.87	19.48	17.74	12.05	
BWCA	20.20	20.04	20.76	20.13	18.18	19.86	17.94	11.61	
Isle Royale	20.53	23.07	21.97	22.35	20.02	21.59	19.43	12.36	
Seney	22.94	25.91	25.38	24.48	23.15	24.37	21.64	12.65	
20% Best Days									
	2000	2001	2002	2003	2004	Baseline Value		Natural Conditions	
Voyageurs	7.01	7.12	7.53	7.68	6.37	7.14		4.26	
BWCA	6.00	6.92	7.00	6.45	5.77	6.43		3.42	
Isle Royale	6.49	7.16	7.07	6.99	6.12	6.77		3.72	
Seney	6.50	6.78	7.82	8.01	6.58	7.14		3.73	
<p>Notes: (1) BWCA values for 2002 - 2004 reflect "substituted" data. (2) New IMPROVE equation values include Kenski, 2007 adjustment for missing days</p> <p>URI = uniform rate of improvement</p>									

As noted above, the goal of the visibility program is to achieve natural conditions. Initially, the natural conditions values for each Class I area were taken directly from EPA guidance (EPA, 2003). These values were calculated using the original IMPROVE equation. This equation was revised by the IMPROVE Steering Committee in 2005, and the new IMPROVE equation was used to calculate updated natural conditions values. The updated values are reported on the VIEWS website.

A summary of the initial and updated natural conditions values are presented in Table 4. The updated natural conditions values (based on the new IMPROVE equation) will be used for SIP planning purposes.

Data Variability: For the four northern Class I areas, the most important PM_{2.5} chemical species are ammonium sulfate, ammonium nitrate, and organic carbon. The contribution of these species on the 20% best and 20% worst visibility days (based on 2000 – 2004 data) is provided in Figure 30. For the 20% worst visibility days, the contributions are: sulfate = 35-55%, nitrate = 25-30%, and organic carbon = 12-22%. Although the chemical composition is similar, sulfate increases in importance from west to east and concentrations are highest at Seney (the easternmost site). It should also be noted that sulfate and nitrate contribute more to light extinction than to PM_{2.5} mass because of their hygroscopic properties.

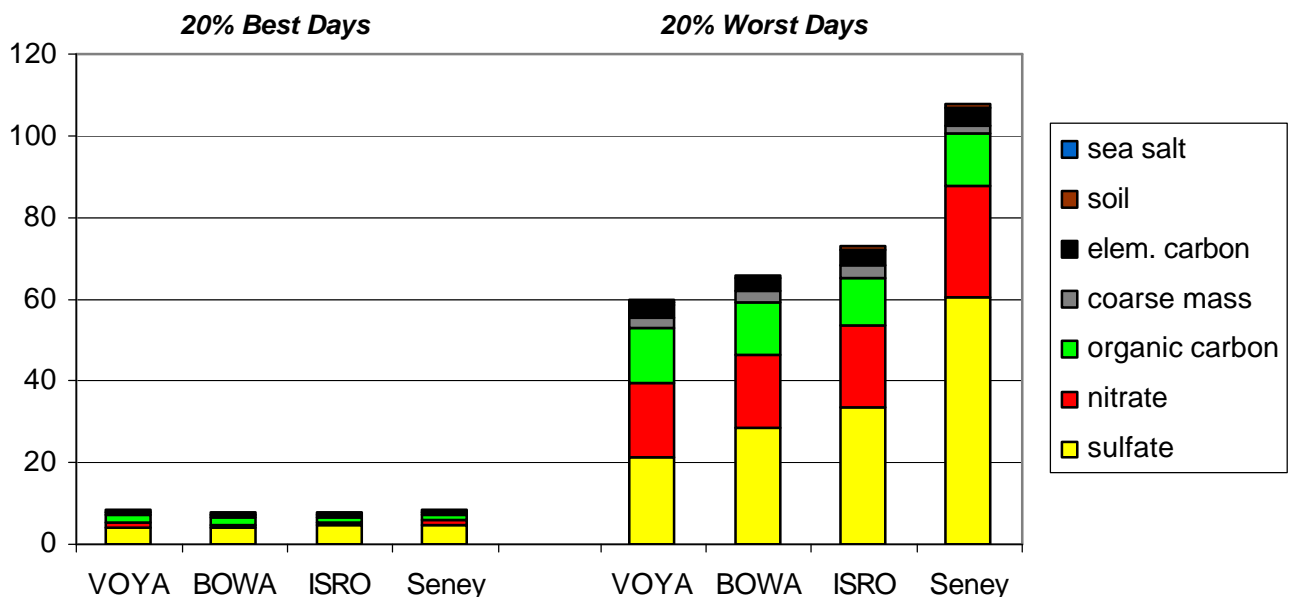


Figure 30. Chemical composition of light extinction for 20% best visibility days (left) and 20% worst visibility days (right) in terms of Mm⁻¹

Analysis of PM_{2.5} mass and chemical species for rural IMPROVE (and IMPROVE-protocol) sites in the eastern U.S. showed a high degree of correlation between PM_{2.5}-mass, sulfate, and nitrate levels (see Figure 31). The Class I sites in northern Michigan and northern Minnesota, in particular, are highly correlated for PM_{2.5} mass, sulfates, and organic carbon mass (AER, 2004).

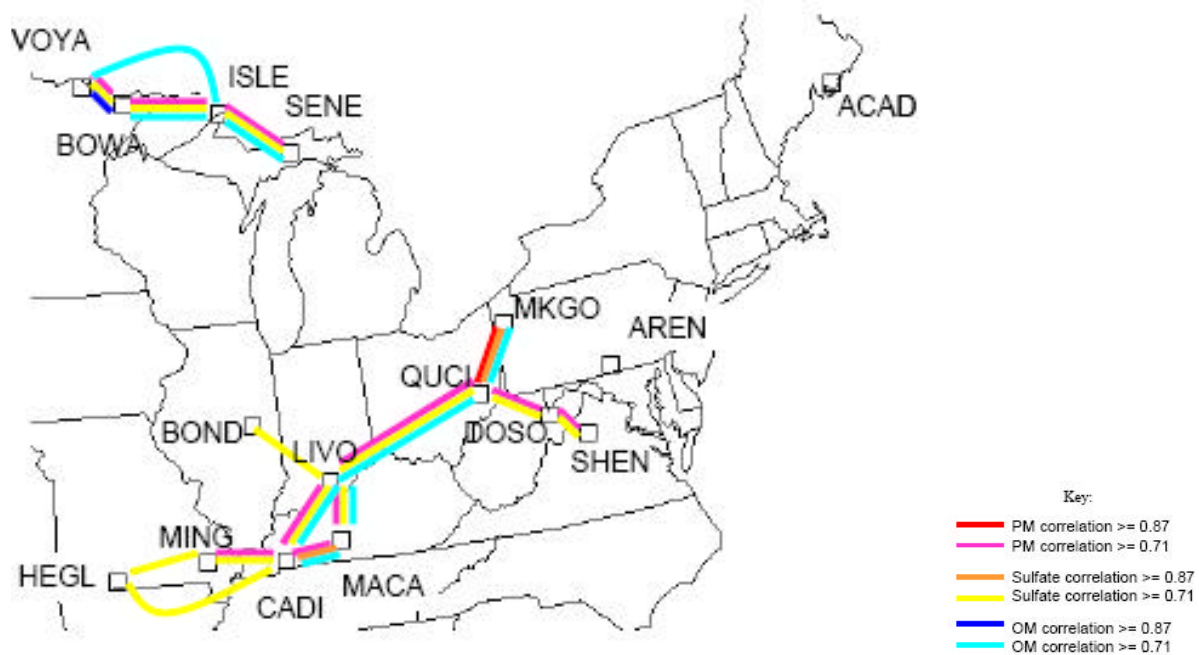


Figure 31. Correlations among IMPROVE (and IMPROVE-protocol) monitoring sites in Eastern U.S.

Long-term trends at Boundary Waters (the only regional site with a sufficient data record) show significant decreases in total $PM_{2.5}$ (-0.005 ug/year) and SO_4 (-0.04 ug/year) and an increase in NO_3 (+0.01 ug/year). These $PM_{2.5}$ and SO_4 trends are generally consistent with long-term trends at other IMPROVE sites in the eastern U.S., which have shown widespread decreases in SO_4 and $PM_{2.5}$ (DeBell, et al, 2006). Detecting changes in nitrate has been hampered by uncertainties in the IMPROVE data for particular years and, thus, this estimate should be considered tentative.

Haze in the Midwest Class I areas has no strong seasonal pattern. Poor visibility days occur throughout the year, as indicated in Figure 32. (Note, in contrast, other parts of the country, such as Shenandoah National Park in Virginia, show a strong tendency for the worst air quality days to occur in the summer months.) This figure and Figure 33 (which presents the monthly average light extinction values based on all sampling days) also show that sulfate and organic carbon concentrations are higher in the summer, and nitrate concentrations are higher in the winter, suggesting the importance of different sources and meteorological conditions at different times of the year.

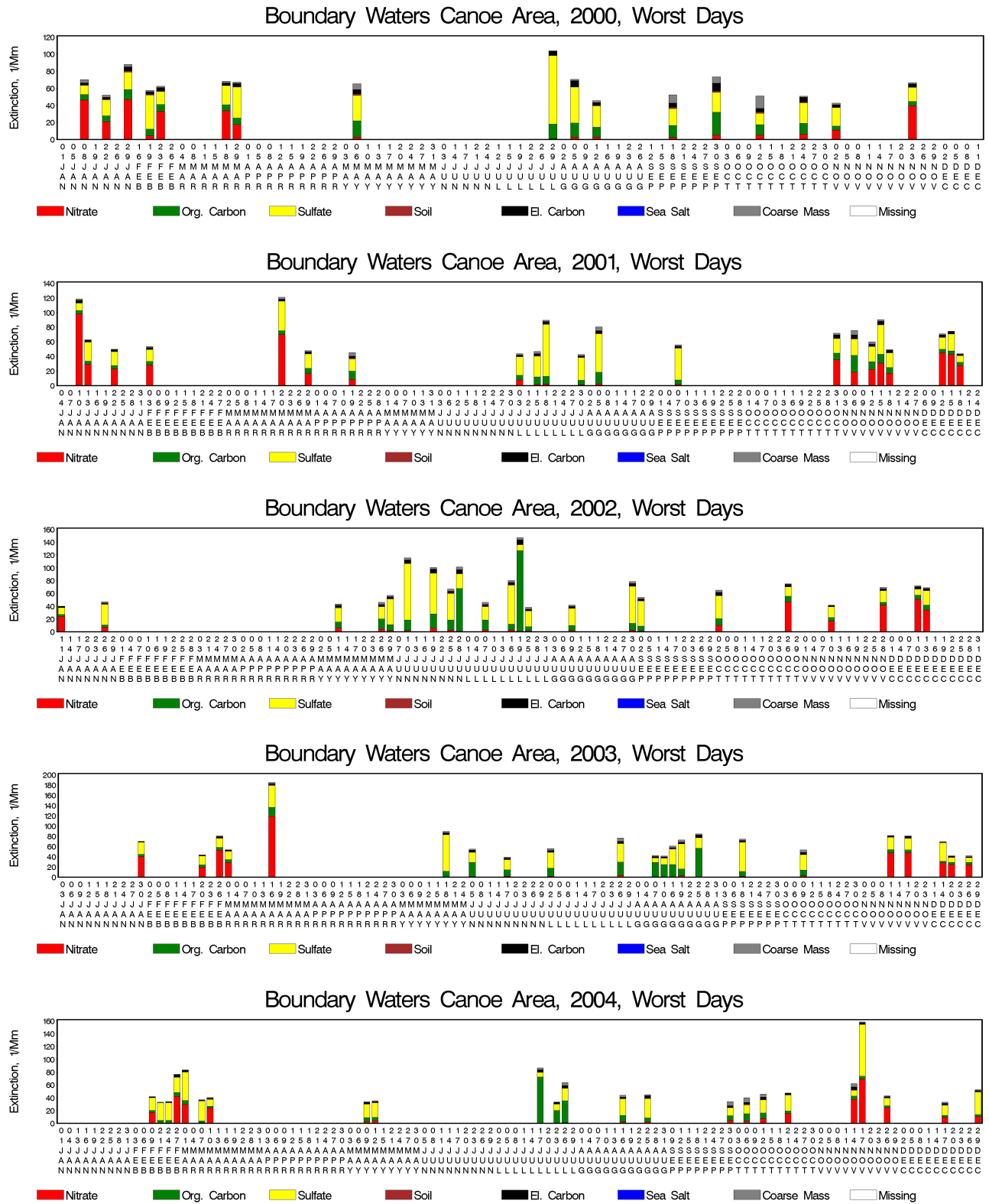
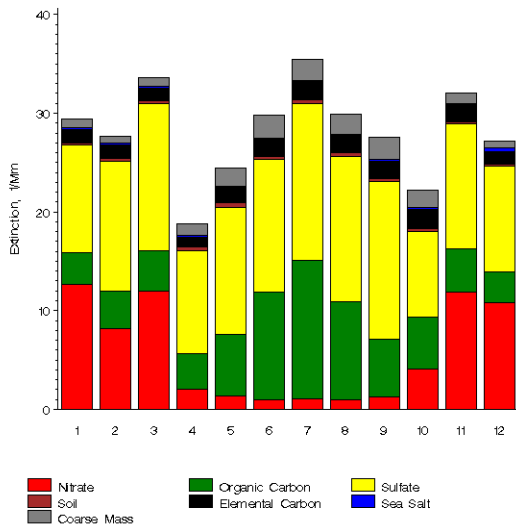
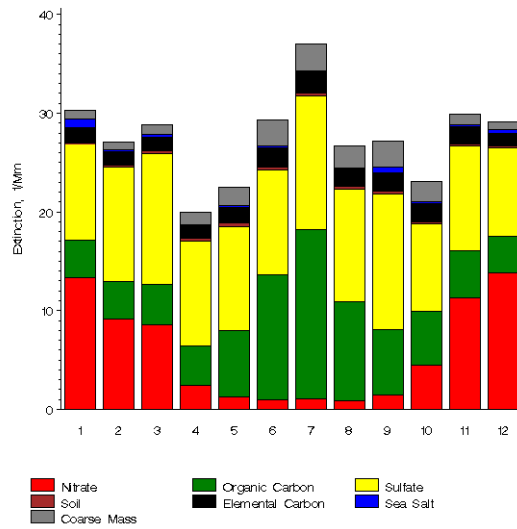


Figure 32. Daily light extinction values for 20% worst days at Boundary Waters (2000 – 2004)

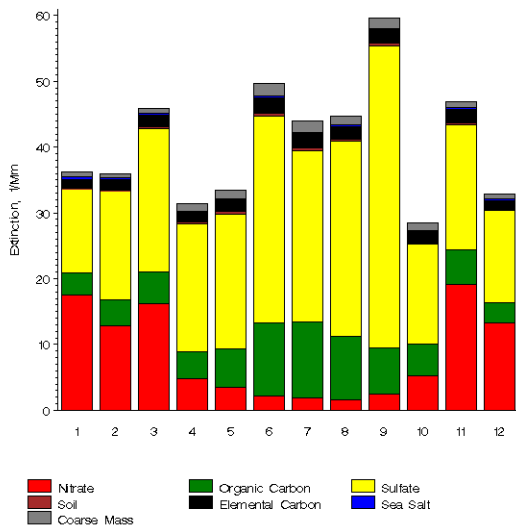
Monthly Extinction, Boundary Waters Canoe Area



Monthly Extinction, Voyageurs National Park 2



Monthly Extinction, Seney



Monthly Extinction, Isle Royale National Park (New)

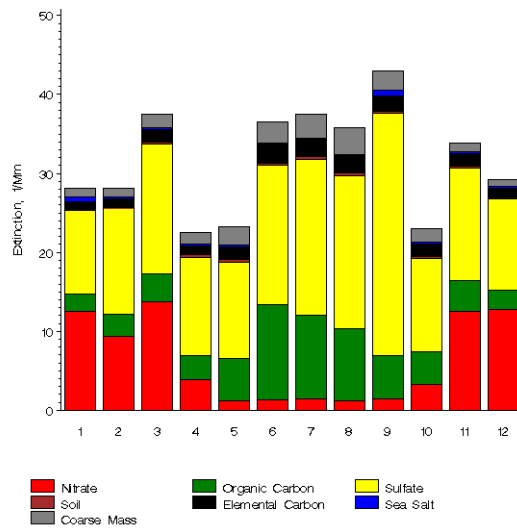


Figure 33. Monthly average light extinction values for northern Class I areas

Precursor Sensitivity: Results from two analyses using thermodynamic equilibrium models provide information on the effect of changes in precursor concentrations on PM_{2.5} concentrations (and, in turn, visibility levels) in the northern Class I areas. First, a preliminary analysis using data collected at Seney indicated that PM_{2.5} there is most sensitive to reductions in sulfate, but is also sensitive to reductions in nitric acid (Blanchard, 2004).

Second, an analysis was performed using data from the Midwest ammonia monitoring network for a site in Minnesota -- Great River Bluffs, which is the closest ammonia monitoring site to the northern Class I areas (Blanchard, 2005b). Figure 34 shows PM_{2.5} concentrations as a function of sulfate, nitric acid (HNO₃), and ammonia (NH₃). Reductions in sulfate (i.e., movement to the left of baseline value [represented by the red star]), as well as reductions in nitric acid (i.e., movement downward) and NH₃ (i.e., movement to the left), result in lower PM_{2.5} concentrations. Thus, reductions in sulfate, nitric acid, and ammonia will lower PM_{2.5} concentrations and improve visibility in the northern Class I areas.

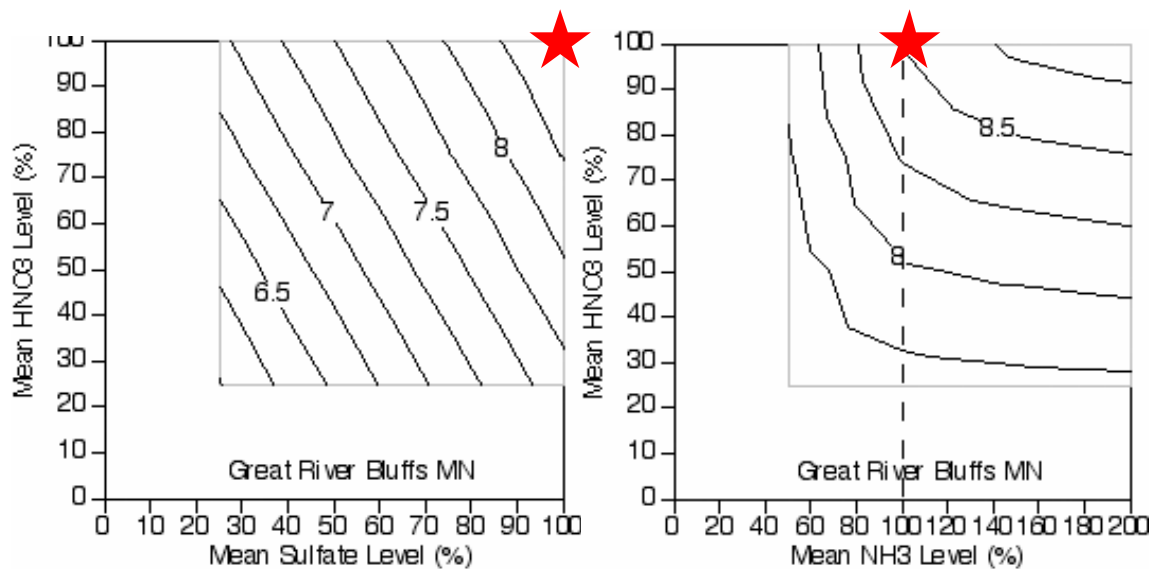


Figure 34. Predicted PM_{2.5} mass concentrations at Great River Bluffs, MN as functions of changes in sulfate, nitric acid, and ammonia

Meteorology and Transport: The role of meteorology in haze is complex. Wind speed and wind direction govern the movement of air masses from polluted areas to the cleaner wilderness areas. As noted above, increasing humidity increases the efficiency with which sulfate and nitrate aerosols scatter light. Temperature and humidity together govern whether ammonium nitrate can form from its precursor gases, nitric acid and ammonia. Temperature and sunlight also play an indirect role in emissions of biogenic organic species that condense to form particulate organic matter; emissions increase in the summer daylight hours.

Trajectory analyses were performed to understand transport patterns for the 20% worst and 20% best visibility days. The composite results for the four northern Class I areas are provided in Figure 35. The orange areas are where the air is most likely to come from, and the green areas are where the air is least likely to come from. As can be seen, bad air days are generally associated with transport from regions located to the south, and good air days with transport from Canada.

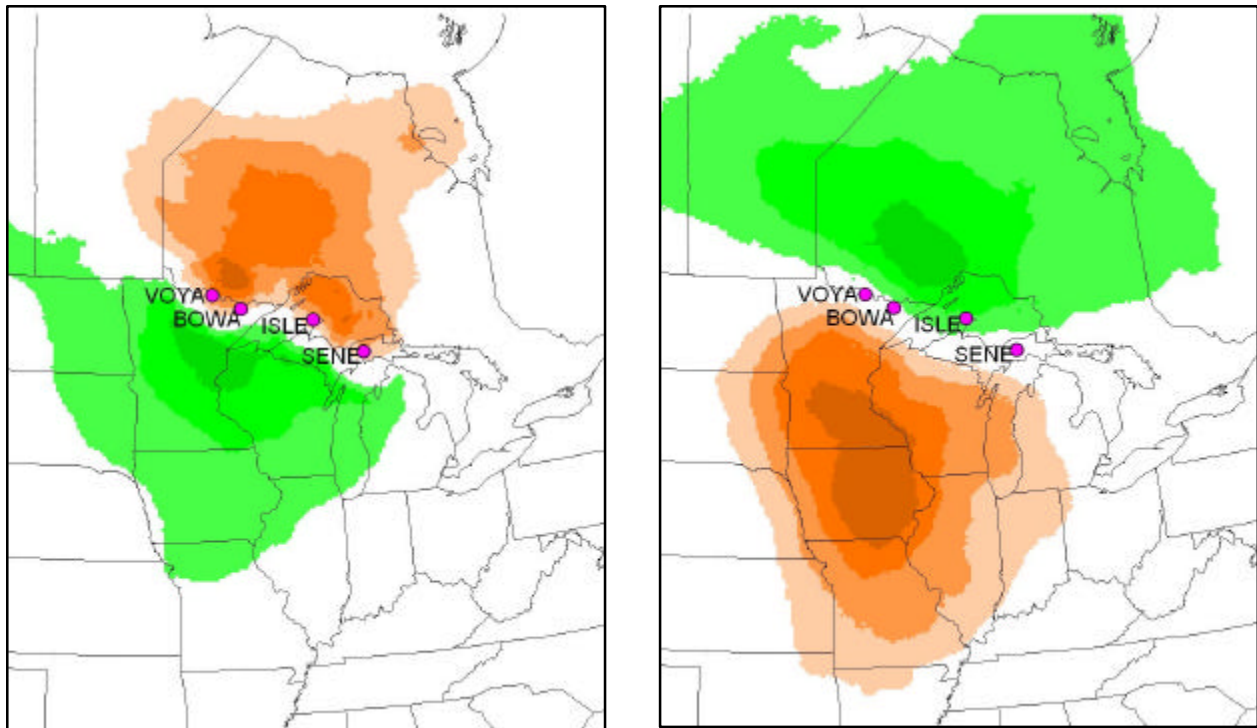


Figure 35. Composite back trajectories for light extinction- 20% best visibility days (left) and 20% worst visibility days (right) (2000 – 2005)

Source Culpability: Air quality data analyses (including the trajectory analyses above) and dispersion modeling were used to provide information on source region and source sector contributions to regional haze in the northern Class I areas (see MRPO, 2008). Based on this information, the most important contributing states are Michigan, Minnesota, and Wisconsin, as well as Missouri, North Dakota, Iowa, Indiana and Illinois (see, for example, Figure 35 above). The most important contributing pollutants and source sectors are SO₂ emissions from electrical generating units (EGUs) and certain non-EGUs, which lead to sulfate formation, and NO_x emissions from a variety of source types (e.g., motor vehicles), which lead to nitrate formation. Ammonia emissions from livestock waste and fertilizer applications are also important, especially for nitrate formation.

A source apportionment study was performed using monitoring data from Boundary Waters and statistical analysis methods (DRI, 2005). The study shows that a large portion of PM_{2.5} mass consists of secondary, regional impacts, which cannot be attributed to individual facilities or sources (e.g., secondary sulfate, secondary nitrate, and secondary organic aerosols). Industrial sources contribute about 3-4% and mobile sources about 4-7% to PM_{2.5} mass.

A special study was performed in Seney to identify sources of organic carbon (Sheesley, et al, 2004). As seen in Figure 36, the highest PM_{2.5} concentrations occurred during the summer, with organic carbon being the dominant species. The higher summer organic carbon concentrations were attributed mostly to secondary organic aerosols of biogenic origin because of the lack of primary emission markers, and concentrations of know biogenic-related species (e.g., pinonic acid – see Figure 36) were also high during the summer.

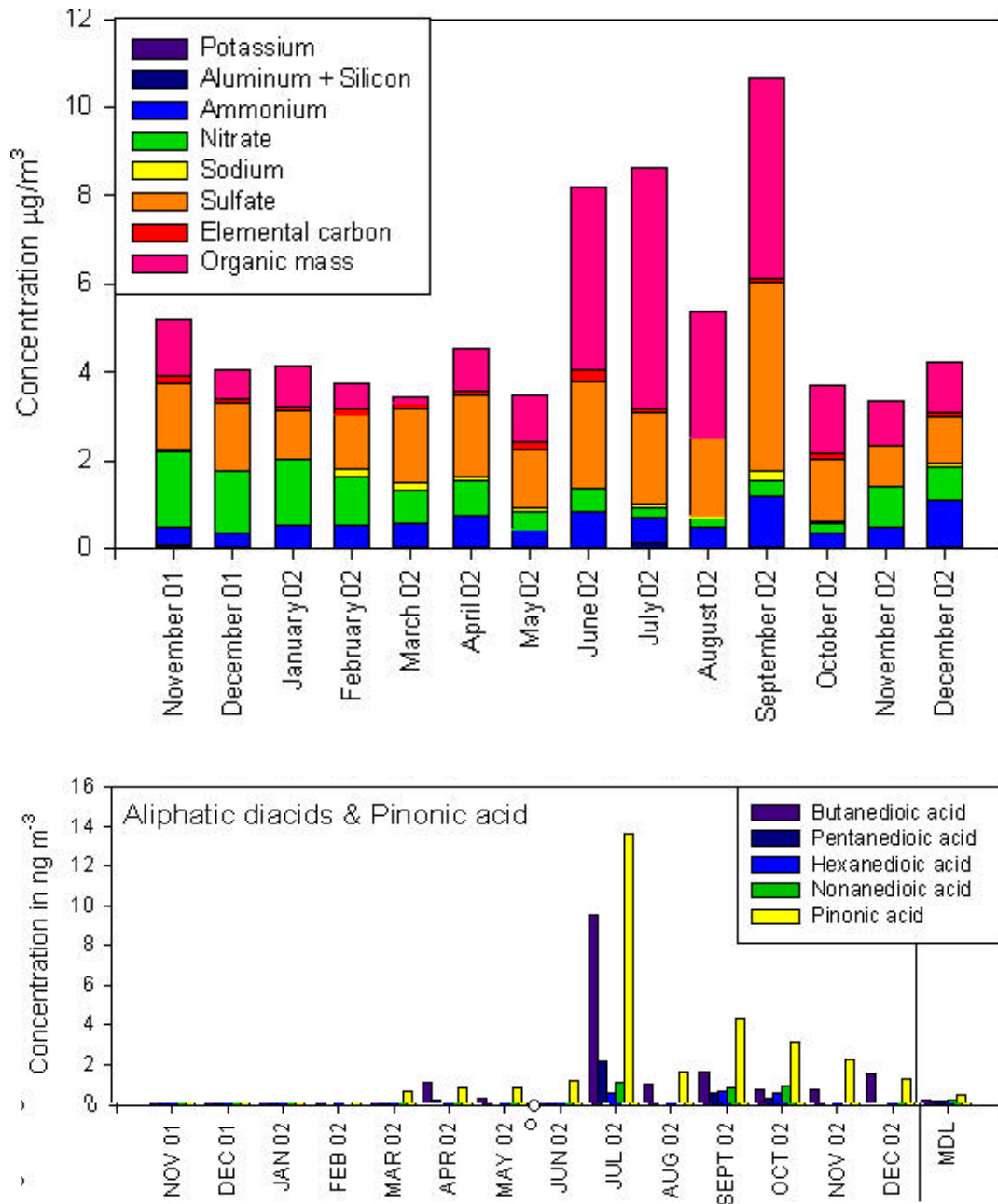


Figure 36. Monthly concentrations of PM_{2.5} species (top), and secondary and biogenic-related organic carbon species in Seney (bottom)

Although the Seney study showed that biomass burning was a relatively small contributor to organic carbon on an annual average basis, episodic impacts are apparent (see, for example, high organic carbon days in Figure 32). To assess further whether burning is a significant contributor to visibility impairment in the northern Class I areas, the PM_{2.5} chemical speciation data were examined for days with high organic carbon and elemental carbon concentrations, which are indicative of biomass burning impacts. Only a handful of such days were identified:

Table 5. Days with high OC and EC concentrations in northern Class I areas

Site	2000	2001	2002	2003	2004
Voyageurs	---	---	Jun 1	Aug 25	Jul 17
			Jun 28		
			Jul 19		
Boundary Waters	---	---	Jun 28	Aug 25	Jul 17
			Jul 19		
Isle Royale	---	---	Jun 1	Aug 25	---
			Jun 28		
Seney	---	---	Jun 28	---	---

Back trajectories on these days point mostly to wildfires in Canada. Elimination of these high organic carbon concentration days has a small effect in lowering the baseline visibility levels in the northern Class I areas (i.e., Minnesota Class I areas change by about 0.3 deciviews and Michigan Class I areas change by less than 0.2 deciviews). This suggests that fire activity, although significant on a few days, is on average a relatively small contributor to visibility impairment in the northern Class I areas.

In summary, these analyses show that organic carbon in the northern Class I is largely uncontrollable.

Section 3.0 Air Quality Modeling

Air quality models are relied on by federal and state regulatory agencies to support their planning efforts. Used properly, models can assist policy makers in deciding which control programs are most effective in improving air quality, and meeting specific goals and objectives. For example, models can be used to conduct “what if” analyses, which provide information for policy makers on the effectiveness of candidate control programs.

The modeling analyses were conducted in accordance with EPA’s modeling guidelines (EPA, 2007a). Further details of the modeling are provided in two protocol documents: LADCO, 2007a and LADCO, 2007b.

This section reviews the development and evaluation of the modeling system used for the multi-pollutant analyses. Application of the modeling system (i.e., attainment demonstration for ozone and PM_{2.5}, and reasonable progress assessment for haze) is covered in the following sections.

3.1 Selection of Base Year

Two base years were used in the modeling analyses: 2002 and 2005. EPA’s modeling guidance recommends using 2002 as the baseline inventory year, but also allows for use of an alternative baseline inventory year, especially a more recent year. Initially, LADCO conducted modeling with a 2002 base year (i.e., Base K/Round 4 modeling, which was completed in 2006). A decision was subsequently made to conduct modeling with a 2005 base year (i.e., Base M/Round 5, which was completed in 2007). As discussed in the previous section, 2002 and 2005 both had above normal ozone conducive conditions, although 2002 was more severe compared to 2005. Examination of multiple base years provides for a more complete technical assessment. Both sets of model runs are discussed in this document.

3.2 Future Years of Interest

To address the multiple attainment requirements for ozone and PM_{2.5}, and reasonable progress goals for regional haze, several future years are of interest:

- 2008 Planning year for ozone basic nonattainment areas (attainment date 2009)⁸
- 2009 Planning year for ozone moderate nonattainment areas and PM_{2.5} nonattainment areas (attainment date 2010)
- 2012 Planning year for ozone moderate nonattainment areas and PM_{2.5} nonattainment areas, with 3-year extension (attainment date 2013)
- 2018 First milestone year for regional haze planning

⁸ According to USEPA’s ozone implementation rule (USEPA, 2005), emission reductions needed for attainment must be implemented by the beginning of the ozone season immediately preceding the area’s attainment date. The PM_{2.5} implementation rule contains similar provisions – i.e., emission reductions should be in place by the beginning of the year preceding the attainment date (USEPA, 2007c). The logic for requiring emissions reductions by the year (or season) immediately preceding the attainment year follows from language in the Clean Air Act, and the ability for an area to receive up to two 1-year extensions. Therefore, emissions in the year preceding the attainment year should be at a level that is consistent with attainment. It also follows that the year preceding the attainment year should be modeled for attainment planning purposes.

Detailed emissions inventories were developed for 2009 and 2018. To support modeling for other future years, less rigorous emissions processing was conducted (e.g., 2012 emissions were estimated for several source sectors by interpolating between 2009 and 2018 emissions).

3.3 Modeling System

The air quality analyses were conducted with the CAMx model, with emissions and meteorology generated using EMS (and CONCEPT) and MM5, respectively. The selection of CAMx as the primary model is based on several factors: performance, operator considerations (e.g., ease of application and resource requirements), technical support and documentation, model extensions (e.g., 2-way nested grids, process analysis, source apportionment, and plume-in-grid), and model science. CAMx model set-up for Base M and Base K is summarized below:

Base M (2005)

- CAMx v4.50
- CB05 gas phase chemistry
- SOA chemistry updates
- AERMOD dry deposition scheme
- ISORROPIA inorganic chemistry
- SOAP organic chemistry
- RADM aqueous phase chemistry
- PPM horizontal transport

Base K (2002)

- * CAMx 4.30
- * CB-IV with updated gas-phase chemistry
- * No SOA chemistry updates
- * Wesley-based dry deposition
- ISORROPIA inorganic chemistry
- SOAP organic chemistry
- RADM aqueous phase chemistry
- PPM horizontal transport

3.4 Domain/Grid Resolution

The National RPO grid projection was used for this modeling. A subset of the RPO domain was used for the LADCO modeling. For PM_{2.5} and haze, the large eastern U.S. grid at 36 km (see box on right side of Figure 36) was used. A PM_{2.5} sensitivity run was also performed for this domain at 12 km. For ozone, the smaller grid at 12 km (see shaded portion of the box on the right side of Figure 37) was used for most model runs. An ozone sensitivity run was also performed with a 4km sub-grid over the Lake Michigan area and Detroit/Cleveland.

The vertical resolution in the air quality model consists of 16 layers extending up to 15 km, with higher resolution in the boundary layer.

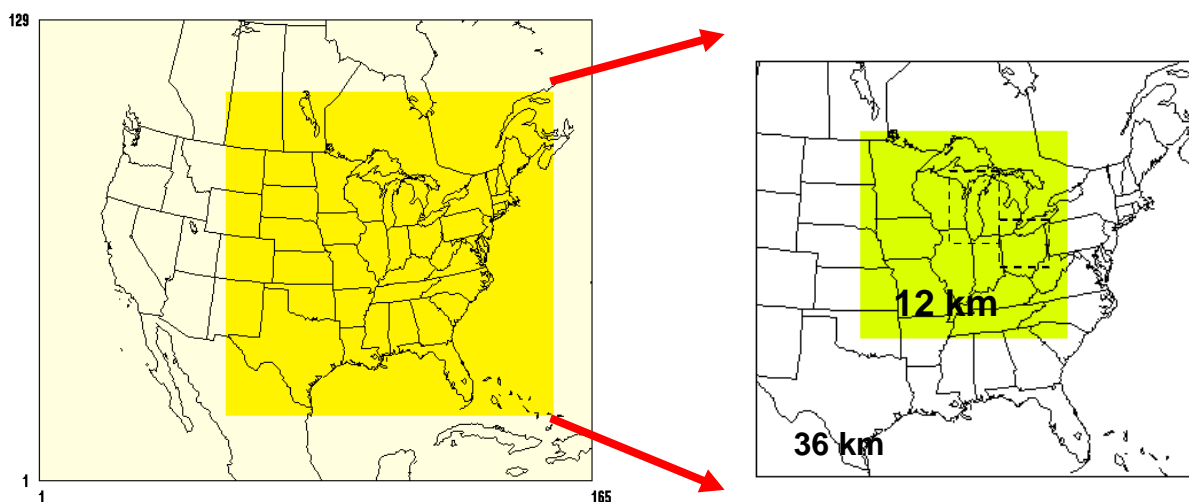


Figure 37. Modeling grids – RPO domain (left) and LADCO modeling domain (right)

3.5 Model Inputs: Meteorology

Meteorological inputs were derived using the Fifth-Generation NCAR/Penn State Meteorological Model (MM5) – version 3.6.3 for the years 2001–2003, and version 3.7 for the year 2005. The MM5 modeling domains are consistent with the National RPO grid projections (see Figure 38).

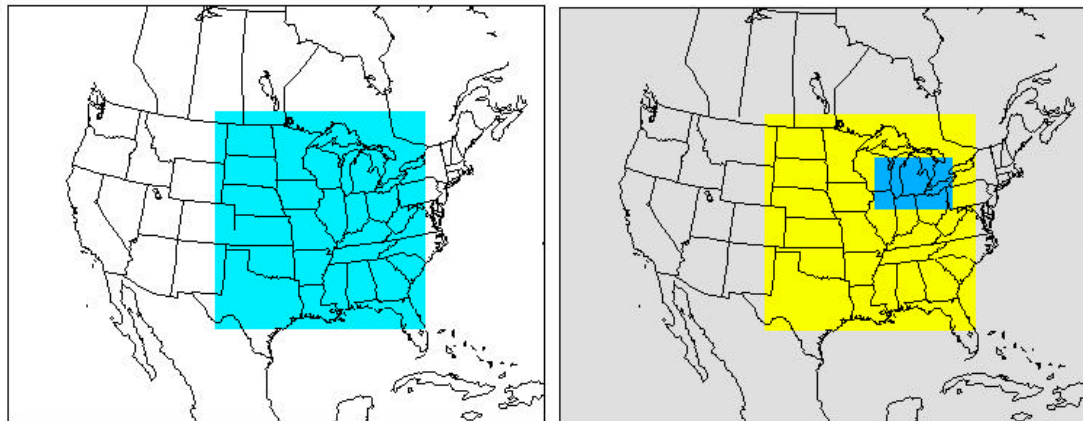


Figure 38. MM5 modeling domain for 2001-2003 (left) and 2005 (right)

The annual 2002 36 km MM5 simulation was completed by Iowa DNR. The 36/12 km 2-way nested simulation for the summers of 2001, 2002, and 2003 were conducted jointly by Illinois EPA and LADCO. The 36 km non-summer portion of the annual 2003 simulation was conducted by Wisconsin DNR. The annual 2005 36/12 km (and summer season 4 km) MM5 modeling was completed by Alpine Geophysics. Wisconsin DNR also completed 36/12 km MM5 runs for the summer season of 2005.

Model performance was assessed quantitatively with the METSTAT tool from Environ. The metrics used to quantify model performance include mean observation, mean prediction, bias, gross error, root mean square error, and index of agreement. Model performance metrics were calculated for several sub-regions of the modeling domain (Figure 39) and represent hourly spatial averages of multiple monitor locations. Additional analysis of rainfall is done on a monthly basis.

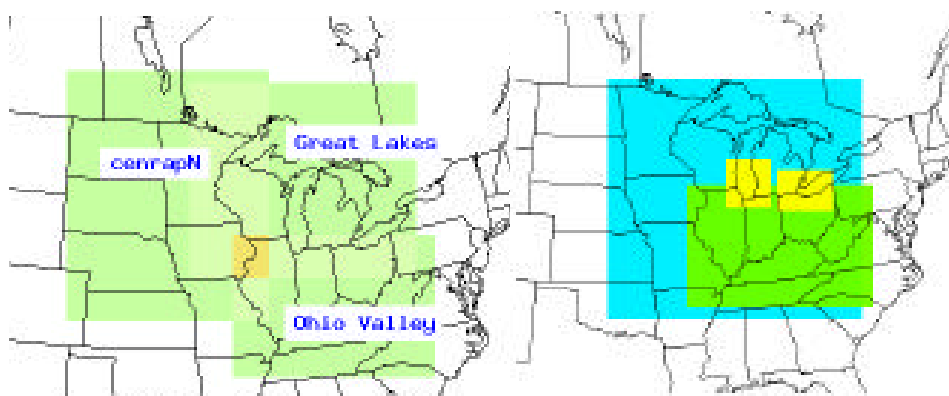


Figure 39. Sub-domains used for model performance for 2001-2003 (left) and 2005 (right)

A summary of the performance evaluation results for the meteorological modeling is provided below. Further details are provided in two summary reports (LADCO, 2005 and LADCO, 2007c).

Temperature: The biggest issue with the performance in the upper Midwest is the existence of a cool diurnal temperature bias in the winter and warm temperature bias over night during the summer (see Figure 40). These features are common to other annual MM5 simulations for the central United States and do not appear to adversely affect model performance.

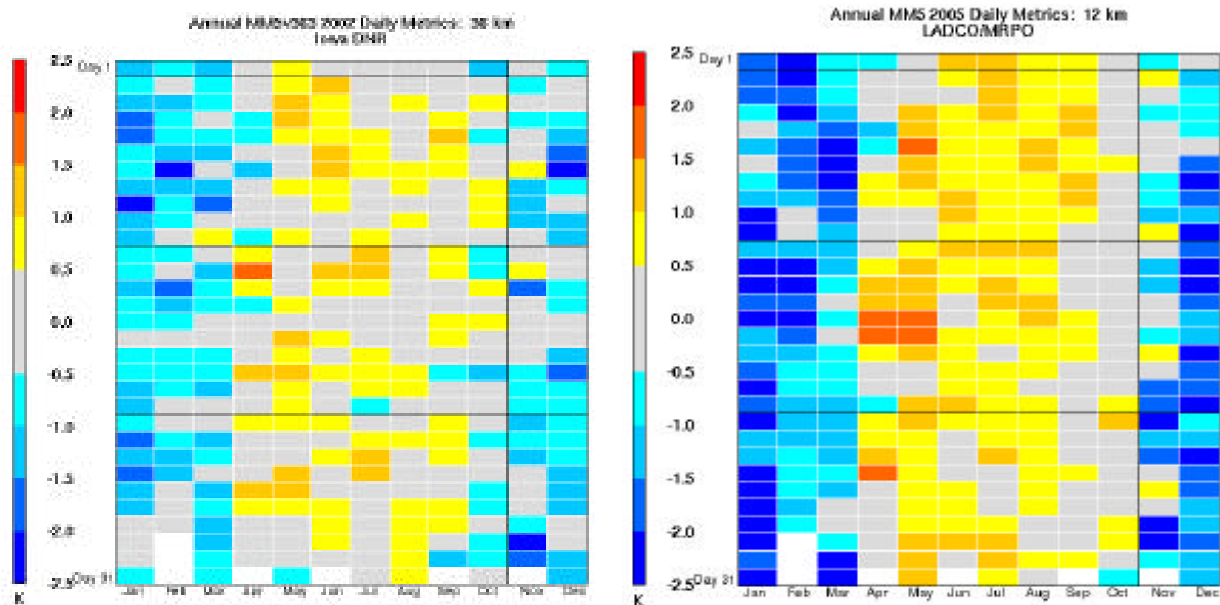


Figure 40. Daily temperature bias for 2002 (left) and 2005 (right) with hotter colors (yellow/orange/red) representing overestimates and cooler colors (blues) representing underestimates

Note: months are represented from left to right (January to December) and days are represented from top to bottom (1 to 30(31) – i.e., upper left hand corner is January 1 and lower right hand corner is December 31

Wind Fields: The wind fields are generally good. Wind speed bias is less than 0.5 m/sec and wind speed error is consistently between 1.0 and 1.5 m/sec. Wind direction error is generally within 15-30 degrees.

Mixing Ratio: The mixing ratio (a measure of humidity) is over-predicted in the late spring and summer months, and mixing ratio error is highest during this period. There is little bias and error during the cooler months when there is less moisture in the air.

Rainfall: The modeled and observed rainfall totals show good agreement spatially and in terms of magnitude in the winter, fall, and early spring months. There are, however, large over-predictions of rainfall in the late spring and summer months (see Figure 41). These over-predictions are seen spatially and in magnitude over the entire domain, particularly in the Southeast United States, and are likely due to excessive convective rainfall being predicted in MM5. This over-prediction of rainfall in MM5 does not necessarily translate into over-prediction of wet deposition in the photochemical model. CAMx does not explicitly use the convective and non-convective rainfall output by MM5, but estimates wet scavenging by hydrometeors using cloud, ice, snow, and rain water mixing ratios output by MM5. Nevertheless, this could have an effect on model performance for PM_{2.5}, as discussed in Section 3.7, and may warrant further attention.

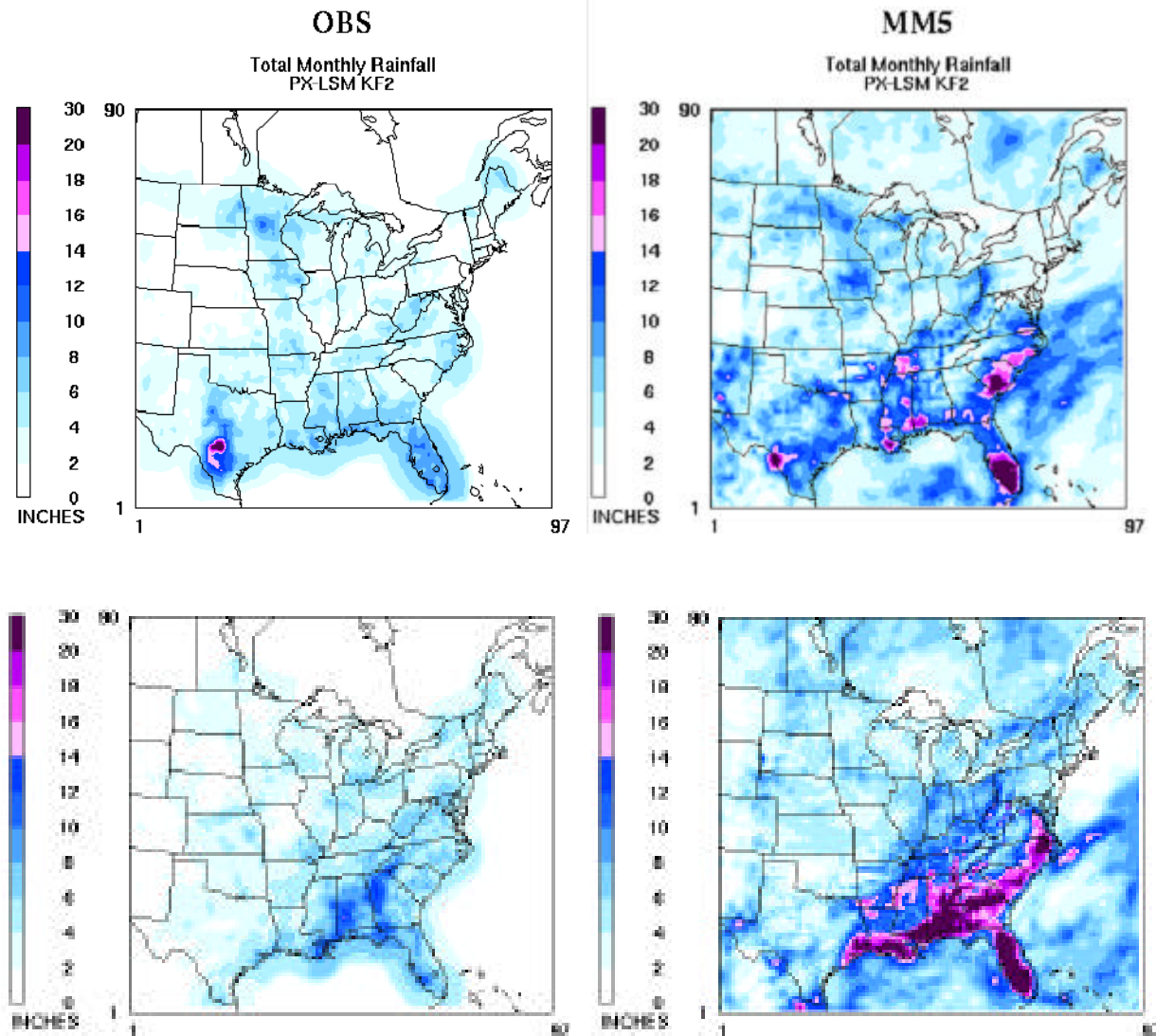


Figure 41. Comparison of observed (left column) and modeled (right column) monthly rainfall for July 2002 (top) and July 2005 (bottom)

3.6 Model Inputs: Emissions

Emission inventories were prepared for two base years: 2002 (Base K) and 2005 (Base M), and several future years: 2008, 2009, 2012, and 2018. Further details of the emission inventories are provided in two summary reports (LADCO, 2006a and LADCO, 2008a) and the following pages of the LADCO web site:

http://www.ladco.org/tech/emis/basek/BaseK_Reports.htm

http://www.ladco.org/tech/emis/r5/round5_reports.htm

For on-road, nonroad, ammonia, and biogenic sources, emissions were estimated by models. For the other sectors (point sources, area sources, and MAR [commercial marine, aircraft, and railroads]), emissions were prepared using data supplied by the LADCO States and other RPOs.

Base Year Emissions: State and source sector emission summaries for 2002 (Base K) and 2005 (Base M) are compared in Figure 42. Additional detail is provided in Tables 6a (all sectors – tons per day) and 6b (EGUs – tons per year).

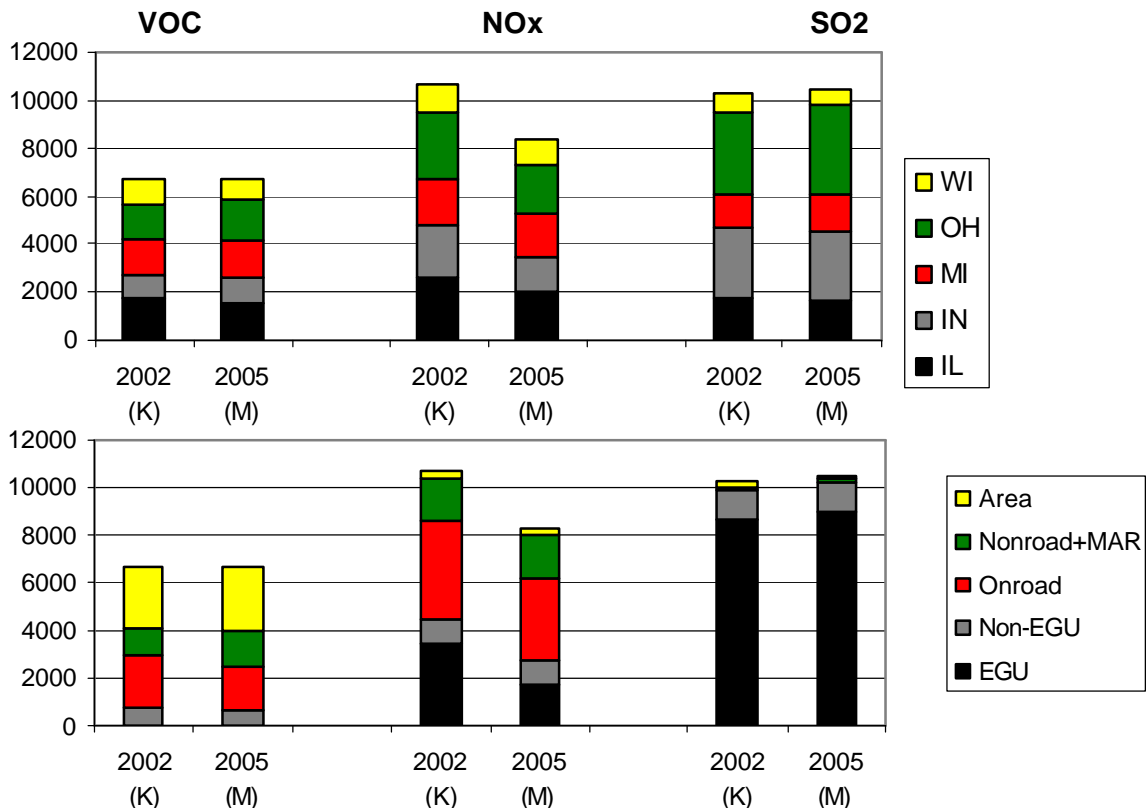


Figure 42. Base K and Base M emissions for 5-state LADCO region by state (top) and source sector (bottom), units: tons per summer weekday

A summary of the base year emissions by sector for the LADCO States is provided below.

	VOC	Base M	BaseK	Base M	BaseK	Base M	NOx	Base M	BaseK	Base M	BaseK	Base M	SOX	Base M	BaseK	Base M	BaseK	Base M	PM2.5	Base M	BaseK	Base M	BaseK	Base M								
July	2002	2005	2009	2009	2012	2018		2002	2005	2009	2009	2012	2018	2018	2002	2005	2009	2009	2012	2018	2018	2002	2005	2009	2009	2012	2018	2018				
Nonroad																																
IL	224	321	164	257	149	130	213	324	333	263	275	224	154	155	31	33	5	5	0.6	0.4	0.4				30		24			14		
IN	125	195	94	160	95	95	128	178	191	142	158	141	141	89	17	19	3	3	3	0.3	0.2				17		13			7		
MI	348	414	307	350	276	222	271	205	239	159	197	133	93	112	19	22	3	3	0.5	0.3	0.3				22		18			11		
OH	222	356	161	294	145	126	238	253	304	195	246	162	109	135	23	29	4	5	0.5	0.3	0.4				27		22			13		
WI	214	238	194	203	175	140	157	145	157	114	129	97	69	77	13	15	2	2	0.3	0.2	0.2				14		12			7		
5-State Total	1133	1524	920	1264	840	713	1007	1105	1224	873	1005	757	566	568	103	118	17	18	4.9	1.5	1.5				110		89			52		
U.S. Total	8463	9815	5442	8448		5244	6581	6041	9060	6057	8120		5832	5100	505	654	117	153		104	13				573		750			475		
MAR																																
IL	10	11	10	10	10	10	6	277	246	201	228	195	186	165	0	22	0	19	0	0	17				7		6			4		
IN	5	5	5	5	5	5	3	123	93	89	87	87	84	65	0.2	8	0.2	7	0.2	0.2	6				2		2			2		
MI	7	7	7	7	7	8	7	114	87	112	82	111	110	65	0.6	21	0.7	14	0.7	0.8	8				3		3			2		
OH	8	7	8	7	8	8	5	177	134	128	126	126	122	94	0.4	14	0.3	12	0.3	0.3	10				4		4			2		
WI	4	4	4	4	4	4	3	79	58	59	54	59	57	41	12.7	8	9.5	6	9.5	8.7	5				2		2			1		
5-State Total	34	34	34	33	34	35	24	770	618	589	577	578	559	430	13.9	73	10.7	58	10.7	10	46				18		17			11		
U.S. Total	307	317	321	157	329	346	334	4968	4515	4002	1813	3964	3919	3812	620	512	509	122	509	503	290				147		57			165		
OtherArea																																
IL	679	675	688	594	700	738	582	62	48	68	48	70	73	49	11	11	12	16	12	13	16				40		64			69		
IN	354	391	365	358	373	398	384	62	56	65	58	67	69	59	158	32	150	32	151	153	32				2		2			2		
MI	518	652	516	562	520	541	549	49	49	52	50	53	54	51	71	29	68	29	68	68	28				111		114			120		
OH	546	604	550	506	558	593	487	50	93	59	108	60	62	108	22	6	34	15	35	35	14				19		35			34		
WI	458	315	467	290	474	506	293	32	37	34	37	34	35	37	9	17	9	13	10	10	13				11		12			12		
5-State Total	2555	2637	2586	2310	2625	2776	2295	255	283	278	301	284	293	304	271	95	273	105	276	279	103				183		227			237		
U.S. Total	17876	21093	18638	18683		20512	24300	3856	4899	4100	4220		4418	5357	2075	2947	2062	2559		2189	2709				2735		2621			2570		
On-Road																																
IL	446	341	314	268	260	197	151	890	748	578	528	474	300	201		9		4			3				13		10			6		
IN	405	282	237	235	193	150	138	703	541	425	402	313	187	173		11		3			2				9		7			2		
MI	522	351	335	269	303	217	163	926	722	680	501	619	385	204		14		4			3				12		9			3		
OH	574	680	365	424	340	238	242	1035	934	609	693	512	270	274		18		4			4				16		12			4		
WI	238	175	144	119	117	88	68	481	457	303	322	226	118	138		9		2			2				8		6			2		
5-State Total	2185	1829	1395	1315	1213	890	762	4035	3402	2595	2446	2144	1260	990		61		17			14				58		44			17		
U.S. Total	14263				7825			23499				13170																				
EGU																																
IL	9	7	8	6	8	9	7	712	305	227	275	244	231	224	1310	1158	944	958	789	810	869				13		34			77		
IN	6	6	6	6	7	6	6	830	393	406	370	424	283	255	2499	2614	1267	1033	1263	1048	1036				16		73			74		
MI	12	6	11	4	11	12	4	448	393	218	242	219	247	243	1103	1251	1022	667	1031	1058	725				15		25			29		
OH	5	4	6	5	7	7	6	1139	408	330	280	322	271	285	3131	3405	1463	1326	994	701	983				28		94			80		
WI	3	5	3	2	4	4	3	293	213	146	165	139	147	177	602	545	512	460	492	500	435				0		22			25		
5-State Total	35	28	34	23	37	38	26	3422	1712	1327	1332	1348	1179	1184	8645	8973	5208	4444	4569	4117	4048				72		248			285		
U.S. Total	214	140	195	124	197	215	138	14371	10316	7746	7274	7721	7007	6095	31839	34545	20163	16903	17629	14727	14133				685		1131			1571		
Non-EGU																																
IL	313	221	286	218	305	350	258	356	330	334	218	338	343	235	373	423	251	335	257	249	346				16		17			19		
IN	150	130	160	137	170	199	167	238	179	212	175	216	225	178	292	218	270	216	274	290	180				35		36			44		
MI	123	116	115	119	122	139	140	216	240	208	242	214	229	271	162	158	166	148	171	185	163				20		21			25		
OH	77	84	75	87	79	90	104	177	175	157	166	160	167	178	240	289	231	288	210	216	293				27		28			33		
WI	88	84	97	87	104	120	106	98	97	91	93	92	94	81	163	156	154	152	155	156	85				0		0.1			0.1		
5-State Total	751	635	733	648	780	898	775	1085	1021	1002	894	1020	1058	943	1230	1244	1072	1139	1067	1096	1067				98		102			121		
U.S. Total	4087	3877	4409		4700	5378		6446	6730	6129		6435	6952		5759	5630	6093		6340	6970							1444			1777		
IL	1681	1576	1470	1353	1432	1434	1217	2621	2010	1671	1572	1545	1287	1029	1725	1656	1212	1337	1059	1072	1251				119		155			189		
IN	1045	1009	867	901	843	853	826	2134	1453	1339	1250	1248	989	819	2966	2902	1690	1294	1691	1492	1256				81		133			131		
MI	1530	1546	1291	1311	1239	1139	1134	1958	1730	1429	1314	1349	1118	946	1356	1495	1260	865	1271	1312	927				183		190			190		
OH	1432	1735	1165	1323	1137	1062	1082	2831	2048	1478	1619	1342	1001	1074	3416	3761	1732	1650	1240	953	1304				121		195			166		
WI	1005	821	909	705	878	862	630	1128	1019	747	800	647	520	551	800	750	687	635	667	675	540				35		54			47		
5-State Total	6693	6687	5702	5593	5529	5350	4889	10672	8260	6664	6555	6131	4915	4419	10263	10564	6581	5781	5928	5504	5280				539		727			723		

Table 6b. EGU Emissions for Midwest States (2018)

	Heat Input (MMBTU/year)	Scenario	SO2 (tons/year)	SO2 (lb/MMBTU)	NOx (tons/year)	NOx (lb/MMBTU)	
IL	980,197,198	2001 - 2003 (average)	362,417	0.74	173,296	0.35	
		IPM 2.1.9	241,000		73,000		
		1,310,188,544	IPM3.0 (base)	277,337	0.423	70,378	0.107
			IPM3.0 - will do	140,296	0.214	62,990	0.096
			IPM3.0 - may do	140,296	0.214	62,990	0.096
IN	1,266,957,401	2001 - 2003 (average)	793,067	1.25	285,848	0.45	
		IPM 2.1.9	377,000		95,000		
		1,509,616,931	IPM3.0 (base)	361,835	0.479	90,913	0.120
			IPM3.0 - will do	417,000	0.552	94,000	0.125
			IPM3.0 - may do	417,000	0.552	94,000	0.125
MI	756,148,700	2001 - 2003 (average)	346,959	0.92	132,995	0.35	
		IPM 2.1.9	399,000		100,000		
		1,009,140,047	IPM3.0 (base)	244,151	0.484	79,962	0.158
			IPM3.0 - will do	244,151	0.484	79,962	0.158
			IPM3.0 - may do	244,151	0.484	79,962	0.158
OH	1,306,296,589	2001 - 2003 (average)	1,144,484	1.75	353,255	0.54	
		IPM 2.1.9	216,000		84,000		
		1,628,081,545	IPM3.0 (base)	316,883	0.389	96,103	0.118
			IPM3.0 - will do	348,000		101,000	
			IPM3.0 - may do	348,000		101,000	
WI	495,475,007	2001 - 2003 (average)	191,137	0.77	90,703	0.36	
		IPM 2.1.9	155,000		46,000		
		675,863,447	IPM3.0 (base)	127,930	0.379	56,526	0.167
			IPM3.0 - will do	150,340	0.445	55,019	0.163
			IPM3.0 - may do	62,439	0.185	46,154	0.137
IA	390,791,671	2001 - 2003 (average)	131,080	0.67	77,935	0.40	
		IPM 2.1.9	147,000		51,000		
		534,824,314	IPM3.0 (base)	115,938	0.434	59,994	0.224
			IPM3.0 - will do	115,938	0.434	59,994	0.224
			IPM3.0 - may do	100,762	0.377	58,748	0.220
MN	401,344,495	2001 - 2003 (average)	101,605	0.50	85,955	0.42	
		IPM 2.1.9	86,000		42,000		
		447,645,758	IPM3.0 (base)	61,739	0.276	41,550	0.186
			IPM3.0 - will do	54,315	0.243	49,488	0.221
			IPM3.0 - may do	51,290	0.229	39,085	0.175
MO	759,902,542	2001 - 2003 (average)	241,375	0.63	143,116	0.37	
		IPM 2.1.9	281,000		78,000		
		893,454,905	IPM3.0 (base)	243,684	0.545	72,950	0.163
			IPM3.0 - will do	237,600	0.532	72,950	0.163
			IPM3.0 - may do	237,600	0.532	72,950	0.163
ND	339,952,821	2001 - 2003 (average)	145,096	0.85	76,788	0.45	
		IPM 2.1.9	109,000		72,000		
		342,685,501	IPM3.0 (base)	41,149	0.240	44,164	0.258
			IPM3.0 - will do	56,175	0.328	58,850	0.343
			IPM3.0 - may do	56,175	0.328	58,850	0.343
SD	39,768,357	2001 - 2003 (average)	12,545	0.63	15,852	0.80	
		IPM 2.1.9	12,000		15,000		
		44,856,223	IPM3.0 (base)	4,464	0.199	2,548	0.114
			IPM3.0 - will do	4,464	0.199	2,548	0.114
			IPM3.0 - may do	4,464	0.199	2,548	0.114

On-road Sources: For 2002, EMS was run by LADCO using VMT and MOBILE6 inputs supplied by the LADCO States. EMS was run to generate 36 days (weekday, Saturday, Sunday for each month) at 36 km, and 9 days (weekday, Saturday, Sunday for June – August) at 12 km. For 2005, CONCEPT was run by a contractor (Environ) using transportation data (e.g., VMT and vehicle speeds) supplied by the state and local planning agencies in the LADCO States and Minnesota for 24 networks. These data were first processed with T3 (Travel Demand Modeling [TDM] Transformation Tool) to provide input files for CONCEPT to calculate link-specific, hourly emission estimates (Environ, 2008). CONCEPT was run with meteorological data for a July and January weekday, Saturday, and Sunday (July 15 – 17 and January 16 – 18). A spatial plot of emissions is provided in Figure 43.

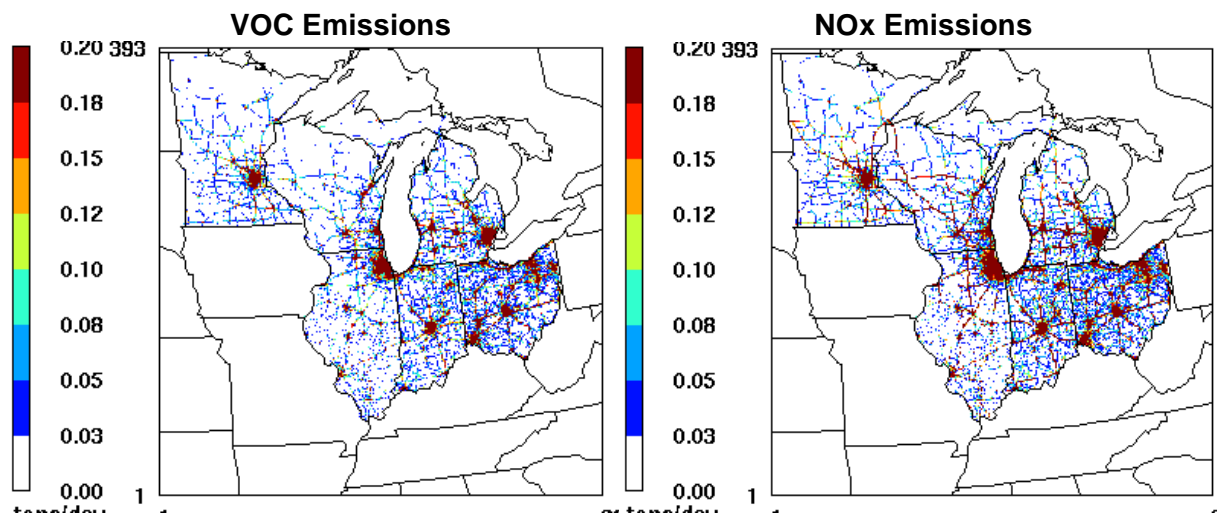


Figure 43. Motor vehicle emissions for VOC (left) and NOx (right) for a July weekday (2005)

Off-road Sources: For 2002 and 2005, NMIM and NMIM2005, respectively, were run by Wisconsin DNR. Additional off-road sectors (i.e., commercial marine, aircraft, and railroads [MAR]) were handled separately. Local data for agricultural equipment, construction equipment, commercial marine, recreational marine, and railroads were prepared by contractors (Environ, 2004, and E.H. Pechan, 2004). For Base M, updated local data for railroads and commercial marine were prepared by a contractor (Environ, 2007b, 2007c). Table 7 compares the Base M 2005 and Base K 2002 emissions. Compared to 2002, the new 2005 emissions reflect substantially lower commercial marine emissions and lower locomotive NOx emissions.

Table 7. Locomotive and commercial marine emissions for the five LADCO States (2002 v. 2005)

	Railroads (TPY)			Commercial Marine (TPY)	
	2002	2005		2002	2005
VOC	7,890	7,625		1,562	828
CO	20,121	20,017		8,823	6,727
NOx	182,226	145,132		64,441	42,336
PM	5,049	4,845		3,113	1,413
SO2	12,274	12,173		25,929	8,637
NH3	86	85		----	----

Area Sources: For 2002 and 2005, EMS was run by LADCO using data supplied by the LADCO States to produce weekday, Saturday, and Sunday emissions for each month. For 2005, special attention was given to two source categories: industrial adhesive and sealant solvents (which were dropped from the inventory to avoid double-counting) and outdoor wood boilers (which were added to the inventory).

Point Sources: For 2002 and 2005, EMS was run by LADCO using data supplied by the LADCO States to produce weekday, Saturday, and Sunday emissions for each month. For EGUs, the annual and summer season emissions were temporalized for modeling purposes using profiles prepared by Scott Edick (Michigan DEQ) based on CEM data.

Biogenics: For Base M, a contractor (Alpine) provided an updated version of the CONCEPT/MEGAN biogenics model. Compared to the previous (EMS/BIOME) emissions, there is more regional isoprene using MEGAN compared to the BIOME estimates used for Base K (see Figure 44). Also, with the secondary organic aerosol updates to the CAMx air quality model, Base M includes emissions for monoterpenes and sesquiterpenes, which are precursors of secondary PM_{2.5} organic carbon mass.

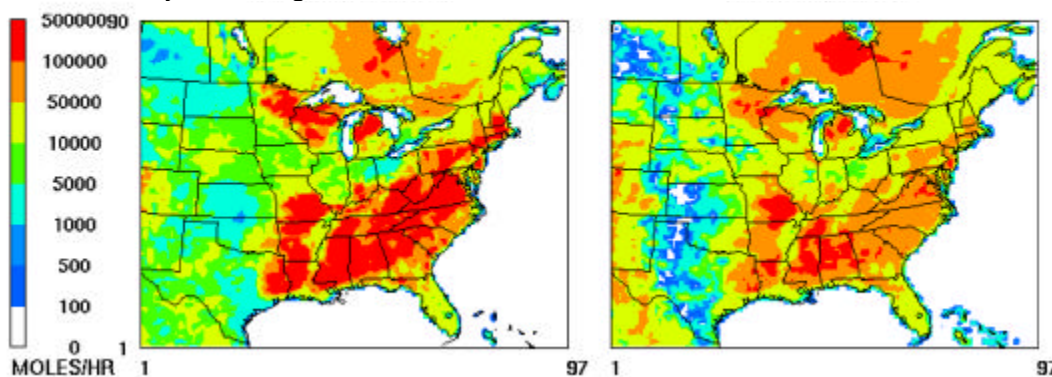


Figure 44. Isoprene emissions for Base M (left) v. Base K (right)

Ammonia: For Base M, the CMU-based 2002 (Base K) ammonia emissions were projected to 2005 using growth factors from the Round 4 emissions modeling. These emissions were then adjusted by applying temporal factors by month based on the process-based ammonia emissions model (Zhang, et al, 2005, and Mansell, et al, 2005). A plot of average daily emissions by state and month is provided in Figure 45. A spatial plot of emissions is provided in Figure 46, which shows high emissions densities in the central U.S.

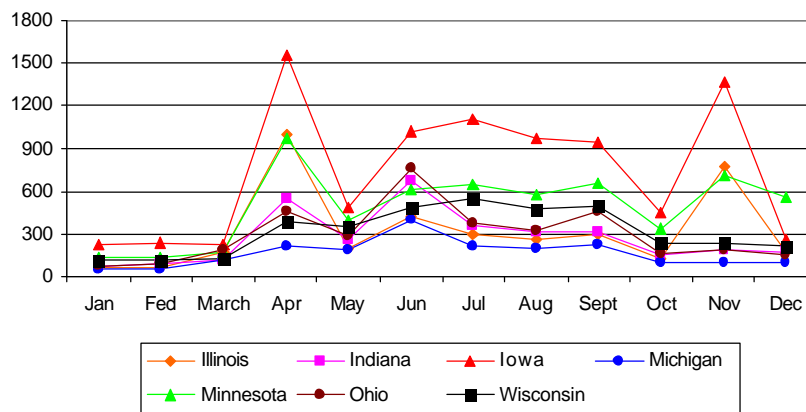


Figure 45. Average daily ammonia emissions for Midwest States by month (2005) - (units: average daily emissions – tons per day)

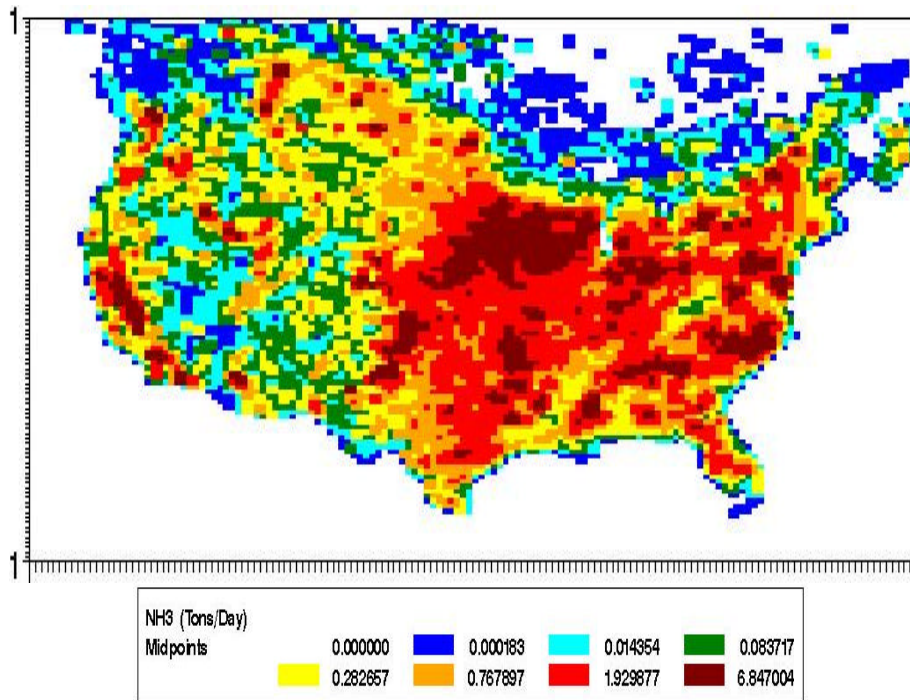


Figure 46. Ammonia emissions for a July weekday (2005) – 12 km modeling domain

Canadian Emissions: For Base M, Scott Edick (Michigan DEQ) processed the 2005 Canadian National Pollutant Release Inventory, Version 1.0 (NPRI). Specifically, a subset of the NPRI data (emissions and stack parameters) relevant to the air quality modeling were reformatted. The resulting emissions represent a significant improvement in the base year emissions.

A spatial plot of point source SO₂ and NO_x emissions is provided in Figure 47. Additional plots and emission reports are available on the LADCO website (<http://www.ladco.org/tech/emis/basem/canada/index.htm>).

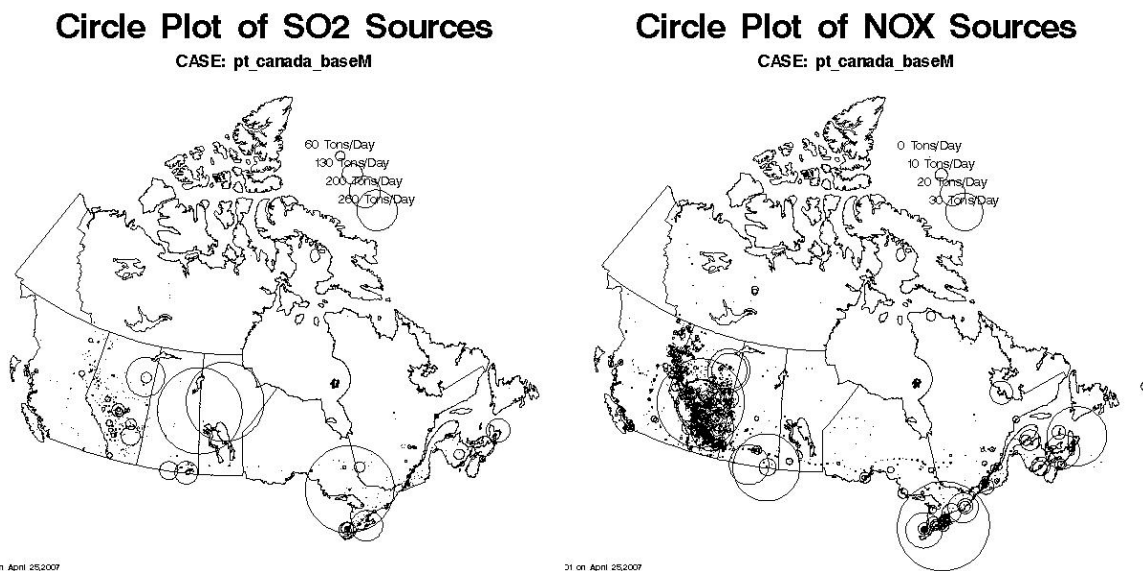


Figure 47. Canadian point source emissions for SO₂ (left) and NO_x (right)

Fires: For Base K, a contractor (EC/R, 2004) developed a 2001, 2002, and 2003 fire emissions inventory for eight Midwest States (five LADCO states plus Iowa, Minnesota, and Missouri), including emissions from wild fires, prescribed fires, and agricultural burns. Projected emissions were also developed for 2010 and 2018 assuming “no smoke management” and “optimal smoke management” scenarios. An early model sensitivity run showed very little difference in modeled PM_{2.5} concentrations. Consequently, the fire emissions were not included in subsequent modeling runs (i.e., they were not in the Base K or Base M modeling inventories).

Future Year Emissions: Complete emission inventories were developed for several future years: Base K – 2009, 2012, and 2018, and Base M – 2009 and 2018. In addition, 2008 (Base K and Base M) and 2012 (Base M) proxy inventories were estimated based on the 2009 and 2018 data. (Note, the EGU emissions for the Base M 2012 inventory were based on EPA’s IPM3.0 modeling.)

Source sector emission summaries for the base years and future years are shown in Figure 48. Additional detail is provided in Tables 6a and 6b.

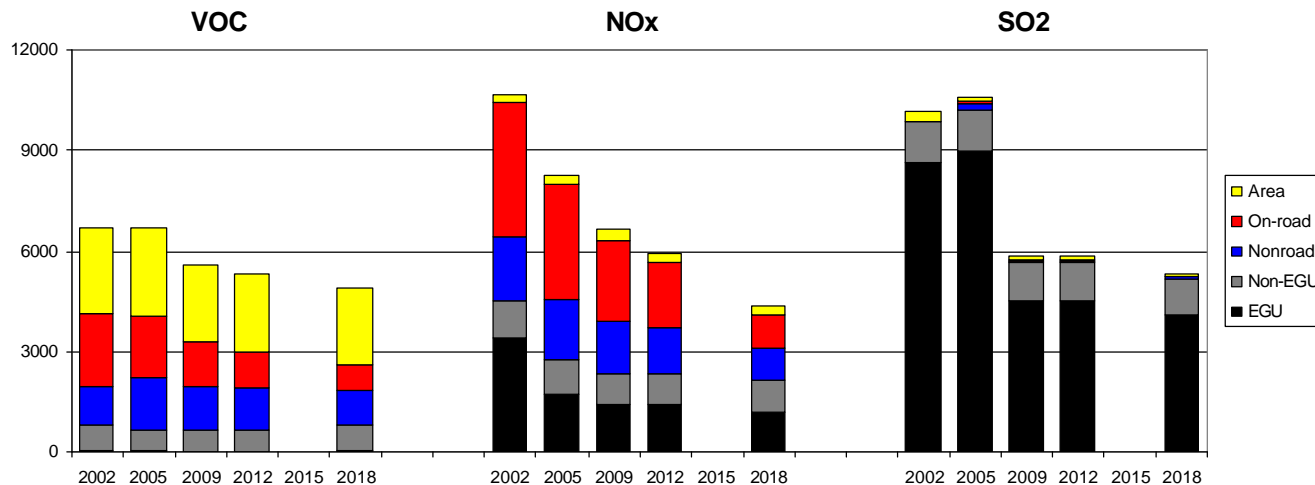


Figure 48. Base year and future year emissions for 5-State LADCO Region (TPD, July weekday)

For on-road, and nonroad, the future year emissions were estimated by models (i.e., EMS/CONCEPT and NMIM, respectively). One adjustment was made to the 2009 and 2018 motor vehicle emission files prepared by Environ with CONCEPT. To reflect newer transportation modeling conducted by CATS for the Chicago area, emissions were increased by 9% in 2009 and 2018. The 2005 base year and adjusted 2009 and 2018 motor vehicle emissions are provided in Table 8.

Table 8. Motor Vehicle Emissions Produced by CONCEPT Modeling (July weekday – tons per day)

Year	State	Sum of CO	Sum of TOG	Sum of NOx	Sum of PM2.5	Sum of SO2	Sum of NH3	Sum of VMT
2005	IL	3,684.3	341.5	748.2	12.9	9.6	35.9	344,087,819.6
	IN	3,384.9	282.0	541.1	8.9	11.1	25.7	245,537,231.9
	MI	4,210.3	351.9	722.0	12.4	13.9	35.3	340,834,025.9
	MN	2,569.1	218.7	380.5	6.3	7.6	17.7	170,024,599.7
	OH	6,113.4	679.8	933.6	16.2	18.8	36.5	360,521,068.6
	WI	2,206.0	175.1	457.5	7.8	9.2	19.7	189,123,964.3
	Total		22,168.0	2,049.0	3,782.9	64.5	70.2	170.8
2009	IL	2,824.4	268.0	527.8	10.1	4.2	38.9	372,132,591.1
	IN	2,839.5	234.9	401.9	6.7	2.8	26.1	249,817,026.3
	MI	3,172.0	269.2	500.9	9.2	4.0	37.1	356,347,010.5
	MN	2,256.8	206.3	307.5	5.1	2.3	21.5	204,443,017.8
	OH	4,619.2	423.7	693.5	11.8	4.7	39.5	387,428,127.2
	WI	1,673.4	119.4	322.1	5.7	2.3	20.6	197,729,964.9
	Total		17,385.3	1,521.5	2,753.6	48.7	20.3	183.6
2018	IL	2,084.7	151.5	200.7	6.3	3.7	43.1	413,887,887.3
	IN	2,217.3	138.4	173.0	4.4	2.6	30.2	288,042,232.1
	MI	2,434.3	163.5	204.1	5.9	3.6	40.5	388,128,431.8
	MN	1,799.6	123.1	137.1	3.6	2.2	24.9	237,022,213.7
	OH	3,361.5	242.5	274.1	6.8	4.0	43.1	421,694,093.4
	WI	1,255.5	68.4	138.5	3.9	2.0	22.2	218,277,167.5
	Total		13,152.9	887.5	1,127.5	30.8	18.1	203.9

For EGUs, future year emissions were based on IPM2.1.9 modeling completed by the RPOs in July 2005 Base K and IPM3.0 completed by EPA in February 2007 for Base M. Several CAIR scenarios were assumed:

Base K

- 1a: IPM2.1.9, with full trading and banking
- 1b: IPM2.1.9, with restricted trading (compliance with state-specific emission budgets) and full trading
- 1d: IPM2.1.9, with restricted trading (compliance with state-specific emission budgets)

Base M

- 5a: EPA's IPM3.0 was assumed as the future year base for EGUs.
- 5b: EPA's IPM3.0, with several "will do" adjustments identified by the States. These adjustments should reflect a legally binding commitment (e.g., signed contract, consent decree, or operating permit).
- 5c: EPA's IPM3.0, with several "may do" adjustments identified by the States. These adjustments reflect less rigorous criteria, but should still be some type of public reality (e.g., BART determination or press announcement).

For other sectors (area, MAR, and non-EGU point sources), the future year emissions for the LADCO States were derived by applying growth and control factors to the base year inventory. These factors were developed by a contractor (E.H. Pechan, 2005 and E.H. Pechan, 2007). For the non-LADCO States, future year emission files were based on data from other RPOs.

Growth factors were based initially on EGAS (version 5.0), and were subsequently modified (for select, priority categories) by examining emissions activity data. Due to a lack of information on future year conditions, the biogenic VOC and NOx emissions, and all Canadian emissions were assumed to remain the constant between the base year and future years.

A "base" control scenario was prepared for each future year based on the following "on the books" controls:

On-Highway Mobile Sources

- Federal Motor Vehicle Emission Control Program, low-sulfur gasoline and ultra-low sulfur diesel fuel
- Inspection - maintenance programs, including IL's vehicle emissions tests (NE IL), IN's vehicle emissions testing program (NW IN), OH's E-check program (NE OH), and WI's vehicle inspection program (SE WI) – note: a special emissions modeling run was done for the Cincinnati/Dayton area to reflect the removal of the state's E-check program and inclusion of low RVP gasoline
- Reformulated gasoline, including in Chicago-Gary,-Lake County, IL,IN; and Milwaukee, Racine, WI

Off-Highway Mobile Sources

- Federal control programs incorporated into NONROAD model (e.g., nonroad diesel rule), plus the evaporative Large Spark Ignition and Recreational Vehicle standards
- Heavy-duty diesel (2007) engine standard/Low sulfur fuel
- Federal railroad/locomotive standards
- Federal commercial marine vessel engine standards

Area Sources (Base M only)

- Consumer solvents
- AIM coatings
- Aerosol coatings
- Portable fuel containers

Power Plants

- Title IV (Phases I and II)
- NOx SIP Call
- Clean Air Interstate Rule

Other Point Sources

- VOC 2-, 4-, 7-, and 10-year MACT standards
- Combustion turbine MACT

Other controls included in the modeling include: consent decrees (refineries, ethanol plants, and ALCOA)⁹, NO_x RACT in Illinois and Ohio¹⁰, and BART for a few non-EGU sources in Indiana and Wisconsin.

For Base K, several additional control scenarios were considered:

Scenario 2 – “base” controls plus additional controls recommended in LADCO White Papers for stationary and mobile sources

Scenario 3 – Scenario 2 plus additional White Papers for stationary and mobile sources

Scenario 4 – “base” controls plus additional candidate control measures under discussion by State Commissioners

Scenario 5 – “base” controls plus additional candidate control measures identified by the LADCO Project Team

3.7 Basecase Modeling Results

The purpose of the basecase modeling is to evaluate model performance (i.e., assess the model's ability to reproduce the observed concentrations). The model performance evaluation focused on the magnitude, spatial pattern, and temporal of modeled and measured concentrations. This exercise was intended to assess whether, and to what degree, confidence in the model is warranted (and to assess whether model improvements are necessary).

Model performance was assessed by comparing modeled and monitored concentrations. Graphical (e.g., side-by-side spatial plots, time series plots, and scatter plots) and statistical analyses were conducted. No rigid acceptance/rejection criteria were used for this study. Instead, the statistical guidelines recommended by EPA and other modeling studies (e.g., modeling by the other RPOs) were used to assess the reasonableness of the results. The model performance results presented here describe how well the model replicates observed ozone and PM_{2.5} concentrations after a series of iterative improvements to model inputs.

Ozone: Spatial plots are provided for high ozone periods in June 2002 and June 2005 (see Figures 49a and 49b). The plots show that the model is doing a reasonable job of reproducing the magnitude, day-to-day variation, and spatial pattern of ozone concentrations. There is a tendency, however, to underestimate the magnitude of regional ozone levels. This is more apparent with the 2002 modeling; the regional concentrations in the 2005 modeling agree better with observations due to model and inventory improvements.

⁹ E.H. Pechan's original control file included control factors for three sources in Wayne County, MI. These control factors were not applied in the regional-scale modeling to avoid double-counting with the State's local-scale analysis for PM_{2.5}

¹⁰ NO_x RACT in Wisconsin is included in the 2005 basecase (and EGU “will do” scenario). NO_x RACT in Indiana was not included in the modeling inventory.

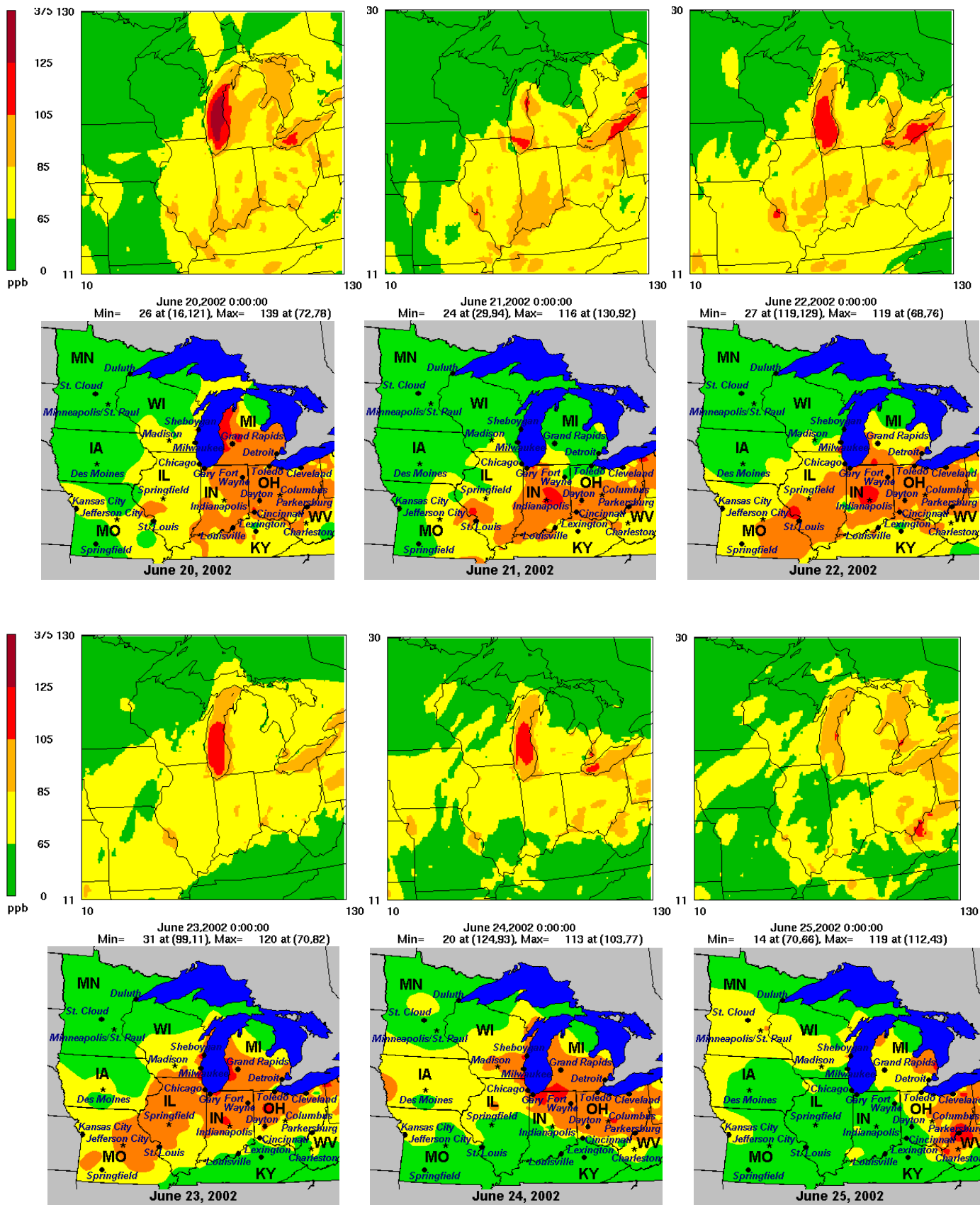


Figure 49a. Modeled (top) v. monitored (bottom) 8-hour ozone concentrations: June 20 – 25, 2002

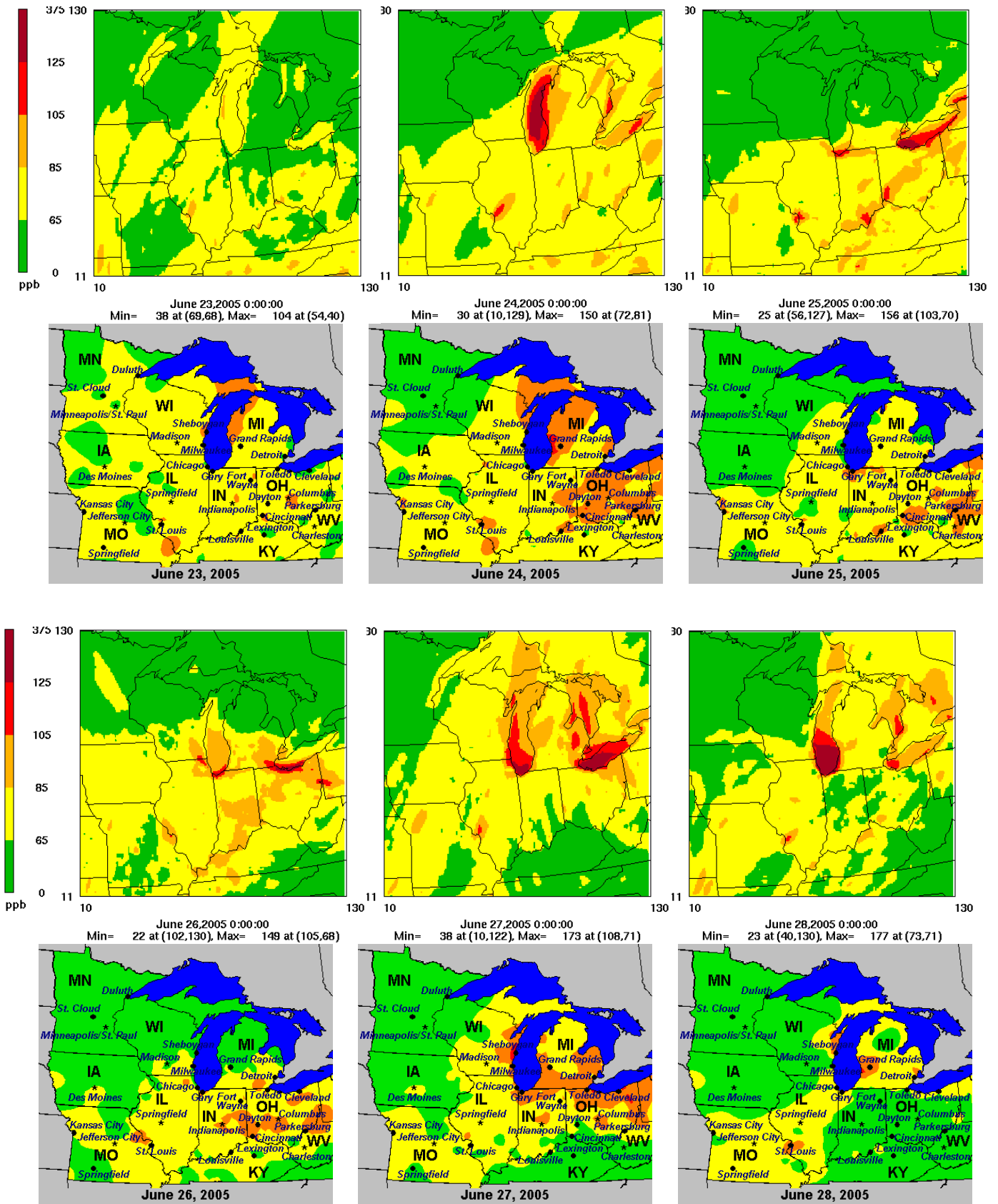


Figure 49b Modeled (top) v. monitored (bottom) 8-hour ozone concentrations: June 23– 28 2005

Standard model performance statistics were generated for the entire 12 km domain, and by day and by monitoring site. The domain-wide mean normalized bias for the 2005 base year is similar to that for the 2002 base year and is generally within 30% (see Figure 50).

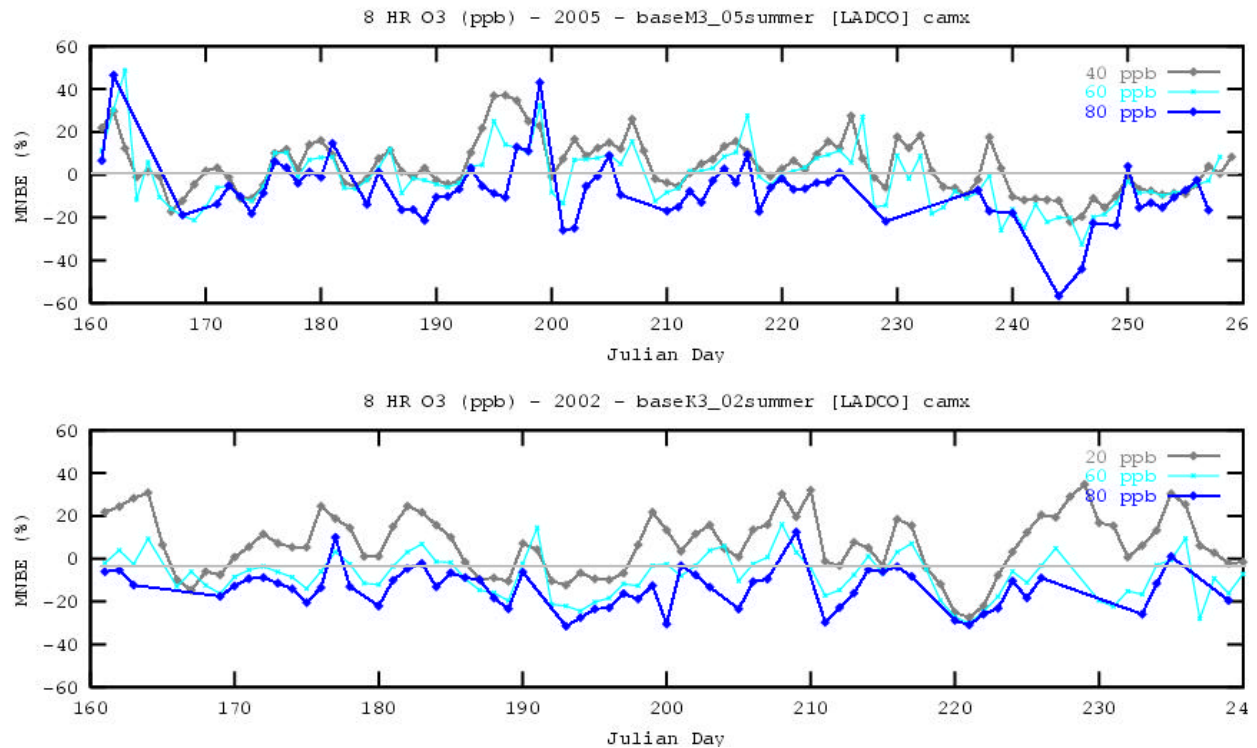


Figure 50. Mean bias for summer 2005 (Base M) and summer 2002 (Base K)

Station-average metrics (over the entire summer) are shown in Figure 51. The bias results further demonstrate the model's tendency to underestimate absolute ozone concentrations.

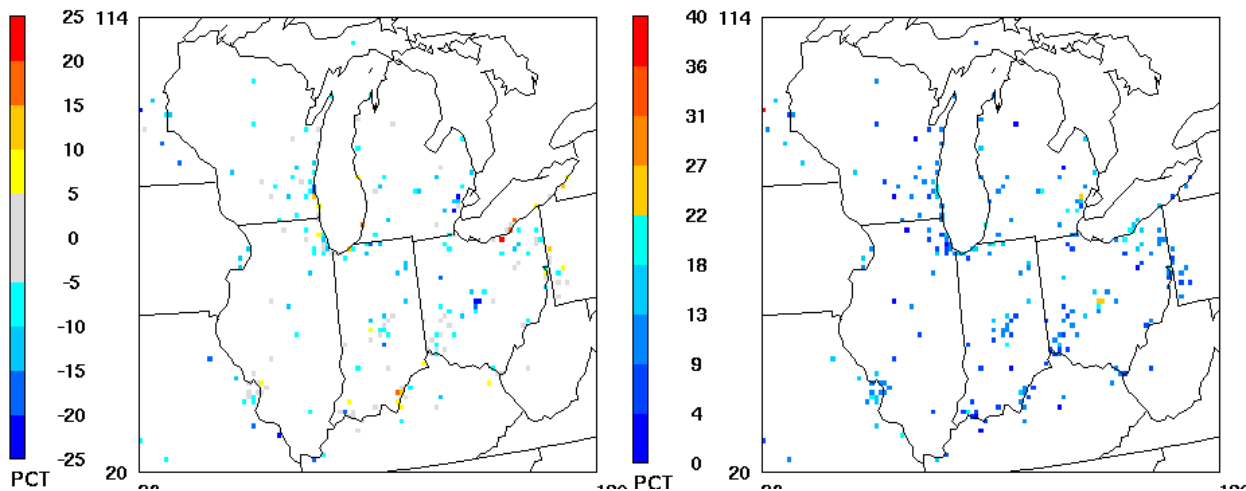


Figure 51. Mean bias (left) and gross error (right) for summer 2005

A limited 4 km ozone analysis was performed by LADCO to address the effect of grid spacing. For this modeling, 4 km grids were placed over Lake Michigan and the Detroit-Cleveland area (see Figure 52). Model inputs included 4 km emissions developed by LADCO (consistent with Base K/Round 4) and the 4 km meteorology developed by Alpine Geophysics.

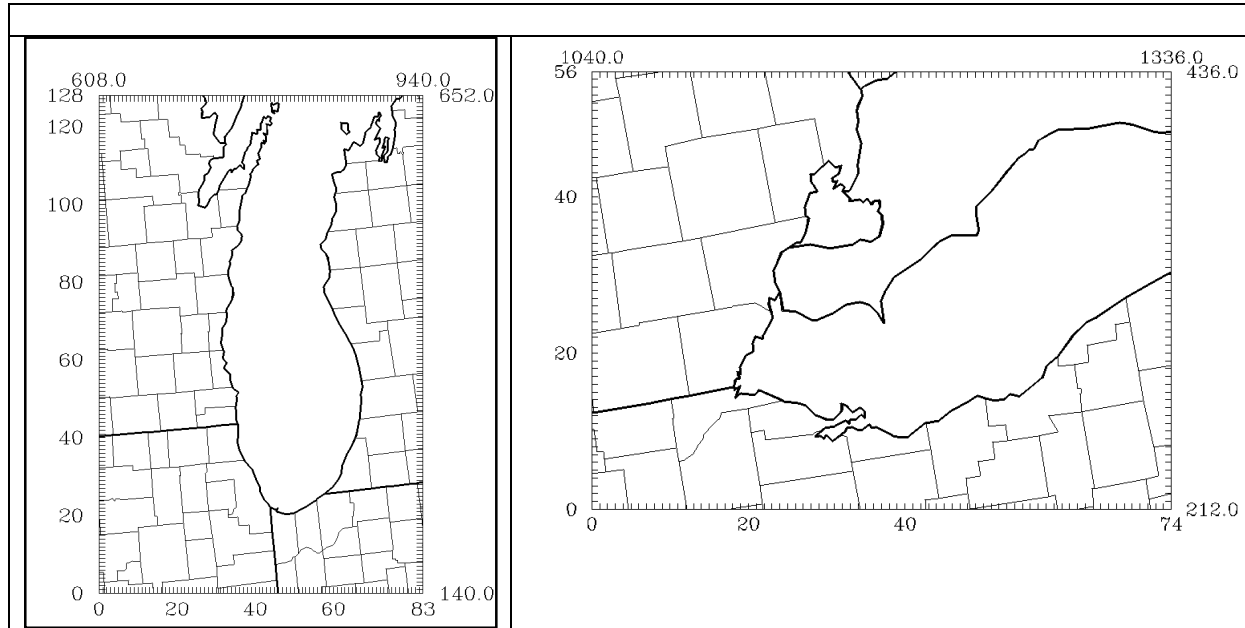


Figure 52. 4 km grids for Lake Michigan region and Detroit-Cleveland region

Hourly time series plots were prepared for several monitors (see Figure 53). The results are similar at 12 km and 4 km, with some site-by-site and day-by-day differences.

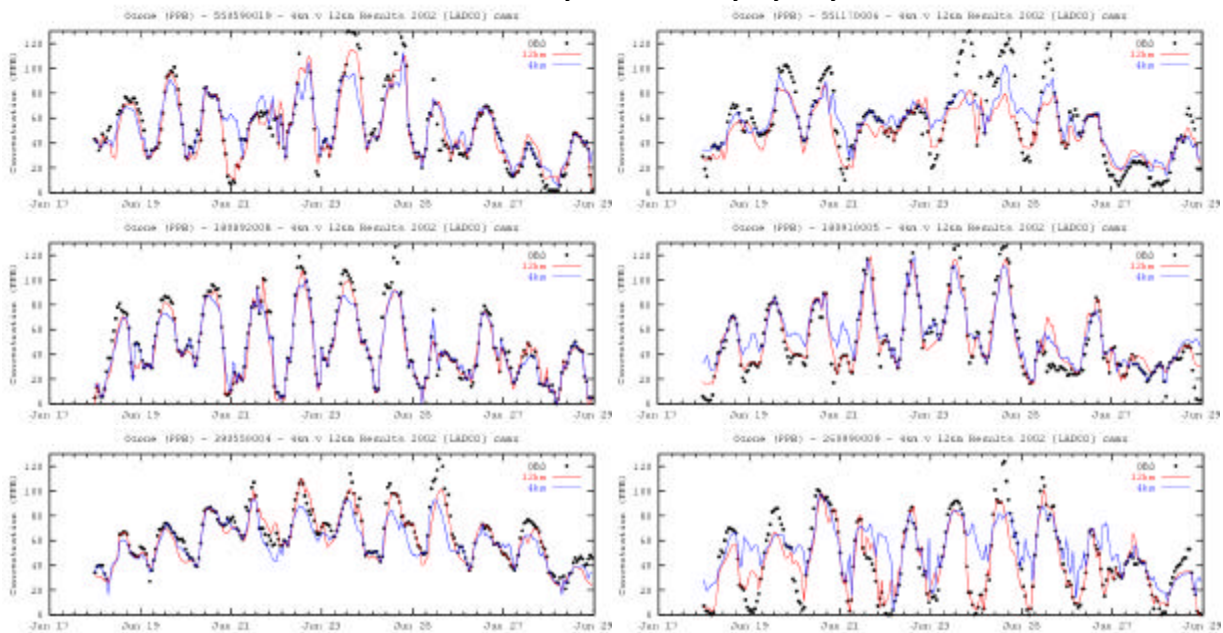


Figure 53. Ozone time series plots for 12 km and 4 km modeling (June 17-29, 2002)

An additional diagnostic analysis was performed to assess the response of the modeling system to changes in emissions (Baker and Kenski, 2007). Specifically, the 2002-to-2005 change in observed ozone concentrations was compared to the change in modeled ozone concentrations based on the 95th percentile (and above) concentration values for each monitor. This analysis was also done with the inclusion of model performance criteria which eliminated poorly performing days (i.e., error > 35%). The results show good agreement in the modeled and monitored ozone concentration changes (e.g., ozone improves by about 9-10 ppb between 2002 and 2005 according to the model and the measurements) – see Figure 54. This provides further support for using the model to develop ozone control strategies.

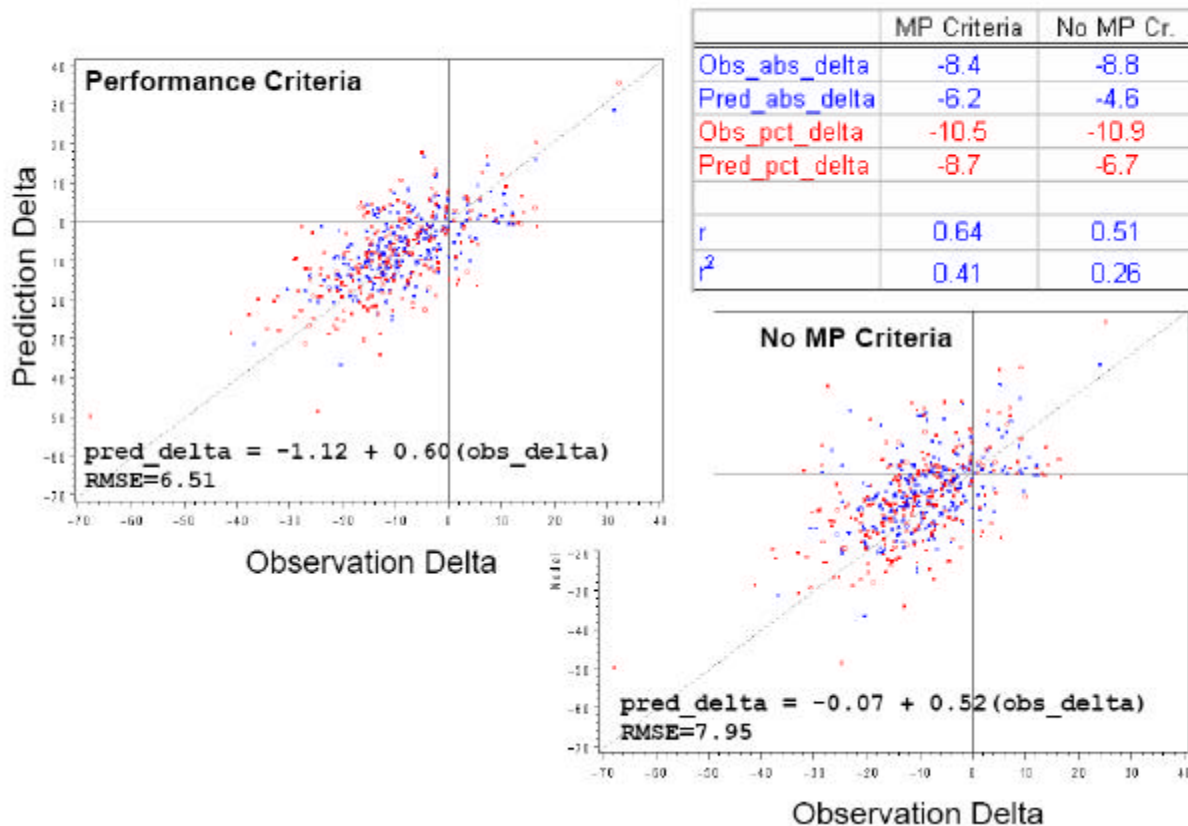


Figure 54. Comparison of change in predicted and observed ozone concentrations (2002 v. 2005)

$PM_{2.5}$: Time series plots of the monthly average mean bias and annual fractional bias for Base M and Base K are shown in Figure 55. As can be seen, Base M model performance for most species is fair (i.e., close to “no bias” throughout most of the year), with two main exceptions. First, the Base M and Base K results for organic carbon are poor, suggesting the need for more work on primary organic carbon emissions. Second, the Base M results for sulfate, while acceptable (i.e., bias values are within 35%), are not as good as the Base K results (e.g., noticeable underprediction during the summer months).

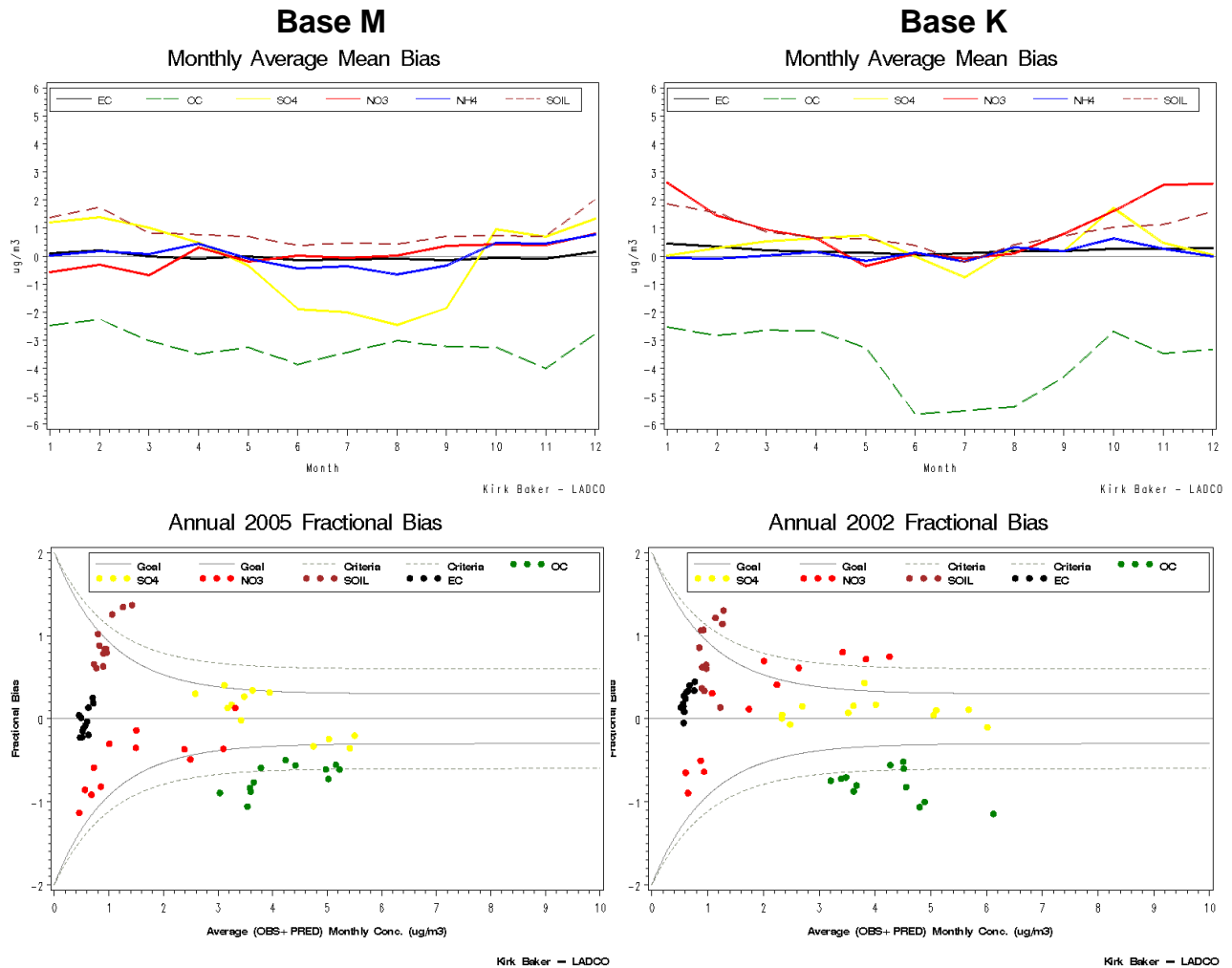


Figure 55. $PM_{2.5}$ Model performance - monthly average mean bias and annual fractional bias for Base M (left column) and Base K (right column)

Two analyses were undertaken to understand sulfate model performance for 2005:

- Assess Meteorological Influences: The MM5 model performance evaluation showed that rainfall is over-predicted by MM5 over most of the domain during the summer months (LADCO, 2007c). Because CAMx does not explicitly use the rainfall output by MM5, this may or may not result in over-prediction sulfate wet deposition (and under-prediction of sulfate concentrations). A sensitivity run was performed with no wet deposition for July, August, and September. The resulting model performance (see green line in Figure 56) showed a noticeable difference from the basecase (i.e., higher sulfate concentrations), and suggests that further evaluation of MM5 precipitation fields may be warranted.
- Assess Emissions Influences: The major contributor to sulfate concentrations in the region is SO₂ emitted from EGUs. The basecase modeling inventory for EGUs is based on annual emissions, which were allocated to a typical weekday, Saturday, and Sunday by month using CEM-based temporal profiles. A sensitivity run was performed using day-specific emissions. The resulting model performance (see purple line in Figure 56) showed little difference from the basecase.

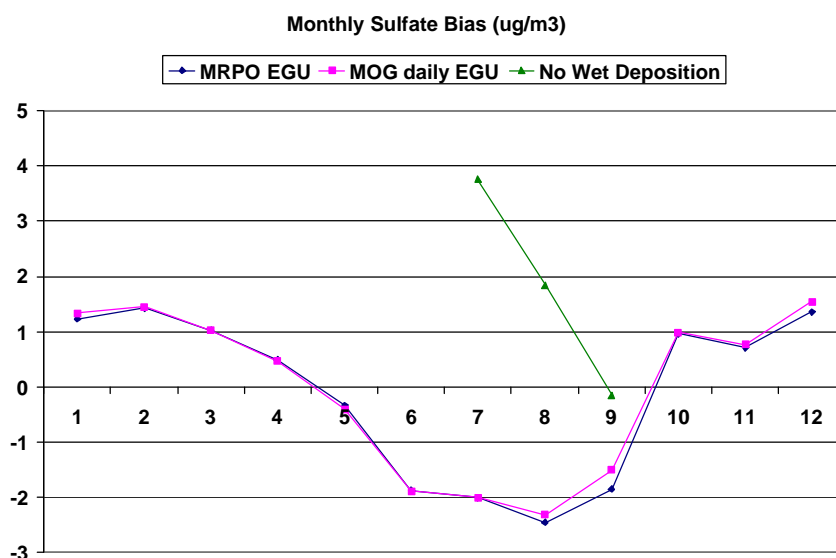


Figure 56. Monthly sulfate bias for Base M (MRPO EGU) v. two sensitivity analyses (Note: positive values indicate over-prediction, negative values indicate under-prediction)

To assess the effect of the wet deposition issue on future year modeled values, another sensitivity run was conducted with no wet deposition in Quarters 2-3 for the base year (2005) and 2018. The resulting future year values were only slightly different from the current base strategy run. In general, the future year values (without wet deposition) were a little higher (+0.15 ug/m³ or less) in the Ohio Valley and a little lower (-.10 ug/m³ or less) in the Great Lakes region. This sensitivity run provides a bound for sulfate wet deposition issue in terms of the attainment test, given that having no wet deposition is unrealistic. The results suggest that even with an improved wet deposition treatment, the Base M strategy results are not expected to change very much.

Time series plots of daily sulfate, nitrate, elemental carbon, and organic carbon concentrations for three Midwestern locations are presented in Figures 57 (2002) and 58 (2005). These results are consistent with the model performance statistics (i.e., good agreement for sulfates and nitrates and poor agreement [large underprediction] for organic carbon).

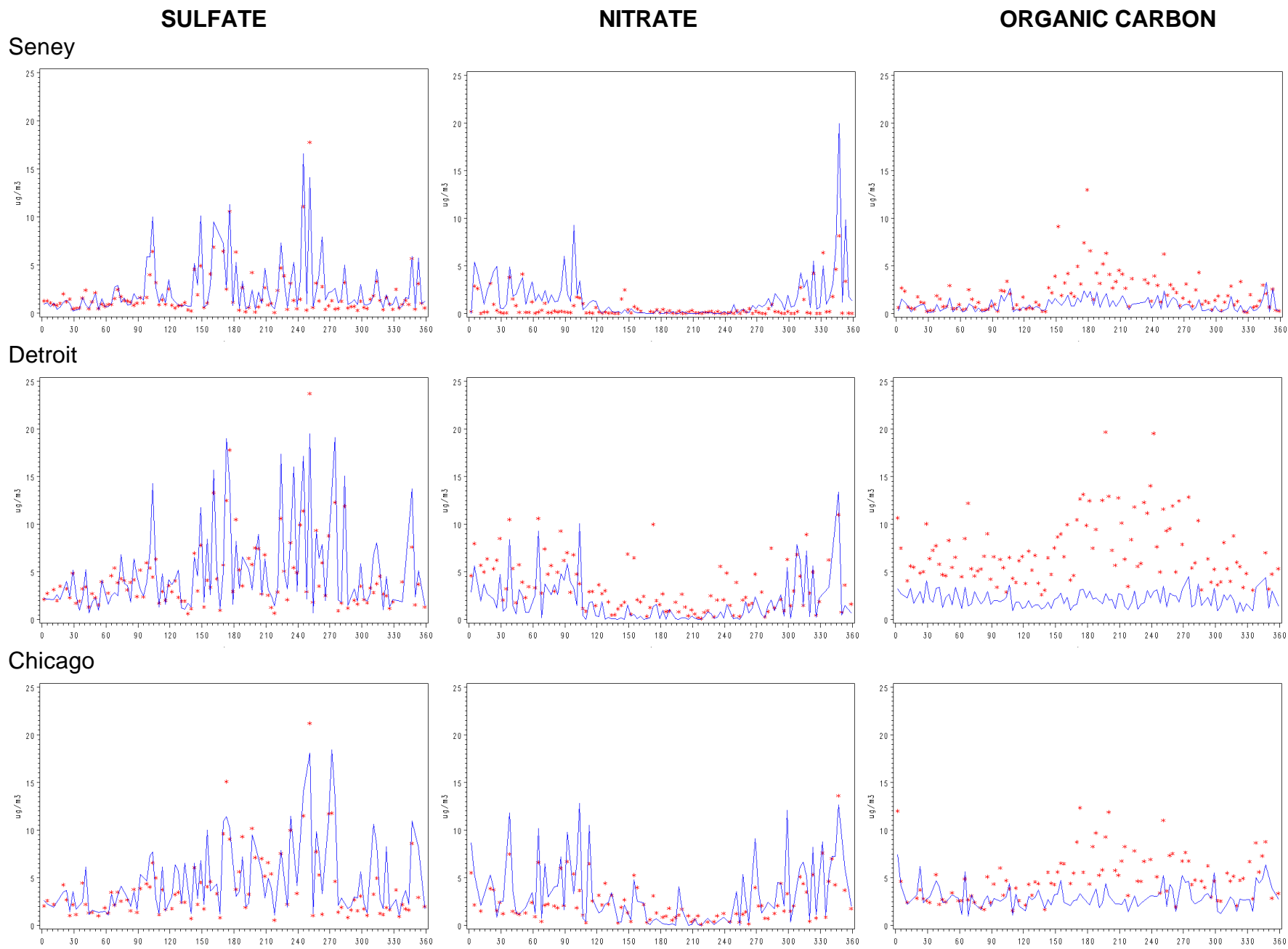


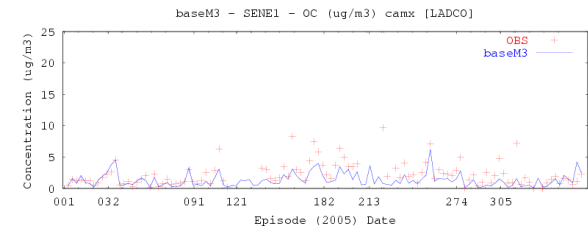
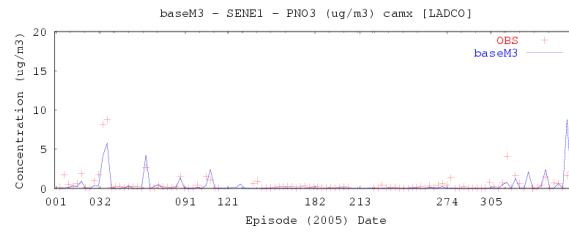
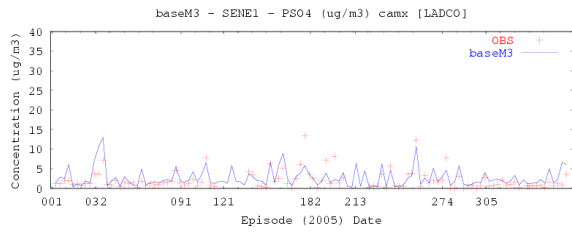
Figure 57. Time series of sulfate, nitrate, and organic carbon at three Midwest sites for 2005

SULFATE

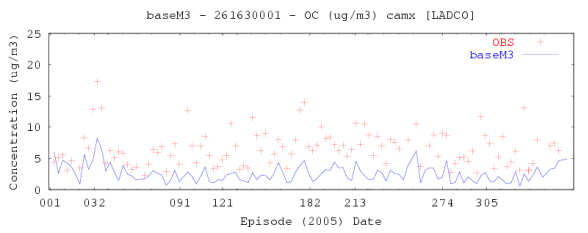
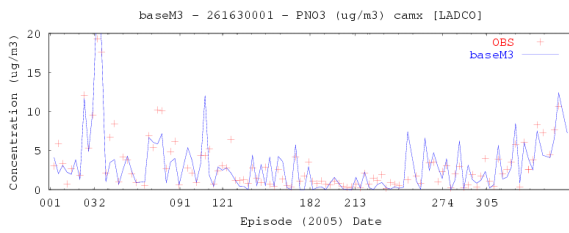
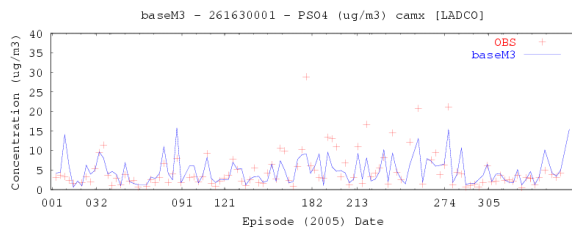
NITRATE

ORGANIC CARBON

Seney



Detroit



Chicago

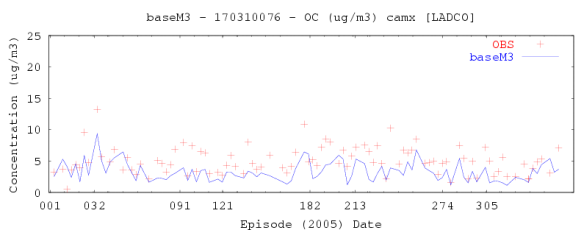
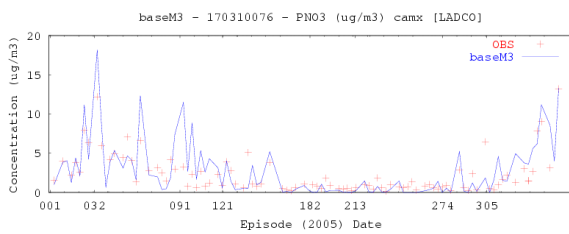
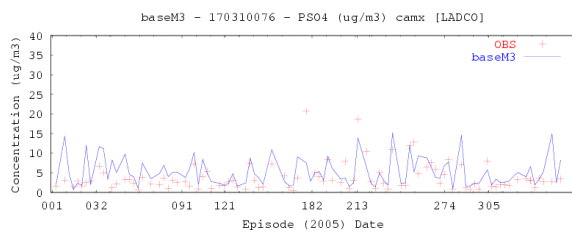


Figure 58. Time series of sulfate, nitrate, and organic carbon at three Midwest sites for 2005

In summary, model performance for ozone and PM_{2.5} is generally acceptable and can be characterized as follows:

Ozone

- Good agreement between modeled and monitored concentration for higher concentration levels (> 60 ppb) – i.e., bias within 30%
- Regional modeled concentrations appear to be underestimated in the 2002 base year, but show better agreement (with monitored data) in the 2005 base year due to model and inventory improvements.
- Day-to-day and hour-to-hour variation in and spatial patterns of modeled concentrations are consistent with monitored data
- Model accurately simulates the change in monitored ozone concentrations due to reductions in precursor emissions.

PM_{2.5}

- Good agreement in the magnitude of fine particle mass, but some species are overestimated and some are underestimated (during periods of the year when it is important)
 - Sulfates: good agreement in the 2002 base year, but underestimated in the summer in the 2005 base year due probably to meteorological factors
 - Nitrates: slightly overestimated in the winter in the 2002 base year, but good agreement in the 2005 base year as a result of model and inventory improvements
 - Organic Carbon: grossly underestimated in the 2002 and 2005 base years due likely to missing primary organic carbon emissions and, possibly, other factors (e.g., grid resolution and model chemistry).
- Temporal variation and spatial patterns of modeled concentrations are consistent with monitored data

Several observations should be noted on the implications of these model performance findings on the attainment modeling presented in the following section. First, it has been demonstrated that model performance overall is acceptable and, thus, the model can be used for air quality planning purposes. Second, consistent with EPA guidance, the model is used in a relative sense to project future year values. EPA suggests that this approach “should reduce some of the uncertainty attendant with using absolute model predictions alone” (EPA, 2007a). Furthermore, the attainment modeling is supplemented by additional information to provide a weight of evidence determination.

Section 4.0 Attainment Demonstration for Ozone and PM_{2.5}

Air quality modeling and other information were used to determine whether existing (“on the books”) controls would be sufficient to provide for attainment of the NAAQS for ozone and PM_{2.5} and if not, then what additional emission reductions would be necessary for attainment. Traditionally, attainment demonstrations involved a “bright line” test in which a single modeled value was compared to the ambient standard. To provide a more robust assessment of expected future year air quality, EPA’s modeling guidelines call for consideration of supplemental information. This section summarizes the results of the primary (guideline) modeling analysis and a weight of evidence determination based on the modeling results and other supplemental analyses.

4.1 Future Year Modeling Results

The purpose of the future year modeling is to assess the effectiveness of existing and possible additional control programs. The model was used in a relative sense to project future year values, which are then compared to the standard to determine attainment/nonattainment. Specifically, the modeling test consists of the following steps:

- (1) Calculate base year design values: For ozone and PM_{2.5}, the base year design values were derived by averaging the three 3-year periods centered on the emissions base year:

2002 base year: 2000-2002, 2001-2003, and 2002-2004

2005 base year: 2003-2005, 2004-2006, and 2005-2007¹¹

- (2) Estimate the expected change in air quality: For each grid cell, a relative reduction factor (RRF) is calculated by taking the ratio of the future year and baseline modeling results.
- (3) Calculate future year values: For each grid cell (with a monitor), the RRFs are multiplied by the base year design values to project the future year values
- (4) Assess attainment: Future year values are compared to the NAAQS to assess attainment or nonattainment.

A comparison of the 2002 and 2005 base year design values for ozone and PM_{2.5} is provided in Figure 59. In general, the figure shows that the 2005 base year design values are much lower than the 2002 base year design values, especially for ozone.

¹¹ A handful of source-oriented PM_{2.5} monitors in Illinois and Indiana were excluded from the annual attainment test, because these monitors are not to be used to judging attainment of the annual standard.

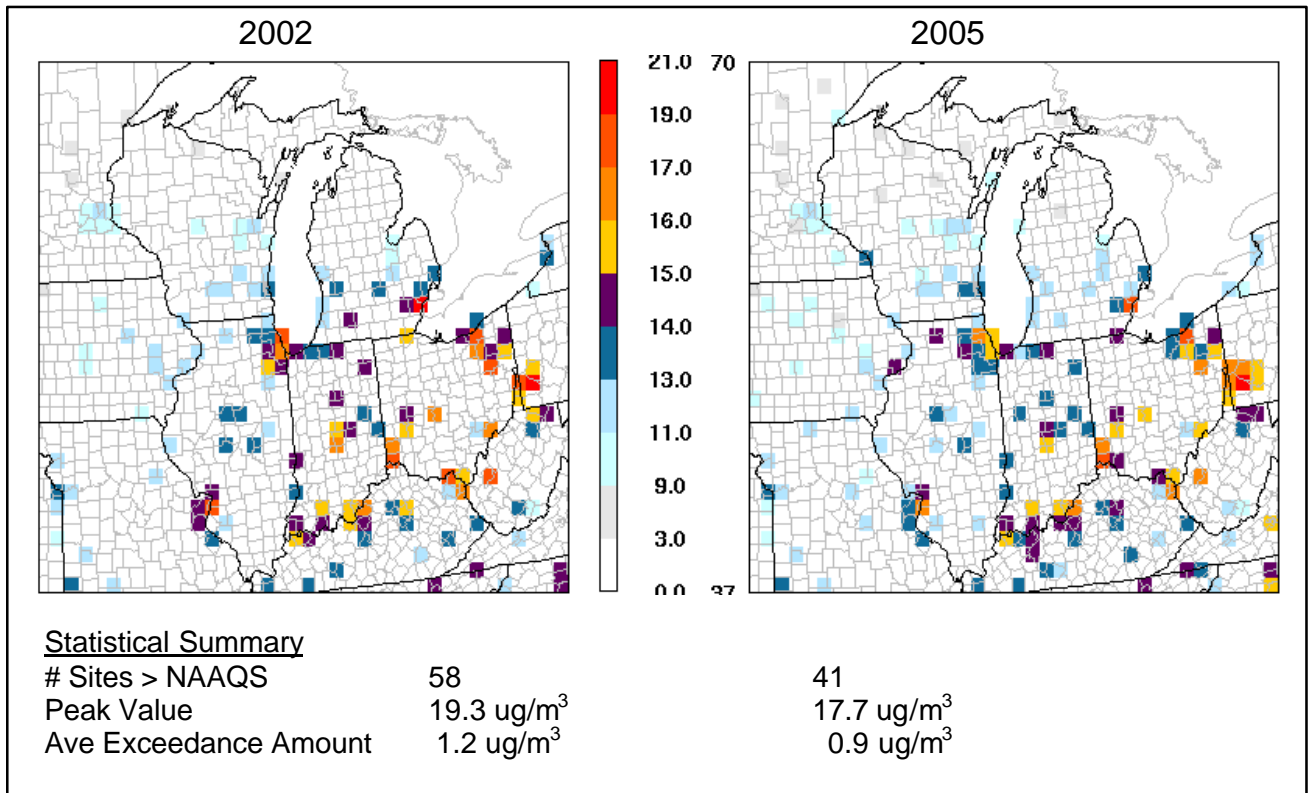
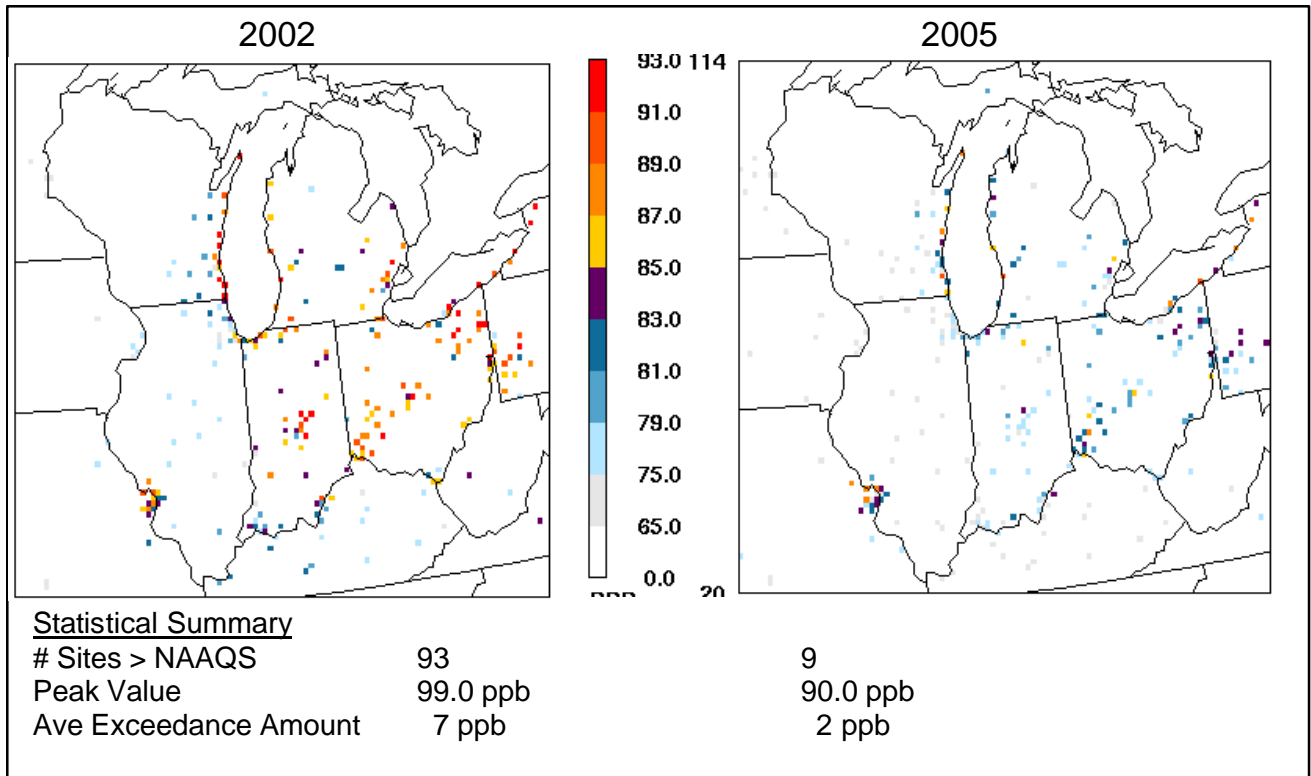


Figure 59. 2002 v. 2005 base year design values for ozone (top) and PM_{2.5} (bottom)

Ozone results are provided for those grid cells with ozone monitors. The RRF calculation considers all nearby grid cells (i.e., 3x3 for 12 km modeling) and a threshold of 85 ppb. (If there were less than 10 days above this value, then the threshold was lowered until either there were 10 days or the threshold reached 70 ppb.) PM_{2.5} results are provided for those grid cells with FRM (PM_{2.5}-mass) monitors. Spatial mapping was performed to extrapolate PM_{2.5}-speciation data from STN and IMPROVE sites to FRM sites. RRF values for PM_{2.5} were derived as a function of quarter and chemical species.

Additional, hot-spot modeling will be performed by the states for certain PM_{2.5} nonattainment areas (e.g., Detroit, Cleveland, and Granite City) to address primary emissions from local point sources which may not be adequately accounted for by the regional grid modeling. This modeling will consist of Gaussian dispersion modeling (e.g., AERMOD) performed in accordance with EPA's modeling guidance (see Section 5.3 of the April 2007 guidance document). Further analyses will need to be undertaken to determine how to best combine the regional modeling and the hot-spot modeling. This could mean some adjustment to the model results presented in this document to reflect better the regional component.

The ozone and PM_{2.5} modeling results are provided in Appendix I for select monitors (high concentration sites) in the 5-state region for the following future years of interest: 2008 (ozone only), 2009, 2012, and 2018. (Note, RRF values for ozone, and for PM_{2.5} by season and chemical species are also included in Appendix I for key monitoring sites.) A summary of the modeling results is provided in Table 9 (ozone) and Table 10 (PM_{2.5}), and spatial maps of the Base M future year concentrations are provided in Figures 60-62.

Table 9. Summary of Ozone Modeling Results

Key Sites		2008		2009		2012		2018
		Round 5	Round 4	Round 5	Round 4	Round 5	Round 4	Round 5
Lake Michigan Area								
Chiwaukee	550590019	82.0	93.0	82.3	92.0	80.9	90.3	76.2
Racine	551010017	77.6	85.9	77.5	84.9	76.1	82.9	71.2
Milwaukee-Bayside	550190085	79.6	85.4	79.8	84.9	78.0	82.3	72.7
Harrington Beach	550890009	80.0	86.7	80.1	85.4	78.3	82.9	72.5
Manitowoc	550710007	81.3	80.3	80.8	78.9	78.6	76.3	72.5
Sheboygan	551170006	84.4	90.0	84.0	88.9	81.8	86.4	75.4
Kewaunee	550610002	78.9	82.5	78.1	81.0	75.9	79.1	69.9
Door County	550290004	84.8	83.6	83.9	81.8	81.5	79.3	74.7
Hammond	180892008	75.4	86.9	75.4	86.6	74.6	86.3	71.6
Whiting	180890030	77.0		77.0		76.2		73.1
Michigan City	180910005	74.2	87.4	73.9	86.5	72.5	85.4	68.1
Ogden Dunes	181270020	75.7	82.3	75.6	82.8	74.5	82.0	70.8
Holland	260050003	85.6	84.9	85.3	83.4	82.8	81.0	76.1
Jenison	261390005	77.9	78.7	77.1	77.6	74.5	75.5	68.7
Muskegon	261210039	80.8	82.7	80.5	81.5	78.0	79.4	71.9
Indianapolis Area								
Noblesville	189571001	78.0	85.2	78.1	83.7	75.6	82.0	68.7
Fortville	180590003	73.9	85.1	73.9	83.8	71.4	82.1	65.1
Fort B. Harrison	180970050	74.8	84.8	75.1	83.7	73.2	82.4	69.1
Detroit Area								
New Haven	260990009	82.7	86.3	81.4	85.3	80.2	83.5	76.1
Warren	260991003	82.5	84.3	81.3	83.3	80.7	81.9	77.6
Port Huron	261470005	79.0	80.5	77.5	79.1	75.5	77.0	70.9
Cleveland Area								
Ashtabula	390071001	84.9	84.7	83.4	82.7	81.0	80.2	75.1
Geauga	390550004	75.7	90.3	74.7	88.8	72.7	86.2	67.3
Eastlake	390850003	82.8	84.2	81.9	82.8	80.5	80.6	76.2
Akron	391530020	79.3	83.0	78.1	81.4	75.6	78.5	68.7
Cincinnati Area								
Wilmington	390271002	77.8	84.8	77.5	83.5	74.9	81.1	68.3
Sycamore	390610006	81.7	85.4	81.9	84.7	80.3	82.9	74.6
Lebanon	391650007	83.6	80.1	83.0	79.0	80.7	77.0	74.2
Columbus Area								
London	390970007	75.4	79.9	75.0	78.4	72.6	76.5	66.3
New Albany	390490029	82.4	84.1	81.8	82.6	79.6	80.2	73.0
Franklin	290490028	77.0	77.7	75.9	76.5	74.1	74.7	69.0
St. Louis Area								
W. Alton (MO)	291831002	82.4	86.1	81.0	85.2	78.6	84.0	74.9
Orchard (MO)	291831004	83.3	83.3	82.0	82.2	80.0	80.4	76.2
Sunset Hills (MO)	291890004	79.5	82.8	78.7	81.9	77.1	80.6	73.9
Arnold (MO)	290990012	78.7	78.4	77.2	77.4	75.6	75.8	72.0
Margaretta (MO)	295100086	79.8	84.0	79.3	83.4	77.9	82.5	74.4
Maryland Heights (MO)	291890014	84.5		83.4		81.7		78.1

Table 10. Summary of PM2.5 Modeling Results

County	Site ID	Site	2009		2012		2018	
			Round 5	Round4	Round 5	Round4	Round 5	Round4
Cook	170310022	Chicago - Washington HS	14.1	14.8	14.0	14.6	13.9	14.4
Cook	170310052	Chicago - Mayfair	14.4	15.8	14.2	15.5	13.9	15.0
Cook	170310057	Chicago - Springfield	13.9	14.5	13.8	14.3	13.7	14.1
Cook	170310076	Chicago - Lawndale	13.8	14.5	13.7	14.3	13.6	14.1
Cook	170312001	Blue Island	13.7	14.5	13.6	14.3	13.4	14.1
Cook	170313301	Summit	14.2	14.8	14.0	14.6	13.9	14.4
Cook	170316005	Cicero	14.4	15.3	14.3	15.1	14.2	14.9
Madison	171191007	Granite City	15.1	16.0	14.9	15.8	14.3	15.5
St. Clair	171630010	E. St. Louis	14.1	14.9	13.9	14.7	13.4	14.5
Clark	180190005	Jeffersonville	13.8	15.5	13.7	15.0	13.4	14.4
Dubois	180372001	Jasper	12.4	13.8	12.2	13.5	11.8	13.0
Lake	180890031	Gary	13.0		12.8		12.4	
Marion	180970078	Indy-Washington Park	12.8	14.5	12.6	14.2	12.0	13.7
Marion	180970083	Indy- Michigan Street	13.4	14.8	13.1	14.9	12.6	14.0
Wayne	261630001	Allen Park	13.0	14.5	12.8	14.1	12.4	13.3
Wayne	261630015	Southwest HS	14.2	15.8	13.9	15.3	13.5	14.4
Wayne	261630016	Linwood	13.1	14.1	12.8	13.7	12.5	13.0
Wayne	261630033	Dearborn	15.8	17.7	15.5	17.1	15.1	16.1
Wayne	261630036	Wyandotte	13.1	15.1	12.8	14.7	12.5	13.9
Butler	390170003	Middleton	13.5	14.2	13.2	13.7	12.8	13.1
Butler	390170016	Fairfield	13.1	13.5	12.9	12.9	12.5	12.2
Cuyahoga	390350027	Cleveland-28th Street	13.5	14.4	13.2	13.8	12.7	12.9
Cuyahoga	390350038	Cleveland-St. Tikhon	15.2	16.1	14.8	15.4	14.3	14.4
Cuyahoga	390350045	Cleveland-Broadway	14.4	14.6	14.0	14.0	13.5	13.1
Cuyahoga	390350060	Cleveland-GT Craig	15.0	15.3	14.6	14.7	14.1	13.7
Cuyahoga	390350065	Newburg Hts - Harvard Ave	14.0	14.1	13.6	13.5	13.1	12.6
Franklin	390490024	Columbus - Fairgrounds	12.9	14.6	12.6	14.0	12.0	13.0
Franklin	390490025	Columbus - Ann Street	12.7	14.1	12.4	13.5	11.9	12.5
Franklin	390490081	Columbus - Maple Canyon	11.7	14.0	11.4	13.4	10.9	12.5
Hamilton	390610014	Cincinnati - Seymour	14.5	15.5	14.3	14.8	13.8	14.0
Hamilton	390610040	Cincinnati - Taft Ave	12.8	13.6	12.6	13.0	12.2	12.3
Hamilton	390610042	Cincinnati - 8th Ave	14.0	14.6	13.8	14.0	13.4	13.2
Hamilton	390610043	Sharonville	12.9	13.6	12.7	13.0	12.3	12.2
Hamilton	390617001	Norwood	13.4	14.2	13.2	13.6	12.8	12.8
Hamilton	390618001	St. Bernard	14.7	15.2	14.4	14.6	14.0	13.8
Jefferson	390810016	Steubenville	12.8	16.3	12.5	15.9	12.7	16.2
Jefferson	390811001	Mingo Junction	13.5	15.5	13.2	15.0	13.4	15.3
Lawrence	390870010	Ironton	12.8	14.2	12.5	13.7	12.3	13.2
Montgomery	391130032	Dayton	13.2	13.7	12.9	13.2	12.4	12.3
Scioto	391450013	New Boston	12.1	15.4	11.9	14.8	11.6	14.2
Stark	391510017	Canton - Dueber	14.0	15.0	13.6	14.3	13.3	13.6
Stark	391510020	Canton - Market	12.6	13.6	12.3	13.0	11.9	12.2
Summit	391530017	Akron - Brittain	13.0	14.4	12.7	13.6	12.3	12.9
Summit	391530023	Akron - W. Exchange	12.3	13.6	12.0	13.0	11.5	12.2

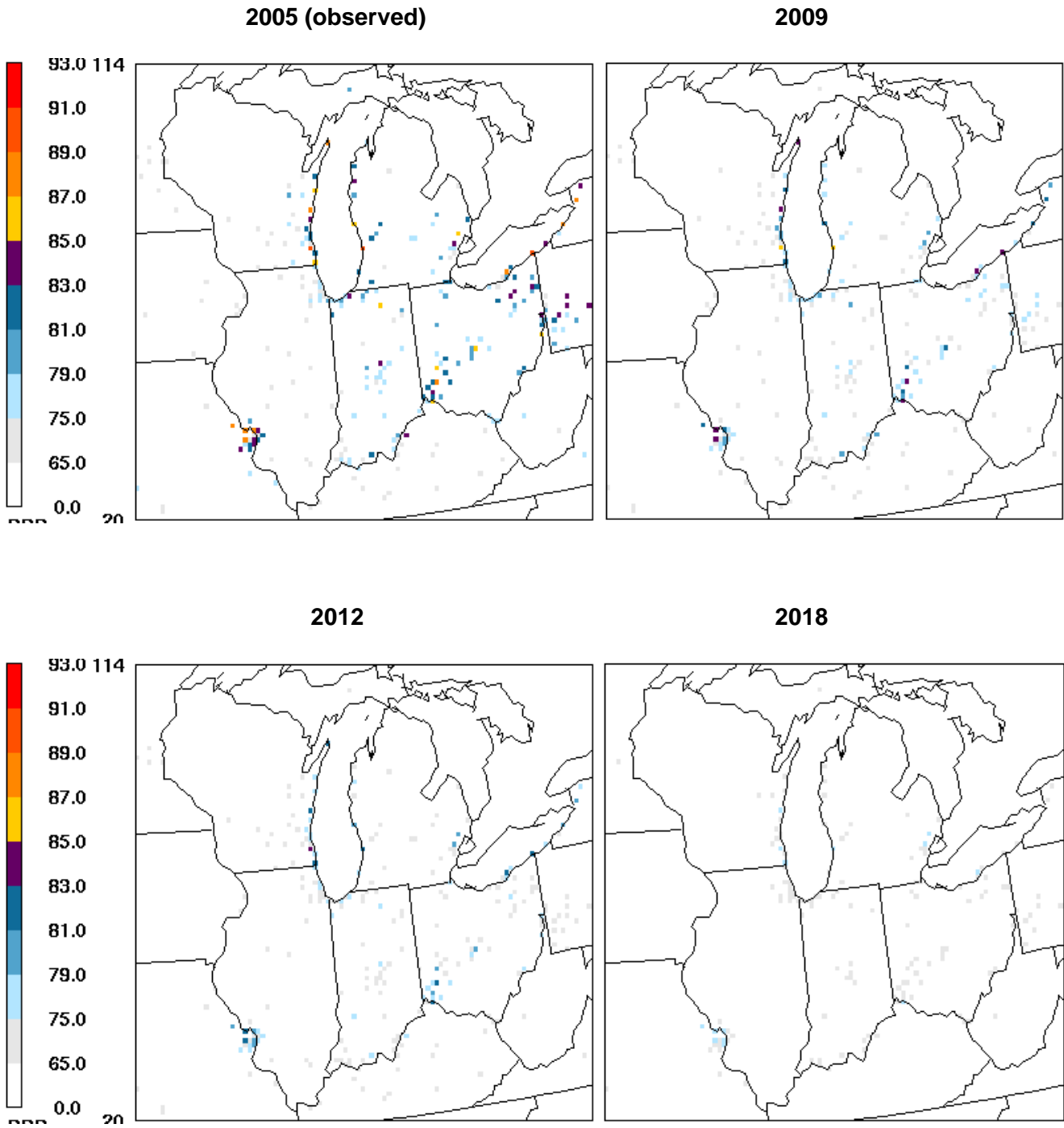


Figure 60. Observed base year and projected future year design values for ozone – Base M

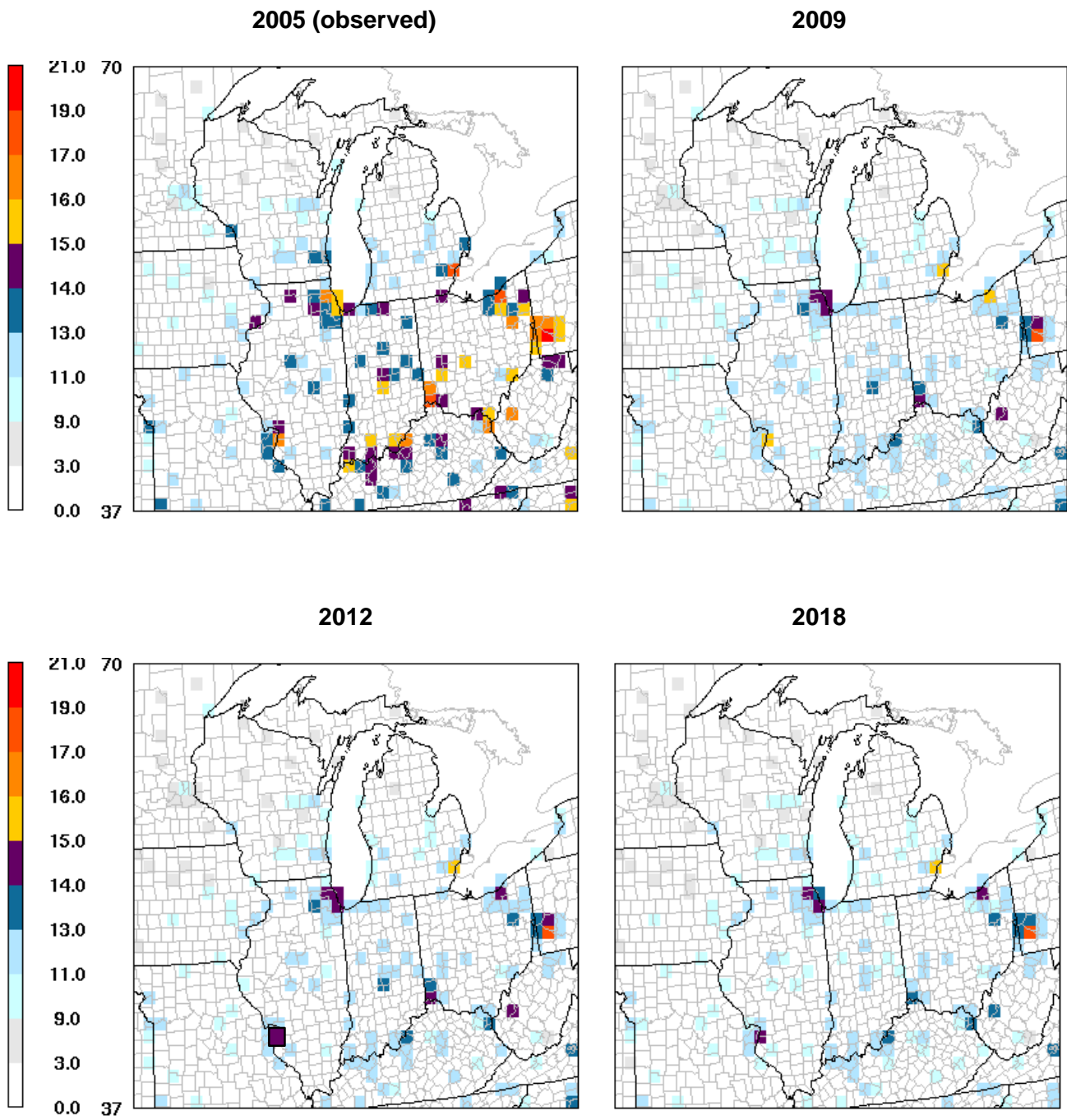


Figure 61. Observed base year and projected future year design values for PM_{2.5} (annual average)–Base M

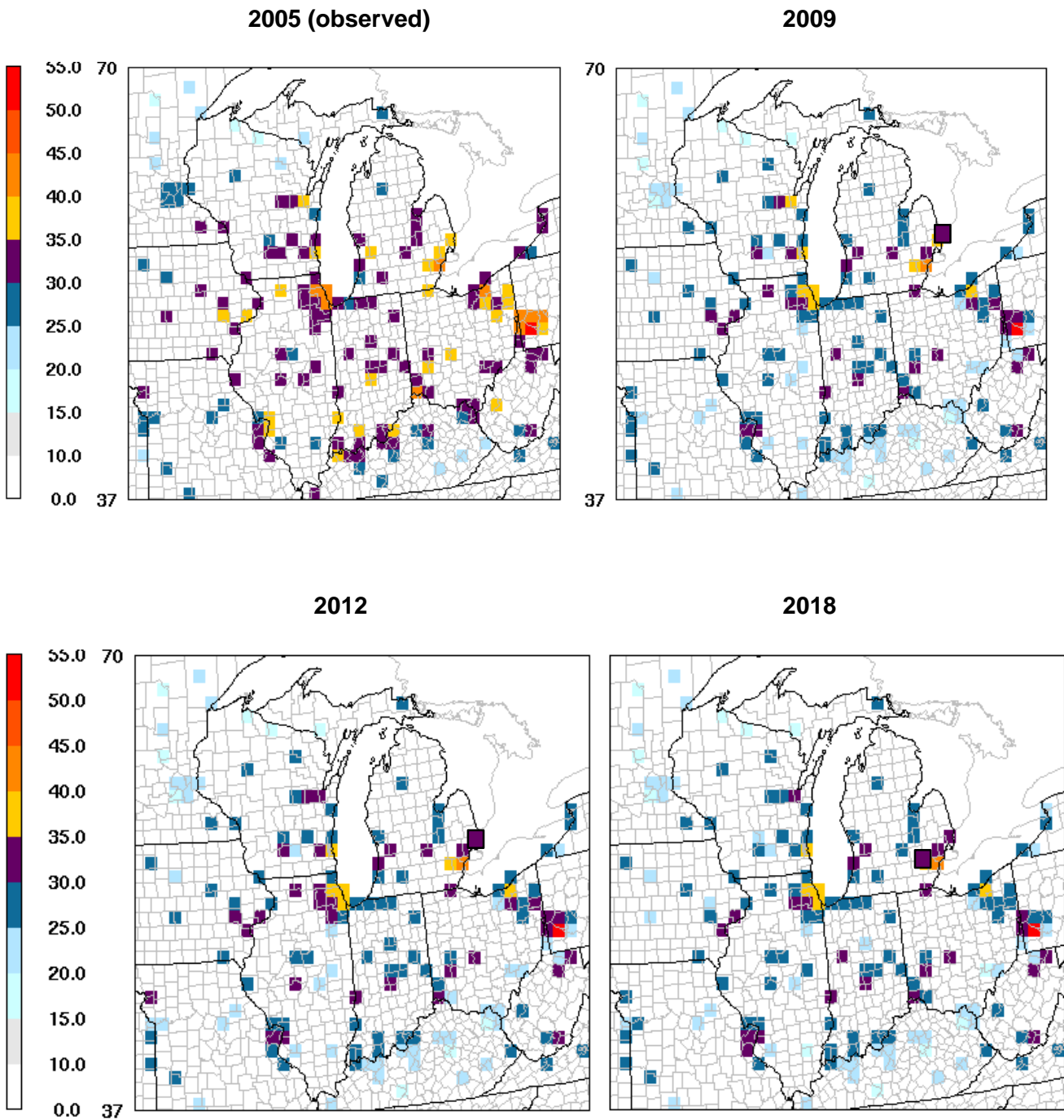


Figure 62. Observed base year and projected future year design values for PM_{2.5} (24-hr average)-Base M

The number of monitors with design values above the standard are as follows:

Table 11. Number of sites above standard

Ozone (8 hour: 85 ppb)								
State	2002	2005	2009		2012		2018	
	BaseK	Base M	BaseK	Base M	BaseK	Base M	BaseK	Base M
IL	3	0	0	0	0	0	0	0
IN	22	0	0	0	0	0	0	0
MI	15	3	1	1	0	0	0	0
OH	40	4	1	0	1	0	0	0
WI	13	2	4	0	3	0	1	0
Total	93	9	6	1	4	0	1	0
PM2.5 (Annual: 15 ug/m³)								
State	2002	2005	2009		2012		2018	
	BaseK	Base M	BaseK	Base M	BaseK	Base M	BaseK	Base M
IL	11	7	3	1	3	0	2	0
IN	10	6	1	0	1	0	0	0
MI	6	2	3	1	2	1	0	0
OH	31	26	7	1	4	0	1	1
WI	0	0	0	0	0	0	2	0
Total	58	41	14	3	10	1	5	1

The modeling results above reflect the “base” controls identified in Section 3.6, with EGU emissions based on IPM modeling (i.e., Round 4 – IPM2.1.9, and Round 5 – IPM3.0). In addition, two sets of alternative future year EGU emissions were examined in Round 5. First, alternative control assumptions were provided for several facilities by the states (i.e., “will do” and “may do” scenarios). In general, these scenarios produced a small change in future year ozone and PM_{2.5} concentrations (i.e., about 0.1 ug/m³ for PM_{2.5} and 0.1-0.2 ppb for ozone). Second, EPA suggested adjustments to the 2010 IPM emissions to reflect 2009 conditions. The revised (2009) SO₂ emissions represent a 5-6% increase in domainwide SO₂ emissions. The increased SO₂ emissions result in slightly greater annual average PM_{2.5} concentrations (on the order of 0.1 – 0.2 ug/m³), but do not produce any new residual nonattainment areas.

The limited 4 km ozone modeling (based on Base K) performed by LADCO included a future year analysis for 2009. The figure below shows the 2009 values with 12 km and 4 km grid spacing for the LADCO modeling and similar modeling conducted by a stakeholder group (Midwest Ozone Group).

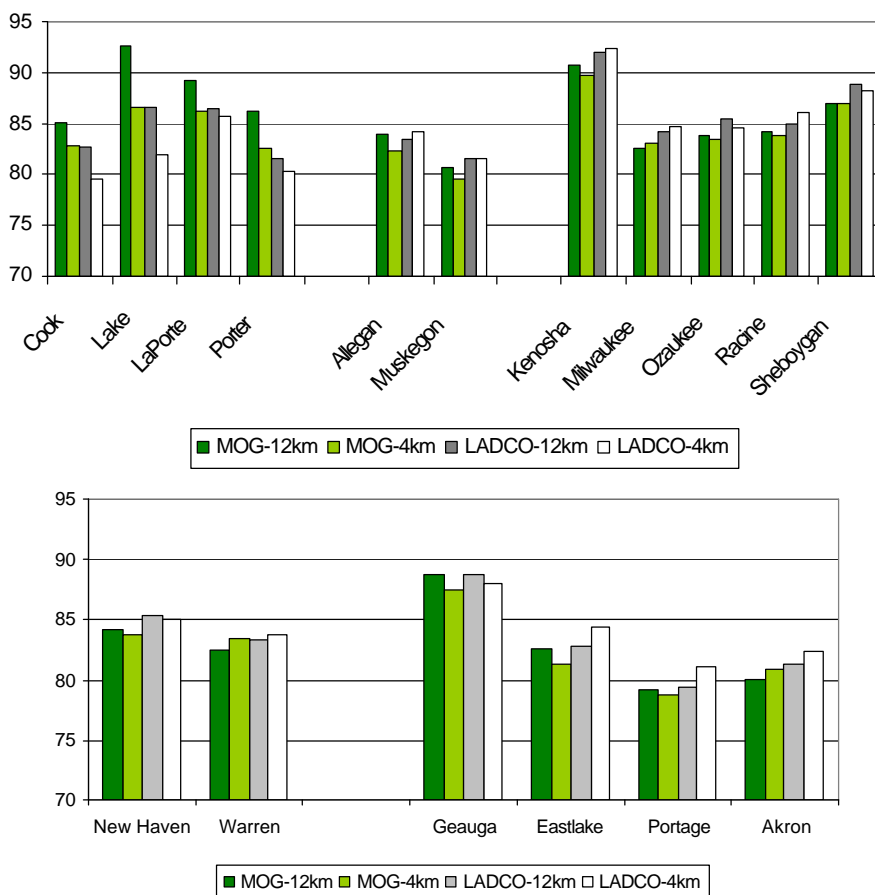


Figure 63. Future year (2009) values for Lake Michigan area (top) and Detroit-Cleveland region (bottom)

These results show that the 12 km and 4 km values are similar, with the most notable changes in northwestern Indiana and northeastern Illinois (e.g., 4 km values are as much as 4 ppb lower than 12 km values). The differences in the southern part of the Lake Michigan area are plausible, given the tight emissions gradient there (i.e., finer grid resolution appears to provide more appropriate representation).

In light of these findings, 12 km grid spacing can continue to be used for ozone modeling, but the Base K/Round 4 results for northwestern Indiana/northeastern Illinois should be viewed with caution (i.e., probably 1 – 4 ppb too high).

In summary, the ozone modeling provides the following information for the nonattainment areas in the region (see Table 12):

Table 12. Ozone Nonattainment Areas in the LADCO Region (as of December 31, 2007)

Area Name	Category	Number of Counties	Attainment Deadline
Detroit-Ann Arbor, MI	Marginal	8	2007
Chicago-Gary-Lake County, IL-IN	Moderate	10	2010
Cleveland-Akron-Lorain, OH	Moderate	8	2010
Milwaukee-Racine, WI	Moderate	6	2010
Sheboygan, WI	Moderate	1	2010
St Louis, MO-IL	Moderate	4	2010
Allegan Co, MI	Subpart 1	1	2009
Cincinnati-Hamilton, OH-KY-IN	Subpart 1	6	2009
Columbus, OH	Subpart 1	6	2009
Door Co, WI	Subpart 1	1	2009
Kewaunee Co, WI	Subpart 1	1	2009
Manitowoc Co, WI	Subpart 1	1	2009
		53	

Marginal Areas (2007 attainment date): No modeling was conducted for the 2006 SIP planning year. Rather, 2005 – 2007 air quality data are available to determine attainment.

Basic (Subpart 1) Areas (2009 attainment date): The modeling results for the 2008 SIP planning year show:

- Base K: all areas in attainment, except Cincinnati and Indianapolis
- Base M: all areas in attainment, except Holland (Allegan County)

Moderate Areas (2010 attainment date): The modeling results for the 2009 SIP planning year show:

- Base K: all areas still in nonattainment
- Base M: all areas in attainment

The PM_{2.5} modeling results show:

- Base K: all areas in attainment, except for Chicago, Cincinnati, Cleveland, Detroit, Granite City (IL), Louisville, Portsmouth (OH), and Steubenville
- Base M: all areas in attainment, except for Cleveland, Detroit, and Granite City (IL)

With respect to the new lower 8-hour ozone standard, the modeling about 30 sites in 2012 and 5 sites in 2018 with design values greater than 75 ppb. With respect to the new lower 24-hour PM_{2.5} standard, the modeling shows 13 sites in 2012 and 10 in 2018 with design values greater than 35 ug/m³.

4.2 Supplemental Analyses

EPA's modeling guidelines recommend that attainment demonstrations consist of a primary (guideline) modeling analysis and supplemental analyses. Three basic types of supplemental analyses are recommended:

- additional modeling
- analyses of trends in ambient air quality and emissions, and
- observational models and diagnostic analyses

Furthermore, according to EPA's guidelines, if the future year modeled values are "close" to the standard (i.e., 82 – 87 ppb for ozone and 14.5 – 15.5 ug/m³ for PM_{2.5}), then the results of the primary modeling should be reviewed along with the supplemental information in a "weight of evidence" assessment of whether each area is likely to achieve timely attainment.

A WOE determination for ozone and PM_{2.5} is provided in the following sections. Special attention is given to the following areas with future year modeled values that exceed or are "close" to the ambient standard (see Appendix I):

Ozone
Lake Michigan area
Cleveland, OH
Cincinnati, OH

PM2.5
Chicago, IL
Cleveland, OH
Cincinnati, OH
Granite City, IL
Detroit, MI

4.3 Weight-of-Evidence Determination for Ozone

The WOE determination for ozone consists of the primary modeling and other supplemental analyses (some of which were discussed in Section 2). A summary of this information is provided below.

Primary (Guideline) Modeling: The guideline modeling is presented in Section 4.1. Key findings from this modeling include:

- Base M regional modeling shows attainment by 2008 and 2009 at all sites, except Holland (MI), and attainment at all sites by 2012.
- Base K modeling results reflect generally higher future year values, and show more sites in nonattainment compared to the Base M modeling. The difference in the two modeling analyses is due mostly to lower base year design values in Base M.
- Base K and Base M modeling analyses are considered "SIP quality", so the attainment demonstration for ozone should reflect a weight-of-evidence approach, with consideration of monitoring based information.
- Base M modeling also shows that the proposed lower 8-hour standard will not be met at many sites, even by 2018, with existing controls.

Additional Modeling: Four additional modeling analyses were considered: (1) re-examination of the primary modeling to estimate attainment probabilities, (2) remodeling with different assumptions, (3) an unmonitored area analysis, and (4) EPA's latest regional ozone modeling. Each of these analyses is described below.

First, the primary modeling results (which were initially processed using EPA's attainment test) were re-examined to estimate the probability of attaining the ozone standard (Lopez, 2007, and LADCO, 2008b). Seven estimates of future year ozone concentrations were calculated based on model-based RRFs and appropriate monitor-based concentrations for each year between 2001 and 2007. RRF values for 2001, 2003, 2004, 2006, and 2007 were derived based on the 2002 and 2005 modeling results. Monitor-based concentrations reflect 4th high values, design values, or average of three design values centered on the year in question. The probability of attainment was determined as the percentage of these seven estimates below the standard. The results indicate that sites in the Lake Michigan area (Chiwaukeewee, Sheboygan, Holland, Muskegon), Cleveland (Ashtabula), and St. Louis (W Alton) have a fairly low probability of attainment by 2009 (i.e., about 50% or less).

Second, the primary modeling analysis was redone with different types of assumptions for calculating base year design values (i.e., using the 3-year period centered on base year, and using the highest 3-year period that includes the base year), and for calculating RRFs (i.e., using all days with base year modeled value > 70 ppb, and using all days with base year modeled value > 85 ppb, with at least 10 days and "acceptable" model performance). The results for several high concentration sites are presented in Tables 13a and 13b for 2009. The different modeling assumptions produce eight estimates of future year ozone concentrations. The highest estimates are associated with base year design values representing the 3-year average for 2001-2003, and the lowest estimates are associated with base year design values representing the 3-year average 2004-2006. The different RRF approaches produce little change in future year ozone concentrations. This suggests that future year concentration estimates are most sensitive to the choice of the base year and the methodology used to derive the base year design values.

Third, EPA's modeling guidelines recommend that an "unmonitored area analysis" be included as a supplemental analysis, particularly in nonattainment areas where the monitoring network just meets or minimally exceeds the size of the network required to report data to EPA's Air Quality System. The purpose of this analysis is to identify areas where future year values are predicted to be greater than the NAAQS.

Based on examination of the spatial plots in Figures 49a and 49b, the most notable areas of high modeled ozone concentrations are over the Great Lakes. Over-water monitoring, however, is not required by EPA¹². A cursory analysis of unmonitored areas for ozone was performed by LADCO using an earlier version of the 2002 base year modeling (i.e, Base I) (Baker, 2005). Base year and future year "observed" values were derived for unmonitored grid cells using the absolute modeled concentrations (in all grid cells) and the observed values (in monitored grid cells). A spatial map of the estimated 2009 values is provided in Figure 64. As can be seen, there are very few (over land) grid cells where additional monitors may be desirable. This indicates that the current modeling analysis, which focuses on monitored locations, is addressing areas of high ozone throughout the region.

¹² Air quality measurements over Lake Michigan were collected by LADCO previously to understand ozone transport in the area (see, for example, Figure 5). Due to cut-backs in USEPA funding, however, these measurements were discontinued in 2003.

Table 13a. Primary and Additional Ozone Modeling Results – Lake Michigan and Cleveland Areas (2009)

2009 Modeling Results	Lake Michigan Area							Cleveland Area		
	Chiwaukee 550590019	Harr.Beach 550890009	Sheboygan 551170006	DoorCounty 550290004	Holland 260050003	Hammond 180892008	MichiganCity 180910005	Ashtabula 390071001	Geauga 390550004	Eastlake 390850003
Attainment Test (based on EPA guidance-2002 baseyear)										
Base Year Design Value (average of three 3-year periods)	98.3	93.0	97.0	91.0	94.0	88.3	90.3	95.7	99.0	92.7
RRF (all days > 85 ppb, or at least 10 days)	0.935	0.918	0.916	0.899	0.888	0.980	0.958	0.865	0.897	0.894
Future Year Design Value	91.9	85.4	88.9	81.8	83.5	86.5	86.5	82.8	88.8	82.9
Attainment Test (based on EPA guidance-2005 baseyear)										
Base Year Design Value (average of three 3-year periods)	84.7	83.3	88.0	88.7	90.0	77.7	77.0	89.0	79.3	86.3
RRF (all days > 85 ppb, or at least 10 days)	0.972	0.961	0.955	0.946	0.948	0.971	0.960	0.937	0.942	0.949
Future Year Design Value	82.3	80.1	84.0	83.9	85.3	75.4	73.9	83.4	74.7	81.9
Weight of Evidence (alternative approaches-2002baseyear)										
Alt 1 - Base Year Des. Value (3-year period centered on 2002)	101.0	98.0	100.0	94.0	97.0	90.0	93.0	99.0	103.0	95.0
Alt 2 - Base Year Des. Value (Highest 3-year period including 2002)	101.0	98.0	100.0	94.0	97.0	92.0	93.0	99.0	103	95.0
RRF (all days > 85 ppb, or at least 10 days)	0.935	0.918	0.916	0.899	0.888	0.980	0.958	0.865	0.897	0.894
Alt 1 - Future Year Projected Value	94.4	90.0	91.6	84.5	86.1	88.2	89.1	85.6	92.4	84.9
Alt 2 - Future Year Projected Value	94.4	90.0	91.6	84.5	86.1	90.2	89.1	85.6	92.4	84.9
Alt 1 - RRF (all days > 70 ppb)	0.933	0.918	0.912	0.907	0.893	0.969	0.947	0.876	0.907	0.900
Alt 1 - Future Year Projected Value	94.2	90.0	91.2	85.3	86.6	87.2	88.1	86.7	93.4	85.5
Alt 2 - Future Year Projected Value	94.2	90.0	91.2	85.3	86.6	89.1	88.1	86.7	93.4	85.5
Alt 2 - RRF (all days > 85 ppb, or at least 10 days; with acceptable model performance)	0.945	0.904	0.910	0.904	0.887	0.976	0.964	0.866	0.896	0.894
Alt 1 - Future Year Projected Value	95.4	88.6	91.0	85.0	86.0	87.8	89.7	85.7	92.3	84.9
Alt 2 - Future Year Projected Value	95.4	88.6	91.0	85.0	86.0	89.8	89.7	85.7	92.3	84.9
Weight of Evidence (alternative approaches-2005baseyear)										
Alt 1 - Base Year Des. Value (3-year period centered on 2005)	83.0	79.0	86.0	86.0	88.0	76.0	76.0	86.0	77.0	86.0
Alt 2 - Base Year Des. Value (Highest 3-year period including 2005)	86.0	88.0	89.0	90.0	93.0	79.0	78.0	91.0	86.0	89.0
Alt 1 - Future Year Projected Value	80.7	75.9	82.1	81.4	83.4	73.8	73.0	80.6	72.5	81.6
Alt 2 - Future Year Projected Value	83.6	84.6	85.0	85.1	88.2	76.7	74.9	85.3	81.0	84.5

Table 13b. Primary and Additional Ozone Modeling Results – Cincinnati, Columbus, St. Louis, Indianapolis, and Detroit (2009)

2009 Modeling Results	Cincinnati Area			Columbus	St. Louis Area		Indianapolis Area		Detroit Area
	Wilmington	Lebanon	Sycamore	NewAlbany	W. Alton	OrchardFarm	Noblesville	Fortville	New Haven
	390271002	39165007	390610006	390490029	291831002	291831004	180571001	18059003	260990009
Attainment Test (based on EPA guidance-2002 baseyear)									
Base Year Design Value (average of three 3-year periods)	94.3	90.7	90.7	94.0	90.0	90.0	93.7	91.3	92.3
RRF (all days > 85 ppb, or at least 10 days)	0.885	0.908	0.938	0.888	0.947	0.914	0.894	0.918	0.924
Future Year Design Value	83.5	82.4	85.1	83.5	85.2	82.3	83.8	83.8	85.3
Attainment Test (based on EPA guidance-2005 baseyear)									
Base Year Design Value (average of three 3-year periods)	82.3	87.7	84.3	86.3	86.3	87.0	83.3	78.7	86.0
RRF (all days > 85 ppb, or at least 10 days)	0.941	0.947	0.967	0.947	0.938	0.942	0.945	0.947	0.947
Future Year Design Value	77.4	83.1	81.5	81.7	80.9	82.0	78.7	74.5	81.4
Weight of Evidence (alternative approaches-2002baseyear)									
Alt 1 - Base Year Des. Value (3-year period centered on 2002)	96.0	92.0	93.0	95.0	91.0	92.0	96.0	94.0	97.0
Alt 2 - Base Year Des. Value (Highest 3-year period including 2002)	96.0	92.0	93.0	96.0	91.0	92.0	96.0	94.0	97.0
RRF (all days > 85 ppb, or at least 10 days)	0.885	0.908	0.938	0.888	0.947	0.914	0.894	0.918	0.924
Alt 1 - Future Year Projected Value	85.0	83.5	87.2	84.4	86.2	84.1	85.8	86.3	89.6
Alt 2 - Future Year Projected Value	85.0	83.5	87.2	85.2	86.2	84.1	85.8	86.3	89.6
Alt 1 - RRF (all days > 70 ppb)	0.885	0.914	0.940	0.901	0.945	0.911	0.912	0.907	0.918
Alt 1 - Future Year Projected Value	85.0	84.1	87.4	85.6	86.0	83.8	87.6	85.3	89.0
Alt 2 - Future Year Projected Value	85.0	84.1	87.4	86.5	86.0	83.8	87.6	85.3	89.0
Alt 2 - RRF (all days > 85 ppb, or at least 10 days; with acceptable model performance)	0.880	0.911	0.940	0.886	0.951	0.913	0.894	0.916	0.935
Alt 1 - Future Year Projected Value	84.5	83.8	87.4	84.2	86.5	84.0	85.8	86.1	90.7
Alt 2 - Future Year Projected Value	84.5	83.8	87.4	85.1	86.5	84.0	85.8	86.1	90.7
Weight of Evidence (alternative approaches-2005baseyear)									
Alt 1 - Base Year Des. Value (3-year period centered on 2005)	80.0	86.0	81.0	84.0	85.0	86.0	80.0	76.0	82.0
Alt 2 - Base Year Des. Value (Highest 3-year period including 2005)	85.0	89.0	86.0	88.0	89.0	89.0	87.0	81.0	90.0
Alt 1 - Future Year Projected Value	75.3	81.4	78.3	79.5	79.7	81.0	75.6	72.0	77.7
Alt 2 - Future Year Projected Value	80.0	84.3	83.2	83.3	83.5	83.8	82.2	76.7	85.2

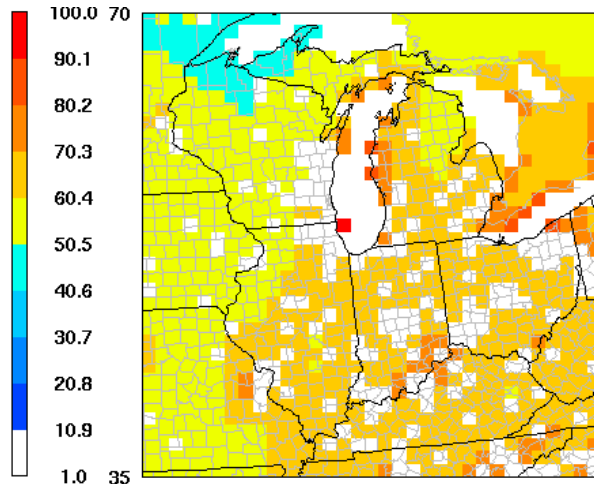


Figure 64. Estimated Future Year Values (unmonitored grid cells)

Finally, EPA's latest regional ozone modeling was considered as corroborative information. This modeling was performed as part of the June 2007 proposal to revise the ozone standard (EPA, 2007b). EPA applied the CMAQ model with 2001 meteorology to first estimate ozone levels in 2020 based on the current standard and national rules in effect or proposed (i.e., the baseline), and then to evaluate strategies for attaining a more stringent (70 ppb) primary standard. Baseline (2020) ozone levels were predicted to be below the current standard in 481 of the 491 counties with ozone monitors. Of the 10 counties predicted to be above the standard, there is one county in the LADCO region (i.e., Kenosha County, WI at 86 ppb). This result is consistent with LADCO's Base K modeling for 2018 (i.e., Kenosha County, WI at 86.7 ppb), which is not surprising given that EPA's modeling and LADCO's Base K modeling have a similar base year (2001 v. 2002).

Analysis of Trends: EPA's modeling guidelines note that while air quality models are generally the most appropriate tools for assessing the expected impacts of a change in emissions, it may also be possible to extrapolate future trends based on measured historical trends of air quality and emissions. To do so, USEPA's guidance suggests that ambient trends should first be normalized to account for year-to-year variations in meteorological conditions (EPA, 2002). Meteorologically-adjusted 4th high 8-hour ozone concentrations were derived using the air quality – meteorological regression model developed by EPA (i.e., Cox method – see Section 2.1).

The historical trend in these met-adjusted ozone concentrations were extrapolated to estimate future year ozone concentrations based on historical and projected trends in precursor emissions. Both VOC and NO_x emissions affect ozone concentrations. Given that observation-based methods show that urban areas in the region are generally VOC-limited and rural areas in the region are NO_x-limited (see Section 2.1), urban VOC emissions and regional NO_x emissions are considered important. The trends in urban VOC and regional NO_x emissions were calculated to produce appropriate weighting factors.

The resulting 2009 and 2012 ozone values are provided in Figure 65, along with the primary and alternative modeling ozone values for key sites in the Lake Michigan, Cleveland, and Cincinnati areas. The results reflect a fairly wide scatter, but, on balance, the supplemental information is supportive of the primary modeling results (i.e., sites in the Lake Michigan area and Cleveland are expected to be close to the standard).

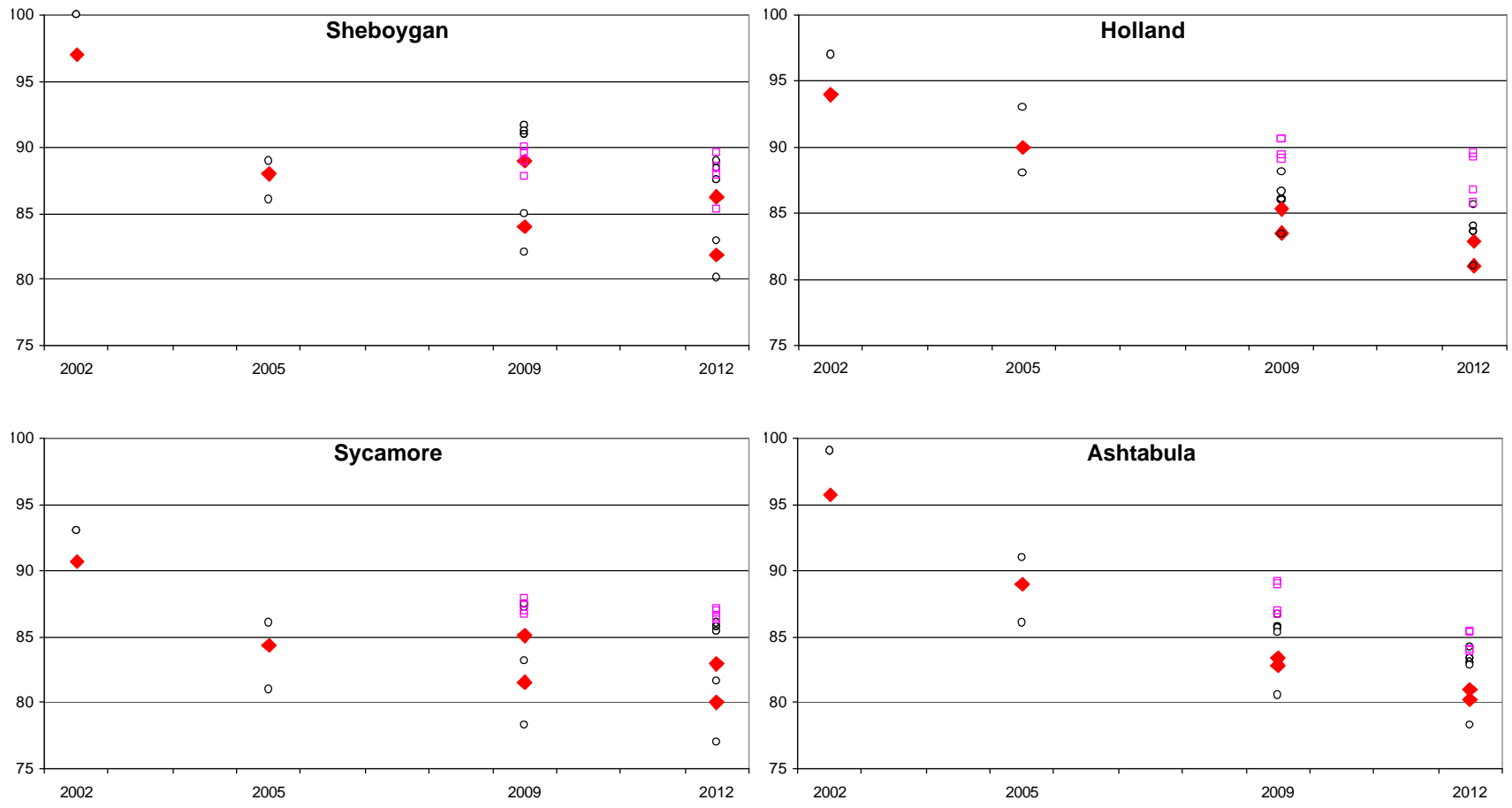


Figure 65. Estimates of Future Year Ozone Concentrations – Lake Michigan Area (Sheboygan and Holland), Cincinnati (Sycamore), and Cleveland (Ashtabula)

Note: Primary (guideline) modeling values (Base K and Base M results) are represented by large red diamonds, additional modeling values by small black circles, and trends-based values by small pink squares

Observational Models and Diagnostic Analyses: The observation-based modeling (i.e., MAPPER) is presented in Section 3. The key findings from this modeling are that most urban areas are VOC-limited and rural areas are NOx-limited.

The primary diagnostic analysis is source apportionment modeling with CAMx to provide more quantitative information on source region (and source sector) impacts (Baker, 2007a). Specifically, the model estimated the impact of 18 geographic source regions (which are identified in Figure 66) and 6 source sectors (EGU point, non-EGU point, on-road, off-road, area, and biogenic sources) at ozone monitoring sites in the region.

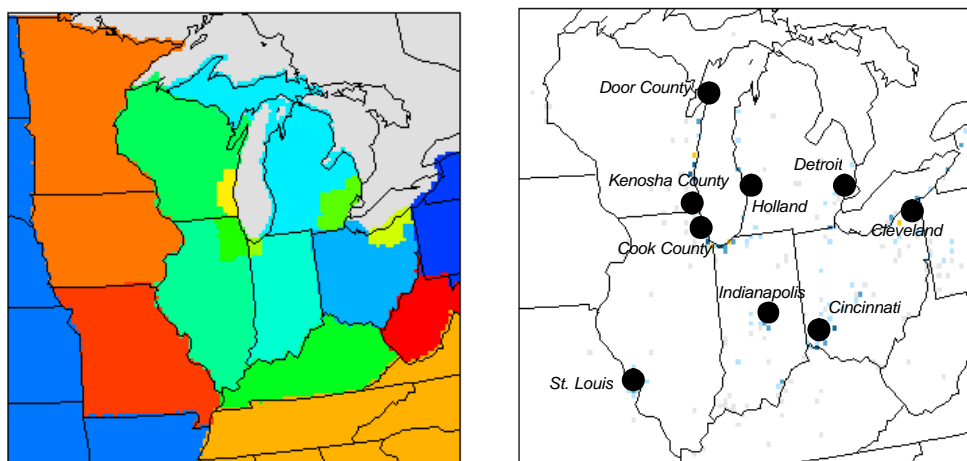


Figure 66. Source regions (left) and key monitoring sites (right) for ozone modeling analysis

Modeling results for 2009 (Base M) and 2012 (Base K) are provided in Appendix II for several key monitoring sites. For each monitoring site, there are two graphs: one showing sector-level contributions, and one showing source region and sector-level contributions in terms of percentages. (Note, in the sector-level graph, the contributions from NOx emissions are shown in blue, and from VOC emissions in green.)

The sector-level results (see, for example, Figure 67) show that on-road and nonroad NOx emissions generally have the largest contributions at the key monitor locations (> 15% each). EGU and non-EGU NOx emissions are also important contributors (> 10% each). The source group contributions vary by receptor location due to emissions inventory differences.

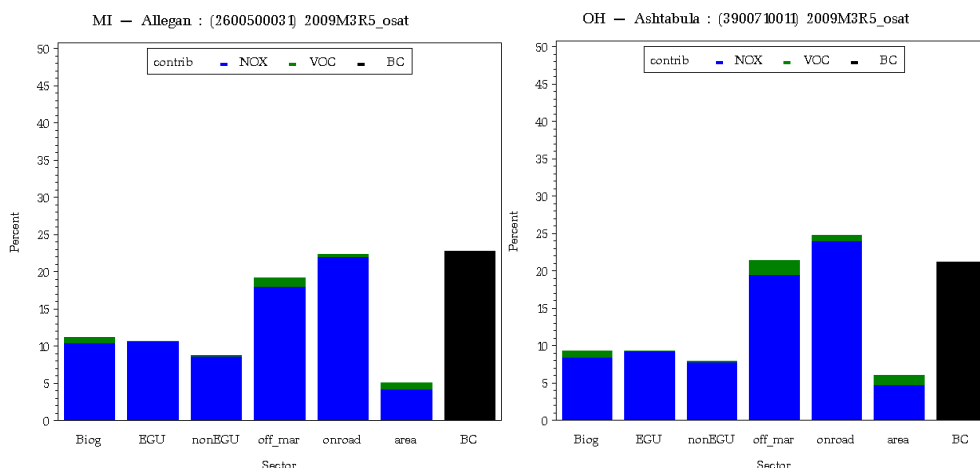


Figure 67. Source-sector results for Holland (left) and Ashtabula (right) monitors – 2009 (Base M)

The source region results (see, for example, Figure 68) show that while nearby areas generally have the highest impacts (e.g., the northeastern IL/northwestern IN/southeastern WI nonattainment area contributes 25-35% to high sites in the Lake Michigan area, and Cleveland nonattainment counties contribute 20-25% to high sites in northeastern Ohio), there is an even larger regional impact (i.e., contribution from other states).

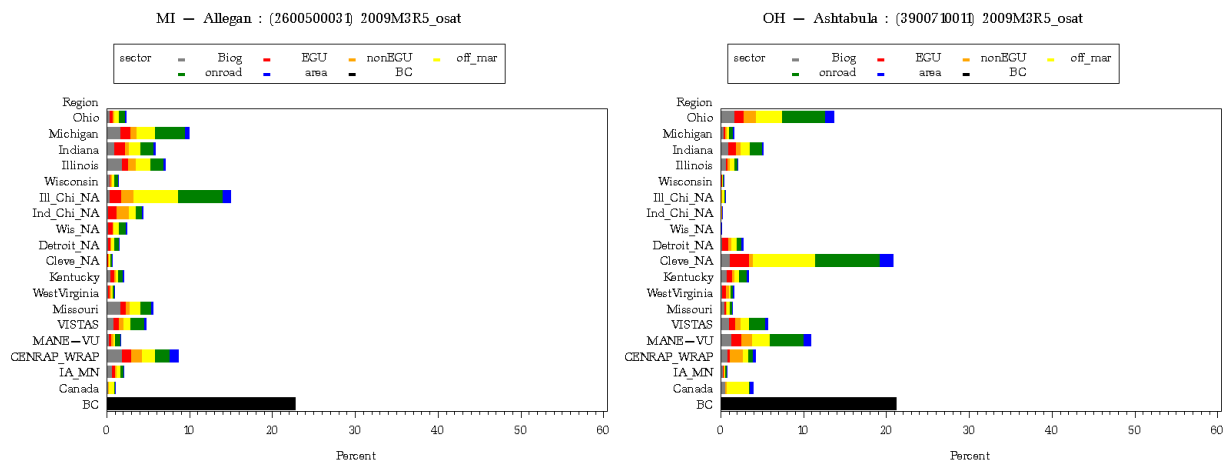


Figure 68. Source-region results for Holland (left) and Ashtabula (right) monitors – 2009 (Base M)

Summary: Air quality modeling and other supplemental analyses were performed to estimate future year ozone concentrations. Based on this information, the following general conclusions can be made:

- Existing (“on the books”) controls are expected to produce significant improvement in ozone air quality.
- The choice of the base year affects the future year model projections. A key difference between the base years of 2002 and 2005 is meteorology. As noted above, 2002 was more ozone conducive than 2005. The choice of which base year to use as the basis for the SIP is a policy decision (i.e., how much safeguard to incorporate).
- Most sites are expected to meet the current 8-hour standard by the applicable attainment date, except, for sites in western Michigan and, possibly, in eastern Wisconsin and northeastern Ohio.
- Current monitoring data show significant nonattainment in these areas (e.g., peak design values on the order of 90 – 93 ppb). It is not clear whether sufficient emission reductions will occur in the next couple of years to provide for attainment.
- Attainment by the applicable attainment date is dependent on actual future year meteorology (e.g., if the weather conditions are consistent with [or less severe than] 2005, then attainment is likely) and actual future year emissions (e.g., if the emission reductions associated with the existing controls are achieved, then attainment is likely). On the other hand, if either of these conditions is not met, then attainment may be less likely.

4.3 Weight-of-Evidence Determination for PM_{2.5}

The WOE determination for PM_{2.5} consists of the primary modeling and other supplemental analyses. A summary of this information is provided below.

Primary (Guideline) Modeling: The results of the guideline modeling are presented in Section 4.1. Key findings from this modeling include:

- Base M regional modeling shows attainment by 2009 at all sites, except Detroit, Cleveland, and Granite City, and attainment at all sites by 2012, except for Detroit and Granite City.

The regional modeling for PM_{2.5} does not reflect any air quality benefit expected from local controls. States are conducting local-scale analyses and will use these results, in conjunction with the regional-scale modeling, to support their attainment demonstrations for PM_{2.5}.

- Base K modeling results reflect generally higher future year values, and show more sites in nonattainment in 2009 and 2012 compared to the Base M modeling. The difference in the two modeling analyses is due mostly to lower base year design values in Base M.
- Base K and Base M modeling analyses are considered “SIP quality”, so the attainment demonstration for PM_{2.5} should reflect a weight-of-evidence approach, with consideration of monitoring based information.
- Base M modeling also shows that the new PM_{2.5} 24-hour standard will not be met at many sites, even by 2018, with existing controls.

Additional Modeling: EPA’s latest regional PM_{2.5} modeling was considered as corroborative information. This modeling was performed as part of the September 2006 revision to the PM_{2.5} standard (USEPA, 2006). EPA applied the CMAQ model with 2001 meteorology to estimate PM_{2.5} levels in 2015 and 2020 first with national rules in effect or proposed, and then with additional controls to attain the current standard (15 ug/m³ annual/65 ug/m³ daily). Additional analyses were performed to evaluate strategies for attaining more stringent standards in 2020 (15/35, and 14/35). Baseline (2015) PM_{2.5} levels were predicted to be above the current standard in four counties in the LADCO region: Madison County, IL at 15.2 ug/m³, Wayne County, MI at 17.4, Cuyahoga County, OH at 15.4, and Scioto County, OH at 15.6. These results are consistent with LADCO’s Base K modeling for 2012/2018, which is not surprising given that EPA’s modeling and LADCO’s Base K modeling have a similar base year (2001 v. 2002).

Observational Models and Diagnostic Analyses: The observation-based modeling (i.e., application of thermodynamic equilibrium models) is presented in Section 3. The key findings from this modeling are that PM_{2.5} mass is sensitive to reductions in sulfate, nitric acid, and ammonia concentrations. Even though sulfate reductions cause more ammonia to be available to form ammonium nitrate (PM-nitrate increases slightly when sulfate is reduced), this increase is generally offset by the sulfate reductions, such that PM_{2.5} mass decreases. Under conditions with lower sulfate levels (i.e., proxy of future year conditions), PM_{2.5} is more sensitive to reductions in nitric acid compared to reductions in ammonia.

The primary diagnostic analysis is source apportionment modeling with CAMx to provide more quantitative information on source region (and source sector) impacts (Baker, 2007b). Specifically, the model estimated the impact of 18 geographic source regions (which are identified in Figure 69) and 6 source sectors (EGU point, non-EGU point, on-road, off-road, area, and biogenic sources) at PM_{2.5} monitoring sites in the region.

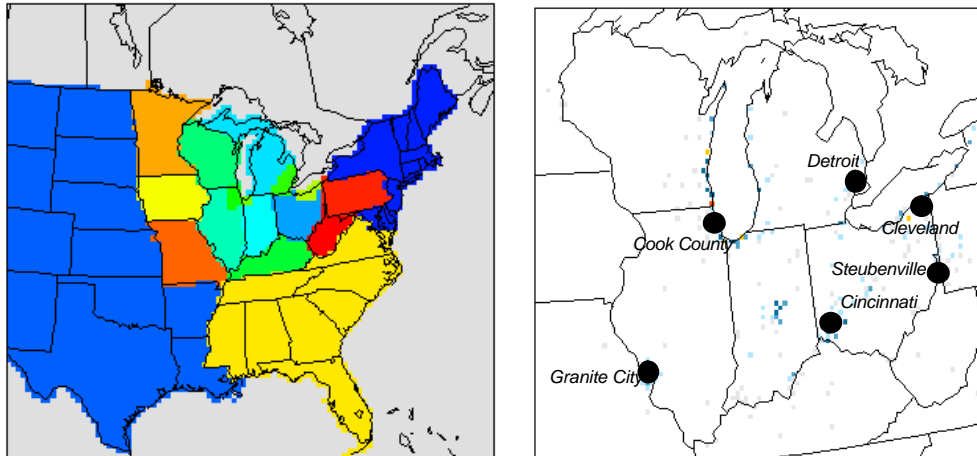


Figure 69. Source regions (left) and key monitoring sites (right) for PM_{2.5} modeling analysis

Modeling results for 2012 (Base K) and 2018 (Base M) are provided in Appendix III for several key monitoring sites. For each monitoring site, there are two graphs: one showing sector-level contributions, and one showing source region and sector-level contributions in terms of absolute modeled values.

The sector-level results (see, for example, Figure 70) show that EGU sulfate, non-EGU-sulfate, and area organic carbon emissions generally have the largest contributions at the key monitor locations (> 15% each). Ammonia emissions are also important contributors (> 10%). The source group contributions vary by receptor location due to emissions inventory differences.

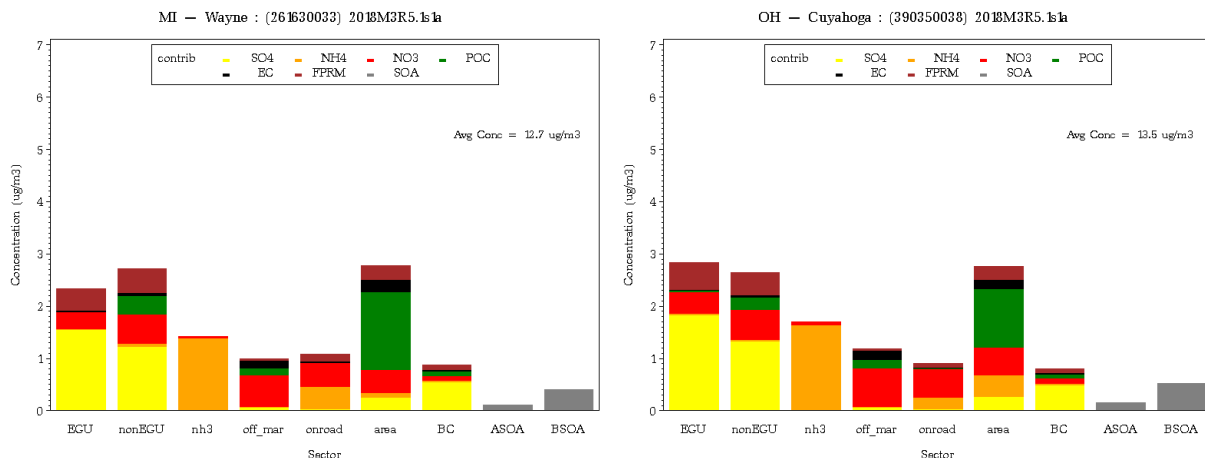


Figure 70. Source-sector results for Detroit (left) and Cleveland (right) monitors – 2018 (Base M)

The source region results (see, for example, Figure 71) show that while nearby areas generally have the highest impacts (e.g., Detroit nonattainment counties contribute 40% to high sites in southeastern Michigan, and Cleveland nonattainment counties contribute 35% to high sites in northeastern Ohio), there is an even larger regional impact (i.e., contribution from other states).

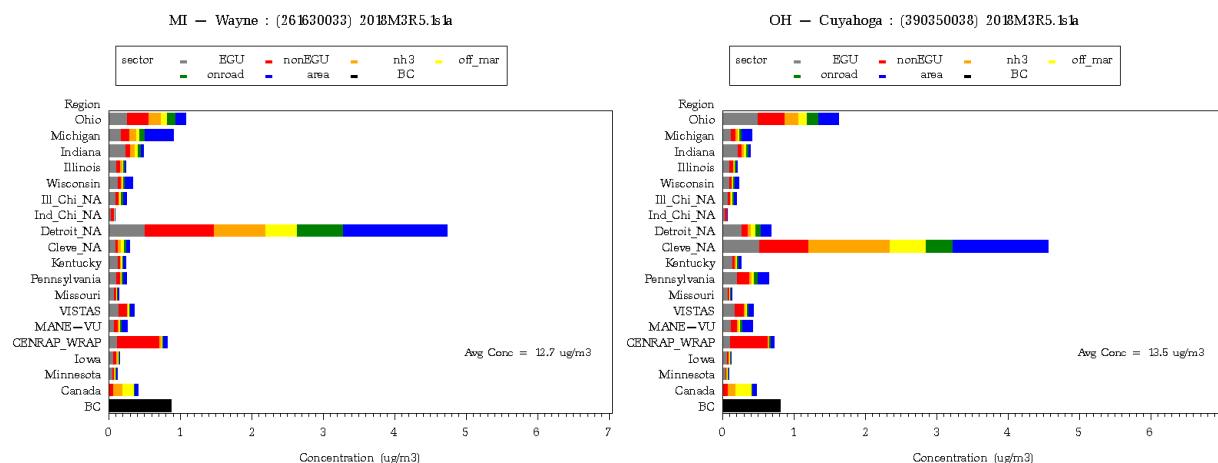


Figure 71. Source-region results for Detroit (left) and Cleveland (right) monitors – 2018 (Base M)

Summary: Air quality modeling and other supplemental analyses were performed to estimate future year PM_{2.5} concentrations. Based on this information, the following general conclusions can be made:

- Existing (“on the books”) controls are expected to produce significant improvement in PM_{2.5} air quality.
- The choice of the base year affects the future year model projections. It is not clear how much of this is attributable to differences in meteorology, because, as noted in Section 3, PM_{2.5} concentrations are not as strongly influenced by meteorology as ozone.
- Most sites are expected to meet the current PM_{2.5} standard by the applicable attainment date, except for sites in Detroit, Cleveland, and Granite City.
- Current monitoring data show significant nonattainment in these areas (e.g., peak design values on the order of 16 – 17 ug/m³). It is not clear whether sufficient emission reductions will occur in the next couple of years to provide for attainment. States are conducting local-scale analyses for Detroit, Cleveland, and Granite City, in particular, to identify appropriate additional local controls.
- Attainment by the applicable attainment date is dependent (possibly) on actual future year meteorology and (more likely) on actual future year emissions (e.g., if the emission reductions associated with the “on the books” controls are achieved, then attainment is likely). On the other hand, if either of these conditions is not met (especially, with respect to emissions), then attainment may be less likely.

Section 5. Reasonable Progress Assessment for Regional Haze

Air quality modeling and other information were used to assess the improvement in visibility that would be provided by existing (“on the books”) controls and possible additional control programs. In determining reasonable progress for regional haze, Section 169A of the Clean Air Act and EPA’s visibility rule requires states to consider five factors:

- costs of compliance
- time necessary for compliance
- energy and non-air quality environmental impacts of compliance
- remaining useful life of any existing source subject to such requirements
- uniform rate of visibility improvement needed to attain natural visibility conditions by 2064

The uniform rate of visibility improvement requirement can be depicted graphically in the form of a “glide path” (see Figure 72).

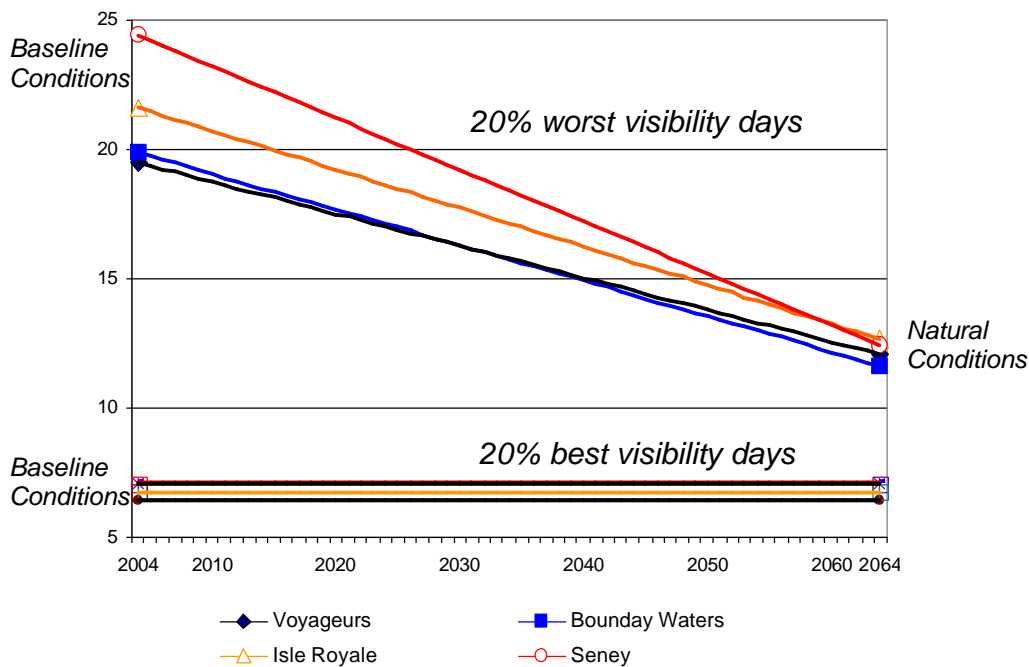


Figure 72. Visibility “glide paths” for northern Class I areas (units: deciviews)

5.1 Class I Areas Impacted

EPA’s visibility rule requires a state to “address regional haze in each mandatory Class I Federal area located within the State and in each mandatory Class I Federal area located outside the State which may be affected by emissions from within the State.” (40 CFR Part 51.308(d)) To meet this requirement, technical analyses conducted by the RPOs were consulted to obtain information on areas of influence and culpability for Class I areas in the eastern U.S. (MRPO, 2007). A summary of this information is provided in Table 1 (MRPO, 2007). The table shows that every LADCO State impacts multiple Class I areas in the eastern U.S.

Table 14. Draft List of Class I Areas Impacted by LADCO States

AREA NAME	IL	IN	MI	OH	WI
81.401 Alabama.					
Sipsey Wilderness Area	(1)	(1)			
81.404 Arkansas.					
Caney Creek Wilderness Area	(2), (4)	(2), (4)		(2), (4)	
Upper Buffalo Wilderness Area	(1),(2),(4),(5)	(2), (4)		(2), (4)	(2)
81.408 Georgia.					
Cohotta Wilderness Area					
Okefenokee Wilderness Area					
Wolf Island Wilderness Area					
81.411 Kentucky.					
Mammoth Cave NP	(1), (2), (5)	(1), (2), (5)	(1), (2)	(1), (2), (5)	
81.412 Louisiana.					
Breton Wilderness Area					
81.413 Maine.					
Acadia National Park	(3)	(3)	(3)	(3)	
Moosehorn Wilderness Area.	(3)	(3)	(3)	(3)	
81.414 Michigan.					
Isle Royale NP.	(1), (2)	(1), (2)	(1), (2)		(1), (2)
Seney Wilderness Area	(1), (2)	(1), (2)	(1), (2)	(1), (2)	(1), (2)
81.415 Minnesota.					
Boundary Waters Canoe Area Wilderness	(2)	(2)	(2)		(1), (2)
Voyageurs NP	(2)	(2)			(1), (2)
81.416 Missouri.					
Hercules-Glades Wilderness Area	(2), (4), (5)	(2), (4), (5)		(2), (4)	(2)
Mingo Wilderness Area	(2), (4), (5)	(2), (4), (5)	(2)	(2), (4)	(2)
81.419 New Hampshire.					
Great Gulf Wilderness Area	(3)	(3)	(3)	(1), (3)	
Pres. Range-Dry River Wilderness Area.					
81.42 New Jersey.					
Brigantine Wilderness Area	(3)	(3)	(1), (3)	(1), (3)	

81.422 North Carolina.					
Great Smoky Mountains NP{1}	(1)	(1)		(1)	
Joyce Kilmer-Slickrock Wilderness Area{2}					
Linville Gorge Wilderness Area.					
Shining Rock Wilderness Area.					
Swanquarter Wilderness Area					
81.426 South Carolina.					
Cape Romain Wilderness					
81.428 Tennessee.					
Great Smoky Mountains NP{1}.	(1)	(1)		(1)	
Joyce Kilmer-Slickrock Wilderness{2}					
81.431 Vermont.					
Lye Brook Wilderness	(2), (3)	(2), (3)	(2), (3)	(1), (2), (3)	
81.433 Virginia.					
James River Face Wilderness.	(2)	(2)	(2)	(2), (5)	
Shenandoah NP	(2), (3)	(1), (2), (3)	(2), (3)	(1),(2),(3),(5)	
81.435 West Virginia.					
Dolly Sods/Otter Creek Wilderness.	(2), (3)	(1), (2), (3)	(1), (2), (3)	(1),(2),(3),(5)	

Key

- (1) MRPO Back Trajectory Analyses
- (2) MRPO PSAT Modeling
- (3) MANE-VU Contribution Assessment
- (4) Missouri-Arkansas Contribution Assessment
- (5) VISTAS Areas of Influence

5.2 Future Year Modeling Results

For regional haze, the calculation of future year conditions assumed:

- baseline concentrations based on 2000-2004 IMPROVE data, with updated (substituted) data for Mingo, Boundary Waters, Voyageurs, Isle Royale, and Seney (see Section 2.3);
- use of the new IMPROVE light extinction equation; and
- use of EPA default values for natural conditions, based on the new IMPROVE light extinction equation.

The uniform rate of visibility improvement values for the 2018 planning year were derived (for the 20% worst visibility days) based on a straight line between baseline concentration value (plotted in the year 2004 -- end year of the 5-year baseline period) and natural condition value (plotted in the year 2064 -- date for achieving natural conditions). Plots of these “glide paths” with the Base M modeling results are presented in Figure 73 for Class I areas in the eastern U.S. A tabular summary of measured baseline and modeled future year deciview values for these Class I areas are provided in Table 15 (2002 base year) and Table 16 (2005 base year)¹³.

The haze results show that several Class I areas in the eastern U.S. are expected to be greater than (less improved than) the uniform rate of visibility improvement values (in 2018), including those in northern Michigan and several in the northeastern U.S. Many other Class I areas in the eastern U.S. are expected to be less than (more improved than) the uniform rate of visibility improvement values (in 2018). As noted above, states should consider these results, along with information on the other four factors, in setting reasonable progress goals.

An assessment of the five factors was performed for LADCO and the State of Minnesota by a contractor (EC/R, 2007). Specifically, ECR examined reductions in SO₂ and NO_x emissions from EGUs and industrial, commercial and institutional (ICI) boilers; NO_x emissions from mobile sources and reciprocating engines and turbines; and ammonia emissions from agricultural operations. The impacts of “on the books” controls were also examined to provide a frame of reference for assessing the impacts of the additional control measures.

The results of ECR’s analysis of the five factors are summarized below:

Factor 1 (Cost of Compliance): The average cost effectiveness values (in terms of \$M per ton) are provided in Table 16. For comparison, cost-effectiveness estimates previously provided for “on the books” controls include:

CAIR SO₂: \$700 - \$1,200, NO_x: \$1,400 – \$2.600 (\$/T)

BART SO₂: \$300 - \$963, NO_x: \$248 - \$1,770

MACT SO₂: \$1,500, NO_x: \$7,600

Most of the cost-effectiveness values for the additional controls are within the range of cost-effectiveness values for “on the books” controls.

¹³ Model results reflect the grid cell where the IMPROVE monitor is located.

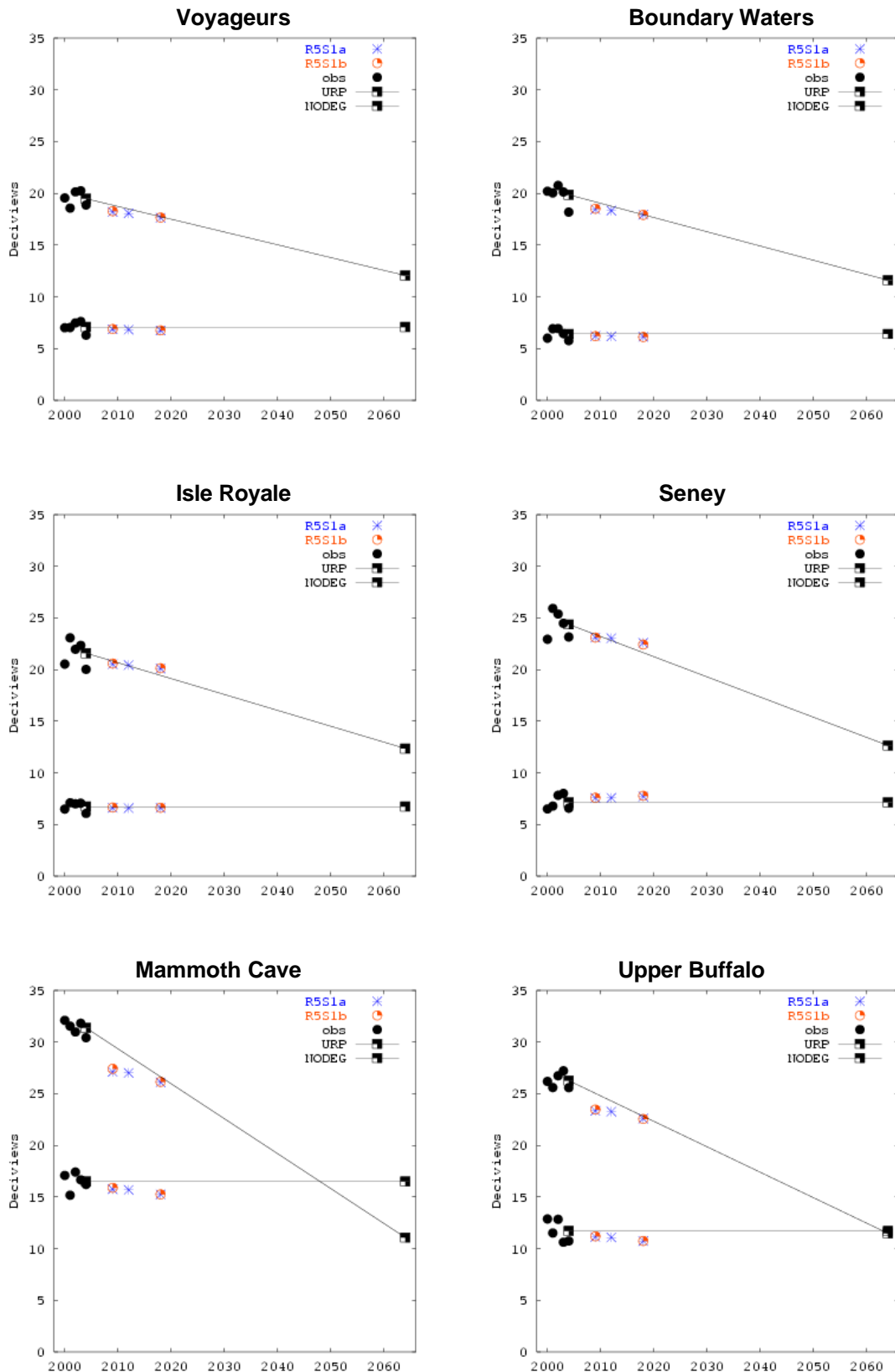


Figure 73. Visibility modeling results for Class I areas in eastern U.S.

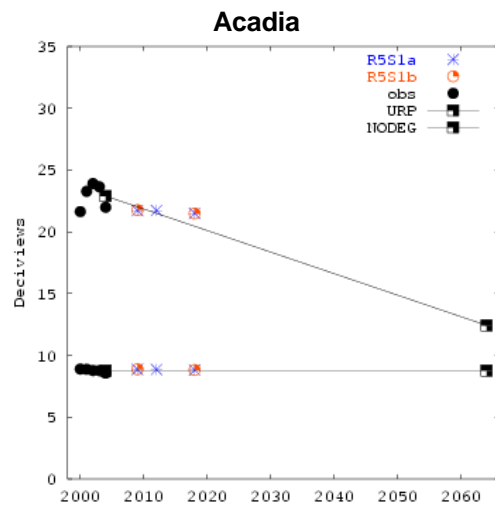
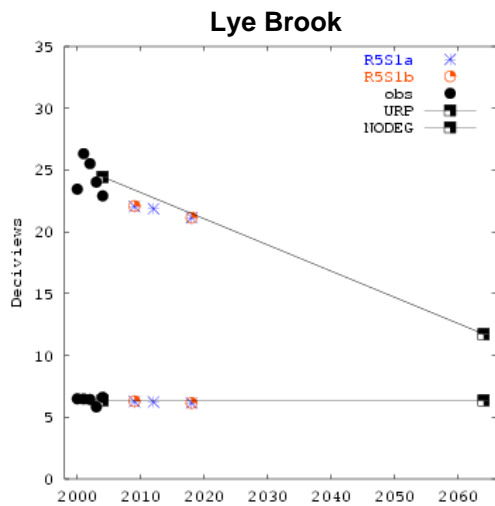
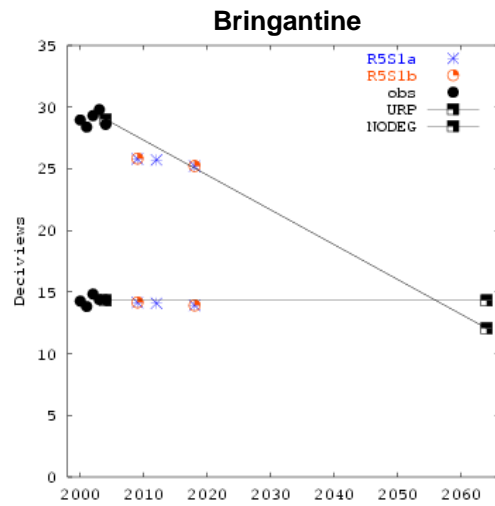
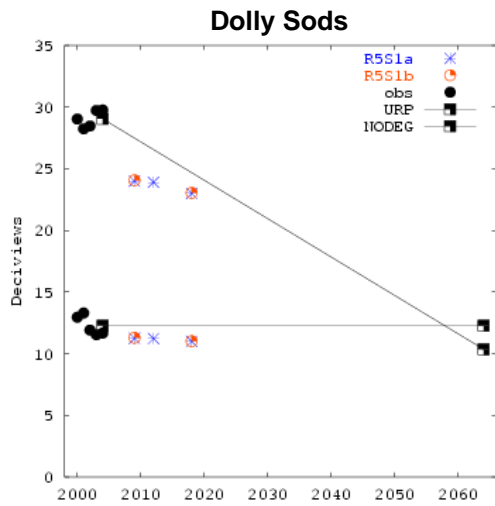
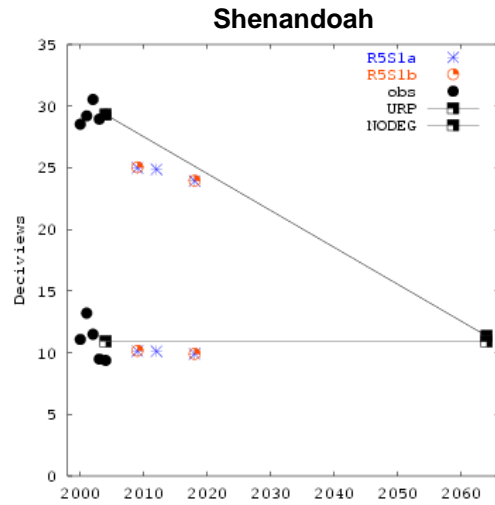
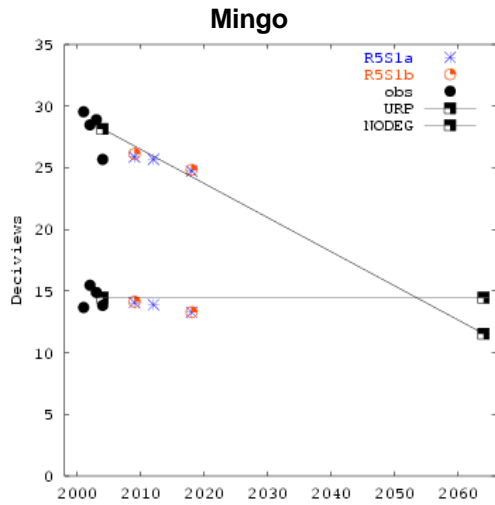


Figure 73 (cont.) Visibility modeling results for Class I areas in eastern U.S.

Table 15. Haze Results - Round 4 (Based on 2000-2004)

Worst 20%		2018	2009	2012	2018	2018	2018
Site	Baseline	URP	OTB	OTB	OTB	EGU2 (5-state region)	EGU2 (12-state region)
BOWA1	19.86	17.70	19.05	19.01	18.94	18.40	17.72
VOYA2	19.48	17.56	19.14	19.19	19.18	18.94	18.38
SENE1	24.38	21.35	22.98	22.71	22.38	21.26	20.63
ISLE1	21.59	19.21	20.46	20.28	20.04	19.09	18.64
HEGL1	26.75	22.76	24.73	24.34	23.85	23.01	22.04
MING1	28.15	24.08	25.18	24.67	24.01	22.53	21.45
CACR1	26.36	22.55	24.01	23.55	22.99	22.43	21.57
UPBU1	26.27	22.47	24.02	23.58	23.06	22.31	21.38
MACA1	31.37	26.14	28.06	27.03	25.52	24.27	22.57
DOSO1	29.04	24.23	24.86	23.59	22.42	21.60	20.15
SHEN1	29.31	24.67	24.06	22.79	21.57	20.43	19.42
JARI1	29.12	24.48	24.81	23.79	22.42	21.59	20.88
BRIG1	29.01	24.68	25.87	25.25	24.39	23.91	23.45
LYBR1	24.45	21.16	21.80	21.32	20.69	20.18	19.79
Best 20%		2018	2009	2012	2018	2018	2018
Site	Baseline	URP	OTB	OTB	OTB	EGU2 (5-state region)	EGU2 (12-state region)
BOWA1	6.42	6.42	6.71	6.73	6.87	6.83	6.81
VOYA2	7.09	7.09	7.21	7.25	7.34	7.31	7.26
SENE1	7.14	7.14	7.19	7.19	7.23	7.06	6.91
ISLE1	6.75	6.75	6.57	6.51	6.47	6.20	6.06
HEGL1	12.84	12.84	12.61	12.62	12.61	12.43	12.02
MING1	14.46	14.46	13.96	13.93	13.94	13.74	13.33
CACR1	11.24	11.24	10.91	10.92	10.90	10.75	10.42
UPBU1	11.71	11.71	11.47	11.46	11.42	11.28	11.01
MACA1	16.51	16.51	16.06	15.91	15.54	15.18	14.75
DOSO1	12.28	12.28	11.72	11.45	11.19	10.93	10.67
SHEN1	10.93	10.93	9.73	9.53	9.17	9.05	8.90
JARI1	14.21	14.21	13.56	13.33	12.97	12.65	12.46
BRIG1	14.33	14.33	13.74	13.69	13.47	13.32	13.21
LYBR1	6.36	6.36	6.12	6.05	5.96	5.88	5.82

Table 16. Haze Results - Round 5.1 (Based on 2000-2004)

Worst 20%						
Site	Baseline	2018 URP	2009 OTB	2012 OTB	2018 OTB	2018 OTB+Will DO
BOWA1	19.86	17.94	18.45	18.33	17.94	17.92
VOYA2	19.48	17.75	18.20	18.07	17.63	17.66
SENE1	24.38	21.64	23.10	23.04	22.59	22.42
ISLE1	21.59	19.43	20.52	20.43	20.09	20.13
ISLE9	21.59	19.43	20.33	20.22	19.84	19.82
HEGL1	26.75	23.13	24.72	24.69	24.22	24.17
MING1	28.15	24.27	25.88	25.68	24.74	24.83
CACR1	26.36	22.91	23.39	23.29	22.44	22.40
UPBU1	26.27	22.82	23.34	23.27	22.59	22.55
MACA1	31.37	26.64	27.11	27.01	26.10	26.15
DOSO1	29.05	24.69	24.00	23.90	23.00	23.04
SHEN1	29.31	25.12	24.99	24.87	23.92	23.95
JARI1	29.12	24.91	25.17	25.01	24.06	24.12
BRIG1	29.01	25.05	25.79	25.72	25.21	25.22
LYBR1	24.45	21.48	22.04	21.86	21.14	21.14
ACAD1	22.89	20.45	21.72	21.72	21.49	21.49
Best 20%						
Site	Baseline	2018 Max	2009 OTB	2012 OTB	2018 OTB	2018 OTB+Will DO
BOWA1	6.42	6.42	6.21	6.19	6.14	6.12
VOYA2	7.09	7.09	6.86	6.83	6.75	6.76
SENE1	7.14	7.14	7.57	7.58	7.71	7.78
ISLE1	6.75	6.75	6.62	6.59	6.60	6.62
ISLE9	6.75	6.75	6.56	6.55	6.52	6.50
HEGL1	12.84	12.84	12.51	12.32	11.66	11.64
MING1	14.46	14.46	14.07	13.89	13.28	13.29
CACR1	11.24	11.24	10.88	10.85	10.52	10.52
UPBU1	11.71	11.71	11.13	11.08	10.73	10.74
MACA1	16.51	16.51	15.76	15.69	15.25	15.25
DOSO1	12.28	12.28	11.25	11.23	11.00	11.01
SHEN1	10.93	10.93	10.13	10.11	9.91	9.91
JARI1	14.21	14.21	13.38	13.38	13.14	13.14
BRIG1	14.33	14.33	14.15	14.08	13.92	13.92
LYBR1	6.37	6.37	6.25	6.23	6.14	6.15
ACAD1	8.78	8.78	8.86	8.86	8.82	8.82

Table 17. Estimated Cost Effectiveness for Potential Control Measures

Emission category	Control strategy	Region	Average Cost effectiveness (\$/ton)		
			SO2	NOX	NH3
EGU	EGU1	3-State	1,540	2,037	
		9-State	1,743	1,782	
	EGU2	3-State	1,775	3,016	
		9-State	1,952	2,984	
ICI boilers	ICI1	3-State	2,992	2,537	
		9-State	2,275	1,899	
	ICI Workgroup	3-State	2,731	3,814	
		9-State	2,743	2,311	
Reciprocating engines and turbines	Reciprocating engines emitting 100 tons/year or more	3-State		538	
		9-State		506	
	Turbines emitting 100 tons/year or more	3-State		754	
		9-State		754	
	Reciprocating engines emitting 10 tons/year or more	3-State		1,286	
		9-State		1,023	
	Turbines emitting 10 tons/year or more	3-State		800	
		9-State		819	
Agricultural sources	10% reduction	3-State			31 - 2,700
		9-State			31 - 2,700
	15% reduction	3-State			31 - 2,700
		9-State			31 - 2,700
Mobile sources	Low-NOX Reflash	3-State		241	
		9-State		241	
	MCDI	3-State		10,697	
		9-State		2,408	
	Anti-Idling	3-State		(430) - 1,700	
		9-State		(430) - 1,700	
	Cetane Additive Program	3-State		4,119	
		9-State		4,119	
Cement Plants	Process Modification	Michigan		-	
	Conversion to dry kiln	Michigan		9,848	
	LoTox™	Michigan		1,399	
Glass Manufacturing	LNB	Wisconsin		1,041	
	Oxy-firing	Wisconsin		2,833	
	Electric boost	Wisconsin		3,426	
	SCR	Wisconsin		1,054	
	SNCR	Wisconsin		1,094	
Lime Manufacturing	Mid-kiln firing	Wisconsin		688	
	LNB	Wisconsin		837	
	SNCR	Wisconsin		1,210	
	SCR	Wisconsin		5,037	
	FGD	Wisconsin		128 - 4,828	
Oil Refinery	LNB	Wisconsin		3,288	
	SNCR	Wisconsin		4,260	
	SCR	Wisconsin		17,997	
	LNB+FGR	Wisconsin		4,768	
	ULNB	Wisconsin		2,242	
	FGD	Wisconsin		1,078	

Factor 2 (Time Necessary for Compliance): All of the control measures can be implemented by 2018. Thus, this factor can be easily addressed.

Factor 3 (Energy and Non-Air Quality Environmental Impacts): The energy and other environmental impacts are believed to be manageable. For example, the increased energy demand from add-on control equipment is less than 1% of the total electricity and steam production in the region, and solid waste disposal and wastewater treatment costs are less than 5% of the total operating costs of the pollution control equipment. It should also be noted that the SO₂ and NO_x controls would have beneficial environmental impacts (e.g., reduced acid deposition and nitrogen deposition).

Factor 4 (Remaining Useful Life): The additional control measures are intended to be market-based strategies applied over a broad geographic region. It is not expected that the control requirements will be applied to units that will be retired prior to the amortization period for the control equipment. Thus, this factor can be easily addressed.

Factor 5 (Visibility Impacts): The estimated incremental improvement in 2018 visibility levels for the additional measures is shown in Figure 74, along with the cost-effectiveness expressed in \$M per deciview improvement). These results show that although EGU and ICI boiler controls have higher cost-per-deciview values (compared to some of the other measures), their visibility impacts are larger.

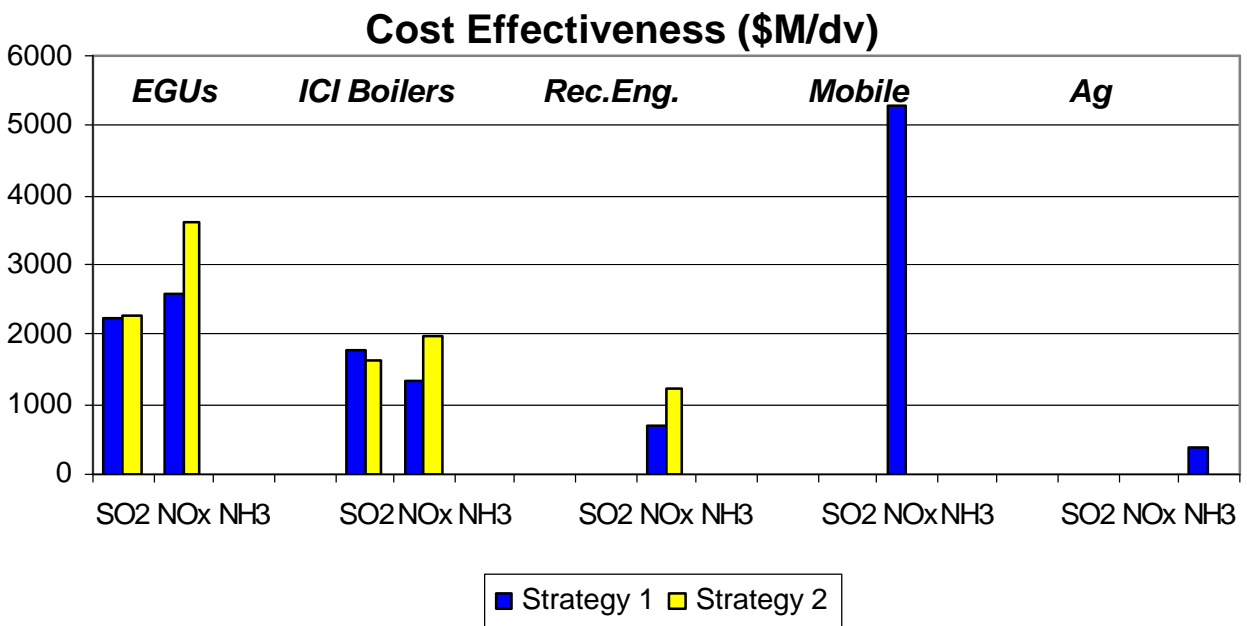
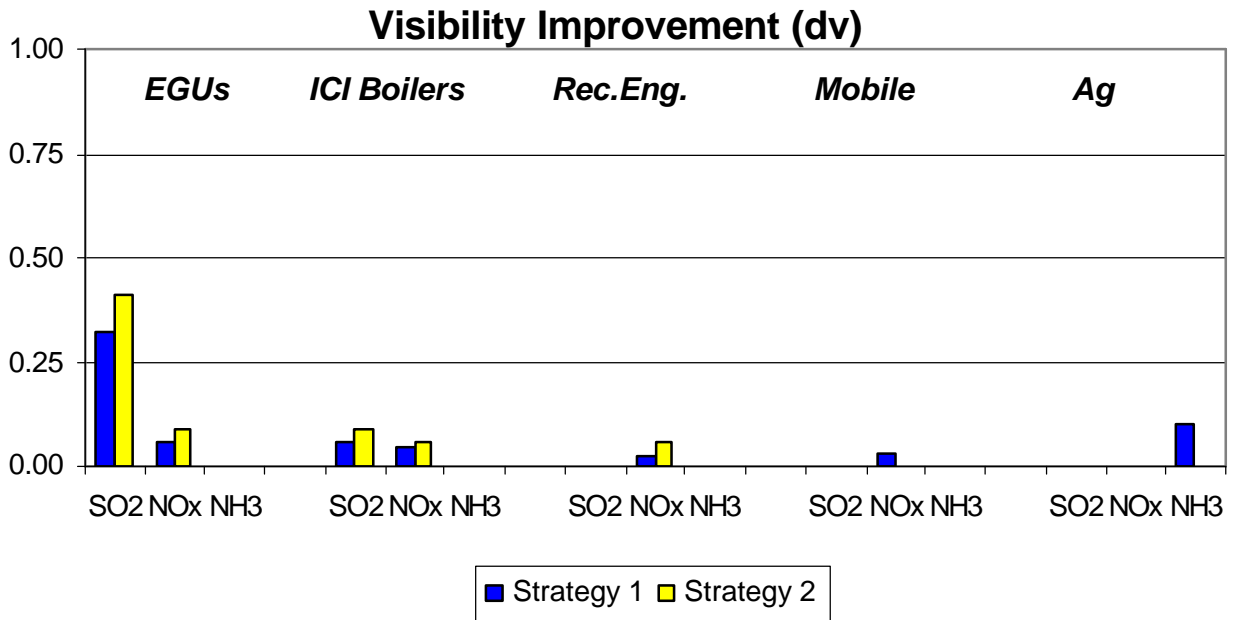


Figure 74. Results of ECR analysis of reasonable progress factors – visibility improvement (Factor 5) is on top, and cost effectiveness (Factor 1) is on bottom

5.3 Weight-of-Evidence Determination for Haze

The WOE determination for haze consists of the primary modeling and other supplemental analyses. A summary of this information is provided below.

Primary (Guideline) Modeling: The results of the guideline modeling are presented in Section 4.1. Key findings from this modeling include:

- Base M modeling results show that the northern Minnesota Class I areas are close to the glide path, whereas the northern Michigan Class I areas are above the glide path in 2018. Other sites in the eastern U.S. are close to (or below) the glide path, except for Mingo (MO), Brigantine (NJ), and Acadia (ME).
- Base K modeling results show that the northern Minnesota and northern Michigan Class I areas are above the glide path in 2018. Other sites in the eastern U.S. are close to (or below) the glide path.
- The difference in the two modeling analyses is due mostly to differences in future year emission projections, especially for EGUs (e.g., use of IPM2.1.9 v. IPM3.0).
- Base K and Base M modeling analyses are considered “SIP quality”, so the attainment demonstration for haze should reflect a weight-of-evidence approach, with consideration of monitoring based information.

Additional Modeling: Two additional modeling analyses were considered: (1) the primary modeling redone with different baseline values, and (2) modeling by the State of Minnesota which looked at different receptor locations in the northern Class I areas (MPCA, 2008). Each of these analyses is described below.

First, the primary modeling analysis (Base M) was revised using an alternative baseline value. Specifically, the data for the period 2000-2005 were used to calculate the baseline, given that the Base M modeling reflects a 2005 base year. The results of this alternative analysis (see Table 18) are generally consistent with the primary modeling (see Table 16).

Second, Minnesota’s modeling reflects a 2002 base year and much of the data developed by LADCO for its modeling. (Note, Minnesota conducted modeling for LADCO’s domain at 36 km, and for a statewide domain at 12 km.) The purpose of the 12 km modeling was to address local scale impacts on the northern Class I areas at several locations, not just the location of the IMPROVE monitor. Results for the Boundary Waters on the 20% worst days range from 18.3 – 19.0 dv, with an average value of 18.7 dv, which is consistent with Minnesota’s 36 km modeling results at the IMPROVE monitor. This variability in visibility levels should be kept in mind when reviewing the values presented in Tables 15, 16, and 18, which reflect results at the IMPROVE monitor locations.

Table 18. Haze Results - Round 5.1 (Based on 2000-2005)

Worst 20%						
Site	Baseline	URP	2009 OTB	2012 OTB	2018 OTB	2018 OTB+Will DO
BOWA1	20.10	18.12	18.63	18.51	18.12	18.09
VOYA2	19.62	17.86	18.27	18.15	17.70	17.72
SENE1	24.77	21.94	23.44	23.39	22.94	22.77
ISLE1	21.95	19.71	20.84	20.76	20.41	20.44
ISLE9	21.95	19.71	20.65	20.55	20.15	20.13
HEGL1	27.45	23.67	25.30	25.27	24.79	24.73
MING1	28.92	24.86	25.88	25.68	24.74	24.83
CACR1	27.05	23.44	23.88	23.78	22.92	22.86
UPBU1	26.97	23.36	23.92	23.85	23.14	23.09
MACA1	31.76	26.93	27.42	27.32	26.39	26.44
DOSO1	29.36	24.92	24.20	24.11	23.19	23.23
SHEN1	29.45	25.23	25.06	24.94	23.98	24.01
JARI1	29.40	25.13	25.32	25.17	24.22	24.28
BRIG1	29.12	25.14	25.84	25.77	25.26	25.26
LYBR1	24.71	21.69	22.22	22.06	21.36	21.36
ACAD1	22.91	20.47	21.72	21.72	21.49	21.49
Best 20%						
Site	Baseline	URP	2009 OTB	2012 OTB	2018 OTB	2018 OTB+Will DO
BOWA1	6.40	6.40	6.20	6.17	6.13	6.10
VOYA2	7.05	7.05	6.82	6.78	6.71	6.71
SENE1	7.20	7.20	7.60	7.61	7.73	7.80
ISLE1	6.80	6.80	6.67	6.64	6.65	6.66
ISLE9	6.80	6.80	6.62	6.61	6.57	6.55
HEGL1	13.04	13.04	12.71	12.51	11.85	11.82
MING1	14.68	14.68	14.07	13.89	13.28	13.29
CACR1	11.62	11.62	11.24	11.20	10.86	10.86
UPBU1	11.99	11.99	11.41	11.36	11.01	11.02
MACA1	16.64	16.64	15.88	15.82	15.37	15.38
DOSO1	12.24	12.24	11.21	11.19	10.96	10.97
SHEN1	10.85	10.85	10.04	10.02	9.82	9.83
JARI1	14.35	14.35	13.51	13.51	13.27	13.27
BRIG1	14.36	14.36	14.17	14.10	13.94	13.94
LYBR1	6.21	6.21	6.11	6.09	6.01	6.01
ACAD1	8.57	8.57	8.67	8.66	8.62	8.62

Observational Models and Diagnostic Analyses: The observation-based modeling (i.e., application of thermodynamic equilibrium models) is presented in Section 3. The key findings from this modeling are that PM_{2.5} mass is sensitive to reductions in sulfate, nitric acid, and ammonia concentrations. Even though sulfate reductions cause more ammonia to be available to form ammonium nitrate (PM-nitrate increases slightly when sulfate is reduced), this increase is generally offset by the sulfate reductions, such that PM_{2.5} mass decreases and visibility improves. Under conditions with lower sulfate levels (i.e., proxy of future year conditions), PM_{2.5} is more sensitive to reductions in nitric acid compared to reductions in ammonia.

As discussed in Section 2, thermodynamic equilibrium modeling based on data collected at Seney indicates that PM_{2.5} there is most sensitive to reductions in sulfate, but also responsive to reductions in nitric acid (Blanchard, 2004). An analysis using data from the Midwest ammonia monitoring network for a site in Minnesota (i.e., Great River Bluffs, which is the closest ammonia monitoring site to the northern Class I areas) suggested that reductions in sulfate, nitric acid, and ammonia concentrations will lower PM_{2.5} concentrations and improve visibility levels in the northern Class I areas.

Trajectory analyses for the 20% worst visibility days for the four northern Class I areas are provided in Figure 75. (Note, this figure is similar to Figure 34, but the trajectory results for each Class I area are displayed separately here.) The orange areas are where the air is most likely to come from, and the green areas are where the air is least likely to come from. Darker shading represents higher frequency. As can be seen, bad air days are generally associated with transport from regions located to the south, and good air days with transport from Canada.

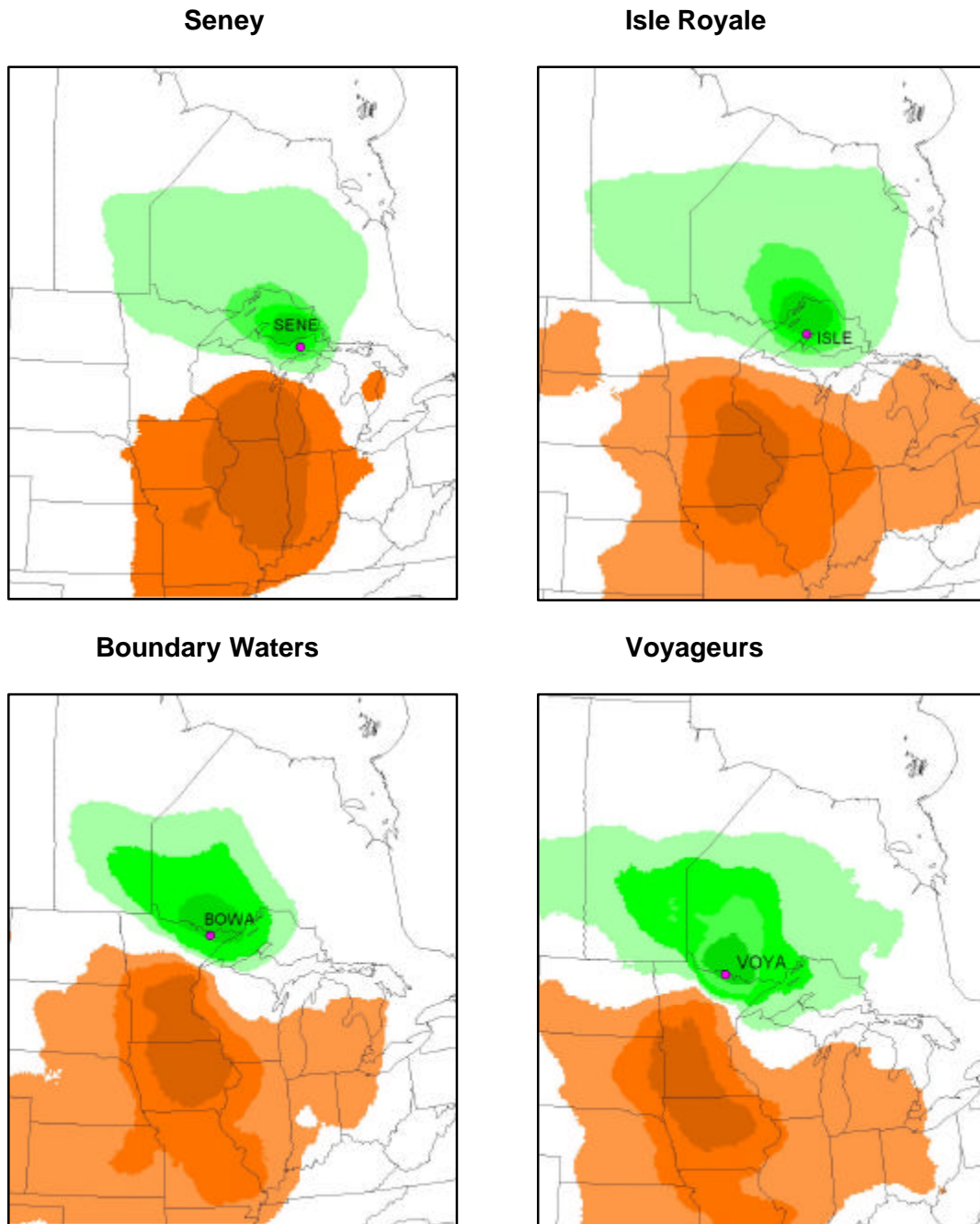


Figure 75. Trajectory analysis results for northern Class I areas on 20% worst visibility days

The primary diagnostic analysis is source apportionment modeling with CAMx to provide more quantitative information on source region (and source sector) impacts (Baker, 2007b). Specifically, the CAMx model was applied to provide source contribution information. Specifically, the model estimated the impact of 18 geographic source regions (which are identified in Figure 76) and 6 source sectors (EGU point, non-EGU point, on-road, off-road, area, and ammonia sources) at visibility/haze monitoring sites in the eastern U.S.

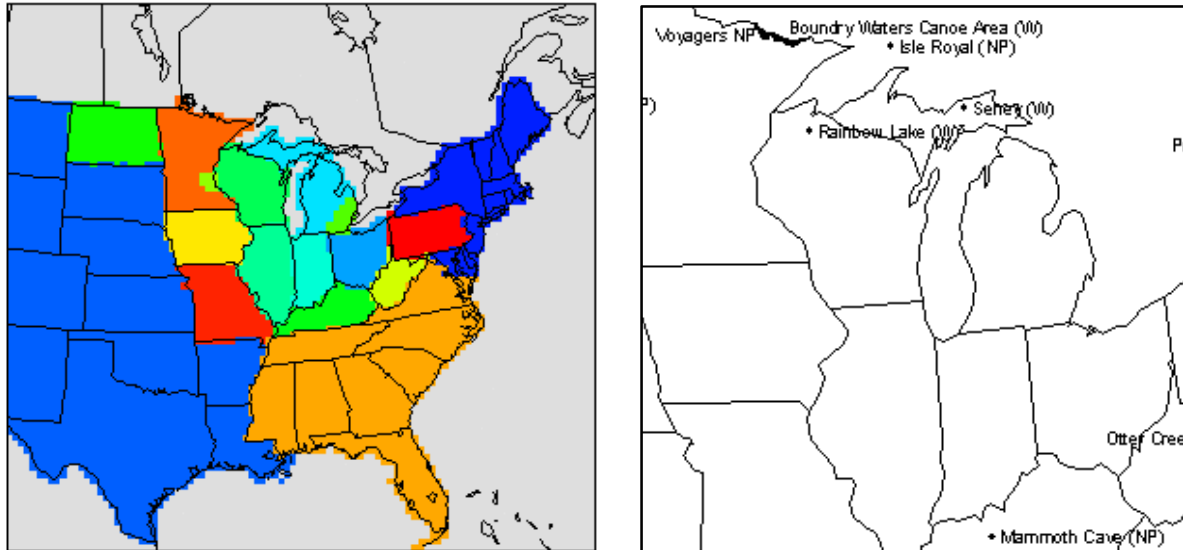


Figure 76. Source regions (left) and key monitoring sites (right) for haze modeling analysis

Modeling results for 2018 (Base K and Base M) are provided in Appendix IV for several key monitoring sites (Class I areas). For each monitoring site, there are two graphs: one showing sector-level contributions, and one showing source region and sector-level contributions in terms of absolute modeled values.

The sector-level results (see, for example, Figure 77) show that EGU sulfate, non-EGU-sulfate, and ammonia emissions generally have the largest contributions at the key monitor locations. The source group contributions vary by receptor location due to emissions inventory differences.

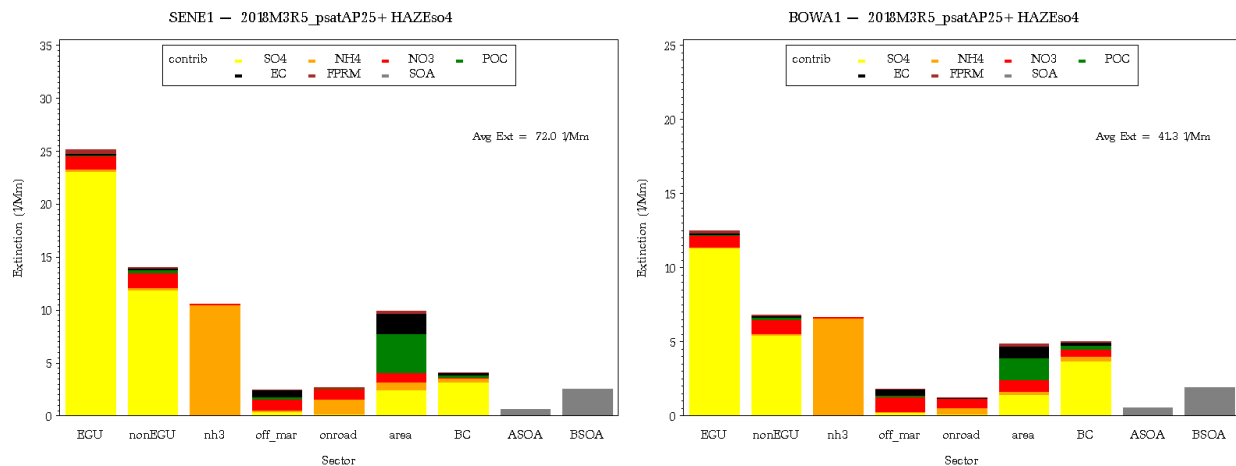


Figure 77. Source-sector results for Seney (left) and Boundary Waters (right) – 2018 (Base M)

The source region results (see, for example, Figure 78) show that emissions from a number of nearby states contribute to regional haze levels.

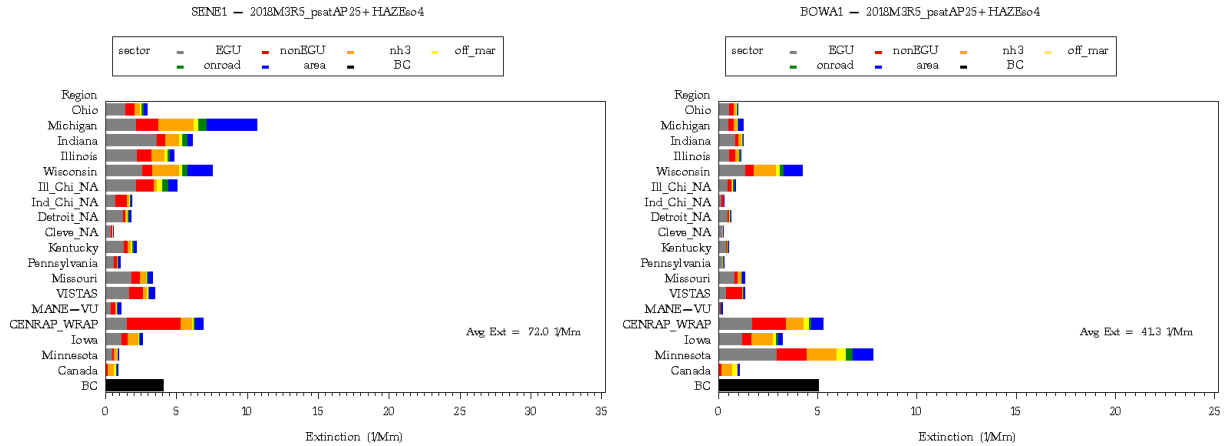


Figure 78. Source-region results for Seney (left) and Boundary Waters (right) – 2018 (Base M)

Table 19 provides a summary of the estimated state-level culpabilities based on the LADCO back trajectory analyses and the PSAT analyses for 2018.

Summary: Air quality modeling and other supplemental analyses were performed to estimate future year visibility levels. Based on this information, the following general conclusions can be made:

- Existing (“on the books”) controls are expected to improve visibility levels in the northern Class I areas.
- Visibility levels in a few Class I areas in the eastern U.S. are expected to be greater than (less improved than) the uniform rate of visibility improvement values in 2018, including those in northern Michigan and some in the northeastern U.S.
- Visibility levels in many other Class I areas in the eastern U.S. are expected to be less than (more improved than) the uniform rate of visibility improvement values in 2018.

Table 19. State Culpabilities Based on PSAT Modeling and Trajectory Analyses

	Boundary Waters						Seney			
	LADCO - Round 4 PSAT	LADCO - Round 5 PSAT	MPCA-PSAT	CENRAP - PSAT	LADCO - Traj. Analysis		LADCO - Round 4 PSAT	LADCO - Round 5 PSAT	CENRAP - PSAT	LADCO - Traj. Analysis
Michigan	3.4%	4.8%	3.0%	1.9%	0.7%		13.8%	18.1%		14.7%
Minnesota	30.5%	23.5%	28.0%	30.6%	37.6%		4.8%	1.6%		3.8%
Wisconsin	10.4%	10.9%	10.0%	6.4%	10.6%		12.6%	10.9%		8.4%
Illinois	5.2%	5.1%	6.0%	3.5%	2.7%		13.0%	14.3%		7.4%
Indiana	2.9%	3.9%	3.0%	1.8%	1.2%		9.6%	11.6%		2.2%
Iowa	7.6%	8.3%	8.0%	2.5%	7.4%		6.2%	3.8%		5.7%
Missouri	5.2%	3.4%	6.0%	2.1%	3.3%		6.5%	4.8%		3.2%
N. Dakota	5.7%	1.1%	6.0%	4.6%	5.9%		1.5%	0.1%		0.6%
Canada	1.9%	2.7%	3.0%	12.5%	15.1%		2.1%	1.2%		11.1%
CENRAP-WRAP	10.9%	13.5%		4.2%	10.1%		13.1%	10.0%		7.0%
	83.6%	77.2%	73.0%	70.2%	94.6%		83.3%	76.4%		64.1%
	Voyageurs						Isle Royale			
	LADCO - Round 4 PSAT	LADCO - Round 5 PSAT	MPCA-PSAT	CENRAP - PSAT	LADCO - Traj. Analysis		LADCO - Round 4 PSAT	LADCO - Round 5 PSAT	CENRAP - PSAT	LADCO - Traj. Analysis
Michigan	2.0%	4.9%	2.0%	1.0%	1.6%		12.7%	13.4%		
Minnesota	35.0%	20.2%	31.0%	31.5%	36.9%		14.1%	9.5%		
Wisconsin	6.3%	7.9%	6.0%	3.7%	9.7%		16.3%	14.7%		
Illinois	3.0%	7.1%	3.0%	1.8%	1.2%		7.0%	8.7%		
Indiana	1.6%	4.6%	2.0%	0.8%			5.6%	5.2%		
Iowa	7.4%	7.1%	7.0%	2.4%	10.2%		6.9%	8.3%		
Missouri	4.3%	4.0%	4.0%	1.6%	0.3%		3.9%	4.6%		
N. Dakota	10.3%	1.7%	13.0%	6.1%	7.1%		3.6%	0.3%		
Canada	2.7%	3.3%	5.0%	17.2%	13.3%		2.2%	1.7%		
CENRAP-WRAP	10.2%	13.7%		6.1%	16.5%		12.5%	12.6%		
	82.7%	74.5%	73.0%	72.2%	96.8%		84.9%	79.0%		

Section 6. Summary

To support the development of SIPs for ozone, PM_{2.5}, and regional haze in the States of Illinois, Indiana, Michigan, Ohio, and Wisconsin, technical analyses were conducted by LADCO, its member states, and various contractors. The analyses include preparation of regional emissions inventories and meteorological modeling data for two base years, evaluation and application of regional chemical transport models, and review of ambient monitoring data.

Analyses of monitoring data were conducted to produce a conceptual model, which is a qualitative summary of the physical, chemical, and meteorological processes that control the formation and distribution of pollutants in a given region. Key findings of the analyses include:

Ozone

- Current monitoring data show about 20 sites in violation of the 8-hour ozone standard of 85 ppb. Historical ozone data show a steady downward trend over the past 15 years, especially since 2001-2003, due likely to federal and state emission control programs.
- Ozone concentrations are strongly influenced by meteorological conditions, with more high ozone days and higher ozone levels during summers with above normal temperatures.
- Inter- and intra-regional transport of ozone and ozone precursors affects many portions of the five states, and is the principal cause of nonattainment in some areas far from population or industrial centers

PM_{2.5}

- Current monitoring data show 30 sites in violation of the annual PM_{2.5} standard of 15 ug/m³. Nonattainment sites are characterized by an elevated regional background (about 12 – 14 ug/m³) and a significant local (urban) increment (about 2 – 3 ug/m³). Historical PM_{2.5} data show a slight downward trend since deployment of the PM_{2.5} monitoring network in 1999.
- PM_{2.5} concentrations are also influenced by meteorology, but the relationship is more complex and less well understood compared to ozone.
- On an annual average basis, PM_{2.5} chemical composition consists of mostly sulfate, nitrate, and organic carbon in similar proportions.

Haze

- Current monitoring data show visibility levels in the Class I areas in northern Michigan are on the order of 22 – 24 deciviews. The goal of EPA's visibility program is to achieve natural conditions, which is on the order of 12 deciviews for these Class I areas, by the year 2064.
- Visibility impairment is dominated by sulfate and nitrate.

Air quality models were applied to support the regional planning efforts. Two base years were used in the modeling analyses: 2002 and 2005. EPA's modeling guidance recommends using

2002 as the baseline inventory year, but also allows for use of an alternative baseline inventory year, especially a more recent year. Initially, LADCO conducted modeling with a 2002 base year (i.e., Base K modeling, which was completed in 2006). A decision was subsequently made to conduct modeling with a 2005 base year (i.e., Base M, which was completed in 2007). Statistical analyses showed that 2002 and 2005 both had above normal ozone-conducive conditions, although 2002 was more severe compared to 2005. Examination of multiple base years provides for a more complete technical assessment. Both sets of model runs are discussed in this document.

Basecase modeling was conducted to evaluate model performance (i.e., assess the model's ability to reproduce the observed concentrations). This exercise was intended to assess whether, and to degree, confidence in the model is warranted (and to assess whether model improvements are necessary). Model performance for ozone and PM_{2.5} was generally acceptable and can be characterized as follows:

Ozone

- Good agreement between modeled and monitored concentration for higher concentration levels (> 60 ppb) – i.e., bias within 30%
- Regional modeled concentrations appear to be underestimated in the 2002 base year, but show better agreement (with monitored data) in the 2005 base year due to model and inventory improvements.
- Day-to-day and hour-to-hour variation in and spatial patterns of modeled concentrations are consistent with monitored data
- Model accurately simulates the change in monitored ozone concentrations due to reductions in precursor emissions.

PM_{2.5}

- Good agreement in the magnitude of fine particle mass, but some species are overestimated and some are underestimated
 - Sulfates: good agreement in the 2002 base year, but underestimated in the summer in the 2005 base year due probably to meteorological factors
 - Nitrates: slightly overestimated in the winter in the 2002 base year, but good agreement in the 2005 base year as a result of model and inventory improvements
 - Organic Carbon: grossly underestimated in the 2002 and 2005 base years due likely to missing primary organic carbon emissions
- Temporal variation and spatial patterns of modeled concentrations are consistent with monitored data

Future year strategy modeling was conducted to determine whether existing (“on the books”) controls would be sufficient to provide for attainment of the standards for ozone and PM_{2.5} and if not, then what additional emission reductions would be necessary for attainment. Traditionally, attainment demonstrations involved a “bright line” test in which a single modeled value (based on EPA guidance) was compared to the ambient standard. To provide a more robust assessment of expected future year air quality, other information was considered. Furthermore, according to EPA’s modeling guidance, if the future year modeled values are “close” to the

standard (i.e., 82 – 87 ppb for ozone and 14.5 – 15.5 ug/m³ for PM_{2.5}), then the results of the primary modeling should be reviewed along with the supplemental information in a “weight of evidence” (WOE) assessment of whether each area is likely to achieve timely attainment. Key findings of the WOE determination include:

- Existing controls are expected to produce significant improvement in ozone and PM_{2.5} concentrations and visibility levels.
- The choice of the base year affects the future year model projections. A key difference between the base years of 2002 and 2005 is meteorology. 2002 was more ozone conducive than 2005. The choice of which base year to use as the basis for the SIP is a policy decision (i.e., how much safeguard to incorporate).
- Most sites are expected to meet the current 8-hour standard by the applicable attainment date, except for sites in western Michigan and, possibly, in eastern Wisconsin and northeastern Ohio.
- Most sites are expected to meet the current PM_{2.5} standard by the applicable attainment date, except for sites in Detroit, Cleveland, and Granite City.

The regional modeling for PM_{2.5} does not reflect air quality benefits expected from local controls. States are conducting local-scale analyses and will use these results, in conjunction with the regional-scale modeling, to support their attainment demonstrations for PM_{2.5}.

- These findings of residual nonattainment for ozone and PM_{2.5} are supported by current (2005 – 2007) monitoring data which show significant nonattainment in the region (e.g., peak ozone design values on the order of 90 – 93 ppb, and peak PM_{2.5} design values on the order of 16 - 17 ug/m³). It is unlikely that sufficient emission reductions will occur in the next few of years to provide for attainment at all sites.
- Attainment at most sites by the applicable attainment date is dependent on actual future year meteorology (e.g., if the weather conditions are consistent with [or less severe than] 2005, then attainment is likely) and actual future year emissions (e.g., if the emission reductions associated with the existing controls are achieved, then attainment is likely). If either of these conditions is not met, then attainment may be less likely.
- The new PM_{2.5} 24-hour standard and the new lower ozone standard will not be met at several sites, even by 2018, with existing controls.
- Visibility levels in a few Class I areas in the eastern U.S. are expected to be greater than (less improved than) the uniform rate of visibility improvement values in 2018 based on existing controls, including those in northern Michigan and some in the northeastern U.S. Visibility levels in many other Class I areas in the eastern U.S. are expected to be less than (more improved than) the uniform rate of visibility improvement values in 2018.

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APPENDIX I

Ozone and PM_{2.5} Modeling Results

Key Sites		4th High 8-hour Value					Des. Values (truncated)			2005 BY	2002 BY	2008 - OTB		
		'03	'04	'05	'06	'07	'03-'05	'04-'06	'05-'07	Average	Average	RRF	Round 5	
Lake Michigan Area														Lake Michigan Area
Chiwaukee	550590019	88	78	93	79	85	86	83	85	84.7	98.3	0.968	82.0	Chiwaukee
Racine	551010017	82	69	95	71	77	82	78	81	80.3	91.7	0.966	77.6	Racine
Milwaukee-Bayside	550190085	92	73	93	73	83	86	79	83	82.7	91.0	0.963	79.6	Milwaukee-Bayside
Harrington Beach	550890009	99	72	94	72	84	88	79	83	83.3	93.0	0.960	80.0	Harrington Beach
Manitowoc	550710007	92	74	95	78	85	87	82	86	85.0	87.0	0.957	81.3	Manitowoc
Sheboygan	551170006	93	78	97	83	88	89	86	89	88.0	97.0	0.959	84.4	Sheboygan
Kewaunee	550610002	97	73	88	76	85	86	79	83	82.7	89.3	0.954	78.9	Kewaunee
Door County	550290004	93	78	101	79	92	90	86	90	88.7	91.0	0.956	84.8	Door County
Hammond	180892008	81	67	87	75	77	78	76	79	77.7	88.3	0.971	75.4	Hammond
Whiting	180890030		64	88	81	88	76	77	85	79.3		0.971	77.0	Whiting
Michigan City	180910005	82	70	84	75	73	78	76	77	77.0	90.3	0.964	74.2	Michigan City
Ogden Dunes	181270020	77	69	90	70	84	78	76	81	78.3	86.3	0.967	75.7	Ogden Dunes
Holland	260050003	96	79	94	91	94	89	88	93	90.0	94.0	0.951	85.6	Holland
Jenison	261390005	91	69	86	83	88	82	79	85	82.0	86.0	0.950	77.9	Jenison
Muskegon	261210039	94	70	90	90	86	84	83	88	85.0	90.0	0.951	80.8	Muskegon
Indianapolis Area														Indianapolis Area
Noblesville	189571001	101	75	87	77	84	87	79	82	82.7	93.7	0.944	78.0	Noblesville
Fortville	180590003	92	72	80	75	81	81	75	78	78.0	91.3	0.948	73.9	Fortville
Fort B. Harrison	180970050	91	73	80	76	83	81	76	79	78.7	90.0	0.951	74.8	Fort B. Harrison
Detroit Area														Detroit Area
New Haven	260990009	102	81	88	78	93	90	82	86	86.0	92.3	0.962	82.7	New Haven
Warren	260991003	101	71	89	78	91	87	79	86	84.0	90.0	0.982	82.5	Warren
Port Huron	261470005	87	74	88	78	89	83	80	85	82.7	88.0	0.956	79.0	Port Huron
Cleveland Area														Cleveland Area
Ashtabula	390071001	99	81	93	86	92	91	86	90	89.0	95.7	0.954	84.9	Ashtabula
Geauga	390550004	97	75	88	70	68	86	77	75	79.3	99.0	0.954	75.7	Geauga
Eastlake	390850003	92	79	97	83	74	89	86	84	86.3	92.7	0.959	82.8	Eastlake
Akron	391530020	89	77	89	77	91	85	81	85	83.7	93.3	0.948	79.3	Akron
Cincinnati Area														Cincinnati Area
Wilmington	390271002	96	78	83	81	82	85	80	82	82.3	94.3	0.945	77.8	Wilmington
Sycamore	390610006	93	76	89	81	90	86	82	86	84.7	90.3	0.965	81.7	Sycamore
Lebanon	391650007	95	81	92	86	88	89	86	88	87.7	87.0	0.954	83.6	Lebanon
Columbus Area														Columbus Area
London	390970007	90	75	81	76	83	82	77	80	79.7	88.7	0.946	75.4	London
New Albany	390490029	94	78	92	82	87	88	84	87	86.3	93.0	0.954	82.4	New Albany
Franklin	290490028	84	73	86	79	79	81	79	81	80.3	86.0	0.958	77.0	Franklin
St. Louis Area														St. Louis Area
W. Alton (MO)	291831002	91	77	89	91	89	85	85	89	86.3	90.0	0.954	82.4	W. Alton (MO)
Orchard (MO)	291831004	90	76	92	92	83	86	86	89	87.0	90.0	0.958	83.3	Orchard (MO)
Sunset Hills (MO)	291890004	88	70	89	80	89	82	79	86	82.3	88.3	0.966	79.5	Sunset Hills (MO)
Arnold (MO)	290990012	82	70	92	79	87	81	80	86	82.3	84.7	0.956	78.7	Arnold (MO)
Margaretta (MO)	295100086	90	72	91	76	91	84	79	86	83.0	87.7	0.962	79.8	Margaretta (MO)
Maryland Heights (MO)	291890014			88	84	94	88	86	88	87.3		0.967	84.5	Maryland Heights (MO)

Key Sites		4th High 8-hour Value					Des. Values (truncated)			2005 BY	2002 BY	2009 - OTB			2009 - Will Do		
		'03	'04	'05	'06	'07	'03-'05	'04-'06	'05-'07	Average	Average	RRF	Round 5	Round 4	RRF	Round 5	
Lake Michigan Area																	Lake Michigan Area
Chiwaukee	550590019	88	78	93	79	85	86	83	85	84.7	98.3	0.972	82.3	92.0	0.971	82.2	Chiwaukee
Racine	551010017	82	69	95	71	77	82	78	81	80.3	91.7	0.965	77.5	84.9	0.964	77.4	Racine
Milwaukee-Bayside	550190085	92	73	93	73	83	86	79	83	82.7	91.0	0.965	79.8	84.9	0.964	79.7	Milwaukee-Bayside
Harrington Beach	550890009	99	72	94	72	84	88	79	83	83.3	93.0	0.961	80.1	85.4	0.960	80.0	Harrington Beach
Manitowoc	550710007	92	74	95	78	85	87	82	86	85.0	87.0	0.951	80.8	78.9	0.949	80.7	Manitowoc
Sheboygan	551170006	93	78	97	83	88	89	86	89	88.0	97.0	0.955	84.0	88.9	0.953	83.9	Sheboygan
Kewaunee	550610002	97	73	88	76	85	86	79	83	82.7	89.3	0.945	78.1	81.0	0.943	78.0	Kewaunee
Door County	550290004	93	78	101	79	92	90	86	90	88.7	91.0	0.946	83.9	81.8	0.945	83.8	Door County
Hammond	180892008	81	67	87	75	77	78	76	79	77.7	88.3	0.971	75.4	86.6	0.970	75.3	Hammond
Whiting	180890030		64	88	81	88	76	77	85	79.3		0.971	77.0		0.970	77.0	Whiting
Michigan City	180910005	82	70	84	75	73	78	76	77	77.0	90.3	0.960	73.9	86.5	0.959	73.8	Michigan City
Ogden Dunes	181270020	77	69	90	70	84	78	76	81	78.3	86.3	0.965	75.6	82.8	0.964	75.5	Ogden Dunes
Holland	260050003	96	79	94	91	94	89	88	93	90.0	94.0	0.948	85.3	83.4	0.947	85.2	Holland
Jenison	261390005	91	69	86	83	88	82	79	85	82.0	86.0	0.940	77.1	77.6	0.939	77.6	Jenison
Muskegon	261210039	94	70	90	90	86	84	83	88	85.0	90.0	0.947	80.5	81.5	0.945	80.3	Muskegon
Indianapolis Area																	Indianapolis Area
Noblesville	189571001	101	75	87	77	84	87	79	82	82.7	93.7	0.945	78.1	83.7	0.946	78.2	Noblesville
Fortville	180590003	92	72	80	75	81	81	75	78	78.0	91.3	0.947	73.9	83.8	0.948	73.9	Fortville
Fort B. Harrison	180970050	91	73	80	76	83	81	76	79	78.7	90.0	0.955	75.1	83.7	0.956	75.2	Fort B. Harrison
Detroit Area																	Detroit Area
New Haven	260990009	102	81	88	78	93	90	82	86	86.0	92.3	0.947	81.4	85.3	0.947	81.4	New Haven
Warren	260991003	101	71	89	78	91	87	79	86	84.0	90.0	0.968	81.3	83.3	0.969	81.4	Warren
Port Huron	261470005	87	74	88	78	89	83	80	85	82.7	88.0	0.937	77.5	79.1	0.938	77.5	Port Huron
Cleveland Area																	Cleveland Area
Ashtabula	390071001	99	81	93	86	92	91	86	90	89.0	95.7	0.937	83.4	82.7	0.941	83.7	Ashtabula
Geauga	390550004	97	75	88	70	68	86	77	75	79.3	99.0	0.942	74.7	88.8	0.945	75.0	Geauga
Eastlake	390850003	92	79	97	83	74	89	86	84	86.3	92.7	0.949	81.9	82.8	0.954	82.4	Eastlake
Akron	391530020	89	77	89	77	91	85	81	85	83.7	93.3	0.934	78.1	81.4	0.935	78.2	Akron
Cincinnati Area																	Cincinnati Area
Wilmington	390271002	96	78	83	81	82	85	80	82	82.3	94.3	0.941	77.5	83.5	0.942	77.6	Wilmington
Sycamore	390610006	93	76	89	81	90	86	82	86	84.7	90.3	0.967	81.9	84.7	0.968	82.0	Sycamore
Lebanon	391650007	95	81	92	86	88	89	86	88	87.7	87.0	0.947	83.0	79.0	0.948	83.1	Lebanon
Columbus Area																	Columbus Area
London	390970007	90	75	81	76	83	82	77	80	79.7	88.7	0.941	75.0	78.4	0.942	75.0	London
New Albany	390490029	94	78	92	82	87	88	84	87	86.3	93.0	0.947	81.8	82.6	0.948	81.8	New Albany
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Orchard (MO)	291831004	90	76	92	92	83	86	86	89	87.0	90.0	0.942	82.0	82.2	0.939	81.7	Orchard (MO)
Sunset Hills (MO)	291890004	88	70	89	80	89	82	79	86	82.3	88.3	0.956	78.7	81.9	0.954	78.5	Sunset Hills (MO)
Arnold (MO)	290990012	82	70	92	79	87	81	80	86	82.3	84.7	0.938	77.2	77.4	0.937	77.1	Arnold (MO)
Margaretta (MO)	295100086	90	72	91	76	91	84	79	86	83.0	87.7	0.955	79.3	83.4	0.955	79.3	Margaretta (MO)
Maryland Heights (MO)	291890014			88	84	94	88	86	88	87.3		0.955	83.4		0.954	83.3	Maryland Heights (MO)

Key Sites		4th High 8-hour Value					Des. Values (truncated)			2005 BY	2002 BY	2012 - OTB			2018 - OTB		
		'03	'04	'05	'06	'07	'03-'05	'04-'06	'05-'07	Average	Average	RRF	Round 5	Round 4	RRF	Round 5	
Lake Michigan Area																	Lake Michigan Area
Chiwaukee	550590019	88	78	93	79	85	86	83	85	84.7	98.3	0.956	80.9	90.3	0.900	76.2	Chiwaukee
Racine	551010017	82	69	95	71	77	82	78	81	80.3	91.7	0.947	76.1	82.9	0.886	71.2	Racine
Milwaukee-Bayside	550190085	92	73	93	73	83	86	79	83	82.7	91.0	0.944	78.0	82.3	0.880	72.7	Milwaukee-Bayside
Harrington Beach	550890009	99	72	94	72	84	88	79	83	83.3	93.0	0.939	78.3	82.9	0.870	72.5	Harrington Beach
Manitowoc	550710007	92	74	95	78	85	87	82	86	85.0	87.0	0.925	78.6	76.3	0.853	72.5	Manitowoc
Sheboygan	551170006	93	78	97	83	88	89	86	89	88.0	97.0	0.930	81.8	86.4	0.857	75.4	Sheboygan
Kewaunee	550610002	97	73	88	76	85	86	79	83	82.7	89.3	0.918	75.9	79.1	0.845	69.9	Kewaunee
Door County	550290004	93	78	101	79	92	90	86	90	88.7	91.0	0.919	81.5	79.3	0.843	74.7	Door County
Hammond	180892008	81	67	87	75	77	78	76	79	77.7	88.3	0.960	74.6	86.3	0.922	71.6	Hammond
Whiting	180890030		64	88	81	88	76	77	85	79.3		0.960	76.2		0.922	73.1	Whiting
Michigan City	180910005	82	70	84	75	73	78	76	77	77.0	90.3	0.942	72.5	85.4	0.884	68.1	Michigan City
Ogden Dunes	181270020	77	69	90	70	84	78	76	81	78.3	86.3	0.951	74.5	82.0	0.904	70.8	Ogden Dunes
Holland	260050003	96	79	94	91	94	89	88	93	90.0	94.0	0.920	82.8	81.0	0.846	76.1	Holland
Jenison	261390005	91	69	86	83	88	82	79	85	82.0	86.0	0.909	74.5	75.5	0.838	68.7	Jenison
Muskegon	261210039	94	70	90	90	86	84	83	88	85.0	90.0	0.918	78.0	79.4	0.846	71.9	Muskegon
Indianapolis Area																	Indianapolis Area
Noblesville	189571001	101	75	87	77	84	87	79	82	82.7	93.7	0.914	75.6	82.0	0.831	68.7	Noblesville
Fortville	180590003	92	72	80	75	81	81	75	78	78.0	91.3	0.916	71.4	82.1	0.835	65.1	Fortville
Fort B. Harrison	180970050	91	73	80	76	83	81	76	79	78.7	90.0	0.931	73.2	82.4	0.879	69.1	Fort B. Harrison
Detroit Area																	Detroit Area
New Haven	260990009	102	81	88	78	93	90	82	86	86.0	92.3	0.932	80.2	83.5	0.885	76.1	New Haven
Warren	260991003	101	71	89	78	91	87	79	86	84.0	90.0	0.961	80.7	81.9	0.924	77.6	Warren
Port Huron	261470005	87	74	88	78	89	83	80	85	82.7	88.0	0.913	75.5	77.0	0.858	70.9	Port Huron
Cleveland Area																	Cleveland Area
Ashtabula	390071001	99	81	93	86	92	91	86	90	89.0	95.7	0.910	81.0	80.2	0.844	75.1	Ashtabula
Geauga	390550004	97	75	88	70	68	86	77	75	79.3	99.0	0.916	72.7	86.2	0.848	67.3	Geauga
Eastlake	390850003	92	79	97	83	74	89	86	84	86.3	92.7	0.932	80.5	80.6	0.883	76.2	Eastlake
Akron	391530020	89	77	89	77	91	85	81	85	83.7	93.3	0.903	75.6	78.5	0.821	68.7	Akron
Cincinnati Area																	Cincinnati Area
Wilmington	390271002	96	78	83	81	82	85	80	82	82.3	94.3	0.910	74.9	81.1	0.830	68.3	Wilmington
Sycamore	390610006	93	76	89	81	90	86	82	86	84.7	90.3	0.948	80.3	82.9	0.881	74.6	Sycamore
Lebanon	391650007	95	81	92	86	88	89	86	88	87.7	87.0	0.921	80.7	77.0	0.846	74.2	Lebanon
Columbus Area																	Columbus Area
London	390970007	90	75	81	76	83	82	77	80	79.7	88.7	0.911	72.6	76.5	0.832	66.3	London
New Albany	390490029	94	78	92	82	87	88	84	87	86.3	93.0	0.922	79.6	80.2	0.845	73.0	New Albany
Franklin	290490028	84	73	86	79	79	81	79	81	80.3	86.0	0.923	74.1	74.7	0.859	69.0	Franklin
St. Louis Area																	St. Louis Area
W. Alton (MO)	291831002	91	77	89	91	89	85	85	89	86.3	90.0	0.911	78.6	84.0	0.868	74.9	W. Alton (MO)
Orchard (MO)	291831004	90	76	92	92	83	86	86	89	87.0	90.0	0.919	80.0	80.4	0.876	76.2	Orchard (MO)
Sunset Hills (MO)	291890004	88	70	89	80	89	82	79	86	82.3	88.3	0.937	77.1	80.6	0.897	73.9	Sunset Hills (MO)
Arnold (MO)	290990012	82	70	92	79	87	81	80	86	82.3	84.7	0.918	75.6	75.8	0.874	72.0	Arnold (MO)
Margaretta (MO)	295100086	90	72	91	76	91	84	79	86	83.0	87.7	0.939	77.9	82.5	0.896	74.4	Margaretta (MO)
Maryland Heights (MO)	291890014			88	84	94	88	86	88	87.3		0.936	81.7		0.894	78.1	Maryland Heights (MO)

Key Site	County	Site ID	Annual Average Conc.					Design Values			2005 BY	2002 BY	2009 Modeling Results		Key Site
			'03	'04	'05	'06	'07	'03 - '05	'04 - '06	'05 - '07	Average w/ 2007	Average	Round 5	Round4	
Chicago - Washington HS	Cook	170310022	15.6	14.2	16.9	13.2	15.7	15.6	14.8	15.3	15.2	15.9	14.1	14.8	Chicago - Washington HS
Chicago - Mayfair	Cook	170310052	15.9	15.3	17.0	14.5	15.5	16.1	15.6	15.7	15.8	17.1	14.4	15.8	Chicago - Mayfair
Chicago - Springfield	Cook	170310057	15.6	13.8	16.7	13.5	15.1	15.4	14.7	15.1	15.0	15.6	13.9	14.5	Chicago - Springfield
Chicago - Lawndale	Cook	170310076	14.8	14.2	16.6	13.5	14.3	15.2	14.8	14.8	14.9	15.6	13.8	14.5	Chicago - Lawndale
Blue Island	Cook	170312001	14.9	14.1	16.4	13.2	14.3	15.1	14.6	14.6	14.8	15.6	13.7	14.5	Blue Island
Summit	Cook	170313301	15.6	14.2	16.9	13.8	14.8	15.6	15.0	15.2	15.2	16.0	14.2	14.8	Summit
Cicero	Cook	170316005	16.8	15.2	16.3	14.3	14.8	16.1	15.3	15.1	15.5	16.4	14.4	15.3	Cicero
Granite City	Madison	171191007	17.5	15.4	18.2	16.3	15.1	17.0	16.6	16.5	16.7	17.3	15.1	16.0	Granite City
E. St. Louis	St. Clair	171630010	14.9	14.7	17.1	14.5	15.6	15.6	15.4	15.7	15.6	16.2	14.1	14.9	E. St. Louis
Jeffersonville	Clark	180190005	15.8	15.1	18.5	15.0	16.5	16.5	16.2	16.7	16.4	17.2	13.8	15.5	Jeffersonville
Jasper	Dubois	180372001	15.7	14.4	16.9	13.5	14.4	15.7	14.9	14.9	15.2	15.5	12.4	13.8	Jasper
Gary	Lake	180890031			16.8	13.3	14.5	16.8	15.1	14.9	15.6		13.0		Gary
Indy-Washington Park	Marion	180970078	15.5	14.3	16.4	14.1	15.8	15.4	14.9	15.4	15.3	16.2	12.8	14.5	Indy-Washington Park
Indy-W 18th Street	Marion	180970081	16.2	15.0	17.9	14.2	16.1	16.4	15.7	16.1	16.0		13.4		Indy-W 18th Street
Indy- Michigan Street	Marion	180970083	16.3	15.0	17.5	14.1	15.9	16.3	15.5	15.8	15.9	16.6	13.4	14.8	Indy- Michigan Street
Allen Park	Wayne	261630001	15.2	14.2	15.9	13.2	12.8	15.1	14.4	14.0	14.5	15.8	13.0	14.5	Allen Park
Southwest HS	Wayne	261630015	16.6	15.4	17.2	14.7	14.5	16.4	15.8	15.5	15.9	17.3	14.2	15.8	Southwest HS
Linwood	Wayne	261630016	15.8	13.7	16.0	13.0	13.9	15.2	14.2	14.3	14.6	15.5	13.1	14.1	Linwood
Dearborn	Wayne	261630033	19.2	16.8	18.6	16.1	16.9	18.2	17.2	17.2	17.5	19.3	15.8	17.7	Dearborn
Wyandotte	Wayne	261630036	16.3	13.7	16.4	12.9	13.4	15.5	14.3	14.2	14.7	16.6	13.1	15.1	Wyandotte
Middleton	Butler	390170003	17.2	14.1	19.0	14.1	15.4	16.8	15.7	16.2	16.2	16.5	13.5	14.2	Middleton
Fairfield	Butler	390170016	15.8	14.7	17.9	14.0	14.9	16.1	15.5	15.6	15.8	15.9	13.1	13.5	Fairfield
Cleveland-28th Street	Cuyahoga	390350027	15.4	15.6	17.3	13.0	14.5	16.1	15.3	14.9	15.4	16.5	13.5	14.4	Cleveland-28th Street
Cleveland-St. Tikhon	Cuyahoga	390350038	17.6	17.5	19.2	14.9	16.2	18.1	17.2	16.8	17.4	18.4	15.2	16.1	Cleveland-St. Tikhon
Cleveland-Broadway	Cuyahoga	390350045	16.4	15.3	19.3	14.1	15.3	17.0	16.2	16.2	16.5	16.7	14.4	14.6	Cleveland-Broadway
Cleveland-E14 & Orange	Cuyahoga	390350060	17.2	16.4	19.4	15.0	15.9	17.7	16.9	16.8	17.1	17.6	15.0	15.3	Cleveland-E14 & Orange
Newburg Hts - Harvard Ave	Cuyahoga	390350065	15.6	15.2	18.6	13.1	15.8	16.5	15.6	15.8	16.0	16.2	14.0	14.1	Newburg Hts - Harvard Ave
Columbus - Fairgrounds	Franklin	390490024	16.4	15.0	16.4	13.6	14.6	15.9	15.0	14.9	15.3	16.5	12.9	14.6	Columbus - Fairgrounds
Columbus - Ann Street	Franklin	390490025	15.3	14.6	16.5	13.8	14.7	15.5	15.0	15.0	15.1	16.0	12.7	14.1	Columbus - Ann Street
Columbus - Maple Canyon	Franklin	390490081	14.9	13.6	14.6	12.9	13.1	14.4	13.7	13.5	13.9	16.0	11.7	14.0	Columbus - Maple Canyon
Cincinnati - Seymour	Hamilton	390610014	17.0	15.9	19.8	15.5	16.5	17.6	17.1	17.3	17.3	17.7	14.5	15.5	Cincinnati - Seymour
Cincinnati - Taft Ave	Hamilton	390610040	15.5	14.6	17.5	13.6	15.1	15.9	15.2	15.4	15.5	15.7	12.8	13.6	Cincinnati - Taft Ave
Cincinnati - 8th Ave	Hamilton	390610042	16.7	16.0	19.1	14.9	15.9	17.3	16.7	16.6	16.9	17.3	14.0	14.6	Cincinnati - 8th Ave
Sharonville	Hamilton	390610043	15.7	14.9	16.9	14.5	14.8	15.8	15.4	15.4	15.6	16.0	12.9	13.6	Sharonville
Norwood	Hamilton	390617001	16.0	15.3	18.4	14.4	15.1	16.6	16.0	16.0	16.2	16.3	13.4	14.2	Norwood
St. Bernard	Hamilton	390618001	17.3	16.4	20.0	15.9	16.1	17.9	17.4	17.3	17.6	17.3	14.7	15.2	St. Bernard
Steubenville	Jefferson	390810016	17.7	15.9	16.4	13.8	16.2	16.7	15.4	15.5	15.8	17.7	12.8	16.3	Steubenville
Mingo Junction	Jefferson	390811001	17.3	16.2	18.1	14.6	15.6	17.2	16.3	16.1	16.5	17.5	13.5	15.5	Mingo Junction
Ironton	Lawrence	390870010	14.3	13.7	17.0	14.4	15.0	15.0	15.0	15.5	15.2	15.7	12.8	14.2	Ironton
Dayton	Montgomery	391130032	15.9	14.5	17.4	13.6	15.6	15.9	15.2	15.5	15.5	15.9	13.2	13.7	Dayton
New Boston	Scioto	391450013	14.7	13.0	16.2	14.3	14.0	14.6	14.5	14.8	14.7	17.1	12.1	15.4	New Boston
Canton - Dueber	Stark	391510017	16.8	15.6	17.8	14.6	15.9	16.7	16.0	16.1	16.3	17.3	14.0	15.0	Canton - Dueber
Canton - Market	Stark	391510020	15.0	14.1	16.6	11.9	14.4	15.2	14.2	14.3	14.6	15.7	12.6	13.6	Canton - Market
Akron - Brittain	Summit	391530017	15.4	15.0	16.4	13.5	14.4	15.6	15.0	14.8	15.1	16.4	13.0	14.4	Akron - Brittain
Akron - W. Exchange	Summit	391530023	14.2	13.9	15.7	12.8	13.7	14.6	14.1	14.1	14.3	15.6	12.3	13.6	Akron - W. Exchange

Key Site	County	Site ID	Annual Average Conc.					Design Values			2005 BY	2002 BY	2012 Modeling Results		Key Site
			'03	'04	'05	'06	'07	'03 - '05	'04 - '06	'05 - '07	Average w/ 2007	Average	Round 5	Round4	
Chicago - Washington HS	Cook	170310022	15.6	14.2	16.9	13.2	15.7	15.6	14.8	15.3	15.2	15.9	14.0	14.6	Chicago - Washington HS
Chicago - Mayfair	Cook	170310052	15.9	15.3	17.0	14.5	15.5	16.1	15.6	15.7	15.8	17.1	14.2	15.5	Chicago - Mayfair
Chicago - Springfield	Cook	170310057	15.6	13.8	16.7	13.5	15.1	15.4	14.7	15.1	15.0	15.6	13.8	14.3	Chicago - Springfield
Chicago - Lawndale	Cook	170310076	14.8	14.2	16.6	13.5	14.3	15.2	14.8	14.8	14.9	15.6	13.7	14.3	Chicago - Lawndale
Blue Island	Cook	170312001	14.9	14.1	16.4	13.2	14.3	15.1	14.6	14.6	14.8	15.6	13.6	14.3	Blue Island
Summit	Cook	170313301	15.6	14.2	16.9	13.8	14.8	15.6	15.0	15.2	15.2	16.0	14.0	14.6	Summit
Cicero	Cook	170316005	16.8	15.2	16.3	14.3	14.8	16.1	15.3	15.1	15.5	16.4	14.3	15.1	Cicero
Granite City	Madison	171191007	17.5	15.4	18.2	16.3	15.1	17.0	16.6	16.5	16.7	17.3	14.9	15.8	Granite City
E. St. Louis	St. Clair	171630010	14.9	14.7	17.1	14.5	15.6	15.6	15.4	15.7	15.6	16.2	13.9	14.7	E. St. Louis
Jeffersonville	Clark	180190005	15.8	15.1	18.5	15.0	16.5	16.5	16.2	16.7	16.4	17.2	13.7	15.0	Jeffersonville
Jasper	Dubois	180372001	15.7	14.4	16.9	13.5	14.4	15.7	14.9	14.9	15.2	15.5	12.2	13.5	Jasper
Gary	Lake	180890031			16.8	13.3	14.5	16.8	15.1	14.9	15.6		12.8		Gary
Indy-Washington Park	Marion	180970078	15.5	14.3	16.4	14.1	15.8	15.4	14.9	15.4	15.3	16.2	12.6	14.2	Indy-Washington Park
Indy-W 18th Street	Marion	180970081	16.2	15.0	17.9	14.2	16.1	16.4	15.7	16.1	16.0		13.2		Indy-W 18th Street
Indy- Michigan Street	Marion	180970083	16.3	15.0	17.5	14.1	15.9	16.3	15.5	15.8	15.9	16.6	13.1	14.9	Indy- Michigan Street
Allen Park	Wayne	261630001	15.2	14.2	15.9	13.2	12.8	15.1	14.4	14.0	14.5	15.8	12.8	14.1	Allen Park
Southwest HS	Wayne	261630015	16.6	15.4	17.2	14.7	14.5	16.4	15.8	15.5	15.9	17.3	13.9	15.3	Southwest HS
Linwood	Wayne	261630016	15.8	13.7	16.0	13.0	13.9	15.2	14.2	14.3	14.6	15.5	12.8	13.7	Linwood
Dearborn	Wayne	261630033	19.2	16.8	18.6	16.1	16.9	18.2	17.2	17.2	17.5	19.3	15.5	17.1	Dearborn
Wyandotte	Wayne	261630036	16.3	13.7	16.4	12.9	13.4	15.5	14.3	14.2	14.7	16.6	12.8	14.7	Wyandotte
Middleton	Butler	390170003	17.2	14.1	19.0	14.1	15.4	16.8	15.7	16.2	16.2	16.5	13.2	13.7	Middleton
Fairfield	Butler	390170016	15.8	14.7	17.9	14.0	14.9	16.1	15.5	15.6	15.8	15.9	12.9	12.9	Fairfield
Cleveland-28th Street	Cuyahoga	390350027	15.4	15.6	17.3	13.0	14.5	16.1	15.3	14.9	15.4	16.5	13.2	13.8	Cleveland-28th Street
Cleveland-St. Tikhon	Cuyahoga	390350038	17.6	17.5	19.2	14.9	16.2	18.1	17.2	16.8	17.4	18.4	14.8	15.4	Cleveland-St. Tikhon
Cleveland-Broadway	Cuyahoga	390350045	16.4	15.3	19.3	14.1	15.3	17.0	16.2	16.2	16.5	16.7	14.0	14.0	Cleveland-Broadway
Cleveland-E14 & Orange	Cuyahoga	390350060	17.2	16.4	19.4	15.0	15.9	17.7	16.9	16.8	17.1	17.6	14.6	14.7	Cleveland-E14 & Orange
Newburg Hts - Harvard Ave	Cuyahoga	390350065	15.6	15.2	18.6	13.1	15.8	16.5	15.6	15.8	16.0	16.2	13.6	13.5	Newburg Hts - Harvard Ave
Columbus - Fairgrounds	Franklin	390490024	16.4	15.0	16.4	13.6	14.6	15.9	15.0	14.9	15.3	16.5	12.6	14.0	Columbus - Fairgrounds
Columbus - Ann Street	Franklin	390490025	15.3	14.6	16.5	13.8	14.7	15.5	15.0	15.0	15.1	16.0	12.4	13.5	Columbus - Ann Street
Columbus - Maple Canyon	Franklin	390490081	14.9	13.6	14.6	12.9	13.1	14.4	13.7	13.5	13.9	16.0	11.4	13.4	Columbus - Maple Canyon
Cincinnati - Seymour	Hamilton	390610014	17.0	15.9	19.8	15.5	16.5	17.6	17.1	17.3	17.3	17.7	14.3	14.8	Cincinnati - Seymour
Cincinnati - Taft Ave	Hamilton	390610040	15.5	14.6	17.5	13.6	15.1	15.9	15.2	15.4	15.5	15.7	12.6	13.0	Cincinnati - Taft Ave
Cincinnati - 8th Ave	Hamilton	390610042	16.7	16.0	19.1	14.9	15.9	17.3	16.7	16.6	16.9	17.3	13.8	14.0	Cincinnati - 8th Ave
Sharonville	Hamilton	390610043	15.7	14.9	16.9	14.5	14.8	15.8	15.4	15.4	15.6	16.0	12.7	13.0	Sharonville
Norwood	Hamilton	390617001	16.0	15.3	18.4	14.4	15.1	16.6	16.0	16.0	16.2	16.3	13.2	13.6	Norwood
St. Bernard	Hamilton	390618001	17.3	16.4	20.0	15.9	16.1	17.9	17.4	17.3	17.6	17.3	14.4	14.6	St. Bernard
Steubenville	Jefferson	390810016	17.7	15.9	16.4	13.8	16.2	16.7	15.4	15.5	15.8	17.7	12.5	15.9	Steubenville
Mingo Junction	Jefferson	390811001	17.3	16.2	18.1	14.6	15.6	17.2	16.3	16.1	16.5	17.5	13.2	15.0	Mingo Junction
Ironton	Lawrence	390870010	14.3	13.7	17.0	14.4	15.0	15.0	15.0	15.5	15.2	15.7	12.5	13.7	Ironton
Dayton	Montgomery	391130032	15.9	14.5	17.4	13.6	15.6	15.9	15.2	15.5	15.5	15.9	12.9	13.2	Dayton
New Boston	Scioto	391450013	14.7	13.0	16.2	14.3	14.0	14.6	14.5	14.8	14.7	17.1	11.9	14.8	New Boston
Canton - Dueber	Stark	391510017	16.8	15.6	17.8	14.6	15.9	16.7	16.0	16.1	16.3	17.3	13.6	14.3	Canton - Dueber
Canton - Market	Stark	391510020	15.0	14.1	16.6	11.9	14.4	15.2	14.2	14.3	14.6	15.7	12.3	13.0	Canton - Market
Akron - Brittain	Summit	391530017	15.4	15.0	16.4	13.5	14.4	15.6	15.0	14.8	15.1	16.4	12.7	13.6	Akron - Brittain
Akron - W. Exchange	Summit	391530023	14.2	13.9	15.7	12.8	13.7	14.6	14.1	14.1	14.3	15.6	12.0	13.0	Akron - W. Exchange

Key Site	County	Site ID	Annual Average Conc.					Design Values			2005 BY	2002 BY	2018 Modeling Results			Key Site
			'03	'04	'05	'06	'07	'03 - '05	'04 - '06	'05 - '07	Average w/ 2007	Average	Round 5 OTB	Round 5 Will Do	Round4	
Chicago - Washington HS	Cook	170310022	15.6	14.2	16.9	13.2	15.7	15.6	14.8	15.3	15.2	15.9	13.9	13.8	14.4	Chicago - Washington HS
Chicago - Mayfair	Cook	170310052	15.9	15.3	17.0	14.5	15.5	16.1	15.6	15.7	15.8	17.1	13.9	13.8	15.0	Chicago - Mayfair
Chicago - Springfield	Cook	170310057	15.6	13.8	16.7	13.5	15.1	15.4	14.7	15.1	15.0	15.6	13.7	13.5	14.1	Chicago - Springfield
Chicago - Lawndale	Cook	170310076	14.8	14.2	16.6	13.5	14.3	15.2	14.8	14.8	14.9	15.6	13.6	13.4	14.1	Chicago - Lawndale
Blue Island	Cook	170312001	14.9	14.1	16.4	13.2	14.3	15.1	14.6	14.6	14.8	15.6	13.4	13.3	14.1	Blue Island
Summit	Cook	170313301	15.6	14.2	16.9	13.8	14.8	15.6	15.0	15.2	15.2	16.0	13.9	13.8	14.4	Summit
Cicero	Cook	170316005	16.8	15.2	16.3	14.3	14.8	16.1	15.3	15.1	15.5	16.4	14.2	14.0	14.9	Cicero
Granite City	Madison	171191007	17.5	15.4	18.2	16.3	15.1	17.0	16.6	16.5	16.7	17.3	14.3	14.2	15.5	Granite City
E. St. Louis	St. Clair	171630010	14.9	14.7	17.1	14.5	15.6	15.6	15.4	15.7	15.6	16.2	13.4	13.3	14.5	E. St. Louis
Jeffersonville	Clark	180190005	15.8	15.1	18.5	15.0	16.5	16.5	16.2	16.7	16.4	17.2	13.4	13.4	14.4	Jeffersonville
Jasper	Dubois	180372001	15.7	14.4	16.9	13.5	14.4	15.7	14.9	14.9	15.2	15.5	11.8	11.9	13.0	Jasper
Gary	Lake	180890031			16.8	13.3	14.5	16.8	15.1	14.9	15.6		12.4	12.4		Gary
Indy-Washington Park	Marion	180970078	15.5	14.3	16.4	14.1	15.8	15.4	14.9	15.4	15.3	16.2	12.0	12.1	13.7	Indy-Washington Park
Indy-W 18th Street	Marion	180970081	16.2	15.0	17.9	14.2	16.1	16.4	15.7	16.1	16.0		12.6	12.7		Indy-W 18th Street
Indy- Michigan Street	Marion	180970083	16.3	15.0	17.5	14.1	15.9	16.3	15.5	15.8	15.9	16.6	12.6	12.6	14.0	Indy- Michigan Street
Allen Park	Wayne	261630001	15.2	14.2	15.9	13.2	12.8	15.1	14.4	14.0	14.5	15.8	12.4	12.4	13.3	Allen Park
Southwest HS	Wayne	261630015	16.6	15.4	17.2	14.7	14.5	16.4	15.8	15.5	15.9	17.3	13.5	13.5	14.4	Southwest HS
Linwood	Wayne	261630016	15.8	13.7	16.0	13.0	13.9	15.2	14.2	14.3	14.6	15.5	12.5	12.5	13.0	Linwood
Dearborn	Wayne	261630033	19.2	16.8	18.6	16.1	16.9	18.2	17.2	17.2	17.5	19.3	15.1	15.1	16.1	Dearborn
Wyandotte	Wayne	261630036	16.3	13.7	16.4	12.9	13.4	15.5	14.3	14.2	14.7	16.6	12.5	12.5	13.9	Wyandotte
Middleton	Butler	390170003	17.2	14.1	19.0	14.1	15.4	16.8	15.7	16.2	16.2	16.5	12.8	12.8	13.1	Middleton
Fairfield	Butler	390170016	15.8	14.7	17.9	14.0	14.9	16.1	15.5	15.6	15.8	15.9	12.5	12.6	12.2	Fairfield
Cleveland-28th Street	Cuyahoga	390350027	15.4	15.6	17.3	13.0	14.5	16.1	15.3	14.9	15.4	16.5	12.7	12.9	12.9	Cleveland-28th Street
Cleveland-St. Tikhon	Cuyahoga	390350038	17.6	17.5	19.2	14.9	16.2	18.1	17.2	16.8	17.4	18.4	14.3	14.5	14.4	Cleveland-St. Tikhon
Cleveland-Broadway	Cuyahoga	390350045	16.4	15.3	19.3	14.1	15.3	17.0	16.2	16.2	16.5	16.7	13.5	13.7	13.1	Cleveland-Broadway
Cleveland-E14 & Orange	Cuyahoga	390350060	17.2	16.4	19.4	15.0	15.9	17.7	16.9	16.8	17.1	17.6	14.1	14.2	13.7	Cleveland-E14 & Orange
Newburg Hts - Harvard Ave	Cuyahoga	390350065	15.6	15.2	18.6	13.1	15.8	16.5	15.6	15.8	16.0	16.2	13.1	13.3	12.6	Newburg Hts - Harvard Ave
Columbus - Fairgrounds	Franklin	390490024	16.4	15.0	16.4	13.6	14.6	15.9	15.0	14.9	15.3	16.5	12.0	12.1	13.0	Columbus - Fairgrounds
Columbus - Ann Street	Franklin	390490025	15.3	14.6	16.5	13.8	14.7	15.5	15.0	15.0	15.1	16.0	11.9	11.9	12.5	Columbus - Ann Street
Columbus - Maple Canyon	Franklin	390490081	14.9	13.6	14.6	12.9	13.1	14.4	13.7	13.5	13.9	16.0	10.9	11.0	12.5	Columbus - Maple Canyon
Cincinnati - Seymour	Hamilton	390610014	17.0	15.9	19.8	15.5	16.5	17.6	17.1	17.3	17.3	17.7	13.8	13.9	14.0	Cincinnati - Seymour
Cincinnati - Taft Ave	Hamilton	390610040	15.5	14.6	17.5	13.6	15.1	15.9	15.2	15.4	15.5	15.7	12.2	12.3	12.3	Cincinnati - Taft Ave
Cincinnati - 8th Ave	Hamilton	390610042	16.7	16.0	19.1	14.9	15.9	17.3	16.7	16.6	16.9	17.3	13.4	13.4	13.2	Cincinnati - 8th Ave
Sharonville	Hamilton	390610043	15.7	14.9	16.9	14.5	14.8	15.8	15.4	15.4	15.6	16.0	12.3	12.4	12.2	Sharonville
Norwood	Hamilton	390617001	16.0	15.3	18.4	14.4	15.1	16.6	16.0	16.0	16.2	16.3	12.8	12.8	12.8	Norwood
St. Bernard	Hamilton	390618001	17.3	16.4	20.0	15.9	16.1	17.9	17.4	17.3	17.6	17.3	14.0	14.1	13.8	St. Bernard
Steubenville	Jefferson	390810016	17.7	15.9	16.4	13.8	16.2	16.7	15.4	15.5	15.8	17.7	12.7	12.7	16.2	Steubenville
Mingo Junction	Jefferson	390811001	17.3	16.2	18.1	14.6	15.6	17.2	16.3	16.1	16.5	17.5	13.4	13.4	15.3	Mingo Junction
Ironton	Lawrence	390870010	14.3	13.7	17.0	14.4	15.0	15.0	15.0	15.5	15.2	15.7	12.3	12.3	13.2	Ironton
Dayton	Montgomery	391130032	15.9	14.5	17.4	13.6	15.6	15.9	15.2	15.5	15.5	15.9	12.4	12.5	12.3	Dayton
New Boston	Scioto	391450013	14.7	13.0	16.2	14.3	14.0	14.6	14.5	14.8	14.7	17.1	11.6	11.6	14.2	New Boston
Canton - Dueber	Stark	391510017	16.8	15.6	17.8	14.6	15.9	16.7	16.0	16.1	16.3	17.3	13.3	13.3	13.6	Canton - Dueber
Canton - Market	Stark	391510020	15.0	14.1	16.6	11.9	14.4	15.2	14.2	14.3	14.6	15.7	11.9	12.0	12.2	Canton - Market
Akron - Brittain	Summit	391530017	15.4	15.0	16.4	13.5	14.4	15.6	15.0	14.8	15.1	16.4	12.3	12.3	12.9	Akron - Brittain
Akron - W. Exchange	Summit	391530023	14.2	13.9	15.7	12.8	13.7	14.6	14.1	14.1	14.3	15.6	11.5	11.6	12.2	Akron - W. Exchange

24-Hour PM _{2.5}			98th Percentile (24-hour)					Design Values			Base Year	Round 5 Modeling Results			Key Site
Key Site	County	Site ID	'03	'04	'05	'06	'07	'03-'05	'04-'06	'05-'07	Average w/ 2007	2009	2012	2018	Key Site
Chicago - Washington HS	Cook	170310022	37.7	32.5	45.7	27.0	35.7	38.6	35.1	36.1	36.6	36	36	35	Chicago - Washington HS
Chicago - Mayfair	Cook	170310052	37.3	38.8	48.3	31.6	39.4	41.5	39.6	39.8	40.3	36	36	36	Chicago - Mayfair
Chicago - Springfield	Cook	170310057	36.4	33.1	46.5	27.7	38.9	38.7	35.8	37.7	37.4	32	32	31	Chicago - Springfield
Chicago - Lawndale	Cook	170310076	32.6	39.7	45.1	29.0	37.2	39.1	37.9	37.1	38.1	35	35	34	Chicago - Lawndale
McCook	Cook	170311016									43.0	39	39	38	McCook
Blue Island	Cook	170312001	39.6	38.5	43.8	28.1	35.1	40.6	36.8	35.7	37.7	34	34	33	Blue Island
Schiller Park	Cook	170313103		40.7	50.3	30.0	36.6	45.5	40.3	39.0	41.6	39	39	39	Schiller Park
Summit	Cook	170313301	38.4	42.4	49.1	27.4	36.7	43.3	39.6	37.7	40.2	38	38	37	Summit
Maywood	Cook	170316005	38.5	42.5	44.6	29.2	36.9	41.9	38.8	36.9	39.2	38	38	37	Maywood
Granite City	Madison	171191007	40.8	35.4	44.1	36.3	36.0	40.1	38.6	38.8	39.2	33	33	32	Granite City
E. St. Louis	St. Clair	171630010	32.6	30.2	39.6	29.2	33.1	34.1	33.0	34.0	33.7	28	28	28	E. St. Louis
Jeffersonville	Clark	180190005		28.4	45.5	35.9	43.3	37.0	36.6	41.6	38.4	29	31	31	Jeffersonville
Jasper	Dubois	180372001	39.5	30.0	41.2	31.6	39.5	36.9	34.3	37.4	36.2	28	29	28	Jasper
Gary - IITRI	Lake	180890022									39.0	34	34	35	Gary - IITRI
Gary - Burr School	Lake	180890026									39.0	33	34	32	Gary - Burr School
Gary	Lake	180890031			38.7	27.1	36.2	38.7	32.9	34.0	35.2	24	24	27	Gary
Indy-West Street	Marion	180970043									38.0	33	33	33	Indy-West Street
Indy-English Avenue	Marion	180970066									38.0	32	32	32	Indy-English Avenue
Indy-Washington Park	Marion	180970078	39.3	31.0	42.5	31.7	37.6	37.6	35.1	37.3	36.6	31	31	32	Indy-Washington Park
Indy-W 18th Street	Marion	180970081	36.2	31.9	45.7	34.8	38.4	37.9	37.5	39.6	38.3	31	31	31	Indy-W 18th Street
Indy- Michigan Street	Marion	180970083	36.7	31.3	40.3	33.5	37.2	36.1	35.0	37.0	36.0	28	28	29	Indy- Michigan Street
Luna Pier	Monroe	261150005	34.7	35.0	49.3	32.6	32.2	39.7	39.0	38.0	38.9	32	32	31	Luna Pier
Oak Park	Oakland	261250001	36.6	32.5	52.2	33.0	35.3	40.4	39.2	40.2	39.9	36	36	35	Oak Park
Port Huron	St. Clair	261470005	37.2	32.2	47.6	37.9	36.3	39.0	39.2	40.6	39.6	34	34	33	Port Huron
Ypsilanti	Washtenaw	261610008	38.8	31.5	52.1	31.3	34.5	40.8	38.3	39.3	39.5	35	35	34	Ypsilanti
Allen Park	Wayne	261630001	40.5	36.9	43.0	34.1	35.9	40.1	38.0	37.7	38.6	35	34	33	Allen Park
Southwest HS	Wayne	261630015	33.6	36.0	49.7	36.2	34.0	39.8	40.6	40.0	40.1	35	35	33	Southwest HS
Linwood	Wayne	261630016	46.2	38.3	51.8	36.9	34.8	45.4	42.3	41.2	43.0	39	39	38	Linwood
E 7 Mile	Wayne	261630019	37.1	35.0	52.3	36.2	33.0	41.5	41.2	40.5	41.0	38	38	37	E 7 Mile
Dearborn	Wayne	261630033	42.8	39.4	50.2	43.1	36.6	44.1	44.2	43.3	43.9	40	40	39	Dearborn
Wyandotte	Wayne	261630036	34.8	32.3	46.7	33.2	28.6	37.9	37.4	36.2	37.2	35	35	34	Wyandotte
Newberry	Wayne	261630038		36.8	57.5	28.6	33.4		39.1	39.8	42.7	38	37	36	Newberry
FIA	Wayne	261630039			43.9	32.4	34.8			37.0	39.7	33	33	31	FIA
Middleton	Butler	390170003	38.6	37.2	47.6	30.2	37.1	41.1	38.3	38.3	39.3	28	28	27	Middleton
Fairfield	Butler	390170016	34.8	32.2	43.4	35.2	34.5	36.8	36.9	37.7	37.1	27	28	27	Fairfield
	Butler	390170017	34.6	34.3	44.9			37.9	39.6		40.8	29	29	28	
Cleveland-28th Street	Cuyahoga	390350027	41.3	40.9	35.7	31.5	39.0	39.3	36.0	35.4	36.9	32	32	31	Cleveland-28th Street
Cleveland-St. Tikhon	Cuyahoga	390350038	47.3	42.5	51.2	36.1	39.7	44.9	47.0	42.3	44.2	36	35	34	Cleveland-St. Tikhon
Cleveland-Broadway	Cuyahoga	390350045	42.2	36.1	46.2	29.5	37.0	41.5	37.3	37.6	38.8	31	30	29	Cleveland-Broadway
Cleveland-GT Craig	Cuyahoga	390350060	45.5	42.2	49.5	31.0	38.7	45.7	40.9	39.7	42.1	37	37	35	Cleveland-GT Craig
Newburg Hts - Harvard Ave	Cuyahoga	390350065	39.1	36.1	47.9	27.8	39.1	41.0	37.3	38.3	38.9	31	30	30	Newburg Hts - Harvard Ave
Columbus - Fairgrounds	Franklin	390490024	39.2	35.1	45.0	34.0	34.2	39.8	38.0	37.7	38.5	33	32	31	Columbus - Fairgrounds
Columbus - Ann Street	Franklin	390490025	37.0	35.5	44.9	34.0	35.5	39.1	38.1	38.1	38.5	31	31	30	Columbus - Ann Street
Cincinnati	Hamilton	390610006			45.0	33.3	34.7			37.7	40.6	27	28	27	Cincinnati
Cincinnati - Seymour	Hamilton	390610014	37.8	42.0	38.5	35.2	38.1	39.4	38.6	37.3	38.4	26	25	24	Cincinnati - Seymour
Cincinnati - Taft Ave	Hamilton	390610040	31.9	30.5	45.8	32.8	34.7	36.1	36.4	37.8	36.7	24	24	23	Cincinnati - Taft Ave
Cincinnati - 8th Ave	Hamilton	390610042	33.8	31.9	44.4	34.5	35.9	36.7	36.9	38.3	37.3	28	28	27	Cincinnati - 8th Ave
Sharonville	Hamilton	390610043	37.3	31.4	39.9	34.9	34.0	36.2	35.4	36.3	36.0	28	28	27	Sharonville
Norwood	Hamilton	390617001	37.1	34.6	47.1	34.0	33.7	39.6	38.6	38.3	38.8	30	30	29	Norwood
St. Bernard	Hamilton	390618001	35.8	33.9	51.4	36.1	35.4	40.4	40.5	41.0	40.6	30	30	29	St. Bernard
Steubenville	Jefferson	390810016	39.6	43.8	43.8	32.1	43.5	42.4	39.9	39.8	40.7	29	28	28	Steubenville
Mingo Junction	Jefferson	390811001	40.9	51.5	44.2	32.9	35.4	45.5	42.9	37.5	42.0	30	30	30	Mingo Junction
Dayton	Montgomery	391130032	42.7	32.5	45.0	30.3	36.9	40.1	35.9	37.4	37.8	30	30	30	Dayton
Canton - Dueber	Stark	391510017	34.2	36.3	47.6	32.2	33.4	39.4	38.7	37.7	38.6	28	28	27	Canton - Dueber
Akron - Brittain	Summit	391530017	36.9	36.9	45.2	31.5	33.3	39.7	37.9	36.7	38.1	30	30	29	Akron - Brittain
Green Bay - Est High	Brown	550090005	33.5	32.3	41.5	36.9	37.1	35.8	36.9	38.5	37.1	35	34	32	Green Bay - Est High
Madison	Dane	550250047	32.0	31.9	40.1	33.4	44.3	34.7	35.1	39.3	36.4	32	31	29	Madison
Milwaukee-Health Center	Milwaukee	550790010	33.2	38.4	38.7	40.7	40.6	36.8	39.3	40.0	38.7	35	34	33	Milwaukee-Health Center
Milwaukee-SER Hdqs	Milwaukee	550790026	29.6	28.7	41.5	42.6	39.8	33.3	37.6	41.3	37.4	34	34	33	Milwaukee-SER Hdqs
Milwaukee-Virginia FS	Milwaukee	550790043	39.2	41.4	37.1	44.0	38	39.2	40.8	39.7	39.9	36	36	36	Milwaukee-Virginia FS
Milwaukee- Fire Dept Hdqs	Milwaukee	550790099	33.7	38.9	37.1	38.3	40.7	36.6	38.1	38.7	37.8	33	32	32	Milwaukee- Fire Dept Hdqs
Waukesha	Waukesha	551330027	29.1	38.4	41.1	28.2	33.8	36.2	35.9	34.4	35.5	31	31	29	Waukesha

PM2.5 RRFs by Species and Season (2009)						
Site ID	State	County	Season	Species	Species Comp. of Ave. FRM (fraction)	Species RRF
1703100521	IL	Cook	winter	so4	0.1772	0.9342
1703100521	IL	Cook	winter	no3	0.3099	1.0128
1703100521	IL	Cook	winter	ocm	0.2147	0.9942
1703100521	IL	Cook	winter	ec	0.0372	0.888
1703100521	IL	Cook	winter	soil	0.0242	1.1674
1703100521	IL	Cook	winter	nh4	0.1421	0.97
1703100521	IL	Cook	winter	pbw	0.0947	0.9678
1703100521	IL	Cook	spring	so4	0.32	0.8018
1703100521	IL	Cook	spring	no3	0.0609	0.9385
1703100521	IL	Cook	spring	ocm	0.2742	1.0629
1703100521	IL	Cook	spring	ec	0.0501	0.8712
1703100521	IL	Cook	spring	soil	0.0505	1.1796
1703100521	IL	Cook	spring	nh4	0.1203	0.8619
1703100521	IL	Cook	spring	pbw	0.0984	0.8492
1703100521	IL	Cook	summer	so4	0.3089	0.725
1703100521	IL	Cook	summer	no3	0	1.0124
1703100521	IL	Cook	summer	ocm	0.1599	1.069
1703100521	IL	Cook	summer	ec	0.0351	0.8683
1703100521	IL	Cook	summer	soil	0.0318	1.204
1703100521	IL	Cook	summer	nh4	0.0932	0.7354
1703100521	IL	Cook	summer	pbw	0.094	0.7217
1703100521	IL	Cook	fall	so4	0.1872	0.9151
1703100521	IL	Cook	fall	no3	0.1628	0.9408
1703100521	IL	Cook	fall	ocm	0.2389	1.0091
1703100521	IL	Cook	fall	ec	0.0403	0.8623
1703100521	IL	Cook	fall	soil	0.0284	1.1443
1703100521	IL	Cook	fall	nh4	0.1062	0.9247
1703100521	IL	Cook	fall	pbw	0.0614	0.9233
1711910071	IL	Madison	winter	so4	0.213	0.9195
1711910071	IL	Madison	winter	no3	0.2705	1.0306
1711910071	IL	Madison	winter	ocm	0.2093	0.9289
1711910071	IL	Madison	winter	ec	0.0434	0.9083
1711910071	IL	Madison	winter	soil	0.0306	1.1782
1711910071	IL	Madison	winter	nh4	0.1528	0.9513
1711910071	IL	Madison	winter	pbw	0.0804	0.9243
1711910071	IL	Madison	spring	so4	0.3194	0.7717
1711910071	IL	Madison	spring	no3	0.0189	0.8611
1711910071	IL	Madison	spring	ocm	0.2455	1.1103
1711910071	IL	Madison	spring	ec	0.0564	1.0046
1711910071	IL	Madison	spring	soil	0.0459	1.2252
1711910071	IL	Madison	spring	nh4	0.1121	0.7894
1711910071	IL	Madison	spring	pbw	0.1085	0.7783
1711910071	IL	Madison	summer	so4	0.313	0.705
1711910071	IL	Madison	summer	no3	0	0.884
1711910071	IL	Madison	summer	ocm	0.153	1.1546
1711910071	IL	Madison	summer	ec	0.0345	1.0513
1711910071	IL	Madison	summer	soil	0.0302	1.2532
1711910071	IL	Madison	summer	nh4	0.102	0.7409
1711910071	IL	Madison	summer	pbw	0.1096	0.7133
1711910071	IL	Madison	fall	so4	0.2058	0.9037
1711910071	IL	Madison	fall	no3	0.1308	0.9426
1711910071	IL	Madison	fall	ocm	0.259	1.0233
1711910071	IL	Madison	fall	ec	0.0563	0.9248
1711910071	IL	Madison	fall	soil	0.0549	1.1412
1711910071	IL	Madison	fall	nh4	0.1073	0.9185
1711910071	IL	Madison	fall	pbw	0.0655	0.918

Site ID	State	County	Season	Species	Species Comp. of Ave. FRM (fraction)	Species RRF
1803720011	IN	Dubois	winter	so4	0.2669	0.8833
1803720011	IN	Dubois	winter	no3	0.2548	0.9526
1803720011	IN	Dubois	winter	ocm	0.1747	0.9374
1803720011	IN	Dubois	winter	ec	0.0313	0.9319
1803720011	IN	Dubois	winter	soil	0.0192	1.1349
1803720011	IN	Dubois	winter	nh4	0.1646	0.9069
1803720011	IN	Dubois	winter	pbw	0.0885	0.9006
1803720011	IN	Dubois	spring	so4	0.4141	0.6808
1803720011	IN	Dubois	spring	no3	0.0022	0.8106
1803720011	IN	Dubois	spring	ocm	0.178	0.9997
1803720011	IN	Dubois	spring	ec	0.0324	0.9083
1803720011	IN	Dubois	spring	soil	0.0218	1.1284
1803720011	IN	Dubois	spring	nh4	0.1432	0.7075
1803720011	IN	Dubois	spring	pbw	0.1556	0.6916
1803720011	IN	Dubois	summer	so4	0.3687	0.644
1803720011	IN	Dubois	summer	no3	0	0.8029
1803720011	IN	Dubois	summer	ocm	0.1174	1.0136
1803720011	IN	Dubois	summer	ec	0.0207	0.913
1803720011	IN	Dubois	summer	soil	0.0213	1.1988
1803720011	IN	Dubois	summer	nh4	0.1168	0.6789
1803720011	IN	Dubois	summer	pbw	0.1246	0.6613
1803720011	IN	Dubois	fall	so4	0.2964	0.8232
1803720011	IN	Dubois	fall	no3	0.138	0.8797
1803720011	IN	Dubois	fall	ocm	0.2116	0.9861
1803720011	IN	Dubois	fall	ec	0.0437	0.9019
1803720011	IN	Dubois	fall	soil	0.03	1.1387
1803720011	IN	Dubois	fall	nh4	0.1449	0.8444
1803720011	IN	Dubois	fall	pbw	0.0941	0.8558
1809700811	IN	Marion	winter	so4	0.2358	0.9192
1809700811	IN	Marion	winter	no3	0.2729	0.9769
1809700811	IN	Marion	winter	ocm	0.1851	0.9546
1809700811	IN	Marion	winter	ec	0.0385	0.8647
1809700811	IN	Marion	winter	soil	0.0239	1.0835
1809700811	IN	Marion	winter	nh4	0.1561	0.9446
1809700811	IN	Marion	winter	pbw	0.0877	0.944
1809700811	IN	Marion	spring	so4	0.3745	0.6868
1809700811	IN	Marion	spring	no3	0.0167	0.8082
1809700811	IN	Marion	spring	ocm	0.2034	0.9881
1809700811	IN	Marion	spring	ec	0.0447	0.8547
1809700811	IN	Marion	spring	soil	0.0376	1.0625
1809700811	IN	Marion	spring	nh4	0.1313	0.7182
1809700811	IN	Marion	spring	pbw	0.1309	0.7056
1809700811	IN	Marion	summer	so4	0.3582	0.6529
1809700811	IN	Marion	summer	no3	0	0.8099
1809700811	IN	Marion	summer	ocm	0.1231	1.0043
1809700811	IN	Marion	summer	ec	0.03	0.8444
1809700811	IN	Marion	summer	soil	0.0253	1.0918
1809700811	IN	Marion	summer	nh4	0.1114	0.6854
1809700811	IN	Marion	summer	pbw	0.1163	0.6674
1809700811	IN	Marion	fall	so4	0.2751	0.8538
1809700811	IN	Marion	fall	no3	0.149	0.9452
1809700811	IN	Marion	fall	ocm	0.223	0.9648
1809700811	IN	Marion	fall	ec	0.0525	0.8412
1809700811	IN	Marion	fall	soil	0.0358	1.089
1809700811	IN	Marion	fall	nh4	0.1378	0.8905
1809700811	IN	Marion	fall	pbw	0.0865	0.8888

Site ID	State	County	Season	Species	Species Comp. of Ave. FRM (fraction)	Species RRF
2616300331	MI	Wayne	winter	so4	0.1587	0.9206
2616300331	MI	Wayne	winter	no3	0.2394	0.9813
2616300331	MI	Wayne	winter	ocm	0.3193	1.0781
2616300331	MI	Wayne	winter	ec	0.0383	0.9279
2616300331	MI	Wayne	winter	soil	0.0541	1.0206
2616300331	MI	Wayne	winter	nh4	0.1188	0.9518
2616300331	MI	Wayne	winter	pbw	0.0714	0.9566
2616300331	MI	Wayne	spring	so4	0.3383	0.7398
2616300331	MI	Wayne	spring	no3	0.0259	0.8787
2616300331	MI	Wayne	spring	ocm	0.3543	1.0234
2616300331	MI	Wayne	spring	ec	0.0504	0.8671
2616300331	MI	Wayne	spring	soil	0.0915	1.0153
2616300331	MI	Wayne	spring	nh4	0.1191	0.7818
2616300331	MI	Wayne	spring	pbw	0.1126	0.7619
2616300331	MI	Wayne	summer	so4	0.3311	0.6681
2616300331	MI	Wayne	summer	no3	0	0.8431
2616300331	MI	Wayne	summer	ocm	0.2297	1.0029
2616300331	MI	Wayne	summer	ec	0.0362	0.8332
2616300331	MI	Wayne	summer	soil	0.061	1.0177
2616300331	MI	Wayne	summer	nh4	0.1027	0.6974
2616300331	MI	Wayne	summer	pbw	0.1073	0.6754
2616300331	MI	Wayne	fall	so4	0.1898	0.854
2616300331	MI	Wayne	fall	no3	0.1075	0.9367
2616300331	MI	Wayne	fall	ocm	0.3689	1.0607
2616300331	MI	Wayne	fall	ec	0.0546	0.8862
2616300331	MI	Wayne	fall	soil	0.1676	1.0317
2616300331	MI	Wayne	fall	nh4	0.0866	0.8919
2616300331	MI	Wayne	fall	pbw	0.0553	0.8821
3903500381	OH	Cuyahoga	winter	so4	0.2117	0.8993
3903500381	OH	Cuyahoga	winter	no3	0.2665	0.9856
3903500381	OH	Cuyahoga	winter	ocm	0.2048	0.9716
3903500381	OH	Cuyahoga	winter	ec	0.0413	0.8903
3903500381	OH	Cuyahoga	winter	soil	0.0465	1.0959
3903500381	OH	Cuyahoga	winter	nh4	0.1459	0.9416
3903500381	OH	Cuyahoga	winter	pbw	0.0832	0.9541
3903500381	OH	Cuyahoga	spring	so4	0.3334	0.7145
3903500381	OH	Cuyahoga	spring	no3	0.0374	0.8393
3903500381	OH	Cuyahoga	spring	ocm	0.2068	1.0899
3903500381	OH	Cuyahoga	spring	ec	0.052	0.9362
3903500381	OH	Cuyahoga	spring	soil	0.0697	1.0601
3903500381	OH	Cuyahoga	spring	nh4	0.1256	0.7666
3903500381	OH	Cuyahoga	spring	pbw	0.115	0.7761
3903500381	OH	Cuyahoga	summer	so4	0.3241	0.6303
3903500381	OH	Cuyahoga	summer	no3	0	0.89
3903500381	OH	Cuyahoga	summer	ocm	0.1306	1.0998
3903500381	OH	Cuyahoga	summer	ec	0.0419	0.9354
3903500381	OH	Cuyahoga	summer	soil	0.0583	1.0906
3903500381	OH	Cuyahoga	summer	nh4	0.1074	0.7038
3903500381	OH	Cuyahoga	summer	pbw	0.1183	0.6674
3903500381	OH	Cuyahoga	fall	so4	0.2055	0.8193
3903500381	OH	Cuyahoga	fall	no3	0.1275	0.9189
3903500381	OH	Cuyahoga	fall	ocm	0.2234	1.0245
3903500381	OH	Cuyahoga	fall	ec	0.0499	0.8913
3903500381	OH	Cuyahoga	fall	soil	0.0675	1.0927
3903500381	OH	Cuyahoga	fall	nh4	0.1034	0.8615
3903500381	OH	Cuyahoga	fall	pbw	0.0637	0.8564

Site ID	State	County	Season	Species	Species Comp. of Ave. FRM (fraction)	Species RRF
3904900241	OH	Franklin	winter	so4	0.2555	0.8622
3904900241	OH	Franklin	winter	no3	0.2373	1.0002
3904900241	OH	Franklin	winter	ocm	0.2082	0.974
3904900241	OH	Franklin	winter	ec	0.0375	0.8537
3904900241	OH	Franklin	winter	soil	0.0259	1.0844
3904900241	OH	Franklin	winter	nh4	0.1495	0.9261
3904900241	OH	Franklin	winter	pbw	0.0861	0.9274
3904900241	OH	Franklin	spring	so4	0.3754	0.6615
3904900241	OH	Franklin	spring	no3	0.0176	0.8436
3904900241	OH	Franklin	spring	ocm	0.2069	1.062
3904900241	OH	Franklin	spring	ec	0.0405	0.8678
3904900241	OH	Franklin	spring	soil	0.0371	1.0551
3904900241	OH	Franklin	spring	nh4	0.1296	0.7212
3904900241	OH	Franklin	spring	pbw	0.128	0.6992
3904900241	OH	Franklin	summer	so4	0.3703	0.622
3904900241	OH	Franklin	summer	no3	0	0.9056
3904900241	OH	Franklin	summer	ocm	0.1343	1.0654
3904900241	OH	Franklin	summer	ec	0.0311	0.8565
3904900241	OH	Franklin	summer	soil	0.0267	1.0667
3904900241	OH	Franklin	summer	nh4	0.1142	0.7021
3904900241	OH	Franklin	summer	pbw	0.1186	0.6614
3904900241	OH	Franklin	fall	so4	0.2692	0.8119
3904900241	OH	Franklin	fall	no3	0.1186	0.9099
3904900241	OH	Franklin	fall	ocm	0.2489	1.019
3904900241	OH	Franklin	fall	ec	0.0533	0.8371
3904900241	OH	Franklin	fall	soil	0.0423	1.0924
3904900241	OH	Franklin	fall	nh4	0.1217	0.8539
3904900241	OH	Franklin	fall	pbw	0.0821	0.8519
3906100141	OH	Hamilton	winter	so4	0.2685	0.8104
3906100141	OH	Hamilton	winter	no3	0.2378	1.0886
3906100141	OH	Hamilton	winter	ocm	0.19	0.961
3906100141	OH	Hamilton	winter	ec	0.035	0.8969
3906100141	OH	Hamilton	winter	soil	0.0229	1.4146
3906100141	OH	Hamilton	winter	nh4	0.1583	0.9077
3906100141	OH	Hamilton	winter	pbw	0.0874	0.8687
3906100141	OH	Hamilton	spring	so4	0.3583	0.6331
3906100141	OH	Hamilton	spring	no3	0.0025	1.0155
3906100141	OH	Hamilton	spring	ocm	0.1986	1.0798
3906100141	OH	Hamilton	spring	ec	0.0466	0.9228
3906100141	OH	Hamilton	spring	soil	0.0289	1.3785
3906100141	OH	Hamilton	spring	nh4	0.1215	0.6968
3906100141	OH	Hamilton	spring	pbw	0.128	0.6307
3906100141	OH	Hamilton	summer	so4	0.3722	0.577
3906100141	OH	Hamilton	summer	no3	0	1.0923
3906100141	OH	Hamilton	summer	ocm	0.121	1.082
3906100141	OH	Hamilton	summer	ec	0.0309	0.9099
3906100141	OH	Hamilton	summer	soil	0.0199	1.537
3906100141	OH	Hamilton	summer	nh4	0.1178	0.6441
3906100141	OH	Hamilton	summer	pbw	0.1261	0.5734
3906100141	OH	Hamilton	fall	so4	0.2608	0.7754
3906100141	OH	Hamilton	fall	no3	0.1184	0.9857
3906100141	OH	Hamilton	fall	ocm	0.213	1.0235
3906100141	OH	Hamilton	fall	ec	0.0512	0.8876
3906100141	OH	Hamilton	fall	soil	0.0328	1.4007
3906100141	OH	Hamilton	fall	nh4	0.1254	0.846
3906100141	OH	Hamilton	fall	pbw	0.0828	0.8172

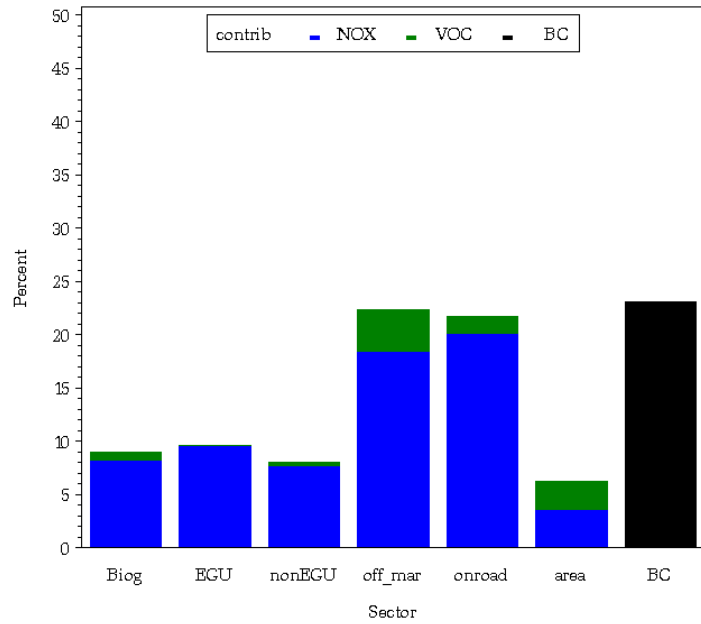
Site ID	State	County	Season	Species	Species Comp. of Ave. FRM (fraction)	Species RRF
3908110011	OH	Jefferson	winter	so4	0.2367	0.8217
3908110011	OH	Jefferson	winter	no3	0.1709	1.0522
3908110011	OH	Jefferson	winter	ocm	0.3288	0.8819
3908110011	OH	Jefferson	winter	ec	0.0435	0.9091
3908110011	OH	Jefferson	winter	soil	0.0272	0.4368
3908110011	OH	Jefferson	winter	nh4	0.1199	0.8904
3908110011	OH	Jefferson	winter	pbw	0.073	0.8583
3908110011	OH	Jefferson	spring	so4	0.3508	0.6666
3908110011	OH	Jefferson	spring	no3	0.0154	0.9156
3908110011	OH	Jefferson	spring	ocm	0.3078	0.9995
3908110011	OH	Jefferson	spring	ec	0.0395	0.9853
3908110011	OH	Jefferson	spring	soil	0.0407	0.4844
3908110011	OH	Jefferson	spring	nh4	0.114	0.7054
3908110011	OH	Jefferson	spring	pbw	0.1095	0.6713
3908110011	OH	Jefferson	summer	so4	0.3779	0.6156
3908110011	OH	Jefferson	summer	no3	0	1.0837
3908110011	OH	Jefferson	summer	ocm	0.2098	1.0145
3908110011	OH	Jefferson	summer	ec	0.0308	0.9689
3908110011	OH	Jefferson	summer	soil	0.0323	0.3632
3908110011	OH	Jefferson	summer	nh4	0.1065	0.6428
3908110011	OH	Jefferson	summer	pbw	0.1007	0.625
3908110011	OH	Jefferson	fall	so4	0.2315	0.7694
3908110011	OH	Jefferson	fall	no3	0.0702	1.0302
3908110011	OH	Jefferson	fall	ocm	0.372	0.9312
3908110011	OH	Jefferson	fall	ec	0.051	0.9086
3908110011	OH	Jefferson	fall	soil	0.0344	0.4555
3908110011	OH	Jefferson	fall	nh4	0.0859	0.8284
3908110011	OH	Jefferson	fall	pbw	0.0629	0.7951
3911300321	OH	Montgomer	winter	so4	0.2613	0.8598
3911300321	OH	Montgomer	winter	no3	0.2407	1.029
3911300321	OH	Montgomer	winter	ocm	0.1954	0.9442
3911300321	OH	Montgomer	winter	ec	0.036	0.8746
3911300321	OH	Montgomer	winter	soil	0.0259	1.1295
3911300321	OH	Montgomer	winter	nh4	0.1531	0.9304
3911300321	OH	Montgomer	winter	pbw	0.0876	0.9205
3911300321	OH	Montgomer	spring	so4	0.3659	0.6606
3911300321	OH	Montgomer	spring	no3	0.0163	0.8639
3911300321	OH	Montgomer	spring	ocm	0.1895	1.0976
3911300321	OH	Montgomer	spring	ec	0.0442	0.9417
3911300321	OH	Montgomer	spring	soil	0.0253	1.0873
3911300321	OH	Montgomer	spring	nh4	0.1313	0.7149
3911300321	OH	Montgomer	spring	pbw	0.1326	0.6839
3911300321	OH	Montgomer	summer	so4	0.375	0.6234
3911300321	OH	Montgomer	summer	no3	0	0.9474
3911300321	OH	Montgomer	summer	ocm	0.128	1.1047
3911300321	OH	Montgomer	summer	ec	0.029	0.9496
3911300321	OH	Montgomer	summer	soil	0.0205	1.1299
3911300321	OH	Montgomer	summer	nh4	0.1114	0.6931
3911300321	OH	Montgomer	summer	pbw	0.1114	0.6482
3911300321	OH	Montgomer	fall	so4	0.3062	0.8033
3911300321	OH	Montgomer	fall	no3	0.1012	0.9634
3911300321	OH	Montgomer	fall	ocm	0.2221	1.0158
3911300321	OH	Montgomer	fall	ec	0.0514	0.877
3911300321	OH	Montgomer	fall	soil	0.028	1.1391
3911300321	OH	Montgomer	fall	nh4	0.1352	0.8625
3911300321	OH	Montgomer	fall	pbw	0.0982	0.8475

Site ID	State	County	Season	Species	Species Comp. of Ave. FRM (fraction)	Species RRF
3915100171	OH	Stark	winter	so4	0.2362	0.8558
3915100171	OH	Stark	winter	no3	0.2234	1.0222
3915100171	OH	Stark	winter	ocm	0.2478	0.9255
3915100171	OH	Stark	winter	ec	0.0414	0.8866
3915100171	OH	Stark	winter	soil	0.0334	1.099
3915100171	OH	Stark	winter	nh4	0.1376	0.925
3915100171	OH	Stark	winter	pbw	0.0802	0.9155
3915100171	OH	Stark	spring	so4	0.3581	0.6834
3915100171	OH	Stark	spring	no3	0.0236	0.855
3915100171	OH	Stark	spring	ocm	0.221	1.0892
3915100171	OH	Stark	spring	ec	0.0501	1.0017
3915100171	OH	Stark	spring	soil	0.058	1.0528
3915100171	OH	Stark	spring	nh4	0.1288	0.7264
3915100171	OH	Stark	spring	pbw	0.1256	0.7009
3915100171	OH	Stark	summer	so4	0.3621	0.6277
3915100171	OH	Stark	summer	no3	0	0.8203
3915100171	OH	Stark	summer	ocm	0.1483	1.0984
3915100171	OH	Stark	summer	ec	0.0403	1.016
3915100171	OH	Stark	summer	soil	0.037	1.0781
3915100171	OH	Stark	summer	nh4	0.1157	0.6739
3915100171	OH	Stark	summer	pbw	0.124	0.651
3915100171	OH	Stark	fall	so4	0.2293	0.8041
3915100171	OH	Stark	fall	no3	0.1262	0.9363
3915100171	OH	Stark	fall	ocm	0.2722	1.0226
3915100171	OH	Stark	fall	ec	0.0545	0.9202
3915100171	OH	Stark	fall	soil	0.0461	1.0959
3915100171	OH	Stark	fall	nh4	0.1105	0.8549
3915100171	OH	Stark	fall	pbw	0.0706	0.8428
3915300171	OH	Summit	winter	so4	0.2511	0.8771
3915300171	OH	Summit	winter	no3	0.2376	1.0052
3915300171	OH	Summit	winter	ocm	0.2185	0.9429
3915300171	OH	Summit	winter	ec	0.0334	0.8677
3915300171	OH	Summit	winter	soil	0.0255	1.0835
3915300171	OH	Summit	winter	nh4	0.1489	0.9374
3915300171	OH	Summit	winter	pbw	0.0851	0.945
3915300171	OH	Summit	spring	so4	0.387	0.7046
3915300171	OH	Summit	spring	no3	0.0072	0.8466
3915300171	OH	Summit	spring	ocm	0.1901	1.0967
3915300171	OH	Summit	spring	ec	0.035	0.9482
3915300171	OH	Summit	spring	soil	0.0304	1.0524
3915300171	OH	Summit	spring	nh4	0.1294	0.7521
3915300171	OH	Summit	spring	pbw	0.1342	0.7384
3915300171	OH	Summit	summer	so4	0.3694	0.6378
3915300171	OH	Summit	summer	no3	0	0.8587
3915300171	OH	Summit	summer	ocm	0.1417	1.1077
3915300171	OH	Summit	summer	ec	0.0332	0.9506
3915300171	OH	Summit	summer	soil	0.0198	1.0744
3915300171	OH	Summit	summer	nh4	0.1121	0.6961
3915300171	OH	Summit	summer	pbw	0.1146	0.6691
3915300171	OH	Summit	fall	so4	0.2443	0.8074
3915300171	OH	Summit	fall	no3	0.1175	0.9392
3915300171	OH	Summit	fall	ocm	0.2636	1.0252
3915300171	OH	Summit	fall	ec	0.0623	0.8883
3915300171	OH	Summit	fall	soil	0.0494	1.086
3915300171	OH	Summit	fall	nh4	0.109	0.8622
3915300171	OH	Summit	fall	pbw	0.0723	0.8506

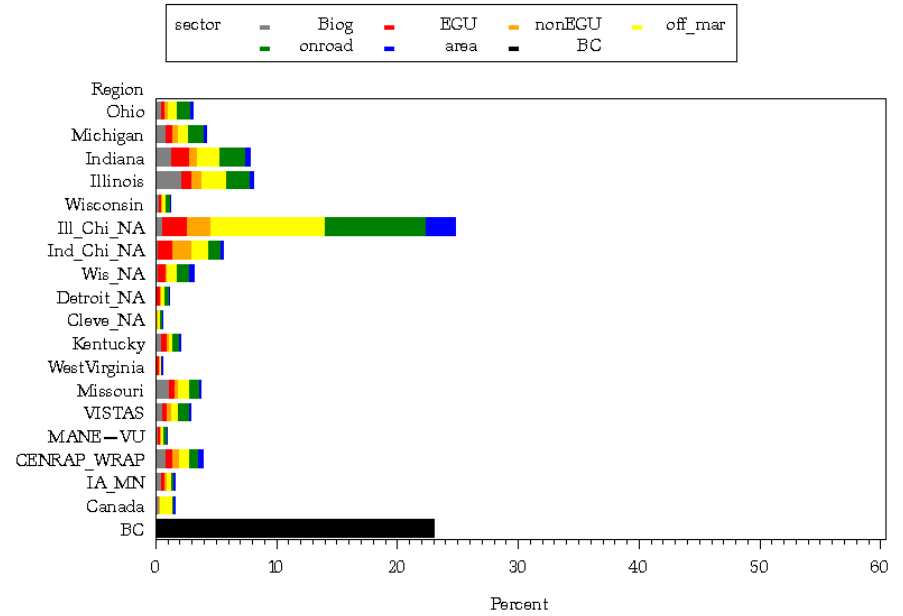
APPENDIX II

Ozone Source Apportionment Modeling Results

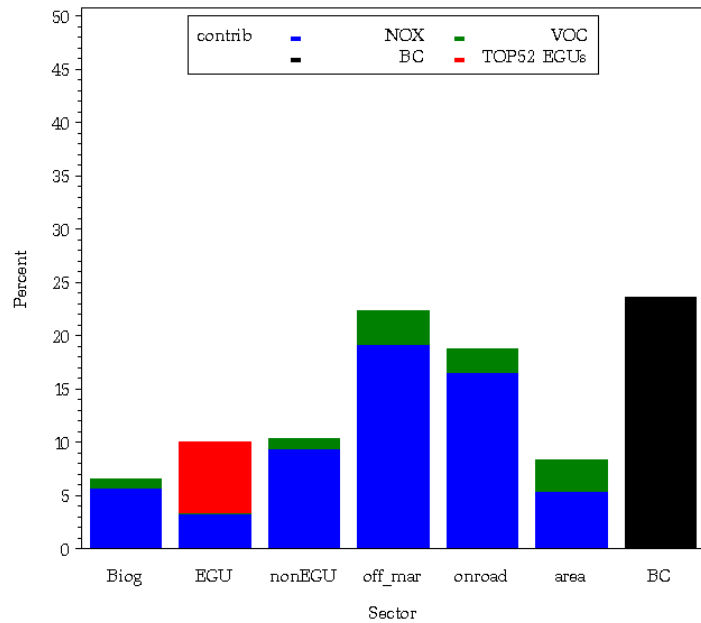
WI — Kenosha : (5505900191) 2009M3R5_osat



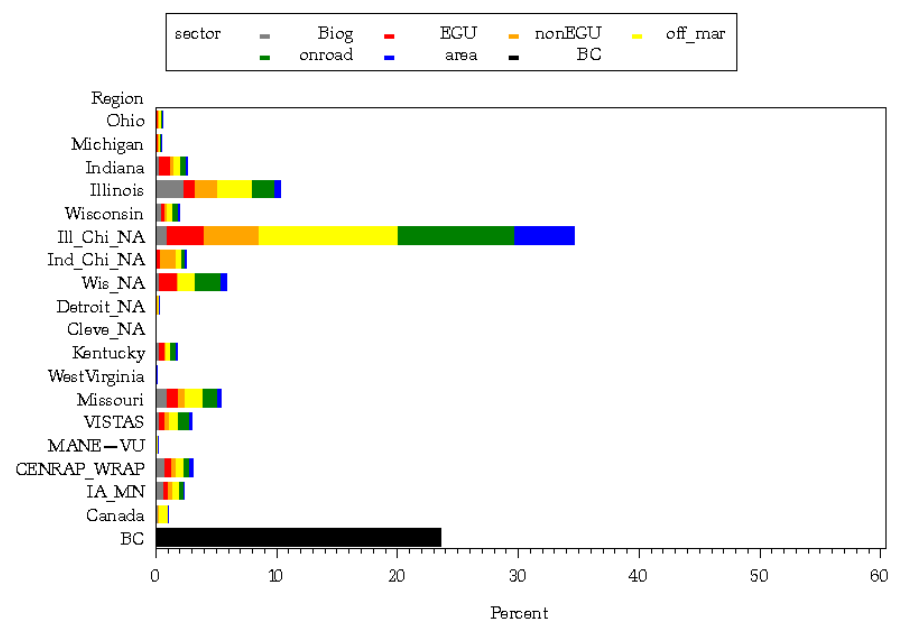
WI — Kenosha : (5505900191) 2009M3R5_osat



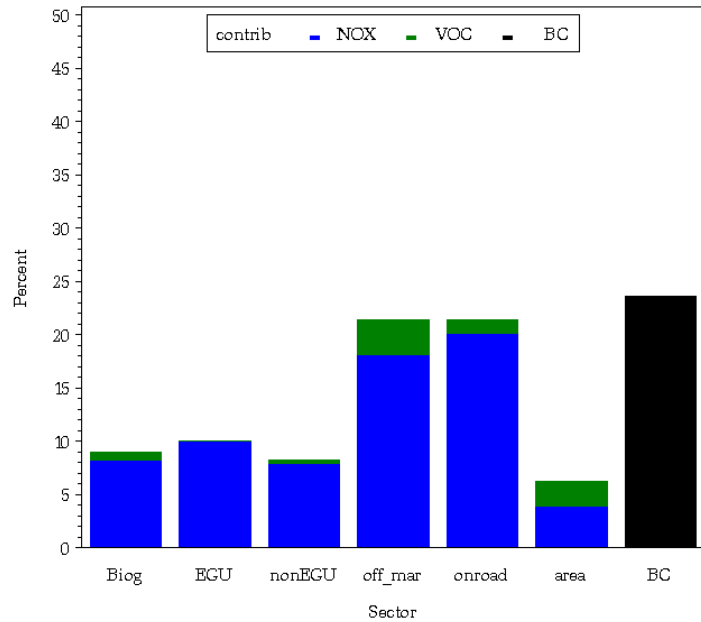
WI — Kenosha : (5505900191) K2012R4S1a_APCA_nopig



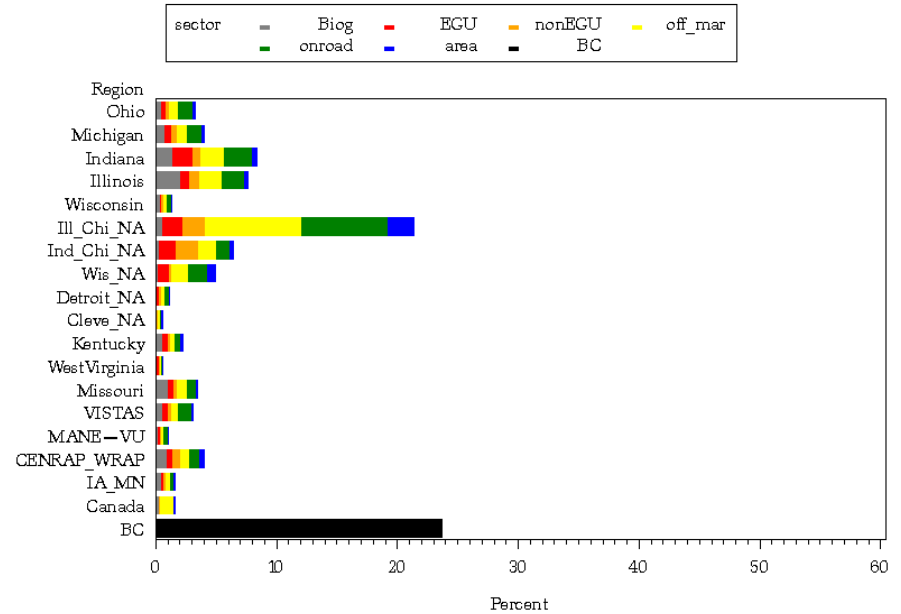
WI — Kenosha : (5505900191) K2012R4S1a_APCA_nopig



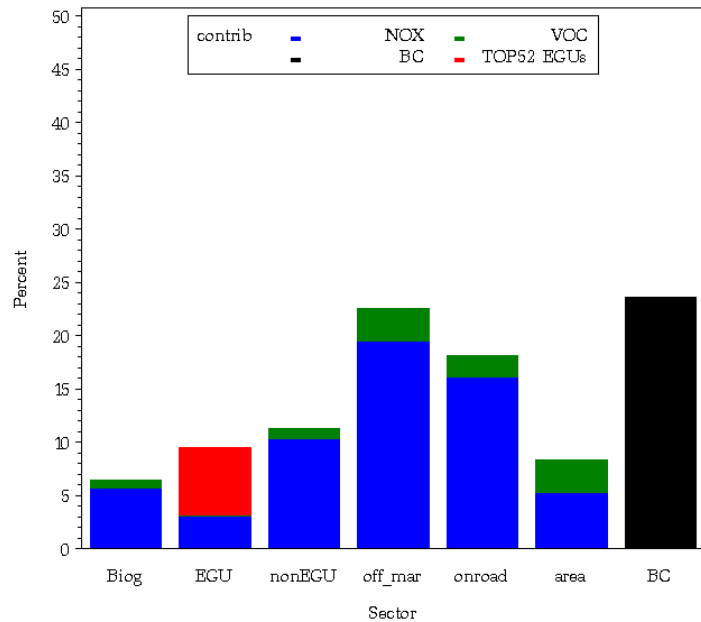
WI - Racine : (5510100171) 2009M3R5_osat



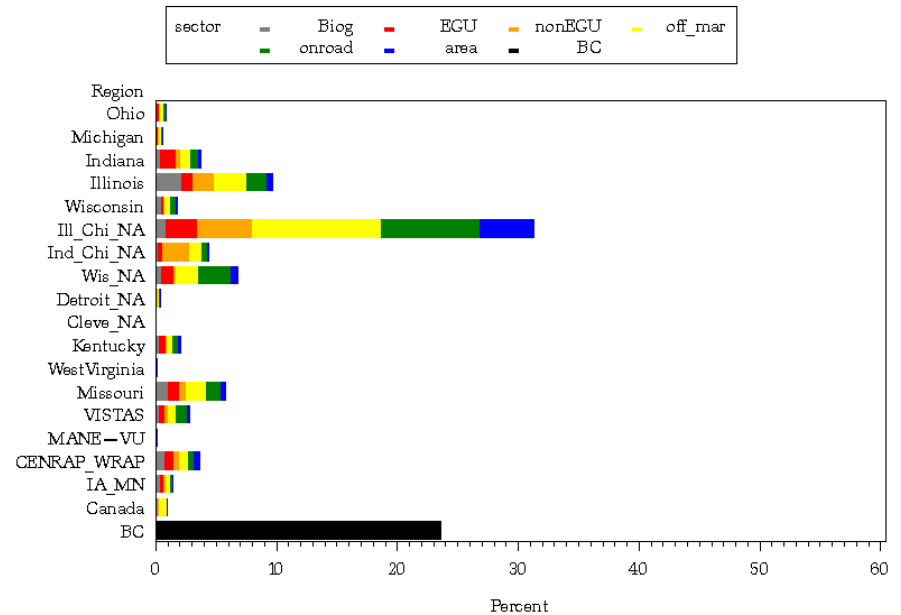
WI - Racine : (5510100171) 2009M3R5_osat



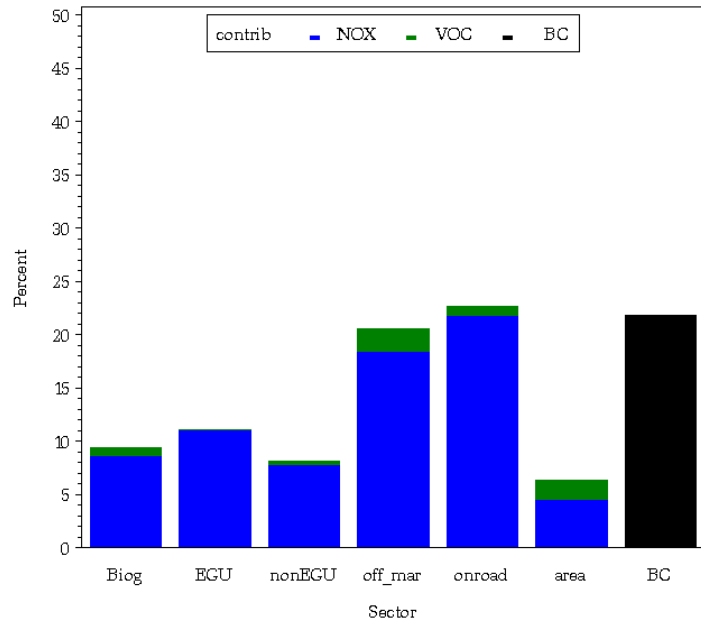
WI - Racine : (5510100171) K2012R4S1a_APCA_nopig



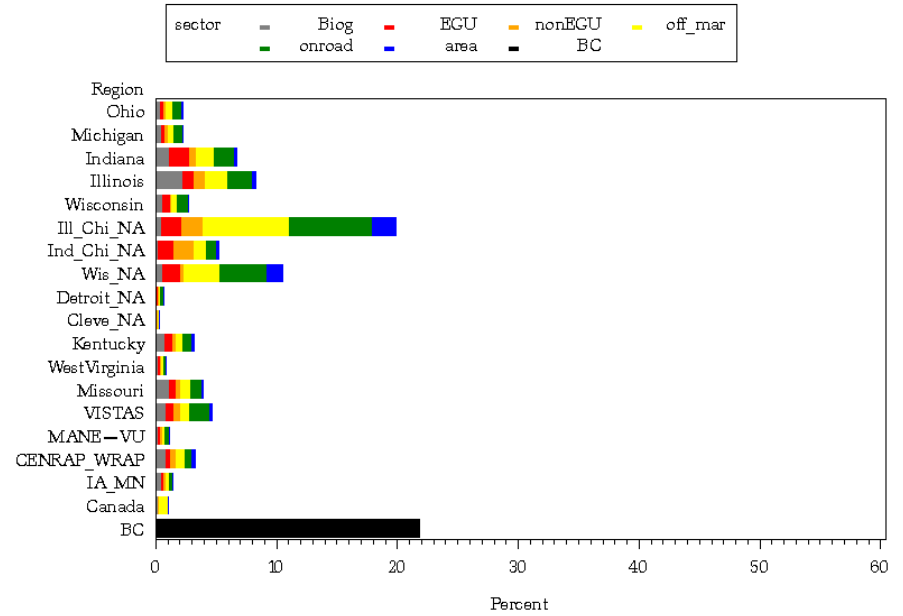
WI - Racine : (5510100171) K2012R4S1a_APCA_nopig



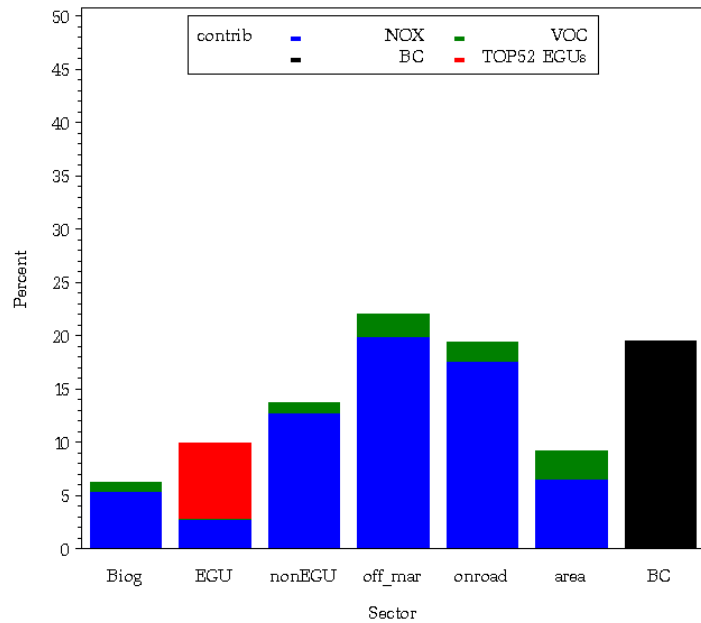
WI — Sheboygan : (5511700061) 2009M3R5_osat



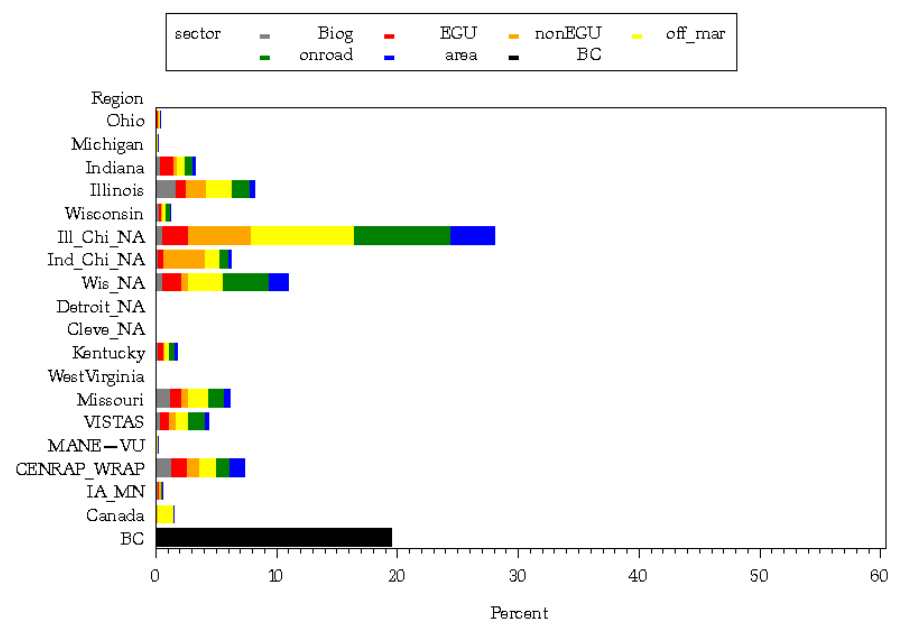
WI — Sheboygan : (5511700061) 2009M3R5_osat



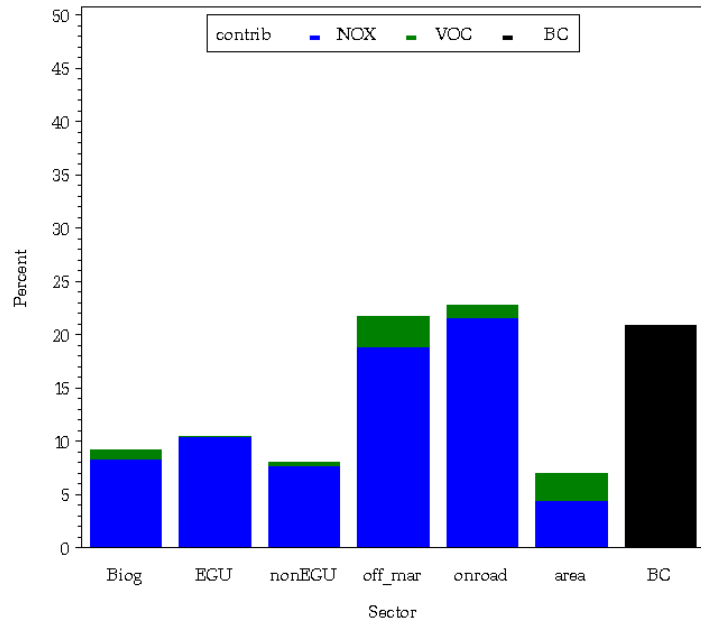
WI — Sheboygan : (5511700061) K2012R4S1a_APCA_nopig



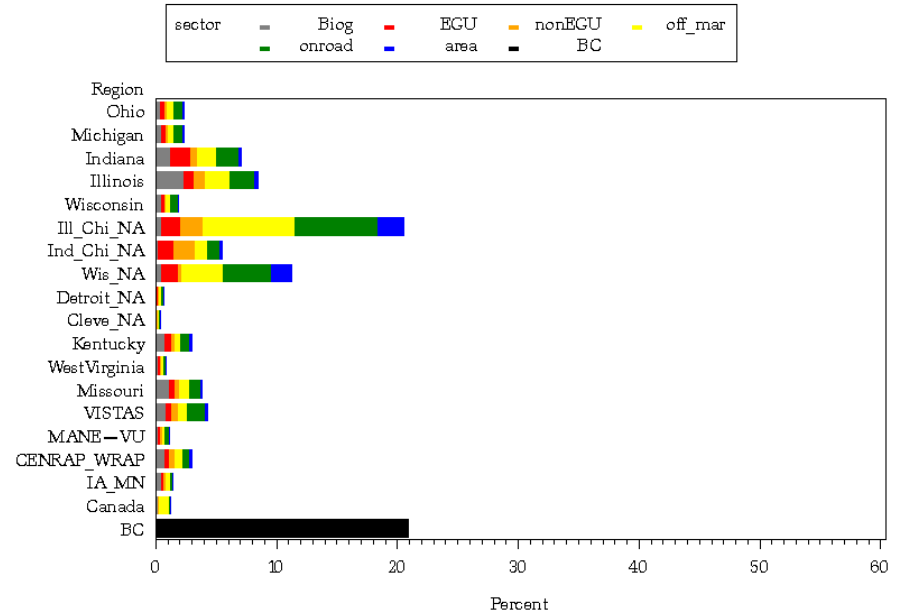
WI — Sheboygan : (5511700061) K2012R4S1a_APCA_nopig



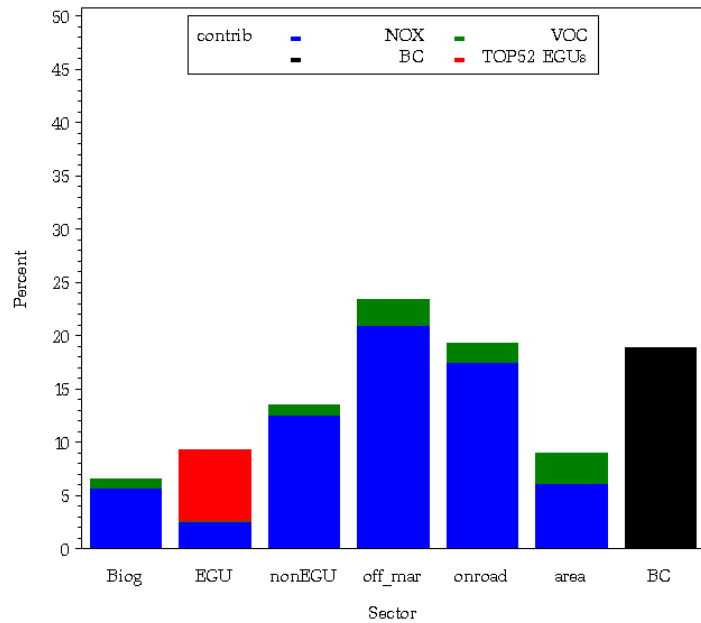
WI - Ozaukee : (5508900091) 2009M3R5_osat



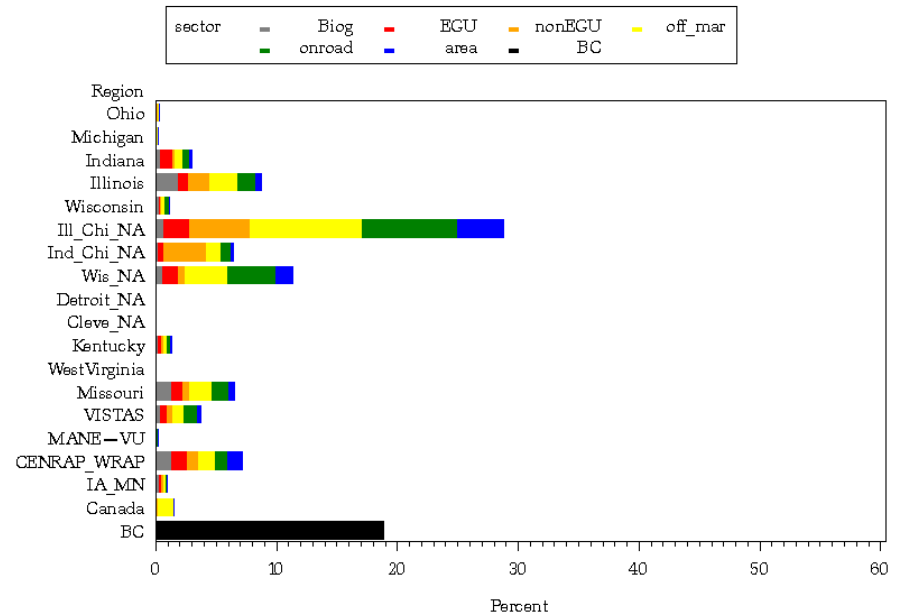
WI - Ozaukee : (5508900091) 2009M3R5_osat



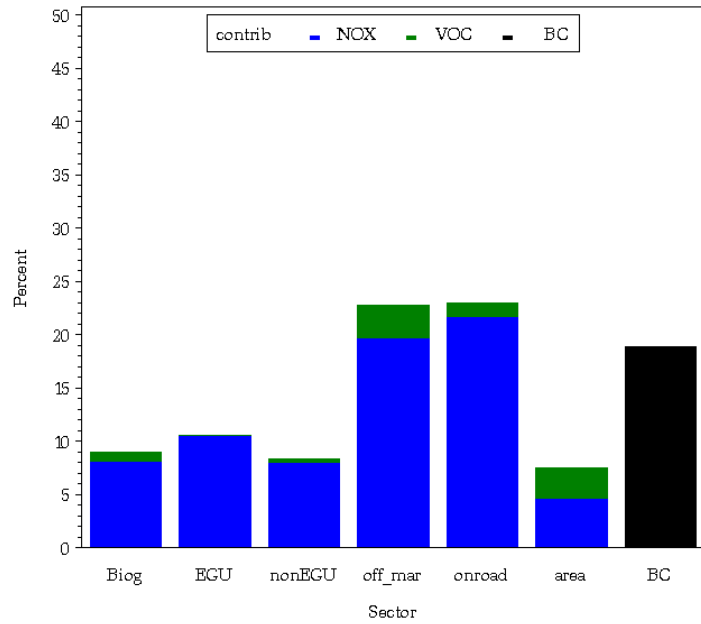
WI - Ozaukee : (5508900091) K2012R4S1a_APCA_nopig



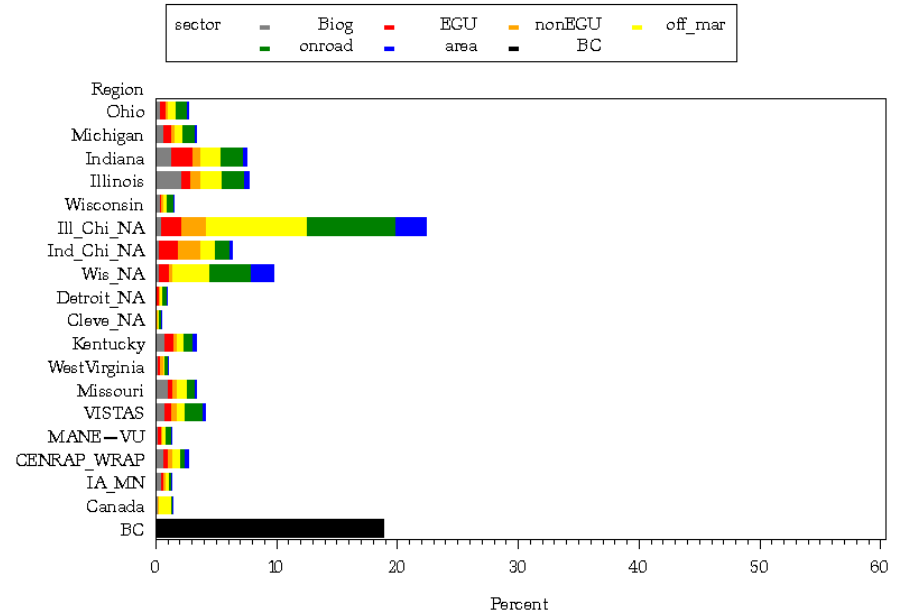
WI - Ozaukee : (5508900091) K2012R4S1a_APCA_nopig



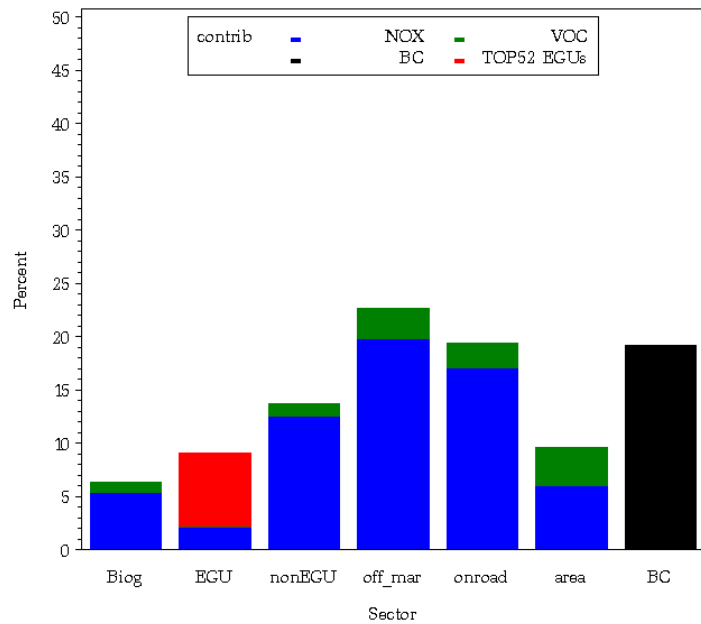
WI — Milwaukee : (550790085J) 2009M3R5_osat



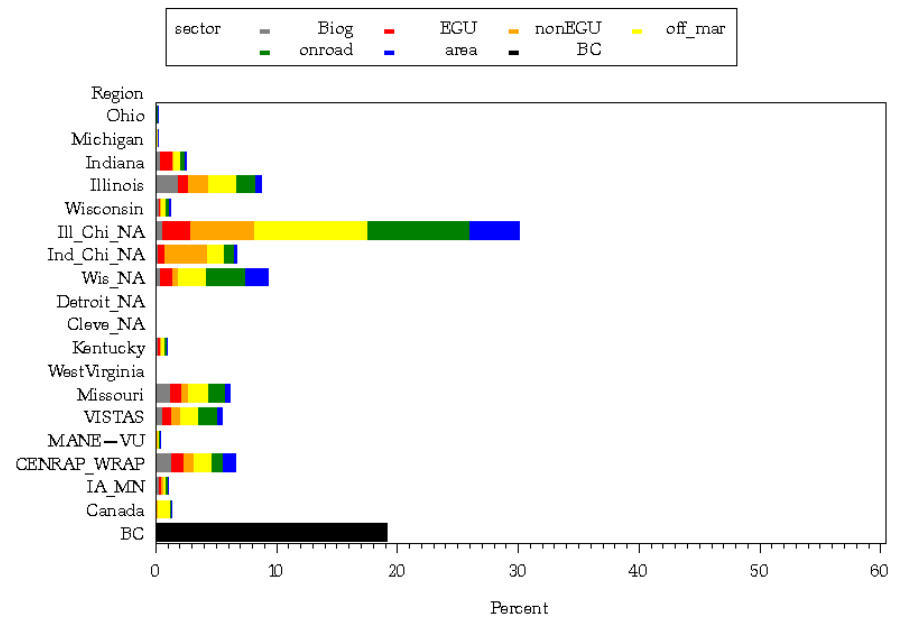
WI — Milwaukee : (550790085J) 2009M3R5_osat



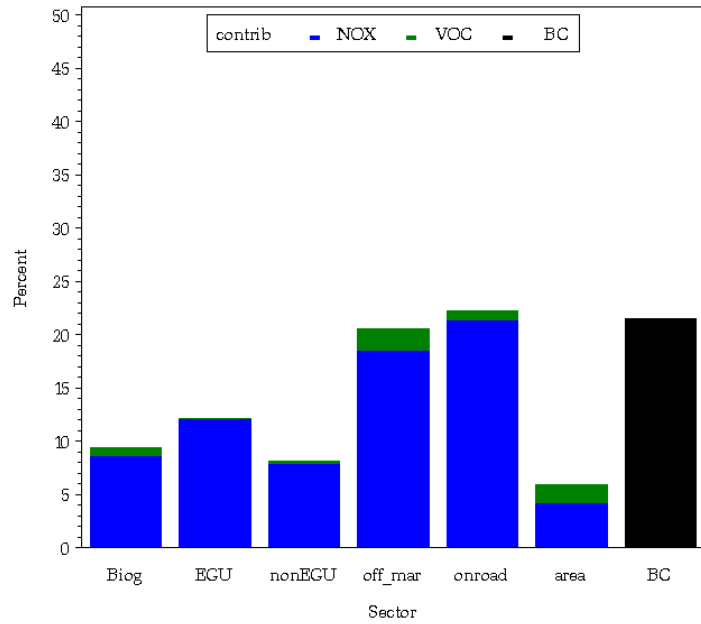
WI — Milwaukee : (550790085J) K2012R4S h_APCA_nopig



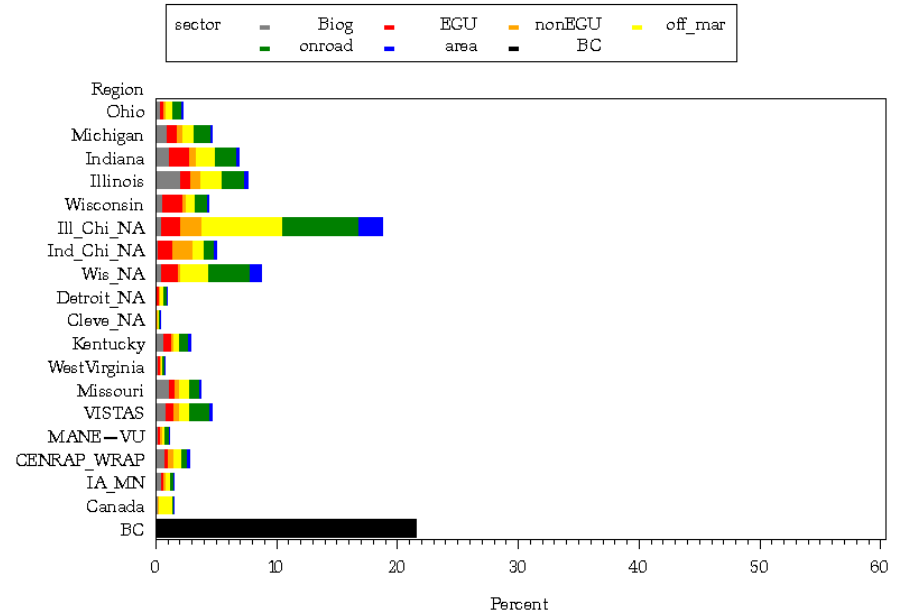
WI — Milwaukee : (550790085J) K2012R4S h_APCA_nopig



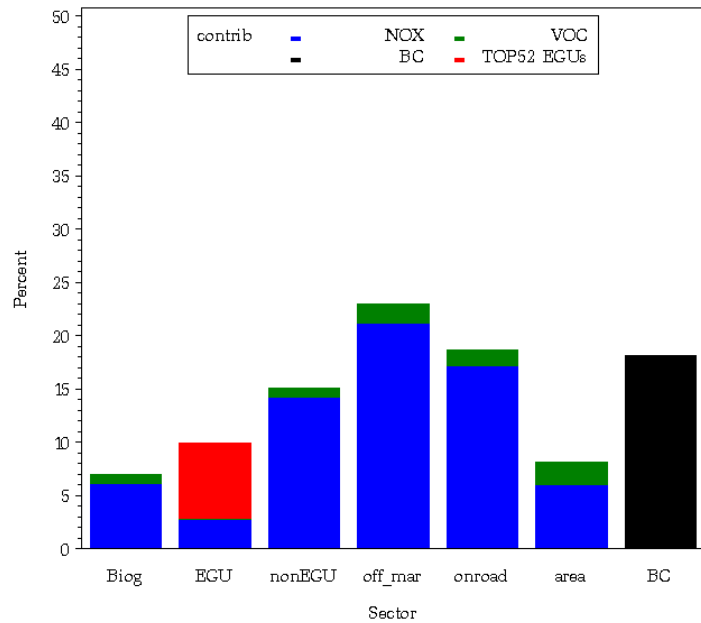
WI — Manitowoc : (5507100071) 2009M3R5_osat



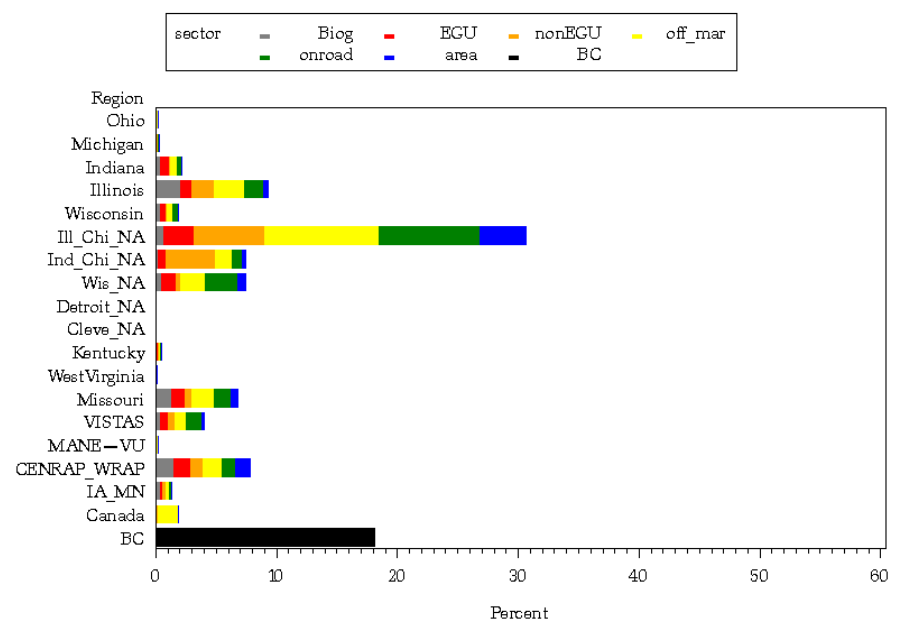
WI — Manitowoc : (5507100071) 2009M3R5_osat



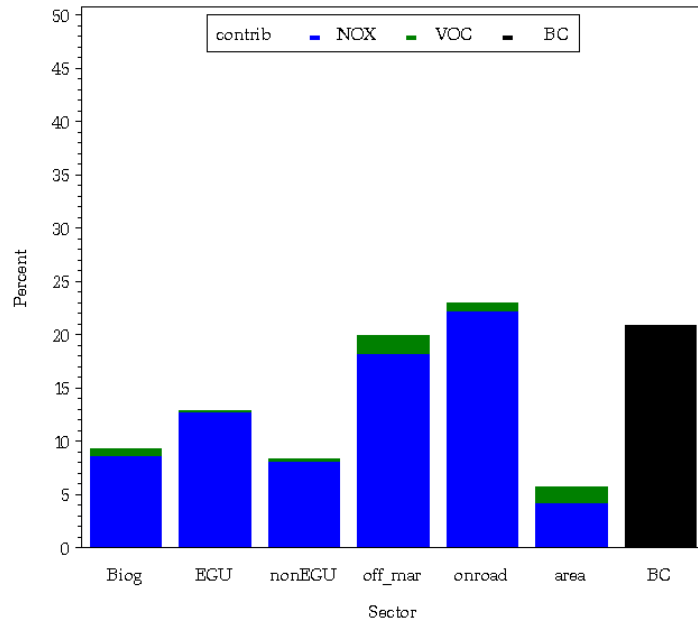
WI — Manitowoc : (5507100071) K2012R4S h_APCA_nopig



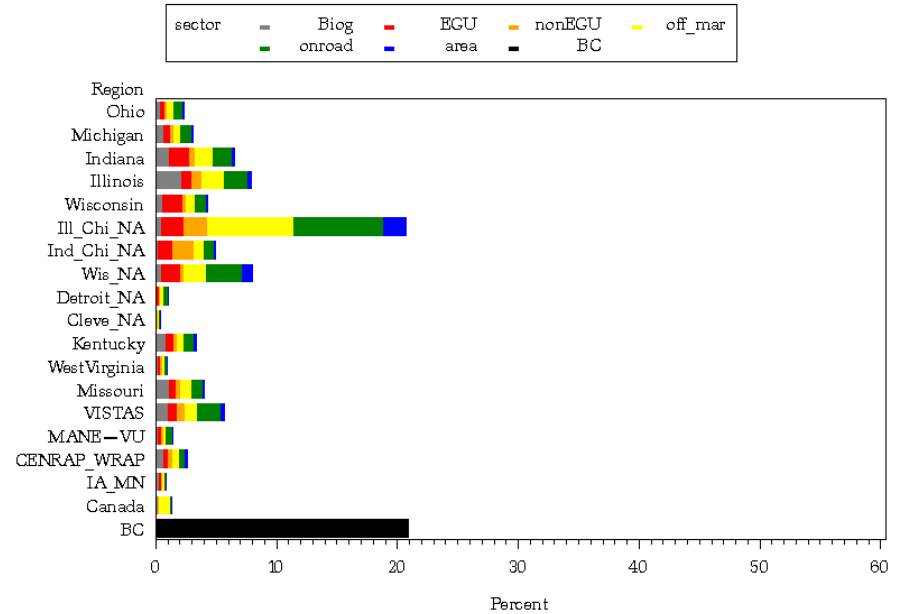
WI — Manitowoc : (5507100071) K2012R4S h_APCA_nopig



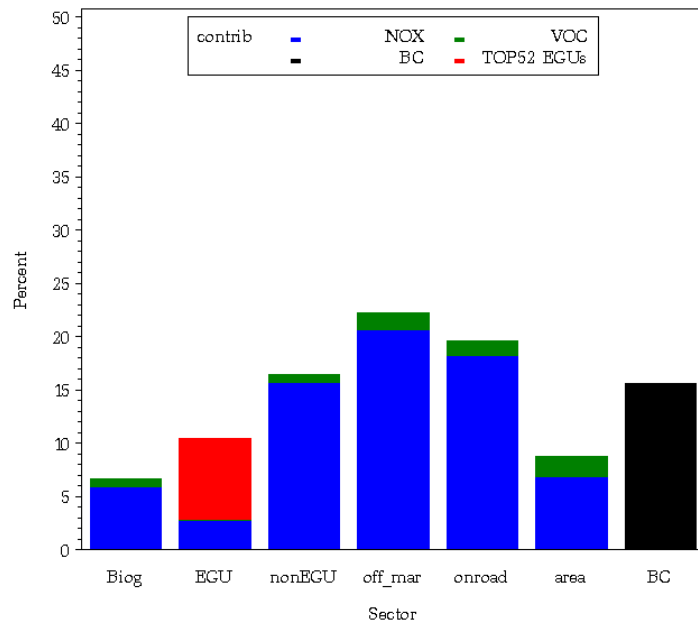
WI — Kewaunee : (5506100021) 2009M3R5_osat



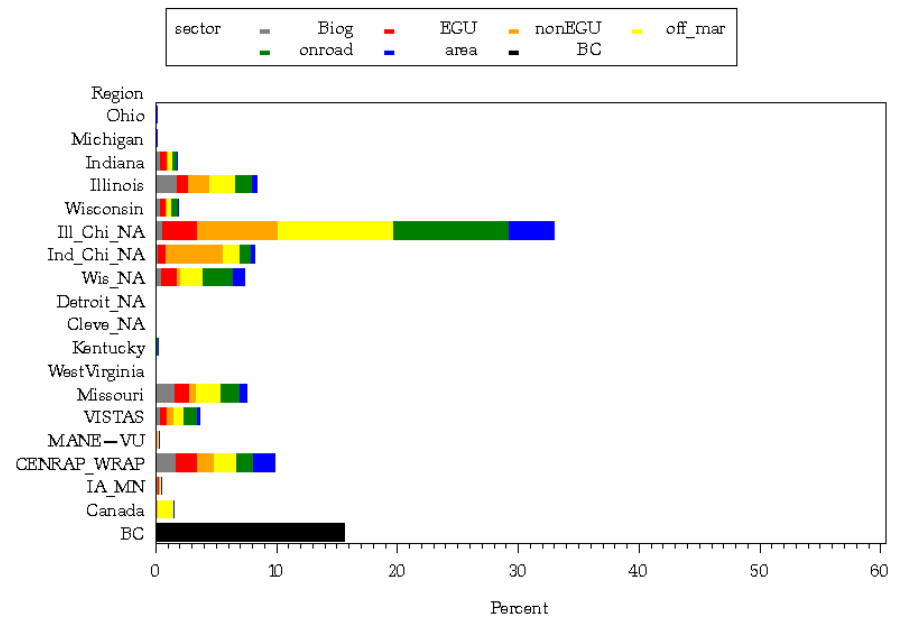
WI — Kewaunee : (5506100021) 2009M3R5_osat



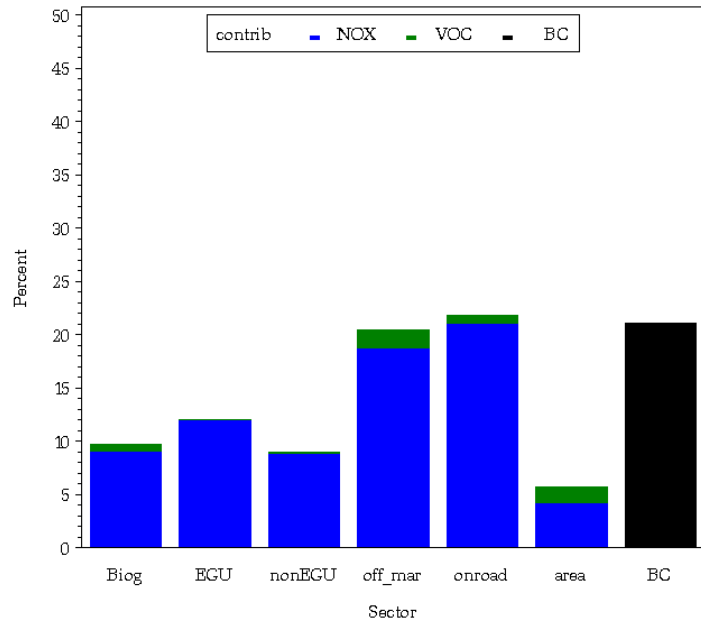
WI — Kewaunee : (5506100021) K2012R4S1a_APCA_nopig



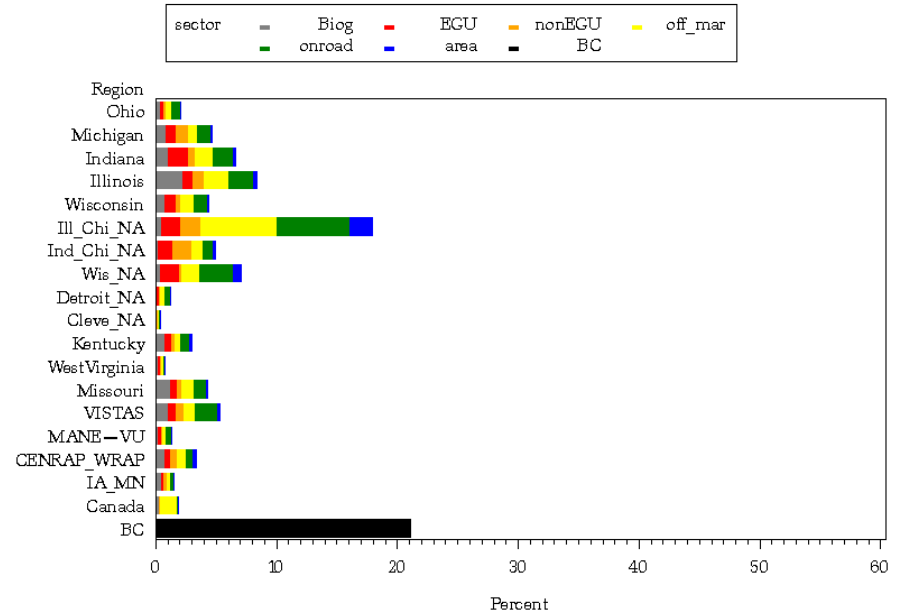
WI — Kewaunee : (5506100021) K2012R4S1a_APCA_nopig



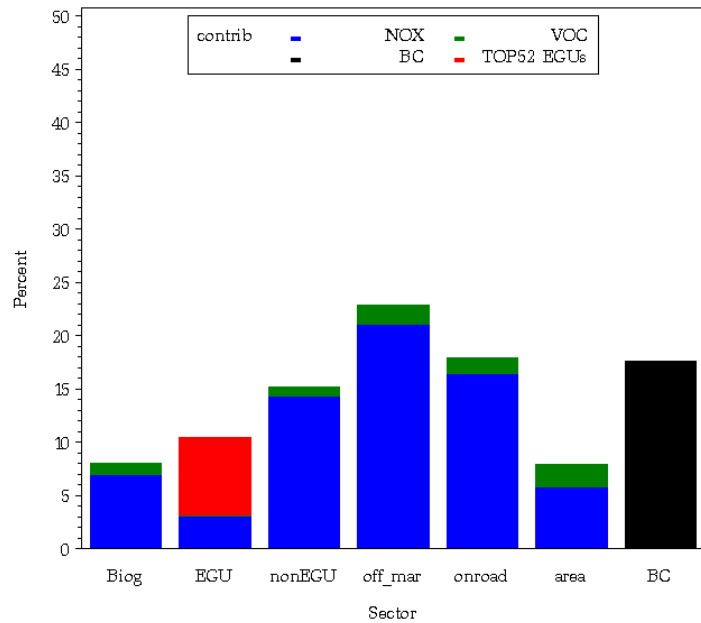
WI — Door : (5502900041) 2009M3R5_osat



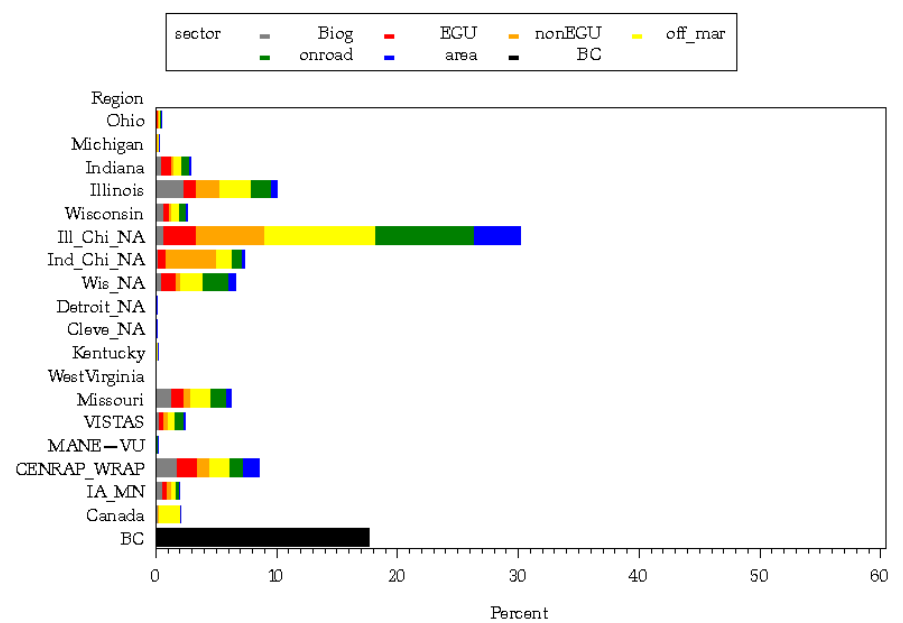
WI — Door : (5502900041) 2009M3R5_osat



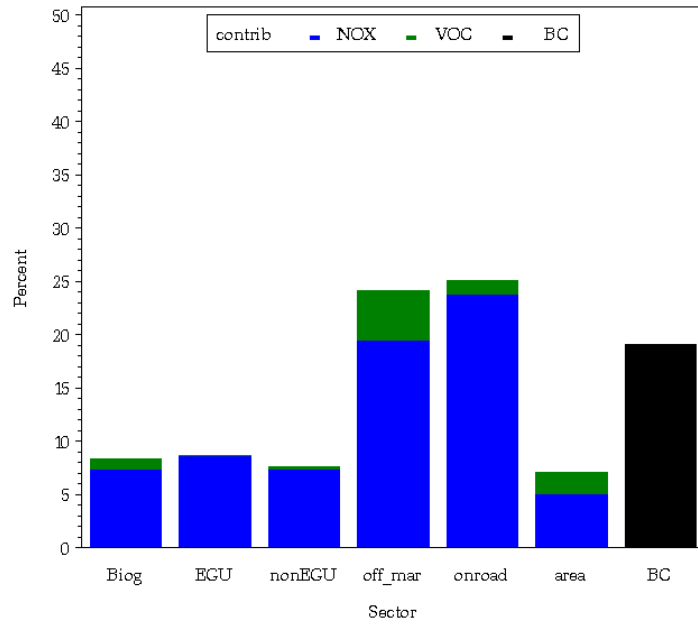
WI — Door : (5502900041) K2012R4S1a_APCA_nopig



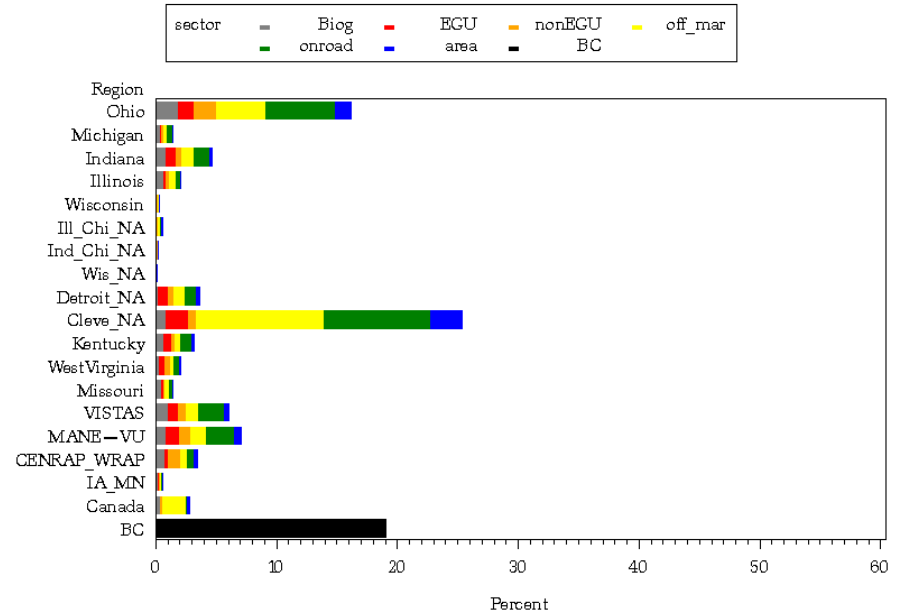
WI — Door : (5502900041) K2012R4S1a_APCA_nopig



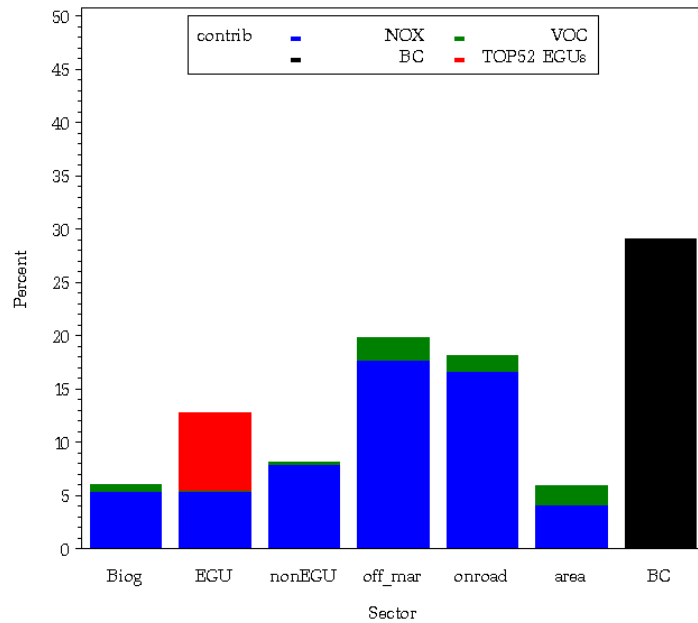
OH — Lake : (3908500031) 2009M3R5_osat



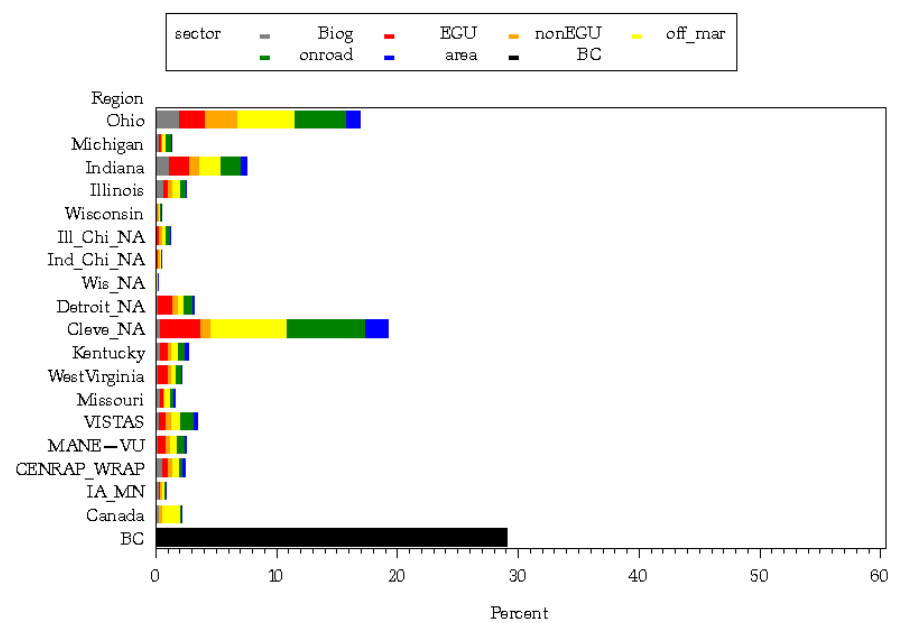
OH — Lake : (3908500031) 2009M3R5_osat



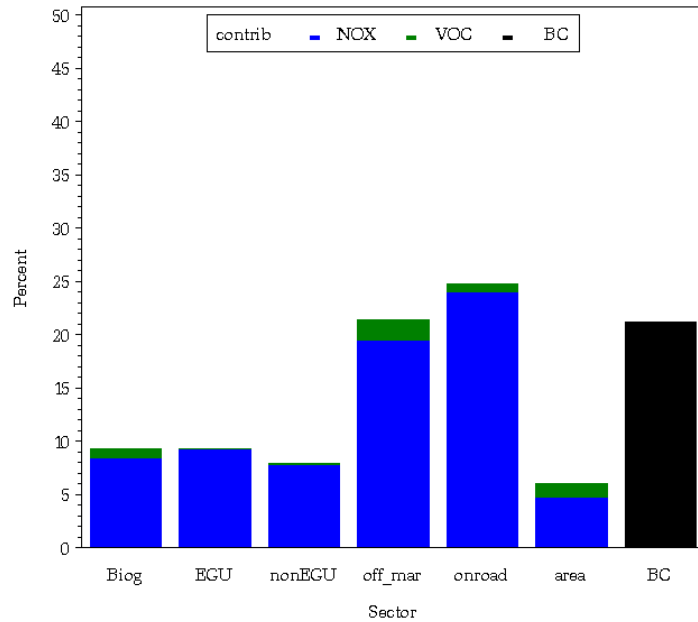
OH — Lake : (3908500031) K2012R4S1a_APCA_nopig



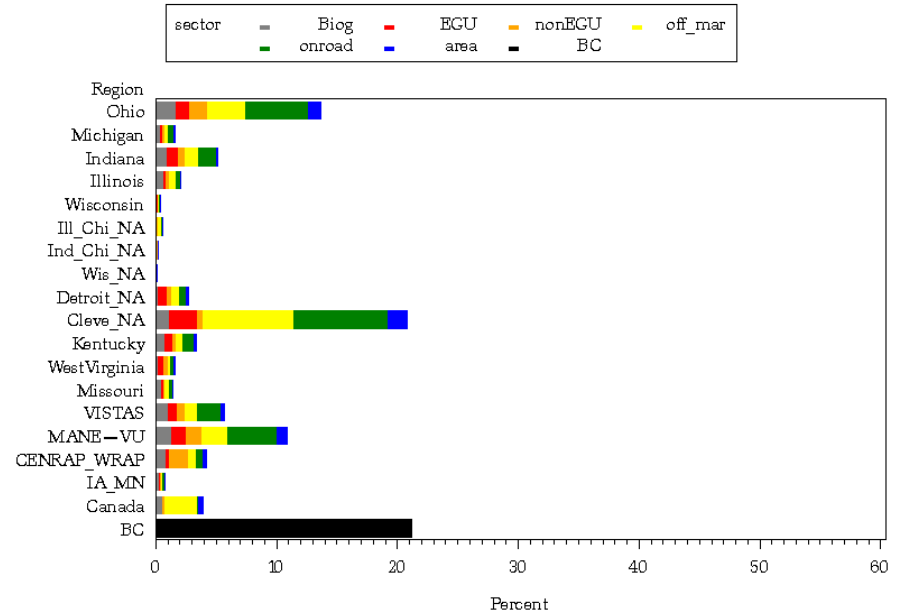
OH — Lake : (3908500031) K2012R4S1a_APCA_nopig



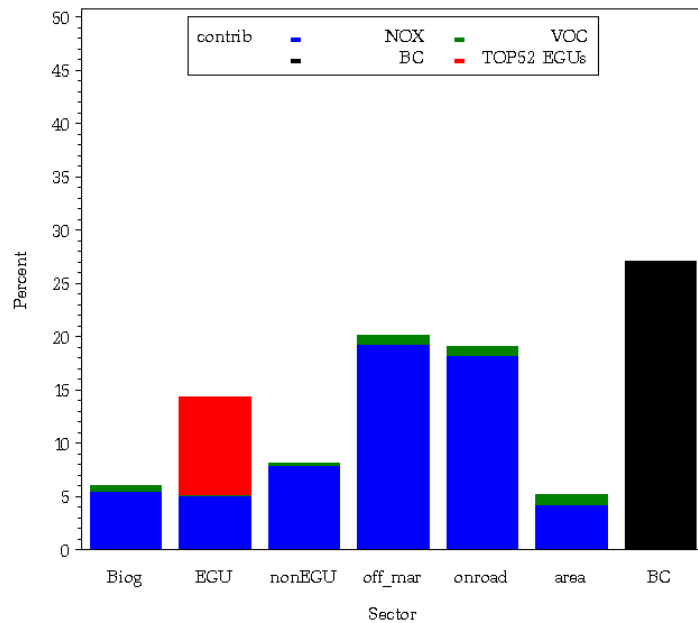
OH — Ashtabula : (3900710011) 2009M3R5_osat



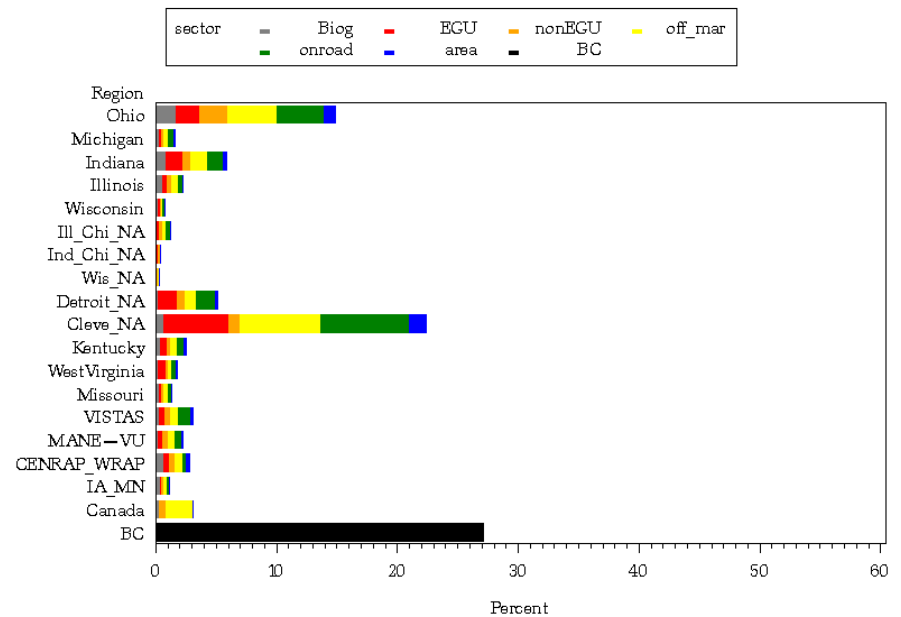
OH — Ashtabula : (3900710011) 2009M3R5_osat



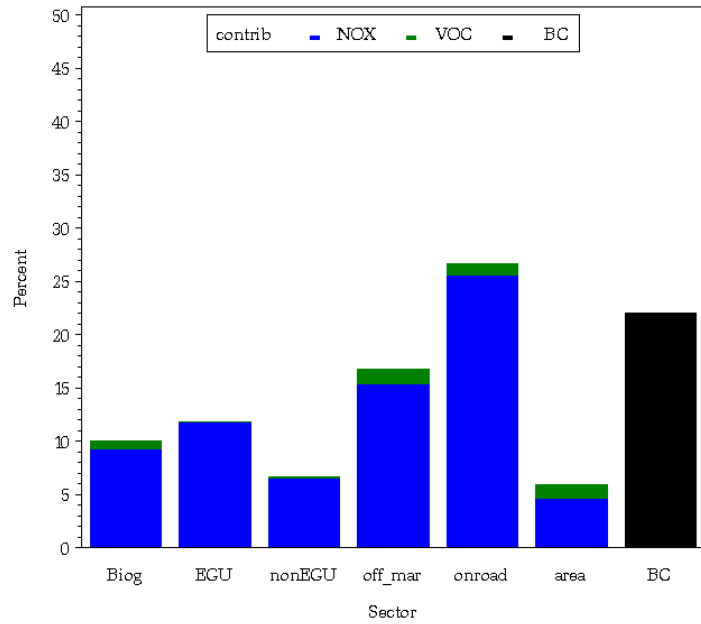
OH — Ashtabula : (3900710011) K2012R4S h_APCA_nopig



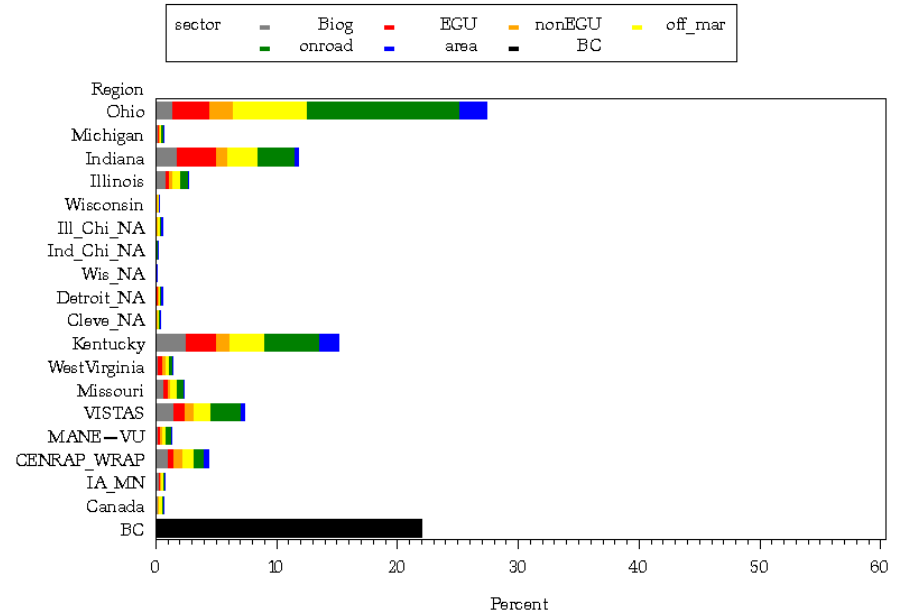
OH — Ashtabula : (3900710011) K2012R4S h_APCA_nopig



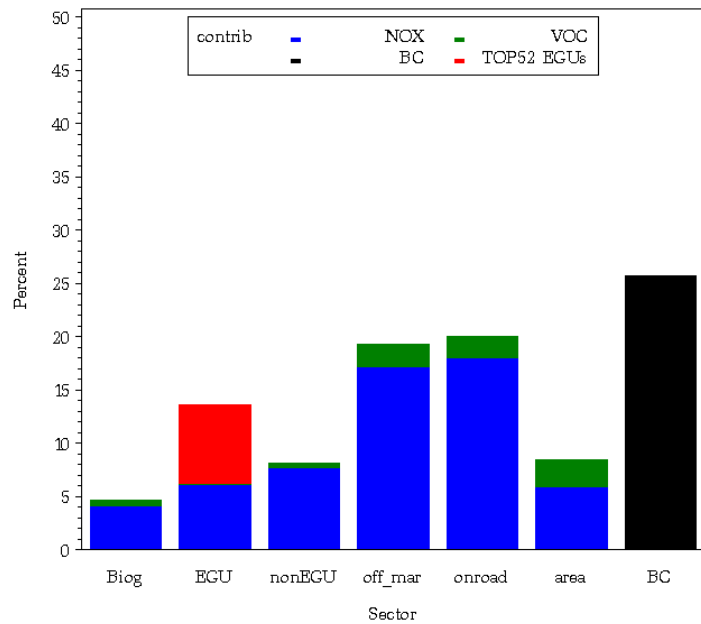
OH — Hamilton : (3906100061) 2009M3R5_osat



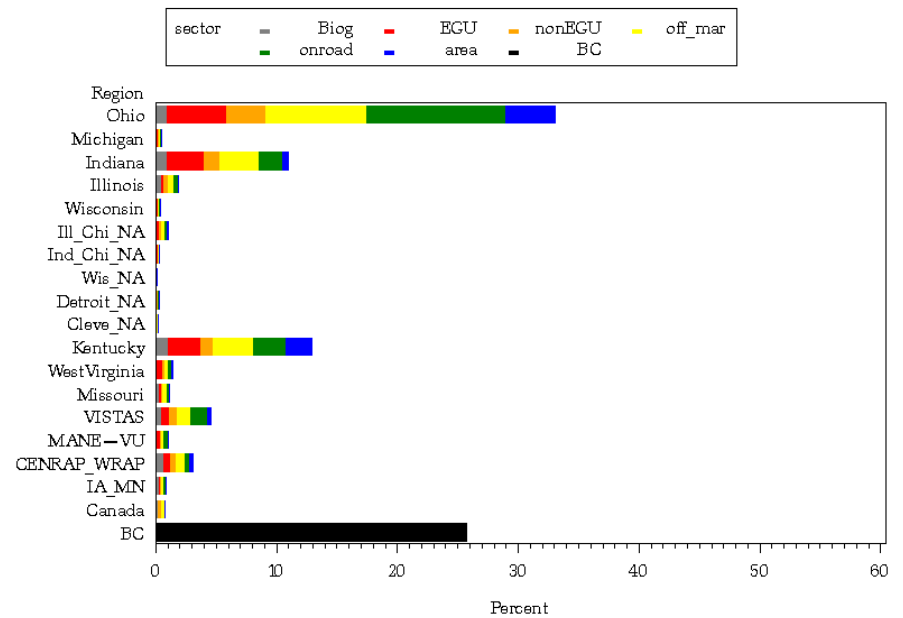
OH — Hamilton : (3906100061) 2009M3R5_osat



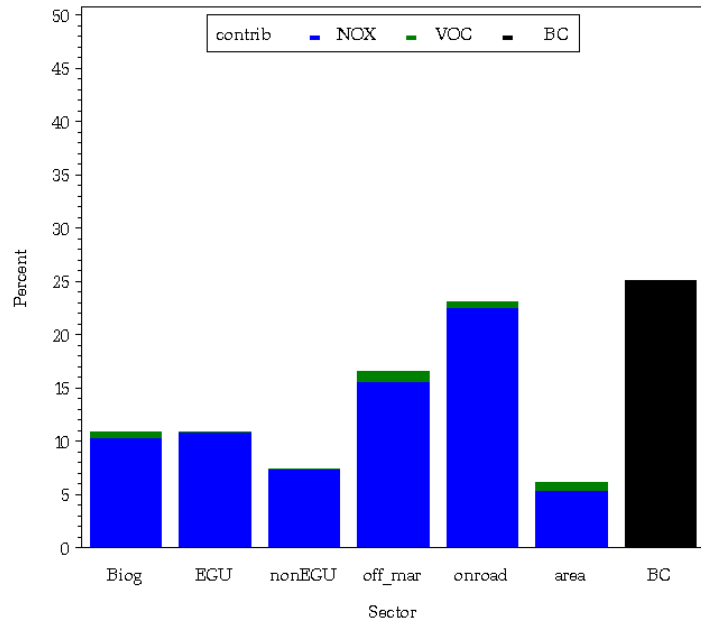
OH — Hamilton : (3906100061) K2012R4S1a_APCA_nopig



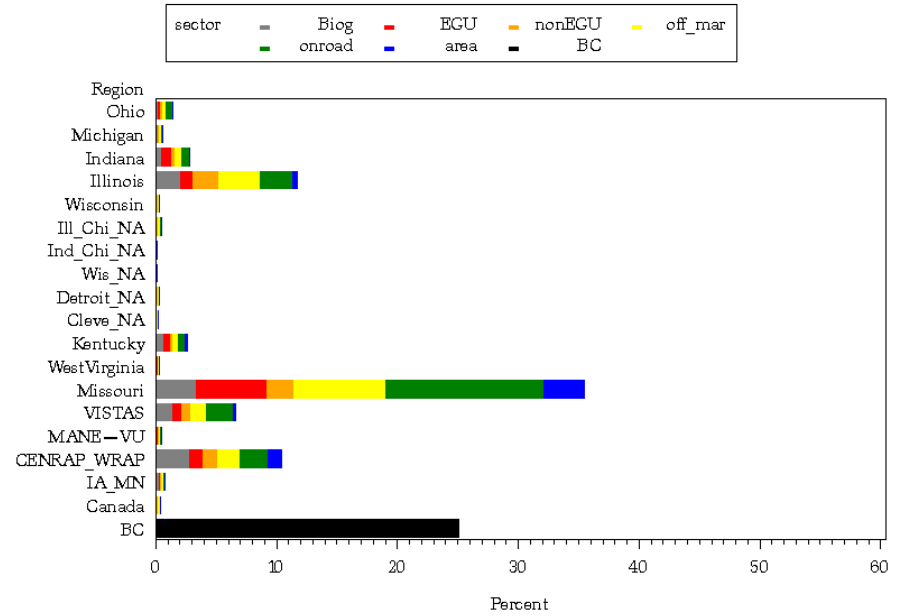
OH — Hamilton : (3906100061) K2012R4S1a_APCA_nopig



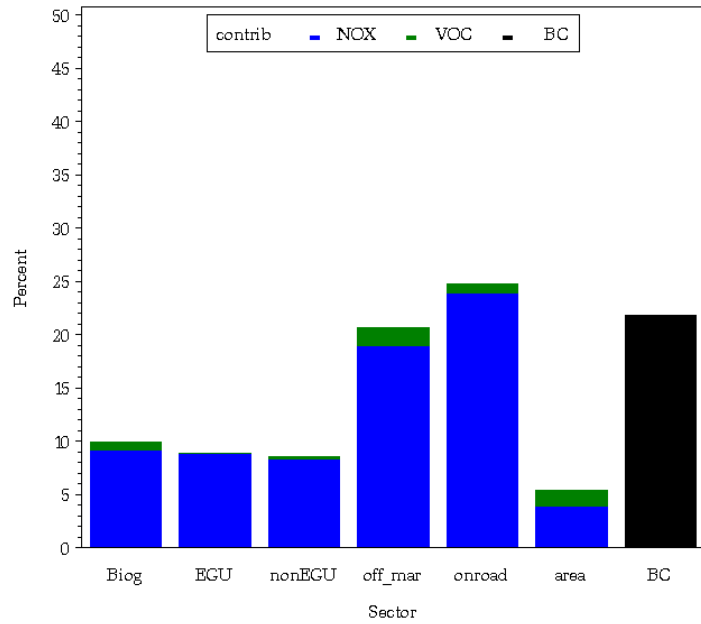
MO — St.Charles : (2918310021) 2009M3R5_osat



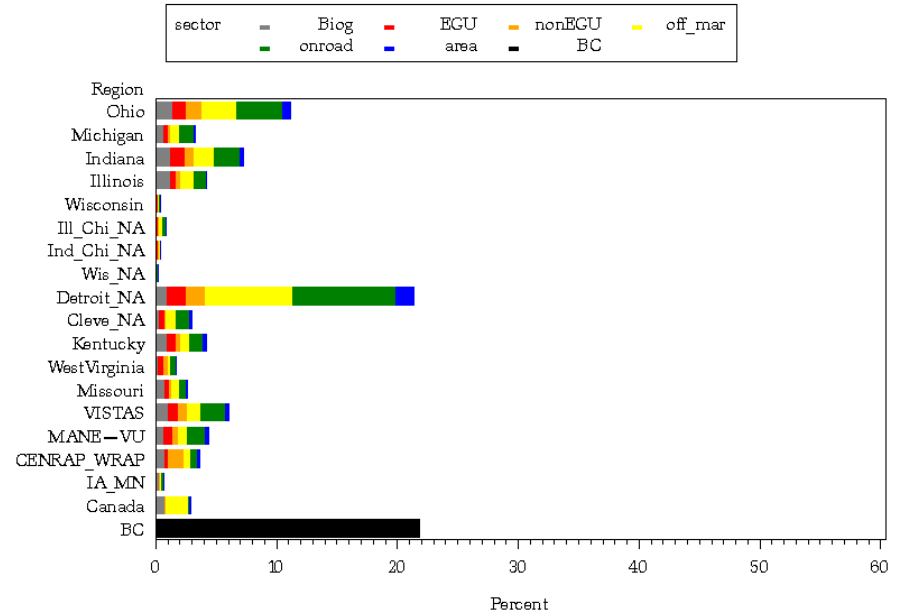
MO — St.Charles : (2918310021) 2009M3R5_osat



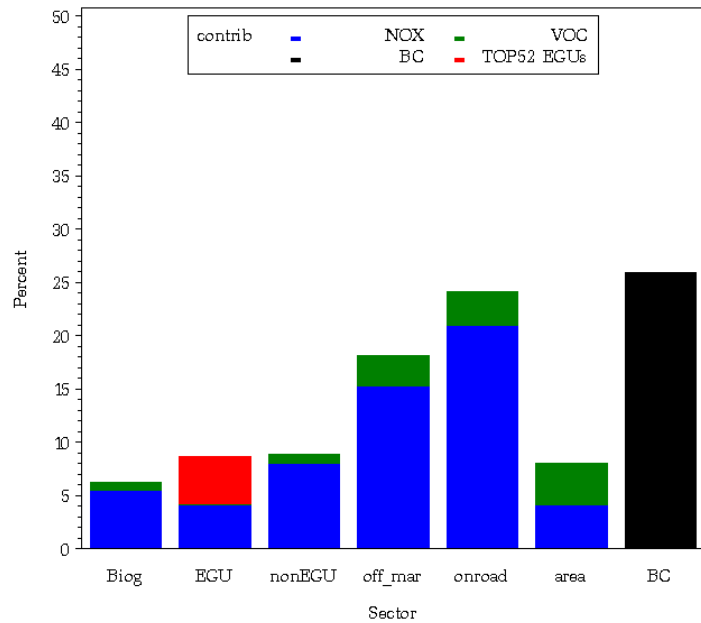
MI - Macomb : (2609900091) 2009M3R5_osat



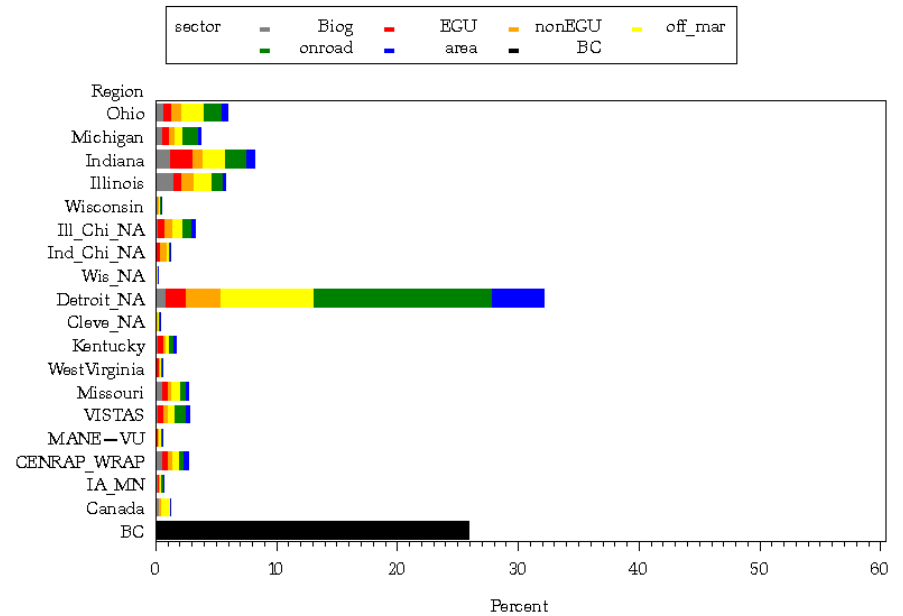
MI - Macomb : (2609900091) 2009M3R5_osat



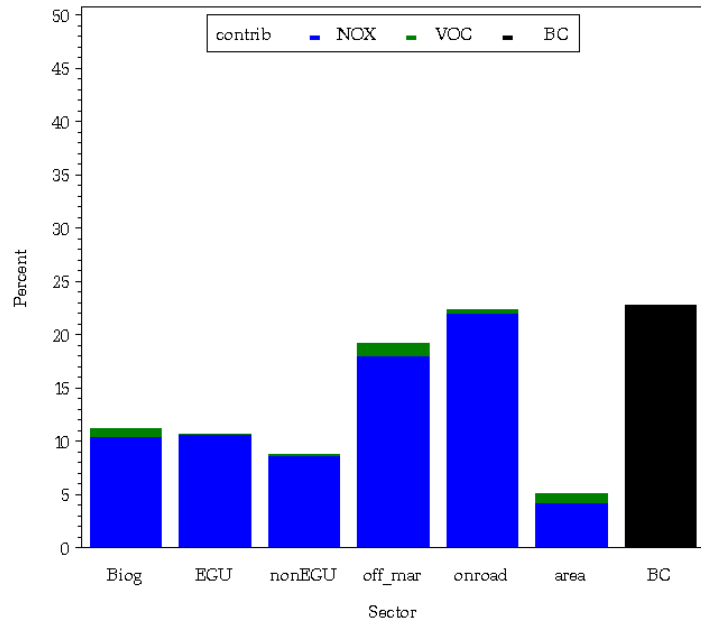
MI - Macomb : (2609900091) K2012R4S1a_APCA_nopig



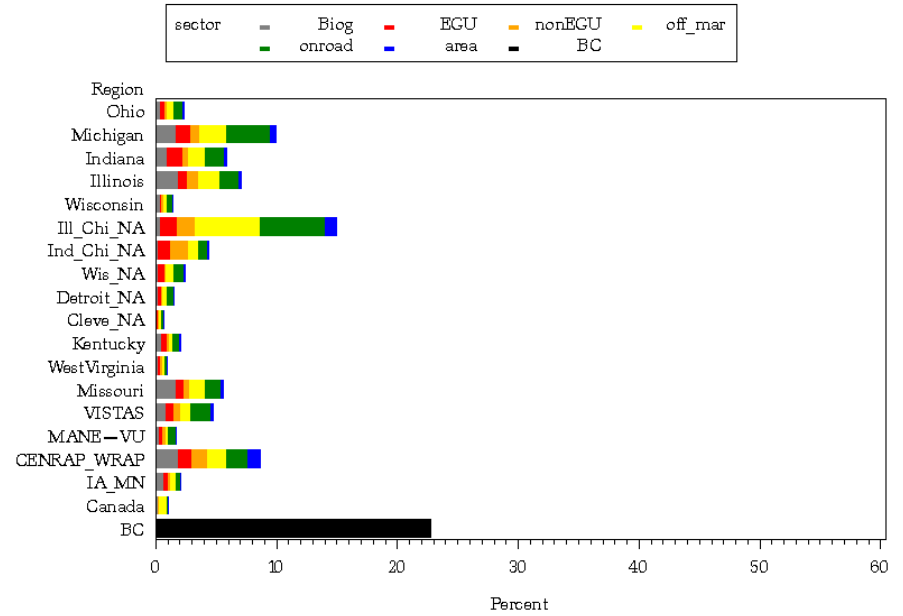
MI - Macomb : (2609900091) K2012R4S1a_APCA_nopig



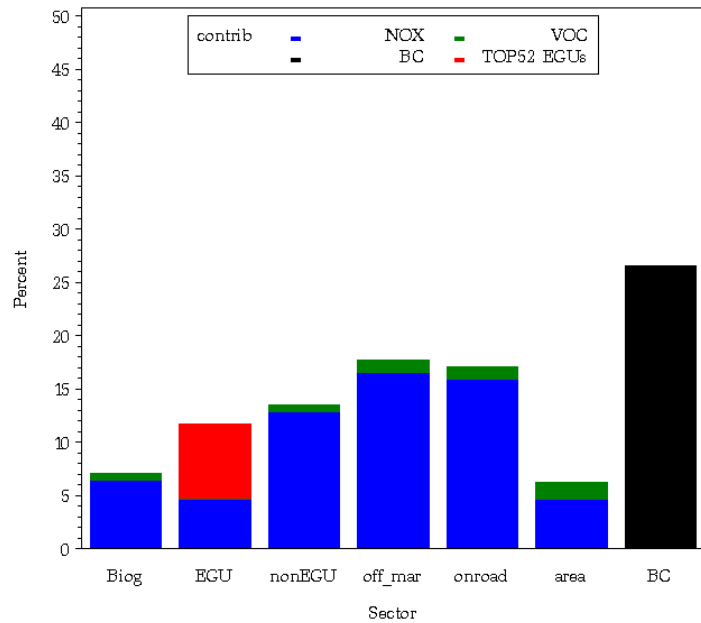
MI — Allegan : (260050003 I) 2009M3R5_osat



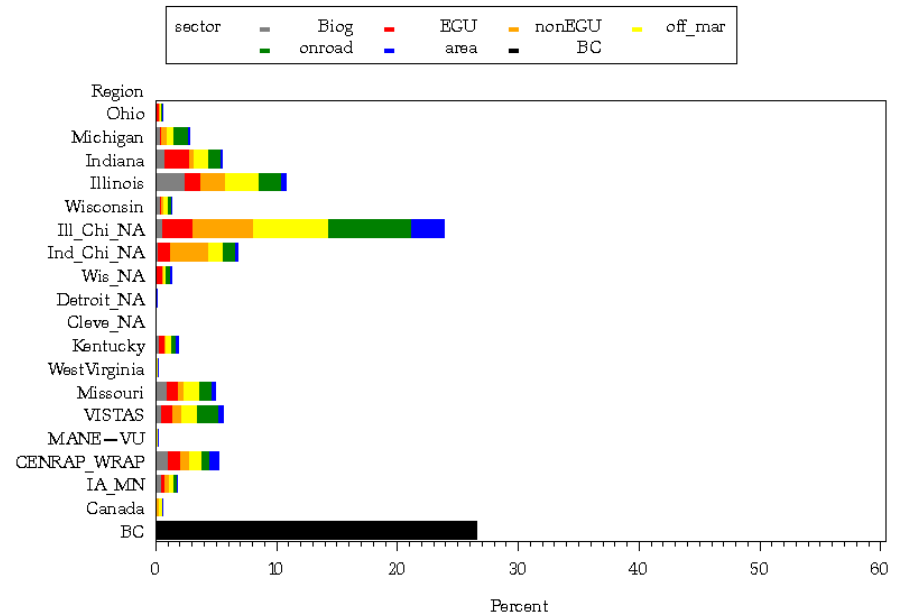
MI — Allegan : (260050003 I) 2009M3R5_osat



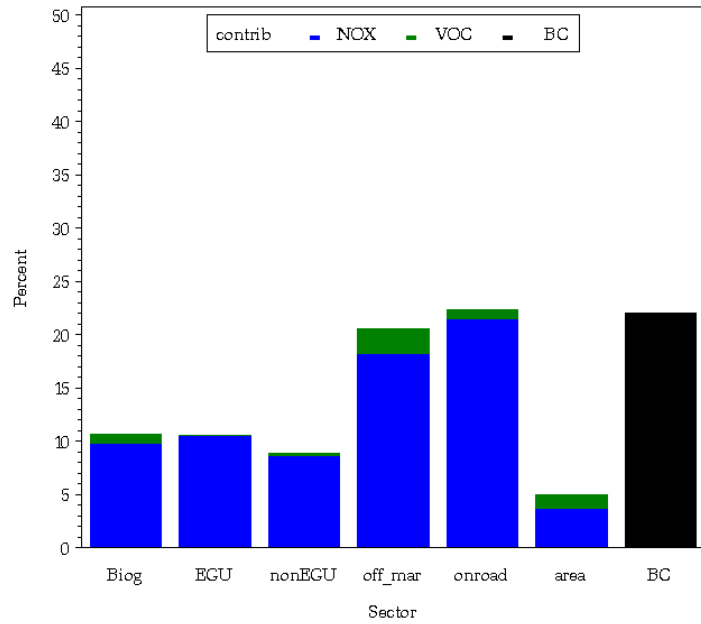
MI — Allegan : (260050003 I) K2012R4S1a_APCA_nopig



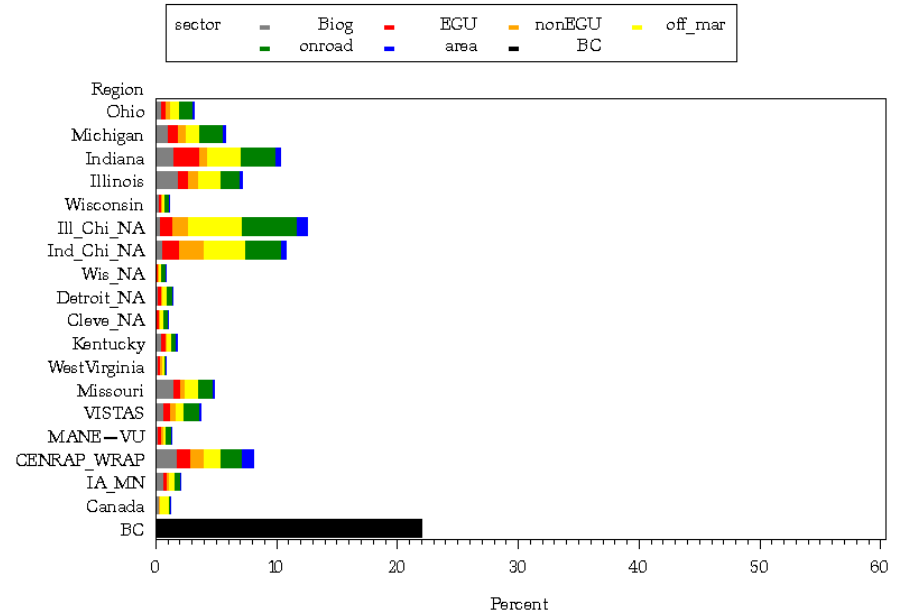
MI — Allegan : (260050003 I) K2012R4S1a_APCA_nopig



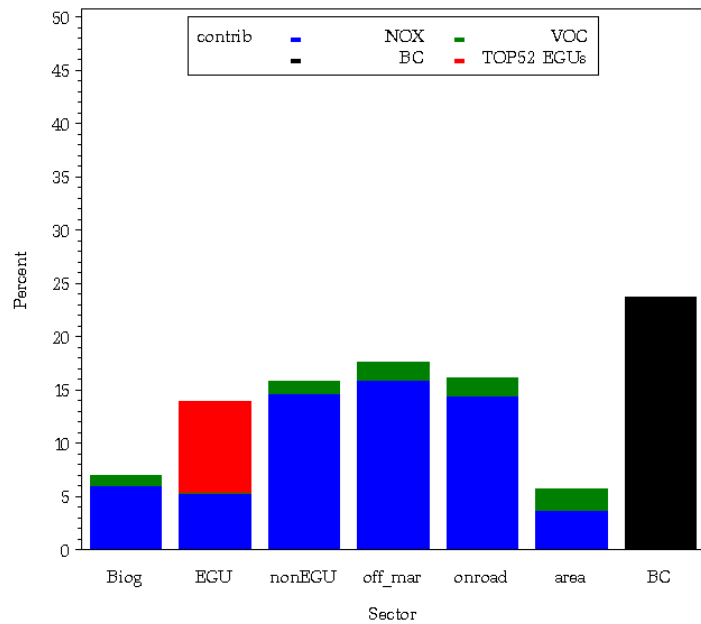
IN — LaPorte : (1809100051) 2009M3R5_osat



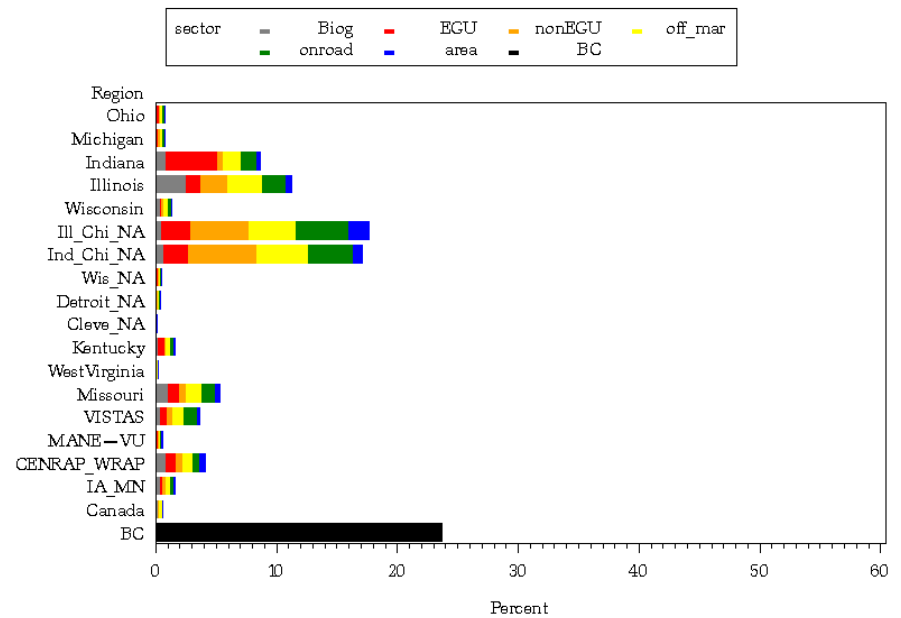
IN — LaPorte : (1809100051) 2009M3R5_osat



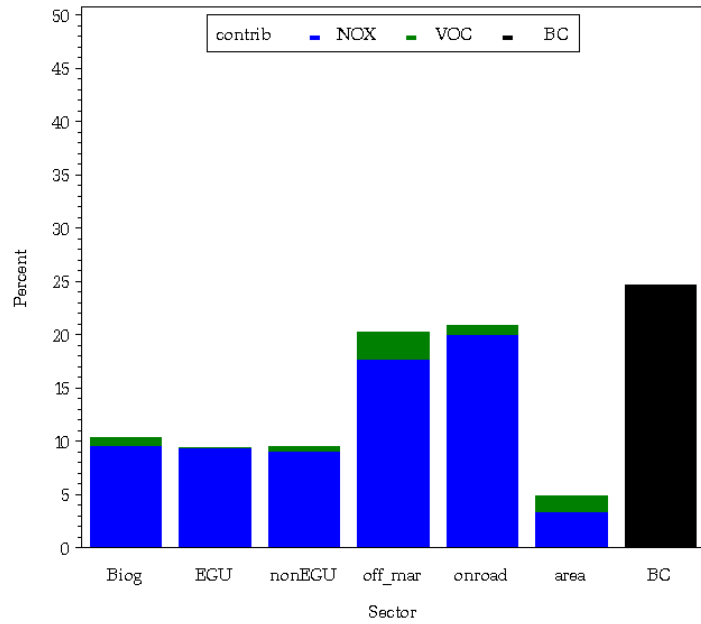
IN — LaPorte : (1809100051) K2012R4Sla_APCA_nopig



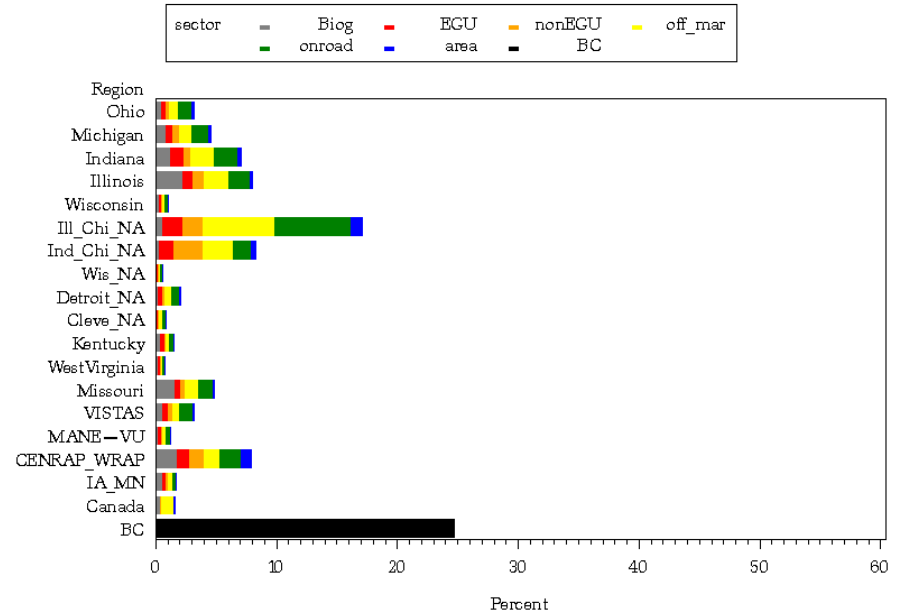
IN — LaPorte : (1809100051) K2012R4Sla_APCA_nopig



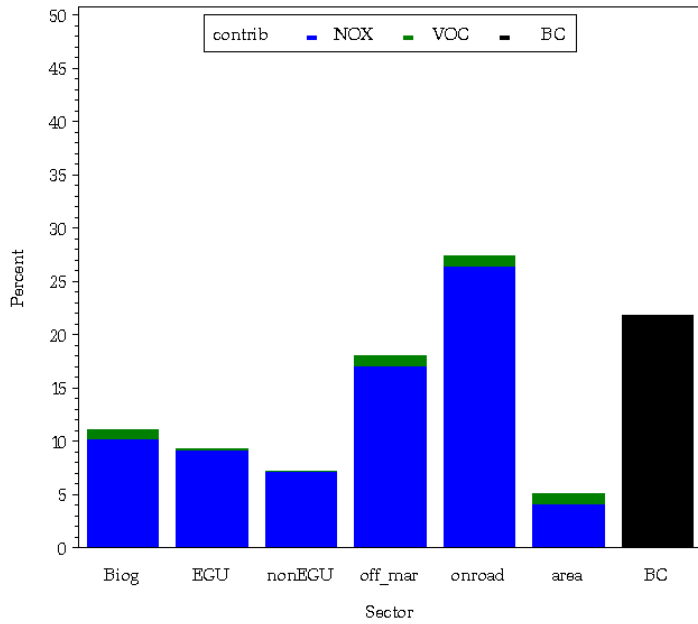
IN - Lake : (180892008) 2009M3R5_osat



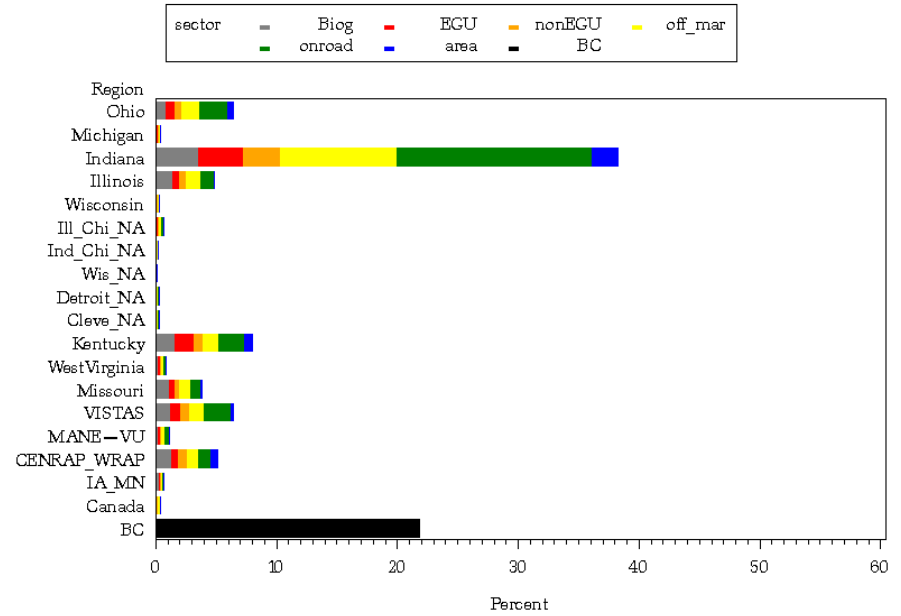
IN - Lake : (180892008) 2009M3R5_osat



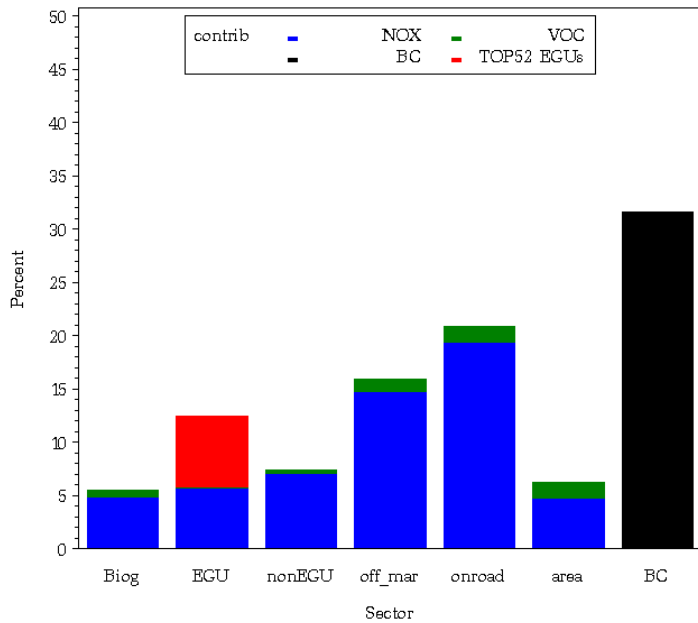
IN — Hamilton : (1805710011) 2009M3R5_osat



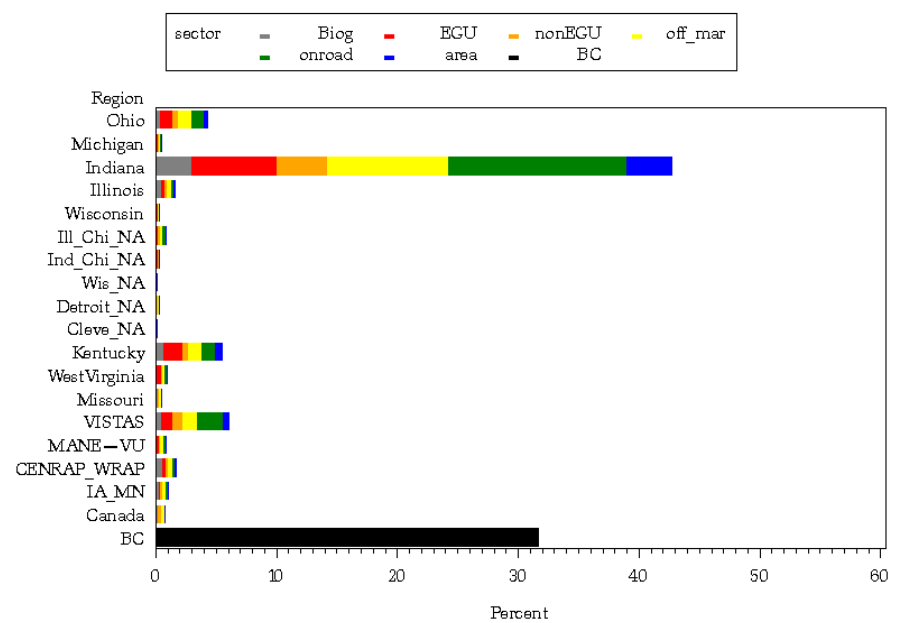
IN — Hamilton : (1805710011) 2009M3R5_osat



IN — Hamilton : (1805710011) K2012R4S1a_APCA_nopig



IN — Hamilton : (1805710011) K2012R4S1a_APCA_nopig



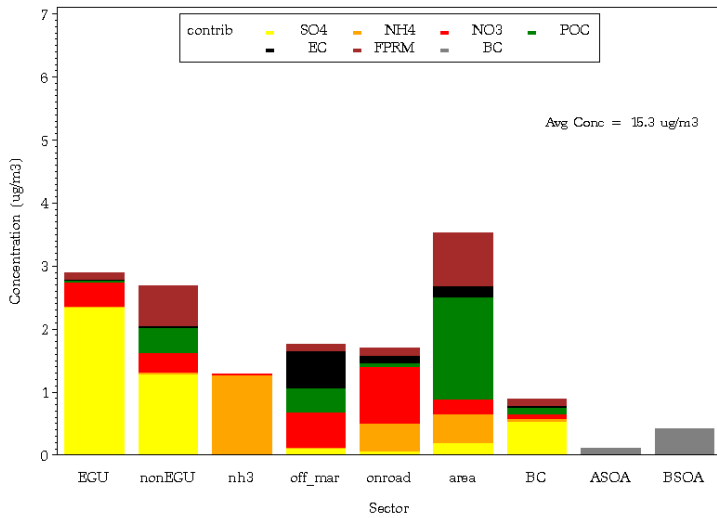
APPENDIX III

PM_{2.5} Source Apportionment Modeling Results

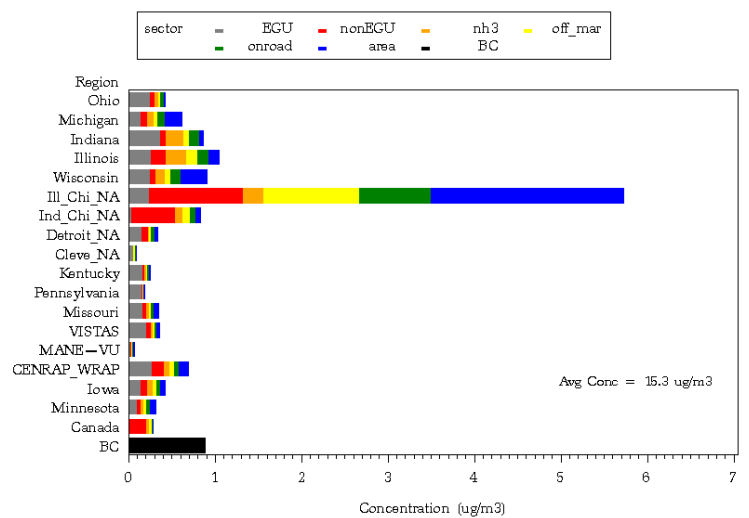
Chicago (Cicero), Illinois

2005 (Round 5)

IL - Cook : (170316005) baseM3

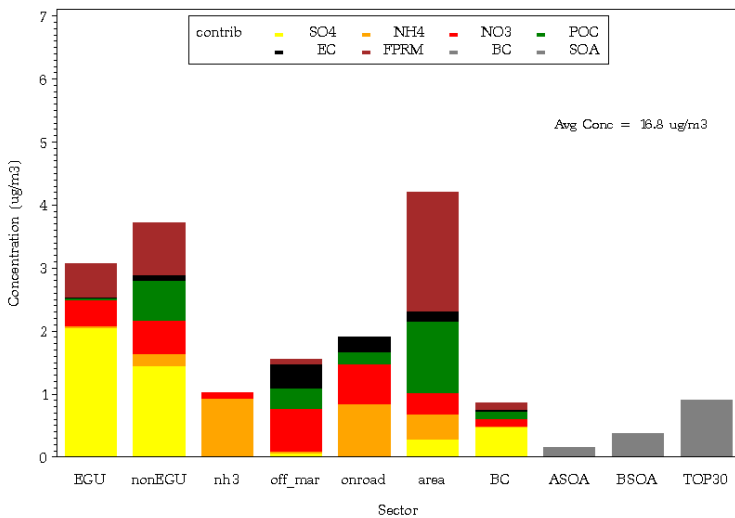


IL - Cook : (170316005) baseM3

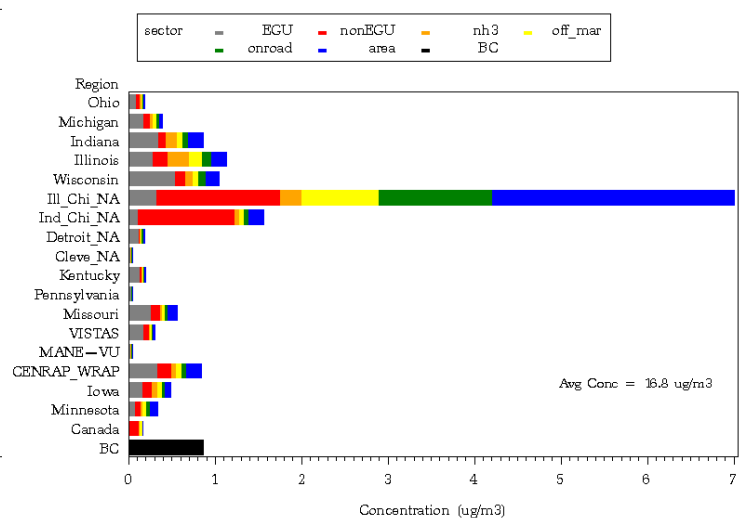


2012 (Round 4)

IL - Cook : (170316005) K2012R4S1a

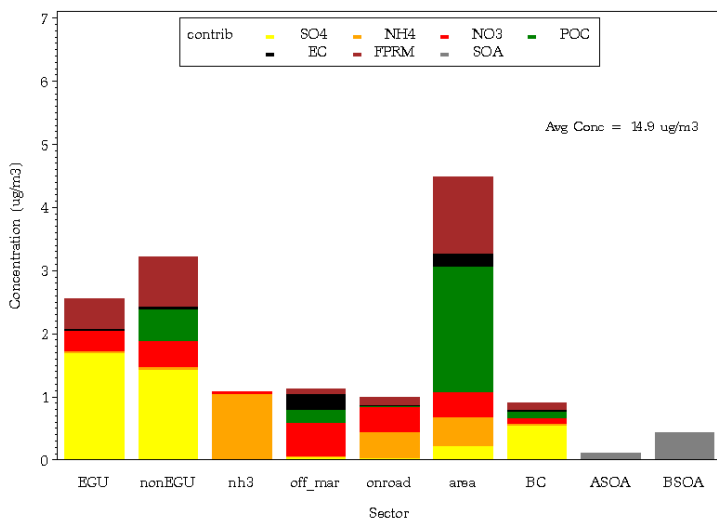


IL - Cook : (170316005) K2012R4S1a

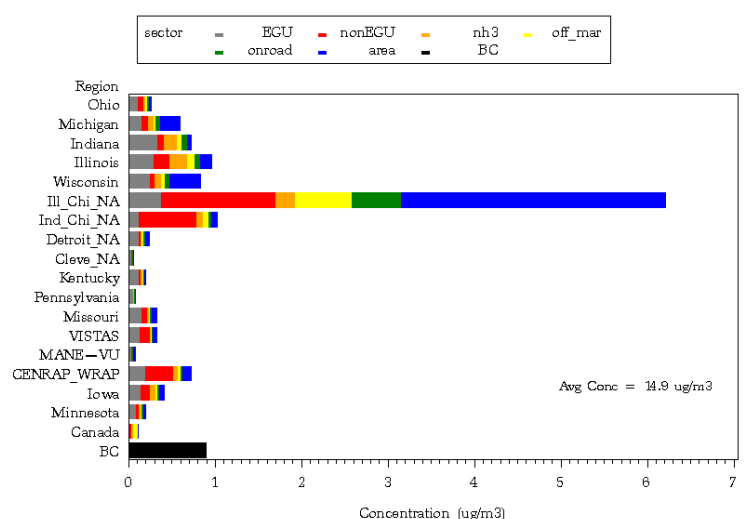


2018 (Round 5)

IL - Cook : (170316005) 2018M3R5.1sh



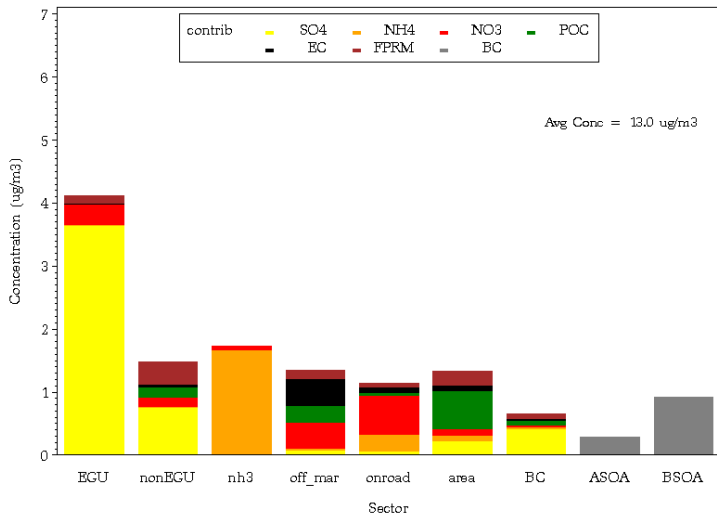
IL - Cook : (170316005) 2018M3R5.1sh



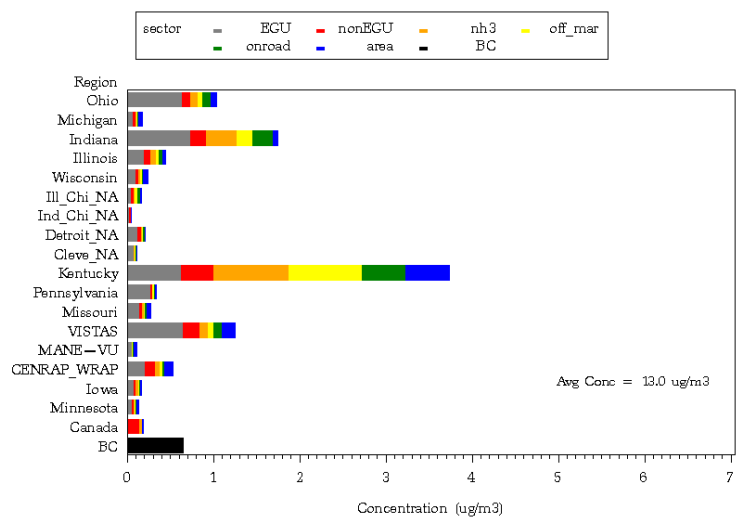
Clark County, Indiana

2005 (Round 5)

IN - Clark : (180190005) baseM3

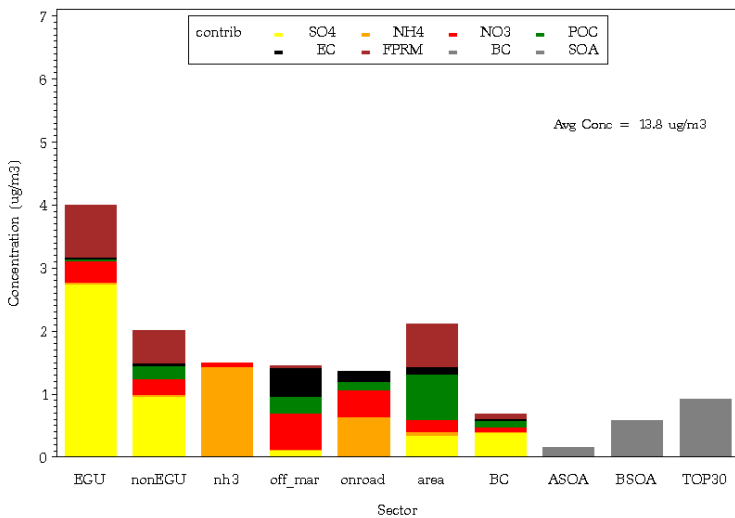


IN - Clark : (180190005) baseM3

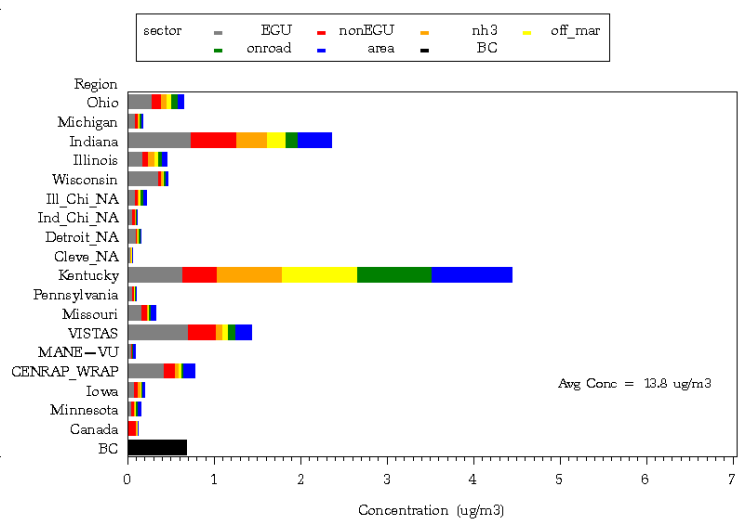


2012 (Round 4)

IN - Clark : (180190005) K2012R4S1a

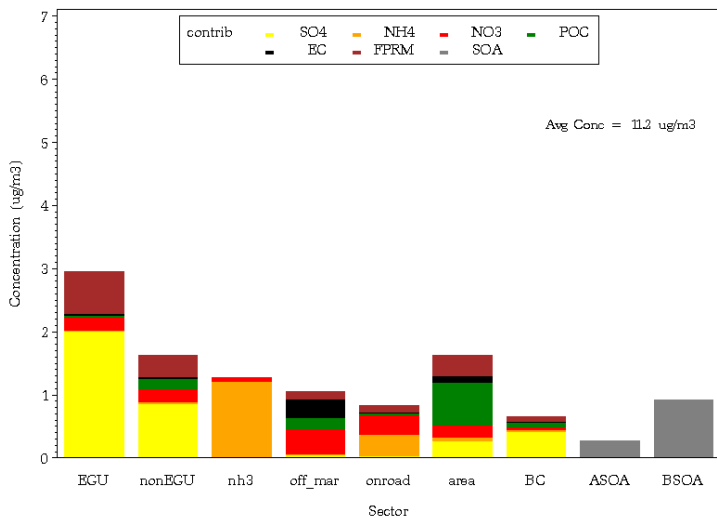


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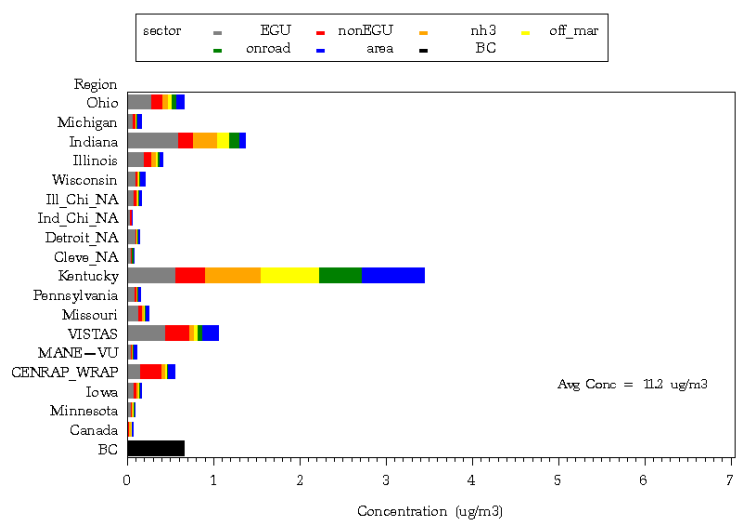


2018 (Round 5)

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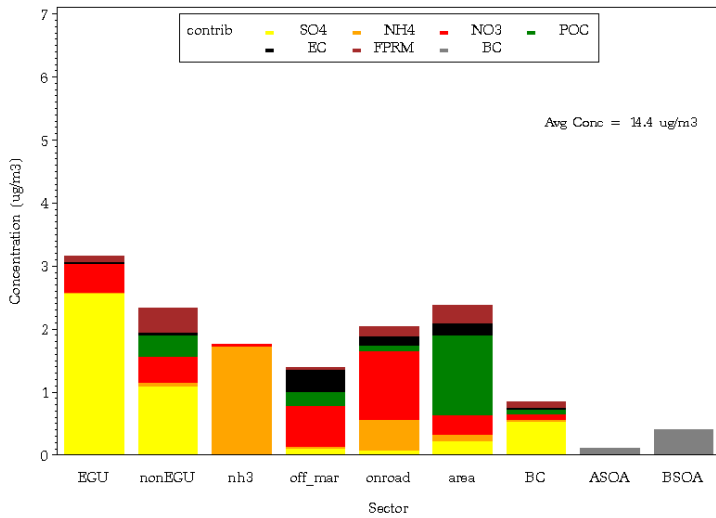
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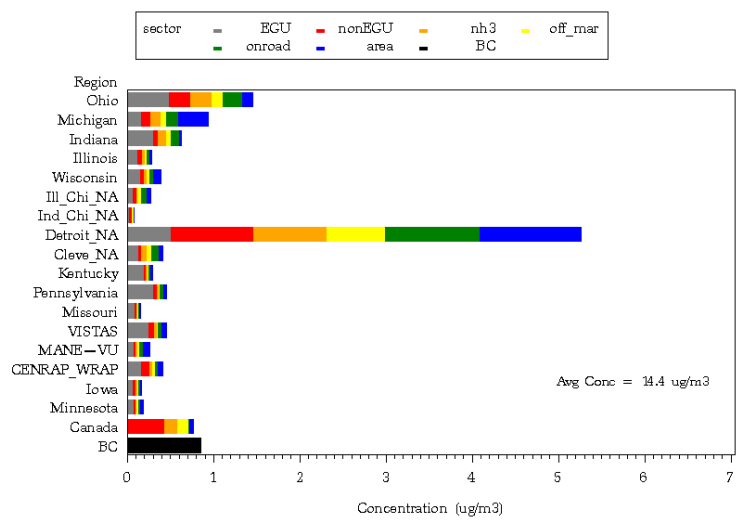
Dearborn, Michigan

2005 (Round 5)

MI - Wayne : (261630033) baseM3

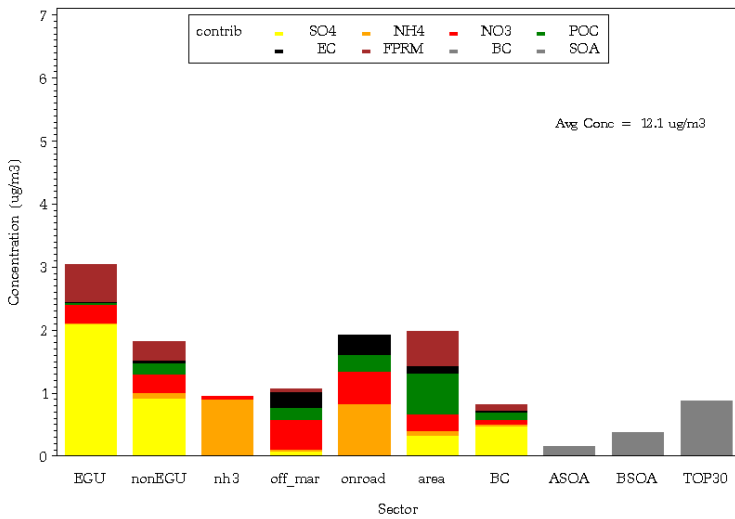


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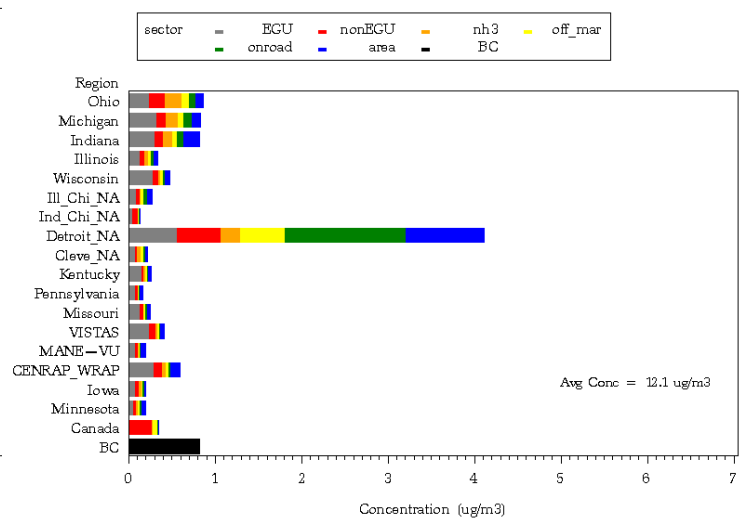


2012 (Round 4)

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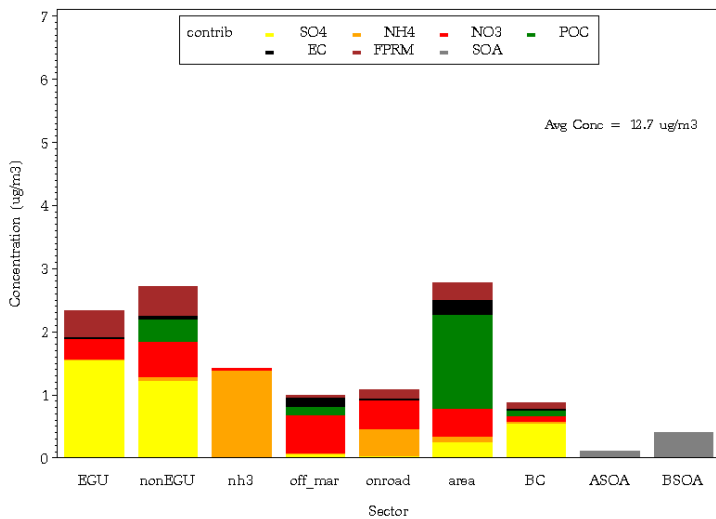


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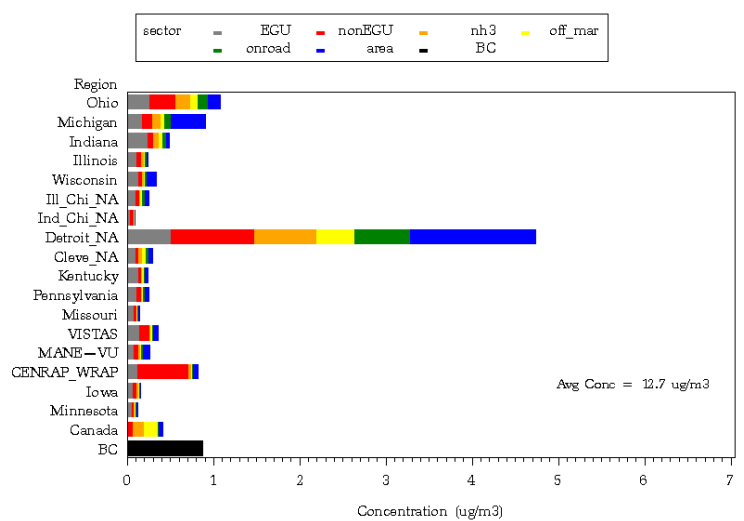


2018 (Round 5)

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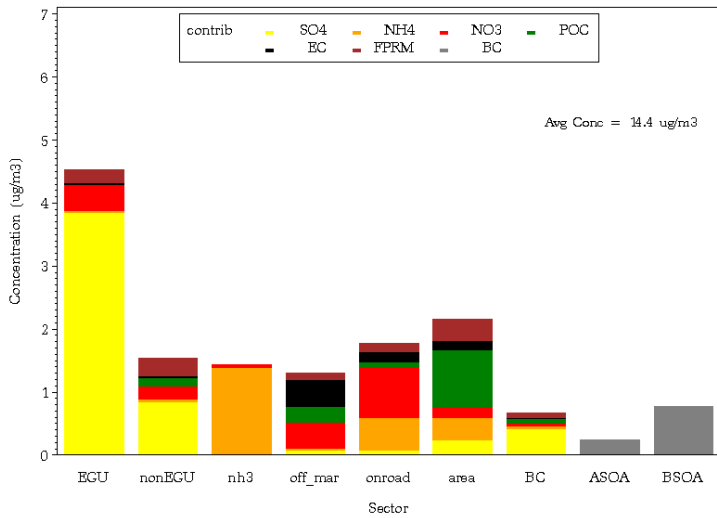
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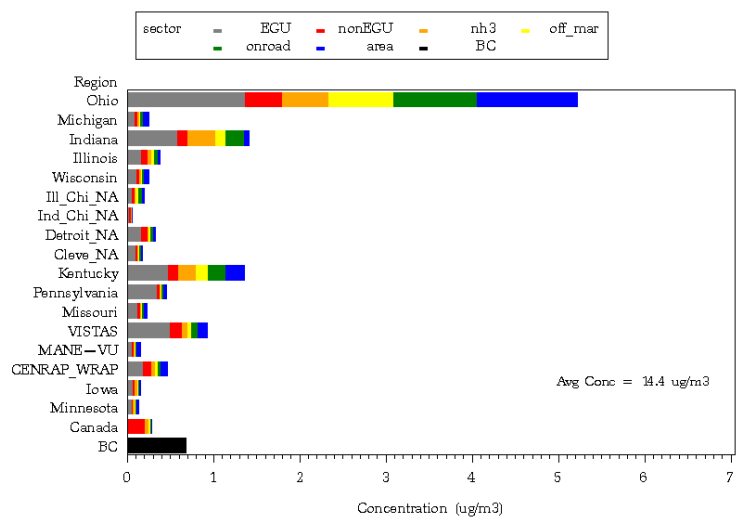
Cincinnati, Ohio

2005 (Round 5)

OH - Hamilton : (39061001) baseM3

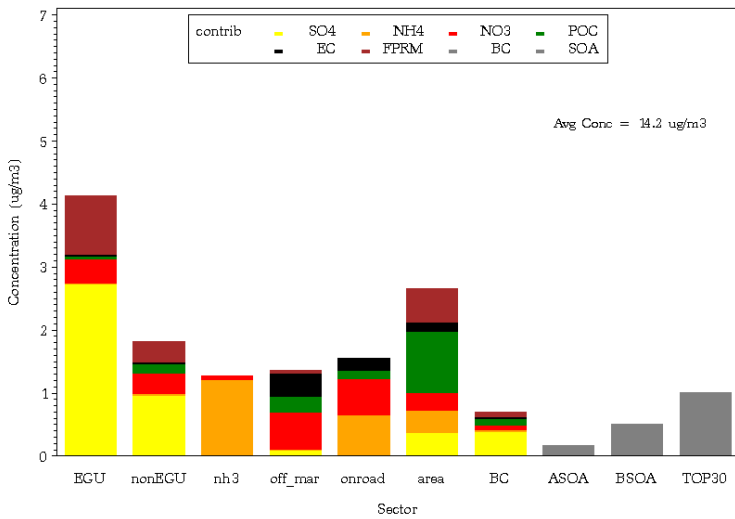


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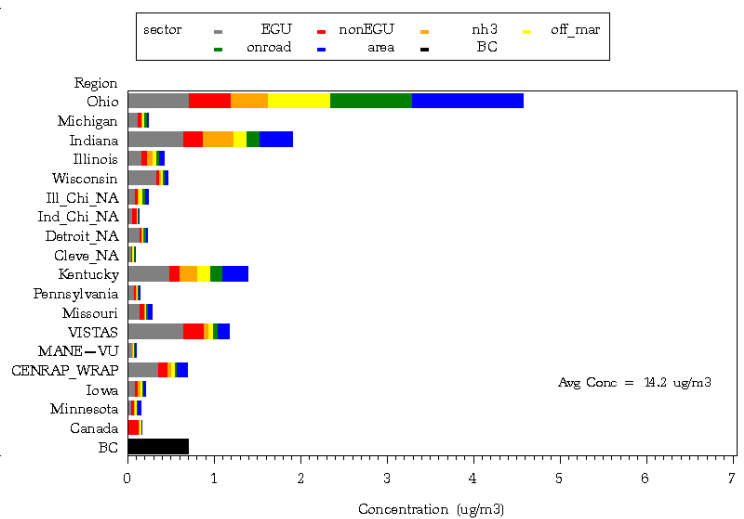


2012 (Round 4)

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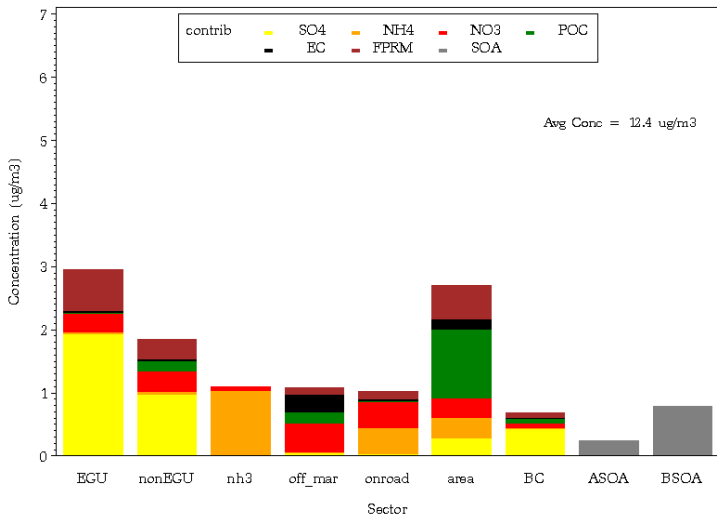


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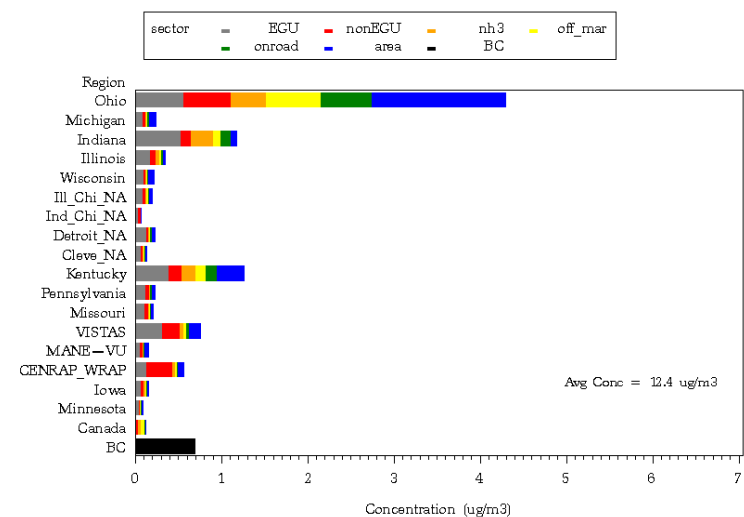


2018 (Round 5)

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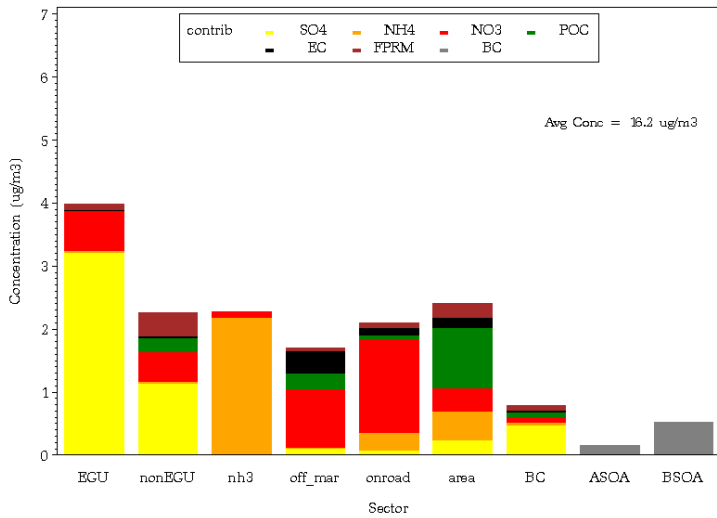
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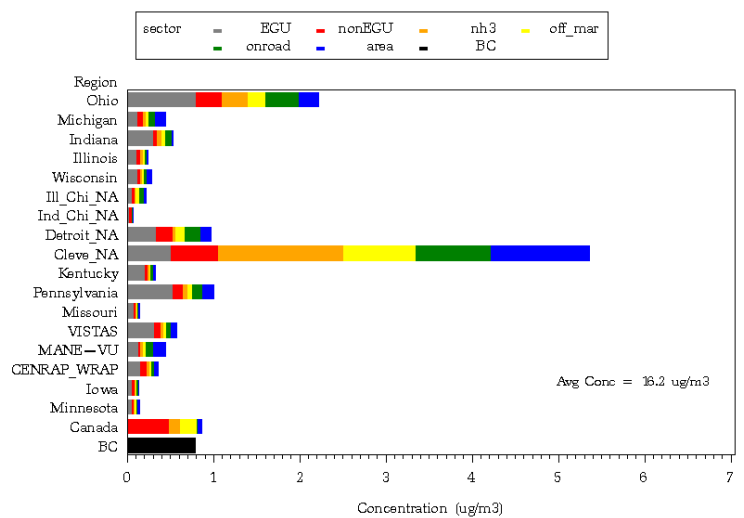
Cleveland, Ohio

2005 (Round 5)

OH - Cuyahoga : (390350038) baseM3

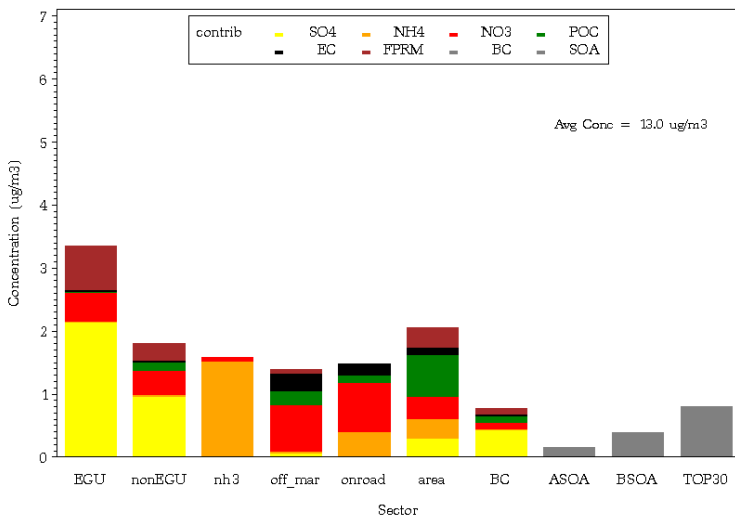


OH - Cuyahoga : (390350038) baseM3

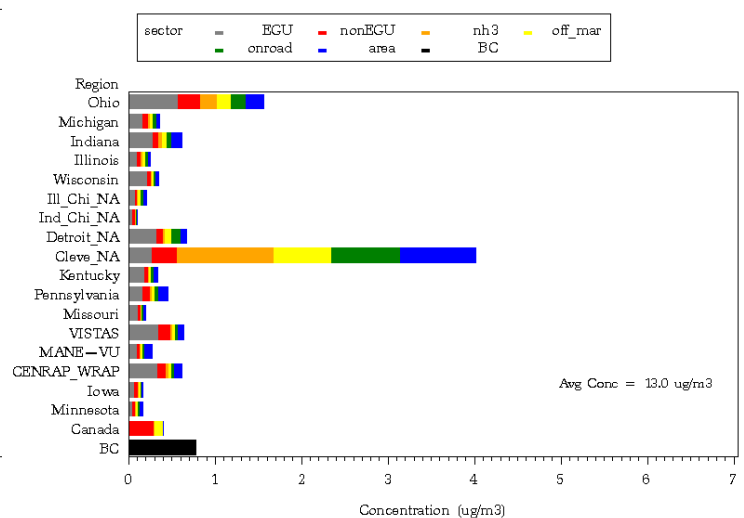


2012 (Round 4)

OH - Cuyahoga : (390350038) K20ER4S1a

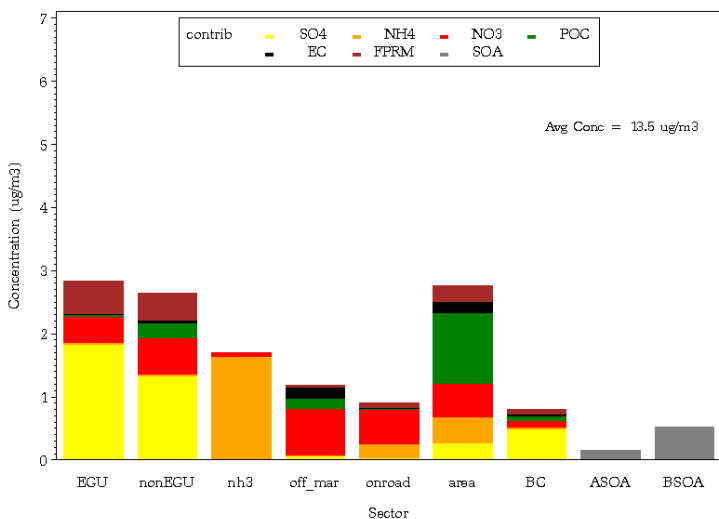


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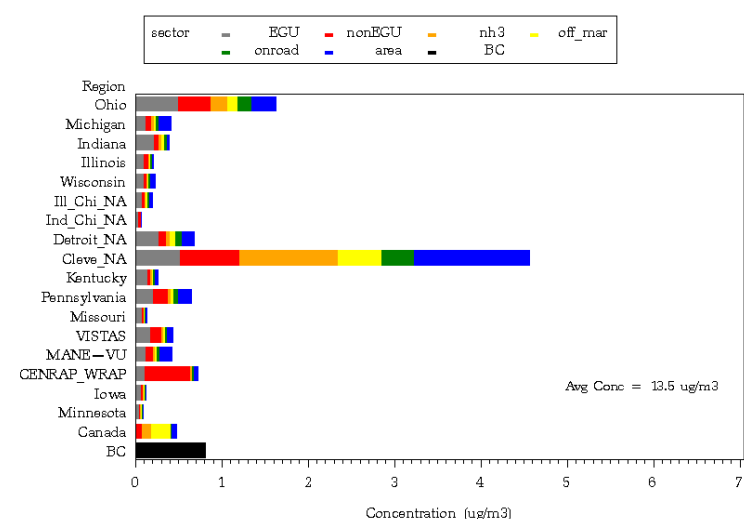


2018 (Round 5)

OH - Cuyahoga : (390350038) 2018M3R5.1a



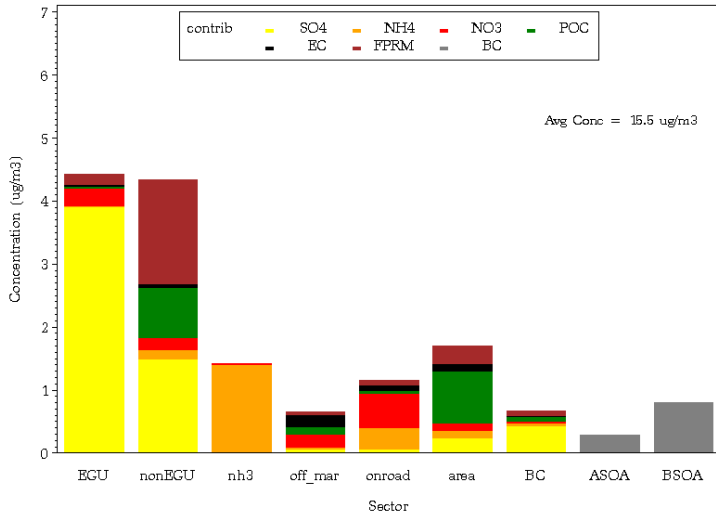
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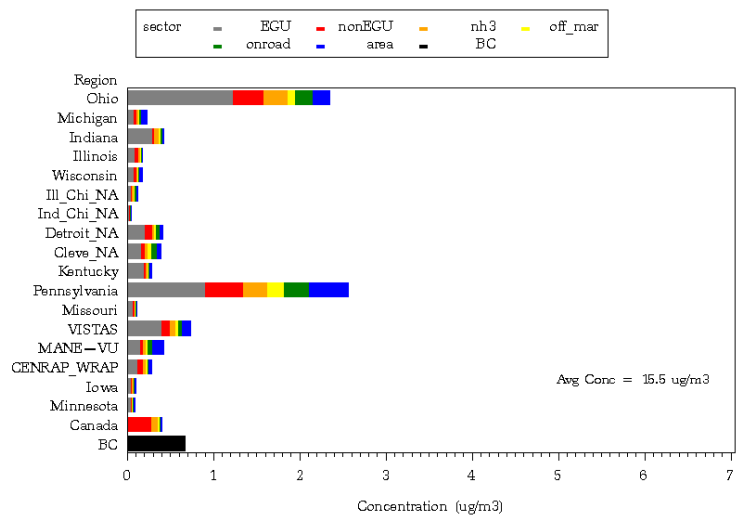
Steubenville, Ohio

2005 (Round 5)

OH — Jefferson : (390810016) baseM3

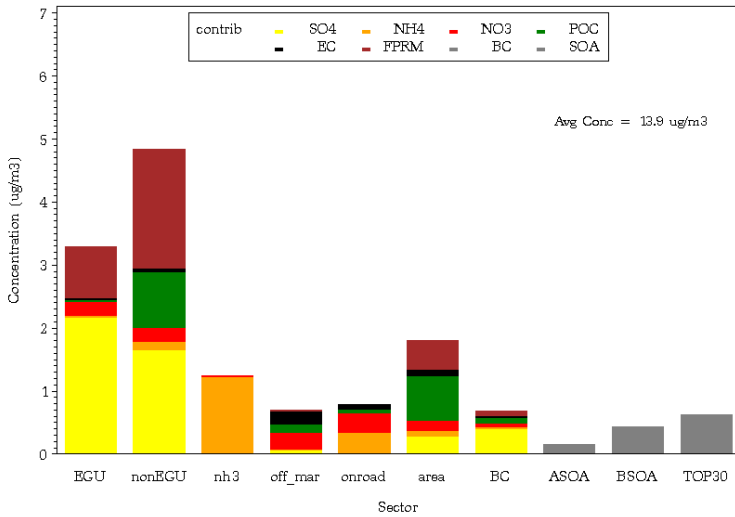


OH — Jefferson : (390810016) baseM3

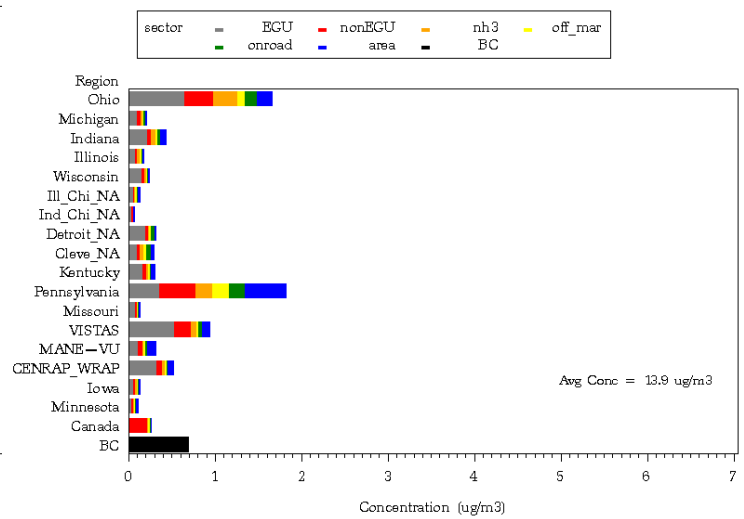


2012 (Round 4)

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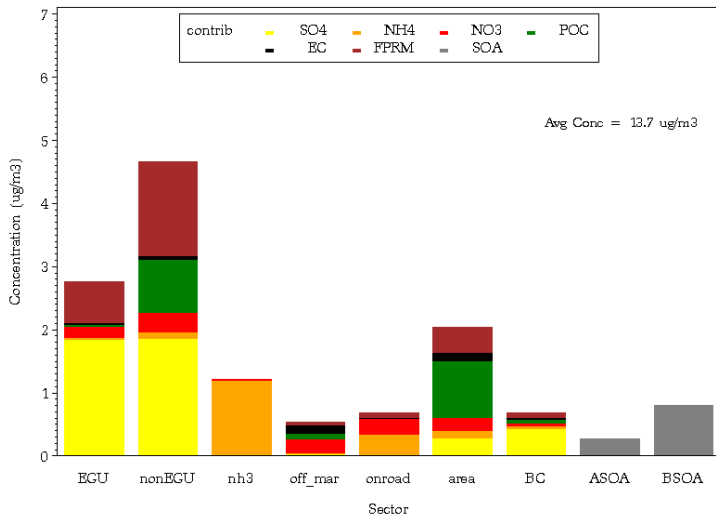


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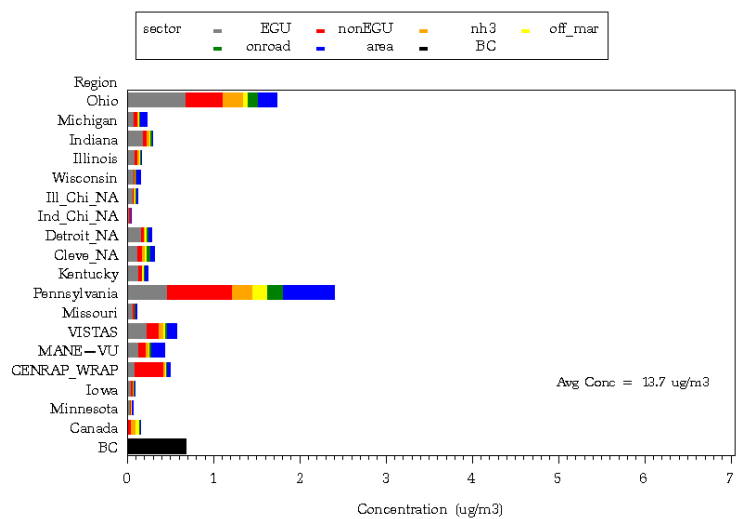


2018 (Round 5)

OH — Jefferson : (390810016) 2018M3R5.1s1a



OH — Jefferson : (390810016) 2018M3R5.1s1a



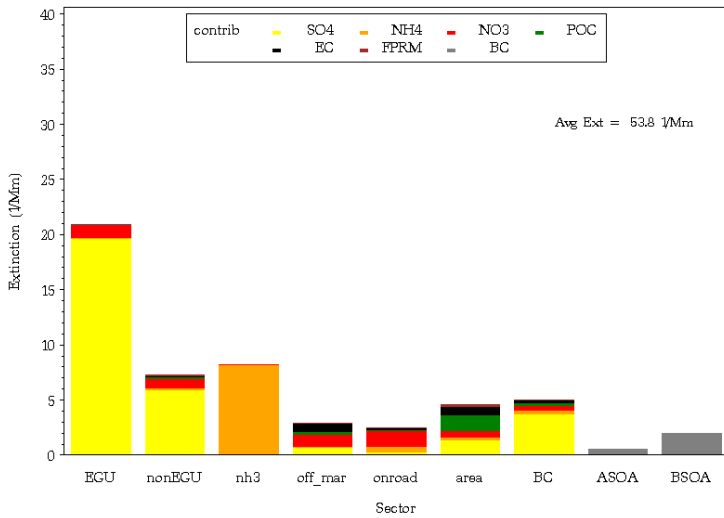
APPENDIX IV

Haze Source Apportionment Modeling Results

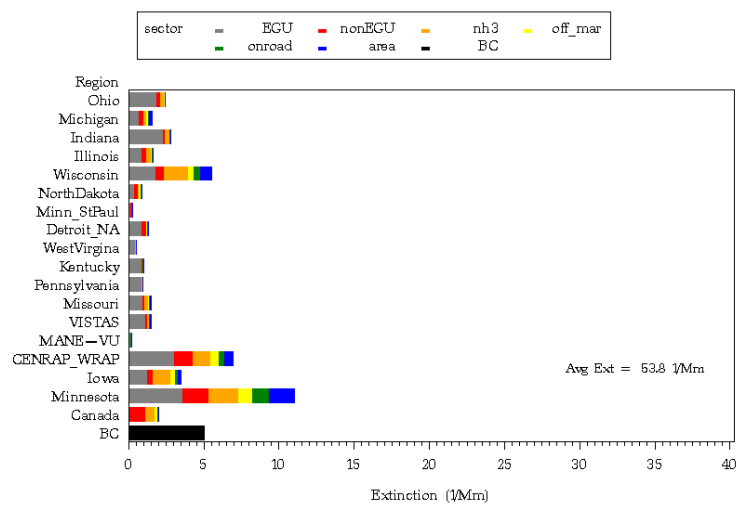
Boundary Waters, Minnesota

2005 (Round 5)

BOWA1 — baseM3_psatAP25so4

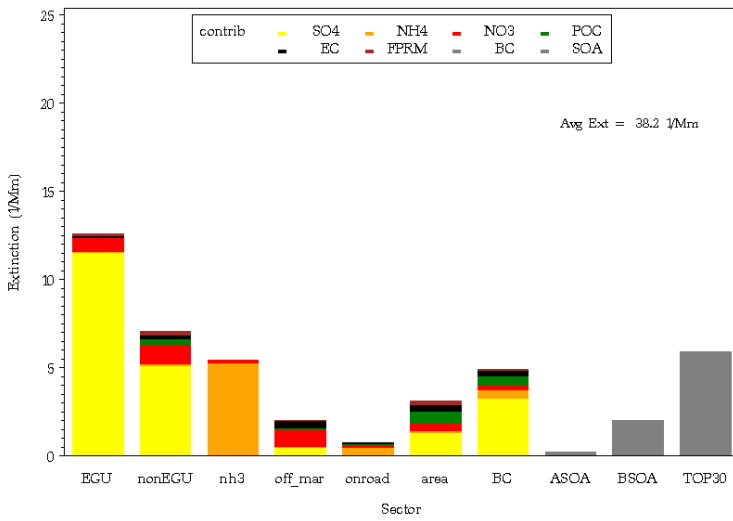


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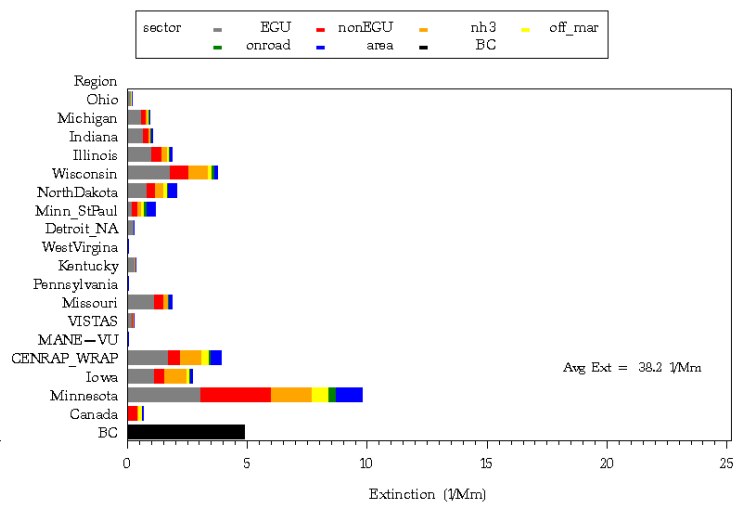


2018 (Round 4)

BOWA1 — K2018R4S1a

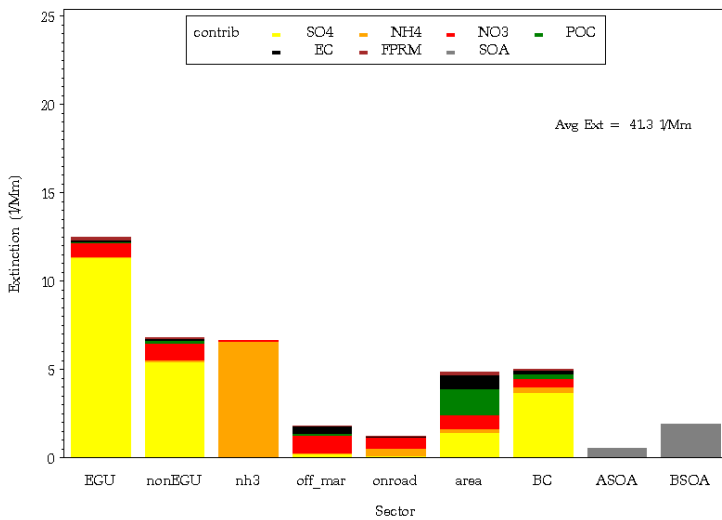


BOWA1 — K2018R4S1a

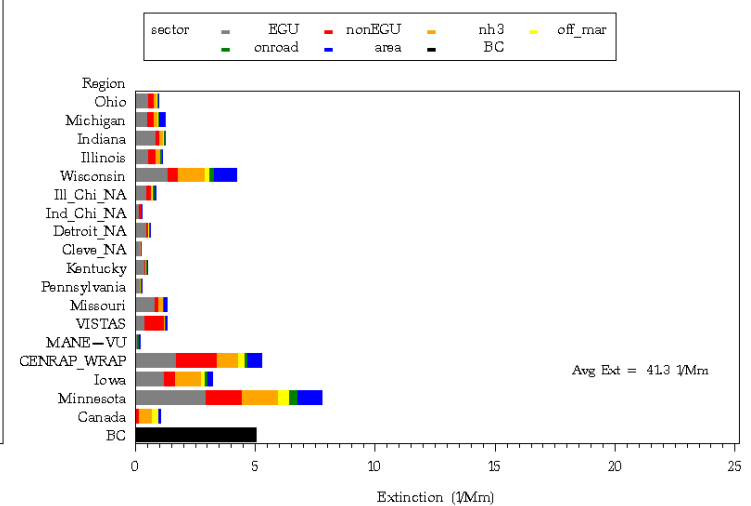


2018 (Round 5)

BOWA1 — 2018M3R5_psatAP25+ HAZEso4



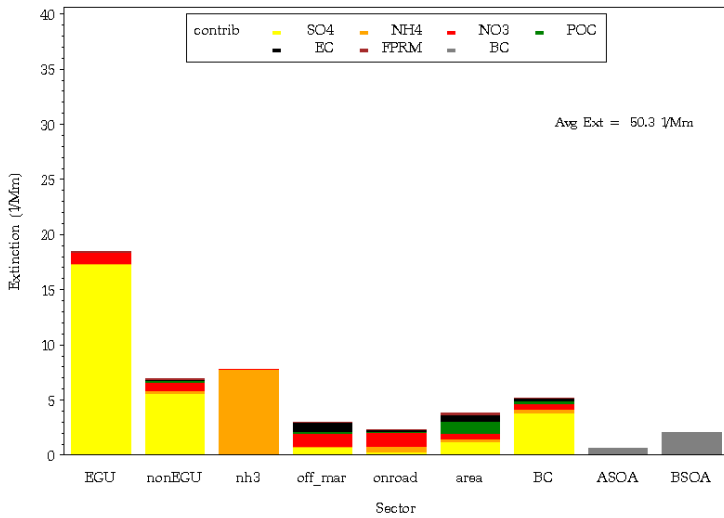
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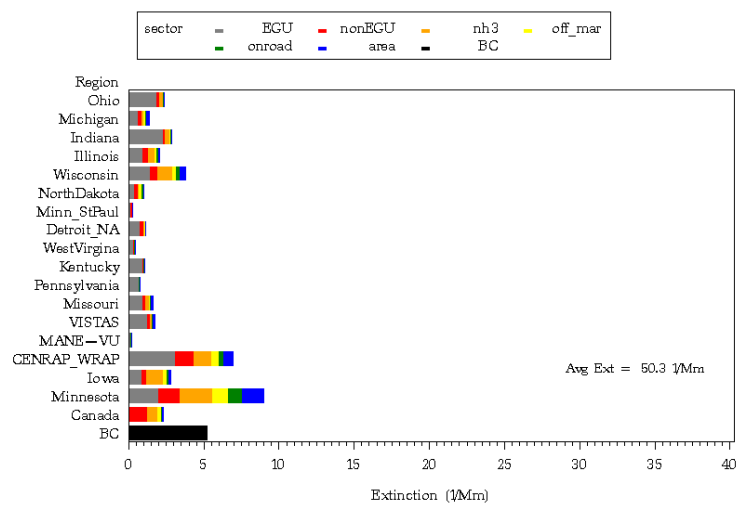
Voyageurs, Minnesota

2005 (Round 5)

VOYA2 - baseM3_psatAP25so4

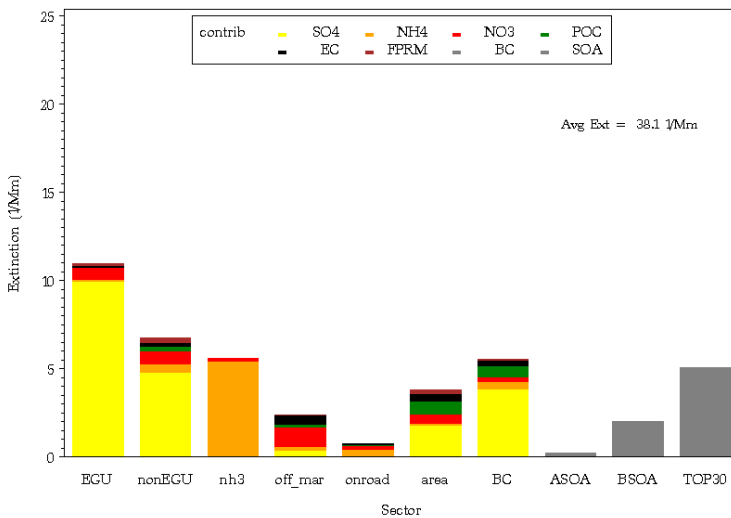


VOYA2 - baseM3_psatAP25so4

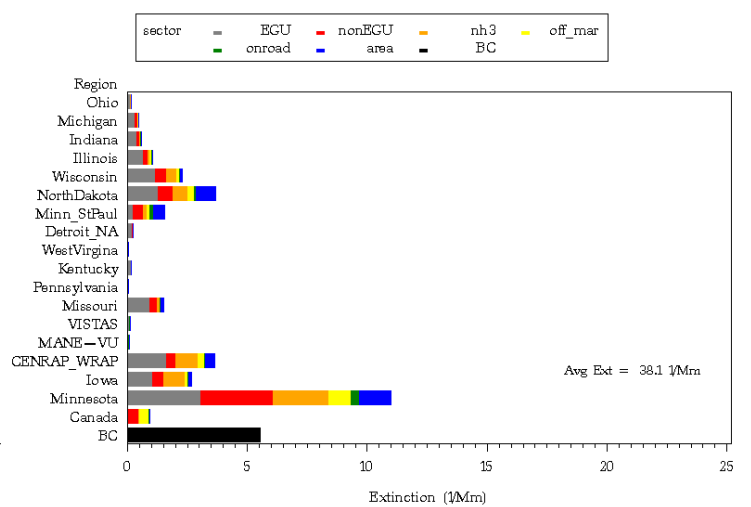


2018 (Round 4)

VOYA2 - K2018R4S1a

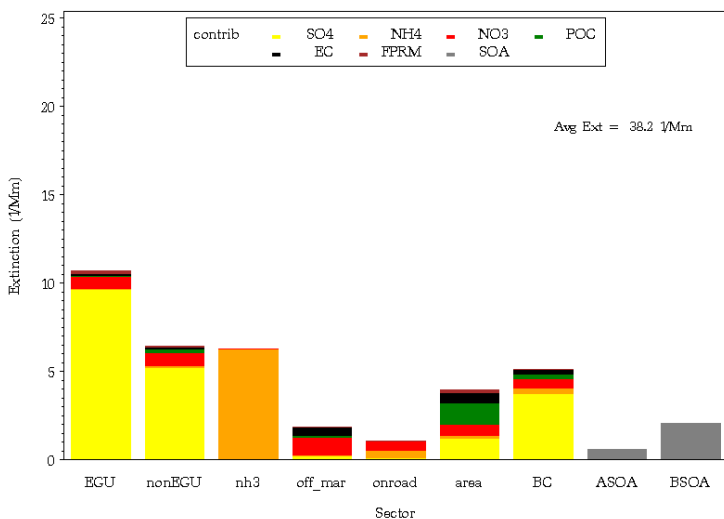


VOYA2 - K2018R4S1a

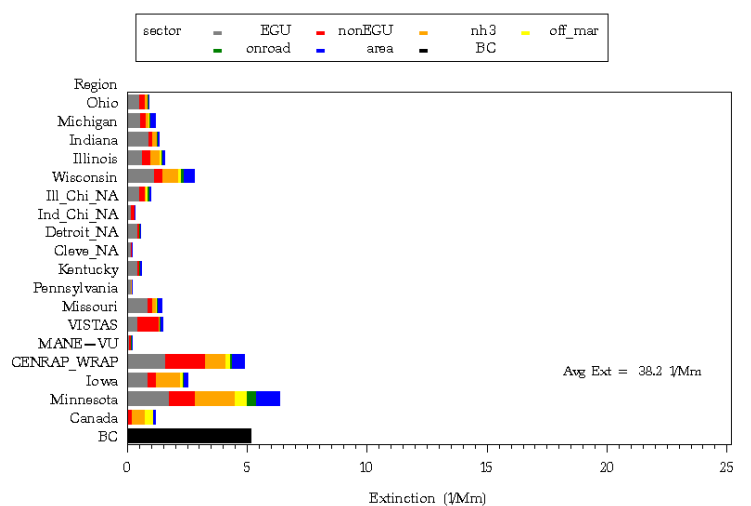


2018 (Round 5)

VOYA2 - 2018M3R5_psatAP25+HAZEso4



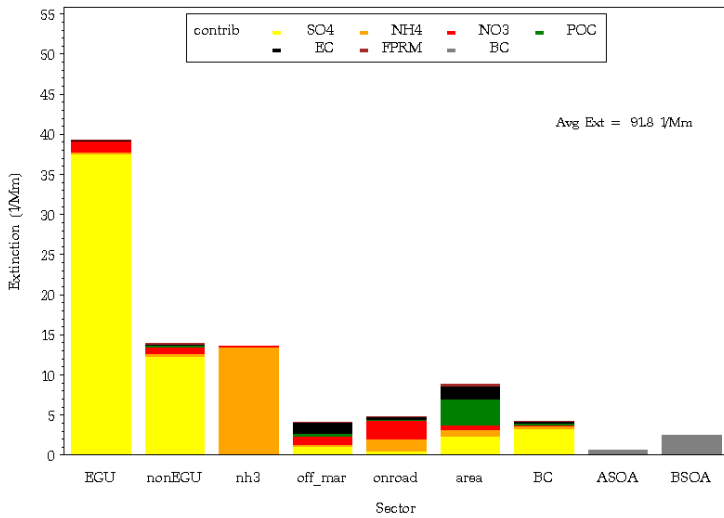
VOYA2 - 2018M3R5_psatAP25+HAZEso4



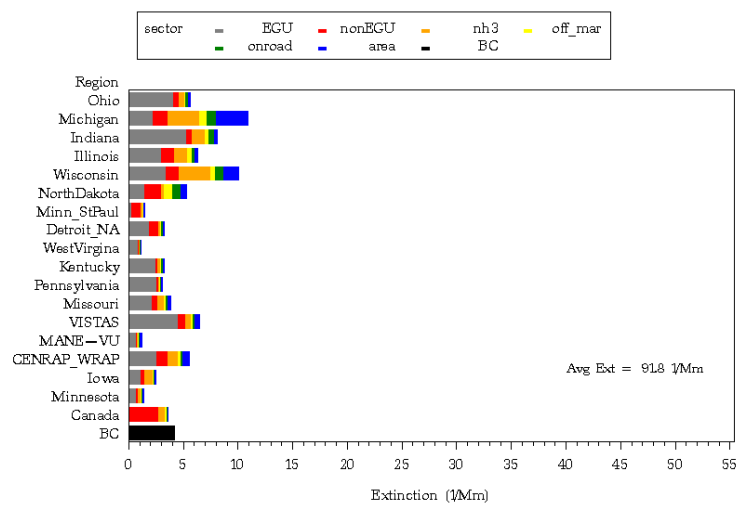
Seney, Michigan

2005 (Round 5)

SENE1 - baseM3_psatAP25so4

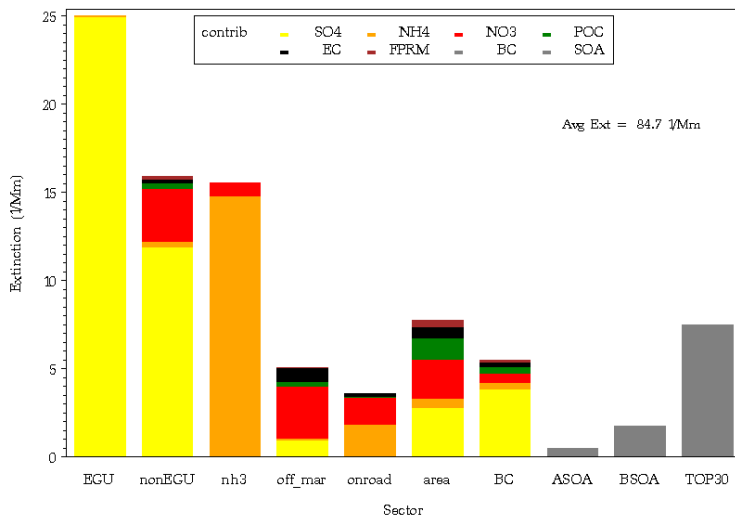


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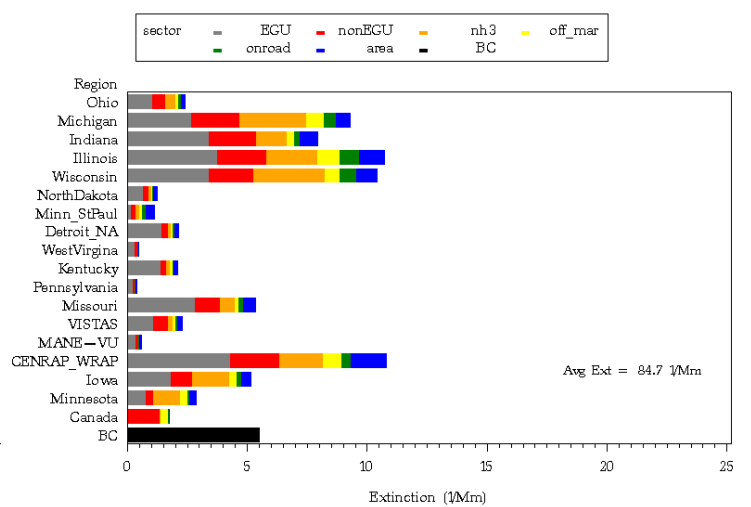


2018 (Round 4)

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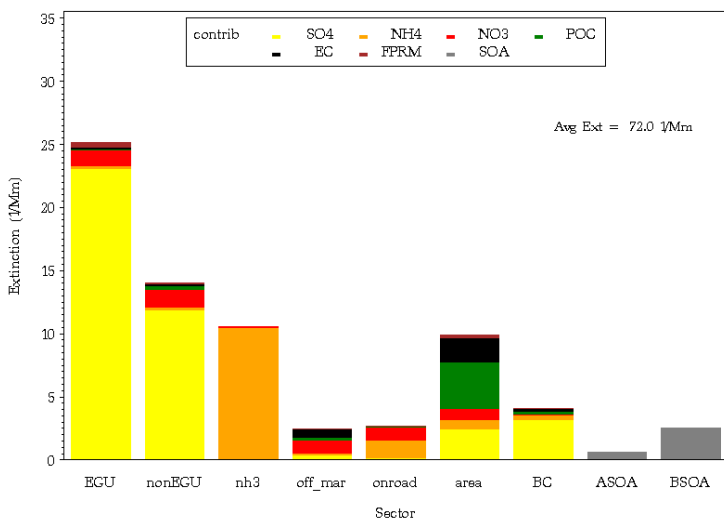


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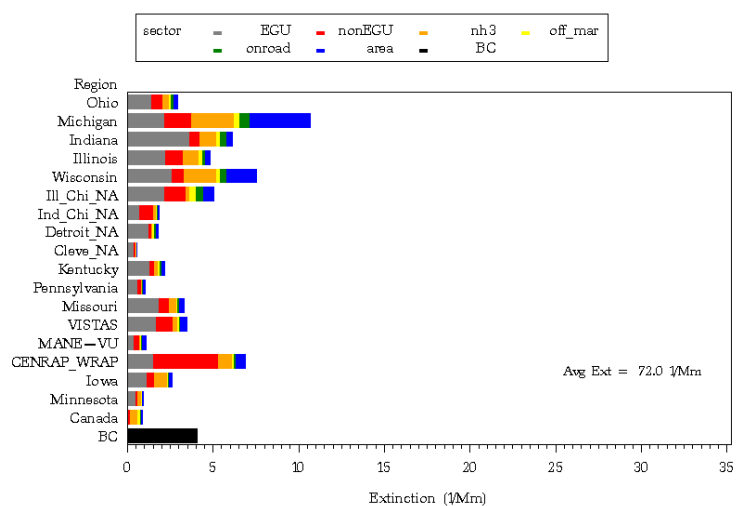


2018 (Round 5)

SENE1 - 2018M3R5_psatAP25+HAZEso4



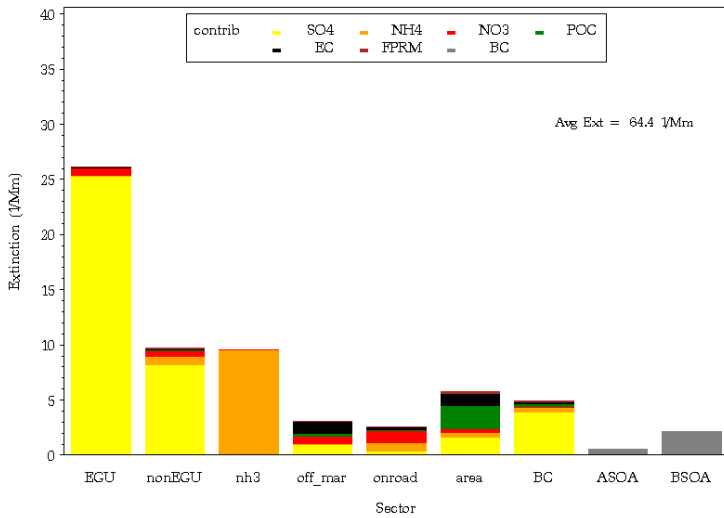
SENE1 - 2018M3R5_psatAP25+HAZEso4



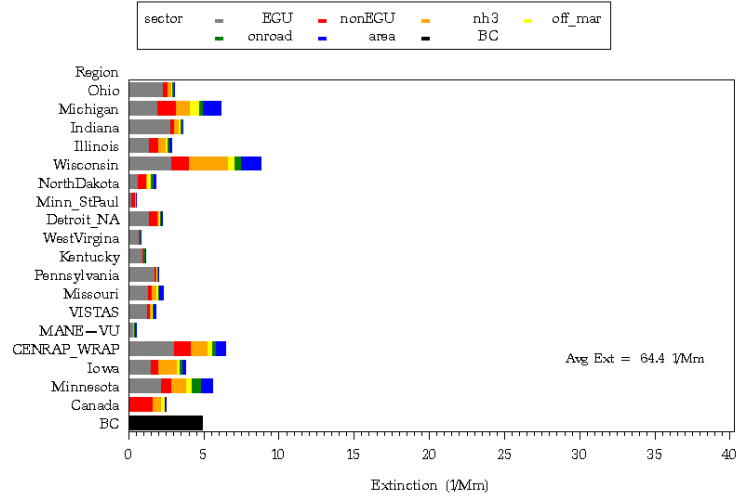
Isle Royale, Michigan

2005 (Round 5)

ISLE1 - baseM3_psatAP25so4

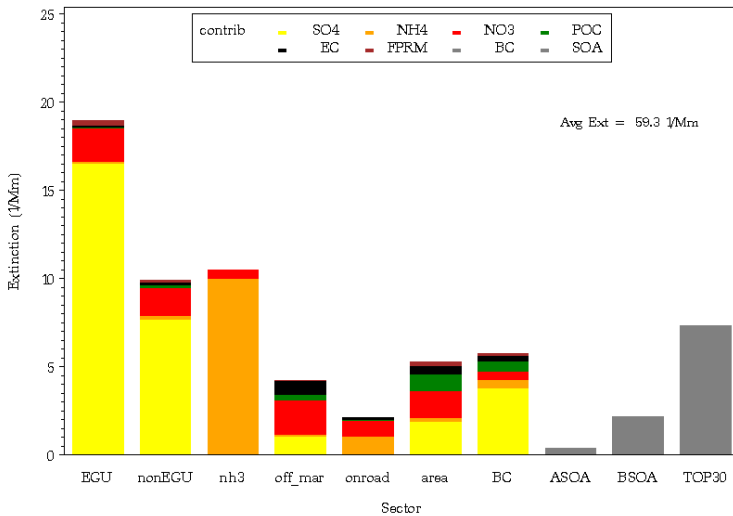


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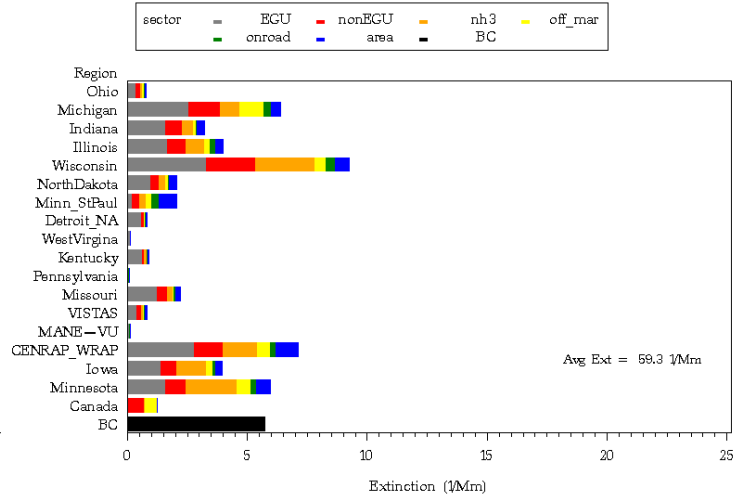


2018 (Round 4)

ISLE1 - K2018R4S1a

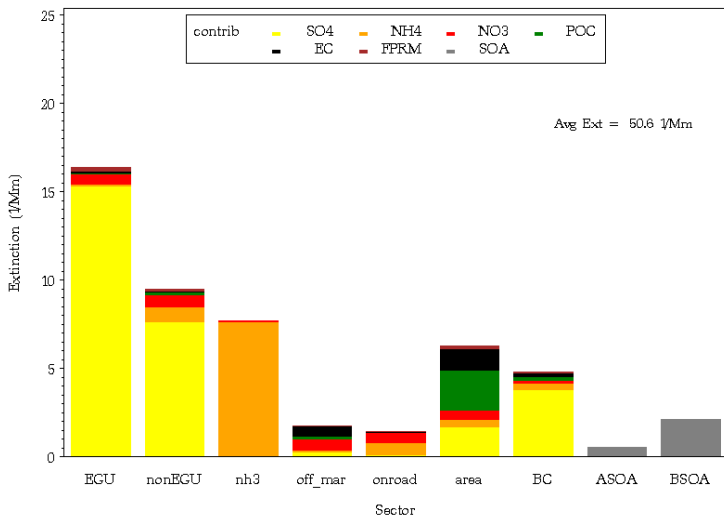


ISLE1 - K2018R4S1a

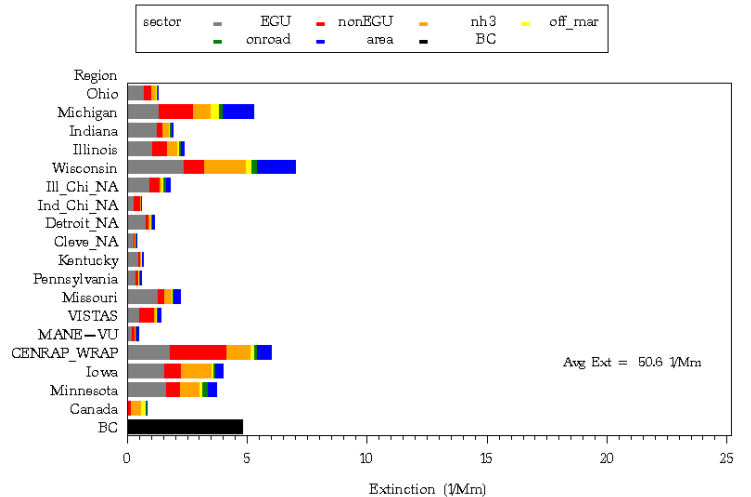


2018 (Round 5)

ISLE1 - 2018M3R5_psatAP25+HAZEso4



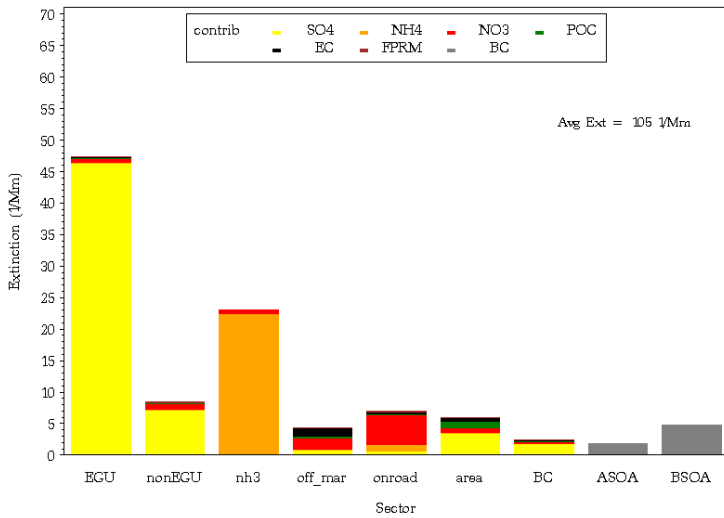
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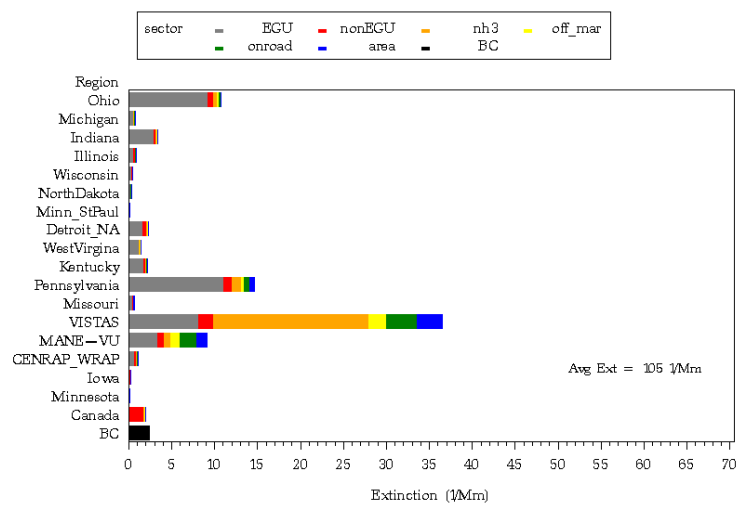
Shenandoah, Virginia

2005 (Round 5)

SHEN1 - baseM3_psatAP25so4

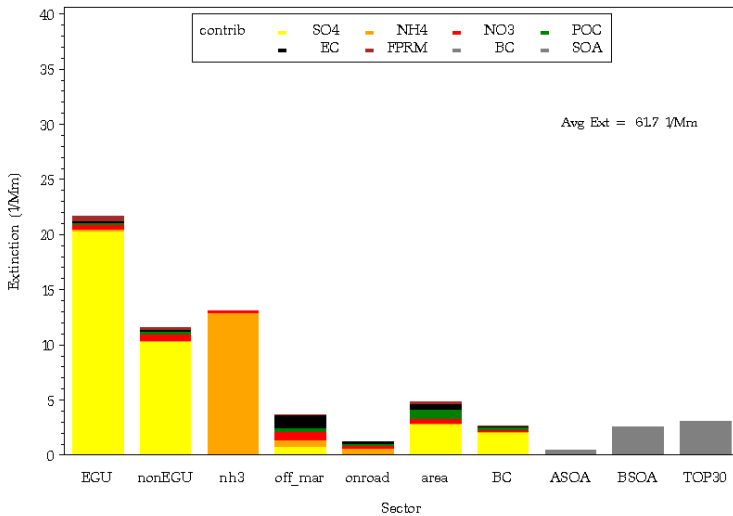


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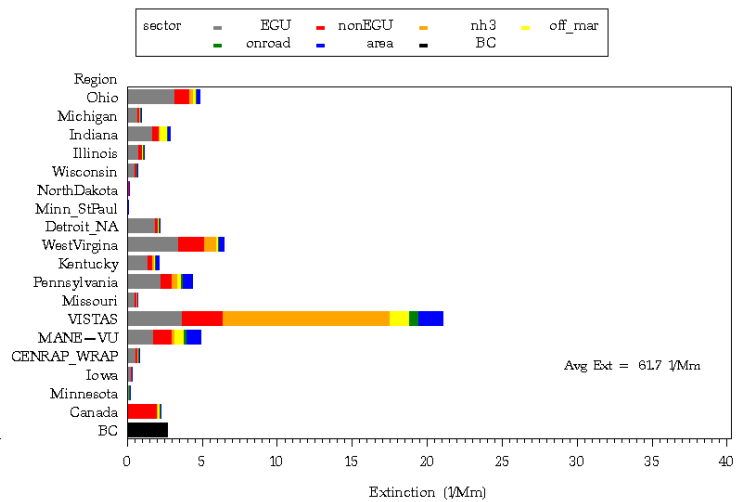


2018 (Round 4)

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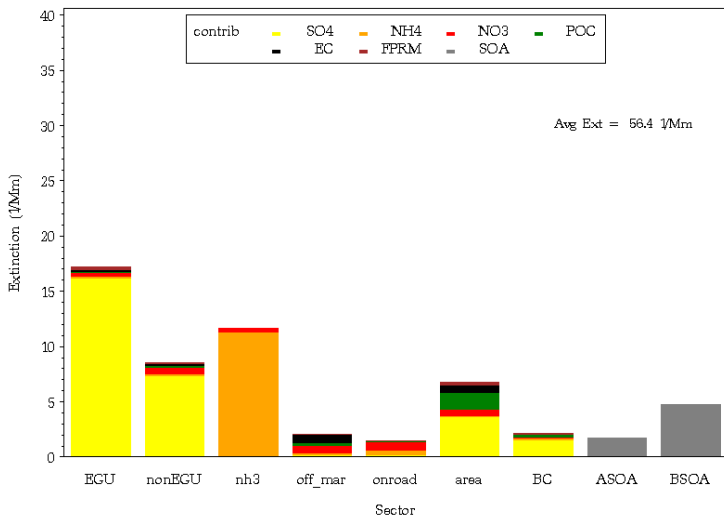


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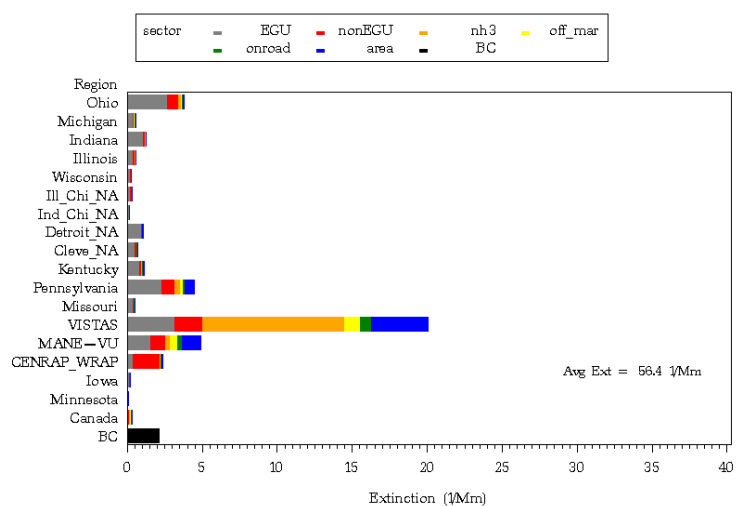


2018 (Round 5)

SHEN1 - 2018M3R5_psatAP25+HAZEso4



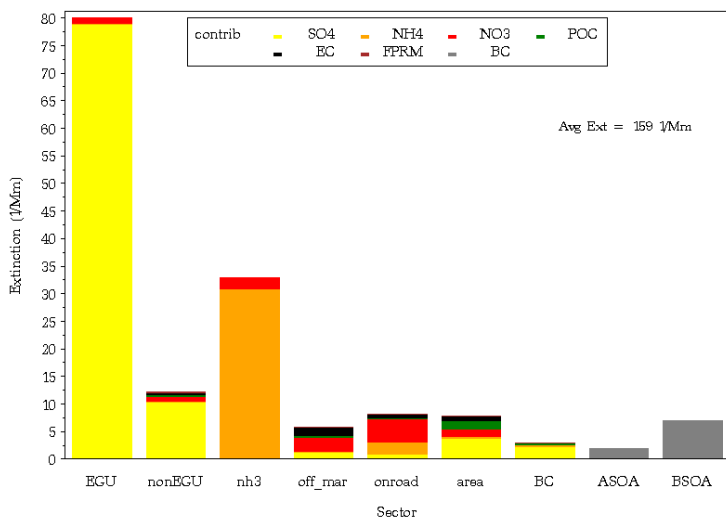
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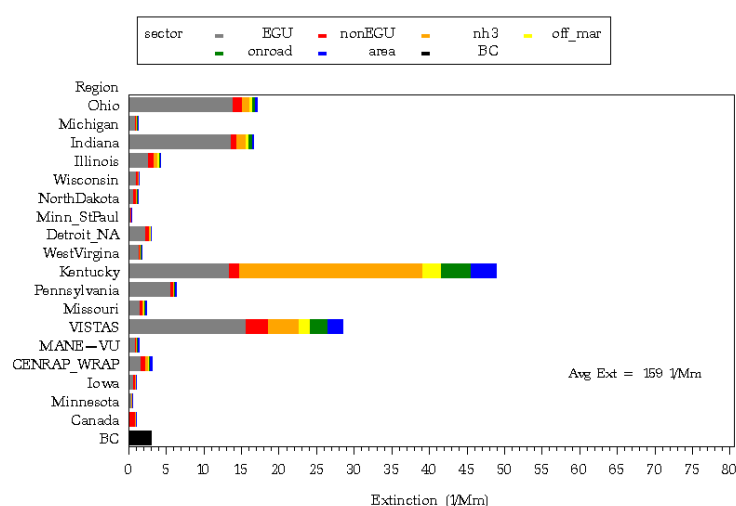
Mammoth Cave, Kentucky

2005 (Round 5)

MACA1 - baseM3_pstatAP25so4

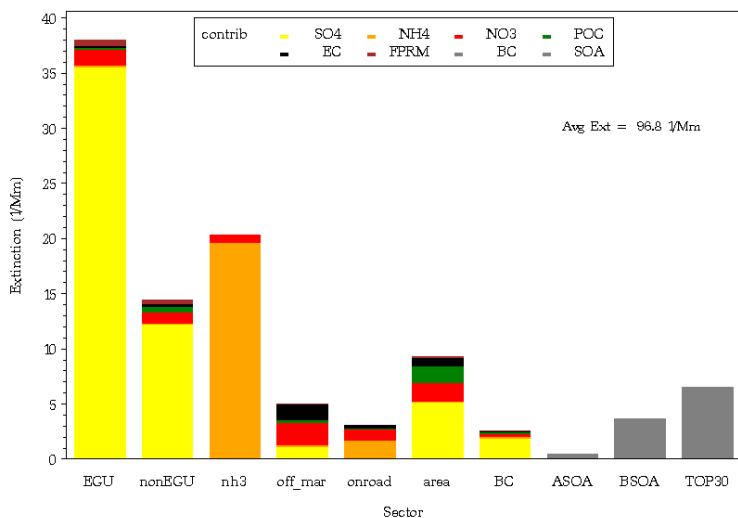


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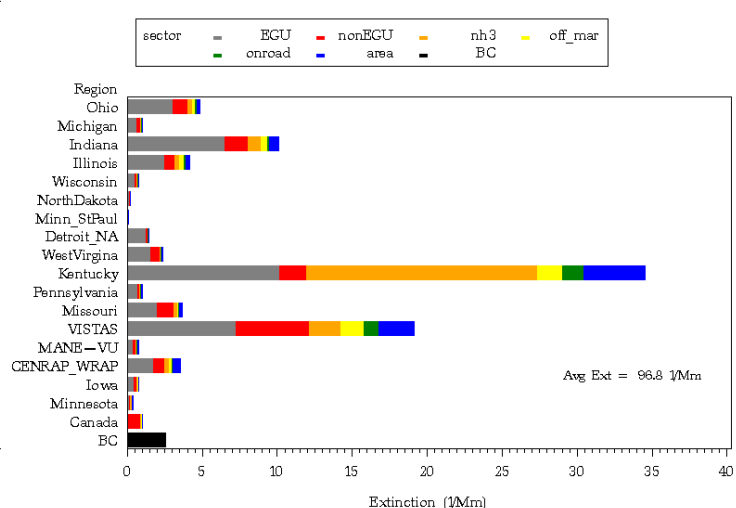


2018 (Round 4)

MACA1 - K2018R4S1a

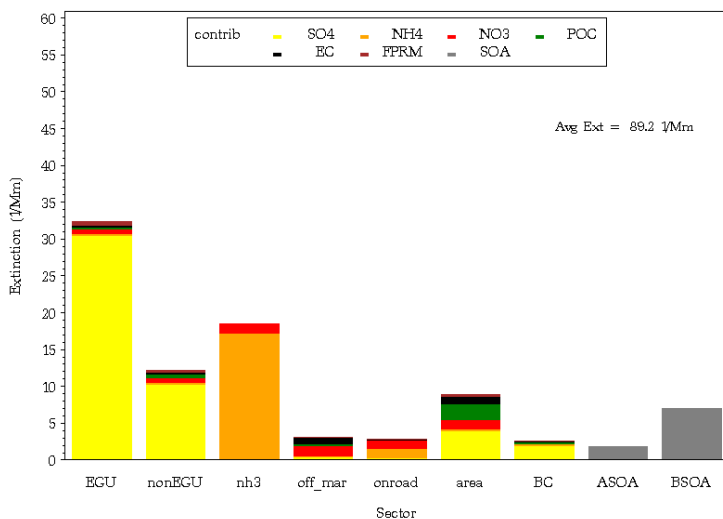


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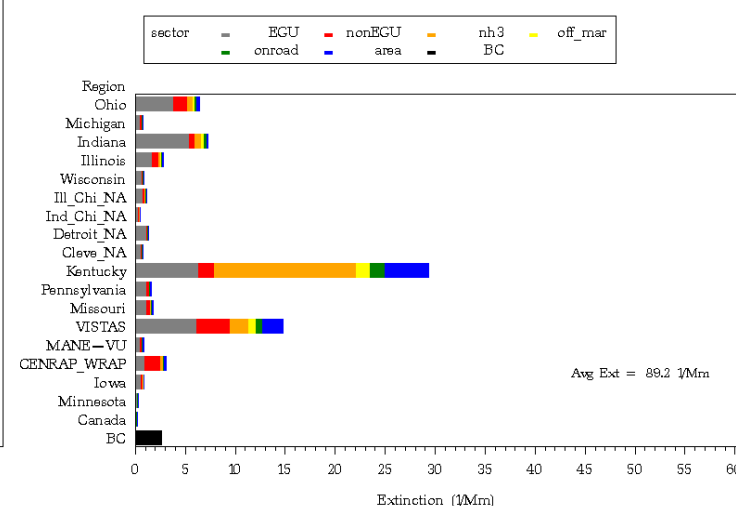


2018 (Round 5)

MACA1 - 2018M3R5_pstatAP25+ HAZEso4



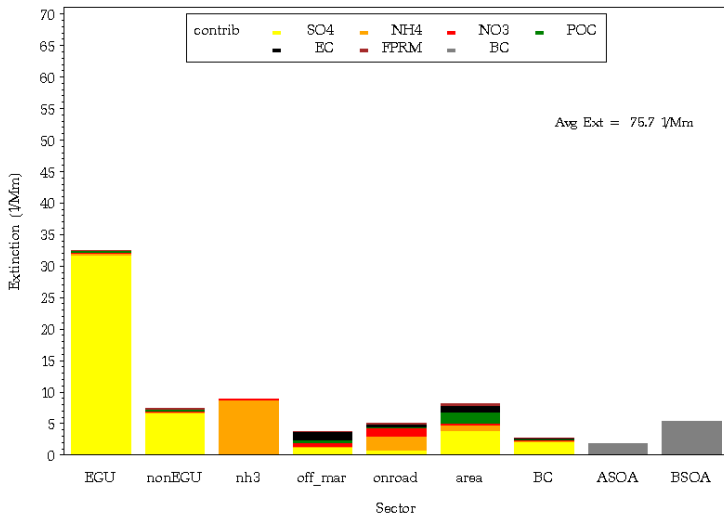
MACA1 - 2018M3R5_pstatAP25+ HAZEso4



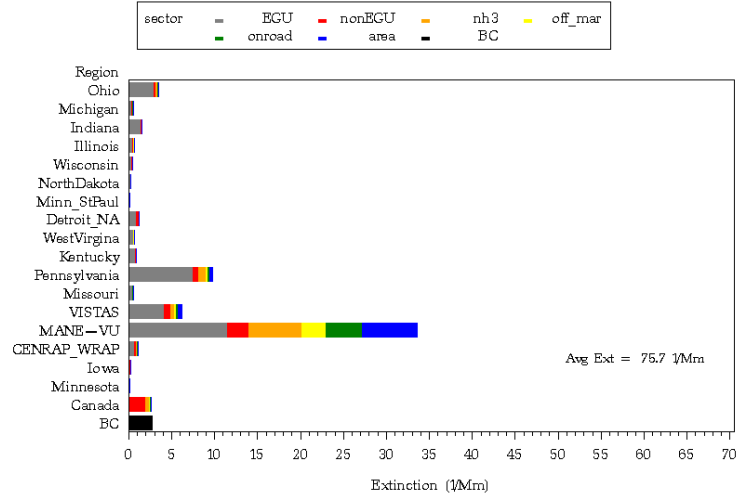
Lye Brook, Vermont

2005 (Round 5)

LYBR1 - baseM3_psatAP25so4

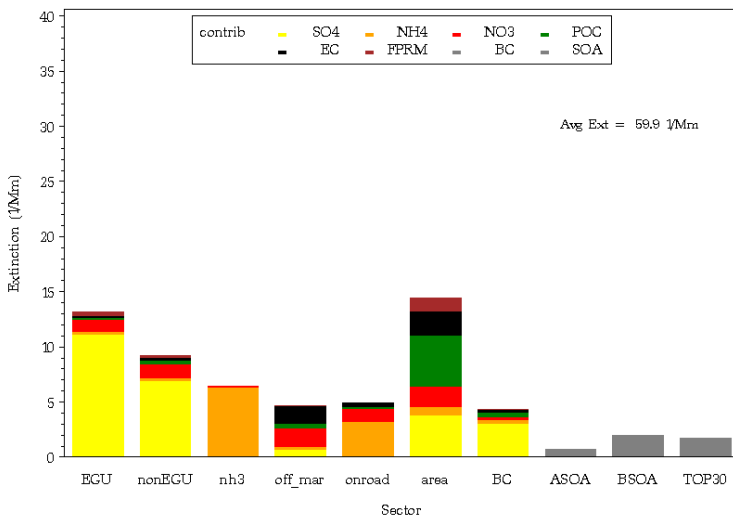


LYBR1 - baseM3_psatAP25so4

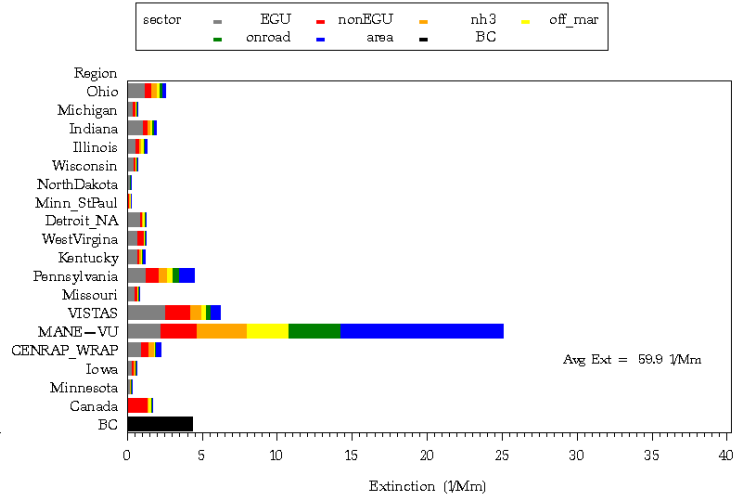


2018 (Round 4)

LYBR1 - K2018R4S1a

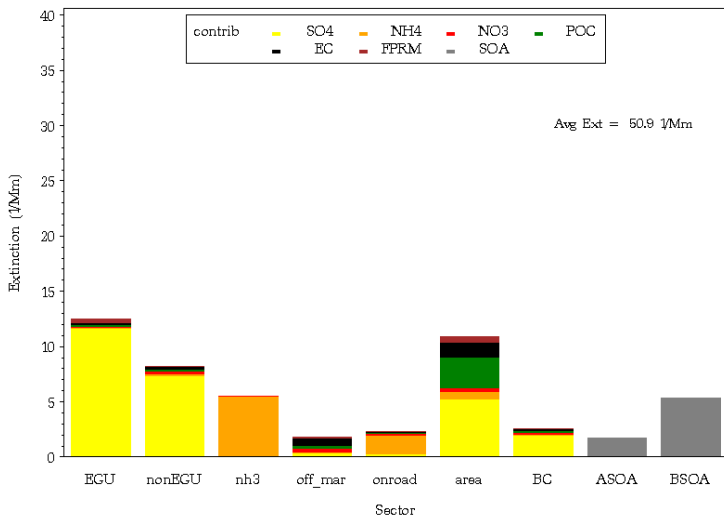


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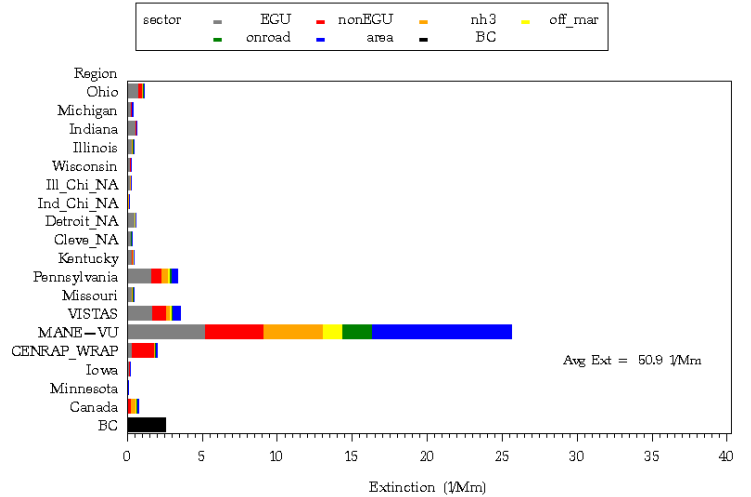


2018 (Round 5)

LYBR1 - 2018M3R5_psatAP25+ HAZEso4



LYBR1 - 2018M3R5_psatAP25+ HAZEso4



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Appendix D2:
Development of 2005 Base Year Growth and Control
Factor for Lake Michigan Air Directors Consortium
(LADCO) Final Report

http://www.ladco.org/reports/rpo/emissions/ladco_2005_base_yr_growth_and_controls_report_final.pdf

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**DEVELOPMENT OF 2005
BASE YEAR GROWTH AND
CONTROL FACTORS FOR
LAKE MICHIGAN AIR
DIRECTORS CONSORTIUM
(LADCO)**

FINAL REPORT

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Durham, NC 27707**

September 2007

Pechan Report No. 07.09.001/9458.000

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CONTENTS

	<u>Page</u>
TABLES	iv
ACRONYMS AND ABBREVIATIONS	v
SECTION I. BACKGROUND	1
SECTION II. EMISSION ACTIVITY GROWTH DATA	3
A. OVERVIEW	3
B. AREA SOURCE/MAR CATEGORIES.....	3
C. NON-EGU POINT SOURCES.....	14
D. NONROAD MODEL SOURCES	23
SECTION III. UPDATED EMISSION CONTROL DATA	27
A. NON-EGU POINT SOURCE CONTROLS.....	27
1. NO _x SIP Call.....	27
2. MACT Standards	27
3. Consent Decrees.....	27
4. On-the-Books (OTB) Control Additions	35
5. Best Available Retrofit Technology (BART).....	35
B. AREA SOURCE/MAR CONTROLS.....	40
1. Area Sources	40
2. MAR Sources (Locomotives and Marine Vessels).....	44
SECTION IV. PREPARATION OF GROWTH AND CONTROL FILES	49
A. GROWTH FACTORS	49
B. CONTROL FACTORS.....	51
1. Point Source Control Factors	51
2. Area Source and MAR Control Factors.....	52
SECTION V. REFERENCES	55

TABLES

Table II-1. Priority Emission Activity Area Source/MAR Categories	4
Table II-2. Growth Indicators for Priority Area Source/MAR Categories	7
Table II-3. Priority Emission Activity Point Source Categories.....	15
Table II-4. Growth Indicators for Priority Point Source Categories.....	19
Table II-5. Priority Emission Activity NONROAD Model Source Categories.....	24
Table II-6. Growth Indicators for Priority NONROAD Model Source Categories.....	25
Table III-1. RICE Engines in Illinois Affected by NO _x SIP Call	28
Table III-2. Post-2005 MACT Standards and Expected VOC, NO _x , and PM Reductions.....	29
Table III-3. LADCO State Non-EGU Point Sources Affected by Consent Decree Requirements and Other On-the-Books Controls	32
Table III-4. Ohio RACT Rule Summary Cleveland/Akron 8-Hour Ozone Nonattainment Area	35
Table III-5. BART Eligible Non-EGU Sources.....	36
Table III-6. Residential Wood Combustion NSPS Emission Reductions	43
Table III-7. Locomotive Emissions Reported in EPA Draft RIA.....	45
Table III-8. Percentage Reductions Associated with Federal Locomotive Standards.....	46
Table III-9. Percentage Reductions Associated with Federal CMV Standards	47
Table III-10. Commercial Marine Vessel Rule Penetration Values	48
Table IV-1. RPO Data Exchange Protocol Format for Growth/Control Data	50
Table IV-2. Fields Populated in Growth Factor File	51
Table IV-3. Fields Populated in Point Source Control Factor File.....	53
Table IV-4. Fields Populated in Area Source/MAR Control Factor File	54

ACRONYMS AND ABBREVIATIONS

AEO	<i>Annual Energy Outlook</i>
AIM	architectural and industrial maintenance
BART	best available retrofit technology
CE	control efficiency
CMV	commercial marine vessel
DEQ	Department of Environmental Quality
DOE	Department of Energy
EGAS	Economic Growth Analysis System
EGU	electric generating unit
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FCCUs	fluid catalytic cracking units
FCU	fluid coking units
FGR	flue gas recirculation
HAP	hazardous air pollutant
IC	internal combustion
LADCO	Lake Michigan Air Directors Consortium
LAER	lowest achievable emission rate
LNB	low NO _x burner
MACT	maximum achievable control technology
MAR	marine, aircraft, and railroad
MSAT	mobile source air toxics
NAAQS	national ambient air quality standards
NH ₃	ammonia
NMIM	National Mobile Inventory Model
NO _x	oxides of nitrogen
NSPS	new source performance standard
OTB	on-the-books
OWB	outdoor wood boiler
Pechan	E.H. Pechan & Associates, Inc.
PFC	portable fuel container
PM	particulate matter
PM-2.5	particulate matter less than or equal to 2.5 micrometers
RACT	reasonably available control technology
RE	rule effectiveness
REMI	Regional Economic Models, Inc.
RIA	Regulatory Impact Analysis
RICE	reciprocating internal combustion engines
ROG	reactive organic gases
RP	rule penetration
RPO	Regional Planning Organization
SCC	source classification code

SIC standard industrial classification
SIP State Implementation Plan
tpy tons per year
SO₂ sulfur dioxide
VOC volatile organic compound

SECTION I. BACKGROUND

E.H. Pechan & Associates, Inc. (Pechan) is supporting the Lake Michigan Air Directors Consortium's (LADCO) efforts to forecast anthropogenic emissions for the purpose of assessing progress for air quality goals, including goals related to regional haze and attainment of the ozone national ambient air quality standards (NAAQS). Under a previous contract with LADCO, Pechan prepared emission activity growth and emission control data for all non-electric generating unit (EGU) point, area, and nonroad source categories relative to a base year (2002) inventory supplied by LADCO. In December 2004, Pechan submitted emissions activity growth and control factor files for use by LADCO in emissions modeling. A December 14, 2004 Pechan report documents the contents and derivation of these files (Pechan, 2004). Revised files were later provided to LADCO in March 2005.

In September 2005, LADCO contracted with Pechan to conduct the following two tasks to develop updated growth and control factors needed to support future year control strategy analyses for regional haze, particulate matter less than or equal to 2.5 micrometers (PM-2.5), and ozone:

Task 1: Update control factors to reflect current information pertaining to:

- (a) Petroleum refinery cases and settlements;
- (b) Maximum achievable control technology (MACT) standard control efficiency assumptions;
- (c) Residential wood combustion unit lifetime; and
- (d) Regional Planning Organization (RPO) inventories.

Task 2: Develop non-EGAS default-based emission activity growth factors for:

- (a) Priority point source categories; and
- (b) Priority area source categories.

A December 2005 report describes Pechan efforts to perform these tasks, which resulted in updated emissions activity growth and control factor files (Pechan, 2005). The updates reflect the use of more recent and/or more detailed information than that used in the earlier study. As with the earlier study, this effort involved the preparation of emission activity growth and control information relative to a 2002 base year inventory for future years of interest. Control information was developed for 2007, 2008, 2009, 2012, and 2018 (e.g., 2018 is the first milestone for regional haze reasonable progress demonstrations). Because the incremental level of effort required to develop emission activity growth factors for each year over the 2003-2018 period was nominal, Pechan prepared non-EGU point and area and nonroad source growth factors for each year over this entire period.

For the current study, LADCO requested that Pechan develop growth and control factor files to support emission projections from a recently compiled 2005 base year inventory for the following LADCO states: Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. LADCO requested that Pechan provide files representing changes in emission activity and emission control between the base year and 2009, 2012, and 2018. As with the previous studies, Pechan provided updated point/area source and marine, aircraft, and railroad (MAR) category

growth factors for each year over the 2006-2018 period. Control factor development focused on the modeling years of interest, or in the case of point source controls, the specific anticipated implementation date within the forecast period.

This report is organized into this Background section and:

- Section II, which describes the development of the emission activity growth data;
- Section III, which discusses how the updated emission control data were compiled;
- Section IV, which describes the preparation of the updated growth and control factor files; and
- Section V, which presents the references consulted in preparing this report.

SECTION II. EMISSION ACTIVITY GROWTH DATA

A. OVERVIEW

As with the two previous studies, Pechan relied on the data incorporated into Version 5.0 of the Economic Growth Analysis System (EGAS) as the default growth factor data source.¹ The EGAS 5.0 projections data are typically derived from two main resources: (1) version 5.5 of Regional Economic Models Incorporated (REMI)'s state-level economic models; and (2) the Department of Energy (DOE)'s *Annual Energy Outlook (AEO) 2004*. While socioeconomic growth indicators from the REMI models provide state-level growth rates, the DOE energy forecasts provide regional or national growth rates (e.g., the same growth rate is applied to each LADCO state because each of these states is included in the DOE's East North Central division). Instead of relying on REMI's population forecasts, Pechan developed growth factors from county-level population projections available from each LADCO region state.

LADCO requested that Pechan review the growth indicators applied to particular source classification codes (SCCs) in the 2005 base year inventory. For these "priority" source categories, Pechan evaluated alternative growth methodologies and data sources before selecting a forecasting approach. The balance of this section describes the emission activity growth data developed in this study. Section IV discusses how these data were compiled into the file format required by LADCO.

B. AREA SOURCE/MAR CATEGORIES

LADCO provided Pechan with a list of priority point/area source and MAR categories for which emission activity projection improvements were to be evaluated. For these source categories, Pechan reviewed U.S. Environmental Protection Agency (EPA) SCC documentation and emission estimation guidance to identify the emissions activity (throughput) data associated with each SCC. Pechan then investigated the availability of LADCO state-specific projections for these data.

Table II-1 presents the descriptions and emissions activity for each priority area source/MAR category. The last column in this table identifies each category's growth indicator assignment under the previous Pechan forecast effort (Pechan, 2005). Table II-2 displays the assigned growth indicator for each priority area/MAR source category and any alternative indicators that were considered. This table also presents the percentage growth rates for the assigned indicators over two forecast periods: 2005-2009 and 2005-2018.

In addition to population data from the LADCO states and REMI employment data, the following information sources supplied data used in estimating emission activity growth for the priority area source/MAR categories:

¹ Information on these EGAS 5.0 data sources is provided in the report documenting the earliest study Pechan performed for LADCO (Pechan, 2004).

Table II-1. Priority Emission Activity Area Source/MAR Categories

POLLUTANT	SCC	DESC2	DESC3	DESC4	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
NH3	2805047100	Agriculture Production - Livestock	Swine production - deep-pit house operations (unspecified animal)	Confinement	Annual average number of swine	REMI Farm sector value added
NH3	2805039200	Agriculture Production - Livestock	Swine production - operations with lagoons (unspecified animal)	Manure handling and storage	Annual average number of swine	REMI Farm sector value added
NH3	2805047300	Agriculture Production - Livestock	Swine production - deep-pit house operations (unspecified animal)	Land application of manure	Annual average number of swine	REMI Farm sector value added
NH3	2805001100	Agriculture Production - Livestock	Beef cattle - finishing operations on feedlots (drylots)	Confinement	Annual average number of beef cattle	REMI Farm sector value added
NH3	2805039100	Agriculture Production - Livestock	Swine production - operations with lagoons (unspecified animal)	Confinement	Annual average number of swine	REMI Farm sector value added
NH3	2805003100	Agriculture Production - Livestock	Beef cattle - finishing operations on pasture/range	Confinement	Annual average number of beef cattle	REMI Farm sector value added
NH3	2805001300	Agriculture Production - Livestock	Beef cattle - finishing operations on feedlots (drylots)	Land application of manure	Annual average number of beef cattle	REMI Farm sector value added
NH3	2630020000	Wastewater Treatment	Public Owned	Total Processed	Volume of wastewater processed	REMI Water and Sanitation sector output
NH3	2805007100	Agriculture Production - Livestock	Poultry production - layers with dry manure management system	Confinement	Annual average number of poultry	Regression with Food/Kindred Products sector value added as explanatory variable
NH3	2805021300	Agriculture Production - Livestock	Dairy cattle - scrape dairy	Land application of manure	Annual average number of dairy cattle	Regression with Farm sector employment as explanatory variable
NH3	2805030000	Agriculture Production - Livestock	Poultry Waste Emissions	Not Elsewhere Classified (see also 28-05-007 -008-009)	Annual average number of poultry	REMI Farm sector value added
NH3	2805021200	Agriculture Production - Livestock	Dairy cattle - scrape dairy	Manure handling and storage	Annual average number of dairy cattle	Regression with Farm sector employment as explanatory variable
NH3	2104008070	Residential	Wood	Outdoor Boiler	Amount of wood burned	
NOX	2285002006	Railroad Equipment	Diesel	Line Haul Locomotives: Class I Operations	Amount of diesel consumed by Class I line-haul locomotives	AEO Freight rail distillate (nat'l) adjusted for relative state growth in REMI Total output
NOX	2280002023	Marine Vessels Commercial	Diesel	Push Boats	Amount of diesel consumed by commercial push boats	AEO Shipping distillate (nat'l) adjusted for relative state growth in REMI Water Transportation sector output
NOX	2102006001	Industrial	Natural Gas	All Boiler Types	Volume of natural gas burned by industrial area source boilers	AEO Industrial natural gas

Table II-1 (continued)

POLLUTANT	SCC	DESC2	DESC3	DESC4	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
NOX	2275020000	Aircraft	Commercial Aircraft	Total: All Types	Number of commercial aircraft landing-takeoff cycles	Federal Aviation Administration (FAA) itinerant air carrier Landing and Take-Off (LTO) forecasts by state
NOX	2285002010	Railroad Equipment	Diesel	Yard Locomotives	Amount of diesel consumed by yard locomotives	AEO Freight rail distillate (nat'l) adjusted for relative state growth in REMI Total output
NOX	2104006000	Residential	Natural Gas	Total: All Combustor Types	Volume of residential natural gas consumed	AEO Residential natural gas
NOX	2285002009	Railroad Equipment	Diesel	Line Haul Locomotives: Commuter Lines	Amount of diesel consumed by commuter locomotives	AEO Commuter rail diesel (nat'l) adjusted for relative growth in population
NOX	2280003200	Marine Vessels Commercial	Residual	Underway emissions	Amount of residual oil consumed by CMV during underway operations	AEO Shipping residual oil (nat'l) adjusted for relative state growth in REMI Water Transportation sector output
NOX	2102006000	Industrial	Natural Gas	Total: Boilers and IC Engines	Volume of natural gas burned by industrial area source boilers and IC engines	AEO Industrial natural gas
NOX	2104008070	Residential	Wood	Outdoor Boiler	Amount of wood burned	
ROG	2461850000	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	All Processes	(Not listed for this SCC)	Region V employment projections for "Pesticide Handlers, Sprayers"
ROG	2461020000	Miscellaneous Non-industrial: Commercial	Asphalt Application: All Processes	Total: All Solvent Types	Amount of solvent used	Region V employment projections for "Paving, Surfacing, & Tamping Operators"
ROG	2401200000	Surface Coating	Other Special Purpose Coatings	Total: All Solvent Types	Amount of solvent used	Population
ROG	2401001000	Surface Coating	Architectural Coatings	Total: All Solvent Types	Amount of solvent used	Regression with Population (inc. county level) as explanatory variable + projected solvent content change
ROG	2460100000	Miscellaneous Non-industrial: Consumer and Commercial	All Personal Care Products	Total: All Solvent Types	Amount of solvent used	Population (county-level for LADCO states)
ROG	2501011010	Petroleum and Petroleum Product Storage	Portable Gas Cans	Residential	Volume of gasoline stored	REMI, Gas and Oil Expenditures
ROG	2501060100	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 2: Total	Volume of gasoline pumped by stations	Regression with Gas and Oil Expenditures as explanatory variable
ROG	2460800000	Miscellaneous Non-industrial: Consumer and Commercial	All FIFRA Related Products	Total: All Solvent Types	Amount of solvent used	Regression with Population (county-level for LADCO states) as explanatory variable
ROG	2501060050	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 1: Total	Volume of gasoline pumped into stations	REMI, Gas and Oil Expenditures
ROG	2460400000	Miscellaneous Non-industrial: Consumer and Commercial	All Automotive Aftermarket Products	Total: All Solvent Types	Amount of solvent used	Population (county-level for LADCO states)
ROG	2425000000	Graphic Arts	All Processes	Total: All Solvent Types	Amount of solvent used	REMI, Printing and Publishing sector output
ROG	2401005000	Surface Coating	Auto Refinishing: SIC 7532	Total: All Solvent Types	Amount of solvent used	REMI, Automobile Parking, Repair, Services sector output
ROG	2460500000	Miscellaneous Non-industrial: Consumer and Commercial	All Coatings and Related Products	Total: All Solvent Types	Amount of solvent used	Population (county-level for LADCO states)

Table II-1 (continued)

POLLUTANT	SCC	DESC2	DESC3	DESC4	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
ROG	2460200000	Miscellaneous Non-industrial: Consumer and Commercial	All Household Products	Total: All Solvent Types	Amount of solvent used	Population (county-level for LADCO states)
ROG	2415020000	Degreasing	Fabricated Metal Products (SIC 34): All Processes	Total: All Solvent Types	Amount of solvent used	REMI, Fabricated Metals sector employment
ROG	2415025000	Degreasing	Industrial Machinery and Equipment (SIC 35): All Processes	Total: All Solvent Types	Amount of solvent used	REMI, Machinery and Computer Equipment sector employment
ROG	2460600000	Miscellaneous Non-industrial: Consumer and Commercial	All Adhesives and Sealants	Total: All Solvent Types	Amount of solvent used	Population (county-level for LADCO states)
ROG	2420000370	Dry Cleaning	All Processes	Special Naphthas	Amount of special naphthas used	SCC is not in current growth file; similar SCC (2420010370) is in file w/ REMI Laundry sector output
ROG	2630010000	Wastewater Treatment	Industrial	Total Processed	Volume of wastewater processed	Projected LADCO NEEDS industrial flow design forecast
ROG	2501060101	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 2: Displacement Loss/Uncontrolled	Volume of gasoline pumped via uncontrolled	Regression with Gas and Oil Expenditures as explanatory variable
ROG	2415360000	Degreasing	Auto Repair Services (SIC 75): Cold Cleaning	Total: All Solvent Types	Amount of solvent used	REMI, Automobile Parking, Repair, Services sector output
ROG	2401002000	Surface Coating	Architectural Coatings - Solvent-based	Total: All Solvent Types	Amount of solvent used	REMI, Housing expenditures
ROG	2401003000	Surface Coating	Architectural Coatings - Water-based	Total: All Solvent Types	Amount of solvent used	REMI, Housing expenditures
ROG	2104008070	Residential	Wood	Outdoor Boiler	Amount of wood burned	
SO2	2601020000	On-site Incineration	Commercial/Institutional	Total	Amount of material burned	REMI, Commercial sector employment
SO2	2102004000	Industrial	Distillate Oil	Total: Boilers and IC Engines	Amount of distillate oil burned by area source industrial boilers/IC engines	AEO Industrial distillate
SO2	2103004000	Commercial/Institutional	Distillate Oil	Total: Boilers and IC Engines	Amount of distillate oil burned by area source commercial boilers/IC engines	No growth based on historical energy data
SO2	2275020000	Aircraft	Commercial Aircraft	Total: All Types	See NOX entry	FAA itinerant air carrier LTO forecasts by state
SO2	2102005000	Industrial	Residual Oil	Total: All Boiler Types	Amount of residual oil burned by area source industrial boilers	AEO Industrial residual
SO2	2102002000	Industrial	Bituminous/Subbituminous Coal	Total: All Boiler Types	Amount of bit/sub coal burned by area source industrial boilers	AEO Industrial steam coal
SO2	2285002006	Railroad Equipment	Diesel	Line Haul Locomotives: Class I Operations	See NOX entry	AEO Freight rail distillate (nat'l) adjusted for relative state growth in Total output
SO2	2104008070	Residential	Wood	Outdoor Boiler	Amount of wood burned	

Table II-2. Growth Indicators for Priority Area Source/MAR Categories

Pollutant	SCC	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
		2005-2009	2005-2018			
NH3	2805047100	-1.7	6.2	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805039200	-2.3	4.4	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805047300	-1.6	6.4	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805001100	5.2	16.7	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805039100	-1.6	6.4	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805003100	3.2	3.5	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805001300	5.2	16.7	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2630020000	2.8	9.5	Municipal design flow forecasts from Drinking Water Infrastructure Needs Survey		
NH3	2805007100	-4.5	8.3	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805021300	-10.2	-39.0	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805030000	-5.3	6.8	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2805021200	-10.2	-39.0	Interpolated SCC/state-level animal count projections from EPA NH3 inventory of Animal Husbandry Operations		Forecast data are state-level
NH3	2104008070	78.0	84.3	Extrapolation of national 1999-2004 trend in OWB sales (exponential growth) thru 2006; linear growth thru 2008; 2009+ based on rural population growth rate		
NOX	2285002006	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -1.4% per year; AEO forecast = 1.4% per year	Note that post-2001 trend has been upward and that historical data shows several ups and downs
NOX	2280002023	4.3	9.9	AEO national Domestic Shipping sector distillate projections adjusted for LADCO region growth in REMI Water Transportation sector output relative to nation	1998-2004 fuel consumption data for barge traffic on regional rivers indicates similar annual growth rate (1.0%)	Forecast data are state-level
NOX	2102006001	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -0.01% per year; AEO forecast = 1.4% per year	
NOX	2275020000	0.0	0.0	No growth due to contradictory historic and forecast trends (Federal Aviation Administration commercial aircraft landing and take-offs data)	FAA 1990-2005 = -0.01% per year; FAA forecast = 1.7% per year	
NOX	2285002010	0.0	0.0	No growth due to contradictory historic and forecast trend (historic trend based on 1996-2002 regional Switch and Terminal Services employment)	1996-2004 = -1.6% per year employment decrease; AEO forecast = 1.4% per year	
NOX	2104006000	1.7	2.8	AEO residential natural gas consumption forecast	DOE 1990-2004 = 0.5% annual; AEO forecast = 0.2%	

Table II-2 (continued)

Pollutant	SCC	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
		2005-2009	2005-2018			
NOX	2285002009	7.4	26.1	Annual growth rate (1.8%) from 2005-2009 diesel fuel consumption projections reported in Marta 2007 budget		
NOX	2280003200	0.4	1.3	1995-2005 Great Lakes region ton-miles trend (0.1% annual growth)	AEO forecasts national Domestic Shipping residual oil consumption +1.1% per year	Used historical growth rate since region-specific
NOX	2102006000	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -0.01% per year; AEO forecast = 1.4% per year	
NOX	2104008070	78.0	84.3	Extrapolation of national 1999-2004 trend in OWB sales (exponential growth) thru 2006; linear growth thru 2008; 2009+ based on rural population growth rate		
ROG	2461850000	4.8	16.1	Regional employment projections for "Pesticide Handlers, Sprayers" combined with projected solvent content change from Freedonia's "Solvents to 2010-Agricultural Chemical Market for Solvents" (-0.4% per year)		Forecast data are state-level
ROG	2461020000	-1.9	-6.0	No employment growth assumption due to contradictory historic and forecast trends in "Paving, Surfacing, & Tamping Operators" employment, combined with projected solvent content change from Freedonia's "Solvents to 2010-Asphalt Production Market for Solvents" (-0.5% per year)		Forecast data are state-level
ROG	2401200000	-6.5	-16.1	Population forecast combined with projected change in paint solvent content from Freedonia's "Solvents to 2010-Paints/Coatings Market for Solvents" (-1.9% per year)		Forecast data are county-level
ROG	2401001000	-9.9	-9.3	Regression with Population forecast as explanatory variable combined with Freedonia projected change in proportion of total Architectural coatings that are solvent-based (-2.0% per year)		Forecast data are county-level
ROG	2460100000	-3.9	-11.6	Population forecast combined with projected solvent content change from Freedonia's "Solvents to 2010-Cosmetics & Toiletries Market for Solvents" (-1.5% per year)		Forecast data are county-level
ROG	2501011010	0.2	0.3	Regression equation with Gas and Oil Expenditures as explanatory variable		Forecast data are state-level
ROG	2501060100	0.2	0.3	Regression equation with Gas and Oil Expenditures as explanatory variable		Forecast data are state-level
ROG	2460800000	-10.5	-15.6	Regression equation with Population as explanatory variable		Forecast data are county-level
ROG	2501060050	0.2	0.3	Regression equation with Gas and Oil Expenditures as explanatory variable		Forecast data are state-level
ROG	2460400000	0.1	3.3	Population forecast combined with projected change in solvent use/vehicle from Freedonia's "Solvents to 2010-Transportation Markets for Solvents" (-0.4% per year)		Forecast data are county-level
ROG	2425000000	0.0	0.0	No employment growth assumption due to contradictory historic and forecast trends for "Printing Machine Operators" employment, and no projected change in solvent content of ink from Freedonia's "Solvents to 2010-Printing Ink Market for Solvents"		
ROG	2401005000	-12.9	-38.9	Employment projections for "Automotive Body and Related Repairers" combined w/ change in proportion of automotive coatings that are solvent-based from Freedonia's "Automotive Coatings, Adhesives & Sealants-Automotive Coatings Demand by Formulation and Substrate" (-4.3% per year)		Forecast data are state-level
ROG	2460500000	-6.5	-16.1	Population forecast combined with projected change in paint solvent content from Freedonia's "Solvents to 2010-Paints/Coatings Market for Solvents" (-1.9% per year)		Forecast data are county-level

Table II-2 (continued)

Pollutant	SCC	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
		2005-2009	2005-2018			
ROG	2460200000	0.6	6.8	Population forecast combined with projected change in cleaning product solvent content from Freedonia's "Solvents to 2010-Cleaning Product Market for Solvents" (-0.1% per year)		Forecast data are county-level
ROG	2415020000	-15.0	-35.9	Fabricated Metals sector employment forecast combined with projected change in solvent use from Freedonia's "Solvents to 2010-Metal Processing Market for Solvents" (-3.7% per year)		Forecast data are state-level
ROG	2415025000	0.2	-11.4	Machinery and Computer Equipment sector employment forecast combined with projected change in solvent use from Freedonia's "Solvents to 2010-Metal Processing Market for Solvents" (-3.7% per year)		Forecast data are state-level
ROG	2460600000	-10.0	-24.4	Population forecast combined with projected change in solvent content from Freedonia's "Solvents to 2010-Adhesives and Sealants Market for Solvents" (-2.7% per year)		Forecast data are county-level
ROG	2420000370	-1.6	-0.4	Regional employment projections for "Laundry and Dry Cleaning Workers" (+0.7% per year) combined with projected solvent content from Freedonia's "Solvents to 2010-Dry Cleaning and Other Markets for Solvents" (-0.7%)		
ROG	2630010000	4.1	13.8	Growth rate from regional industrial wastewater flow design forecast from Drinking Water Infrastructure Needs Survey		
ROG	2501060101	0.2	0.3	Regression equation with Gas and Oil Expenditures as explanatory variable		Forecast data are state-level
ROG	2415360000	2.4	10.3	Regional employment projections for "Automotive Service Technicians and Mechanics" combined with forecast change in solvent use from "Solvents to 2010-Transportation Markets for Solvents" (-0.4% per year)		
ROG	2401002000	-9.9	-9.3	Regression with Population forecast as explanatory variable combined with Freedonia projected change in proportion of total Architectural coatings that are solvent-based (-2.0% per year)		Forecast data are state-level
ROG	2401003000	3.6	12.3	Regression equation with Population as explanatory variable		Forecast data are state-level
ROG	2104008070	78.0	84.3	Extrapolation of national 1999-2004 trend in OWB sales (exponential growth) thru 2006; linear growth thru 2008; 2009+ based on rural population growth rate		
SO2	2601020000	7.2	15.0	Commercial sector employment forecast		Forecast data are state-level
SO2	2102004000	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = +0.5% per year; AEO forecast = -0.3% per year	
SO2	2103004000	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -2.0% per year; AEO forecast = 0.8% per year	
SO2	2275020000	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.7% per year	
SO2	2102005000	-49.4	-49.6	AEO forecast for industrial sector residual oil consumption	DOE 1990-2004 = -6.6% per year; AEO forecast = -5.1% per year	
SO2	2102002000	2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	

Table II-2 (continued)

Pollutant	SCC	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
		2005-2009	2005-2018			
SO2	2285002006	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -1.4% per year; AEO forecast = +1.4% per year	Note that post-2001 trend is upward & historical data has several ups/downs
SO2	2104008070	78.0	84.3	Extrapolation of national 1999-2004 trend in OWB sales (exponential growth) thru 2006; linear growth thru 2008; 2009+ based on rural population growth rate		

- Animal Husbandry: projected number of animals from EPA’s ammonia emission forecasts for animal husbandry operations (EPA, 2004);
- Marine Vessels Commercial, Diesel–Push Boats: historical (1998-2004) fuel consumption for barge traffic on rivers in LADCO region (ENVIRON, 2007a);
- Multiple Fuel Combustion categories: DOE East North Central region energy forecasts from *AEO 2007* and 1990-2004 LADCO region energy consumption data (DOE, 2007a and 2007b);
- Commercial Aircraft: state-level itinerant aircraft operations (FAA, 2007);
- Diesel Line Haul Locomotives–Commuter Lines: Metra diesel fuel expenditure/price projections (Metra, 2007);
- Pesticide Application–Agricultural: LADCO region projected number of “pesticide handlers, sprayers, and applicators, vegetation” (BLS, 2007);
- Commercial Asphalt Application–All Processes: LADCO region projected number of “paving, surfacing, and tamping operators” (BLS, 2007);
- Graphic Arts –All Processes: LADCO region projected number of “printing machine operators” (BLS, 2007);
- Surface Coating–Auto Refinishing: SIC 7532: LADCO region projected number of “Automotive Body and Related Repairers” (BLS, 2007);
- Dry Cleaning, All Processes–Special Naphthas: LADCO region projected number of “Laundry and Dry Cleaning Workers” (BLS, 2007);
- Wastewater Treatment–Industrial: LADCO region projected wastewater treatment industrial design flow (EPA, 2007a); and
- Degreasing–Auto Repair Services (SIC 75): Cold Cleaning: LADCO region projected number of “Automotive Service Technicians and Mechanics” (BLS, 2007).

Many of the above are solvent use categories for which Pechan also incorporated projected solvent content changes as forecast by The Freedonia Group, Inc. (Freedonia, 2006).

In cases where energy consumption is the emissions activity, a common growth factor development approach was to compare available regional historical (1990-2004) energy consumption data to *AEO 2007* forecast data to determine if the forecast growth rates appear suspect relative to historical trends. Pechan conducted similar historical/forecast activity trend comparisons for the non-fuel combustion priority categories whenever historical trend data were readily available (e.g., occupational employment data). In selecting from alternative data

sources/trend data, the general decision-making hierarchy was as follows, listed in order of preference:

1. If the forecast and historical trends were in the same direction, Pechan relied on forecast data (an exception was made, however, in cases where forecast data were only available on a national-level, but historical data were available for the LADCO region).
2. If the forecast and historical trends were in different directions (e.g., forecast trend is for an increase in activity, but historical trend was a decrease), Pechan applied a no growth assumption.

Outdoor Wood Boilers

Residential Wood Combustion from Outdoor Wood Boilers (SCC 2104008070) was not originally identified as a source category for growth indicator review because this category was only recently added to LADCO's emissions inventory. Outdoor Wood Boilers (OWBs) have become much more prevalent in the last several years as homeowners seek ways to avoid recent large increases in natural gas and home heating oil prices. This source category does not exist in EPA's official SCC list, and there is no current EPA emission inventory preparation guidance for this sector. Pechan assumed that this category's emissions are based on the estimated number of wood boilers, the average amount of wood burned in each boiler, and emission factors that are related to the amount of wood burned.

Investigations indicate little historical and forecast OWB data exist to assist in identifying future trends in LADCO region OWB use: state-specific sales from nine manufacturers obtained by EPA from nine manufacturers, and national sales data obtained by the New York Attorney General's Office via subpoena of 21 manufacturers. These sales data are for 1999-2004. Because of the much greater manufacturer coverage for the national data, and because the state estimates indicate that the majority of recent OWBs sales have occurred in the LADCO states, Pechan focused the historical trend analysis on the national data. These data indicate an extremely high average growth rate of 41 percent per year over the 1999-2004 period. Manufacturers indicate that although OWBs have been available for sale since the 1980s, the very large OWB sales growth rates are new phenomenon. The growth rates appear to mainly result from homeowner reactions to recent large increases in residential heating prices (e.g., between 1999 and 2004, residential natural gas and distillate oil prices rose 61 and 87 percent, respectively). Because DOE data indicate that natural gas accounts for the majority of residential energy consumption in the LADCO States, and increases in residential natural gas prices continued through 2006 (the average annual price for residential natural gas increased 28 percent between 2004 and 2006), Pechan forecast the national number of OWBs through 2006 via extrapolation of the 1999-2004 national OWB trend. In particular, Pechan fit an exponential equation to the 1994-2004 data, and used the equation to estimate 2005 and 2006 OWB counts.

Next, Pechan reviewed *AEO 2007* projections of residential natural gas prices for the East North Central region (which includes 5 of the 6 LADCO region States) to identify whether recent increases are expected to continue. The *AEO 2007* projects the average 2007 price for residential

natural gas in the East North Central region to be 4 percent lower than in 2006, and forecasts continued price decreases through the 2008-2018 period (see table below).

Year	Residential Natural Gas Price (\$/million Btu)	% Change from 2006
2006	12.08	
2007	10.92	-4.1
2008	10.80	-5.1
2009	10.28	-9.7
2010	10.02	-11.9
2011	9.61	-15.5
2012	9.48	-16.9
2013	9.28	-18.4
2014	9.32	-18.1
2015	9.27	-18.6
2016	9.37	-17.7
2017	9.60	-15.7
2018	9.56	-20.8

Given the projected modest price decreases thru 2008, and the fact that distillate oil prices are forecast to increase 6.1 percent between 2006 and 2008, and because one expects a time lag in responding to energy price changes, Pechan assumes that OWB sales will continue to increase at a significant rate through 2008. Pechan specifically fit a linear trend line to the 1999-2004 OWB, and projected OWBs in 2007 and 2008 by extending the trend through 2008, and applying each year's growth rate to the estimated count of OWBs in 2006.

By 2009, Pechan projects that the larger projected declines in natural gas prices, and forecasted decreases in other heating fuel prices, will significantly restrain OWB growth. In addition, because of neighborhood smoke nuisance concerns, and the need for ready access to inexpensive wood, it is expected that the market for OWBs will be generally constrained to heavily-wooded rural areas. Therefore, Pechan forecasts post-2008 year OWB growth to more closely trend with population growth in these areas. To approximate this growth, Pechan compiled 1990 and 2000 total and rural area population data for the LADCO region. These data indicate that rural area population grew at approximately 60 percent of the rate of total population over this period. Pechan estimated rural area population growth for the LADCO region by multiplying this adjustment factor by the forecasted growth rate for total population in the LADCO region. The following table displays the projected count of OWBs in the LADCO region for 2005, 2009, 2012, and 2018.

Year	Estimated # of OWBs
2005	81,082
2009	144,356
2012	145,911
2018	149,421

It is important to note that it is particularly challenging to forecast OWB activity given the extremely high OWB sales growth rates that have occurred in recent years. LADCO will want to closely monitor activity and emission trends for this category given its relative importance in the emissions inventory, recent historical growth rates, and additional unique characteristics.

Finally, Pechan reviewed the complete list of area/MAR source categories in the LADCO base year inventory to identify the priority category growth indicators that could be applied to non-priority area/MAR categories. This step yielded priority category growth indicator assignments for an additional 26 area/MAR categories.

C. NON-EGU POINT SOURCES

Table II-3 displays the priority point source categories, including the description and emissions activity associated with each category. The last column in this table identifies each category's growth indicator assignment under the previous growth and control factor contract. Table II-4 presents the assigned growth indicator for each priority point source category and identifies any alternative growth indicators that were considered. Pechan first considered the use of historical throughput data from LADCO state point source inventories to identify recent trends that provided sufficient support for extrapolation. As mentioned above, for energy consumption sectors, Pechan compared regional historical (1990-2004) energy consumption data to *AEO 2007* forecast data to determine if the forecast growth rates appear suspect relative to historical trends.

In selecting from alternative growth indicator data sources, the general decision-making hierarchy was as follows, listed in order of preference:

- (1) If throughput data were available for states representing a majority of emissions for a given category, and these data indicated a consistent trend, the historical throughput trend was extended thru 2009, and held constant thereafter (two reasons for not extending the trend throughout the entire forecast period are that throughput data are only available for a three or a six-year period, and in some cases the historical throughput decrease was so large that it would eventually result in no activity);
- (2) If the forecast and historical trends were in the same direction, Pechan relied on the forecast data (an exception was made, however, if the forecast data were only available on a national-level, but the historical data were available for the LADCO region); and

If the forecast and historical trends were in different directions (e.g., forecast trend is for an increase in activity, but historical trend was a decrease), Pechan applied a no growth assumption.

Table II-3. Priority Emission Activity Point Source Categories

POLLUTANT	SCC	DESC2	DESC3	DESC4	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
NH3	10200601	Industrial	Natural Gas	> 100 Million Btu/hr	Volume of natural gas burned in industrial pt source boilers of >100 MMBtu	No growth based on historical (1990-2001) energy data
NH3	30102599	Chemical Manufacturing	Cellulosic Fiber Production	Other Not Classified	Amount of cellulosic fiber produced	Avg of REMI employment & output GFs for Plastics, Materials, & Synthetics sector
NH3	10200602	Industrial	Natural Gas	10-100 Million Btu/hr	Volume of natural gas burned in industrial pt source boilers of 10-100 MMBtu	No growth based on historical energy data
NH3	30199999	Chemical Manufacturing	Other Not Classified	Specify in Comments Field	Amount of (unknown) chemical products produced	Avg of REMI employment & output GFs for Chemicals sector
NH3	10200204	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker	Amount of bituminous coal burned in spreader stoker industrial pt source boilers	AEO Industrial steam coal
NOX	20200202	Industrial	Natural Gas	Reciprocating	Volume of natural gas burned in industrial pt source reciprocating engines	No growth based on historical energy data
NOX	30500606	Mineral Products	Cement Manufacturing (Dry Process)	Kilns	Amount of cement produced via dry process	LADCO region historical cement production growth rate
NOX	30600201	Petroleum Industry	Catalytic Cracking Units	Fluid Catalytic Cracking Unit	Amount of fresh feed processed via fluid catalytic cracking units (FCCU)	AEO Refined Petroleum Products Supplied (national)
NOX	30600104	Petroleum Industry	Process Heaters	Gas-fired	Volume of gas burned in petroleum industry pt source process heaters	AEO Refining sector natural gas (national)
NOX	10200202	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom	Amount of bituminous coal burned in dry bottom industrial pt source boilers	AEO Industrial steam coal
NOX	10200601	Industrial	Natural Gas	> 100 Million Btu/hr	Volume of natural gas burned in industrial pt source boilers of >100 MMBtu	No growth based on historical energy data
NOX	30300304	Primary Metal Production	By-product Coke Manufacturing	Quenching	Amount of coal charged to manufacture coke	REMI output for Blast Furnaces and Basic Steel products sector
NOX	10200217	Industrial	Bituminous/Subbituminous Coal	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous)	Amount of bituminous coal burned in bubbling bed industrial pt source boilers	AEO Industrial steam coal
NOX	10200707	Industrial	Process Gas	Coke Oven Gas	Volume of process gas burned in coke ovens	AEO Metallurgical coal consumption projections (national)
NOX	10200602	Industrial	Natural Gas	10-100 Million Btu/hr	Volume of natural gas burned in industrial pt source boilers of 10-100 MMBtu	No growth based on historical energy data

Table II-3 (continued)

POLLUTANT	SCC	DESC2	DESC3	DESC4	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
NOX	20200254	Industrial	Natural Gas	4-cycle Lean Burn	Volume of natural gas burned in industrial sector 4-cycle lean burn IC engines	No growth based on historical energy data
NOX	20100102	Electric Generation	Distillate Oil (Diesel)	Reciprocating	Amount of distillate oil burned in reciprocating engines for electricity	AEO Electric Generation distillate oil
NOX	20200201	Industrial	Natural Gas	Turbine	Volume of natural gas burned in industrial sector turbines	No growth based on historical energy data
NOX	39000689	In-process Fuel Use	Natural Gas	General	Volume of industrial process pt source natural gas burned	No growth based on historical energy data
NOX	10200201	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom	Amount of bituminous coal burned in wet bottom industrial pt source boilers	AEO Industrial steam coal
NOX	10200701	Industrial	Process Gas	Petroleum Refinery Gas	Volume of petroleum refinery (still) gas burned	No growth based on historical energy data
ROG	30100399	Chemical Manufacturing	Ammonia Production	Other Not Classified	Amount of ammonia produced	REMI output for Agricultural Chemicals sector
ROG	30201916	Food and Agriculture	Vegetable Oil Processing	Oil Extraction	Amount of extractor feed cake produced	REMI output for Grain Mill Products and Fats and Oils sector
ROG	40500511	Printing/Publishing	General	Gravure: 2754	Amount of solvent in ink used by pt sources	REMI output for Commercial Printing and Business Forms sector
ROG	30199999	Chemical Manufacturing	Other Not Classified	Specify in Comments Field	Amount of (unknown) chemical products produced	Avg of REMI employment & output GFs for Chemicals sector
ROG	30125099	Chemical Manufacturing	Methanol/Alcohol Production	Other Not Classified	Amount of methanol/alcohol produced	REMI output for Industrial Chemicals sector
ROG	40201301	Surface Coating Operations	Paper Coating	Coating Operation	Amount of solvent in coating used by pt sources	No growth based on historical LADCO emissions trend
ROG	40200101	Surface Coating Operations	Surface Coating Application - General	Paint: Solvent-base	Amount of coating mix applied by pt sources	No growth based on historical LADCO emissions trend
ROG	30102599	Chemical Manufacturing	Cellulosic Fiber Production	Other Not Classified	Amount of cellulosic fiber produced	Avg of REMI employment & output GFs for Plastics, Materials, & Synthetics sector
ROG	30500201	Mineral Products	Asphalt Concrete	Rotary Dryer: Conventional Plant (see 3-05-002-50 to -53 for	Amount of hot mix asphalt produced by pt sources	Avg of REMI employment & output GFs for Misc. Petroleum and Coal Products sector
ROG	30201906	Food and Agriculture	Vegetable Oil Processing	Corn Oil: General	Amount of extractor feed cake produced	REMI output for Grain Mill Products and Fats and Oils sector
ROG	30201919	Food and Agriculture	Vegetable Oil Processing	Fugitive Leaks	Amount of extractor feed cake produced	REMI output for Grain Mill Products and Fats and Oils sector
ROG	40200110	Surface Coating Operations	Surface Coating Application - General	Paint: Solvent-base	Amount of solvent-based coatings applied by pt sources	Historical LADCO throughput data trend
ROG	40201899	Surface Coating Operations	Metal Coil Coating	Other Not Classified	Amount of solvent in coating used by pt sources	REMI output for Nonferrous Rolling and Drawing sector
ROG	40388801	Petroleum Product Storage at Refineries	Fugitive Emissions	Specify in Comments Field	Petroleum product storage capacity at refineries	AEO Refined Petroleum Products Supplied (national)
ROG	40200701	Surface Coating Operations	Surface Coating Application - General	Adhesive Application	Amount of adhesive coatings applied by pt sources	REMI output for Total Manufacturing sector

Table II-3 (continued)

POLLUTANT	SCC	DESC2	DESC3	DESC4	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
SO2	30600201	Petroleum Industry	Catalytic Cracking Units	Fluid Catalytic Cracking Unit	Amount of fresh feed processed via FCCU	AEO Refined Petroleum Products Supplied (national)
SO2	10200202	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom	Amount of bituminous coal burned in dry bottom industrial pt source boilers	AEO Industrial steam coal
SO2	30600805	Petroleum Industry	Fugitive Emissions	Miscellaneous: Sampling/Non-Asphalt Blowing/Purging/etc.	Barrels of refinery feed processed	AEO Refined Petroleum Products Supplied (national)
SO2	30199999	Chemical Manufacturing	Other Not Classified	Specify in Comments Field	Amount of (unknown) chemical products produced	Avg of REMI employment & output GFs for Chemicals sector
SO2	10200217	Industrial	Bituminous/Subbituminous Coal	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous)	Amount of bituminous coal burned in bubbling bed industrial pt source boilers	AEO Industrial steam coal
SO2	10200201	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom	Amount of bituminous coal burned in wet bottom industrial pt source boilers	AEO Industrial steam coal
SO2	10200225	Industrial	Bituminous/Subbituminous Coal	Traveling Grate (Overfeed) Stoker (Subbituminous Coal)	Amount of subbituminous coal burned in overfeed stoker industrial pt source boilers	AEO Industrial steam coal
SO2	30500606	Mineral Products	Cement Manufacturing (Dry Process)	Kilns	Amount of cement produced via dry process	LADCO region historical cement production growth
SO2	30600401	Petroleum Industry	Blowdown Systems	Blowdown System with Vapor Recovery System with Flaring	Barrels of refinery feed processed	AEO Refined Petroleum Products Supplied (national)
SO2	10200204	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker	Amount of bituminous coal burned in spreader stoker industrial pt source boilers	AEO Industrial steam coal
SO2	10300217	Commercial/Institutional	Bituminous/Subbituminous Coal	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bitumin.)	Amount of bituminous coal burned in bubbling bed commercial pt source boilers	AEO Commercial coal
SO2	39000701	In-process Fuel Use	Process Gas	Coke Oven or Blast Furnace	Volume of coke oven or blast furnace gas burned	AEO Metallurgical coal consumption projections (national)
SO2	30103201	Chemical Manufacturing	Elemental Sulfur Production	Mod. Claus: 2 Stage w/o Control (92-95% Removal)	Amount of 100% sulfur produced	REMI output for Industrial Chemicals sector
SO2	10300225	Commercial/Institutional	Bituminous/Subbituminous Coal	Traveling Grate (Overfeed) Stoker (Subbituminous Coal)	Amount of subbituminous coal burned in overfeed stoker commercial pt source boilers	AEO Commercial coal
SO2	10300209	Commercial/Institutional	Bituminous/Subbituminous Coal	Spreader Stoker (Bituminous Coal)	Amount of bituminous coal burned in spreader stoker commercial pt source boilers	AEO Commercial coal
SO2	10200401	Industrial	Residual Oil	Grade 6 Oil	Amount of residual oil (No. 6) burned in industrial pt source boilers	No growth based on historical energy data

Table II-3 (continued)

POLLUTANT	SCC	DESC2	DESC3	DESC4	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
EMISSION TREND ANALYSIS CATEGORIES NOT LISTED ABOVE WITH CONSISTENT THROUGHPUT TRENDS						
VOC	40202201	Petroleum and Solvent Evaporation	Surface Coating Operations	Plastic Parts: Coating Operation	Amount of solvent used in coating applied	Historical LADCO throughput data trend
NOX	39000699	In Process Fuel Use	Natural Gas	General	Amount of nat gas used in industrial processes	No growth based on historical energy data

Table II-4. Growth Indicators for Priority Point Source Categories

Pollutant	SCC	Emissions Priority Category	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
			2005-2009	2005-2018			
NH3	10200601	NOx	-11.5	-11.5	Historic throughput trend from 3 states (-3.0% per year) extended thru 2009; post-2009 held constant.	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	
NH3	30102599		4.9	18.2	Avg of REMI employment & output growth factors for Plastics, Materials, & Synthetics sector		Forecast data are state-level
NH3	10200602	NOx	-12.2	-12.2	Historic throughput trend from 4 states (-3.2% per year) extended thru 2009; post-2009 held constant.	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	
NH3	30199999		8.9	25.6	Avg of REMI employment & output growth factors for Chemicals sector		Forecast data are state-level
NH3	10200204	NOx	2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	Did not use throughput since available states represent <50% of regional emissions
NOX	20200202	NOx	0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	Did not use throughput since available state represent <50% of regional emissions
NOX	30500606		8.2	29.4	LADCO region historical cement production growth rate (+2.0% per year)		
NOX	30600201	SO2	0.4	0.4	AEO refinery distillation projections for Petroleum Administration District (PAD) II, which includes all LADCO states plus additional surrounding states	Similar 1990-2005 data also includes states not in LADCO region and shows very small growth rate	Did not use throughput since available states represent <50% of regional emissions
NOX	30600104		5.9	20.6	1991-2002 Midwest Census region Refining sector natural gas consumption growth rate (+1.5% per year)	AEO National Refining sector natural gas consumption forecast is +2.7% per year	Used historical growth rate because it is regional and of similar direction to AEO national forecast
NOX	10200202	NOx	2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	Did not use throughput since available states represent <50% of regional emissions
NOX	10200601	NOx	-11.5	-11.5	Historic throughput trend from 3 states (-3.0% per year) extended thru 2009; post-2009 held constant.	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	
NOX	30300304		-6.2	-19.8	AEO forecast for metallurgical coal consumption	DOE 1990-2004 = -3.0% per year; AEO forecast = -1.7% per year	
NOX	10200217		2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	
NOX	10200707		-6.2	-19.8	AEO forecast for metallurgical coal consumption	DOE 1990-2004 = -3.0% per year; AEO forecast = -1.7% per year	
NOX	10200602	NOx	-12.2	-12.2	Historic throughput trend from 4 states (-3.2% per year) extended thru 2009; post-2009 held constant.	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	
NOX	20200254		0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	

Table II-4 (continued)

Pollutant	SCC	Emissions Priority Category	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
			2005-2009	2005-2018			
NOX	20100102		1.7	5.5	DOE 1990-2004 historic trend (+0.4%)	AEO forecast = +5.0% per year thru 2009, but near equivalent decrease from 2009 to 2018	Used historic trend because of large difference between 2009 and 2018 forecast, & historic growth rate is in between the 2 forecast values
NOX	20200201		0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	
NOX	39000689		0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -0.01% per year; AEO forecast = +1.4% per year	
NOX	10200201	SO2	2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	No throughput data available
NOX	10200701		-1.3	-4.1	DOE 1990-2004 historic trend (-0.3% per year)	AEO forecast = 2009 (-1.0% per year) and 2018 (-0.1% per year)	Used historic trend because is region-specific (forecast is national), and historic change is in between the 2009 & 2018 AEO growth rates
ROG	30100399		-19.7	-28.6	Freedonia's "Chemical Catalysts to 2009-Ammonia Catalyst Demand" - national projections adjusted for relative state growth in REMI output for Agricultural Chemicals sector		Forecast data are state-level
ROG	30201916		2.2	11.9	Avg of REMI employment & output growth factors for Grain Mill Products and Fats and Oils sector		Forecast data are state-level
ROG	40500511		0.0	0.0	No growth due to contradictory historic trend versus forecast trend in regional employment for "Printing Machine Operators"		Freedonia's "Solvents to 2010-Printing Ink Market for Solvents" indicates no projected change in solvent content of ink
ROG	30199999		8.9	25.6	Avg of REMI employment & output growth factors for Chemicals sector		Forecast data are state-level
ROG	30125099		1.1	5.3	Freedonia's "Chemical Catalysts to 2009-Alcohols Catalyst Demand by Application" - national projections adjusted for relative state growth in REMI output for Industrial Chemicals sector		Forecast data are state-level
ROG	40201301		0	0	No growth based on consistent historic LADCO emissions trend		2005 emissions data confirm previous no growth approach
ROG	40200101	VOC	-6.4	-21.4	Regional employment projections for "Coating, Painting, and Spraying Machine Operators, and Tenders" adjusted for solvent content of paints and coatings from Freedonia's "Solvents to 2010-Paints and Coatings Market for Solvents" (-1.9% per year)		Forecast data are state-level; adopted approach believed better than available historic throughput data

Table II-4 (continued)

Pollutant	SCC	Emissions Priority Category	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
			2005-2009	2005-2018			
ROG	30102599		4.9	18.2	Avg of REMI employment & output growth factors for Plastics, Materials, & Synthetics sector		Forecast data are state-level
ROG	30500201		8.3	21.5	Avg of REMI employment & output growth factors for Misc. Petroleum and Coal Products sector		Forecast data are state-level
ROG	30201906		2.2	11.9	Avg of REMI employment & output growth factors for Grain Mill Products and Fats and Oils sector		Forecast data are state-level
ROG	30201919		2.2	11.9	Avg of REMI employment & output growth factors for Grain Mill Products and Fats and Oils sector		Forecast data are state-level
ROG	40200110	VOC	-6.4	-21.4	Regional employment projections for "Coating, Painting, and Spraying Machine Operators, and Tenders" adjusted for solvent content of paints and coatings from Freedonia's "Solvents to 2010-Paints and Coatings Market for Solvents" (-1.9% per year)		Forecast data are state-level; adopted approach believed better than available historic throughput data
ROG	40201899		6.9	26.0	Freedonia's "Protective Coatings to 2009-Demand for Coil Coatings" - national projections adjusted for relative state growth in REMI output for Nonferrous Rolling and Drawing sector, adjusted for projected solvent content information for paints and coatings from "Solvents to 2010-Paints/Coatings Market for Solvents" (-1.9% per year)		Forecast data are state-level; coil coating has seen significant growth historically, and such growth is projected to continue in the future
ROG	40388801		0.4	0.4	AEO refinery distillation projections for Petroleum Administration District (PAD) II, which includes all LADCO states plus additional surrounding states	1990-2005 data also includes states not in LADCO region and shows similar very small growth rate	
ROG	40200701		-1.6	-1.0	Freedonia's "Solvents to 2010-Adhesives & Sealants Market for Solvents" national projections, adjusted for relative state growth in REMI output in Total Manufacturing sector		
SO2	30600201	SO2	0.4	0.4	AEO refinery distillation projections for Petroleum Administration District (PAD) II, which includes all LADCO states plus additional surrounding states	1990-2005 data also includes states not in LADCO region and shows similar very small growth rate	Did not use throughput since available state represent <50% of regional emissions
SO2	10200202	NOx	2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	No throughput data available
SO2	30600805	SO2	0.4	0.4	AEO refinery distillation projections for Petroleum Administration District (PAD) II, which includes all LADCO states plus additional surrounding states	1990-2005 data also includes states not in LADCO region and shows similar very small growth rate	No throughput data available
SO2	30199999		8.9	25.6	Avg of REMI employment & output GFs for Chemicals sector		Forecast data are state-level
SO2	10200217		2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	
SO2	10200201	SO2	2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	No throughput data available
SO2	10200225		2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	
SO2	30500606		8.2	29.4	LADCO region historical cement production growth rate (+2.0% per year)		

Table II-4 (continued)

Pollutant	SCC	Emissions Priority Category	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
			2005-2009	2005-2018			
SO2	30600401		0.4	0.4	AEO refinery distillation projections for Petroleum Administration District (PAD) II, which includes all LADCO states plus additional surrounding states	1990-2005 data also includes states not in LADCO region and shows similar very small growth rate	
SO2	10200204	NOx	2.9	-0.6	AEO forecast for other industrial coal combustion	DOE 1990-2004 = -1.5% per year; AEO forecast = <-0.1% per year	Did not use throughput since available states represent <50% of regional emissions
SO2	10300217		0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -1.2% per year; AEO forecast = +0.0% per year	
SO2	39000701		-6.2	-19.8	AEO forecast for metallurgical coal consumption	DOE 1990-2004 = -3.0% per year; AEO forecast = -1.7% per year	
SO2	30103201		2.5	8.2	1996-2005 recovered elemental sulfur production growth rate (+0.6% per year) for IL + MI + MN + OH		
SO2	10300225		0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -1.2% per year; AEO forecast = +0.0% per year	
SO2	10300209		0.0	0.0	No growth due to contradictory historic and forecast trends	DOE 1990-2004 = -1.2% per year; AEO forecast = +0.0% per year	
SO2	10200401	SO2	-49.4	-49.6	AEO forecast for industrial residual oil consumption (-5.1% per year)	DOE 1990-2004 = -6.6% per year	Used AEO forecast due to similarity with AEO historical trend and throughput trend (-6.1%)
NON-PRIORITY CATEGORIES INCLUDED IN EMISSION TREND ANALYSIS WITH CONSISTENT THROUGHPUT TRENDS:							
VOC	40202201	VOC	-33.5	-33.5	Historic throughput trend from 3 states (-9.7%) extended thru 2009; post-2009 held constant.		
NOX	39000699	NOx	-15.8	-15.8	Historic throughput trend from 3 states (-4.2%) extended thru 2009; post-2009 held constant.		

Table II-4 also presents the 2005-2009 and 2005-2018 growth rates for the final assigned point source growth indicators. In addition, Pechan reviewed the complete list of point SCCs in the LADCO base year inventory to identify the priority category growth indicators that could be applied to non-priority point source categories. This step yielded priority category growth indicator assignments for an additional 539 point source categories.

D. NONROAD MODEL SOURCES

At LADCO's request, Pechan analyzed potential improvements to the default growth indicators for the 25 NONROAD model priority source categories displayed in Table II-5. With the exception of the all-terrain vehicle, offroad motorcycle, and snowmobile categories, 1989-1996 national equipment population trends form the basis for the NONROAD growth rates. For these other three categories, NONROAD relies on national equipment population forecasts prepared by a relevant trade association (see Table II-5 for details).

Table II-6 reports this study's growth indicator assignments for priority NONROAD model source categories. Given the acknowledged shortcomings of the NONROAD growth rates (use of 1989-1996 national equipment populations to project future equipment populations in each region of the country), the growth factor improvements generally reflect the use of regional/state-level forecast data that are expected to correlate with use of the equipment (i.e., regional occupational employment projections, state-level economic sector employment forecasts, or state-level landing/take-off projections). Table II-6 also displays any alternative growth indicators that were considered. For the three categories for which NONROAD relies on forecasts rather than historical 1989-1996 trends, Pechan compiled available recent historical equipment population estimates. This information was used to revise the current national forecast approach to reflect more recent information, and whenever possible, recent LADCO region-specific equipment population trends.

Although the NONROAD model growth rates are fuel-specific, Pechan was unable to develop fuel-specific forecast data. Therefore, Pechan updated a priority category's growth rates only when the 1989-1996 national equipment populations indicated that the category's fuel-specific growth rate had traditionally been similar to the overall sector's equipment population growth rate. Table II-6 identifies instances where the past fuel-specific growth rate substantially differed from the overall sector's growth rate. In these cases, Pechan retained the NONROAD model fuel-specific forecast approach. Section IV.A. describes how Pechan incorporated the updated equipment population growth rates into the NONROAD model

Table II-5. Priority Emission Activity NONROAD Model Source Categories

SCC	DESCRIPTION SUMMARY	EMISSIONS ACTIVITY	CURRENT GROWTH BASIS
2260001030	2-Stroke ATV	Population of 2-stroke gasoline ATVs	NONROAD (Motorcycle Industry Council national 2-stroke gasoline ATV projections)
2265001030	4-Stroke ATV	Population of 4-stroke gasoline ATVs	NONROAD (Motorcycle Industry Council national 4-stroke gasoline ATV projections)
2260001010	2-Stroke Offroad Motorcycles	Population of 2-stroke gasoline offroad motorcycles	NONROAD (Motorcycle Industry Council national off-highway motorcycle population projections)
2265001010	4-Stroke Offroad Motorcycles	Population of 4-stroke gasoline offroad motorcycles	NONROAD (Motorcycle Industry Council national off-highway motorcycle population projections)
2267006000	LPG Light Commercial	Population of light commercial LPG-fueled equipment	NONROAD (national 1989-1996 LPG light commercial equipment population growth rate)
2270004000	Diesel Lawn & Garden Equipment	Population of lawn & garden diesel-fueled equipment	NONROAD (national 1989-1996 diesel lawn & garden equipment population growth rate)
2270008000	Diesel Airport Service Equipment	Population of airport service diesel-fueled equipment	NONROAD (national 1989-1996 diesel airport service equipment population growth rate)
2267008000	LPG Airport Service Equipment	Population of airport service LPG-fueled equipment	NONROAD (national 1989-1996 total airport service equipment population growth rate)
2268008000	CNG Airport Service Equipment	Population of airport service CNG-fueled equipment	NONROAD (national 1989-1996 total airport service equipment population growth rate)
2260001020	2-Stroke Snowmobiles	Population of 2-stroke gasoline snowmobiles	NONROAD national growth (see below) with state adjustment based on real disposable income forecasts
2265001020	4-Stroke Snowmobiles	Population of 4-stroke gasoline snowmobiles	NONROAD (International Snowmobile Manufacturers Association national snowmobile population projections)
2260007000	2-Stroke Logging Equipment	Population of logging 2-stroke gasoline equipment	NONROAD (national 1989-1996 gasoline logging equipment population growth rate)
2265007000	4-Stroke Logging Equipment	Population of logging 4-stroke gasoline equipment	NONROAD (national 1989-1996 gasoline logging equipment population growth rate)
2270006000	Diesel Light Commercial	Population of light commercial diesel-fueled equipment	NONROAD (national 1989-1996 diesel light commercial equipment population growth rate)
2268006000	CNG Light Commercial	Population of light commercial CNG-fueled equipment	NONROAD (national 1989-1996 CNG light commercial equipment population growth rate)
2267007000	LPG Logging Equipment	Population of logging LPG-fueled equipment	NONROAD (national 1989-1996 logging equipment population growth rate)
2268007000	CNG Logging Equipment	Population of logging CNG-fueled equipment	NONROAD (national 1989-1996 logging equipment population growth rate)
2285002000	Diesel Railway Maintenance	Population of railway maintenance diesel-fueled equipment	NONROAD (national 1989-1996 diesel railway maintenance equipment population growth rate)
2260006000	2-Stroke Light Commercial	Population of light commercial 2-stroke gasoline equipment	NONROAD (national 1989-1996 gasoline light commercial equipment population growth rate)
2265006000	4-Stroke Light Commercial	Population of light commercial 4-stroke gasoline equipment	NONROAD (national 1989-1996 gasoline light commercial equipment population growth rate)
2270002000	Diesel Construction Equipment	Population of construction diesel-fueled equipment	NONROAD national growth with state adjustment based on Construction employment forecasts
2270003000	Diesel Industrial Equipment	Population of industrial diesel-fueled equipment	NONROAD (national 1989-1996 diesel industrial equipment population growth rate)
2267003000	LPG Industrial Equipment	Population of industrial LPG-fueled equipment	NONROAD (national 1989-1996 LPG industrial equipment population growth rate)
2270001000	Diesel Recreational Vehicles	Population of diesel recreational vehicles	NONROAD (national 1989-1996 diesel recreational equipment population growth rate)
2282020000	Diesel Recreational Marine	Population of diesel recreational marine vessels	NONROAD (national 1989-1996 diesel recreational equipment population growth rate)

Table II-6. Growth Indicators for Priority NONROAD Model Source Categories

SCC	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
	2005-2009	2005-2018			
2260001030	10.8	39.7	50% higher growth rate than overall LADCO region "Recreational Vehicle Service Technicians" employment projections, which is 1.7%/yr, based on premise that ATV market is less mature than market for other recreation vehicles	Available ATV/OHV registration data for MI+MN+WI indicate avg. annual growth of 14.6% between 2000 and 2005; however, 2006 data for each state is only +1 or +1.1%; NONROAD shows 2005-2006 = +10.5%. National ATV sales (not population) of +3.8% per year for 2000-2005; 2005-2006 sales = -4.2%	Did not use long-term historical trend as ATV market appears to be maturing based on most recent data (this is predicted by NONROAD model, but not until post-2010; NONROAD shows 2010-2018 = +2.7%/yr)
2265001030	10.8	39.7	50% higher growth rate than overall LADCO region "Recreational Vehicle Service Technicians" employment projections, which is 1.7%/yr, based on premise that ATV market is less mature than market for other recreation vehicles	Available ATV/OHV registration data for MI+MN+WI indicate avg. annual growth of 14.6% between 2000 and 2005; however, 2006 data for each state is only +1 or +1.1%; NONROAD shows 2005-2006 = +10.5%. National ATV sales (not population) of +3.8% per year for 2000-2005; 2005-2006 sales = -4.2%	Did not use long-term historical trend as ATV market appears to be maturing based on most recent data (this is predicted by NONROAD model, but not until post-2010; NONROAD shows 2010-2018 = +2.7%/yr)
2260001010	5.1	17.7	LADCO region employment projections for "Motorcycle Mechanics"	Unable to compile regional registration trends; national off-road motorcycle sales for 2000-2006 = +2.3%, but 2001-2006 = -1.6%	Employment projections are LADCO region-specific and fall in-between recent national sales trends
2265001010	5.1	17.7	LADCO region employment projections for "Motorcycle Mechanics"	Unable to compile regional registration trends; national off-road motorcycle sales for 2000-2006 = +2.3%, but 2001-2006 = -1.6%	Employment projections are LADCO region-specific and fall in-between recent national sales trends
2267006000	19.8	57.5	NONROAD (national 1989-1996 LPG light commercial equipment population growth rate)	REMI Commercial sector employment forecast for LADCO region (2005-2009=+1.8%/yr; 2005-2018 = +1.1%/yr)	Did not use alternative because historical period indicates substantially different growth rate for LPG than overall sector
2270004000	5.8	20.1	LADCO region employment projections for "Landscaping and Groundskeeping Workers"		
2270008000	-0.7	18.0	State-level FAA itinerant air carrier + air taxi landing and take-off (LTO) forecast (updated as of December 2006)		
2267008000	-0.7	18.0	State-level FAA itinerant air carrier + air taxi landing and take-off (LTO) forecast (updated as of December 2006)		
2268008000	-0.7	18.0	State-level FAA itinerant air carrier + air taxi landing and take-off (LTO) forecast (updated as of December 2006)		
2260001020	3.5	11.9	50% lower growth rate than overall LADCO region "Recreational Vehicle Service Technicians" employment projections, which is 1.7%/yr, based on premise that snowmobile market is more mature than market for other recreation vehicles	Annual growth in snowmobile registrations for states representing 92% of 2006 LADCO region registrations: 2000-2006 = +0.0%	No growth assumption not adopted because lack of snowfall often cited as major contributing factor for recent stagnation in snowmobile registrations
2265001020	3.5	11.9	50% lower growth rate than overall LADCO region "Recreational Vehicle Service Technicians" employment projections, which is 1.7%/yr, based on premise that snowmobile market is more mature than market for other recreation vehicles	Annual growth in snowmobile registrations for states representing 92% of 2006 LADCO region registrations: 2000-2006 = +0.0%	No growth assumption not adopted because lack of snowfall often cited as major contributing factor for recent stagnation in snowmobile registrations

Table II-6 (continued)

SCC	Total % Change		Growth Indicator Basis	Alternatives Considered	Comment
	2005-2009	2005-2018			
2260007000	2.2	7.3			
2265007000	2.2	7.3	LADCO region employment projections for "Logging Equipment Operators"		
2270006000	7.2	15.0	REMI Commercial sector employment forecast for LADCO region		
2268006000	7.2	15.0	REMI Commercial sector employment forecast for LADCO region		
2267007000	2.2	7.3	LADCO region employment projections for "Logging Equipment Operators"		
2268007000	2.2	7.3	LADCO region employment projections for "Logging Equipment Operators"		
2285002000	12.2	36.7	NONROAD (national 1989-1996 diesel railway maintenance equipment population growth rate)	LADCO region employment projections for "Rail-Track Laying & Maintenance Equipment Operators" (-1.6%/yr)	Did not use alternative because historical period indicates substantially different growth rate for diesel than overall sector
2260006000	7.2	15.0	REMI Commercial sector employment forecast for LADCO region		
2265006000	7.2	15.0	REMI Commercial sector employment forecast for LADCO region		
2270002000	4.7	16.2	LADCO region employment projections for "Operating Engineers and Other Construction Equipment Operators"		
2270003000	0.1	0.2	LADCO region employment projections for "Industrial Machinery Mechanics"		
2267003000	0.1	0.2	LADCO region employment projections for "Industrial Machinery Mechanics"		
2270001000	10.4	31.5	NONROAD (national 1989-1996 diesel recreational equipment population growth rate)	LADCO region employment projections for "Recreational Vehicle Service Technicians" (+1.7%/yr)	Did not use alternative because historical period indicates substantially different growth rate for diesel than overall sector
2282020000	10.4	31.5	NONROAD (national 1989-1996 diesel recreational equipment population growth rate)	Two options: 1996-2005 LADCO region recreational boat registration growth rate (0.8%/yr) and LADCO region employment projections (+1.5%/yr) for "Motorboat Mechanics"	Did not use alternatives because historical period indicates substantially different growth rate for diesel than overall sector.

SECTION III. UPDATED EMISSION CONTROL DATA

A. NON-EGU POINT SOURCE CONTROLS

1. NO_x SIP Call

All states in the LADCO region affected by the NO_x (oxides of nitrogen) SIP (State Implementation Plan) Call requirements (OH, IN, IL, MI) indicated that their sources were complying in 2005. The only exception to this is for reciprocating internal combustion engines (RICE) in Illinois. The State of Illinois recommended that an 82 percent NO_x control efficiency be applied to large RICE engines that are affected by the SIP Call. The RICE engine requirement in Illinois has a January 1, 2008 compliance date. Table III-1 lists these engines and the associated NO_x control efficiencies applied in the emission projections. This requirement is expected to affect NO_x emissions in all projection years.

2. MACT Standards

Table III-2 summarizes the control factors used to estimate the post-2005 effects of MACT emission standards on volatile organic compounds (VOC), NO_x, and PM emissions in the projection years. The information in this table was developed from EPA guidance on estimating the criteria pollutant emission benefits of MACT standards (Page, 2007). Any post-2005 MACT standards that have no expected criteria pollutant emission reductions according to the draft EPA guidance were not included in Table III-2. Table III-2 was circulated to the states for review, and Wisconsin provided its own estimates of the expected VOC and PM emission reductions from these MACT standards in its state. The State of Michigan concurred with the emission reduction estimates made by Wisconsin. Those VOC and PM emission reduction percentages are shown in the two right-most columns of Table III-2. So, the control factor file reflects the EPA estimated values for IL, IN, MN, and OH, and the Wisconsin-provided estimates for MI and WI.

3. Consent Decrees

Previous Pechan-developed control efficiencies by source (Pechan, 2005) and pollutant were merged with the LADCO state 2005 point source file and control factors assigned accordingly. The 2005 point source control efficiencies (CEs) for sulfur dioxide (SO₂) and NO_x for fluid catalytic cracking units (FCCUs) and heaters and boilers were checked to see whether there is any compliance by 2005. Pechan also added all MACTEC revisions/additions from their earlier report to the control factor file (MACTEC incorporated cases and settlements control factors for refineries that were not evaluated for the 812 study) and made any changes/additions that were provided by the state air pollution control agencies. Table III-3 lists all of the LADCO state Non-EGU Point Sources affected by consent decrees. These sources all have post-2005 control factors applied in the analysis. There are two refineries in the study area who had either complied with their consent decrees or curtailed applicable operations by 2005, so no future year control factors were applied in this analysis. These two refineries are Premcor Refining in IL and the Flint Hills Refinery in MN.

Table III-1. RICE Engines in Illinois Affected by NO_x SIP Call

Id Number	Device	Process	Device Description	Pollutant	% Reduction	Comments
027807AAC	0003	01	ENGINES 09-ENG AND 10-ENG	NOX	59	50/50 for 2 engines = .5+.5(.18) = 59% reduction
041804AAC	0009	01	ENGINE 1213	NOX	82	
041804AAC	0010	01	ENGINE 1214	NOX	82	
041804AAC	0011	01	ENGINE 1215	NOX	82	
041804AAC	0012	01	ENGINE 1216	NOX	82	
041804AAC	0013	01	ENGINE 1217	NOX	82	
073816AAA	0001	01	WORTHINGTON MLV-10 COMPRESSOR & GAS FIRED ENGINE #12	NOX	82	
073816AAA	0004	01	CLARK TCV-10 COMPRESSOR & GAS FIRED ENGINE ENGINE #9	NOX	82	
073816AAA	0012	01	WORTHINGTON MLV-10 COMPRESSOR AND GAS FIRED ENGINE NO. 13	NOX	82	
073816AAA	0013	01	WORTHINGTON MLV-10 COMPRESSOR AND GAS FIRED ENGINE NO. 14	NOX	82	
073816AAA	0014	01	WORTHINGTON MLV-10 COMPRESSOR AND GAS FIRED ENGINE NO. 15	NOX	82	
073816AAA	0015	01	WORTHINGTON MLV-14 ENGINE #10	NOX	82	
085809AAA	0010	01	3 CLARK COMPRESSORS	NOX	82	
093802AAF	0003	01	ENGINE E-1008	NOX	82	
113817AAA	0002	01	ENGINE EC21	NOX	82	
113817AAA	0003	01	ENGINE IC11	NOX	82	
113821AAA	0002	01	ENTERPRISE RECIP COMP EC-21 4000 MP EF 3.3.2-1	NOX	82	
113821AAA	0005	01	COOPER COMPRESSOR CC22 EF 3.3.2-1 4000 HP	NOX	82	
149820AAB	0002	01	2 RECIPROCATING ENGINES (1013 - 1014)	NOX	59	50/50 for 2 engines = .5+.5(.18) = 59% reduction
149820AAB	0003	01	3 RECIPROCATING ENGINES (1015 - 1017)	NOX	82	
167801AAA	0001	01	ENGINES 1116 AND 1117	NOX	82	
167801AAA	0003	01	1-COOPER RECIPROCATING ENGINE, 4000HP, 1115	NOX	82	
167801AAA	0008	01	ENGINES 1118 AND 1119	NOX	59	50/50 for 2 engines = .5+.5(.18) = 59% reduction

Table III-2. Post-2005 MACT Standards and Expected VOC, NO_x, and PM Reductions

MACT Standard – Source Category	Code of Federal Regulations Subpart	Compliance Date (existing sources)	VOC (% Reduction)	NO _x (% Reduction)	Total PM (% Reduction)	Affected SCCs	MACT Code	Wisconsin and Michigan Values	
								VOC	PM
Asphalt Processing and Asphalt Roofing Manufacture	LLLLL	5/1/2006	85			30505001, 30500101, 30500102, 30505010, 30601101	0418	10	0
Auto and Light Duty Trucks	IIII	4/26/2007	40			40201601 to 40201632; 40201699	0702	0	0
Coke Ovens: Pushing, Quenching and Battery Stacks	CCCCC	4/14/2006	0			30300304; 30300303	0303	10	0
Fabric Printing, Coating & Dyeing	OOOO	5/29/2006	60			40201101 to 40201199; 40201201; 40201210	0713	10	0
Integrated Iron and Steel	FFFFF	5/20/2006	(5)		20	30301501 to 30301596	0305	0	10
Iron and Steel Foundries	EEEEEE	4/22/2007	5			304003XX, 304007XX	0308	5	0
Lime Manufacturing	AAAAA	1/5/2007			23	305016XX	0408	0	10
Metal Can	KKKKK	11/13/2006	70			40201702; 40201703 to 40201799	0707	0	0
Metal Furniture	RRRRR	5/23/2006	0			402020XX		10	0
Misc. Coating Manufacturing	HHHHH	12/11/2006	64			402026XX	1642	10	0
Misc. Metal Parts and Products	MMMMM	1/2/2007	0			402025XX		10	0
Misc. Organic Chemical Production and Processes (MON)	FFFFF	11/10/2006	66			645200XX; 30113001 to 30113007; 684300XX; 30101005 to 30101099; 68445001; 68445010; 68445013; 68445020; 68445022; 68445101; 68445201; 30110002 to 30110099; 64820001; 64820010; 64821001; 64821010; 64822001; 64822010; 64823001; 64823010; 64823001; 64823010; 64880001; 64882001; 64882002; 64882599; 30105001; 30105101 to 30105130; 30801001; 31604001; 31604002; 31600403; 68510001; 68510010; 68510011; 68580001; 68582001; 68582002; 68582599; 30101837; 64610301 to 64610350; 64610001 to 64610050; 64610101 to 64610150;	1641	10	0

Table III-2 (continued)

MACT Standard – Source Category	Code of Federal Regulations Subpart	Compliance Date (existing sources)	VOC (% Reduction)	NO _x (% Reduction)	Total PM (% Reduction)	Affected SCCs	MACT Code	Wisconsin and Michigan Values	
								VOC	PM
						64610201 to 64610250; 64615001 to 64615030; 64620001 to 64620038; 64630001 to 64630083; 64631001 to 64631083; 64632001 to 64632083; 64680001; 64682001; 64682002; 64682501; 64682502; 64682599; 64130001 to 64130025; 64130101 to 64130125; 64130201 to 64130225; 64131010 to 64131030; 64132001 to 64132030; 64133001 to 64133030; 64180001; 64182001; 64182002; 64182599; 64615001; 64620001; 65135001			
Organic Liquids Distribution	EEEE	2/3/2007	70			40300102, 40300104, 40300106, 40300107, 40301010-40301021	0602	10	0
Plastic Parts	PPPP	4/19/2007	0			402022XX		10	0
Plywood and Composite Wood Products	DDDD	10/1/2007	54			307007XX; 30700921 to 30700971; 30701001 to 30701057; 30700602 to 30700661	1624		
Refractory Products Manufacturing	SSSS	4/17/2006	81	0			0406	10	0
Reinforced Plastic Composites Production	WWWW	4/21/2006	39	0			1337	10	0
Site Remediation	GGGGG	10/8/2006	50	0		504001XX; 50400201, 50400202; 504002XX; 504100XX; 504101XX; 504102XX; 504103XX; 504102XX; 504103XX; 04104XX; 504105XX; 504106XX; 504107XX; 50480001; 50482001; 50482002; 50482599; 50480004	0805	10	0

Table III-2 (continued)

MACT Standard – Source Category	Code of Federal Regulations Subpart	Compliance Date (existing sources)	VOC (% Reduction)	NO _x (% Reduction)	Total PM (% Reduction)	Affected SCCs	MACT Code	Wisconsin and Michigan Values	
								VOC	PM
Stationary Combustion Turbines	YYYY	3/5/2007	13	17		20100101, 20100201, 20200101, 20200103, 20200201, 20200203, 20200901, 20300102, 20300202, 20300203	0105	0	0
Taconite Iron Ore Processing	RRRRR	10/30/2006	0	0	62	32302371 to 32302399	0411	0	10
Wood Building Products	QQQQ	5/28/2006	63	0		40202101 to 40202199	0703	10	0

**Based on organic hazardous air pollutant (HAP) emission reductions

Table III-3. LADCO State Non-EGU Point Sources Affected by Consent Decree Requirements and Other On-the-Books Controls

Identification Codes			Company	Location	State	FCCU Requirements		Heater/Boiler Requirements	
State	County	Facility*				SO ₂	NO _x	SO ₂	NO _x
18	089	00003	BP Amoco	Whiting	IN	FCCU 500: Install wet gas scrubber; FCCU 600: Use SO ₂ adsorbing catalyst additive and/or hydrotreatment.	FCCU 600: Install SCR; FCCU 500: Low NO _x combustion promoter and NO _x adsorbing catalyst additive	Elimination of oil burning and restricting H ₂ S in refinery fuel gas	Use qualifying controls to reduce NO _x emissions by 9632 tons per year (tpy).
39	095	0448010246	BP Amoco	Toledo	OH	SO ₂ catalyst additive	Install SNCR system	Elimination of oil burning and restricting H ₂ S in refinery fuel gas	Use qualifying controls to reduce NO _x emissions by 9632 tpy.
17	197	197090AAI	CITGO Global Refinery	Lemont	IL	New wet gas scrubber	Low NO _x combustion promoter (20 ppmvd limit)	Comply with NSPS Subparts A and J for fuel gas combustion devices. Eliminate fuel oil burning.	Use qualifying controls to reduce NO _x emissions from listed units by at least 50% of the revised baseline
17	119	119090AAA	Conoco Philips Global Refinery	Roxanna (Wood River)	IL	Install new wet gas scrubber (25 ppmvd or lower)	FCCU 1: Scrubber-based NO _x emission reduction technology to achieve 20 ppmvd	Subject to NSPS Subparts A and J for fuel gas combustion devices	Use qualifying controls to reduce NO _x emissions from combustion units by 4951 tpy
17	119	119090AAA	Conoco Philips Global Refinery	Hartford (Wood River)	IL	Install new wet gas scrubber (25 ppmvd or lower)	FCCU 2: Enhanced SNCR	Subject to NSPS Subparts A and J for fuel gas combustion devices	Use qualifying controls to reduce NO _x emissions from combustion units by 4951 tpy
17	197	197800AAA	Exxon-Mobil Refinery	Joliet	IL	Install new wet gas scrubber (25 ppmvd or lower)	Install and operate an SCR system	Accept NSPS Subpart J applicability for heaters and boilers and reduce or eliminate fuel oil firing	Use qualifying controls to reduce NO _x emissions from combustion units
17	033	033808AAB	Marathon Ashland Refinery	Robinson	IL	Existing wet gas scrubber	Catalyst additive	Accept NSPS Subpart J applicability for heaters and boilers and reduce or eliminate fuel oil firing	Reduce overall NO _x emissions from the controlled heaters and boilers at MAP refineries by 4,000 tpy. Control methods can include: SCR or SNCR; ULNB; technologies to reach 0.040 lbs per MMBtu or lower; alternate SO ₂ single burner technology to achieve 0.055 lbs per MMBtu or lower; unit shutdowns.

Table III-3 (continued)

Identification Codes			Company	Location	State	FCCU Requirements		Heater/Boiler Requirements	
State	County	Facility*				SO ₂	NO _x	SO ₂	NO _x
26	163	A9831	Marathon Ashland Refinery	Detroit	MI	SO ₂ catalyst additive	Catalyst additive	Accept NSPS Subpart J applicability for heaters and boilers and reduce or eliminate fuel oil firing	Reduce overall NO _x emissions from the controlled heaters and boilers at MAP refineries by 4,000 tpy. Control methods can include: SCR or SNCR; ULNB; technologies to reach 0.040 lbs per MMBtu or lower; alternate SO ₂ single burner technology to achieve 0.055 lbs per MMBtu or lower; unit shutdowns.
27	163	2716300003	Marathon Ashland Refinery	St Paul Park	MN	New wet gas scrubber on unit 1; catalyst additive on other unit	Catalyst additive	Accept NSPS Subpart J applicability for heaters and boilers and reduce or eliminate fuel oil firing	Reduce overall NO _x emissions from the controlled heaters and boilers at MAP refineries by 4,000 tpy. Control methods can include: SCR or SNCR; ULNB; technologies to reach 0.040 lbs per MMBtu or lower; alternate SO ₂ single burner technology to achieve 0.055 lbs per MMBtu or lower; unit shutdowns.
39	151	1576000301	Marathon Ashland Refinery	Canton	OH	SO ₂ catalyst additive	Catalyst additive	Accept NSPS Subpart J applicability for heaters and boilers and reduce or eliminate fuel oil firing	Reduce overall NO _x emissions from the controlled heaters and boilers at MAP refineries by 4,000 tpy. Control methods can include: SCR or SNCR; ULNB; technologies to reach 0.040 lbs per MMBtu or lower; alternate SO ₂ single burner technology to achieve 0.055 lbs per MMBtu or lower; unit shutdowns.
39	095	0448010246	Sunoco Petroleum Refinery	Toledo	OH	Install new wet gas scrubber to meet 25 ppmvd SO ₂	Install SCR systems or alternate technology to meet 20 ppmvd	Accept NSPS Subpart J applicability and reduce or eliminate fuel oil burning	

Table III-3 (continued)

Identification Codes						
State	County	Facility*	Company	Location	State	Notes
17	115	115015AAE	ADM	Decatur	IL	Settlement agreement
17	143	143065AJE	ADM	Peoria	IL	Settlement agreement
17	001	001815AAF	ADM	Quincy	IL	Settlement agreement
18	173	00002	Alcoa	Warrick Units 1,2,3	IN	Settlement agreement

*Facility identification codes are those used in the 2002 point source files.

The Michigan Department of Environmental Quality (DEQ) provided information about the expected emissions reductions associated with settlements affecting Michigan sources. The information from Michigan DEQ was provided for Severstal (iron and steel), US Steel, and Marathon refinery. For Severstal, the key information provided indicated that NO_x emissions after the summer 2007 would be reduced at the blast furnace B and C stoves via a low NO_x burner (LNB) installation. A 50 percent NO_x control factor was applied with 2007 implementation year based on information in the Ozone Transport Rulemaking analysis about the expected emission reduction of LNB applied to a blast furnace. For US Steel, the Michigan DEQ-provided information indicated that PM controls would be installed during 2005 or 2006 on the basic oxygen furnace and blast furnace B, so it was assumed that these were base year controls and no future year control factor was applied. For the Marathon refinery in Michigan, the Michigan DEQ estimated that catalyst additives applied to the FCCU would reduce NO_x emissions by 25-50 percent and SO₂ emissions by 60-80 percent. The midpoint of each range was used to estimate post-2005 control factors for this refinery. All other expected controls at Marathon are to reduce PM emissions and were assumed to have occurred by 2005, so no future year PM control factors were applied.

4. On-the-Books (OTB) Control Additions

Table III-3 lists on-the-books controls that were applied to individual facilities/sources in the future year control factor file. This information was developed from the OTB updated control factor file provided by LADCO from the 2002 base year projections. The compliance date information in this file was used to eliminate controls that had compliance dates of 2005 or earlier. Ohio EPA provided information about the expected effects of NO_x Reasonably Available Control Technology (RACT) rules in achieving post-2005 emission reductions in the Cleveland-Akron, Ohio 8-hour ozone nonattainment area. Table III-4 summarizes the source categories, associated emission control equipment to meet the requirements, and the estimated NO_x control percentages.

Table III-4. Ohio RACT Rule Summary Cleveland/Akron 8-Hour Ozone Nonattainment Area

Source Category	Unit Size (MMBtu/hour)	NO _x Control	Estimated NO _x Control Efficiency
RICE Engines	All	Low Emission Combustion	80%
ICI Boilers	20-49	Burner Tune-up	10%
ICI Boilers	50-99	LNB+FGR	61%
ICI Boilers	100-249	LNB+FGR	61%
ICI Boilers	>250	LNB+FGR	61%
Combustion Turbine	All	Dry LNB	70%

SOURCE: Ohio EPA Division of Air Pollution Control.

5. Best Available Retrofit Technology (BART)

Table III-5 lists the BART-eligible sources for the states in the LADCO study region. In instances where criteria air pollutant control percentages (for SO₂ and NO_x) are listed in this table, those control percentages were applied in estimating 2018 emissions.

Table III-5. BART Eligible Non-EGU Sources

State	State ID	Source Name	County	County ID	Source ID	BART Emission Unit ID	Description	Stack ID	Est. Emission Reduction	
									SO ₂	NO _x
ILLINOIS	17	Conoco Phillips	Madison	11D	119090AAA					
ILLINOIS	17	Exxon Mobil	Will	197	197800AAA					
ILLINOIS	17	CITGO	Will	197	197090AAI					
ILLINOIS	17	National Steel – Granite City	Madison	119	119813AAI					
INDIANA	18	AGC DIVISION-ALCOA POWER GENERATING	Warrick	173	2	Boiler #2	Dry Bottom, pulverized coal-fired boiler	241-242	95	90
						Boiler #3	Dry Bottom pulverized coal-fired boiler	242	95	90
						Boiler #4	Dry Bottom, pulverized coal-fired boiler	243	95	90
INDIANA	18	Alcoa Inc. – Warrick	Warrick	173	7	105m.1, 10	POTLINE #3. ROOMS 105 AND 106 gtc	105M	95	40
						107M, 108M	POTLINE #4. ROOMS 107 AND 108 GTC	107M	95	40
						109M, 110M	POTLINE #5, ROOMS 109 AND 110, A-398	109M	95	40
						111M, 112M,	POTLINE #6		95	40
						130m.1, 104	potline #2, Rooms 103 and 104, A-398	103m.1	95	40
						134.63	HDC FURNACE COMPLEXES	1EH	0	40
						134.71	OFFLINES #2	134.71	0	40
INDIANA	18	ESSROC CEMENT CORP. (Speed)	Clark	19	8	EU20	Kiln #1		95	70
						EU21	Kiln #2		95	70
INDIANA	18	GE PLASTICS MT. VERNON INC.	Posey	129	2	08-706	CO AND ORGANIC SULFIDE STREAM FROM PHOSGENE FED	08-706 707	95	0
						09-001	B&W NATURAL GAS AND OIL FIRED BOILER	09-001	0	70
						09-001	Riley Boiler	12-001	95	70
						12-001	Hot Oil Heater		0	0
						09-002	LASKER BOILER	09-002	95	75
						09-002	ERIE BOILER	09-002	95	75

Table III-5 (continued)

State	State ID	Source Name	County	County ID	Source ID	BART Emission Unit ID	Description	Stack ID	Est. Emission Reduction	
									SO ₂	NO _x
INDIANA	18	ISG-BURNS HARBOR (Formerly Beth. Steel)	Porter	127	1	460-01	#7 Boiler	4	95	75
						46002	#8 Boiler	5	95	75
						460-03	#9 Boiler	6	95	75
						460-04	#10 Boiler	7	95	75
						460-05	Boiler #11	8	95	75
						460-06	#12 Boiler	9	95	75
						512-06	#1 COKE BATTERY PUSHING	11	0	0
						512-08	#1 Coke Battery Underfire	13	95	75
						512-14	#2 COKE BATTERY PUSHING	12	0	0
						512-16	#2 COKE BATTERY UNDERFIRE STACK	14	95	75
						520	BLAST FURNACE FUGITIVES		0	0
						520-04	SINTER WINDBOX STACK	25	95	75
						520-18	BLAST FURNACE D CASTHOUSE EMISSIONS	33	0	0
						520-18	C BLAST FURNACE STOVES	31	0	0
						520-19	BLAST FURNACE D STOVES	34	0	0
						520-19	BLAST FURNACE C CASTHOUSE	33	0	0
						534	STEELMAKING FUGITIVES		0	0
						534-01	STEELMAKING HMD STATION #1	57	0	0
						534-02	STEELMAKING HMD #2	59	0	0
						534-10	STEELMAKING VESSELS #1 & #2	62	0	0
						534-11	STEELMAKING VESSELS	64	0	0
						534-23	STEELMAKING FM BOILER	65	0	0

Table III-5 (continued)

State	State ID	Source Name	County	County ID	Source ID	BART Emission Unit ID	Description	Stack ID	Est. Emission Reduction	
									SO ₂	NO _x
						595-24	CASTER #1	80	0	0
						670-05	HOT STRIP FURNACE #1	90	95	75
						670-07	HOT STRIP #3 FURNACE	92	95	75
						670-07	HOT STRIP	91	95	75
						673-14	160" OKATE MILL FURNACE #1	112	0	75
						673-15	160" PLATE MILL FURNACE #2	113	0	75
						673-16.17	160" PLATE MILL FURNACES 4&5	110	0	0
						673-18.19	160" PLATE MILL FURNACES 6&7	111	0	0
						673-20	160" PLATE MILL FURNACE #8	114	0	0
						674.26,27	110" PLATE MILL FURNACES #1	122	0	0
MICHIGAN	26	Lafarge Midwest Inc.	Alpena	7	B1477	Kilns #1-#5				
MICHIGAN	26	Stone Container Corp.	Ononagon	131	A5754	Riley Boiler				
						Paper Machine #2				
MICHIGAN	26	Tilden Mining Co	Marquette	103	B4885	Pelletizing Line #1, includes kiln, furnace, cooler, dryer				
						Boiler #2				
						Primary crusher				
MICHIGAN	26	Empire Iron Mining	Marquette	103	B1827	Pelletizing Lines #1 - #3 furnace				
						Boilers #1 - #3				
						Primary crusher				
MICHIGAN	26	St. Mary's Cement (CEMEX)	Charlevoix	29	B1559	Kiln and pre-calciner				
MICHIGAN	26	New Page Paper (Escanaba)	Delta	41	A0884	Boiler #8				
						Boiler #9				
						Recovery furnace				
						Lime kiln				
MINNESOTA	27	Ipsat Inland	St. Louis	137	2713700062					
MINNESOTA	27	EVTAC-Fairlane	St. Louis	137	2713700113					
MINNESOTA	27	National Steel (Keewatin)	St. Louis	137	2713700063					
MINNESOTA	27	Hibbing Taconite	St. Louis	137	2713700061					
MINNESOTA	27	USS Minntac	St. Louis	137	2713700005					
MINNESOTA	27	Northshore Mining	Lake	75	2707500003					

Table III-5 (continued)

State	State ID	Source Name	County	County ID	Source ID	BART Emission Unit ID	Description	Stack ID	Est. Emission Reduction	
									SO ₂	NO _x
N. DAKOTA	38	Great River Energy – Coal Creek	McLean	55	17					
N. DAKOTA	38	Basin Electric Power – Leland Olds	Mercer	57	1					
N. DAKOTA	38	Great River Energy – Stanton	Mercer	57	4					
N. DAKOTA	38	Minnkota Power – MR Young	Oliver	65	1					
OHIO	39	Mead Paper Division	Ross	67	671010028					
WISCONSIN	55	Georgia-Pacific Consumer Products (Formerly Fort James)	Brown	9	405032870	Boiler B26	stoker (coal, tire and other fuels), 350 mmBtu/hr	S10	85	50
						Boiler B27	cyclone, 615 mmBtu/hr	S10	85	88

B. AREA SOURCE/MAR CONTROLS

1. Area Sources

Pechan worked with the LADCO states to determine how to estimate the effect of federal/state/local rules on area source category emissions. The sub-sections below describe the results of this effort.

a. VOC Solvent Categories

For VOC emissions from consumer products and architectural and maintenance coatings, it was decided to estimate post-2005 VOC emission reduction credits using EPA guidance to states for estimating the benefits of three Federal rules being promulgated during calendar year 2007 (Harnett, 2007). These rules will establish or amend VOC content limits for (1) aerosol coatings (new rule), (2) architectural and industrial maintenance (AIM) coatings (amendments), and (3) household and institutional consumer products (amendments).

EPA estimated that the aerosol coatings rule will achieve the equivalent of a 19 percent reduction in mass VOC emissions from the 1990 baseline. The year 1990 represents the baseline, since there has been no previous Federal rulemaking for aerosol coatings. The creditable reduction that may be claimed is 0.114 pounds per capita. In the LADCO state 2005 emission inventory, this VOC emission reduction is applied to SCC 2460500000, which are Coatings and related products. A 12 percent VOC emission reduction is applied to SCC 2460500000 in each forecast analysis year (i.e., 2009, 2012, and 2018) to estimate the benefit of the federal aerosol coatings rule. This percentage is lower than the equivalent value estimated by EPA because the aerosol coatings rule is a subset of the Coatings and related products category represented by SCC 2460500000.

For AIM coatings, EPA estimates that the amended Federal AIM rule will achieve a reduction of 31 percent from the post-1998 Federal rule baseline of 3.6 pounds per capita. This is a creditable reduction of 1.1 pounds per capita. AIM coating emission reductions are applied to the following SCCs in the base year LADCO inventory for each analysis year: 2401001000; 2401002000; 2401003000; 2401008000; 2401008999.²

For consumer products, EPA has calculated that the amended Federal rule will achieve a VOC reduction of approximately 29 percent beyond that achieved by the 1998 Federal rule. This is a creditable reduction of 0.9 pounds per capita. Emission reductions from the Federal rule are applied to all Consumer Product source categories (SCCs 2460*) in each analysis year.

b. Portable Fuel Containers

For portable fuel containers (PFCs), while there are state-by-state differences in likely rule adoption dates, all state's control factors are based on the EPA mobile source air toxics (MSAT) rule requirements. EPA adopted emission standards for portable fuel containers (such as gas

² Note that subsequent to delivery of the area source/MAR control file, Wisconsin stated that this last SCC should not be included for their state.

cans) under the consumer products authority of the Clean Air Act. Starting with containers manufactured in 2009, the standard limits evaporation and permeation emissions from these containers to 0.3 grams of hydrocarbons per gallon per day. EPA also adopted test procedures and a certification and compliance program in order to ensure that containers meet the emission standard over a range of in-use conditions.

The VOC emission reduction benefits were estimated assuming that the new rule affects PFC sales starting during 2009, and that each PFC that meets the MSAT standard has 75 percent lower emissions than the PFC being replaced.

To account for the fact that growth in the portable fuel container population and turnover from old to new containers will be affected by the MSAT rule,³ Pechan calculated projection year emissions using the following equation:

$$Q_N = Q_o \left\{ \left[(G_N) - 1 \right] F_n + \left[(1 - R_i)^t \right] F_e + \left[1 - (1 - R_i)^t \right] F_n \right\} \quad (Eq. 1)$$

where:

Q_N	=	emissions in projection year
Q_o	=	emissions in base year
R_i	=	annual retirement rate
F_e	=	emission factor ratio for existing sources (1.0)
G_N	=	projection year growth factor (projection year activity/base year activity)
F_n	=	emission factor ratio for new sources relative to existing sources
t	=	number of years between base year (2002) and projection year

The first term in the equation represents new source growth and controls, the second term accounts for retirement and controls for existing sources, and the third term accounts for replacement source controls. Because retirement was not estimated using a constant annual rate (5 percent were assumed to be retired in the first year, with 10 percent retired in each additional forecast year), Pechan replaced the $(1-R_i)^t$ terms in this equation with the appropriate proportion of containers retired between the base year and the appropriate forecast year. Pechan then computed an overall emission reduction for each future year of interest by comparing the forecast year controlled emissions calculated from this equation to the forecast year uncontrolled emissions. For example, an overall VOC emission reduction of 26.4 percent was computed for Illinois. Pechan then back-calculated the appropriate rule penetration (RP) value for each forecast year based on the overall emissions reduction, the 75 percent CE value, and an rule effectiveness (RE) of 100 percent (e.g., the calculated RP for Illinois for 2012 is 35.2 percent).

³ Note that to simplify the analysis Pechan assumed that all post-2005 new container growth would be affected by the MSAT rule (due to low growth rates, this assumption does not have a significant impact on the overall emission reduction estimates of this rule).

c. Residential Wood Heating (Woodstoves and Fireplace Inserts)

Pechan developed control factors by pollutant and year to account for the effect of the replacement of retired wood stoves/inserts that emit at pre-residential wood heater new source performance standard (NSPS) levels. These control factors were developed using an annual 2 percent retirement rate for wood stoves/fireplaces along with pre- and post-NSPS wood stove and fireplace emission factors. SCCs for "controlled" wood stoves and fireplace inserts have no control factors applied. Pechan developed updated residential wood combustion control factors for the LADCO states using the same algorithms applied previously (Pechan, 2004). Table III-6 displays the emission reduction, control efficiency, and rule penetration percentages modeled.

d. Stage II Vehicle Refueling

Pechan developed updated (2005 base year) Stage II vehicle refueling control factors via MOBILE runs for the LADCO states. Onroad refueling control factors were calculated based on the percentage difference between the projection year (2009, 2012, and 2018) MOBILE6 refueling emission factors and the 2005 MOBILE6 refueling emission factors.

MOBILE6 emission factors were calculated at January and July temperature and fuel conditions. July emission factors were used as the surrogate for the five-month ozone season (May through September) and the January emission factors were used as the surrogates for the remaining seven months. Temperatures modeled were the January and July average daily monthly maximum and minimum temperatures for each state (i.e., Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin) based on 30-year average temperature data, as used in EPA's second Section 812 Prospective analysis. MOBILE6 input files were created for each unique combination of: January and July Reid vapor pressure, reformulated gasoline, oxygenated fuel, gasoline sulfur, and Stage II control programs for each of the states mentioned above. Fuel data and Stage II control program information for each state and corresponding projection year were based on EPA's National Mobile Inventory Model (NMIM) County Database (version NDC20060201). Data extracted from NMIM's County Database for these input parameters were based on January and July values.

Stage II control programs for IL, IN, and WI began in 1998 with a phase-in year of one year and with a percent efficiency value of 86.0 percent for LDGVs and LDGTs in the program. Similarly, the HDGVs in the program have 86.0 percent efficiency. For Ohio, these control programs began in 1993 with a two-year phase-in and 77.0 percent efficiency for both the LDGVs + LDGTs and HDGVs in the program.

Modeling these temperature, fuel, and Stage II control inputs (where applicable), Pechan calculated MOBILE6 emission factors for calendar years 2005, 2009, 2012, and 2018.

The resulting MOBILE6 emission factors were first weighted according to the default MOBILE6 VMT mix to determine the weighted average refueling emission factor for all gasoline vehicle types. The resulting January and July emission factors were weighted together according to the number of days in the seven-month season (212 days) and the five-month ozone season (153).

**Table III-6. Residential Wood Combustion NSPS Emission Reductions
(percentage values)**

SCC	SCC Description	Pollutant	2009			2012			2018		
			Reduction	Control Efficiency	Rule Penetration	Reduction	Control Efficiency	Rule Penetration	Reduction	Control Efficiency	Rule Penetration
2104008001	Total Fireplaces	CO	2.9	55.0	5.3	4.9	55.0	8.9	8.5	55.0	15.5
2104008010	Total Woodstoves	CO	3.1	55.0	5.6	5.2	55.0	9.5	9.0	55.0	16.4
2104008000	Total Fireplaces & Woodstoves	CO	3.0	55.0	5.5	5.1	55.0	9.3	8.9	55.0	16.2
2104008001	Total Fireplaces	NOX	1.9	28.6	6.6	3.3	28.6	11.5	5.6	28.6	19.6
2104008010	Total Woodstoves	NOX	2.0	28.6	7.0	3.4	28.6	11.9	5.8	28.6	20.3
2104008000	Total Fireplaces & Woodstoves	NOX	2.0	28.6	7.0	3.3	28.6	11.5	5.8	28.6	20.3
2104008001	Total Fireplaces	PM10-PRI	2.3	35.9	6.4	4.0	35.9	11.1	6.9	35.9	19.2
2104008010	Total Woodstoves	PM10-PRI	2.5	35.9	7.0	4.2	35.9	11.7	7.2	35.9	20.1
2104008000	Total Fireplaces & Woodstoves	PM10-PRI	2.4	35.9	6.7	4.1	35.9	11.4	7.1	35.9	19.8
2104008001	Total Fireplaces	PM25-PRI	2.3	35.9	6.4	4.0	35.9	11.1	6.9	35.9	19.2
2104008010	Total Woodstoves	PM25-PRI	2.5	35.9	7.0	4.2	35.9	11.7	7.2	35.9	20.1
2104008000	Total Fireplaces & Woodstoves	PM25-PRI	2.4	35.9	6.7	4.1	35.9	11.4	7.1	35.9	19.8
2104008001	Total Fireplaces	VOC	5.9	77.4	7.6	9.8	77.4	12.7	17.1	77.4	22.1
2104008010	Total Woodstoves	VOC	5.6	77.4	7.2	9.4	77.4	12.1	16.4	77.4	21.2
2104008000	Total Fireplaces & Woodstoves	VOC	5.4	77.4	7.0	9.2	77.4	11.9	16.0	77.4	20.7

Note: Rule effectiveness (RE) of 100 percent for each SCC/year.

After this was done for all of the modeled years and state or sub-state areas, the overall control efficiency for refueling, due to fleet turnover, was calculated based on the percentage difference between the 2005 and corresponding projection year emission factors. These control efficiencies were then assigned to individual counties, based on the mapping of fuel and Stage II control parameters to those modeled in the MOBILE6 files.

2. MAR Sources (Locomotives and Marine Vessels)

EPA issued a proposed rule this spring affecting future criteria pollutant emissions from railroad locomotives and commercial marine vessels (CMVs) (EPA, 2007b). These are the two off-road source categories that are addressed in this report. Base year emissions (2005) information for these two source categories was developed by ENVIRON under contract to LADCO (ENVIRON, 2007a and b).

Control factors for criteria air pollutants were developed using Chapter 3 (Emissions Inventory) of EPA's "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder" (EPA, 2007b). This chapter presents EPA's analysis of the emissions impact of the proposed rule for three source categories affected: commercial marine diesel engines, recreational marine diesel engines, and locomotives. The proposed control requirements include NO_x and PM emission standards for Category 1 and Category 2 commercial marine diesel engines (both above and below 37 kilowatts). New NO_x and PM emission standards would also apply to all recreational diesel engines and locomotives. There are no new standards for HC or CO; however, the PM standards are also expected to decrease HC emissions.

For locomotives, the EPA Regulatory Impact Analysis (RIA) chapter was used to develop 2009, 2012 and 2018 estimates of baseline and post-control emissions by pollutant by locomotive usage. This information is summarized in Table III-7. The RIA examined the effect of the proposed rule on emissions for (1) large line haul, (2) large switch, (3) small railroads, and (4) passenger commuter trains. Each of these four usage types was assigned to the base year 2005 emission inventory SCCs. The SCC assignments are shown at the bottom of Table III-7.

Table III-7. Locomotive Emissions Reported in EPA Draft RIA

Year	Large Line Haul		Large Switch		Small Railroads		Passenger Commuter	
	Baseline	Controlled	Baseline	Controlled	Baseline	Controlled	Baseline	Controlled
Volatile Organic Compounds								
2006	43,874		5,501		2,891		1,609	
2009	43,486	42,008	5,696	5,552	3,032	3,032	1,546	1546
2012	42,891	35,890	5,898	5,364	3,179	3,179	1,476	1301
2018	41,684	23,607	6,325	5,066	3,497	3,497	1,332	771
PM-2.5								
2006	27,082		2,202		907		992	
2009	24,216	23,661	2,120	2,070	870	870	861	861
2012	23,800	20,672	2,188	2,006	912	912	819	738
2018	22,542	14,516	2,309	1,896	991	991	719	466
PM-10								
2006	27,919		2,270		935		1,023	
2009	24,965	24,393	2,185	2,134	897	897	888	888
2012	24,536	21,311	2,256	2,068	940	940	845	761
2018	23,240	14,965	2,380	1,954	1,022	1,022	741	480
Oxides of Nitrogen								
2006	779,842		86,861		37,690		38,466	
2009	755,490	751,364	88,573	87,999	39,528	39,528	32,338	32,338
2012	730,031	692,606	88,909	86,614	41,456	41,456	27,212	25,933
2018	708,525	608,010	90,875	84,612	44,299	44,299	22,559	19,496
SCC(s)	2285002006		2285002010		2285002007		2285002008; 2285002009	

Because the federal locomotive emission standards modeled under previous LADCO contracts will continue to achieve emission reductions, it was necessary for Pechan to adjust the information in the new RIA to estimate the total post-base year reductions from the effects of both the existing and proposed locomotive standards. Pechan computed a revised set of projected emissions for modeling years 2009, 2012, and 2018 that reflect application of EPA's assumed locomotive growth rate (1.6 percent per year) to the base year (2006) emissions from their analysis. This step was used to estimate the emissions for each modeling year excluding the effects of both sets of emission standards. Next, Pechan computed the percentage reduction in emissions between the revised emissions in each modeling year and the controlled emissions reported in EPA's draft RIA. Table III-8 shows how the revised baseline and percent reduction for each modeling year. For example, for large line haul railroads, the baseline 2009 uncontrolled VOC emissions are estimated to be 46,014 tons nationally. Controlled emissions of 42,008 tons represent an 8.7 percent VOC reduction from this uncontrolled emission estimate ($46,014 - 42,008 = 4,010$; $4,010/46,014 * 100 = 8.7$).

Table III-8. Percentage Reductions Associated with Federal Locomotive Standards

Year	Large Line Haul		Large Switch		Small Railroads		Passenger Commuter	
	Revised Baseline	% Reduction	Revised Baseline	% Reduction	Revised Baseline	% Reduction	Revised Baseline	% Reduction
Volatile Organic Compounds								
2006								
2009	46,014	8.7%	5,769	3.8%	3,032	0.0%	1,687	8.4%
2012	48,258	25.6%	6,051	11.3%	3,180	0.0%	1,770	26.5%
2018	53,080	55.5%	6,655	23.9%	3,498	0.0%	1,947	60.4%
PM-2.5								
2006								
2009	28,403	16.7%	2,309	10.4%	951	8.5%	1,040	17.2%
2012	29,788	30.6%	2,422	17.2%	998	8.6%	1,091	32.4%
2018	32,765	55.7%	2,664	28.8%	1,097	9.7%	1,200	61.2%
PM-10								
2006								
2009	29,281	16.7%	2,381	10.4%	981	8.5%	1,073	17.2%
2012	30,709	30.6%	2,497	17.2%	1,028	8.6%	1,125	32.4%
2018	33,777	55.7%	2,746	28.9%	1,131	9.7%	1,238	61.2%
Oxides of Nitrogen								
2006								
2009	817,877	8.1%	91,097	3.4%	39,528	0.0%	40,342	19.8%
2012	857,766	19.3%	95,540	9.3%	41,456	0.0%	42,310	38.7%
2018	943,477	35.6%	105,087	19.5%	45,599	2.8%	46,537	58.1%
SCC(s)	2285002006		2285002010		2285002007		2285002008; 2285002009	

Note: emissions reported in short tons.

Analogous control factor calculations to those described above for locomotives were used to compute total CMV emission reduction values representing the effects of both existing and proposed emission standards. Table III-9 presents the EPA baseline emissions, Pechan’s revised baseline emissions (computed using EPA’s 0.9 percent annual growth assumption), EPA’s controlled emissions, and the percentage reduction estimates applied in this analysis. For example, the CMV standards are expected to reduce VOC emissions by 33.9 percent in 2018.

Table III-9. Percentage Reductions Associated with Federal CMV Standards

Year	Emissions (short tons)			% Reduction
	Baseline	Revised Baseline	Controlled	
Volatile Organic Compounds				
2005	17,295			
2009	16,870	17,926	16,863	5.9%
2012	16,495	18,414	16,344	11.2%
2018	16,034	19,431	12,851	33.9%
PM-2.5				
2005	30,042			
2009	27,327	31,138	27,324	12.2%
2012	26,657	31,987	26,582	16.9%
2018	22,553	33,753	19,308	42.8%
PM-10				
2005	30,972			
2009	28,172	32,102	28,169	12.3%
2012	27,481	32,977	27,403	16.9%
2018	23,251	34,798	19,905	42.8%
Oxides of Nitrogen				
2005	825,229			
2009	781,105	855,341	781,105	8.7%
2012	743,915	878,643	742,453	15.5%
2018	686,966	927,171	591,991	36.2%
Sulfur Dioxide				
2005	82,543			
2009	46,838	85,555	46,839	45.3%
2012	42,515	87,886	42,515	51.6%
2018	6,054	92,740	5,630	93.9%
Carbon Monoxide				
2005	153,499			
2009	149,966	159,100	149,966	5.7%
2012	146,227	163,434	146,227	10.5%
2018	140,443	172,461	140,443	18.6%

For commercial marine diesel engines, the RIA examines expected rule emission benefits for four different engine types/sizes. The total CMV emission benefits in each year were used and applied equally to most of the affected SCCs in the 2005 inventory. However, Pechan applied rule penetration (RP) values to two CMV SCCs based on an ENVIRON table indicating RP values of less than 100 percent for these SCCs (see Table III-10).

Table III-10. Commercial Marine Vessel Rule Penetration Values

Source Category Code (SCC)	Source Definition	Purpose	Geographic Area	Percentage of Engines Affected by Proposed EPA Standards				
				NOx	PM-10	HC	CO	SOx
2280002023	Push Boats	Barge Freight	River Traffic	100%	100%	100%	100%	100%
			Lake Traffic	100%	100%	100%	100%	100%
2280002021	Tugs	Vessel assist and support functions	Near port	100%	100%	100%	100%	100%
2280003200	Deep draft	Laker and ocean-going large vessels	Mid-Great Lakes	85%	81%	86%	86%	77%
2280003100			Near port	81%	71%	87%	83%	63%
2280002022	Ferries	River or lake ferrying	Regular routes	100%	100%	100%	100%	100%
2280002024	Other Commercial Vessels	Excursion boats primarily	Near dock	100%	100%	100%	100%	100%
2280002025	Dredges	Dredging projects	Varies	100%	100%	100%	100%	100%
2280002029	Support Vessels	General work boats	Near port	100%	100%	100%	100%	100%
2280002030, 2280004030 ¹	Commercial Fishing	Market fishing	Great Lakes	100%	100%	100%	100%	100%
2280002040, 2280004040 ¹	Military	Coast Guard and Navy	Great Lakes	100%	100%	100%	100%	100%

SECTION IV. PREPARATION OF GROWTH AND CONTROL FILES

This section describes the contents of the growth and control factor files submitted to LADCO earlier this month. The first subsection discusses the preparation of the point and area source/MAR factor file and the revised NONROAD model growth file. The final subsection describes the contents of the control factor files.

Table IV-1 presents the RPO Data Exchange Protocol Format for reporting emission growth and control data. Pechan utilized this format to create growth and control factor files for LADCO. Because the growth factors (unlike the control factors) do not differ by pollutant, Pechan developed a separate file containing only the point and area source/MAR growth factors. Pechan revised the growth packet portion of the NONROAD model growth file (*NATION.GRW*) to replace the default model equipment population growth rates with growth rates based on more recent/more region-specific information. Two sets of control factor files were prepared: one for area source/MAR categories and one for point source categories. The point and area source/MAR growth and control files were developed in fixed field ascii format. The format of the default NONROAD model growth file was retained in the revised version prepared for LADCO. The following subsections describe the contents of the growth and control factor files.

A. GROWTH FACTORS

Pechan compiled the LADCO region growth factor information into the file *\$LADCO_2005_GF_Final_RPO.txt*. Table IV-2 displays the RPO Data Exchange Protocol Format fields and identifies the fields that were populated in this file. The file contains separate records for each SCC/state for each year between 2006 and 2018 (population-based growth indicator records are reported by SCC/state/county because population projections were available at the county-level).

Pechan revised the input file used by the NONROAD model (*NATION.GRW*) to reflect historical equipment population changes and to estimate future equipment population changes. In particular, Pechan incorporated LADCO state-specific records to the GROWTH packet portion of this file. The fixed field format of the data in this packet is as follows:

<u>Characters</u>	<u>Description</u>
1-5	FIPS code (00000 = applies to entire nation; ss000 = applies to all of state ss)
6-10	subregion code (left blank)
11-15	year of estimate (4-digit year)
17-20	indicator code (alphanumeric code identified within NONROAD)
26-45	value for indicator

Table IV-1. RPO Data Exchange Protocol Format for Growth/Control Data

Field Name	Field Description	Field Length
RECORD TYPE	A code that identifies the type of record (G for growth, C for control)	2
COUNTRY CODE	A code that identifies the country (US = United States)	2
STATE PROVINCE TRIBAL CODE	The code for the state/province/tribe	4
COUNTY FIPS	The FIPS code for the county	3
SIC	4-digit SIC, or 2 digit SIC with remaining digits blank (not zero)	4
SCC	EPA source classification code or a fraction of the code	10
SITE ID	Unique state/local/tribal ID reported consistently over time	15
EMISSION UNIT ID	Unique state/local/tribal ID reported consistently over time	6
EMISSION RELEASE POINT ID	State/ local/tribal ID for point /location where emissions are released to ambient air	6
POLLUTANT CODE	Pollutant code	9
PROCESS ID	Unique state/local/tribal ID reported consistently over time	6
BASE DATE	Date that the control strategy comes into effect	6
FUTURE DATE	Future date that the control strategy affects	6
PRIMARY CONTROL EQUIPMENT CODE	Primary control equipment code	10
BASE DATE CONTROL EFFICIENCY	Base year % control efficiency(60% reduction = 60)	6
FUTURE DATE CONTROL EFFICIENCY	Future year % control efficiency(60% reduction = 60)	6
FUTURE DATE GROWTH FACTOR	Growth factor based on changes in throughput, economic growth (unrelated to controls). This is an absolute growth rate not an annual growth rate.	11
CONTROL TYPE	MACT, RACT, LAER, SPCALL, BART, etc	10
FUTURE DATE CHEMICAL SPECIATION PROFILE	Code matching speciate chemical speciation profile unless in base year	6
ALLOWABLE EMISSIONS CAP	Allowable emissions cap units must be in TONS/day	10
MARKET PENETRATION OF NEW SPECIATION PROFILE	Fraction of future year emissions using new speciation profile	6
RESERVED FOR FUTURE USE FIELD 3	(Field used to enter future year control efficiency value where available)	10
RESERVED FOR FUTURE USE FIELD 2	(Field used to enter future year rule effectiveness value where available)	10
RESERVED FOR FUTURE USE FIELD 1	(Field used to enter future year RP value where available)	10
CONTROL DESCRIPTION	A text description of the control	80
PRIMARY CONTACT	Email address of the primary contact/developer of this record	30

Table IV-2. Fields Populated in Growth Factor File

Field Name	Populated in Growth Factor File?
RECORD TYPE	Yes
COUNTRY CODE	Yes
STATE PROVINCE TRIBAL CODE	Yes
COUNTY FIPS	Yes (with "000" except for population data)
SIC	No
SCC	Yes
SITE ID	No
EMISSION UNIT ID	No
EMISSION RELEASE POINT ID	No
POLLUTANT CODE	No
PROCESS ID	No
BASE DATE	Yes
FUTURE DATE	Yes
PRIMARY CONTROL EQUIPMENT CODE	No
BASE DATE CONTROL EFFICIENCY	No
FUTURE DATE CONTROL EFFICIENCY	No
FUTURE DATE GROWTH FACTOR	Yes
CONTROL TYPE	No
FUTURE DATE CHEMICAL SPECIATION PROFILE	No
ALLOWABLE EMISSIONS CAP	No
MARKET PENETRATION OF NEW SPECIATION PROFILE	No
RESERVED FOR FUTURE USE FIELD 3 (<i>future year CE</i>)	No
RESERVED FOR FUTURE USE FIELD 2 (<i>future year RE</i>)	No
RESERVED FOR FUTURE USE FIELD 1 (<i>future year RP</i>)	No
CONTROL DESCRIPTION	No
PRIMARY CONTACT	Yes

B. CONTROL FACTORS

Pechan compiled control factors for the LADCO states in two sets of ascii files: one set for point source controls (*LADCO 2005 Base Year Point Control File.txt*), and the other set for area source/MAR controls (*LADCO 2005 Base Year Area Source and MAR Control File.txt*).

1. Point Source Control Factors

The *LADCO 2005 Base Year Point Control File.txt* file reports control information at the Process ID-level and for the specific date that each control is expected to be implemented. Note that the Base Date Control Efficiency field is populated with a zero for every record because Pechan did not have any base year control information other than that reported in the base year inventory supplied by LADCO. LADCO should rely on the control information in the base year inventory to identify the base year level of control. For MACT standards, the point source control factors are incremental to base year control levels. Because all other point source control

factors represent absolute control levels, LADCO should subtract any existing 2005 inventory level of control from the control factor level of control to determine net reductions for non-MACT controls. Pechan found very few point source records with control information, so LADCO should expect very little control overlap between the 2005 inventory and the control file. Table IV-3 identifies the RPO Data Exchange Protocol fields that are populated in the point source control file.

2. Area Source and MAR Control Factors

Pechan compiled the area source and MAR control factor information into a single ascii file that reports the level of control for each year of interest (2009, 2012, and 2018). In cases where there is no change in emission reduction after the initial implementation year, the level of control is repeated for each year. For controls where emission reductions increase over time (due to increased levels of RP), the level of control increases for each successive modeling year. Except for the single control for which emission reductions are county-specific (Stage II Vehicle Refueling), the area source and MAR control factor file is expressed at the state-level. In cases where it was feasible to do so, Pechan populated the 5th, 4th, and 3rd fields from the end of each control factor file (“RESERVED FOR FUTURE USE” in the RPO Data Exchange Protocol Format) with future year CE, RE, and RP values, respectively (the field “FUTURE DATE CONTROL EFFICIENCY” was populated with the overall percentage emission reduction). Table IV-4 identifies the RPO Data Exchange Protocol fields that are populated in this file.

Table IV-3. Fields Populated in Point Source Control Factor File

RPO Data Exchange Protocol Format Field Name	Populated in Point Source Control Factor File
RECORD TYPE	Yes
COUNTRY CODE	Yes
STATE PROVINCE TRIBAL CODE	Yes
COUNTY FIPS	Yes
SIC	Yes
SCC	Yes
SITE ID	Yes
EMISSION UNIT ID	Yes
EMISSION RELEASE POINT ID	Yes
POLLUTANT CODE	Yes
PROCESS ID	Yes
BASE DATE	Yes
FUTURE DATE ¹	Yes
PRIMARY CONTROL EQUIPMENT CODE	No
BASE DATE CONTROL EFFICIENCY ²	Yes
FUTURE DATE CONTROL EFFICIENCY ³	Yes
FUTURE DATE GROWTH FACTOR	No
CONTROL TYPE	Yes
FUTURE DATE CHEMICAL SPECIATION PROFILE	No
ALLOWABLE EMISSIONS CAP	No
MARKET PENETRATION OF NEW SPECIATION PROFILE	No
RESERVED FOR FUTURE USE FIELD 3 (<i>future year CE</i>)	No
RESERVED FOR FUTURE USE FIELD 2 (<i>future year RE</i>)	No
RESERVED FOR FUTURE USE FIELD 1 (<i>future year RP</i>)	No
CONTROL DESCRIPTION	Yes
PRIMARY CONTACT	Yes

¹ Represents date that control is first implemented.

² All records populated with "0" - LADCO should rely on control information reported in base year inventory.

³ Populated with overall percentage emission reduction.

Table IV-4. Fields Populated in Area Source/MAR Control Factor File

RPO Data Exchange Protocol Format Field Name	Populated in Area Source/MAR Control Factor File
RECORD TYPE	Yes
COUNTRY CODE	Yes
STATE PROVINCE TRIBAL CODE	Yes
COUNTY FIPS	Yes
SIC	No
SCC	Yes
SITE ID	No
EMISSION UNIT ID	No
EMISSION RELEASE POINT ID	No
POLLUTANT CODE	Yes
PROCESS ID	No
BASE DATE	Yes
FUTURE DATE	Yes
PRIMARY CONTROL EQUIPMENT CODE	No
BASE DATE CONTROL EFFICIENCY	Yes
FUTURE DATE CONTROL EFFICIENCY ¹	Yes
FUTURE DATE GROWTH FACTOR	No
CONTROL TYPE	No
FUTURE DATE CHEMICAL SPECIATION PROFILE	No
ALLOWABLE EMISSIONS CAP	No
MARKET PENETRATION OF NEW SPECIATION PROFILE	No
RESERVED FOR FUTURE USE FIELD 3 (<i>future year CE</i>)	Yes ²
RESERVED FOR FUTURE USE FIELD 2 (<i>future year RE</i>)	Yes ²
RESERVED FOR FUTURE USE FIELD 1 (<i>future year RP</i>)	Yes ²
CONTROL DESCRIPTION	Yes
PRIMARY CONTACT	Yes

¹ Populated with overall percentage emission reduction (product of CE, RE, and RP).

² Not populated for Federal locomotive standards or Stage II Vehicle Refueling control program.

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