# Chapter 7: Ambient Air Quality

## Sulfur Dioxide and Nitrogen Oxides Trends

The Acid Rain Program (ARP), $NO_x$ Budget Trading Program (NBP), and the Clean Air Interstate Rule (CAIR) were designed to reduce sulfur dioxide ($SO_2$) and nitrogen oxides ($NO_x$) emissions from power plants. These pollutants contribute to the formation of ground level ozone (smog) and particulate matter (soot), which cause a range of serious health effects. The dramatic emission reductions achieved under these programs have improved air quality and delivered significant human health and ecological benefits across the United States.

To evaluate the impact of emission reductions on air quality, scientists and policymakers use data collected from long-term national air quality monitoring networks. These networks provide information on a variety of indicators useful for tracking and understanding trends in regional air quality over time and in different areas.

## Analysis and Background Information

### Sulfur Dioxide

$SO_2$ is one of a group of highly reactive gases known as "oxides of sulfur." The primary source of $SO_2$ emissions is fossil fuel combustion at power plants. Smaller sources of $SO_2$ emissions include industrial processes such as extracting metal from ore, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment. $SO_2$ contributes to the formation of fine particle pollution ($PM_{2.5}$) and is linked with a number of adverse health effects on the respiratory system.[1] In addition, sulfates degrade visibility and, because they are typically acidic, can harm ecosystems when deposited.

### Nitrogen Oxides

$NO_x$ is a group of highly reactive gases including nitric oxide (NO) and nitrogen dioxide ($NO_2$). In addition to contributing to the formation of ground-level ozone and $PM_{2.5}$, $NO_x$ is linked with a number of adverse health effects on the respiratory system.[2, 3] $NO_x$ also reacts in the atmosphere to form nitric acid ($HNO_3$) and particulate ammonium nitrate ($NH_4NO_3$). Nitric acid and $NH_4NO_3$, reported as total nitrate, can also lead to adverse health effects and, when deposited, cause damage to sensitive ecosystems.

Although the ARP, $NO_x$ State Implementation Plan (SIP) Call, and CAIR $NO_x$ programs have contributed to significant $NO_x$ reductions, primarily from electricity generating units, and improvements in air quality, emissions from other sources (such as motor vehicles and agriculture) contribute to ambient nitrate concentrations in many areas. Ambient nitrate levels can also be affected by emissions transported via air currents over wide regions.

# Key Points

## National $SO_2$ Air Quality

- Based on EPA's air trends data, the national average of $SO_2$ annual mean ambient concentrations decreased from 12.1 ppb to 1.5 ppb (87 percent) between 1980 and 2013.
- The two largest single-year reductions (over 20 percent) occurred in the first year of the ARP, between 1994 and 1995, and recently between 2008 and 2009, just prior to the start of the CAIR $SO_2$ program.

## Regional Changes in Air Quality

- Average ambient $SO_2$ concentrations declined in all regions following implementation of the ARP and other emission reduction programs. The most dramatic decline was along the Ohio River Valley and in western Pennsylvania where regional average concentrations declined 86 percent from 1989-1991 to 2011-2013 observation periods.
- Ambient particulate sulfate concentrations have decreased since the ARP was implemented, with average concentrations decreasing by 60 to 65 percent in observed regions from 1989-1991 to 2011-2013.
- Average annual ambient total nitrate concentrations declined 47 percent from 1989 -1991 to 2011-2013, with the biggest reductions in the Mid-Atlantic and Northeast.

# More Information

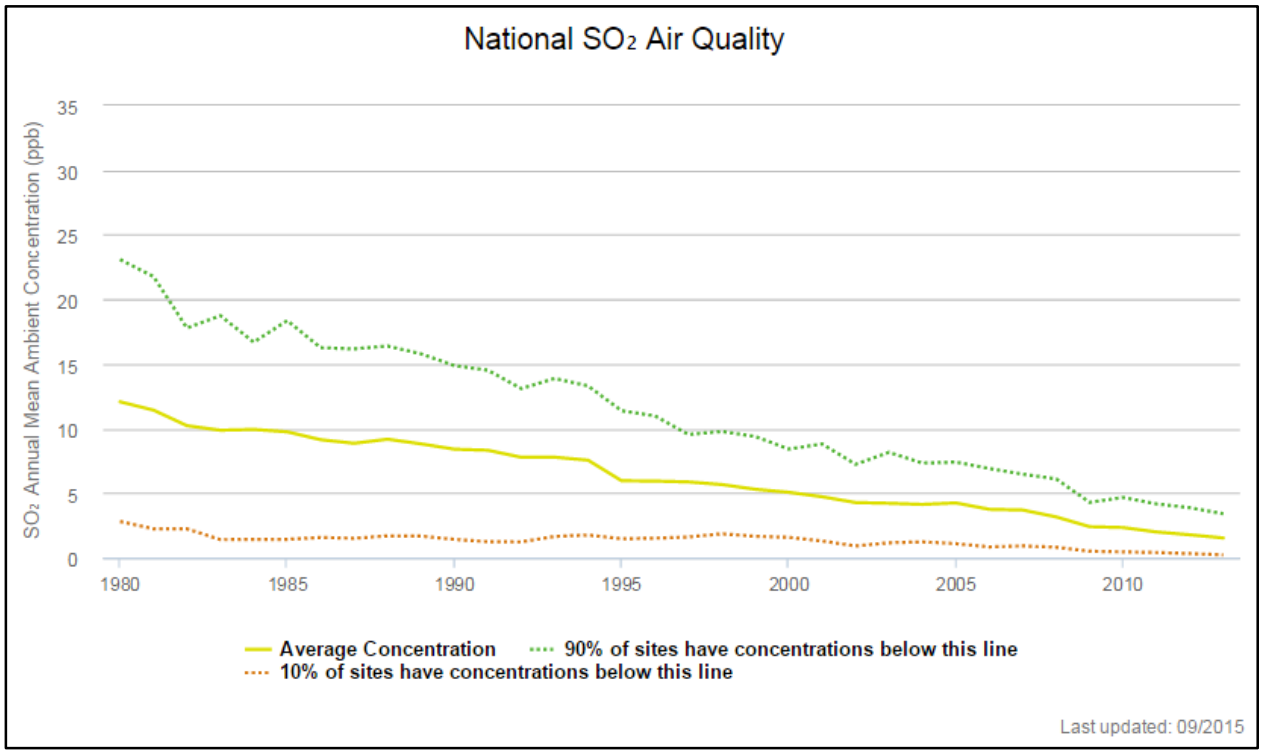
Clean Air Status and Trends Network (CASTNET) http://epa.gov/castnet/javaweb/index.html
Air Quality System (AQS) http://www.epa.gov/aqs
Learn more about National Ambient Air Quality Standards http://www3.epa.gov/ttn/naaqs/criteria.html
Learn more about $SO_2$ http://www.epa.gov/oaqps001/sulfurdioxide/
Learn more about $NO_x$ http://www.epa.gov/airquality/nitrogenoxides/
Learn more about EPA's Clean Air Market Programs http://www.epa.gov/airmarkets/programs

# References

1. U.S. Environmental Protection Agency (U.S. EPA). 2009. Acid Rain and Related Programs: 2008 Emission, Compliance, and Market Analyses Progress Report. September.
2 U.S. Environmental Protection Agency (U.S. EPA). 2009. The $NO_x$ Budget Trading Program: 2008 Environmental Results Progress Report. September.
3. U.S. Environmental Protection Agency (U.S. EPA). 2011. EPA's $NO_x$ Reduction Program and Clean Air Interstate Rule 2009 Environmental and Health Results Progress Report. January.

# Figures

## Subtopic: Sulfur Dioxide and Nitrogen Oxides Trends




Notes:

- Data based on state, local, and EPA monitoring sites which are located primarily in urban areas.

**Figure 1. National $SO_2$ Air Quality**

## Regional Changes in Air Quality

| Measurement | Region | Annual Average, 1989-1991 | Annual Average, 2011-2013 | Percent Change | Number of Sites | Statistical Significance |
|---|---|---|---|---|---|---|
| Ambient particulate sulfate concentration (µg/m³) | Mid-Atlantic | 6.3 | 2.4 | -62 | 12 | *** |
| | Midwest | 5.8 | 2.3 | -60 | 9 | *** |
| | Northeast | 3.4 | 1.2 | -65 | 4 | |
| | Southeast | 5.5 | 2.1 | -62 | 8 | *** |
| Ambient sulfur dioxide concentration (µg/m³) | Mid-Atlantic | 13.0 | 2.0 | -85 | 12 | *** |
| | Midwest | 11.0 | 2.3 | -79 | 9 | *** |
| | Northeast | 5.2 | 0.7 | -87 | 4 | |
| | Southeast | 5.1 | 0.9 | -82 | 8 | *** |
| Ambient total nitrate concentration (µg/m³) | Mid-Atlantic | 3.3 | 1.7 | -48 | 12 | *** |
| | Midwest | 4.6 | 2.7 | -41 | 9 | *** |
| | Northeast | 1.7 | 0.8 | -53 | 4 | |
| | Southeast | 2.2 | 1.2 | -45 | 8 | *** |

Source EPA, 2014

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Notes:

- Averages are the arithmetic mean of all sites in a region that were present and met the completeness criteria in both averaging periods. Thus, average concentrations for 1989 to 1991 may differ from past reports.
- Statistical significance was determined at the 95 percent confidence level ($p < 0.05$). Changes that are not statistically significant may be unduly influenced by measurements at only a few locations or large variability in measurements.

**Figure 2. Regional Changes in Air Quality**