UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Corrections to Relative Humidity Values Used in the Draft Urban-Focused Visibility Assessment, Corrected Graphics and Tables, and Availability of Detailed Data File for Current Conditions

FROM: Philip A. Lorang, Leader
Air Quality Analysis Group
Office of Air Quality Planning and Standards, EPA

TO: PM NAAQS Review Docket (EPA-HQ-OAR-2007-0492)

Subsequent to the CASAC review of the Draft Urban-Focused Visibility Assessment (UFVA) document, EPA staff have identified an error in the 1-hour relative humidity (RH) values used in that assessment. This error has been corrected. Based on an examination of corrected versions of key figures and tables (attached), the correction of the error does not affect the major conclusions that can reasonably have been drawn from the original draft UFVA.

This memorandum describes the error and, in qualitative terms, the changes that are anticipated when all affected figures and tables in the draft UFVA are corrected. This memorandum also describes a large data file that is being made available to the public, containing detailed corrected hourly inputs and outputs for the process of estimating current visibility conditions in the 15 study areas.

Description of the Error

The intended approach for obtaining hourly RH values was to use the RH value reported by the nearest National Weather Service (NWS) station or air quality monitoring station which reported RH to the Air Quality System (AQS) for that hour. However, due to a coding error, instead, what was selected was the RH value reported by the furthest away of the five nearest AQS stations and the five nearest NWS stations. This resulted in the use of data from RH measurement sites that are unnecessarily distant from the $PM_{2.5}$ monitoring site being used to develop the visibility characterization for the study area. In the most affected case, most RH data for the Rubidoux site in the "Los Angeles" study area were taken from a NWS site in Lancaster, California, which is 68 miles away and is more inland, higher elevation, and drier than Rubidoux.

Attached are a box-and-whisker plot and a table illustrating the distribution of the differences between the incorrect and corrected hourly RH values, by study site (both titled "Ramification of RH Error").

The erroneous code has been corrected and re-run to obtain appropriate, more representative RH values for each hour and study area. Light extinction under current conditions has been re-estimated with the corrected RH values.

Assessment of the Implications of Correcting the Relative Humidity Data Error

Comparison of the original Figure 3-8 in the Draft UFVA and the corrected version (attached) reveals that the revised estimates of light extinction under current conditions for each study area have moved in the direction suggested by the central point of the distribution of correction amounts shown in the first attached graphic. That is, for areas where the new RH data are generally in the direction of higher RH levels, the distributions of daylight and maximum daylight 1-hour light extinction estimates have shifted towards higher values. The shifts in light extinction values are largest for the Los Angeles study area, which had the largest upward shift in the distribution of RH values. The reverse is true for areas where the new RH values are generally lower than the original values, for example, in Birmingham.

The number of days above the candidate CPLs (Table 3-6) and the light extinction design values based on the 90th and 95th percentile forms for each study area (Table 4-2) have shifted in the obvious direction given the direction of the shift in light extinction levels. Similarly, greater or lesser reductions in non-PRB light extinction are needed to meet NAAQS scenarios (Table 4-3).

The Los Angeles study area is now estimated to have notably more adverse light extinction level under conditions than previously. In terms of the percentage of days that CPLs are exceeded, Los Angeles still falls within the range of eastern areas, but its light extinction design values for the 90th percentile and 95th percentiles are now about a factor of two higher than any other area.

Major conclusions which could reasonably be drawn from the original Draft UFVA still hold:

- Light extinction levels under current conditions frequently exceed the candidate protective levels. See corrected Figure 3-8.
- Western areas other than Fresno and Los Angeles generally have better light extinction conditions than eastern areas (see corrected Figure 3-8), and would need smaller reductions than eastern areas to meet NAAQS scenarios based on light extinction (see corrected Table 4-3).

- Light extinction levels under the 15/35 and 12/25 $PM_{2.5}$ mass NAAQS scenarios would frequently exceed the CPLs. Fresno, Los Angeles, and eastern areas would have more days and hours with light extinction levels above the CPLs than would the other (western) areas. (See corrected Figure 4-1(b)).
- Correlations between $PM_{2.5}$ mass over sub-24-hour periods and light extinction (Appendix D) indicate that such a $PM_{2.5}$ mass indicator would be significantly less precise in limiting periods of high light extinction. (Corrected graphics are not yet available, but the correlations in the original UFVA graphics are quite poor and are unlikely to be improved notably in any area since there is no reason to expect the RH corrections to improve the correlation between RH and $PM_{2.5}$ concentrations, which would be necessary to improve the correlation between $PM_{2.5}$ and light extinction.)

Corrections to Figures and Tables

Attached are the following corrected graphics and tables:

- Figure 3-7 (c). Distribution of PM parameters and relative humidity across the 2005-2007 period, by study area. 1-hour relative humidity.
- Figure 3-8 (a). Distributions of estimated daylight 1-hour total light extinction and maximum daily daylight 1-hour total light extinction across the 2005-2007 period, by study area. Individual 1-hour values.
- Figure 3-8 (b). Distributions of estimated daylight 1-hour total light extinction and maximum daily daylight 1-hour total light extinction across the 2005-2007 period, by study area. Maximum daily values.
- Figure 4-1(b). Distributions of daily maximum daylight 1-hour total light extinction under two "just meeting" secondary NAAQS scenarios. Secondary NAAQS of 15 $\mu g/m^3$ for the annual average and 35 $\mu g/m^3$ for the 98^{th} percentile 24-hour average.
- Table 3-6. Percentage of days in which daily maximum daylight 1-hour total light extinction exceeded three candidate protective levels across the 2005-2007 period, by study area.
- Table 4-2. Current conditions total light extinction design values for the study areas.
- Table 4-3. Percentage reductions in non-PRB light extinction required to "just meet" the NAAQS scenarios based on measured light extinction.

Other graphics and tables affected by the error will be corrected in the final version of the UFVA. The following bullets identify those that will be affected by the correction and the nature of the change that can be expected.

- Figure 3-9. Distributions of 1-hour total light extinction levels by daylight hour across the 2005-2007 period, by study area.
  - The distribution by hour for each study area will shift, consistent with the direction and relative magnitude of the shifts seen in Figure 3-8 (a).

- Figure 3-10. Distributions of 1-hour relative humidity levels by daylight hour across the 2005-2007 period, by study area.
  - Distributions of relative humidity by hour will shift.
- Figure 3-11. Scatter plot of daylight 1-hour relative humidity (percent) vs. reconstructed total light extinction (Mm^{-1}) across the 2005-2007 period, by study area.
  - Because the RH value is used to calculate the light extinction value in each hour, individual 1-hour data points will shift upward and to the right or downward and to the left, depending on whether hourly RH has increased or decreased. Los Angeles will have more high RH/high light extinction data points.
- Figures 3-12 through 3-19. Light Extinction Budgets for the Top 10 Percent of Days for Maximum Daily 1-hour PM Light Extinction for 2005-2007.
  - The days that are among the top 10 percent may change somewhat. In Los Angeles, sulfate and nitrate will be a larger part of the extinction budgets. Changes in other areas will be mixed and smaller, with nitrate and sulfate being more important than in the uncorrected version in those areas where the distribution of RH values has shifted towards higher RH.
- Figure 4-1 (a). Distributions of daily maximum daylight 1-hour total light extinction under two "just meeting" secondary NAAQS scenarios. Secondary NAAQS based on measured total light extinction with a level of 122 Mm^{-1} and a 90^{th} percentile form.
  - Only small changes are expected in the box-and-whisker plot for this NAAQS scenario based on light extinction, since rollback forces light extinction levels towards the NAAQS goal regardless of where those levels are in the current conditions scenario.
- Table 4-5. Total light extinction design values for "just meeting" secondary NAAQS scenarios based on measured total light extinction.
  - There may be very minor changes to some table entries.
- Table 4-6. Total light extinction design values for "just meeting" secondary NAAQS scenarios based on $PM_{2.5}$ mass.
  - Design values will likely increase notably in Los Angeles, consistent with the shifts in Figure 4-1. Changes in other areas will be mixed, and smaller.
- Table 4-7. Percentage of days across 3 years (two in the case of Phoenix and Houston) with maximum 1-hour daylight total light extinction above CPLs when "just meeting" the NAAQS scenarios.
  - Entries for Los Angeles will increase notably for the 15/35 and 12/25 NAAQS scenarios. Changes in other areas for these scenarios will be mixed and smaller. Only much smaller changes are expected in entries for the NAAQS scenarios based on light extinction, since rollback forces light extinction levels towards the NAAQS goal regardless of where those levels are in the current conditions scenario.

- Figure B-1 (c). Distribution of daily maximum $PM_{2.5}$, $PM_{10-2.5}$, and relative humidity across the 2005-2007 period, by study area.
  - Distributions of relative humidity will shift.
- Table C-3. 2005-2007 Average Policy Relevant Background Daylight Total Light Extinction.
  - Policy relevant background light extinction values will only change slightly because these are dominated by PM components other than sulfate and nitrate.
- Tables and Figures in Appendix D Relationships Between PM Mass Concentration and Total Light Extinction Under Current Conditions.
  - Data points in the scatter plots will move up or down depending on whether the corrected RH for that time period is higher or lower than the uncorrected RH. In Los Angeles, upward movements will be more common, and the correlations between $PM_{2.5}$ mass and light extinction will likely be reduced. Changes in other areas will be smaller.
- Tables and Figures in Appendix E Differences in Daily Patterns of Relative Humidity and Total Light Extinction Between Areas and Seasons.
  - All plotted points will shift. Red and black points will shift in the same directions. Because Los Angeles is the only study area where the corrected RH values come from a site with distinctly different climatology than did the uncorrected RH values, it likely will be the only study area where the shifts may be notable.
- Tables and Figures in Appendix F Distributions of Maximum Daily Daylight Total Light Extinction Under "Just Meet" Conditions.
  - Changes to graphics (a) through (f) should be minor since the rollback procedure forces light extinction levels towards the level of the light extinction NAAQS. In graphics (g) and (h) for the 15/35 and 12/25 NAAQS scenarios, the distributions of light extinction levels will shift. The distribution for Los Angeles will shift notably upwards. Changes in other areas will be mixed and smaller.

Availability of Detailed Data File for Current Conditions

EPA has posted to the public website (http://www.epa.gov/ttn/analysis/pm.htm) a file titled "UFVA data file w RH fixed Nov 04 2009.txt" containing the following input and output variables associated with the estimate of 1-hour light extinction and PRB light extinction for the 15 study areas. The file size is 10.4 Mbytes when zipped and 32.1 Mbytes unzipped. This list of variable names and meanings is included in the zipped file.

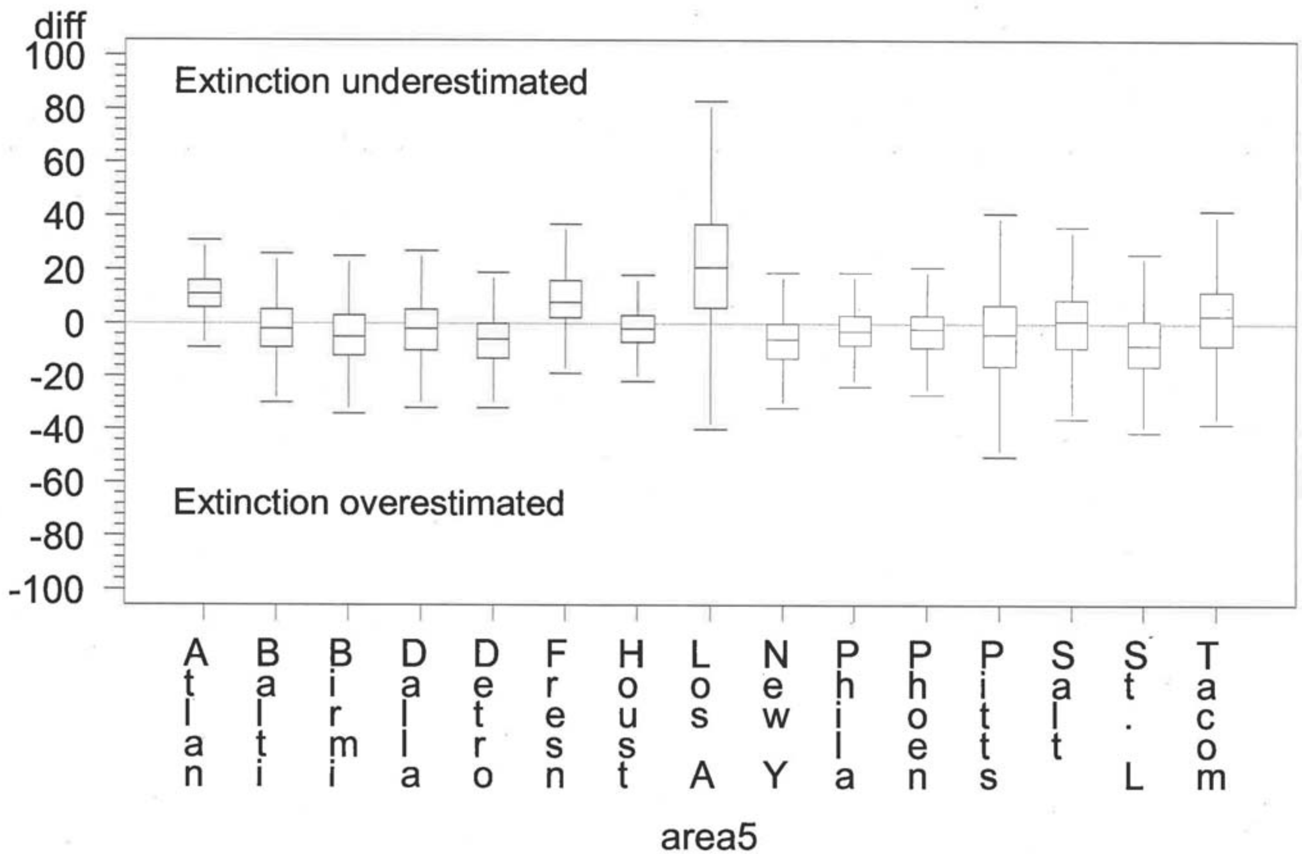
area	number code for study area
RH	hourly relative humidity (input)
Datetime	date and time of start of hour, 0:00 is midnight
hrly_frm	continuous 1-hour $PM_{2.5}$ normalized to match the FRM for 24-hour average
hrlyso4	1-hr sulfate, fully neutralized (final result)
hrlyno3	1-hour nitrate, fully neutralized CSN-consistent (not sandwich) (final result)

hrlyocm	1-hour OCM by sandwich (final result)
hrlysoil	1-hour $PM_{2.5}$ soil by IMPROVE fine soil formula (final result)
hrlyec	1-hour EC (final result)
hrlynon_frm	sum of the above 5
prb.soil	PRB fine soil, from CMAQ (input)
prb.ec	PRB elemental carbon, from CAMQ (input)
prb.no3	PRB nitrate, no NH4, from CMAQ (input)
prb.so4	PRB sulfate, no NH4, from CMAQ (input)
prb.ocm	PRB ocm including non-carbon, from CMAQ (input)
hrly_total_prb	sum of the above 5, no NH4 or H_2O added
pmt_lc	1-hour PM_{10} in LC, used to calculate pmc (input)
pmc	1-hr $PM_{10\text{-}2.5}$ (final result)
pmc_flag	a code to indicate how pmc was estimated 81102 means hourly PM_{10} first had to be converted from STP to LC 85101 means hourly PM_{10} was reported as LC, no conversion needed Ratio means pmc = a regional factor x raw_hrly_pm25 (always in LC)
frh	F(RH)
bext	light extinction calculated from the 5 "hrly" $PM_{2.5}$ components, pmc, and Rayleigh
so4bext	a term in the bext summation
no3bext	a term in the bext summation
ocmbext	a term in the bext summation
ecbext	a term in the bext summation
soilbext	a term in the bext summation
pmcbext	a term in the bext summation
dayshrs	code for whether the hour was treated as daylight (0=nondaylight, 1=daylight)
sdate	dd/mm/yyyy
areaname	name of study area
raw_hrly_pm25	original hourly $PM_{2.5}$ from continuous instruments (input)

Attachments

Ramification of RH error – Providing the furthest of the 5 closest AQS sites and 5 closest NWS sites … instead of the closest

Diff = (closest RH) – (RH provided Mike Rizzo)



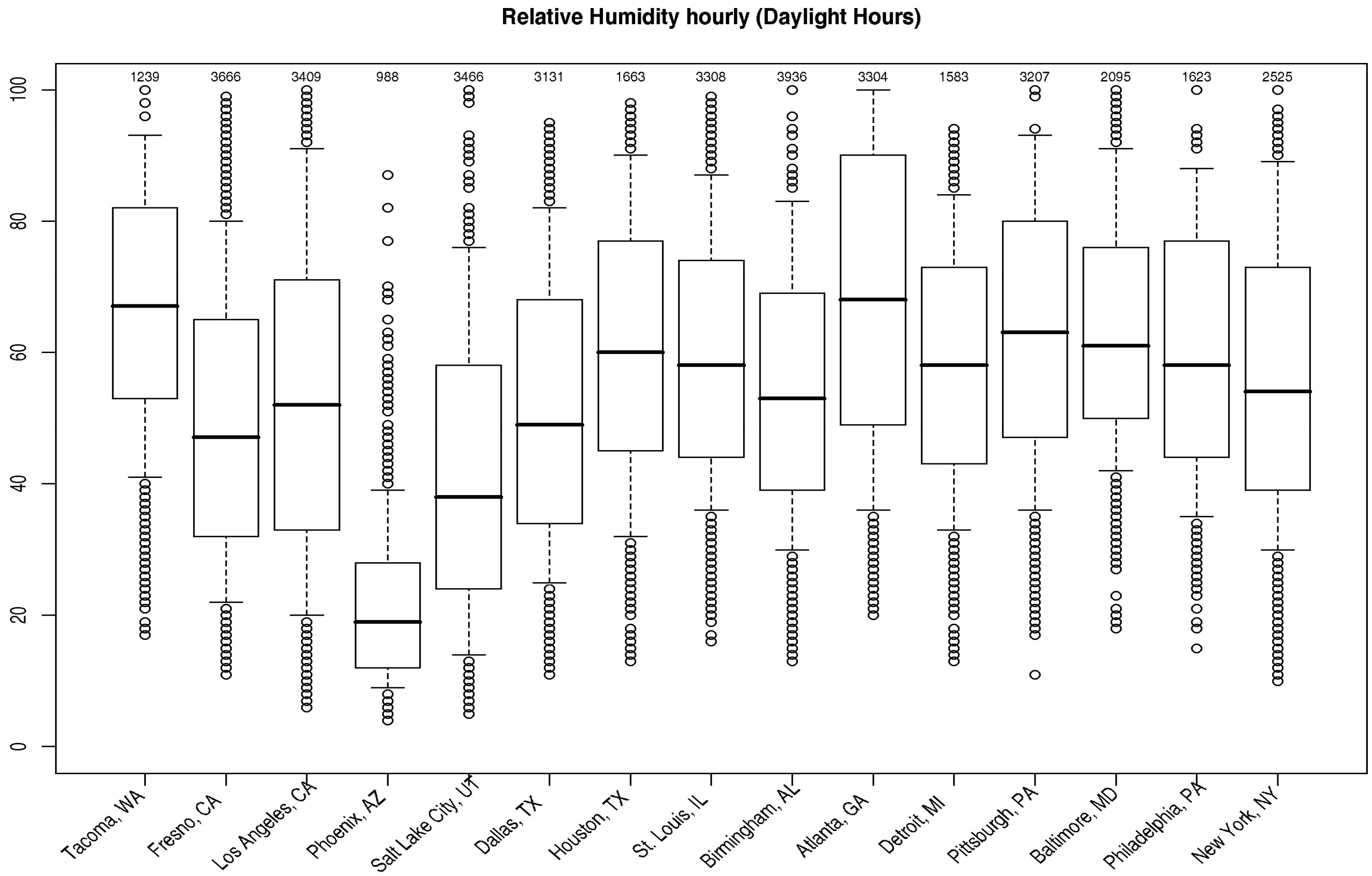
Ramification of RH error – Providing the furthest of the 5 closest AQS sites and 5 closest NWS sites … instead of the closest

Diff = (closest RH) – (RH provided Mike Rizzo)

area	site	n	max	q3	mean	med	q1	min	Pct5	Pct95
Atlanta, GA	130890002	7080	73	16	10.48	11	6	-77	-7	27
Baltimore MD	240053001	4488	36	5	-2.66	-2	-9	-43	-21	14
Birmingham, AL	010730023	8400	48	3	-4.50	-5	-12	-63	-25	17
Dallas, TX	481130069	6576	57	5	-2.51	-2	-10	-56	-24	20
Detroit, MI	261630033	3384	39	0	-6.39	-6	-13	-55	-24	10
Fresno, CA	060190008	7776	62	16	8.41	8	2	-54	-10	28
Houston, TX	482010024	3576	45	3	-2.07	-2	-7	-52	-18	13
Los Angeles, CA	060658001	7248	93	37	21.56	21	6	-67	-20	63
New York, NY	340390004	5444	37	0	-7.45	-6	-13	-55	-27	7
Philadelphia, PA\	100032004	3480	38	3	-2.64	-3	-8	-37	-17	13
Phoenix AZ	040137020	2064	40	3	-3.80	-2	-9	-64	-25	12
Pittsburgh PA	420030008	6816	70	7	-4.03	-4	-16	-82	-37	28
Salt Lake City, UT	490353006	7344	77	9	0.30	1	-9	-72	-26	28
St. Louis MO-IL	295100085	7056	46	1	-7.78	-8	-16	-52	-27	12
Tacoma, WA	530530029	2640	72	12	2.54	3	-8	-57	-23	30.5

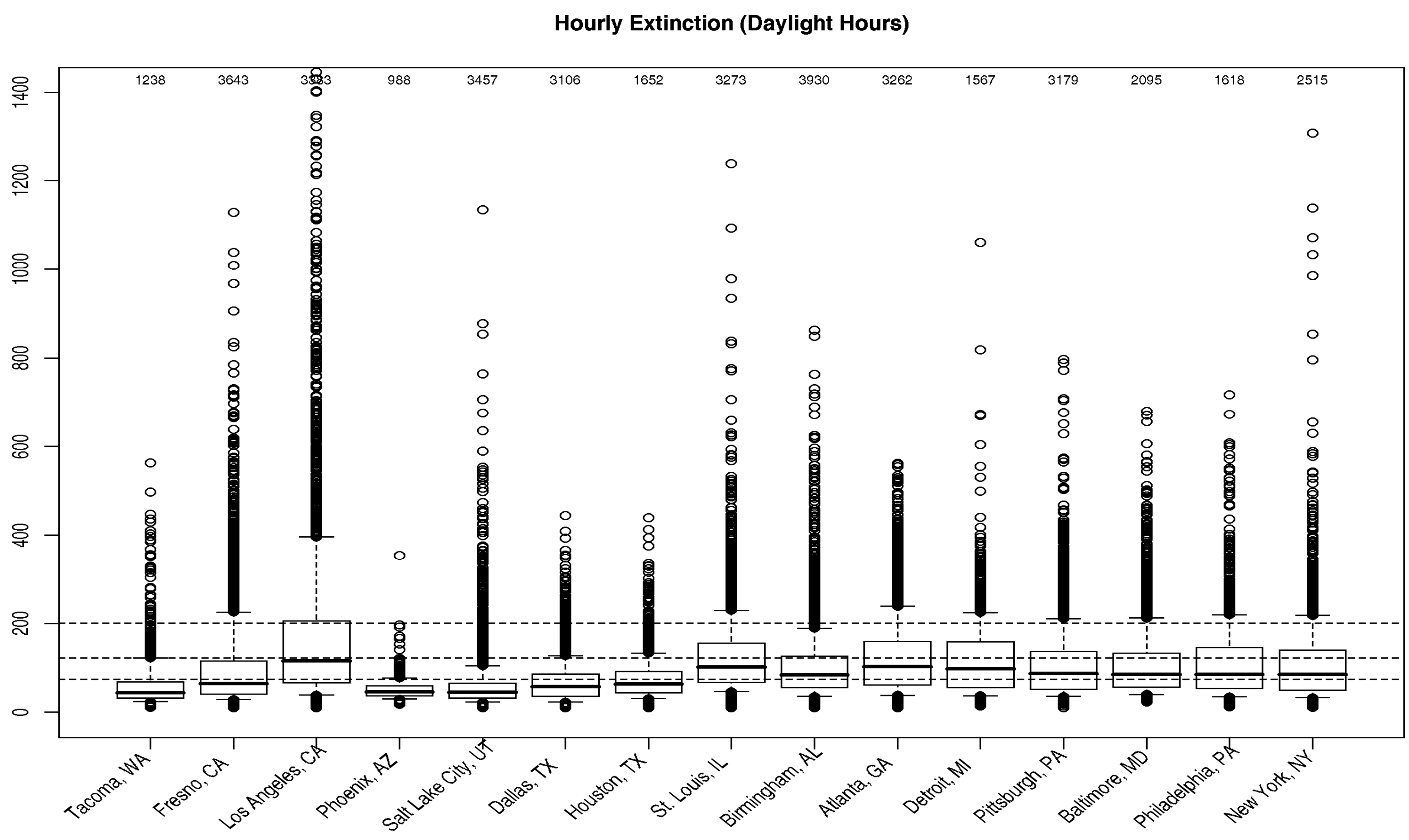
Corrected Figure 3-7 (c). Distribution of PM parameters and relative humidity across the 2005-2007 period, by study area.

1-hour relative humidity.



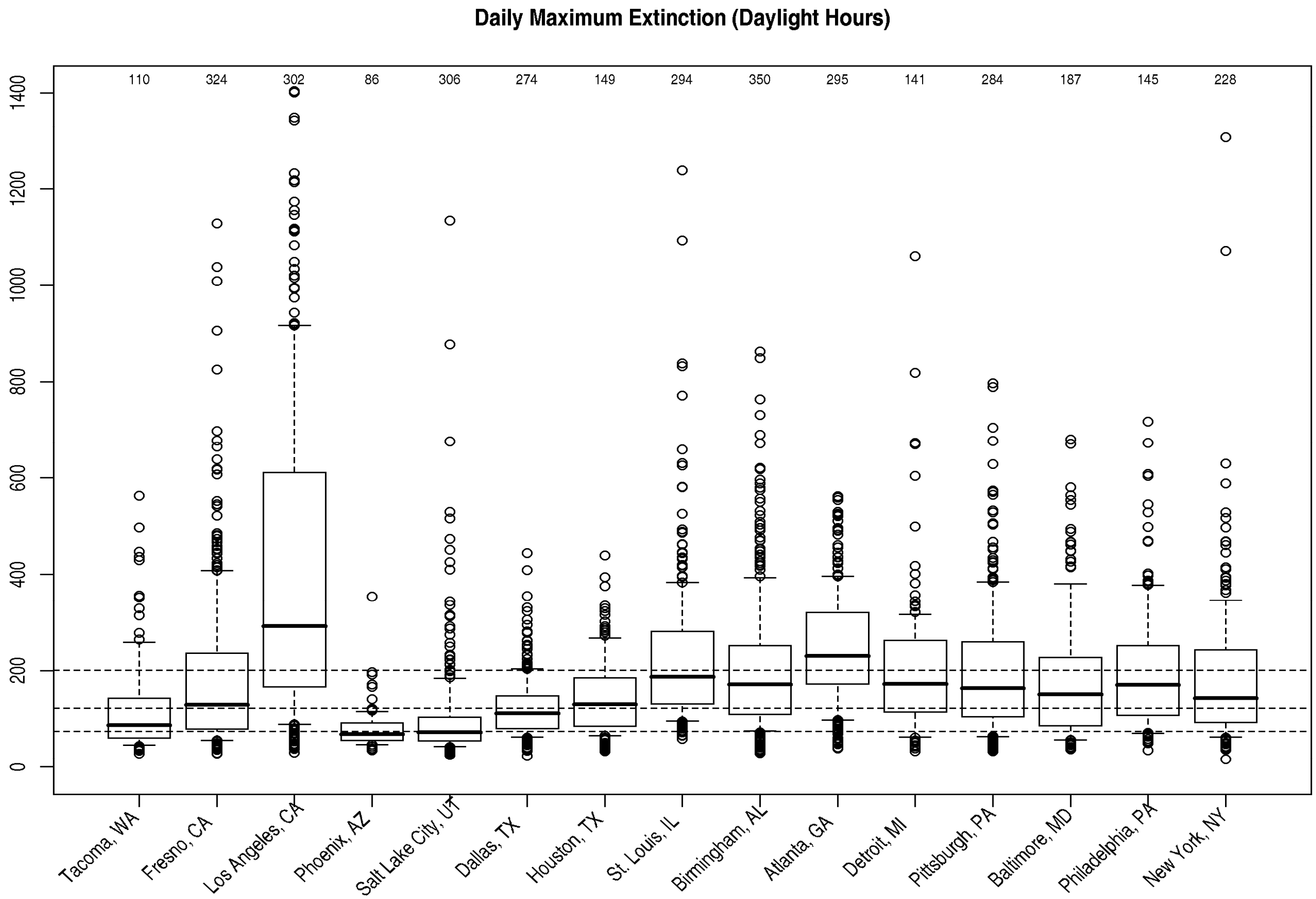
Corrected Figure 3-8 (a). Distributions of estimated daylight 1-hour total light extinction and maximum daily daylight 1-hour total light extinction across the 2005-2007 period, by study area.

Individual 1-hour values.



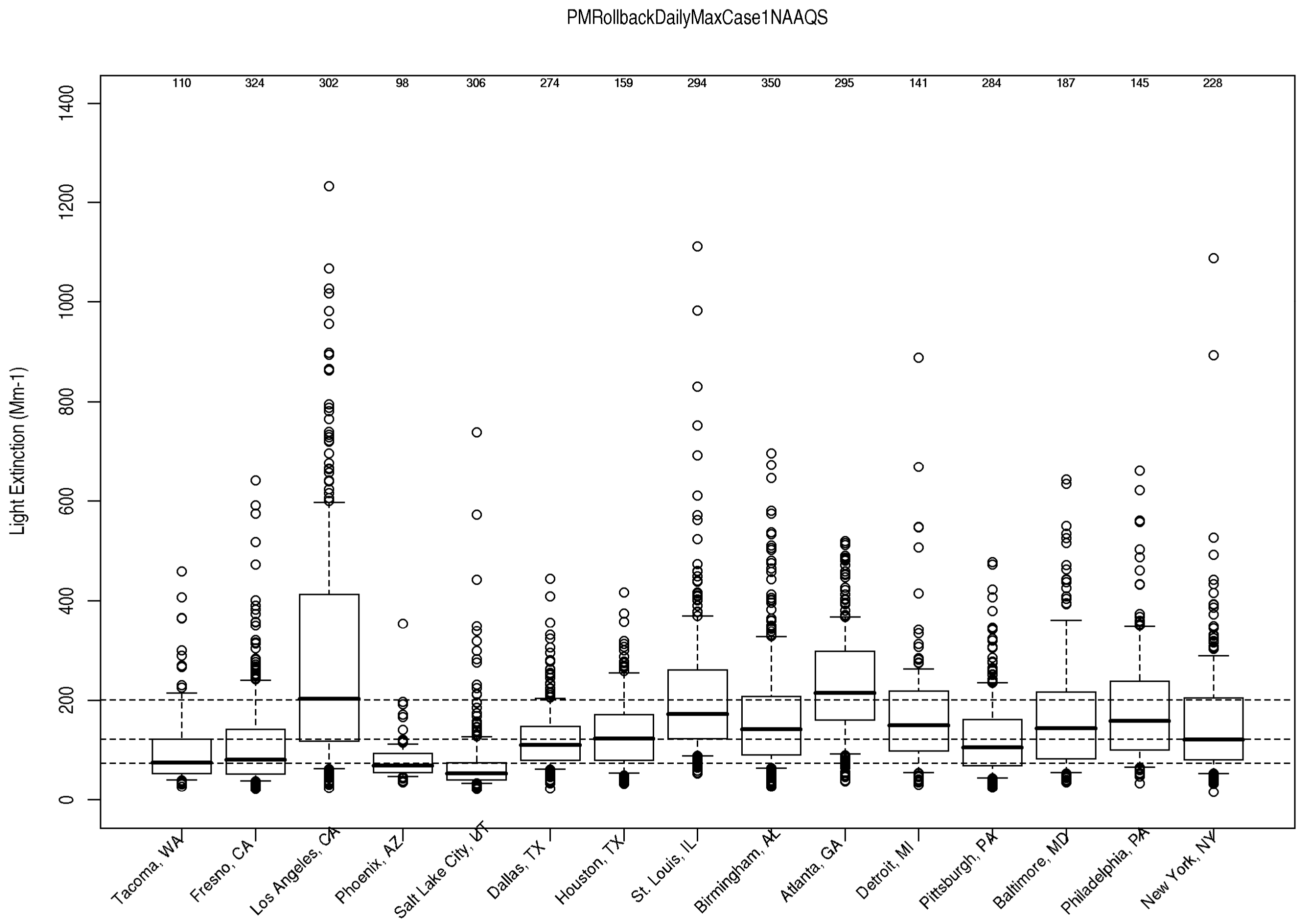
Corrected Figure 3-8 (b). Distributions of estimated daylight 1-hour total light extinction and maximum daily daylight 1-hour total light extinction across the 2005-2007 period, by study area.

Maximum daily values.



Corrected Figure 4-1 (b). Distributions of daily maximum daylight 1-hour total light extinction under two "just meeting" secondary NAAQS scenarios.

Secondary NAAQS of 15 μg/m^3 for the annual average and 35 μg/m^3 for the 98th percentile 24-hour average.



Corrected Table 3-6. Percentage of days in which daily maximum daylight 1-hour total light extinction exceeded three candidate protective levels across the 2005-2007 period, by study area.

Study Area	**Number of Days with Estimates**	**Candidate Protective Level**		
		74 Mm-1	**122 Mm-1**	**201 Mm-1**
		Percentage of days		
Tacoma	110	61	36	15
Fresno	324	77	53	31
Los Angeles-South Coast Air Basin	302	92	84	67
Phoenix	86	42	7	1
Salt Lake City	306	47	18	9
Dallas	274	80	42	11
Houston	149	83	55	19
St. Louis	294	98	80	46
Birmingham	350	91	69	39
Atlanta	295	95	86	63
Detroit-Ann Arbor	141	87	70	44
Pittsburgh	284	87	67	37
Baltimore	187	82	58	32
Philadelphia-Wilmington	145	88	69	42
New York-N. New Jersey-Long Island	228	84	63	35
Average	***232***	80	57	33

Corrected Table 4-2. Current Conditions total light extinction design values for the study areas.

Study Area	**Design Value for 90th Percentile Form (Mm-1)**	**Design Value for 95th Percentile Form (Mm-1)**
Tacoma	254	381
Fresno	391	543
Los Angeles-South Coast Air Basin	929	1150
Phoenix	115*	154*
Salt Lake City	186*	276
Dallas	199*	249
Houston	263	289
St. Louis	369	433
Birmingham	376	506
Atlanta	390	472
Detroit-Ann Arbor	323	483
Pittsburgh	378	510
Baltimore	409	456
Philadelphia-Wilmington	392	459
New York-N.New Jersey-Long Island	349	425

* This design value meets one or more of the NAAQS scenarios.

Corrected Table 4-3. Percentage reductions in non-PRB light extinction required to "just meet" the NAAQS scenarios based on measured light extinction.

	NAAQS Scenarios Based on Maximum Daily 1-hour Daylight Total Light Extinction, Average of Percentile Value Over Three Years					
Total Light Extinction Level (Mm-1)	**201**	**201**	**122**	**122**	**74**	**74**
Percentile Form	**90th**	**95th**	**90th**	**95th**	**90th**	**95th**
Area	**Percentage Reduction Required in Non-PRB Total Light Extinction**					
Tacoma	24	50	60	72	82	85
Fresno	51	66	73	81	86	90
Los Angeles	81	85	90	92	95	96
Phoenix	0	0	0	23	42	59
Salt Lake City	0	29	38	59	66	77
Dallas	0	21	44	55	72	76
Houston	26	33	60	63	80	81
St. Louis	48	57	71	76	85	88
Birmingham	49	63	72	79	85	89
Atlanta	52	61	74	78	87	89
Detroit	40	61	66	78	82	88
Pittsburgh	49	63	72	79	85	89
Baltimore	54	59	74	77	87	89
Philadelphia	51	59	72	77	85	88
New York	45	56	69	75	83	87