Quantifying PM NAAQS Attainment Status

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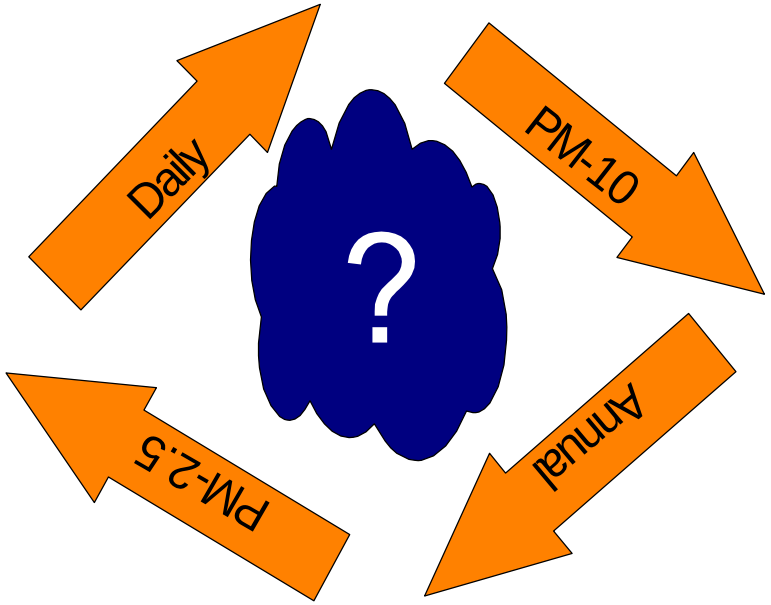
How to Calculate the Particulate NAAQS...



Overview of the Standard

- New National Ambient Air Quality Standards (NAAQS) were promulgated for particulate matter (PM) in 1997. [Three new standards were enacted, and one existing standard was retained.]
- The standards for PM are based on two indicators: PM_{10} and $PM_{2.5}$.
- Each measurement has an annual standard and a daily standard.

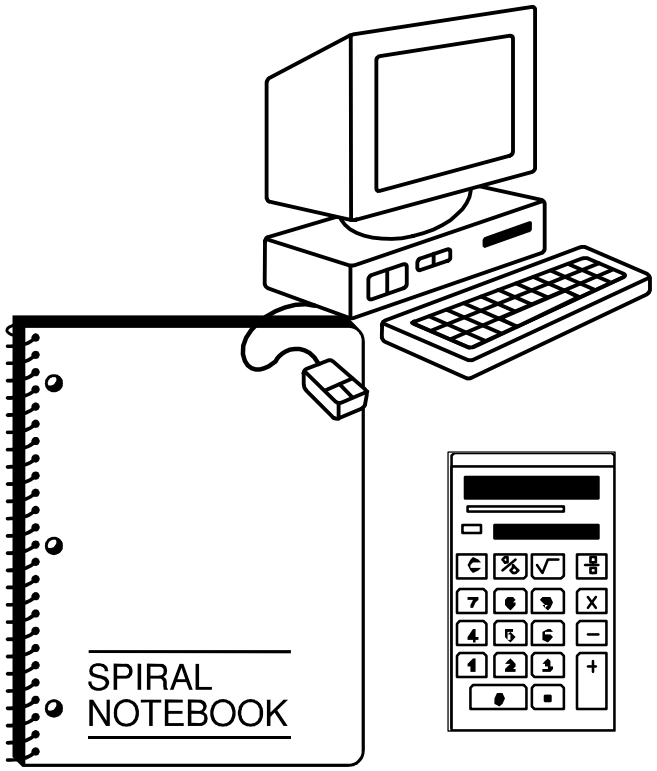
	Daily Standard ($\mu g/m^3$)	Annual Standard ($\mu g/m^3$)
PM_{10}	150	50
$PM_{2.5}$	65	15

Forms of the Standards

- **Annual**
  - ⇒ The annual standards are based on arithmetic averages. First, derive quarterly averages; then compute an annual average from the four quarterly averages.
  - ⇒ There is also an option to use a network-derived spatial mean for $PM_{2.5}$.
- **Daily**
  - ⇒ Daily standards are based on a percentile of a year's worth of daily values.
  - ⇒ The percentiles are 99^{th} for PM_{10} and 98^{th} for $PM_{2.5}$.
- **Both**
  - ⇒ Daily and annual standards are computed over three years.

Guidelines on Data Handling and Computation

- Daily Standards:
  - ⇒ Calculations
  - ⇒ Rounding
  - ⇒ Data Completeness
- Annual Standards:
  - ⇒ Calculations
  - ⇒ Rounding
  - ⇒ Data Completeness



Daily Standards - Calculations (1 of 2)

- Sort the Data
  - ⇒ For one year of measured data at one site, sort the data from lowest to highest.
  - ⇒ n = number of valid measurements for the year.
- Calculate which sorted value is the percentile
  - ⇒ I = int(n * P) + 1
  - ⇒ Where P is the percentile expressed as a fraction (e.g., 0.99 for PM_{10} and 0.98 for $PM_{2.5}$), and "int" is the integer part of the product of P and n.
  - ⇒ See the "Fact sheet on PM data handling" under technical fact sheets at <http://www.epa.gov/ttn/oarpg/naaqsfin/fs122398.html>

Daily Standards - Calculations (2 of 2)

- The first line of the table is representative of sampling every sixth day and 75% data completeness.
- The second line of the table is representative of (a) sampling every sixth day achieving 85% to 100% data completeness and (b) sampling every third day achieving 75% to 80% data completeness.
- The third line of the table is representative of sampling every third day achieving 81% to 100% data completeness.

Look-up table for determining the 98th or 99th percentile.

SAMPLES	nth Max for 98th percentile	nth max for 99th percentile
1 - 50	1	1
51 - 100	2	1
101 - 150	3	2
151 - 200	4	2
201 - 250	5	3
251 - 300	6	3
301 - 350	7	4
351 - 366	8	4

where
samples = number of monitored daily PM values in a year
nth Max for the 98th percentile = the nth highest value in a year that represents the 98th percentile (1 is the highest value measured in a year, 2 is the second highest value, etc.)
nth Max for the 99th percentile = the nth highest value in a year that represents the 99th percentile

Daily Standards - Rounding the 3-Year Average

- PM_{10} values are rounded to the nearest 10.
  - $\Rightarrow$ 155 $\mu g/m^3$ rounds to 160 $\mu g/m^3$ (a violation).
  - $\Rightarrow$ 154 $\mu g/m^3$ rounds to 150 $\mu g/m^3$ (non-violation).
- $PM_{2.5}$ values are rounded to the nearest 1.
  - $\Rightarrow$ 65.5 $\mu g/m^3$ rounds to 66 $\mu g/m^3$ (a violation).
  - $\Rightarrow$ 65.4 $\mu g/m^3$ rounds to 65 $\mu g/m^3$ (non-violation).

Daily Standards - Data Completeness

- To demonstrate attainment, 75% of all scheduled samples in each quarter must be collected and valid. The definition of "scheduled" is whatever schedule fulfills regulations in part 58 (monitoring).
- To demonstrate non-attainment, all values at or below the 98^{th} percentile (for $PM_{2.5}$) or the 99^{th} percentile (for PM_{10}) must be below the standard (i.e., if any value in the three years is above the appropriate percentile, non-attainment is achieved).

Daily Standards - Example

A $PM_{2.5}$ site, daily sampling with 281, 304, and 296 samples in Year 1, Year 2, and Year 3, respectively.

Year 1		Year 2		Year 3	
Rank	Measured value	Rank	Measured value	Rank	Measured value
275	57.9	296	54.3	290	66.0
276	62.0	297	57.1	291	68.4
277	62.2	298	63.0	292	69.8

- Using either the formula or table, the 98th percentile equals the 276th value for Year 1, the 298th value for Year 2, and the 291st value for Year 3.
- The 3-yr average is the mean of 62.0, 63.0, and 68.4 $\mu g/m^3$ (64.467, rounded is 64) which is less than the standard of 65 $\mu g/m^3$.
- Note that ranks are the opposite of an nth maximum (i.e., the first maximum would have the largest rank). Also, only round your data <u>just before</u> comparing to the level of the standard.

Annual Standards - Calculations

- Steps for Non-Spatial Annual Arithmetic Mean.
  - ⇒ Calculate quarterly means.
  - ⇒ Calculate annual means from quarterly means.
  - ⇒ Calculate 3-yr means from annual means.
- Steps for Spatial Annual Arithmetic Mean.
  - ⇒ Select sites to be used.
  - ⇒ Calculate quarterly means.
  - ⇒ Calculate annual means from quarterly means.
  - ⇒ Calculate spatial annual means for each year.
  - ⇒ Calculate 3-yr means from spatial annual means.

Annual Standards - Rounding the 3-Year Average

- PM_{10} values are rounded to the nearest 1.
  - $\Rightarrow$ 50.5 $\mu g/m^3$ rounds to 51 $\mu g/m^3$ (a violation).
  - $\Rightarrow$ 50.4 $\mu g/m^3$ rounds to 50 $\mu g/m^3$ (non-violation).
- $PM_{2.5}$ values are rounded to nearest 0.1.
  - $\Rightarrow$ 15.05 $\mu g/m^3$ rounds to 15.1 $\mu g/m^3$ (a violation).
  - $\Rightarrow$ 15.04 $\mu g/m^3$ rounds to 15.0 $\mu g/m^3$ (non-violation).

Annual Standards - Data Completeness

- To demonstrate attainment, 75% of all scheduled samples in each quarter are required.
- To demonstrate non-attainment, at least 11 samples in a quarter are required.
- Annual means are included in a spatial mean for a single year if they meet the data completeness requirements for that year.
- For spatial means, annual means from sites meeting either of the above criteria are included in the spatial mean.

Annual Standards - Example 1

- The 3-yr mean PM_{10} concentration = 65.94 $\mu g/m^3$ for a PM_{10} site with annual means of 52.42, 82.17, and 63.23 $\mu g/m^3$ calculated from quarterly means.
- This value rounds to 66 $\mu g/m^3$ which is greater than the level of the annual standard (50 $\mu g/m^3$).

Annual Standards - Example 2

A $PM_{2.5}$ network with annual means calculated from quarterly means

		Site 1	Site 2	Site 3	Site 4	Spatial mean
Year 1	Ann. mean	12.7				12.7
	% Comp.	80	0	0	0	
Year 2	Ann. mean	12.6	17.5	15.2		15.05
	% Comp.	90	83	38	0	
Year 3	Ann. mean	12.5	18.5	14.1	16.9	15.50
	% Comp.	90	80	85	50	
3-Year mean						14.42

- Annual means are averaged across sites (spatial mean) before averaging across years.
- This calculation assumes the site with 38% data completeness (Site 3, year 2) had less than 11 samples in each quarter. Thus, the 15.2 $\mu g/m^3$ annual mean was left out of the spatial mean calculation.
- If we also assume that the site with 50% data completeness (Site 4, year 4) resulted in all quarters with at least 11 samples, then the 16.9 $\mu g/m^3$ annual mean at that site is included in the spatial mean.
- The 3-yr mean rounds to 14.4 $\mu g/m^3$ which is less than the level of the standard of 15.0 $\mu g/m^3$.

Tools for Design Value Computation and Forecasting

- **AIRS** is a computer-based repository of information about airborne pollution in the United States and various World Health Organization (WHO) member countries. The availability subsystem contains measurements of ambient air pollutant concentrations and meteorological data from thousands of monitoring stations including descriptive information about each station (e.g., its geographic location and who operates it.
- **AMDAS** is a PC-based, user-friendly, menu-driven program that provides air quality analysts and managers with easy point-and-click access to air quality data for browsing, preparing tabular and graphical summaries, and performing statistical analyses. AMDAS can be used to analyze meteorological data, routine air quality data (i.e., hourly ozone, oxides of nitrogen, carbon monoxide, etc.), and atmospheric particulate matter data, including PM_{10} and $PM_{2.5}$ total mass and speciated sample data. AMDAS requires S-Plus for Windows version 4.5 or above. AMDAS is available at <http://www.environ.org/amdas>.

Exceptional Events

Exceptional events are unusual conditions that may cause or contribute to air quality violations. U.S. Environmental Protection Agency (1999) provides guidance on how to handle exceptional events with PM data as summarized next.

- Review the following three documents:
  - ⇒ *Guideline on the Identification and Use of Air Quality Data Affected by Exceptional Event*s, EPA 450/4-86-007, July, 1986. This document addresses uncontrollable events such as structural fires, high pollen count, chemical spills and industrial accidents, and activities that temporarily affect a nearby monitor.
  - ⇒ *Areas Affected by PM-10 Natural Event*s, Memorandum from Mary D. Nichols, Assistant Administrator for Air and Radiation, to EPA Regional Office Air Program Directors, May 30, 1996. This document addresses the treatment of data that are affected by volcanic and seismic activities, unwanted wildland fires (wildfires), and high wind events.
  - ⇒ *Interim Air Quality Policy on Wildland and Prescribed Fire*s, Memorandum from Richard D. Wilson, Acting Assistant Administrator for Air and Radiation, to EPA Regional Administrators, May 15, 1998. This document addresses the treatment of air quality data that are affected by wildland and prescribed fires that are managed to achieve resource benefits. Actions to be taken depend upon whether the wildland and prescribed fires managed for resource benefits significantly contribute to violations of the PM NAAQS.
- Review U.S. Environmental Protection Agency (1999).

Network Design Issues

Items to keep in mind with respect to network design and attainment issues include the following

⇒Ambient air is everywhere, irrespective of the population density "represented" by data from a monitoring site.

⇒Metrics are needed

- to express data representativeness and completeness of individual sites and networks for categorical source impacts
- to meet EPA monitoring objectives in the CFR and guidance documents
- to express population density distribution and change over time
- to assess primary and secondary aerosol formation, decomposition, and deposition

⇒Availability, reporting, storage, and retrieval of metadata for each site.

Summary

- This workbook section furnishes guidelines on how to perform calculations of the daily and annual standards, provides rounding conventions, and discusses how to determine data completeness.
- Discussions of available tools to assist in quantifying the PM NAAQS attainment status and of timely issues such as treatment of exceptional events, spatial network issues, and attainment design will be added to future versions of the workbook.

References

AMDAS is available at <http://www.environ.org/amdas>.

Fitz-Simmons T. (1999) How to calculate the particulate NAAQS. Paper presented at the National AIRS conference, San Francisco, May.

Nichols M.D. (1996) *Areas Affected by PM-10 Natural Event*s, Memorandum from the Assistant Administrator for Air and Radiation, to EPA Regional Office Air Program Directors, May 30. Available at <http://www.epa.gov/ttn/caaa/t1/memoranda/nepol.pdf>.

U.S. Environmental Protection Agency (1986) *Guideline on the Identification and Use of Air Quality Data Affected by Exceptional Event*s, EPA 450/4-86-007, July.

U.S. Environmental Protection Agency (1998a) Fact sheet on PM data handling available at <http://www.epa.gov/ttn/oarpg/naaqsfin/fs122398.html>.

U.S. Environmental Protection Agency (1998b) Code of Federal Regulations, Part 50. National primary and secondary ambient air quality standards. Available at <http://earth1.epa.gov/epacfr40/chapt_1.info/subch_C/40P0050.pdf>.

U.S. Environmental Protection Agency (1999) Guideline on data handling conventions for the PM NAAQS. Prepared by the office of air quality planning and standards, Research Triangle Park, North Carolina. EPA-454/R-99-008. April. Available at <http://www.epa.gov/ttn/oarpg/t1/memoranda/pmfinal.pdf>.

Wilson R.D. (1998) *Interim Air Quality Policy on Wildland and Prescribed Fire*s, Memorandum from Acting Assistant Administrator for Air and Radiation, to EPA Regional Administrators, May 15, 1998. Available at <http://www.epa.gov/ttncaaa1/t1/meta/m27340.html>.