United States Environmental Protection Agency

EPA/600/R-10/021
February 2010
www.epa.gov

Hierarchical Bayesian Model (HBM)-Derived Estimates of Air Quality for 2006

Annual Report

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Developed by the U.S. Environmental Protection Agency
Office of Research and Development (ORD)
National Exposure Research Laboratory (NERL)

And

Office of Air and Radiation (OAR)
Office of Air Quality Planning and Standards (OAQPS)

Interagency Agreement Number: RW75922615-01-0 (EPA)
Interagency Agreement Number: 07FED63951 (CDC)

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Acknowledgements

The following people served as reviewers of this document and provided valuable comments that were included: Chris Clark (EPA/OEI), Alice Gilliland (EPA/ORD), David Holland (EPA/ORD), Steve Howard (EPA/ORD), David Mintz (EPA/OAR), Ed Lillis (EPA/OAR), and Doug Solomon (EPA/OAR).

Table of Contents

Appendices

List of Tables

List of Figures

1.0 Introduction

This report describes EPA's Hierarchical Bayesian model-generated (HBM) estimates of O_3 and $PM_{2.5}$ concentrations throughout the continental United States during the 2006 calendar year. HBM estimates provide the spatial and temporal variance of O_3 and $PM_{2.5}$, allowing estimation of their concentration values across the U.S., independent of where air quality monitors are physically located. HBM estimates are generated through the statistical 'fusion' of measured air quality monitor concentration values and air quality model predicted concentration values from EPA's Community Multiscale Air Quality (CMAQ) computer model. Information on EPA's air quality monitors, CMAQ model, and HBM model is included to provide the background and context for understanding the data output presented in this report.

The data contained in this report are an outgrowth of a collaborative research partnership between EPA scientists from the Office of Research and Development's (ORD) National Exposure Research Laboratory (NERL) and personnel from EPA's Office of Air and Radiation's (OAR) Office of Air Quality Planning and Standards (OAQPS). NERL's Human Exposure and Atmospheric Sciences Division (HEASD), Atmospheric Modeling Division (AMD), and Environmental Sciences Division (ESD), in conjunction with OAQPS, work together to provide air quality monitoring data and model estimates to the Centers for Disease Control and Prevention (CDC) for use in their Environmental Public Health Tracking (EPHT) Network.

The research which serves as the basis of this report falls under EPA's Long Term Goal 1, Clean Air and Global Climate Change, Objective 1.6, Enhance Science and Research, Subobjective 1.6.2, Conduct Air Pollution Research of EPA's Strategic Plan. Under Long Term Goal 1, EPA's objective is to protect and improve the air so it is healthy to breathe and risks to human health and the environment are reduced. Detailed information on Long Term Goal 1 can be found at: http://www.epa.gov/ocfo/par/2007par/par07goal1_goal.pdf.

As noted under Subobjective 1.6.2, through 2010, EPA provides methods, models, data, and assessment research associated with air pollutants. Under this research effort, EPA provides modeling support, air quality monitoring data and air quality modeling estimates for CDC to use in its public health tracking network. It allows EPA and CDC to link air quality data with public health (health outcome) data. This research provides scientific information and tools for understanding and characterizing environmental outcomes associated with national, urban, and residual criteria pollutants. The research contributes to an important EPA research objective, which is to understand the relationship between exposure to pollution and the resultant health effects on people.

CDC's EPHT Network supports linkage of air quality data with human health outcome data for use by various public health agencies throughout the U.S. The EPHT Network Program is a multidisciplinary collaboration that involves the ongoing collection, integration, analysis, interpretation, and dissemination of data from: environmental hazard monitoring activities; human exposure assessment information; and surveillance of noninfectious health conditions. As part of the National EPHT Program efforts, the CDC is leading the initiative to build the National EPHT Network (http://www.cdc.gov/nceh/tracking/default.htm). The National EPHT Program, with the EPHT Network as its cornerstone, is the CDC's response to requests calling for improved understanding of how the environment affects human health. The EPHT Network is designed to provide the means to identify, access, and organize hazard, exposure, and health data from a variety of sources and to examine, analyze and interpret those data based on their spatial and temporal characteristics. The EPHT Network is a standards-based, secure information network that was created to be used by many different entities, including epidemiologists, public health practitioners, academic researchers, schools of public health, local, state, and federal agencies such as EPA. Levels of access to the data in the EPHT Network will vary among stakeholders based upon their role and their purpose for using the data. Data access will be carefully controlled to ensure compliance with federal and state privacy laws which address the use of health data and other protected personal information. The CDC's National EPHT Program is establishing the EPHT Network by collaborating with a wide range of partners with expertise from federal, state, and local health and environmental agencies; nongovernmental organizations (NGOs); state public health and environmental laboratories; and Schools of Public Health.

Since 2002, EPA has collaborated with the CDC on the development of the EPHT Network. On September 30, 2003, the Secretary of Health and Human Services (HHS) and the Administrator of EPA signed a joint Memorandum of Understanding (MOU) with the objective of advancing efforts to achieve mutual environmental public health goals.[1] HHS, acting through the CDC and the Agency for Toxic Substances and Disease Registry (ATSDR), and EPA agreed to expand their cooperative activities in support of the CDC EPHT Network and EPA's Central Data Exchange Node on the Environmental Information Exchange Network in the following areas:

- Collecting, analyzing and interpreting environmental and health data from both agencies (HHS and EPA).
- Collaborating on emerging information technology practices related to building, supporting, and operating the CDC EPHT Network and the Environmental Information Exchange Network.
- Developing and validating additional environmental public health indicators.
- Sharing reliable environmental and public health data between their respective networks in an efficient and effective manner.
- Consulting and informing each other about dissemination of results obtained through work carried out under the MOU and the associated Interagency Agreement (IAG) between EPA and CDC.

Under the auspices of the HHS/EPA MOU, a research project was implemented between 2004 and 2006 to investigate the utility of EPA-generated air quality estimates as an input to the EPHT Network. The relationship between air pollutants and human health is of interest to both Agencies. EPA develops and funds ambient air quality monitoring networks to monitor air pollution and to provide data that may be used to mitigate its impact on our ecosystems and human health. (**Note**: AQS and AIRNow are EPA databases containing data collected from EPA's air quality monitoring networks.) Air quality monitoring data has been used by researchers to investigate the linkages between human health outcomes and air quality, and by

[1]Available at www.cdc.gov/nceh/tracking/epa_mou.htm

environmental and public health professionals to develop environmental health indicators which provide measures of potential human health impacts. However, an analysis of the currently available methods for generating and characterizing air quality estimates that could be developed and delivered systematically, and which were also readily available to link with public health surveillance data, had not been previously attempted. EPA collaborated with the CDC and state public health agencies in New York, Maine, and Wisconsin on the Public Health Air Surveillance Evaluation (PHASE) project to address this issue. The project focused on generating concentration surfaces for ozone and $PM_{2.5}$, which were subsequently linked with asthma and cardiovascular disease data. Results of this research project indicated that using a Hierarchical Bayesian approach to statistically "combine" Community Multiscale Air Quality (CMAQ) model estimates and air quality monitoring data documented in EPA's AQS provided better overall estimates of air quality at locations without monitors than those obtained through other well-known, statistically-based estimating techniques (e.g., kriging).

Ambient air quality monitoring data stored in the Air Quality System (AQS), along with air quality modeling estimates from CMAQ, can be statistically combined, via a Hierarchical Bayesian statistical space-time modeling (HBM) system, to provide air quality estimates (hereafter referred to as Hierarchical Bayesian-derived air quality estimates). These Hierarchical Bayesian-derived air quality estimates serve as well-characterized inputs to the EPHT Network. The air quality monitor data, CMAQ modeling estimates, and the Hierarchical Bayesian-derived air quality estimates can be used to develop meaningful environmental public health indicators and to link ozone and $PM_{2.5}$ concentrations with health outcome data. The Hierarchical Bayesian-derived air quality estimates are based on EPA's current knowledge of predicting spatial and temporal variations in pollutant concentrations derived from multiple sources of information. EPA is continuing its research in this critical science area and is implementing this project to establish procedures for routinely generating the Hierarchical Bayesian-derived air quality estimates developed in the PHASE project. This effort will assist EPA in making both ambient air quality monitoring (raw) data and the Hierarchical Bayesian-derived air quality estimates available to the CDC EPHT Network through EPA's Central Data Exchange (CDX) Node on the Environmental Information Exchange Network.

Because of EPA's expertise related to generation, analysis, scientific visualization, and reporting of air quality monitoring data, air quality modeling estimates, and Hierarchical Bayesian-derived air quality estimates and associated research, the CDC approached EPA to provide technical support for incorporating air quality data and estimates into its EPHT Network. Because the air quality data generated could be used by EPA to achieve other research goals related to linking air quality data and health effects and performing cumulative risk assessments, EPA proposed an interagency agreement under which each agency would contribute funding and/or in-kind support to efficiently leverage the resources of both agencies. The major objective of this research is to provide data and guidance to CDC to assist them in tracking estimated population exposure to ozone and $PM_{2.5}$; estimating health impacts to individuals and susceptible subpopulations; guiding public health actions; and conducting analytical studies linking human health outcomes and environmental conditions.

This report is divided into six sections and five appendices. The first major section of the report describes the air quality data obtained from EPA's nationwide monitoring network and the importance of the monitoring data in determining health potential health risks. The second major section of the report details the emissions inventory data, how it is obtained and its role as a key input into air quality computer models. The third major section of the report describes the CMAQ computer model and its role in providing estimates of pollutant concentrations across the U.S. based on either 12-km grid cells (Eastern U.S.) or 36-km grid cells (entire continental U.S.). The fourth major section of the report explains the 'hierarchical' Bayesian statistical modeling system which is used to combine air quality monitoring data and air quality estimates from the CMAQ model into a continuous concentration surface which includes regions without air quality monitors. The fifth major section provides guidelines and requisite understanding that users must have when using the 'hierarchical' Bayesian statistical modeling system. The appendices provide detailed information on air quality data and the hierarchical Bayesian statistical modeling system.

2.0 Air Quality Data

To compare health outcomes with air quality measures, it is important to understand the origins of those measures and the methods for obtaining them. This section provides a brief overview of the origins and process of air quality regulation in this country. It provides a detailed discussion of ozone (O_3) and particulate matter (PM). The PHASE project focused on these two pollutants, since numerous studies have found them to be harmful to public health and the environment, and there was more extensive monitoring and modeling data available.

2.1 Introduction to Air Quality Impacts in the United States

2.1.1 The Clean Air Act

In 1970, the Clean Air Act (CAA) was signed into law. Under this law, EPA sets limits on how much of a pollutant can be in the air anywhere in the United States. This ensures that all Americans have the same basic health and environmental protections. The CAA has been amended several times to keep pace with new information. For more information on the CAA, go to http://www.epa.gov/oar/caa/.

Under the CAA, the U.S. EPA has established standards or limits for six air pollutants, known as the criteria air pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), and particulate matter (PM). These standards, called the National Ambient Air Quality Standards (NAAQS), are designed to protect public health and the environment. The CAA established two types of air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. The law requires EPA to periodically review these standards. For more specific information on the NAAQS, go to www.epa.gov/air/criteria.html. For general information on the criteria pollutants, go to http://www.epa.gov/air/urbanair/6poll.html.

When these standards are not met, the area is designated as a nonattainment area. States must develop state implementation plans (SIPs) that explain the regulations and controls it will use to clean up the nonattainment areas. States with an EPA-approved SIP can request that the area be redesignated from nonattainment to attainment by providing three consecutive years of data showing NAAQS compliance. The state must also provide a maintenance plan to demonstrate how it will continue to comply with the NAAQS and demonstrate compliance over a 10-year period, and what corrective actions it will take should a NAAQS violation occur after redesignation. EPA must review and approve the NAAQS compliance data and the maintenance plan before redesignating the area; thus, a person may live in an area designated as non-attainment even though no NAAQS violation has been observed for quite some time. For more information on designations, go to http://www.epa.gov/ozonedesignations/ and http://www.epa.gov/pmdesignations.

2.1.2 Ozone

Ozone is a colorless gas composed of three oxygen atoms. Ground level ozone is formed when pollutants released from cars, power plants, and other sources react in the presence of heat and sunlight. It is the prime ingredient of what is commonly called "smog." When inhaled, ozone can cause acute respiratory problems, aggravate asthma, cause inflammation of lung tissue, and even temporarily decrease the lung capacity of healthy adults. Repeated exposure may permanently scar lung tissue. Toxicological, human exposure, and epidemiological studies were integrated by EPA in "Air Quality Criteria for Ozone and Related Photochemical Oxidants." It is available at http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_index.html. The current (as of October 2008) NAAQS for ozone, in place since 1997, is an 8-hour maximum of 0.075 parts per million [ppm] (for details, see http://www.epa.gov/ozonedesignations/). An 8-hour maximum is the maximum of the 24 possible running 8-hour average concentrations for each calendar day. The Clean Air Act requires EPA to review the NAAQS at least every five years and revise them as appropriate in accordance with Section 108 and Section 109 of the Act. The 'allowable' ozone values are shown in the table below:

Table 2-1. Ozone Standard

Parts Per Million: Measurement – (ppm)	1997	2008
1-Hour Standard	0.12	0.12
8-Hour Standard	0.08	0.075

2.1.3 Fine Particulate Matter

PM air pollution is a complex mixture of small and large particles of varying origin that can contain hundreds of different chemicals, including cancer-causing agents like polycyclic aromatic hydrocarbons (PAH), as well as heavy metals such as arsenic and cadmium. PM air pollution results from direct emissions of particles as well as particles formed through chemical transformations of gaseous air pollutants. The characteristics, sources, and potential health effects of particulate matter depend on its source, the season, and atmospheric conditions.

As practical convention, PM is divided by sizes[2] into classes with differing health concerns and potential sources. Particles less than 10 micrometers in diameter (PM_{10}) pose a health concern because they can be inhaled into and accumulate in the respiratory system. Particles less than 2.5 micrometers in diameter ($PM_{2.5}$) are referred to as "fine" particles. Because of their small size, fine particles can lodge deeply into the lungs. Sources of fine particles include all types of combustion (motor vehicles, power plants, wood burning, etc.) and some industrial processes. Particles with diameters between 2.5 and 10 micrometers ($PM_{10-2.5}$) are referred to as "coarse" or

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[2]The measure used to classify PM into sizes is the aerodynamic diameter. The measurement instruments used for PM are designed and operated to separate large particles from the smaller particles. For example, the $PM_{2.5}$ instrument only captures and thus measures particles with an aerodynamic diameter less than 2.5 micrometers. The EPA method to measure PMc is designed around taking the mathematical difference between measurements for PM_{10} and $PM_{2.5.}$

PMc. Sources of PMc include crushing or grinding operations and dust from paved or unpaved roads. The distribution of PM_{10}, $PM_{2.5}$ and PMc varies from the Eastern U.S. to arid western areas.

Epidemiological and toxicological studies have demonstrated associations between fine particles and respiratory and cardiovascular health effects, including irritation of the airways, coughing, decreased lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in people with heart or lung disease. These studies are summarized and integrated in "Air Quality Criteria for Particulate Matter" (EPA 2004). This document and other technical documents related to PM standards are available at http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_index.html.

The current (as of October 2008) NAAQS for $PM_{2.5}$ includes both a 24-hour standard to protect against short-term effects, and an annual standard to protect against long-term effects. The annual average $PM_{2.5}$ concentration must not exceed 15 ug/m^3, and the 24-hr average concentration must not exceed 35 micrograms per cubic meter (ug/m^3). The current annual $PM_{2.5}$ NAAQS was set in 1997 and the current 24-hr $PM_{2.5}$ NAAQS was set in 2006 (for details, see http://www.epa.gov/air/criteria.html) and http://www.epa.gov/oar/particlepollution/naaqsrev2006.html). The EPA quality assurance standards for $PM_{2.5}$ monitors specify that the coefficient of variation (CV = standard deviation/mean) of a monitor measurement must be less than 10%. The relative bias (tendency for measured values to be higher or lower than 'true' value) for $PM_{2.5}$ monitor measurements must be between the range of -10% to +10%. The 'allowable' $PM_{2.5}$ values are shown in the table below:

Table 2-2. $PM_{2.5}$ Standard

Micrograms Per Cubic Meter: Measurement - (ug/m^3)	1997	2006
Annual Average	15	15
24-Hour Average	65	35

2.2 Ambient Air Quality Monitoring in the United States

2.2.1 Monitoring Networks

The Clean Air Act requires every state to establish a network of air monitoring stations for criteria pollutants, following specific guidelines for their location and operation. The monitoring stations in this network have been called the State and Local Air Monitoring Stations (SLAMS). The SLAMS network consists of approximately 4,000 monitoring sites whose distribution is largely determined by the needs of State and local air pollution control agencies. All ambient monitoring networks selected for use in SLAMS are tested periodically to assess the quality of the SLAMS data being produced. Measurement accuracy and precision are estimated for both automated and manual methods. The individual results of these tests for each method or analyzer are reported to EPA. Then, EPA calculates quarterly integrated estimates of precision and accuracy for the SLAMS data.

The National Air Monitoring Station network (NAMS) is about a 1,000-site subset of the SLAMS network, with emphasis on areas of maximum concentrations and high population density in urban and multi-source areas. The NAMS monitoring sites are designed to obtain more timely and detailed information about air quality in strategic locations and must meet more stringent monitor siting, equipment type, and quality assurance criteria. NAMS monitors also must submit detailed quarterly and annual monitoring results to EPA.

The SLAMS and NAMS networks experienced accelerated growth throughout the 1970s. The networks were further expanded in 1999 following the 1997 revision of the CAA to include separate standards for fine particles ($PM_{2.5}$) based on their link to serious health problems ranging from increased symptoms, hospital admissions, and emergency room visits, to premature death in people with heart or lung disease. While most of the monitors in these networks are located in populated areas of the country, "background" and rural monitors are an important part of these networks. For criteria pollutants other than ozone and $PM_{2.5}$, the number of monitors has declined. For more information on SLAMS and NAMS, as well as EPA's other air monitoring networks go to www.epa.gov/ttn/amtic.

In summary, state and local agencies and tribes implement a quality-assured monitoring network to measure air quality across the United States. EPA provides guidance to ensure a thorough understanding of the quality of the data produced by these networks. These monitoring data have been used to characterize the status of the nation's air quality and the trends across the U.S. (see www.epa.gov/airtrends).

2.2.2 Air Quality System Database

The Air Quality System (AQS) database contains ambient air pollution data collected by EPA, state, local, and tribal air pollution control agencies from thousands of monitoring stations (SLAMS and NAMS). AQS also contains meteorological data, descriptive information about each monitoring station (including its geographic location and its operator), and data quality assurance and quality control information. State and local agencies are required to submit their air quality monitoring data into AQS by the end of the quarter following the quarter in which the data were collected. This ensures timely submission of these data for use by state, local, and tribal agencies, EPA, and the public. EPA's Office of Air Quality Planning and Standards and other AQS users rely upon the data in AQS to assess air quality, assist in attainment vs. non-attainment designations, evaluate SIPs, perform modeling for permit review analysis, and perform other air quality management functions.

AQS was recently converted from a mainframe system to a UNIX-based Oracle system which is easily accessible to users through the Internet. This new system went into production status in January 2002. Today, state, local, and tribal agencies submit their data directly to AQS. Registered users may also retrieve data through the AQS application and through the use of third-party software such as the Discoverer tool from Oracle Corporation. For more detailed information about the AQS database, go to http://www.epa.gov/ttn/airs/airsaqs/index.htm.

2.2.3 Advantages and Limitations of the Air Quality Monitoring and Reporting System

Air quality data is required to assess public health outcomes that are affected by poor air quality. The challenge is to get surrogates for air quality on time and spatial scales that are useful for Environmental Public Health Tracking activities.

The advantage of using ambient data from EPA monitoring networks for comparing with health outcomes is that these measurements of pollution concentrations are the best characterization of the concentration of a given pollutant at a given time and location, and require no further analysis. Furthermore, the data are supported by a comprehensive quality assurance program, ensuring data of known quality. One disadvantage of using the ambient data is that it is usually out of spatial and temporal alignment with health outcomes. This spatial and temporal 'misalignment' between air quality monitoring data and health outcomes is influenced by the following key factors: the living and/or working locations (microenvironments) where a person spends their time not being co-located with an air quality monitor; time(s)/date(s) when a patient experiences a health outcome/symptom (e.g., asthma attack) not coinciding with time(s)/date(s) when an air quality monitor records ambient concentrations of a pollutant high enough to affect the symptom (e.g., asthma attack either during or shortly after a high $PM_{2.5}$ day). To compare/correlate ambient concentrations with acute health effects, daily local air quality data is needed. Spatial gaps exist in the air quality monitoring network, especially in rural areas, since the air quality monitoring network is designed to focus on measurement of pollutant concentrations in high population density areas. Temporal limits also exist. Samples from Federal Reference Method (FRM) $PM_{2.5}$ monitors are generally collected only one day in every three days, due in part to the time and costs involved in collecting and analyzing the samples. However, over the past several years Tapered Element Oscillating Microbalance (TEOM) monitors, which can automatically collect, analyze, and report $PM_{2.5}$ measurements on an hourly basis, have been introduced. These monitors are available in most of the major metropolitan areas and (as of October 2008) are being assessed for their equivalency to the FRM. Ozone is monitored daily, but mostly during the ozone season (the warmer months, approximately April through October). However, year-long data is extremely useful to evaluate whether ozone is a factor in health outcomes during the non-ozone seasons.

2.2.4 Use of Air Quality Monitoring Data

Air quality monitoring data has been used to provide the information for the following situations:

(1) Assessing effectiveness of SIPs in addressing NAAQS nonattainment areas
(2) Characterizing local, state, and national air quality status and trends
(3) Associating health and environmental damage with air quality levels/concentrations

For the EPHT effort, EPA is providing air quality data to support efforts associated with (2), and (3) above. Data supporting (3) is generated by EPA through the use of its air quality data and its hierarchical Bayesian space-time statistical model (HBM).

Most studies that associate air quality with health outcomes use air monitoring as a surrogate for exposure to the air pollutants being investigated. Many studies have used the monitoring networks operated by state and federal agencies in the implementation of Clean Air Act requirements. Some studies perform special monitoring that can better represent exposure to the air pollutants: community monitoring, near residences, in-house or work place monitoring, and personal monitoring. For the EPHT program, special monitoring is generally not supported, though it could be used on a case-by-case basis.

Many approaches may be used to assign exposure from monitors or estimate concentrations for a new time period or location based on existing data. On the simplest level for example, data from monitoring sites are averaged and applied to the population in an entire county, or the nearest monitor is assigned to a subject's address. At the next level, variogram analysis may be used to describe the spatial correlation of the data and interpolate concentrations across space. Such approaches work well for temporally and spatially robust data, but where data are missing (for example for $PM_{2.5}$ data with samples taken every third day), further assumptions and modeling are needed which add uncertainty into the interpolated concentrations. Finally, air quality monitoring data can be used with air quality modeling estimates (using emissions inventories) and incorporated into a Bayesian model to enhance the prediction of ambient air concentrations in space and time. There are two methods used in EPHT to provide estimates of ambient concentrations of air pollutants: air quality monitoring data and the Hierarchical Bayesian-derived air quality estimate, which is a statistical 'combination' of air quality monitor data and air quality modeling estimates.

2.3 Air Quality Indicators Developed for the EPHT Network

Air quality indicators have been developed for use in the Environmental Public Health Tracking Network. The approach used divides "indicators" into two categories. First, basic air quality measures were developed to compare air quality levels over space and time within a public health context (e.g., using the NAAQS as a benchmark). Next, indicators were developed that mathematically link air quality data to public health tracking data (e.g., daily $PM_{2.5}$ levels and hospitalization data for acute myocardial infarction). Table 2-3 and Table 2-4 describe the issues impacting calculation of basic air quality indicators.

Table 2-3. Public Health Surveillance Goals and Current Results

Goal	Status
(1) Air data sets and metadata required for air quality indicators are available to EPHT state Grantees.	AQS data is available through state agencies and EPA's AirData and AirExplorer. EPA and CDC have set up an IAG for data and air quality data along with HBM data that was delivered to CDC in August 2008. Metadata drafts have been completed.

(2) Estimate the linkage or association of $PM_{2.5}$ and ozone on health to: A. Identify populations that may have higher risk of adverse health effects due to $PM_{2.5}$ and ozone, B. Generate hypothesis for further research, and C. Provide information to support prevention and pollution control strategies.	Discussions have begun on health-air linked indicators and the CDC/HEI/EPA workshop held in January 2008. This goal will be supported further by the development of health-air indicators.
(3) Produce and disseminate basic indicators and other findings in electronic and print formats to provide the public, environmental health professionals, and policymakers, with current and easy-to-use information about air pollution and the impact on public health.	Templates and "how to" guides for $PM_{2.5}$ and ozone have been developed for routine indicators. Calculation techniques and presentations for the indicators have been developed. Regular, ongoing discussions are needed between air quality and public health staffs; dialogue has begun.

Table 2-4. Basic Air Quality Indicators

Ozone (daily 8-hr period with maximum concentration – ppm – by Federal Reference Method (FRM))
<u>Number of days</u> with maximum ozone concentration over the NAAQS (or other relevant benchmarks (by county and MSA)
<u>Number of person-days</u> with maximum 8-hr average ozone concentration over the NAAQS & other relevant benchmarks (by county and MSA)
$PM_{2.5}$ (daily 24-hr integrated samples by FRM)
<u>Average ambient concentrations</u> of particulate matter (< 2.5 microns in diameter) and compared to annual $PM_{2.5}$ NAAQS (by state).
<u>% population</u> exceeding annual $PM_{2.5}$ NAAQS (by state).
<u>% of days</u> with $PM_{2.5}$ concentration over the daily NAAQS (or other relevant benchmarks (by county and MSA)
<u>Number of person-days</u> with $PM_{2.5}$ concentration over the daily NAAQS & other relevant benchmarks (by county and MSA)

2.3.1 Rationale for the Air Quality Indicators

The CDC EPHT Network is initially focusing on ozone and $PM_{2.5}$. These air quality indicators are based mainly around the NAAQS health findings and program-based measures (measurement, data and analysis methodologies). The indicators will allow comparisons across space and time for EPHT actions. They are in the context of health-based benchmarks. By bringing population into the measures, they roughly distinguish between potential exposures (at broad scale).

2.3.2 Air Quality Data Sources

The air quality data will be available based on the state/federal air program's data collection and processing. Air quality data management (EPA's Air Quality System – AQS) and delivery systems (AirData and AirExplorer) have been used in the PHASE project as the pilot test for air quality indicators.

2.3.3 Use of Air Quality Indicators for Public Health Practice

The basic indicators will be used to inform policymakers and the public regarding the degree of hazard within a state and across states (national). For example, the number of days per year that ozone is above the NAAQS can be used to communicate to sensitive populations (such as asthmatics) the number of days that they may be exposed to unhealthy levels of ozone. This is the same level used in the Air Quality Alerts that inform these sensitive populations when and how to reduce their exposure. These indicators, however, are not a surrogate measure of exposure and therefore will not be linked with health data.

3.0 Emissions Data

3.1 Introduction to the 2006 Platform

The U.S. EPA, hereto referred to as "we," has developed a 2002-based air quality modeling platform. This is considered to be the 2002 Platform version 3 because the emission inventories are primarily from Version 3 of the 2002 National Emission Inventory (NEI) (http://www.epa.gov/ttn/chief/eiinformation.html). This section is a summary of the emissions inventory and emissions modeling for Criteria Air Pollutants (CAPs), and describes the approach and data used to produce emissions inputs to the air quality model. The air quality modeling, meteorological inputs and boundary conditions are described in a separate section. A complete description of the 2002 Platform is available as "Technical Support Document: Preparation of Emissions Inventories for the 2002-based Platform, Version 3, Criteria Air Pollutants, Staff Report, U.S. EPA, Research Triangle Park, NC 27711, January 2008 (Draft)."

The 2002 Platform for CAPs uses the Community Multiscale Air Quality (CMAQ) model (http://www.epa.gov/AMD/CMAQ/) for the purposes of modeling ozone (O_3) and particulate matter (PM). The version of CMAQ we used requires hourly and gridded emissions of species from the following inventory pollutants: carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOC), sulfur dioxide (SO_2), ammonia (NH_3), particulate matter less than or equal to 10 microns (PM_{10}), and individual component species for particulate matter less than or equal to 2.5 microns ($PM_{2.5}$). It builds upon the concepts, tools and emissions modeling data from EPA's 2001 Platform, which was most recently developed for the Regulatory Impact Analyses for the National Ambient Air Quality Standards for Particle Pollution referred to here as "PM NAAQS." An earlier version of the 2002 Platform was used for the Clean Air Interstate Rule Analysis, referred to here as "CAIR."

The effort to create the emission inputs for the 2002 Platform included: (1) development of emission inventories for a 2002 model evaluation case; (2) updates to the emissions modeling tools; (3) updates to the emissions modeling ancillary files used with the tools; and (4) execution of the tools. The 2002 evaluation case uses 2002-specific fire emissions and 2002-specific continuous emission monitoring (CEM) data for electric generating units (EGUs).

The primary emissions modeling tool used to create the CMAQ model-ready emissions was the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system. We used this tool to create emissions files for a 36-km national grid, and a 12-km Eastern grid (a 12-km Western grid was also generated by the model). Electronic copies of the data used with SMOKE for the criteria air pollutants (CAP) 2002 Platform are available at the emissions modeling clearinghouse, http://www.epa.gov/ttn/chief/emch/, under the section entitled "CAP 2002-Based Platform, Version 3."

This summary contains two additional sections. Section 3.2 describes the 2002-2005 inventories input to SMOKE. Section 3.2 also describes the emissions modeling and the ancillary files used with the emission inventories. Note: Some of the technical methods used are influenced by the need to project 2002 emissions to future years in other applications of the 2002 modeling platform.

3.2 2002 Emission Inventories and Approaches

This section describes the 2002-2005 emissions data created for input to SMOKE. The primary basis for the 2002-2005 emission inputs for the 2002 Platform is the 2002 National Emission Inventory (NEI), which includes emissions of CO, NO_x, VOC, SO_2, NH_3, PM_{10}, and $PM_{2.5}$. Version 3 of the 2002 NEI was used for the 2002 Platform and is documented at http://www.epa.gov/ttn/chief/net/2002inventory.html#documentation. For inventories outside of the United States, which include Canada, Mexico and offshore emissions, we used the latest available base year inventories.

The 2002 NEI includes five source sectors: a) nonpoint (formerly called "stationary area") sources; b) point sources; c) nonroad mobile sources; d) onroad mobile sources; and e) fires. The fires portion of the inventory includes emissions from wildfires and prescribed burning computed as hour-specific point sources. For purposes of preparing the CMAQ-ready emissions, we split the 2002 emissions inventory into several additional "platform" sectors for use in emissions modeling, and we added biogenic emissions and emissions from sources other than the NEI such as the Canadian, Mexican and offshore inventories. The significance of an emissions modeling or a "platform" sector is that it is run through all of the SMOKE programs except the final merge (Mrggrid) that is independent from the other sectors. The final merge program combines the sector-specific gridded, speciated and temporalized emissions to create the CMAQ emission inputs.

Table 3-1 presents the sectors in the 2002 Platform for CAPs. The sector abbreviations are provided in italics; these abbreviations are used in the SMOKE modeling scripts and inventory file names and throughout the remainder of this section. Annual emission summaries for 2002 for this platform are shown in Table 3-2, which provides a summary of 2002 Platform emissions for the U.S. anthropogenic sectors (i.e., excluding biogenic emissions). Table 3-3 provides a summary of emissions for the anthropogenic sectors containing Canadian, Mexican and offshore sources.

The emission inventories for input to SMOKE for the 2002 evaluation case are available at the 2002v3CAP site under the link "Data Files" (see "2002emis" directory). The "readme" file provided indicates the particular zipped files associated with each platform sector. The remainder of Section 3.2 provides details of the data contained in each of the sectors. Different levels of detail are provided for different sectors depending upon the availability of reference information for the data and the degree of changes or manipulation of the data needed for preparing it for input to SMOKE.

3.2.1 2002 Point Sources (ptipm and ptnonipm)

Point sources are sources of emissions for which specific geographic coordinates (e.g., latitude/longitude) are specified, as in the case of an individual facility. A facility may have multiple emission points, which may be characterized as units such as boilers, reactors, spray booths, kilns, etc. A unit may have multiple processes (e.g., a boiler that sometimes burns residual oil and sometimes burns natural gas).

Table 3-1. Platform Sectors Used in Emissions Modeling for the CAP 2002 Platform

PLATFORM SECTOR	2002 NEI SECTOR	Description and Resolution of the Data Input to SMOKE
IPM sector: *ptipm*	Point	NEI point source EGUs mapped to the Integrated Planning Model (IPM) model using the National Electric Energy Database System (NEEDS) database. Hourly files for continuous emission monitoring (CEM) sources are included only for the 2002 evaluation case. Day-specific emissions for non-CEM sources created for input into SMOKE.
Non-IPM sector: *ptnonipm*	Point	All NEI point source records not matched to the ptipm sector, annual resolution.
Point source fire sector: *ptfire*	Fires	Point source day-specific wildfires and prescribed fires for 2002.
Nonpt fire sector: *nonptfire*	Fires and Nonpoint	Prescribed fires for 2002 for which day-specific data were not available, county and annual resolution.
Agricultural sector: *ag*	Nonpoint	NH_3 emissions from NEI nonpoint livestock and fertilizer application sources, county and annual resolution.
Area fugitive dust sector: *afdust*	Nonpoint	PM_{10} and $PM_{2.5}$ from fugitive dust sources from the NEI nonpoint inventory (e.g., building construction, road construction, paved roads, unpaved roads, agricultural dust), county and annual resolution.
Remaining nonpoint sector: *nonpt*	Nonpoint	All nonpoint sources not otherwise included in other SMOKE sectors, county and annual resolution.
Nonroad sector: *nonroad*	Mobile: Nonroad	Monthly nonroad emissions from the National Mobile Inventory Model (NMIM) using NONROAD2005, other than for California. Monthly emissions for California created using annual emissions submitted by the California Air Resources Board (CARB) for the 2002 NEI.
Aircraft, locomotive, marine: *alm*	Mobile: Nonroad	Aircraft, locomotive, commercial marine vessel emissions sources, county and annual resolution.
Onroad: *onroad*	Mobile: onroad	Monthly onroad emissions from NMIM using MOBILE6, other than for California. Monthly emissions for California created using annual emissions submitted by CARB for the 2002 NEI.
Biogenic: *biog*	NA	Hour-specific, grid cell-specific emissions generated from the BEIS3.13 model (includes emissions in Canada and Mexico).
Other point sources not from the NEI: *othpt*	NA	Point sources from Canada's 2000 inventory, Mexico's 1999 inventory, and offshore point sources from the 2001 Platform, annual resolution.
Other nonpoint and nonroad not from the NEI: *othar*	NA	Canada (province resolution) and Mexico (municipio resolution) nonpoint and nonroad mobile inventories, annual resolution.
Other onroad sources not from the NEI: *othon*	NA	Canada (province resolution) and Mexico (municipio resolution) onroad mobile inventories, annual resolution.

Table 3-2. Summaries by Sector of 2002 Base Year Emissions for the Continental United States (48 states + District of Columbia)

Year	Sector	[tons/yr] VOC	[tons/yr] NO_X	[tons/yr] CO	[tons/yr] SO_2	[tons/yr] NH_3	[tons/yr] PM_{10}	[tons/yr] $PM_{2.5}$
2002	afdust	0	0	0	0	0	8,901,461	1,830,271
	Ag	0	0	0	0	3,251,990	0	0
	Alm	123,676	2,259,844	806,471	312,313	904	97,039	86,719
	avefire	451,127	189,428	8,554,550	49,094	36,777	796,229	684,034
	nonpt	7,929,917	1,531,602	7,526,723	1,250,265	135,542	1,377,055	1,100,884
	nonroad	2,873,622	2,176,159	21,386,059	187,284	1,859	227,875	216,658
	onroad	4,847,990	7,786,709	59,810,866	242,379	290,708	205,914	146,003
	ptipm	42,378	4,618,944	605,148	10,359,102	29,991	608,718	501,998
	ptnonipm	1,425,158	2,368,987	3,195,469	2,249,550	154,180	603,606	372,330
2002 Total		**17,693,869**	**20,931,673**	**101,885,285**	**14,649,986**	**3,901,951**	**12,817,898**	**4,938,898**

Table 3-3. Summaries by Sector for the Other ("oth") – Canada, Mexico, and Offshore – 2002 Base Year Emissions Within the 36-km Domain

Year	Country & Sector	[tons/yr] VOC	[tons/yr] NO_X	[tons/yr] CO	[tons/yr] SO_2	[tons/yr] NH_3	[tons/yr] PM_{10}	[tons/yr] $PM_{2.5}$
2002	Canada othar	1,878,996	1,060,097	4,282,782	227,942	569,738	1,462,643	400,493
	Canada othon	410,981	874,564	5,810,763	26,376	18,332	19,692	18,071
	Canada othpt	237,957	628,175	1,149,266	2,115,572	23,866	241,081	129,342
	Canada Subtotal	**2,527,933**	**2,562,836**	**11,242,811**	**2,369,890**	**611,937**	**1,723,417**	**547,906**
	Mexico othar	586,842	249,045	644,733	101,047	486,484	143,816	92,861
	Mexico othon	183,563	147,519	1,456,285	8,276	2,549	6,960	6,377
	Mexico othpt	113,044	258,510	88,957	980,359	0	125,385	88,132
	Mexico Subtotal	**883,448**	**655,074**	**2,189,976**	**1,089,682**	**489,033**	**276,161**	**187,370**
	Offshore othpt	70,329	26,628	6,205	0	0	0	0
2002 Total		**6,893,091**	**6,462,448**	**26,871,779**	**6,919,144**	**2,201,939**	**3,999,156**	**1,470,552**

We created two platform sectors from the 2002 point source NEI, v3 for input into SMOKE: the Integrated Planning Model (IPM) sector (ptipm) and the non-IPM sector (ptnonipm). The ptnonipm emissions were provided to SMOKE as annual emissions. The ptipm were provided as hourly emissions data for CEM sources and as day-specific emissions for non-CEM sources. The point source file was separated into these sectors to facilitate the use of different SMOKE temporal processing techniques for these sectors; these sectors are described in the following subsections. We further describe the approach for creating the day-specific non-CEM emissions in Section 3.2.9. Documentation for the development of the point source NEI is at: http://www.epa.gov/ttn/chief/net/2002inventory.html#documentation.

3.2.1.1 IPM Sector (ptipm)

This sector contains emissions from EGUs in the 2002 NEI that we were able match to the 2006 NEEDS database (http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html), which is used by the IPM, version 3.0. The IPM model provides future year emission inventories for the universe of EGUs contained in the NEEDS database. As described below, this matching was done in order to (1) provide consistency between the 2002 EGU sources and future year EGU emissions for sources which are forecasted by IPM and (2) avoid double counting in projecting point source emissions. The 2002 NEI point source inventory contains emissions estimates for both EGU and non-EGU sources.

Because the IPM v3.0 units are based on the 2006 NEEDS database, we also used this NEEDS database to identify the set of EGUs in the 2002 NEI point source data to assign to the ptipm sector. Because of the inconsistencies in identification information for EGU units in the various available data sets, we performed an extensive analysis to link the NEEDS units to the NEI for the purpose of splitting the 2002 NEI file into ptipm and ptnonipm sectors. The available data sets include the 2006 NEEDS, EPA's Clean Air Markets Division (CAMD) hourly CEM program data and the 2002 NEI. The 2002 NEI point source file includes ORIS Plant IDs and CAMD Boiler IDs for most of the EGUs to indicate where substitution of hourly CEM emissions can be reliably performed.

For sources not matching the CEM data ("non-CEM" sources), we computed daily emissions from the NEI annual emissions using a standard query language (SQL) program and state-average CEM data. To allocate annual emissions to each month, we created state-specific, three-year averages of 2001-2003 CEM data. These average annual-to-month factors were assigned to non-CEM sources by state. To allocate the monthly emissions to each day, we used the 2002 CEM data to compute state-specific month-to-day factors, averaged across all units in each state. The resulting daily emissions were input into SMOKE. The daily-to-hourly allocation was performed in SMOKE using diurnal profiles. The development of these diurnal ptipm-specific profiles, which are considered ancillary data for SMOKE, is described in Section 3.3.2.

3.2.1.2 Non-IPM Sector (ptnonipm)

The non-IPM (ptnonipm) sector contains all 2002 NEI point sources that we did not include in the IPM (ptipm) sector.[3] The ptnonipm sector contains fugitive dust PM emissions from vehicular traffic on paved or unpaved roads at an industrial facility or coal handling at a coal mine.[4] Prior to input to SMOKE, we adjusted the fugitive dust PM emissions by applying county-specific fugitive dust transportable fraction factors (less than 1). This is discussed further in Section 3.2.5.

For some geographic areas, some of the sources in the ptnonipm sector belong to source categories that are contained in other sectors. This occurs in the inventory when states, tribes or local programs report certain inventory emissions as point sources because they have specific

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[3]Except for the day-specific point source fire emissions data which are included in a separate sector, as discussed in Section 3.2.1.

[4]Point source fugitive dust emissions, which represent a very small amount of PM, were treated as a separate sector in the 2001 Platform.

geographic coordinates for these sources. We reviewed these sources to determine whether there were any cases for which the emissions were double counted with those in other sectors; we found that any double counting is very small.

3.2.2 2002 Nonpoint Sources (afdust, ag, nonpt)

We created several sectors from the 2002 nonpoint NEI. All of these are at county-level and annual resolution. We removed the nonpoint tribal-submitted emissions as we did not know the extent to which they may be double counted with the county-level emissions. In addition, the tribal data would have been dropped during SMOKE processing since there are no spatial surrogates for tribal data in the 2002 Platform. In the rest of this section, we describe in more detail each of the platform sectors into which we separated the 2002 nonpoint NEI and the changes we made to these data. The documentation for the nonpoint sector of the 2002 NEI is available at: http://www.epa.gov/ttn/chief/net/2002inventory.html

3.2.2.1 Area Fugitive Dust Sector (afdust)

The area-source fugitive dust (afdust) sector contains PM_{10} and $PM_{2.5}$ emission estimates for 2002 NEI nonpoint SCCs identified as dust sources by inventory experts. This sector is separated from other nonpoint sectors to make it easier to apply a “transport fraction” which reduces emissions based on diminished transport at the scale of our modeling. Application of the transport fraction prevents the overestimation of fugitive dust impacts in the grid modeling as compared to ambient samples. Categories included in this sector are paved roads, unpaved roads and airstrips, construction (residential, industrial, road and total) agriculture production and mining. It does not include fugitive dust from grain elevators because these are elevated sources.

We created the afdust sector from the 2002 NEI based on SCCs and pollutant codes (i.e., PM_{10} and $PM_{2.5}$) that are considered “fugitive.” A complete list of all possible fugitive dust SCCs (including both 8-digit point source SCCs and 10-digit nonpoint SCCs) is provided at: http://www.epa.gov/ttn/chief/emch/invent/tf_scc_list2002nei_v2.xls. However, not all of the SCCs in this file are present in the 2002 NEI. Our approach was to apply the transportable fractions by county (all afdust SCCs in the same county would receive the same factor). The approach used to calculate the county fractions and the fractions themselves are available at: http://www.epa.gov/ttn/chief/emch/invent/transportable_fraction_080305_rev.pdf. A limitation of the transportable fraction approach is the lack of monthly variability which would be expected due to seasonal changes in vegetative cover. An electronic version of the county-level transport fractions can be found at:
http://www.epa.gov/ttn/chief/emch/invent/transportfractions052506rev.xls. Note: After the CMAQ modeling was completed, we discovered that the transportable fraction factors for $PM_{2.5}$ were inadvertently not applied; therefore, the $PM_{2.5}$ emissions from this sector are overestimated in the current version (v3) of the 2002 Platform.

3.2.2.2 Agricultural Ammonia Sector (ag)

The agricultural NH_3 “ag” sector comprises livestock and agricultural fertilizer application emissions from the nonpoint sector of the 2002 NEI. In building this sector, we extracted livestock and fertilizer emissions based on the SCC. The “ag” sector includes all of the NH_3 emissions from fertilizer from the NEI. However, the “ag” sector does include all of the livestock ammonia emissions, as there are also significant NH_3 emissions from livestock in the point source inventory. Most of the point source livestock NH_3 emissions were reported by the states of Kansas and Minnesota. For these two states, farms with animal operations were provided as point sources.[5]

There are also selected livestock NH_3 emissions in the point source inventory. We identified these sources as livestock NH_3 point sources based on their facility name. The reason why we needed to identify livestock NH_3 in the ptnonipm sector was to properly implement the emission projection techniques for livestock sources, which cover all livestock sources, not only those in the ag sector but also those in the ptnonipm sector.

3.2.2.3 Other Nonpoint Sources (nonpt)

Nonpoint sources that were not subdivided into the afdust, ag or nonpt (Section 3.2.4) sectors were assigned to the "nonpt" sector. In preparing the nonpt sector, we excluded catastrophic releases since we found that these emissions were dominated by tire burning, which is an episodic, location-specific emissions category. Tire burning accounts for significant emissions of particulate matter in some parts of the country. Because such sources are reported by a very small number of states, and are inventoried as county annual totals without the information in the NEI to temporally and spatially allocate the emissions to the time and location where the event occurred, we excluded catastrophic releases from the 2002 Platform.

The nonpt sector includes emission estimates for Portable Fuel Containers (PFCs), also known as "gas cans." Inventories for PFCs were recently developed for EPA's Mobile Source Air Toxics (MSAT) rule and were incorporated into the 2002 NEI v3. The PFC inventory consists of five distinct sources of PFC emissions, further distinguished by residential or commercial use. The five sources are: (1) displacement of the vapor within the can; (2) spillage of gasoline while filling the can; (3) spillage of gasoline during transport; (4) emissions due to evaporation (i.e., diurnal emissions); and (5) emissions due to permeation. Note that spillage and vapor displacement associated with using PFCs to refuel nonroad equipment are included in the nonroad inventory.

Statewide total annual VOC inventories were allocated to counties using county-level fuel consumption ratios from the NONROAD model. Of note from this documentation, the developers derived the 2002 PFC inventory by linearly interpolating inventories developed for 1999 and 2010.

3.2.3 Fires (ptfire, nonptfire and avefire)

Wildfire and prescribed burning emissions are contained in the ptfire, nonptfire and avefire sectors. The ptfire sector has emissions provided at geographic coordinates (point locations) and has daily emissions values, whereas the nonptfire and avefire sectors are county-summed inventories and have annual total emissions values. For the 2002 model evaluation case, we modeled 2002 year-specific fires using the emissions from the ptfire and nonptfire sectors. The universe of sources included with fires sectors for the 2002 Platform exclude agricultural burning

[5] These point source emissions are also identified by the segment ID, which is one of the following: "SWINE," "CATTLE," "DAIRY," or "PLTRY."

and other open burning sources. These sources are in the nonpt sector of the 2002 Platform rather than the fire sectors. We chose to keep agricultural burning and other open burning sources in the nonpt sector. Their year-to-year impacts are not as variable as wildfires and prescribed/managed burns.

3.2.4 Day-Specific Point Source Fires (ptfire)

The ptfire sector includes wildfire and prescribed[6] burning emissions occurring in 2002, which were used for the 2002 model evaluation case. This sector includes emissions for all 2002 wildfires and most prescribed burns with daily estimates of each fire's emissions. It includes the latitude/longitude of the fire's origin and other parameters associated with the emissions such as acres burned and fuel load, which allow for an estimation of plume rise. The inventory development approach assumed that smoldering occurs in the same grid cell as the flaming emissions for wildfires only, and on the day after the flaming emissions. In addition to day-specific pollutant emissions, the ptfire inventories contained data on the acres burned and fuel consumption for each day. As described in Section 3.2.4, these additional parameters are used in SMOKE for plume rise calculation.

3.2.5 County-Level Fires (nonptfire)

The nonptfire sector consists of all of the prescribed burning and managed burning emission sources for which emissions are not available at the spatial or temporal resolution required for processing in the ptfire sector. Note that there are no wildfires in this sector. The nonptfire emissions were generated using: (1) point source fire emissions for managed and prescribed burning in Georgia, as discussed in Section 2.3.1 above, and (2) nonpoint emissions for managed burning (slash burning) for those states without point source managed burning emissions (i.e., Maryland, North Carolina, and Texas).

3.2.6 Development of Wildland Fire Emission Inventories for 2002-2006

INTRODUCTION

The BlueSky smoke modeling framework and the Satellite Mapping Automatic Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) were applied to facilitate the development of day-specific wildland fire emission inventories for the continental U.S. for 2003-2005. The FCCS, Consume 3.0, and FEPS models were used within the BlueSky framework to model vegetation distribution, fuel consumption, and emission rates, respectively.

Modeling wildland fire emissions requires many pieces of information, including fire location, ignition time and growth rate, fire intensity, and final size. This information is needed at a daily or better temporal resolution to be useful for air quality modeling of smoke impacts. Note that there is significant uncertainty in each of these pieces of information. Emissions from each wildland fire can be modeled using the formula: $E_s = A * F * c * EF_s$ where

E_s = emissions of species *s*
A = area burned

[6]For purposes of this document prescribed burning also includes managed burning, i.e., "Other Combustion; Managed Burning, Slash (Logging Debris)"

F = fuel available for consumption
c = fraction of available fuel consumed
EF_s = emission factor (mass of species s emitted per mass of fuel consumed)

DISCUSSION

Fire Detection Data Sets and Tools

Documenting the occurrence of fires, their locations, and their area burned is one of the most important uncertainties that can be constrained using available observations. Data from the National Fire Center's ICS-209 ground reporting system provides valuable information on fires larger than 100 acres that had a federal firefighting response. However, ICS-209 reports have several limitations as a data source for predicting daily emissions. Daily estimates of actively burning areas are needed, but ICS-209 reports provide only the ignition point of the fire and an estimate of the total area burned over the lifetime of the fire. Also, ICS-209 reports are only created for a subset of fires. Fires that are not tracked with ICS-209 reports include prescribed burns, agricultural burns, and wildfires for which there is no federal response.

Satellites have been used to detect fires globally for several decades[7] and more recently they have been used to estimate fire size and day-to-day movement to help estimate fire emissions. However, there are limitations in the use of satellite data for emission inventories. For example, accurate estimation of the area burned is difficult due to inability of the satellite's sensors to detect and resolve thermal anomalies. Satellite detection cannot distinguish between a managed burn and a wildfire. Also, fires that are small, rapidly burning, or obscured by clouds or forest cover can go undetected.

The National Oceanic and Atmospheric Administration's (NOAA) Hazard Mapping System (HMS) provides a useful almost real-time database of fire detects.[8] The HMS product relies on data from the MODIS, Advanced Very High Resolution Radiometer (AVHRR), and Geostationary Earth Observing Satellite (GOES) instruments. Individual detections are inspected by a trained analyst for false detects and inaccurate geolocation. However, the HMS data are still ultimately subject to the above limitations.

Ideally, additional information is needed to compensate for the limitations of the satellite-derived fire detects and the ICS-209 data set. SMARTFIRE uses both satellite-detected and ground-reported fires to produce daily fire locations and area burned.[9] It reconciles ICS-209 ground

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[7]Dozier J. 1981. A method for satellite identification of surface temperature fields of subpixel resolution. Remote Sensing of Environment 11 (3), 221-229.

[8]Ruminski M., Kondragunta S., Draxler R.R., and Zeng J. 2006. Recent changes to the Hazard Mapping System. 15th International Emission Inventory Conference, New Orleans, LA. Available on the Internet at ftp://satepsanone.nesdis.noaa.gov/Publications/EPA_msy-conf.pdf.

[9]Sullivan D.C., Raffuse S.M., Pryden D.A., Craig K.J., Reid S.B., Wheeler N.J.M., Chinkin L.R., Larkin N.K., Solomon R., and Strand T. 2008. Development and applications of systems for modeling emissions and smoke from fires: the BlueSky smoke modeling framework and SMARTFIRE: 17th International Emission Inventory Conference, Portland, OR, June 2-5. Available on the Internet at http://www.epa.gov/ttn/chief/conference/ei17/session12/raffuse_pres.pdf.

reports and hot spots from the HMS. SMARTFIRE was used in this work to prepare four years (2003-2006) of daily emission estimates for wildland fires for the lower 48 United States, including wildfire, wildland fire use (WFU), and prescribed burns. Agricultural fires were also included in the inventory (by assigning a fire as agricultural if agriculture is the underlying land use of the fire detection area).

The inventory was reproduced three times using different fire information sources: ICS-209 reports alone, MODIS anomalies alone, and the HMS data (which includes both MODIS anomalies and GOES fire detects) combined with the 209 reports using SMARTFIRE. The SMARTFIRE application found more fires than either the ICS reports or MODIS detects alone. Details of the resulting intercomparison and fire detection characteristics spatially and temporally are presented elsewhere.[10]

BlueSky Emissions Modeling Pathway

The emissions for all three fire information cases were processed in the same way using the BlueSky smoke modeling framework.[11] The BlueSky framework is designed to facilitate the operation of predictive models that simulate cumulative smoke impacts, air quality, and emissions from forest, agricultural, and range fires. The BlueSky framework allows users to combine state-of-the-science emissions and meteorological and dispersion models to generate results based on the best available models. In other words, the BlueSky framework connects models that provide values for the terms in the above equation. BlueSky allows the user to choose one of several models at each step in the smoke modeling process. The models used for this study are shown below:

Table 3-4. Process/Emissions Model Mapping

Process	Model Used
Fuel Loading	Fuel Characteristic Classification System (FCCS)
Fuel Consumption	Consume 3.0
Emissions	Fire Emission Production Simulator (FEPS)

In addition to the standard emission products produced by FEPS ($PM_{2.5}$, CO, etc.), 29 HAP species emissions were estimated. Fires were assigned fuel moisture values based on the nearest weather station from the USDA-FS Wildland Fire Assessment System.

[10]Raffuse S., Sullivan D., Chinkin L., Gilliland E., Larkin S., Solomon R., and Pace T.G. 2008. Development of wildland fire emission inventories for 2002-2006 and sensitivity analyses: 17th International Emission Inventory Conference, Portland, OR, June 2-5. Available on the Internet at http://www.epa.gov/ttn/chief/conference/ei17/session12/mraffuse_pres.pdf.

[11]Larkin N.K., O'Neill S.M., Solomon R., Krull C., Raffuse S.M., Rorig M., Peterson J., and Ferguson S.A. 2008. The BlueSky smoke modeling framework. Int. J. Wildland Fire (in review).

Emissions Estimates using SMARTFIRE

As seen below in Figure 3-1, wildland fire emissions in the lower 48 states exhibit a bimodal yearly pattern, with peaks in the spring and late summer/early fall. Over the four years modeled, emissions in the spring season were fairly consistent year to year. The summer/fall season, however, showed much more variability. This concentration can be seen in the plot of monthly average emissions shown below. The springtime emissions are mostly from the southeastern states, where prescribed burning is a common management practice in spring.

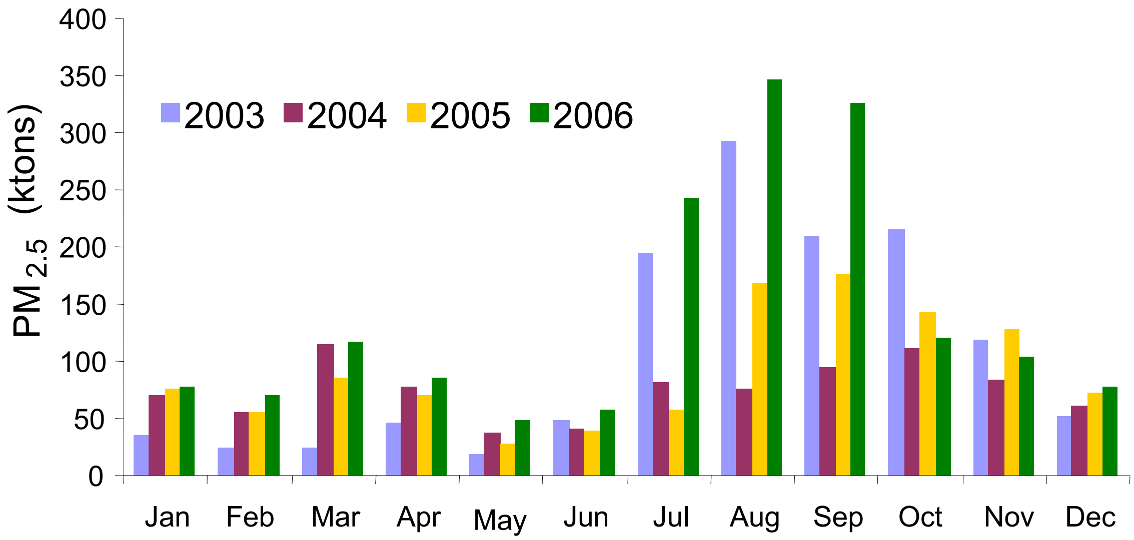

Figure 3-1. Wildfire Emissions in the Contiguous 48 States

Below in Figure 3-2 is the modeled average monthly $PM_{2.5}$ emitted for the entire modeled time period (August 2002 through December 2006). The area burned in the spring is similar in quantity to the area burned in the summer/fall, but the $PM_{2.5}$ emitted is greater in the summer/fall. The summer/fall burning is dominated by large wildfires in the West, while the spring burning is largely prescribed burning in the Southeast, which results in less $PM_{2.5}$ per area burned than the western wildfires.

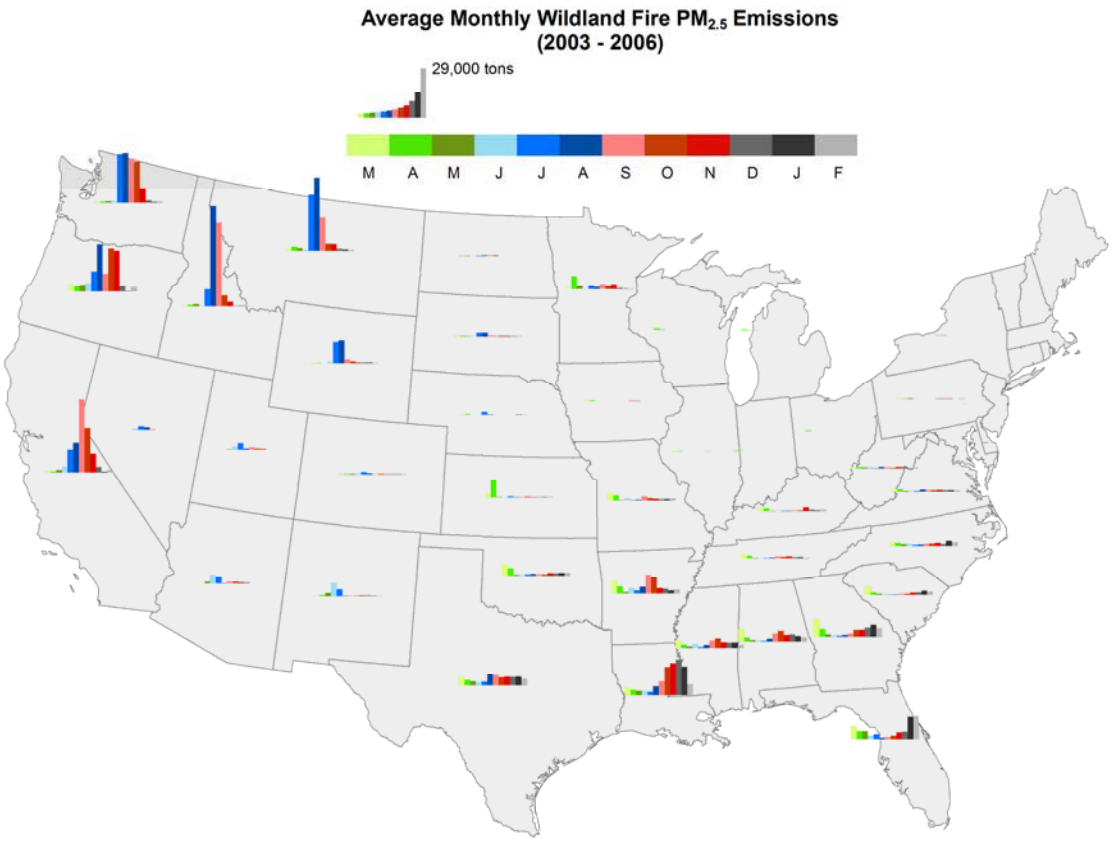

Figure 3-2. Distribution of $PM_{2.5}$ Emissions

CONCLUSIONS

The BlueSky framework was used to produce wildland fire emission inventories for the conterminous United States from August 2002 to December 2006 using SMARTFIRE as the fire information source and the most recent models for emission processing (FCCS, Consume 3.0, and FEPS). The emission inventory processing for 2003-2006 was repeated using ICS-209 reports as the fire information source and repeated again using MODIS fire detection hot spots.

All fire information sources produce similar estimates of area burned in the wildfire-driven western United States. In the southeastern United States, which has significant prescribed burning, ICS-209 reports provide little information on area burned. SMARTFIRE reports more burning than MODIS because it incorporates information from more satellite instruments, particularly the GOES satellites, which are able to detect many short-lived fires that MODIS may miss. Previous emission inventory work has treated prescribed burning as an area source, with county-level spatial resolution and monthly temporal resolution. Satellite data provides better resolution of the spatial and temporal nature of wildland fire, but more analysis of the detection rates for different instruments is warranted.

There is significant spatio-temporal variability in wildland fire emissions, especially wildfires. An annual emission inventory needs to be year-, day-, and location-specific to accurately account for these emissions. Using one year's emissions for another year may result in poor emission estimates for modeling purposes.

3.2.7 Biogenic Sources (biog)

For CMAQ, we computed the biogenic emissions based on 2002 meteorology data using the BEIS3.13 model from SMOKE. The BEIS3.13 model creates gridded, hourly, model-species emissions from vegetation and soils. It estimates CO, VOC, and NO_x emissions for the U.S., Mexico, and Canada. The BEIS3.13 model is described further in: http://www.cmascenter.org/conference/2005/abstracts/2_7.pdf.

The inputs to BEIS include: (1) temperature data at 10 meters which were obtained from the CMAQ meteorological input files, and (2) land-use data from the Biogenic Emissions Land use Database, version 3 (BELD3). BELD3 provides data on the 230 vegetation classes at 1-km resolution over most of North America; the same land-use data were used for the 2001 Platform.

3.2.8 2002 Mobile Sources (onroad, nonroad, alm)

We created three sectors from the mobile source emissions in the 2002 NEI: onroad, nonroad and a sector containing emissions for aircraft, locomotive and commercial marine vessels (alm). We created these three separate sectors to handle differences in emissions processing related to the temporal nature of the inventories and differences in projection methods. All three sectors are at county and SCC resolution.

The onroad and nonroad sectors utilize emissions generated by the EPA's Office of Transportation and Air Quality (OTAQ) using the National Mobile Inventory Model (NMIM) for all of the U.S., except for California.[12] NMIM relies on calculations from the MOBILE6 and NONROAD2005 models as described below, and in NEI documentation. Inputs to NMIM are posted with the 2002 Emission Inventory. The direct link is: ftp://ftp.epa.gov/EmisInventory/2002finalnei/mobile_sector_data/ncd_files/ncd20070727_2002.zip. NMIM creates the onroad and nonroad emissions on a month-specific basis that accounts for temperature, fuel types, and other variables that vary by month. Inventory documentation for the 2002 NEI v3 onroad and nonroad sectors is also posted with other 2002 NEI documentation; the direct link is: ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/mobile/2002_mobile_nei_version_3_report_092807.pdf.

While aircraft, locomotive, and commercial marine sources are considered nonroad sources in the 2002 NEI, they comprise a separate sector for the 2002 platform denoted as "alm." We developed the alm sector for the convenience of emission processing and projections. The NMIM-based nonroad emissions are monthly whereas the alm emissions are annual. In addition, the NMIM-based nonroad emissions are projected using NMIM, whereas the alm emissions use national, annual activity-based projection factors. Documentation for "alm" inventory

[12]Although OTAQ generated emissions using NMIM for California, these were not used in the 2002 NEI version 3, but rather were replaced by state-submitted emissions.

development is available in several separate documents, http://www.epa.gov/ttn/chief/net/2002inventory.html#documentation, and additional revisions to this documentation are provided in Section 2.5.3.

3.2.9 2002 Onroad Mobile Sources (onroad)

This sector includes exhaust, evaporative, brake wear and tire wear emissions from onroad sources derived from NMIM (except for California), which contained the version of MOBILE6 used for the final MSAT rule. We did not include the refueling onroad emissions generated by NMIM in the onroad sector, because the NEI treats onroad refueling as a stationary source, and it is in the nonpt sector. We therefore removed refueling emissions from the NMIM outputs prior to generating onroad emission files.

The 2002 Platform onroad sector contains VOC emissions separately for exhaust and evaporative modes, which allowed us to use mode-specific speciation profiles. For the 2002 Platform, the inventory includes PM_{10} and $PM_{2.5}$ emissions for three modes[13]: a) exhaust (EXH); b) brake wear (BRK) and; c) tire wear (TIR), which similarly facilitated mode-appropriate speciation profiles. The emission modes are included as part of the pollutant name for the SMOKE emission inputs. For example, exhaust and evaporative modes for VOC are indicated by EXH__VOC and EVP__VOC, respectively.

Because the California Air Resources Board (CARB) has their own onroad mobile source estimation model (EMFAC2002), which is tailored to specific California mobile sources, we used the CARB-submitted data for the 2002 NEI v3 as well as the platform. CARB provided EPA with annual-total onroad mobile emissions. We adjusted these emissions using NMIM-based California emissions to (1) temporalize the emissions to monthly resolution and (2) to provide them on a consistent basis (i.e., same SCCs and modes) as the NMIM-derived data. CARB updated their model (EMFAC2007) prior to the completion of our modeling, but they were not able to provide the results in time for use with version 3 of the 2002 Platform.

3.2.10 Nonroad Mobile Sources – NMIM-Based Nonroad (nonroad)

This sector includes monthly exhaust, evaporative and refueling emissions from nonroad engines (not including commercial marine, aircraft, and locomotives) derived from NMIM. The NMIM relied on the version of the NONROAD2005 model used for the marine (spark ignited) SI and small SI engine proposed rule, published May 18, 2007. We used the NMIM monthly emissions for all states except California.

Like the onroad emissions, NMIM provides nonroad emissions for VOC by three emission modes: exhaust, evaporative and refueling. Unlike the onroad sector, refueling emissions for nonroad sources are not included in the nonpt sector. Rather, we kept these emissions in the nonroad sector.

The NEI nonroad data for California provided by CARB are annual emissions that do not have the mode-specific data for VOC (exhaust, evaporative, and refueling). We created monthly, mode-specific emissions for California's nonroad emissions (except for alm sources) using

[13] PM_{10} and $PM_{2.5}$ in the 2001 Platform were not broken out by mode.

NMIM results for California. The process erroneously dropped emissions for certain sources (FIPS code/SCC combinations) that were not computed via NMIM; however, the error was small.

3.2.11 Nonroad Mobile Sources: Aircraft, Locomotive and Commercial Marine (alm)

The aircraft, locomotive and commercial marine (alm) sector contains annual emissions. These emissions are consistent with the 2002 NEI v3. Note that some aircraft emissions for California, Illinois, and Minnesota are also contained in the ptnonipm sector, as described above. The documentation of the 2002 NEI for the alm sector is available at http://www.epa.gov/ttn/chief/net/2002inventory.html#documentation. It does not include a description of the changes to some locomotive and commercial marine sources from v2 of the 2002 NEI, which were made in conjunction with the development of the 2002 Platform. The updates reflect changes to national total emissions, which were made as part of the proposed Locomotive/Marine Rule. To preserve the state-submitted data from the 2002 NEI v2, we adjusted only the EPA-generated emissions. They were adjusted such that the sum of the v2 state-submitted emissions and the revised EPA-generated emissions matched OTAQ's national totals.

3.2.12 Emissions from Canada, Mexico and Offshore Drilling Platforms (othpt, othar, othon)

The emissions from Canada, Mexico, and Offshore Drilling Platforms are included as parts of three sectors: othpt, othar, and othon. The "oth" refers to the fact that these emissions are "other" than those in the 2002 NEI, and the last two digits provide the SMOKE source types: 1) "pt" for point; 2) "ar" for area, and; 3) "on" for onroad mobile. Except for Mexico, the 2002 Platform used data sets previously used for 2001. For Canada, we used emissions for 2000 since these were the most recent set of emissions available at the time the 2002 Platform was developed. For Mexico, we used emissions for 1999. This inventory includes emissions from all states in Mexico.

The offshore emissions include point source offshore oil and gas drilling platforms. Based on the CAIR emission inventory documentation, the offshore sources were provided by the Texas Commission on Environmental Quality (TCEQ). This inventory included emissions for 1992 and was grown to 2002 based on instructions from TCEQ.

3.2.13 Adjustments to 2002 NEI for 2003-2005

EGUs

Annual emissions estimates for EGUs for all NEI air pollutants (both Criteria and Hazardous air pollutants) for three years (2003, 2004, 2005) were developed using data reported to the USEPA's Clean Air Marketing Division's (CAMD) Acid Rain database. The Acid Rain database contains hourly emissions for SO_2 and NO_x emissions plus hourly heat input amounts. These three values are reported to the database by the largest electric generating facilities, usually based upon continuous emissions monitors (CEMs). The general approach to develop emission estimates for all pollutants for these sources that would be compatible in both structure and individual process identification and release point parameters with the NEI requirements was to ratio the existing 2002 NEI emissions values up or down to the other three years, using information from the Acid Rain database to determine the appropriate ratios.

For all pollutants except the directly monitored SO_2 and NO_x, the ratio of the Acid Rain heat input for one of the three years to the Acid Rain heat input for 2002 was used as the adjusting ratio to estimate the 2003, 2004, or 2005 emissions. For SO_2 and NO_x, the ratio of the actual Acid Rain emissions values to the 2002 NEI emissions values were used as the adjusting ratio to estimate the 2003, 2004, or 2005 emissions. The SO_2 and NO_x emissions in the NEI for 2003, 2004, and 2005 will thus be equal to the actual monitored emissions seen in the Acid Rain database. For all other pollutants, the NEI emissions for the three years essentially assume that each unit was emitting at the same rate (per BTU of heat input) as it did in 2002.

The ratios were developed for each emissions unit that could be found and reliably matched between the 2002 NEI and the 2002 Acid Rain database. If a unit was found in both of these data sets, then the Acid Rain values for the additional three years were either found or it was verified that the unit had ceased operating (in which case a ratio of zero was used to zero out 2003, 2004, or 2005 emissions). The ratios were developed using annual total sums of the reported hourly SO_2, NO_x, or heat input. Ratios were developed for a total of 2,144 emission units that could be matched between the 2002 NEI and the 2002 Acid Rain database. The 2,144 units are uniquely identified by the combination of fields "ORISPL_CODE" and "UNITID" in the Acid Rain database. These 2144 Acid Rain units matched up to 2,168 units as defined in the 2002 NEI, due to differences in the way some state and local air agencies identify or define individual units in their NEI submissions. For the instances where multiple NEI "units" had been matched to a single Acid Rain unit, the sum of all SO_2 and NO_x emissions in the 2002 NEI was used as the denominator of the ratio. Lastly, the ratios that were thus developed at the emission unit level were applied to all individual process-level emissions at those units. All NEI emissions are reported at the process-level, which is a sub-division of an emission unit. For EGU and other combustion sources, the processes within an emission unit typically represent the different fuels that were burned in the unit.

The Acid Rain data used for this procedure was downloaded March 26, 2007 from CAMD's "Data and Maps" Web page (http://camddataandmaps.epa.gov/gdm/).

1. Select "Emissions":
(http://camddataandmaps.epa.gov/gdm/index.cfm?fuseaction=emissions.wizard)

2. Select "Unit Level Emissions" on left side of Web page

3. Select "Time Frame" on left side of Web page

4. Select "Annual" in menu box in center of Web page

5. Select "2002" in second menu box that appears in center of Web page

6. Select "Quick Reports" on left side of Web page

7. Select “Unit Level Emissions Quick Report” in menu box in top-center of Web page

8. Select “Annual” in menu box in mid-center of Web page

9. Select “2002” in second menu box that appears in mid-center of Web page

10. Select “Acid Rain Program” in menu box in bottom-center of Web page

11. Select “Get Report” button at bottom of Web page

The resulting query will provide the number of facilities and number of units for the selected year(s). There are buttons to allow the user to: a) obtain report definitions; b) print the report page; c) download the data from the query (in either *.csv or *.txt format); d) download the caveats for the data (in either *.csv or *.txt format); or e) start a new query. This procedure can be repeated for multiple years. The *.csv formats can be imported to an MS Excel spreadsheet or an MS Access database.

Other Stationary Sources (Point and Nonpoint)

Emission estimates for other stationary sources, including both point and nonpoint stationary sources, were held constant at the level in Version 3 of the 2002 NEI. The only exception to this was that some information on plants that closed after 2002 was incorporated into the emissions modeled. Emissions for plants that closed were set to zero.

Onroad and Nonroad Mobile Sources

Emission estimates for all pollutants were developed using EPA’s National Mobile Inventory Model (NMIM), which uses MOBILE6 to calculate onroad emission factors. State and local agencies had an opportunity to provide model inputs (vehicle populations, fuel characteristics, VMT, etc) for base years 2002 and 2005v2. Where applicable, these inputs were used in the other years. For example, for each of these three years, a full VMT database at the county, roadway type, and vehicle type level of detail was developed from Federal Highway Administration (FHWA) information. For states and local areas that submitted VMT data that were incorporated in the 2002 NEI, the 2002 NEI VMT data were grown to 2003, 2004, and 2005v1 using growth factors developed from the FHWA data. These grown VMT data replaced the baseline FHWA-based VMT data. For 2005v2, where state and local agencies provided new 2005 VMT estimates, they replaced the 2005v1 VMT.

Emission estimates for NONROAD model engines were developed using EPA’s National Mobile Inventory Model (NMIM), which incorporates NONROAD2005. Where states provided alternate nonroad inputs, these data replaced EPA default inputs, as described above.

Details on the model versions used for each base year’s run are documented in the table below. For more information on how NMIM is run, refer to the 2005 NEI documentation posted at ftp://ftp.epa.gov/EmisInventory/2005_nei/mobile/2005_mobile_nei_version_2_report.pdf

Table 3-5. MOBILE6 Onroad and Nonroad Model Versions

Inventory Year	MOBILE Version	NONROAD Version	NMIM Version	NCD Version
2003	M6203CHC\M6203ChcOxFixNMIM.exe	nr05c-BondBase\NR05c.exe	NMIM20070410	NCD20070727
2004	M6203CHC\M6203ChcOxFixNMIM.exe	nr05c-BondBase\NR05c.exe	NMIM20070410	NCD20070912
2005 V1	M6203ChcOxFixNMIM	NR05c-BondBase	NMIM20070410	NCD20070912

Fires

This data will be supplied upon completion of the processing/analysis for the fires data.

3.3 Emissions Modeling Summary

The CMAQ model requires hourly emissions of specific gas and particle species for the horizontal and vertical grid cells contained within the modeled region (i.e., modeling domain). To provide emissions in the form and format required by CMAQ, it is necessary to "preprocess" the "raw" emissions (i.e., emissions input to SMOKE) for the sectors described in Section 3.2. In brief, this preprocessing step transforms these emissions from their original temporal resolution, pollutant resolution, and spatial resolution into the data required by CMAQ. As seen in Section 3.2, the temporal resolution of the emissions input to SMOKE for the 2002 Platform varies across sectors and may be hourly, monthly, or annual total emissions. The spatial resolution, which also can be different for different sectors, may be individual point sources or county totals (province totals for Canada, municipio totals for Mexico). The pollutants for all sectors except for biogenics are those inventoried for the NEI. The preprocessing steps involving temporal allocation, spatial allocation, pollutant speciation, and vertical allocation of point sources are referred to as emissions modeling. This section provides basic information about the tools and data files used for emissions modeling as part of the 2002 Platform for CAPs. We have limited this section's descriptions to the ancillary data SMOKE uses to perform the emissions modeling steps. All SMOKE inputs and scripts for the 2002 Platform emissions are available at the Clearinghouse for Inventories and Emissions Factors (CHIEF) Emissions Modeling Clearinghouse (EMCH) Web site, http://www.epa.gov/ttn/chief/emch/index.html#2002.

3.3.1 The SMOKE Modeling System

We used SMOKE to preprocess the raw emissions to create the emissions inputs for CMAQ. The SMOKE version 2.4 source code and executables can be used to reproduce our emissions modeling, and these are available from the Community Multiscale Analysis System (CMAS) Center at http://www.cmascenter.org. The scripts used for running SMOKE are available on the CHIEF Web site provided previously in this section.

We made revisions to the SMOKE model for this effort, resulting in SMOKE version 2.4. These revisions are documented in the SMOKE release notes for SMOKE versions 2.3 and 2.4, available with the SMOKE documentation at http://www.smoke-model.org. Although the release of SMOKE version 2.4 happened after we completed our modeling, SMOKE version 2.4 provides essentially the same version of SMOKE used for the 2002-based modeling platform.

Major updates to SMOKE that we developed for the 2002 Platform include:

- Support of point-source, day-specific wildfire and prescribed burning fires
- Extended one record per line (ORL) format that includes more metadata fields, particularly fields about the source of the inventory data for each record (e.g., state, EPA).
- New capabilities for temporal allocation using CEM hourly emissions data from EGUs
- The ability to use surrogate data files from the Spatial Surrogate Tool
- Support for multiple and nonsequential days in the temporal processor
- New processing scripts that make it easier to process more sectors than the traditional sectors of nonpoint, point, onroad, nonroad, and biogenics.

3.3.2 Key Emissions Modeling Settings

Each sector is processed separately through SMOKE, up until the final merge program (Mrggrid), which combines the model-ready, sector-specific emissions across sectors. The SMOKE settings in the run scripts and the data in the SMOKE ancillary files control the approaches used for the individual SMOKE programs for each sector. Table 3-6 summarizes the major processing steps of each platform sector. The "Spatial" column shows the spatial approach: a) "point" indicates that SMOKE maps the source from a point location to a grid cell; b) "surrogates" indicate that some or all of the sources use spatial surrogates to allocate county emissions to grid cells; and c) "area-to-point" indicates that some of the sources use the SMOKE area-to-point feature to grid the emissions (further described in Sections 3.2.7, 3.2.8, 3.2.9, and 3.2.10). The "Speciation" column indicates that all sectors use the SMOKE speciation step, though biogenics speciation is done within BEIS3 and not as a separate SMOKE step. The "Inventory resolution" column shows the inventory temporal resolution from which SMOKE needs to calculate hourly emissions. Finally, the "Plume rise" column indicates the sectors for which SMOKE computes vertical plume rise and creates merged emissions that are 3-dimensional instead of one layer.

Table 3-6. Key Emissions Modeling Steps by Sector

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
Ptipm	point	Yes	daily & hourly	Yes
Ptnonipm	point	Yes	annual	Yes
Othpt	point	Yes	annual	Yes
Nonroad	surrogates & area-to-point	Yes	monthly	
Other	surrogates	Yes	annual	
Alm	surrogates & area-to-point	Yes	annual	
Onroad	surrogates	Yes	monthly	
Othon	surrogates	Yes	annual	

Nonpt	surrogates & area-to-point	Yes	annual	
Ag	surrogates	Yes	annual	
Afdust	surrogates	Yes	annual	
Biog	pre-gridded land use	in BEIS	hourly	
Ptfire	point	Yes	daily	Yes
Nonptfire	surrogates	Yes	annual	
Avefire	surrogates	Yes	annual	

3.3.3 Spatial Configuration

For the 2002 Platform, we ran SMOKE and CMAQ for modeling domains with 36-km and 12-km spatial resolution. Figure 3-3 shows the 36-km Continental United States "CONUS" modeling domain and the 12-km Eastern US (EUS) domain. All three grids use a Lambert-Conformal projection, with Alpha = 33, Beta = 45 and Gamma = -97, with a center of X = -97 and Y = 40. Sections 3.2.7, 3.2.8, 3.2.9, and 3.2.10 provide the details on the spatial surrogates and area-to-point data used to accomplish spatial allocation with SMOKE.

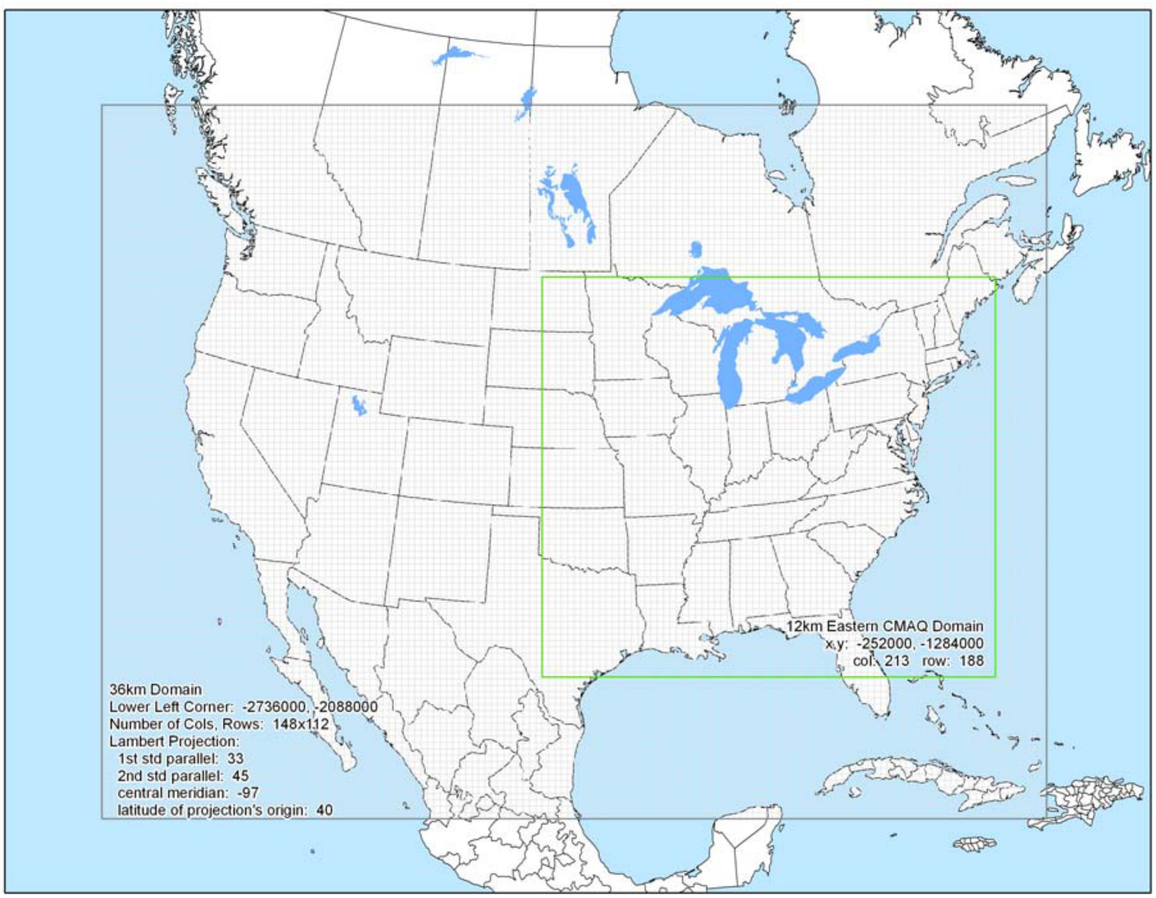

Figure 3-3. CMAQ Modeling Domain

3.3.4 Chemical Speciation Configuration

The emissions modeling step for chemical speciation creates "model species" needed by the air quality model for a specific chemical mechanism. These model species are either individual chemical compounds or groups of species, called "model species." The chemical mechanism used for the 2002 Platform is the Carbon Bond 05 (CB05) mechanism. Table 3-7 lists the model species produced by SMOKE for use in CMAQ with the CB05.

For VOC, the speciation approach involves three major steps, as performed by SMOKE: (1) assignment of speciation profiles to each emission source; (2) conversion of VOC from the emission source to TOG; and (3) application of speciation profiles that disaggregate TOG into CB05 model species. The approach for $PM_{2.5}$ emissions is somewhat simpler, since it does not

Table 3-7. Model Species Produced by SMOKE for CB05

Inventory Pollutant	Model Species	Model Species Description
CO	CO	Carbon monoxide
NO_X	NO	Nitrogen oxide
	NO_2	Nitrogen dioxide
SO_2	SO_2	Sulfur dioxide
	SULF	Sulfuric acid vapor
NH_3	NH_3	Ammonia
VOC	ALD2	Acetaldehyde
	ALDX	Propionaldehyde and higher aldehydes
	ETH	Ethene
	ETHA	Ethane
	ETOH	Ethanol
	FORM	Formaldehyde
	IOLE	Internal olefin carbon bond (R-C=C-R)
	ISOP	Isoprene
	MEOH	Methanol
	OLE	Terminal olefin carbon bond (R-C=C)
	PAR	Paraffin carbon bond
	TOL	Toluene and other monoalkyl aromatics
	XYL	Xylene and other polyalkyl aromatics
Various additional VOC species from the biogenics model which do not map to the above model species	TERP	Terpenes
PM_{10}	PMC	Coarse PM > 2.5 microns and ≤ 10 microns
$PM_{2.5}$	PEC	Particulate elemental carbon ≤ 2.5 microns
	PNO_3	Particulate nitrate ≤ 2.5 microns
	POC	Particulate organic carbon (carbon only) ≤ 2.5 microns
	PSO_4	Particulate sulfate ≤ 2.5 microns
	PMFINE	Other particulate matter ≤ 2.5 microns

require the second step. Figure 3-4 shows the steps involved in chemical speciation for both VOC and $PM_{2.5}$, and it identifies the underlying inputs used to develop the CB05-based ancillary files for the 2002 Platform for CAPs. Section 3.2.29 provides the details about the chemical speciation ancillary data files used to accomplish these speciation processing steps.

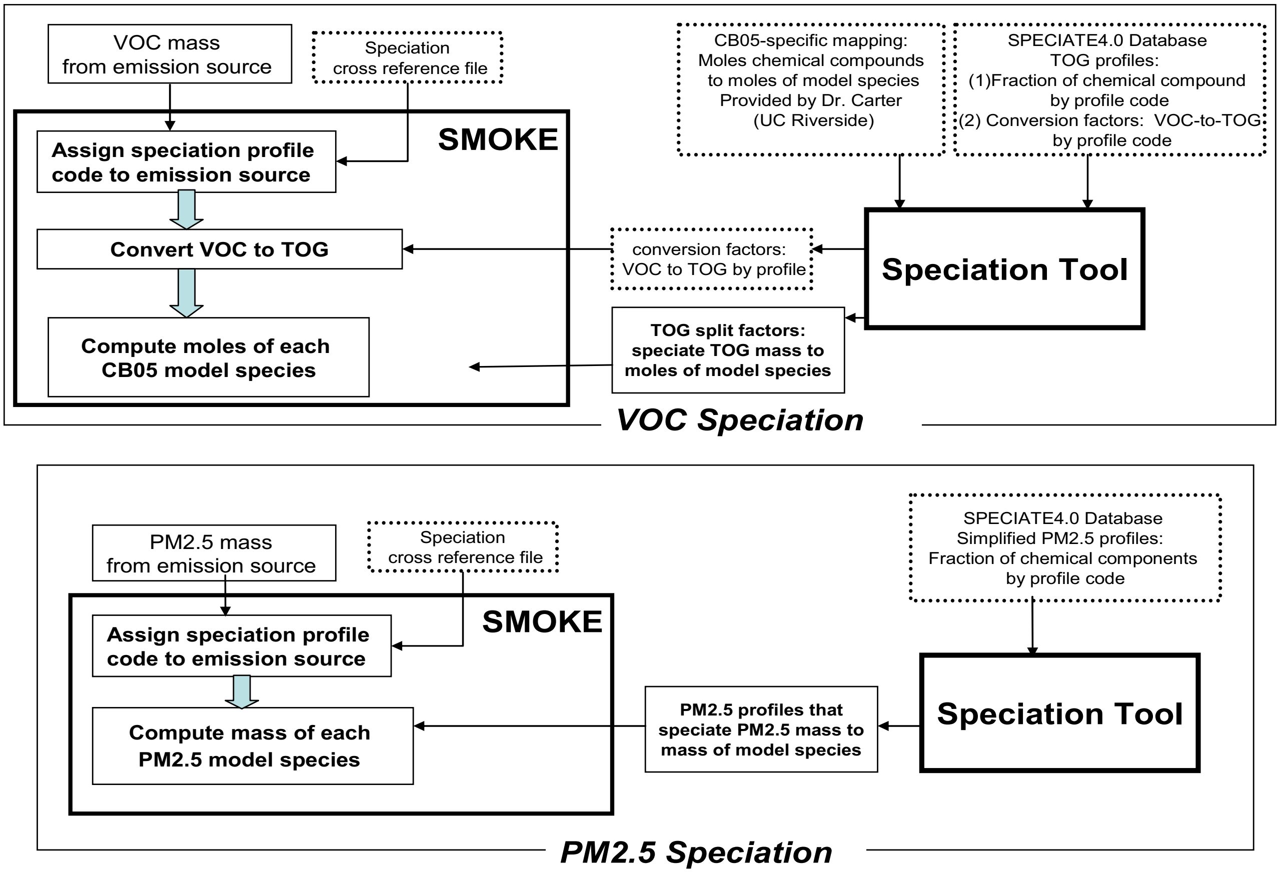

Figure 3-4. Chemical Speciation Approach Used for the 2002-Based Platform

3.3.5 Temporal Processing Configuration

Table 3-8 summarizes the temporal aspect of the emissions processing configuration. It compares the key approaches we used for temporal processing across the sectors. We control temporal aspect of SMOKE processing through (a) the scripts T_TYPE (Temporal type) and M_TYPE (Merge type) settings and (b) the ancillary data files described in Section 3.3.6.

In addition to the resolution, temporal processing includes a ramp-up period for several days prior to January 1, 2002, which is intended to mitigate the effects of initial condition concentrations. The same procedures were used for all grids, but with different ramp-up periods for each grid:

- 36 km: 10 days (Dec. 22 - 31)
- 12 km (East): 3 days (Dec. 29 - 31)

- 12 km (West): 2 days (Dec 30 - 31)

For most sectors, our approach used the emissions from December 2002 to fill in surrogate emissions for the end of December 2001.

Table 3-8. Temporal Settings Used for the Platform Sectors in SMOKE

Platform sector	Inventory resolution	Monthly profiles used?	Daily temporal approach[1,2]	Merge processing approach[1,3]	Process Holidays as separate days?
Ptipm	daily & hourly		all	All	yes
ptnonipm	annual	yes	mwdss	All	yes
Othpt	annual	yes	mwdss	All	
nonroad	monthly		mwdss	Mwdss	yes
Other	annual	yes	mwdss	Mwdss	
Alm	annual	yes	mwdss	Mwdss	
Onroad	monthly		week	Week	yes
Othon	annual	yes	mwdss*	Mwdss*	
Nonpt	annual	yes	mwdss	Mwdss	yes
Ag	annual	yes	aveday	aveday	
Afdust	annual	yes	aveday	aveday	
Biog	hourly		n/a	n/a	
Ptfire	daily		all	All	
nonptfire	annual	yes	aveday	aveday	

[1] **Definitions for processing resolution:**

all = hourly emissions computed for every day of the year, inventory is already daily.

week = hourly emissions computed for all days in one "representative" week, representing all weeks for each month, which means emissions have day-of-week variation but not week-to-week variation within the month.

mwdss = hourly emissions for one representative Monday, representative weekday, representative Saturday and representative Sunday for each month, which means emissions have variation between Mondays, other weekdays, Saturdays and Sundays within the month but not week-to-week variation within the month. Also, Tuesdays, Wednesdays and Thursdays are treated the same.

aveday = hourly emissions computed for one representative day of each month, which means emissions for all days of each month are the same.

[2] **Daily temporal approach** refers to the temporal approach for getting daily emissions from the inventory using the Temporal program. The values given are SMOKE's T_TYPE setting.

[3] **Merge processing approach** refers to the days used to represent other days in the month for the merge step. If not "all," then the SMOKE merge step just runs for representative days, which could include holidays as indicated by the rightmost column. The values given are SMOKE's M_TYPE setting.

* We discovered after the modeling that "week" would have been a more appropriate setting because this sector includes weekly profiles that vary across days of the week.

3.3.6 Vertical Allocation of Day-Specific Fire Emissions

We used SMOKE to compute vertical plume rise for all of the SMOKE point-source sectors, which is typically done for emissions modeling for CMAQ. One new feature of the vertical allocation for the 2002 Platform was the modeling of wildfires and prescribed burning fires as point sources with plume rise.

The ptfire inventory contains data on the acres burned (acres per day) and fuel consumption (tons fuel per acre) for each day. SMOKE uses these additional parameters to estimate the plume rise of emissions into layers above the surface model layer. Specifically, SMOKE uses these data to calculate heat flux, which is then used to estimate plume rise. In addition to the acres burned and fuel consumption, SMOKE needs the heat content of the fuel to compute heat flux. We assumed the heat content to be 8000 Btu/lb of fuel for all fires, because specific data on the fuels were unavailable in the inventory. Since SMOKE can use a fire-specific heat content value, we inserted the default 8000 Btu/lb value into the SMOKE-ready fire inventory data for all fires. The ptfire inventory includes both flaming and smoldering emissions. Smoldering emissions also have plume rise subject to the meteorological conditions on the day they occur.

The plume rise algorithm applied to the fires is a modification of the Briggs algorithm with a stack height of zero and a heat release estimated from the fuel loading and fire size. The SMOKE program Laypoint uses the Briggs algorithm to determine the plume top and bottom, and then computes the plumes' distributions into the vertical layers that the plumes intersect. Laypoint uses the pressure difference across each layer over the pressure difference across the entire plume as a weighting factor to assign the emissions to layers. This approach gives plume fractions by layer and source. See http://www.smoke-model.org/version2.4/ for full documentation of Laypoint and the new day-specific formats for the fire files.

3.3.7 Emissions Modeling Ancillary Files

In this section, we summarize the ancillary data that SMOKE used to perform spatial allocation, chemical speciation, and temporal allocation for the 2002 Platform. The ancillary data files provide the specific inventory resolution at which spatial, speciation, and temporal factors are applied.

3.3.7.1 Spatial Allocation Ancillary Files

As described in Section 3.3.2, we performed spatial allocation for a national 36-km domain and an Eastern 12-km domain (a Western 12-km domain was also generated). To do this, SMOKE used national 36-km and 12-km spatial surrogates and a SMOKE area-to-point data file. The spatial data files we used are available from the 2002v3CAP Web site. The 12-km surrogates cover the entire CONUS domain, though they are used directly as inputs for the two separate Eastern and Western domains shown in Figure 3-1. The SMOKE model windowed the Eastern and Western grids while it created these emissions. The remainder of this subsection provides further detail on the origin of the data used for the spatial surrogates and area-to-point data.

3.3.7.2 Surrogates for U.S. Emissions

There are 66 spatial surrogates available for spatially allocating U.S. county-level emissions to the CMAQ 36-km and 12-km grid cells. An area-to-point approach overrides the use of surrogates for some sources. We used the Surrogate Tool to generate all of the surrogates. The shapefiles we input to the Surrogate Tool are provided and documented at http://www.epa.gov/ttn/chief/emch/spatial/spatialsurrogate.html. The document ftp://ftp.epa.gov/EmisInventory/emiss_shp2006/us/list_of_shapefiles.pdf provides a list and summary of these shapefiles. The shapefiles used for the surrogate attributes (e.g., population, agricultural land, marine ports) are the same as those used for the 2001 Platform with two exceptions: we developed new shapefiles for the "population change" and "oil and gas" surrogates. We developed these shapefiles to enable the Surrogate Tool to generate these complex surrogates, which utilize data with different formats (e.g., point locations of refineries and tank farms versus polygon data for gas stations). Combining the data within a new shapefile allowed us to generate the surrogates using the Surrogate Tool. The detailed steps in developing the county boundaries for the 2002 Platform are at ftp://ftp.epa.gov/EmisInventory/emiss_shp2006/us/metadata_for_2002_county_boundary_shapefiles_rev.pdf.

3.3.7.3 Allocation Method for Airport-Related Sources in the U.S.

There are numerous airport-related emission sources in the 2002 NEI, such as aircraft, airport ground support equipment, and jet refueling. Most of these emissions are contained in sectors with county-level resolution – alm (aircraft), nonroad (airport ground support) and nonpt (jet refueling). We used the SMOKE "area-to-point" approach to allocate the emissions to airport locations, rather than using airport spatial surrogates, which we found exclude many airports. Under this approach, SMOKE allocates county emissions to one or more grid cells using an "ARTOPNT" ancillary file that contains (1) geographic coordinates of airport locations and (2) allocation factors based on airport-specific aircraft activity. For the 2002 Platform, each airport was assigned to a single location. Thus, the emissions associated with each airport were allocated to a single grid cell.

For the 2002 Platform, we created a new 2002-specific ARTOPNT file. The geographic coordinates and 2002-specific activity information (i.e., landing and takeoffs) used for allocating emissions to multiple airports in a county were largely taken from the "supplemental" geographic information system (GIS) data provided with the 2002 NEI, posted under the "Inventory Data" section ("Mobile Sector Data") at ftp://ftp.epa.gov/EmisInventory/2002finalnei/mobile_sector_data/ncd_files/gis_allocation. The supplemental data includes geographic coordinates and landing and takeoff (LTO) information for specific airports, which were used in the development of the aircraft emissions in the 2002 NEI v3.

3.3.7.4 Surrogates for Canada and Mexico Emission Inventories

Detailed documentation about the Canadian spatial surrogates, their development, and the data are available at: http://www.epa.gov/ttn/chief/emch/spatial/newsurrogate.html.

Only the population surrogate was used to grid sources in the Mexico emission inventory, provided by municipios (analogous to U.S. counties). We updated this surrogate from the 1999-based population surrogate used in the 2001 Platform to include additional municipios and updated 2000 population data. We created this updated population surrogate using the Surrogate Tool. The update to include additional municipios was required because the updated Mexican inventories (discussed in Section 3.2.16) include more municipios than the inventories previously used. We obtained the municipio boundaries from the Institute for the Environment, Center for Environmental Modeling and Policy Development at the University of North Carolina at Chapel Hill. Municipio population data from the year 2000 were obtained from www.inegi.gob.mx for only those Mexican states that are within the CONUS 36-km national domain. The shapefiles used are available at http://www.epa.gov/ttn/chief/emch/spatial/spatialsurrogate.html and the 12-km and 36-km surrogate files are on the 2002v3CAP site. Note that the population is "zero" in the Mexico_pop shapefile for municipios that are part of states located outside the 36-km CONUS domain.

3.3.7.5 Chemical Speciation Ancillary Files

The following data file, provided at the 2002v3CAP site, contains the SMOKE inputs used for chemical speciation of the inventory species to the CMAQ model species: **ancillary_2002v3mpCAP_smokeformat.zip**. This file includes speciation cross-reference (GSREF), speciation VOC-to-TOG conversion factors (GSCNV) and speciation profiles (GSPRO). SMOKE environmental variable names, used in the file names, are shown in capital letters in parentheses.

For VOC speciation, we generated SMOKE-ready TOG-to-model species profiles for the CB05 chemical mechanism using the Speciation Tool. We also used the Speciation Tool to generate a SMOKE-ready file ("GSCNV") containing profile-specific VOC-to-TOG conversion factors. One problem identified after using the "GSCNV" file created for 2002 is that it was missing some entries for mode-specific VOC, "EVP__VOC" and "EXH__VOC." Because most of the missing entries were not assigned to emissions in 2002 or had a conversion factor of 1.0 (the default used if the entry is missing), the impact on the speciated VOC was small.

For $PM_{2.5}$, neither the mass-based $PM_{2.5}$ files nor the $PM_{2.5}$ emissions have to be further converted for use in SMOKE, though the speciation tool was used to convert the profiles from a database format to SMOKE-ready format. The TOG and $PM_{2.5}$ speciation factors that are the basis of the chemical speciation approach were developed from the SPECIATE4.0 database (http://www.epa.gov/ttn/chief/software/speciate/index.html), which is EPA's repository of TOG and PM speciation profiles of air pollution sources. EPA developed SPECIATE4.0 through a collaboration involving EPA's Office of Research and Development (ORD) and EPA's Office of Air Quality Planning and Standards (OAQPS) at Research Triangle Park, NC, and Environment Canada. The SPECIATE4.0 database contains speciation profiles for TOG, speciated into individual chemical compounds, VOC-to-TOG conversion factors associated with the TOG profiles, and speciation profiles for $PM_{2.5}$. The database also contains the $PM_{2.5}$ speciated into both individual chemical compounds (e.g., zinc, potassium, manganese, lead), and into the "simplified" $PM_{2.5}$ components used in the air quality model. These simplified components are: PSO_4, PNO_3, PEC, POC, and PMFINE.

The assignment of profiles in the SPECIATE4.0 database to emissions sources was done in two steps: (1) an initial profile assignment list was prepared with the SPECIATE4.0 database, and (2) the list was completed and reviewed by emission inventory development, emission modeling and emission factor staff in the EPA's OAQPS and the EPA's ORD. For VOC speciation factors, recommendations for mobile sources and upstream (i.e., petroleum distribution) sources were obtained from subject experts at OTAQ.

Speciation profiles for use with BEIS are not included in SPECIATE. We added the BEIS3.13 profiles to the SMOKE speciation profiles for CMAQ for CB05. The profile code associated with BEIS3.13 profiles for use with CB05 is "B10C5."

3.3.7.6 Temporal Allocation Ancillary Files

The emissions modeling step for temporal allocation creates the 2002 hourly emission inputs for CMAQ by adjusting the emissions from the inventory resolution (annual, monthly, daily or hourly) that are input into SMOKE. The following data file, provided at the 2002v3CAP site, contains the files used for temporal allocation of the inventory emissions to hourly emissions: **ancillary_2002v3mpCAP_smokeformat.zip** which includes speciation cross-reference (GSREF), speciation VOC-to-TOG conversion factors (GSCNV) and speciation profiles (GSPRO). SMOKE environmental variable names, used in the file names, are shown in capital letters in parentheses.

4.0 CMAQ Air Quality Model Estimates

4.1 Introduction to the CMAQ Modeling Platform

The Clean Air Act (CAA) provides a mandate to assess and manage air pollution levels to protect human health and the environment. EPA has established National Ambient Air Quality Standards (NAAQS), requiring the development of effective emissions control strategies for such pollutants as ozone and particulate matter. Air quality models are used to develop these emission control strategies to achieve the objectives of the CAA.

Historically, air quality models have addressed individual pollutant issues separately. However, many of the same precursor chemicals are involved in both ozone and aerosol (particulate matter) chemistry; therefore, the chemical transformation pathways are dependent. Thus, modeled abatement strategies of pollutant precursors, such as volatile organic compounds (VOC) and NO_x to reduce ozone levels, may exacerbate other air pollutants such as particulate matter.

To meet the need to address the complex relationships between pollutants, EPA developed the Community Multiscale Air Quality (CMAQ) modeling system. The primary goals for CMAQ are to:

- Improve the environmental management community's ability to evaluate the impact of air quality management practices for multiple pollutants at multiple scales.
- Improve the scientist's ability to better probe, understand, and simulate chemical and physical interactions in the atmosphere.

The CMAQ modeling system brings together key physical and chemical functions associated with the dispersion and transformations of air pollution at various scales. It was designed to approach air quality as a whole by including state-of-the-science capabilities for modeling multiple air quality issues, including tropospheric ozone, fine particles, toxics, acid deposition, and visibility degradation. CMAQ relies on emission estimates from various sources, including the U.S. EPA Office of Air Quality Planning and Standards' current emission inventories, observed emission from major utility stacks, and model estimates of natural emissions from biogenic and agricultural sources. CMAQ also relies on meteorological predictions that include assimilation of meteorological observations as constraints. Emissions and meteorology data are fed into CMAQ and run through various algorithms that simulate the physical and chemical processes in the atmosphere to provide estimated concentrations of the pollutants. Traditionally, the model has been used to predict air quality across a regional or national domain and then to simulate the effects of various changes in emission levels for policymaking purposes. For health studies, the model can also be used to provide supplemental information about air quality in areas where no monitors exist.

CMAQ was also designed to have multi-scale capabilities so that separate models were not needed for urban and regional scale air quality modeling. The grid spatial resolutions for CMAQ are typically 36 km x 36 km per grid for the "parent" domain, and nested within that domain are 12-km x 12-km grid resolution domains. The parent domain typically covers the continental United States, and the nested 12-km x 12-km domain covers the Eastern or Western United States. For urban applications, CMAQ has also been applied with a 4-km x 4-km grid resolution for urban core areas; however, the uncertainties in emissions and meteorology information can actually increase at this high of a resolution. Currently, 12 km x 12 km resolution is recommended for most applications as the highest resolution. With the temporal flexibility of the model, simulations can be performed to evaluate longer term (annual to multi-year) pollutant climatologies as well as short-term (weeks to months) transport from localized sources. By making CMAQ a modeling system that addresses multiple pollutants and different temporal and spatial scales, CMAQ has a "one atmosphere" perspective that combines the efforts of the scientific community. Improvements will be made to the CMAQ modeling system as the scientific community further develops the state-of-the-science.

For more information on CMAQ, go to http://www.epa.gov/asmdnerl/CMAQ or http://www.cmascenter.org.

4.1.1 Advantages and Limitations of the CMAQ Air Quality Model

An advantage of using the CMAQ model output for comparing with health outcomes is that it has the potential to provide complete spatial and temporal coverage. Additionally, meteorological predictions, which are also needed when comparing health outcomes, are available for every grid cell along with the air quality predictions.

A disadvantage of using CMAQ is that, as a deterministic model, it has none of the statistical qualities of interpolation techniques that fit the observed data to one degree or another. Furthermore, the emissions and meteorological data used in CMAQ each have large uncertainties, in particular for unusual emission or meteorological events. There are also uncertainties associated with the chemical transformation and fate process algorithms used in air quality models. Thus, emissions and meteorological data plus modeling uncertainties cause CMAQ to predict best on longer time scale bases (e.g., synoptic, monthly, and annual scales) and be most error prone at high time and space resolutions compared to direct measures.

One practical disadvantage of using CMAQ output is that the regularly spaced grid cells do not line up directly with counties or ZIP codes which are the geographical units over which health outcomes are likely to be aggregated. But it is possible to overlay grid cells with county or ZIP code boundaries and devise means of assigning an exposure level that nonetheless provides more complete coverage than that available from ambient data alone. Another practical disadvantage is that CMAQ requires significant data and computing resources to obtain results for daily environmental health surveillance.

This section describes the 2003-2006 Air Quality Modeling Platform. A modeling platform is a structured system of connected modeling-related tools and data that provide a consistent and transparent basis for assessing the air quality response to changes in emissions and/or meteorology. A platform typically consists of a specific air quality model, emissions estimates, a set of meteorological inputs, and estimates of "boundary conditions" representing pollutant transport from source areas outside the region modeled. We used the CMAQ[14] as part of the 2003-2006 Platform to provide a national scale air quality modeling analysis. The CMAQ model

[14]Byun, D.W., and K. L. Schere, 2006: Review of the Governing Equations, Computational Algorithms, and Other Components of the Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. Applied Mechanics Reviews, Volume 59, Number 2 (March 2006), pp. 51-77.

simulates the multiple physical and chemical processes involved in the formation, transport, and destruction of ozone and fine particulate matter ($PM_{2.5}$).

This section provides a description of each of the main components of the 2003-2006 Platform along with the results of a model performance evaluation in which the 2003-2006 model predictions are compared to corresponding measured concentrations. It is drawn entirely from the following publication: Technical Support Document for the Proposed Locomotive/Marine Rule: Air Quality Modeling," U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC, EPA 454/R-07-004, March 2007.

4.2 CMAQ Model Version, Inputs and Configuration

4.2.1 Model Version

CMAQ is a non-proprietary computer model that simulates the formation and fate of photochemical oxidants, including $PM_{2.5}$ and ozone, for given input sets of meteorological conditions and emissions. This analysis employed a version of CMAQ based on the latest publicly released version of CMAQ (i.e., version 4.7[15]). CMAQ version 4.7 reflects updates to previous versions of the model to improve the underlying science. These model enhancements in version 4.7 include:

1) Aerosols

- Secondary Organic Aerosol (SOA) Model Enhancements
  + Updates: isoprene SOA, sesquiterpene SOA, polymerization, acid-catalyzed SOA, NO_x-dependent SOA yields, and enthalpy of vaporization
  + In-cloud SOA formation pathways (glyoxal, methylglyoxal)
  + Changes in gas-phase chemistry mechanism, emissions speciation, and biogenic emissions model, to represent SOA precursors
- Coarse PM
  + Semi-volatile inorganic components (NO_3^-, Cl^-, and NH_4^+) can condense and evaporate from the coarse mode, via dynamic mass transfer
  + Nonvolatile sulfate can condense on the coarse mode
  + Variable standard deviation of coarse mode size distribution
  + Emissions of sea salt from the surf zone
- Heterogeneous reaction probability
  + Re-derived parameterization based on Davis et al. (2008)

2) Chemistry

- HONO enhancements
  + Heterogeneous reaction on aerosol and ground surfaces

[15]CMAQ version 4.7 was released on December 1, 2008. It is available from the Community Modeling and Analysis System (CMAS) at: http://www.cmascenter.org.

+ Emissions from mobile sources

- Photolysis Options (beta versions)
  + In-line photolysis rate module, with aerosol feedback
  + Photolysis rates adjusted using satellite-derived cloud information (currently table-approach only)
- Aqueous Chemistry
  + Added two organic oxidation reactions (glyoxal, methylglyoxal)
  + Updates to Henry's Law constants based on literature review
- Base CB05 mechanism with C_{l2} chemistry
- Multi-pollutant Capability
  + Include HAPs and Hg in single modeling platform

3) In-line options

- Dry Deposition
  + Moved calculation into CCTM
- Emissions
  + Integrated BEIS into CCTM
  + Incorporated Plume-rise into CCTM
- Bi-directional NH_3 and Hg surface flux
  + For NH_3, fertilizer emissions will be applied through the flux model (under development)

4) Emissions

- Biogenic emissions: added sesquiterpene emissions
- Sea-salt emissions
  + Updated flux parameterizations and surf zone emissions
  + Used spatial allocator to produce ocean file
- Speciation changes for HONO and benzene

5) Clouds

- Convective cloud model
  + Revised to reduce layer configuration differences
  + Changed the integration timestep
- Resolved cloud model
  + Correction in precipitation flux calculation

4.2.2 Model Domain and Grid Resolution

The CMAQ modeling analyses were performed for a domain covering the continental United States, as shown in Figure 4-1. This domain has a parent horizontal grid of 36 km with two finer-scale 12-km grids over a portion of the Eastern U.S. The model extends vertically from the surface to 100 millibars (approximately 15 km) using a sigma-pressure coordinate system. Air quality conditions at the outer boundary of the 36-km domain were taken from a global model and did not change over the simulations. In turn, the 36-km grid was only used to establish the incoming air quality concentrations along the boundaries of the 12-km grids. Table 4-1 provides some basic geographic information regarding the CMAQ domains.

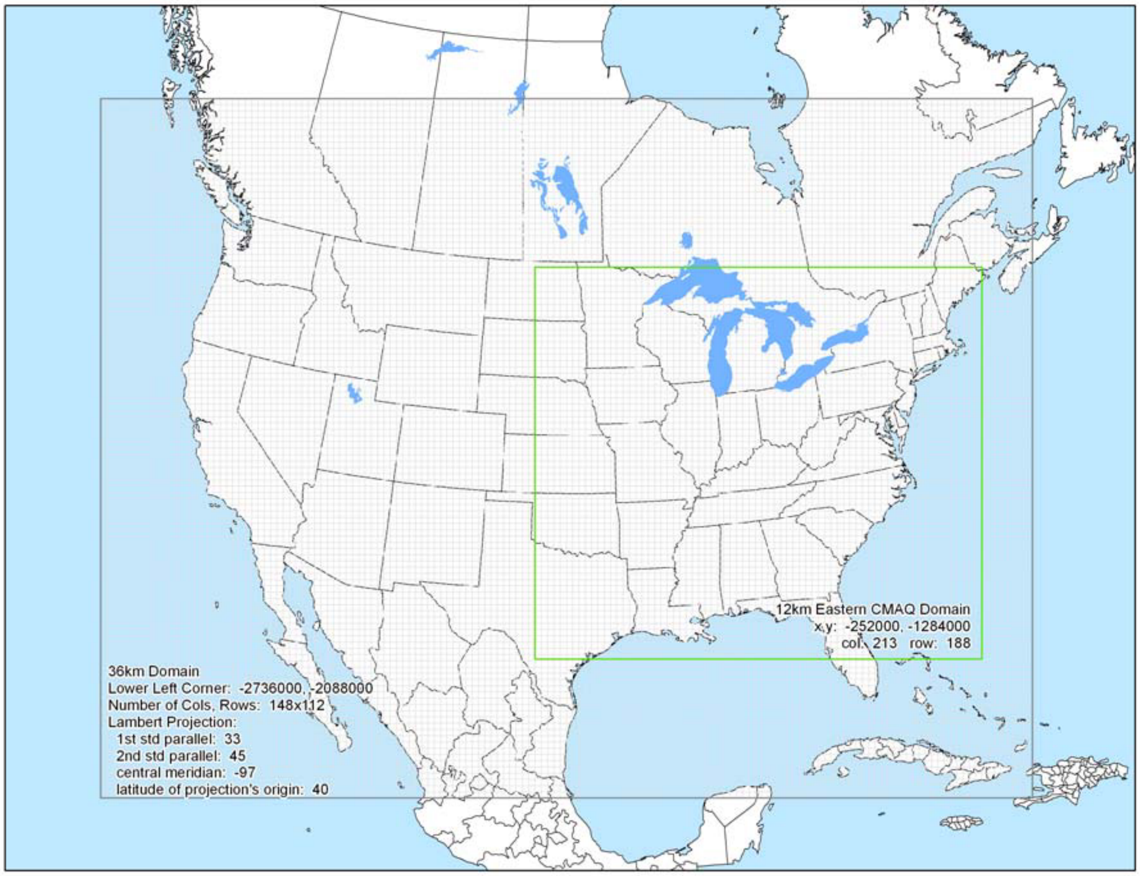

Figure 4-1. Map of the CMAQ Modeling Domain. The blue-gray outer box denotes the 36-km national modeling domain and the light green inner box is the 12-km Eastern U.S. fine grid. (Same as Figure 3-3.)

Table 4-1. Geographic Information for Modeling Domains

	CMAQ Modeling Configuration	
	National Grid	**Eastern U.S. Fine Grid**
Map Projection	Lambert Conformal Projection	
Grid Resolution	36 km	12 km
Coordinate Center	97 W, 40 N	
True Latitudes	33 and 45 N	
Dimensions	148 x 112 x 24	279 x 1240 x 24
Vertical extent	24 Layers: Surface to 100 mb level (see Table 4-2)	

4.2.3 Modeling Period / Ozone Episodes

The 36-km and both 12-km CMAQ modeling domains were modeled for the entire years of 2003-2006. All 365 (366 in 2004) model days were used in the annual average levels of $PM_{2.5}$. For the 8-hour ozone, we used modeling results from the period between May 1 and September 30. This 153-day period generally conforms to the ozone season across most parts of the U.S. and contains the majority of days that observed high ozone concentrations.

4.2.4 Model Inputs: Emissions, Meteorology and Boundary Conditions

2003-2006 Emissions: The emissions inventories used in the 2003-2006 air quality modeling are described in Section 3, above.

Meteorological Input Data: The gridded meteorological data for the entire years of 2003-2006 at 36 km were derived from simulations of the Pennsylvania State University / National Center for Atmospheric Research Mesoscale Model. This model, commonly referred to as MM5,[16] is a limited-area, nonhydrostatic, terrain-following system that solves for the full set of physical and thermodynamic equations which govern atmospheric motions. For this analysis, version 3.7.4 of MM5 was used for both the 36- and 12-km domains. The 36-km horizontal domain consisted of 165 by 129 cell grids. The 12-km MM5 domain consisted of a 290 x 251 grid cell domain that extends well beyond the 12-km CMAQ grid.

The meteorological outputs from both MM5 sets were processed to create model-ready inputs for CMAQ using the Meteorology-Chemistry Interface Processor (MCIP),[17] version 3.4, to derive the specific inputs to CMAQ: horizontal wind components (i.e., speed and direction), temperature, moisture, vertical diffusion rates, and rainfall rates for each grid cell in each vertical layer. The MM5 was run on the same map projection as CMAQ. Both the 36- and 12-km MM5 simulations utilized 34 vertical layers with a surface layer of approximately 38 meters. The MM5 and CMAQ vertical structures are shown in Table 4-2 and do not vary by horizontal grid resolution.

Table 4-2. Vertical Layer Structure for MM5 and CMAQ (heights are layer top)

CMAQ Layers	MM5 Layers	Sigma P	Approximate Height (m)	Approximate Pressure (mb)
0	0	1.000	0	1000
1	1	0.995	38	995
2	2	0.990	77	991
3	3	0.985	115	987
	4	0.980	154	982
4	5	0.970	232	973

[16]Grell, G., J. Dudhia, and D. Stauffer, 1994: A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5), NCAR/TN-398+STR., 138 pp, National Center for Atmospheric Research, Boulder, CO.

[17]Byun, D.W., and Ching, J.K.S., Eds, 1999. Science algorithms of EPA Models-3 Community Multiscale Air Quality (CMAQ modeling system, EPA/600/R-99/030, Office of Research and Development). Please also see: http://www.cmascenter.org.

	6	0.960	310	964
5	7	0.950	389	955
	8	0.940	469	946
6	9	0.930	550	937
	10	0.920	631	928
	11	0.910	712	919
7	12	0.900	794	910
	13	0.880	961	892
	14	0.860	1,130	874
8	15	0.840	1,303	856
	16	0.820	1,478	838
	17	0.800	1,657	820
9	18	0.770	1,930	793
	19	0.740	2,212	766
10	20	0.700	2,600	730
	21	0.650	3,108	685
11	22	0.600	3,644	640
	23	0.550	4,212	595
12	24	0.500	4,816	550
	25	0.450	5,461	505
	26	0.400	6,153	460
13	27	0.350	6,903	415
	28	0.300	7,720	370
	29	0.250	8,621	325
	30	0.200	9,625	280
14	31	0.150	10,764	235
	32	0.100	12,085	190
	33	0.050	13,670	145
	34	0.000	15,674	100

The key MM5 model physics options that were utilized are as follows:

- Cumulus Parameterization: Kain-Fritsch 2
- Planetary Boundary Layer Scheme: Asymmetric Convective Model version 2
- Explicit Moisture Scheme: Reisner 2
- Radiation Scheme: RRTM
- Land Surface Model: Pleim-Xiu

Similar to the 2001 MM5 model performance evaluations, we used an approach which included a combination of qualitative and quantitative analyses to assess the adequacy of the MM5 simulated fields. The qualitative aspects involved comparisons of the model-estimated synoptic patterns against observed patterns from historical weather chart archives. Qualitatively, the model fields closely matched the observed synoptic patterns, which is expected given the use of nudging.

Initial and Boundary Conditions: The lateral boundary and initial species concentrations are provided by a three-dimensional global atmospheric chemistry model, the GEOS-CHEM[18] model. The global GEOS-CHEM model simulates atmospheric chemical and physical processes driven by assimilated meteorological observations from the NASA's Goddard Earth Observing System (GEOS). This model was run for 2002 with a grid resolution of 2.0 degrees x 2.5 degrees (latitude-longitude) and 24 vertical layers. The 2003-2006 CMAQ 36-km simulations used non-year specific GEOS-CHEM data, which was created by taking the median value of the 2002 GEOS-CHEM data described above. The predictions were used to provide one-way dynamic boundary conditions at three-hour intervals and an initial concentration field for the CMAQ simulations. More information is available about the GEOS-CHEM model and other applications using this tool at: http://www-as.harvard.edu/chemistry/trop/geos.

4.3 CMAQ Model Performance Evaluation

The statistical portion of the evaluation examined the model bias and error for temperature, water vapor mixing ratio, and the index of agreement for the wind fields. These statistical values were calculated on a regional basis. Table 4-3 shows the results of the statistical evaluation of ozone data calculated for a threshold of 40 ppb of observed and modeled concentrations, for the 12-km Eastern U.S. domain and the four subregions (Midwest, Northeast, Southeast, and Central U.S.).

An operational model performance evaluation for ozone and $PM_{2.5}$ and its related speciated components was conducted for 2003-2006 using state/local monitoring sites data in order to estimate the ability of the CMAQ modeling system to replicate the base year concentrations for the 12-km Eastern domain.

There are various statistical metrics available and used by the science community for model performance evaluation. For a robust evaluation, the principal evaluation statistics used to evaluate CMAQ performance were two bias metrics, normalized mean bias (NMB) and fractional bias (FB); and two error metrics, normalized mean error (NME) and fractional error (FE). Normalized mean bias (NMB) is used as a normalization to facilitate a range of concentration magnitudes. This statistic averages the difference (model - observed) over the sum of observed values. It is a useful model performance indicator because it avoids overinflating the observed range of values, especially at low concentrations. Normalized mean bias is defined as:

$$\text{NMB} = \frac{\sum_{1}^{n}(P-O)}{\sum_{1}^{n}(O)} * 100$$, where P = predicted concentrations and O = observed

[18]Yantosca, B., 2004. GEOS-CHEMv7-01-02 User's Guide, Atmospheric Chemistry Modeling Group, Harvard University, Cambridge, MA, October 15, 2004.

Table 4-3. Summary of CMAQ 2006 Hourly O_3 Model Performance Statistics

CMAQ 2006 Hourly Ozone: Threshold of 40 ppb		No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
May	12-km EUS	247067	-2.8	13.4	-3.61	14.3
	Northeast	50662	-1.6	13.3	-2.11	13.8
	Midwest	44988	-6.2	14.8	-7.98	16.6
	Southeast	77206	-3.6	12.7	-4.12	13.4
	Central	46408	0.1	14.0	-0.98	14.7
	West	NA	NA	NA	NA	NA
June	12-km EUS	253885	-8.2	15.6	-9.62	17.1
	Northeast	38581	-6.1	16.1	-7.55	17.3
	Midwest	60442	-11.4	17.3	-14.1	20.2
	Southeast	71533	-6.8	14.1	-7.26	14.8
	Central	52916	-8.8	15.6	-10.3	17.2
	West	NA	NA	NA	NA	NA
July	12-km EUS	245304	-2.1	16.1	-3.22	16.7
	Northeast	55802	0.4	15.8	-0.72	16.3
	Midwest	45661	-7.1	16.5	-8.45	17.8
	Southeast	58758	0.2	14.9	0.01	14.9
	Central	56161	-0.6	16.8	-2.19	17.4
	West	NA	NA	NA	NA	NA
August	12-km EUS	203882	-3.8	15.9	-5.1	16.9
	Northeast	39827	-4.1	15.2	-5.54	16.4
	Midwest	40127	-9.5	17.6	-11.2	19.4
	Southeast	56310	-0.5	15.1	-0.86	15.2
	Central	43056	-0.5	15.5	-2.24	16.3
	West	NA	NA	NA	NA	NA
September	12-km EUS	118945	-4.0	14.1	-5.27	15.2
	Northeast	13597	1.5	13.5	0.13	13.8
	Midwest	34358	-10.6	16.2	-12.9	18.7
	Southeast	41359	-1.7	13.1	-2.49	13.8
	Central	16736	-0.7	12.5	-2.29	13.5
	West	NA	NA	NA	NA	NA
Summer Aggregate	12-km EUS	1069083	-4.2	15.0	-5.36	16.0
	Northeast	198469	-1.98	14.8	-3.16	15.5
	Midwest	225576	-8.96	16.5	-10.9	18.5
	Southeast	305166	-2.48	14.0	-2.94	14.4
	Central	215277	-2.1	14.9	-3.6	15.8
	West	NA	NA	NA	NA	NA

Normalized mean error (NME) is also similar to NMB, where the performance statistic is used as a normalization of the mean error. NME calculates the absolute value of the difference (model - observed) over the sum of observed values. Normalized mean error is defined as:

$$NME = \frac{\sum_{1}^{n} |P - O|}{\sum_{1}^{n} (O)} * 100$$

where P = predicted concentrations and O = observed

Fractional bias is defined as:

$$\text{FB} = \frac{1}{n}\left(\frac{\sum_{1}^{n}(P-O)}{\sum_{1}^{n}\left(\frac{(P+O)}{2}\right)}\right) \text{*100, where P = predicted concentrations and O = observed}$$

FB is a useful model performance indicator because it has the advantage of equally weighting positive and negative bias estimates. The single largest disadvantage in this estimate of model performance is that the estimated concentration (i.e., prediction, P) is found in both the numerator and denominator.

Fractional error (FE) is similar to fractional bias except the absolute value of the difference is used so that the error is always positive. Fractional error is defined as:

$$\text{FE} = \frac{1}{n}\left(\frac{\sum_{1}^{n}|P-O|}{\sum_{1}^{n}\left(\frac{(P+O)}{2}\right)}\right) \text{*100, where P = predicted concentrations and O = observed}$$

Ozone (12 km Eastern U.S.): The operational model performance evaluation for hourly and 8-hour daily maximum ozone was conducted using the statistics defined above. Ozone measurements from 836 sites for 2003, 750 sites for 2004, 817 sites for 2005, and 874 sites for 2006 in the Eastern U.S. were included in the evaluation and were taken from the 2003-2006 state/local monitoring site data in the Air Quality System (AQS) Aerometric Information Retrieval System (AIRS). The performance statistics were calculated using predicted and observed data that were paired in time and space on an hourly and/or 8-hour basis. Statistics were generated for the following geographic groupings: domainwide and four large subregions[19]: Midwest, Northeast, Southeast, and Central U.S.

Hourly Ozone Evaluation

Ozone (O_3): Table 4-4 provides hourly ozone model performance statistics calculated for a threshold of 40 ppb of observed and modeled concentrations, for the 12-km Eastern U.S. domain and the four subregions (Midwest, Northeast, Southeast, and Central U.S.). Hourly ozone is under-predicted domainwide when applying a threshold of 40 ppb for these modeled time periods.

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[19]The subregions are defined by states where: Midwest is IL, IN, MI, OH, and WI; Northeast is CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, and VT; Southeast is AL, FL, GA, KY, MS, NC, SC, TN, VA, and WV; Central is AR, IA, KS, LA, MN, MO, NE, OK, and TX.

Table 4-4. Summary of CMAQ 2006 8-Hour Daily Maximum O_3 Model Performance Statistics

CMAQ 2006 Maximum 8-hr Average Ozone: Threshold of 40 ppb		No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
May	12-km EUS	19514	0.80	10.4	1.19	10.5
	Northeast	3889	1.8	10.1	2.35	10.0
	Midwest	3637	-1.6	11.2	-1.46	11.4
	Southeast	5972	-1.1	9.8	-0.65	9.94
	Central	3916	4.4	11.2	4.51	11.0
	West	NA	NA	NA	NA	NA
June	12-km EUS	19187	-4.7	11.9	-4.41	12.0
	Northeast	3027	-1.7	11.8	-1.59	11.7
	Midwest	4225	-7.5	13.1	-7.19	13.4
	Southeast	5389	-4.5	10.9	-4.14	11.0
	Central	4395	-4.5	11.8	-4.4	12.0
	West	NA	NA	NA	NA	NA
July	12-km EUS	19433	2.0	13.3	2.04	13.2
	Northeast	4271	4.9	12.8	5.06	12.6
	Midwest	3500	-2.9	13.6	-2.69	13.8
	Southeast	5004	2.6	12.3	3.01	12.1
	Central	4494	4.6	14.4	4.13	14.0
	West	NA	NA	NA	NA	NA
August	12-km EUS	17853	-0.10	12.6	-0.10	12.6
	Northeast	3292	-1.4	11.0	-1.48	11.2
	Midwest	3410	-5.3	14.0	-4.99	14.2
	Southeast	5112	2.8	12.4	3.12	12.2
	Central	3941	3.2	12.6	2.77	12.4
	West	NA	NA	NA	NA	NA
September	12-km EUS	11231	-0.3	11.0	-0.23	11.0
	Northeast	1231	5.2	10.9	4.55	10.4
	Midwest	3015	-7.3	12.4	-7.09	12.5
	Southeast	4036	1.9	10.5	1.92	10.5
	Central	1710	2.5	9.9	1.97	9.97
	West	NA	NA	NA	NA	NA
Summer Aggregate	12-km EUS	87244	-0.46	11.8	-0.30	11.9
	Northeast	15710	1.76	13.7	1.78	11.2
	Midwest	17787	-4.92	12.9	-4.68	13.1
	Southeast	25513	0.34	11.2	0.65	11.1
	Central	18456	2.04	12.0	1.87	11.9
	West	NA	NA	NA	NA	NA

$PM_{2.5}$: The $PM_{2.5}$ evaluation focuses on $PM_{2.5}$ total mass and its components, including sulfate (SO_4), nitrate (NO_3), total nitrate ($TNO_3 = NO_3 + HNO_3$), ammonium (NH_4), elemental carbon (EC), and organic carbon (OC). The $PM_{2.5}$ performance statistics were calculated for each month and season individually and for the entire year, as a whole. Seasons were defined as: winter (December-January-February), spring (March-April-May), summer (June-July-August), and fall (September-October-November). $PM_{2.5}$ ambient measurements for 2003-2006 were obtained from the following networks for model evaluation: **S**peciation **T**rends **N**etwork (STN – total of 199 sites for 2003, 205 sites for 2004, 203 sites for 2005, and 178 sites for 2006), **I**nteragency **M**onitoring of **PRO**tected **V**isual **E**nvironments (IMPROVE – total of 89 sites for 2003, 98 sites for 2004 and 2005, and 92 sites for 2006), and **C**lean **A**ir **S**tatus and **T**rends **Net**work (CASTNet – total of 66 sites for 2003, 67 sites for 2004 and 2005, and 68 sites for 2006). For $PM_{2.5}$ species that are measured by more than one network, we calculated separate sets of statistics for each network. For brevity, Table 4-5 provides annual model performance statistics for $PM_{2.5}$ and its component species for the 12-km Eastern domain and the four sub-regions defined above (Northeast, Midwest, Southeast and Central U.S.).

Table 4-5. Summary of CMAQ 2006 Annual $PM_{2.5}$ Species Model Performance Statistics

CMAQ 2006 Annual			No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
$PM_{2.5}$ Total Mass	STN	12-km EUS	9925	2.3	38.1	-0.53	38.1
		Northeast	2505	11.2	39.8	9.21	37.8
		Midwest	1795	7.6	46.1	4.65	43.3
		Southeast	2438	-17.1	39.4	-19.4	44.9
		Central	2250	5.2	34.6	2.11	34.3
		West	NA	NA	NA	NA	NA
	IMPROVE	12-km EUS	8686	-4.1	45.0	-11.2	47.1
		Northeast	2075	11.9	47.4	4.65	42.0
		Midwest	2192	-1.5	45.8	-3.56	46.1
		Southeast	1528	-17.1	39.4	-19.4	44.9
		Central	469	3.0	39.7	-1.77	40.7
Sulfate	STN	12-km EUS	11333	-6.7	30.6	-3.86	33.9
		Northeast	2857	-3.3	29.9	1.34	33.0
		Midwest	2191	-14.2	35.9	-9.37	39.2
		Southeast	2847	-9.8	27.8	-9.51	30.0
		Central	2421	-0.8	31.7	1.86	34.5
		West	NA	NA	NA	NA	NA
	IMPROVE	12-km EUS	7023	-10.5	33.9	-4.56	39.1
		Northeast	1712	-0.1	35.5	5.06	40.1
		Midwest	1795	-22.6	37.1	-17.5	41.8
		Southeast	1064	-14.2	29.9	-9.53	33.0
		Central	359	-9.5	29.0	-7.71	32.4
		West	NA	NA	NA	NA	NA
	CASTNet	12-km EUS	3216	-10.2	19.7	-11.4	23.1
		Northeast	782	-4.6	18.4	-3.28	19.5
		Midwest	321	-26.6	29.9	-30.4	35.7
		Southeast	1123	-11.5	18.8	-12.7	21.4
		Central	625	-7.3	18.3	-8.21	21.6
		West	NA	NA	NA	NA	NA
Nitrate	STN	12-km EUS	10850	28.2	72.4	-9.43	77.7
		Northeast	2857	33.4	68.5	0.72	72.1
		Midwest	1709	24.1	68.9	-7.16	75.8
		Southeast	2847	34.8	91.9	-28.2	90.1
		Central	2420	27.2	67.4	9.52	66.4
		West	NA	NA	NA	NA	NA
	IMPROVE	12-km EUS	7022	41.3	90.8	-25.6	96.1
		Northeast	1712	65.5	102.0	-0.56	87.8
		Midwest	1795	25.1	74.4	-18.1	90.9
		Southeast	1064	60.1	116.0	-19.6	99.3
		Central	359	44.3	93.0	8.42	87.0
		West	NA	NA	NA	NA	NA

Total Nitrate (NO_3 + HNO_3)	CASTNet	12-km EUS	3216	33.3	47.0	22.4	41.5
		Northeast	782	46.9	52.3	35.9	44.1
		Midwest	321	8.2	39.9	-0.25	40.3
		Southeast	1123	29.5	49.1	20.5	44.6
		Central	625	40.2	45.0	32.0	36.7
		West	NA	NA	NA	NA	NA
Ammonium	STN	12-km EUS	11333	12.7	42.3	16.8	43.8
		Northeast	2857	14.2	41.3	23.6	44.6
		Midwest	2191	10.3	48.0	14.3	47.7
		Southeast	2847	7.3	38.2	8.08	39.5
		Central	2421	18.4	43.6	23.0	43.7
		West	NA	NA	NA	NA	NA
	CASTNet	12-km EUS	3216	16.0	36.0	14.3	34.4
		Northeast	782	17.9	36.0	19.7	33.6
		Midwest	321	21.9	43.3	15.2	40.4
		Southeast	1123	5.1	30.7	6.58	32.2
		Central	625	31.4	41.9	28.0	37.2
		West	NA	NA	NA	NA	NA
Elemental Carbon	STN	12-km EUS	11385	18.8	59.2	13.3	50.9
		Northeast	2869	19.2	56.6	13.4	48.2
		Midwest	2223	60.6	92.3	39.8	62.9
		Southeast	2847	8.6	52.5	5.14	46.2
		Central	2424	4.7	43.9	4.84	44.3
		West	NA	NA	NA	NA	NA
	IMPROVE	12-km EUS	8606	-20.8	49.3	-33.4	56.2
		Northeast	1946	-0.7	49.5	-15.9	50.3
		Midwest	2137	-15.2	47.8	-21.9	50.2
		Southeast	1518	-43.7	51.3	-53.9	63.8
		Central	583	-34.0	42.5	-41.9	56.2
		West	NA	NA	NA	NA	NA
Organic Carbon	STN	12-km EUS	10436	-32.3	51.8	-30.4	61.7
		Northeast	2753	-23.2	51.0	-17.3	60.1
		Midwest	1700	-24.9	55.7	-27.0	60.2
		Southeast	2753	-37.6	51.0	-42.5	63.7
		Central	2287	-40.2	51.0	-34.8	60.6
		West	NA	NA	NA	NA	NA
	IMPROVE	12-km EUS	8603	-25.8	55.6	-45.3	65.6
		Northeast	1953	-7.4	54.3	-20.3	54.9
		Midwest	2139	-25.2	55.2	-41.7	62.7
		Southeast	1523	-36.8	51.1	-57.3	67.9
		Central	585	-39.5	48.6	-49.8	64.0
		West	NA	NA	NA	NA	NA

5.0 Bayesian Model-Derived Air Quality Estimates

5.1 Introduction

The need for improved spatial and temporal estimates of air quality has grown rapidly in recent years, as the development of more thorough air quality related health studies have begun requiring more thorough characterizations of ground-level air pollution levels. The most direct way to obtain accurate air quality information is from measurements made at surface monitoring stations across the country. However, many areas of the U.S. are not monitored and typically, air monitoring sites are sparsely and irregularly spaced over large areas. One way to address the limits to ambient air quality data is to combine air quality monitoring data and numerical model output in a scientifically coherent way for improved spatial and temporal predictions of air quality. This type of statistical modeling could provide spatial predictions over the temporal scales used to assess the associations between ambient air quality and public health outcomes and for assessing progress in air quality under new emission control programs. Hierarchical Bayesian Modeling (HBM) is used in numerous applications to combine different data sources with varying levels of uncertainty. This section will briefly introduce the Hierarchical-Bayesian approach developed by EPA for use in the EPHT program.

The approach discussed in this section combines the strength of both modeled and monitored pollution concentration values to characterize air quality with estimated accuracy and enhanced spatial and temporal coverage. The statistical approach is explained in McMillan, N., Holland, D.M., Morara, M, and Feng, J., "Combining Different Sources of Particulate Data Using Bayesian Space-Time Modeling," *Environmetrics*, **2009**, DOI: 10.1002/env.984.

5.2 Hierarchical Bayesian Space-Time Modeling System

5.2.1 Introduction to the Hierarchical-Bayesian Approach

EPA's Hierarchical-Bayesian (HB) space-time statistical model combines ambient air quality data from monitors with modeled CMAQ air quality output to produce daily predictions of pollution concentrations for defined time and space boundaries. Bayesian analysis decomposes a complex problem into appropriate linked stages (functions), i.e., a) air quality data; b) CMAQ model output; c) measurement errors and model bias; and d) the underlying 'true' concentration surface. A Bayesian approach incorporates 'prior knowledge' (e.g., numerical information describing known attributes/behaviors, statistical distributions, etc.) of the unknown parameters in the hierarchical model, which results in an improved estimation of the uncertainty of the 'true' air pollutant concentration at any location in space and time. A hierarchical model builds a combined solution, superior to either air quality monitor data or air quality modeling data alone. The predictions of the ambient concentration 'surface' provided by EPA's HB Model are for a selected year and with spatial scope spanning across the contiguous U.S. (i.e., the 'lower 48' states). The HB Model methodology blends the best characteristics of monitored concentration values and modeled concentration values for prediction of the 'true' concentration values (surface) over time when both sources of data are available. Air quality monitors are assumed to measure the true pollutant concentration surface with some measurement error, but no bias. In contrast, numerical output from source-oriented air quality models is assumed to approximate the variability of the true surface while exhibiting both measurement error and bias (additive and multiplicative) across space and time. Given the typical exponentially distributed nature of air quality data, the HB Model performs its analysis with log-transformed monitoring and modeling inputs. The HB Model gives more weight to accurate monitoring data in areas where monitoring data exists, and relies on bias-adjusted model output in non-monitored areas. The HB Model approach offers the ability to predict important pollution gradients and uncertainties that might otherwise be unknown using interpolation results based solely on air quality monitoring data. EPA's HB Model can be used to obtain surrogate measures of air quality for studies addressing health outcomes.

5.2.2 Advantages and Limitations of the Hierarchical-Bayesian Approach

At a high level, the advantage of HB modeling methodology is its inherent ability to predict air quality estimates for selected times and spatial scales using air quality monitoring and air quality modeling data as input, while minimizing the limitations which arise when either of these methods are applied separately. Another important advantage of the HB modeling approach is the ability to predict estimates of errors in air quality. The HB modeling approach generates estimates of air quality for days when monitoring data is missing, in addition to estimating air quality in areas without monitors. An important disadvantage of HB modeling is the computational burden imposed on model users. Typically, these models are 'adjusted' by running numerous simulations, and at times the solutions are difficult to program and require significant computer resources. Thus, there is the need for EPA to develop an operational approach to HB modeling. It requires experience and statistical expertise to ensure that proper (initial) modeling assumptions have been used, that proper convergence criteria have been used for the HB Model, and that the results are reasonable.

In setting up the procedures for developing the HB Model estimates, EPA selected a set of data quality objectives, DQOs, to guide the acceptance of the results. Based on an independent data set (not used in the predictions), EPA calculates (1) the *Bias* as the absolute difference between the (log-transformed) measurement generated from the monitor at that location (i.e., the "true" value) and the log-transformed prediction that is made by the particular model; and (2) the *Mean Square Error (MSE),* calculated as the square of the bias. EPA presents three different types of MSE summaries: (a) day-specific MSE, averaged over all monitoring locations; (b) location-specific MSE, averaged over all monitoring days; and (c) the overall MSE (i.e., averaged across locations and time). MSE is a statistical score that represents overall (average) performance in which large deviation from the "true" value yields larger penalties compared to small errors. While these performance measures were used in evaluating the results, they have no absolute acceptance/rejection values and are considered on a case-by-case basis when evaluating the performance of any years of HB Model application. In general, while the DQO's usefulness is still being studied and EPA attempts to achieve these DQOs, these measures are helpful at this time to describe the quality of the HB predictions from one model year to another.

In developing and providing the HB Model results, EPA is attempting to advance the use of improved air quality estimates. As such, the proper use of the EPA results is important and discussed further in Section 5.6.

5.3 Results for O_3 and $PM_{2.5}$

The HB Model yields a predicted daily concentration and error estimate for those predictions within each grid cell for each day within the time period of interest. The concentrations are daily $PM_{2.5}$ or 8-hour maximum ozone levels. These predictions fall along a smooth (congruent) response surface across the entire region. The grid used by the HB Model is the same as that used in generating the CMAQ estimates. The smoothness of the surface is achieved by: 1) the choice of prior distributions for air data, CMAQ output, and the true underlying predictive surface; and 2) the conditional autoregressive model (CAR) spatial covariance structure where a grid's predicted concentration is assumed to be correlated with neighboring cells (note the HB Model can handle different size neighborhoods). The resulting HB Model prediction surface approximates the true underlying response surface while accounting for such factors as measurement error and potential space-time bias in the CMAQ output.

EPA stores the set of back-transformed predictions (pm25_pred, O3_pred) and standard errors (pm25_stdd, O3_stdd) from a given execution of the HB Model in tabular (comma-delimited) format within a file named as in the following example: pm25_surface_36km_2001.csv. Table 5-1 presents an example of the output that can be obtained from this file. One row exists in this file for each grid cell-date combination within the study area. The relevant variables in this file, in the order in which they exist (and are portrayed within the column headings of the table), are as follows:

- Date: Represented by the data given in this row, in MM/DD/YYYY format.
- Longitude: The x-coordinate value transformed to longitude (degrees).
- Latitude: The y-coordinate value transformed to latitude (degrees).
- Column: The column associated with model results.
- Row: The row associated with model results.
- pm25_pred or O3_pred
- pm25_stdd or O3_stdd

Table 5-1. HB Model Prediction: Example Data File

Date	Longitude	Latitude	Column	Row	O3_pred (ppb)	O3_stdd (ppb)
01/01/2001	-119.315	23.43627	12	15	23.011	4.6122
01/01/2001	-119.398	23.74126	12	16	22.979	4.6784
01/01/2001	-119.483	24.04658	12	17	22.919	4.8484
01/01/2001	-119.567	24.35223	12	18	22.987	4.7917
01/01/2001	-119.653	24.6582	12	19	23.19	4.84
01/01/2001	-119.739	24.96448	12	20	23.018	4.8264
01/01/2001	-119.826	25.27106	12	21	23.12	4.8651
01/01/2001	-119.913	25.57793	12	22	22.997	4.84
01/01/2001	-120.001	25.88509	12	23	22.968	4.8308
01/01/2001	-120.09	26.19253	12	24	22.949	4.8357

Note: The exact contents of this table may change over time. Please check the accompanying metadata files.

5.4 Overview of HB Model Predictions

Below is a short description of the inputs and outputs for a HB Model application for 2006, 12 km grid, $PM_{2.5}$. A description of the input metadata and HB Model application can be found in Appendix E. The air quality data come from EPA AQS, the CMAQ was run by EPA as documented elsewhere in this report and the HB Model was applied at EPA's NERL. The domain of the CMAQ model (and therefore the HB Model predictions) is found in the following table.

Table 5-2. HB Model Domains for 12-km Applications

Study Year	Bounding West Longitude	Bounding East Longitude	Bounding North Latitude	Bounding South Latitude
2006	111.1 deg W lon	65.4 deg W lon	51.25 deg N lat	23.0 deg N lat

Figure 5-1 shows the HB Model prediction for $PM_{2.5}$ during July 1-4, 2002. On July 1, the $PM_{2.5}$ levels were the highest along the U.S.-Canada border northeast of Lake Erie and into the mid-Atlantic region. As the days passed, the elevated $PM_{2.5}$ decreased in intensity and moved southeast. Examining the figure, it is possible to see the change in $PM_{2.5}$ level at any point in the domain. Figure 5-2 shows a close up of the HB Model predictions for July 2. The 12-km grid can be seen as small squares. Within each grid the predicted $PM_{2.5}$ concentrations are constant. As such, the $PM_{2.5}$ concentrations represent an average over the area where the public is exposed to ambient $PM_{2.5}$. Although actual concentrations within grid cells vary over space and time during a day, the ambient exposure is likely to be somewhat averaged as people move about within and between grid cells. Given the relationship between ambient concentrations, ambient exposures and personal exposure is not understood well, one area of study is the degree of misclassification between exposure and health outcomes based on varying grid sizes.

The HB Model results can track with the AQS data and CMAQ estimates and the predictions can differ from either the AQS data or the CMAQ estimates. Figure 5-3 shows HB predictions for a location where the predictions generally follow temporally the CMAQ and AQ data. This figure shows a series of days where AQS data and CMAQ estimates are fairly consistent. In such cases, the HB Model predictions track closely to both inputs. Figure 5-4 shows how the HB Model fills in $PM_{2.5}$ predictions for days when AQS data are not available (many $PM_{2.5}$ monitors are operational and collect samples during 1 day in every 3-day time period). On the unmonitored days, the HB Model predictions track well with the CMAQ estimates. Figure 5-5 shows a situation where AQS and CMAQ do not agree well and, while the HB Model tends to mitigate the bias of CMAQ, the HB Model the predictions can be highly affected by CMAQ, although the day-to-day trends are maintained.

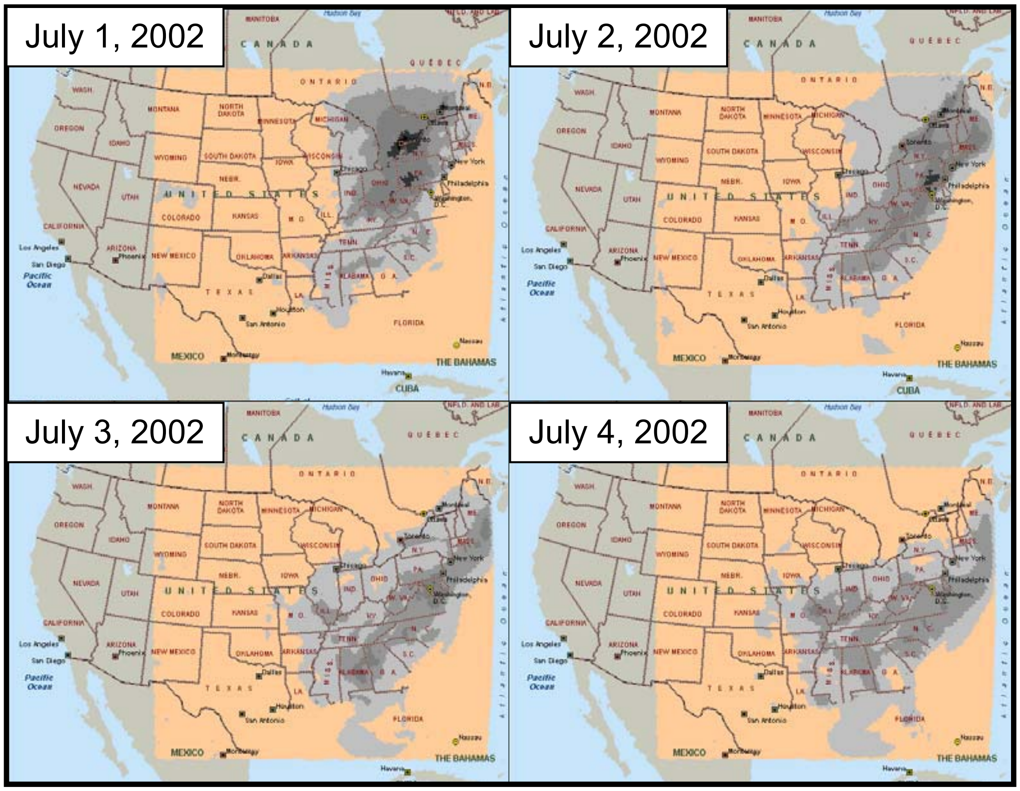
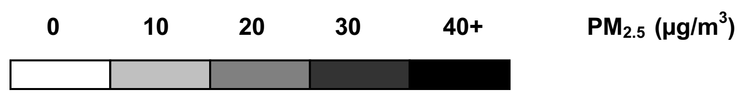


Figure 5-1. HB Prediction ($PM_{2.5}$) During July 1-4, 2002 (12 km grid cells)



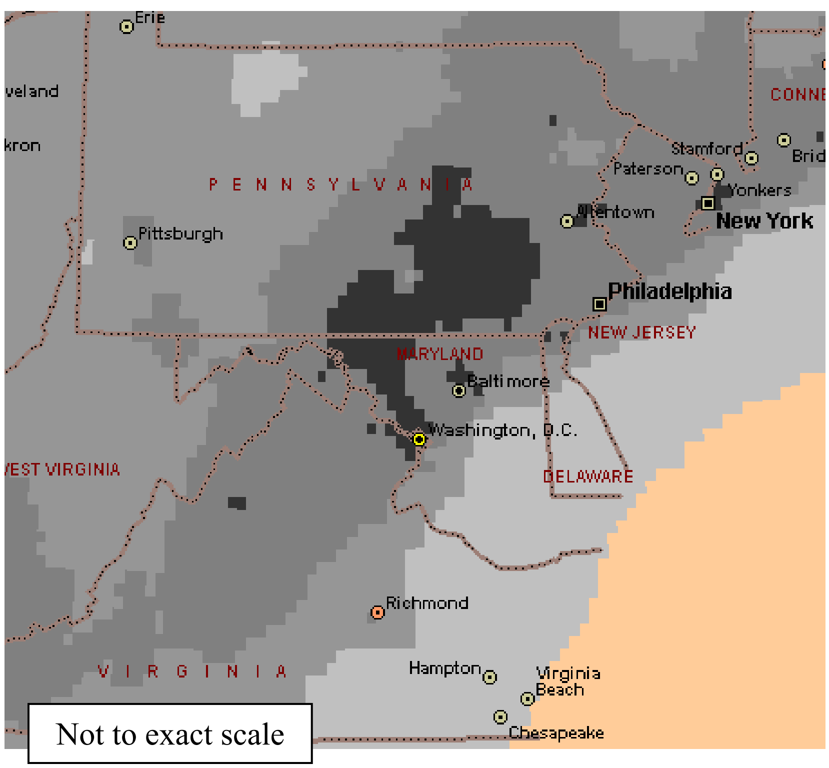


Figure 5-2. HB Prediction ($PM_{2.5}$) on July 2, 2002 (12 km grid cells)

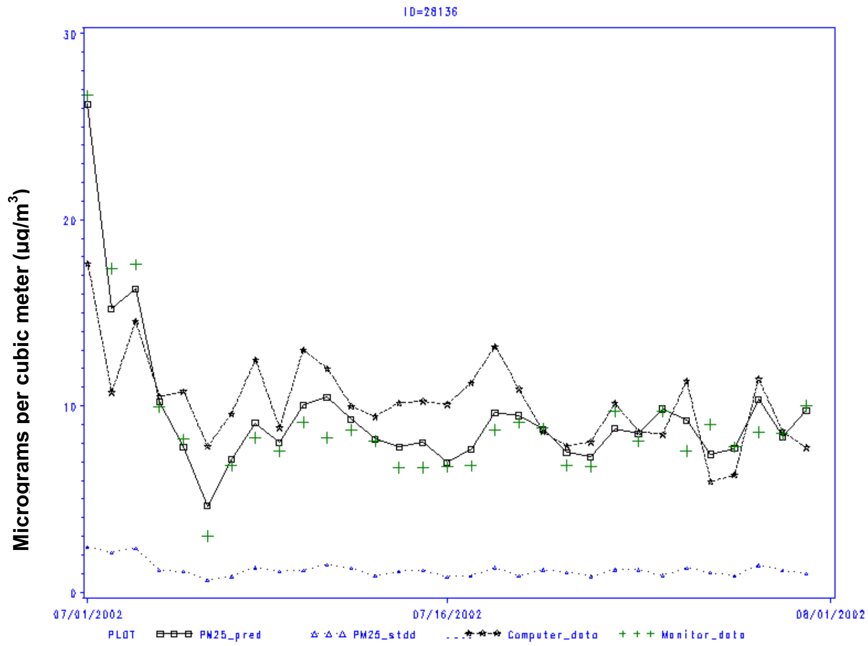


Figure 5-3. HB Prediction ($PM_{2.5}$) Temporarily Matches AQS Data and CMAQ Estimates

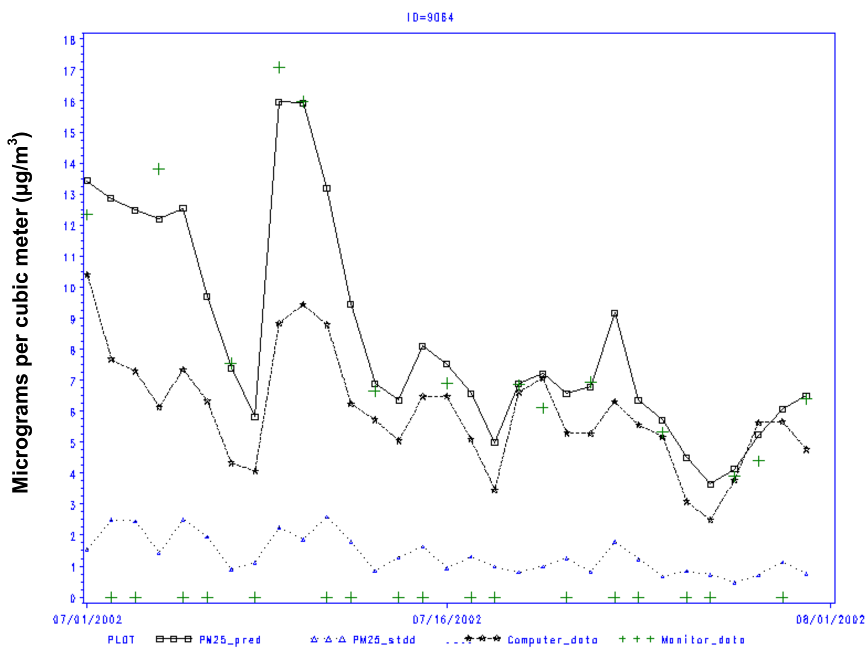


Figure 5-4. HB Prediction ($PM_{2.5}$) Compensates When AQS Data is Unavailable

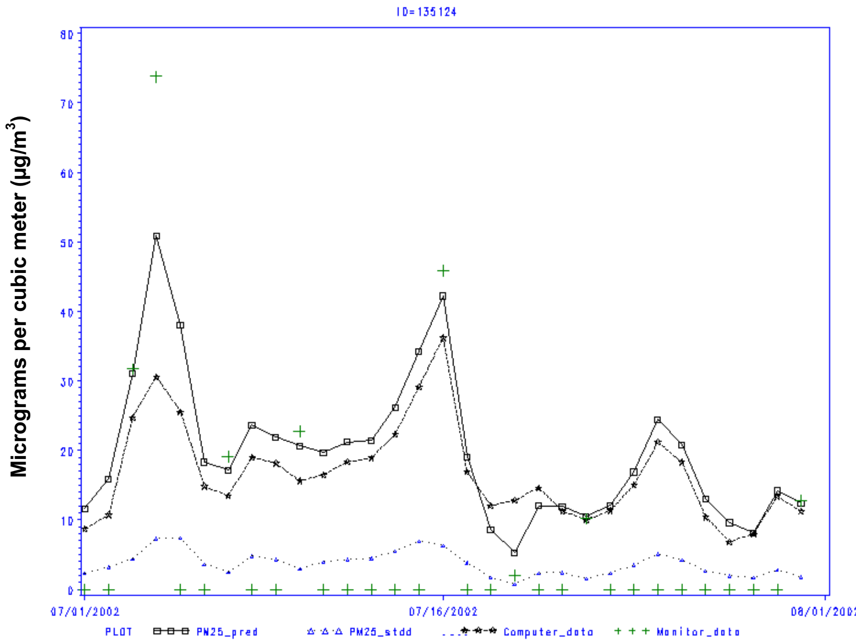


Figure 5-5. HB Prediction ($PM_{2.5}$) Mitigates CMAQ Bias when AQS and CMAQ Values Diverge

Another way to view the ability of the HB Model to fill in estimates of air quality where no monitor exists can be seen in the following figures. The HB Model response surface is plotted with the grid demarcations in Figure 5-6 along with the measurements taken at the monitoring stations. Figure 5-7 rotates this plot to portray its 3-dimensionality, so that differences between the HB Model predictions and the monitoring data points can be better seen. The view portrayed in Figure 5-7 is as seen from the position of the red arrow in Figure 5-6. As in the previous figures, different colors represent different concentration gradients (as noted within the legend included in the plot). These figures show how the HB Model prediction surface aligns closely with the monitoring station data in most instances, except for a cluster of data points in the upper center of the plot.

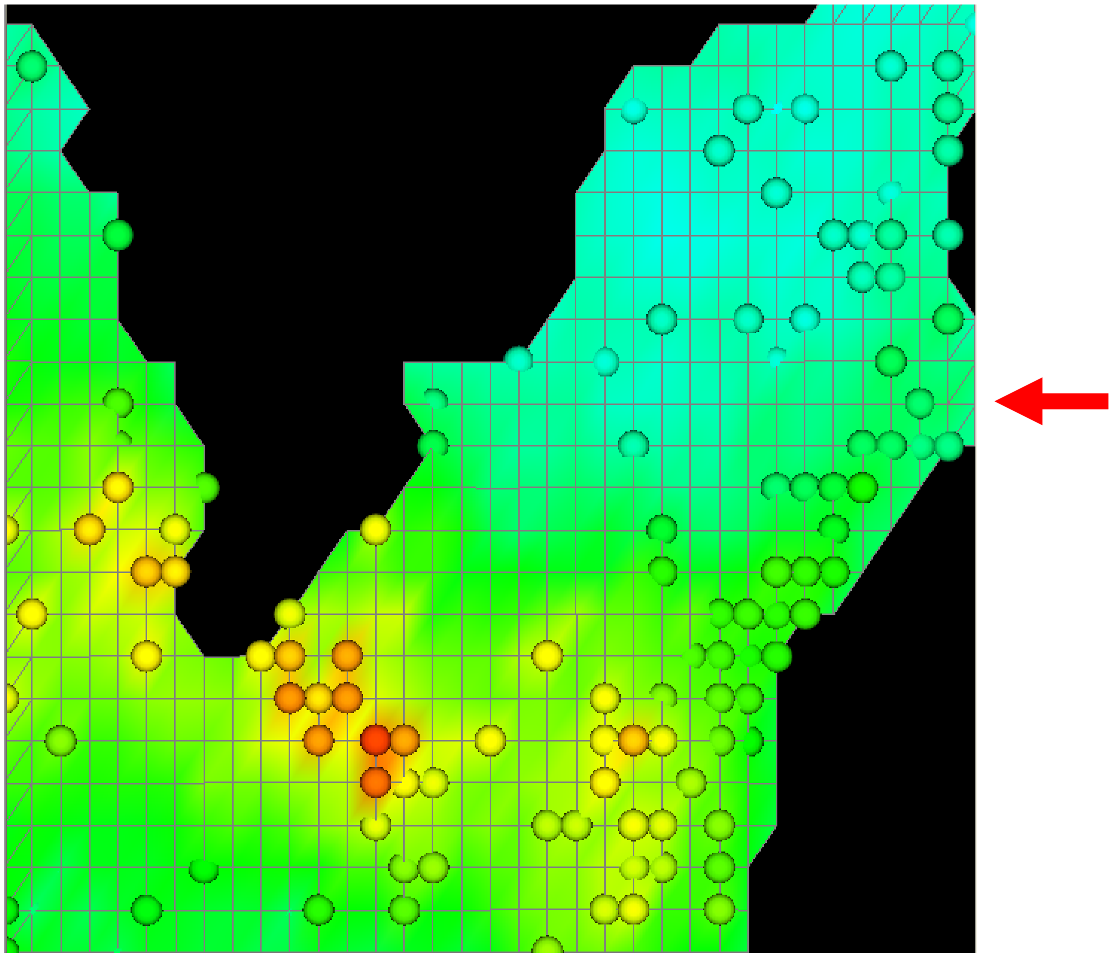


Figure 5-6. Plot of the Response Surface of $PM_{2.5}$ Concentrations as Predicted by the HB Model on a Specific Monitoring Day in the Northeast U.S., Along With $PM_{2.5}$ Measurements on a Specific Monitoring Day from FRM Monitors in the NAMS/SLAMS Network

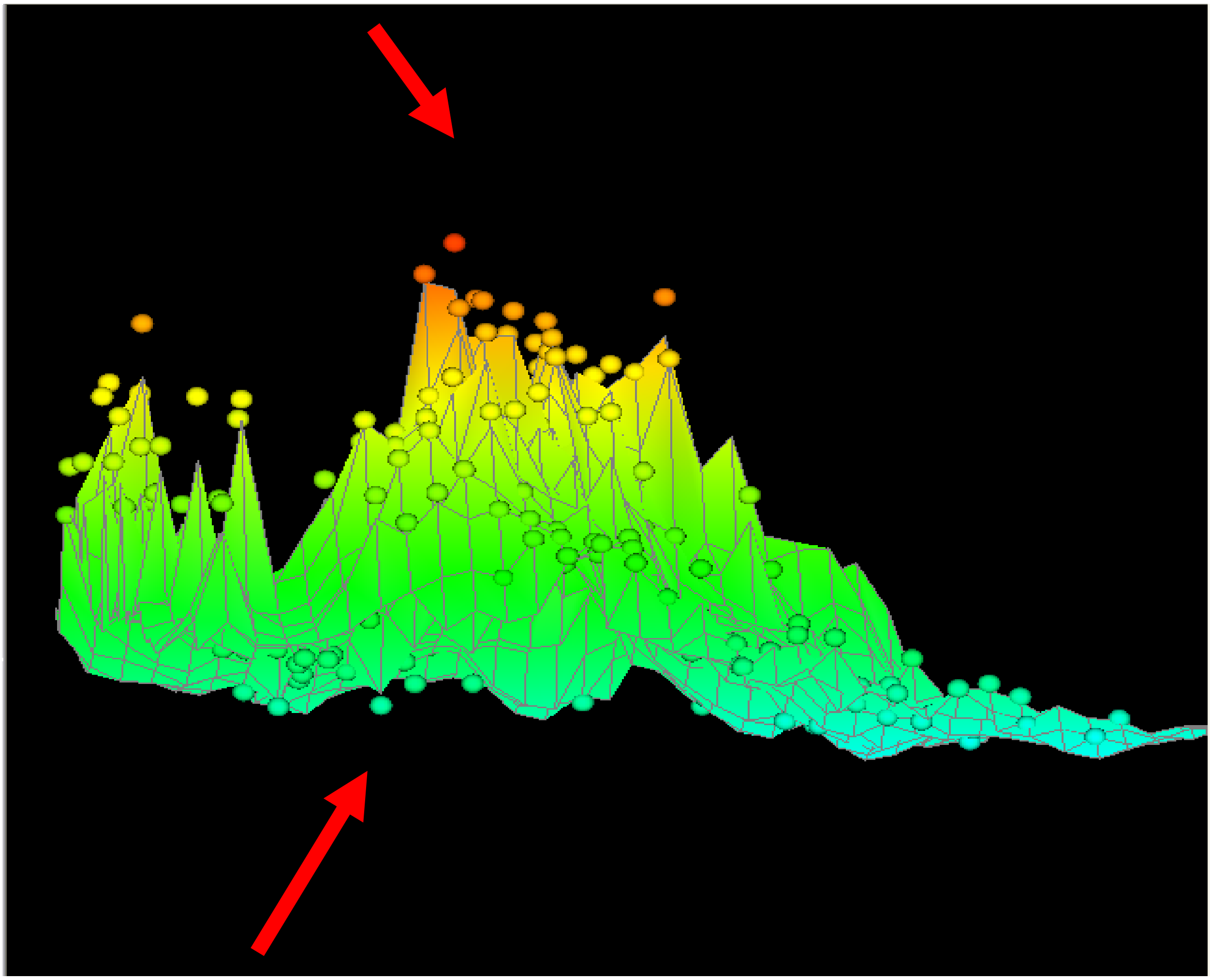


Figure 5-7. Rotated View of the Response Surface of $PM_{2.5}$ Concentrations as Predicted by the HBM on a Specific Monitoring Day in the Northeast U.S., Along With $PM_{2.5}$ Measurements on a Specific Monitoring Day from FRM Monitors in the NAMS/SLAMS Network

Figure 5-8 portrays the same plot as Figure 5-6, but with the CMAQ-estimated $PM_{2.5}$ surface added. The CMAQ surface features have more yellow shading within them, implying that the CMAQ concentration values somewhat underestimate the concentrations relative to the HB Model and the monitoring stations. However, in areas in which there are few or no monitoring stations, the HB Model surface corresponds closely with the CMAQ surface. This is to be expected, as the HB Model weighs (uses a bias adjustment of) the CMAQ data more heavily in areas without monitoring data.

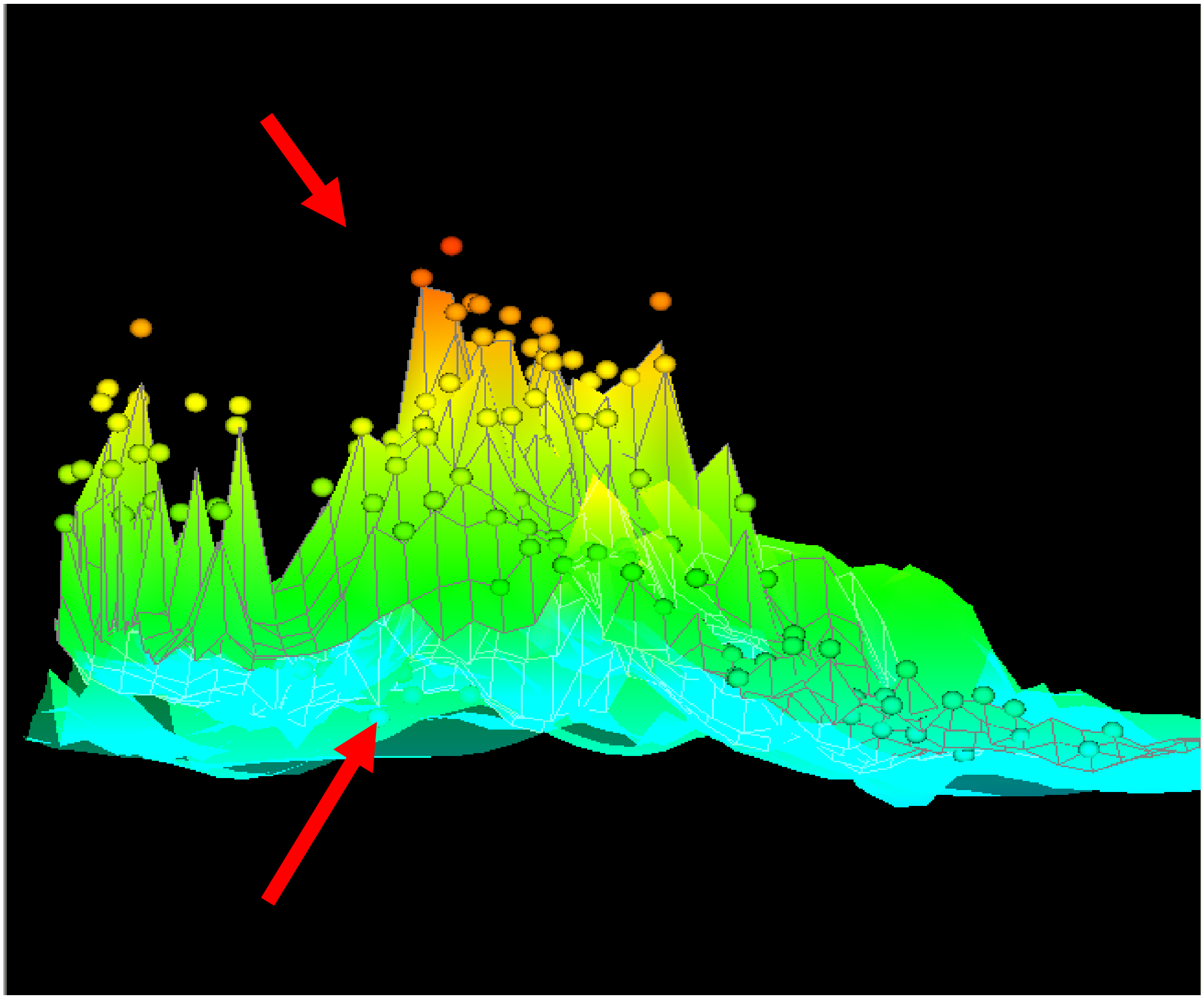


Figure 5-8. Rotated View of the Response Surface of $PM_{2.5}$ Concentrations as Predicted by the HBM on a Specific Monitoring Day in the Northeast U.S., Along With $PM_{2.5}$ Measurements on a Specific Monitoring Day from FRM Monitors in the NAMS/SLAMS Network, and the Response Surface as Predicted by the CMAQ Modeling System

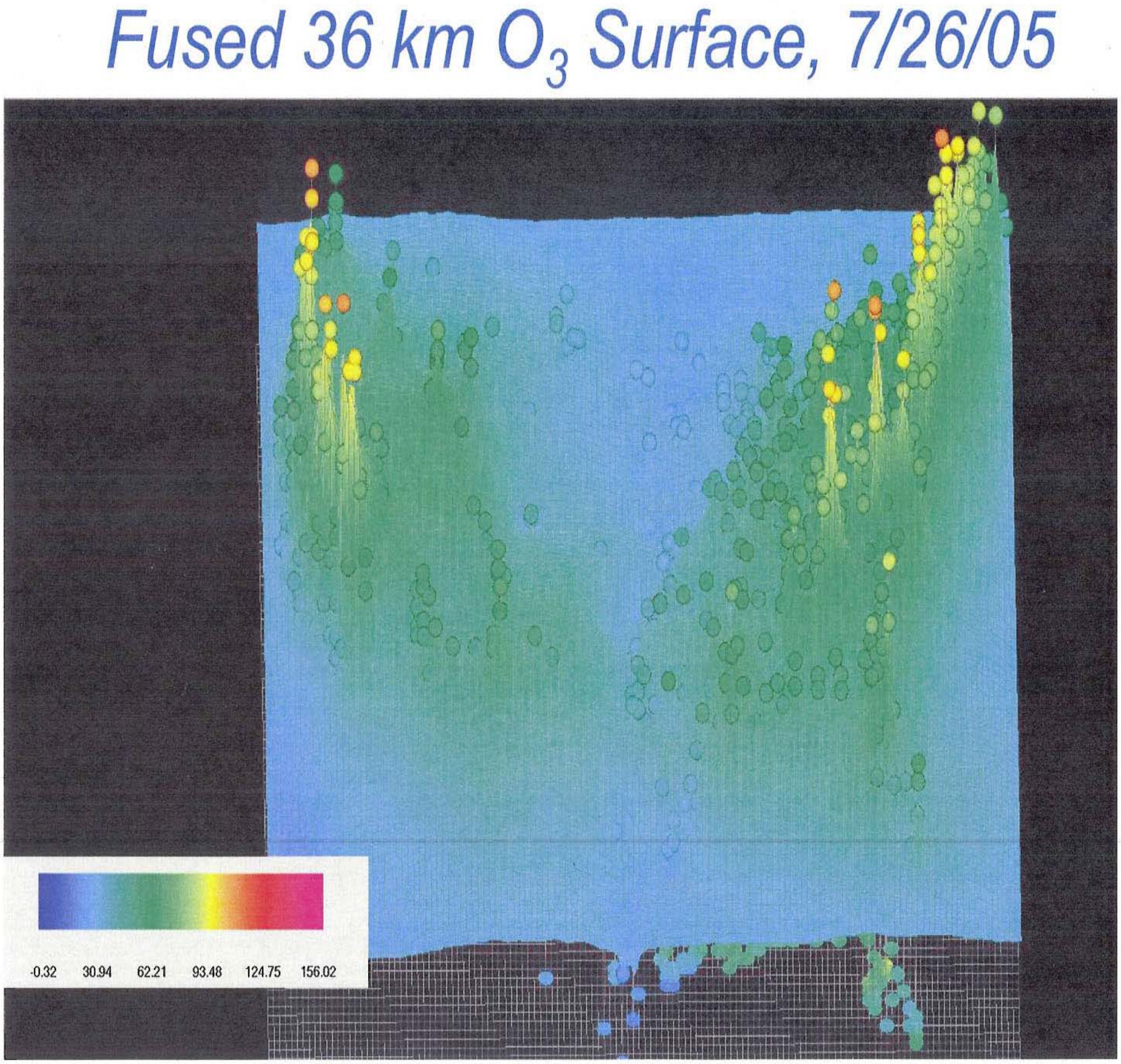


Figure 5-9. Fused 36 km O_3 Surface for the Continental U.S. (July 26, 2005).

Figure 5-9 displays the ozone concentration for the continental U.S. on July 26, 2005. The spheres represent the concentrations recorded at monitor locations. The green, blue, and yellow represent the HB concentration surface, which combines the CMAQ model estimates and the $PM_{2.5}$ monitor measurements.

5.5 Evaluation of HB Model Estimates

As reported in the McMillan paper (*Environmetrics*, 2009), model validation analysis was performed to compare the HB predictive results at 2001 STN/IMPROVE monitoring sites to predictions at those locations from two other approaches: (1) traditional kriging predictions based solely on the FRM monitoring data and (2) CMAQ output at these locations. In doing so, it was assumed the STN/IMPROVE measurements represent the "truth." The IMPROVE measurements are representative of rural areas (with few monitors) and may help assess the HBM results for these areas of interest. The potential bias in either the STN or IMPROVE gravimetric mass measurements compared to FRM data were not considered, although for gravimetric mass the monitors generally produce the same results. STN data collocated with FRM monitoring sites used in fitting the HB Model were eliminated from the validation data set, leaving 44 sites for the validation analysis.

In the validation analysis, mean squared prediction error and bias were calculated to evaluate the predictive capability of these three different models. To assess the ability of the HB Model to accurately characterize prediction uncertainty, the percentage of validation data within the 95 percent prediction credible interval was calculated. In the analysis, a similar analysis was performed for the kriging model by calculating 95 percent confidence intervals at the validation sites. An exponential variogram model was used for the kriging model. The exponential parameters were estimated by fitting this model to an empirical variogram based on combining the daily empirical variograms.

In this analysis, predictions for each day were obtained for the STN/IMPROVE site locations from the three modeling approaches and the validations statistics were calculated across all days and sites. The validation only occurs every third day, according to the sampling schedule of STN/IMPROVE. This corresponds to the full network FRM schedule. Thus, the analysis did not evaluate sparse monitoring days where data fusion is expected to outperform interpolation techniques based solely on the monitoring data.

In the analysis, the HBM was run several times using a range of reasonable priors. Then, the validation analysis assessed the relative predictive performance of the HBM, traditional kriging, and CMAQ as described above. In terms of mean squared prediction error (MSE), the HBM and kriging approaches provided similar results across all HBM runs. For bias, the HBM outperformed kriging by 10 to 15 percent depending on the prior assumptions for τ^X and τ^Y. CMAQ was nearly unbiased for this analysis.

Kriging uncertainties were reflected in the small percentage (59%) of kriging prediction intervals capturing the validation data. This compares to HBM predictive interval results of 80 to 90 percent depending on the HBM run. This occurs from the difference between the HBM results and the 95 percent nominal rate to the difference in the measurement errors in the validation to those in the FRM data used in fitting the HBM model. Unfortunately, error-free $PM_{2.5}$ monitoring data are not available with current $PM_{2.5}$ monitoring approaches.

5.6 Use of EPA HB Model Predictions

Over the next several years, NERL will be working to improve spatial and temporal estimates of ambient pollutant concentrations to facilitate improved modeling of human exposure. The goal is to improve exposure modeling for intracity and intercity exposure comparisons and to develop better understood exposure surrogates for use in air pollution health studies. Given the uncertain characterization of air quality, especially at locations at a distance from central monitoring sites, NERL has been working to develop the HB Model (and other approaches) for estimating ambient and exposure concentrations for use in health studies, benefits assessments, and other air program analyses.

The HB Model as developed by NERL is part of an emerging research program. Accordingly, it should be understood by users of the HB predictions that the underlying statistical model is continuing to be studied and improved. However, given the uncertain nature of air quality, especially at locations well-removed from monitoring sites, NERL has been working to develop the HB Model (and other approaches) for estimating ambient and exposure concentrations for use in health studies, benefits assessments, and other air program analyses. To encourage assessments of these predictions from the HB Model, NERL is making the predictions available based on a general DQO approach of determining whether the predictions from the HB Model are appropriate for use for these purposes. This approach allows use of uncertain results by providing the statistical error estimates for the predictions and an assessment of the predictions. In this manner, users can assess the effects of the uncertainty for the predictions with their studies.

Based on NERL's current model evaluation results, the HB Model predictions provide credible predictive surfaces of air quality (ozone and $PM_{2.5}$), in particular away from monitoring sites. The HB Model, as initially configured, predicts to the central tendency with the potential distributions (that is, each estimate represents a mean value from the distribution of possible values for each space-time point). This means that the HB Model will tend to under-predict very high values (the implications of this are being investigated). Nevertheless, the HB predictions, by "filling-in" pollutant concentration values for missing (non-monitored) locations and missing (unsampled) days of air quality estimates, are likely to be an improvement compared to simply using the monitoring results. In addition, as the HB Model is a space-time model, it is more credible than statistical interpolation of the monitoring data where there are missing monitoring data (this is the predominate issue for 1 in 3 day $PM_{2.5}$ monitoring sites across the U.S.). The HB Model, and other statistical methods, is more scientifically credible than simple mathematical techniques, such as inverse distance weighting.

Given the uncertainty and the complexity of using the HB Model predictions, careful use of the HB predictions is needed. Until a thorough study of several prediction years and scales (grid sizes) is completed, the results should be used by professionals with an ability to understand anomalous outcomes when using the predictions in a health study. An exception-based review of the HB predictions should be undertaken by each researcher, in the context of a study's data needs, to ensure "outliers" do not influence subsequent analyses. The HB predictions include a few very high values which cannot be rejected out-of-hand without further study. Studies of the representativeness of the HB Model predictions and additional experience with the prediction will provide a better understanding of the limits of using these predictions. The HB Model was initially designed for use as a source of air quality estimates in case-crossover analyses where temporal and spatial variability was needed. The predictions could be used within the EPHT program in health surveillance activities, to generate hypotheses for further studies, and as a basis for indicators in counties without monitors. They also can be used in Health Impact Assessments in place of interpolated monitoring data.

EPA continues to research approaches to combining air quality data and model results to predict statistically air quality estimates for use in health studies and elsewhere in the air program. There are key scientific questions that the HB Model (and other techniques) may help address. For example, determining the most representative scale (36 km, 12 km or smaller scale) of ambient air quality measures (as surrogate for ambient exposure or personal exposure) for use in associating health outcome data with air quality changes needs to be better understood. The effect of (monitor) measurement variability and CMAQ bias on the usefulness of the HB predictions is also an important aspect for further improvement of air quality measures used in health studies.

Appendix A

Acronyms

Acronyms

BEIS	Biogenic Emissions Inventory System
BlueSky	Emissions modeling framework
CAIR	Clean Air Interstate Rule
CAMD	EPA's Clean Air Markets Division
CAP	Criteria Air Pollutant
CAR	Conditional Auto Regressive model
CEM	Continuous Emissions Monitoring
CHIEF	Clearinghouse for Inventories and Emissions Factors
CMAQ	Community Multiscale Air Quality model
CMV	Commercial marine vessel
CO	Carbon monoxide
DQO	Data Quality Objectives
EGU	Electric Generating Units
Emission inventory	Listing of elements contributing to atmospheric release of pollutant substances
EPA	Environmental Protection Agency
EMFAC	Emission Factor (California's onroad mobile model)
FAA	Federal Aviation Administration
FDDA	Four Dimensional Data Assimilation
FIPS	Federal Information Processing Standards
HMS	Hazard Mapping System
ICS-209	Incident Status Summary form
IPM	Integrated Planning Model
ITN	Itinerant
LSM	Land Surface Model
MOBILE	OTAQ's model for estimation of onroad mobile emissions factors
MODIS	Moderate Resolution Imaging Spectroradiometer
NEEDS	National Electric Energy Database System
NEI	National Emission Inventory
NERL	National Exposure Research Laboratory
NESHAP	National Emission Standards for Hazardous Air Pollutants
NH_3	Ammonia
NMIM	National Mobile Inventory Model
NONROAD	OTAQ's model for estimation of nonroad mobile emissions
NO_X	Nitrogen oxides
OAQPS	EPA's Office of Air Quality Planning and Standards
OAR	EPA's Office of Air and Radiation
OTAQ	EPA's Office of Transportation and Air Quality
ORD	EPA's Office of Research and Development
ORL	One Record per Line
PFC	Portable Fuel Container
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns
PM_{10}	Particulate matter less than or equal to 10 microns

Prescribed fire	Intentionally set fire to clear vegetation
RIA	Regulatory Impact Analysis
RPO	Regional Planning Organization
RRTM	Rapid Radiative Transfer Model
SCC	Source Classification Code
SMARTFIRE	Satellite Mapping Automatic Reanalysis Tool for Fire Incident Reconciliation
SMOKE	Sparse Matrix Operator Kernel Emissions
TCEQ	Texas Commission on Environmental Quality
TSD	Technical support document
VOC	Volatile organic compounds
VMT	Vehicle miles traveled
Wildfire	Uncontrolled forest fire
WRAP	Western Regional Air Partnership

Appendix B

Total U.S. Emissions Summary by Sector and by Region for $PM_{2.5}$

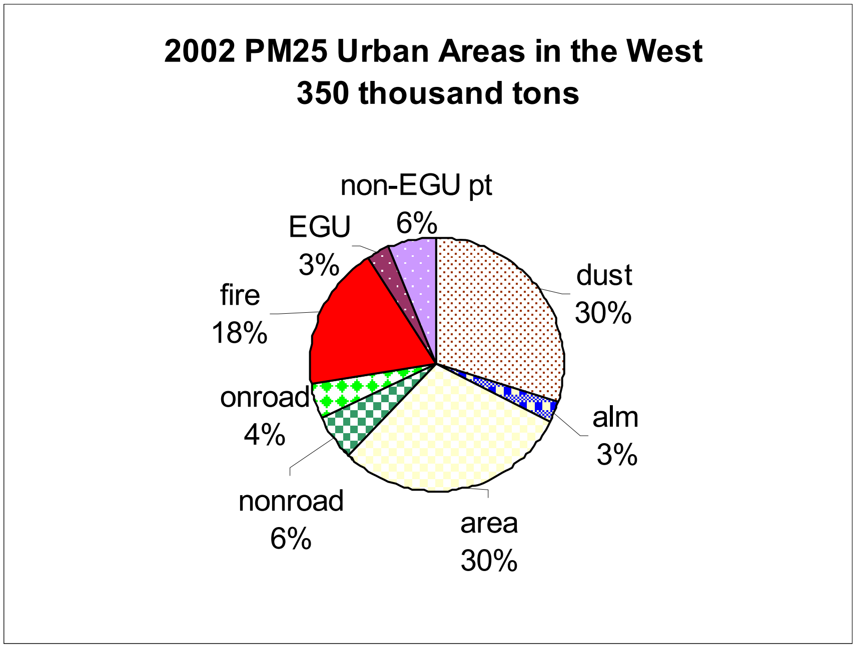


Figure B-1. $PM_{2.5}$ in Urban Areas in Western U.S. (2002)

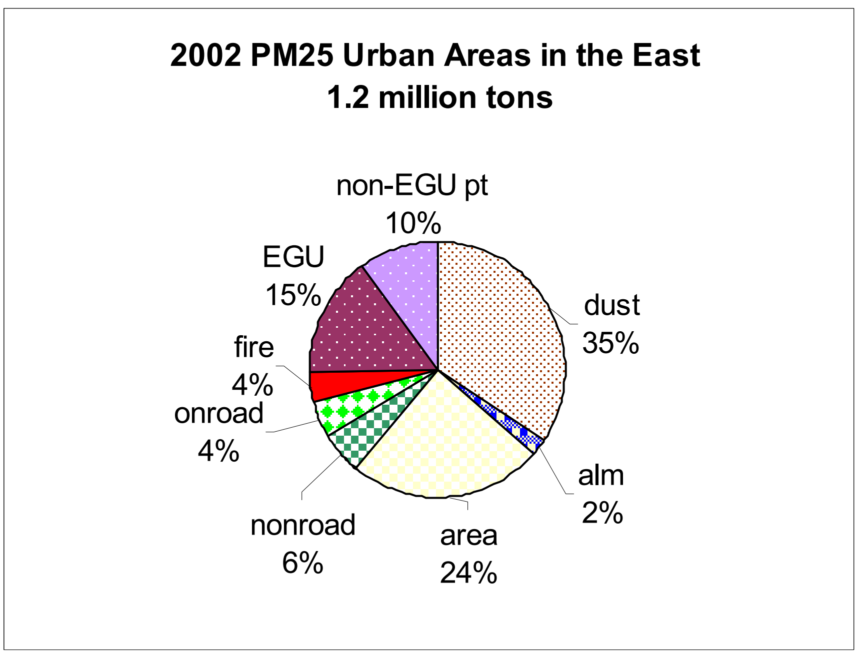


Figure B-2. $PM_{2.5}$ in Urban Areas in Eastern U.S. (2002)

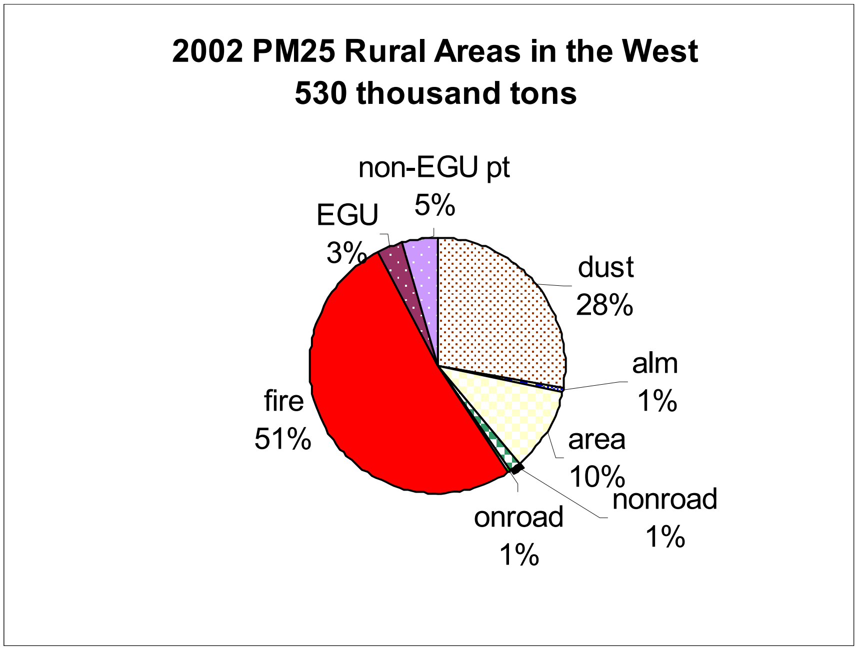


Figure B-3. PM$_{2.5}$ in Rural Areas in Western U.S. (2002)

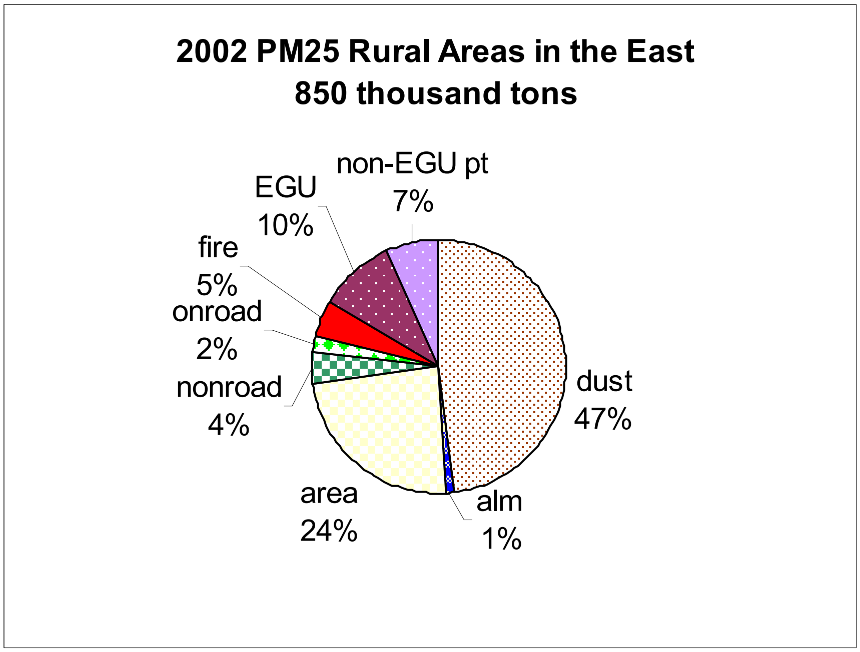


Figure B-4. PM$_{2.5}$ in Rural Areas in Eastern U.S. (2002)

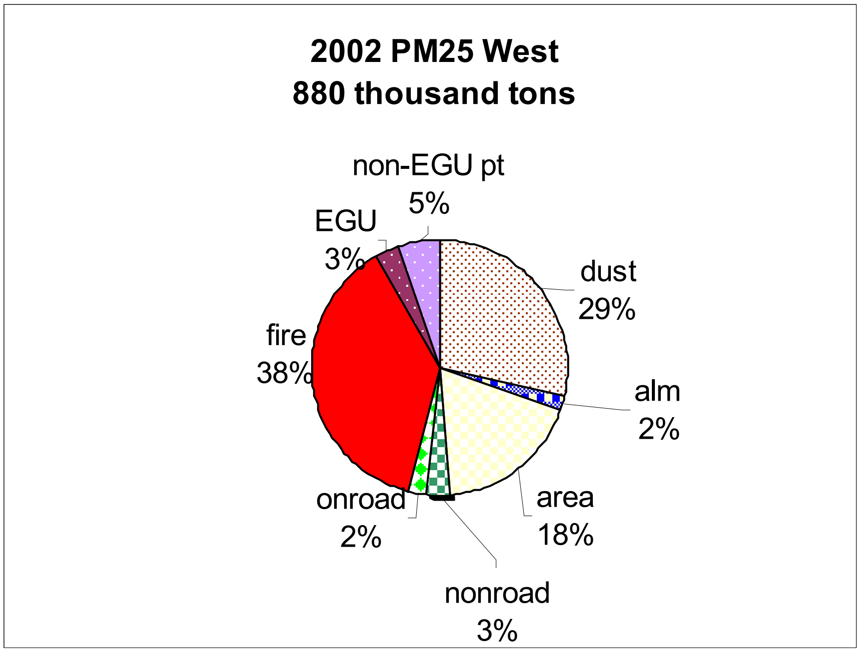


Figure B-5. PM$_{2.5}$ in Western U.S. – Rural and Urban (2002)

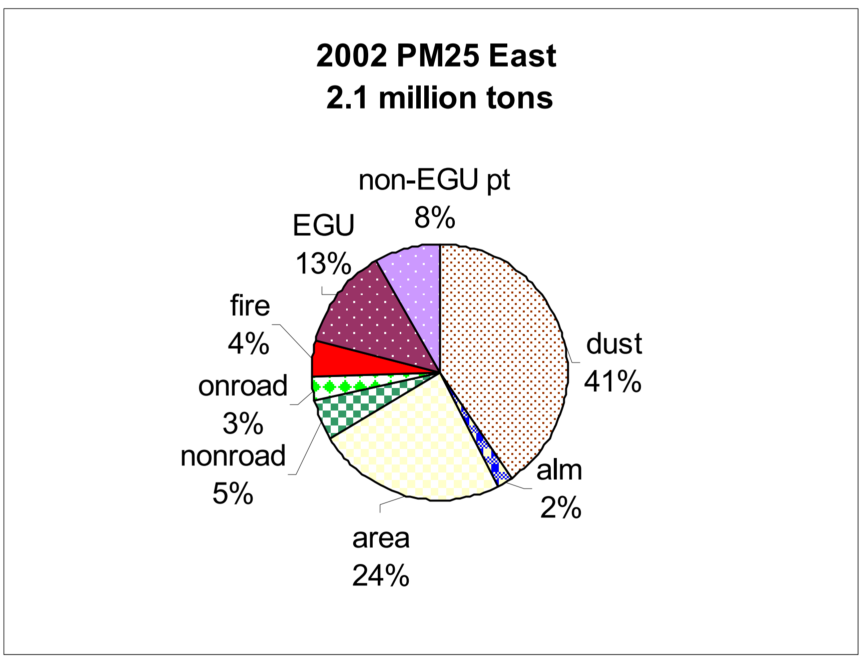


Figure B-6. PM$_{2.5}$ in Eastern U.S. – Rural and Urban (2002)

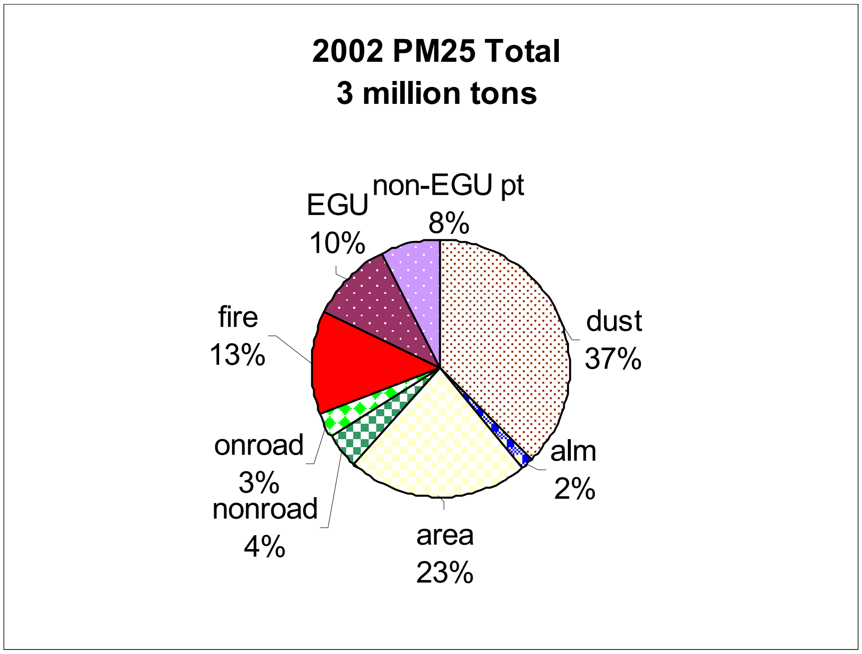


Figure B-7. Total $PM_{2.5}$ in U.S. (2002)

Appendix C

State-Sector Emissions Summaries for 2002

Table C-1. 2002 State Sector Emissions

State-Sector Emissions Summaries for 2002 Base Case
(taken from Appendix D)

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2002 NO_X	[tons/yr] 2002 CO	[tons/yr] 2002 SO_2	[tons/yr] 2002 NH_3	[tons/yr] 2002 PM_{10}	[tons/yr] 2002 $PM_{2.5}$
Alabama	afdust	0	0	0	0	0	100,288	33,476
	ag	0	0	0	0	57,802	0	0
	alm	2,383	36,047	10,328	4,801	13	2,236	1,878
	avefire	8,951	3,814	175,140	983	752	16,251	13,938
	nonpt	213,956	32,024	188,564	52,325	426	27,785	23,973
	nonroad	55,574	29,396	378,753	2,734	28	3,195	3,044
	onroad	104,783	153,968	1,237,459	5,599	5,627	4,223	3,117
	ptipm	1,394	161,767	10,879	448,329	783	26,138	22,612
	ptnonipm	47,722	80,901	174,483	89,762	2,224	19,710	13,647
Alabama Total		**434,763**	**497,917**	**2,175,607**	**604,533**	**67,655**	**199,826**	**115,685**
Arizona	afdust	0	0	0	0	0	121,322	19,626
	ag	0	0	0	0	29,493	0	0
	alm	3,482	30,813	20,495	2,297	12	2,617	2,060
	avefire	21,385	10,532	440,419	2,888	2,020	43,005	37,151
	nonpt	80,463	8,637	44,127	2,571	4,391	12,456	8,596
	nonroad	53,546	38,699	440,675	3,858	35	4,174	3,993
	onroad	85,187	159,756	836,126	2,876	5,150	4,021	2,951
	ptipm	626	85,967	8,185	70,709	566	9,551	7,565
	ptnonipm	4,611	11,439	8,259	21,702	72	5,723	3,044
Arizona Total		**249,300**	**345,843**	**1,798,285**	**106,900**	**41,740**	**202,868**	**84,987**
Arkansas	afdust	0	0	0	0	0	92,523	24,639
	ag	0	0	0	0	110,954	0	0
	alm	2,295	39,743	14,371	4,648	19	1,348	1,243
	avefire	5,821	2,654	123,699	728	556	12,027	10,315
	nonpt	99,381	21,453	174,777	27,260	7,386	24,094	23,062
	nonroad	35,683	28,527	231,619	2,762	23	3,229	3,097
	onroad	56,465	83,722	735,366	3,078	3,001	2,202	1,612
	ptipm	520	42,218	4,182	70,754	346	2,004	1,750
	ptnonipm	32,044	27,605	51,502	19,032	1,255	14,101	9,593
Arkansas Total		**232,209**	**245,923**	**1,335,515**	**128,262**	**123,540**	**151,529**	**75,312**

California	afdust	0	0	0	0	0	196,231	47,562
	ag	0	0	0	0	152,308	0	0
	alm	19,726	175,373	108,995	40,887	180	10,124	9,534
	avefire	54,619	24,563	1,157,187	6,735	5,117	113,231	97,301
	nonpt	461,331	121,882	458,977	77,672	14,758	90,509	73,873
	nonroad	148,269	240,256	1,058,968	1,015	161	18,590	16,334
	onroad	343,693	643,919	3,434,055	4,786	37,468	23,103	12,395
	ptipm	1,288	13,071	23,900	1,018	1,380	1,905	1,876
	ptnonipm	54,610	91,967	97,092	41,761	3,367	26,854	16,655
California Total		**1,083,536**	**1,311,031**	**6,339,176**	**173,874**	**214,738**	**480,546**	**275,530**
Colorado	afdust	0	0	0	0	0	110,878	25,559
	ag	0	0	0	0	62,907	0	0
	alm	1,366	19,208	10,641	1,224	5	606	553
	avefire	13,610	6,271	288,013	1,719	1,299	28,019	24,054
	nonpt	87,037	11,464	85,393	6,460	71	15,059	13,545
	nonroad	42,009	35,398	389,240	3,545	31	3,909	3,746
	onroad	84,387	127,564	1,103,120	4,146	4,408	3,216	2,357
	ptipm	973	79,167	7,578	92,562	453	5,446	4,444
	ptnonipm	90,768	39,499	28,063	5,331	86	17,366	8,922
Colorado Total		**320,150**	**318,571**	**1,912,049**	**114,989**	**69,260**	**184,499**	**83,181**
Connecticut	afdust	0	0	0	0	0	12,528	2,725
	ag	0	0	0	0	4,029	0	0
	alm	845	3,945	12,149	778	1	231	210
	avefire	31	14	667	4	3	65	56
	nonpt	105,580	12,554	69,769	18,455	1,438	10,716	10,446
	nonroad	32,327	17,897	258,776	1,382	17	1,702	1,619
	onroad	47,757	66,813	641,901	1,667	3,257	1,610	1,067
	ptipm	305	6,161	1,920	13,689	182	742	510
	ptnonipm	4,602	6,706	2,133	2,338	91	882	691
Connecticut Total		**191,447**	**114,091**	**987,315**	**38,313**	**9,017**	**28,476**	**17,323**

Delaware	afdust	0	0	0	0	0	6,258	863
	ag	0	0	0	0	12,536	0	0
	alm	483	10,429	2,890	3,470	0	452	401
	avefire	64	23	1,332	6	5	102	87
	nonpt	15,468	3,259	11,640	5,859	279	2,007	1,826
	nonroad	8,677	5,308	65,811	471	5	560	534
	onroad	11,382	21,679	155,366	556	903	572	406
	ptipm	91	9,533	866	33,104	30	1,969	1,693
	ptnonipm	4,659	7,308	8,853	41,342	161	1,041	783
Delaware Total		**40,823**	**57,538**	**246,758**	**84,810**	**13,918**	**12,961**	**6,594**
District of Columbia	afdust	0	0	0	0	0	2,255	411
	alm	22	571	79	45	0	13	13
	avefire	0	0	1	0	0	0	0
	nonpt	4,118	1,740	1,819	1,559	13	489	427
	nonroad	1,918	3,060	18,061	343	2	298	288
	onroad	5,423	8,772	65,418	271	398	219	150
	ptipm	4	710	50	1,432	8	30	22
	ptnonipm	69	418	247	625	4	98	43
District of Columbia Total		**11,554**	**15,271**	**85,676**	**4,275**	**426**	**3,402**	**1,353**
Florida	afdust	0	0	0	0	0	145,566	28,017
	ag	0	0	0	0	37,099	0	0
	alm	3,053	55,127	43,166	6,892	11	2,391	2,175
	avefire	56,159	25,600	1,193,147	7,018	5,366	115,996	99,484
	nonpt	459,700	29,533	202,108	70,489	448	41,371	38,847
	nonroad	239,540	117,138	1,762,587	12,540	125	13,637	13,001
	onroad	362,851	448,520	3,797,717	21,410	18,267	12,433	9,041
	ptipm	2,236	272,057	52,142	473,636	5,013	32,299	28,293
	ptnonipm	37,204	54,078	86,821	57,060	3,030	32,193	23,604
Florida Total		**1,160,742**	**1,002,054**	**7,137,689**	**649,045**	**69,359**	**395,887**	**242,462**

Georgia	afdust	0	0	0	0	0	181,397	59,910
	ag	0	0	0	0	80,733	0	0
	alm	1,776	39,986	11,058	3,247	12	1,332	1,135
	avefire	21,834	7,955	350,924	2,010	1,299	28,079	24,082
	nonpt	248,214	38,919	194,402	56,830	60	46,751	41,847
	nonroad	81,856	57,979	730,260	5,674	52	6,136	5,867
	onroad	185,962	307,544	2,245,133	11,238	10,642	8,539	6,366
	ptipm	1,182	146,351	9,371	512,983	593	31,663	25,407
	ptnonipm	33,735	51,170	131,306	56,203	4,571	21,224	15,692
Georgia Total		**574,559**	**649,905**	**3,672,454**	**648,183**	**97,962**	**325,121**	**180,308**
Idaho	afdust	0	0	0	0	0	139,528	28,351
	ag	0	0	0	0	62,376	0	0
	alm	713	8,297	10,893	645	3	471	447
	avefire	29,989	14,024	630,971	3,845	2,856	61,433	52,808
	nonpt	141,328	30,317	95,417	2,915	1,684	56,403	27,367
	nonroad	23,153	15,611	137,661	1,616	14	1,973	1,889
	onroad	27,934	44,628	389,120	1,310	1,418	1,068	785
	ptipm	0	19	4	0	0	1	1
	ptnonipm	2,113	11,467	23,977	17,597	1,074	4,569	2,528
Idaho Total		**225,230**	**124,363**	**1,288,044**	**27,928**	**69,425**	**265,445**	**114,175**
Illinois	afdust	0	0	0	0	0	444,909	88,100
	ag	0	0	0	0	106,685	0	0
	alm	4,205	120,834	16,365	11,979	45	3,556	3,351
	avefire	156	71	3,323	20	15	323	277
	nonpt	278,553	47,645	99,568	5,395	1,631	16,972	15,181
	nonroad	99,398	115,426	830,513	10,913	88	11,316	10,881
	onroad	164,697	297,056	2,090,188	8,514	10,654	7,772	5,700
	ptipm	1,536	179,125	14,627	366,157	174	19,147	14,783
	ptnonipm	71,066	94,009	78,820	138,126	694	30,111	15,136
Illinois Total		**619,612**	**854,165**	**3,133,402**	**541,103**	**119,986**	**534,106**	**153,409**

Indiana	afdust	0	0	0	0	0	345,635	65,707
	ag	0	0	0	0	90,815	0	0
	alm	2,224	52,285	14,057	5,540	19	1,719	1,561
	avefire	194	88	4,124	24	19	401	344
	nonpt	179,635	30,185	74,953	59,775	4,214	60,255	32,611
	nonroad	58,290	64,575	490,545	5,981	48	6,039	5,803
	onroad	140,188	216,188	1,738,790	8,564	7,343	5,518	4,081
	ptipm	2,015	283,890	15,540	785,603	580	40,884	33,805
	ptnonipm	55,935	80,147	364,487	97,442	3,144	25,808	15,085
Indiana Total		**438,480**	**727,359**	**2,702,495**	**962,930**	**106,183**	**486,257**	**158,996**
Iowa	afdust	0	0	0	0	0	341,542	57,643
	ag	0	0	0	0	245,778	0	0
	alm	1,653	33,166	7,209	2,787	8	1,021	997
	avefire	197	90	4,185	25	19	407	349
	nonpt	77,838	15,150	68,958	19,832	7,404	12,833	11,476
	nonroad	52,138	62,066	309,048	6,248	47	7,210	6,949
	onroad	75,852	115,521	1,055,157	2,999	3,091	2,355	1,726
	ptipm	579	81,995	5,444	133,047	391	9,907	8,904
	ptnonipm	37,943	38,861	36,521	51,329	4,663	13,439	7,572
Iowa Total		**246,201**	**346,849**	**1,486,523**	**216,267**	**261,401**	**388,712**	**95,615**
Kansas	afdust	0	0	0	0	0	455,984	74,515
	ag	0	0	0	0	97,384	0	0
	alm	2,133	41,147	9,118	2,895	11	1,237	1,207
	avefire	828	378	17,600	103	79	1,711	1,468
	nonpt	135,449	42,286	850,800	36,381	12,467	108,571	83,174
	nonroad	24,728	47,653	240,503	4,858	32	5,360	5,179
	onroad	52,786	85,617	683,936	2,893	2,870	2,200	1,629
	ptipm	1,062	96,943	6,793	129,827	421	7,246	5,912
	ptnonipm	26,274	70,704	74,809	10,793	60,100	9,430	4,941
Kansas Total		**243,261**	**384,728**	**1,883,560**	**187,750**	**173,364**	**591,738**	**178,025**

Kentucky	afdust	0	0	0	0	0	99,481	23,529
	ag	0	0	0	0	50,821	0	0
	alm	2,487	70,391	17,830	10,096	15	4,285	3,625
	avefire	2,909	1,326	61,812	364	278	6,010	5,155
	nonpt	105,281	17,557	108,397	34,229	231	23,283	18,590
	nonroad	39,806	31,792	282,098	3,008	25	3,376	3,236
	onroad	82,321	147,749	1,052,158	5,554	4,824	3,816	2,842
	ptipm	1,479	200,955	12,544	486,499	919	22,342	20,004
	ptnonipm	44,884	38,541	110,047	34,482	1,672	16,375	9,937
Kentucky Total		**279,168**	**508,311**	**1,644,885**		**574,230**	**58,787**	**178,967**
Louisiana	afdust	0	0	0	0	0	81,493	20,962
	ag	0	0	0	0	35,159	0	0
	alm	3,960	216,290	45,941	32,796	42	7,000	6,819
	avefire	7,137	3,254	151,658	892	682	14,746	12,647
	nonpt	135,934	27,559	139,222	2,378	23,169	19,038	17,862
	nonroad	61,307	28,899	364,963	2,834	29	3,331	3,174
	onroad	77,802	124,192	943,962	4,409	4,364	3,379	2,506
	ptipm	1,239	82,293	12,682	108,106	1,399	7,487	5,990
	ptnonipm	79,781	211,449	134,203	177,507	7,878	28,722	21,082
Louisiana Total		**367,159**	**693,935**	**1,792,631**	**328,922**	**72,722**	**165,196**	**91,043**
Maine	afdust	0	0	0	0	0	13,067	4,134
	ag	0	0	0	0	6,154	0	0
	alm	365	1,708	3,650	195	1	455	405
	avefire	1,258	566	26,592	150	115	2,480	2,127
	nonpt	88,028	7,423	104,033	9,969	1,616	13,876	13,726
	nonroad	30,025	8,271	138,111	766	11	1,200	1,131
	onroad	26,131	47,227	360,595	1,122	1,467	1,178	876
	ptipm	67	1,188	1,084	2,137	129	86	65
	ptnonipm	5,151	18,895	15,861	20,778	809	5,963	4,268
Maine Total		**151,026**	**85,277**	**649,927**	**35,116**	**10,302**	**38,304**	**26,732**

Maryland	afdust	0	0	0	0	0	35,393	7,393
	ag	0	0	0	0	24,562	0	0
	alm	5,360	17,106	17,581	5,707	22	1,635	496
	avefire	353	137	6,129	32	24	613	531
	nonpt	126,362	21,715	141,960	40,864	606	25,058	19,764
	nonroad	51,369	27,495	414,390	2,577	28	3,102	2,954
	onroad	71,591	121,659	1,004,611	3,966	5,594	3,162	2,194
	ptipm	478	73,527	4,546	256,761	271	17,996	15,722
	ptnonipm	5,758	22,109	94,448	34,255	222	6,303	3,759
Maryland Total		**261,270**	**283,748**	**1,683,666**	**344,162**	**31,330**	**93,261**	**52,813**
Massachusetts	afdust	0	0	0	0	0	49,646	14,810
	ag	0	0	0	0	2,208	0	0
	alm	2,443	17,144	18,602	2,519	7	988	874
	avefire	747	341	15,878	93	71	1,544	1,324
	nonpt	176,731	34,373	136,753	25,261	4,070	28,552	26,536
	nonroad	52,921	30,046	423,212	2,385	28	2,871	2,732
	onroad	71,646	128,362	960,011	3,172	5,509	3,253	2,268
	ptipm	595	32,561	10,922	91,888	1,103	3,730	3,224
	ptnonipm	7,722	15,394	10,656	14,079	403	2,795	1,842
Massachusetts Total		**312,806**	**258,220**	**1,576,034**	**139,397**	**13,401**	**93,379**	**53,610**
Michigan	afdust	0	0	0	0	0	208,843	40,894
	ag	0	0	0	0	55,273	0	0
	alm	2,504	43,025	26,763	14,466	5	2,637	2,389
	avefire	724	330	15,380	91	69	1,495	1,283
	nonpt	248,382	43,499	94,909	42,066	429	30,989	24,216
	nonroad	173,241	70,912	1,013,991	6,367	78	8,199	7,782
	onroad	207,762	315,420	2,744,658	13,508	9,813	7,881	5,894
	ptipm	1,243	141,908	13,367	348,377	286	13,170	10,648
	ptnonipm	39,832	82,202	66,873	72,631	952	17,151	10,346
Michigan Total		**673,689**	**697,296**	**3,975,941**	**497,505**	**66,906**	**290,363**	**103,451**

Minnesota	afdust	0	0	0	0	0	432,054	79,303
	ag	0	0	0	0	134,830	0	0
	alm	1,611	55,371	8,411	6,592	12	1,665	1,643
	avefire	5,047	2,300	107,237	631	482	10,427	8,943
	nonpt	125,318	56,700	139,234	14,747	1,226	26,968	24,496
	nonroad	97,104	68,820	452,734	6,525	59	8,097	7,759
	onroad	102,566	163,172	1,314,360	2,816	5,362	3,790	2,740
	ptipm	646	86,917	7,468	102,152	69	7,437	234
	ptnonipm	29,541	67,813	47,015	27,263	27,525	22,425	4,097
Minnesota Total		**361,833**	**501,094**	**2,076,459**	**160,725**	**169,566**	**512,863**	**129,215**
Mississippi	afdust	0	0	0	0	0	139,219	38,120
	ag	0	0	0	0	58,575	0	0
	alm	2,386	66,650	10,656	9,163	18	3,057	2,668
	avefire	8,407	3,833	178,646	1,051	804	17,370	14,897
	nonpt	156,390	12,212	129,408	6,796	196	17,827	16,769
	nonroad	36,056	22,180	214,179	2,119	19	2,479	2,370
	onroad	62,375	105,505	739,190	3,591	3,606	3,058	2,309
	ptipm	629	45,850	5,286	67,593	456	3,122	2,625
	ptnonipm	43,224	60,244	54,587	36,519	1,414	19,535	10,019
Mississippi Total		**309,467**	**316,473**	**1,331,952**	**126,831**	**65,088**	**205,667**	**89,778**
Missouri	afdust	0	0	0	0	0	458,324	96,070
	ag	0	0	0	0	107,023	0	0
	alm	3,439	79,583	18,171	8,610	19	2,548	2,489
	avefire	1,488	678	31,611	186	142	3,074	2,636
	nonpt	162,795	32,910	168,352	44,573	3,830	32,399	28,217
	nonroad	63,279	52,997	479,319	5,143	43	5,929	5,690
	onroad	124,106	200,379	1,598,930	6,148	6,918	5,199	3,819
	ptipm	1,496	145,232	10,827	249,942	705	8,868	5,818
	ptnonipm	34,704	38,025	108,389	111,547	322	14,083	7,424
Missouri Total		**391,308**	**549,803**	**2,415,599**	**426,149**	**119,002**	**530,423**	**152,163**

Montana	afdust	0	0	0	0	0	188,368	40,180
	ag	0	0	0	0	45,890	0	0
	alm	1,309	22,873	5,814	1,688	6	711	690
	avefire	10,085	5,187	203,759	1,422	946	19,949	17,311
	nonpt	23,573	3,797	35,673	1,961	50	5,765	5,569
	nonroad	12,968	18,777	85,304	2,009	14	2,344	2,261
	onroad	20,451	36,727	283,678	1,062	1,032	908	688
	ptipm	355	36,577	3,047	23,396	11	2,404	2,077
	ptnonipm	6,807	16,588	29,410	13,271	265	5,538	2,576
Montana Total		**75,548**	**140,526**	**646,686**	**44,809**	**48,214**	**225,987**	**71,352**
Nebraska	afdust	0	0	0	0	0	320,650	50,787
	ag	0	0	0	0	166,773	0	0
	alm	3,524	68,904	10,222	4,764	18	1,958	1,942
	avefire	837	381	17,780	105	80	1,729	1,483
	nonpt	40,762	13,820	66,672	29,575	3,143	12,679	8,655
	nonroad	18,442	39,889	155,107	4,181	27	4,637	4,484
	onroad	36,940	66,226	473,870	2,011	1,874	1,723	1,312
	ptipm	635	47,900	3,420	67,576	190	1,551	1,191
	ptnonipm	6,527	11,385	5,717	6,018	421	1,623	806
Nebraska Total		**107,667**	**248,506**	**732,788**	**114,229**	**172,525**	**346,550**	**70,659**
Nevada	afdust	0	0	0	0	0	61,096	11,371
	ag	0	0	0	0	5,598	0	0
	alm	1,057	12,958	11,214	990	3	445	419
	avefire	10,740	4,910	227,965	1,346	1,026	22,169	19,018
	nonpt	22,874	5,308	14,700	12,476	199	4,389	2,735
	nonroad	22,720	18,990	208,377	2,025	17	2,115	2,027
	onroad	26,884	28,320	301,082	360	1,532	644	399
	ptipm	483	48,366	2,798	49,276	460	3,629	3,283
	ptnonipm	1,649	7,509	6,985	1,342	164	3,240	1,435
Nevada Total		**86,406**	**126,362**	**773,121**	**67,815**	**8,999**	**97,728**	**40,687**

New Hampshire	afdust	0	0	0	0	0	6,175	2,194
	ag	0	0	0	0	1,354	0	0
	alm	118	1,866	2,305	238	0	98	86
	avefire	301	137	6,398	38	29	622	534
	nonpt	61,483	11,235	74,137	7,408	835	13,351	12,658
	nonroad	21,832	8,150	122,530	673	9	942	891
	onroad	21,682	38,799	294,533	880	1,266	969	714
	ptipm	104	7,000	643	44,009	58	2,632	2,305
	ptnonipm	1,496	2,786	2,082	2,570	56	459	390
New Hampshire Total		**107,015**	**69,973**	**502,627**	**55,815**	**3,607**	**25,248**	**19,772**
New Jersey	afdust	0	0	0	0	0	16,305	1,392
	ag	0	0	0	0	3,827	0	0
	alm	2,236	35,998	14,960	14,587	11	1,786	1,611
	avefire	488	223	10,375	61	47	1,009	865
	nonpt	151,657	26,393	84,145	10,726	2,648	15,987	13,074
	nonroad	78,629	40,876	635,064	3,378	41	4,162	3,958
	onroad	101,094	161,872	1,325,445	3,658	7,635	3,805	2,537
	ptipm	1,048	34,188	3,865	51,299	170	4,835	4,010
	ptnonipm	13,282	17,206	8,375	9,930	475	3,131	2,464
New Jersey Total		**348,436**	**316,756**	**2,082,228**	**93,640**	**14,854**	**51,020**	**29,910**
New Mexico	afdust	0	0	0	0	0	440,334	80,348
	ag	0	0	0	0	36,340	0	0
	alm	1,982	36,714	8,473	2,550	9	1,110	1,084
	avefire	27,488	12,582	583,216	3,450	2,626	56,719	48,662
	nonpt	36,950	7,532	29,666	2,825	39	5,984	5,346
	nonroad	13,499	9,681	119,501	975	9	1,062	1,016
	onroad	45,763	77,574	587,028	2,254	2,323	1,965	1,476
	ptipm	563	78,547	5,539	51,016	10	8,024	5,557
	ptnonipm	15,691	60,358	32,228	18,179	44	3,986	3,290
New Mexico Total		**141,935**	**282,988**	**1,365,651**	**81,249**	**41,401**	**519,183**	**146,779**

New York	afdust	0	0	0	0	0	139,896	29,997
	ag	0	0	0	0	49,281	0	0
	alm	2,473	40,659	22,205	9,353	29	1,780	1,394
	avefire	903	412	19,195	113	86	1,866	1,601
	nonpt	608,921	89,986	404,592	125,559	3,964	83,468	58,823
	nonroad	151,345	78,279	1,175,721	6,797	79	8,303	7,909
	onroad	212,929	290,698	2,822,801	8,075	14,582	8,059	5,547
	ptipm	857	81,201	12,204	238,034	2,439	13,669	12,081
	ptnonipm	6,218	38,992	54,133	59,078	1,241	8,565	4,410
New York Total		**983,646**	**620,228**	**4,510,852**	**447,008**	**71,702**	**265,606**	**121,762**
North Carolina	afdust	0	0	0	0	0	91,287	25,474
	ag	0	0	0	0	158,188	0	0
	alm	1,472	22,608	9,957	1,840	7	6,752	4,789
	avefire	58,889	11,424	429,388	696	532	11,509	9,870
	nonpt	231,094	18,869	321,101	22,020	236	40,945	38,389
	nonroad	88,972	61,664	746,344	5,750	54	6,313	6,035
	onroad	143,187	242,379	1,786,813	8,683	7,953	6,517	4,874
	ptipm	920	153,226	12,112	471,337	124	22,259	16,031
	ptnonipm	61,685	49,273	52,414	56,065	1,485	13,744	9,828
North Carolina Total		**586,219**	**559,444**	**3,358,129**	**566,392**	**168,580**	**199,327**	**115,291**
North Dakota	afdust	0	0	0	0	0	269,751	50,500
	ag	0	0	0	0	71,302	0	0
	alm	1,256	23,072	4,832	1,601	6	684	670
	avefire	527	240	11,204	66	50	1,089	934
	nonpt	14,911	4,007	20,488	5,768	69	3,751	3,241
	nonroad	13,565	38,012	91,869	4,106	25	4,634	4,486
	onroad	15,356	24,832	206,627	700	733	608	455
	ptipm	781	75,947	5,237	140,535	378	7,625	6,479
	ptnonipm	1,249	9,929	5,778	15,449	139	1,437	1,105
North Dakota Total		**47,645**	**176,039**	**346,035**	**168,224**	**72,703**	**289,580**	**67,870**

Ohio	afdust	0	0	0	0	0	236,316	49,900
	ag	0	0	0	0	98,711	0	0
	alm	3,632	96,728	29,188	11,191	32	3,393	3,113
	avefire	178	81	3,787	22	17	368	316
	nonpt	285,528	41,466	150,302	19,810	8,527	25,444	23,761
	nonroad	103,414	90,812	910,152	8,254	74	8,400	8,043
	onroad	205,348	327,388	2,600,918	12,682	10,986	8,049	5,933
	ptipm	1,773	373,299	14,817	1,145,194	74	62,308	55,730
	ptnonipm	29,515	65,850	238,412	111,233	6,370	14,370	10,000
Ohio Total		**629,389**	**995,625**	**3,947,575**	**1,308,387**	**124,789**	**358,650**	**156,798**
Oklahoma	afdust	0	0	0	0	0	395,931	70,686
	ag	0	0	0	0	95,061	0	0
	alm	1,551	26,294	10,093	1,890	7	886	841
	avefire	3,749	1,709	79,673	469	359	7,747	6,644
	nonpt	200,442	94,574	385,235	7,542	11,358	54,339	43,886
	nonroad	38,015	31,331	308,218	3,093	26	3,494	3,353
	onroad	86,133	133,152	1,069,135	5,344	4,626	3,501	2,592
	ptipm	984	90,302	13,661	111,841	909	3,350	1,722
	ptnonipm	35,176	72,670	50,750	38,495	3,118	9,175	5,241
Oklahoma Total		**366,050**	**450,033**	**1,916,764**	**168,673**	**115,463**	**478,422**	**134,966**
Oregon	afdust	0	0	0	0	0	82,013	30,637
	ag	0	0	0	0	40,655	0	0
	alm	1,843	43,439	12,401	4,212	9	1,498	1,371
	avefire	37,328	17,857	778,193	4,896	3,542	75,861	65,350
	nonpt	242,829	16,998	342,444	9,845	1,061	50,681	49,407
	nonroad	39,821	26,372	304,850	2,559	24	2,902	2,773
	onroad	91,766	109,066	1,078,005	3,488	3,270	2,707	2,021
	ptipm	142	9,006	1,105	12,285	162	711	326
	ptnonipm	14,567	15,958	34,389	5,307	787	9,828	6,203
Oregon Total		**428,297**	**238,696**	**2,551,388**	**42,592**	**49,509**	**226,200**	**158,088**

Pennsylvania	afdust	0	0	0	0	0	130,508	32,224
	ag	0	0	0	0	76,675	0	0
	alm	2,425	67,118	25,047	8,354	14	2,376	2,268
	avefire	256	117	5,450	32	25	530	454
	nonpt	281,740	53,435	265,035	68,349	3,689	41,841	31,263
	nonroad	96,797	62,168	856,737	5,203	55	6,256	5,969
	onroad	184,268	294,414	2,420,525	7,885	10,618	7,250	5,219
	ptipm	1,212	210,149	17,018	907,734	401	63,198	53,067
	ptnonipm	36,871	89,064	104,570	88,132	1,334	22,391	11,549
Pennsylvania Total		**603,569**	**776,465**	**3,694,382**	**1,085,688**	**92,811**	**274,351**	**142,015**
Rhode Island	afdust	0	0	0	0	0	2,501	481
	ag	0	0	0	0	235	0	0
	alm	162	876	2,923	78	0	8	0
	avefire	8	4	171	1	1	17	14
	nonpt	16,875	2,964	5,421	3,365	15	1,171	1,107
	nonroad	8,491	4,663	65,923	354	4	427	406
	onroad	14,366	16,720	188,240	425	854	343	209
	ptipm	39	712	453	18	58	12	11
	ptnonipm	1,894	2,060	1,781	2,649	47	288	173
South Carolina	afdust	0	0	0	0	0	82,088	25,657
	ag	0	0	0	0	27,945	0	0
	alm	961	19,378	9,393	1,946	4	714	668
	avefire	5,171	2,357	109,880	646	494	10,684	9,163
	nonpt	185,429	20,281	145,294	30,016	223	19,393	18,139
	nonroad	50,041	29,982	377,166	2,816	27	3,102	2,960
	onroad	89,994	134,542	1,141,561	5,021	4,710	3,588	2,648
	ptipm	506	91,296	4,749	212,572	306	17,707	13,734
	ptnonipm	36,778	40,417	56,640	57,307	1,552	12,696	8,159
South Carolina Total		**368,879**	**338,253**	**1,844,682**	**310,324**	**35,263**	**149,971**	**81,128**

South Dakota	afdust	0	0	0	0	0	202,326	38,332
	ag	0	0	0	0	101,949	0	0
	alm	321	4,164	2,979	318	1	172	156
	avefire	3,985	1,817	84,689	498	381	8,235	7,062
	nonpt	19,597	5,200	24,107	10,304	51	6,683	4,463
	nonroad	12,322	27,219	79,151	2,901	18	3,289	3,181
	onroad	16,177	29,910	219,053	852	843	746	564
	ptipm	111	15,922	632	12,545	50	450	420
	ptnonipm	2,431	4,776	4,068	1,480	50	609	291
South Dakota Total		**54,944**	**89,008**	**414,679**	**28,898**	**103,343**	**222,509**	**54,470**
Tennessee	afdust	0	0	0	0	0	95,767	22,530
	ag	0	0	0	0	34,210	0	0
	alm	2,152	50,692	13,001	6,292	12	1,853	1,707
	avefire	2,220	1,012	47,175	277	212	4,587	3,934
	nonpt	148,677	18,676	119,973	32,714	164	26,842	20,663
	nonroad	60,023	40,970	460,143	3,728	35	4,225	4,040
	onroad	140,405	240,312	1,681,568	7,674	6,671	6,128	4,667
	ptipm	843	155,926	6,596	333,618	425	16,268	13,910
	ptnonipm	84,610	69,070	115,767	84,316	2,394	30,328	22,054
Tennessee Total		**438,930**	**576,659**	**2,444,222**	**468,619**	**44,124**	**185,996**	**93,505**
Texas	afdust	0	0	0	0	0	1,290,391	242,993
	ag	0	0	0	0	354,873	0	0
	alm	11,279	236,223	67,547	27,280	57	8,936	8,146
	avefire	13,201	4,890	256,966	1,178	1,118	25,228	21,578
	nonpt	695,600	274,338	463,577	109,215	1,983	72,265	47,394
	nonroad	174,723	152,771	1,578,739	14,990	128	15,766	15,126
	onroad	308,904	621,483	3,787,848	21,522	21,943	16,034	11,699
	ptipm	4,745	259,612	215,207	562,594	5,941	34,257	24,920
	ptnonipm	149,554	344,073	283,294	245,060	2,297	38,861	27,189
Texas Total		**1,358,006**	**1,893,390**	**6,653,179**	**981,840**	**388,340**	**1,501,740**	**399,045**

Tribal Data	alm	218	858	302	132	1	58	0
	ptipm	241	97	828	6	65	31	31
	ptnonipm	601	6,623	2,573	204	4	1,872	856
Tribal Data Total[1]		**1,060**	**7,578**	**3,703**	**342**	**69**	**1,961**	**887**
Utah	afdust	0	0	0	0	0	54,020	7,864
	ag	0	0	0	0	20,448	0	0
	alm	2,596	14,640	10,805	1,065	5	153	140
	avefire	15,469	7,052	328,713	1,934	1,479	31,961	27,412
	nonpt	54,443	6,948	79,323	3,427	1,268	10,385	9,079
	nonroad	25,488	15,026	172,729	1,437	14	1,703	1,625
	onroad	56,206	76,518	764,714	1,989	2,457	1,658	1,187
	ptipm	418	73,220	4,506	33,167	269	6,351	4,901
	ptnonipm	5,826	14,998	45,052	9,305	529	6,893	2,955
Utah Total		**160,444**	**208,401**	**1,405,842**	**52,325**	**26,469**	**113,124**	**55,162**
Vermont	afdust	0	0	0	0	0	13,658	4,814
	ag	0	0	0	0	8,821	0	0
	alm	53	49	1,220	6	0	29	21
	avefire	393	179	8,347	49	38	812	696
	nonpt	18,887	3,438	43,091	5,385	214	5,823	5,415
	nonroad	10,446	4,170	58,906	368	5	516	490
	onroad	18,139	21,783	237,164	622	939	645	465
	ptipm	0	0	0	0	11	0	0
	ptnonipm	1,097	790	1,078	911	16	337	237
Vermont Total		**49,015**	**30,409**	**349,807**	**7,341**	**10,043**	**21,819**	**12,137**

Virginia	afdust	0	0	0	0	0	60,865	19,662
	ag	0	0	0	0	43,811	0	0
	alm	3,084	39,676	17,758	5,595	13	1,905	1,836
	avefire	3,194	1,456	67,866	399	305	6,599	5,659
	nonpt	201,748	53,605	208,041	32,923	1,621	53,941	29,947
	nonroad	67,441	45,848	520,042	4,289	41	4,809	4,593
	onroad	125,474	214,393	1,722,600	6,662	7,889	4,939	3,486
	ptipm	726	86,763	6,714	239,777	192	15,400	14,431
	ptnonipm	43,184	61,730	63,978	67,691	3,500	13,041	9,734
Virginia Total		**444,850**	**503,471**	**2,606,999**	**357,338**	**57,373**	**161,498**	**89,350**
Washington	afdust	0	0	0	0	0	106,176	26,908
	ag	0	0	0	0	42,133	0	0
	alm	2,248	66,992	20,193	11,488	151	2,416	2,271
	avefire	2,674	1,484	52,086	407	248	5,126	4,487
	nonpt	166,658	16,911	204,125	7,254	1,711	35,624	31,983
	nonroad	64,611	42,800	486,615	5,380	39	4,776	4,567
	onroad	159,797	199,767	1,820,900	5,539	5,168	4,545	3,407
	ptipm	219	16,122	1,665	19,108	62	2,456	2,025
	ptnonipm	12,429	24,522	39,106	24,623	774	4,970	3,224
Washington Total		**408,636**	**368,598**	**2,624,689**	**73,799**	**50,285**	**166,089**	**78,872**
West Virginia	afdust	0	0	0	0	0	24,640	11,305
	ag	0	0	0	0	9,879	0	0
	alm	1,180	32,148	5,139	5,707	8	1,478	1,281
	avefire	1,721	785	36,578	215	165	3,557	3,050
	nonpt	59,489	14,519	70,069	14,589	72	12,220	11,130
	nonroad	16,935	8,407	117,839	780	8	1,005	956
	onroad	36,949	60,216	502,130	2,675	1,950	1,542	1,149
	ptipm	1,175	227,827	10,319	509,488	210	31,248	28,884
	ptnonipm	14,241	46,627	89,898	54,107	688	10,625	7,450
West Virginia Total		**131,691**	**390,529**	**831,973**	**587,561**	**12,981**	**86,314**	**65,205**

Wisconsin	afdust	0	0	0	0	0	103,735	30,705
	ag	0	0	0	0	113,949	0	0
	alm	2,060	30,307	24,321	4,781	11	1,353	1,182
	avefire	561	256	11,924	70	54	1,159	994
	nonpt	230,068	21,994	166,779	6,369	266	26,104	25,407
	nonroad	111,779	53,430	569,467	5,015	52	6,090	5,796
	onroad	96,058	172,043	1,321,240	7,218	6,006	4,479	3,317
	ptipm	964	91,128	10,725	192,946	375	5,576	5,029
	ptnonipm	31,057	38,283	34,197	63,651	397	10,466	5,856
Wisconsin Total		**472,549**	**407,440**	**2,138,654**	**280,051**	**121,110**	**158,961**	**78,287**
Wyoming	afdust	0	0	0	0	0	272,299	41,010
	ag	0	0	0	0	18,575	0	0
	alm	1,569	30,368	4,758	2,088	8	866	857
	avefire	8,852	4,035	188,099	1,106	846	18,289	15,686
	nonpt	16,411	4,309	19,192	6,181	91	3,717	2,922
	nonroad	9,088	5,470	53,551	559	5	689	659
	onroad	18,072	32,643	246,059	905	893	799	606
	ptipm	849	85,207	7,078	83,423	386	9,599	7,936
	ptnonipm	16,771	36,500	23,341	33,676	301	19,234	14,143
Wyoming Total		**71,613**	**198,533**	**542,078**	**127,938**	**21,104**	**325,494**	**83,819**
Grand Total		**17,693,869**	**20,931,673**	**101,885,285**	**14,649,986**	**3,901,951**	**12,817,898**	**4,938,898**

[1]The small quantity of "alm" tribal emissions that were in the SMOKE inputs were not modeled because the extent to which they may have already been accounted for in the county estimates was not known. The point estimates were modeled.

Appendix D

State-Sector Emissions Summaries for 2002 Base and Future-Year Base Cases: 2009, 2014, 2020 and 2030

The following tables contain the state-sector emission summaries for the 2002 base case and future-year base cases. Table D-1a contains data for VOC, NOX and CO, and Table D-1b contains data for SO2, NH3, PM_{10}, and $PM_{2.5}$.

Table D-1a: Continental US, VOC, NOx, and CO Emissions by Sector for 2002, and Projection years 2009, 2014, 2020, and 2030

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Alabama	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,383	2,831	2,916	3,065	3,379	36,047	32,548	32,194	32,815	35,753	10,328	11,057	11,603	12,303	13,561
	avefire	8,951	8,951	8,951	8,951	8,951	3,814	3,814	3,814	3,814	3,814	175,140	175,140	175,140	175,140	175,140
	nonpt	213,956	205,838	197,006	193,002	193,002	32,024	31,978	31,945	31,906	31,906	188,564	184,082	180,879	177,034	177,034
	nonroad	55,574	46,218	40,250	36,029	36,955	29,396	25,392	20,092	15,494	13,611	378,753	253,823	237,277	242,916	267,149
	onroad	104,783	67,451	53,305	43,750	39,517	153,968	91,435	57,113	37,772	28,545	1,237,459	733,435	637,881	615,780	640,439
	ptipm	1,394	1,335	1,423	1,462	1,462	161,767	71,365	47,854	39,998	39,998	10,879	13,708	15,854	15,825	15,825
	ptnonipm	47,722	38,365	38,365	38,365	38,365	80,901	68,040	68,040	68,040	68,040	174,483	174,092	174,092	174,092	174,092
Alabama Total		**434,763**	**370,990**	**342,216**	**324,624**	**321,631**	**497,917**	**324,573**	**261,053**	**229,839**	**221,667**	**2,175,607**	**1,545,339**	**1,432,727**	**1,413,091**	**1,463,241**
Arizona	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	3,482	3,599	3,818	4,102	4,374	30,813	26,449	26,197	26,459	26,959	20,495	21,458	23,081	24,938	27,011
	avefire	21,385	21,385	21,385	21,385	21,385	10,532	10,532	10,532	10,532	10,532	440,419	440,419	440,419	440,419	440,419
	nonpt	80,463	76,919	71,758	71,115	71,115	8,637	8,618	8,605	8,589	8,589	44,127	42,569	41,456	40,120	40,120
	nonroad	53,546	41,848	37,833	35,883	38,007	38,699	32,525	25,480	18,219	14,796	440,675	337,232	321,243	336,841	376,783
	onroad	85,187	65,051	54,052	46,416	46,068	159,756	104,428	66,634	43,914	37,539	836,126	621,952	567,416	580,651	693,201
	ptipm	626	947	950	992	992	85,967	74,862	50,463	50,569	50,569	8,185	19,127	19,204	18,769	18,769
	ptnonipm	4,611	4,164	4,164	4,164	4,164	11,439	11,439	11,439	11,439	11,439	8,259	8,259	8,259	8,259	8,259
Arizona Total		**249,300**	**213,913**	**193,959**	**184,056**	**186,105**	**345,843**	**268,853**	**199,350**	**169,721**	**160,422**	**1,798,285**	**1,491,014**	**1,421,078**	**1,449,996**	**1,604,562**
Arkansas	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,295	2,357	2,380	2,418	2,514	39,743	34,685	33,722	33,539	35,309	14,371	14,980	15,847	16,829	18,376
	avefire	5,821	5,821	5,821	5,821	5,821	2,654	2,654	2,654	2,654	2,654	123,699	123,699	123,699	123,699	123,699
	nonpt	99,381	96,818	92,455	91,751	91,751	21,453	21,436	21,424	21,410	21,410	174,777	173,439	172,484	171,336	171,336
	nonroad	35,683	31,954	27,582	23,439	23,324	28,527	24,467	19,384	14,231	10,579	231,619	162,754	151,555	152,274	163,858
	onroad	56,465	36,323	29,742	24,814	23,579	83,722	50,832	32,840	22,581	18,207	735,366	426,247	372,017	360,469	396,136

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
	ptipm	520	690	790	799	799	42,218	24,262	26,839	26,271	26,271	4,182	9,082	12,018	10,968	10,968
	ptnonipm	32,044	27,717	27,717	27,717	27,717	27,605	27,370	27,370	27,370	27,370	51,502	51,437	51,437	51,437	51,437
Arkansas Total		**232,209**	**201,682**	**186,488**	**176,760**	**175,506**	**245,923**	**185,706**	**164,233**	**148,055**	**141,799**	**1,335,515**	**961,639**	**899,055**	**887,013**	**935,810**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
California	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	19,726	20,089	20,729	21,681	23,104	175,373	161,455	155,977	154,530	164,113	108,995	112,003	117,785	124,485	133,684
	avefire	54,619	54,619	54,619	54,619	54,619	24,563	24,563	24,563	24,563	24,563	1,157,187	1,157,187	1,157,187	1,157,187	1,157,187
	nonpt	461,331	450,831	449,537	451,112	451,112	121,882	121,674	121,525	121,347	121,347	458,977	447,100	438,618	428,438	428,438
	nonroad	148,269	127,633	114,489	108,594	128,506	240,256	193,950	153,910	110,789	84,400	1,058,968	1,028,012	1,040,768	1,101,374	1,313,702
	onroad	343,693	202,321	149,537	114,486	87,676	643,919	492,500	346,901	231,335	160,727	3,434,055	1,942,479	1,360,507	935,177	654,302
	ptipm	1,288	1,076	1,372	1,800	1,800	13,071	13,111	15,031	16,691	16,691	23,900	53,864	65,409	82,171	82,171
	ptnonipm	54,610	46,571	46,767	47,121	47,121	91,967	91,434	91,261	92,143	92,143	97,092	97,332	98,997	100,789	100,789
California Total		**1,083,536**	**903,139**	**837,050**	**799,413**	**793,938**	**1,311,031**	**1,098,687**	**909,168**	**751,398**	**663,984**	**6,339,176**	**4,837,976**	**4,279,271**	**3,929,619**	**3,870,272**
Colorado	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,366	1,453	1,499	1,557	1,608	19,208	16,132	15,818	15,869	16,103	10,641	11,608	12,543	13,661	14,931
	avefire	13,610	13,610	13,610	13,610	13,610	6,271	6,271	6,271	6,271	6,271	288,013	288,013	288,013	288,013	288,013
	nonpt	87,037	85,653	83,973	84,311	84,311	11,464	11,412	11,375	11,331	11,331	85,393	82,106	79,758	76,940	76,940
	nonroad	42,009	33,318	30,177	27,864	29,057	35,398	30,263	24,069	17,609	13,876	389,240	263,050	250,944	261,675	291,702
	onroad	84,387	61,463	53,663	46,984	46,833	127,564	83,534	55,858	40,184	36,093	1,103,120	709,657	659,782	681,244	822,227
	ptipm	973	731	769	838	838	79,167	64,412	60,593	61,605	61,605	7,578	11,267	12,124	11,529	11,529
	ptnonipm	90,768	37,097	35,068	34,442	34,442	39,499	38,342	38,342	38,342	38,342	28,063	27,533	27,533	27,533	27,533
Colorado Total		**320,150**	**233,324**	**218,759**	**209,606**	**210,698**	**318,571**	**250,366**	**212,326**	**191,211**	**183,620**	**1,912,049**	**1,393,233**	**1,330,698**	**1,360,595**	**1,532,875**
Connecticut	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	845	876	956	1,061	1,169	3,945	3,834	3,868	4,003	4,140	12,149	12,666	13,976	15,652	17,271
	avefire	31	31	31	31	31	14	14	14	14	14	667	667	667	667	667
	nonpt	105,580	100,907	99,011	96,848	96,848	12,554	12,498	12,459	12,411	12,411	69,769	65,429	62,328	58,604	58,604
	nonroad	32,327	23,609	20,404	19,242	20,383	17,897	14,869	11,646	9,285	8,635	258,776	188,681	175,215	181,777	203,437
	onroad	47,757	30,899	24,426	18,176	15,441	66,813	38,434	23,218	13,530	8,997	641,901	369,126	315,324	293,072	307,897
	ptipm	305	109	134	181	181	6,161	3,391	4,095	5,447	5,447	1,920	8,434	8,853	8,932	8,932
	ptnonipm	4,602	4,182	4,182	4,182	4,182	6,706	6,571	6,571	6,571	6,571	2,133	2,131	2,131	2,131	2,131
Connecticut Total		**191,447**	**160,613**	**149,143**	**139,721**	**138,234**	**114,091**	**79,613**	**61,871**	**51,261**	**46,215**	**987,315**	**647,133**	**578,494**	**560,836**	**598,940**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
California	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	19,726	20,089	20,729	21,681	23,104	175,373	161,455	155,977	154,530	164,113	108,995	112,003	117,785	124,485	133,684
	avefire	54,619	54,619	54,619	54,619	54,619	24,563	24,563	24,563	24,563	24,563	1,157,187	1,157,187	1,157,187	1,157,187	1,157,187
	nonpt	461,331	450,831	449,537	451,112	451,112	121,882	121,674	121,525	121,347	121,347	458,977	447,100	438,618	428,438	428,438
	nonroad	148,269	127,633	114,489	108,594	128,506	240,256	193,950	153,910	110,789	84,400	1,058,968	1,028,012	1,040,768	1,101,374	1,313,702
	onroad	343,693	202,321	149,537	114,486	87,676	643,919	492,500	346,901	231,335	160,727	3,434,055	1,942,479	1,360,507	935,177	654,302
	ptipm	1,288	1,076	1,372	1,800	1,800	13,071	13,111	15,031	16,691	16,691	23,900	53,864	65,409	82,171	82,171
	ptnonipm	54,610	46,571	46,767	47,121	47,121	91,967	91,434	91,261	92,143	92,143	97,092	97,332	98,997	100,789	100,789
California Total		**1,083,536**	**903,139**	**837,050**	**799,413**	**793,938**	**1,311,031**	**1,098,687**	**909,168**	**751,398**	**663,984**	**6,339,176**	**4,837,976**	**4,279,271**	**3,929,619**	**3,870,272**
Colorado	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,366	1,453	1,499	1,557	1,608	19,208	16,132	15,818	15,869	16,103	10,641	11,608	12,543	13,661	14,931
	avefire	13,610	13,610	13,610	13,610	13,610	6,271	6,271	6,271	6,271	6,271	288,013	288,013	288,013	288,013	288,013
	nonpt	87,037	85,653	83,973	84,311	84,311	11,464	11,412	11,375	11,331	11,331	85,393	82,106	79,758	76,940	76,940
	nonroad	42,009	33,318	30,177	27,864	29,057	35,398	30,263	24,069	17,609	13,876	389,240	263,050	250,944	261,675	291,702
	onroad	84,387	61,463	53,663	46,984	46,833	127,564	83,534	55,858	40,184	36,093	1,103,120	709,657	659,782	681,244	822,227
	ptipm	973	731	769	838	838	79,167	64,412	60,593	61,605	61,605	7,578	11,267	12,124	11,529	11,529
	ptnonipm	90,768	37,097	35,068	34,442	34,442	39,499	38,342	38,342	38,342	38,342	28,063	27,533	27,533	27,533	27,533
Colorado Total		**320,150**	**233,324**	**218,759**	**209,606**	**210,698**	**318,571**	**250,366**	**212,326**	**191,211**	**183,620**	**1,912,049**	**1,393,233**	**1,330,698**	**1,360,595**	**1,532,875**
Connecticut	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	845	876	956	1,061	1,169	3,945	3,834	3,868	4,003	4,140	12,149	12,666	13,976	15,652	17,271
	avefire	31	31	31	31	31	14	14	14	14	14	667	667	667	667	667
	nonpt	105,580	100,907	99,011	96,848	96,848	12,554	12,498	12,459	12,411	12,411	69,769	65,429	62,328	58,604	58,604
	nonroad	32,327	23,609	20,404	19,242	20,383	17,897	14,869	11,646	9,285	8,635	258,776	188,681	175,215	181,777	203,437
	onroad	47,757	30,899	24,426	18,176	15,441	66,813	38,434	23,218	13,530	8,997	641,901	369,126	315,324	293,072	307,897
	ptipm	305	109	134	181	181	6,161	3,391	4,095	5,447	5,447	1,920	8,434	8,853	8,932	8,932
	ptnonipm	4,602	4,182	4,182	4,182	4,182	6,706	6,571	6,571	6,571	6,571	2,133	2,131	2,131	2,131	2,131
Connecticut Total		**191,447**	**160,613**	**149,143**	**139,721**	**138,234**	**114,091**	**79,613**	**61,871**	**51,261**	**46,215**	**987,315**	**647,133**	**578,494**	**560,836**	**598,940**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Delaware	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	483	531	557	599	695	10,429	10,912	11,292	12,258	15,326	2,890	3,012	3,160	3,382	3,884
	avefire	64	64	64	64	64	23	23	23	23	23	1,332	1,332	1,332	1,332	1,332
	nonpt	15,468	14,558	14,210	13,919	13,919	3,259	3,251	3,246	3,239	3,239	11,640	11,085	10,688	10,211	10,211
	nonroad	8,677	6,386	5,514	5,153	5,408	5,308	4,559	3,692	2,882	2,500	65,811	48,862	45,738	47,229	52,261
	onroad	11,382	7,514	5,695	4,639	4,191	21,679	12,180	7,214	4,404	3,535	155,366	89,775	78,499	76,475	81,702
	ptipm	91	122	151	152	152	9,533	9,675	9,380	8,327	8,327	866	1,710	2,124	1,938	1,938
	ptnonipm	4,659	4,193	4,193	4,193	4,193	7,308	4,682	4,682	4,682	4,682	8,853	8,733	8,733	8,733	8,733
Delaware Total		**40,823**	**33,368**	**30,383**	**28,719**	**28,621**	**57,538**	**45,281**	**39,529**	**35,813**	**37,631**	**246,758**	**164,509**	**150,274**	**149,301**	**160,062**
District of Columbia	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	22	30	31	32	33	571	560	535	527	508	79	95	102	111	128
	avefire	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
	nonpt	4,118	3,917	3,882	3,882	3,882	1,740	1,739	1,738	1,738	1,738	1,819	1,756	1,711	1,658	1,658
	nonroad	1,918	1,412	1,235	1,203	1,290	3,060	2,536	1,921	1,244	919	18,061	15,551	14,178	14,543	16,130
	onroad	5,423	3,621	2,719	2,215	1,984	8,772	4,772	2,703	1,536	1,235	65,418	39,318	33,810	33,048	35,654
	ptipm	4	0	0	0	0	710	3	6	6	6	50	3	6	6	6
	ptnonipm	69	69	69	69	69	418	418	418	418	418	247	247	247	247	247
District of Columbia Total		**11,554**	**9,048**	**7,935**	**7,400**	**7,257**	**15,271**	**10,027**	**7,321**	**5,468**	**4,824**	**85,676**	**56,971**	**50,055**	**49,614**	**53,824**
Florida	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	3,053	3,190	3,387	3,652	4,052	55,127	52,369	51,374	52,172	57,895	43,166	44,681	47,476	50,664	54,692
	avefire	56,159	56,159	56,159	56,159	56,159	25,600	25,600	25,600	25,600	25,600	1,193,147	1,193,147	1,193,147	1,193,147	1,193,147
	nonpt	459,700	455,329	434,205	432,980	432,980	29,533	29,492	29,463	29,428	29,428	202,108	198,701	196,267	193,346	193,346
	nonroad	239,540	176,943	159,802	153,184	162,071	117,138	104,404	89,130	69,322	60,662	1,762,587	1,222,617	1,063,733	1,110,608	1,237,135
	onroad	362,851	225,931	179,866	150,140	147,070	448,520	274,295	178,863	125,477	102,919	3,797,717	2,105,543	1,867,949	1,870,423	2,054,738
	ptipm	2,236	1,869	2,143	2,522	2,522	272,057	80,931	56,740	61,118	61,118	52,142	64,310	75,293	75,276	75,276
	ptnonipm	37,204	34,201	34,201	34,201	34,201	54,078	54,030	54,030	54,030	54,030	86,821	86,821	86,821	86,821	86,821
Florida Total		**1,160,742**	**953,622**	**869,762**	**832,839**	**839,056**	**1,002,054**	**621,122**	**485,199**	**417,147**	**391,651**	**7,137,689**	**4,915,820**	**4,530,685**	**4,580,285**	**4,895,156**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Georgia	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,776	1,976	2,034	2,120	2,239	39,986	35,539	35,200	35,767	37,633	11,058	11,973	12,968	14,244	15,948
	avefire	21,834	21,834	21,834	21,834	21,834	7,955	7,955	7,955	7,955	7,955	350,924	350,924	350,924	350,924	350,924
	nonpt	248,214	242,922	235,296	234,053	234,053	38,919	38,853	38,806	38,750	38,750	194,402	189,012	185,162	180,543	180,543
	nonroad	81,856	63,348	56,758	52,569	55,247	57,979	48,390	38,051	27,695	22,875	730,260	519,187	466,525	485,869	542,255
	onroad	185,962	123,053	101,749	84,255	79,932	307,544	185,968	116,118	75,433	57,840	2,245,133	1,362,639	1,218,661	1,207,141	1,346,768
	ptipm	1,182	1,316	1,363	1,426	1,426	146,351	84,937	59,755	60,722	60,722	9,371	13,152	15,058	14,990	14,990
	ptnonipm	33,735	27,728	27,728	27,728	27,728	51,170	42,554	42,554	42,554	42,554	131,306	130,600	130,600	130,600	130,600
Georgia Total		**574,559**	**482,177**	**446,762**	**423,986**	**422,461**	**649,905**	**444,198**	**338,439**	**288,877**	**268,330**	**3,672,454**	**2,577,487**	**2,379,898**	**2,384,311**	**2,582,027**
Idaho	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	713	722	749	782	815	8,297	7,008	6,857	6,777	6,778	10,893	11,307	12,190	13,265	14,386
	avefire	29,989	29,989	29,989	29,989	29,989	14,024	14,024	14,024	14,024	14,024	630,971	630,971	630,971	630,971	630,971
	nonpt	141,328	139,434	137,490	136,421	136,421	30,317	30,305	30,296	30,285	30,285	95,417	94,196	93,323	92,276	92,276
	nonroad	23,153	21,173	18,319	15,135	14,525	15,611	13,849	11,345	8,507	6,374	137,661	96,798	91,736	91,464	97,589
	onroad	27,934	19,329	16,912	14,608	13,944	44,628	28,237	18,306	12,480	10,483	389,120	237,761	215,805	213,957	246,310
	ptipm	0	14	22	26	26	19	94	270	367	367	4	549	612	646	646
	ptnonipm	2,113	1,725	1,725	1,725	1,725	11,467	11,467	11,467	11,467	11,467	23,977	23,977	23,977	23,977	23,977
Idaho Total		**225,230**	**212,386**	**205,206**	**198,686**	**197,444**	**124,363**	**104,983**	**92,565**	**83,906**	**79,777**	**1,288,044**	**1,095,559**	**1,068,615**	**1,066,556**	**1,106,156**
Illinois	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	4,205	4,211	4,185	4,183	4,320	120,834	104,171	99,880	98,522	102,737	16,365	17,898	18,787	20,165	23,326
	avefire	156	156	156	156	156	71	71	71	71	71	3,323	3,323	3,323	3,323	3,323
	nonpt	278,553	274,561	269,109	268,977	268,977	47,645	47,588	47,548	47,500	47,500	99,568	93,967	89,967	85,166	85,166
	nonroad	99,398	77,488	67,523	61,819	64,816	115,426	94,695	72,953	51,566	39,673	830,513	656,876	599,591	609,879	674,750
	onroad	164,697	108,448	87,212	72,527	68,277	297,056	182,060	111,020	69,518	51,760	2,090,188	1,272,670	1,121,004	1,106,338	1,226,854
	ptipm	1,536	2,381	2,560	2,657	2,657	179,125	83,848	89,782	71,620	71,620	14,627	15,791	17,649	18,614	18,614
	ptnonipm	71,066	58,404	58,591	58,821	58,821	94,009	71,002	71,514	73,036	73,036	78,820	78,198	79,893	81,767	81,767
Illinois Total		**619,612**	**525,649**	**489,337**	**469,141**	**468,026**	**854,165**	**583,435**	**492,768**	**411,834**	**386,397**	**3,133,402**	**2,138,723**	**1,930,214**	**1,925,253**	**2,113,801**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Indiana	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,224	2,606	2,682	2,790	2,954	52,285	46,823	45,667	45,598	47,880	14,057	15,202	16,157	17,366	19,391
	avefire	194	194	194	194	194	88	88	88	88	88	4,124	4,124	4,124	4,124	4,124
	nonpt	179,635	175,119	169,044	167,998	167,998	30,185	30,143	30,113	30,077	30,077	74,953	71,175	68,477	65,240	65,240
	nonroad	58,290	45,641	39,383	35,579	37,055	64,575	53,155	40,427	28,951	23,097	490,545	348,138	310,959	311,512	341,744
	onroad	140,188	88,653	73,730	62,110	56,619	216,188	129,374	82,459	55,049	42,080	1,738,790	1,012,624	897,036	878,274	949,534
	ptipm	2,015	2,165	2,228	2,296	2,296	283,890	133,912	124,167	89,313	89,313	15,540	17,814	18,639	19,602	19,602
	ptnonipm	55,935	51,787	51,787	51,787	51,787	80,147	67,032	67,032	67,032	67,032	364,487	364,486	364,486	364,486	364,486
Indiana Total		**438,480**	**366,164**	**339,048**	**322,754**	**318,904**	**727,359**	**460,527**	**389,953**	**316,109**	**299,568**	**2,702,495**	**1,833,563**	**1,679,878**	**1,660,603**	**1,764,121**
Iowa	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,653	1,661	1,649	1,634	1,631	33,166	26,959	25,825	25,333	25,870	7,209	7,866	8,426	9,118	10,227
	avefire	197	197	197	197	197	90	90	90	90	90	4,185	4,185	4,185	4,185	4,185
	nonpt	77,838	75,491	71,828	70,642	70,642	15,150	15,090	15,046	14,995	14,995	68,958	64,017	60,487	56,251	56,251
	nonroad	52,138	36,504	33,409	30,975	31,468	62,066	54,867	44,687	32,571	21,882	309,048	222,598	205,436	203,942	215,849
	onroad	75,852	48,452	40,299	34,011	31,136	115,521	73,751	48,103	32,218	26,448	1,055,157	621,002	532,276	496,019	557,162
	ptipm	579	850	908	980	980	81,995	55,090	58,628	59,383	59,383	5,444	7,942	8,769	9,377	9,377
	ptnonipm	37,943	32,631	32,631	32,631	32,631	38,861	38,837	38,837	38,837	38,837	36,521	36,501	36,501	36,501	36,501
Iowa Total		**246,201**	**195,786**	**180,921**	**171,071**	**168,686**	**346,849**	**264,683**	**231,217**	**203,427**	**187,504**	**1,486,523**	**964,111**	**856,081**	**815,394**	**889,552**
Kansas	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,133	2,163	2,140	2,106	2,064	41,147	33,193	31,895	31,222	31,119	9,118	9,928	10,669	11,524	12,849
	avefire	828	828	828	828	828	378	378	378	378	378	17,600	17,600	17,600	17,600	17,600
	nonpt	135,449	134,134	131,964	131,970	131,970	42,286	42,260	42,242	42,219	42,219	850,800	848,391	846,669	844,604	844,604
	nonroad	24,728	18,953	16,491	15,041	15,502	47,653	40,898	32,678	23,003	14,394	240,503	157,861	143,592	143,812	154,768
	onroad	52,786	33,638	27,861	23,429	22,563	85,617	50,252	31,627	21,109	17,589	683,936	391,573	344,300	335,289	382,426
	ptipm	1,062	821	844	864	864	96,943	70,545	51,433	51,547	51,547	6,793	6,229	6,453	7,235	7,235
	ptnonipm	26,274	22,766	22,766	22,766	22,766	70,704	70,616	70,616	70,616	70,616	74,809	74,779	74,779	74,779	74,779
Kansas Total		**243,261**	**213,303**	**202,893**	**197,004**	**196,557**	**384,728**	**308,143**	**260,868**	**240,094**	**227,862**	**1,883,560**	**1,506,360**	**1,444,062**	**1,434,843**	**1,494,262**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Kentucky	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,487	2,629	2,716	2,868	3,195	70,391	64,975	63,275	63,565	69,851	17,830	19,313	20,293	21,803	24,580
	avefire	2,909	2,909	2,909	2,909	2,909	1,326	1,326	1,326	1,326	1,326	61,812	61,812	61,812	61,812	61,812
	nonpt	105,281	101,927	97,456	96,199	96,199	17,557	17,480	17,424	17,358	17,358	108,397	102,054	97,523	92,085	92,085
	nonroad	39,806	33,708	29,041	25,361	25,698	31,792	26,961	21,171	15,738	12,617	282,098	203,444	187,975	190,518	207,956
	onroad	82,321	51,892	42,149	34,769	31,858	147,749	85,183	51,140	32,067	24,626	1,052,158	599,767	523,949	508,439	543,459
	ptipm	1,479	1,561	1,615	1,696	1,696	200,955	95,712	68,876	62,024	62,024	12,544	28,316	28,389	29,085	29,085
	ptnonipm	44,884	42,586	42,581	42,589	42,589	38,541	28,382	28,382	28,382	28,382	110,047	110,047	110,047	110,047	110,047
Kentucky Total		**279,168**	**237,212**	**218,465**	**206,392**	**204,145**	**508,311**	**320,019**	**251,594**	**220,459**	**216,183**	**1,644,885**	**1,124,751**	**1,029,988**	**1,013,789**	**1,069,025**
Louisiana	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	3,960	4,264	4,498	4,966	6,236	216,290	209,740	204,037	205,657	233,694	45,941	47,622	48,188	50,103	56,877
	avefire	7,137	7,137	7,137	7,137	7,137	3,254	3,254	3,254	3,254	3,254	151,658	151,658	151,658	151,658	151,658
	nonpt	135,934	133,648	127,217	126,631	126,631	27,559	27,535	27,518	27,498	27,498	139,222	137,300	135,926	134,278	134,278
	nonroad	61,307	51,973	44,943	39,985	40,623	28,899	25,735	21,286	16,835	14,547	364,963	245,591	232,521	236,980	257,335
	onroad	77,802	49,098	38,299	31,376	31,178	124,192	70,328	43,492	28,662	23,290	943,962	539,202	464,965	451,997	512,934
	ptipm	1,239	574	645	714	714	82,293	25,960	27,522	27,607	27,607	12,682	26,764	28,465	28,817	28,817
	ptnonipm	79,781	61,820	61,820	61,820	61,820	211,449	211,225	211,225	211,225	211,225	134,203	133,982	133,982	133,982	133,982
Louisiana Total		**367,159**	**308,515**	**284,560**	**272,630**	**274,339**	**693,935**	**573,776**	**538,334**	**520,739**	**541,115**	**1,792,631**	**1,282,120**	**1,195,706**	**1,187,815**	**1,275,881**
Maine	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	365	370	375	388	423	1,708	1,716	1,711	1,781	2,112	3,650	3,769	3,981	4,206	4,459
	avefire	1,258	1,258	1,258	1,258	1,258	566	566	566	566	566	26,592	26,592	26,592	26,592	26,592
	nonpt	88,028	82,684	79,463	75,901	75,901	7,423	7,334	7,270	7,192	7,192	104,033	97,029	92,024	86,014	86,014
	nonroad	30,025	28,193	24,234	19,744	18,497	8,271	7,400	6,302	5,464	5,307	138,111	105,822	99,160	97,010	103,051
	onroad	26,131	17,146	14,673	12,325	10,670	47,227	26,670	16,408	10,550	7,687	360,595	210,877	187,476	181,502	189,853
	ptipm	67	236	214	132	132	1,188	6,660	6,208	3,969	3,969	1,084	5,986	5,357	3,798	3,798
	ptnonipm	5,151	4,542	4,542	4,542	4,542	18,895	18,045	18,045	18,045	18,045	15,861	15,107	15,107	15,107	15,107
Maine Total		**151,026**	**134,429**	**124,759**	**114,290**	**111,422**	**85,277**	**68,390**	**56,509**	**47,566**	**44,878**	**649,927**	**465,182**	**429,698**	**414,230**	**428,874**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Maryland	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	5,360	5,482	5,733	6,069	6,432	17,106	16,209	15,875	16,480	18,380	17,581	18,062	19,265	20,716	22,413
	avefire	353	353	353	353	353	137	137	137	137	137	6,129	6,129	6,129	6,129	6,129
	nonpt	126,362	120,308	118,030	116,078	116,078	21,715	21,667	21,633	21,592	21,592	141,960	138,168	135,459	132,206	132,206
	nonroad	51,369	38,023	33,652	32,241	34,382	27,495	23,271	18,960	14,651	12,719	414,390	339,878	322,626	340,408	382,289
	onroad	71,591	48,559	38,202	31,292	28,704	121,659	68,358	41,721	25,955	20,660	1,004,611	599,433	526,263	519,267	575,218
	ptipm	478	521	616	693	693	73,527	18,640	20,882	22,653	22,653	4,546	10,599	11,472	12,092	12,092
	ptnonipm	5,758	4,570	4,570	4,570	4,570	22,109	17,826	17,826	17,826	17,826	94,448	94,404	94,404	94,404	94,404
Maryland Total		**261,270**	**217,815**	**201,154**	**191,296**	**191,211**	**283,748**	**166,108**	**137,033**	**119,293**	**113,967**	**1,683,666**	**1,206,675**	**1,115,618**	**1,125,222**	**1,224,752**
Massachusetts	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,443	2,487	2,601	2,734	2,921	17,144	15,668	15,702	16,151	17,570	18,602	19,525	20,876	22,357	24,040
	avefire	747	747	747	747	747	341	341	341	341	341	15,878	15,878	15,878	15,878	15,878
	nonpt	176,731	168,492	165,353	161,951	161,951	34,373	34,283	34,219	34,143	34,143	136,753	129,917	125,034	119,169	119,169
	nonroad	52,921	39,377	34,017	31,809	33,486	30,046	25,055	19,746	15,707	14,545	423,212	313,857	292,004	302,871	339,056
	onroad	71,646	45,768	35,321	28,541	26,110	128,362	67,279	38,153	22,168	17,469	960,011	542,302	495,891	497,918	557,054
	ptipm	595	384	370	427	427	32,561	11,748	10,341	12,444	12,444	10,922	9,109	8,673	7,936	7,936
	ptnonipm	7,722	6,559	6,559	6,559	6,559	15,394	14,849	14,849	14,849	14,849	10,656	10,621	10,621	10,621	10,621
Massachusetts Total		**312,806**	**263,814**	**244,968**	**232,768**	**232,202**	**258,220**	**169,223**	**133,352**	**115,802**	**111,360**	**1,576,034**	**1,041,209**	**968,976**	**976,750**	**1,073,754**
Michigan	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,504	2,732	2,987	3,375	4,065	43,025	44,993	47,692	53,325	69,133	26,763	28,629	31,302	34,872	39,287
	avefire	724	724	724	724	724	330	330	330	330	330	15,380	15,380	15,380	15,380	15,380
	nonpt	248,382	236,151	227,606	226,489	226,489	43,499	43,424	43,371	43,306	43,306	94,909	96,472	97,588	98,928	98,928
	nonroad	173,241	147,590	124,499	104,755	103,718	70,912	63,773	52,230	43,538	41,589	1,013,991	688,696	620,623	605,349	649,546
	onroad	207,762	124,457	104,607	88,580	79,226	315,420	189,800	120,465	80,551	60,564	2,744,658	1,461,558	1,273,212	1,221,058	1,283,487
	ptipm	1,243	1,350	1,562	1,602	1,602	141,908	83,271	80,290	79,933	79,933	13,367	12,926	15,503	17,748	17,748
	ptnonipm	39,832	32,854	32,854	32,854	32,854	82,202	77,597	77,597	77,597	77,597	66,873	66,685	66,685	66,685	66,685
Michigan Total		**673,689**	**545,857**	**494,838**	**458,378**	**448,677**	**697,296**	**503,189**	**421,975**	**378,581**	**372,452**	**3,975,941**	**2,370,346**	**2,120,292**	**2,060,020**	**2,171,061**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Minnesota	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,611	1,662	1,672	1,712	1,871	55,371	50,040	48,393	48,235	52,459	8,411	8,982	9,212	9,710	11,224
	avefire	5,047	5,047	5,047	5,047	5,047	2,300	2,300	2,300	2,300	2,300	107,237	107,237	107,237	107,237	107,237
	nonpt	125,318	121,402	116,713	115,950	115,950	56,700	56,616	56,557	56,485	56,485	139,234	132,191	127,159	121,121	121,121
	nonroad	97,104	86,673	76,510	67,902	60,721	68,820	59,324	48,614	36,926	28,213	452,734	385,326	358,959	356,686	369,793
	onroad	102,566	73,518	62,866	53,880	46,670	163,172	106,140	65,740	43,094	35,370	1,314,360	897,668	786,262	764,896	834,696
	ptipm	646	672	815	916	916	86,917	38,630	41,007	42,469	42,469	7,468	5,933	8,643	9,316	9,316
	ptnonipm	29,541	26,591	26,652	26,726	26,726	67,813	66,107	66,325	66,615	66,615	47,015	47,365	48,177	49,063	49,063
Minnesota Total		**361,833**	**315,564**	**290,274**	**272,132**	**257,902**	**501,094**	**379,158**	**328,936**	**296,125**	**283,912**	**2,076,459**	**1,584,702**	**1,445,649**	**1,418,029**	**1,502,451**
Mississippi	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,386	2,516	2,548	2,651	2,997	66,650	61,821	60,034	60,314	67,010	10,656	11,332	11,801	12,595	14,577
	avefire	8,407	8,407	8,407	8,407	8,407	3,833	3,833	3,833	3,833	3,833	178,646	178,646	178,646	178,646	178,646
	nonpt	156,390	154,665	149,624	148,789	148,789	12,212	12,169	12,139	12,103	12,103	129,408	125,242	122,266	118,696	118,696
	nonroad	36,056	31,622	27,255	23,620	23,727	22,180	19,058	15,120	11,400	9,220	214,179	149,762	139,143	139,898	150,980
	onroad	62,375	40,881	31,707	26,200	24,829	105,505	62,300	37,951	24,286	18,302	739,190	448,208	388,570	379,133	410,973
	ptipm	629	363	429	472	472	45,850	29,058	23,371	20,263	20,263	5,286	4,402	6,799	6,440	6,440
	ptnonipm	43,224	37,751	37,751	37,751	37,751	60,244	58,269	56,826	56,826	56,826	54,587	53,581	53,581	53,581	53,581
Mississippi Total		**309,467**	**276,205**	**257,721**	**247,890**	**246,971**	**316,473**	**246,507**	**209,274**	**189,025**	**187,557**	**1,331,952**	**971,174**	**900,807**	**888,989**	**933,893**
Missouri	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	3,439	3,537	3,603	3,712	3,926	79,583	70,030	68,145	67,979	71,968	18,171	19,635	20,840	22,505	25,361
	avefire	1,488	1,488	1,488	1,488	1,488	678	678	678	678	678	31,611	31,611	31,611	31,611	31,611
	nonpt	162,795	157,282	151,104	149,030	149,030	32,910	32,785	32,695	32,588	32,588	168,352	158,163	150,885	142,152	142,152
	nonroad	63,279	50,345	43,558	39,288	40,437	52,997	46,091	37,054	27,534	20,719	479,319	333,739	311,545	318,976	350,123
	onroad	124,106	79,858	65,168	53,630	51,200	200,379	121,016	75,598	49,135	38,513	1,598,930	923,851	800,044	768,803	863,675
	ptipm	1,496	1,692	1,771	1,764	1,764	145,232	80,814	75,127	73,116	73,116	10,827	12,552	13,483	13,461	13,461
	ptnonipm	34,704	27,517	27,517	27,517	27,517	38,025	33,144	33,144	33,144	33,144	108,389	108,361	108,361	108,361	108,361
Missouri Total		**391,308**	**321,719**	**294,210**	**276,429**	**275,362**	**549,803**	**384,556**	**322,440**	**284,174**	**270,726**	**2,415,599**	**1,587,913**	**1,436,771**	**1,405,869**	**1,534,746**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Montana	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,309	1,306	1,302	1,297	1,291	22,873	18,260	17,546	17,175	17,180	5,814	6,365	6,862	7,457	8,299
	avefire	10,085	10,085	10,085	10,085	10,085	5,187	5,187	5,187	5,187	5,187	203,759	203,759	203,759	203,759	203,759
	nonpt	23,573	22,543	21,452	21,032	21,032	3,797	3,767	3,746	3,720	3,720	35,673	33,199	31,432	29,312	29,312
	nonroad	12,968	11,853	10,184	8,322	7,914	18,777	16,576	13,643	9,792	6,048	85,304	60,793	57,185	56,226	58,516
	onroad	20,451	13,325	11,525	9,863	9,039	36,727	20,801	12,900	8,538	6,842	283,678	164,018	146,187	142,895	158,758
	ptipm	355	318	393	421	421	36,577	36,169	31,948	32,457	32,457	3,047	4,273	4,906	5,141	5,141
	ptnonipm	6,807	6,431	6,431	6,431	6,431	16,588	16,122	15,684	15,684	15,684	29,410	29,410	29,410	29,410	29,410
Montana Total		**75,548**	**65,861**	**61,373**	**57,451**	**56,213**	**140,526**	**116,883**	**100,654**	**92,552**	**87,117**	**646,686**	**501,817**	**479,741**	**474,201**	**493,194**
Nebraska	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	3,524	3,523	3,463	3,384	3,294	68,904	54,285	51,946	50,703	50,664	10,222	11,459	12,380	13,530	15,482
	avefire	837	837	837	837	837	381	381	381	381	381	17,780	17,780	17,780	17,780	17,780
	nonpt	40,762	39,632	37,860	37,441	37,441	13,820	13,798	13,782	13,763	13,763	66,672	64,882	63,603	62,069	62,069
	nonroad	18,442	14,727	12,636	11,084	11,092	39,889	34,573	27,908	19,576	11,818	155,107	108,019	98,448	97,078	102,149
	onroad	36,940	24,026	20,116	17,017	16,795	66,226	40,028	24,974	16,298	13,340	473,870	276,172	241,994	234,283	276,293
	ptipm	635	545	549	602	602	47,900	54,034	38,052	38,911	38,911	3,420	4,404	4,601	5,028	5,028
	ptnonipm	6,527	5,906	5,906	5,906	5,906	11,385	11,385	11,385	11,385	11,385	5,717	5,717	5,717	5,717	5,717
Nebraska Total		**107,667**	**89,196**	**81,368**	**76,271**	**75,966**	**248,506**	**208,485**	**168,427**	**151,019**	**140,263**	**732,788**	**488,432**	**444,524**	**435,483**	**484,518**
Nevada	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,057	1,094	1,150	1,223	1,290	12,958	11,168	11,212	11,566	12,047	11,214	11,954	13,121	14,601	16,127
	avefire	10,740	10,740	10,740	10,740	10,740	4,910	4,910	4,910	4,910	4,910	227,965	227,965	227,965	227,965	227,965
	nonpt	22,874	23,491	21,718	21,792	21,792	5,308	5,306	5,304	5,302	5,302	14,700	14,229	13,893	13,490	13,490
	nonroad	22,720	16,988	15,504	14,803	15,760	18,990	16,487	13,033	9,176	7,244	208,377	135,971	130,610	137,077	152,899
	onroad	26,884	22,191	19,306	17,057	16,380	28,320	20,307	14,625	11,256	9,913	301,082	231,710	223,133	236,365	262,598
	ptipm	483	445	597	674	674	48,366	46,403	32,260	34,817	34,817	2,798	8,072	9,139	7,369	7,369
	ptnonipm	1,649	1,493	1,493	1,493	1,493	7,509	7,509	7,509	7,509	7,509	6,985	6,985	6,985	6,985	6,985
Nevada Total		**86,406**	**76,441**	**70,506**	**67,783**	**68,130**	**126,362**	**112,090**	**88,854**	**84,537**	**81,742**	**773,121**	**636,888**	**624,847**	**643,851**	**687,433**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
New Hampshire	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	118	124	132	143	159	1,866	1,781	1,752	1,783	2,004	2,305	2,398	2,553	2,721	2,916
	avefire	301	301	301	301	301	137	137	137	137	137	6,398	6,398	6,398	6,398	6,398
	nonpt	61,483	57,548	55,511	53,263	53,263	11,235	11,178	11,137	11,088	11,088	74,137	69,710	66,547	62,750	62,750
	nonroad	21,832	18,910	16,065	13,661	13,333	8,150	6,965	5,763	4,818	4,616	122,530	96,954	85,458	85,704	93,178
	onroad	21,682	14,879	12,393	10,267	9,342	38,799	23,734	14,685	9,164	6,716	294,533	180,168	158,722	155,253	171,336
	ptipm	104	150	165	189	189	7,000	2,619	3,065	3,964	3,964	643	3,375	3,404	3,140	3,140
	ptnonipm	1,496	721	721	721	721	2,786	2,783	2,783	2,783	2,783	2,082	2,080	2,080	2,080	2,080
New Hampshire Total		**107,015**	**92,633**	**85,289**	**78,545**	**77,308**	**69,973**	**49,197**	**39,322**	**33,737**	**31,309**	**502,627**	**361,082**	**325,161**	**318,046**	**341,798**
New Jersey	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,236	2,326	2,456	2,653	2,999	35,998	35,363	34,759	35,709	40,992	14,960	15,509	16,429	17,644	19,580
	avefire	488	488	488	488	488	223	223	223	223	223	10,375	10,375	10,375	10,375	10,375
	nonpt	151,657	144,567	142,238	140,176	140,176	26,393	26,342	26,305	26,261	26,261	84,145	79,593	76,342	72,437	72,437
	nonroad	78,629	57,795	50,544	48,222	51,422	40,876	35,077	28,499	23,040	21,269	635,064	467,523	442,732	464,876	523,535
	onroad	101,094	64,465	46,651	36,413	32,216	161,872	85,611	48,496	26,860	18,353	1,325,445	751,380	654,205	632,680	704,191
	ptipm	1,048	335	398	450	450	34,188	7,767	9,427	11,022	11,022	3,865	7,240	8,009	7,822	7,822
	ptnonipm	13,282	10,897	10,897	10,897	10,897	17,206	15,578	15,578	15,578	15,578	8,375	8,316	8,316	8,316	8,316
New Jersey Total		**348,436**	**280,873**	**253,673**	**239,299**	**238,649**	**316,756**	**205,961**	**163,286**	**138,694**	**133,699**	**2,082,228**	**1,339,937**	**1,216,408**	**1,214,149**	**1,346,255**
New Mexico	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,982	1,992	1,971	1,941	1,903	36,714	29,265	27,994	27,361	27,304	8,473	9,222	9,911	10,732	11,960
	avefire	27,488	27,488	27,488	27,488	27,488	12,582	12,582	12,582	12,582	12,582	583,216	583,216	583,216	583,216	583,216
	nonpt	36,950	35,170	33,450	33,088	33,088	7,532	7,517	7,505	7,492	7,492	29,666	28,367	27,439	26,326	26,326
	nonroad	13,499	11,181	10,062	9,237	9,636	9,681	8,353	6,706	4,981	4,047	119,501	78,164	74,832	78,007	86,466
	onroad	45,763	31,131	26,206	22,451	21,317	77,574	46,462	29,322	19,600	15,429	587,028	361,579	326,293	326,676	360,766
	ptipm	563	489	491	519	519	78,547	63,814	58,498	58,562	58,562	5,539	6,016	6,052	6,433	6,433
	ptnonipm	15,691	10,786	10,786	10,786	10,786	60,358	60,297	60,240	60,240	60,240	32,228	32,228	32,228	32,228	32,228
New Mexico Total		**141,935**	**118,237**	**110,454**	**105,510**	**104,738**	**282,988**	**228,288**	**202,848**	**190,819**	**185,657**	**1,365,651**	**1,098,792**	**1,059,971**	**1,063,618**	**1,107,396**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
New York	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,473	2,619	2,745	2,936	3,266	40,659	38,350	38,161	39,370	44,334	22,205	23,864	25,657	27,886	30,840
	avefire	903	903	903	903	903	412	412	412	412	412	19,195	19,195	19,195	19,195	19,195
	nonpt	608,921	613,062	621,635	634,915	634,915	89,986	90,323	90,564	90,853	90,853	404,592	431,581	450,860	473,993	473,993
	nonroad	151,345	121,199	105,522	95,842	98,761	78,279	67,078	55,658	44,756	40,396	1,175,721	895,734	810,175	839,288	937,245
	onroad	212,929	137,568	102,389	80,584	74,771	290,698	165,594	103,189	62,605	44,498	2,822,801	1,596,877	1,390,297	1,328,878	1,526,678
	ptipm	857	1,082	1,100	1,107	1,107	81,201	39,914	34,490	33,735	33,735	12,204	20,230	17,499	17,890	17,890
	ptnonipm	6,218	5,365	5,365	5,365	5,365	38,992	32,096	32,096	32,096	32,096	54,133	54,080	54,080	54,080	54,080
New York Total		**983,646**	**881,799**	**839,659**	**821,652**	**819,089**	**620,228**	**433,767**	**354,570**	**303,826**	**286,322**	**4,510,852**	**3,041,562**	**2,767,764**	**2,761,211**	**3,059,922**
North Carolina	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,472	1,615	1,690	1,794	1,916	22,608	19,886	19,482	19,554	20,381	9,957	10,817	11,615	12,623	13,872
	avefire	58,889	58,889	58,889	58,889	58,889	11,424	11,424	11,424	11,424	11,424	429,388	429,388	429,388	429,388	429,388
	nonpt	231,094	222,255	212,129	210,082	210,082	18,869	18,761	18,684	18,591	18,591	321,101	312,266	305,955	298,382	298,382
	nonroad	88,972	68,628	59,717	54,845	57,309	61,664	50,178	38,433	27,759	22,701	746,344	586,105	540,968	560,093	622,450
	onroad	143,187	93,913	76,576	63,583	58,393	242,379	141,370	87,185	55,801	41,119	1,786,813	1,075,088	923,026	897,310	965,793
	ptipm	920	1,103	1,163	1,256	1,256	153,226	67,924	67,442	59,724	59,724	12,112	11,366	12,286	12,761	12,761
	ptnonipm	61,685	53,635	53,633	53,632	53,632	49,273	37,071	37,071	37,071	37,071	52,414	52,062	52,062	52,062	52,062
North Carolina Total		**586,219**	**500,039**	**463,797**	**444,081**	**441,477**	**559,444**	**346,614**	**279,721**	**229,924**	**211,012**	**3,358,129**	**2,477,092**	**2,275,301**	**2,262,619**	**2,394,709**
North Dakota	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,256	1,254	1,240	1,219	1,195	23,072	18,121	17,336	16,916	16,912	4,832	5,291	5,706	6,195	6,944
	avefire	527	527	527	527	527	240	240	240	240	240	11,204	11,204	11,204	11,204	11,204
	nonpt	14,911	14,177	13,461	13,174	13,174	4,007	3,987	3,972	3,955	3,955	20,488	18,845	17,671	16,262	16,262
	nonroad	13,565	11,430	9,536	7,778	7,197	38,012	33,288	27,270	19,093	10,734	91,869	66,050	59,029	54,726	53,229
	onroad	15,356	9,829	8,318	6,933	6,511	24,832	14,432	8,967	5,824	4,722	206,627	116,879	101,483	96,390	109,994
	ptipm	781	846	838	882	882	75,947	45,049	44,009	44,560	44,560	5,237	7,659	11,260	11,383	11,383
	ptnonipm	1,249	1,124	1,124	1,124	1,124	9,929	9,385	9,385	9,385	9,385	5,778	5,765	5,765	5,765	5,765
North Dakota Total		**47,645**	**39,188**	**35,045**	**31,637**	**30,610**	**176,039**	**124,502**	**111,180**	**99,974**	**90,509**	**346,035**	**231,693**	**212,118**	**201,925**	**214,782**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Ohio	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	3,632	4,064	4,207	4,423	4,798	96,728	88,052	85,793	85,843	92,415	29,188	31,189	32,881	35,103	38,849
	avefire	178	178	178	178	178	81	81	81	81	81	3,787	3,787	3,787	3,787	3,787
	nonpt	285,528	275,689	272,521	271,610	271,610	41,466	41,405	41,360	41,307	41,307	150,302	145,351	141,813	137,566	137,566
	nonroad	103,414	77,465	67,241	61,754	64,960	90,812	74,081	55,950	40,458	34,425	910,152	623,175	564,041	573,594	633,745
	onroad	205,348	124,133	100,380	81,331	74,335	327,388	192,777	113,811	72,024	57,376	2,600,918	1,476,811	1,265,027	1,236,418	1,362,343
	ptipm	1,773	1,971	2,106	2,149	2,149	373,299	94,744	99,033	92,780	92,780	14,817	20,543	21,862	22,421	22,421
	ptnonipm	29,515	26,436	26,436	26,436	26,436	65,850	58,970	58,185	58,185	58,185	238,412	238,412	238,412	238,412	238,412
Ohio Total		**629,389**	**509,937**	**473,070**	**447,881**	**444,466**	**995,625**	**550,110**	**454,213**	**390,678**	**376,570**	**3,947,575**	**2,539,269**	**2,267,823**	**2,247,301**	**2,437,123**
Oklahoma	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,551	1,566	1,563	1,555	1,543	26,294	21,261	20,464	20,088	20,149	10,093	10,553	11,225	11,963	12,989
	avefire	3,749	3,749	3,749	3,749	3,749	1,709	1,709	1,709	1,709	1,709	79,673	79,673	79,673	79,673	79,673
	nonpt	200,442	196,496	192,447	191,677	191,677	94,574	94,542	94,518	94,490	94,490	385,235	382,569	380,664	378,379	378,379
	nonroad	38,015	29,720	25,931	23,686	24,511	31,331	26,945	21,961	16,410	12,410	308,218	206,115	186,014	190,974	209,343
	onroad	86,133	56,321	46,067	39,279	37,822	133,152	80,016	51,065	34,569	28,819	1,069,135	636,945	557,794	555,227	630,913
	ptipm	984	958	1,019	1,088	1,088	90,302	83,945	64,740	62,434	62,434	13,661	28,415	29,821	27,970	27,970
	ptnonipm	35,176	23,733	23,733	23,733	23,733	72,670	72,517	71,835	71,835	71,835	50,750	50,750	50,750	50,750	50,750
Oklahoma Total		**366,050**	**312,543**	**294,508**	**284,767**	**284,123**	**450,033**	**380,935**	**326,293**	**301,535**	**291,847**	**1,916,764**	**1,395,018**	**1,295,939**	**1,294,935**	**1,390,016**
Oregon	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,843	2,027	2,115	2,253	2,487	43,439	40,199	39,073	39,085	42,312	12,401	13,077	13,756	14,654	16,159
	avefire	37,328	37,328	37,328	37,328	37,328	17,857	17,857	17,857	17,857	17,857	778,193	778,193	778,193	778,193	778,193
	nonpt	242,829	239,638	238,352	239,218	239,218	16,998	17,009	17,018	17,028	17,028	342,444	333,115	326,451	318,454	318,454
	nonroad	39,821	32,299	28,149	25,088	25,679	26,372	22,638	18,141	13,685	11,363	304,850	212,615	193,709	199,468	220,481
	onroad	91,766	58,567	47,310	39,312	32,647	109,066	69,772	50,073	33,701	21,232	1,078,005	619,048	517,087	478,542	485,899
	ptipm	142	151	151	152	152	9,006	9,740	9,740	9,768	9,768	1,105	3,932	3,932	3,942	3,942
	ptnonipm	14,567	10,990	10,990	10,990	10,990	15,958	15,767	15,767	15,767	15,767	34,389	33,794	33,794	33,794	33,794
Oregon Total		**428,297**	**381,001**	**364,395**	**354,342**	**348,502**	**238,696**	**192,982**	**167,669**	**146,890**	**135,326**	**2,551,388**	**1,993,775**	**1,866,922**	**1,827,046**	**1,856,922**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Pennsylvania	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,425	2,559	2,673	2,851	3,196	67,118	63,037	61,438	61,811	67,924	25,047	26,618	28,094	30,087	33,258
	avefire	256	256	256	256	256	117	117	117	117	117	5,450	5,450	5,450	5,450	5,450
	nonpt	281,740	264,980	261,647	260,079	260,079	53,435	53,333	53,260	53,173	53,173	265,035	256,636	250,638	243,439	243,439
	nonroad	96,797	79,165	69,633	63,072	65,413	62,168	51,401	40,177	30,881	27,101	856,737	612,784	547,716	566,481	631,795
	onroad	184,268	115,276	89,483	69,513	63,170	294,414	165,444	99,133	58,609	40,758	2,420,525	1,323,428	1,104,821	1,039,116	1,137,007
	ptipm	1,212	1,712	1,766	1,753	1,753	210,149	91,466	74,225	69,570	69,570	17,018	18,116	19,163	18,236	18,236
	ptnonipm	36,871	30,914	30,914	30,914	30,914	89,064	76,602	74,324	74,324	74,324	104,570	103,784	103,784	103,784	103,784
Pennsylvania Total		**603,569**	**494,863**	**456,372**	**428,439**	**424,781**	**776,465**	**501,400**	**402,674**	**348,484**	**332,967**	**3,694,382**	**2,346,814**	**2,059,664**	**2,006,592**	**2,172,969**
Rhode Island	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	162	166	180	197	214	876	824	874	950	1,028	2,923	3,009	3,290	3,628	3,959
	avefire	8	8	8	8	8	4	4	4	4	4	171	171	171	171	171
	nonpt	16,875	16,553	16,483	16,457	16,457	2,964	2,960	2,958	2,955	2,955	5,421	5,142	4,942	4,703	4,703
	nonroad	8,491	6,010	5,080	4,822	5,137	4,663	3,890	3,053	2,457	2,309	65,923	48,379	44,582	46,080	51,531
	onroad	14,366	10,124	7,869	6,810	5,805	16,720	9,655	6,550	4,125	3,514	188,240	113,984	101,917	97,100	105,592
	ptipm	39	49	45	41	41	712	475	396	357	357	453	1,926	1,751	1,616	1,616
	ptnonipm	1,894	1,360	1,360	1,360	1,360	2,060	1,938	1,938	1,938	1,938	1,781	1,758	1,758	1,758	1,758
Rhode Island Total		**41,835**	**34,271**	**31,025**	**29,697**	**29,023**	**27,997**	**19,747**	**15,774**	**12,786**	**12,104**	**264,911**	**174,368**	**158,410**	**155,056**	**169,329**
South Carolina	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	961	997	1,019	1,050	1,107	19,378	17,077	16,521	16,424	17,422	9,393	9,933	10,554	11,272	12,270
	avefire	5,171	5,171	5,171	5,171	5,171	2,357	2,357	2,357	2,357	2,357	109,880	109,880	109,880	109,880	109,880
	nonpt	185,429	185,163	181,315	182,844	182,844	20,281	20,275	20,271	20,267	20,267	145,294	145,455	145,570	145,708	145,708
	nonroad	50,041	38,078	32,999	30,535	31,883	29,982	24,512	18,902	13,850	11,690	377,166	295,785	271,673	280,073	310,041
	onroad	89,994	58,070	47,272	39,608	37,165	134,542	82,299	52,555	35,593	27,866	1,141,561	691,670	590,040	570,319	618,756
	ptipm	506	609	655	746	746	91,296	50,236	48,449	34,085	34,085	4,749	5,535	6,509	6,829	6,829
	ptnonipm	36,778	27,298	27,298	27,298	27,298	40,417	29,336	29,336	29,336	29,336	56,640	56,448	56,448	56,448	56,448
South Carolina Total		**368,879**	**315,385**	**295,729**	**287,252**	**286,214**	**338,253**	**226,092**	**188,391**	**151,912**	**143,023**	**1,844,682**	**1,314,706**	**1,190,675**	**1,180,530**	**1,259,932**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
South Dakota	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	321	324	331	339	346	4,164	3,349	3,252	3,202	3,216	2,979	3,160	3,398	3,655	3,947
	avefire	3,985	3,985	3,985	3,985	3,985	1,817	1,817	1,817	1,817	1,817	84,689	84,689	84,689	84,689	84,689
	nonpt	19,597	18,840	17,980	17,644	17,644	5,200	5,177	5,160	5,140	5,140	24,107	22,176	20,796	19,141	19,141
	nonroad	12,322	10,531	8,874	7,352	6,964	27,219	23,755	19,402	13,665	7,961	79,151	59,285	53,433	50,681	50,964
	onroad	16,177	10,656	9,022	7,539	7,203	29,910	18,071	11,071	6,963	5,621	219,053	129,758	113,555	108,684	126,091
	ptipm	111	110	120	142	142	15,922	2,353	2,364	2,740	2,740	632	552	604	785	785
	ptnonipm	2,431	1,449	1,449	1,449	1,449	4,776	4,776	4,776	4,776	4,776	4,068	4,068	4,068	4,068	4,068
South Dakota Total		**54,944**	**45,897**	**41,762**	**38,451**	**37,734**	**89,008**	**59,298**	**47,843**	**38,304**	**31,271**	**414,679**	**303,689**	**280,543**	**271,703**	**289,686**
Tennessee	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,152	2,363	2,449	2,594	2,866	50,692	46,834	45,791	46,115	50,251	13,001	14,117	14,987	16,228	18,286
	avefire	2,220	2,220	2,220	2,220	2,220	1,012	1,012	1,012	1,012	1,012	47,175	47,175	47,175	47,175	47,175
	nonpt	148,677	145,508	137,119	135,241	135,241	18,676	18,604	18,552	18,490	18,490	119,973	114,059	109,836	104,767	104,767
	nonroad	60,023	49,015	42,584	38,065	39,112	40,970	34,909	27,163	20,352	16,955	460,143	305,294	281,937	287,728	316,789
	onroad	140,405	94,247	75,248	60,871	56,534	240,312	147,688	93,956	59,503	43,543	1,681,568	992,698	875,126	840,777	901,356
	ptipm	843	925	1,015	1,202	1,202	155,926	53,647	54,945	39,841	39,841	6,596	7,203	8,021	9,475	9,475
	ptnonipm	84,610	73,801	73,801	73,801	73,801	69,070	50,451	50,451	50,451	50,451	115,767	115,278	115,278	115,278	115,278
Tennessee Total		**438,930**	**368,080**	**334,436**	**313,994**	**310,976**	**576,659**	**353,145**	**291,871**	**235,764**	**220,543**	**2,444,222**	**1,595,825**	**1,452,359**	**1,421,428**	**1,513,126**
Texas	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	11,279	11,889	12,303	13,009	14,522	236,223	220,853	216,266	218,785	242,786	67,547	71,359	75,840	81,884	91,779
	avefire	13,201	13,201	13,201	13,201	13,201	4,890	4,890	4,890	4,890	4,890	256,966	256,966	256,966	256,966	256,966
	nonpt	695,600	675,342	669,427	668,063	668,063	274,338	274,244	274,177	274,096	274,096	463,577	455,678	450,036	443,265	443,265
	nonroad	174,723	135,696	120,305	113,364	119,864	152,771	126,111	98,419	70,456	54,433	1,578,739	1,196,045	1,128,017	1,174,843	1,309,218
	onroad	308,904	199,858	154,959	128,066	128,916	621,483	334,266	186,632	116,542	95,623	3,787,848	2,152,885	1,873,424	1,875,580	2,180,504
	ptipm	4,745	4,575	4,771	5,010	5,010	259,612	136,697	135,504	135,714	135,714	215,207	78,627	86,950	86,882	86,882
	ptnonipm	149,554	111,767	111,767	111,767	111,767	344,073	336,557	331,121	331,121	331,121	283,294	281,797	281,797	281,797	281,797
Texas Total		**1,358,006**	**1,152,328**	**1,086,732**	**1,052,479**	**1,061,342**	**1,893,390**	**1,433,617**	**1,247,009**	**1,151,604**	**1,138,663**	**6,653,179**	**4,493,357**	**4,153,030**	**4,201,216**	**4,650,411**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Tribal Data	alm	218	217	212	206	199	858	672	642	626	626	302	347	376	413	484
	ptipm	241	30	30	24	24	97	232	232	182	182	828	1,171	1,171	918	918
	ptnonipm	601	389	383	382	382	6,623	6,620	6,620	6,620	6,620	2,573	2,573	2,581	2,587	2,587
Tribal Data Total		**1,060**	**636**	**625**	**612**	**605**	**7,578**	**7,524**	**7,494**	**7,428**	**7,428**	**3,703**	**4,091**	**4,127**	**3,918**	**3,989**
Utah	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,596	2,737	2,969	3,276	3,565	14,640	12,158	11,959	12,044	12,307	10,805	11,601	12,705	14,099	15,617
	avefire	15,469	15,469	15,469	15,469	15,469	7,052	7,052	7,052	7,052	7,052	328,713	328,713	328,713	328,713	328,713
	nonpt	54,443	53,042	50,928	50,352	50,352	6,948	6,937	6,929	6,920	6,920	79,323	78,434	77,799	77,036	77,036
	nonroad	25,488	23,357	20,391	17,151	16,833	15,026	13,024	10,343	7,840	6,675	172,729	119,498	113,186	114,711	124,803
	onroad	56,206	39,609	34,748	30,914	28,693	76,518	51,752	35,867	25,070	19,835	764,714	452,333	422,640	423,561	477,048
	ptipm	418	501	600	644	644	73,220	62,979	58,224	59,235	59,235	4,506	5,583	6,340	6,468	6,468
	ptnonipm	5,826	5,070	5,070	5,070	5,070	14,998	14,681	14,531	14,531	14,531	45,052	45,029	45,029	45,029	45,029
Utah Total		**160,444**	**139,784**	**130,175**	**122,875**	**120,626**	**208,401**	**168,583**	**144,906**	**132,692**	**126,554**	**1,405,842**	**1,041,191**	**1,006,412**	**1,009,617**	**1,074,714**
Vermont	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	53	57	61	66	70	49	51	57	64	71	1,220	1,280	1,372	1,469	1,560
	avefire	393	393	393	393	393	179	179	179	179	179	8,347	8,347	8,347	8,347	8,347
	nonpt	18,887	18,265	17,993	17,744	17,744	3,438	3,416	3,400	3,382	3,382	43,091	41,058	39,605	37,862	37,862
	nonroad	10,446	9,755	8,420	6,901	6,524	4,170	3,597	2,898	2,354	2,123	58,906	42,042	38,858	38,196	40,914
	onroad	18,139	11,951	9,772	7,646	6,600	21,783	13,393	8,581	5,448	3,908	237,164	131,797	119,269	119,078	133,225
	ptipm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ptnonipm	1,097	1,025	1,025	1,025	1,025	790	790	790	790	790	1,078	1,078	1,078	1,078	1,078
Vermont Total		**49,015**	**41,445**	**37,664**	**33,774**	**32,356**	**30,409**	**21,427**	**15,905**	**12,217**	**10,453**	**349,807**	**225,602**	**208,529**	**206,029**	**222,985**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Virginia	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	3,084	3,198	3,264	3,381	3,605	39,676	36,966	35,646	35,676	38,394	17,758	18,414	19,296	20,457	22,189
	avefire	3,194	3,194	3,194	3,194	3,194	1,456	1,456	1,456	1,456	1,456	67,866	67,866	67,866	67,866	67,866
	nonpt	201,748	190,207	185,542	181,688	181,688	53,605	53,529	53,475	53,409	53,409	208,041	201,223	196,351	190,501	190,501
	nonroad	67,441	50,452	44,451	41,960	44,479	45,848	36,688	28,740	21,036	17,403	520,042	473,574	442,744	463,608	518,461
	onroad	125,474	86,161	72,948	63,234	62,669	214,393	123,035	78,620	53,731	49,108	1,722,600	1,099,794	976,391	954,294	1,121,935
	ptipm	726	536	679	719	719	86,763	69,736	44,145	39,719	39,719	6,714	9,909	11,740	11,202	11,202
	ptnonipm	43,184	36,335	36,335	36,335	36,335	61,730	46,246	46,246	46,246	46,246	63,978	63,557	63,557	63,557	63,557
Virginia Total		**444,850**	**370,082**	**346,413**	**330,511**	**332,689**	**503,471**	**367,656**	**288,327**	**251,274**	**245,737**	**2,606,999**	**1,934,337**	**1,777,945**	**1,771,484**	**1,995,711**
Washington	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,248	2,433	2,548	2,738	3,152	66,992	65,363	65,801	69,264	82,840	20,193	21,483	22,856	24,617	27,397
	avefire	2,674	2,674	2,674	2,674	2,674	1,484	1,484	1,484	1,484	1,484	52,086	52,086	52,086	52,086	52,086
	nonpt	166,658	159,930	154,329	150,839	150,839	16,911	16,812	16,742	16,658	16,658	204,125	196,158	190,466	183,628	183,628
	nonroad	64,611	50,334	43,632	39,373	40,459	42,800	36,553	29,715	22,539	18,753	486,615	359,916	319,178	328,381	363,147
	onroad	159,797	109,815	94,849	81,074	68,508	199,767	123,689	87,124	58,303	38,337	1,820,900	1,174,345	1,016,289	938,502	954,906
	ptipm	219	342	350	349	349	16,122	17,357	17,581	17,552	17,552	1,665	6,954	7,264	7,158	7,158
	ptnonipm	12,429	11,631	11,631	11,631	11,631	24,522	24,522	24,522	24,522	24,522	39,106	39,106	39,106	39,106	39,106
Washington Total		**408,636**	**337,160**	**310,013**	**288,679**	**277,612**	**368,598**	**285,781**	**242,970**	**210,321**	**200,146**	**2,624,689**	**1,850,047**	**1,647,245**	**1,573,478**	**1,627,429**
West Virginia	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,180	1,291	1,333	1,422	1,664	32,148	30,383	30,081	31,151	36,257	5,139	5,692	6,067	6,676	8,049
	avefire	1,721	1,721	1,721	1,721	1,721	785	785	785	785	785	36,578	36,578	36,578	36,578	36,578
	nonpt	59,489	56,958	54,651	54,047	54,047	14,519	14,487	14,464	14,436	14,436	70,069	67,360	65,425	63,103	63,103
	nonroad	16,935	16,469	14,419	11,990	11,889	8,407	6,869	5,665	4,437	3,935	117,839	102,117	87,138	89,867	98,181
	onroad	36,949	21,900	17,904	14,639	12,233	60,216	32,252	19,840	13,006	9,265	502,130	270,712	225,844	210,771	206,623
	ptipm	1,175	1,289	1,328	1,332	1,332	227,827	55,352	50,926	45,760	45,760	10,319	10,228	10,492	10,572	10,572
	ptnonipm	14,241	12,089	12,089	12,089	12,089	46,627	37,778	37,778	37,778	37,778	89,898	89,898	89,898	89,898	89,898
West Virginia Total		**131,691**	**111,717**	**103,446**	**97,239**	**94,975**	**390,529**	**177,906**	**159,538**	**147,353**	**148,216**	**831,973**	**582,585**	**521,442**	**507,465**	**513,003**

State	Sector	[tons/yr] 2002 VOC	[tons/yr] 2009 Base VOC	[tons/yr] 2014 Base VOC	[tons/yr] 2020 Base VOC	[tons/yr] 2030 Base VOC	[tons/yr] 2002 NOX	[tons/yr] 2009 Base NOX	[tons/yr] 2014 Base NOX	[tons/yr] 2020 Base NOX	[tons/yr] 2030 Base NOX	[tons/yr] 2002 CO	[tons/yr] 2009 Base CO	[tons/yr] 2014 Base CO	[tons/yr] 2020 Base CO	[tons/yr] 2030 Base CO
Wisconsin	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	2,060	2,263	2,387	2,558	2,799	30,307	27,468	27,538	28,600	32,248	24,321	25,819	28,228	31,276	34,712
	avefire	561	561	561	561	561	256	256	256	256	256	11,924	11,924	11,924	11,924	11,924
	nonpt	230,068	229,658	228,764	231,695	231,695	21,994	21,984	21,976	21,967	21,967	166,779	162,598	159,612	156,028	156,028
	nonroad	111,779	96,076	81,098	68,764	69,593	53,430	45,761	36,575	28,977	26,142	569,467	416,240	377,144	372,039	409,058
	onroad	96,058	61,689	51,408	43,691	39,473	172,043	103,786	61,755	38,899	30,805	1,321,240	763,639	678,392	689,891	777,211
	ptipm	964	1,085	1,178	1,186	1,186	91,128	53,488	57,160	56,119	56,119	10,725	10,728	11,908	12,152	12,152
	ptnonipm	31,057	26,592	26,592	26,592	26,592	38,283	38,282	38,282	38,282	38,282	34,197	34,197	34,197	34,197	34,197
Wisconsin Total		**472,549**	**417,924**	**391,988**	**375,047**	**371,899**	**407,440**	**291,025**	**243,541**	**213,100**	**205,819**	**2,138,654**	**1,425,145**	**1,301,406**	**1,307,507**	**1,435,283**
Wyoming	afdust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	alm	1,569	1,567	1,540	1,503	1,462	30,368	23,784	22,747	22,184	22,173	4,758	5,359	5,787	6,322	7,211
	avefire	8,852	8,852	8,852	8,852	8,852	4,035	4,035	4,035	4,035	4,035	188,099	188,099	188,099	188,099	188,099
	nonpt	16,411	15,646	15,077	14,867	14,867	4,309	4,295	4,285	4,273	4,273	19,192	18,058	17,248	16,276	16,276
	nonroad	9,088	8,874	7,619	6,154	5,774	5,470	4,713	3,958	3,017	2,312	53,551	40,841	36,120	35,787	37,725
	onroad	18,072	11,859	9,726	8,177	7,416	32,643	17,780	10,807	6,983	5,542	246,059	143,301	121,503	116,959	129,138
	ptipm	849	834	892	947	947	85,207	83,587	59,212	60,438	60,438	7,078	6,715	7,202	7,654	7,654
	ptnonipm	16,771	13,552	13,552	13,552	13,552	36,500	36,385	36,385	36,385	36,385	23,341	23,341	23,341	23,341	23,341
Wyoming Total		**71,613**	**61,185**	**57,257**	**54,052**	**52,869**	**198,533**	**174,578**	**141,430**	**137,316**	**135,158**	**542,078**	**425,714**	**399,299**	**394,438**	**409,445**
Grand Total		**17,693,869**	**14,934,802**	**13,867,583**	**13,220,304**	**13,138,328**	**20,931,673**	**14,898,719**	**12,440,017**	**10,930,663**	**10,452,858**	**101,885,285**	**71,586,336**	**65,672,193**	**64,912,870**	**69,431,177**

Table D-1b: Continental US, SO2, NH3, PM_{10}, and $PM_{2.5}$ Emissions by Sector for 2002, and Projection Years 2009, 2014, 2020, and 2030.

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Alabama	afdust	0	0	0	0	0	0	0	0	0	0	100,288	100,332	100,364	100,402	100,402	33,476	33,491	33,501	33,514	33,514
	ag	0	0	0	0	0	57,802	64,346	69,023	74,633	74,633	0	0	0	0	0	0	0	0	0	0
	alm	4,801	3,667	3,602	4,241	6,220	13	15	16	17	20	2,236	2,248	2,281	2,379	2,663	1,878	1,883	1,896	1,963	2,202
	avefire	983	983	983	983	983	752	752	752	752	752	16,251	16,251	16,251	16,251	16,251	13,938	13,938	13,938	13,938	13,938
	nonpt	52,325	52,318	52,313	52,308	52,308	426	426	426	426	426	27,785	27,295	26,944	26,524	26,524	23,973	23,483	23,133	22,712	22,712
	nonroad	2,734	464	42	45	50	28	31	33	37	41	3,195	2,625	2,144	1,552	1,270	3,044	2,491	2,028	1,460	1,184
	onroad	5,599	729	605	667	745	5,627	6,012	6,512	7,075	7,776	4,223	3,019	2,453	2,298	2,447	3,117	1,943	1,357	1,129	1,142
	ptipm	448,329	269,794	244,393	187,851	187,851	783	882	1,044	1,034	1,034	26,138	16,214	19,576	39,221	39,221	22,612	12,147	15,281	34,364	34,364
	ptnonipm	89,762	88,763	88,763	88,763	88,763	2,224	2,224	2,224	2,224	2,224	19,710	18,644	18,644	18,644	18,644	13,647	13,017	13,017	13,017	13,017
Alabama Total		**604,533**	**416,719**	**390,702**	**334,858**	**336,920**	**67,655**	**74,688**	**80,030**	**86,198**	**86,906**	**199,826**	**186,627**	**188,657**	**207,271**	**207,422**	**115,685**	**102,393**	**104,151**	**122,098**	**122,074**
Arizona	afdust	0	0	0	0	0	0	0	0	0	0	121,322	121,322	121,322	121,322	121,322	19,626	19,626	19,626	19,626	19,626
	ag	0	0	0	0	0	29,493	29,674	29,804	29,958	29,958	0	0	0	0	0	0	0	0	0	0
	alm	2,297	713	419	475	531	12	14	15	17	20	2,617	2,572	2,602	2,649	2,688	2,060	2,017	2,036	2,071	2,098
	avefire	2,888	2,888	2,888	2,888	2,888	2,020	2,020	2,020	2,020	2,020	43,005	43,005	43,005	43,005	43,005	37,151	37,151	37,151	37,151	37,151
	nonpt	2,571	2,568	2,567	2,564	2,564	4,391	4,391	4,391	4,391	4,391	12,456	12,253	12,109	11,935	11,935	8,596	8,396	8,253	8,081	8,081
	nonroad	3,858	681	41	43	48	35	40	44	49	57	4,174	3,425	2,855	2,086	1,649	3,993	3,264	2,712	1,967	1,538
	onroad	2,876	862	735	888	1,125	5,150	6,417	7,561	8,994	11,238	4,021	3,441	3,002	3,112	3,839	2,951	2,225	1,656	1,532	1,812
	ptipm	70,709	41,901	40,434	36,801	36,801	566	1,408	1,414	1,529	1,529	9,551	7,943	7,887	8,403	8,403	7,565	5,936	5,897	6,467	6,467
	ptnonipm	21,702	21,702	21,702	21,702	21,702	72	72	72	72	72	5,723	5,574	5,574	5,574	5,574	3,044	2,963	2,963	2,963	2,963
Arizona Total		**106,900**	**71,315**	**68,786**	**65,361**	**65,658**	**41,740**	**44,036**	**45,321**	**47,030**	**49,285**	**202,868**	**199,535**	**198,356**	**198,087**	**198,416**	**84,987**	**81,577**	**80,294**	**79,858**	**79,736**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Arkansas	afdust	0	0	0	0	0	0	0	0	0	0	92,523	92,523	92,523	92,524	92,524	24,639	24,639	24,639	24,639	24,639
	ag	0	0	0	0	0	110,954	118,597	124,059	130,611	130,611	0	0	0	0	0	0	0	0	0	0
	alm	4,648	3,013	2,708	3,067	4,454	19	22	24	26	29	1,348	1,328	1,320	1,340	1,452	1,243	1,225	1,217	1,235	1,339
	avefire	728	728	728	728	728	556	556	556	556	556	12,027	12,027	12,027	12,027	12,027	10,315	10,315	10,315	10,315	10,315
	nonpt	27,260	27,258	27,256	27,254	27,254	7,386	7,386	7,386	7,386	7,386	24,094	23,911	23,780	23,622	23,622	23,062	22,878	22,747	22,590	22,590
	nonroad	2,762	468	33	35	38	23	26	28	31	35	3,229	2,517	1,951	1,314	890	3,097	2,403	1,858	1,246	834
	onroad	3,078	405	346	387	463	3,001	3,231	3,526	3,871	4,529	2,202	1,613	1,338	1,280	1,463	1,612	1,034	739	631	684
	ptipm	70,754	97,797	39,079	39,582	39,582	346	622	858	843	843	2,004	4,182	5,463	5,820	5,820	1,750	3,413	4,656	4,995	4,995
	ptnonipm	19,032	18,999	18,999	18,999	18,999	1,255	1,290	1,316	1,346	1,346	14,101	13,812	13,812	13,812	13,812	9,593	9,473	9,473	9,473	9,473
Arkansas Total		**128,262**	**148,667**	**89,149**	**90,050**	**91,517**	**123,540**	**131,731**	**137,754**	**144,672**	**145,337**	**151,529**	**151,915**	**152,215**	**151,740**	**151,611**	**75,312**	**75,381**	**75,645**	**75,125**	**74,870**
California	afdust	0	0	0	0	0	0	0	0	0	0	196,231	196,525	196,736	196,989	196,989	47,562	47,615	47,653	47,698	47,698
	ag	0	0	0	0	0	152,308	156,311	159,176	162,610	162,610	0	0	0	0	0	0	0	0	0	0
	alm	40,887	27,491	19,337	14,863	21,107	180	193	203	215	237	10,124	9,970	9,726	9,692	10,788	9,534	9,381	9,148	9,113	10,148
	avefire	6,735	6,735	6,735	6,735	6,735	5,117	5,117	5,117	5,117	5,117	113,231	113,231	113,231	113,231	113,231	97,301	97,301	97,301	97,301	97,301
	nonpt	77,672	77,641	77,619	77,592	77,592	14,758	14,665	14,600	14,520	14,520	90,509	88,498	87,062	85,338	85,338	73,873	71,938	70,555	68,896	68,896
	nonroad	1,015	455	516	597	790	161	181	198	220	255	18,590	16,219	14,290	12,637	15,177	16,334	13,989	12,025	10,216	11,712
	onroad	4,786	1,855	2,002	2,189	2,502	37,468	27,409	22,337	19,206	17,590	23,103	23,613	22,170	21,262	22,604	12,395	12,463	11,365	10,559	11,026
	ptipm	1,018	6,577	6,259	6,204	6,204	1,380	3,307	4,213	5,522	5,522	1,905	469	512	574	574	1,876	348	374	412	412
	ptnonipm	41,761	41,477	41,089	41,128	41,128	3,367	3,367	3,367	3,367	3,367	26,854	25,998	25,998	25,998	25,998	16,655	16,284	16,284	16,284	16,284
California Total		**173,874**	**162,231**	**153,557**	**149,308**	**156,058**	**214,738**	**210,550**	**209,211**	**210,777**	**209,217**	**480,546**	**474,524**	**469,725**	**465,721**	**470,699**	**275,530**	**269,318**	**264,705**	**260,479**	**263,477**
Colorado	afdust	0	0	0	0	0	0	0	0	0	0	110,878	110,878	110,878	110,878	110,878	25,559	25,559	25,559	25,559	25,559
	ag	0	0	0	0	0	62,907	63,846	64,517	65,320	65,320	0	0	0	0	0	0	0	0	0	0
	alm	1,224	315	137	156	175	5	5	6	6	8	606	595	590	590	582	553	539	531	526	514
	avefire	1,719	1,719	1,719	1,719	1,719	1,299	1,299	1,299	1,299	1,299	28,019	28,019	28,019	28,019	28,019	24,054	24,054	24,054	24,054	24,054
	nonpt	6,460	6,459	6,458	6,457	6,457	71	71	71	71	71	15,059	14,719	14,475	14,183	14,183	13,545	13,204	12,961	12,669	12,669
	nonroad	3,545	611	43	45	50	31	36	39	44	50	3,909	3,163	2,602	1,901	1,452	3,746	3,018	2,474	1,796	1,356
	onroad	4,146	614	550	645	816	4,408	5,220	6,002	6,976	8,754	3,216	2,518	2,179	2,191	2,665	2,357	1,600	1,189	1,069	1,241
	ptipm	92,562	73,481	55,605	49,733	49,733	453	529	582	535	535	5,446	5,502	5,712	7,003	7,003	4,444	4,713	4,932	6,018	6,018
	ptnonipm	5,331	5,322	5,322	5,322	5,322	86	86	86	86	86	17,366	16,676	16,677	16,679	16,679	8,922	8,527	8,528	8,529	8,529
Colorado Total		**114,989**	**88,522**	**69,834**	**64,078**	**64,274**	**69,260**	**71,091**	**72,603**	**74,337**	**76,123**	**184,499**	**182,071**	**181,134**	**181,445**	**181,461**	**83,181**	**81,213**	**80,226**	**80,219**	**79,940**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Connecticut	afdust	0	0	0	0	0	0	0	0	0	0	12,528	12,528	12,528	12,528	12,528	2,725	2,725	2,725	2,725	2,725
	ag	0	0	0	0	0	4,029	4,232	4,377	4,551	4,551	0	0	0	0	0	0	0	0	0	0
	alm	778	751	764	874	1,268	1	1	1	1	1	231	237	241	253	301	210	215	218	227	271
	avefire	4	4	4	4	4	3	3	3	3	3	65	65	65	65	65	56	56	56	56	56
	nonpt	18,455	18,447	18,441	18,434	18,434	1,438	1,407	1,385	1,358	1,358	10,716	10,152	9,749	9,266	9,266	10,446	9,882	9,479	8,996	8,996
	nonroad	1,382	249	27	29	33	17	18	20	22	25	1,702	1,408	1,195	933	823	1,619	1,335	1,130	876	766
	onroad	1,667	363	340	368	413	3,257	3,515	3,779	4,042	4,510	1,610	1,316	1,182	1,165	1,276	1,067	766	610	557	592
	ptipm	13,689	6,200	5,795	12,473	12,473	182	245	247	244	244	742	829	3,992	11,942	11,942	510	791	3,891	11,696	11,696
	ptnonipm	2,338	2,330	2,330	2,330	2,330	91	91	91	91	91	882	880	880	880	880	691	690	690	690	690
Connecticut Total		**38,313**	**28,343**	**27,701**	**34,512**	**34,955**	**9,017**	**9,512**	**9,902**	**10,311**	**10,783**	**28,476**	**27,415**	**29,833**	**37,032**	**37,081**	**17,323**	**16,460**	**18,798**	**25,823**	**25,792**
Delaware	afdust	0	0	0	0	0	0	0	0	0	0	6,258	6,258	6,258	6,258	6,258	863	863	863	863	863
	ag	0	0	0	0	0	12,536	14,172	15,342	16,745	16,745	0	0	0	0	0	0	0	0	0	0
	alm	3,470	3,243	3,234	3,664	5,371	0	0	0	0	1	452	511	561	655	907	401	454	499	583	810
	avefire	6	6	6	6	6	5	5	5	5	5	102	102	102	102	102	87	87	87	87	87
	nonpt	5,859	5,858	5,857	5,857	5,857	279	275	272	268	268	2,007	1,933	1,879	1,815	1,815	1,826	1,751	1,698	1,634	1,634
	nonroad	471	83	7	8	9	5	6	6	7	8	560	446	367	275	224	534	424	348	259	209
	onroad	556	114	101	112	124	903	994	1,078	1,178	1,294	572	417	359	355	383	406	253	188	171	178
	ptipm	33,104	23,047	21,650	20,757	20,757	30	119	148	132	132	1,969	6,352	6,466	6,610	6,610	1,693	3,083	3,217	3,421	3,421
	ptnonipm	41,342	11,538	11,538	11,538	11,538	161	152	152	152	152	1,041	904	904	904	904	783	576	576	576	576
Delaware Total		**84,810**	**43,889**	**42,394**	**41,941**	**43,662**	**13,918**	**15,722**	**17,003**	**18,487**	**18,604**	**12,961**	**16,923**	**16,896**	**16,974**	**17,203**	**6,594**	**7,492**	**7,478**	**7,596**	**7,779**
District of Columbia	afdust	0	0	0	0	0	0	0	0	0	0	2,255	2,255	2,255	2,255	2,255	411	411	411	411	411
	alm	45	9	2	2	3	0	0	0	0	0	13	11	11	11	10	13	11	11	10	10
	avefire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	nonpt	1,559	1,559	1,559	1,559	1,559	13	13	13	13	13	489	481	476	469	469	427	419	413	406	406
	nonroad	343	59	3	3	3	2	3	3	3	4	298	226	176	109	64	288	218	170	104	60
	onroad	271	46	42	47	52	398	423	457	508	567	219	155	141	144	158	150	88	72	68	74
	ptipm	1,432	0	0	0	0	8	0	0	0	0	30	0	0	0	0	22	0	0	0	0
	ptnonipm	625	625	625	625	625	4	4	4	4	4	98	21	21	21	21	43	12	12	12	12
District of Columbia Total		**4,275**	**2,299**	**2,230**	**2,236**	**2,242**	**426**	**443**	**477**	**529**	**589**	**3,402**	**3,149**	**3,080**	**3,008**	**2,977**	**1,353**	**1,159**	**1,088**	**1,011**	**973**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Florida	afdust	0	0	0	0	0	0	0	0	0	0	145,566	145,655	145,718	145,794	145,794	28,017	28,035	28,047	28,063	28,063
	ag	0	0	0	0	0	37,099	38,583	39,643	40,914	40,914	0	0	0	0	0	0	0	0	0	0
	alm	6,892	5,893	5,843	6,685	9,612	11	12	12	13	15	2,391	2,426	2,469	2,575	2,936	2,175	2,199	2,223	2,307	2,636
	avefire	7,018	7,018	7,018	7,018	7,018	5,366	5,366	5,366	5,366	5,366	115,996	115,996	115,996	115,996	115,996	99,484	99,484	99,484	99,484	99,484
	nonpt	70,489	70,484	70,480	70,475	70,475	448	448	448	448	448	41,371	40,935	40,623	40,248	40,248	38,847	38,410	38,098	37,724	37,724
	nonroad	12,540	2,110	174	184	207	125	139	151	166	192	13,637	10,831	8,952	6,680	5,412	13,001	10,302	8,489	6,287	5,040
	onroad	21,410	2,358	2,152	2,477	2,886	18,267	21,200	23,969	27,284	31,607	12,433	9,367	8,217	8,251	9,258	9,041	5,803	4,407	4,006	4,316
	ptipm	473,636	155,118	154,529	92,816	92,816	5,013	3,571	4,445	4,318	4,318	32,299	22,325	22,166	29,274	29,274	28,293	14,447	14,405	20,220	20,220
	ptnonipm	57,060	57,024	57,024	57,024	57,024	3,030	3,030	3,030	3,030	3,030	32,193	31,655	31,655	31,655	31,655	23,604	23,430	23,430	23,430	23,430
Florida Total		**649,045**	**300,004**	**297,220**	**236,679**	**240,037**	**69,359**	**72,348**	**77,064**	**81,539**	**85,889**	**395,887**	**379,190**	**375,795**	**380,473**	**380,573**	**242,462**	**222,108**	**218,584**	**221,520**	**220,912**
Georgia	afdust	0	0	0	0	0	0	0	0	0	0	181,397	181,397	181,397	181,397	181,397	59,910	59,910	59,910	59,910	59,910
	ag	0	0	0	0	0	80,733	89,607	95,949	103,556	103,556	0	0	0	0	0	0	0	0	0	0
	alm	3,247	1,969	1,807	2,101	2,860	12	13	14	16	18	1,332	1,320	1,327	1,363	1,457	1,135	1,122	1,120	1,142	1,218
	avefire	2,010	2,010	2,010	2,010	2,010	1,299	1,299	1,299	1,299	1,299	28,079	28,079	28,079	28,079	28,079	24,082	24,082	24,082	24,082	24,082
	nonpt	56,830	56,821	56,815	56,807	56,807	60	60	60	60	60	46,751	46,054	45,556	44,958	44,958	41,847	41,150	40,652	40,054	40,054
	nonroad	5,674	975	76	80	90	52	59	64	71	82	6,136	5,022	4,150	3,021	2,412	5,867	4,783	3,940	2,847	2,250
	onroad	11,238	1,525	1,308	1,503	1,809	10,642	12,213	13,708	15,548	18,473	8,539	6,232	5,184	5,043	5,785	6,366	4,025	2,868	2,477	2,699
	ptipm	512,983	212,600	210,100	146,083	146,083	593	840	989	971	971	31,663	24,007	23,976	35,951	35,951	25,407	17,485	17,485	29,266	29,266
	ptnonipm	56,203	56,188	56,188	56,188	56,188	4,571	4,581	4,588	4,597	4,597	21,224	20,585	20,585	20,585	20,585	15,692	15,426	15,426	15,426	15,426
Georgia Total		**648,183**	**332,087**	**328,304**	**264,772**	**265,847**	**97,962**	**108,672**	**116,673**	**126,119**	**129,057**	**325,121**	**312,696**	**310,254**	**320,398**	**320,626**	**180,308**	**167,984**	**165,482**	**175,206**	**174,907**
Idaho	afdust	0	0	0	0	0	0	0	0	0	0	139,528	139,669	139,770	139,891	139,891	28,351	28,376	28,393	28,414	28,414
	ag	0	0	0	0	0	62,376	62,655	62,855	63,094	63,094	0	0	0	0	0	0	0	0	0	0
	alm	645	168	70	74	81	3	4	4	4	5	471	453	449	449	445	447	427	421	419	413
	avefire	3,845	3,845	3,845	3,845	3,845	2,856	2,856	2,856	2,856	2,856	61,433	61,433	61,433	61,433	61,433	52,808	52,808	52,808	52,808	52,808
	nonpt	2,915	2,913	2,912	2,910	2,910	1,684	1,684	1,684	1,684	1,684	56,403	56,235	56,116	55,972	55,972	27,367	27,199	27,080	26,936	26,936
	nonroad	1,616	275	19	20	22	14	16	18	20	22	1,973	1,582	1,253	871	600	1,889	1,506	1,189	823	560
	onroad	1,310	205	179	203	246	1,418	1,645	1,853	2,083	2,514	1,068	821	691	669	772	785	527	380	328	360
	ptipm	0	0	192	308	308	0	43	47	49	49	1	2	146	242	242	1	1	128	214	214
	ptnonipm	17,597	17,597	17,597	17,597	17,597	1,074	1,074	1,074	1,074	1,074	4,569	4,409	4,409	4,409	4,409	2,528	2,441	2,441	2,441	2,441
Idaho Total		**27,928**	**25,003**	**24,815**	**24,958**	**25,009**	**69,425**	**69,977**	**70,390**	**70,864**	**71,298**	**265,445**	**264,604**	**264,267**	**263,935**	**263,763**	**114,175**	**113,286**	**112,841**	**112,383**	**112,147**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Illinois	afdust	0	0	0	0	0	0	0	0	0	0	444,909	444,909	444,909	444,909	444,909	88,100	88,100	88,100	88,100	88,100
	ag	0	0	0	0	0	106,685	108,164	109,220	110,486	110,486	0	0	0	0	0	0	0	0	0	0
	alm	11,979	7,122	6,358	7,425	10,872	45	52	56	62	72	3,556	3,431	3,343	3,329	3,561	3,351	3,231	3,144	3,125	3,340
	avefire	20	20	20	20	20	15	15	15	15	15	323	323	323	323	323	277	277	277	277	277
	nonpt	5,395	5,387	5,382	5,376	5,376	1,631	1,631	1,631	1,631	1,631	16,972	16,262	15,755	15,147	15,147	15,181	14,471	13,964	13,356	13,356
	nonroad	10,913	1,933	126	132	148	88	102	112	124	145	11,316	8,576	6,671	4,450	3,103	10,881	8,220	6,375	4,224	2,912
	onroad	8,514	1,449	1,220	1,373	1,607	10,654	11,429	12,465	13,748	15,809	7,772	5,916	4,888	4,615	5,125	5,700	3,849	2,751	2,291	2,410
	ptipm	366,157	294,394	270,363	272,107	272,107	174	962	1,095	1,149	1,149	19,147	13,378	14,852	37,527	37,527	14,783	11,017	12,328	34,584	34,584
	ptnonipm	138,126	110,325	110,401	110,500	110,500	694	683	683	683	683	30,111	28,118	28,118	28,118	28,118	15,136	13,619	13,619	13,619	13,619
Illinois Total		**541,103**	**420,630**	**393,869**	**396,933**	**400,630**	**119,986**	**123,039**	**125,276**	**127,898**	**129,989**	**534,106**	**520,913**	**518,859**	**538,417**	**537,812**	**153,409**	**142,786**	**140,559**	**159,578**	**158,599**
Indiana	afdust	0	0	0	0	0	0	0	0	0	0	345,635	345,635	345,635	345,635	345,635	65,707	65,707	65,707	65,707	65,707
	ag	0	0	0	0	0	90,815	93,856	96,027	98,632	98,632	0	0	0	0	0	0	0	0	0	0
	alm	5,540	3,649	3,419	4,024	5,873	19	22	24	26	31	1,719	1,710	1,707	1,746	1,909	1,561	1,552	1,544	1,576	1,727
	avefire	24	24	24	24	24	19	19	19	19	19	401	401	401	401	401	344	344	344	344	344
	nonpt	59,775	59,770	59,765	59,760	59,760	4,214	4,214	4,214	4,214	4,214	60,255	59,765	59,414	58,994	58,994	32,611	32,120	31,770	31,350	31,350
	nonroad	5,981	1,042	73	77	86	48	55	60	67	78	6,039	4,593	3,562	2,367	1,691	5,803	4,398	3,401	2,246	1,588
	onroad	8,564	974	811	914	1,087	7,343	7,896	8,618	9,482	10,975	5,518	4,064	3,353	3,195	3,622	4,081	2,633	1,872	1,581	1,693
	ptipm	785,603	377,625	375,790	336,644	336,644	580	1,076	1,132	1,198	1,198	40,884	40,455	40,305	44,864	44,864	33,805	27,477	27,287	31,624	31,624
	ptnonipm	97,442	97,349	97,349	97,349	97,349	3,144	3,144	3,144	3,144	3,144	25,808	25,083	25,083	25,083	25,083	15,085	14,751	14,751	14,751	14,751
Indiana Total		**962,930**	**540,433**	**537,231**	**498,791**	**500,823**	**106,183**	**110,283**	**113,238**	**116,784**	**118,291**	**486,257**	**481,705**	**479,460**	**482,284**	**482,198**	**158,996**	**148,983**	**146,677**	**149,179**	**148,783**
Iowa	afdust	0	0	0	0	0	0	0	0	0	0	341,542	341,542	341,542	341,542	341,542	57,643	57,643	57,643	57,643	57,643
	ag	0	0	0	0	0	245,778	252,909	257,995	264,101	264,101	0	0	0	0	0	0	0	0	0	0
	alm	2,787	1,161	860	1,007	1,454	8	10	10	11	13	1,021	986	961	949	961	997	961	934	919	926
	avefire	25	25	25	25	25	19	19	19	19	19	407	407	407	407	407	349	349	349	349	349
	nonpt	19,832	19,824	19,818	19,811	19,811	7,404	7,404	7,404	7,404	7,404	12,833	12,192	11,734	11,185	11,185	11,476	10,835	10,378	9,828	9,828
	nonroad	6,248	1,063	59	61	66	47	53	58	64	74	7,210	5,048	3,805	2,539	1,419	6,949	4,859	3,654	2,427	1,340
	onroad	2,999	427	360	404	496	3,091	3,367	3,659	4,002	4,781	2,355	1,771	1,450	1,365	1,585	1,726	1,153	815	677	741
	ptipm	133,047	110,609	115,301	116,360	116,360	391	428	483	519	519	9,907	7,681	8,074	8,386	8,386	8,904	5,985	6,288	6,513	6,513
	ptnonipm	51,329	51,329	51,329	51,329	51,329	4,663	4,663	4,663	4,663	4,663	13,439	11,162	11,162	11,162	11,162	7,572	6,395	6,395	6,395	6,395
Iowa Total		**216,267**	**184,437**	**187,751**	**188,996**	**189,540**	**261,401**	**268,852**	**274,292**	**280,784**	**281,574**	**388,712**	**380,789**	**379,135**	**377,535**	**376,647**	**95,615**	**88,180**	**86,455**	**84,751**	**83,736**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Kansas	afdust	0	0	0	0	0	0	0	0	0	0	455,984	455,984	455,984	455,984	455,984	74,515	74,515	74,515	74,515	74,515
	ag	0	0	0	0	0	97,384	97,802	98,101	98,458	98,458	0	0	0	0	0	0	0	0	0	0
	alm	2,895	603	131	152	194	11	12	13	15	17	1,237	1,185	1,152	1,127	1,087	1,207	1,155	1,120	1,093	1,051
	avefire	103	103	103	103	103	79	79	79	79	79	1,711	1,711	1,711	1,711	1,711	1,468	1,468	1,468	1,468	1,468
	nonpt	36,381	36,378	36,375	36,373	36,373	12,467	12,467	12,467	12,467	12,467	108,571	108,281	108,075	107,826	107,826	83,174	82,885	82,678	82,430	82,430
	nonroad	4,858	828	41	42	46	32	37	41	46	53	5,360	3,794	2,817	1,838	972	5,179	3,660	2,712	1,764	922
	onroad	2,893	379	312	348	431	2,870	3,081	3,343	3,657	4,421	2,200	1,576	1,279	1,206	1,427	1,629	1,019	710	594	665
	ptipm	129,827	77,367	48,068	52,641	52,641	421	377	393	454	454	7,246	7,037	7,178	7,749	7,749	5,912	5,723	5,953	6,244	6,244
	ptnonipm	10,793	10,793	10,793	10,793	10,793	60,100	60,994	61,633	62,398	62,398	9,430	8,890	8,890	8,890	8,890	4,941	4,718	4,718	4,718	4,718
Kansas Total		**187,750**	**126,450**	**95,823**	**100,452**	**100,580**	**173,364**	**174,849**	**176,070**	**177,574**	**178,347**	**591,738**	**588,460**	**587,087**	**586,333**	**585,647**	**178,025**	**175,143**	**173,874**	**172,825**	**172,013**
Kentucky	afdust	0	0	0	0	0	0	0	0	0	0	99,481	99,481	99,481	99,481	99,481	23,529	23,529	23,529	23,529	23,529
	ag	0	0	0	0	0	50,821	53,024	54,598	56,486	56,486	0	0	0	0	0	0	0	0	0	0
	alm	10,096	8,624	8,713	10,226	14,957	15	17	18	19	22	4,285	4,409	4,627	5,007	5,730	3,625	3,710	3,850	4,123	4,723
	avefire	364	364	364	364	364	278	278	278	278	278	6,010	6,010	6,010	6,010	6,010	5,155	5,155	5,155	5,155	5,155
	nonpt	34,229	34,219	34,211	34,203	34,203	231	231	231	231	231	23,283	22,460	21,872	21,167	21,167	18,590	17,767	17,180	16,474	16,474
	nonroad	3,008	511	38	40	44	25	29	32	35	40	3,376	2,667	2,108	1,452	1,052	3,236	2,547	2,008	1,377	987
	onroad	5,554	657	529	587	662	4,824	5,161	5,604	6,121	6,776	3,816	2,731	2,200	2,048	2,204	2,842	1,776	1,225	1,004	1,027
	ptipm	486,499	291,244	244,599	223,737	223,737	919	703	741	784	784	22,342	24,029	25,780	37,131	37,131	20,004	17,733	19,050	30,135	30,135
	ptnonipm	34,482	28,587	28,587	28,587	28,587	1,672	1,672	1,672	1,672	1,672	16,375	15,729	15,729	15,729	15,729	9,937	9,566	9,566	9,566	9,566
Kentucky Total		**574,230**	**364,205**	**317,041**	**297,744**	**302,553**	**58,787**	**61,115**	**63,174**	**65,626**	**66,289**	**178,967**	**177,516**	**177,807**	**188,025**	**188,503**	**86,919**	**81,783**	**81,563**	**91,364**	**91,597**
Louisiana	afdust	0	0	0	0	0	0	0	0	0	0	81,493	81,493	81,493	81,493	81,493	20,962	20,962	20,962	20,962	20,962
	ag	0	0	0	0	0	35,159	36,915	38,171	39,676	39,676	0	0	0	0	0	0	0	0	0	0
	alm	32,796	30,726	31,131	35,876	52,721	42	46	48	51	56	7,000	7,145	7,072	7,302	9,023	6,819	6,932	6,827	7,007	8,606
	avefire	892	892	892	892	892	682	682	682	682	682	14,746	14,746	14,746	14,746	14,746	12,647	12,647	12,647	12,647	12,647
	nonpt	2,378	2,374	2,372	2,370	2,370	23,169	23,169	23,169	23,169	23,169	19,038	18,790	18,612	18,399	18,399	17,862	17,614	17,436	17,223	17,223
	nonroad	2,834	473	42	45	49	29	32	34	37	42	3,331	2,634	2,091	1,476	1,138	3,174	2,500	1,980	1,390	1,061
	onroad	4,409	566	469	526	642	4,364	4,631	5,037	5,547	6,620	3,379	2,355	1,912	1,819	2,125	2,506	1,520	1,058	894	990
	ptipm	108,106	89,892	86,289	87,803	87,803	1,399	690	821	960	960	7,487	3,828	3,905	4,612	4,612	5,990	3,292	3,370	4,021	4,021
	ptnonipm	177,507	177,507	177,507	177,507	177,507	7,878	7,879	7,880	7,881	7,881	28,722	28,429	28,429	28,429	28,429	21,082	20,899	20,899	20,899	20,899
Louisiana Total		**328,922**	**302,432**	**298,703**	**305,018**	**321,985**	**72,722**	**74,044**	**75,843**	**78,004**	**79,087**	**165,196**	**159,421**	**158,260**	**158,276**	**159,965**	**91,043**	**86,365**	**85,179**	**85,042**	**86,409**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Maine	afdust	0	0	0	0	0	0	0	0	0	0	13,067	13,067	13,067	13,067	13,067	4,134	4,134	4,134	4,134	4,134
	ag	0	0	0	0	0	6,154	6,540	6,816	7,147	7,147	0	0	0	0	0	0	0	0	0	0
	alm	195	155	131	126	178	1	1	1	1	1	455	494	524	585	772	405	441	467	522	694
	avefire	150	150	150	150	150	115	115	115	115	115	2,480	2,480	2,480	2,480	2,480	2,127	2,127	2,127	2,127	2,127
	nonpt	9,969	9,956	9,947	9,936	9,936	1,616	1,566	1,530	1,486	1,486	13,876	12,996	12,368	11,613	11,613	13,726	12,846	12,218	11,463	11,463
	nonroad	766	132	18	19	21	11	13	14	15	17	1,200	1,117	960	741	632	1,131	1,047	897	690	585
	onroad	1,122	198	160	176	196	1,467	1,574	1,700	1,841	2,024	1,178	834	667	622	660	876	544	372	306	307
	ptipm	2,137	34,757	33,238	21,911	21,911	129	381	328	180	180	86	454	432	299	299	65	415	394	266	266
	ptnonipm	20,778	19,390	19,390	19,390	19,390	809	343	343	343	343	5,963	5,243	5,243	5,243	5,243	4,268	3,750	3,750	3,750	3,750
Maine Total		**35,116**	**64,738**	**63,033**	**51,708**	**51,783**	**10,302**	**10,533**	**10,847**	**11,129**	**11,313**	**38,304**	**36,685**	**35,740**	**34,649**	**34,766**	**26,732**	**25,304**	**24,359**	**23,259**	**23,327**
Maryland	afdust	0	0	0	0	0	0	0	0	0	0	35,393	35,393	35,393	35,393	35,393	7,393	7,393	7,393	7,393	7,393
	ag	0	0	0	0	0	24,562	26,618	28,088	29,851	29,851	0	0	0	0	0	0	0	0	0	0
	alm	5,707	4,007	3,140	2,825	3,921	22	24	25	27	30	1,635	1,594	1,609	1,645	1,735	496	495	507	539	621
	avefire	32	32	32	32	32	24	24	24	24	24	613	613	613	613	613	531	531	531	531	531
	nonpt	40,864	40,857	40,852	40,846	40,846	606	579	559	535	535	25,058	24,553	24,191	23,757	23,757	19,764	19,258	18,897	18,463	18,463
	nonroad	2,577	452	41	43	49	28	31	34	38	43	3,102	2,537	2,150	1,677	1,440	2,954	2,408	2,033	1,575	1,340
	onroad	3,966	681	632	709	822	5,594	6,280	6,909	7,634	8,764	3,162	2,506	2,245	2,263	2,571	2,194	1,496	1,175	1,091	1,200
	ptipm	256,761	50,757	47,642	53,433	53,433	271	409	460	495	495	17,996	6,995	16,915	23,811	23,811	15,722	5,312	14,953	21,591	21,591
	ptnonipm	34,255	34,061	34,061	34,061	34,061	222	222	222	222	222	6,303	5,477	5,477	5,477	5,477	3,759	3,332	3,332	3,332	3,332
Maryland Total		**344,162**	**130,846**	**126,399**	**131,949**	**133,164**	**31,330**	**34,187**	**36,322**	**38,826**	**39,965**	**93,261**	**79,668**	**88,593**	**94,638**	**94,798**	**52,813**	**40,225**	**48,821**	**54,515**	**54,470**
Massachusetts	afdust	0	0	0	0	0	0	0	0	0	0	49,646	49,646	49,646	49,646	49,646	14,810	14,810	14,810	14,810	14,810
	ag	0	0	0	0	0	2,208	2,244	2,269	2,299	2,299	0	0	0	0	0	0	0	0	0	0
	alm	2,519	1,819	1,681	1,835	2,503	7	8	9	10	11	988	993	1,005	1,033	1,132	874	876	886	912	1,003
	avefire	93	93	93	93	93	71	71	71	71	71	1,544	1,544	1,544	1,544	1,544	1,324	1,324	1,324	1,324	1,324
	nonpt	25,261	25,248	25,239	25,228	25,228	4,070	4,021	3,986	3,944	3,944	28,552	27,661	27,025	26,261	26,261	26,536	25,646	25,010	24,246	24,246
	nonroad	2,385	429	46	49	55	28	31	34	37	43	2,871	2,373	2,005	1,541	1,330	2,732	2,252	1,896	1,448	1,240
	onroad	3,172	678	593	658	755	5,509	6,023	6,562	7,185	8,201	3,253	2,460	2,187	2,205	2,467	2,268	1,460	1,136	1,061	1,147
	ptipm	91,888	12,991	10,825	22,019	22,019	1,103	737	674	601	601	3,730	2,349	7,323	20,948	20,948	3,224	1,734	6,724	20,104	20,104
	ptnonipm	14,079	13,814	13,814	13,814	13,814	403	401	401	401	401	2,795	2,705	2,705	2,705	2,705	1,842	1,794	1,794	1,794	1,794
Massachusetts Total		**139,397**	**55,073**	**52,291**	**63,696**	**64,468**	**13,401**	**13,537**	**14,006**	**14,548**	**15,571**	**93,379**	**89,732**	**93,440**	**105,884**	**106,033**	**53,610**	**49,896**	**53,581**	**65,699**	**65,667**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Michigan	afdust	0	0	0	0	0	0	0	0	0	0	208,843	208,843	208,843	208,843	208,843	40,894	40,894	40,894	40,894	40,894
	ag	0	0	0	0	0	55,273	56,151	56,778	57,531	57,531	0	0	0	0	0	0	0	0	0	0
	alm	14,466	15,415	17,203	21,207	31,136	5	6	6	6	7	2,637	3,000	3,337	3,929	5,386	2,389	2,711	3,009	3,537	4,848
	avefire	91	91	91	91	91	69	69	69	69	69	1,495	1,495	1,495	1,495	1,495	1,283	1,283	1,283	1,283	1,283
	nonpt	42,066	42,066	42,066	42,066	42,066	429	429	429	429	429	30,989	30,209	29,653	28,985	28,985	24,216	23,295	22,638	21,849	21,849
	nonroad	6,367	1,063	117	125	140	78	88	94	102	117	8,199	6,935	5,650	4,058	3,298	7,782	6,554	5,326	3,803	3,068
	onroad	13,508	1,362	1,106	1,226	1,404	9,813	10,307	11,090	12,003	13,412	7,881	5,651	4,538	4,220	4,579	5,894	3,714	2,569	2,108	2,154
	ptipm	348,377	228,218	245,203	243,651	243,651	286	771	947	1,122	1,122	13,170	12,070	12,685	12,451	12,451	10,648	8,179	8,739	8,620	8,620
	ptnonipm	72,631	71,976	71,976	71,976	71,976	952	946	946	946	946	17,151	15,417	15,417	15,417	15,417	10,346	9,326	9,326	9,326	9,326
Michigan Total		**497,505**	**360,190**	**377,761**	**380,341**	**390,463**	**66,906**	**68,767**	**70,360**	**72,209**	**73,633**	**290,363**	**283,621**	**281,619**	**279,398**	**280,454**	**103,451**	**95,954**	**93,782**	**91,419**	**92,042**
Minnesota	afdust	0	0	0	0	0	0	0	0	0	0	432,054	432,054	432,054	432,054	432,054	79,303	79,303	79,303	79,303	79,303
	ag	0	0	0	0	0	134,830	136,892	138,364	140,130	140,130	0	0	0	0	0	0	0	0	0	0
	alm	6,592	5,024	4,826	5,562	8,164	12	14	15	16	18	1,665	1,655	1,619	1,633	1,869	1,643	1,627	1,587	1,594	1,812
	avefire	631	631	631	631	631	482	482	482	482	482	10,427	10,427	10,427	10,427	10,427	8,943	8,943	8,943	8,943	8,943
	nonpt	14,747	14,737	14,730	14,721	14,721	1,226	1,226	1,226	1,226	1,226	26,968	26,093	25,468	24,718	24,718	24,496	23,621	22,996	22,245	22,245
	nonroad	6,525	1,138	84	88	97	59	68	74	82	93	8,097	6,277	4,957	3,540	2,319	7,759	5,990	4,716	3,348	2,171
	onroad	2,816	729	618	688	779	5,362	5,827	6,356	6,992	7,902	3,790	2,972	2,427	2,282	2,451	2,740	1,920	1,347	1,122	1,143
	ptipm	102,152	57,217	60,954	64,060	64,060	69	345	720	770	770	7,437	11,798	12,544	13,093	13,093	234	9,113	9,811	10,230	10,230
	ptnonipm	27,263	23,844	23,866	23,895	23,895	27,525	28,560	29,298	30,186	30,186	22,425	20,345	20,357	20,370	20,370	4,097	3,924	3,933	3,942	3,942
Minnesota Total		**160,725**	**103,320**	**105,707**	**109,644**	**112,346**	**169,566**	**173,414**	**176,535**	**179,883**	**180,807**	**512,863**	**511,620**	**509,853**	**508,117**	**507,301**	**129,215**	**134,440**	**132,636**	**130,728**	**129,790**
Mississippi	afdust	0	0	0	0	0	0	0	0	0	0	139,219	139,251	139,274	139,302	139,302	38,120	38,130	38,137	38,146	38,146
	ag	0	0	0	0	0	58,575	63,939	67,773	72,371	72,371	0	0	0	0	0	0	0	0	0	0
	alm	9,163	8,214	8,487	10,082	14,822	18	20	21	22	25	3,057	3,085	3,091	3,203	3,736	2,668	2,689	2,680	2,764	3,235
	avefire	1,051	1,051	1,051	1,051	1,051	804	804	804	804	804	17,370	17,370	17,370	17,370	17,370	14,897	14,897	14,897	14,897	14,897
	nonpt	6,796	6,790	6,786	6,781	6,781	196	196	196	196	196	17,827	17,289	16,904	16,443	16,443	16,769	16,232	15,847	15,386	15,386
	nonroad	2,119	356	29	30	33	19	22	23	25	29	2,479	1,959	1,537	1,055	777	2,370	1,864	1,459	996	726
	onroad	3,591	501	382	429	505	3,606	3,866	4,190	4,584	5,203	3,058	2,281	1,817	1,695	1,915	2,309	1,527	1,044	854	907
	ptipm	67,593	51,938	50,434	56,664	56,664	456	327	513	497	497	3,122	2,777	3,378	10,168	10,168	2,625	1,860	2,475	9,133	9,133
	ptnonipm	36,519	29,914	29,914	29,914	29,914	1,414	852	852	852	852	19,535	18,524	18,524	18,524	18,524	10,019	9,307	9,307	9,307	9,307
Mississippi Total		**126,831**	**98,763**	**97,082**	**104,951**	**109,771**	**65,088**	**70,024**	**74,371**	**79,351**	**79,976**	**205,667**	**202,537**	**201,896**	**207,760**	**208,235**	**89,778**	**86,507**	**85,847**	**91,483**	**91,739**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Missouri	afdust	0	0	0	0	0	0	0	0	0	0	458,324	458,324	458,324	458,324	458,324	96,070	96,070	96,070	96,070	96,070
	ag	0	0	0	0	0	107,023	108,403	109,390	110,571	110,571	0	0	0	0	0	0	0	0	0	0
	alm	8,610	5,550	5,106	5,930	8,593	19	22	23	25	29	2,548	2,514	2,491	2,531	2,769	2,489	2,448	2,419	2,448	2,664
	avefire	186	186	186	186	186	142	142	142	142	142	3,074	3,074	3,074	3,074	3,074	2,636	2,636	2,636	2,636	2,636
	nonpt	44,573	44,557	44,545	44,531	44,531	3,830	3,830	3,830	3,830	3,830	32,399	31,072	30,123	28,985	28,985	28,217	26,890	25,941	24,803	24,803
	nonroad	5,143	885	61	65	72	43	49	54	59	68	5,929	4,506	3,519	2,444	1,671	5,690	4,311	3,357	2,320	1,567
	onroad	6,148	947	797	889	1,059	6,918	7,468	8,133	8,903	10,427	5,199	3,836	3,144	2,975	3,367	3,819	2,479	1,750	1,470	1,574
	ptipm	249,942	235,578	231,753	241,550	241,550	705	743	806	814	814	8,868	11,539	11,541	12,431	12,431	5,818	9,222	9,174	10,080	10,080
	ptnonipm	111,547	110,331	110,331	110,331	110,331	322	322	322	322	322	14,083	13,678	13,678	13,678	13,678	7,424	7,084	7,084	7,084	7,084
Missouri Total		**426,149**	**398,034**	**392,779**	**403,482**	**406,322**	**119,002**	**120,978**	**122,699**	**124,666**	**126,203**	**530,423**	**528,542**	**525,895**	**524,442**	**524,298**	**152,163**	**151,141**	**148,432**	**146,911**	**146,480**
Montana	afdust	0	0	0	0	0	0	0	0	0	0	188,368	188,368	188,368	188,368	188,368	40,180	40,180	40,180	40,180	40,180
	ag	0	0	0	0	0	45,890	46,222	46,459	46,743	46,743	0	0	0	0	0	0	0	0	0	0
	alm	1,688	340	62	72	83	6	7	8	9	10	711	675	659	648	633	690	653	636	623	606
	avefire	1,422	1,422	1,422	1,422	1,422	946	946	946	946	946	19,949	19,949	19,949	19,949	19,949	17,311	17,311	17,311	17,311	17,311
	nonpt	1,961	1,957	1,954	1,951	1,951	50	50	50	50	50	5,765	5,446	5,218	4,944	4,944	5,569	5,249	5,021	4,747	4,747
	nonroad	2,009	340	17	17	18	14	16	18	20	22	2,344	1,697	1,261	821	431	2,261	1,632	1,210	786	407
	onroad	1,062	145	115	128	153	1,032	1,109	1,207	1,323	1,549	908	621	486	452	512	688	411	274	223	238
	ptipm	23,396	17,149	21,174	22,221	22,221	11	195	233	247	247	2,404	5,150	8,524	9,203	9,203	2,077	3,585	5,604	6,179	6,179
	ptnonipm	13,271	12,239	9,688	9,688	9,688	265	265	265	265	265	5,538	5,388	5,323	5,323	5,323	2,576	2,454	2,414	2,414	2,414
Montana Total		**44,809**	**33,592**	**34,433**	**35,499**	**35,536**	**48,214**	**48,810**	**49,185**	**49,601**	**49,832**	**225,987**	**227,295**	**229,788**	**229,709**	**229,364**	**71,352**	**71,475**	**72,650**	**72,464**	**72,084**
Nebraska	afdust	0	0	0	0	0	0	0	0	0	0	320,650	320,650	320,650	320,650	320,650	50,787	50,787	50,787	50,787	50,787
	ag	0	0	0	0	0	166,773	168,886	170,397	172,205	172,205	0	0	0	0	0	0	0	0	0	0
	alm	4,764	950	163	188	225	18	21	22	24	29	1,958	1,862	1,791	1,732	1,651	1,942	1,844	1,773	1,712	1,630
	avefire	105	105	105	105	105	80	80	80	80	80	1,729	1,729	1,729	1,729	1,729	1,483	1,483	1,483	1,483	1,483
	nonpt	29,575	29,572	29,570	29,568	29,568	3,143	3,143	3,143	3,143	3,143	12,679	12,447	12,281	12,082	12,082	8,655	8,422	8,257	8,058	8,058
	nonroad	4,181	712	32	33	36	27	31	34	38	44	4,637	3,257	2,391	1,530	747	4,484	3,144	2,304	1,471	711
	onroad	2,011	286	217	242	314	1,874	1,998	2,159	2,353	2,968	1,723	1,253	975	893	1,092	1,312	849	566	452	515
	ptipm	67,576	118,340	41,587	39,642	39,642	190	266	282	307	307	1,551	3,082	3,761	4,012	4,012	1,191	2,484	3,163	3,346	3,346
	ptnonipm	6,018	6,018	6,018	6,018	6,018	421	422	422	422	422	1,623	1,614	1,614	1,614	1,614	806	801	801	801	801
Nebraska Total		**114,229**	**155,982**	**77,691**	**75,796**	**75,907**	**172,525**	**174,846**	**176,539**	**178,571**	**179,197**	**346,550**	**345,893**	**345,192**	**344,243**	**343,578**	**70,659**	**69,815**	**69,134**	**68,109**	**67,330**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Nevada	afdust	0	0	0	0	0	0	0	0	0	0	61,096	61,096	61,096	61,096	61,096	11,371	11,371	11,371	11,371	11,371
	ag	0	0	0	0	0	5,598	5,647	5,682	5,723	5,723	0	0	0	0	0	0	0	0	0	0
	alm	990	454	377	429	479	3	3	3	4	4	445	442	450	464	473	419	414	420	431	438
	avefire	1,346	1,346	1,346	1,346	1,346	1,026	1,026	1,026	1,026	1,026	22,169	22,169	22,169	22,169	22,169	19,018	19,018	19,018	19,018	19,018
	nonpt	12,476	12,475	12,474	12,473	12,473	199	199	199	199	199	4,389	4,331	4,289	4,238	4,238	2,735	2,676	2,634	2,584	2,584
	nonroad	2,025	358	22	23	26	17	20	22	24	28	2,115	1,713	1,418	1,018	779	2,027	1,636	1,349	961	726
	onroad	360	177	194	235	278	1,532	1,964	2,339	2,795	3,309	644	638	664	750	876	399	347	328	353	406
	ptipm	49,276	31,272	26,457	30,331	30,331	460	585	645	483	483	3,629	5,097	9,268	13,192	13,192	3,283	4,072	7,846	11,430	11,430
	ptnonipm	1,342	1,342	1,342	1,342	1,342	164	164	164	164	164	3,240	3,196	3,196	3,196	3,196	1,435	1,420	1,420	1,420	1,420
Nevada Total		**67,815**	**47,424**	**42,213**	**46,179**	**46,276**	**8,999**	**9,608**	**10,080**	**10,418**	**10,937**	**97,728**	**98,682**	**102,548**	**106,123**	**106,017**	**40,687**	**40,954**	**44,385**	**47,569**	**47,393**
New Hampshire	afdust	0	0	0	0	0	0	0	0	0	0	6,175	6,175	6,175	6,175	6,175	2,194	2,194	2,194	2,194	2,194
	ag	0	0	0	0	0	1,354	1,377	1,394	1,414	1,414	0	0	0	0	0	0	0	0	0	0
	alm	238	219	220	252	363	0	0	0	0	0	98	100	103	108	123	86	87	89	93	107
	avefire	38	38	38	38	38	29	29	29	29	29	622	622	622	622	622	534	534	534	534	534
	nonpt	7,408	7,400	7,394	7,387	7,387	835	803	780	753	753	13,351	12,797	12,401	11,926	11,926	12,658	12,104	11,708	11,233	11,233
	nonroad	673	119	15	16	18	9	10	11	12	14	942	833	707	541	463	891	784	664	506	430
	onroad	880	180	148	165	193	1,266	1,417	1,564	1,723	1,999	969	760	619	579	639	714	497	347	286	298
	ptipm	44,009	8,279	9,970	14,096	14,096	58	259	258	231	231	2,632	1,318	3,470	8,806	8,806	2,305	1,195	3,305	8,540	8,540
	ptnonipm	2,570	2,570	2,570	2,570	2,570	56	56	56	56	56	459	459	459	459	459	390	390	390	390	390
New Hampshire Total		**55,815**	**18,803**	**20,354**	**24,524**	**24,664**	**3,607**	**3,952**	**4,092**	**4,217**	**4,495**	**25,248**	**23,064**	**24,556**	**29,216**	**29,213**	**19,772**	**17,785**	**19,231**	**23,776**	**23,726**
New Jersey	afdust	0	0	0	0	0	0	0	0	0	0	16,305	16,305	16,305	16,305	16,305	1,392	1,392	1,392	1,392	1,392
	ag	0	0	0	0	0	3,827	3,953	4,044	4,152	4,152	0	0	0	0	0	0	0	0	0	0
	alm	14,587	15,243	16,581	20,019	29,344	11	12	13	13	15	1,786	1,889	1,963	2,142	2,749	1,611	1,703	1,764	1,922	2,478
	avefire	61	61	61	61	61	47	47	47	47	47	1,009	1,009	1,009	1,009	1,009	865	865	865	865	865
	nonpt	10,726	10,718	10,713	10,707	10,707	2,648	2,648	2,648	2,648	2,648	15,987	15,375	14,937	14,411	14,411	13,074	12,462	12,024	11,498	11,498
	nonroad	3,378	607	65	69	78	41	45	49	54	63	4,162	3,432	2,915	2,283	1,992	3,958	3,255	2,756	2,144	1,855
	onroad	3,658	845	800	880	1,016	7,635	8,373	9,081	9,860	11,338	3,805	3,107	2,830	2,894	3,198	2,537	1,802	1,456	1,405	1,477
	ptipm	51,299	20,935	19,045	20,861	20,861	170	537	592	566	566	4,835	3,176	4,565	6,656	6,656	4,010	2,594	3,832	5,731	5,731
	ptnonipm	9,930	6,233	6,233	6,233	6,233	475	475	475	475	475	3,131	2,966	2,966	2,966	2,966	2,464	2,337	2,337	2,337	2,337
New Jersey Total		**93,640**	**54,642**	**53,498**	**58,829**	**68,300**	**14,854**	**16,091**	**16,948**	**17,815**	**19,303**	**51,020**	**47,259**	**47,490**	**48,667**	**49,286**	**29,910**	**26,409**	**26,425**	**27,294**	**27,633**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
New Mexico	afdust	0	0	0	0	0	0	0	0	0	0	440,334	440,334	440,334	440,334	440,334	80,348	80,348	80,348	80,348	80,348
	ag	0	0	0	0	0	36,340	36,476	36,574	36,690	36,690	0	0	0	0	0	0	0	0	0	0
	alm	2,550	522	106	122	140	9	11	12	13	15	1,110	1,060	1,029	1,004	966	1,084	1,033	1,000	974	934
	avefire	3,450	3,450	3,450	3,450	3,450	2,626	2,626	2,626	2,626	2,626	56,719	56,719	56,719	56,719	56,719	48,662	48,662	48,662	48,662	48,662
	nonpt	2,825	2,823	2,821	2,820	2,820	39	39	39	39	39	5,984	5,816	5,696	5,552	5,552	5,346	5,178	5,058	4,914	4,914
	nonroad	975	167	12	13	14	9	10	11	12	14	1,062	859	700	501	380	1,016	818	665	472	355
	onroad	2,254	337	280	319	370	2,323	2,638	2,961	3,339	3,862	1,965	1,416	1,151	1,100	1,211	1,476	926	641	540	563
	ptipm	51,016	26,035	25,999	26,112	26,112	10	392	398	464	464	8,024	5,334	5,347	5,544	5,544	5,557	4,673	4,686	4,874	4,874
	ptnonipm	18,179	16,513	16,513	16,513	16,513	44	44	44	44	44	3,986	3,821	3,821	3,821	3,821	3,290	3,179	3,179	3,179	3,179
New Mexico Total		**81,249**	**49,846**	**49,182**	**49,349**	**49,420**	**41,401**	**42,236**	**42,665**	**43,226**	**43,754**	**519,183**	**515,360**	**514,798**	**514,576**	**514,528**	**146,779**	**144,818**	**144,239**	**143,964**	**143,830**
New York	afdust	0	0	0	0	0	0	0	0	0	0	139,896	139,896	139,896	139,896	139,896	29,997	29,997	29,997	29,997	29,997
	ag	0	0	0	0	0	49,281	49,900	50,342	50,873	50,873	0	0	0	0	0	0	0	0	0	0
	alm	9,353	7,050	6,128	6,277	9,061	29	31	33	35	39	1,780	1,826	1,865	1,965	2,267	1,394	1,441	1,494	1,600	1,861
	avefire	113	113	113	113	113	86	86	86	86	86	1,866	1,866	1,866	1,866	1,866	1,601	1,601	1,601	1,601	1,601
	nonpt	125,559	125,618	125,661	125,711	125,711	3,964	4,158	4,297	4,463	4,463	83,468	87,036	89,585	92,644	92,644	58,823	62,022	64,307	67,049	67,049
	nonroad	6,797	1,209	125	134	151	79	89	97	107	123	8,303	6,886	5,734	4,304	3,512	7,909	6,535	5,427	4,047	3,274
	onroad	8,075	1,710	1,595	1,756	2,170	14,582	15,853	17,084	18,456	22,335	8,059	7,022	6,174	5,596	6,781	5,547	4,426	3,491	2,752	3,227
	ptipm	238,034	140,744	113,238	111,224	111,224	2,439	1,609	1,279	1,279	1,279	13,669	8,019	28,290	31,952	31,952	12,081	6,441	26,168	29,757	29,757
	ptnonipm	59,078	59,043	59,043	59,043	59,043	1,241	1,239	1,239	1,239	1,239	8,565	7,661	7,661	7,661	7,661	4,410	3,752	3,752	3,752	3,752
New York Total		**447,008**	**335,486**	**305,901**	**304,257**	**307,473**	**71,702**	**72,966**	**74,457**	**76,538**	**80,437**	**265,606**	**260,213**	**281,073**	**285,884**	**286,580**	**121,762**	**116,215**	**136,236**	**140,555**	**140,518**
North Carolina	afdust	0	0	0	0	0	0	0	0	0	0	91,287	91,287	91,287	91,287	91,287	25,474	25,474	25,474	25,474	25,474
	ag	0	0	0	0	0	158,188	168,029	175,054	183,488	183,488	0	0	0	0	0	0	0	0	0	0
	alm	1,840	1,044	928	1,084	1,516	7	8	9	10	11	6,752	7,029	7,746	8,718	9,680	4,789	4,977	5,468	6,137	6,808
	avefire	696	696	696	696	696	532	532	532	532	532	11,509	11,509	11,509	11,509	11,509	9,870	9,870	9,870	9,870	9,870
	nonpt	22,020	22,006	21,996	21,984	21,984	236	236	236	236	236	40,945	39,800	38,981	38,000	38,000	38,389	37,243	36,425	35,443	35,443
	nonroad	5,750	989	81	86	97	54	60	66	73	84	6,313	5,104	4,185	3,033	2,406	6,035	4,862	3,974	2,861	2,247
	onroad	8,683	1,147	963	1,095	1,250	7,953	8,925	9,900	11,115	12,540	6,517	4,723	3,865	3,701	4,026	4,874	3,077	2,157	1,827	1,884
	ptipm	471,337	202,194	154,504	144,734	144,734	124	574	639	670	670	22,259	21,598	22,962	29,362	29,362	16,031	16,477	17,377	23,517	23,517
	ptnonipm	56,065	54,306	54,306	54,306	54,306	1,485	1,469	1,470	1,470	1,470	13,744	13,326	13,326	13,326	13,326	9,828	9,391	9,391	9,391	9,391
North Carolina Total		**566,392**	**282,382**	**233,475**	**223,985**	**224,583**	**168,580**	**179,835**	**187,906**	**197,594**	**199,032**	**199,327**	**194,376**	**193,860**	**198,935**	**199,596**	**115,291**	**111,371**	**110,135**	**114,520**	**114,634**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
North Dakota	afdust	0	0	0	0	0	0	0	0	0	0	269,751	269,751	269,751	269,751	269,751	50,500	50,500	50,500	50,500	50,500
	ag	0	0	0	0	0	71,302	71,557	71,739	71,957	71,957	0	0	0	0	0	0	0	0	0	0
	alm	1,601	316	51	59	68	6	7	7	8	10	684	652	630	612	587	670	637	614	595	569
	avefire	66	66	66	66	66	50	50	50	50	50	1,089	1,089	1,089	1,089	1,089	934	934	934	934	934
	nonpt	5,768	5,765	5,763	5,761	5,761	69	69	69	69	69	3,751	3,539	3,387	3,205	3,205	3,241	3,029	2,877	2,695	2,695
	nonroad	4,106	696	28	28	30	25	29	32	36	41	4,634	3,177	2,282	1,433	603	4,486	3,072	2,205	1,382	577
	onroad	700	100	78	85	107	733	758	804	857	1,037	608	430	336	305	360	455	286	191	152	168
	ptipm	140,535	78,026	36,622	43,908	43,908	378	370	364	376	376	7,625	5,960	6,124	5,960	5,960	6,479	5,059	5,202	5,076	5,076
	ptnonipm	15,449	11,305	11,305	11,305	11,305	139	139	139	139	139	1,437	1,422	1,422	1,422	1,422	1,105	1,103	1,103	1,103	1,103
North Dakota Total		**168,224**	**96,275**	**53,913**	**61,212**	**61,244**	**72,703**	**72,979**	**73,204**	**73,491**	**73,678**	**289,580**	**286,021**	**285,022**	**283,777**	**282,978**	**67,870**	**64,618**	**63,626**	**62,437**	**61,623**
Ohio	afdust	0	0	0	0	0	0	0	0	0	0	236,316	236,316	236,316	236,316	236,316	49,900	49,900	49,900	49,900	49,900
	ag	0	0	0	0	0	98,711	101,976	104,307	107,105	107,105	0	0	0	0	0	0	0	0	0	0
	alm	11,191	8,372	8,056	9,339	13,647	32	36	39	42	49	3,393	3,424	3,437	3,561	4,095	3,113	3,135	3,134	3,235	3,722
	avefire	22	22	22	22	22	17	17	17	17	17	368	368	368	368	368	316	316	316	316	316
	nonpt	19,810	19,810	19,810	19,810	19,810	8,527	8,420	8,344	8,253	8,253	25,444	24,784	24,312	23,746	23,746	23,761	23,101	22,629	22,063	22,063
	nonroad	8,254	1,429	112	119	134	74	83	91	101	117	8,400	6,603	5,278	3,649	2,902	8,043	6,299	5,018	3,443	2,713
	onroad	12,682	1,414	1,171	1,305	1,519	10,986	11,569	12,466	13,570	15,357	8,049	5,875	4,807	4,549	5,058	5,933	3,792	2,673	2,246	2,364
	ptipm	1,145,194	425,975	364,335	299,575	299,575	74	1,207	1,292	1,330	1,330	62,308	40,958	37,583	39,452	39,452	55,730	30,936	27,757	29,467	29,467
	ptnonipm	111,233	109,789	101,330	101,330	101,330	6,370	6,370	6,370	6,370	6,370	14,370	14,039	13,858	13,858	13,858	10,000	9,705	9,576	9,576	9,576
Ohio Total		**1,308,387**	**566,810**	**494,835**	**431,499**	**436,037**	**124,789**	**129,677**	**132,925**	**136,787**	**138,597**	**358,650**	**332,368**	**325,960**	**325,500**	**325,796**	**156,798**	**127,183**	**121,004**	**120,246**	**120,120**
Oklahoma	afdust	0	0	0	0	0	0	0	0	0	0	395,931	395,931	395,931	395,931	395,931	70,686	70,686	70,686	70,686	70,686
	ag	0	0	0	0	0	95,061	97,973	100,054	102,549	102,549	0	0	0	0	0	0	0	0	0	0
	alm	1,890	469	181	207	269	7	8	8	9	11	886	853	838	828	813	841	809	791	779	762
	avefire	469	469	469	469	469	359	359	359	359	359	7,747	7,747	7,747	7,747	7,747	6,644	6,644	6,644	6,644	6,644
	nonpt	7,542	7,538	7,535	7,531	7,531	11,358	11,358	11,358	11,358	11,358	54,339	53,993	53,746	53,449	53,449	43,886	43,540	43,293	42,996	42,996
	nonroad	3,093	520	36	38	42	26	29	32	35	40	3,494	2,636	2,063	1,452	1,012	3,353	2,521	1,967	1,377	948
	onroad	5,344	619	524	594	728	4,626	5,089	5,637	6,296	7,538	3,501	2,565	2,123	2,038	2,401	2,592	1,652	1,173	1,000	1,118
	ptipm	111,841	165,330	79,570	64,002	64,002	909	1,010	1,186	1,067	1,067	3,350	5,373	6,598	7,609	7,609	1,722	4,311	5,534	6,350	6,350
	ptnonipm	38,495	33,153	33,153	33,153	33,153	3,118	3,118	3,118	3,118	3,118	9,175	8,903	8,903	8,903	8,903	5,241	4,852	4,852	4,852	4,852
Oklahoma Total		**168,673**	**208,098**	**121,468**	**105,994**	**106,194**	**115,463**	**118,943**	**121,752**	**124,790**	**126,040**	**478,422**	**478,000**	**477,948**	**477,956**	**477,863**	**134,966**	**135,015**	**134,941**	**134,685**	**134,357**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Oregon	afdust	0	0	0	0	0	0	0	0	0	0	82,013	82,013	82,013	82,013	82,013	30,637	30,637	30,637	30,637	30,637
	ag	0	0	0	0	0	40,655	41,158	41,518	41,949	41,949	0	0	0	0	0	0	0	0	0	0
	alm	4,212	3,487	3,423	3,923	5,694	9	10	10	11	13	1,498	1,509	1,513	1,560	1,770	1,371	1,377	1,373	1,409	1,599
	avefire	4,896	4,896	4,896	4,896	4,896	3,542	3,542	3,542	3,542	3,542	75,861	75,861	75,861	75,861	75,861	65,350	65,350	65,350	65,350	65,350
	nonpt	9,845	9,846	9,846	9,847	9,847	1,061	1,061	1,061	1,061	1,061	50,681	49,765	49,110	48,325	48,325	49,407	48,479	47,816	47,020	47,020
	nonroad	2,559	434	35	37	41	24	27	29	32	37	2,902	2,358	1,920	1,386	1,080	2,773	2,243	1,822	1,306	1,008
	onroad	3,488	450	398	448	504	3,270	3,758	4,181	4,656	5,213	2,707	2,151	1,697	1,537	1,622	2,021	1,458	994	778	767
	ptipm	12,285	12,552	12,552	12,606	12,606	162	298	298	298	298	711	392	392	449	449	326	331	331	385	385
	ptnonipm	5,307	5,307	5,307	5,307	5,307	787	787	787	787	787	9,828	9,532	9,532	9,532	9,532	6,203	6,042	6,042	6,042	6,042
Oregon Total		**42,592**	**36,971**	**36,457**	**37,064**	**38,896**	**49,509**	**50,641**	**51,426**	**52,337**	**52,900**	**226,200**	**223,580**	**222,039**	**220,662**	**220,651**	**158,088**	**155,917**	**154,365**	**152,927**	**152,808**
Pennsylvania	afdust	0	0	0	0	0	0	0	0	0	0	130,508	130,508	130,508	130,508	130,508	32,224	32,224	32,224	32,224	32,224
	ag	0	0	0	0	0	76,675	79,474	81,473	83,870	83,870	0	0	0	0	0	0	0	0	0	0
	alm	8,354	6,729	6,553	7,510	10,928	14	16	17	18	21	2,376	2,396	2,399	2,478	2,857	2,268	2,276	2,267	2,329	2,677
	avefire	32	32	32	32	32	25	25	25	25	25	530	530	530	530	530	454	454	454	454	454
	nonpt	68,349	68,335	68,326	68,314	68,314	3,689	3,689	3,689	3,689	3,689	41,841	40,757	39,983	39,053	39,053	31,263	30,179	29,404	28,475	28,475
	nonroad	5,203	918	89	95	107	55	62	68	75	87	6,256	5,295	4,442	3,335	2,782	5,969	5,028	4,205	3,138	2,596
	onroad	7,885	1,369	1,169	1,285	1,504	10,618	11,363	12,227	13,212	15,234	7,250	5,426	4,514	4,293	4,821	5,219	3,436	2,475	2,108	2,253
	ptipm	907,734	244,722	206,230	188,589	188,589	401	1,234	1,311	1,237	1,237	63,198	31,689	31,114	30,850	30,850	53,067	24,131	23,255	23,155	23,155
	ptnonipm	88,132	81,441	75,605	75,605	75,605	1,334	1,298	1,298	1,298	1,298	22,391	20,443	20,393	20,393	20,393	11,549	10,265	10,186	10,186	10,186
Pennsylvania Total		**1,085,688**	**403,546**	**358,004**	**341,431**	**345,080**	**92,811**	**97,160**	**100,108**	**103,424**	**105,460**	**274,351**	**237,044**	**233,883**	**231,440**	**231,794**	**142,015**	**107,994**	**104,472**	**102,070**	**102,021**
Rhode Island	afdust	0	0	0	0	0	0	0	0	0	0	2,501	2,501	2,501	2,501	2,501	481	481	481	481	481
	ag	0	0	0	0	0	235	237	239	241	241	0	0	0	0	0	0	0	0	0	0
	alm	78	64	68	77	85	0	0	0	0	0	8	8	8	7	7	0	0	0	0	0
	avefire	1	1	1	1	1	1	1	1	1	1	17	17	17	17	17	14	14	14	14	14
	nonpt	3,365	3,364	3,364	3,364	3,364	15	15	15	15	15	1,171	1,136	1,110	1,080	1,080	1,107	1,072	1,046	1,016	1,016
	nonroad	354	63	7	8	9	4	5	5	6	6	427	342	285	218	189	406	324	270	205	176
	onroad	425	86	85	94	107	854	940	1,023	1,122	1,274	343	290	292	313	356	209	150	141	147	165
	ptipm	18	0	0	0	0	58	151	137	126	126	12	7	7	6	6	11	4	4	4	4
	ptnonipm	2,649	2,349	2,349	2,349	2,349	47	47	47	47	47	288	256	256	256	256	173	153	153	153	153
Rhode Island Total		**6,889**	**5,928**	**5,874**	**5,892**	**5,915**	**1,213**	**1,395**	**1,467**	**1,557**	**1,710**	**4,767**	**4,556**	**4,475**	**4,398**	**4,412**	**2,401**	**2,199**	**2,110**	**2,020**	**2,010**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
South Carolina	afdust	0	0	0	0	0	0	0	0	0	0	82,088	82,099	82,108	82,117	82,117	25,657	25,661	25,664	25,667	25,667
	ag	0	0	0	0	0	27,945	29,692	30,941	32,440	32,440	0	0	0	0	0	0	0	0	0	0
	alm	1,946	1,231	1,108	1,267	1,842	4	5	5	6	7	714	711	709	720	779	668	662	656	663	715
	avefire	646	646	646	646	646	494	494	494	494	494	10,684	10,684	10,684	10,684	10,684	9,163	9,163	9,163	9,163	9,163
	nonpt	30,016	30,008	30,003	29,996	29,996	223	223	223	223	223	19,393	18,766	18,318	17,780	17,780	18,139	17,512	17,064	16,526	16,526
	nonroad	2,816	482	41	44	49	27	30	33	36	41	3,102	2,489	2,041	1,490	1,208	2,960	2,368	1,936	1,404	1,127
	onroad	5,021	651	551	617	720	4,710	5,163	5,643	6,206	7,137	3,588	2,629	2,163	2,055	2,283	2,648	1,695	1,200	1,013	1,067
	ptipm	212,572	150,469	122,606	97,472	97,472	306	343	415	424	424	17,707	17,282	17,579	22,636	22,636	13,734	12,638	12,799	17,647	17,647
	ptnonipm	57,307	56,870	56,870	56,870	56,870	1,552	1,552	1,552	1,552	1,552	12,696	11,699	11,699	11,699	11,699	8,159	7,403	7,403	7,403	7,403
South Carolina Total		**310,324**	**240,357**	**211,824**	**186,911**	**187,595**	**35,263**	**37,504**	**39,307**	**41,381**	**42,319**	**149,971**	**146,357**	**145,299**	**149,182**	**149,186**	**81,128**	**77,100**	**75,884**	**79,486**	**79,315**
South Dakota	afdust	0	0	0	0	0	0	0	0	0	0	202,326	202,326	202,326	202,326	202,326	38,332	38,332	38,332	38,332	38,332
	ag	0	0	0	0	0	101,949	102,814	103,432	104,172	104,172	0	0	0	0	0	0	0	0	0	0
	alm	318	69	18	20	23	1	1	1	2	2	172	167	168	170	172	156	151	151	152	152
	avefire	498	498	498	498	498	381	381	381	381	381	8,235	8,235	8,235	8,235	8,235	7,062	7,062	7,062	7,062	7,062
	nonpt	10,304	10,301	10,299	10,296	10,296	51	51	51	51	51	6,683	6,434	6,256	6,042	6,042	4,463	4,214	4,036	3,822	3,822
	nonroad	2,901	492	21	22	23	18	21	23	26	30	3,289	2,286	1,658	1,051	477	3,181	2,207	1,599	1,012	455
	onroad	852	125	95	103	129	843	901	968	1,041	1,280	746	548	419	372	436	564	370	240	185	203
	ptipm	12,545	12,249	4,275	4,865	4,865	50	34	37	48	48	450	231	476	589	589	420	218	447	531	531
	ptnonipm	1,480	1,480	1,480	1,480	1,480	50	50	50	50	50	609	515	515	515	515	291	249	249	249	249
South Dakota Total		**28,898**	**25,214**	**16,685**	**17,284**	**17,314**	**103,343**	**104,253**	**104,944**	**105,770**	**106,013**	**222,509**	**220,741**	**220,052**	**219,300**	**218,791**	**54,470**	**52,803**	**52,116**	**51,345**	**50,806**
Tennessee	afdust	0	0	0	0	0	0	0	0	0	0	95,767	95,767	95,767	95,767	95,767	22,530	22,530	22,530	22,530	22,530
	ag	0	0	0	0	0	34,210	35,494	36,411	37,512	37,512	0	0	0	0	0	0	0	0	0	0
	alm	6,292	5,318	5,393	6,362	9,273	12	14	15	16	18	1,853	1,869	1,858	1,906	2,193	1,707	1,720	1,707	1,749	2,012
	avefire	277	277	277	277	277	212	212	212	212	212	4,587	4,587	4,587	4,587	4,587	3,934	3,934	3,934	3,934	3,934
	nonpt	32,714	32,705	32,698	32,690	32,690	164	164	164	164	164	26,842	26,074	25,526	24,869	24,869	20,663	19,896	19,348	18,690	18,690
	nonroad	3,728	642	54	57	64	35	39	43	47	54	4,225	3,416	2,759	1,954	1,496	4,040	3,253	2,620	1,845	1,399
	onroad	7,674	1,039	830	946	1,104	6,671	7,448	8,258	9,235	10,488	6,128	4,447	3,539	3,319	3,671	4,667	2,982	2,026	1,658	1,719
	ptipm	333,618	158,140	137,637	153,894	153,894	425	436	487	572	572	16,268	10,716	14,520	38,254	38,254	13,910	8,769	12,704	35,970	35,970
	ptnonipm	84,316	83,903	83,903	83,903	83,903	2,394	2,394	2,394	2,394	2,394	30,328	27,121	27,121	27,121	27,121	22,054	19,684	19,684	19,684	19,684
Tennessee Total		**468,619**	**282,025**	**260,792**	**278,130**	**281,205**	**44,124**	**46,202**	**47,986**	**50,152**	**51,415**	**185,996**	**173,997**	**175,677**	**197,775**	**197,957**	**93,505**	**82,769**	**84,553**	**106,059**	**105,938**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Texas	afdust	0	0	0	0	0	0	0	0	0	0	1,290,391	1,290,973	1,291,390	1,291,887	1,291,887	242,993	243,086	243,153	243,232	243,232
	ag	0	0	0	0	0	354,873	360,460	364,456	369,242	369,242	0	0	0	0	0	0	0	0	0	0
	alm	27,280	23,890	24,302	28,470	41,368	57	63	67	73	82	8,936	8,940	8,759	8,857	10,280	8,146	8,147	7,980	8,070	9,380
	avefire	1,178	1,178	1,178	1,178	1,178	1,118	1,118	1,118	1,118	1,118	25,228	25,228	25,228	25,228	25,228	21,578	21,578	21,578	21,578	21,578
	nonpt	109,215	109,204	109,195	109,185	109,185	1,983	1,983	1,983	1,983	1,983	72,265	71,333	70,666	69,867	69,867	47,394	46,461	45,795	44,995	44,995
	nonroad	14,990	2,566	180	189	211	128	145	158	175	202	15,766	12,270	9,862	6,978	5,127	15,126	11,733	9,401	6,607	4,798
	onroad	21,522	3,084	2,506	2,863	3,479	21,943	24,625	27,464	31,029	37,361	16,034	12,192	10,036	10,043	11,798	11,699	7,710	5,342	4,834	5,466
	ptipm	562,594	346,683	339,382	338,519	338,519	5,941	4,839	5,537	6,148	6,148	34,257	35,123	35,202	38,150	38,150	24,920	24,844	24,955	27,849	27,849
	ptnonipm	245,060	172,556	164,923	164,923	164,923	2,297	2,279	2,279	2,279	2,279	38,861	36,535	36,020	36,020	36,020	27,189	25,562	25,310	25,310	25,310
Texas Total		**981,840**	**659,160**	**641,666**	**645,327**	**658,863**	**388,340**	**395,512**	**403,063**	**412,046**	**418,416**	**1,501,740**	**1,492,592**	**1,487,162**	**1,487,030**	**1,488,357**	**399,045**	**389,120**	**383,512**	**382,476**	**382,608**
Tribal Data	alm	132	25	3	4	4	1	1	1	1	1	58	55	52	50	48	0	0	0	0	0
	ptipm	6	0	0	0	0	65	92	92	72	72	31	4	4	3	3	31	3	3	2	2
	ptnonipm	204	203	203	203	203	4	4	4	4	4	1,872	1,868	1,868	1,868	1,868	856	852	852	852	852
Tribal Data Total		**342**	**228**	**206**	**207**	**207**	**69**	**96**	**96**	**76**	**77**	**1,961**	**1,927**	**1,925**	**1,922**	**1,919**	**887**	**855**	**855**	**854**	**854**
Utah	afdust	0	0	0	0	0	0	0	0	0	0	54,020	54,020	54,020	54,020	54,020	7,864	7,864	7,864	7,864	7,864
	ag	0	0	0	0	0	20,448	20,960	21,326	21,765	21,765	0	0	0	0	0	0	0	0	0	0
	alm	1,065	344	213	242	272	5	6	7	8	9	153	152	157	162	166	140	140	144	148	152
	avefire	1,934	1,934	1,934	1,934	1,934	1,479	1,479	1,479	1,479	1,479	31,961	31,961	31,961	31,961	31,961	27,412	27,412	27,412	27,412	27,412
	nonpt	3,427	3,426	3,425	3,423	3,423	1,268	1,268	1,268	1,268	1,268	10,385	10,268	10,185	10,085	10,085	9,079	8,970	8,893	8,800	8,800
	nonroad	1,437	251	21	22	25	14	16	18	20	22	1,703	1,463	1,199	845	647	1,625	1,389	1,135	796	604
	onroad	1,989	335	310	361	432	2,457	2,903	3,335	3,851	4,579	1,658	1,327	1,165	1,176	1,352	1,187	829	628	570	628
	ptipm	33,167	39,360	41,355	44,170	44,170	269	372	416	418	418	6,351	5,480	7,400	8,532	8,532	4,901	4,265	5,940	6,933	6,933
	ptnonipm	9,305	8,454	7,790	7,790	7,790	529	529	529	529	529	6,893	6,577	6,551	6,551	6,551	2,955	2,810	2,809	2,809	2,809
Utah Total		**52,325**	**54,103**	**55,047**	**57,942**	**58,045**	**26,469**	**27,534**	**28,377**	**29,336**	**30,069**	**113,124**	**111,248**	**112,639**	**113,333**	**113,315**	**55,162**	**53,678**	**54,825**	**55,332**	**55,203**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
Vermont	afdust	0	0	0	0	0	0	0	0	0	0	13,658	13,658	13,658	13,658	13,658	4,814	4,814	4,814	4,814	4,814
	ag	0	0	0	0	0	8,821	8,851	8,872	8,898	8,898	0	0	0	0	0	0	0	0	0	0
	alm	6	6	7	7	8	0	0	0	0	0	29	30	32	35	37	21	22	24	26	28
	avefire	49	49	49	49	49	38	38	38	38	38	812	812	812	812	812	696	696	696	696	696
	nonpt	5,385	5,382	5,380	5,378	5,378	214	214	214	214	214	5,823	5,539	5,336	5,093	5,093	5,415	5,151	4,962	4,736	4,736
	nonroad	368	64	7	8	9	5	5	6	6	7	516	463	390	292	236	490	436	366	273	220
	onroad	622	125	103	118	148	939	1,047	1,147	1,262	1,467	645	632	554	557	720	465	418	322	291	355
	ptipm	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ptnonipm	911	911	911	911	911	16	16	16	16	16	337	337	337	337	337	237	237	237	237	237
Vermont Total		**7,341**	**6,538**	**6,458**	**6,471**	**6,503**	**10,043**	**10,172**	**10,293**	**10,434**	**10,639**	**21,819**	**21,471**	**21,119**	**20,783**	**20,893**	**12,137**	**11,774**	**11,422**	**11,072**	**11,085**
Virginia	afdust	0	0	0	0	0	0	0	0	0	0	60,865	60,865	60,865	60,865	60,865	19,662	19,662	19,662	19,662	19,662
	ag	0	0	0	0	0	43,811	45,905	47,402	49,197	49,197	0	0	0	0	0	0	0	0	0	0
	alm	5,595	3,378	2,998	3,428	4,904	13	15	16	18	21	1,905	1,875	1,854	1,872	2,004	1,836	1,801	1,774	1,783	1,900
	avefire	399	399	399	399	399	305	305	305	305	305	6,599	6,599	6,599	6,599	6,599	5,659	5,659	5,659	5,659	5,659
	nonpt	32,923	32,910	32,901	32,889	32,889	1,621	1,621	1,621	1,621	1,621	53,941	52,867	52,100	51,179	51,179	29,947	28,873	28,106	27,185	27,185
	nonroad	4,289	741	60	63	71	41	46	51	56	64	4,809	3,897	3,247	2,437	2,009	4,593	3,709	3,079	2,294	1,872
	onroad	6,662	1,019	920	1,032	1,269	7,889	8,893	9,831	10,881	13,168	4,939	3,736	3,278	3,306	3,976	3,486	2,250	1,711	1,589	1,850
	ptipm	239,777	151,541	148,291	135,834	135,834	192	353	471	435	435	15,400	10,317	13,940	15,885	15,885	14,431	8,356	11,602	13,372	13,372
	ptnonipm	67,691	67,253	67,253	67,253	67,253	3,500	3,498	3,498	3,498	3,498	13,041	11,869	11,869	11,869	11,869	9,734	8,671	8,671	8,671	8,671
Virginia Total		**357,338**	**257,240**	**252,821**	**240,899**	**242,619**	**57,373**	**60,638**	**63,196**	**66,011**	**68,310**	**161,498**	**152,025**	**153,752**	**154,011**	**154,385**	**89,350**	**78,981**	**80,264**	**80,215**	**80,171**
Washington	afdust	0	0	0	0	0	0	0	0	0	0	106,176	106,176	106,176	106,176	106,176	26,908	26,908	26,908	26,908	26,908
	ag	0	0	0	0	0	42,133	42,712	43,126	43,622	43,622	0	0	0	0	0	0	0	0	0	0
	alm	11,488	10,791	11,291	13,423	19,682	151	171	193	236	339	2,416	2,601	2,758	3,074	3,959	2,271	2,447	2,594	2,895	3,749
	avefire	407	407	407	407	407	248	248	248	248	248	5,126	5,126	5,126	5,126	5,126	4,487	4,487	4,487	4,487	4,487
	nonpt	7,254	7,241	7,231	7,219	7,219	1,711	1,711	1,711	1,711	1,711	35,624	34,598	33,864	32,983	32,983	31,983	31,023	30,337	29,513	29,513
	nonroad	5,380	707	57	60	67	39	44	48	53	61	4,776	3,742	3,044	2,207	1,704	4,567	3,563	2,890	2,081	1,590
	onroad	5,539	790	688	794	914	5,168	6,206	7,111	8,125	9,323	4,545	3,315	2,767	2,685	2,941	3,407	2,161	1,550	1,330	1,380
	ptipm	19,108	3,954	3,946	4,064	4,064	62	512	537	528	528	2,456	3,091	3,090	3,213	3,213	2,025	2,465	2,464	2,582	2,582
	ptnonipm	24,623	24,601	24,601	24,601	24,601	774	771	771	771	771	4,970	4,895	4,895	4,895	4,895	3,224	3,189	3,189	3,189	3,189
Washington Total		**73,799**	**48,491**	**48,221**	**50,569**	**56,954**	**50,285**	**52,375**	**53,744**	**55,293**	**56,602**	**166,089**	**163,544**	**161,720**	**160,359**	**160,997**	**78,872**	**76,244**	**74,419**	**72,985**	**73,398**

State	Sector	[tons/yr] 2002 SO2	[tons/yr] 2009 Base SO2	[tons/yr] 2014 Base SO2	[tons/yr] 2020 Base SO2	[tons/yr] 2030 Base SO2	[tons/yr] 2002 NH3	[tons/yr] 2009 Base NH3	[tons/yr] 2014 Base NH3	[tons/yr] 2020 Base NH3	[tons/yr] 2030 Base NH3	[tons/yr] 2002 PM10	[tons/yr] 2009 Base PM10	[tons/yr] 2014 Base PM10	[tons/yr] 2020 Base PM10	[tons/yr] 2030 Base PM10	[tons/yr] 2002 PM2_5	[tons/yr] 2009 Base PM2_5	[tons/yr] 2014 Base PM2_5	[tons/yr] 2020 Base PM2_5	[tons/yr] 2030 Base PM2_5
West Virginia	afdust	0	0	0	0	0	0	0	0	0	0	24,640	24,644	24,647	24,650	24,650	11,305	11,309	11,311	11,314	11,314
	ag	0	0	0	0	0	9,879	10,474	10,898	11,408	11,408	0	0	0	0	0	0	0	0	0	0
	alm	5,707	5,433	5,830	7,090	10,433	8	9	10	11	12	1,478	1,526	1,573	1,689	2,036	1,281	1,322	1,357	1,453	1,763
	avefire	215	215	215	215	215	165	165	165	165	165	3,557	3,557	3,557	3,557	3,557	3,050	3,050	3,050	3,050	3,050
	nonpt	14,589	14,585	14,582	14,578	14,578	72	72	72	72	72	12,220	11,866	11,613	11,310	11,310	11,130	10,776	10,523	10,219	10,219
	nonroad	780	128	13	14	15	8	9	10	11	13	1,005	906	751	541	455	956	856	707	508	424
	onroad	2,675	248	201	217	230	1,950	1,957	2,056	2,175	2,273	1,542	1,004	792	725	732	1,149	648	440	358	343
	ptipm	509,488	200,473	178,167	168,660	168,660	210	628	644	649	649	31,248	22,049	21,938	21,957	21,957	28,884	16,535	16,219	16,230	16,230
	ptnonipm	54,107	54,106	54,106	54,106	54,106	688	688	688	688	688	10,625	10,097	10,097	10,097	10,097	7,450	7,113	7,113	7,113	7,113
West Virginia Total		**587,561**	**275,187**	**253,113**	**244,879**	**248,237**	**12,981**	**14,002**	**14,544**	**15,178**	**15,280**	**86,314**	**75,648**	**74,967**	**74,526**	**74,794**	**65,205**	**51,609**	**50,721**	**50,246**	**50,457**
Wisconsin	afdust	0	0	0	0	0	0	0	0	0	0	103,735	103,735	103,735	103,735	103,735	30,705	30,705	30,705	30,705	30,705
	ag	0	0	0	0	0	113,949	114,789	115,389	116,109	116,109	0	0	0	0	0	0	0	0	0	0
	alm	4,781	3,992	4,195	5,137	7,496	11	13	14	15	17	1,353	1,417	1,492	1,632	1,954	1,182	1,236	1,300	1,421	1,709
	avefire	70	70	70	70	70	54	54	54	54	54	1,159	1,159	1,159	1,159	1,159	994	994	994	994	994
	nonpt	6,369	6,370	6,370	6,370	6,370	266	266	266	266	266	26,104	25,736	25,474	25,159	25,159	25,407	25,040	24,777	24,462	24,462
	nonroad	5,015	845	81	87	99	52	60	65	71	83	6,090	4,944	3,967	2,840	2,296	5,796	4,684	3,747	2,666	2,138
	onroad	7,218	815	676	766	897	6,006	6,492	7,111	7,894	9,065	4,479	3,403	2,810	2,684	2,985	3,317	2,215	1,573	1,327	1,395
	ptipm	192,946	141,203	125,070	123,645	123,645	375	583	662	680	680	5,576	8,465	8,831	8,890	8,890	5,029	7,151	7,432	7,441	7,441
	ptnonipm	63,651	63,431	63,431	63,431	63,431	397	397	397	397	397	10,466	9,199	9,199	9,199	9,199	5,856	5,445	5,445	5,445	5,445
Wisconsin Total		**280,051**	**216,726**	**199,892**	**199,507**	**202,009**	**121,110**	**122,653**	**123,957**	**125,486**	**126,672**	**158,961**	**158,058**	**156,666**	**155,297**	**155,377**	**78,287**	**77,469**	**75,972**	**74,461**	**74,288**
Wyoming	afdust	0	0	0	0	0	0	0	0	0	0	272,299	272,299	272,299	272,299	272,299	41,010	41,010	41,010	41,010	41,010
	ag	0	0	0	0	0	18,575	18,801	18,963	19,156	19,156	0	0	0	0	0	0	0	0	0	0
	alm	2,088	404	56	65	75	8	9	10	11	13	866	824	793	766	730	857	814	782	754	717
	avefire	1,106	1,106	1,106	1,106	1,106	846	846	846	846	846	18,289	18,289	18,289	18,289	18,289	15,686	15,686	15,686	15,686	15,686
	nonpt	6,181	6,179	6,178	6,176	6,176	91	91	91	91	91	3,717	3,571	3,467	3,342	3,342	2,922	2,776	2,672	2,547	2,547
	nonroad	559	95	7	8	8	5	6	7	7	8	689	565	450	312	214	659	537	426	295	200
	onroad	905	122	95	103	122	893	931	997	1,075	1,252	799	524	402	365	407	606	347	226	180	189
	ptipm	83,423	62,706	58,597	58,204	58,204	386	414	443	470	470	9,599	8,653	9,763	10,727	10,727	7,936	7,053	8,032	8,875	8,875
	ptnonipm	33,676	33,653	33,653	33,653	33,653	301	301	301	301	301	19,234	18,528	18,528	18,528	18,528	14,143	13,941	13,941	13,941	13,941
Wyoming Total		**127,938**	**104,266**	**99,692**	**99,315**	**99,345**	**21,104**	**21,398**	**21,656**	**21,957**	**22,136**	**325,494**	**323,255**	**323,991**	**324,629**	**324,536**	**83,819**	**82,164**	**82,775**	**83,288**	**83,165**
Grand Total		**14,649,986**	**9,233,950**	**8,473,877**	**8,171,411**	**8,295,030**	**3,901,951**	**4,023,868**	**4,123,379**	**4,241,636**	**4,297,455**	**12,817,898**	**12,554,430**	**12,551,458**	**12,671,074**	**12,680,651**	**4,938,898**	**4,671,411**	**4,661,327**	**4,768,531**	**4,764,633**

Appendix E

Metadata

Metadata

Output Data

The pm25_surface_36km_2006.csv file is the output file from EPA's Hierarchical Bayesian Model (HBM) that combines $PM_{2.5}$ or O_3 monitoring data from National Air Monitoring Stations/State and Local Air Monitoring Stations (NAMS/SLAMS) and Models-3/Community Multiscale Air Quality (CMAQ) computer-simulated $PM_{2.5}$ or O_3 data. This file provides a spatial interpolation of air quality that takes advantage of the strengths of monitoring network observations and modeling estimates to generate daily surrogate measures for $PM_{2.5}$ and relates these measures to available public health data. The file covers the contiguous lower 48 states of the United States. The time frame covered is January 1, 2006 through December 31, 2006. The standard errors of the estimates should be taken in to account when using the results. This file is a comma-separated values (CSV) file. This is a flat file that is platform-independent. In the Microsoft Windows computing environment, this file can be read easily by Excel.

The file contains the posterior means and standard errors of the estimated space-time surface, the posterior means and standard errors of the estimated space-time bias surface, and the posterior means and standard errors for a surface made up of 12 km x 12 km or 36 km x 36 km contiguous grids. The contiguous 36 km x 36 km grids cover the whole lower 48 contiguous states of the United States. The contiguous 126 km x 12 km grids cover either an Eastern segment of the U.S. or Western segment of the U.S. (lower 48 contiguous states of the United States). The file includes the following variables: Date, Latitude, Longitude, posterior mean estimated $PM_{2.5}$ or O_3 concentration on natural log scale (PredAvg), row position of grid cell, column position of grid cell, standard error of the estimated $PM_{2.5}$ or O_3 concentration on the natural log scale (PredStd), the natural log of the estimated CMAQ model data bias (Bias), and the standard error of the estimated CMAQ model data bias (BiasStd). Values of -999 in the data set represent missing (or excluded) values. Missing values are generated when grid cells are not included in the model calculation. These are not actual missing values but intentionally not included in the grid for calculation of the estimated surface. An example of such a grid cell not included is grid cells that fall over water.

Input Data

The actual monitoring data from the NAMS/SLAMS network were downloaded from the Air Quality System (AQS) database. Only Federal Reference Method (FRM) samplers and only those samplers with sample duration of one day (24-hour integrated sample) were included in the data set.

The CMAQ data was created from version 4.6 of the model using CBIV mechanism. The $PM_{2.5}$ data is a 24-hour integrated $PM_{2.5}$ concentration calculated on a 12-km x 12-km grid for the Eastern United States and a 36-km x 36-km grid for the entire United States. These CMAQ results are based on (1) the emissions data from the EPA's National Emissions Inventory (NEI) 2001 version 3 (developed using mobile emissions model Mobile 6 but no daily continuous emissions monitoring (CEM) data for the major

NO_x point sources). In addition, the meteorological data used for these model results is from Mesoscale Model 5 (MM5) version 3.6.3 simulations (Four Dimensional Data Assimilation [FDDA], Pleim-Xiu Land Surface Model [LSM]).

The HBM combines the actual monitoring data (NAMS/SLAMS), the estimated $PM_{2.5}$ or O_3 concentration surface (CMAQ), and the prediction of $PM_{2.5}$ or O_3 through space and time. The model assumes that both the actual monitoring data and the CMAQ data provide good information about the same underlying pollutant surface, but with different measurement error structures. It gives more weight to the accurate monitoring data in areas where monitoring data exists and relies on the CMAQ data and satellite data in areas where no monitoring data is available. The modeling is divided into hierarchical components where each level of the hierarchy is modeled conditional on the preceding levels. To fit the model, a custom-designed Monte Carlo Markov Chain (MCMC) software algorithm was used. Model-specific input parameters of statistical distributions for the model and simulation parameters (priors) are specified for each run of the model. The projections for the grid cell structure are as follows:

Projection: Lambert conformal with spherical earth, radius = 6370.0 km

36-km Resolution	**12-km Resolution**
NCOLS = 148	NCOLS = 279
NROWS = 112	NROWS = 240
P_ALP = 33.00	P_ALP = 33.00
P_BET = 45.00	P_BET = 45.00
P_GAM = -97.00	P_GAM = -97.00
XCENT = -97.00	XCENT = -97.00
YCENT = 40.00	YCENT = 40.00
XORIG = -2736000.00	XORIG = -1008000.00
YORIG = -2088000.00	YORIG = -1620000.00
XCELL = 36000.00	XCELL = 12000.00
YCELL = 36000.00	YCELL = 12000.00

These values are for the 36- and 12-km grid resolution of CMAQ.

The geographic boundaries of the HB output cover the following region:

111.1 degrees W longitude – West Bounding Coordinate
65.4 degrees W longitude – East Bounding Coordinate
51.25 degrees N latitude – North Bounding Coordinate
23.0 degrees N latitude – South Bounding Coordinate

The definitions for the 12-km x 12-km and 36-km x 36-km CMAQ grid cells are contained in separate text (*.txt) files. These files contain the latitude and longitude coordinates of the following points for each grid cell: 1) center; 2) southwest corner; 3) southeast corner; 4) northwest corner; and 5) northeast corner. The AQS data for $PM_{2.5}$ and O_3 are contained in separate text (*.txt) files. These files contain the following data: parameter occurrence code (for pollutant); state code; city code; site ID; sampling frequency; data; sample value; monitor protocol (i.e., 1 in 3 days); partition, etc. Example figures of a) a separate air quality monitor with CMAQ data, and b) combined air quality monitor data and CMAQ data for $PM_{2.5}$ are shown below.

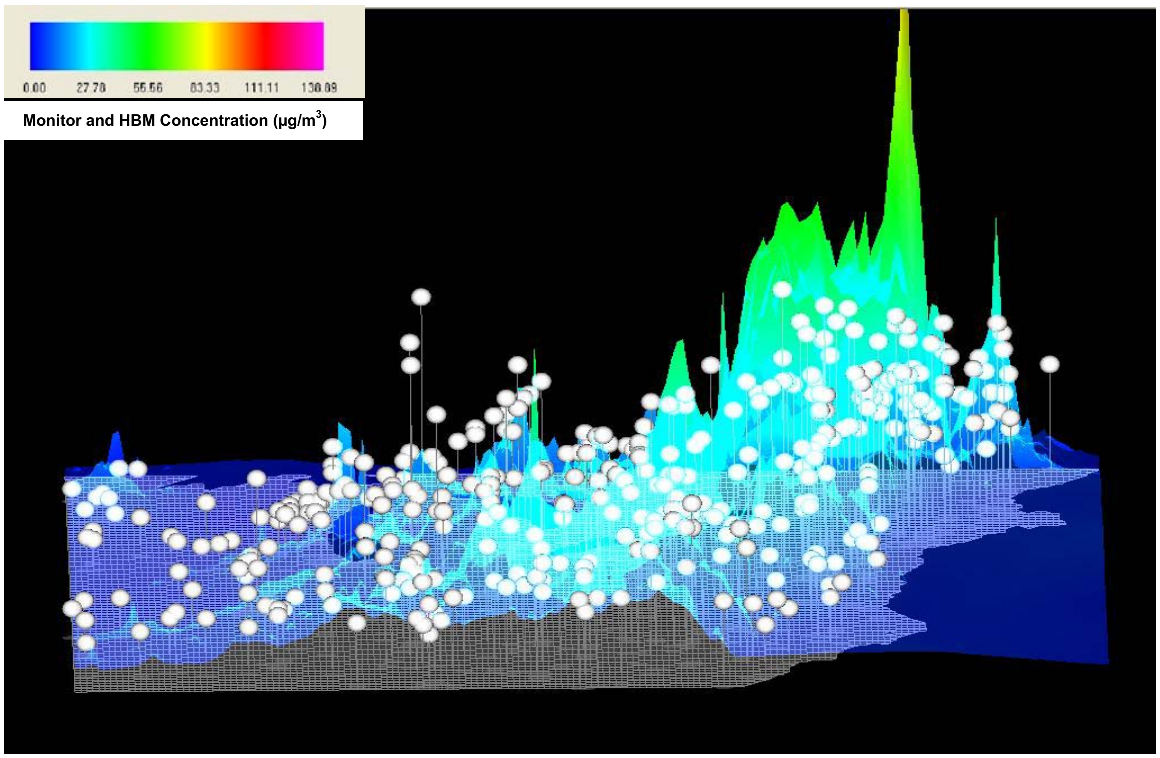


Figure E-1. $PM_{2.5}$ Monitoring Data and CMAQ Surface (Separately Displayed – White Spheres Represent Monitor Locations and Associated Concentration Values)

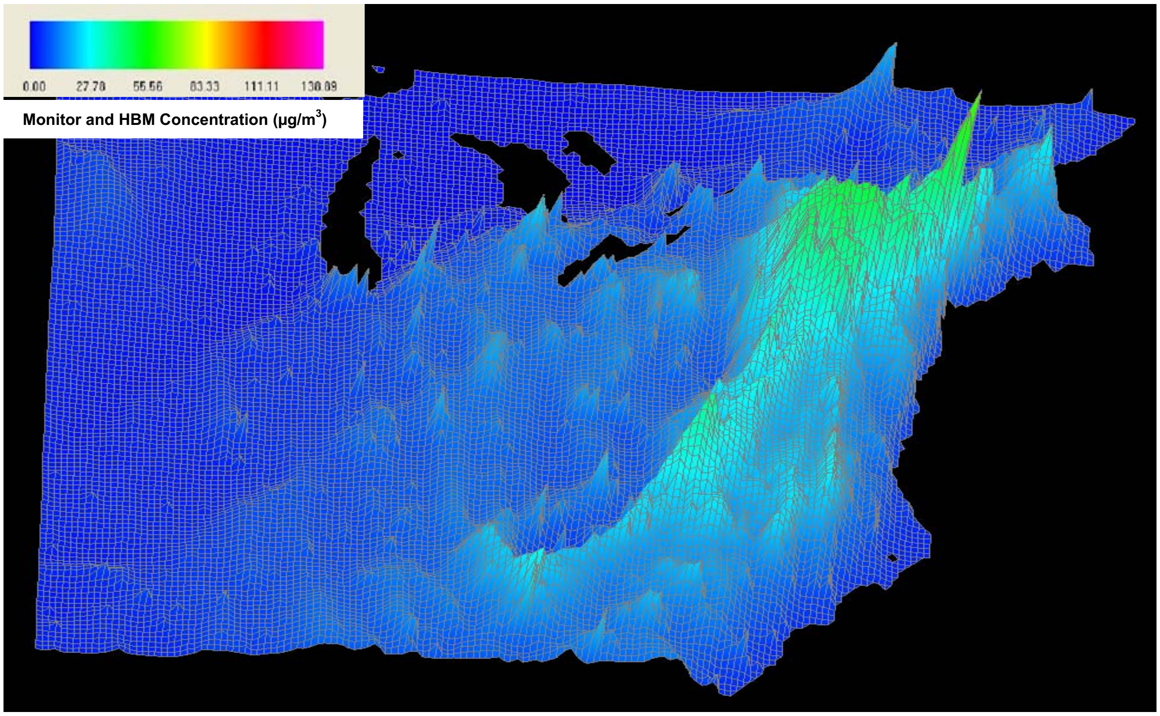


Figure E-2. Combined $PM_{2.5}$ Monitoring Data and CMAQ Surface (Via HBM)

Use of HB Data to Generate Health Indicators

The HB output data can be used to generate health (air) indicators which are useful to researchers when developing health impact assessments (HIA). The HB output is provided in a gridded (x-y/row-column) format and that format must be translated to different coordinate systems (e.g., county-based/relevant coordinates) to provide health indicator data for the area(s) of interest. An important coordinate projection system used as a standard coordinate representation format to express different location designation systems in consistent terms is the Lambert Conformal Conic (LCC) projection coordinate system. The North American Datum (NAD) geodetic system describes the Earth's ellipsoid based on the latitude and longitude location of an initial point, and serves as the basis of maps and surveys of the Earth's surface. The NAD-27 datum is based on the Clarke Ellipsoid (Earth spheroid) of 1866 and is centered at a base station on the Meades Ranch in Kansas. The NAD-83 grid projection/datum is based on the Geodetic Reference Spheroid (GRS) of 1980 and is geocentric (e.g., based on the Earth's center with no directionality or initial point located on the Earth's surface). The NAD coordinate system is important because health-related data (used to calculate health indicators) are collected and cataloged based on this coordinate system (e.g., U.S. Census data is based on NAD-83 coordinates).

The HB output provides ambient concentration data for both ozone and fine particulate matter in x-y-based grid cells, and to correlate this concentration data with health data, the x-y locations must be 'mapped' to latitude/longitude locations and then mapped to the correct datum/projection system linked with the health data. The typical latitude and longitude grids are based on the World Geodetic System (WGS) projection for 1984 (WGS-84), while the U.S. Census uses the NAD-83 grid and the SAS statistical analysis software uses NAD-83 grid projection. When generating the linkage between the ambient concentration data and the health data, a methodology or protocol must be developed to relate the appropriate coordinate system/geocoding information between them.

CDC, EPA, and the state departments of air and/or health of New York, New Jersey, Massachusetts, and Minnesota have developed an initial set of health indicators using the HB output data correlated with available health data/information. They have developed a 'relationship file' to map the x-y-based grid cells to latitude/longitude format with the appropriate datum/projection system(s). Shapefile information also resides in this file allowing compatibility with GIS map formats/applications. The relationship file has a grid ID, representing the row and column of the grid cell. This grid ID is a six-digit identifier from the HB raw data set that concatenates column and row designation. There are 66,000 grid cells per day times 365 days worth of data (the New York State Health Department uses SAS to process this data and CDC uses ArcGIS to process the data). The relationship file recognizes the importance of having consistent geocoding data for HB grids for Health Impact Analyses (HIA). The U.S. Census files (TIGER2000 files) are in NAD-83 format, which is what the SAS statistical software processes. The WGS-84 format is almost exactly like NAD-83 format except there is an offset of a few feet for grid points (centroids). WGS-84 is used by the CMAQ air quality model. Air Quality models such as CMAQ, which serve as input to the HB model, uses the meteorological software MM5 which is based on the Lambert Conformal Conic (LCC) projection. As long as the HB output data (latitude and longitude grid coordinates) can be mapped to the NAD-83 or NAD-84 (WGS-84) to match census data, air indicators can be generated for HIA. The x and y coordinates given in the HB are used to plot the latitude and longitude with an offset to match non-NAD-83 grid references. When defining Earth points, coordinate information should be modified into a format compatible with county-based maps and transformed into an elliptical projection. NetCDF file can be converted in ArcGIS to make shape files. The New Jersey state air department used the Theissen Polygon tool on HB data to generate shapefiles.

Note: The value for the Earth's radius used for 2003 – 2005 versions of CMAQ changed from 6370.997 km (pre-2003) to 6370.000 km.

<u>How CMAQ and HB x-y grid locations are transformed to latitude and longitude values:</u>

There is an IOAPI file providing rows/columns, cell height/width, origin in LCC, offset by ½ cell width/height to get center cell (centroid). Conversion uses an LCC routine in IOAPI library, passing parameters (Earth radius, central meridian [longitude: -97 degrees]), two key latitude values 33 degrees and 45 degrees, central meridian, -97 and latitude of origin, 40.0. These arguments are required for the LCC routine, which returns latitude and longitude. The code for transforming an LCC projection (e.g., CMAQ and HB Model x-y grid coordinates) to latitude and longitude values:

LCPGEO Fortran Code – LCC Conversion Program

****
Fortran Code for converting Lambert Conformal Conic to geodetic (lat/lon):

```
      subroutine lcpgeo(iway,phic,xlonc,truelat1,truelat2,xloc,yloc,
     &                  xlon,ylat)
c      write(*,*)'INCALL:',phic,xlonc,truelat1,truelat2
c
c     LCPGEO performs Lambert Conformal to geodetic (lat/lon) translation
c
c     Code based on the TERRAIN preprocessor for MM5 v2.0,
c     developed by Yong-Run Guo and Sue Chen, National Center for
c     Atmospheric Research, and Pennsylvania State University
c     10/21/1993
c
c     Input arguments:
c        iway              Conversion type
c                          0 = geodetic to Lambert Conformal
c                          1 = Lambert Conformal to geodetic
c        phic              Central latitude (deg, neg for southern hem)
c        xlonc             Central longitude (deg, neg for western hem)
c        truelat1          First true latitute (deg, neg for southern hem)
c        truelat2          Second true latitute (deg, neg for southern hem)
c        xloc/yloc         Projection coordinates (km)
c        xlon/ylat         Longitude/Latitude (deg)
c
c     Output arguments:
c        xloc/yloc         Projection coordinates (km)
c        xlon/ylat         Longitude/Latitude (deg)
c

      data conv/57.29578/, a/6370./
c
c-----Entry Point
c
      if (phic.lt.0) then
        sign = -1.
      else
        sign = 1.
      endif
      pole = 90.
      if (abs(truelat1).gt.90.) then
        truelat1 = 60.
        truelat2 = 30.
        truelat1 = sign*truelat1
```

```
        truelat2 = sign*truelat2
      endif
      xn = alog10(cos(truelat1/conv)) - alog10(cos(truelat2/conv))
      xn = xn/(alog10(tan((45. - sign*truelat1/2.)/conv)) -
     &        alog10(tan((45. - sign*truelat2/2.)/conv)))
      psi1 = 90. - sign*truelat1
      psi1 = psi1/conv
      if (phic.lt.0.) then
        psi1 = -psi1
        pole = -pole
      endif
      psi0 = (pole - phic)/conv
      xc = 0.
      yc = -a/xn*sin(psi1)*(tan(psi0/2.)/tan(psi1/2.))**xn
c
c-----Calculate lat/lon of the point (xloc,yloc)
c
      if (iway.eq.1) then
        xloc = xloc + xc
        yloc = yloc + yc
        if (yloc.eq.0.) then
          if (xloc.ge.0.) flp = 90./conv
          if (xloc.lt.0.) flp = -90./conv
        else
          if (phic.lt.0.) then
            flp = atan2(xloc,yloc)
          else
            flp = atan2(xloc,-yloc)
          endif
        endif
        flpp = (flp/xn)*conv + xlonc
        if (flpp.lt.-180.) flpp = flpp + 360.
        if (flpp.gt. 180.) flpp = flpp - 360.
        xlon = flpp
c
        r = sqrt(xloc*xloc + yloc*yloc)
        if (phic.lt.0.) r = -r
        cell = (r*xn)/(a*sin(psi1))
        rxn  = 1.0/xn
        cel1 = tan(psi1/2.)*cell**rxn
        cel2 = atan(cel1)
        psx  = 2.*cel2*conv
        ylat = pole - psx
c
c-----Calculate x/y from lat/lon
c
```

```
      else
        ylon = xlon - xlonc
        if (ylon.gt. 180.) ylon = ylon - 360.
        if (ylon.lt.-180.) ylon = ylon + 360.
        flp = xn*ylon/conv
        psx = (pole - ylat)/conv
        r = -a/xn*sin(psi1)*(tan(psx/2.)/tan(psi1/2.))**xn
        if (phic.lt.0.) then
          xloc = r*sin(flp)
          yloc = r*cos(flp)
        else
          xloc = -r*sin(flp)
          yloc =  r*cos(flp)
        endif
      endif
c
c      write(*,*)xloc,xc,yloc,yc
      xloc = xloc - xc
      yloc = yloc - yc
c
      return
      end
```

****

CMAQ Projection Information – Source:

http://www.baronams.com/products/ioapi/GRIDDESC.html

Coordinate Information

COORD-NAME	COORDTYPE	P_ALP	P_BET	P_GAM	XCENT	YCENT
'LAM_40N97W'	2	33.000	45.000	-97.000	-97.000	40.000

Grid Information

GRID-NAME	COORD-NAME	XORIG (m)	YORIG (m)	XCELL (m)	YCELL (m)	NCOLS	NROWS	NTHIK
36US1	'LAM_40N97W'	-2736000	-2088000	36000	36000	148	112	1

P_ALP = "PROJ_ALPHA"

P_BET = "PROJ_BETA"

LAMGRD3 = P_ALP <= P_BET. These are the two latitudes which determine the projection cone.

P_GAM = the central meridian

XCENT, **YCENT** = lat/lon coordinates for the center (0, 0) of the Cartesian coordinate system.

X_ORIG is the X coordinate of the grid origin (lower left corner of the cell at column=row=1), given in map projection units (meters, except in Lat-Lon coordinate systems).

Y_ORIG is the Y coordinate of the grid origin (lower left corner of the cell at column=row=1), given in map projection units (meters, except in Lat-Lon coordinate systems).

X_CELL is the cell dimension parallel to the X coordinate axis, given in map projection units (meters, except for Lat-Lon coordinate systems).

Y_CELL is the cell dimension parallel to the Y coordinate axis, given in map projection units (meters, except for Lat-Lon coordinate systems).

NCOLS is the number of columns (dimensionality in the X direction).

NROWS is the number of rows (dimensionality in the Y direction).

NTHIK is the thickness (number) of cells on the boundary domain required to accurately describe boundary mass flux (e.g., CMAQ uses NTHIK = 1)

ArcMap Projection Information (HB grid example):

Data Type: File Geodatabase Feature Class
Location:
U:\Projects\MMccourtney\Grids\templates\grid_templates.gdb
Feature Class: template_mdhi_12_nb
Feature Type: Simple
Geometry Type: Polygon

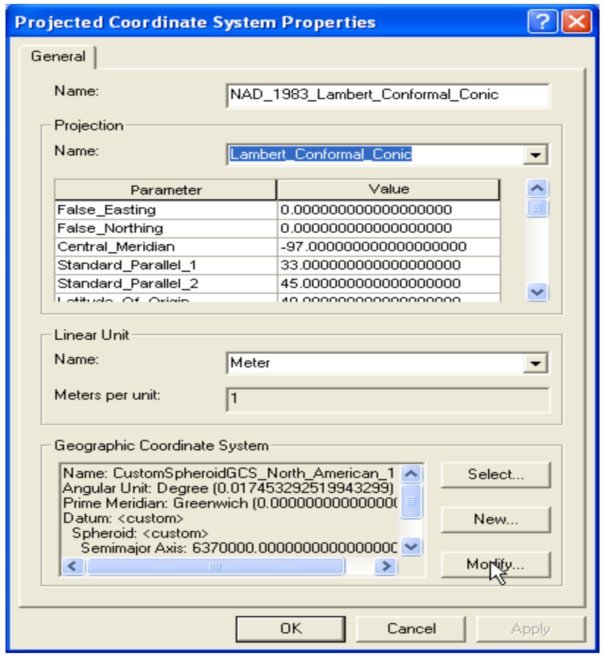
Projected Coordinate System: NAD_1983_Lambert_Conformal_Conic
Projection: Lambert_Conformal_Conic
False_Easting: 0.00000000
False_Northing: 0.00000000
Central_Meridian: -97.00000000
Standard_Parallel_1: 33.00000000
Standard_Parallel_2: 45.00000000
Latitude_Of_Origin: 40.00000000
Linear Unit: Meter

Geographic Coordinate System: CustomSpheroidGCS_North_American_1983
Datum: <custom>
Prime Meridian: Greenwich
Angular Unit: Degree

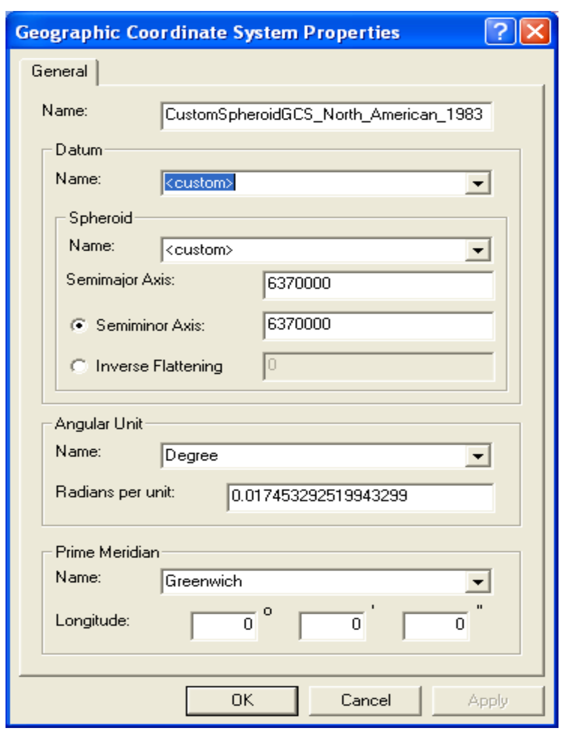
Changing a data set's spheroid to a sphere.

1) In ArcCatalog, right click the data set of interest, and choose **Properties**. Click the **XY Coordinate System** tab. Click Modify…

2) From the Geographic Coordinate System of the Projected Coordinate System Properties window, click Modify…



3) From the Geographic Coordinate System window, first choose <custom> in the list of datum (it's at the top) and then choose <custom> for the spheroid. Enter 6370000 in both the semimajor and semiminor boxes.



Projection Information for HB Grid – Example #1

Year	Geographic Coordinate System	Datum	Prime Meridian	Angular Unit	Projected Coordinate System	False Easting	False Northing	Central Meridian	Standard Parallel_1	Standard Parallel_2	Scale Factor	Latitude of Origin	Linear Unit
2001	Lat/Lon	Spherical R=6370997	NA	Degrees	Lambert Conformal Conic	0.0	0.0	-97.0	33.0	45.0	1.0	40.0	Meters
2002	:	Spherical R=6370000	:	:	:	:	:	:	:	:	:	:	:
2003	:	:	:	:	:	:	:	:	:	:	:	:	:
2004	:	:	:	:	:	:	:	:	:	:	:	:	:
2005	:	:	:	:	:	:	:	:	:	:	:	:	:
2006	:	:	:	:	:	:	:	:	:	:	:	:	:

Grid Descriptive Parameters

Year	Grid Resolution (km)	XORIG (m)	YORIG (m)	XCELL (m)	YCELL (m)	NCOLS	NROWS
2001	12	-252000	-1284000	12000	12000	213	188
2001	36	-2736000	-2088000	36000	36000	148	112
2002	12	-1008000	-1620000	12000	12000	279	240
2002	36	-2736000	-2088000	36000	36000	148	112
2003	12	-1008000	-1620000	12000	12000	279	240
2003	36	-2736000	-2088000	36000	36000	148	112
2004	12	-1008000	-1620000	12000	12000	279	240
2004	36	-2736000	-2088000	36000	36000	148	112
2005	12	-1008000	-1620000	12000	12000	279	240
2005	36	-2736000	-2088000	36000	36000	148	112
2006	12						
2006	36						

Projection Information for HB Grid – Example #2

Year	Datum	Semimajor Axis (m)	Semiminor Axis (m)	Angular Unit	Projected Coordinate System	False Easting	False Northing	Longitude of Central Meridian	Latitude of Standard Parallel_1	Latitude of Standard Parallel_2	Latitude of Origin	Linear Unit
2001	*(i.e., NAD83 or WGS84)*	*(i.e., 6370000)*	*(i.e., 637000)*	*(i.e., degree or radians)*	*(i.e., Lambert Conformal Conic)*	*(i.e., 0.0)*	*(i.e., 0.0)*	*(i.e., -97.000)*	*(i.e., 33.000)*	*(i.e., 45.000)*	*(i.e., 40.0)*	*(i.e., meters)*
2002												
2003												
2004												
2005												
2006												

Grid Descriptive Parameters

Year	Grid Resolution (km)	XORIG (m)	YORIG (m)	XCELL (m)	YCELL (m)	NCOLS	NROWS
2001	12						
2001	36	*(i.e., -2736000)*	*(i.e., -2088000)*	*(i.e., 36000)*	*(i.e., 36000)*	*(i.e., 148)*	*(i.e., 112)*
2002	12						
2002	36						
2003	12						
2003	36						
2004	12						
2004	36						
2005	12						
2005	36						
2006	12						
2006	36						

United States
Environmental Protection
Agency