Emissions Inventory Development for Fine-Scale Air Quality Modeling

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ABSTRACT

In the U.S., many state and local agencies are now doing multi-pollutant fine-scale air quality modeling for SIP in attainment demonstrations. The U.S. Environmental Protection Agency (EPA) formed a focus group of emissions inventory developers in agencies that are building experience developing more locally representative emissions inventories to support fine-scale air quality modeling. The group was invited to share information on the types of problems they are trying to solve and approaches taken with the inventory development. This paper discusses the findings of the focus group and emphasizes the types of data analysis identified as particularly beneficial to scoping and prioritizing the inventory work. Also included are recommendations on how the group's findings can be translated to the EPA's National Emissions Inventory (NEI) and descriptions of the types of NEI data analysis that can support state and local agencies who want to develop more locally representative emissions data for fine-scale air quality modeling.

INTRODUCTION

In the air quality modeling community, photochemical grid models are generally run for horizontal grid resolutions of 36 km and 12 km; however, increasing attention is given to resolving pollutant concentrations at finer spatial scales in response to a variety of air quality management issues.

For example, the Regulatory Impact Analysis (RIA) for the recent fine particulate matter ($PM_{2.5}$) National Ambient Air Quality Standards (NAAQS) suggests that modeling at a 12-km resolution may not adequately capture local source impacts on ambient $PM_{2.5}$ concentrations at Federal Reference Method (FRM) monitoring sites, or the benefits achievable through controlling such local sources [1]. Similarly, EPA guidance on the use of models for NAAQS attainment demonstrations includes a discussion on the use of dispersion models for "local area analysis" in areas with large spatial gradients of primary $PM_{2.5}$ [2]. As a result, many state and local agencies are now conducting local area analyses and performing fine-scale air quality modeling for State Implementation Plan (SIP) attainment demonstrations. Such efforts require the development of local-scale emissions inventories that are more representative of individual facilities and other local sources than information contained in the NEI, EPA's AP-42 emission factor compendium and other inventory "building blocks."

In addition to $PM_{2.5}$ attainment issues, fine-scale concentration gradients are of concern for air toxics evaluations, which exhibit areas of high concentration near emissions sources such as roadways [3]. These "hot spots" generally occur on scales that cannot be resolved with air quality modeling performed at a 12-km grid resolution. Because both air toxics and criteria pollutants, such as $PM_{2.5}$, present a need for local-scale evaluations, there is an increasing need to provide multi-pollutant and multi-scale air quality information. As a result, EPA's Office of Air Quality Planning and Standards (OAQPS) recently conducted a pilot study in Detroit, Michigan, to develop and undertake multi-pollutant, risk-based analyses. The purpose of this study was to evaluate the distribution of emissions among source types, to identify possible sources for "co-control" across multiple pollutants, and to determine how the atmosphere responds to reductions in key pollutants. The project approach featured hybrid air quality modeling that combined regional modeling at a 12-km grid resolution with urban-scale dispersion modeling at a 1-km resolution. This hybrid approach was designed to account for the contribution of local sources to $PM_{2.5}$ and air toxics concentrations in the Detroit area [4].

To build capacity in EPA's Emissions Inventory and Analysis Group (EIAG) and the state, local, regional, and tribal (SLRT) inventory community for local-scale emissions inventory evaluation and improvement techniques, EPA solicited input from SLRT agencies regarding their approaches to develop more locally representative emissions inventories and the results of fine-scale modeling efforts that use such inventories. To facilitate the sharing of information on local-scale inventories, EPA staff formed a focus group from state and local agencies that are developing local-scale inventories for fine-scale modeling. The objectives of the project were to:

- Determine the types of inventory data analyses that can assist SLRT agencies with local-scale inventory development.
- Prioritize beneficial analyses and recommend how they might be systematically applied to the EPA's NEI and distributed as data and/or results.
- Assess availability of local-scale emissions data and how these data are related to data in the EPA's Emission Inventory System (EIS) and the NEI data collection process.

Sonoma Technology, Inc. (STI), an environmental consulting firm based in Petaluma, California, provided support to EPA by helping facilitate teleconferences, reviewing technical documentation provided by state and local agencies, and documenting project findings.

TECHNICAL APPROACH

At the outset of this project, EPA staff identified SLRT agencies that are developing local-scale inventories for fine-scale modeling and recruited representatives from these agencies to participate in the local-scale emissions inventory focus group. During this process, two types of focus group participants were recruited: (1) core participants who would present information on local-scale analyses performed by their agencies; and (2) peer reviewers who would participate in group meetings and review group work products. **Table 1** provides a list of all group participants and summarizes the types of local-scale analyses conducted by core participants' agencies.

Table 1. List of local-scale emissions inventory focus group participants.

Agency	Staff Members	Purpose of Local-Scale Analyses
Core Participants		
Allegheny County (PA) Health Department	Jayme Graham Jason Maranche	Evaluation of local emissions contributing to monitored $PM_{2.5}$ concentrations.
Alabama Department of Environmental Management	Leigh Bacon Lisa Cole Tim Martin	SIP attainment demonstrations for ozone and $PM_{2.5}$.
Cleveland Division of Air Quality	David Hearne	Multi-pollutant study assessing the impacts of local and regional sources on $PM_{2.5}$ and air toxics concentrations in Cleveland.
Georgia Department of Natural Resources	Jim Boylan Byeong Kim	$PM_{2.5}$ attainment demonstration for Atlanta.
Illinois Environmental Protection Agency	Jeff Sprague Buzz Asselmeier	Development of a multi-pollutant air quality management plan for St. Louis. $PM_{2.5}$ attainment demonstration for Granite City, IL.
Missouri Department of Natural Resources	Jeff Bennett Stacey Allen	Development of a multi-pollutant air quality management plan for St. Louis.
Wyoming Department of Environmental Quality	Brian Bohlmann Ken Rairigh	Evaluation of wintertime high ozone episodes associated with oil and gas production sources.
Peer Reviewers and Other Participants		
Indiana Department of Environmental Management	Scott DeLoney Jeff Stoakes	
Pennsylvania Department of Environmental Protection	Sherry Bogart	
Maricopa County (AZ) Air Quality Department	Bob Downing	
Maricopa Association of Governments	Matt Poppen	
Pinal County (AZ) Air Quality Control Division	Kate Edwards	
Puget Sound (WA) Clean Air Agency	Kathy Himes Strange	
EPA Region 3	Alice Chow	
EPA Region 7	Steven Brown	
EPA Region 8	Mark Komp	

The focus group met via teleconference on a biweekly basis from June 15 through August 24, 2010. Core participants presented and discussed information related to several charge questions:

1) What type of air quality problems were addressed with the fine-scale modeling conducted by state and local agencies?
2) What analysis techniques were used to evaluate emission biases, identify key sources in their area, and prioritize emissions inventory improvement work?
3) For which source categories were emissions estimates improved, and what methods were used?

4) What changes to emissions estimates and modeling results occurred because of local-scale emissions inventory development efforts?

5) Would any NEI-related analyses be helpful to their efforts? (If so, at what step in the process would such analyses be beneficial?)

In addition, SLRT agencies provided EPA and STI with technical support documents related to their local-scale inventory development and fine-scale modeling efforts. These documents were reviewed to gain additional insights into issues identified by the charge questions listed above. At the conclusion of the project, EPA and STI summarized the information gathered from SLRT agencies, highlighted patterns in approaches taken and results achieved, and developed recommendations for local-scale inventory development practices and potential NEI analyses that could assist the local-scale inventory development process.

RESULTS AND DISCUSSION

The sub-sections that follow present and discuss results from the focus group meetings, with project findings organized by the five charge questions listed above.

Air Quality Problems Addressed

The Clean Air Act requires that states submit SIPs to demonstrate how EPA-designated "non-attainment" areas (NAAs) for $PM_{2.5}$, ozone, or other pollutants will attain the violated standard(s). Almost exclusively, state and local agencies that participated in the focus group conducted local-scale emissions inventory development and fine-scale modeling as part of SIP attainment demonstrations or related investigations of local source contributions to pollutant concentrations.

$PM_{2.5}$ Attainment Issues

In particular, state and local agencies focused their efforts on local area analyses conducted to address local source primary $PM_{2.5}$ contributions to "excess" $PM_{2.5}$ concentrations at individual monitoring sites. For example, the Allegheny County Health Department (HD) conducted a local area analysis in the Liberty-Clairton NAA, an area covering only 12 square miles in southeastern Allegheny County. The Liberty-Clairton NAA and its environs are home to several large industrial facilities, including the largest coke plant in the country [5]. Moreover, the NAA lies in complex river valley terrain, where nighttime temperature inversions trap local primary $PM_{2.5}$ emissions. Allegheny County HD's local area analysis focused on the Liberty monitor, which tracks other area monitors during daylight hours but exhibits significantly higher $PM_{2.5}$ concentrations during nighttime hours [6].

Similarly, Illinois EPA conducted a local area analysis in Granite City, Illinois, which is part of the St. Louis $PM_{2.5}$ NAA, as annual average NAAQS exceedances at the Granite City monitoring site could not be resolved with photochemical grid modeling alone. Illinois EPA's local area analysis focused on iron and steel manufacturing in the area around the Granite City site and featured fine-scale dispersion modeling with American Meteorological Society/EPA Regulatory Model Improvement Committee (AERMIC) Dispersion Model (AERMOD) for local sources [7].

Fine-scale $PM_{2.5}$ modeling in the Atlanta area conducted by the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources (DNR) was also driven by $PM_{2.5}$ exceedances at a single monitor: the Fire Station #8 (FS#8) monitor in Fulton County. The FS#8 monitor exhibits higher annual average $PM_{2.5}$ measurements than other monitors in the Atlanta NAA and is located near three large rail yards and Marietta Blvd., a roadway with high volumes of truck traffic. EPD's attainment demonstration for Atlanta featured updated emissions inventories for the rail yards and other local sources, as well as AERMOD dispersion modeling for the immediate vicinity of the FS#8 site [8].

Ozone Attainment Issues

While local sources of primary $PM_{2.5}$ were the primary focus of local-scale emissions inventory development and fine-scale modeling by state and local agencies, ozone non-attainment issues also played a role in some cases. For example, the Wyoming Department of Environmental Quality (DEQ) has recommended that the Upper Green River Basin (UGRB) in Sublette County be designated as non-attainment for the 2008 8-hr ozone NAAQS of 75 ppb. Monitoring data for 2006-2008 indicated that the entire state of Wyoming is in compliance with this standard except for the Boulder monitor in the UGRB. Ozone exceedances at the Boulder monitor are driven by the rapid growth of oil and gas production activities in the UGRB, as well as the distinct meteorological conditions in this area (e.g., persistent wintertime inversion events with low mixing heights). As a result, Wyoming DEQ has been working to develop detailed, well-specific emissions inventories for the UGRB and other oil and gas production fields in the state, and to incorporate these updated emissions data in ozone modeling efforts [9].

The state of Alabama is also faced with potential new ozone NAAs as a result of revised ozone standards. The Alabama Department of Environmental Management (DEM) has previously conducted fine-scale $PM_{2.5}$ modeling with AERMOD for non-attainment monitors in the Birmingham area, and Alabama DEM anticipates that fine-scale modeling for ozone will be needed in the future for several areas of the state, including Mobile and Huntsville [10].

Multi-Pollutant Issues

Multi-pollutant interrelationships exist because release, control, and chemical reactions of pollutants in the atmosphere are often interdependent, and EPA has recently undertaken analyses of multi-pollutant, risk-based (MPRB) control strategies to evaluate the impact of such strategies on concentrations of ozone, $PM_{2.5}$, and air toxics in urban areas. The Detroit area was selected by EPA as a "proof-of-concept" project for MPRB analyses and EPA has recently undertaken a multi-pollutant study in Cleveland. As part of this project, STI worked with EPA and the Cleveland Division of Air Quality (DAQ) to develop improved emissions inventories for local industrial facilities and other sources in Cleveland. These inventories will be used as inputs for modeling $PM_{2.5}$ and air toxics concentrations with the Community Multiscale Air Quality (CMAQ) model [11].

Similarly, Illinois EPA and the Missouri Department of Natural Resources are preparing to implement a multi-pollutant air quality management plan (AQMP) for St. Louis, work that involves emissions inventory improvements and fine-scale modeling for ozone, $PM_{2.5}$, and selected air toxics for a core area of St. Louis and selected outlying metropolitan areas. It is anticipated that this work will integrate NAAQS attainment with environmental justice concerns, energy issues, and climate change mitigation [12]. In addition, Illinois EPA is considering emissions inventory development and fine-scale SO_2 modeling for oilfield production sources around Bridgeport and Petrolia, Illinois [13].

Analysis Techniques

Among the state and local agencies that participated in the focus group, a variety of analysis techniques were used to evaluate emission biases, identify key sources in areas of interest, and prioritize emissions inventory improvement work. Techniques that were widely used by the participating agencies include receptor modeling with positive matrix factorization (PMF), inter-monitor comparisons, and meteorological analyses.

Receptor Modeling

Receptor modeling is the process of applying multivariate statistical methods to help identify and quantify air pollutants and their corresponding emissions sources. PMF is a multivariate factor analysis tool that is used to identify a group of sources that best characterize ambient data at a monitoring site and the amount of mass contributed by each source to measured pollutant concentrations [14]. A number of state and local agencies that participated in the focus group used PMF to assess local source impacts at monitors with pollutant concentrations that exceeded the NAAQS and prioritize local sources to be addressed during emissions inventory development activities.

For example, Georgia EPD used PMF to investigate the contribution of local sources to the $PM_{2.5}$ increment at the FS#8 site, which recorded $PM_{2.5}$ levels substantially higher than at any other Atlanta NAA site. Since speciated data were not available from the FS#8 site, X-ray fluorescence (XRF) was used to analyze selected $PM_{2.5}$ filter data from 2002 through 2004 to quantify ambient trace metal concentrations. Running PMF with metals data only, EPD found that the steel- and zinc-rich factors showed the highest contribution to the local $PM_{2.5}$ increment at FS#8. EPD estimated the source of the metals associated with steel to be activity at an adjacent rail yard and attributed the zinc-rich factor to local diesel sources, such as truck traffic on Marietta Blvd. or idling locomotives at the rail yard. Rail yards and roadways were subsequently prioritized during the development of a local-scale emissions inventory [15].

Similarly, Allegheny County HD used PMF to characterize the $PM_{2.5}$ increment at the Liberty monitor in Allegheny County's Liberty-Clairton NAA. The Liberty monitor measures 54 different species of $PM_{2.5}$ in addition to the total mass concentration; PMF modeling of the speciated data resulted in the identification of 12 source factors. Apart from secondary ammonium sulfate, the factor with the highest contribution to $PM_{2.5}$ mass at the Liberty monitor was the "carbon-rich" factor, which contains high percentages of elemental and organic carbon. The Allegheny County HD estimated that the majority of this factor was contributed by a constant industrial source, most likely a large coke plant that was subsequently prioritized for improved emissions estimation [16].

PMF modeling was also used to investigate local source contributions to measured $PM_{2.5}$ concentrations in Birmingham by Alabama DEM [10] and in East St. Louis and Granite City by Illinois EPA and Missouri DNR [7].

Wind Direction Analysis

Ambient measurement data can be combined with wind direction data to determine which wind directions are prevalent when high pollutant concentrations are observed at a monitoring site. Such analyses can provide insights into local sources that may be impacting a monitoring site.

For example, Georgia EPD plotted $PM_{2.5}$ concentrations against wind direction data at three monitoring sites in the Atlanta NAA, including the FS#8 site. Results showed that $PM_{2.5}$ levels at all three sites were highest when winds were from the south, which was expected, as all three sites lie north of downtown Atlanta. However, $PM_{2.5}$ peaks were observed on days of southwesterly winds at the FS#8 site, but not at the other two sites. This finding may indicate impacts on the FS#8 site from a large rail yard southwest of the site [15].

Illinois EPA took a somewhat more refined approach to wind direction analysis by separating local and regional contributions to $PM_{2.5}$ contributions at the Granite City monitoring site. $PM_{2.5}$

measurements from the Granite City site were compared to measurements at a second site in downtown St. Louis to identify time periods when the Granite City site showed "excess" $PM_{2.5}$ concentrations above levels that would be attributable to regional transport and urban sources (e.g., motor vehicles). Measurements from these time periods were combined with surface meteorological data to identify source regions contributing to the excess $PM_{2.5}$. This analysis showed that excess $PM_{2.5}$ was observed at the Granite City site when winds were from the south and southwest, indicating impacts from a large steel mill in the vicinity [7].

These types of wind direction analyses and "pollution rose" plots were also used by EPA and Cleveland DAQ as part of the Cleveland multi-pollutant study [17], as well as Allegheny County HD and Alabama DEM for local-scale analyses in their regions.

Inter-Monitor Comparisons

In addition to the wind direction-based comparisons between the Granite City and downtown St. Louis sites described above, Illinois EPA developed daily average "base concentration" data for eight compliance monitoring stations in the St. Louis area and compared these base values to monitor-specific daily average $PM_{2.5}$ concentrations. The base concentrations were based on the fifth lowest measurement value at a given time-step among all monitoring stations over multiple years of data. When plotted against monitor-specific data, it was clear that monitoring sites in Granite City (and, to a lesser extent, East St. Louis), showed $PM_{2.5}$ impacts above the base concentrations. Illinois EPA also compared speciated $PM_{2.5}$ data from the Gateway Medical Center site in Granite City and the Blair site in downtown St. Louis. For most species, measurements from the two sites showed good agreement; however, significantly higher iron measurements were routinely observed at the Gateway Medical Center site [7].

Allegheny County HD operates two $PM_{2.5}$ speciation monitors as part of EPA's Speciation Trends Network (STN): the Lawrenceville site, an urban residential site downwind of downtown Pittsburgh, and the Liberty site in the heavily industrialized Liberty-Clairton NAA. Allegheny County HD compared measurements from these two sites for an 18-month period in 2003 through 2005 and found that, while levels of sulfates and nitrates are similar for the two sites, the Liberty site is dominated by organic and elemental carbon year-round. By calculating differences in measurements for major species, Allegheny County HD estimated that elemental and organic carbon account for about 74% of the localized excess mass at the Liberty site [18]. When combined with results from other analyses, this finding helped to identify local source impacts at the Liberty site.

Also, during the development of a SIP for the Atlanta $PM_{2.5}$ NAA, Georgia EPD compared ambient monitoring data from FRM monitors and a speciation monitor in the Atlanta NAA as part of an evaluation of long-term trends in $PM_{2.5}$ levels. Trends in different $PM_{2.5}$ species were also compared to speciation data from other NAAs in Georgia to help identify key contributors to $PM_{2.5}$ levels in the Atlanta area [15].

Other Analyses

In addition to the analyses described above, state and local agencies that participated in the focus group used other techniques to identify key sources in areas of interest and prioritize emissions inventory improvement work. For example, Alabama DEM used emissions-to-distance ratios to evaluate the probability that emissions from individual facilities would contribute to monitored $PM_{2.5}$ concentrations in the Birmingham area. Emission rates (Q) and distance from a monitor (D) were combined to calculate the Q/D for each facility, and the Q/D values were used to rank all facilities evaluated [10]. Alabama also used fence-line sampling at key industrial facilities to evaluate the potential contributions of these facilities to $PM_{2.5}$ species concentrations at non-attainment monitors [19].

Also, when Georgia EPD was selecting industrial facilities for a local area analysis around the FS#8 monitoring site, EPD ranked all sources according to annual PM emissions and established an emissions threshold of 5 tons per year for inclusion in the analysis [8]. Similarly, prior to the development of a local-scale emissions inventory for the Cleveland Multiple Air Pollutant Study (CMAPS), Cleveland DAQ used permit data to identify the top ten industrial sources of $PM_{2.5}$, NO_x, SO_2, and CO in Cleveland; a list of 21 unique facilities was prioritized for subsequent data collection efforts [11].

Emissions Inventory Improvement Methods

Local-scale emissions inventory development efforts undertaken by state and local agencies in support of attainment demonstrations and other analyses focused primarily on large industrial sources such as steel mills. However, areawide sources (e.g., oil and gas production wells), non-road mobile sources (e.g., locomotives at rail yards), and on-road mobile sources were also addressed. The following subsections provide information on the methods used to improve emissions estimates for these various source sectors.

<u>Industrial Facilities</u>

Methods used to improve emissions estimates for industrial facilities included facility surveys, stack testing, and evaluation of stack parameters and other modeling inputs. For CMAPS, after a list of key Cleveland facilities was identified from permit data (as described above), representatives from each facility were invited to Cleveland DAQ's offices to meet with staff from EPA, Cleveland DAQ, and STI. At this meeting, facility representatives were provided with background information on the study, preliminary findings from air quality monitoring efforts, and a description of the types of data that would be required to develop an updated stationary source inventory for Cleveland for the 2009-2010 CMAPS study period. Subsequently, STI contacted each of the 21 prioritized facilities by telephone and/or email to collect information on emissions and operations during the CMAPS study period, particularly the months of August 2009 and February 2010, when intensive air quality monitoring was being conducted. Specific data requested from each facility included:

- Monthly emissions or operations data (e.g., production, throughput, or fuel combustion) for 2009 and the first quarter of 2010
- Daily operations data for August 2009 and February 2010
- Typical operating schedules, as well as any unusual conditions during August 2009 and February 2010 (e.g., shut-downs, emissions "upsets," etc.)

These data were successfully collected from 17 of the 21 facilities and used to replace 2005 NEI data (where current emissions were provided) or to scale 2005 NEI emissions to 2009-2010 levels (where production or fuel consumption data were provided). In addition, operating schedules and production data were used to generate facility-specific temporal profiles and daily emissions files that were used to prepare CMAQ-ready emissions inputs [11].

The Allegheny County HD's local-scale inventory also focused primarily on industrial sources and relied on updated stack test emissions for facilities near the Liberty-Clairton NAA. The most important revisions were made to emissions for a large coke plant, where recent (2007) source testing resulted in a large increase in the emission factor for quench tower condensable $PM_{2.5}$ emissions (from 0.00031 lb/ton to 0.56 lb/ton of coal charged). For filterable $PM_{2.5}$ emissions from quench towers, the implementation of baffle washing led to an emission factor decrease from 0.31 lb/ton to 0.0785 lb/ton.

Local sources in a 150 km x 150 km domain were modeled with California Puff model (CALPUFF) and CALPUFF outputs were combined with regional CMAQ results [6].

Similarly, the local-scale inventory Illinois EPA used for the $PM_{2.5}$ local area analysis for Granite City, Illinois, featured improved emissions estimates for iron and steel manufacturing operations. Methods used to update the point source inventory included communications with company staff, stack test results, and internal communications with permit analysts and field operations staff. Local sources were modeled with the AERMOD dispersion model [7]. This same approach was taken by Alabama DEM for the Birmingham $PM_{2.5}$ attainment demonstration, where facility emission rates, stack parameters, and location coordinates were reviewed and updated prior to inclusion in fine-scale modeling with AERMOD. Some smaller facilities were included in the AERMOD inventories because of their proximity to monitoring sites, though these facilities were not part of previous Prevention of Significant Deterioration (PSD) modeling inventories [10]. Georgia EPD also included nine local facilities in the AERMOD modeling performed as part of the local area analysis in Atlanta, including smaller facilities that had not been treated as individual point sources before [15].

Areawide Sources

Stationary sources that are too small and numerous to treat individually are typically aggregated in emissions inventories as "areawide" or "non-point" sources. However, for local-scale analyses, it may be necessary to gather the detailed information required to model such sources on an individual basis.

Typically, oil and gas wells are treated in an emissions inventory as an area-wide source, with emissions estimated using "top-down" methods such as applying per-well emission rates to the number of wells drilled in a given geographic area [20]. However, because of the rapid expansion of oil and gas production activities in Wyoming's UGRB and the contribution of these sources to elevated wintertime ozone concentrations, Wyoming DEQ has instituted an extensive minor-source permitting program that covers all the oil and gas production wells in the state. In 2009, Wyoming DEQ began collecting "bottom-up" emissions data for all permitted wells, including speciated hydrocarbon emissions for some source types. These well-specific inventories cover 14 emissions sources, including drill rigs, stationary engines, process burners, tanks, dehydration units, pneumatic pumps, and non-road mobile sources. In addition, Wyoming DEQ is in the process of developing gas field-specific emission equations for flashing emissions from condensate storage tanks and uncontrolled emissions from glycol dehydration units [9]. Combined with well-specific location coordinates, these emissions data allow wells to be treated as individual point sources in air quality modeling applications.

Non-Road Mobile Sources

The local area analysis conducted by Georgia EPD in support of the Atlanta $PM_{2.5}$ SIP was focused on the FS#8 monitor in Fulton County, which is near three large rail yards—Inman, Tilford, and Howells. Georgia EPD estimated base year (2002) and future year (2012) $PM_{2.5}$ emissions from switching and line haul locomotives operating at these rail yards and treated these emissions as volume sources in AERMOD [8].

The three rail yards have a total of 25 switchers. Base year emissions for these locomotives were based on an EPA national average fuel consumption estimate of 82,490 gallons per year per switcher. Future year emissions estimates accounted for the replacement of all 25 switchers with ultra-low emission Genset locomotives. Line haul locomotive emissions were based on the system-wide fuel combustion index (FCI) for the Norfolk Southern Railway, which operates the Inman rail yard, and CSX Transportation, which operates the Tilford and Howells yards. FCI data were combined with the number of track miles in the modeling area and fuel-based emission factors to estimate line haul emissions in the modeling area. The Inman and Tilford yards were each treated as two volume sources in AERMOD, while the Howells yard was treated as a single volume source. Source release heights and initial vertical coordinates were calculated from a typical locomotive height of 12 feet and the initial lateral coordinate was estimated from the rail yard sizes (width and length) [15].

Non-road mobile sources were also considered during the development of a local-scale emissions inventory for the CMAPS study. Commercial marine vessel emissions for the Port of Cleveland from the 2005 NEI were updated according to 2009 vessel call data obtained from the local port authority. Differences in the number of vessel calls between 2005 and 2009 were used to adjust 2005 NEI emissions for marine vessels, and monthly vessel call data for 2009 were used to allocate marine vessel emissions to specific months [11].

On-Road Mobile Sources

In addition to three rail yards, Atlanta's FS#8 monitor is in the vicinity of Marietta Blvd. and other heavily-traveled roadways. Georgia EPD estimated $PM_{2.5}$ emissions from on-road mobile sources for segments of Marietta Blvd., Bolton Road, and Marietta Road by using link-based vehicle miles traveled (VMT) data for these roadways. Individual roadway segments were treated as volume sources in AERMOD with release heights and initial vertical coordinates calculated from a typical truck height of 12 feet. Initial lateral coordinates were estimated from the roadway size (width and length) [15].

For the CMAPS study, on-road mobile source emissions in the Cleveland metropolitan area were estimated using EPA's MOVES model and VMT data derived from travel demand model outputs provided by the Northeast Ohio Areawide Coordinating Agency (NOACA). On-road emissions were allocated to the CMAPS modeling domain using NOACA's link-level travel demand model outputs [11].

Initial Outcomes of Local-Scale Analyses

Initial outcomes of the local-scale analyses conducted by state and local agencies included emissions estimates for sources that not had been treated as individual point sources before, updated emissions estimates for key facilities and other sources, and dispersion modeling results that captured fine-scale gradients in pollutant concentrations. Examples of results for individual analyses are provided below.

Allegheny County Local Area Analysis

Allegheny County HD revised its 2002 base year inventory and 2012 future year inventory for local sources near the Liberty-Clairton NAA. The most important inventory revisions related to a large coke plant in the area, where updates resulted in a base-year increase of over 1,700 tons per year for primary $PM_{2.5}$ emissions (see **Table 2**). Allegheny County HD revisions to the 2012 inventory captured the effects of proposed modifications, including the shutdown of two battery lines and changes in battery configurations, to the Clairton coke plant. These updates resulted in a future-year decrease of 450 tons of primary $PM_{2.5}$ emissions. As a result, modeled $PM_{2.5}$ concentrations at the Liberty-Clairton monitor decreased by 2 $\mu g/m^3$ on an annual basis and 8 $\mu g/m^3$ on a 24-hour basis [5].

Table 2. Detailed 2002 emissions inventory changes for the Clairton coke plant.

Source	Update	Change in Primary $PM_{2.5}$ from the NEI (tons/year)
Quench towers	Adjusted emissions based on 2007 stack test	1,728.0
Soaking	Batteries treated as lightly smoking flares (not previously estimated)	8.2
Underfiring	Increased particle size fraction for $PM_{2.5}$ based on data provided by the facility	100.2
Traveling hot car	Updated methodology that treated hot car emissions as combustion emissions	(52.3)
Pushing fugitives	Changed capture efficiencies for baghouse dust collection	(27.0)
Material handling	Reduced particle size fraction for $PM_{2.5}$	(3.4)
Coal and coke pile erosion	Reduced particle size fraction for $PM_{2.5}$	(5.7)
Paved and unpaved road dust	Reduced particle size fraction for $PM_{2.5}$	(3.8)
Total		**1,744**

<u>Atlanta, Georgia, Local Area Analysis</u>

When Georgia EPD conducted air quality modeling using CMAQ alone, the model predicted future year (2012) design values below the 15.0 $\mu g/m^3$ annual standard for all monitoring locations except the FS#8 site, which had a predicted design value of 15.4 $\mu g/m^3$. However, the 12-km CMAQ modeling could not accurately capture the impact of local sources on $PM_{2.5}$ measurements at FS#8, which necessitated the local area analysis undertaken by Georgia EPD.

This local area analysis focused on emissions from rail yards, on-road mobile sources, and industrial sources. **Table 3** provides a summary of $PM_{2.5}$ emissions estimates for these sources for the 2002 base year and the 2012 future year. **Table 4** provides a summary of modeled source impacts on $PM_{2.5}$ concentrations at the FS#8 monitor. Based on the modeled impact of these local sources, the predicted 2012 design value for the FS#8 monitor was adjusted from 15.4 to 14.5 $\mu g/m^3$ [15].

Table 3. 2002 and 2012 $PM_{2.5}$ emissions for local sources in Atlanta.

Source	2002 $PM_{2.5}$ (tons)	2012 $PM_{2.5}$ (tons)	Reduction Ratio
Inman rail yard	22.0	7.6	0.35
Tilford rail yard	14.0	4.4	0.31
Howells rail yard	0.8	0.1	0.13
On-road mobile sources	3.9	1.7	0.44
Industrial sources	399.0	399.0	N/A

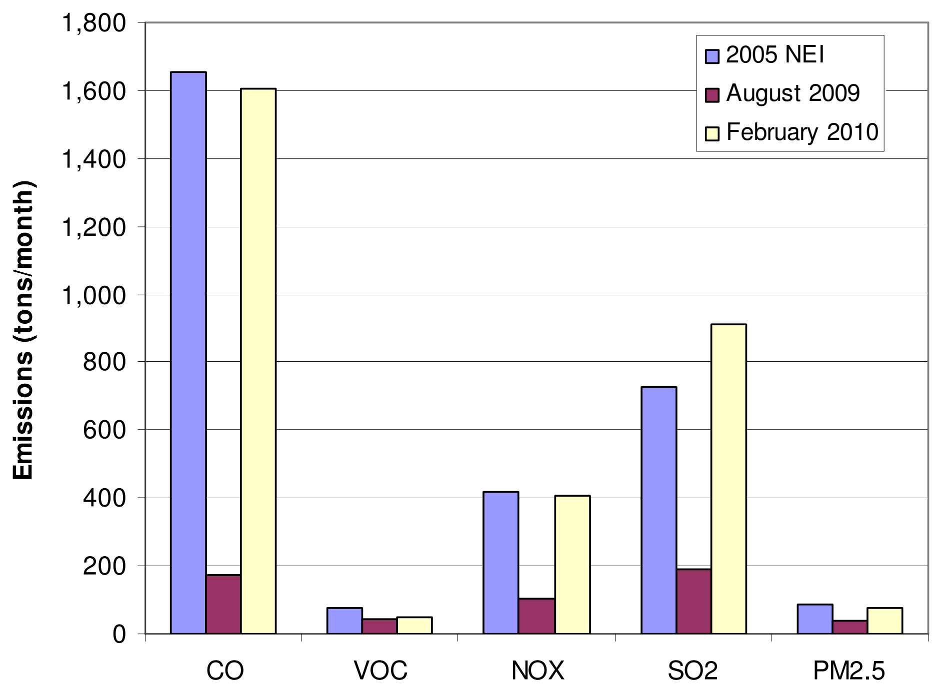
Table 4. 2002 and 2012 source contributions to $PM_{2.5}$ concentrations at the FS#8 monitor.

Source	2002 $PM_{2.5}$ Contribution at FS#8 ($\mu g/m^3$)	2012 $PM_{2.5}$ Contribution at FS#8 ($\mu g/m^3$)	Reduction ($\mu g/m^3$)
Rail yards	1.9	0.6	1.3
On-road mobile sources	0.4	0.2	0.2
Industrial sources	1.3	1.3	0.0
Total	**3.6**	**2.1**	**1.5**

Cleveland Multiple Air Pollutant Study

The 2009-2010 local-scale emissions inventory developed as CMAQ model inputs for CMAPS focused on local industrial sources and mobile sources and differed significantly from the 2005 NEI. For example, **Figure 1** shows a comparison of average monthly emissions for key Cleveland-area facilities from the 2005 NEI, with updated emissions estimates developed for August 2009 and February 2010. For all facilities combined, August 2009 emissions were 39% to 90% lower than average monthly emissions in 2005, largely because a large steel plant and a local power plant were not active during that month. Total February 2010 emissions from all facilities combined were comparable to 2005 levels (±30%) because the steel and power plants were back in operation during that month.

Figure 1. Comparison of 2005 and 2009-2010 point source emissions for key facilities in Cleveland.



Collection of local-scale emissions and activity data in Cleveland and surrounding Cuyahoga County also resulted in day-specific emissions inventories that captured temporal variability in emissions from industrial sources and commercial marine vessels at the Port of Cleveland. **Figures 2 and 3** show daily variations in Cuyahoga County SO_2 emissions for August 2009 and February 2010, the two months when intensive air quality monitoring was conducted. Note that daily SO_2 emissions average about 16 tons in August 2009 and about 43 tons in February 2010. These differences are due to the temporary shutdowns at the local steel plant and power plant.

Figure 2. Daily SO_2 emissions for Cuyahoga County for August 2009.

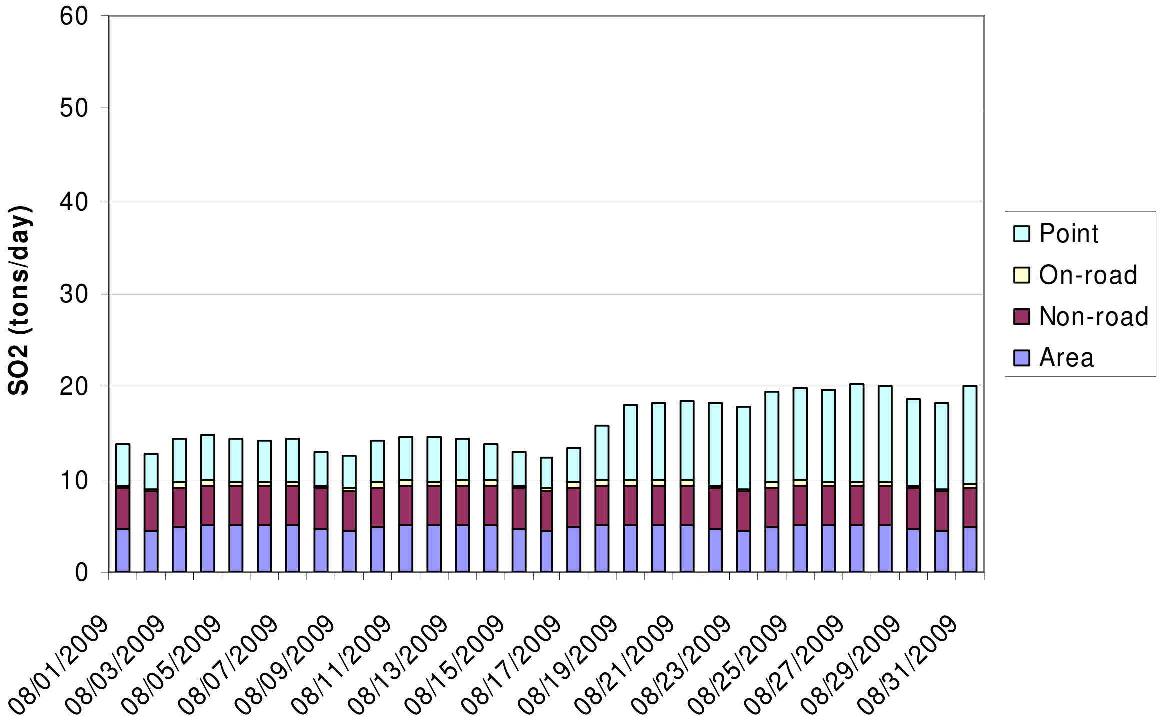
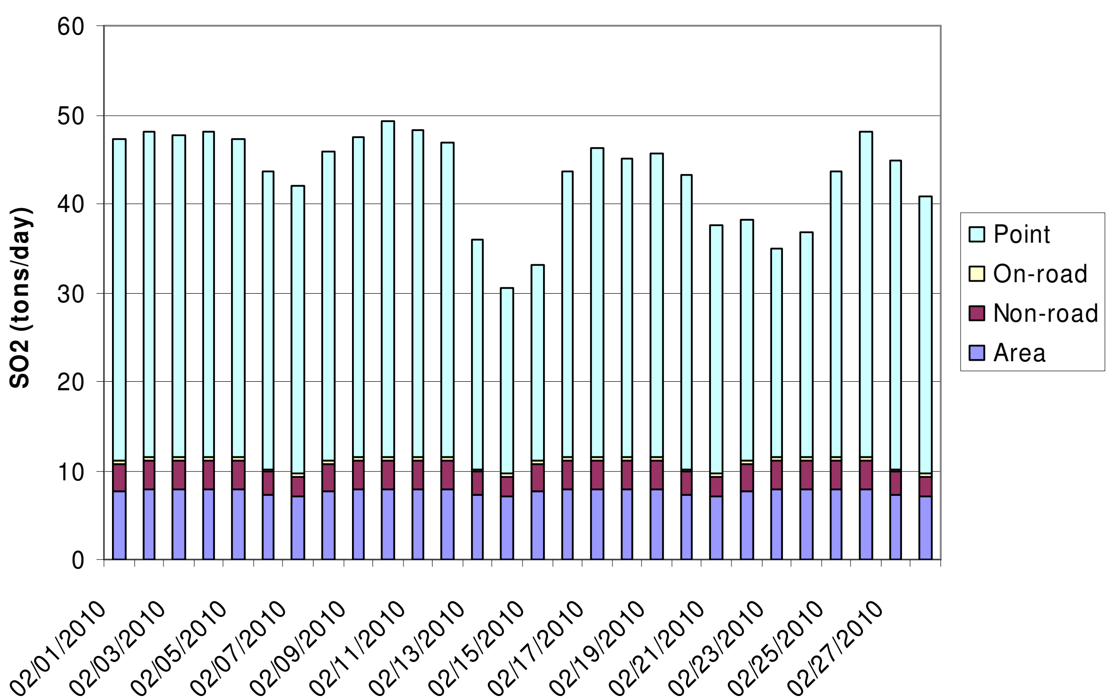


Figure 3. Daily SO_2 emissions for Cuyahoga County for February 2010.



Wyoming Ozone Evaluation

To support ongoing ozone modeling efforts in Wyoming's UGRB, Wyoming DEQ has begun collecting well-specific emissions data from all oil and gas operations in the state. For the 2008 bottom-up oil and gas production inventory, **Table 5** provides a summary of total emissions by source type for criteria pollutants.

Table 5. Criteria pollutant emissions (tons) from oil and gas production for 2008.

Source	NO_x	VOC	PM_{10}	SO_2
Stationary engines	1,929	496	112	35
Heaters	2,879	158	219	17
Tanks and pressurized vessels	572	47,176	1	971
Dehydration units	290	23,549	0	12
Pneumatic pumps	64	18,305	1	0
Fugitive losses	0	10,335	0	0
Venting and blowdown events	8	3,267	19	2
Drill rigs	5,320	839	157	291
Well completions	2,083	445	127	265
Truck loading	0	1,268	0	0
Total wellhead emissions	**13,145**	**105,841**	**635**	**1,594**

As part of the emissions data collection, Wyoming DEQ also requested speciated hydrocarbon emissions for several sources, including glycol dehydration units, pneumatic pumps, and well venting and blow-down events. Currently, Wyoming DEQ is examining the reactivity of different speciated hydrocarbons to improve model performance and identify effective control strategies.

NEI-Related Analyses

State and local agencies that participated in the local-scale focus group observed that, while the NEI serves as a good starting point for regional modeling applications, concerns exist about the quality and detail of the data with respect to local-scale analyses; specifically, the quality of stack parameter information, location coordinates, temporal resolution, and spatial resolution (e.g., county-level vs. link-based mobile source estimates).

Some focus group time was devoted to discussing the relationship between local-scale inventories and the NEI, and the extent to which emissions inventory improvements made during local area analyses are captured in their local data systems and made available to EPA's EIS. Based on these discussions, there appears to be a lack of connection between local-scale inventories developed for SIP modeling purposes and state inventories submitted to EPA's EIS for inclusion in the NEI. SLRT agencies that participated in the focus group indicated that, though some of the emission rates, stack parameters, and other local-scale information collected will be included in EIS submittals, a number of barriers exist that hinder this process. Specific barriers identified include:

- The timing of inventory updates – in some cases, local-scale emissions inventory work is happening on the heels of a state's EIS submittal, and new information developed for the local-scale inventory may not be submitted as a correction, though the information may be carried forward for future submittals. As a result, emissions inventories prepared for local area analyses and SIP modeling are often developed on a separate track from the emissions inventories submitted to the EIS.

- Resource requirements – it may be labor-intensive or difficult to prepare detailed local-scale emissions inventory data for submittal to the EIS. For example, the well-by-well inventories developed by the state of Wyoming for the majority of minor sources related to oil and gas fields are aggregated to the county level for EIS submittal purposes because submitting individual point source data for tens of thousands of wells would be too time-consuming. The more significant individual point sources (approximately 1,500 facilities) are being processed for submittal to the EIS.

- Modelers may update inventories using information obtained from permit staff or individual facilities and these updates may not be communicated back to the agency's emissions team.

- Emissions thresholds – for some local area analyses, detailed inventories were developed for facilities that did not meet emissions thresholds requiring them to be reported to the NEI under the Air Emissions Reporting Rule (AERR). As a result, some state and local agencies chose not to submit data for these inventories to the EIS.

- Usefulness for other agencies – some SLRT agencies observed that, while their emissions inventory improvements impacted fine-scale modeling results, the magnitude of emissions changes was unlikely to impact regional air quality modeling performed by other states. Therefore, there was no motivation to ensure that the updated data were captured in EIS submittals.

These findings provide insight into reasons why the best-available emissions inventory information may not be reflected in EIS submittals and point to the need for additional investigation into the relationship between local-scale emissions inventories and the NEI and its uses.

CONCLUSIONS

The SLRT agencies that participated in the local-scale emissions inventory focus group provided valuable, experience-based information on local-scale inventory development and fine-scale modeling issues. This information is useful for providing guidance to other SLRT agencies that will be undertaking local-scale analyses in the future, as well as providing insight into the relationship between local-scale inventories and the NEI.

Regarding guidance for other SLRT agencies, the following actions were identified by focus group participants as a potential checklist for local-scale emissions inventory development:

- Start with what you know – begin by identifying emissions sources in your area of interest using existing inventories, permit data, and other sources of information.

- Use simple approaches, such as emissions-to-distance (Q/D) analysis, to prioritize sources in terms of potential impact on monitoring sites. Emissions-to-distance ratios provide a quick way of comparing local sources.

- Understand your monitoring data thoroughly, particularly speciated data. Investigate the variation of species concentrations by site, seasonal, hour, etc. before attempting more detailed analyses such as receptor modeling.

- When conducting analyses on local source contributions, use a weight of evidence approach, combining the results of receptor modeling, wind analyses, and inter-monitor comparisons to zero in on sources with significant impacts on monitored concentrations.

- Take care to collect detailed information on stack parameters as well as emission rates. Work with facility operators to determine the best way to characterize sources for modeling, particularly fugitive sources.

- Communicate with owners/operators of individual facilities early and often. Use multiple channels of communication, including letters and face-to-face meetings, to educate facility owners/operators on local air quality issues, the results of analyses that have evaluated their facility's impact on monitored pollutant concentrations, and the need for controls. Explain why it is in everyone's best interest to make sure that the best data is being used for modeling.

- Perform a thorough quality assurance (QA) check on any data you receive from individual facilities. Talk to a permit engineer who understands the facility or industry to ensure that reported data are reasonable.

- Compare modeling results with results from other analyses (e.g., Q/D, PMF) to see if the modeling confirms earlier findings. If not, it may be necessary to reevaluate modeled emissions rates or stack parameters.

Project findings also provided insight into the relationship between local-scale emissions inventories developed by SLRT agencies and the NEI. Focus group participants identified potential barriers that may prevent local-scale emissions data from reaching the EIS. These barriers include timing issues, resource limitations, and the development of separate modeling inventories by agency modelers. As a result, the authors recommend further investigation into NEI data analyses that can support SLRT agencies that are developing more locally representative emissions data for fine-scale air quality modeling, as well as provide additional incentives to SLRT agencies to ensure that locally representative emissions data are reflected in EIS submittals.

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