EPA's Report on the Environment

Technical Documentation

Identification

1. Indicator Title

Carbon Monoxide 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 carbon monoxide (CO) emissions data for 1990, 1996, 1999, 2002, 2005, 2008, 2011, and 2014. CO emissions (combined with atmospheric fate and transport processes) determine corresponding ambient CO concentration levels.

4. Revision History

05/2019

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

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 CO emissions data in EPA's NEI (2002, 2005, 2008, 2011, and 2014 data: https://www.epa.gov/air-emissions-inventories; pre-2008 data: https://www.epa.gov/air-emissions-inventories/pollutant-emissions-summary-files-earlier-neis). The most recent data are from Version 2 of the 2014 NEI. This indicator aggregates the raw NEI data by source type (i.e., anthropogenic, biogenic, or forest wildfire), source category, and EPA Region.

Methodology

7. Data Collection

The carbon monoxide (CO) emissions data in NEI are based largely on emissions estimates, not direct measurements.

Mobile sources of CO emissions include on-road vehicles (i.e., cars, trucks, buses, and motorcycles) and nonroad vehicles and engines (e.g., farm equipment, construction equipment, lawnmowers, chainsaws, marine vessels, snowmobiles, and aircraft). Mobile sources account for the overwhelming majority of nationwide estimated CO air emissions (e.g., 82 percent of anthropogenic emissions in 2014). Pre-2002 emissions from on-road mobile sources are estimated using EPA's Mobile Source Emissions Factor Model (MOBILE). Emissions from on-road mobile sources for 2002, 2005, 2008, 2011, and 2014 are estimated using the MOtor Vehicle Emissions Simulator (MOVES) model, which replaced MOBILE as EPA's preferred model for estimating emissions from on-road mobile sources. Input data on vehicle miles traveled are based on estimates provided by the Federal Highway Administration or the state and local agencies. Emissions from nonroad mobile sources are either estimated using EPA's NONROAD emissions model or using other methodologies, as described in sections of the 2014 NEI Technical Support Document on aircraft, locomotives, and commercial marine vessels (U.S. EPA, 2018). 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 the current and previous versions of these models is publicly available (see: https://www.epa.gov/moves). Additionally, documentation on how these models were used specifically to develop NEI data is publicly available (U.S. EPA, 2018).

Point sources of CO emissions include fuel combustion sources (e.g., coal-, gas-, and oil-fired power plants; industrial, commercial, and institutional sources; residential heaters and boilers) and other industrial processes (i.e., chemical production, petroleum refining, metals production, and processes other than fuel combustion). Point sources account for a relatively small fraction of the estimated nationwide CO emissions. 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., U.S. EPA, 2018), 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. See

references (e.g., U.S. EPA, 2016, 2017) for further information on approaches commonly taken to estimate air emissions from various sources.

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 may be 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 emission inventory guides (U.S. EPA, 2016) and procedures (see: https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data) on acceptable methods for estimating emissions. For CO, this often means using the models discussed above. In some cases, the data provided by state 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 nonpoint 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 CO 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.

The indicator also includes estimates of biogenic and forest wildfire CO emissions in 2014. Biogenic emissions were estimated using the Biogenic Emissions Inventory System Model, Version 3.61, with data from the Biogenic Emissions Landcover Database, Version 4.1, and 2014 annual meteorological data. The emission trends indicator excludes CO estimates of prescribed burning, forest wildfires, and other miscellaneous sources because those data were either not readily available in the 1990 inventory or are small contributors to the total inventory, and because the emissions from prescribed burning and forest wildfires are highly variable over time.

8. Indicator Derivation

The indicator describes nationwide CO emissions for 1990, 1996, 1999, 2002, 2005, 2008, 2011, and 2014. 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.

Reproducing the entire NEI database would require reproducing tens of thousands of emissions estimates or measurements that state and local air quality management agencies and other parties submit to EPA. Reproducing these figures would be an extremely daunting and time-consuming task, as populating the NEI database requires a large level of effort and access to data generated by hundreds of different parties. Note, however, that 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 CO 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 enter the inventory and are 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, 2018).

Analysis

10. Reference Points

The concept of reference points does not apply to emissions indicators. There are no thresholds or ranges of values associated with "safe" levels of CO 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 (especially trends mediated by anthropogenic activities), but they do not provide direct insight 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, 2011, and 2014) 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 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* (EPA, 1996), has a lengthy discussion on the uncertainty associated with emission estimates.

For CO, uncertainties in emissions from mobile sources are particularly important given that these account for the overwhelming majority of the corresponding anthropogenic nationwide totals. Periodic updates to the MOBILE, MOVES, and NONROAD models to account for advances in the scientific understanding of mobile source emissions likely reduce model uncertainty; however, quantitative uncertainty estimates cannot be made for regional and nationwide emissions data derived from these models.

13. Sources of Variability

Variability in mobile source emissions would be expected to account for a considerable portion of the spatial and temporal variability in the nationwide aggregate CO emissions. The indicator likely accounts for this variability through changing input parameters used in the underlying emission estimation models (e.g., in terms of vehicle fleets and fuels).

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. CO emissions estimates through the NEI are provided only for the triennial NEI years starting with 1990 and continuing through 2014, with the exception of 1993.
2. CO emissions from "miscellaneous sources," including forest wildfires and prescribed burning, are not included in the total anthropogenic emissions. Yearly fluctuations in forest wildfire emissions have the potential to mask trends in anthropogenic emissions and therefore have been excluded from this indicator's exhibits.
3. The emissions data for CO are largely based on estimates that employ emission factors generated from empirical and engineering studies, rather than on actual measurements of CO 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 any revisions must be considered in the context of those changes.
5. Not all states and local agencies provide the same data or level of detail for a given year.
6. NEI emissions from on-road mobile sources prior to 2002 were estimated using the MOBILE model, and 2002, 2005, 2008, 2011, and 2014 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.

References

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