UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 29 2010

OFFICE OF THE ADMINISTRATOR

MEMORANDUM

SUBJECT: Analyses of $PM_{2.5}$ Data for the PM NAAQS Review

FROM: Beth Hassett-Sipple, OAQPS/HEID
Mark Schmidt, OAQPS/AQAD
Pradeep Rajan, OAQPS/HEID

TO: PM NAAQS review docket EPA-HQ-OAR-2007-0492

General

This memo documents $PM_{2.5}$ air quality analysis conducted in support of the current review of the national ambient air quality standards (NAAQS) for particulate matter (PM). The purpose of this analysis was to provide insights to better characterize $PM_{2.5}$ air quality at which health effect associations have been observed in selected multi-city epidemiological studies. This analysis supplements additional air quality data submitted by study authors, as requested by EPA, to effectively place key epidemiological studies in a policy-relevant context (Hassett-Sipple and Stanek, 2009).[1]

In considering not only the level but also the form of the current $PM_{2.5}$ standards, we recognize that there may be differences between $PM_{2.5}$ concentrations averaged across monitors within a city/county as is typically considered in epidemiological studies, compared to the current forms of the $PM_{2.5}$ standards which typically focus on ambient measurements from the monitor reporting the highest concentration within an area. More specifically, the current forms of the $PM_{2.5}$ standards are as follows (for details, see 40 CFR Part 50, Appendix N):

- Annual $PM_{2.5}$ Standard – annual arithmetic mean (seasonally-weighted), averaged over 3 years, from single or multiple community-oriented monitoring sites. Measurements from multiple community-oriented monitoring sites can only be

[1] Emails from Beth M. Hassett-Sipple, EPA/OAQPS, and Lindsay W. Stanek, EPA/NCEA-RTP, to authors of recent U.S. and Canadian epidemiological studies evaluating health effects associated with exposure to fine and thoracic coarse particles: Request for PM Air Quality Data. May 2, 2009 and October 20, 2009. Docket No. EPA-HQ-ORD-2007-0517-0050 and EPA-HQ-ORD-2007-0517-0104.

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on 100% Recycled Paper (20% Postconsumer)

spatially averaged annual mean, (2) the daily values for each monitoring site pair yield a correlation coefficient of at least 0.9 for each quarter, and (3) evidence shows that all of the encompassed monitoring sites are principally affected by the same major emission sources of $PM_{2.5}$ (e.g., this could be demonstrated by site-specific chemical speciation profiles confirming all major component concentration averages to be within 10 percent for each calendar quarter). The 3-year average annual mean air quality metric (whether from a single site or a group of sites) is called the annual standard design value (DV). An area's annual standard DV is simply the highest valid site-level annual standard DV in that area for a given 3-year period unless EPA has approved the use of spatial averaging to average across multiple monitoring sites.[2]

- 24-hour $PM_{2.5}$ Standard – annual 98th percentile of the distribution of 24-hour concentrations at each population-oriented monitoring site, averaged over 3 years. The 3-year average 98th percentile concentration is called the 24-hour standard DV. An area's 24-hour standard DV is simply the highest valid site-level 24-hour DV in that area for a given 3-year period.

For this analysis, EPA extracted official federal reference method (FRM) data for the geographic areas and time periods utilized by the study authors of selected long- and short-term epidemiological studies noted below, and then computed NAAQS-like air quality metrics for each city/county per year (henceforth, referred to as area-period air quality metrics) using two approaches for assessing the air quality distribution: (1) a composite monitor or spatial averaging approach and (2) a maximum value or highest monitor approach. The former method is similar to approaches used by many health researchers. The latter method is more comparable to the metrics used to inform NAAQS attainment decisions (see additional details below). By having both sets of statistics available for the same sets of study areas, EPA could better understand the air quality distributions considered in the epidemiological studies to place these studies in a policy-relevant context.

Epidemiological Studies

Based upon epidemiological evidence assessed and presented in the *Integrated Science Assessment for Particulate Matter* (ISA, December 2009)[3] and discussed in the first draft PA, EPA selected six multi-city U.S. studies published since the last review of the PM NAAQS as the main focus of this analysis. These studies were selected because they considered multiple locations representing varying regions across several seasons that provide evidence on the influence of climate and particle mixes on health effects associated with long- or short-term $PM_{2.5}$ exposures. In addition, these multi-city studies considered relatively more recent air quality conditions (1999 to 2005).[4] The studies included in this analysis are as follows:

[2] The spatial averaging option has not been exercised in any area since revisions were made to the criteria in 2006 (71 FR 61144, October 17, 2006).
[3] EPA 600/R-08/139F. Available: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546.
[4] The network of $PM_{2.5}$ FRMs reporting to the AQS has been operational since 1999.

Long-term $PM_{2.5}$ Exposure Studies:

- *Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality*; Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi Y, Turner MC, Pope AC III, Thurston G, Calle EE, Thun MJ; 2009; HEI Research Report 140; $PM_{2.5}$ air quality area-period: 1999-2000.

- *Fine Particulate Matter and Mortality: A Comparison of the Six Cities and American Cancer Society Cohorts With a Medicare Cohort*; Eftim SE, Samet JM, Janes H, McDermott A, Dominici F. ; 2008; Epidemiology, 19: 209- 216; $PM_{2.5}$ air quality area-period: 2000-2002.

- *Long-term exposure to air pollution and incidence of cardiovascular events in women*; Miller KA, Siscovick DS, Sheppard L, Shepherd K, Sullivan JH, Anderson GL, Kaufman JD; 2007; N Engl J Med, 356: 447-458; $PM_{2.5}$ air quality area-period: 2000.

Short-term $PM_{2.5}$ Exposure Studies:

- *Seasonal and regional short-term effects of fine particles on hospital admissions in 202 U.S. counties, 1999-2005*; Bell ML, Ebisu K, Peng RD, Walker J, Samet JM, Zeger SL, Dominic F.; 2008; Am J Epidemiol, 168:1301-1310; $PM_{2.5}$ air quality area-period: 1999-2005.

- *Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases*; Dominici F, Peng RD, Bell ML, Pham L, McDermott A, Zeger SL, Samet JL.; 2006; JAMA, 295: 1127-1134; $PM_{2.5}$ air quality area-period: 1999-2002.

- *The effect of fine and coarse particulate air pollution on mortality: A national analysis*; Zanobetti A, Schwartz J.; 2009; Environ Health Perspect, 117: 1-40; $PM_{2.5}$ air quality area-period: 1999-2005.

Air Quality Data Used in the EPA Analysis

The EPA database for this project emanated from the site-based $PM_{2.5}$ FRM summary files processed for official DV calculations (circa. July 7, 2009); the data and associated processing details are posted at http://epa.gov/airtrends/pdfs/dv_pm25_2006_2008rev102809.xls. The original source of the raw data used to produce statistics in these posted summary files was the EPA's Air Quality System (AQS) data base, the official repository of NAAQS-comparable ambient measurements. Site-level annual mean concentrations and annual 98th percentile $PM_{2.5}$ concentrations were extracted from the posted Excel summary file for the geographic areas and years covered by the epidemiological studies noted above. The extracted annual air quality

metrics exclude significant, policy-relevant exceptional events[5], that is, flagged data points that were approved ("concurred") by an EPA Regional Office.

Note that the extracted area-period air quality metrics (i.e., annual mean concentrations and 98th percentiles), and not the 3-year average DVs themselves, were utilized for this analysis due to reasons discussed below. A data completeness criterion of a minimum of 11 observations per calendar quarter for all 4 quarters of a year was imposed, across the board, to validate the annual site-level metrics in this analysis. The 11 sample minimum (per quarter, for all 4 quarters of a year) is just one of several codified Appendix N options for validating annual metrics, but implemented "across-the-board" simplifies data characterization and permits utilization of a larger, more robust distribution of AQ data for the areas/years under consideration.

Area-period air quality metrics reported as annual mean and 98th percentile $PM_{2.5}$ concentrations in this analysis were calculated as follows:

- Composite monitor approach: valid (i.e., met data completeness criteria noted above) site-level annual metrics were averaged by year, and then those annual area means averaged over the relevant area-period assessed in each epidemiological study.

- Maximum value approach: the highest valid site level metric in the area was selected for each year, and then those annual area maxima averaged over the relevant area-period assessed in each epidemiological study.

Example calculations for a specific area are shown below:

[5] Exceptional events are events for which the normal planning and regulatory process established by the Clean Air Act (CAA) is not appropriate. Section 319 of the CAA defines an event as an exceptional event if the event affects air quality; is an event that is not reasonably controllable or preventable; is an event caused by human activity that is unlikely to recur at a particular location or a natural event; and is determined by EPA to be an exceptional event. The statutory definition of exceptional event specifically excludes stagnation of air masses or meteorological inversions; a meteorological event involving high temperatures or lack of precipitation; or air pollution relating to source noncompliance (72 FR 13561, March 22, 2007).

Calculation of area-period means

Site	Annual Means Using 11+ Obs Per Quarter Completeness Criteria								Area period means ↓
	1999	2000	2001	2002	2003	2004	2005		
Site A	26.21452	22.63237	21.82623	24.07894	19.62577	18.19531	19.10024		
Site B	8.523726		6.078743	7.865525	6.417973		5.842289		
Site C	23.80206	22.50693	21.16621	22.68761	17.1071	18.85816	17.9632		
Site D		7.759517		8.193643	5.907679	5.968588	7.012836		
Site E		20.26033	20.84112	23.5308	17.81862	17.41642	19.81719		
area annual averages →	19.51344	18.28979	17.47808	17.2713	13.37543	15.10962	13.94715	period average of the annual averages (a.k.a. community monitor means) (avg. of 7 values to the left) →	16.4264
area annual maxima →	26.21452	22.63237	21.82623	24.07894	19.62577	18.85816	19.81719	period average of the annual maxima (a.k.a. **maximum value means** (avg. of 7 values to the left) →	21.86474

Calculation of area-period 98th percentiles

Site	Annual 98th Percentiles Using 11+ Obs Per Quarter Completeness								Area period 98th %iles ↓
	1999	2000	2001	2002	2003	2004	2005		
Site A	95.3	93.9	95.9	80.4	51.9	53.9	74.9		
Site B	15.8		13.9	27.3	15		15.7		
Site C	97.4	92.7	94.9	73	48.3	61.5	63.2		
Site D		25.4		28	11.9	15.2	16.2		
Site E		76.5	90.6	66.8	47.5	47.6	66.4		
area annual averages →	69.5	72.125	73.825	55.1	34.92	44.55	47.28	period average of the annual averages (a.k.a. **community monitor 98th percentiles** (avg. of 7 values to the left) →	56.75714
area annual maxima →	97.4	93.9	95.9	80.4	51.9	61.5	74.9	period average of the annual maxima (a.k.a. **maximum value 98th pecentiles** (avg. of 7 values to the left) →	79.41429

After computing area-period air quality metric statistics in this analysis, overall study estimates were derived by averaging the area-period air quality metric values and identifying distribution percentile values for all cities and all years assessed in each study. Thus, a study median represents the middle value of a sorted array of area-period air quality metric values (i.e., annual mean and 98th percentile concentrations).

As mentioned above, area-period air quality metrics (both mean and 98th percentile $PM_{2.5}$ concentrations) computed using the maximum value approach are more comparable to the actual NAAQS metrics than area-period air quality metrics computed using the composite monitor approach, including for comparison to the current primary annual $PM_{2.5}$ standard since, as noted above, no area currently utilizes the codified spatial averaging option. However, even though the maximum value approach estimates are more comparable to the actual NAAQS metrics, there are some noteworthy differences. These include the following:

- Years of Air Quality Data Considered: This analysis matched measurement data from AQS for the years assessed in the selected epidemiological studies, resulting in 1 to 6 years of air quality data considered. For the purpose of determining attainment/nonattainment, 3-year average site-level metrics (i.e., DVs) are calculated from the annual site-level metrics, and the highest valid 3-year site-level average (DV) in an area is deemed that area's DV (for the given 3-year period). A 3-year site-

based aggregation was not performed in this evaluation because some of the epidemiological studies evaluated area-periods that were less than or more than three years.[6] If only 3-year averages were used to construct area-period air quality metrics, it would mean that study periods of less than 3 years would have no estimates, and that study periods of 4 or more years would be biased to the middle years. For example, for a study encompassing 2000-2005, taking an average of the 2000-2002, 2001-2003, 2002-2004, and 2003-2005 DVs would mean that the 2003 annual metric would be used three times, the 2002 and 2004 annual metrics would be used twice, and the 2001 and 2005 annual metrics would be used only once.

- Data Completeness Criteria: This analysis required (across the board) a minimum of 11 or more samples for all 4 quarters in a year in order to validate the annual air quality metrics (mean and 98th percentile $PM_{2.5}$ concentrations). This approach is consistent with analyses previously conducted by EPA to characterize air quality data including recent air quality characterizations of $PM_{2.5}$ presented in chapter 3 of the ISA. The official NAAQS data handling requirements for the annual metric components of design values are more complex; see 40 CFR Part 50, Appendix N for details.

After computing area-period air quality metrics and overall study air quality statistics, the values were compared, when available, to corresponding author supplied air quality data. Differences, generally minor in nature, may be related to a number of factors, including, but not limited to:

- Definition of Geographic Areas: Where specific monitoring site-level identifiers were provided in the study reports or directly by the study authors, EPA utilized this information to define geographic study areas. Where this information was not available, EPA utilized standard geographic area definitions in concert with methodological information included in the published reports. In some cases, there may be a difference in the area definitions, and thus in the set of monitoring sites evaluated by EPA compared to the study authors. For example, the study authors may have used metropolitan statistical area/consolidated metropolitan statistical area (MSA/CMSA) definitions while EPA utilized core-based statistical areas/combined statistical areas (CBSA/CSA) definitions.

- Air Quality Measurements - Utilization of Non-FRM and/or Non-AQS data: The EPA analysis considered only FRM data housed in the AQS database. However, study authors may have used a combination of FRM and non-FRM data. Also, study authors may have procured all or some of their data from sources other than AQS. For example, one study (Bell et al., 2008) identified some site/monitor minimum values of less than 0.0 $\mu g/m^3$ but AQS does not allow the entry of negative $PM_{2.5}$ FRM values; hence, we believe that at least some of the data used by the authors of

[6] Note, only one of the six studies considered, Etfim, et al., 2008, considered 3 years of air quality data.

this study were non-reference FRM data and/or obtained from sources in addition to the AQS data base.

- Collocated Monitors - It is not uncommon for collocated monitors to exist in the $PM_{2.5}$ monitoring network. The EPA aggregated data from collocated monitors per requirements specified in 40 CFR Part 50, Appendix N. Study authors may have aggregated data from collocated monitors using different criteria. For example, study authors may have averaged measurements across monitors or treated collocated monitors independently.

- Exceptional Events - The EPA excluded data flagged as related to an exceptional event. The study authors may or may not have censored concurred exceptional event data. Most of the study reports do not include information on the handling of exceptional events.

- Data Completeness Criteria - There may have been differences in the implemented data completeness criteria. Most of the study reports do not include information on data completeness criteria.

- Computational Differences - The EPA computed summary mean statistics by first averaging values by quarter first, then calculated an annual mean by averaging the four quarterly means, and then obtained a study mean by averaging across years. Study authors may have computed means differently, for example, they may have calculated annual means by averaging all data points in the year without regard to quarter. In addition, the EPA analysis used an independent, non-routine method (per 40 CFR Part 50, Appendix N) to identify a discrete reported observation as an annual 98th percentile value, while study authors may have used a commercially available software package function to estimate them. Furthermore, rounding protocols could have been different for the EPA analysis versus the study author computations

EPA Analysis Results and Comparison to Published Study Results

Attachment A details the EPA derived area-period air quality metrics and overall study summary results for each of the six selected epidemiological studies. Attachment B plots the EPA derived study summary statistics along with the same statistics from the published studies or from data supplied by the study authors. The annual mean $PM_{2.5}$ concentrations are plotted in Figure 1 and the 98th percentiles $PM_{2.5}$ concentrations are plotted in Figure 2.

Attachments

Bell (ST), 1999-2005

Overall Study Summary Statistics

Area	Composite monitor approach		Max value approach	
	annual mean	98th percentile	annual mean	98th percentile
n areas	204	204	204	204
study min	4.4	10	5.0	12
study P05	8.5	23	8.9	23
study P10	9.5	24	9.8	26
study P25	11.0	29	11.4	31
study med	13.0	33	13.5	34
study mean	12.9	33.5	13.4	35.4
study P75	14.7	37	15.2	39
study P90	16.3	40	17.0	42
study P95	16.8	44	19.0	51
study max	19.2	67	26.4	79
study SD	2.7	7	3.1	9
mn - 1 SD	10.2	26	10.3	26
mn + 1 SD	15.5	41	16.6	45

Area-period Statistics

Area	Composite monitor approach		Max value approach	
	annual mean	98th percentile	annual mean	98th percentile
Alabama_Jefferson	16.3	38	19.6	45
Alabama_Madison	14.5	34	14.5	34
Alabama_Mobile	13.4	30	13.9	32
Alabama_Montgomery	15.3	35	15.3	35
Alaska_Anchorage	6.4	23	6.5	24
Arizona_Maricopa	11	29	12	34
Arizona_Pima	6.9	15	7.2	16
Arkansas_Pulaski	14.2	32	14.6	33
California_Alameda	11.1	38	11.4	40
California_ContraCosta	10.7	42	10.7	42
California_Fresno	18.7	67	19.9	75
California_Kern	16.4	57	21.9	79
California_LosAngeles	19.2	50	22.7	61
California_Riverside	18.6	46	26.4	70
California_Sacramento	12.6	52	13.3	55
California_SanBernardino	18.9	50	24.1	69
California_SanDiego	14.2	36	15.6	42
California_SanFrancisco	11.2	42	11.2	42
California_SanJoaquin	15	52	15	52
California_SanMateo	10.4	37	10.4	37
California_SantaClara	12.3	45	12.8	47
California_Stanislaus	17.1	65	17.1	65
Colorado_Adams	10	25	10	25
Colorado_Arapahoe	8.5	23	8.5	23
Colorado_Denver	10.3	28	10.3	28
Connecticut_Fairfield	12.8	35	13.5	38
Connecticut_Hartford	11.6	33	12	34
Connecticut_NewHaven	13.9	37	16.1	40
Delaware_NewCastle	14.7	37	15.8	40
DistrictofCo_DistrictofColumbia	15.3	39	15.8	41
Florida_Alachua	10.2	23	10.3	23
Florida_Broward	8.5	20	8.6	21
Florida_Duval	10.6	26	10.8	26
Florida_Escambia	12.3	28	12.3	28
Florida_Hillsborough	11.6	25	11.7	26
Florida_Lee	8.8	19	8.8	19
Florida_Leon	12.9	29	12.9	29

Bell (ST), 1999-2005

Area-period Statistics, continued

Area	Composite monitor approach		Max value approach	
	annual mean	98th percentile	annual mean	98th percentile
Florida_Orange	10.4	24	10.5	24
Florida_PalmBeach	8.1	19	8.2	19
Florida_Pinellas	10.6	23	10.7	24
Florida_Seminole	9.8	23	9.8	23
Florida_Volusia	9.7	22	9.7	22
Georgia_Chatham	14.7	32	14.9	33
Georgia_Clayton	17.5	41	17.5	41
Georgia_Cobb	16.6	38	16.6	38
Georgia_DeKalb	16.9	38	17.3	40
Georgia_Fulton	17.8	38	19	41
Hawaii_Honolulu	4.4	10	5	12
Idaho_Ada	8.9	30	9.2	32
Illinois_Cook	16.1	40	18.9	46
Illinois_DuPage	14.6	35	14.6	35
Illinois_Kane	14	34	14	34
Illinois_Lake	12.5	32	12.5	32
Illinois_Madison	16.6	37	19.1	41
Illinois_McHenry	13	33	13	33
Illinois_St.Clair	15.9	36	16.5	38
Illinois_Will	13.7	33	14.5	35
Illinois_Winnebago	13.4	31	13.4	31
Indiana_Allen	14.1	34	14.3	34
Indiana_Marion	16.6	37	18.1	40
Indiana_St.Joseph	13.8	33	14.1	34
Iowa_Polk	10.6	29	10.8	30
Kansas_Johnson	11.5	27	11.7	29
Kansas_Sedgwick	11.2	26	11.4	27
Kentucky_Fayette	15.3	35	15.7	35
Kentucky_Jefferson	16.3	39	16.9	40
Louisiana_Caddo	13	29	13	29
Louisiana_E.BatonRouge	13.1	29	13.7	32
Louisiana_Jefferson	12.2	28	12.4	29
Louisiana_Orleans	12.9	30	13	32
Maine_Cumberland	10.7	30	11.4	32
Maryland_AnneArundel	14.2	36	15.5	38
Maryland_Baltimore	14.7	36	15.1	38
Maryland_Baltimore(city)	15.8	39	16.9	42
Maryland_Montgomery	13	34	13	34
Maryland_PrinceGeorge's	13.9	35	14.5	36
Massachusetts_Bristo	11.8	32	12.1	33
Massachusetts_Essex	10.5	30	10.7	31
Massachusetts_Hampden	12.5	35	13.7	38
Massachusetts_Middlesex	9.8	27	9.8	27
Massachusetts_Norfolk	12	31	12	31
Massachusetts_Plymouth	10.9	31	10.9	31
Massachusetts_Suffolk	13.3	32	14.4	35
Massachusetts_Worcester	11.3	31	11.9	32
Michigan_Genesee	12.3	33	12.3	33
Michigan_Ingham	12.9	34	12.9	34
Michigan_Kent	13.5	37	13.5	37
Michigan_Macomb	13.2	35	13.2	35
Michigan_Oakland	14.6	40	14.6	40
Michigan_Ottawa	13.1	35	13.1	35
Michigan_Saginaw	10.6	31	10.6	31
Michigan_Washtenaw	13.6	36	14.4	38

Bell (ST), 1999-2005

Area-period Statistics, continued

Area	Composite monitor approach annual mean	Composite monitor approach 98th percentile	Max value approach annual mean	Max value approach 98th percentile
Minnesota_Hennepin	10.4	28	10.7	30
Minnesota_Ramsey	11.3	30	12.1	34
Minnesota_St.Louis	7	21	8	24
Mississippi_Hinds	13.9	31	14.1	33
Missouri_Jackson	12.8	30	13.5	31
Missouri_St.Louis	13.9	35	14.3	36
Missouri_St.Louis(city)	14.9	35	15.3	36
Nevada_Clark	6.9	17	10.3	28
Nevada_Washoe	8.4	29	8.9	32
NewHampshire_Hillsborough	10.2	32	10.9	33
NewHampshire_Rockingham	9.5	28	9.6	28
NewJersey_Bergen	13.7	36	13.7	36
NewJersey_Camden	14.1	37	14.2	38
NewJersey_Essex	14.2	38	14.3	39
NewJersey_Gloucester	13.7	33	13.7	33
NewJersey_Hudson	15.2	40	15.3	40
NewJersey_Middlesex	12.4	34	12.4	34
NewJersey_Morris	11.4	32	12	33
NewJersey_Passaic	13	37	13	37
NewJersey_Union	14.5	38	15.7	41
NewMexico_Bernalillo	6.5	18	6.9	19
NewYork_Albany	11.4	33	11.6	33
NewYork_Bronx	14.7	38	15.8	40
NewYork_Broome	11.4	31	11.4	31
NewYork_Erie	13.6	37	14.4	38
NewYork_Kings	14.8	37	15	38
NewYork_Monroe	11.3	31	11.5	32
NewYork_Nassau	12	33	12.1	34
NewYork_NewYork	15.8	40	16.8	41
NewYork_Niagara	12.4	34	12.4	34
NewYork_Oneida	11.9	33	11.9	33
NewYork_Onondaga	10.9	30	11.1	31
NewYork_Queens	13.1	35	13.2	36
NewYork_Richmond	12.9	33	13.6	35
NewYork_Suffolk	11.9	33	11.9	33
NewYork_Westchester	12.2	34	12.2	34
NorthCarolina_Buncombe	13.5	30	13.5	30
NorthCarolina_Durham	14.4	33	14.4	33
NorthCarolina_Forsyth	14.9	34	15.1	35
NorthCarolina_Guilford	14.8	33	14.8	33
NorthCarolina_Mecklenburg	15.3	32	15.8	33
NorthCarolina_Wake	14.1	32	14.3	33
Ohio_Butler	16.3	38	16.8	40
Ohio_Cuyahoga	16.7	41	19	47
Ohio_Franklin	16.3	39	16.9	40
Ohio_Hamilton	17.1	39	18.5	44
Ohio_Lake	13.5	38	13.5	38
Ohio_Lorain	14.3	36	14.6	37
Ohio_Lucas	15	38	15.2	39
Ohio_Mahoning	15.7	38	15.8	39
Ohio_Montgomery	16	38	16.5	40
Ohio_Stark	16.7	39	17.4	40
Ohio_Summit	16.1	40	16.5	41
Ohio_Trumbull	15.4	39	15.4	39
Oklahoma_Oklahoma	10.3	26	10.5	28
Oklahoma_Tulsa	11.9	29	12.1	31
Oregon_Lane	9.4	34	13	55

Bell (ST), 1999-2005

Area-period Statistics, continued

Area	Composite monitor approach annual mean	Composite monitor approach 98th percentile	Max value approach annual mean	Max value approach 98th percentile
Oregon_Multnomah	8.7	26	8.9	27
Oregon_Washington	8.4	29	9	31
Pennsylvania_Allegheny	16.1	44	20.8	63
Pennsylvania_Berks	16	40	16	40
Pennsylvania_Cumberland	14.7	40	14.7	40
Pennsylvania_Dauphin	15.5	41	15.5	41
Pennsylvania_Delaware	15.2	36	15.2	36
Pennsylvania_Erie	13.3	35	13.3	35
Pennsylvania_Lackawanna	12.1	34	12.1	34
Pennsylvania_Lancaster	17	43	17	43
Pennsylvania_Northampton	14	37	14	37
Pennsylvania_Philadelphia	14.5	37	15.4	40
Pennsylvania_York	16.8	41	16.8	41
RhodeIsland_Providence	11.4	30	13.2	34
SouthCarolina_Charleston	12	29	12.3	29
SouthCarolina_Greenville	15.3	33	15.8	34
SouthCarolina_Lexington	14.4	31	14.7	32
SouthCarolina_Richland	14.1	31	14.5	32
SouthCarolina_Spartanburg	14.4	32	14.4	32
Tennessee_Davidson	14.8	34	15.3	36
Tennessee_Knox	16.8	36	17.6	38
Tennessee_Shelby	14	33	14.7	35
Texas_Bexar	9.1	24	9.7	28
Texas_Cameron	9.8	24	9.8	24
Texas_Collin	11.6	28	11.6	28
Texas_Dallas	13.3	30	14.2	32
Texas_ElPaso	12.6	32	14.8	41
Texas_Galveston	10.5	26	10.9	29
Texas_Harris	12.5	29	14.5	32
Texas_Hidalgo	10.8	26	11	27
Texas_Jefferson	11.3	29	11.5	30
Texas_McLennan	10.1	33	10.1	33
Texas_Montgomery	11.2	27	11.2	27
Texas_Nueces	9.9	23	10.2	25
Texas_Tarrant	12.3	27	12.7	29
Texas_Travis	10.4	24	11.5	26
Utah_Davis	9.5	44	9.5	44
Utah_SaltLake	12.1	50	14.4	57
Virginia_Fairfax	14	35	14.4	37
Virginia_Henrico	13.6	32	13.9	33
Virginia_Norfolk(city)	13.2	31	13.2	31
Washington_Clark	9.9	37	9.9	37
Washington_King	9.5	27	11.5	34
Washington_Pierce	11	39	11.2	43
Washington_Spokane	9.5	29	10.3	31
Washington_Thurston	9.3	34	9.3	34
WestVirginia_Kanawha	16.8	38	17.4	39
Wisconsin_Brown	11.1	34	11.4	35
Wisconsin_Dane	12.4	34	12.5	34
Wisconsin_Milwaukee	13.2	36	13.8	40
Wisconsin_Waukesha	13.4	36	13.7	36

Dominici (ST), 1999-2002				
Overall Study Summary Statistic				
	Composite monitor approach		Max value approach	
Area	annual mean	98th percentile	annual mean	98th percentile
n areas	204	204	204	204
study min	4.5	11	4.9	13
study P05	8.8	23	9.2	24
study P10	9.6	25	10.1	26
study P25	11.2	30	11.6	32
study med	13.4	34	13.9	35
study mean	13.3	34.5	13.9	36.6
study P75	15.1	38	15.6	40
study P90	16.8	41	17.7	45
study P95	17.5	50	19.9	55
study max	20.8	77	29.2	92
study SD	2.9	8.6	3.4	10.4
mn - 1 SD	10.4	25.9	10.5	26.2
mn + 1 SD	16.1	43.1	17.3	47.0

Dominici (ST), 1999-2002				
Area-period Statistics				
	Composite monitor approach		Max value approach	
Area	annual mean	98th percentile	annual mean	98th percentile
Alabama_Jefferson	17.2	39	20.6	46
Alabama_Madison	15.1	34	15.1	34
Alabama_Mobile	14.1	31	14.6	33
Alabama_Montgomery	16.2	36	16.2	36
Alaska_Anchorage	6.2	24	6.4	26
Arizona_Maricopa	11.2	29	12.2	35
Arizona_Pima	7.6	17	7.9	19
Arkansas_Pulaski	14.7	32	15.1	33
California_Alameda	12.6	45	12.8	48
California_ContraCosta	11.7	48	11.7	48
California_Fresno	19.9	74	21.8	86
California_Kern	18.1	68	23.7	92
California_LosAngeles	20.8	53	24.7	65
California_Riverside	20.4	50	29.2	73
California_Sacramento	13.6	60	14.5	62
California_SanBernardino	20.4	53	26	73
California_SanDiego	15.4	38	16.9	44
California_SanFrancisco	12.5	52	12.5	52
California_SanJoaquin	16.4	61	16.4	61
California_SanMateo	11.5	45	11.5	45
California_SantaClara	13.3	51	13.6	52
California_Stanislaus	19.5	77	19.5	77
Colorado_Adams	10	26	10	26
Colorado_Arapahoe	8.9	23	8.9	23
Colorado_Denver	10.9	30	10.9	30
Connecticut_Fairfield	12.9	34	13.4	37
Connecticut_Hartford	11.7	31	12.1	32
Connecticut_NewHaven	14.1	36	16.6	40
Delaware_NewCastle	15	38	16.3	42
DistrictofCo_DistrictofColumbia	15.8	40	16.3	43
Florida_Alachua	10.7	25	10.9	25
Florida_Broward	8.8	22	8.8	23
Florida_Duval	11	27	11.3	28
Florida_Escambia	12.8	27	12.8	27
Florida_Hillsborough	12.1	26	12.2	27
Florida_Lee	9.2	21	9.2	21
Florida_Leon	13.2	30	13.2	30
Florida_Manatee	10.3	28	10.3	28

Dominici (ST), 1999-2002				
Area-period Statistics, continued				
	Composite monitor approach		Max value approach	
Area	annual mean	98th percentile	annual mean	98th percentile
Florida_Miami-Dade	9.4	20	10.6	22
Florida_Orange	10.9	26	11	26
Florida_PalmBeach	8.3	19	8.3	19
Florida_Pinellas	11.2	25	11.5	26
Florida_Seminole	10.1	23	10.1	23
Florida_Volusia	10.1	24	10.1	24
Georgia_Chatham	15.5	36	15.6	36
Georgia_Clayton	18.2	43	18.2	43
Georgia_Cobb	17.1	39	17.1	39
Georgia_DeKalb	18	41	18.5	43
Georgia_Fulton	18.6	40	20.2	43
Hawaii_Honolulu	4.5	11	4.9	13
Idaho_Ada	9.3	33	9.6	36
Illinois_Cook	16.8	40	20.2	47
Illinois_DuPage	15.3	34	15.3	34
Illinois_Kane	14.6	35	14.6	35
Illinois_Lake	13.1	33	13.1	33
Illinois_Madison	17.3	38	20.1	42
Illinois_McHenry	13.6	34	13.6	34
Illinois_St.Clair	16.5	39	17.2	40
Illinois_Will	14.6	33	15.5	36
Illinois_Winnebago	14.9	34	14.9	34
Indiana_Allen	14.2	34	14.5	34
Indiana_Marion	16.9	38	18.3	42
Indiana_St.Joseph	14.2	33	14.4	34
Iowa_Polk	10.7	27	11	28
Kansas_Johnson	11.9	27	12.2	28
Kansas_Sedgwick	11.4	26	11.7	27
Kentucky_Fayette	15.8	37	16.2	38
Kentucky_Jefferson	17.1	41	17.7	42
Louisiana_Caddo	13.4	30	13.4	30
Louisiana_E.BatonRouge	13.5	31	14.1	34
Louisiana_Jefferson	12.6	29	12.9	30
Louisiana_Orleans	13.3	30	13.4	32
Maine_Cumberland	10.1	30	11.1	33
Maryland_AnneArundel	14.7	36	15.7	38
Maryland_Baltimore	14.8	37	15.2	38
Maryland_Baltimore(city)	16	39	17	43
Maryland_Montgomery	13.4	37	13.4	37
Maryland_PrinceGeorge's	15.2	38	16.4	40
Massachusetts_Bristo	11.8	32	12.1	33
Massachusetts_Essex	11.2	31	11.4	32
Massachusetts_Hampden	13.2	37	14.4	40
Massachusetts_Middlesex	9.8	27	9.8	27
Massachusetts_Norfolk	12	31	12	31
Massachusetts_Plymouth	11.7	33	11.7	33
Massachusetts_Suffolk	13.8	33	14.8	36
Massachusetts_Worcester	11.5	31	12.5	33
Michigan_Genesee	12.7	34	12.7	34
Michigan_Ingham	13.2	36	13.2	36
Michigan_Kent	13.9	37	13.9	37
Michigan_Macomb	13.3	36	13.3	36
Michigan_Oakland	14.8	40	14.8	40
Michigan_Ottawa	13.4	36	13.4	36
Michigan_Saginaw	10.7	31	10.7	31
Michigan_Washtenaw	14	34	14.5	35
Michigan_Wayne	16.7	41	19.9	46

Dominici (ST), 1999-2002

Area-period Statistics, continued

Area	Composite monitor approach annual mean	Composite monitor approach 98th percentile	Max value approach annual mean	Max value approach 98th percentile
Minnesota_Dakota	10.8	31	10.9	32
Minnesota_Hennepin	11.2	31	11.5	32
Minnesota_Ramsey	11.9	33	12.7	37
Minnesota_St.Louis	7.5	22	8.5	25
Mississippi_Hinds	14.3	32	14.5	34
Missouri_Jackson	13	30	13.9	31
Missouri_St.Louis	14.3	36	14.7	37
Missouri_St.Louis(city)	15.3	37	15.7	37
Nevada_Clark	7.6	19	11.1	31
Nevada_Washoe	8.6	28	9.6	33
NewHampshire_Hillsborough	11.4	34	11.5	36
NewHampshire_Rockingham	10	29	10.2	29
NewJersey_Bergen	14	36	14	36
NewJersey_Camden	14.3	36	14.4	36
NewJersey_Essex	14.6	38	14.9	39
NewJersey_Gloucester	14	35	14	35
NewJersey_Hudson	15.7	40	15.9	40
NewJersey_Middlesex	12.2	32	12.2	32
NewJersey_Morris	11.5	31	12.1	33
NewJersey_Passaic	12.9	37	12.9	37
NewJersey_Union	14.7	38	15.9	41
NewMexico_Bernalillo	6.2	17	6.8	20
NewYork_Albany	10.9	31	11.3	32
NewYork_Bronx	15	38	16	40
NewYork_Broome	11.4	31	11.4	31
NewYork_Erie	13.9	37	15	39
NewYork_Kings	14.9	36	15.4	37
NewYork_Monroe	11.5	32	11.7	33
NewYork_Nassau	12	32	12.1	32
NewYork_NewYork	16.4	39	17.5	40
NewYork_Niagara	12.5	34	12.5	34
NewYork_Oneida	11.9	33	11.9	33
NewYork_Onondaga	11.2	34	11.8	35
NewYork_Queens	13.5	35	13.7	37
NewYork_Richmond	13.3	34	14.2	37
NewYork_Suffolk	12.4	32	12.4	32
NewYork_Westchester	12.5	34	12.5	34
NorthCarolina_Buncombe	14.2	31	14.2	31
NorthCarolina_Durham	14.9	33	14.9	33
NorthCarolina_Forsyth	15.4	35	15.7	36
NorthCarolina_Guilford	15.5	34	15.6	35
NorthCarolina_Mecklenburg	15.7	33	16.2	34
NorthCarolina_Wake	14.6	33	14.8	35
Ohio_Butler	16.8	38	17.3	40
Ohio_Cuyahoga	17.1	41	19.6	47
Ohio_Franklin	17.1	39	17.7	41
Ohio_Hamilton	17.5	40	18.9	44
Ohio_Lake	13.9	39	13.9	39
Ohio_Lorain	14.9	37	14.9	39
Ohio_Lucas	15.4	39	15.6	39
Ohio_Mahoning	16	39	16	39
Ohio_Montgomery	16.5	38	17	39
Ohio_Stark	17.3	41	18.1	42
Ohio_Summit	16.8	41	17.2	42
Ohio_Trumbull	15.9	39	15.9	39
Oklahoma_Oklahoma	10.5	27	10.8	29
Oklahoma_Tulsa	12.2	29	12.6	30

Dominici (ST), 1999-2002

Area-period Statistics, continued

Area	Composite monitor approach annual mean	Composite monitor approach 98th percentile	Max value approach annual mean	Max value approach 98th percentile
Oregon_Lane	9.6	36	13.4	56
Oregon_Multnomah	8.8	26	9	27
Oregon_Washington	8.5	31	9.2	34
Pennsylvania_Allegheny	16.5	45	20.8	60
Pennsylvania_Berks	15.9	41	15.9	41
Pennsylvania_Cumberland	14.2	39	14.2	39
Pennsylvania_Dauphin	15.3	43	15.3	43
Pennsylvania_Delaware	14.9	36	14.9	36
Pennsylvania_Erie	13.7	36	13.7	36
Pennsylvania_Lackawanna	12	35	12	35
Pennsylvania_Lancaster	16.7	42	16.7	42
Pennsylvania_Northampton	14	38	14	38
Pennsylvania_Philadelphia	14.9	39	15.5	41
Pennsylvania_York	16.5	41	16.5	41
RhodeIsland_Providence	11.6	30	14.1	35
SouthCarolina_Charleston	12.1	29	12.5	30
SouthCarolina_Greenville	15.5	33	15.8	34
SouthCarolina_Lexington	14.6	30	15	31
SouthCarolina_Richland	14.5	31	14.8	31
SouthCarolina_Spartanburg	14.7	31	14.7	31
Tennessee_Davidson	15.5	35	16.2	38
Tennessee_Knox	18.1	38	19.1	40
Tennessee_Shelby	14.6	33	15.4	36
Texas_Bexar	9.1	24	9.7	28
Texas_Cameron	9.7	20	9.7	20
Texas_Collin	11.6	28	11.6	28
Texas_Dallas	13.8	31	14.5	34
Texas_ElPaso	9.6	26	12.7	39
Texas_Galveston	10.5	29	11.1	34
Texas_Harris	12.1	30	14.1	34
Texas_Hidalgo	10.6	24	10.7	25
Texas_Jefferson	11.1	34	11.4	34
Texas_McLennan	10.1	33	10.1	33
Texas_Montgomery	10.7	25	10.7	25
Texas_Nueces	10.1	23	10.3	24
Texas_Tarrant	12.2	28	12.6	29
Texas_Travis	10.4	24	11.5	26
Utah_Davis	9.5	44	9.5	44
Utah_SaltLake	12.3	54	14.1	61
Virginia_Fairfax	14.2	36	14.6	37
Virginia_Henrico	13.7	32	14	33
Virginia_Norfolk(city)	13.4	31	13.4	31
Washington_Clark	9.9	38	9.9	38
Washington_King	9.6	28	11.8	37
Washington_Pierce	11.1	38	11.5	45
Washington_Spokane	9.3	30	10.4	33
Washington_Thurston	9.7	36	9.7	36
WestVirginia_Kanawha	17.5	39	18.1	41
Wisconsin_Brown	11.1	33	11.8	34
Wisconsin_Dane	12.7	34	12.9	34
Wisconsin_Milwaukee	13.5	36	14.2	40
Wisconsin_Waukesha	13.4	36	13.8	37

Zanobetti (ST) 1999-2005

Overall Study Summary Statistics

	Composite monitor approach		Max value approach	
Area	annual mean	98th percentile	annual mean	98th percentile
n areas	99	99	99	99
study min	6.4	17	6.7	19
study P05	9.2	24	9.7	24
study P10	10.4	26	10.5	28
study P25	11.6	30	12.0	32
study med	13.5	35	14.3	36
study mean	13.7	35.6	14.1	36.9
study P75	15.4	39	15.8	41
study P90	16.8	42	17.6	45
study P95	18.2	52	19.1	55
study max	26.4	75	26.4	79
study SD	3.0	9.4	3.2	9.7
mn - 1 SD	10.7	26.2	11.0	27.2
mn + 1 SD	16.8	45.0	17.3	46.6

Zanobetti (ST) 1999-2005

Area-period Statistics

	Composite monitor approach		Max value approach	
Area	annual mean	98th percentile	annual mean	98th percentile
Akron	16.1	40	16.5	41
Albuquerque	6.4	17	6.7	19
Allentown	14	37	14	37
Anaheim	17.6	51	17.6	51
Annandale	13.8	35	13.8	35
Atlanta	18.1	39	19	41
Austin	11.5	26	11.5	26
Bakersfield	21	75	21.9	79
Baltimore	15.8	39	16.9	42
Baton Rouge	13.6	30	13.7	32
Bend	7.6	23	7.6	23
Birmingham	18.8	44	19.6	45
Boston	13.3	32	14.4	35
Carlisle	14.9	41	14.9	41
Cedar Rapids	11.1	31	11.2	32
Charleston	12	29	12	29
Charlotte	15.3	32	15.8	33
Chesapeake	12.9	31	12.9	31
Chicago	16.3	39	17.2	43
Cincinnati	17.3	39	18.4	43
Cleveland	17	42	19	47
Columbia	14.5	32	14.5	32
Columbus	16.3	39	16.9	40
Dallas	13.3	30	14.2	32
Davenport	12.4	31	12.8	33
Davie	8.4	20	8.4	20
Dayton	16	38	16.5	40
Denver	10.4	28	10.5	28
Des Moines	10.8	29	10.8	30
Detroit	15.9	42	17.2	44
Durham	14.4	33	14.4	33
El Cajon	14.8	39	14.8	39
Elizabeth	15	39	15.7	41
Elpaso	12.4	31	14.8	41
Erie	13.3	35	13.3	35
Eugene	9.1	36	9.1	36
Fresno	19.7	72	19.9	73
Gary	16.3	40	17.5	45

Zanobetti (ST) 1999-2005

Area-period Statistics, continued

	Composite monitor approach		Max value approach	
Area	annual mean	98th percentile	annual mean	98th percentile
Grand Rapids	13.5	37	13.5	37
Greensb	14.8	33	14.8	33
Harrisburg	15.5	41	15.5	41
Hartford	12.6	35	12.6	35
Holland	12.2	35	12.2	35
Houston	12.9	29	14.5	32
Indianapolis	16.6	37	18.1	40
Jacksonville	10.6	26	10.8	26
Kansas City	12.8	30	13.7	32
Klamath	10.7	41	10.7	41
Knoxville	16.8	36	17.6	38
Little Rock	14.3	32	14.6	33
Los Angeles	21.2	58	21.2	58
Louisville	16.3	39	16.9	40
Medford	11.1	39	11.2	40
Memphis	14.4	33	14.7	35
Miami	9.2	20	10.1	21
Middletown	16.2	38	16.6	40
Milwaukee	13.2	36	13.8	40
Minneapolis	10.5	29	10.7	30
Nashville	14.8	34	15.3	36
Newhaven	14.6	38	16	40
New Orleans	12.9	30	13	32
New York	14.5	37	16.8	42
Norfolk	13.2	31	13.2	31
Oklahoma	10.3	26	10.5	28
Omaha	10.4	27	10.7	29
Orlando	10.4	24	10.4	24
Pensacola	12.4	28	12.4	28
Philadelphia	14.5	37	15.4	40
Phoenix	11.4	31	12	34
Pittsburgh	15.3	39	15.7	42
Portarthur	11.5	30	11.5	30
Portland	8.7	26	8.9	27
Providence	11.4	30	12.5	33
Provo	10.4	38	10.4	38
Raleigh	14.1	32	14.3	33
Richmond	14.4	33	14.4	33
Rubidoux	26.4	70	26.4	70
Sacramento	12.6	52	13.3	55
Salt Lake	13	52	14.4	55
Sanantonio	9.8	22	9.8	22
Scranton	12.1	34	12.1	34
Seattle	10.1	28	11.5	31
Spokane	9.7	29	10.3	31
Springfield	13.3	37	13.7	38
State College	13.2	38	13.2	38
Steubenville	17.8	45	17.8	45
Stlouis	14.9	35	15.3	36
Tacoma	11.2	39	11.2	41
Tampa	11.6	25	11.7	26
Taylors	14.8	33	14.8	33
Toledo	15	38	15.2	39
Tulsa	11.9	29	12.1	31
Warren	15.4	39	15.4	39
Washington	15	36	15	36
Waukesha	13.4	36	13.7	36
Wilmington	15.8	39	15.8	39
Winston	14.9	34	15.1	35
Worcester	12	32	12.3	32
Youngstown	15.7	38	15.8	39

Miller (LT), 2000		
Overall Study Summary Statistics		
Area	Composite monitor approach annual mean	Max value approach annual mean
n areas	36	36
study min	4.7	5.0
study P05	9.4	11.4
study P10	9.7	12.1
study P25	10.8	14.2
study med	12.5	17.1
study mean	12.9	16.8
study P75	15.1	18.7
study P90	16.9	21.2
study P95	17.8	23.1
study max	18.3	28.3
study SD	3.0	4.3
mn - 1 SD	9.8	12.5
mn + 1 SD	15.9	21.0

Miller (LT), 2000		
Area-period Statistics		
Area	Comp mon approach annual mean	Max value approach annual mean
Birmingham	17.9	22.3
Bronx	13.8	18.4
Buffalo	12.8	16.1
Chestnut Hill	11.3	15.8
Chicago	14.5	18.3
Cincinnati	16.5	19.3
Columbus	16.8	19.3
Davenport	12.9	15.3
Decatur	17.7	21.5
Des Moines	10.4	11.4
Detroit	14.7	20.1
Durham	14.8	17.9
Fall River	11.6	16.2
Gainesville	12.4	18.1
Honolulu	4.7	5
Houston	11.9	14.3
Iowa City	11.3	14.8
Jacksonville	12.2	15.6
La Jolla	17	25.3
Los Angeles	18.3	28.3
Memphis	15.5	16.9
Miami	9.6	11.3
Middleton	12.6	16.5
Milwaukee	12.7	17.3
Minneapolis	10.9	13.8
Oakland	11.8	18.7
Phoenix	10.2	12.1
Pittsburgh	15.8	20.9
Portland	8.9	12.8
Reno	9.7	18.7
Sacramento	10.9	18.7
San Antonio	10.1	12.1
Seattle	10.4	13
Tucson	9.5	12.6
Washington	15	17.8
Winston-Salem	15.7	17.9

Krewski (LT), 1999-2000		
Overall Study Summary Statistics		
Area	Composite monitor approach annual mean	Max value approach annual mean
n areas	38	38
study min	6.3	9
study P05	8.8	9.7
study P10	10.0	10.2
study P25	13.3	13.9
study med	15.1	16.1
study mean	14.8	16.3
study P75	17.1	18.8
study P90	19.0	22.5
study P95	19.8	23.2
study max	20.5	24.9
study SD	3.5	4.3
mn - 1 SD	11.3	12.0
mn + 1 SD	18.3	20.6

Krewski (LT), 1999-2000		
Area-period Statistics		
Area	Composite monitor approach annual mean	Max value approach annual mean
Akron	16.4	17.3
Albuquerque	6.3	8.5
Ashland	15	15
Atlanta	19.8	22.3
Bakersfield	18.9	24.4
Bethlehem	13.2	13.6
Birmingham	19.2	22.9
Boise	9.2	9.8
Buffalo	14.2	16.1
Butte	10.4	10.4
Camden	14.6	14.8
Charlotte	16.4	17.2
Chattanooga	18.6	19
Chicago	16.5	21
Cincinnati	18.3	19.7
Cleveland	17.2	20.5
Dallas	13.6	15.2
Dayton	17	17.8
Denver	8.5	9.7
Durham	14.7	15.7
El Paso	8.9	9.7
Fresno	20.5	23
Gary	15.1	16.9
Hartford	11	11.3
Houston	12.2	14.3
Indianapolis	17.1	18.1
Jackson	15.7	16.1
Jersey City	13.8	16.6
Little rock	15.7	16
Los Angeles	19.9	24.9
Minneapolis	18.3	20.2
Mobile	16.3	16.8
Nashville	16.9	18
Norfolk	13.4	13.7
Oklahoma City	10.5	10.9
Omaha	10.7	11.4
Pasadena	14.6	16.1
Philadelphia	13.9	15.3

Krewski (LT), 1999-2000		
Area-period Statistics, continued		
Area	Composite monitor approach annual mean	Max value approach annual mean
Phoenix	10.3	12.6
Portland	8.4	9.4
Providence	10.9	14.9
Reno	8.5	9.4
Salt Lake City	10.7	13.4
San Francisco	12	12.6
San Jose	14.6	14.9
Seattle	10.6	12.3
Spokane	9.4	10.6
St. Paul	12.8	13.8
Steubenville	18.7	19.4
Tampa	12.3	13.2
Topeka	11.6	11.6
Wichita	11.8	12.1
Youngstown	16.3	16.5

Eftim (LT), 2000-2002		
Overall Study Summary Statistics		
Area	Composite monitor approach annual mean	Max value approach annual mean
n areas	38	38
study min	6.7	9.1
study P05	9.0	10.3
study P10	9.7	10.9
study P25	12.6	13.7
study med	14.5	15.4
study mean	14.0	15.8
study P75	16.2	18.6
study P90	16.9	20.0
study P95	17.8	20.6
study max	20.2	24.4
study SD	3.0	3.6
mn - 1 SD	11.1	12.2
mn + 1 SD	17.0	19.4

Eftim (LT), 2000-2002		
Area-period Statistics		
Area	Composite monitor approach annual mean	Max value approach annual mean
Akron	16.2	17.0
Albuquerque	6.7	10.2
Ashland	15.5	15.5
Atlanta	17.1	19.3
Bakersfield	17.7	22.8
Bethlehem	14.3	14.6
Birmingham	16.1	19.6
Boise	9.7	10.3
Buffalo	13.5	15.0
Butte	9.1	9.1
Camden	14.3	14.6
Charlotte	15.1	15.7
Chattanooga	16.2	16.8
Chicago	15.8	19.6
Cincinnati	16.8	18.6
Cleveland	16.3	19.2
Dallas	12.5	13.7
Dayton	15.7	16.8
Denver	8.5	11.0
Durham	13.7	14.7
El Paso	9.7	13.8
Fresno	18.6	19.9
Gary	15.3	17.7
Hartford	12.0	12.5
Houston	11.5	14.1
Indianapolis	16.8	18.5
Jackson	13.6	14.0
Jersey City	13.7	15.9
Little rock	14.4	15.1
Los Angeles	20.2	24.4
Minneapolis	14.7	20.1
Mobile	13.0	13.4
Nashville	14.6	15.3
Norfolk	12.9	13.3
Oklahoma City	10.1	10.8
Omaha	10.5	11.1
Pasadena	16.3	20.2
Philadelphia	14.8	16.2

Eftim (LT), 2000-2002		
Area-period Statistics, continued		
Area	Composite monitor approach annual mean	Max value approach annual mean
Phoenix	9.6	11.9
Portland	8.5	9.8
Providence	10.7	14.1
Reno	8.1	9.5
Salt Lake City	11.9	14.6
San Francisco	11.8	12.5
San Jose	12.4	12.8
Seattle	10.3	11.9
Spokane	9.4	10.4
St. Paul	11.9	12.7
Steubenville	18.1	18.6
Tampa	11.4	12.0
Topeka	10.8	10.9
Wichita	11.0	11.4
Youngstown	15.7	15.8

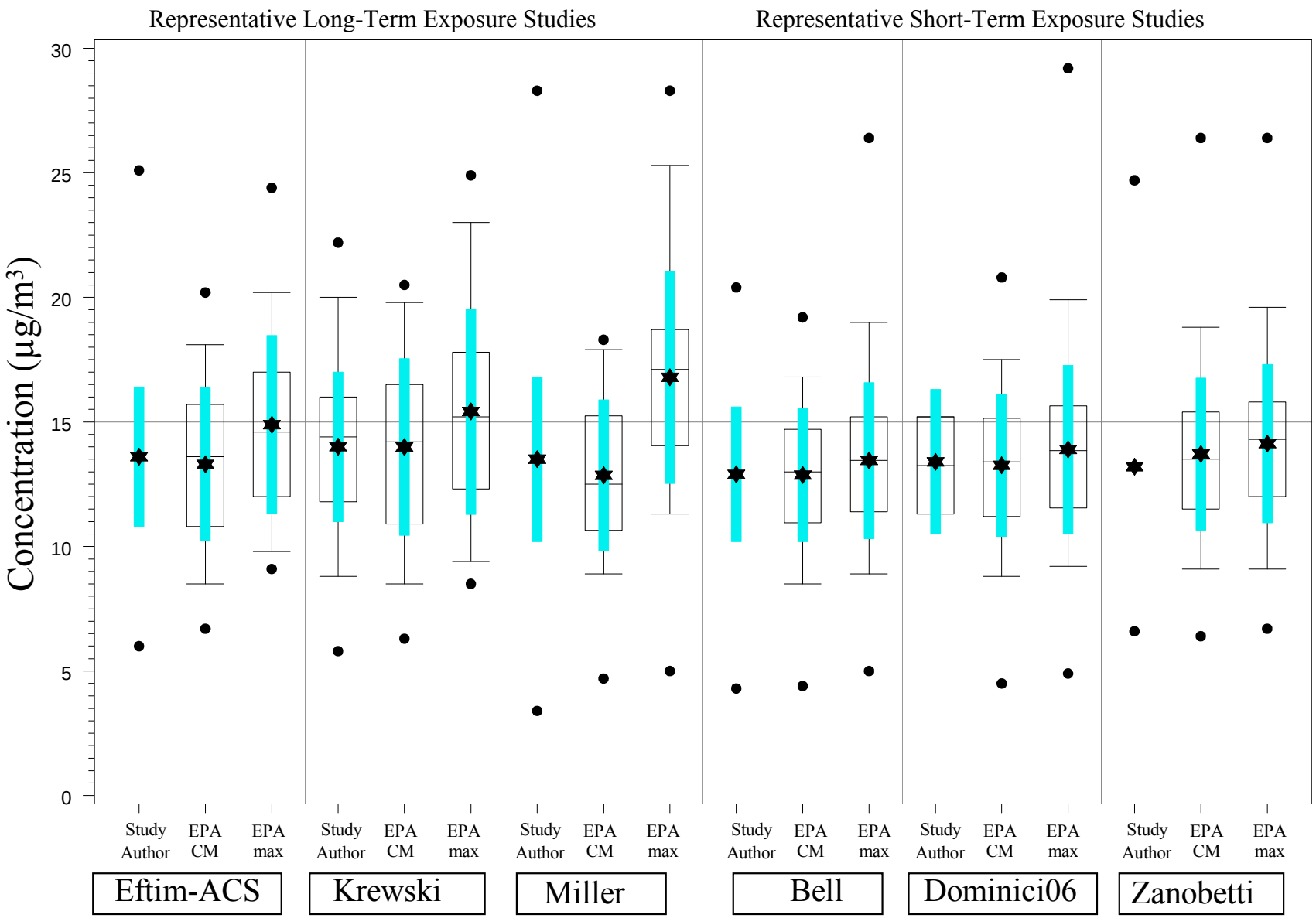

Figure 1: Distribution of study-specific area means: Left plots represent the study author results; middle plots represent EPA replication results using a composite monitor (spatial average) approach; and right plots represent EPA replication results using a maximum value approach (max monitor mean for each year averaged over the study timeframe). Black outlined boxes denote inter-quartile range and medians, stars denote means with cyan rectangles spanning +/- one standard deviation from the mean, and dots represent the minimum and maximum values.

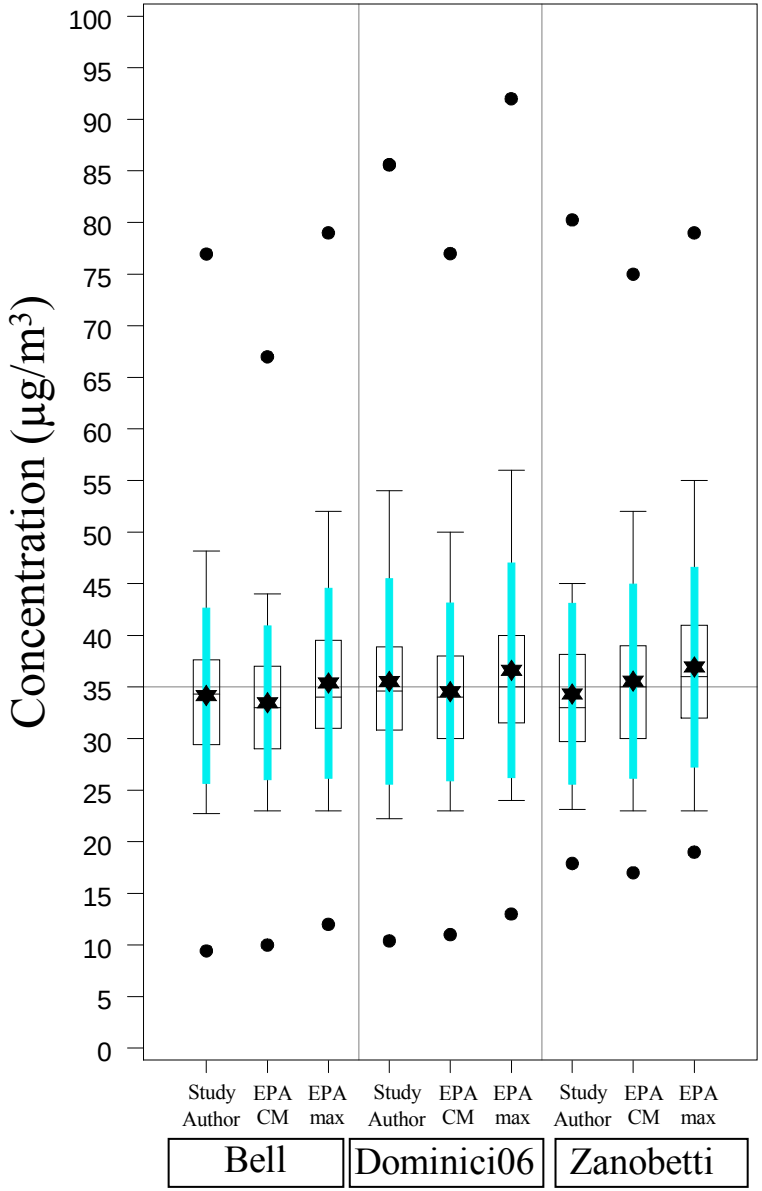

Figure 2: Distribution of EPA derived study-specific area 98th percentiles: Left plots represent the study author results; middle plots represent EPA replication results using a composite monitor (spatial average) approach; and right plots represent EPA replication results using a maximum value approach (max monitor 98th percentile for each year averaged over the study timeframe). Black outlined boxes denote inter-quartile range and medians, stars denote means with cyan rectangles spanning +/- one standard deviation from the mean, and dots represent the minimum and maximum values.