# Air Toxics Data Analysis Workbook


U.S. Environmental Protection Agency
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# Disclaimer

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The Environmental Protection Agency welcomes public input on this document at any time. Comments should be sent to Barbara Driscoll (driscoll.barbara@epa.gov).

# Workbook Content Summary

- Introduction
  - Brief overview of the workbook and its motivation.
- Definitions and acronyms
- Background
  - Summary of air toxics information to provide a basis for the analyst regarding emissions, formation, transport, and sampling/analysis of air toxics.
- Preparing data for analysis
  - Methods and examples for validating air toxics data and preparing daily, quarterly, and annual averages.
- Characterizing air toxics
  - Methods and examples of characterizing air toxics concentrations including spatial patterns, relationships, and time of day/seasonal variations.
- Quantifying trends in air toxics
  - Methods and examples for preparing data for inter-annual trend analyses, identifying and quantifying trends, and tying these trends to changes in emissions.
- Advanced data analysis techniques
  - Brief overview of advanced methods for data analysis including source apportionment.
- Suggested analyses
  - Summary of basic set of analyses that could be performed with air toxics at a local, state, and regional level to better understand the data and inform policy makers.

# Workbook Purpose

- This workbook was designed to
  - serve as an overview of the sizeable topic of air toxics data analysis;
  - provide suggestions on the methodology to use in analyzing air toxics data, building on the experience gained in the past several years of national level data analysis efforts; and
  - document current methodology being used in national data analysis efforts.
- The workbook contains a different topic area in each section. Distinctions between methods used to assess the data at a national level and methods that can be applied at a site level are provided.
- Sections contain a range of information and examples. Basic knowledge of summary statistics and data analysis techniques is assumed. The more advanced analyses or statistical techniques are separately discussed.
- Figures are used to show example analyses. The figures are not intended to show the only way in which to perform an analysis but rather to provide the analyst with a starting point. Most figure captions list the tool used to present the data, the data used in the analysis, an observation or interpretation point, and a reference. When a reference is not provided, the figure was prepared by the workbook authors specifically for the workbook.
- References are provided at the end of each section.

# Introduction to Air Toxics

# Introduction to Air Toxics
## *What's Covered in This Section?*

- What are air toxics?
- Why analyze ambient air toxics data?
- Types of questions analysts want to answer
- Suggested analyses overview
- Using the workbook

# What Are Air Toxics?

- There are 188 Hazardous air pollutants (HAPs) defined in the Clean Air Act Amendments of 1990. HAPs are also referred to as air toxics, which is a broader term and includes additional pollutants such as hydrogen sulfide. For this document, the two terms "HAPs" and "air toxics" will be used interchangeably. Air toxics are those pollutants known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects.
- Examples of toxic air pollutants include
  - Benzene, which is found in gasoline.
  - Perchloroethylene, which is emitted from some dry cleaning facilities.
  - Methylene chloride, which is used as a solvent and paint stripper by a number of industries.
  - Metals such as arsenic, mercury, chromium, and lead compounds, which are emitted, for example, from metal processing operations.
  - Semivolatile organic compounds (SVOCs) such as naphthalene, which is emitted in petroleum refining and fossil fuel and wood combustion.
- Most air toxics originate from anthropogenic sources, including mobile sources (e.g., cars, trucks, buses) and stationary sources (e.g., factories, refineries, power plants), and indoor sources (e.g., some building materials and cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires.
- EPA is working with state, local, and tribal governments to reduce air toxics releases to the environment (www.epa.gov/air/toxicair/newtoxics.html).
  - EPA has issued rules covering over 80 categories of major industrial sources, such as chemical plants, oil refineries, aerospace manufacturers, and steel mills, as well as categories of smaller sources, such as dry cleaners, commercial sterilizers, secondary lead smelters, and chromium electroplating facilities.
  - EPA and state governments (e.g., California) have reduced emissions of benzene, toluene, and other air toxics from mobile sources by requiring the use of reformulated gasoline and placing limits on tailpipe emissions.

# List of 188 Hazardous Air Pollutants

| | | | | | |
|---|---|---|---|---|---|
| **1,1,2,2-Tetrachloroethane** | **Cobalt (Tsp)** | **Vinyl Chloride** | Mercury (Pm10) Stp | *Acrylamide* | *Hydrochloric acid* |
| **1,1,2-Trichloroethane** | **Cobalt Pm2.5 Lc** | 1,2-Dibromo-3-Chloropropane | Mercury (Vapor) | *Acrylic acid* | *Hydrogen fluoride* |
| **1,1-Dichloroethane** | **Dichloromethane** | 1,3-Dichloropropene(Total) | Mercury Pm10 Lc | *Asbestos* | *Hydrogen sulfide* |
| **1,1-Dichloroethylene** | **Ethyl Acrylate** | 1,4-Dioxane | Methanol | *Benzidine* | *Hydroquinone* |
| **1,2,4-Trichlorobenzene** | **Ethylbenzene** | 2,4,5-Trichlorophenol | Methoxychlor | *Benzotrichloride* | *Maleic anhydride* |
| **1,2-Dichloropropane** | **Ethylene Dibromide** | 2,4,6-Trichlorophenol | M-Xylene | *beta-Propiolactone* | *m-Cresol* |
| **1,3-Butadiene** | **Ethylene Dichloride** | 2,4-Dinitrophenol | Nickel (Coarse Particulate) | *Bis(chloromethyl)ether* | *Methyl hydrazine* |
| **1,4-Dichlorobenzene** | **Formaldehyde** | 2,4-Dinitrotoluene | Nickel Pm10 Lc | *Calcium cyanamide* | *Methyl iodide (Iodomethane)* |
| **2,2,4-Trimethylpentane** | **Hexachlorobutadiene** | 3-Chloropropene | Nitrobenzene | *Captan* | *Methyl isocyanate* |
| **Acetaldehyde** | **Isopropylbenzene** | 4,6-Dinitro-2-Methylphenol | O-Cresol | *Carbaryl* | *Methylene diphenyl diisocyanate* |
| **Acetonitrile** | **Lead (Pm10) Stp** | 4-Nitrophenol | P-Cresol | *Carbonyl sulfide* | *N,N-Diethyl aniline* |
| **Acrolein** | **Lead (Tsp)** | Aniline | Pentachlorophenol | *Catechol* | *N-Nitrosodimethylamine* |
| **Acrylonitrile** | **Lead Pm2.5 Lc** | Antimony (Pm10) Stp | Phenol | *Chloramben* | *N-Nitrosomorpholine* |
| **Antimony (Tsp)** | **M/P-Xylene** | Antimony Pm10 Lc | Phosphorus (Tsp) | *Chlordane* | *N-Nitroso-N-methylurea* |
| **Antimony Pm2.5 Lc** | **Manganese (Pm10) Stp** | Arsenic Pm10 Lc | Phosphorus Pm10 Lc | *Chloroacetic acid* | *o-Anisidine* |
| **Arsenic (Pm10) Stp** | **Manganese (Tsp)** | Beryllium Pm10 Lc | P-Xylene | *Chlorobenzilate* | *o-Toluidine* |
| **Arsenic (Tsp)** | **Manganese Pm2.5 Lc** | Biphenyl | Selenium Pm10 Lc | *Chloromethyl methyl ether* | *Parathion* |
| **Arsenic Pm2.5 Lc** | **Mercury (Tsp)** | Bis (2-Chloroethyl)Ether | Xylene(S) | *Coke Oven Emissions* | *Pentachloronitrobenzene* |
| **Benzene** | **Mercury Pm2.5 Lc** | Bis(2-Ethylhexyl)Phthalate | *1,1-Dimethyl hydrazine* | *Cresols/Cresylic acid* | *Phosgene* |
| **Benzyl Chloride** | **Methyl Chloroform** | Cadmium Pm10 Lc | *1,2-Diphenylhydrazine* | *Cyanide Compounds* | *Phosphine* |
| **Beryllium (Pm10) Stp** | **Methyl Isobutyl Ketone** | Caprolactam | *1,2-Epoxybutane* | *DDE* | *Phthalic anhydride* |
| **Beryllium (Tsp)** | **Methyl Methacrylate** | Chlorine (Tsp) | *1,2-Propylenimine* | *Diazomethane* | *Polychlorinated biphenyls* |
| **Bromoform** | **Methyl Tert-Butyl Ether** | Chlorine Pm10 Lc | *1,3-Propane sultone* | *Dichlorvos* | *Polycylic Organic Matter* |
| **Bromomethane** | **Naphthalene** | Chromium (Coarse Particulate) | *2,3,7,8-Tetrachlorodibenzo-p-dioxin* | *Diethanolamine* | *p-Phenylenediamine* |
| **Cadmium (Pm10) Stp** | **N-Hexane** | Chromium Pm10 Lc | *2,4-D, salts and esters* | *Diethyl sulfate* | *Propoxur (Baygon)* |
| **Cadmium (Tsp)** | **Nickel (Pm10) Stp** | Cobalt Pm10 Lc | *2,4-Toluene diamine* | *Dimethyl aminoazobenzene* | *Propylene oxide* |
| **Cadmium Pm2.5 Lc** | **Nickel (Tsp)** | Dibenzofurans | *2,4-Toluene diisocyanate* | *Dimethyl carbamoyl chloride* | *Quinoline* |
| **Carbon Disulfide** | **Nickel Pm2.5 Lc** | Dimethyl Phthalate | *2-Acetylaminofluorene* | *Dimethyl formamide* | *Quinone* |
| **Carbon Tetrachloride** | **O-Xylene** | Di-N-Butyl Phthalate | *2-Chloroacetophenone* | *Dimethyl sulfate* | *Radionuclides (including radon)* |
| **Chlorine Pm2.5 Lc** | **Phosphorus Pm2.5 Lc** | Ethylene Oxide | *2-Nitropropane* | *Epichlorohydrin* | *Styrene oxide* |
| **Chlorobenzene** | **Propionaldehyde** | Heptachlor | *3,3-Dichlorobenzidene* | *Ethyl carbamate (Urethane)* | *Titanium tetrachloride* |
| **Chloroethane** | **Selenium (Pm10) Stp** | Hexachlorobenzene | *3,3-Dimethoxybenzidine* | *Ethylene glycol* | *Toxaphene* |
| **Chloroform** | **Selenium (Tsp)** | Hexachlorocyclopentadiene | *3,3'-Dimethyl benzidine* | *Ethylene imine (Aziridine)* | *Triethylamine* |
| **Chloromethane** | **Selenium Pm2.5 Lc** | Hexachloroethane | *4,4-Methylene bis(2-chloroaniline)* | *Ethylene thiourea* | *Trifluralin* |
| **Chloroprene** | **Styrene** | Isophorone | *4,4-Methylenedianiline* | *Fine mineral fibers* | *Vinyl bromide* |
| **Chromium (Pm10) Stp** | **Tetrachloroethylene** | Lead Pm10 Lc | *4-Aminobiphenyl* | *Glycol ethers* | |
| **Chromium (Tsp)** | **Toluene** | Lindane | *4-Nitrobiphenyl* | *Hexamethylene-1,6-diisocyanate* | |
| **Chromium Pm2.5 Lc** | **Trichloroethylene** | Manganese (Coarse Particulate) | *Acetamide* | *Hexamethylphosphoramide* | |
| **Cobalt (Pm10) Stp** | **Vinyl Acetate** | Manganese Pm10 Lc | *Acetophenone* | *Hydrazine* | |

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**Abundance of data: > 20 monitoring sites with sufficient data to create a valid annual average between 2003-2005, up to 434 sites**

Little data: < 20 monitoring sites with sufficient data to create a valid annual average between 2003-2005, between 1-17 sites

*No Data: No valid annual averages between 2003-2005*

From: http://www.epa.gov/ttn/atw/188polls.html

# Why Analyze Ambient Air Toxics Data?

- National level analyses provide an overview of the air toxics program and build on the power of a large data set to find the central tendencies in the data. Data anomalies at an individual site have little influence on the overall results on a national scale.
- On a site-by-site basis, a much finer level of detail is needed to understand the characteristics and trends observed. Knowledge is needed of the nearby sources, operating schedules, facility upsets and closures, new emission sources, types of emissions, types of controls and scheduled implementation, data reporting and quality issues, changes in sampling and methodology, local meteorology, and other details to fully understand changes in ambient pollutant concentrations.
- States collecting data have unique “local” perspectives on data quality, meteorology, and sources, and in articulating policy-relevant data analysis questions.
- Air toxics data analysis is needed at all levels to track progress in risk reduction.

# Types of Questions Analysts May Want to Consider

- How do I ensure that the data I plan to use for analysis are of good quality?
  - How do I treat data below detection? What kinds of data metrics do I need for subsequent analyses? (See *Preparing Data for Analysis*, Section 4)
- How do air toxics concentrations change spatially and by time of day, day of week, and season?
  - Which air toxics have similar patterns? (See *Characterizing Air Toxics*, Section 5)
  - Do these air toxics have common sources? (See *Background*, Section 3)
- What are the most important air toxics in terms of potential risk?
  - Are we measuring them and, if so, are we measuring them well? Where are they important?
  - Which pollutants are not monitored well enough to characterize their risk or hazard? (See *Advanced Analyses*, Section 7)
- How do concentration levels for a given city/area compare to other cities?
  - Are concentrations comparable? What is the variability of air toxics concentrations within cities? Do specific cities, states, or regions experience demonstrably higher or lower concentrations? Do rural and remote sites show demonstrably lower concentrations? Are there differences in concentrations associated with geo-political or agency differences? (See *Characterizing Air Toxics*, Section 5)
- Have air toxics concentrations declined over time in response to emission control programs? (See *Quantifying and Interpreting Trends in Air Toxics*, Section 8)
- How do the most important air toxics compare with model output (e.g., are ambient concentrations high in locations not shown by the model)? (See *Characterizing Air Toxics*, Section 5)

# Suggested Analyses
## *Overview*

- A list of suggested air toxics data analyses is compiled here to provide direction on those analyses that may be performed by air toxics monitoring agencies and to give an overview of analyses covered in the workbook.
- EPA compiled this list of suggested air toxics data analyses based on analyses that would help regional, state, and local organizations determine which factors contribute to air toxics concentrations in their area and whether the control strategies they have implemented have been successful at reducing these pollutants.
- This list is a suggested set of analyses that each area may wish to use to help understand air toxics concentrations in the area. There are several key areas of interest:
  - Are data of sufficient quality for analysis?
  - How would air toxics be characterized in the area?
  - What are local sources of air toxics?
  - Do toxics concentrations change over time?
- For the most informative results, some of these analyses could be performed annually.

# Suggested Analyses (1 of 4)

| Questions | Example Analyses |
|---|---|
| **Are data of sufficient quality for analysis?** | |
| How have data been validated? | Run screening checks on data from AQS; identify outliers |
| Does suspect data quality appear in any years or species measurements? | Review collocated data; inspect summary statistics and concentration ranges; review time series plots of concentrations and detection limits |
| Have data been censored? | Assess concentration distributions; compare concentrations to detection limits |
| Are sufficient samples available for detailed analyses? | Determine number of samples/species with concentrations above detection |

# Suggested Analyses (2 of 4)

| Questions | Example Analyses |
|---|---|
| **What is the nature and extent of air toxics problems in your area?** | |
| What are the most abundant air toxics at each site on a risk-weighted basis? | Determine median concentrations and concentration ranges and compare to appropriate risk levels |
| How do these species vary by measurement season, month, and time of day? Are findings consistent with national level results? | Prepare box plots of concentrations by season, month, and time of day; compare to national results and expectations based on local conditions |
| Do species show any day-of-week patterns? | Prepare box plots of concentrations by day of week; compare results to expected patterns of local emissions |
| How do concentrations compare to other locations, risk levels, remote background, or reference concentrations? | Compare monitor-level data to national-perspective plots |

# Suggested Analyses (3 of 4)

| Questions | Example Analyses |
|---|---|
| **What are local sources of air toxics?** | |
| What are the potential toxics sources in the area? | Investigate Google map of area; overlay VOC, $PM_{2.5}$, and air toxics emission inventory information |
| Do the air toxics corroborate the source mixture? | • Examine key species noted as tracers for the expected sources in the area using scatter plots and correlation matrices<br>• Compare concentrations of air toxics and nontoxic tracer species to further assess sources (e.g., $PM_{2.5}$ components, hydrocarbons) |

# Suggested Analyses (4 of 4)

| Questions | Example Analyses |
|---|---|
| **Do air toxics concentrations change over time?** | |
| What are the annual trends in air toxics concentrations? | Prepare annual box plots of key species to evaluate trends |
| How might changes in air toxics concentrations be related to emissions controls? | • Compare trends in co-emitted pollutants<br>• Assess timing of controls and expected reductions relevant to local monitoring of pollutants. |

# Using the Workbook

- This workbook documents methodology used in national-scale analyses, extends these methodologies to possible use in local-scale analyses, and suggests methodology for further exploration.
- Skills needed by analysts to conduct the analyses shown in this workbook vary. Analyses require a range of tools, skills, and knowledge. A fundamental understanding of databases, spreadsheets, and summary statistics is desirable. Some analyses require special training (e.g., source apportionment tools) and/or tools (e.g., sophisticated statistical treatments). In general, analyses described in the following sections are arranged from “easiest” to “most difficult” to perform.
- Examples are provided from the national-scale analyses and some analyses were custom-designed for the workbook.
- Space available in the workbook is limited; therefore, many details are, of necessity, provided in the literature. A reference section is provided at the end of each chapter.

# References


- Agency for Toxic Substances and Disease Registry (ASTDR) (2007) Frequently asked questions about contaminants found at hazardous waste sites. Available on the Internet at http://www.atsdr.cdc.gov/toxfaq.html.
- U.S. Environmental Protection Agency, FERA (Fate, Exposure and Risk Analysis) Risk Assessment and Modeling web site. Available on the Internet at http://www.epa.gov/ttn/fera/risk_atoxic.html
- U.S. Environmental Protection Agency (2007a) EPA air toxics web site. Available on the Internet at http://www.epa.gov/ttn/atw/allabout.html
- U.S. Environmental Protection Agency ( 2007b) About air toxics, health and ecological effects. Available on the Internet at http://www.epa.gov/air/toxicair/newtoxics.html.

# Definitions and Acronyms

This section lists definitions of terms and acronyms used in this workbook.

# Definitions and Acronyms (1 of 12)

**Aerosol** A particle of solid and/or liquid matter that can remain suspended in the air because of its small size (generally under one micron).

**AIRNow** The U.S. EPA, NOAA, tribal, state, and local agencies developed the AIRNow web site to provide the public with easy access to national air quality information. The web site offers daily air quality index (AQI) forecasts as well as real-time AQI conditions for over 300 cities across the United States, and provides links to more detailed state and local air quality web sites <http://airnow.gov/>.

**Airshed** A geographic area that, because of topography, meteorology, and/or climate, is frequently affected by the same air mass.

**Air Toxics –** Any pollutant that causes or may cause cancer, respiratory, cardiovascular, or developmental effects, reproductive dysfunctions, neurological disorders, heritable gene mutations, or other serious or irreversible chronic or acute health effects in humans. See hazardous air pollutant**.**

**AMTIC –** Ambient Monitoring Technology Information Center. An EPA website that contains information and files on ambient air quality monitoring programs, details on monitoring methods, monitoring- related documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. http://www.epa.gov/ttn/amtic/.

**Anthropogenic** Caused or produced by human activities.

**Anthropogenic emissions** Emissions from man-made sources as opposed to natural (biogenic) sources**.**

**AQS** Air Quality System; the EPA's repository of ambient air quality data http://www.epa.gov/ttn/airs/airsaqs/.

**Back trajectory** A trace backwards in time showing where an air mass has been.

# Definitions and Acronyms (2 of 12)

**Background Levels** The concentration of a chemical already present in an environmental medium due to sources other than those under study. Two type of background levels may exist for chemical substances: (a) naturally occurring levels of substances present in the environment, and (b) concentrations of substances present in the environment due to human associated activities (e.g., automobile or industrial emissions).

**Benchmark Dose** An exposure due to the dose of a substance associated with a specified low incidence of risk, generally in the range of 1% to 10% of a health effect; or the dose associated with a specified measure or change of a biological effect.

**Black Carbon (BC)** Black carbon measured using light absorption, typically with an AethalometerTM. Used in the air toxics monitoring network as a potential surrogate measure (although not unique or quantitative) of diesel particulate matter.

**Cancer benchmark** A potential regulatory threshold concentration of concern related to long term exposure to a chemical associated with increased cancer risk.

**Cancer Incidence** The number of new cases of a disease diagnosed each year.

**Cancer Risk Estimates** The probability of developing cancer from exposure to a chemical agent or a mixture of chemicals over a specified period of time. In quantitative terms, risk is expressed in values ranging from zero (representing an estimate that harm certainly will not occur) to one (representing an estimate that harm certainly will occur). The following are examples of how risk is commonly expressed: 1.E-04 or $1x\ 10^{-4}$ = a risk of 1 additional cancer in an exposed population of 10,000 people (i.e., 1/10,000); 1.5E-5 or $1x\ 10^{-5}$ + 1/100,000.

**Cd** Cadmium.

**Censored Data** The measured value is replaced with a proxy: Typical examples are MDL, MDL/2, MDL/10, or zero.

# Definitions and Acronyms (3 of 12)

**Census tract** Census tracts are small, relatively permanent statistical subdivisions of a county. Census tracts are delineated for most metropolitan areas (MAs) and other densely populated counties by local census statistical areas committees following Census Bureau guidelines (more than 3,000 census tracts have been established in 221 counties outside MA's). Six states (California, Connecticut, Delaware, Hawaii, New Jersey, and Rhode Island) and the District of Columbia are covered entirely by census tracts. Census tracts usually represent between 2,500 and 8,000 people and, when first delineated, are designed to be homogeneous with respect to population characteristics, economic status, and living conditions. Census tracts do not cross county boundaries. The spatial size of census tracts varies widely depending on the density of settlement <http://www.census.gov/geo/www/cen_tract.html>.

**Chemical Speciation Network** The CSN monitors speciated $PM_{2.5}$. CSN includes both the 54 Speciation Trends sites and about 150 state and local monitoring sites.

**Cluster analysis** A multivariate procedure for grouping data by similarity among samples (i.e., samples with similar chemical compound concentrations are grouped).

**CMAQ** Community Multiscale Air Quality system. An air quality simulation model of tropospheric ozone, acid deposition, visibility, and fine particulate matter from urban to regional scales.

**CMB** Chemical mass balance model. A receptor model.

**Coefficient of Correlation, r** A statistic representing how closely two variables co-vary; they can vary from -1 (perfect negative correlation) through 0 (no correlation) to +1 (perfect positive correlation).

**Collinearity** A situation in which a near-perfect linear relationship exists among some or all of the independent variables in a regression model; in practical terms, there is some degree of redundancy or overlap among the variables.

# Definitions and Acronyms (4 of 12)

**Conditional probability function (CPF)** A method that analyzes local source impacts from varying wind directions using the source contribution estimates from PMF coupled with the corresponding wind directions.

**Confidence Interval (CI)** CI for a population parameter is an interval with an associated probability p that is generated from a random sample of an underlying population such that if the sampling was repeated numerous times and the confidence interval recalculated from each sample according to the same method, a proportion p of the confidence intervals would contain the population parameter in question.

**Covariance** A statistical measure of correlation of the fluctuations of two different quantities.

**Cr** Chromium.

**Data Quality** The encompassing term regarding the quality of information used for analysis and/or dissemination of data. Utility, objectivity, and integrity are essential parts of data quality.

**Data Quality Objectives (DQOs)** Qualitative and quantitative statements derived from the DQO process that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support the decisions.

**Data Quality Objectives Process** A systematic planning tool to facilitate the planning of environmental data collection activities. Data quality objectives are the qualitative and quantitative outputs from the DQO process.

**Detection limit (DL)** The lowest concentration of a chemical that can reliably with analytical methods be distinguished from a zero concentration. See also *method detection limit*.

# Definitions and Acronyms (5 of 12)

**Dispersion model** A source-oriented approach in which a pollutant emission rate and meteorological information are input into a mathematical model that disperses (and may also chemically transform) the emitted pollutant, generating a prediction of the resulting pollutant concentration at a point in space and time.

**DPM** Diesel particulate matter.

**Edge** A line that defines the boundary of the relationship between two parameters on a scatter plot.

**Elemental carbon (EC)** Black carbon material with little or no hydrogen; non-volatile carbon material; often called black carbon or soot.

**Emission Inventory (EI)** A list of air pollutants emitted into a community's atmosphere in amounts (commonly tons) per day or year, by type of source.

**EPA** U.S. Environmental Protection Agency.

**EPA PMF** A standalone version of PMF created by the EPA in 2005.

**Environmental justice** The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

**F-test** The F-test provides a statistical measure of the confidence that a relationship exists between the two variables (i.e., the regression line does not have a slope of zero, which would indicate the dependent variable is not related to the independent variable).

**F-value** Output of the F-test. Large F-values indicate a stronger correlation between the two variables (i.e., the slope of the regression line is NOT zero).

**Factor analysis** A procedure for grouping data by similarity among variables (i.e., variables that are highly correlated are grouped).

**Factor strength** (source strength). See *Source contribution*.

# Definitions and Acronyms (6 of 12)

**Federal Reference Method (FRM)** Provides for the measurement of the mass concentration of fine particulate matter having an aerodynamic diameter less than or equal to a nominal 2.5 microns ($PM_{2.5}$) in ambient air over a 24-hr period for purposes of determining whether the primary and secondary National Ambient Air Quality Standards for fine particulate matter are met. Designation of a particle sampler as a Federal Reference Method (FRM) is based on a demonstration that a vendor's instrument meets the design specifications, performance requirements, and quality control standards specified in the regulation.

**Fine particles** Particulate matter with diameter less than 2.5 microns; $PM_{2.5}$.

**HAPs (hazardous air pollutants)** Hazardous air pollutants, also known as air toxics, have been associated with a number of adverse human health effects, including cancers, asthma and other respiratory ailments, and neurological problems such as learning disabilities and hyperactivity.

**Hazard Quotient (HQ)** The ratio of a single substance exposure level over a specified time period (e.g., chronic) to a reference value (e.g., an RfC) for that substance derived from a similar exposure period.

**HYSPLIT** HYbrid Single-Particle Lagrangian Integrated Trajectory model; a system for computing simple air parcel trajectories <http://www.arl.noaa.gov/ready/hysplit4.html>.

**IMPROVE** Interagency Monitoring of Protected Visual Environments. A collaborative monitoring program to establish present visibility levels and trends, and to identify sources of man-made impairment <http://vista.cira.colostate.edu/improve/Default.htm>.

**Interquartile range** The difference between the 75$^{th}$ and 25$^{th}$ percentiles of a data set.

# Definitions and Acronyms (7 of 12)

**Level 0 validation** Routine checks made during the initial data processing and generation of data, including proper data file identification, review of unusual events, review of field data sheets and result reports, instrument performance checks, and deterministic relationships.

**Level I validation** Tests for internal consistency to identify values in the data that appear atypical when compared to values of the entire data set.

**Level II validation** Comparison of the current data set with historical data to verify consistency over time. This level can be considered a part of the data interpretation or analysis process.

**Level III validation** Tests for parallel consistency with data sets from the same population (i.e., region, period of time, air mass, etc.) to identify systematic bias. This level can also be considered a part of the data interpretation or analysis process.

**LC** Local conditions; refers to ambient PM measurements.

**MACT** Maximum achievable control technology. MACTs are technology-based air emission standards established under Title III of the 1990 Clean Air Act Amendments <http://www.epa.gov/region08/compliance/mact/mact.html>.

**Mean** The sum of all values divided by the number of samples.

**Median** The middle value in a sorted list of samples if there is an odd number of samples, or the average of the two middle values if there is an even number of samples.

**Method Detection Limit (MDL)** The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte

**Mobile sources** Motor vehicles and other moving objects that release pollution; mobile sources include cars, trucks, buses, planes, trains, motorcycles, and gasoline-powered lawn mowers. Mobile sources are divided into two groups: road vehicles, which include cars, trucks, and buses, and non-road vehicles, which include trains, planes, and lawn mowers.

# Definitions and Acronyms (8 of 12)

**Mobile source air toxics (MSATs)** Compounds that are emitted by mobile sources and have the potential for serious adverse health effects.

**National Ambient Air Quality Standards (NAAQS)** Health-based pollutant concentration limits established by the EPA that apply to outside air.

**NATA** National air toxics assessment <http://www.epa.gov/ttn/atw/nata1999/nsata99.html>. EPA's national-scale assessment of 1999 air toxics emissions. The purpose of the national-scale assessment is to identify and prioritize air toxics, emission source types and locations that are of greatest potential concern in terms of contributing to population risk.

**NATTS** National air toxics trends stations <http://www.epa.gov/ttn/amtic/natts.html>.

**NEI** National emissions inventory <http://www.epa.gov/ttn/chief/net/>.

**NOAA** National Oceanic and Atmospheric Administration.

**NWS** National Weather Service.

**OAQPS Toxicity Table** The EPA Office of Air and Radiation recommended default chronic toxicity values for hazardous air pollutants. They are generally appropriate for screening-level risk assessments, including assessments of select contaminants, exposure routes, or emission sources of potential concern, or to help set priorities for further research. For more complex, refined risk assessments developed to support regulatory decisions for single sources or substances, dose-response data may be evaluated in detail for each "risk driver' to incorporate appropriate new toxicological data. **http://www.epa.gov/ttn/atw/toxsource/summary.html**

**OH** Hydroxyl radical; the driving force behind the daytime reactions of hydrocarbons in the troposphere.

**$O_3$** Ozone; a major component of smog. Ozone is not emitted directly into the air but is formed by the reaction of VOCs and $NO_x$ in the presence of heat and sunlight.

**Organic carbon (OC)** Consists of hundreds of separate semi-volatile and particulate compounds.

# Definitions and Acronyms (9 of 12)

**Outliers** Data physically, spatially, or temporally inconsistent.

**P-value** Provides a measure of the percentage confidence that the slope is not zero: % confidence slope is not zero = 100%(1 – P). Generally, 95% confidence is used as a cutoff value, corresponding to a P-value of 0.05.

**PAMS** Photochemical Assessment Monitoring Stations <http://epa.gov/air/oaqps/pams/freqfile.html>.

**Particulate matter (PM)** A generic term referring to liquid and/or solid particles suspended in the air.

**Percentile** The *p*th percentile of a data set is the number such that *p*% of the data is less than that number.

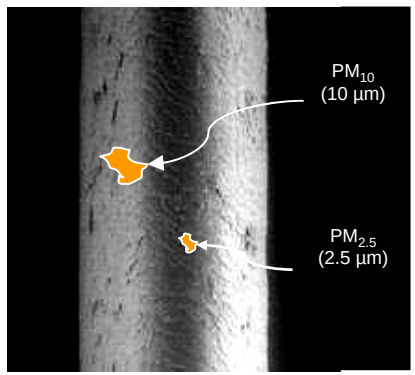
**$PM_{2.5}$** Particulate matter less than 2.5 microns. Tiny solid and/or liquid particles, generally soot and aerosols. The size of the particles (2.5 microns or smaller, about 0.0001 inches or less) allows them to easily enter the air sacs deep in the lungs where they may cause adverse health effects; $PM_{2.5}$ also causes visibility reduction.

**$PM_{10}$** Particulate matter less than 10 microns. Tiny solid and/or liquid particles of soot, dust, smoke, fumes, and aerosols. The size of the particles (10 microns or smaller, about 0.0004 inches or less) allows them to easily enter the air sacs in the lungs where they may be deposited, resulting in adverse health effects. $PM_{10}$ also causes visibility reduction and is a criteria air pollutant.

**PMF** Positive matrix factorization; a receptor model. PMF can be used to determine source profiles and source contributions based on the ambient data.

**POC** Pollutant occurrence code used in the AQS.

Human hair
cross-section (70 µm)



# Definitions and Acronyms (10 of 12)

**Point source** Point sources include industrial and nonindustrial stationary equipment or processes considered significant sources of air pollution emissions. A facility is considered to have significant emissions if it emits about one ton or more in a calendar year. Examples of point sources include industrial and commercial boilers, electric utility boilers, turbine engines, industrial surface coating facilities, refinery and chemical processing operations, and petroleum storage tanks.

**Potential Source Contribution Function (PSCF)** A method that combines the source contribution estimates from PMF with the air parcel backward trajectories to identify possible source areas and pathways that give rise to the observed high particulate mass concentrations from the potential sources.

**Precursor** Compounds that change chemically or physically after being emitted into the air and eventually produce air pollutants. For example, sulfur and nitrogen oxides are precursors for particulate matter.

**Primary particles** The fraction of $PM_{10}$ and $PM_{2.5}$ that is directly emitted from combustion and fugitive dust sources.

**QA** Quality assurance; a set of external tasks to provide certainty that the quality control system is satisfactory. These tasks include independent performance audits, on-site system audits, interlaboratory comparisons, and periodic evaluations of internal quality control data.

**QC** Quality control; a set of internal tasks performed to provide accurate and precise measured ambient air quality data. These tasks address sample collection, handling, analysis, and reporting (e.g., periodic calibrations, routine service checks, instrument-specific monthly quality control maintenance checks, and duplicate analyses on split and spiked samples).

**R-squared, $r^2$** Statistical measure of how well a regression line approximates real data points; an $r^2$ of 1.0 (100%) indicates a perfect fit.

# Definitions and Acronyms (11 of 12)

**Receptor model** A receptor-oriented approach for identifying and quantifying the sources of ambient air contaminants at a receptor primarily on the basis of concentration measurements at that receptor.

**Reference Concentration (RfC)** An estimate (with uncertainty of perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

**Reid Vapor Pressure (RVP)** A measure of gasoline volatility.

**RFG** Reformulated gasoline.

**Residuals** Measured concentrations minus modeled concentrations.

**SEARCH** SouthEastern Aerosol Research and Characterization Study.

**Secondary formation** The fraction of a pollutant that is formed in the atmosphere (e.g., formaldehyde is both emitted directly and formed in the atmosphere through secondary photochemical processes).

**Selected ion monitoring (SIM)** A mass spectral mode in which the mass spectrometer is set to scan over a very small mass range, typically one mass unit, providing higher sensitivity results than a full mass scan.

**Slope** Statistical measure of the average ratio of the predicted to measured concentrations of a species; a slope closer to 1.0 demonstrates a closer fit.

**Source apportionment** The process of apportioning ambient pollutants to an emissions source. Also known as source attribution.

**Source contribution** Total mass of material from a source measured in a sample.

**Source-dispersion model** See Dispersion model.

**Source profile** Listing of individual chemical species emitted by a specific source category.

# Definitions and Acronyms (12 of 12)

**Speciation Trends Network (STN)** A network of sampling locations established by the EPA in 2001 to characterize $PM_{2.5}$ composition in urban areas. Roughly 300 sites nationwide are part of this network. Now part of the Chemical Speciation Network (CSN).

**Standard Deviation** A measure of how much the average varies. The square root of the average squared deviation of the observations from their mean.

**Standard operating procedure (SOP)** A set of instructions used to ensure data quality.

**Standardized residual** Ratio of the residual to the uncertainty of a species in a specific sample determined by the user.

**State implementation plan (SIP)** A detailed description of the programs a state will use to carry out its responsibilities under the Clean Air Act. State implementation plans are collections of the regulations used by a state to reduce air pollution. The Clean Air Act requires that the EPA approve each state implementation plan.

**SVOC** Semi-volatile organic compound.

**Toxicity** The degree to which a substance or mixture of substances can harm humans or environmental receptors.

**TRI** Toxic Release Inventory. Publicly available EPA database that contains information about toxic chemical releases and other waste management activities reported annually by certain covered industry groups as well as federal facilities <http://www.epa.gov/tri/index.htm>.

**TSP** Total suspended particulate.

**Uncensored data** Data reported "as is" with no substitution for values below detection.

**Variance** The square of the standard deviation.

**VOC** Volatile organic compound.

**WD** Wind direction.

**WS** Wind speed.

**XRF** Energy dispersive X-ray fluorescence. Method used to quantify particulate metals.

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