EPA's Report on the Environment

Technical Documentation

Identification

1. Indicator Title

Particulate Matter Emissions

2. ROE Question(s) This Indicator Helps to Answer

What are the trends in outdoor air quality and their effects on human health and the environment?

3. Indicator Abstract

This indicator presents regional and national particulate matter (PM) emissions data for 1990, 1996, 1999, 2002, 2005, 2008, and 2011. Data are presented for two different PM size fractions. PM emissions (combined with atmospheric fate and transport processes) determine corresponding ambient PM concentration levels.

4. Revision History

07/2015

Data Sources

5. Data Sources

The emissions data for this indicator come from EPA's National Emissions Inventory (NEI). The NEI is a composite of data from many different sources, including state, tribal, and local air quality management agencies; EPA models; and industry.

6. Data Availability

Summary data in this indicator were provided by EPA's Office of Air Quality Planning and Standards, based on PM emissions data in EPA's NEI. EPA makes the complete underlying data set (i.e., the NEI) and all data dictionaries available through its website named "Clearinghouse for Inventories and Emission Factors" (CHIEF). Summary data in this indicator were provided by EPA's Office of Air Quality Planning and Standards, based on raw PM emissions data in EPA's NEI (2002, 2005, 2008, and 2011 data: https://www.epa.gov/air-emissions-inventories; pre-2002 data: https://www.epa.gov/air-emissions-inventories/pollutant-emissions-summary-files-earlier-neis). The most recent data are from Version 1 of the 2011 NEI. This indicator aggregates the raw NEI data by source type (i.e., anthropogenic or biogenic), source category, and EPA Region. The trend lines in the indicator track changes in only filterable PM emissions, because condensable PM emissions data are not available dating back to 1990.

Methodology

7. Data Collection

The particulate matter (PM) emissions data in NEI are based almost entirely on emissions estimates, not direct measurements.

Mobile sources include PM emissions from on-road vehicles (i.e., cars, trucks, buses, and motorcycles) and nonroad vehicles and engines (e.g., farm and construction equipment, lawnmowers, chainsaws, boats, ships, snowmobiles, aircraft). Pre-2002 emissions from on-road mobile sources are estimated using EPA's Mobile Source Emissions Factor Model (MOBILE), with input data on vehicle miles traveled based on estimates provided by the Federal Highway Administration. Emissions from on-road mobile sources for 2002, 2005, 2008, and 2011 are estimated using the MOtor Vehicle Emissions Simulator (MOVES), which replaced MOBILE as EPA's preferred model for estimating emissions from on-road mobile sources. Emissions from nonroad mobile sources are either estimated using EPA's NONROAD emissions model or using other methodologies, as described in sections of the 2011 NEI Technical Support Document on aircraft, locomotives, and commercial marine vessels (U.S. EPA, 2015). The MOBILE, MOVES, and NONROAD emissions models are considered to be scientifically and technically valid, and many aspects of these models have been subject to external, independent peer review. Full documentation of these models is publicly available (U.S. EPA, 2007c, 2007d, 2012). Additionally, documentation on how these models were used specifically to develop NEI data is publicly available (U.S. EPA, 2015).

Point sources of PM emissions include fuel combustion sources (i.e., coal-, gas-, and oil-fired power plants and industrial, commercial, and institutional sources, as well as residential heaters and boilers) and other industrial processes (i.e., chemical production, petroleum refining, metals production, and processes other than fuel combustion). Emissions from point sources are primarily estimates, generated by using emission factors, stack tests, engineering judgment, or other estimation methodologies. Though the estimated emission rates have inherent uncertainties, the approaches used to estimate these emissions are well documented (e.g., in U.S. EPA, 2015), widely accepted as technically valid, and have been peer reviewed. The NEI data include the reported method used to

calculate the emissions. Moreover, efforts are made to update and improve the estimation methodologies periodically.

The PM emissions data in NEI cover particles of two different size fractions (PM_{10} and $PM_{2.5}$) and physical states (filterable and condensable). PM_{10} includes particles that have aerodynamic diameters less than or equal to 10 microns (μm), and $PM_{2.5}$ is the subset of PM_{10} particles that have aerodynamic diameters less than or equal to 2.5 μm. Filterable PM refers to particles or droplets that can be collected on filters in the stack exhaust; condensable PM exists in the vapor phase in the stack, but readily condenses into particulate (liquid) form upon being released from the stack and exposed to ambient conditions. Starting in 1999, the NEI began tracking condensable PM separate from filterable PM. The primary trends tracked in this indicator are for filterable PM_{10} emissions and filterable $PM_{2.5}$ emissions; nationwide data for emissions of condensable PM have only recently become available and are not included in this indicator unless otherwise specified. This indicator presents trends in annual average primary PM emissions data tracked by the NEI. The NEI tracks emissions data, both measured and estimated, for primary particles only and therefore may only be representative of a small fraction of all emissions that serve to form $PM_{2.5}$.

The NEI is a composite of data from many different sources. State, local, and tribal air quality management agencies and other parties provide much of the data to EPA. Although these original data are accompanied with little or no documentation on the specific methods used to estimate emissions, state and local air quality management agencies and other parties generally follow procedures documented in an emission inventory guidebook on acceptable methods for estimating emissions (U.S. EPA, 2007b). See U.S. EPA (2007a and 2007b) for further information on approaches commonly taken to estimate air emissions from various sources.

In some cases, the data provided by state, tribal, and local air quality management agencies and other parties are absent or incomplete. When this occurs, EPA fills the gaps using various methods, such as using data from previous years (primarily for point sources) or creating independent estimates of county-level emissions (primarily for non-point sources). Prior to the 2002 NEI, EPA has also filled gaps by inferring data for a given county based on data from other counties believed to have common properties that influence emissions (e.g., population density, daily low and high temperatures).

Emissions data in the inventory cover all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. Thus, NEI data are meant to capture an estimate of all PM emissions released in the U.S. The NEI characterizes emissions sources, not human populations or ecosystems. NEI data provide insights on emissions sources throughout the country, including localized areas that might be near sensitive populations or ecosystems, although the focus of this indicator is on regional and national trends.

For 2011 only, this indicator includes a comparison of anthropogenic sources with emissions from miscellaneous and other sources, such as agriculture and forestry, wildfires and managed burning, and fugitive dust from paved and unpaved roads.

8. Indicator Derivation

The indicator describes nationwide and regional PM emissions for 1990, 1996, 1999, 2002, 2005, 2008, and 2011. Data were not extrapolated beyond the scope of data collection, and no statistical generalization was performed to generate the regional and national emissions trends presented in this indicator. The regional trends were computed by totaling all emissions data for individual facilities and counties within the corresponding EPA Region for the specific inventory years. Similarly, national data represent totals across all states and territories considered in the inventory.

While the NEI database is composed of tens of thousands of emissions estimates or measurements from dozens of state and local air quality management agencies and other parties, key aspects of NEI development and implementation (including emission factors and models) are subject to independent peer review to ensure that the data are scientifically sound and technically accurate. Individuals interested in conducting further analyses of the PM emissions data in NEI can download data files for different inventory years at https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei.

9. Quality Assurance and Quality Control

The data in the NEI are gathered from numerous sources. Though the quality of the original data submitted to EPA can vary, several quality assurance (QA) and quality control (QC) measures are in place to ensure that data of acceptable quality enters the inventory and is processed correctly. It is presumed that state agencies supplying emissions data have QA plans, but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who support the Agency on inventory development operate under general contract-wide QA plans, which can be made available on request. In addition, EPA's more recent QC practices performed during the blending and merging of data from numerous sources are publicly available (U.S. EPA, 2007b).

Analysis

10. Reference Points

The concepts of reference points, thresholds, and ranges of values "that unambiguously reflect the state of the environment" do not really apply to emissions indicators. There are no thresholds or ranges of values associated with "safe" levels of PM emissions across an entire region or nation. The air quality impacts associated with a given regional or national emissions total depend on the distribution of emissions among individual sources and the release parameters (e.g., stack heights, exit velocities) at these sources. Emissions data can provide general insights on air quality trends, but cannot be used alone to gauge "the state of the environment" (i.e., ambient air concentrations of PM). The indicator on ambient PM concentrations, however, provides more direct insights on the state of the environment.

11. Comparability Over Time and Space

NEI data have been collected since 1990. Data are presented for those years (i.e., 1990, 1996, 1999, 2002, 2005, 2008, and 2011) in which NEI data have been fully updated using generally consistent methodologies. Assuming the providers of the data abide by these consistent estimation methodologies, the emissions data should be reasonably comparable over both time and space.

12. Sources of Uncertainty

At present, quantified uncertainty measures are not available for the NEI emissions estimates because the parties that submit emissions estimates to EPA are not asked to include quantitative uncertainty measurements or estimates. Consequently, no quantitative uncertainty estimates can be developed for the aggregate regional or national figures. Many of the variables and emission factors used to estimate emissions are based on the best available information sources, but some underlying data are implied or not highly characterized, and therefore do not lend themselves well to quantitative uncertainty analyses. The technical report *Emission Inventory Improvement Program*, specifically *Chapter 4: Evaluating the Uncertainty of Emission Estimates* (U.S. EPA, 1996), has a lengthy discussion on the uncertainty associated with emission estimates. Research is currently

underway at EPA to calculate the level of uncertainty associated with certain emission factors.

For PM, uncertainties in emissions from all four anthropogenic source categories (fuel combustion, other industrial processes, on-road vehicles, and nonroad vehicles and engines) are important because they each account for a considerable portion of the nationwide totals of anthropogenic emissions. While the approaches used to estimate these emissions over the years are consistently applied, quantitative uncertainty estimates cannot be made for regional and nationwide emissions data derived from these models.

13. Sources of Variability

The decrease in nationwide PM emissions between 1990 and 2011 resulted from reductions in emissions from multiple source categories. Variability in PM emissions from specific sources (and source categories) results from many factors. Average precipitation amounts and wind speeds, for instance, affect the variability in emissions of wind-blown dust. These and other sources of variability are explicitly accounted for in the emissions estimation approaches, to the extent that the underlying algorithms account for them.

14. Statistical/Trend Analysis

This indicator presents a time series of regional and national emissions estimates. No special statistical techniques or analyses were used to characterize the long-term trends or their statistical significance.

Limitations

15. Data Limitations

Limitations to this indicator include the following:

1. PM emissions estimates through the NEI are provided only for the triennial NEI years starting with 1990 and continuing through 2011, with the exception of 1993.
2. Because the emissions indicators focus on sources of anthropogenic origin, PM emissions from miscellaneous sources (e.g., wildfires) are not included in the trend line. Details on emissions from these sources can be found by downloading 2011 NEI inventory data for the "nonpoint sector" (https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei).
3. The emissions data for PM are largely based on estimates that employ emission factors generated from empirical and engineering studies, rather than on actual measurements of PM emissions. Although these estimates are generated using well-established approaches, including extensively reviewed mobile source models, the estimates have uncertainties inherent in the emission factors and emissions models used to represent sources for which emissions have not been directly measured.
4. The methodology for estimating emissions is continually reviewed and is subject to revision. Trend data prior to these revisions must be considered in the context of those changes.
5. The indicator tracks primary PM emissions. Particles that form in the air through secondary processes are not included in this indicator, but are considered in the PM Concentrations indicator.
6. Not all states and local air quality management agencies provide the same data or level of detail for a given year.
7. NEI emissions from on-road mobile sources prior to 2002 were estimated using the MOBILE

model, and 2002, 2005, 2008, and 2011 emissions for this source category were estimated using different versions of the MOVES model which applied different methods. Therefore, the outputs may not be directly comparable across years; the change in model is reflected as part of the trend shown.

8. Version 1 of the 2011 NEI was completed prior to the release of the most recent MOVES model (MOVES2014).

References

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