



United States  
Environmental  
Protection Agency

# Our Nation's Air

STATUS AND TRENDS THROUGH 2010





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U.S. Environmental Protection Agency  
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# Highlights

Improving public health by reducing air pollution and improving air quality is one of the U.S. Environmental Protection Agency's (EPA's) top priorities. This summary report presents EPA's most recent evaluation of our nation's air quality status and trends through 2010.

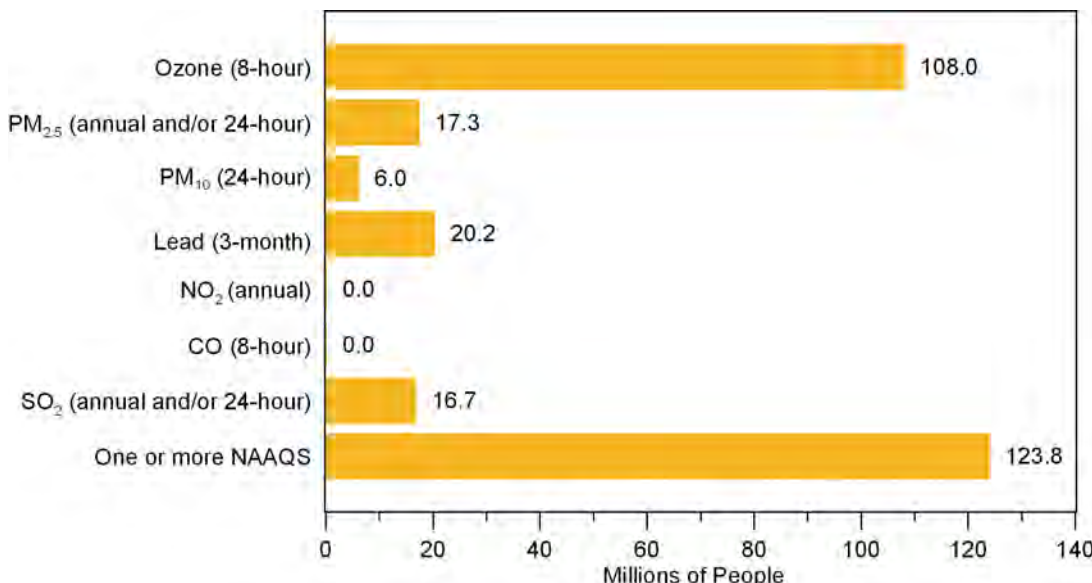
## Levels of Six Common Pollutants Continue to Decline

- Cleaner cars, industries, and consumer products have contributed to cleaner air for much of the U. S.
- Since 1990, nationwide air quality has improved significantly for the six common air pollutants. These six pollutants are ground-level ozone, particle pollution [particles 2.5 micrometers in diameter and smaller ( $PM_{2.5}$ ) and particles 10 micrometers and smaller ( $PM_{10}$ )], lead, nitrogen dioxide ( $NO_2$ ), carbon monoxide (CO), and sulfur dioxide ( $SO_2$ ). Nationally, air pollution was lower in 2010 than in 1990 for:
  - 8-hour ozone, by 17 percent
  - 24-hour  $PM_{10}$ , by 38 percent
  - 3-month average lead, by 83 percent
  - annual  $NO_2$ , by 45 percent
  - 8-hour CO, by 73 percent
  - annual  $SO_2$ , by 75 percent

- Nationally, annual  $PM_{2.5}$  concentrations were 24 percent lower in 2010 compared to 2001. 24-hour  $PM_{2.5}$  concentrations were 28 percent lower in 2010 compared to 2001.
- Ozone levels did not improve in much of the East until 2002, after which there was a significant decline. 8-hour ozone concentrations were 13 percent lower in 2010 than in 2001. This decline is largely due to reductions in oxides of nitrogen ( $NO_x$ ) emissions required by EPA rules including the  $NO_x$  State Implementation Plan (SIP) Call, preliminary implementation of the Clean Air Interstate Rule (CAIR), and Tier 2 Light Duty Vehicle Emissions Standards.
- Despite clean air progress, approximately 124 million people lived in counties that exceeded one or more national ambient air quality standard (NAAQS) in 2010, as shown in Figure 1. Ground-level ozone and particle pollution still present challenges in many areas of the country.

## Levels of Many Toxic Air Pollutants Have Declined

- Total emissions of toxic air pollutants have decreased by approximately 42 percent between 1990 and 2005. Control programs for mobile sources and facilities such as chemical plants, dry cleaners, coke ovens, and incinerators are primarily responsible for these reductions.



**Figure 1. Number of people (in millions) living in counties with air quality concentrations above the level of the primary (health-based) National Ambient Air Quality Standards (NAAQS) in 2010.**

Note: Projected population data for 2009 (U.S. Census Bureau, 2009). Ozone (8-hour) is based on the 2008 revised ozone NAAQS of 0.075 ppm. The revised 1-hour standards for  $NO_2$  and  $SO_2$  are not included.

## Highlights

- Monitored concentrations of toxic pollutants such as benzene, 1,3-butadiene, ethylbenzene, and toluene decreased by 5 percent or more per year between 2003 and 2010 at more than half of ambient monitoring sites. Other toxic air pollutants of concern to public health such as carbon tetrachloride, formaldehyde, and several metals, declined at most sites.

## Air Quality and Greenhouse Gases

- EPA has concluded that there is compelling evidence that many fundamental measures of climate in the United States (e.g., air temperature) are changing, and many of these changes are linked to the accumulation of greenhouse gases (GHGs) in the atmosphere. GHG emissions from the U.S. have increased by approximately 7 percent since 1990 and global GHG emissions are increasing at an even greater rate. Among other impacts, climate change also contributes to worsening air quality that can endanger public health.
- While reductions in emissions of long-lived GHGs like CO<sub>2</sub> will be essential for addressing

climate change in the long term, there are also climate benefits associated with reductions in certain short lived pollutants. In addition to known health benefits, reductions in black carbon particle pollution and ozone are also likely to lead to climate benefits.

## More Improvements Anticipated

EPA expects air quality to continue to improve as recently adopted regulations are fully implemented and states work to meet current and recently revised national air quality standards. Key regulations include the Locomotive Engines and Marine Compression-Ignition Engines Rule, the Tier 2 Vehicle and Gasoline Sulfur Rule, the Heavy-Duty Highway Diesel Rule, the Clean Air Non-Road Diesel Rule, the Mobile Source Air Toxics Rule, the Cross State Air Pollution Rule and the Mercury and Air Toxics Standards.



# Air Pollution

## Health and Environmental Impacts

Air pollution can affect our health in many ways. Numerous scientific studies have linked air pollution to a variety of health problems including: (1) aggravation of respiratory and cardiovascular disease; (2) decreased lung function; (3) increased frequency and severity of respiratory symptoms such as difficulty breathing and coughing; (4) increased susceptibility to respiratory infections; (5) effects on the nervous system, including the brain, such as IQ loss and impacts on learning, memory, and behavior; (6) cancer; and (7) premature death. Some sensitive individuals appear to be at greater

risk for air pollution-related health effects, for example, those with pre-existing heart and lung diseases (e.g., heart failure/ischemic heart disease, asthma, emphysema, and chronic bronchitis), diabetics, older adults, and children.

Air pollution also damages our environment. For example, ozone can damage vegetation, adversely impacting the growth of plants and trees. These impacts can reduce the ability of plants to uptake carbon dioxide (CO<sub>2</sub>) from the atmosphere and indirectly affect entire ecosystems.

### Sources and Health Effects of Air Pollution

| Pollutant                             | Sources  | Health Effects  |
|---------------------------------------|--|---|
| Ozone (O <sub>3</sub> )               | Secondary pollutant typically formed by chemical reaction of volatile organic compounds (VOCs) and NO <sub>x</sub> in the presence of sunlight.                                  | Decreases lung function and causes respiratory symptoms, such as coughing and shortness of breath; aggravates asthma and other lung diseases leading to increased medication use, hospital admissions, emergency department (ED) visits, and premature mortality.               |
| Particulate Matter (PM)               | Emitted or formed through chemical reactions; fuel combustion (e.g., burning coal, wood, diesel); industrial processes; agriculture (plowing, field burning); and unpaved roads. | Short-term exposures can aggravate heart or lung diseases leading to respiratory symptoms, increased medication use, hospital admissions, ED visits, and premature mortality; long-term exposures can lead to the development of heart or lung disease and premature mortality. |
| Lead                                  | Smelters (metal refineries) and other metal industries; combustion of leaded gasoline in piston engine aircraft; waste incinerators; and battery manufacturing.                  | Damages the developing nervous system, resulting in IQ loss and impacts on learning, memory, and behavior in children. Cardiovascular and renal effects in adults and early effects related to anemia.  |
| Oxides of Nitrogen (NO <sub>x</sub> ) | Fuel combustion (e.g., electric utilities, industrial boilers, and vehicles) and wood burning.   | Aggravate lung diseases leading to respiratory symptoms, hospital admissions, and ED visits; increased susceptibility to respiratory infection.   |
| Carbon Monoxide (CO)                  | Fuel combustion (especially vehicles).   | Reduces the amount of oxygen reaching the body's organs and tissues; aggravates heart disease, resulting in chest pain and other symptoms leading to hospital admissions and ED visits.   |
| Sulfur Dioxide (SO <sub>2</sub> )     | Fuel combustion (especially high-sulfur coal); electric utilities and industrial processes; and natural sources such as volcanoes.   | Aggravates asthma and increased respiratory symptoms. Contributes to particle formation with associated health effects.   |

## Sources of Air Pollution

Air pollution consists of gas and particle contaminants that are present in the atmosphere. Gaseous pollutants include  $\text{SO}_2$ ,  $\text{NO}_x$ , ozone, CO, volatile organic compounds (VOCs), certain toxic air pollutants, and some gaseous forms of metals. Particle pollution ( $\text{PM}_{2.5}$  and  $\text{PM}_{10}$ ) includes a mixture of compounds. The majority of these compounds can be grouped into five categories: sulfate, nitrate, elemental (black) carbon, organic carbon, and crustal material.

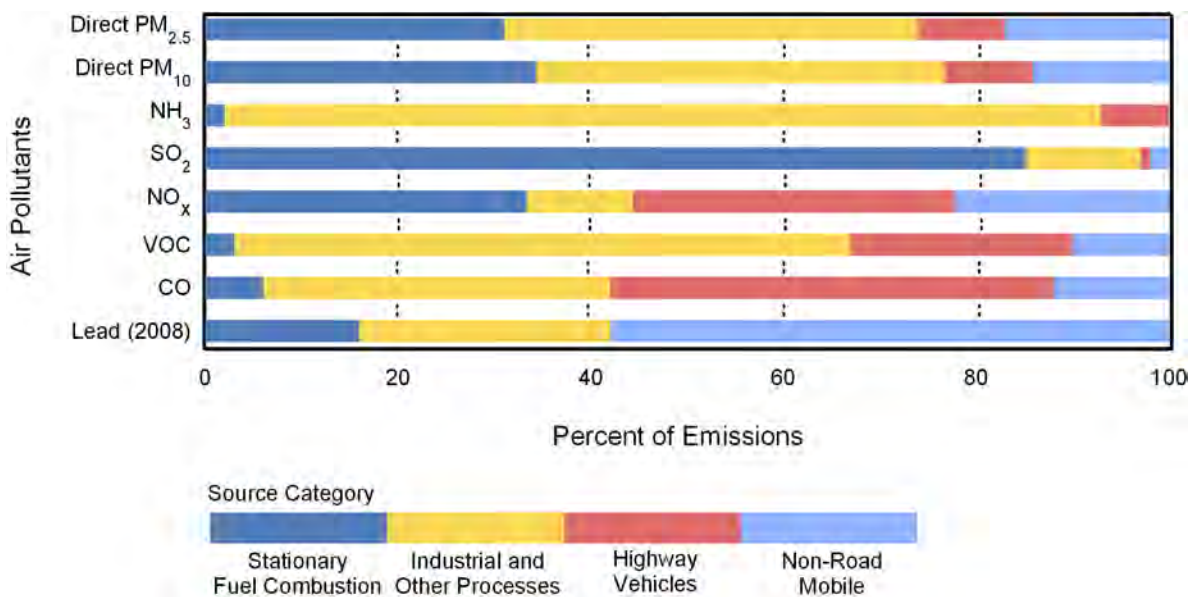
Some pollutants are released directly into the atmosphere. Other pollutants are formed in the air. Ground-level ozone forms when emissions of  $\text{NO}_x$  and VOCs react in the presence of sunlight. Similarly, some particles are formed from other directly emitted pollutants. For example, sulfate particles are formed from complex reactions in the atmosphere of  $\text{SO}_2$  emissions from power plants and industrial facilities. Weather plays an important role in the formation of secondarily formed air pollutants, as discussed later in the Ozone and Particle Pollution sections.

EPA and states track direct emissions of air pollutants and emissions that contribute to the formation of key pollutants, also known as precursor emissions. Emissions data are compiled from many different organizations, including industry and state, tribal, and local agencies. Some emissions data are based on actual

measurements while others are estimates.

Generally, emissions come from large stationary fuel combustion sources (such as electric utilities and industrial boilers), industrial and other processes (such as metal smelters, petroleum refineries, cement kilns, manufacturing facilities, and solvent utilization), and mobile sources including highway vehicles and non-road sources (such as recreational and construction equipment, marine vessels, aircraft, and locomotives). Sources emit different combinations of pollutants. For example, electric utilities release  $\text{SO}_2$ ,  $\text{NO}_x$ , and particles.

Figure 2 shows the distribution of national total emissions estimates by source category for specific pollutants in 2010. Electric utilities contribute over 60 percent of national  $\text{SO}_2$  emissions. Agricultural operations (included in the “other processes” category) contribute over 80 percent of national  $\text{NH}_3$  emissions. Almost 50 percent of the national VOC emissions originate from solvent use (included in the “other processes” category). Highway vehicles and non-road mobile sources together contribute approximately 60 percent of national CO emissions. Pollutant levels differ across regions of the country and within local areas, depending on the size and type of sources present.



**Figure 2. Distribution of national total emissions estimates by source category for specific pollutants, 2010.**

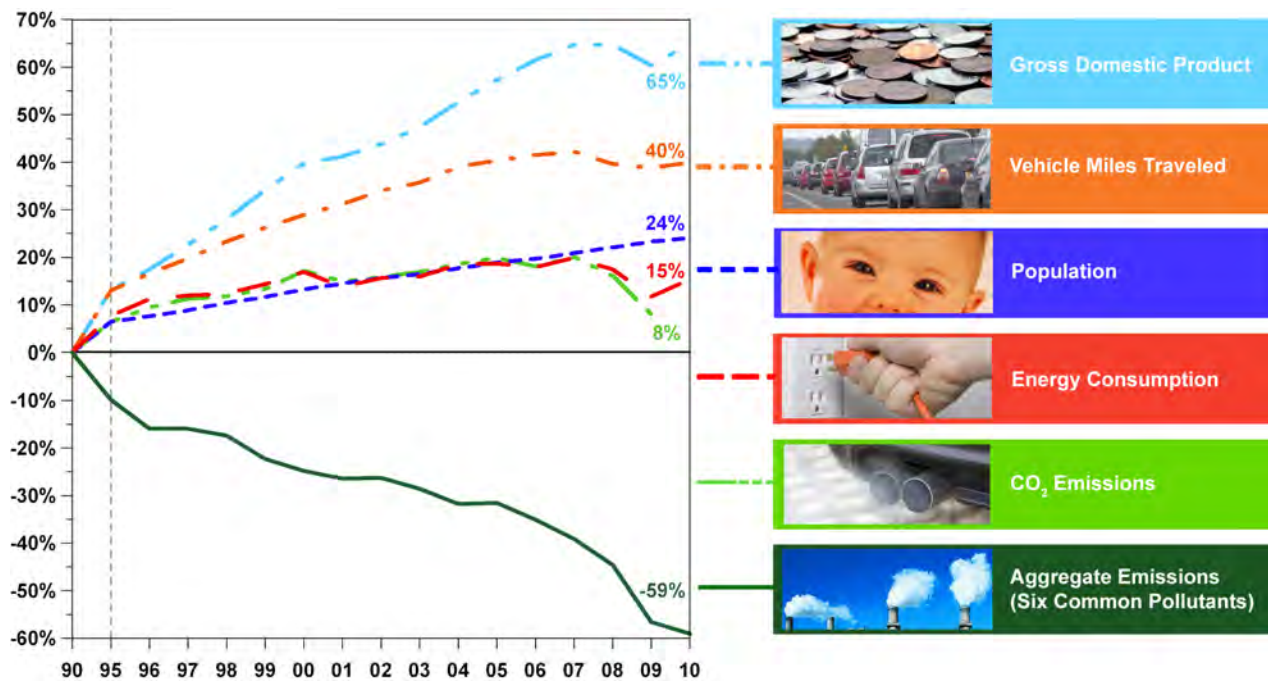
Note: Lead emissions estimates are for 2008.



## Tracking Pollutant Emissions

Since 1990, national annual air pollutant emissions have declined, with the greatest percentage drop in lead emissions. Direct PM<sub>2.5</sub> emissions have declined by more than half; PM<sub>10</sub> and SO<sub>2</sub> emissions have declined by more than 60 percent, and NO<sub>x</sub> and VOC emissions have declined by more than 40 percent. The combined emissions of the six common pollutants and their precursors (PM<sub>2.5</sub> and PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub>, VOCs, CO, and lead) dropped 59 percent on average since 1990, as shown in Figure 3. This progress has occurred while the U.S. economy continued to grow, Americans drove more miles, and population and energy use increased. These emissions reductions were achieved through regulations, voluntary measures taken by industry, partnerships between federal, state, local,

and tribal governments; academia; industrial groups; and environmental organizations. This environmental progress has occurred while overall, the U.S. economy grew 65 percent, Americans drove 40 percent more miles, and population and energy use increased by 24 and 15 percent respectively. There was a noticeable decline in Gross Domestic Product between 2008 and 2009. There was also a notable reduction in vehicle miles traveled and energy consumed from 2007 to 2009. Factors likely contributing to these reductions include the nationwide spike in gasoline prices during 2008 and the economic recession that began in 2008. These indicators showed an increase in 2010. Figure 3 also shows total CO<sub>2</sub> emissions increasing by about 8 percent from 1990 to 2009 (<http://epa.gov/climatechange/emissions/usinventoryreport.html>).



**Figure 3. Comparison of growth measures and emissions, 1990-2010.**

Note: CO<sub>2</sub> emissions estimates are from 1990 to 2009.

# Six Common Pollutants

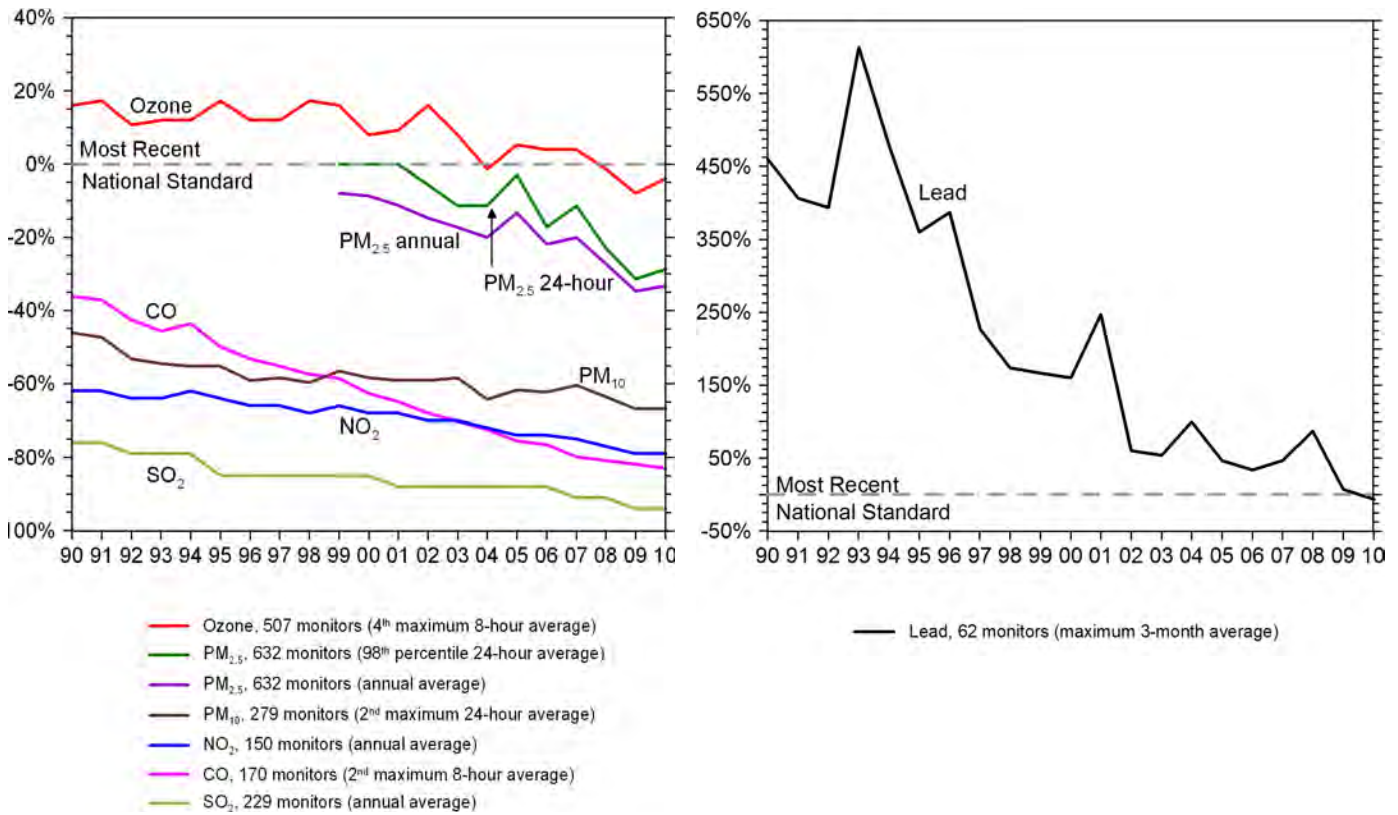
The Clean Air Act requires EPA to set national air quality standards for specific pollutants to safeguard human health and the environment. These standards define the levels of air quality that EPA determines are necessary to protect against the adverse impacts of air pollution based on scientific evidence. EPA has established standards for six common air pollutants, which are referred to as “criteria” pollutants: ozone (O<sub>3</sub>), particle pollution (PM), lead (Pb), nitrogen dioxide (NO<sub>2</sub>), carbon monoxide (CO), and sulfur dioxide (SO<sub>2</sub>).

## Trends in National Air Quality Concentrations

Air quality has improved continuously across the U.S.

since the Clean Air Act was amended more than two decades ago. The downward trend in air pollution has been especially evident over the past several years as shown in Figure 4. The record-low air pollution levels observed in 2009 were primarily the result of numerous national and local regulations that have sharply reduced emissions. Also, meteorological conditions favorable to lower air pollution levels and the economic slowdown likely also contributed to the relatively clean conditions in 2009. This downward trend in air quality concentrations is expected to have had profound health benefits for the American people.

Figure 4 shows the national trend in lead and the national trends in the other five criteria pollutants between 1990 and 2010, relative to their respective



**Figure 4. Comparison of national levels of the six common pollutants to the most recent national ambient air quality standards, 1990-2010. National levels are averages across all monitors with complete data for the time period. Note: Air quality data for PM2.5 start in 1999.**

national ambient air quality standards. As noted above, most pollutants show a steady decline throughout that time period. For lead, there are significant year-to-year changes in lead concentrations largely driven by changes in lead concentrations at monitoring sites near stationary sources. These year-to-year changes reflect changes in operating schedules and plant closings. For ozone and particle pollution shown in Figure 4, the trends exhibit an even sharper decline over the past three to five years although meteorological conditions favorable to higher levels of ozone and particle pollution likely contributed to higher levels in 2010 compared to 2009.

### Air Quality in Nonattainment Areas

EPA works collaboratively with state, local, and tribal agencies to identify areas of the U.S. that do not meet the national ambient air quality standards (NAAQS). These areas, known as nonattainment areas, must develop plans to reduce air pollution and attain the NAAQS. EPA tracks the progress these areas make to assure air quality continues to improve in places where improvements are most needed.

Consistent with national averages, air quality in nonattainment areas has also improved. As of 2010, there were no violations of the annual standards for

CO, NO<sub>2</sub>, and SO<sub>2</sub>. Figure 5 shows trends in average concentrations of ozone and particle pollution only in existing nonattainment areas with air quality exceeding one or more of these standards in 2010. Although many areas exceeded the level of the standard in 2010, there have been improvements in the levels of these pollutants in nonattainment areas since 2001. For example, between 2001 and 2010, ozone nonattainment areas showed a 9 percent improvement in ozone concentration levels. Figure 5 does not include all areas that are designated nonattainment for the pollutant shown. For more information on areas designated as nonattainment visit [www.epa.gov/airquality/greenbook](http://www.epa.gov/airquality/greenbook).

Despite these improvements, further reductions in air pollution are needed over parts of the country. EPA expects air quality to continue to improve as recent regulations are fully implemented and new measures are finalized. EPA periodically reviews and revises the national air quality standards as needed to protect public health and the environment. This means that although there is clear progress in reducing air pollution, and we expect that trend to continue, there may be a need to implement further control measures to meet new more protective air quality standards.

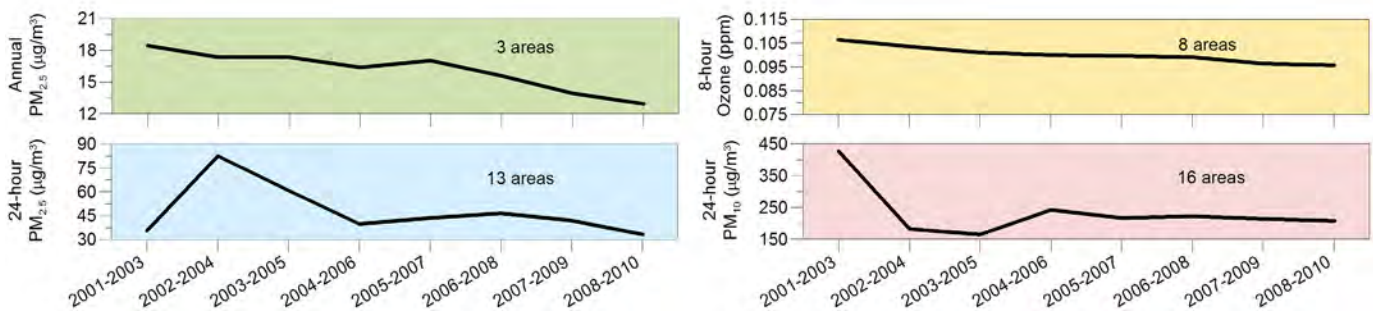


Figure 5. Air quality trends in nonattainment areas exceeding the ozone and particle pollution standards in 2010.



# Ozone

## Trends in Ground-Level Ozone Concentrations

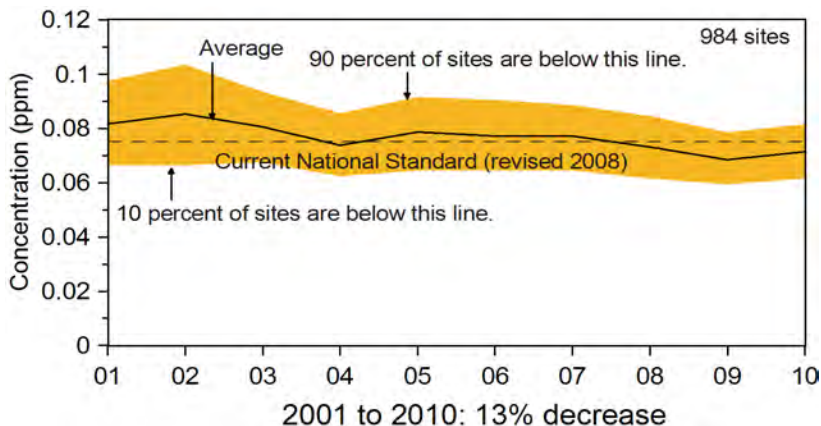
In March 2008, EPA strengthened the national standards for ground-level ozone, setting an 8-hour standard at 0.075 parts per million (ppm). Nationally, average ground-level ozone concentrations were 13 percent lower in 2010 than in 2001, as shown in Figure 7. The trend showed a notable decline after 2002. When comparing the three-year periods 2001-2003 and 2008-2010, approximately 82 percent of the monitoring sites recorded a significant decline (> 0.005 ppm) in ozone concentrations. Sites that showed the greatest improvement were in or near the following metropolitan areas: South Bend, IN; Buffalo, NY; Chicago, IL; Milwaukee, WI; and Cleveland, OH. Ozone trends can vary locally. One site may show increases in ozone levels while nearby sites show decreases.

## Ozone

Figure 8 shows a snapshot of ozone concentrations in 2010. The highest ozone concentrations occurred in California. Note that the high concentration levels in Utah occurred in winter. Elevated wintertime ozone concentrations are most likely to occur when local sources of NO<sub>x</sub> and VOC emissions are trapped in a snow-covered valley on a clear day with light winds. Nationally, approximately 24 percent of all sites measured concentrations above the standard of 0.075 ppm on four or more days in 2010.

Over the years, EPA has adopted a number of regulations that helped reduce ozone levels nationwide. Other recently adopted regulations will help to continue to make progress toward lower, healthier ozone levels. These regulations include:

- Coordinated steps to reduce power plant pollution
  - » NO<sub>x</sub> State Implementation Plan (SIP) Call
  - » Acid Rain Program
  - » Cross-State Air Pollution Rule (CSAPR)
- Requiring other stationary sources to reduce pollution
  - » Aerosol, architectural, autobody, and miscellaneous coatings
  - » Consumer products
  - » Regional haze requirements
- Limiting emissions from mobile sources
  - » Light Duty Tier 2 Rule - new cars, SUVs, trucks and vans
  - » Heavy-Duty Diesel Rule on and nonroad
  - » Requirements for marine vehicles, and locomotives
- On December 30, 2011, the D.C. Circuit Court stayed the CSAPR rule pending judicial review. This decision delays implementation of CSAPR and leaves the Clean Air Interstate Rule in place pending the court's decision.



**Figure 7. National 8-hour ozone air quality trend, 2001-2010 (average of annual fourth highest daily maximum 8 hour concentrations in ppm).**

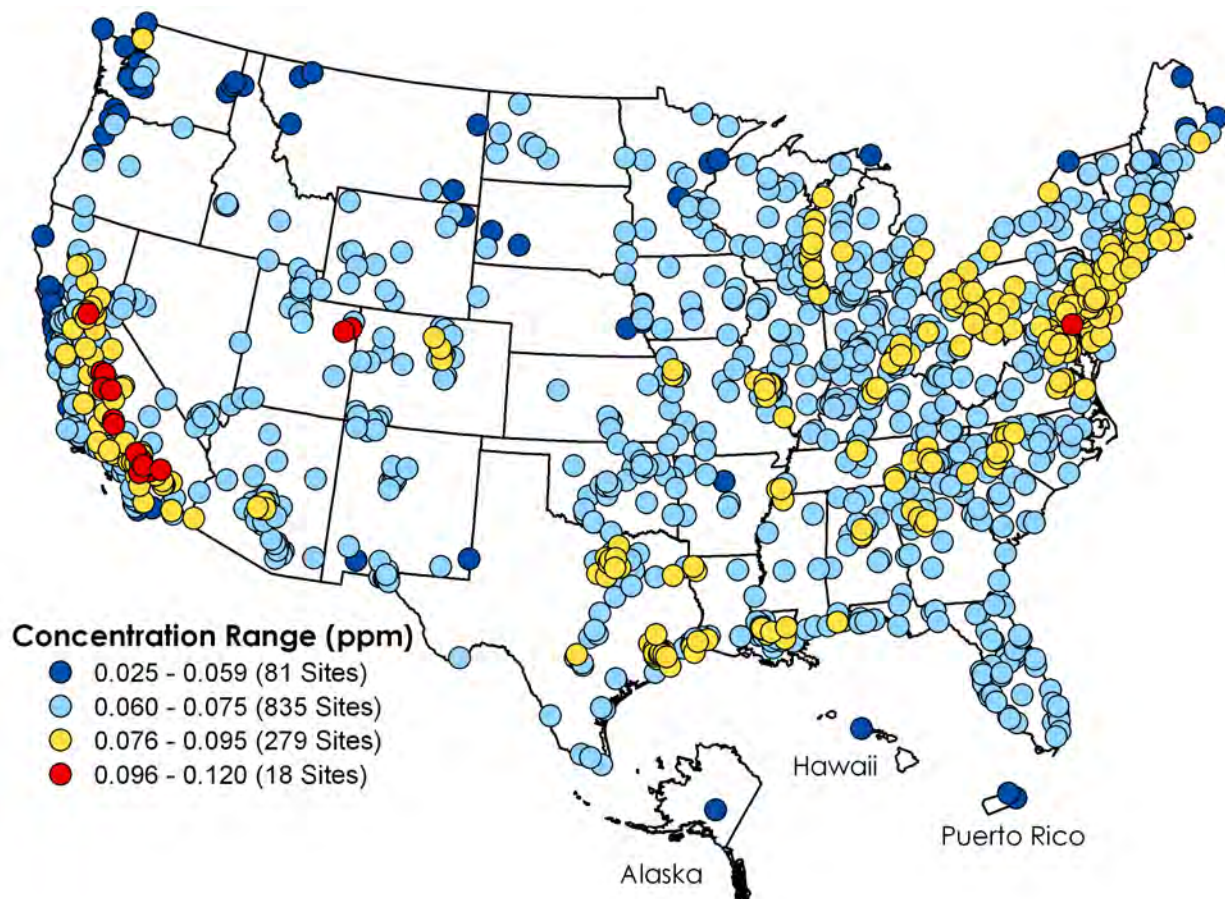


Figure 8. Ozone concentrations in ppm, 2010 (fourth highest daily maximum 8-hour concentration).

## Weather Influences Ozone

In addition to precursor emissions, weather plays an important role in the formation of ozone. A large number of hot, dry days can lead to higher ozone levels in any given year, even if ozone-forming emissions remain unchanged. To better evaluate the progress and effectiveness of ozone precursor emission reduction programs, EPA uses a statistical model to estimate the influence of weather on ozone formation.

Figure 9 shows trends in average seasonal ozone levels from 2001 through 2010 across 180 selected sites, before and after adjusting for weather-related effects. For example, the summer of 2009 was characterized by cooler than normal conditions across much of the Eastern U.S., which contributed to less ozone formation and resulted in an upward adjustment to the ozone trend. By contrast, hot and dry conditions in the

Eastern U.S. during the summer of 2010 contributed to more ozone formation, resulting in a downward adjustment to the ozone trend.

Both the observed and adjusted ozone trends are characterized by a large decrease in ozone in the Eastern U.S. between 2002 and 2004. This abrupt decline in ozone levels coincides with the large reduction in NO<sub>x</sub> emissions brought about by EPA's NO<sub>x</sub> SIP Call program which began in 2003 and was fully implemented in 2004. Removing the effects of weather confirms that ozone levels have continued to improve across the U.S. in recent years due to emission reduction programs.

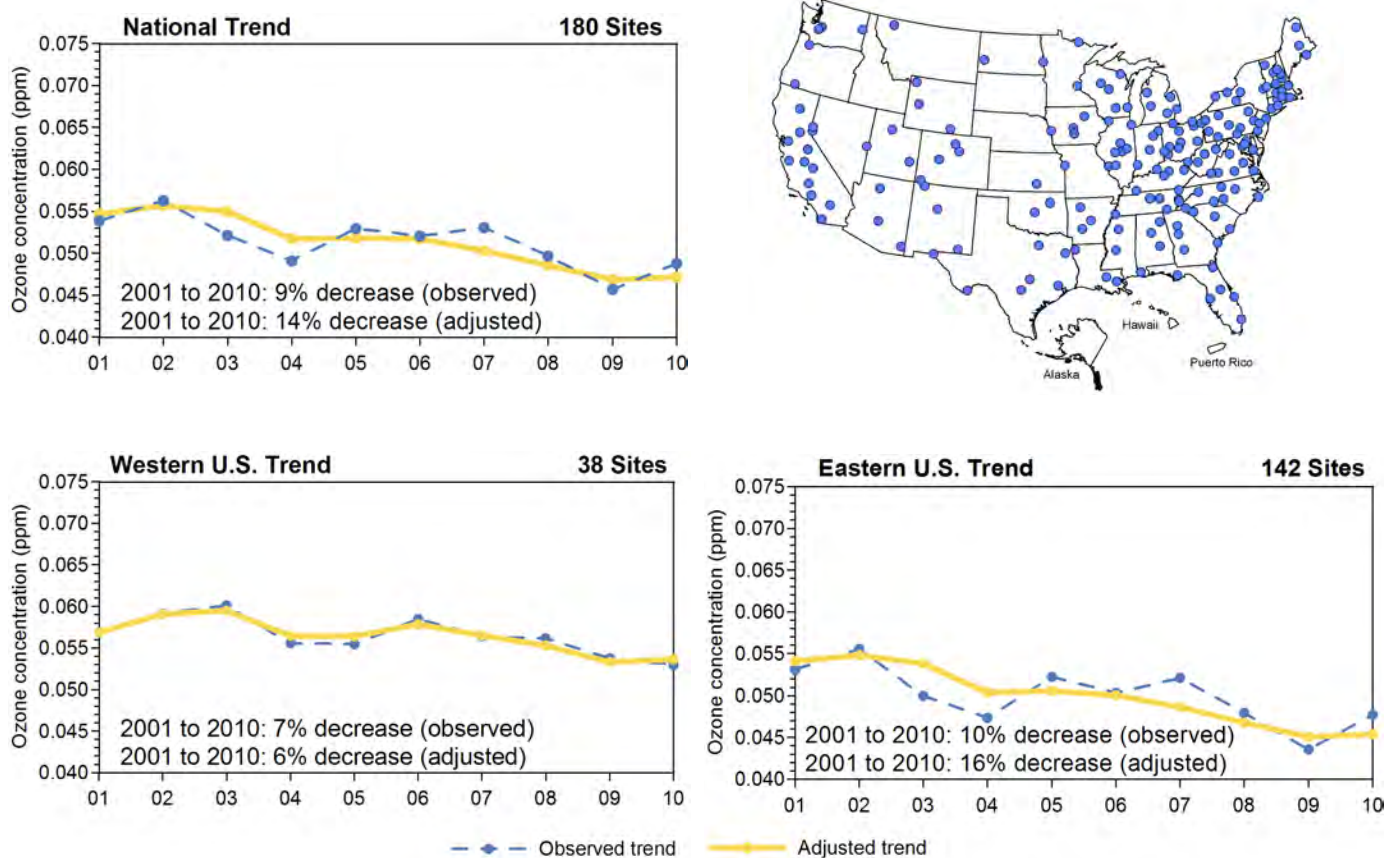


Figure 9. Trends in average summertime daily maximum 8-hour ozone concentrations in ppm (May-September), before and after adjusting for weather nationally, in western states, and in eastern states, (and the location of monitoring sites used in the averages).

# Particle Pollution

EPA has set national standards to protect against the health and welfare effects associated with exposure to fine and coarse particles. Fine particles are generally considered to be less than or equal to 2.5 micrometers ( $\mu\text{m}$ ) in aerodynamic diameter, or  $\text{PM}_{2.5}$ . Coarse particles are those between 2.5 and 10  $\mu\text{m}$  in diameter.  $\text{PM}_{10}$  is the indicator used for the coarse particle standard.

## Trends in $\text{PM}_{2.5}$ Concentrations

There are two national air quality standards for  $\text{PM}_{2.5}$ : an annual standard ( $15 \mu\text{g}/\text{m}^3$ ) and a 24-hour standard ( $35 \mu\text{g}/\text{m}^3$ ). Nationally, annual and 24-hour  $\text{PM}_{2.5}$  concentrations declined by 24 and 28 percent, respectively, between 2001 and 2010, as shown in Figure 10.

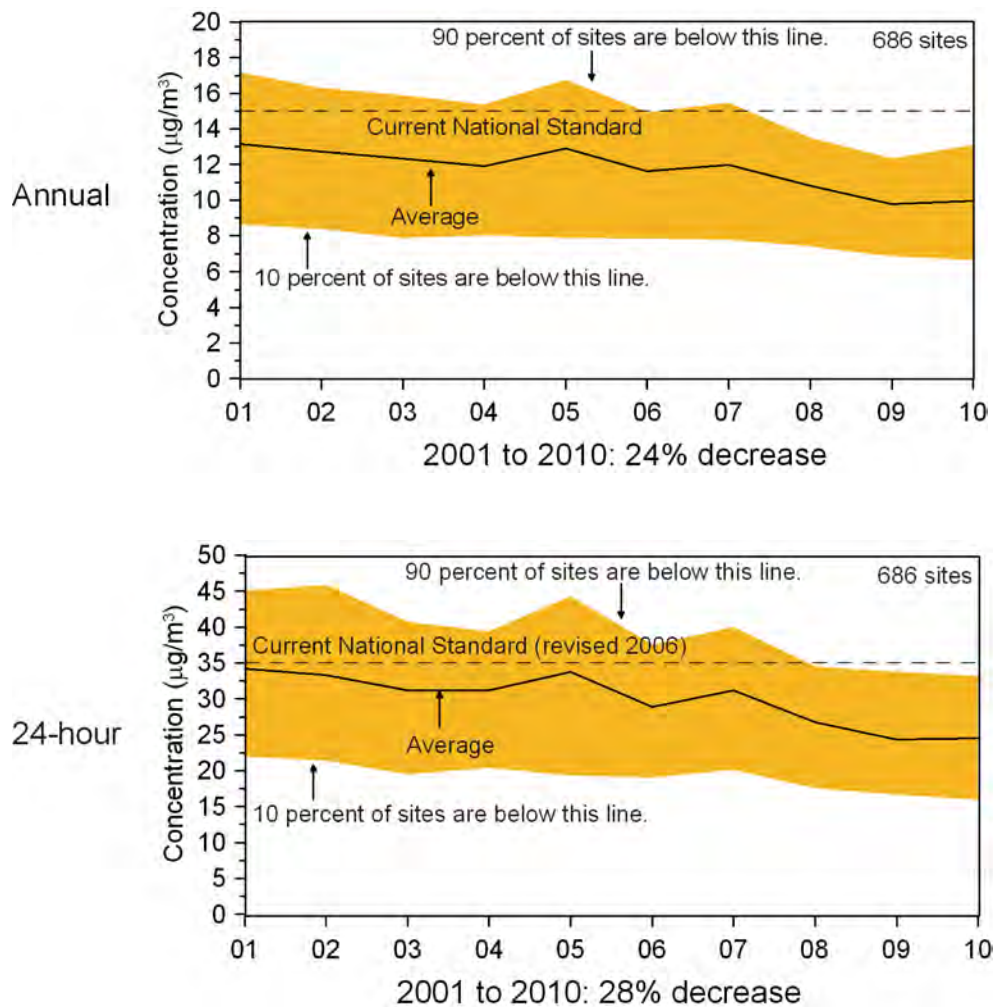


Figure 10. National  $\text{PM}_{2.5}$  air quality trends, 2001-2010 (annual average concentration and 98<sup>th</sup> percentile of 24-hour concentration in  $\mu\text{g}/\text{m}^3$ ).



In 2010, the highest annual average  $PM_{2.5}$  concentrations were in California, Indiana, Pennsylvania and Hawaii, as shown in Figure 11. The highest 24-hour  $PM_{2.5}$  concentrations were in California and Alaska.

Some sites showed high 24-hour  $PM_{2.5}$  concentrations but low annual  $PM_{2.5}$  concentrations. Sites that show high 24-hour concentrations but low or moderate annual concentrations exhibit substantial variability from season to season. For example, sites in the Northwest generally show low concentrations in warm

months but are prone to much higher concentrations in the winter. Factors that contribute to the higher levels in the winter are extensive woodstove use coupled with prevalent cold temperature inversions that trap pollution near the ground. Nationally, more sites exceeded the level of the 24-hour  $PM_{2.5}$  standard than the annual  $PM_{2.5}$  standard, as indicated by yellow and red dots on the maps below. Of the 6 sites that exceeded the annual standard and 43 sites that exceeded the 24-hour standard, 4 sites exceeded both.

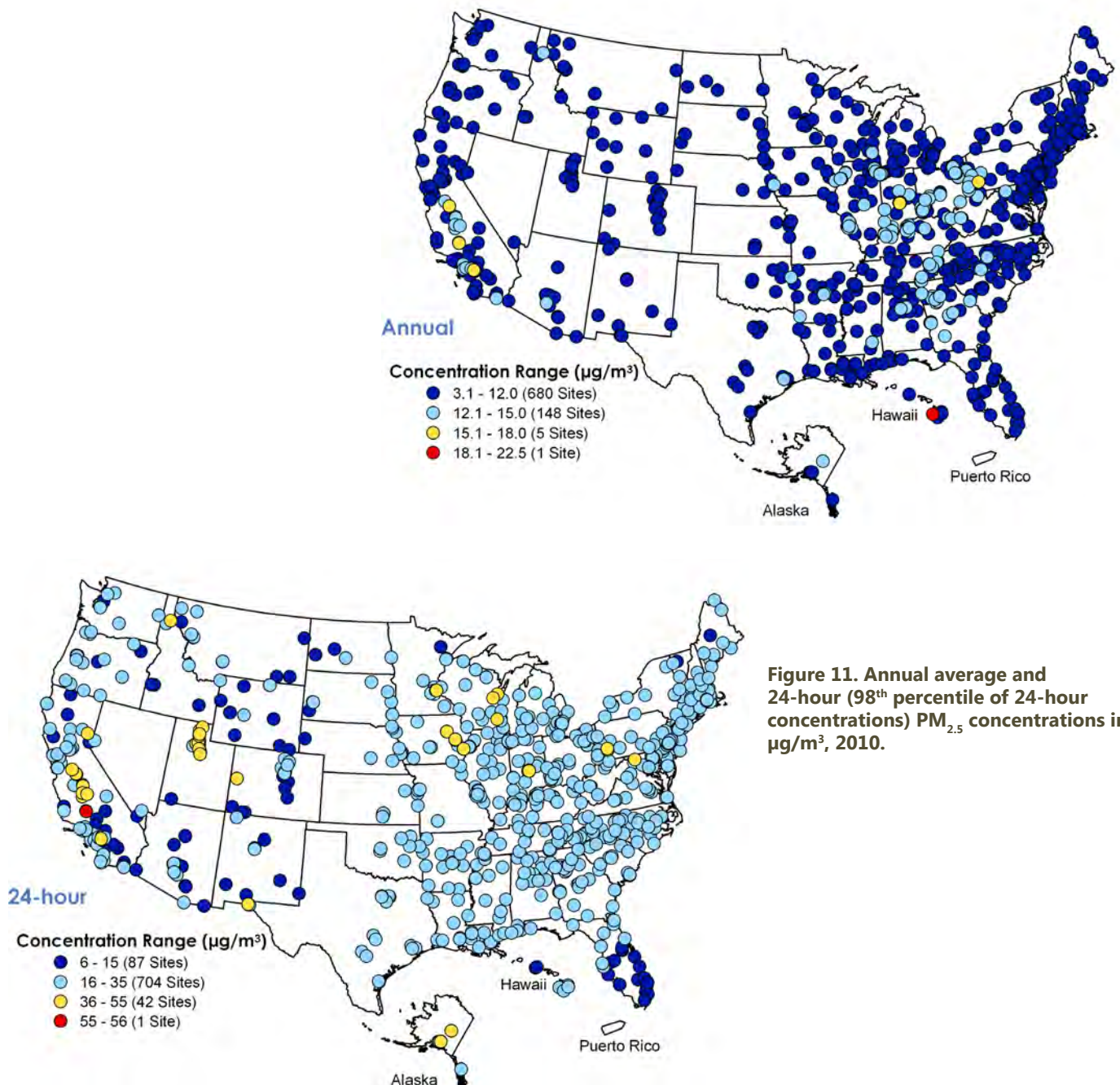


Figure 11. Annual average and 24-hour (98<sup>th</sup> percentile of 24-hour concentrations)  $PM_{2.5}$  concentrations in  $\mu\text{g}/\text{m}^3$ , 2010.

## Weather Influences PM<sub>2.5</sub>

In addition to emissions, weather plays an important role in the formation of PM<sub>2.5</sub>. PM<sub>2.5</sub> tends to be dominated by different components at different times of the year (e.g. sulfates in the summer and nitrates in the winter), so the statistical model adjusting the PM<sub>2.5</sub> trend for weather is split into a ‘warm months’ trend running from May to September and a ‘cool months’ trend encompassing the remaining months of the year. The two trends were combined to form the annual trend using a weighted average.

Figure 12 shows trends in PM<sub>2.5</sub> from 2001 to 2010, averaged across 145 selected sites before and after adjusting for weather. The warm months trend is characterized by a large decrease in average PM<sub>2.5</sub> between 2008 and 2010, while the cool months trend shows a slow but steady decrease in PM<sub>2.5</sub> over the past decade. Overall, average PM<sub>2.5</sub> concentrations in the U.S. have declined steadily since 2005 after removing the effects due to weather indicating improvement based on recently enacted emissions reduction programs.

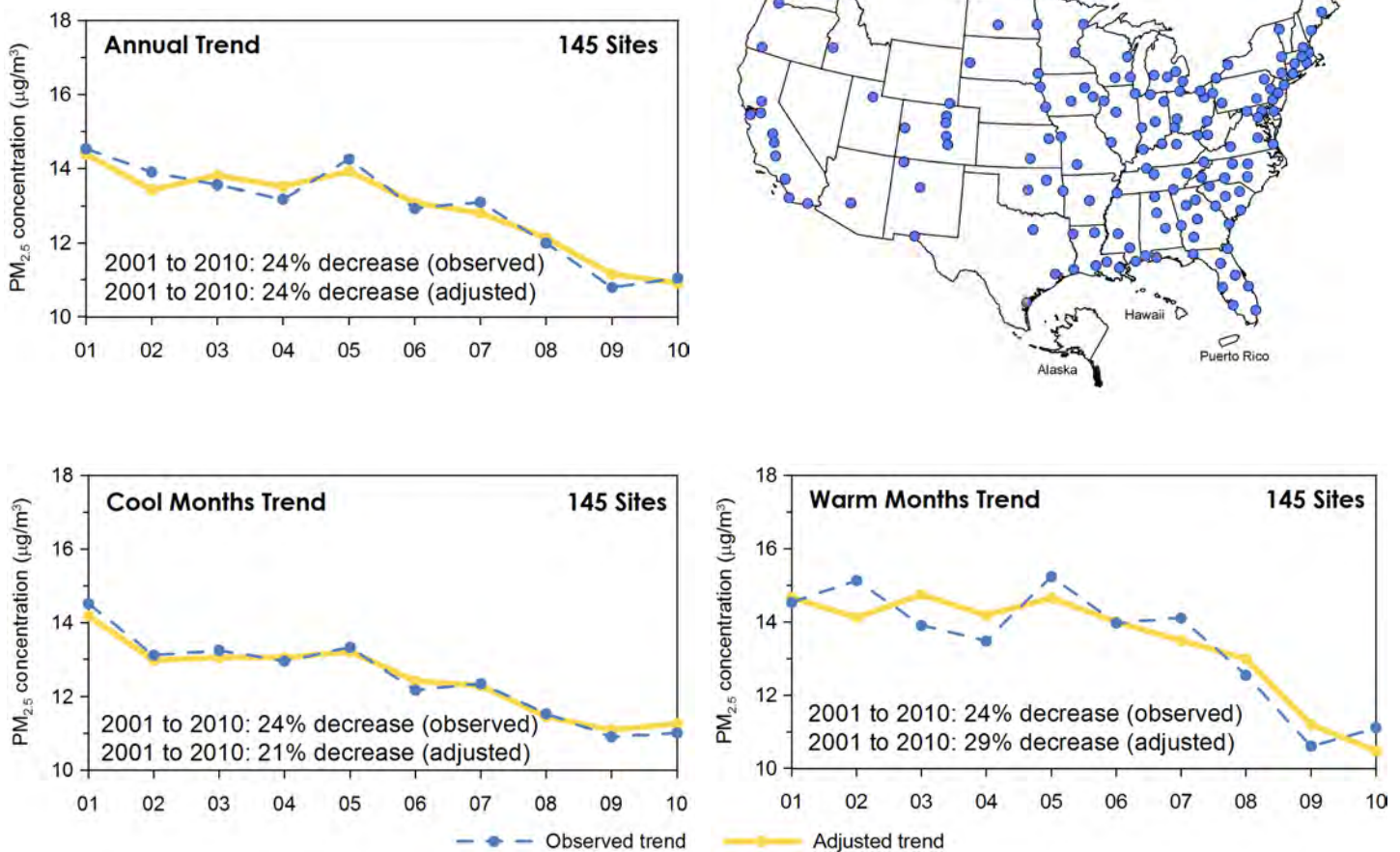


Figure 12. Trends in annual, cool-month (October–April) and warm-month (May–September) average PM<sub>2.5</sub> concentrations in µg/m<sup>3</sup> (before and after adjusting for weather), and the location of monitoring sites used in the average.

## Trends in PM<sub>10</sub> Concentrations

Nationally, 24-hour PM<sub>10</sub> concentrations declined by 29 percent between 2001 and 2010, as shown in Figure 13.

Figure 14 shows that in 2010, the highest PM<sub>10</sub> concentrations were located in California, Utah, Colorado and New Mexico. However, within these same states some sites showed a decline greater than 50 µg/m<sup>3</sup>. Highest concentrations are largely located in dry and/or industrial areas with a high number of coarse particle sources.

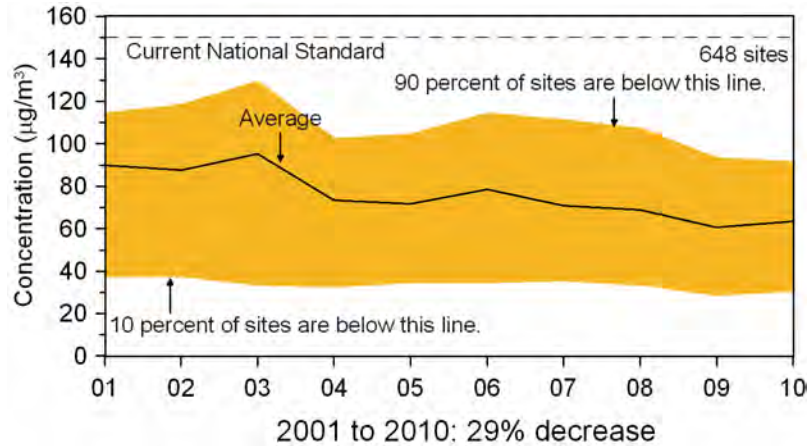
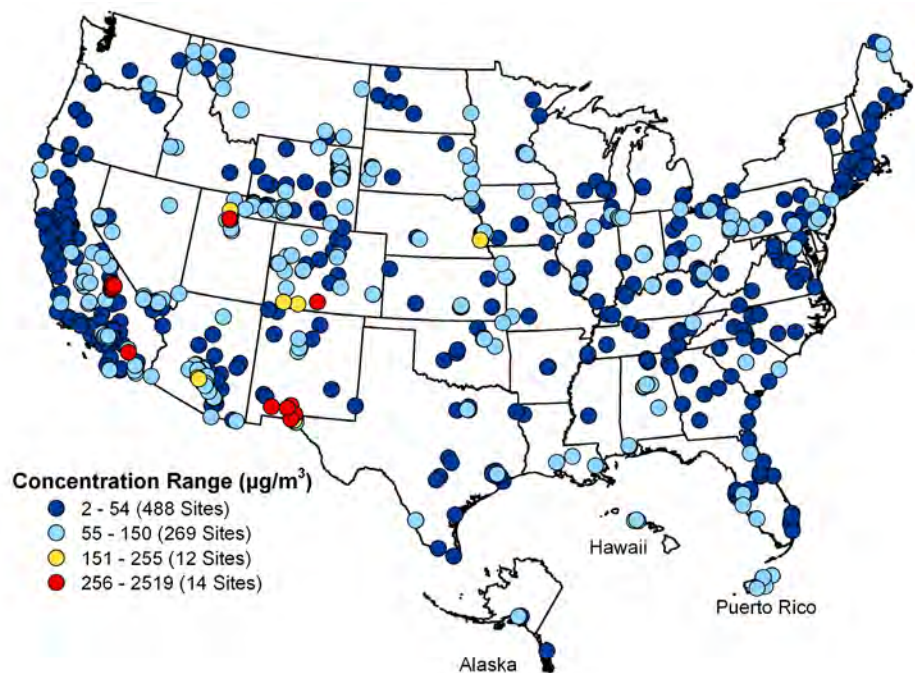


Figure 13. National PM<sub>10</sub> air quality trend, 2001-2010 (second maximum 24-hour concentration in µg/m<sup>3</sup>).

Figure 14. PM<sub>10</sub> concentrations in µg/m<sup>3</sup>, 2010 (second maximum 24-hour concentration).



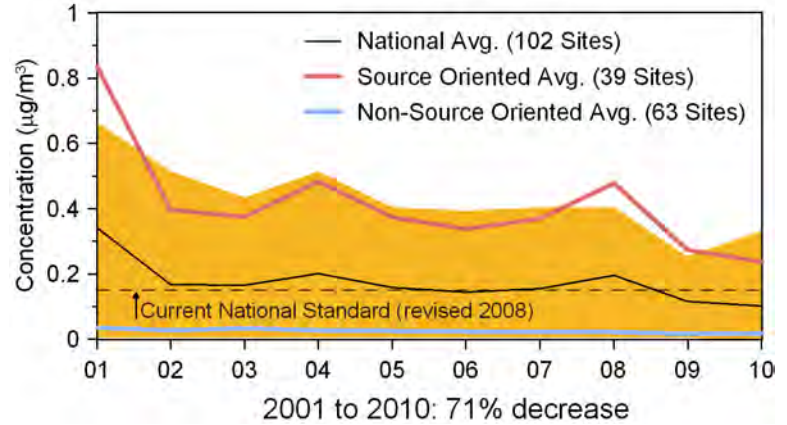


# Lead

## Trends in Lead Concentrations

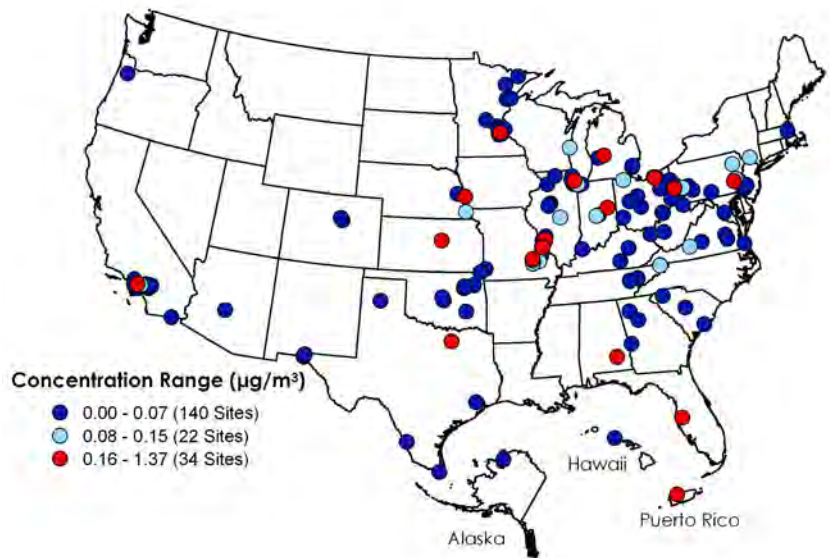
Concentrations of lead decreased approximately 71 percent between 2001 and 2010, as shown in Figure 15. Average concentrations are shown for 39 sites near large stationary sources and 63 sites that are not near stationary industrial sources. The typical average concentration near a stationary source (e.g., metals processors, battery manufacturers, and mining operations) is approximately eight times the typical concentration at a site that is not near a stationary industrial source. There are significant year-to-year changes in lead concentrations at sites near stationary sources; these reflect changes in emissions due to changes in operating schedules and plant closings. For example, national lead concentrations declined between 2001 and 2002, mostly due to lower lead concentrations at sites in Herculaneum, MO.

Figure 16 shows lead concentrations in 2010. Of the 196 sites shown, 34 sites exceeded the 2008 lead standard (0.15  $\mu\text{g}/\text{m}^3$ ). All of these sites are located near stationary lead sources. Also in 2010, EPA promulgated requirements for monitoring near additional stationary lead sources that are estimated to have 0.50 or more tons per year (tpy) lead emissions. Up to 270 new locations will be monitoring lead concentrations by the end of 2011 as a result of changes to the monitoring requirements made in 2008 and 2010.



**Figure 15. National lead air quality trend, 2001-2010 (maximum 3-month average in  $\mu\text{g}/\text{m}^3$ ).**

Note: 90 percent of sites are shown in the orange area.



**Figure 16. Lead concentrations in  $\mu\text{g}/\text{m}^3$ , 2010 (maximum 3-month averages).**

Note: The number of sites in Figure 15 (102) differs from the number of sites in Figure 16 (196) due to differences in the requirements for lead data to be considered complete for each figure



# NO<sub>2</sub>, CO, SO<sub>2</sub>

## Trends in NO<sub>2</sub>, CO, and SO<sub>2</sub> Concentrations

Nationally, annual mean concentrations of NO<sub>2</sub> decreased 33 percent between 2001 and 2010, as shown in Figure 17. In 2010, NO<sub>2</sub> concentrations were the lowest of the ten-year period. All recorded concentrations were well below the level of the annual standard (53 ppb).

Nationally, concentrations of 8-hour CO decreased 52 percent between 2001 and 2010, as shown in Figure 18. In 2010, CO concentrations were the lowest in the past ten years. All concentrations were below the 8-hour standard (9 ppm) and 1-hour standard (35 ppm).

Nationally, annual mean concentrations of SO<sub>2</sub> decreased 50 percent between 2001 and 2010, as shown in Figure 19. In 2010, annual SO<sub>2</sub> concentrations were the lowest of the ten-year period. One site in Hawaii showed concentrations above the level of the annual standard (30 ppb) and four sites in Hawaii showed concentrations above the level of the 24-hour standard (140 ppb). These high measurements were probably caused by emissions from a nearby volcano.

Downward trends in annual NO<sub>2</sub>, CO, and SO<sub>2</sub> are the result of various national emissions control programs. Even though concentrations of these pollutants are low with respect to national annual standards, EPA continues to track these pollutants because of their contribution to other air pollutants (e.g., ozone and PM<sub>2.5</sub>) and reduced visibility. On August 12, 2011, EPA finalized the decision to retain existing primary CO standards.

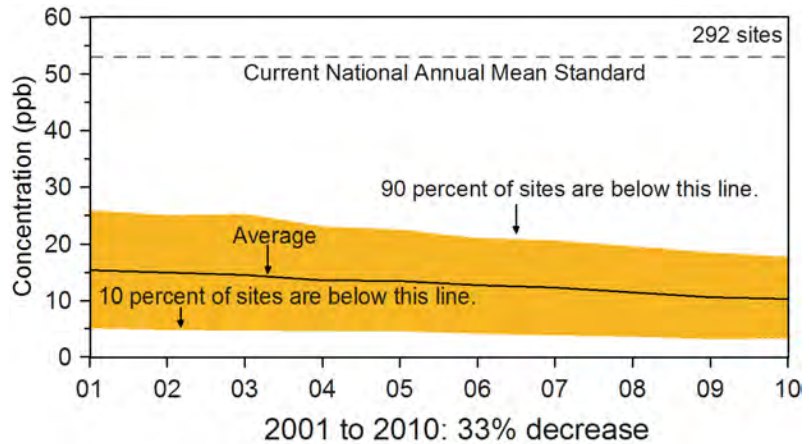


Figure 17. National NO<sub>2</sub> air quality trend, 2001-2010 (annual average in ppm).

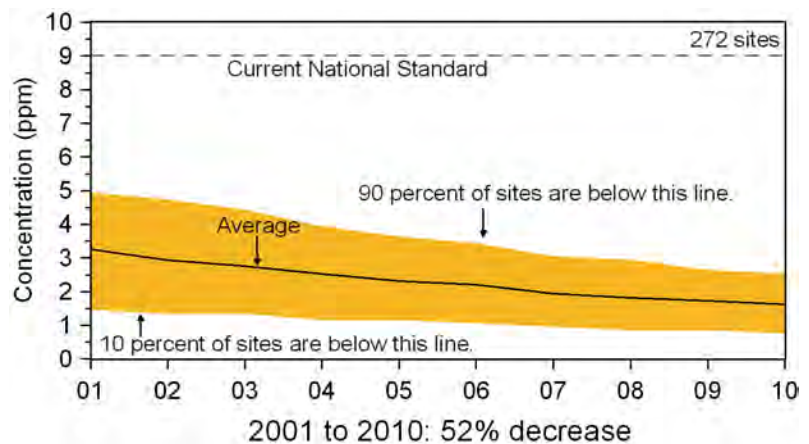


Figure 18. National CO air quality trend, 2001-2010 (second maximum 8-hour average in ppm).

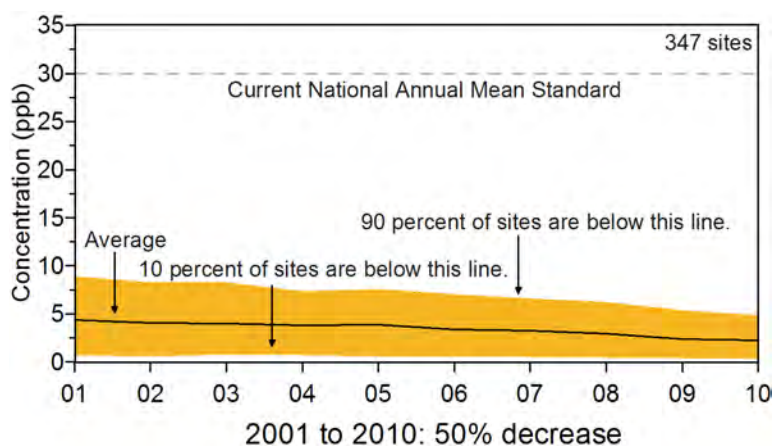


Figure 19. National SO<sub>2</sub> air quality trend, 2001-2010 (annual average in ppm).

## 2010 NO<sub>2</sub> and SO<sub>2</sub> Standards

On January 22, 2010, EPA strengthened the health-based NAAQS for NO<sub>2</sub>. This action did not impact the NO<sub>2</sub> secondary standard, set to protect public welfare. EPA set the new 1-hour NO<sub>2</sub> standard at the level of 100 ppb. The form for the 1-hour NO<sub>2</sub> standard is the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations. EPA also retained, with no change, the current annual average NO<sub>2</sub> standard of 53 ppb. Although this new standard is a 3-year average, Figure 20 shows a snapshot of the 98th percentile of the 1-hour daily maximum NO<sub>2</sub> concentration for 2010 only.

On June 2, 2010, EPA strengthened the health-based NAAQS for SO<sub>2</sub>. This action did not impact the SO<sub>2</sub> secondary standard, set to protect public welfare, which is currently under review. EPA replaced the existing annual and 24-hour primary SO<sub>2</sub> standards with a new 1-hour SO<sub>2</sub> standard set at 75 ppb to better protect public health by reducing exposure to high short-term (5 minutes to 24 hours) concentrations of SO<sub>2</sub>. Although this new standard is based on a 3-year average, Figure 21 shows a snapshot of the 99th percentile of the daily 1-hour maximum SO<sub>2</sub> concentration for 2010 only. Note that Figure 21 shows that the highest daily 1-hour maximum SO<sub>2</sub> concentrations occurred at sites in the Upper Midwest and portions of the Northeastern U.S.

On July 12, 2011, EPA proposed action on the combined review of the secondary NAAQS for oxides of nitrogen (NO<sub>x</sub>) and oxides of sulfur (SO<sub>x</sub>). EPA sets secondary standards to protect against environmental damage caused by certain air pollutants. Consistent with the scientific evidence pointing to the interrelated impacts of NO<sub>x</sub> and SO<sub>x</sub> on plants, soils, lakes, and streams, EPA assessed the environmental effects of these pollutants together. Based on this scientific evidence, EPA is proposing to retain the existing secondary standards for NO<sub>x</sub> and SO<sub>x</sub>. The existing secondary standards are:

NO<sub>2</sub>: 53 ppb (parts per billion) averaged over a year; and

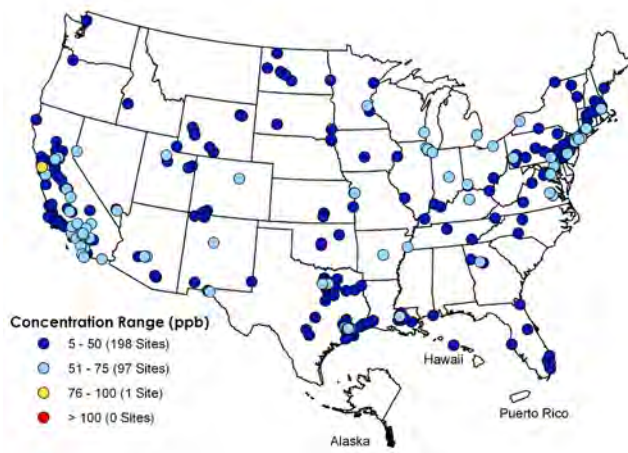
SO<sub>2</sub>: 0.5 ppm averaged over three hours, not to be exceeded more than once per year.

Also, EPA is proposing to establish an additional set of secondary standards identical to the new health-based primary standards the Agency set in 2010. The proposed new secondary standards would be:

For NO<sub>2</sub>: 100 ppb (parts per billion) averaged over one hour; and

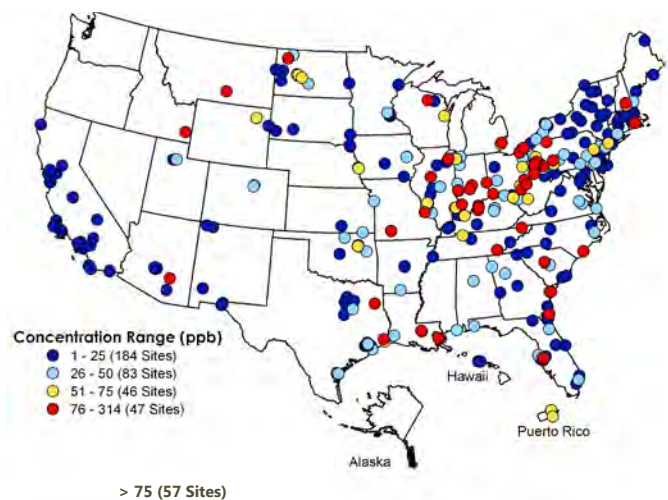
For SO<sub>2</sub>: 75 ppb averaged over one hour.

For additional information on the proposed secondary standards visit [www.epa.gov/air/nitrogenoxides/actions.html](http://www.epa.gov/air/nitrogenoxides/actions.html).



**Figure 20. NO<sub>2</sub> concentrations in ppb, 2010 (98th percentile of daily 1-hr maximum).**

Note: Typically the 1-hour standard is determined as the three-year average of the 98th (NO<sub>2</sub>) or 99th (SO<sub>2</sub>) percentile of the daily maximum 1-hour average; however, these maps only include one year (2010).



**Figure 21. SO<sub>2</sub> concentrations in ppb, 2010 (99th percentile of daily 1-hr maximum).**



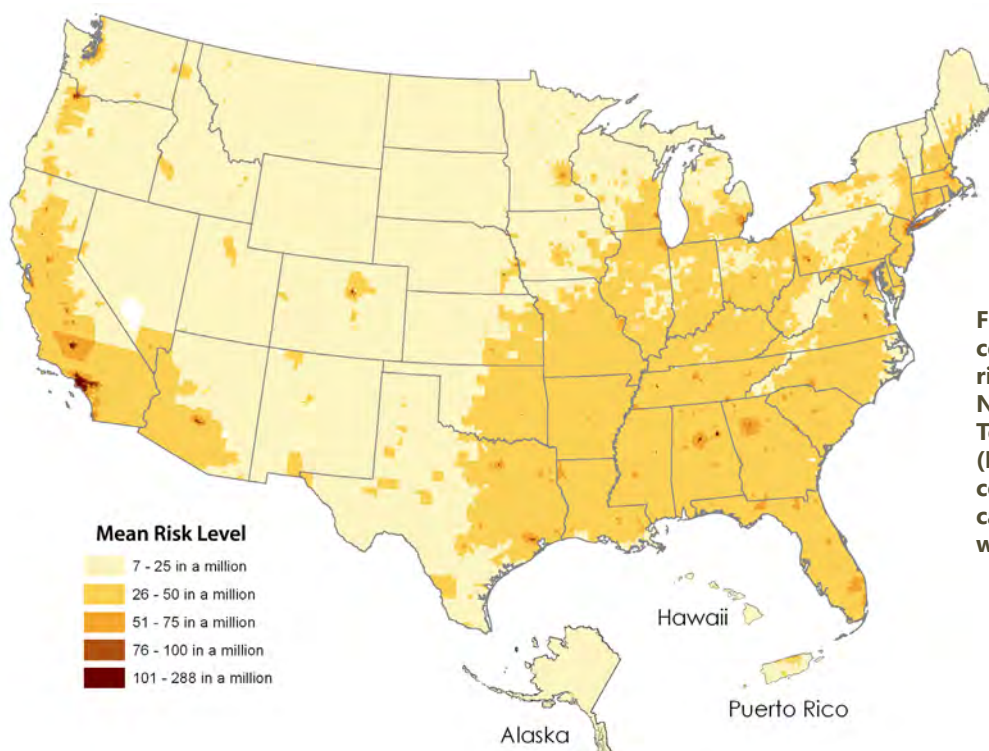
# Toxic Air Pollutants

## Trends in Toxic Air Pollutant Concentrations

Under the Clean Air Act, EPA regulates 187 toxic air pollutants. Toxicity levels, or the potential for adverse effects on human health and the environment, vary from pollutant to pollutant. For example, a few pounds of a relatively toxic pollutant may have a greater health effect than several tons of emissions of a less toxic pollutant. EPA recommends a set of benchmark toxicity levels for estimating the effects of exposure to individual toxic air pollutants. For more information, visit <http://www.epa.gov/ttn/atw/toxsource/table1.pdf>.

EPA frequently relies on modeling studies to supplement air toxic monitoring data and to better define trends in toxic air pollutants. One such modeling study, the National-Scale Air Toxics Assessment (NATA), is a nationwide study of ambient levels, inhalation exposures, and health risks associated with emissions of 177 toxic air pollutants plus diesel particulate (assessed for noncancer only). NATA examines individual pollutant effects as well as cumulative effects on human health.

Figure 22 shows the estimated lifetime cancer risk across the continental U.S. by census tract based on 2005 NATA model estimates. The national average cancer risk level in 2005 is 50 in a million. Many urban areas as well as transportation corridors show a risk above the national average. From a national perspective, formaldehyde and benzene are the most significant toxic air pollutants for which EPA could estimate cancer risk. These toxic air pollutants contributed nearly 60 percent of the average individual cancer risk identified in the 2005 assessment. In addition to the census tract level ambient concentrations predicted by the NATA 2005, EPA also used the model to compare with monitored air toxics concentrations at over 1000 locations. When comparing modeling results to monitored data, a model-to-monitor ratio close to 1 for a particular toxic pollutant at a monitoring site indicates a high level of confidence in the modeling results for that toxic pollutant and monitoring site. Good agreement was seen between the model and monitors for the following pollutants: acetaldehyde, arsenic (PM<sub>2.5</sub>), benzene, carbon tetrachloride, formaldehyde, methyl chloride and toluene. Results



**Figure 22. Estimated census-tract cancer risk from the 2005 National-Scale Air Toxics Assessment (NATA2005). Darker colors show greater cancer risk associated with toxic air pollutants.**

## Toxic Air Pollutants

of this model-to-monitor comparison can be found at <http://www.epa.gov/ttn/atw/nata2005/compare.html>.

Though not included in the figure below, exposure to diesel exhaust is also widespread. EPA has not adopted specific risk estimates for diesel exhaust but has concluded that diesel exhaust is a likely human carcinogen and ranks with the other substances that the national-scale assessment suggests pose the greatest relative risk to human health. For more information on NATA visit <http://www.epa.gov/ttn/atw/natamain>.

Since 2003, EPA, working with state and local partners, has nationally monitored air toxic pollutants through the National Air Toxics Trends Station (NATTS) program. The principal objective of the NATTS network is to provide long-term monitoring data across representative areas of the country for NATA priority pollutants (e.g., benzene, formaldehyde, 1,3-butadiene, hexavalent chromium, and polycyclic aromatic hydrocarbons [PAHs] such as naphthalene) in order to establish overall trends. During 2010, data were collected every one in six days at 27 NATTS sites as shown in Figure 23 (20 urban and 7 rural) for PM10 metals, VOCs, carbonyls, hexavalent chromium, and PAHs. In addition to the NATTS program, about 300

monitoring sites—operated by state, local, and tribal agencies—are currently collecting data to help track toxic air pollutant levels across the country. For more information on NATTS visit <http://www.epa.gov/ttn/amtic/natts.html>.

Figure 24 shows the trends from 2003 to 2010 in ambient monitoring levels for some of the important air toxic pollutants. When the median percent change per year (marked by an x for each pollutant shown) is below zero, the majority of sites in the U.S. show a decrease in concentrations. Ambient monitoring data show that some of the toxic air pollutants of greatest widespread concern to public health, such as benzene, 1,3-butadiene, formaldehyde and several metals, are declining at most sites. Monitoring data shown in Figure 24 represent compilation of data from monitoring sites nationwide including data from the NATTS sites. Pollutants represented have at least a minimum of 40 valid trends sites with 35 percent of the data being measured at levels above monitor detection limits. Some pollutants which are more widely monitored such as lead and manganese may include data from several hundred sites which meet the 35 percent criteria. Some pollutants such as methyl

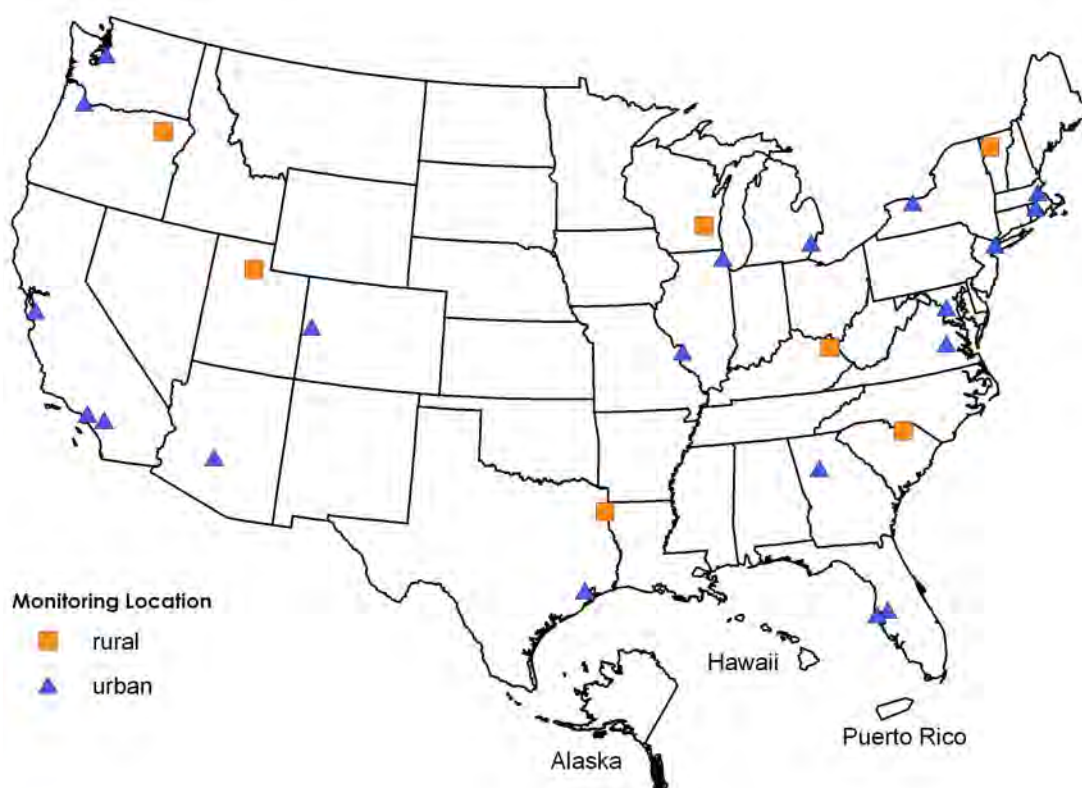


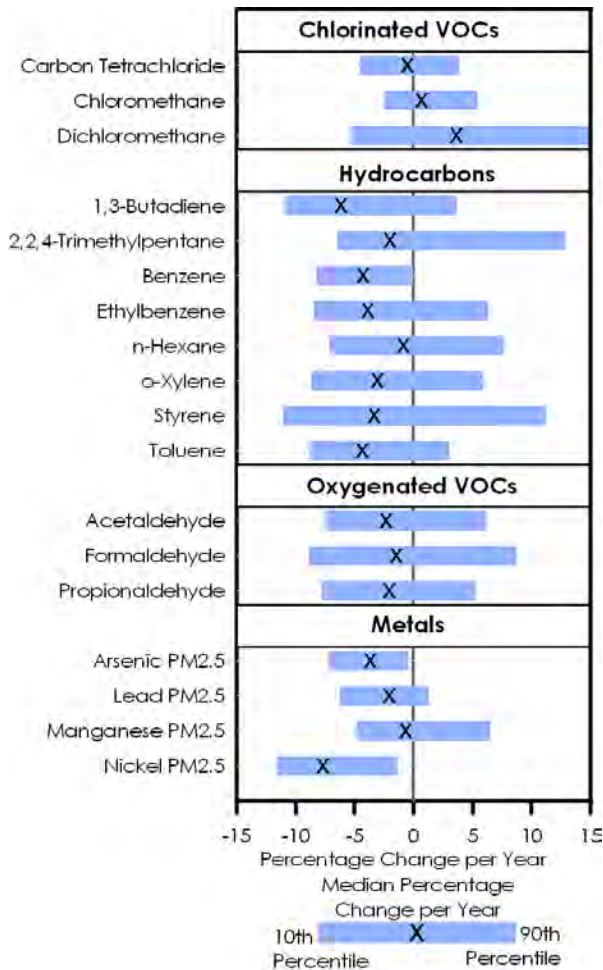
Figure 23. National Air Toxics Trends Sites (NATTS)



tert-butyl ether (MTBE) whose use was discontinued after 2006 are no longer being measured at ambient monitoring sites as the levels are very low. There are two chlorinated VOCs which appear to have increased slightly, dichloromethane (methylene chloride) which is commonly used as a solvent, and chloromethane which was once used as a refrigerant and is also naturally formed in the oceans.

### Assessing Outdoor Air Near Schools

In March 2009, EPA released a list of schools that would be part of an initiative to understand whether outdoor toxic air pollution poses health concerns to schoolchildren. The monitoring took place at 65 schools in 22 states and 2 tribal areas. EPA selected the schools using a number of factors, including results from computer modeling analyses – the 2002 NATA, results presented in a newspaper series on air toxics at schools, and in consultation with state and local air agencies. The pollutants monitored varied by school. EPA identified pollutants to measure at each school based on the best available information about the pollution sources, potential air concentrations, and risk in each area. Initial monitoring was completed for all schools in May 2010. EPA posted monitoring results after data was quality-assured and intends to post final reports for each monitoring location as the information is analyzed. For the majority of schools, monitored concentrations have been lower than EPA's models predicted. However, additional monitoring will be conducted for a few schools for various reasons. As a follow on to the schools program, EPA issued a request in 2011 for proposals for grants for community-scale air toxics ambient monitoring projects. Through these grants, local air toxics concerns will be investigated by state and local agencies. For more information, visit <http://www.epa.gov/schoolair/>.



**Figure 24. Distribution of changes in ambient concentrations at U.S. toxic air pollutant monitoring sites, 2003-2010 (percent change in annual average concentrations).**



# Climate Change & Air Quality

## Climate Change and GHG Emissions Trends

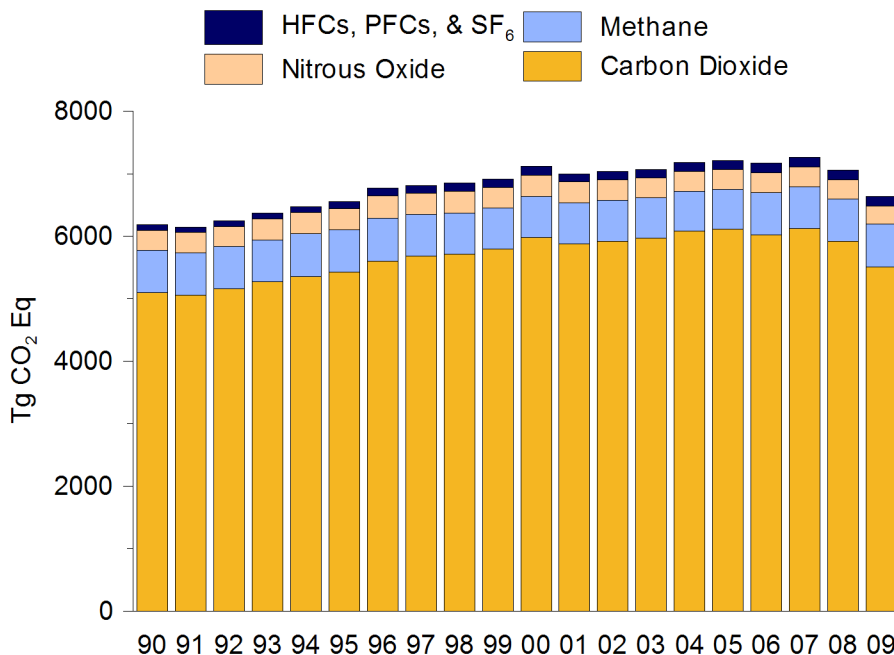
Climate change and air pollution are closely coupled. Just as air pollution can have adverse effects on human health and ecosystems, it can also impact the Earth's climate. When energy from the sun reaches the Earth, the planet absorbs some of this energy and radiates the rest back to space as heat. The Earth's surface temperature depends on this balance between incoming and outgoing energy. Atmospheric greenhouse gases (GHGs) like carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) can trap this energy and prevent the heat from escaping.

In 2009, EPA issued a finding under the Clean Air Act that GHGs constitute air pollution that threatens public health and welfare. The science supporting that finding allowed EPA to conclude that warming of the climate system is unequivocal, and that most of the observed increase in global average temperatures since the mid-20th century is very likely due to the anthropogenic increase in GHG concentrations (EPA, 2009). EPA has further concluded that there is compelling evidence that many fundamental measures of climate in the United States are changing, and

many of these changes are linked to the accumulation of GHGs in the atmosphere. Examples of these climate-driven effects include warmer air and ocean temperatures, more high-intensity rainfall events, and more frequent heat waves.

In collaboration with other government agencies, EPA tracks both GHG emissions (EPA, 2011) and indicators of climate change (EPA, 2010). Figure 25 shows trends in domestic GHG emissions over the past two decades. Total U.S. GHG emissions have increased 7.3 percent from 1990 to 2009. The majority of domestic GHG emissions result from electricity generation and transportation.

In January 2012, EPA released for the first time comprehensive greenhouse gas (GHG) emissions data reported directly from large facilities and suppliers across the country through the GHG Reporting Program. The 2010 GHG data includes public information from facilities in nine industry groups that directly emit large quantities of GHGs (e.g., power plants, petroleum refineries, landfills, etc.) as well as suppliers of certain fossil fuels. EPA's online data publication tool allows users to view and sort GHG



**Figure 25. Domestic greenhouse gas emissions in teragrams of carbon dioxide equivalents (Tg CO<sub>2</sub> eq), 1990-2009. (EPA, 2011)**

Notes: A teragram is equal to 1 million metric tons. Emissions in the figure include fluorocarbons (HFCs, PFCs) and sulfur hexafluoride (SF<sub>6</sub>). CO<sub>2</sub> eq refers to the global warming potential (GWP) of each greenhouse gas (e.g., nitrous oxide) as compared to the GWP of CO<sub>2</sub> (EPA, 2011)

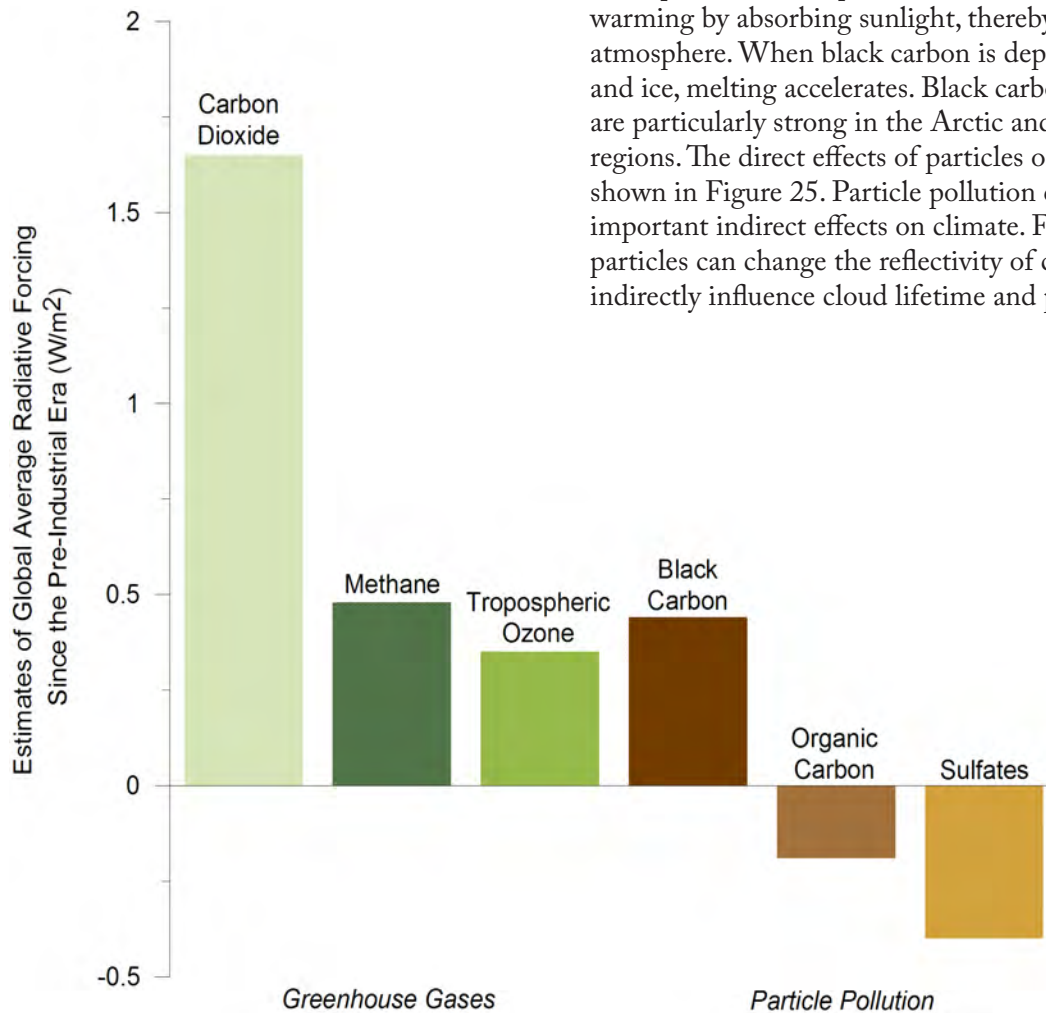
data from more than 6,700 facilities in a variety of ways; including by facility, location, industrial sector, and type of GHG emitted. This information can be used by communities to identify nearby sources of greenhouse gas emissions, help businesses track emissions and find cost- and fuel-saving opportunities, and provide information to the finance and investment communities. For more information, visit <http://epa.gov/climatechange/emissions/ghgdata>.

## Climate Impacts of Air Pollution

Conventional air pollutants such as ozone and particle pollution can also contribute to climate change. Because ozone and particle pollution stay in the atmosphere for only a few days or weeks, reducing these emissions can help reduce climate impacts in the near-term.

Ozone is a significant contributor to climate warming, as shown in Figure 25. The climate impacts of ozone are greatest when the ozone is located in the upper part of the troposphere. Concentrations of ozone in this part of the Earth's atmosphere, sometimes referred to as "global background ozone," are determined by worldwide emissions of CH<sub>4</sub>, CO, NO<sub>x</sub>, and VOCs; as well as by natural processes like lightning and transport from the stratosphere. While ground-level ozone concentrations over the U.S. are generally declining, there is evidence that global background ozone levels continue to rise (Cooper, 2010).

Particle pollution can also have significant impacts on climate, both directly and indirectly. The direct effects come from particles' ability to absorb and scatter light. Different types of particles have different impacts on climate: some warm (e.g., black carbon); others cool (e.g., sulfates and nitrates). Black carbon, a component of soot particles, contributes to global warming by absorbing sunlight, thereby heating the atmosphere. When black carbon is deposited on snow and ice, melting accelerates. Black carbon's effects are particularly strong in the Arctic and other alpine regions. The direct effects of particles on climate are shown in Figure 25. Particle pollution can also have important indirect effects on climate. For example, particles can change the reflectivity of clouds and also indirectly influence cloud lifetime and precipitation.



**Figure 26. Estimates of global average radiative forcing (W/m<sup>2</sup>) resulting from changes in key climate-related air pollutants between the pre-industrial era and 2005. Data source: Forster, et. al., 2007. For additional information on the level of scientific understanding for key climate-related air pollutants see Forster, et.al., 2007.**

The net effect for all particles in the atmosphere is cooling, as scattering generally dominates, though effects can vary dramatically by region (Forster et. al., 2007). While the health benefits of reducing all types of emissions contributing to particle pollution are relatively clear, the net climate impact of emissions reduction strategies will depend on the relative reductions in particles of different types.

## Air Quality Impacts of Climate Change

The close connection between climate and air quality is also reflected in the impacts of climate change on air pollution levels. As previously discussed, ozone and particle pollution are strongly influenced by shifts in the weather (e.g., heat waves or droughts). Based on projected future climate scenarios, and in the absence of additional emissions reductions, the Intergovernmental Panel on Climate Change (IPCC) projected “declining air quality in cities” into the future as a result of climate change. Further, EPA concluded in 2009 that GHG emissions “may reasonably be anticipated both to endanger public health and to endanger public welfare.”

This endangerment finding was based, in part, on the potential for climate change to worsen air quality over the U.S. and the accompanying public health impacts that would result.

EPA has concluded (EPA, 2009) that climate change could have the following impacts on national air quality levels:

- Produce 2-8 ppb increases in summertime average ground-level ozone concentrations in many regions of the country.
- Further exacerbate ozone concentrations on days when weather is already conducive to high ozone concentrations
- Lengthen the ozone season
- Produce both increases and decreases in particle pollution over different regions of the U.S.

Because climate represents meteorological conditions over a long period of time, it is difficult to identify a climate fingerprint in the current trends in air quality discussed earlier in this report. Given the general improvement in air quality over the past decade, it appears that emissions reductions from air quality regulations are outpacing any climate-driven impacts.





# Appendix

## Terminology

|                 |   |                   |  |
|-----------------|---|-------------------|--|
| AQI             | Air Quality Index                         | NEI               | National Emissions Inventory                     |
| AQS             | Air Quality System                        | NH <sub>3</sub>   | ammonia  |
| BC              | black carbon                              | NO <sub>x</sub>   | oxides of nitrogen                               |
| CASTNET         | Clean Air Status and Trends Network       | NO <sub>2</sub>   | nitrogen dioxide                                 |
| CFCs            | chlorofluorocarbons                       | O <sub>3</sub>    | ground-level ozone                               |
| CH <sub>4</sub> | methane                                   | PAHs              | polycyclic aromatic hydrocarbons                 |
| CO              | carbon monoxide                           | PFCs              | perfluorinated compounds                         |
| CO <sub>2</sub> | carbon dioxide                            | PM                | particulate matter (particle pollution)          |
| EPA             | U.S. Environmental Protection Agency      | PM <sub>2.5</sub> | particulate matter (fine) 2.5 μm or less in size |
| GHG             | greenhouse gas                            | PM <sub>10</sub>  | particulate matter 10 μm or less in size         |
| HFCs            | hydrofluorocarbons                        | ppb               | parts per billion                                |
| IPCC            | Intergovernmental Panel on Climate Change | ppm               | parts per million                                |
| NAAQS           | National Ambient Air Quality Standards    | SF <sub>6</sub>   | sulfur hexafluoride                              |
| NAS             | National Academy of Sciences              | SIP               | state implementation plan                        |
| NATA            | National-Scale Air Toxic Assessment       | SO <sub>2</sub>   | sulfur dioxide                                   |
| NATTS           | National Air Toxics Trends Stations       | μm                | micrometers (microns)                            |
|                 |   | μg/m <sup>3</sup> | micrograms per cubic meter                       |
|                 |   | VOCs              | volatile organic compounds                       |

## Websites

### Background/General Information

Air Quality Index: <http://www.airnow.gov>

Air Quality System: <http://www.epa.gov/ttn/airs/airsaqs/>

Air Quality System Detailed Data: <http://www.epa.gov/ttn/airs/airsaqs/detaildata>

Health and Ecological Effects: <http://www.epa.gov/air/urbanair/>

National Ambient Air Quality Standards: <http://www.epa.gov/air/criteria.html>

National Center for Environmental Assessment: <http://cfpub.epa.gov/ncea/>

Office of Air and Radiation: <http://www.epa.gov/air/>

Office of Air Quality Planning and Standards: <http://www.epa.gov/air/oaqps/>

Office of Atmospheric Programs: <http://www.epa.gov/air/oap.html>

Office of Transportation and Air Quality: <http://www.epa.gov/otaq/>

### Climate Change

Climate change: <http://www.epa.gov/climatechange/>

U.S. Climate Change Science Program: <http://www.climatescience.gov>

Emissions and trends in greenhouse gases:

<http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

Intergovernmental Panel on Climate Change: <http://www.ipcc.ch>

### Emissions and Control Programs

Emissions: <http://www.epa.gov/air/emissions/>

NO<sub>x</sub> Budget Trading Program/NO<sub>x</sub> SIP Call: <http://www.epa.gov/airmarkets/progsregs/nox/sip.html>

### Toxic Air Pollutants

2002 National-Scale Air Toxics Assessment: <http://www.epa.gov/ttn/atw/nata2002/>

### Measurements and Trends

Air Quality Trends: <http://www.epa.gov/airtrends/>

Air Trends Design Values: <http://www.epa.gov/air/airtrends/values.html>

Clean Air Status and Trends Network: <http://www.epa.gov/castnet/>

EPA Monitoring Network: <http://www.epa.gov/ttn/amtic/>

Local air quality trends: <http://www.epa.gov/airtrends/where.html>

National Core Monitoring Network: <http://www.epa.gov/ttn/amtic/ncore/index.html>

Trends in ozone adjusted for weather conditions: <http://www.epa.gov/airtrends/weather.html>

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United States  
Environmental  
Protection Agency

Office of Air Quality Planning and Standards · EPA Publication No. EPA-454/R-11-001  
Air Quality Assessment Division  
Research Triangle Park, NC