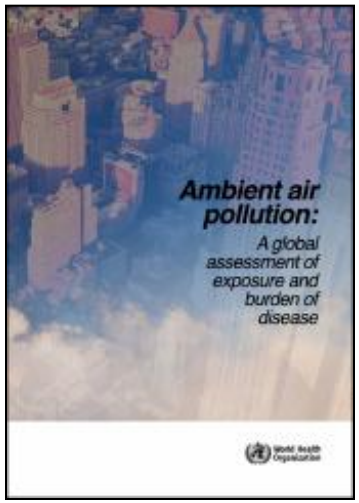
# Regulations and Public Policies

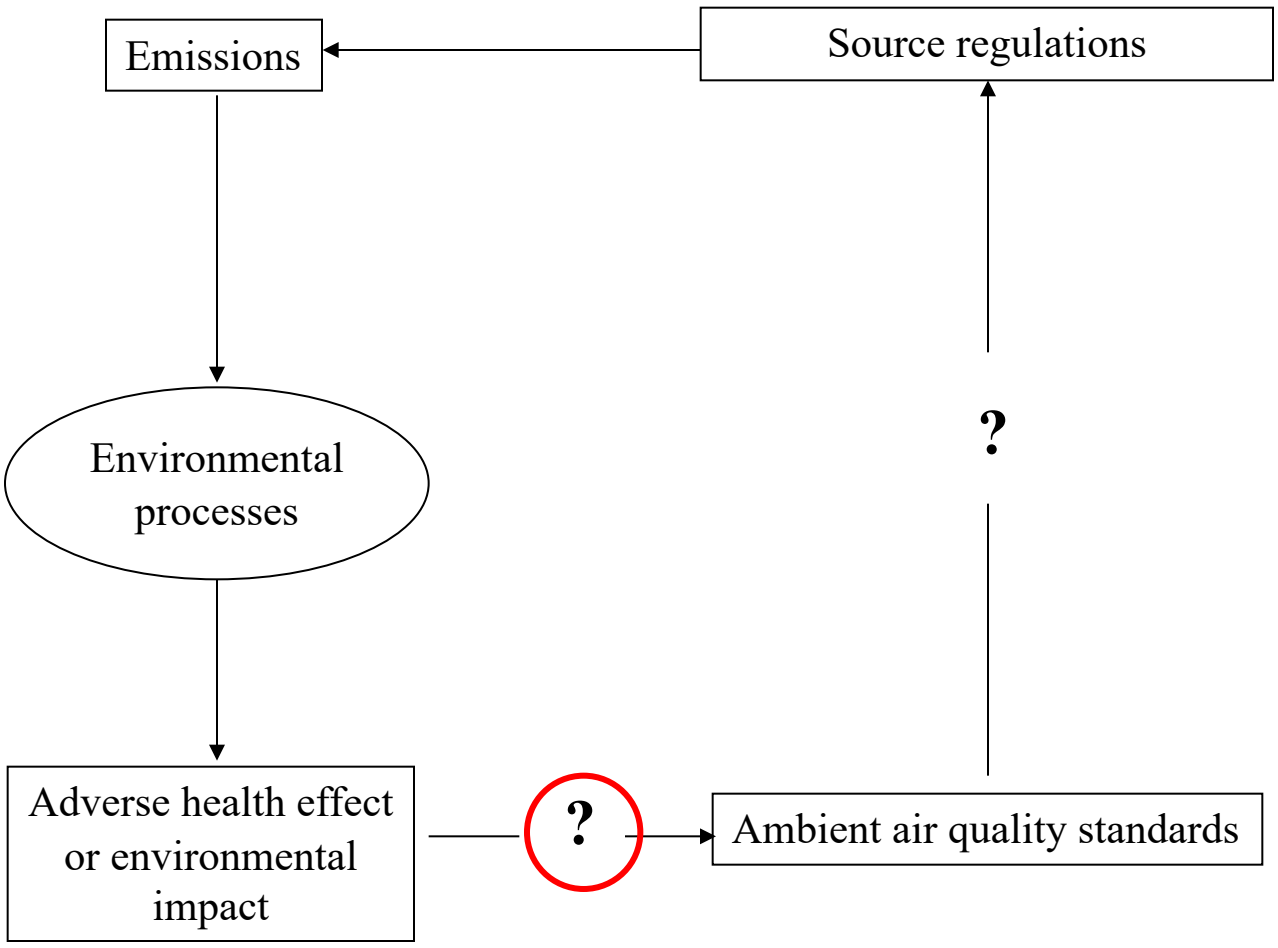
- Air quality regulations
- Public policies
  - United States
  - France
- Regulations for atmospheric deposition and global pollution

# Health Effects of Air Pollution

Outdoor ambient air pollution kills about
**3 million people annually worldwide**
(Source : “Ambient air pollution”,
World Health Organization, 2016)



# Regulatory Framework



# Regulatory Concentrations

- For some air pollutants, it is possible to identify a concentration below which there are no adverse health effects (CO, $O_3$, $NO_2$, $SO_2$).
- For carcinogenic air pollutants (for example, benzene), there is no threshold and some acceptable risk must be selected.
- For atmospheric particulate patter, results from epidemiological studies have not identified a threshold concentration below which no adverse health effects would occur (some sensitive people may be affected at low concentrations).
- Nevertheless, air quality regulations are based on a threshold below which the health risk is considered acceptable.

# Regulatory Concentrations

- Regulatory concentrations are based on the the results of toxicological and epidemiological studies.
  - Coherence between toxicological and epidemiological studies: the statistical association between some adverse health effect and exposure to an air pollutant is coherent with a cause-to-effect relationship.
  - Consistency among epidemiological studies: several epidemiological studies lead to similar relative risks (or odds ratios).

# Adverse Health Effects of Selected Air Pollutants

| Pollutant | Health Effects |
|---|---|
| Lead | Mental retardation and other health effects |
| Carbon monoxide | Intoxication (carboxyhemoglobin => hypoxia) |
| Sulfur dioxide | Respiratory effects |
| Nitrogen dioxide | Respiratory effects |
| Ozone | Respiratory effects |
| Fine particles | Cardiovascular and respiratory effects |
| Benzene | Carcinogenic (leukemia) |

# Health Effects => Regulations

Toxicological and epidemiological studies => regulations represented by a concentration value not to be exceeded (or exceeded a limited number of times)

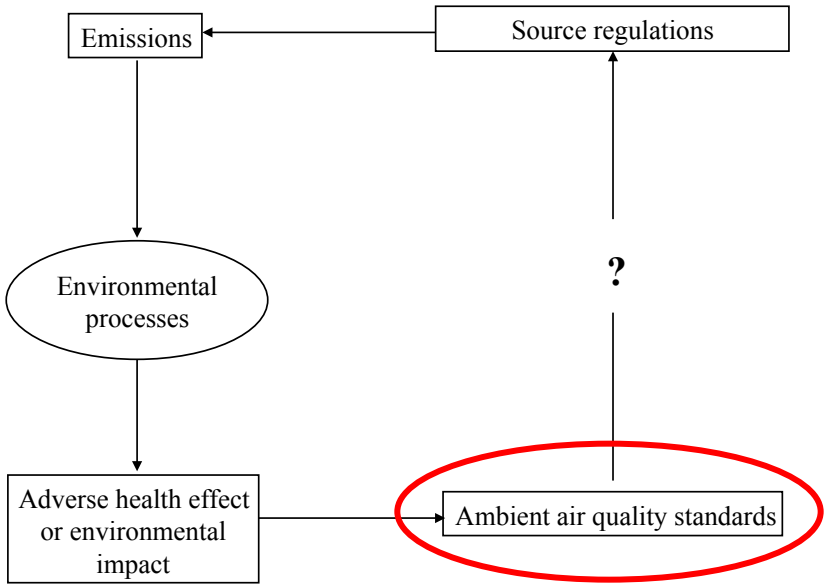
For example:

- Concentration values below which there is no adverse health effect, if possible with a margin of safety: CO, $NO_2$, $SO_2$, and $O_3$

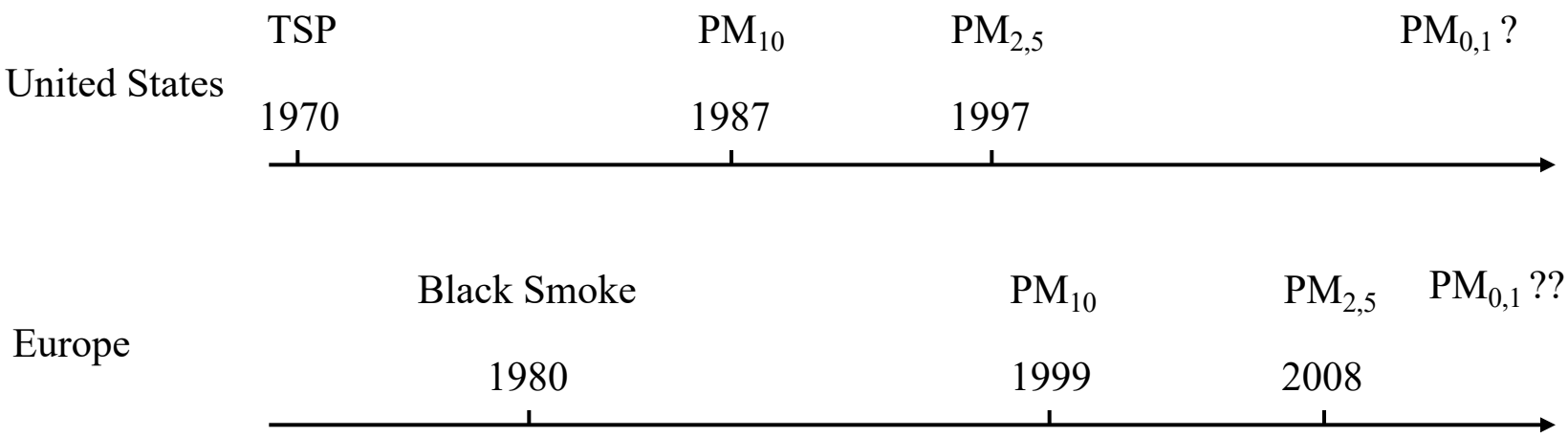
- For air pollutants that do not present such a threshold (for example, carcinogenic air pollutants): one uses some criterion that is considered to be protective of public health: for example, an excess cancer risk due to benzene of $10^{-5}$.

# Air Pollutant Regulations

- A regulation consists of six elements:
  - Indicator species
  - Exposure duration
  - Location of monitoring stations
  - Concentration value
  - Statistical form of the regulation
  - Measurement method



# Indicator Species
# Example of Particulate Matter




The indicator species for atmospheric particulate matter has evolved over time

# Exposure Duration

- Epidemiological studies are used to determine whether the air pollutant leads to adverse health effects via acute or chronic exposure (or both).

- Examples of some exposure durations:
  - Pb: 3 months and 1 year
  - CO: 1 hour and 8 hours
  - $NO_2$: 1 hour and 1 year
  - $SO_2$: 1 hour, 3 hours, and 1 year
  - $O_3$: 8 hours
  - $PM_{2.5}$ and $PM_{10}$: 24 hours and 1 year

# Monitoring Stations

- Location of the monitoring stations
  - Near air pollution sources
  - Urban background
  - Suburban or rural background

Example: In the U.S., monitoring of $NO_2$ (2009) and $PM_{2.5}$ (2013) was changed from urban background locations to near-source locations (mostly near on-road traffic).

# Regulatory Concentrations

| Pollutant, exposure duration | Toxicology | Epidemiology | Ambient concentrations |
|---|---|---|---|
| Pb, 3 months | | ✓ | ✓ |
| CO, 1 hour | ✓ | | |
| CO, 8 hours | ✓ | | |
| $SO_2$, 1 hour | ✓ | | ✓ |
| $NO_2$, 1 hour | ✓ | ✓ | ✓ |
| $NO_2$, 1 year | | ✓ | |
| $O_3$, 8 hours | ✓ | ✓ | |
| $PM_{10}$, 1 day | | ✓ | |
| $PM_{2,5}$, 1 day | | ✓ | |
| $PM_{2,5}$, 1 year | | ✓ | |

# Statistical Form

- The statistical form of the air quality standard provides some robustness so that extreme events do not affect the air pollutant concentration that is to be regulated. Thus, the highest concentrations, which result from extreme meteorological events and are random from one year to the next, are eliminated.
  - For short-term concentrations (e.g., 1-, 8-, and 24-hour averaged), a limited number of exceedances is allowed (which may be presented as a percentile of the concentration distribution).
  - For long-term concentrations (e.g., annual averaged), the long averaging time dampens the effect of short-term extreme meteorological events.
- In addition, one may account for interannual meteorological variability by averaging concentrations over several years (typically three). This approach may be used for both short-term and long-term concentration averages.

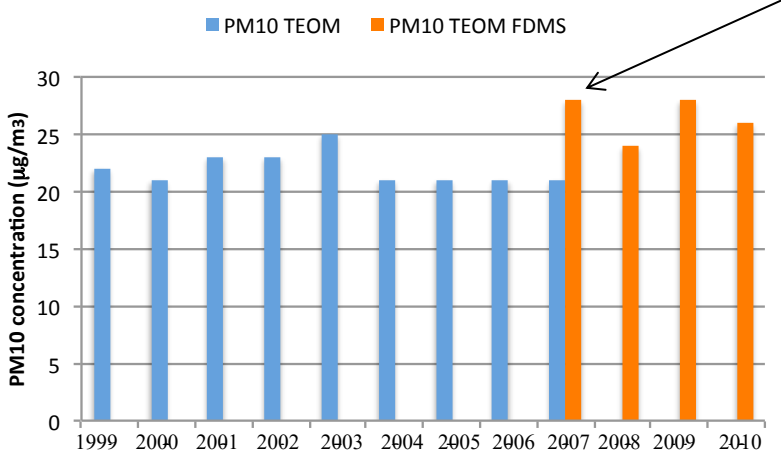
# Statistical Form

- Examples of statistical forms of an air quality standard: Ozone
  - $O_3$ in France : 120 μg/$m^3$ for the 93$^{rd}$ percentile (25 days of exceedance are allowed)
  - $O_3$ in the U.S: 147 μg/$m^3$ for the 99$^{th}$ percentile (3 days of exeedance are allowed)

# Monitoring Method

- Monitoring methods
  - Reference method
  - Equivalent methods

In 2007, there was an improvement in the Paris region monitoring method to make it equivalent to the reference method, thereby leading to about a 30 % increase in $PM_{10}$ measured concentrations.




Example of $PM_{10}$ monitoring with TEOM* without and with FDMS#

* Tapered element oscillating microbalance
\# Filter dynamics measurement system

Source: Airparif (www.airparif.asso.fr)

# Air Quality Standards in the United States

| Pollutant | Concentration | Sampling duration | Statistical form (number of authorized exceedances per year) |
|---|---|---|---|
| Pb | 0.15 μg $m^{-3}$ | 3 mo | (0) |
| CO | 40 mg $m^{-3}$, 35 ppm | 1 h | 99.99$^{th}$ percentile (1) |
| | 10 mg $m^{-3}$, 9 ppm | 8 h | 99.99$^{th}$ percentile (1) |
| $SO_2$ | 197 μg $m^{-3}$, 75 ppb | 1 h | 99$^{th}$ percentile (2) |
| $NO_2$ | 189 μg $m^{-3}$, 100 ppb | 1 h | 98$^{th}$ percentile (7) |
| | 100 μg $m^{-3}$, 53 ppb | 1 year | (0) |
| $O_3$ | 137 μg $m^{-3}$, 70 ppb | 8 h | 99$^{th}$ percentile (3) |
| $PM_{10}$ | 150 μg $m^{-3}$ | 24 h | 99.7$^{th}$ percentile (1) |
| $PM_{2.5}$ | 35 μg $m^{-3}$ | 24 h | 98$^{th}$ percentile (7) |
| | 12 μg $m^{-3}$ | 1 year | (0) |

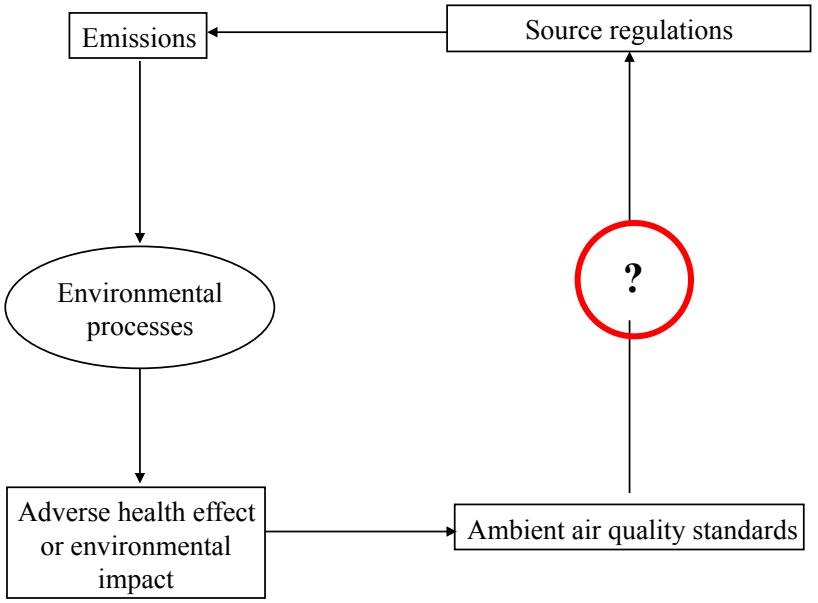
# Air Quality Standards in France

| Pollutant | Concentration | Sampling duration | Statistical form (number of authorized exceedances) |
|---|---|---|---|
| Pb | 0.5 μg $m^{-3}$ | 1 year | (0) |
| CO | 10 mg $m^{-3}$, 9 ppm | 8 h | (0) |
| $SO_2$ | 350 μg $m^{-3}$, 133 ppb | 1 h | $99.7^{th}$ percentile (24) |
| | 125 μg $m^{-3}$, 47 ppb | 24 h | $99.2^{th}$ percentile (3) |
| $NO_2$ | 200 μg $m^{-3}$, 106 ppb | 1 h | $99.8^{th}$ percentile (18) |
| | 40 μg $m^{-3}$, 21 ppb | 1 year | (0) |
| $O_3$ | 120 μg $m^{-3}$, 61 ppb | 8 h | $93^{th}$ percentile (25) |
| $PM_{10}$ | 50 μg $m^{-3}$ | 24 h | $90.4^{th}$ percentile (35) |
| | 40 μg $m^{-3}$ | 1 year | (0) |
| $PM_{2.5}$ | 25 μg $m^{-3}$ | 1 year | (0) |
| $C_6H_6$ | 5 μg $m^{-3}$, 1.5 ppb | 1 year | (0) |

# Regulatory Framework

Development of public policies to attain the air quality standards:

- United States
- France

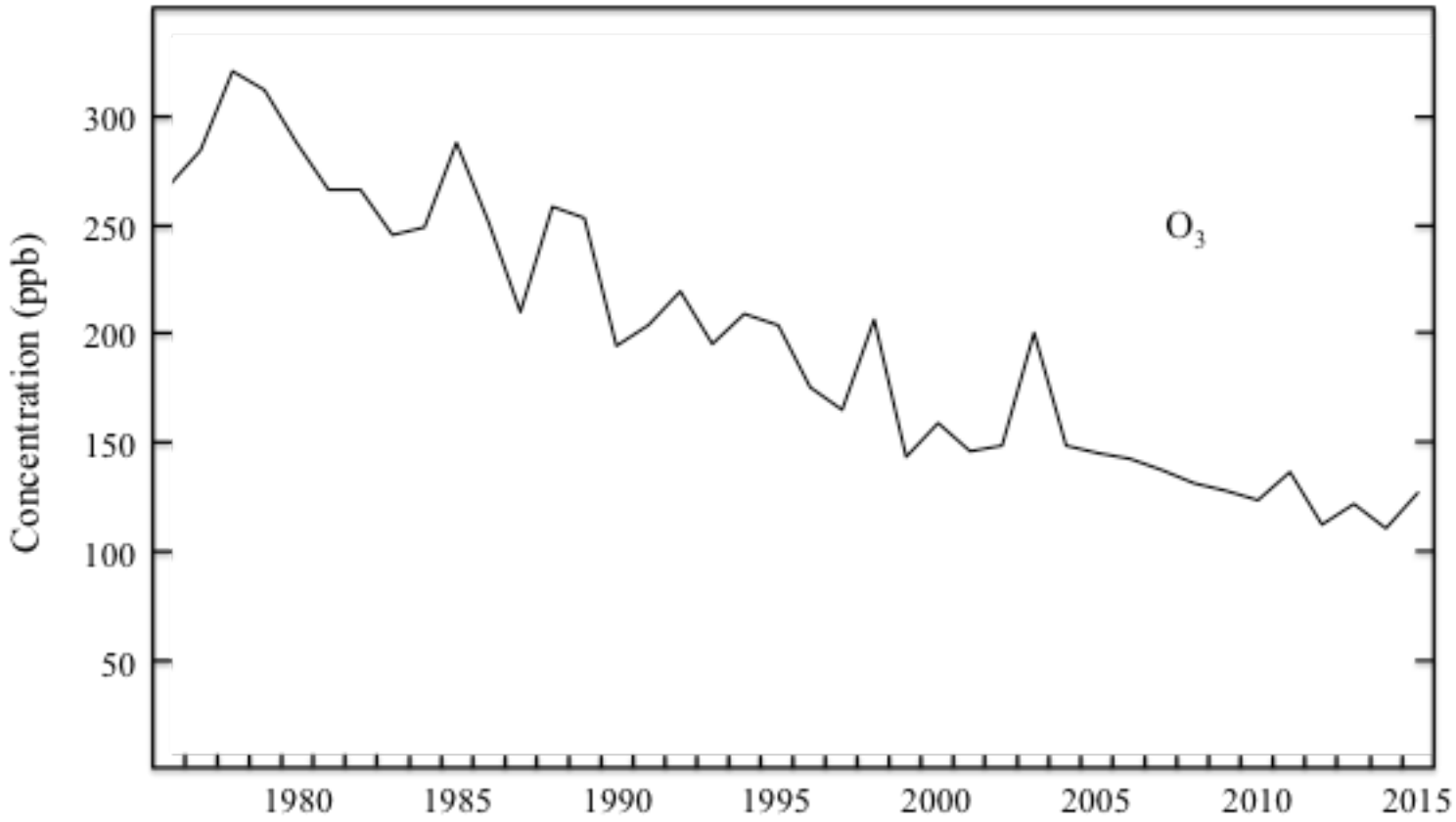


# Regulations in the United States

- At the federal level, the U.S. Environmental Protection Agency (EPA) is responsible for the regulation of ambient concentrations
  - Clean Air Act
  - Development of air pollutant regulations: National ambient air quality standards **(NAAQS)**
- States that are not in attainment of the NAAQS (i.e., non-attainment) must prepare a State Implementation Plan (SIP), which demonstrates which regulatory measures will be implemented to reduce air pollutant emissions in order to reach the NAAQS.
- Regulation of sources
  - Mobile sources are regulated at the federal level (except for California).
  - Stationary sources are regulated at the federal level or by the states (e.g., those that are in non-attainment).

# Air Quality Trends in Los Angeles

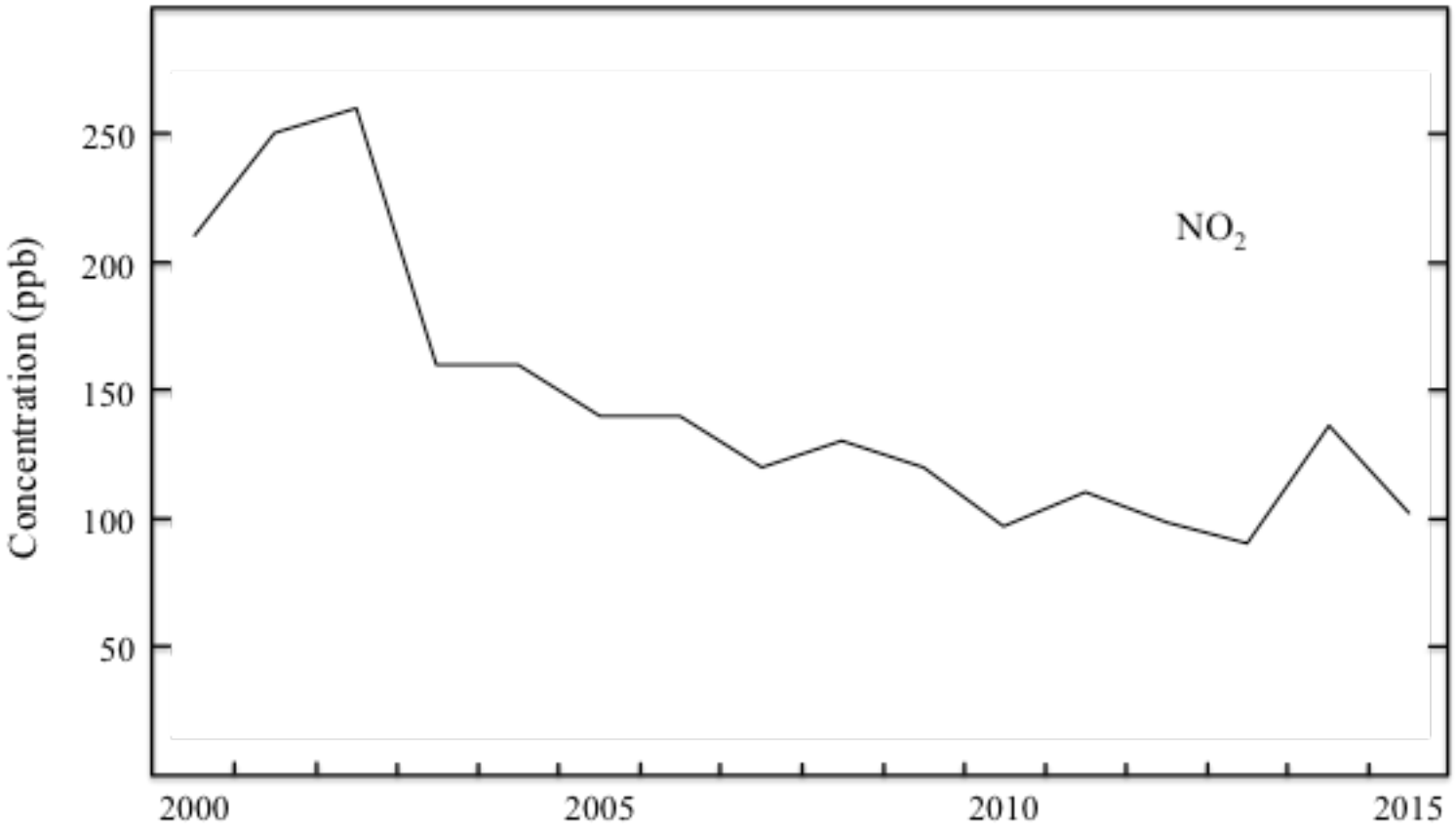
Evolution of $O_3$ concentrations in the Los Angeles Basin, California




Source: SCAQMD, 2017

# Air Quality Trends in Los Angeles

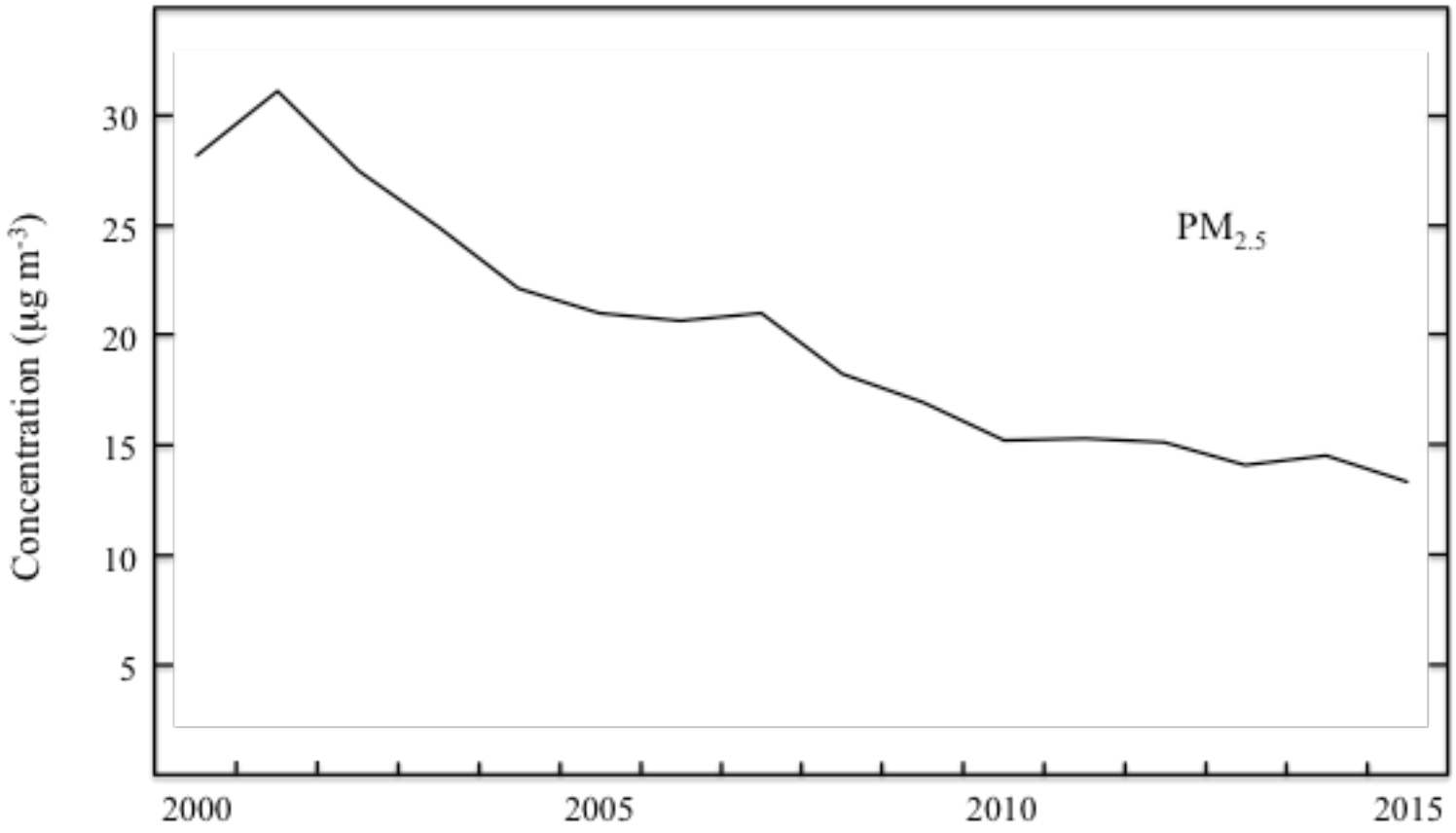
Evolution of $NO_2$ concentrations in the Los Angeles Basin, California




Source: SCAQMD, 2017

# Air Quality Trends in Los Angeles

Evolution of $PM_{2.5}$ concentrations in the Los Angeles Basin, California




Source: SCAQMD, 2017

# Regulations in Europe

- In Europe, it is a two-step process:
  - Development of a directive by the European Commission
  - Development at the national level via laws that reflect the European directive
- Each country must then demonstrate to the European administration that the air pollutant concentration are below the limit values (i.e., the regulatory concentrations). If not, an action plan must be submitted to the European administration (e.g., in the case of France: a plan has been submitted for $NO_2$ and $PM_{10}$).

# Regulations in France

- In France, once a European directive has been transcribed into law by decree ("Code de l'environnement"), the implementation of the regulations is delegated to the administrative regions.
- The various regulatory threshold for air pollutants include the following:
  - Quality objectives (to be attained in the long term)
  - Target values for health protection (to be attained over some given period)
  - Limit values: regulatory values that correspond to the European directives
  - Information thresholds (compulsory public information); they may correspond to the limit values
  - Alert thresholds: they correspond to a greater concentration than the limit value and their exceedance may trigger short-term emission control measures (e.g., traffic limitations)

# Regulations in France

- The main action plans that originated from the French air quality law of 1996 ("Loi sur l'air et l'utilisation rationnelle de l'énergie", i.e., **LAURE**) are:
  - Urban traffic plans ("Plans de déplacement urbains", **PDU**), which are developed by the 59 metropolitan areas of more than 100 000 inhabitants; they typically have little effect on air quality.
  - Regional plans for climate, air quality, and energy ("Schémas régionaux climat air énergie, **SRCAE**), which are developed by the administrative regions; they are submitted for public review. They are updated every five years. A SRCAE is a planning tool rather than a regulatory tool.
  - Atmosphere protection plans ("Plans de protection de l'atmosphère", **PPA**), which are developed for the 24 metropolitan areas of more than 250 000 inhabitants by the head of the administrative region. They are updated every five years. A PPA is a regulatory tool.

- These three plans must be coherent among each other.

# Regulations in France

- Air quality monitoring is conducted by the air quality non-governmental organizations (AASQA*), which transfer the results into a data base (BDQA#). Some European guidelines must be followed.
- Mobile sources (vehicles) are regulated at the European level.
- Emission control of stationary sources is the responsibility of the administrative regions (e.g., the DRIEE$ in the Paris region).
- A fundamental difference between the U.S. and French approaches is that in France the NGO (AASQA) that monitors air quality is seprate from the administration agency that develops the plan to meet air quality attainment (DRIEE or DREAL£).

* AASQA: "Association agréée (loi de 1901) de surveillance de la qualité de l'air"

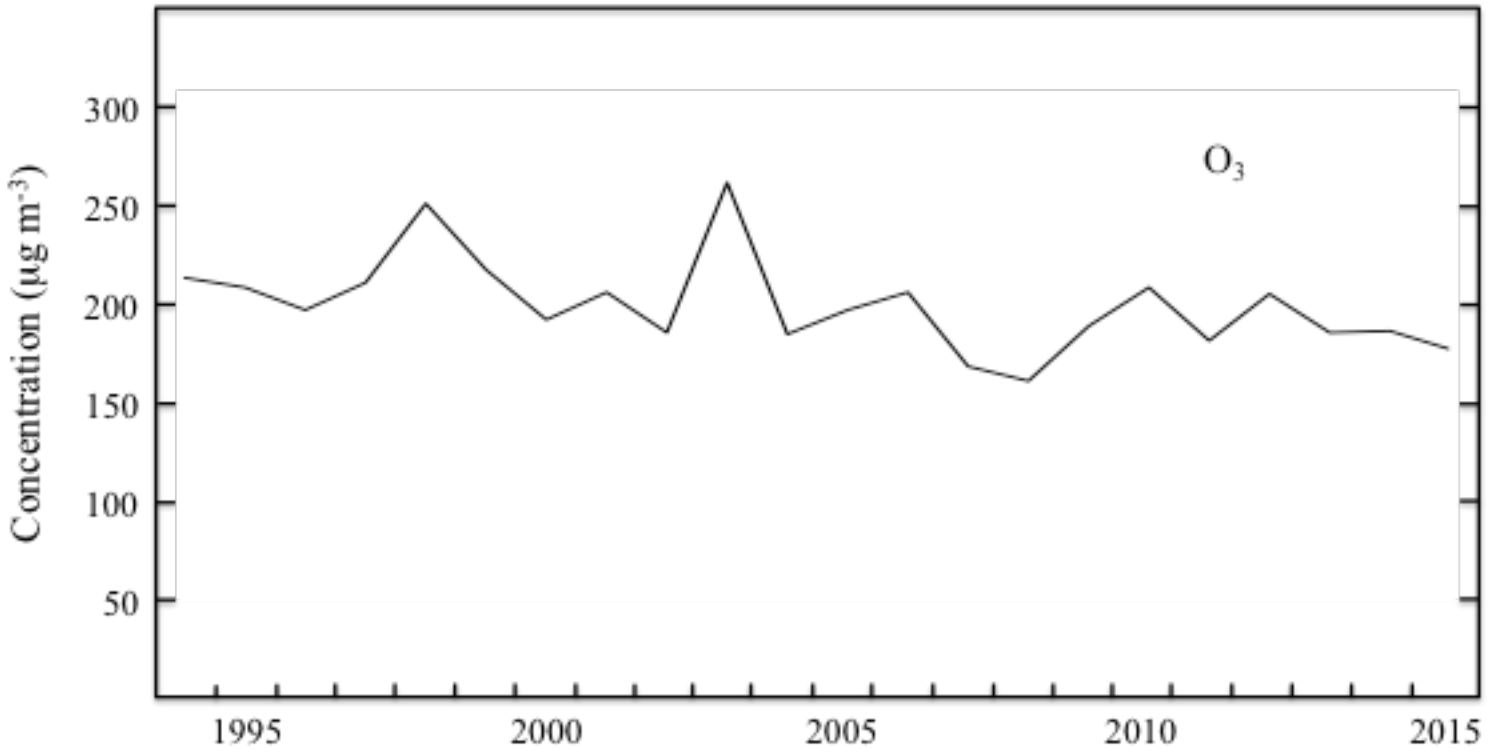
# BDQA: "Base de données sur la qualité de l'air"

$ DRIEE: "Direction régionale et interdépartementale de l'environnement et de l'énergie"

£ DREAL: "Direction régionale de l'environnement, de l'aménagement et du logement"

# Air Quality Trends in Paris

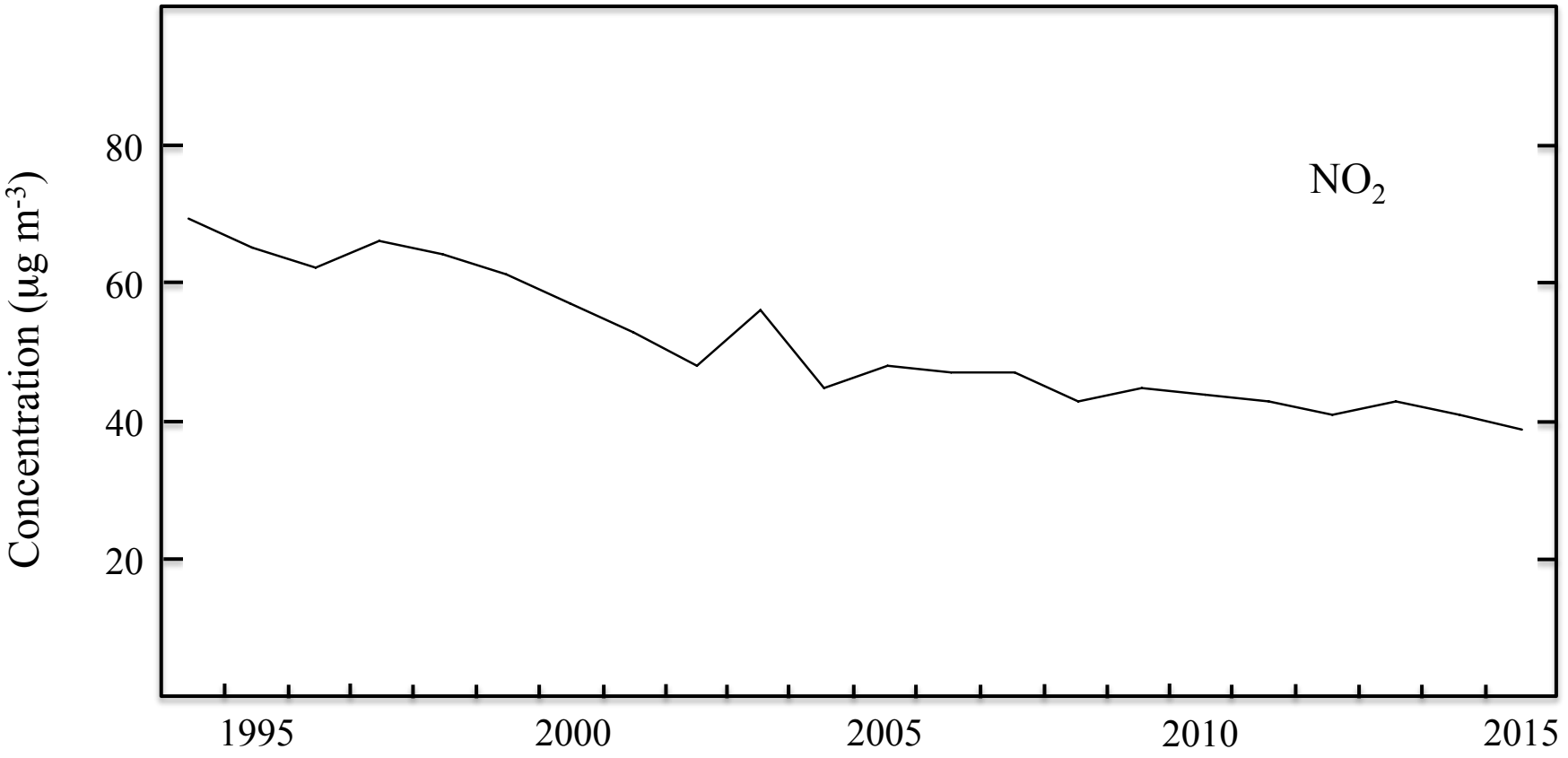
Evolution of $O_3$ concentrations in Paris, France




Source: Airparif, 2016

# Air Quality Trends in Paris

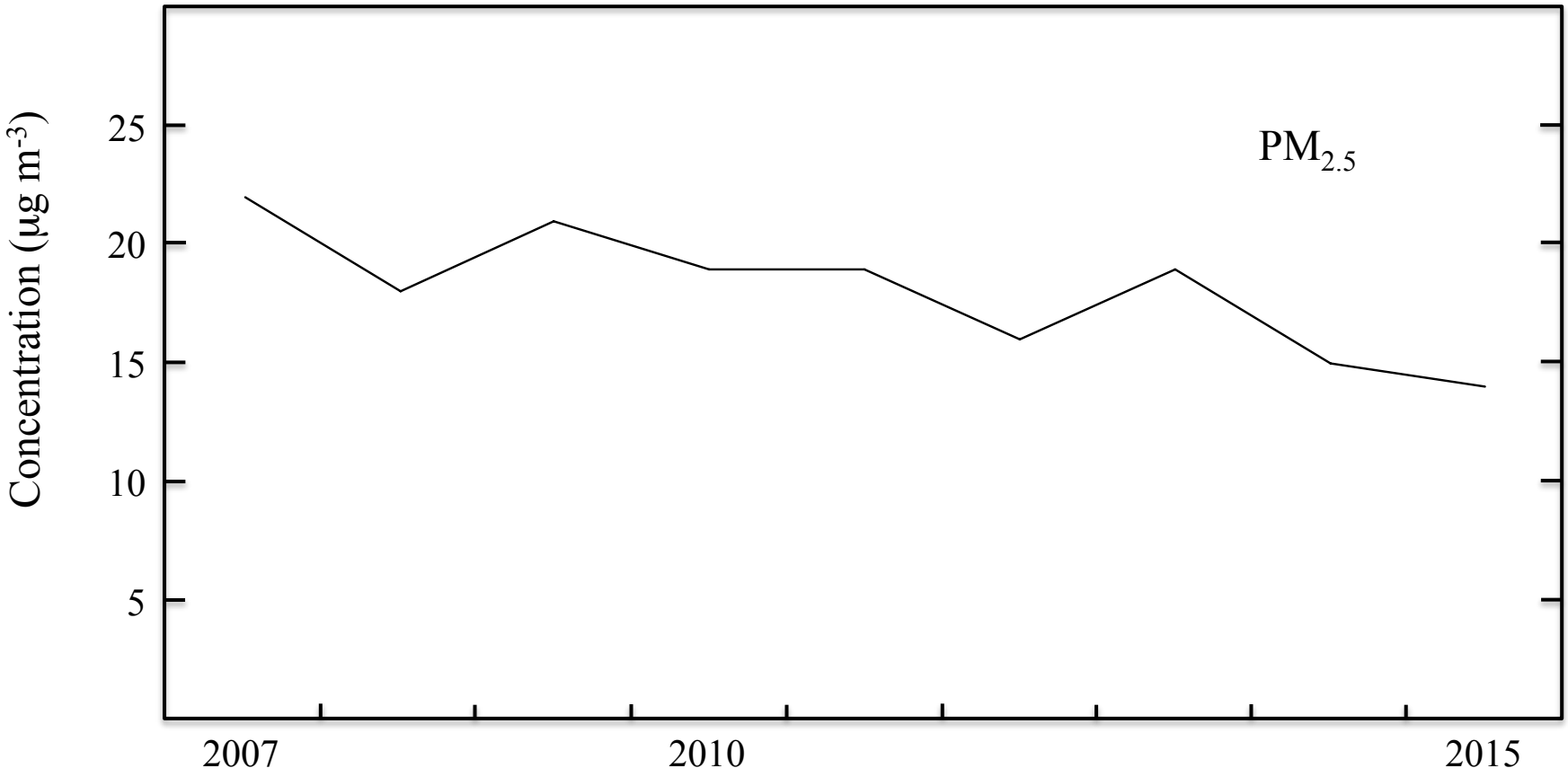
Evolution of $NO_2$ concentrations in Paris, France




Source: Airparif, 2016

# Air Quality Trends in Paris

Evolution of $PM_{2.5}$ concentrations in Paris, France




Source: Airparif, 2016

# Regulations for Atmospheric Deposition and Global Pollution

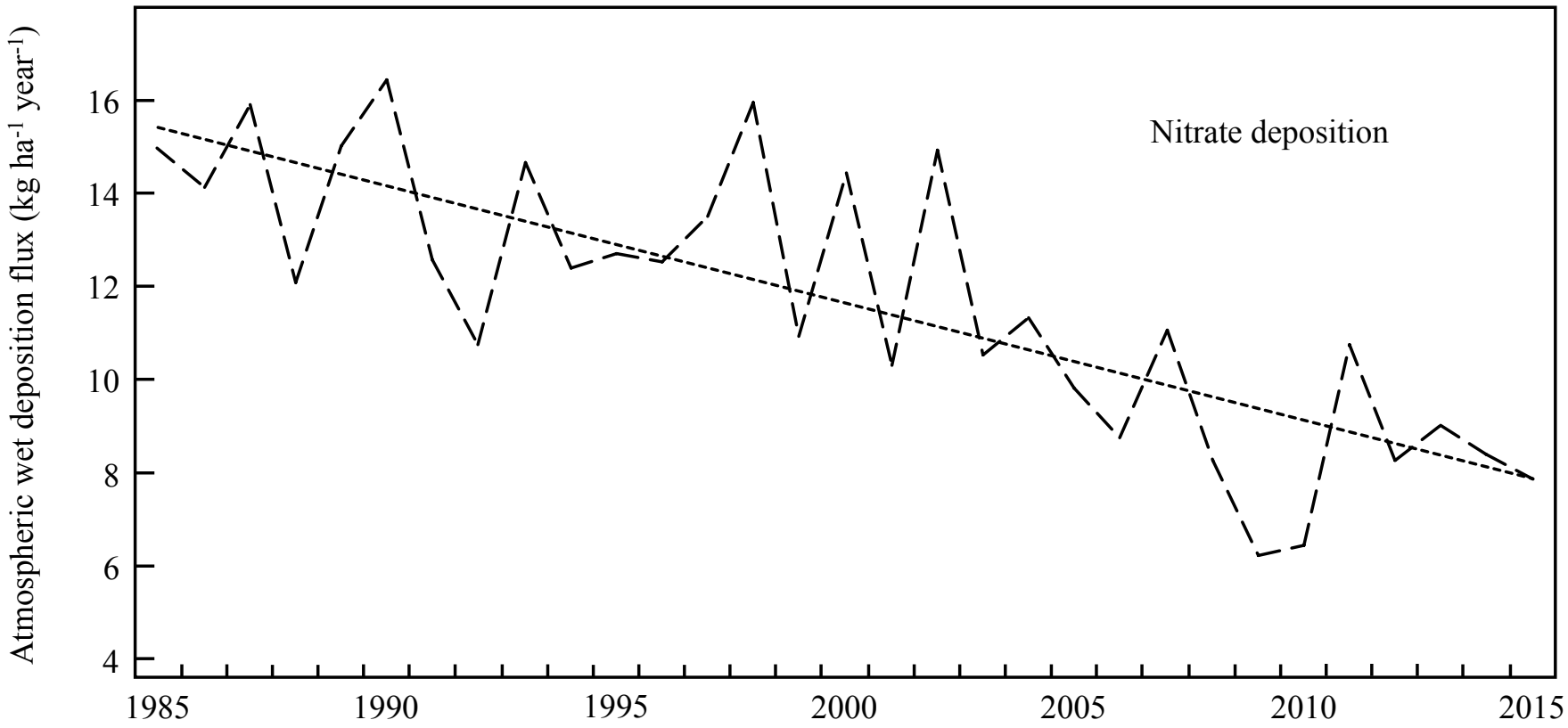
- Three main approaches for air pollution emission controls:
  - Total ban of the emissions of an air pollutant (e.g., DDT in North America and Europe)
  - Emission limits of some air pollutants defined by source categories and to be met by each individual source of a given category (e.g., dioxin/furan emissions from incinerators in France and mercury emissions from fossil-fueled fired power plants in the U.S.)
  - Overall emission limit of some air pollutants for a source category to be met by the sources of that given category as a whole (e.g., $SO_2$ and $NO_x$ emissions from coal-fired power plants in the U.S.)

# Regulations for Atmospheric Deposition and Global Pollution

- Montreal Protocol of 1987 (and its subsequent amendments) for the elimination of chloroflurocarbons and other substances depleting the stratospheric ozone layer
- Stockholm Convention of 2001 for the reduction of the emissions of persistent organic pollutants (POP)
- Minamata Convention of 2013 for the reduction of mercury emissions
- Göteborg Protocol of 1999 for the reduction of the emissions of $NO_x$, $SO_x$, $NH_3$, and VOC to reduce acid deposition, eutrophication, and ozone formation
- Paris Agreement of 2015 for the reduction of the greenhouse gas emissions

# Atmospheric Deposition Trends in New York State

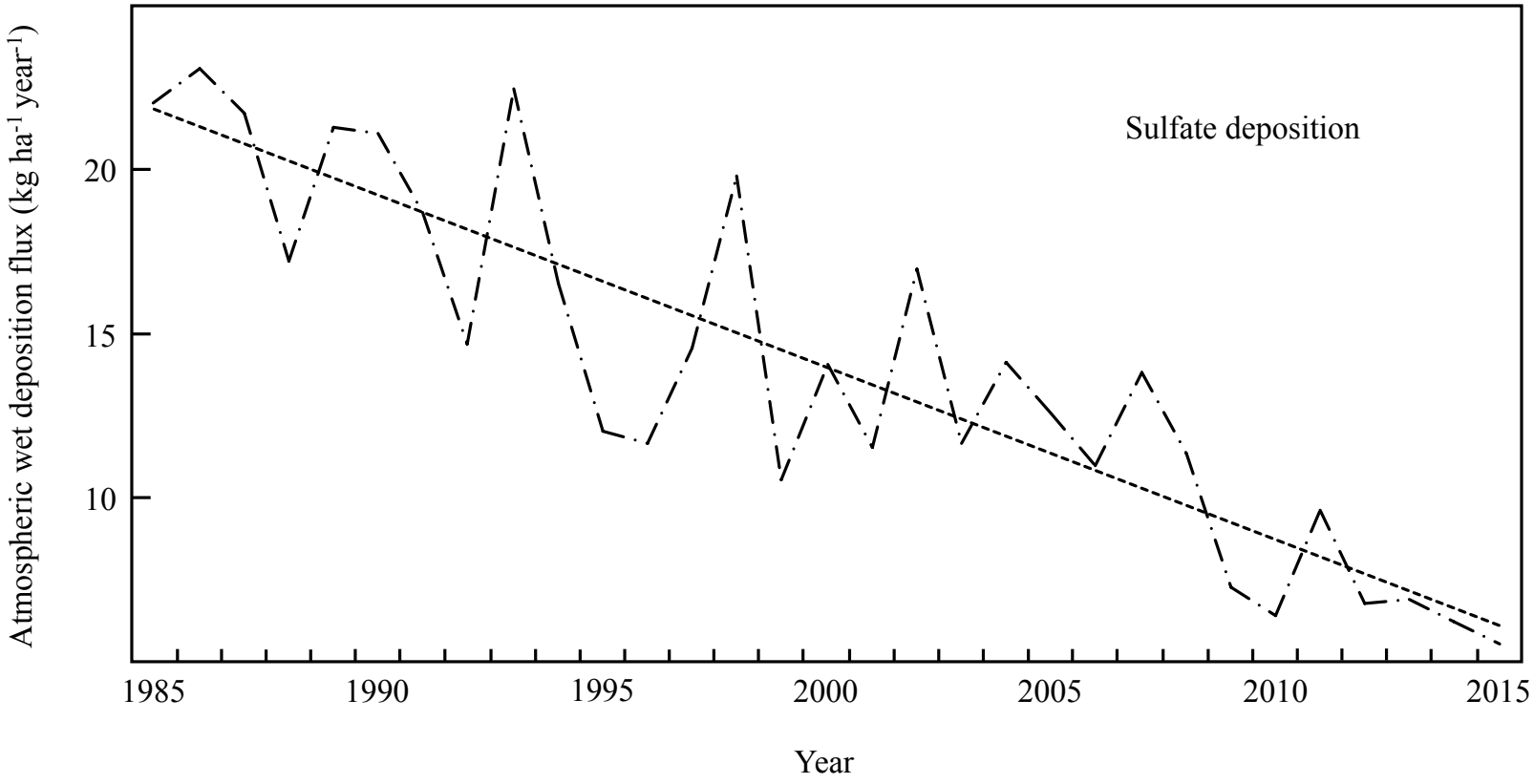
Evolution of atmospheric nitrate deposition at White Face Mountain, NY




Source: NADP, 2017

# Atmospheric Deposition Trends in New York State

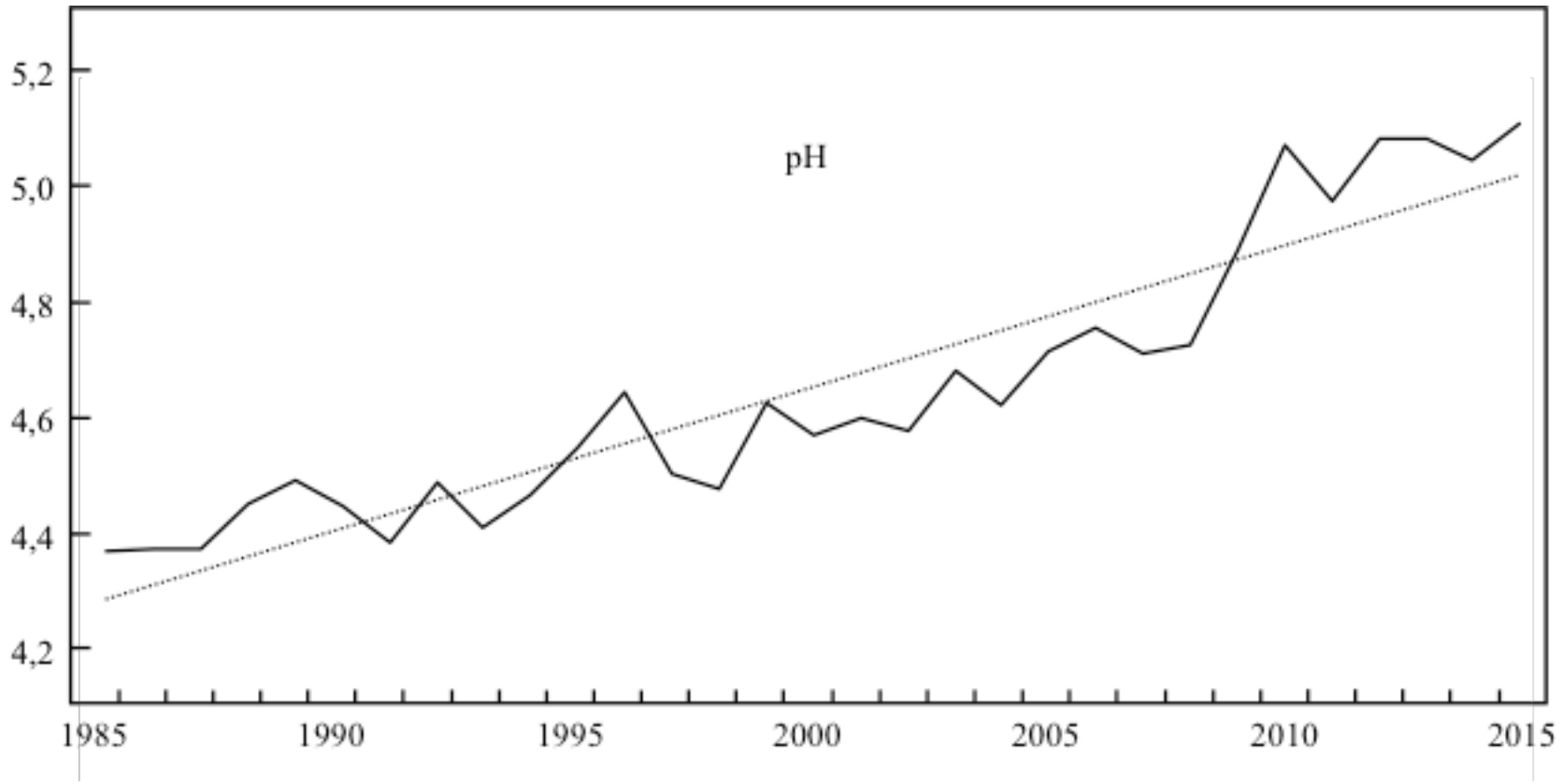
Evolution of atmospheric sulfate deposition at White Face Mountain, NY




Source: NADP, 2017

# Atmospheric Deposition Trends in New York State

Evolution of precipitation pH at White Face Mountain, NY




Source: NADP, 2017