

Particulate Matter Concentrations

“Particulate matter” (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. Airborne PM comes from many different sources. “Primary” particles are released directly into the atmosphere from sources such as cars, trucks, heavy equipment, forest fires, and other burning activities (e.g., burning waste, wood stoves, wood-fired boilers). Primary particles also consist of crustal material from sources such as unpaved roads, stone crushing, construction sites, and metallurgical operations. “Secondary” particles are formed in the air from reactions involving precursor chemicals such as sulfates (which are formed from sulfur dioxide emissions from power plants and industrial facilities), nitrates (which are formed from nitrogen dioxide emissions from cars, trucks, and power plants), and carbon-containing reactive organic gas emissions from cars, trucks, industrial facilities, forest fires, and biogenic sources such as trees (U.S. EPA, 2009).

Ambient air monitoring stations throughout the country measure air concentrations of PM, with most monitoring for two size ranges: PM_{2.5} and PM₁₀. PM_{2.5} consists of “fine particles” with aerodynamic diameters less than or equal to 2.5 microns (µm). PM₁₀ includes both fine particles (PM_{2.5}) and “coarse particles,” with aerodynamic diameters greater than 2.5 µm and less than or equal to 10 µm. The chemical makeup of particles varies across the U.S. For example, fine particles in the eastern half of the U.S. contain more sulfates than those in the West, while fine particles in southern California contain more nitrates than those in other areas of the U.S. Carbon is a substantial component of fine particles everywhere (U.S. EPA, 2004, 2009).

Fine particles also have seasonal patterns. PM_{2.5} concentrations in the eastern half of the U.S. are typically higher in the third calendar quarter (July-September), when sulfates are more commonly formed from sulfur dioxide emissions from power plants in that part of the country. Fine particle concentrations tend to be higher in the fourth calendar quarter (October-December) in many areas of the West, in part because fine particle nitrates are more readily formed in cooler weather, and wood stove and fireplace use produces more carbon. Additionally, nitrate concentrations within particles are highest during the winter in the upper Midwest (U.S. EPA, 2009).

An extensive body of scientific evidence shows that short- or long-term exposures to fine particles can cause adverse cardiovascular effects, including heart attacks and strokes resulting in hospitalizations and, in some cases, premature death. A number of studies have also linked fine particle exposures to respiratory effects, including the exacerbation of asthma and other respiratory illnesses (short-term exposures) and the impairment of lung development (long-term exposures). More limited scientific evidence provides support for associations with a broader range of health effects (e.g., developmental and reproductive effects, cancer) and for health effects following exposures to PM size fractions other than fine particles (i.e., thoracic coarse particles, ultrafine particles) (U.S. EPA, 2009).

Specific groups within the general population are at increased risk for experiencing adverse health effects related to PM exposures including older adults, individuals with cardiopulmonary diseases such as asthma or heart disease, children, and people with lower socioeconomic status (U.S. EPA, 2009).

Unlike other criteria pollutants, PM is not a single specific chemical entity, but rather a mixture of particles from different sources with different chemical compositions. Efforts to evaluate the relationships between PM composition and health effects continue to evolve. While many constituents of PM have been linked with health effects, the available evidence does not allow the

identification of particular components, groups of components, or sources that are more closely related to specific health outcomes. The available evidence also does not allow the exclusion of any individual component, group of components, or sources from the particle mixture of concern (U.S. EPA, 2009).

PM also can cause adverse impacts to the environment. PM-related welfare effects include visibility impairment, climate impacts, effects on materials (e.g., building surfaces), and ecological effects (U.S. EPA, 2009).

This indicator presents trends in PM₁₀ and PM_{2.5} concentrations, using averaging times consistent with the pollutants' corresponding National Ambient Air Quality Standards (NAAQS). For PM₁₀, trend data from 1988 to 2016 are presented for the second highest 24-hour concentrations measured at the trend sites during each calendar year. For PM_{2.5}, trend data from 1999 to 2016 are presented both for annual average concentrations and for the 98th percentiles of 24-hour average concentrations measured at the trend sites averaged over three consecutive calendar years. Trend data are based on measurements from the State and Local Air Monitoring Stations network and from other special purpose monitors. This indicator presents PM₁₀ trends for 123 monitoring sites in 89 counties nationwide and annual average PM_{2.5} trends for 429 monitoring sites in 323 counties nationwide. For both PM₁₀ and PM_{2.5}, the indicator displays trends for the entire nation and for the ten EPA Regions.

The indicator's exhibits display the pollutants' NAAQS as points of reference. However, the fact that the national values or those shown for EPA Regions fall below the standards does not mean that all monitoring sites nationally or in any particular EPA Region also are below the standards. The indicator displays trends in the number of PM₁₀ monitoring sites and PM_{2.5} monitoring sites nationwide that recorded ambient air concentrations above the level of the standards, but these statistics are not displayed for each EPA Region.

What the Data Show

PM₁₀ Concentration Trends

In 2016, the national 24-hour PM₁₀ concentration (based on the second highest 24-hour concentrations across all sites) was 43 percent lower than the average 1988 level (Exhibit 1). Additionally, of the 123 sites used to determine this trend (out of 686 total monitoring sites that were operating in 2016), the number reporting PM₁₀ concentrations above the level of the 24-hour standard declined 83 percent between 1988 and 2016 (Exhibit 2). All EPA Regions experienced a decrease in 24-hour PM₁₀ concentrations over this period (Exhibit 3). EPA Region 10 showed the greatest relative decrease (85 percent) since 1988.

Also shown in Exhibit 1 are the 90th and 10th percentiles based on the distribution of annual statistics at the monitoring sites. This provides additional graphical representation of the distribution of measured concentrations across the monitoring sites for a given year. Thus, the graphic displays the concentration range where 80 percent of measured values occurred for that year. (Note that this presentation style also applies to Exhibits 4 and 7, discussed below.)

PM_{2.5} Concentration Trends

Annual average PM_{2.5} concentrations decreased 38 percent between the 1999-2001 averaging period and the 2014-2016 averaging period (Exhibit 4). This trend is based on measurements collected at 429 monitoring sites that have sufficient data to assess trends over that period. The number of monitoring sites in this trend (429 out of 810 total sites that were operating in 2016) reporting ambient air concentrations above the level of the annual average PM_{2.5} standard decreased

by 96 percent over this period (Exhibit 5). Regional declines were greatest in EPA Regions 1 and 4, where annual average PM_{2.5} concentrations over the 2014-2016 averaging period were 44 percent lower than those in the 1999-2001 averaging period (Exhibit 6).

In 2014-2016, the average of 98th percentiles of 24-hour PM_{2.5} concentrations at the 429 monitoring sites used for the trend was 40 percent lower than the 1999-2001 level (Exhibit 7). The number of monitoring sites in this trend (429 out of a total of 809 sites that were operating in 2016) reporting ambient air concentrations above the level of the 24-hour PM_{2.5} standard declined 92 percent over this period (Exhibit 8). All ten EPA Regions experienced decreasing 24-hour PM_{2.5} concentrations between the 1999-2001 averaging period and the 2014-2016 averaging period, with Region 4 showing the largest decline (47 percent) (Exhibit 9).

Limitations

- Because there are far more PM₁₀ and PM_{2.5} monitors in urban areas than in rural areas, the trends might not accurately reflect conditions outside the immediate urban monitoring areas.
- PM₁₀ and PM_{2.5} measurement data are based on monitoring methods that are consistent with those used to establish EPA's National Ambient Air Quality Standards. These "indicator" measurements provide mass concentrations that may be different than the concentrations of particulate matter (PM₁₀ and PM_{2.5}) in the ambient air. These potential differences are due to losses from volatilization of nitrates and other semi-volatile materials and retention of particle-bound water associated with hygroscopic species. A study of six locations in the Eastern U.S. showed that the net difference was less than 10 percent (Frank, 2006).
- Due to the relatively small number of monitoring sites in some EPA Regions, the regional trends are subject to greater uncertainty than the national trends. Some EPA Regions with low average concentrations may include areas with high local concentrations, and vice versa. In addition, the trend sites in this indicator are not dispersed uniformly across all states in the EPA Regions. For instance, the 123 PM₁₀ trend sites are located in 29 states and Puerto Rico. In the remaining 21 states, there currently are insufficient long-term data from the existing PM₁₀ monitoring sites to include in this indicator. In contrast, the 429 annual average PM_{2.5} trend sites are located in 47 states, the District of Columbia, and Puerto Rico. The remaining three states did not have sufficient long-term data from the existing PM_{2.5} sites to include in this indicator.
- To ensure that long-term trends are based on a consistent set of monitoring sites, selection criteria were applied to identify the subset of PM monitoring sites with sufficient data to assess trends over the time frames covered by this indicator. Monitoring sites without sufficient data are not included in the trend analysis. Some excluded monitoring sites reported PM concentrations above the level of the PM standard during the years covered by this indicator. In 2016, for example, 40 monitoring sites nationwide recorded 24-hour PM₁₀ concentrations above the level of the NAAQS: this includes the two sites shown in Exhibit 2, and 38 sites that did not have sufficient long-term data to be included in this indicator.

Data Sources

Summary data in this indicator were provided by EPA's Office of Air Quality Planning and Standards, based on PM ambient air monitoring data in EPA's Air Quality System (U.S. EPA, 2017a) (<https://www.epa.gov/aqs>). National and regional trends in this indicator are based on the subset of PM monitoring stations that have sufficient data to assess trends over the period of record (i.e., since 1988 for PM₁₀ and since 1999 for PM_{2.5}).

References

Frank, N.H. 2006. Retained nitrate, hydrated sulfates, and carbonaceous mass in federal reference method fine particulate matter for six eastern U.S. cities. *Journal of the Air and Waste Management Association* 56:500-11.

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U.S. EPA. 2017b. History of the national ambient air quality standards for particulate matter. Accessed 2017. https://www3.epa.gov/ttn/naaqs/standards/pm/s_pm_history.html.

U.S. EPA. 2009. Integrated science assessment for particulate matter. EPA/600/R-08/139F. Research Triangle Park, NC. <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=216546>.

U.S. EPA. 2004. The particle pollution report: Current understanding of air quality and emissions through 2003. EPA 454-R-04-002. Research Triangle Park, NC. <https://nepis.epa.gov/Exe/ZyPDF.cgi/30005VAS.PDF?Dockey=30005VAS.pdf> (PDF) (32 pp, 4.8MB).

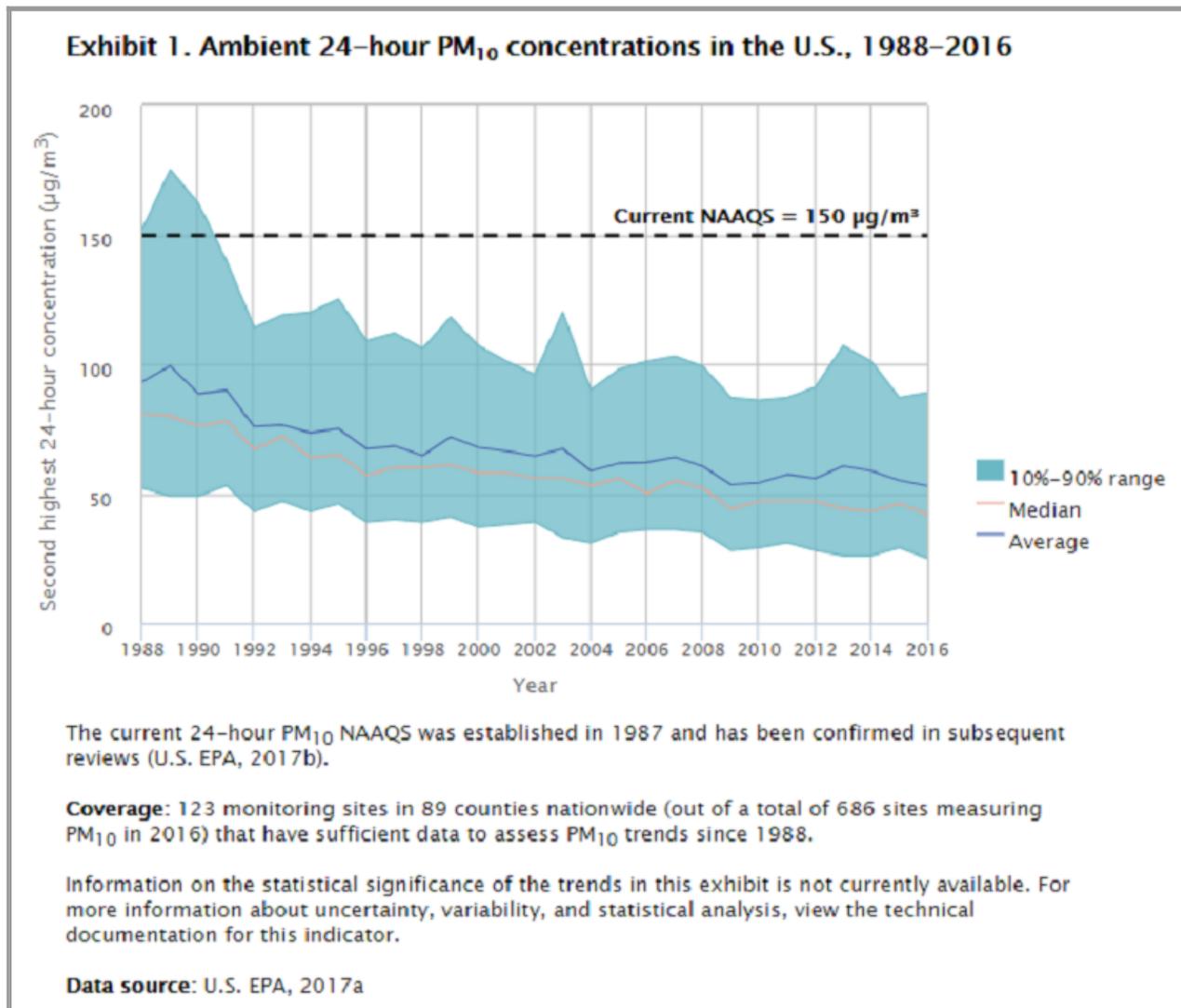
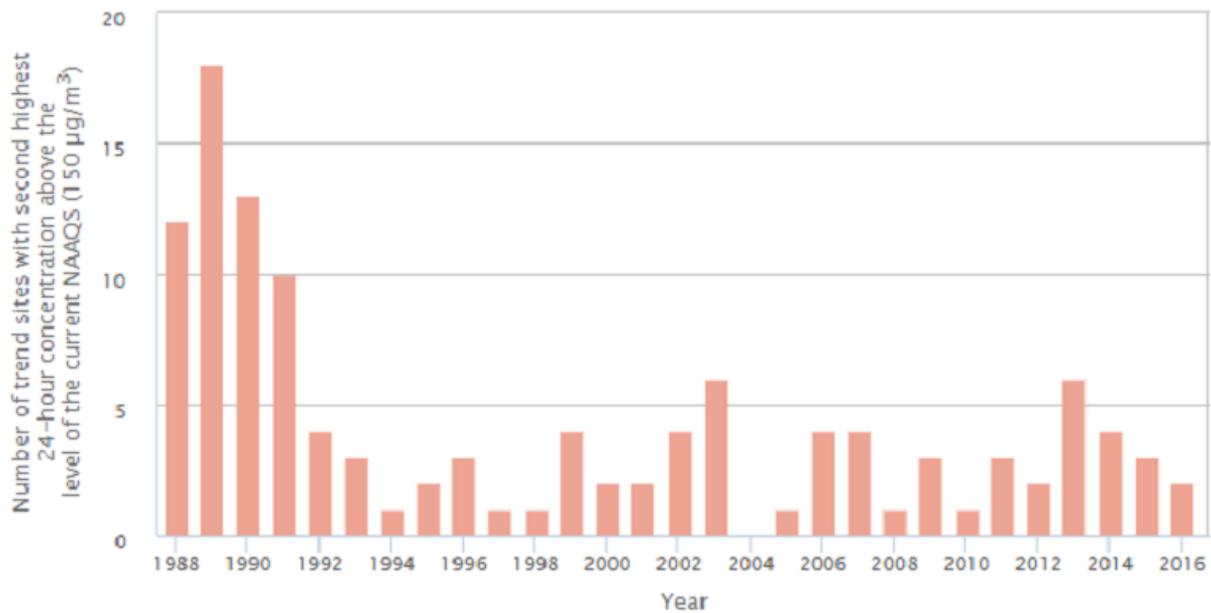


Exhibit 2. Ambient 24-hour PM₁₀ concentrations above the level of the current NAAQS in the U.S., 1988–2016



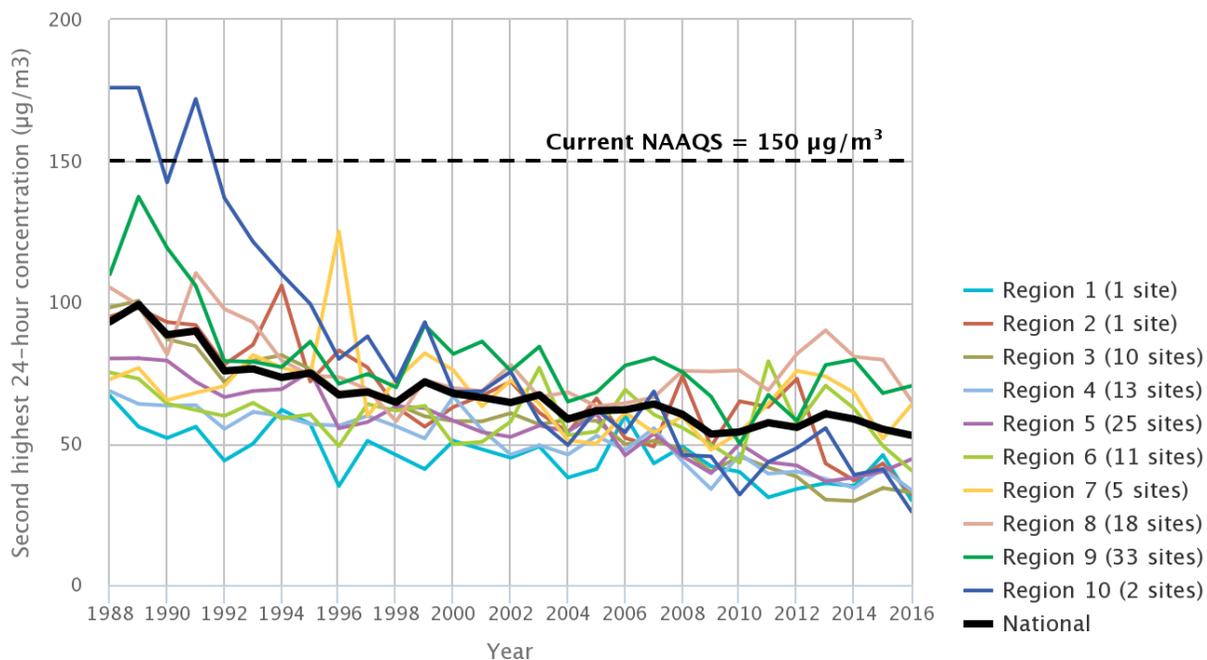
The current 24-hour PM₁₀ NAAQS was established in 1987 and has been confirmed in subsequent reviews (U.S. EPA, 2017b).

Coverage: 123 monitoring sites in 89 counties nationwide (out of a total of 686 sites measuring PM₁₀ in 2016) that have sufficient data to assess PM₁₀ trends since 1988.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a

Exhibit 3. Ambient 24-hour PM10 concentrations in the contiguous U.S. by EPA Region, 1988-2016



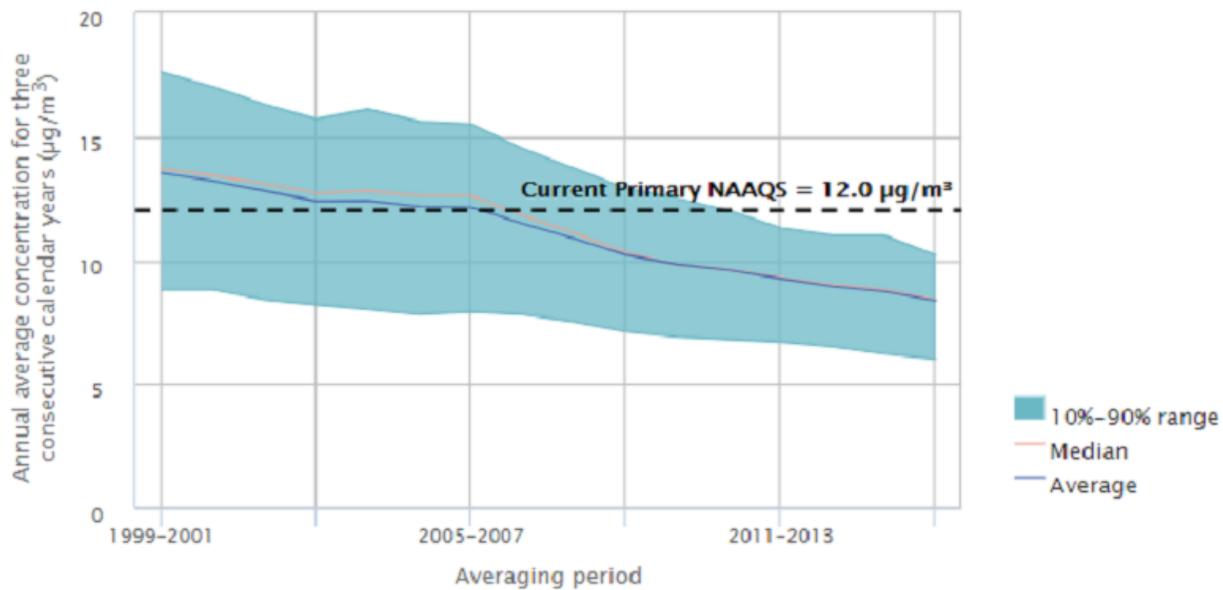
The current 24-hour PM10 NAAQS was established in 1987 and has been confirmed in subsequent reviews (U.S. EPA, 2017b).

Coverage: 119 monitoring sites in 86 counties nationwide (out of a total of 686 sites measuring PM10 in 2016) that have sufficient data to assess PM10 trends since 1988.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a

Exhibit 4. Ambient annual PM_{2.5} concentrations in the U.S., 1999–2016



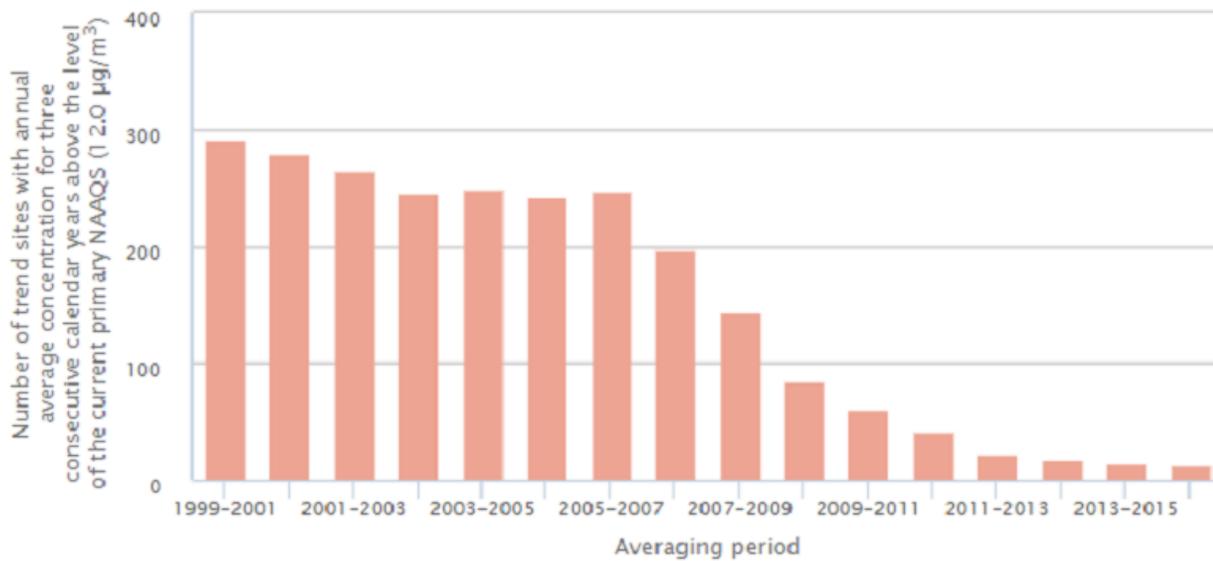
The current annual average PM_{2.5} NAAQS was established in 2012 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous annual average PM_{2.5} NAAQS (e.g., the concentration levels for the previous annual average PM_{2.5} NAAQS are higher) (U.S. EPA, 2017b).

Coverage: 429 monitoring sites in 323 counties nationwide (out of a total of 810 sites measuring PM_{2.5} in 2016) that have sufficient data to assess PM_{2.5} trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a

Exhibit 5. Ambient annual PM_{2.5} concentrations above the level of the current primary NAAQS in the U.S., 1999–2016



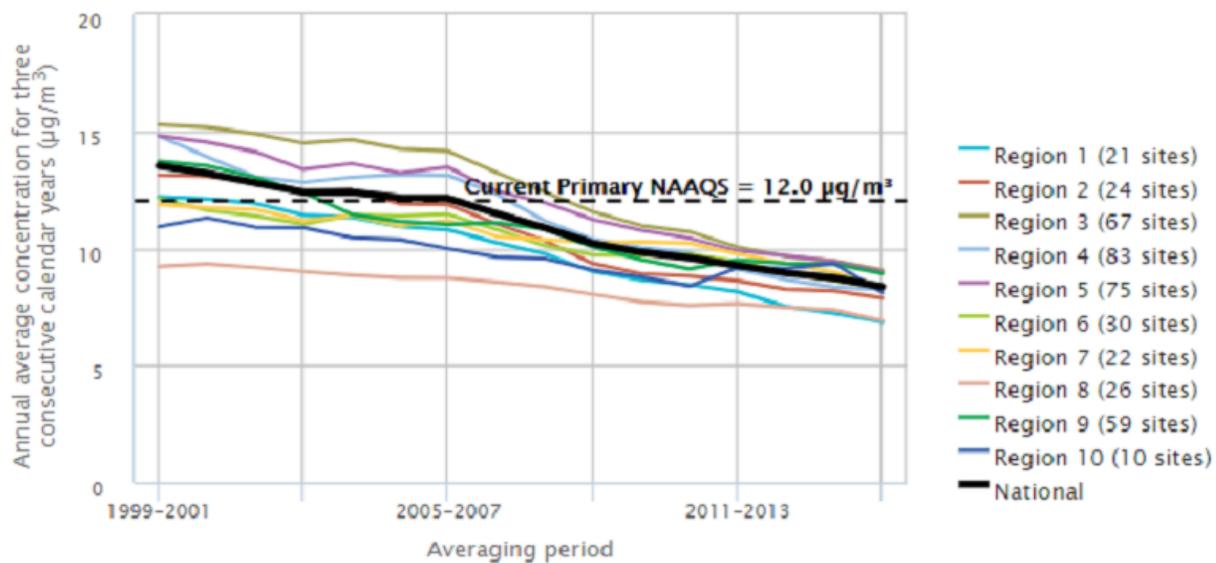
The current annual average PM_{2.5} NAAQS was established in 2012 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous annual average PM_{2.5} NAAQS (e.g., the concentration levels for the previous annual average PM_{2.5} NAAQS are higher) (U.S. EPA, 2017b).

Coverage: 429 monitoring sites in 323 counties nationwide (out of a total of 810 sites measuring PM_{2.5} in 2016) that have sufficient data to assess PM_{2.5} trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a

Exhibit 6. Ambient annual PM_{2.5} concentrations in the contiguous U.S. by EPA Region, 1999–2016



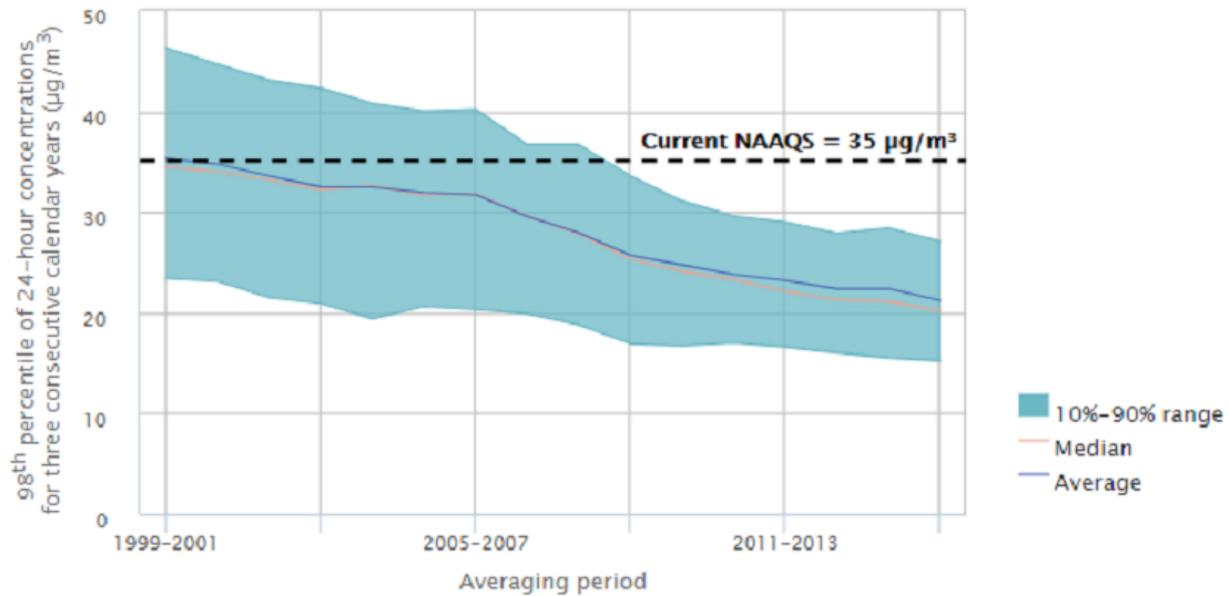
The current annual average PM_{2.5} NAAQS was established in 2012 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous annual average PM_{2.5} NAAQS (e.g., the concentration levels for the previous annual average PM_{2.5} NAAQS are higher) (U.S. EPA, 2017b).

Coverage: 417 monitoring sites in 314 counties in the EPA Regions (out of a total of 810 sites measuring PM_{2.5} in 2016) that have sufficient data to assess PM_{2.5} trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a

Exhibit 7. Ambient 24-hour PM_{2.5} concentrations in the U.S., 1999–2016



The current 24-hour PM_{2.5} NAAQS was established in 2006 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous 24-hour PM_{2.5} NAAQS (e.g., the concentration levels for the previous 24-hour PM_{2.5} NAAQS are higher) (U.S. EPA, 2017b).

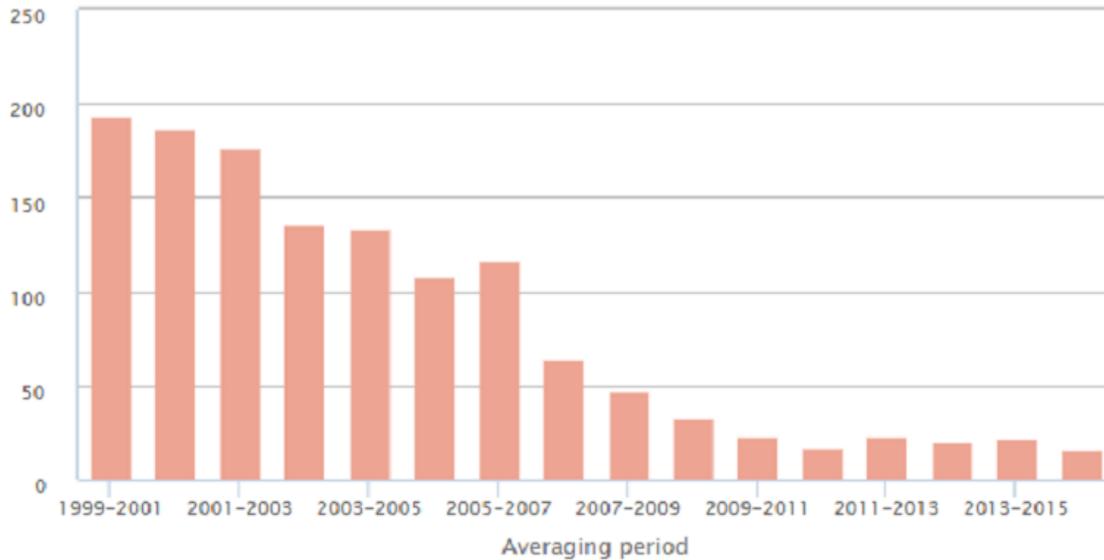
Coverage: 429 monitoring sites in 323 counties nationwide (out of a total of 809 sites measuring PM_{2.5} in 2016) that have sufficient data to assess PM_{2.5} trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a

Exhibit 8. Ambient 24-hour PM_{2.5} concentrations above the level of the current NAAQS in the U.S., 1999–2016

Number of trend sites with 98th percentile of 24-hour concentrations for three consecutive calendar years above the level of the current NAAQS (35 µg/m³)



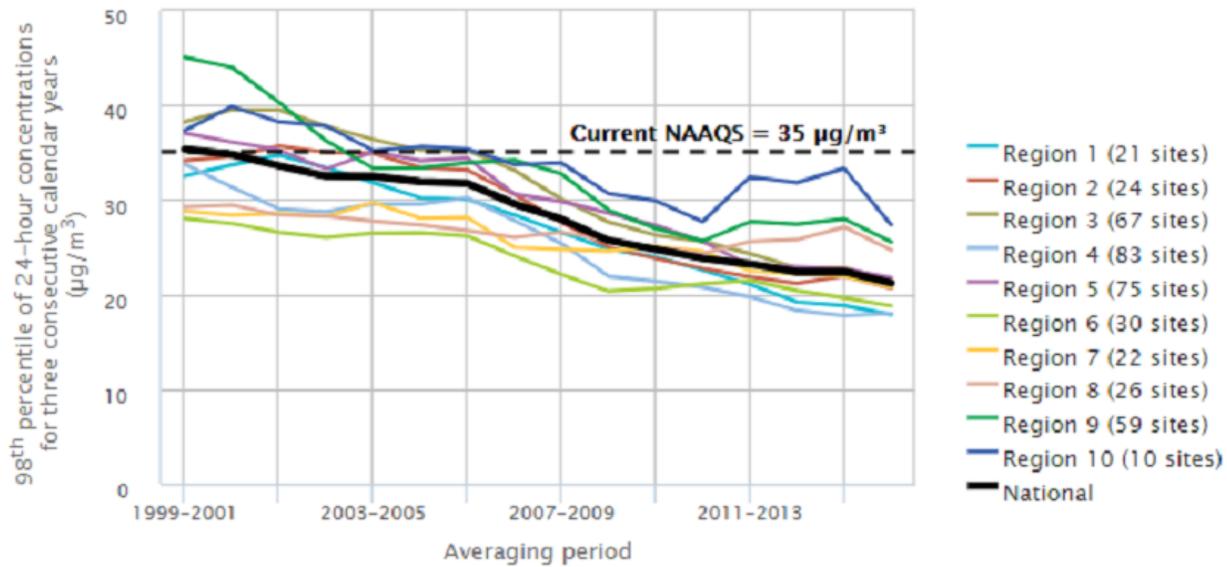
The current 24-hour PM_{2.5} NAAQS was established in 2006 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous 24-hour PM_{2.5} NAAQS (e.g., the concentration levels for the previous 24-hour PM_{2.5} NAAQS are higher) (U.S. EPA, 2017b).

Coverage: 429 monitoring sites in 323 counties nationwide (out of a total of 809 sites measuring PM_{2.5} in 2016) that have sufficient data to assess PM_{2.5} trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a

Exhibit 9. Ambient 24-hour PM_{2.5} concentrations in the contiguous U.S. by EPA Region, 1999–2016



The current 24-hour PM_{2.5} NAAQS was established in 2006 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous 24-hour PM_{2.5} NAAQS (e.g., the concentration levels for the previous 24-hour PM_{2.5} NAAQS are higher) (U.S. EPA, 2017b).

Coverage: 417 monitoring sites in 314 counties in the EPA Regions (out of a total of 809 sites measuring PM_{2.5} in 2016) that have sufficient data to assess PM_{2.5} trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2017a