TSD-1g

Relative Response Factor (RRF) and "Modeled Attainment Test"

Bureau of Air Quality Analysis and Research

Division of Air Resources

New York State Department of Environmental Conservation

Albany, NY 12233

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EPA guidance (EPA 2005) and the subsequent document (EPA 2006) require the use of a *modeled attainment test* which is described as a procedure in which an air quality model is used to simulate current and future air quality. If future estimates of ozone concentrations are <= 84 ppb, then this element of the attainment test is satisfied. A *modeled attainment demonstration* that consists of (a) analyses which estimate whether selected emissions reductions will result in ambient concentrations that meet the NAAQS or progress goals and (b) an identified set of control measures which will result in the required emissions reductions is provided elsewhere.

For this modeled attainment test, model estimates are used in a "relative" rather than "absolute" sense. That is, one calculates the ratio of the model's future to current (baseline) predictions at ozone monitors. These ratios are called *relative response factors (RRF)*. Future ozone concentrations are estimated at existing monitoring sites by multiplying modeled RRF at locations "near" each monitor by the observation-based monitor-specific "baseline" ozone design value. Therefore, the following equation describes approach as applied to a monitoring site i:

$$\mathbf{(DVF)_i = (RRF)_i \times (DVC)_i} \qquad \textbf{(Equation 1)}$$

Where $(DVC)_i$ is the baseline concentration monitored at site i; $(RRF)_i$ is the relative response factor, calculated for site i, and $(DVF)_i$ is the estimated future design value for site i. The RRF is the ratio of the future 8-hour daily maximum concentration predicted at a monitor to the baseline 8-hour daily maximum concentration predicted at the monitor location averaged over multiple days determined from the base case.

The following sections describe the calculation of each of the elements in Equation 1 as implemented by NYSDEC through an in-house computer program (fortran). Note, the subscript "i" from equation is dropped in the following description. However, all calculations are still performed on a monitor-by-monitor basis.

1. <u>Calculation of DVC</u>

Design values (DV) at each monitoring site are calculated in accordance with 40 CFR Part 50.10, Appendix I. The DV is calculated as the 3 year average of the fourth highest monitored daily 8-hour maximum value at each monitoring site. For example, the design value for the 2000-2002 is the average of the fourth highest monitored daily 8-hour maximum values in 2000, 2001 and 2002. Design values are labeled with the *last* year of the design value period, i.e. the design value for the 2000 – 2002 is labeled as "2002 design value".

For the "modeled attainment test", the guidance defines the DVC in Equation 1 as the average of the design values, which straddle the baseline inventory year. In our case, the baseline inventory year is 2002. Therefore, DVC is the average of the "2002 design value" (determined from 2000-2002 observations), the "2003 design value" (determined

from 2001-2003 observations), and the "2004 design value" (determined from 2002-2004 observations). Consequently, DVC is derived from observations covering a five year period and is a weighted average with 2002 observations "weighted" three times, 2001 and 2003 observations weighted twice, and 2000 and 2004 observations weighted once.

The following criteria concerning missing DV were implemented in the fortran code calculating DVC:

- For monitors with only four years of consecutive data, the guidance allows DVC to be computed as the average of two DV within that period.
- For monitors with only three years of consecutive data, the DVC is equal to the DV calculated for that three year period
- For monitors with less than three years of consecutive data, no DVC can be estimated

2. Calculation of RRF

The guidance requires the calculation of RRF with CMAQ output from grids that are "near" a monitor. Because of the 12km grid spacing used in the CMAQ simulations, model predictions in a 3*3 grid array centered on the monitoring location are considered "near" that monitor. For each day, the maximum base case and control case concentration within that array is selected for RRF calculation as set forth in the guidance document.

Because photochemical models were found to be less responsive to emission reductions on days of lower simulated ozone concentrations, the guidance recommends applying screening criteria to the daily model predictions at individual monitors to determine whether that day's predictions are to be used to calculate the RRF or not. Only "high ozone days" are to be selected:

RRF = (average control case over high ozone days selected based on base case concentrations) / (average base case over selected high ozone days)

In addition, the guidance recommends that preferably ten or more "high ozone days", as identified below, be selected for RRF calculation. In no case can the RRF be calculated with fewer than five "high ozone days".

The following describes the logic with which NYSDEC implemented these screening criteria into its Fortran code for RRF calculation:

a. Selecting concentrations from grid cells surrounding the monitor

   i. Determine the grid cell in which the monitor is located and include the surrounding 8 grid cells to form a 3*3 grid cell array

   ii. Determine daily maximum 8-hr ozone concentrations for each day for each of the 9 grid cells for both the base case and control case

iii. For each day, pick the highest daily maximum 8-hr ozone value out of all 9 grid cells. This is the daily maximum 8-hr ozone concentration for that monitor for that day to be used in RRF calculations (following the screening criteria below).

iv. This is done for both the base case and the control case. Note that the grid cell selected on any given day for the base case need not be the same as the grid cell selected for the same day in the control case.

b. Selecting modeling days to be used in the RRF computation (again, this is done on a monitor-by-monitor basis)

i. Starting with a ozone threshold (TO_3) of 85 ppb and a minimum required number of days (Dmin) of 10, determine all days for which the simulated base case concentration (as determined in step (a) is at or above the threshold TO_3.

ii. If the number of such days is greater to or equal Dmin, identify these days and proceed to step (c). Otherwise, continue to b(iii), below.

iii. Lower the threshold (TO_3) by 1ppb interval and go back to b(i) to identify the days. If the minimum number of days is not reached then reduce that requirement by 1 but no lower than 5 days and with TO_3 > =70 ppb and go back to b(i). Otherwise proceed to b(iv) below.

iv. Stop. No RRF can be calculated for this monitor because there were less than 5 days with base case daily maximum concentration > =70 ppb.

c. RRF computation: Compute the RRF by averaging the daily maximum 8-hr ozone concentrations for base case and control case determined in step (a) over all of the days determined in step (b). The RRF is the ratio of average control case concentrations over average base case concentrations.

3. Computation of DVF

Compute DVF as the product of DVC from step (1) and RRF from step (2). Note, the following conventions on numerical precision (truncation, rounding) were applied:

a. DV are truncated in accordance with 40 CFR Part 50.10, Appendix I. This applies to the “2002 DV”, the “2003 DV”, and the “2004 DV”

b. DVC (averages of DV over multiple years) are calculated in ppb and carried to 1 significant digit

c. RRF are calculated and carried to three significant digits

d. DVF is calculated by multiplying DVC with RRF, followed by truncation

References

EPA (2005) Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS. EPA-454/R-05-002.

EPA (2006) Guidance on the use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. Draft 3.2-September 2006.

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TSD-1h

Projected 8-h ozone air quality over the Ozone Transport Region

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The USEPA guidance (EPA 2005 and EPA 2006) recommends the use of relative reduction factor (RRF) approach for demonstrating the attainment of the 8-hr ozone NAAQS. The OTC Modeling committee implemented this recommended approach in performing attainment assessment of the areas.

Attainment year 2009

As described in TSD-1g (2007), the RRFs were determined for all OTR monitors for the two future year simulations with 2009OTW and 2009BOTW emissions data. The base design value (DVc) for 2002 representing the number of DVs estimated on the basis of 3-yr averages available from 2000 to 2004 are listed in Tables 1 and 2 along with the RRF, the number of days, the level of threshold, and future year projected concentrations for each monitor identified by its AIRS ID, common name and the county. The values in bold represent projected design values that exceed the 8-hr ozone NAAQS.

In general both simulations do not differ much from each other in that they yield similar design values with the 2009BOTW providing concentrations that are about one or two ppb lower than the 2009OTW. However it should be noted that the Guidance provides for a window (82 to 87 ppb) that can be considered as demonstrating attainment provided there is sufficient information to support in the form of weight of evidence (WOE) that suggests that the projected design value would be at or less than the 8-hr ozone NAAQS, taking into consideration the current measured design value and other projected emissions reductions within and outside the modeling domain.

If such a consideration is given then there are only 6 monitors above 87 ppb in the OTR, and without such an option of WOE there would be 21 monitors that have projected design value above 84 ppb. It should be noted that in either case, a majority of them are located in the Baltimore–Philadelphia-New York City-Connecticut portion of inner OTR corridor associated with high emissions region.

These Tables also list monitors for which no future DV (DVF) was calculated, listed as -9 in all columns except for DVC, which is a limitation inherent in the method for calculating the RRF. Often these monitors have DVC less than 84 ppb, with the exception of the monitor at the summit of Whiteface, NY (360310002), that has a DVC of 88.3 ppb while at the base of Whiteface (360311003) the measured DVC is 84.3 ppb. In both instances, there were fewer than 5 days that the model simulation predicted base concentrations in the 9-grid cells surrounding these monitors was below the threshold of 70 ppb, resulting in assigning no RRF and no estimate of DVF for these monitors.

Attainment year 2012

One other option that was considered by the OTC Modeling committee is the simulation of 2012BOTW emissions within the OTR. The details of the development of the 2012BOTW inventory are provided in TSD-1f (2007). The CMAQ simulation was performed with the 2012BOTW emissions in the OTR with the remainder of the

modeling domain also at 2012 emissions. The results of the simulation were processed in a manner similar to those of 2009 and the resulting future year design values are listed in Table 3 in a format similar to those in Tables 1 and 2.

The listed future DVs indicate that there are 5 monitors that would have a projected design value above 84 ppb, again located in the inner OTR corridor. However it should be noted that if consideration is given to these monitors along with WOE then these would be within the prescribed range of WOE, thereby demonstrating ***modeled attainment for all monitors in the OTR*** under this scenario.

Non-monitored locations

One of the requirements of the EPA guidance is the need to investigate if there are locations within the modeling domain where the predicted future design values (DVF) are above the level of NAAQS but are not associated with a monitor to provide DVC. While the EPA has recommended the use of modeled attainment test software (MATS) to investigate such occurrences, it was decided by the Modeling committee that such an assessment should be undertaken by the individual areas themselves as part of their SIP analysis.

References

EPA (2005) Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS. EPA-454/R-05-002.

EPA (2006) Guidance on the use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. Draft 3.2-September 2006.

TSD-1f (2007) Future Year Emissions Inventory for 8-h OTC Ozone Modeling

TSD-1g (2007) Relative response factor (RRF) and “Modeled Attainment Test”

Table 1 Projected 8-hr Ozone Design Values over OTR based on 2009OTW Emissions Inventory

AIRS-ID	County	Monitor	#ofDV	DVC	DVF	RRF	#Days	Threshold
340290006	Ocean	Colliers Mills	3	106	**92**	0.87	20	85
90013007	Fairfield	Stratford	3	98.3	**90**	0.922	38	85
361030009	Suffolk	Holtsville	3	97	**90**	0.928	34	85
90093002	New Haven	Madison	3	98.3	**89**	0.908	39	85
340070003	Camden	Camden	3	98.3	**88**	0.9	26	85
340155001	Gloucester	Clarksboro	3	98.3	**88**	0.9	25	85
420170012	Bucks	Bristol	3	99	**88**	0.898	25	85
90010017	Fairfield	Greenwich	3	95.7	**87**	0.915	30	85
340071001	Camden	Ancora St. Hos	3	100.7	**87**	0.873	27	85
421010024	Philadelphia	Northeast (Air	3	96.7	**87**	0.903	23	85
90011123	Fairfield	Danbury	3	95.7	**86**	0.9	18	85
340210005	Mercer	Rider Univ.	3	97	**86**	0.891	23	85
510130020	Arlington	Arlington Co.	3	96.7	**86**	0.897	24	85
510590018	Fairfax	Fairfax Co. -	3	96.7	**86**	0.892	20	85
90019003	Fairfield	Westport	3	94	**85**	0.911	37	85
90070007	Middlesex	Middletown	3	95.7	**85**	0.892	21	85
90099005	New Haven	Hamden	3	93.3	**85**	0.915	25	85
240251001	Harford	Edgewood	3	100.3	**85**	0.854	41	85
340030005	Bergen	Teaneck	3	91.7	**85**	0.93	18	85
361030002	Suffolk	Babylon	3	93.7	**85**	0.917	22	85
361192004	Westchester	White Plains	3	91.3	**85**	0.936	22	85
240030014	Anne Arundel	Davidsonville	3	98	84	0.86	30	85
240030019	Anne Arundel	Ft. Meade	3	97	84	0.871	30	85
340230011	Middlesex	Rutgers Univ.	3	96	84	0.876	22	85
340250005	Monmouth	Monmouth Univ.	3	95.7	84	0.881	45	85
340273001	Morris	Chester	3	95.3	84	0.884	13	85
360290002	Erie	Amherst	3	95.7	84	0.884	11	78
360850067	Richmond	Susan Wagner	3	93	84	0.905	42	85
510590030	Fairfax	Fairfax Co. -	3	95	84	0.887	21	85
250213003	Norfolk	MILTON	1	91	83	0.914	13	85
340190001	Hunterdon	Flemington	3	95.3	83	0.88	15	85
510591005	Fairfax	Fairfax Co. -	1	94	83	0.887	21	85
516500004	Hampton City	Hampton	3	88.3	83	0.94	36	85
110010043	DC	McMillan Reser	3	92.7	82	0.89	22	85
240259001	Harford	Aldino	3	97	82	0.849	35	85
240330002	Prince Georges	Greenbelt	2	94	82	0.874	28	85
250092006	Essex	LYNN	3	90	82	0.918	16	85
360631006	Niagara	Middleport	3	91.7	82	0.895	15	85
360790005	Putnam	Mt. Ninham	3	91.3	82	0.899	14	85
420290050	Chester	West Chester	1	95	82	0.871	12	85
421010014	Philadelphia	Northwest (Rox	3	90.7	82	0.913	20	85
440090007	Washington	EPA Lab	3	93.3	82	0.879	33	85

518000004	Suffolk City	Suffolk - TCC	3	87	82	0.953	26	85
100031010	New Castle	Brandywine	3	92.7	81	0.878	19	85
240150003	Cecil	Fair Hill	3	97.7	81	0.834	18	85
240338003	Prince Georges	PG Coun.Eques.	1	94	81	0.87	28	85
340110007	Cumberland	Millville	3	95.7	81	0.849	16	85
360130006	Chautauqua	Dunkirk	3	93	81	0.878	20	85
360270007	Dutchess	Millbrook	3	92	81	0.882	12	80
420030010	Allegheny	Pittsburgh (Ca	3	90.7	81	0.9	16	85
420070002	Beaver	Hookstown	3	91.3	81	0.89	10	82
420450002	Delaware	Chester	3	91.7	81	0.887	23	85
420910013	Montgomery	Norristown	3	92.3	81	0.886	21	85
510850003	Hanover	Hanover Co.	2	92	81	0.886	11	85
90131001	Tolland	Stafford	3	92.3	80	0.872	11	85
240053001	Baltimore	Essex	3	91.3	80	0.881	48	85
240290002	Kent	Millington	3	95.3	80	0.842	17	85
250010002	Barnstable	TRURO	3	92	80	0.879	23	85
250051002	Bristol	FAIRHAVEN	3	91	80	0.882	23	85
250130008	Hampden	CHICOPEE	3	92	80	0.877	10	83
250250041	Suffolk	BOSTON (Long I	3	88.7	80	0.911	21	85
360450002	Jefferson	Perch River	3	91.3	80	0.879	10	81
420030008	Allegheny	Lawrenceville	3	89.3	80	0.9	16	85
420030067	Allegheny	South Fayette	3	89.3	80	0.899	13	85
440030002	Kent	Alton Jones	3	93.3	80	0.866	17	85
510360002	Charles City	Charles City C	3	89.3	80	0.9	14	85
515100009	Alexandria Cit	Alexandria	3	90	80	0.892	20	85
90110008	New London	Groton	3	90	79	0.883	38	85
100031007	New Castle	Lums Pond	2	94.5	79	0.846	18	85
100031013	New Castle	Bellefonte	3	90.3	79	0.876	21	85
110010025	DC	Takoma Park	3	88.7	79	0.895	24	85
110010041	DC	River Terrace	3	89	79	0.89	22	85
230090102	Hancock	ANP Cadillac M	3	91.7	79	0.871	10	82
420290100	Chester	New Garden (Ai	3	94.7	79	0.839	19	85
100010002	Kent	Killens Pond	3	88.3	78	0.893	25	85
340315001	Passaic	Ramapo	3	86.7	78	0.9	19	85
360050083	Bronx	Botanical Gard	3	83.7	78	0.939	20	85
420031005	Allegheny	Harrison Twp	3	91.3	78	0.864	14	85
420070005	Beaver	Brighton Twp	3	89.7	78	0.876	12	82
420490003	Erie	Erie	3	89	78	0.88	23	85
420770004	Lehigh	Allentown	3	90.7	78	0.87	11	84
420950025	Northampton	Freemansburg	3	90	78	0.874	11	85
440071010	Providence	Francis School	3	89.7	78	0.872	17	85
510870014	Henrico	Henrico Co.	3	88.3	78	0.893	15	85
511071005	Loudon	Loudoun Co.	3	90	78	0.872	15	85
90031003	Hartford	E. Hartford	3	88	77	0.88	16	85
90050005	Litchfield	Cornwall	1	89	77	0.874	11	84
100051003	Sussex	Lewes	3	87	77	0.896	26	85
230312002	York	Kennebunkport	3	88.3	77	0.877	19	85
240051007	Baltimore	Padonia	3	88.7	77	0.874	26	85

340010005	Atlantic	Nacote Creek	3	89	77	0.876	27	85
340170006	Hudson	Bayonne	3	84.7	77	0.911	22	85
420050001	Armstrong	Kittanning	3	90.7	77	0.856	11	84
420550001	Franklin	Methodist Hill	3	90.7	77	0.849	11	77
420710007	Lancaster	Lancaster	3	90.7	77	0.853	17	85
420850100	Mercer	Farrell	3	91.3	77	0.85	10	82
421290008	Westmoreland	Greensburg	3	88	77	0.881	18	85
421330008	York	York	3	89	77	0.866	17	85
510595001	Fairfax	Fairfax Co. -	3	88	77	0.886	21	85
100051002	Sussex	Seaford	3	90	76	0.846	10	80
240170010	Charles	S Maryland	3	93	76	0.819	17	85
240313001	Montgomery	Rockville	3	86.7	76	0.885	26	85
250094004	Essex	NEWBURY	3	86	76	0.884	27	85
360130011	Chautauqua	Westfield	3	87	76	0.88	12	85
420110009	Berks	Reading	3	88.7	76	0.861	10	85
420958000	Northampton	Easton	3	88	76	0.873	12	85
421250005	Washington	Charleroi	3	86.3	76	0.883	15	85
240130001	Carroll	South Carroll	3	88.7	75	0.853	12	85
250154002	Hampshire	WARE	3	86.3	75	0.877	10	81
360551004	Monroe	Rochester	3	83.7	75	0.898	18	85
361030004	Suffolk	Riverhead	3	83	75	0.904	36	85
420590002	Greene	Holbrook	3	87.7	75	0.858	10	85
421010136	Philadelphia	Southwest (Elm	3	83	75	0.907	23	85
510410004	Chesterfield	Chesterfield C	3	84.7	75	0.893	10	85
510590005	Fairfax	Fairfax Co. -	3	87	75	0.871	18	85
511790001	Stafford	Stafford Co.	3	86	75	0.878	36	85
230313002	York	Kittery	3	85.3	74	0.871	16	85
240210037	Frederick	Frederick Airp	3	87.3	74	0.858	11	85
250171102	Middlesex	STOW	3	85.7	74	0.875	10	80
330111010	Hillsborough	Nashua	2	86	74	0.871	10	75
360010012	Albany	Loudonville	3	83	74	0.899	8	70
360810124	Queens	Queens College	2	83	74	0.895	26	85
360910004	Saratoga	Stillwater	3	84.7	74	0.878	6	70
361173001	Wayne	Williamson	3	84	74	0.889	18	85
420431100	Dauphin	Hershey	3	86.7	74	0.857	16	85
421255001	Washington	Florence	3	85.7	74	0.868	10	83
511530009	Prince William	Prince William	3	85	74	0.876	12	83
230052003	Cumberland	Cape Elizabeth	3	84.3	73	0.874	18	85
230130004	Knox	Port Clyde	3	83.7	73	0.873	13	85
240430009	Washington	Hagerstown	3	85.3	73	0.857	10	84
250034002	Berkshire	ADAMS	3	83.3	73	0.881	9	70
330115001	Hillsborough	Peterborough	1	84	73	0.877	10	73
360671015	Onondoga	East Syracuse	3	82.3	73	0.896	8	70
360715001	Orange	Valley Central	3	84.7	73	0.87	10	76
420010002	Adams	Biglerville (P	3	85	73	0.868	10	80
420070014	Beaver	Beaver Falls	3	85	73	0.868	10	83
420430401	Dauphin	Harrisburg	3	85	73	0.862	15	85
421174000	Tioga	Tioga County (	3	85	73	0.859	5	70

421250200	Washington	Washington	3	85.3	73	0.86	11	85
511611004	Roanoke	Roanoke Co.	3	83.7	73	0.873	11	76
230090103	Hancock	ANP McFarland	3	83.7	72	0.872	10	82
250130003	Hampden	AGAWAM	1	83	72	0.878	10	83
250270015	Worcester	WORCESTER	3	84	72	0.867	10	79
330150012	Rockingham	Rye	2	83.5	72	0.871	16	85
420110001	Berks	Kutztown	2	84.5	72	0.858	10	85
420334000	Clearfield	Moshannon (PSU	3	87.3	72	0.827	11	76
421290006	Wetsmoreland	Murrysville	3	82	72	0.89	20	85
510690010	Frederick	Frederick Co.	3	82.7	72	0.873	11	81
518000005	Suffolk City	Suffolk - Holl	3	82.3	72	0.878	10	76
420210011	Cambria	Johnstown	3	85	71	0.844	10	85
420274000	Centre	Penn Nursery (	3	84.7	71	0.85	11	74
420690101	Lacakawana	Peckville	3	83.3	71	0.858	10	75
420990301	Perry	Perry County	3	83.3	71	0.853	10	77
511130003	Madison	Madison Co. -	3	84.7	71	0.845	11	71
420270100	Centre	State College	3	84.3	70	0.839	10	76
420692006	Lacakawana	Scranton	3	82	70	0.858	10	75
420791101	Luzerene	Wilkes-Barre	3	83.7	70	0.844	10	76
500030004	Bennington	Bennington	3	79.7	70	0.888	8	70
510330001	Caroline	Caroline Co.	3	82.3	70	0.852	10	84
360650004	Oneida	Camden	3	79.7	69	0.869	10	70
420130801	Blair	Altoona	3	83.3	69	0.837	10	80
420810100	Lycoming	Montoursville	1	82	69	0.851	11	75
230112005	Kennebec	Gardiner Pray	3	78	68	0.872	10	71
330150013	Rockingham	999	1	80	68	0.86	10	73
420791100	Luzerene	Nanticoke	3	81.7	68	0.844	10	76
330173002	Strafford	Rochester	2	78.5	67	0.863	11	71
510610002	Fauqier	Fauquier Co.	3	79.3	67	0.852	11	73
511390004	Page	Page Co.	3	79.7	67	0.844	12	72
250250042	Suffolk	BOSTON (Harris	3	73	66	0.91	16	85
420730015	Lawrence	New Castle	3	78.3	66	0.849	10	83
230090301	Hancock	Castine	1	75	65	0.878	10	79
250150103	Hampshire	AMHERST	3	74.7	65	0.878	10	76
420814000	Lycoming	Tiadaghton (PS	3	78.7	65	0.837	10	72
511630003	Rockbridge	Rockbridge Co.	3	76.7	65	0.856	8	70
230310038	York	West Buxton	1	75	64	0.862	9	70
330050007	Cheshire	Keene	3	74.3	64	0.869	10	72
360430005	Herkimer	Nick's Lake	3	74	64	0.874	6	70
421010004	Philadelphia	Frankford (Lab	3	71.3	64	0.908	25	85
250090005	Essex	LAWRENCE	1	70	61	0.883	10	82
330150015	Rockingham	Portsmouth	1	68	59	0.871	16	85
CC0040002	999	Roosevelt-Camp	3	58.3	51	0.889	10	75
230038001	Aroostook	Ashland135	3	64	-9	-9	-9	-999
230173001	Oxford	North Lovell	3	60.7	-9	-9	-9	-999
230194007	Penobscot	Howland	3	66.7	-9	-9	-9	-999
230194008	Penobscot	Holden Rider B	2	79	-9	-9	-9	-999
330012004	Belknap	Laconia	2	76.5	-9	-9	-9	-999

330031002	Carroll	Conway	1	67	-9	-9	-9	-999
330090008	Grafton	Haverhill	3	70.3	-9	-9	-9	-999
330130007	Merrimack	Concord	3	74.7	-9	-9	-9	-999
330190003	Sullivan	Claremont	3	74.3	-9	-9	-9	-999
360150003	Chemung	Elmira	3	80.3	-9	-9	-9	-999
360310002	Essex	Whiteface Summ	3	88.3	-9	-9	-9	-999
360310003	Essex	Whiteface Base	3	84.3	-9	-9	-9	-999
360410005	Hamilton	Piseco Lake	3	78.7	-9	-9	-9	-999
360530006	Madison	Camp Georgetow	3	79.7	-9	-9	-9	-999
361111005	Ulster	Belleayre	3	81.3	-9	-9	-9	-999
500070007	Chittenden	Underhill	3	77	-9	-9	-9	-999
511970002	Wythe	Wythe Co.	3	79.7	-9	-9	-9	-999

Table 2 Projected 8-hr Ozone Design Values over OTR based on 2009BOTW Emissions Inventory

AIRS-ID	County	Monitor	#ofDV	DVC	DVF	RRF	#Days	Threshold
340290006	Ocean	Colliers Mills	3	106	**92**	0.868	20	85
90013007	Fairfield	Stratford	3	98.3	**90**	0.919	38	85
361030009	Suffolk	Holtsville	3	97	**89**	0.926	34	85
90093002	New Haven	Madison	3	98.3	**88**	0.905	39	85
340070003	Camden	Camden	3	98.3	**88**	0.898	26	85
340155001	Gloucester	Clarksboro	3	98.3	**88**	0.898	25	85
420170012	Bucks	Bristol	3	99	**88**	0.896	25	85
90010017	Fairfield	Greenwich	3	95.7	**87**	0.913	30	85
340071001	Camden	Ancora St. Hos	3	100.7	**87**	0.872	27	85
421010024	Philadelphia	Northeast (Air	3	96.7	**87**	0.901	23	85
340210005	Mercer	Rider Univ.	3	97	**86**	0.889	23	85
510130020	Arlington	Arlington Co.	3	96.7	**86**	0.895	24	85
510590018	Fairfax	Fairfax Co. -	3	96.7	**86**	0.891	20	85
90011123	Fairfield	Danbury	3	95.7	**85**	0.897	18	85
90019003	Fairfield	Westport	3	94	**85**	0.909	37	85
90099005	New Haven	Hamden	3	93.3	**85**	0.912	25	85
240251001	Harford	Edgewood	3	100.3	**85**	0.852	41	85
340030005	Bergen	Teaneck	3	91.7	**85**	0.928	18	85
361030002	Suffolk	Babylon	3	93.7	**85**	0.917	22	85
361192004	Westchester	White Plains	3	91.3	**85**	0.935	22	85
90070007	Middlesex	Middletown	3	95.7	84	0.888	21	85
240030014	Anne Arundel	Davidsonville	3	98	84	0.858	30	85
240030019	Anne Arundel	Ft. Meade	3	97	84	0.869	30	85
340250005	Monmouth	Monmouth Univ.	3	95.7	84	0.88	45	85
340273001	Morris	Chester	3	95.3	84	0.882	13	85
360290002	Erie	Amherst	3	95.7	84	0.884	11	78
360850067	Richmond	Susan Wagner	3	93	84	0.904	42	85
510590030	Fairfax	Fairfax Co. -	3	95	84	0.886	21	85
340190001	Hunterdon	Flemington	3	95.3	83	0.877	15	85
340230011	Middlesex	Rutgers Univ.	3	96	83	0.874	22	85
510591005	Fairfax	Fairfax Co. -	1	94	83	0.886	21	85
110010043	DC	McMillan Reser	3	92.7	82	0.888	22	85
240259001	Harford	Aldino	3	97	82	0.846	35	85
250092006	Essex	LYNN	3	90	82	0.916	16	85
250213003	Norfolk	MILTON	1	91	82	0.911	13	85
420290050	Chester	West Chester	1	95	82	0.868	12	85
421010014	Philadelphia	Northwest (Rox	3	90.7	82	0.911	20	85
516500004	Hampton City	Hampton	3	88.3	82	0.939	36	85
518000004	Suffolk City	Suffolk - TCC	3	87	82	0.952	26	85
100031010	New Castle	Brandywine	3	92.7	81	0.875	19	85
240150003	Cecil	Fair Hill	3	97.7	81	0.831	18	85
240330002	Prince Georges	Greenbelt	2	94	81	0.872	28	85
240338003	Prince	PG Coun.Eques.	1	94	81	0.868	28	85

	Georges							
340110007	Cumberland	Millville	3	95.7	81	0.847	16	85
360130006	Chautauqua	Dunkirk	3	93	81	0.876	20	85
360631006	Niagara	Middleport	3	91.7	81	0.893	15	85
360790005	Putnam	Mt. Ninham	3	91.3	81	0.895	14	85
420030010	Allegheny	Pittsburgh (Ca	3	90.7	81	0.898	16	85
420070002	Beaver	Hookstown	3	91.3	81	0.889	10	82
420450002	Delaware	Chester	3	91.7	81	0.885	23	85
420910013	Montgomery	Norristown	3	92.3	81	0.883	21	85
440090007	Washington	EPA Lab	3	93.3	81	0.876	33	85
510850003	Hanover	Hanover Co.	2	92	81	0.885	11	85
90131001	Tolland	Stafford	3	92.3	80	0.867	11	85
240053001	Baltimore	Essex	3	91.3	80	0.879	48	85
250010002	Barnstable	TRURO	3	92	80	0.877	23	85
250130008	Hampden	CHICOPEE	3	92	80	0.872	10	83
250250041	Suffolk	BOSTON (Long I	3	88.7	80	0.909	21	85
360270007	Dutchess	Millbrook	3	92	80	0.879	12	80
420030008	Allegheny	Lawrenceville	3	89.3	80	0.898	16	85
420030067	Allegheny	South Fayette	3	89.3	80	0.897	13	85
440030002	Kent	Alton Jones	3	93.3	80	0.862	17	85
510360002	Charles City	Charles City C	3	89.3	80	0.899	14	85
515100009	Alexandria Cit	Alexandria	3	90	80	0.891	20	85
90110008	New London	Groton	3	90	79	0.879	38	85
100031007	New Castle	Lums Pond	2	94.5	79	0.843	18	85
110010025	DC	Takoma Park	3	88.7	79	0.894	24	85
110010041	DC	River Terrace	3	89	79	0.888	22	85
230090102	Hancock	ANP Cadillac M	3	91.7	79	0.869	10	82
240290002	Kent	Millington	3	95.3	79	0.838	17	85
250051002	Bristol	FAIRHAVEN	3	91	79	0.878	23	85
360450002	Jefferson	Perch River	3	91.3	79	0.876	10	81
420290100	Chester	New Garden (Ai	3	94.7	79	0.835	19	85
100010002	Kent	Killens Pond	3	88.3	78	0.891	25	85
100031013	New Castle	Bellefonte	3	90.3	78	0.873	21	85
360050083	Bronx	Botanical Gard	3	83.7	78	0.939	20	85
420031005	Allegheny	Harrison Twp	3	91.3	78	0.862	14	85
420070005	Beaver	Brighton Twp	3	89.7	78	0.874	12	82
420490003	Erie	Erie	3	89	78	0.879	23	85
420770004	Lehigh	Allentown	3	90.7	78	0.867	11	84
420950025	Northampton	Freemansburg	3	90	78	0.87	11	85
510870014	Henrico	Henrico Co.	3	88.3	78	0.892	15	85
511071005	Loudon	Loudoun Co.	3	90	78	0.87	15	85
90031003	Hartford	E. Hartford	3	88	77	0.876	16	85
90050005	Litchfield	Cornwall	1	89	77	0.87	11	84
100051003	Sussex	Lewes	3	87	77	0.893	26	85
230312002	York	Kennebunkport	3	88.3	77	0.875	19	85
240051007	Baltimore	Padonia	3	88.7	77	0.872	26	85
340010005	Atlantic	Nacote Creek	3	89	77	0.874	27	85
340170006	Hudson	Bayonne	3	84.7	77	0.911	22	85

340315001	Passaic	Ramapo	3	86.7	77	0.898	19	85
420050001	Armstrong	Kittanning	3	90.7	77	0.854	11	84
420850100	Mercer	Farrell	3	91.3	77	0.85	10	82
421290008	Westmoreland	Greensburg	3	88	77	0.878	18	85
440071010	Providence	Francis School	3	89.7	77	0.868	17	85
510595001	Fairfax	Fairfax Co. -	3	88	77	0.885	21	85
240313001	Montgomery	Rockville	3	86.7	76	0.883	26	85
360130011	Chautauqua	Westfield	3	87	76	0.879	12	85
420550001	Franklin	Methodist Hill	3	90.7	76	0.841	11	77
420710007	Lancaster	Lancaster	3	90.7	76	0.843	17	85
420958000	Northampton	Easton	3	88	76	0.869	12	85
100051002	Sussex	Seaford	3	90	75	0.843	10	80
240130001	Carroll	South Carroll	3	88.7	75	0.847	12	85
240170010	Charles	S Maryland	3	93	75	0.816	17	85
250094004	Essex	NEWBURY	3	86	75	0.882	27	85
250154002	Hampshire	WARE	3	86.3	75	0.873	10	81
420110009	Berks	Reading	3	88.7	75	0.855	10	85
421010136	Philadelphia	Southwest (Elm	3	83	75	0.905	23	85
421250005	Washington	Charleroi	3	86.3	75	0.879	15	85
421330008	York	York	3	89	75	0.853	17	85
510410004	Chesterfield	Chesterfield C	3	84.7	75	0.892	10	85
510590005	Fairfax	Fairfax Co. -	3	87	75	0.869	18	85
511790001	Stafford	Stafford Co.	3	86	75	0.876	36	85
230313002	York	Kittery	3	85.3	74	0.869	16	85
250171102	Middlesex	STOW	3	85.7	74	0.87	10	80
330111010	Hillsborough	Nashua	2	86	74	0.867	10	75
360551004	Monroe	Rochester	3	83.7	74	0.895	18	85
360810124	Queens	Queens College	2	83	74	0.894	26	85
361030004	Suffolk	Riverhead	3	83	74	0.901	36	85
361173001	Wayne	Williamson	3	84	74	0.886	18	85
420590002	Greene	Holbrook	3	87.7	74	0.855	10	85
421255001	Washington	Florence	3	85.7	74	0.867	10	83
511530009	Prince William	Prince William	3	85	74	0.873	12	83
230052003	Cumberland	Cape Elizabeth	3	84.3	73	0.873	18	85
240210037	Frederick	Frederick Airp	3	87.3	73	0.846	11	85
250034002	Berkshire	ADAMS	3	83.3	73	0.877	9	70
330115001	Hillsborough	Peterborough	1	84	73	0.873	10	73
360010012	Albany	Loudonville	3	83	73	0.89	8	70
360671015	Onondoga	East Syracuse	3	82.3	73	0.889	8	70
360715001	Orange	Valley Central	3	84.7	73	0.868	10	76
360910004	Saratoga	Stillwater	3	84.7	73	0.869	6	70
420070014	Beaver	Beaver Falls	3	85	73	0.866	10	83
420431100	Dauphin	Hershey	3	86.7	73	0.845	16	85
421250200	Washington	Washington	3	85.3	73	0.858	11	85
230090103	Hancock	ANP McFarland	3	83.7	72	0.871	10	82
230130004	Knox	Port Clyde	3	83.7	72	0.871	13	85
240430009	Washington	Hagerstown	3	85.3	72	0.845	10	84
250130003	Hampden	AGAWAM	1	83	72	0.873	10	83

250270015	Worcester	WORCESTER	3	84	72	0.863	10	79
330150012	Rockingham	Rye	2	83.5	72	0.869	16	85
421174000	Tioga	Tioga County (	3	85	72	0.856	5	70
421290006	Wetsmoreland	Murrysville	3	82	72	0.887	20	85
511611004	Roanoke	Roanoke Co.	3	83.7	72	0.872	11	76
518000005	Suffolk City	Suffolk - Holl	3	82.3	72	0.876	10	76
420010002	Adams	Biglerville (P	3	85	71	0.837	10	80
420110001	Berks	Kutztown	2	84.5	71	0.852	10	85
420210011	Cambria	Johnstown	3	85	71	0.841	10	85
420274000	Centre	Penn Nursery (	3	84.7	71	0.843	11	74
420334000	Clearfield	Moshannon (PSU	3	87.3	71	0.824	11	76
420430401	Dauphin	Harrisburg	3	85	71	0.841	15	85
510690010	Frederick	Frederick Co.	3	82.7	71	0.869	11	81
511130003	Madison	Madison Co. -	3	84.7	71	0.844	11	71
420270100	Centre	State College	3	84.3	70	0.833	10	76
420690101	Lacakawana	Peckville	3	83.3	70	0.849	10	75
420791101	Luzerene	Wilkes-Barre	3	83.7	70	0.838	10	76
420990301	Perry	Perry County	3	83.3	70	0.841	10	77
500030004	Bennington	Bennington	3	79.7	70	0.883	8	70
360650004	Oneida	Camden	3	79.7	69	0.867	10	70
420130801	Blair	Altoona	3	83.3	69	0.835	10	80
420692006	Lacakawana	Scranton	3	82	69	0.849	10	75
420810100	Lycoming	Montoursville	1	82	69	0.845	11	75
510330001	Caroline	Caroline Co.	3	82.3	69	0.85	10	84
330150013	Rockingham	999	1	80	68	0.858	10	73
420791100	Luzerene	Nanticoke	3	81.7	68	0.839	10	76
230112005	Kennebec	Gardiner Pray	3	78	67	0.869	10	71
330173002	Strafford	Rochester	2	78.5	67	0.86	11	71
510610002	Fauqier	Fauquier Co.	3	79.3	67	0.85	11	73
511390004	Page	Page Co.	3	79.7	67	0.842	12	72
250250042	Suffolk	BOSTON (Harris	3	73	66	0.908	16	85
420730015	Lawrence	New Castle	3	78.3	66	0.848	10	83
230090301	Hancock	Castine	1	75	65	0.879	10	79
250150103	Hampshire	AMHERST	3	74.7	65	0.874	10	76
420814000	Lycoming	Tiadaghton (PS	3	78.7	65	0.832	10	72
511630003	Rockbridge	Rockbridge Co.	3	76.7	65	0.855	8	70
230310038	York	West Buxton	1	75	64	0.86	9	70
330050007	Cheshire	Keene	3	74.3	64	0.865	10	72
360430005	Herkimer	Nick's Lake	3	74	64	0.873	6	70
421010004	Philadelphia	Frankford (Lab	3	71.3	64	0.906	25	85
250090005	Essex	LAWRENCE	1	70	61	0.88	10	82
330150015	Rockingham	Portsmouth	1	68	59	0.869	16	85
CC0040002	999	Roosevelt-Camp	3	58.3	51	0.888	10	75
230038001	Aroostook	Ashland135	3	64	-9	-9	-9	-999
230173001	Oxford	North Lovell	3	60.7	-9	-9	-9	-999
230194007	Penobscot	Howland	3	66.7	-9	-9	-9	-999

230194008	Penobscot	Holden Rider B	2	79	-9	-9	-9	-999
330012004	Belknap	Laconia	2	76.5	-9	-9	-9	-999
330031002	Carroll	Conway	1	67	-9	-9	-9	-999
330090008	Grafton	Haverhill	3	70.3	-9	-9	-9	-999
330130007	Merrimack	Concord	3	74.7	-9	-9	-9	-999
330190003	Sullivan	Claremont	3	74.3	-9	-9	-9	-999
360150003	Chemung	Elmira	3	80.3	-9	-9	-9	-999
360310002	Essex	Whiteface Summ	3	88.3	-9	-9	-9	-999
360310003	Essex	Whiteface Base	3	84.3	-9	-9	-9	-999
360410005	Hamilton	Piseco Lake	3	78.7	-9	-9	-9	-999
360530006	Madison	Camp Georgetow	3	79.7	-9	-9	-9	-999
361111005	Ulster	Belleayre	3	81.3	-9	-9	-9	-999
500070007	Chittenden	Underhill	3	77	-9	-9	-9	-999
511970002	Wythe	Wythe Co.	3	79.7	-9	-9	-9	-999

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361030009	Suffolk	Holtsville	3	97	**86**	0.896	34	85
340155001	Gloucester	Clarksboro	3	98.3	**85**	0.865	25	85
420170012	Bucks	Bristol	3	99	**85**	0.859	25	85
90010017	Fairfield	Greenwich	3	95.7	84	0.882	30	85
90093002	New Haven	Madison	3	98.3	84	0.859	39	85
340070003	Camden	Camden	3	98.3	84	0.862	26	85
421010024	Philadelphia	Northeast (Air	3	96.7	84	0.87	23	85
510130020	Arlington	Arlington Co.	3	96.7	84	0.875	24	85
510590018	Fairfax	Fairfax Co. -	3	96.7	84	0.87	20	85
340071001	Camden	Ancora St. Hos	3	100.7	83	0.827	27	85
361030002	Suffolk	Babylon	3	93.7	83	0.892	22	85
361192004	Westchester	White Plains	3	91.3	83	0.912	22	85
90011123	Fairfield	Danbury	3	95.7	82	0.86	18	85
90019003	Fairfield	Westport	3	94	82	0.875	37	85
90099005	New Haven	Hamden	3	93.3	82	0.881	25	85
240251001	Harford	Edgewood	3	100.3	82	0.821	41	85
340030005	Bergen	Teaneck	3	91.7	82	0.901	18	85
340210005	Mercer	Rider Univ.	3	97	82	0.855	23	85
360290002	Erie	Amherst	3	95.7	82	0.866	11	78
510590030	Fairfax	Fairfax Co. -	3	95	82	0.871	21	85
516500004	Hampton City	Hampton	3	88.3	82	0.93	36	85
240030019	Anne Arundel	Ft. Meade	3	97	81	0.838	30	85
360850067	Richmond	Susan Wagner	3	93	81	0.875	42	85
510591005	Fairfax	Fairfax Co. -	1	94	81	0.871	21	85
518000004	Suffolk City	Suffolk - TCC	3	87	81	0.942	26	85
90070007	Middlesex	Middletown	3	95.7	80	0.846	21	85
240030014	Anne Arundel	Davidsonville	3	98	80	0.822	30	85
340230011	Middlesex	Rutgers Univ.	3	96	80	0.837	22	85
340250005	Monmouth	Monmouth Univ.	3	95.7	80	0.844	45	85
340273001	Morris	Chester	3	95.3	80	0.84	13	85
360631006	Niagara	Middleport	3	91.7	80	0.882	15	85
110010043	DC	McMillan Reser	3	92.7	79	0.862	22	85
240330002	Prince Georges	Greenbelt	2	94	79	0.842	28	85
250092006	Essex	LYNN	3	90	79	0.883	16	85
250213003	Norfolk	MILTON	1	91	79	0.878	13	85
340190001	Hunterdon	Flemington	3	95.3	79	0.837	15	85
360130006	Chautauqua	Dunkirk	3	93	79	0.854	20	85
420030010	Allegheny	Pittsburgh (Ca	3	90.7	79	0.874	16	85
421010014	Philadelphia	Northwest (Rox	3	90.7	79	0.882	20	85
510850003	Hanover	Hanover Co.	2	92	79	0.864	11	85
100031010	New Castle	Brandywine	3	92.7	78	0.842	19	85
240259001	Harford	Aldino	3	97	78	0.81	35	85

240338003	Prince Georges	PG Coun.Eques.	1	94	78	0.834	28	85
360450002	Jefferson	Perch River	3	91.3	78	0.862	10	81
420030008	Allegheny	Lawrenceville	3	89.3	78	0.874	16	85
420290050	Chester	West Chester	1	95	78	0.829	12	85
420450002	Delaware	Chester	3	91.7	78	0.855	23	85
420910013	Montgomery	Norristown	3	92.3	78	0.853	21	85
515100009	Alexandria Cit	Alexandria	3	90	78	0.87	20	85
110010025	DC	Takoma Park	3	88.7	77	0.874	24	85
240053001	Baltimore	Essex	3	91.3	77	0.854	48	85
240150003	Cecil	Fair Hill	3	97.7	77	0.794	18	85
250250041	Suffolk	BOSTON (Long I	3	88.7	77	0.876	21	85
340110007	Cumberland	Millville	3	95.7	77	0.805	16	85
360270007	Dutchess	Millbrook	3	92	77	0.838	12	80
360790005	Putnam	Mt. Ninham	3	91.3	77	0.851	14	85
420030067	Allegheny	South Fayette	3	89.3	77	0.867	13	85
440090007	Washington	EPA Lab	3	93.3	77	0.833	33	85
510360002	Charles City	Charles City C	3	89.3	77	0.869	14	85
511071005	Loudon	Loudoun Co.	3	90	77	0.856	15	85
100031007	New Castle	Lums Pond	2	94.5	76	0.805	18	85
110010041	DC	River Terrace	3	89	76	0.862	22	85
240290002	Kent	Millington	3	95.3	76	0.802	17	85
250010002	Barnstable	TRURO	3	92	76	0.829	23	85
250051002	Bristol	FAIRHAVEN	3	91	76	0.838	23	85
340170006	Hudson	Bayonne	3	84.7	76	0.902	22	85
360050083	Bronx	Botanical Gard	3	83.7	76	0.917	20	85
420490003	Erie	Erie	3	89	76	0.861	23	85
420850100	Mercer	Farrell	3	91.3	76	0.842	10	82
440030002	Kent	Alton Jones	3	93.3	76	0.815	17	85
510595001	Fairfax	Fairfax Co. -	3	88	76	0.871	21	85
510870014	Henrico	Henrico Co.	3	88.3	76	0.872	15	85
90110008	New London	Groton	3	90	75	0.837	38	85
90131001	Tolland	Stafford	3	92.3	75	0.821	11	85
100010002	Kent	Killens Pond	3	88.3	75	0.86	25	85
100031013	New Castle	Bellefonte	3	90.3	75	0.84	21	85
230090102	Hancock	ANP Cadillac M	3	91.7	75	0.823	10	82
250130008	Hampden	CHICOPEE	3	92	75	0.826	10	83
420031005	Allegheny	Harrison Twp	3	91.3	75	0.83	14	85
420070002	Beaver	Hookstown	3	91.3	75	0.827	10	82
420290100	Chester	New Garden (Ai	3	94.7	75	0.797	19	85
420770004	Lehigh	Allentown	3	90.7	75	0.828	11	84
100051003	Sussex	Lewes	3	87	74	0.862	26	85
240051007	Baltimore	Padonia	3	88.7	74	0.838	26	85
240313001	Montgomery	Rockville	3	86.7	74	0.862	26	85
340010005	Atlantic	Nacote Creek	3	89	74	0.837	27	85
340315001	Passaic	Ramapo	3	86.7	74	0.862	19	85
360130011	Chautauqua	Westfield	3	87	74	0.859	12	85
420050001	Armstrong	Kittanning	3	90.7	74	0.817	11	84
420070005	Beaver	Brighton Twp	3	89.7	74	0.835	12	82

420950025	Northampton	Freemansburg	3	90	74	0.829	11	85
421290008	Westmoreland	Greensburg	3	88	74	0.845	18	85
440071010	Providence	Francis School	3	89.7	74	0.825	17	85
510590005	Fairfax	Fairfax Co. -	3	87	74	0.854	18	85
511790001	Stafford	Stafford Co.	3	86	74	0.869	36	85
90031003	Hartford	E. Hartford	3	88	73	0.833	16	85
90050005	Litchfield	Cornwall	1	89	73	0.826	11	84
100051002	Sussex	Seaford	3	90	73	0.814	10	80
230312002	York	Kennebunkport	3	88.3	73	0.827	19	85
420550001	Franklin	Methodist Hill	3	90.7	73	0.81	11	77
420710007	Lancaster	Lancaster	3	90.7	73	0.809	17	85
421250005	Washington	Charleroi	3	86.3	73	0.853	15	85
421330008	York	York	3	89	73	0.821	17	85
510410004	Chesterfield	Chesterfield C	3	84.7	73	0.862	10	85
240170010	Charles	S Maryland	3	93	72	0.784	17	85
250094004	Essex	NEWBURY	3	86	72	0.838	27	85
360551004	Monroe	Rochester	3	83.7	72	0.872	18	85
360810124	Queens	Queens College	2	83	72	0.87	26	85
361173001	Wayne	Williamson	3	84	72	0.859	18	85
420110009	Berks	Reading	3	88.7	72	0.821	10	85
420590002	Greene	Holbrook	3	87.7	72	0.823	10	85
420958000	Northampton	Easton	3	88	72	0.826	12	85
421010136	Philadelphia	Southwest (Elm	3	83	72	0.872	23	85
511530009	Prince William	Prince William	3	85	72	0.857	12	83
511611004	Roanoke	Roanoke Co.	3	83.7	72	0.867	11	76
240130001	Carroll	South Carroll	3	88.7	71	0.811	12	85
250154002	Hampshire	WARE	3	86.3	71	0.828	10	81
360010012	Albany	Loudonville	3	83	71	0.863	8	70
360671015	Onondoga	East Syracuse	3	82.3	71	0.866	8	70
230313002	York	Kittery	3	85.3	70	0.822	16	85
240210037	Frederick	Frederick Airp	3	87.3	70	0.812	11	85
250034002	Berkshire	ADAMS	3	83.3	70	0.842	9	70
250171102	Middlesex	STOW	3	85.7	70	0.826	10	80
330111010	Hillsborough	Nashua	2	86	70	0.821	10	75
360910004	Saratoga	Stillwater	3	84.7	70	0.834	6	70
361030004	Suffolk	Riverhead	3	83	70	0.852	36	85
420070014	Beaver	Beaver Falls	3	85	70	0.832	10	83
421174000	Tioga	Tioga County (	3	85	70	0.831	5	70
421290006	Wetsmoreland	Murrysville	3	82	70	0.861	20	85
510690010	Frederick	Frederick Co.	3	82.7	70	0.852	11	81
511130003	Madison	Madison Co. -	3	84.7	70	0.834	11	71
230052003	Cumberland	Cape Elizabeth	3	84.3	69	0.825	18	85
240430009	Washington	Hagerstown	3	85.3	69	0.812	10	84
330115001	Hillsborough	Peterborough	1	84	69	0.83	10	73
360715001	Orange	Valley Central	3	84.7	69	0.826	10	76
420010002	Adams	Biglerville (P	3	85	69	0.814	10	80
420110001	Berks	Kutztown	2	84.5	69	0.818	10	85
420210011	Cambria	Johnstown	3	85	69	0.814	10	85

420334000	Clearfield	Moshannon (PSU	3	87.3	69	0.795	11	76
420431100	Dauphin	Hershey	3	86.7	69	0.806	16	85
421250200	Washington	Washington	3	85.3	69	0.82	11	85
421255001	Washington	Florence	3	85.7	69	0.808	10	83
510330001	Caroline	Caroline Co.	3	82.3	69	0.843	10	84
518000005	Suffolk City	Suffolk - Holl	3	82.3	69	0.85	10	76
230090103	Hancock	ANP McFarland	3	83.7	68	0.824	10	82
230130004	Knox	Port Clyde	3	83.7	68	0.824	13	85
250130003	Hampden	AGAWAM	1	83	68	0.829	10	83
250270015	Worcester	WORCESTER	3	84	68	0.816	10	79
330150012	Rockingham	Rye	2	83.5	68	0.822	16	85
360650004	Oneida	Camden	3	79.7	68	0.858	10	70
420274000	Centre	Penn Nursery (	3	84.7	68	0.814	11	74
420430401	Dauphin	Harrisburg	3	85	68	0.801	15	85
420130801	Blair	Altoona	3	83.3	67	0.813	10	80
420270100	Centre	State College	3	84.3	67	0.804	10	76
420690101	Lacakawana	Peckville	3	83.3	67	0.815	10	75
420791101	Luzerene	Wilkes-Barre	3	83.7	67	0.805	10	76
420990301	Perry	Perry County	3	83.3	67	0.808	10	77
500030004	Bennington	Bennington	3	79.7	67	0.847	8	70
420692006	Lacakawana	Scranton	3	82	66	0.815	10	75
420810100	Lycoming	Montoursville	1	82	66	0.812	11	75
510610002	Fauqier	Fauquier Co.	3	79.3	66	0.839	11	73
511390004	Page	Page Co.	3	79.7	66	0.83	12	72
420791100	Luzerene	Nanticoke	3	81.7	65	0.806	10	76
230112005	Kennebec	Gardiner Pray	3	78	64	0.822	10	71
330150013	Rockingham	999	1	80	64	0.806	10	73
360430005	Herkimer	Nick's Lake	3	74	64	0.871	6	70
420730015	Lawrence	New Castle	3	78.3	64	0.82	10	83
511630003	Rockbridge	Rockbridge Co.	3	76.7	64	0.842	8	70
250250042	Suffolk	BOSTON (Harris	3	73	63	0.874	16	85
330173002	Strafford	Rochester	2	78.5	63	0.812	11	71
420814000	Lycoming	Tiadaghton (PS	3	78.7	63	0.804	10	72
230090301	Hancock	Castine	1	75	62	0.832	10	79
250150103	Hampshire	AMHERST	3	74.7	62	0.833	10	76
421010004	Philadelphia	Frankford (Lab	3	71.3	62	0.872	25	85
330050007	Cheshire	Keene	3	74.3	61	0.821	10	72
230310038	York	West Buxton	1	75	60	0.809	9	70
250090005	Essex	LAWRENCE	1	70	58	0.833	10	82
330150015	Rockingham	Portsmouth	1	68	55	0.822	16	85
CC0040002	999	Roosevelt-Camp	3	58.3	49	0.852	10	75
230038001	Aroostook	Ashland135	3	64	-9	-9	-9	-999
230173001	Oxford	North Lovell	3	60.7	-9	-9	-9	-999
230194007	Penobscot	Howland	3	66.7	-9	-9	-9	-999
230194008	Penobscot	Holden Rider B	2	79	-9	-9	-9	-999
330012004	Belknap	Laconia	2	76.5	-9	-9	-9	-999
330031002	Carroll	Conway	1	67	-9	-9	-9	-999
330090008	Grafton	Haverhill	3	70.3	-9	-9	-9	-999

330130007	Merrimack	Concord	3	74.7	-9	-9	-9	-999
330190003	Sullivan	Claremont	3	74.3	-9	-9	-9	-999
360150003	Chemung	Elmira	3	80.3	-9	-9	-9	-999
360310002	Essex	Whiteface Summ	3	88.3	-9	-9	-9	-999
360310003	Essex	Whiteface Base	3	84.3	-9	-9	-9	-999
360410005	Hamilton	Piseco Lake	3	78.7	-9	-9	-9	-999
360530006	Madison	Camp Georgetow	3	79.7	-9	-9	-9	-999
361111005	Ulster	Belleayre	3	81.3	-9	-9	-9	-999
500070007	Chittenden	Underhill	3	77	-9	-9	-9	-999
511970002	Wythe	Wythe Co.	3	79.7	-9	-9	-9	-999

TSD-1i

A Modeling Protocol for the OTC SIP Quality Modeling System for Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region

December 31, 2006

The Modeling Committee of the
Ozone Transport Commission

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APPENDIX A: Workgroups for the Development and Application of the OTC SIP Quality Modeling System For Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region

APPENDIX B: Work Plan for the Development and Application of the OTC SIP Quality Modeling System For Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region

1 STUDY DESIGN

1.1 Background

Moderate non-attainment areas in the Ozone Transport Region (OTR) are required to attain the 8-hour ozone NAAQS by 2010. Modeled or monitored attainment is based on the summer ozone season preceding 2010, so the target year for attainment modeling is 2009 for moderate non-attainment areas. The Ozone Transport Commission (OTC) has embarked on the task of preparing a State Implementation Plan (SIP) ozone modeling system for exercising photochemical grid model(s) to assess the impact of candidate ozone control strategies in moderate and serious non-attainment areas in the OTR. The OTC Directors endorsed the Modeling Protocol for the OTC SIP Quality Modeling System For Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region at the November 12-13, 2003 Fall meeting of the OTC. The subject protocol has been modified since then to incorporate CMAQ model modifications and emission inventory improvements.

This modeling protocol outlines procedures to prepare and use the OTC SIP ozone modeling system to help design an ozone attainment strategy to attain the ozone 8-hour NAAQS in the OTR. Emission inventories for point, area, on–road and off-road sources of NO_x, VOC and CO will be developed for a base year of 2002. BEIS3 will be used to estimate biogenic emissions. MM5 will be used at a 12 km grid resolution and, in the photochemical grid model, 4 km grid cells will be nested in urban areas where appropriate. A model performance evaluation will be prepared for 2002. If model performance is satisfactory, emission input files reflecting candidate control strategy scenarios for 2009 will be prepared, and 2009 ozone levels will be simulated with the modeling system. OTC States with moderate and serious non-attainment areas will then use these modeling results to help support required ozone attainment demonstrations. However, it has become apparent that modeling at a higher resolution than 12 km is not possible without improvements in the modeling system in terms of the physical and chemical formulation as well as the need for development of emissions estimates at spatial resolutions higher than county-level estimates.

1.2 Objective

The New York Department of Environmental Conservation has agreed to be the lead agency for developing a SIP quality ozone modeling system for assessing the future year attainment of the ozone 8-hour NAAQS in the OTR. The CMAQ model will be used to evaluate the effectiveness of control strategies in the OTR Modeling Domain. The regulatory objective will be to design an ozone control strategy that will result in attainment of the 8-hour ozone NAAQS in moderate non-attainment areas by 2009.

1.3 Photochemical Modeling System

The OTC Modeling Committee in its prior work exercised both CMAQ and CAMx and noticed that even though these models had performed similarly in estimating ozone on an over-all basis, the level of agreement between the simulated and measured concentrations varied from good to bad depending on the model and depending upon the simulation day. So, as part of this

protocol, both models (which continue to be updated by their developers) will be applied for an episode that occurred in 2002. However, it was soon recognized that there was a need for application of a *one-atmosphere* modeling system that would provide estimates of both ozone and particulate matter and that the same base year emissions and meteorological data would be utilized in the development of appropriate SIPs. This together with USEPA's launching of the CMAS center that provides a venue for sharing information from other modelers led the OTC modeling committee to select the CMAQ model for application in its SIP Quality Ozone Modeling System for testing the effectiveness of proposed control strategies in the OTR.

The OTC Modeling Committee also examined the performances of two emissions processors (EMS2001 and SMOKE, both using CB4 chemistry) from prior work and concluded that there are differences between them that could be minimized by forcing the models to use a common speciation and surrogate database. Since CMAQ was the air quality model of choice, given that it handled inputs from SMOKE more readily than it did from the EMS2001 processor, the SMOKE emission processor was selected for constructing emission files for the SIP Quality Ozone Modeling System for the OTR Domain.

1.4 Deliverables

The key deliverables for the SIP quality ozone modeling system for the OTR are listed below.

- Select Ozone Episodes
- Prepare Meteorological Fields
- Prepare 2002 Emission Inventories for each OTC State
- Acquire 2002 Emission Inventories for non-OTC States in the OTR Domain
- Prepare 2002 Emission Input Files for the OTR Domain
- Complete 2002 Model Performance Evaluation for the OTR Domain
- Prepare 2009 CAA Emission Inventories for each OTC State
- Acquire 2009 CAA Emission Inventories for non-OTC States in the OTR Domain
- Prepare 2009 CAA Emission Input Files for the OTR Domain
- Complete Modeling Runs for 2009 CAA Scenarios
- Design Control Strategy for the OTR Modeling Domain.
- Prepare 2009 Emission Input Files for OTR Control Strategy
- Complete Modeling Runs for the OTR Control Strategy for 2009
- Complete Evaluation Report for 2009 Control Strategy

1.5 Schedule

The schedule for developing the SIP quality modeling system and the assessment of the ozone NAAQS in the Ozone Transport Region is provided in Appendix A. Because of delays encountered in developing, integrating and processing state-of-the-art emission inventories from Regional Planning Organizations in the MANE-VU modeling domain, schedule target dates have been moved back approximately 9 months (complete Modeling TSD report in March of 2007 instead of June of 2006).

2 MANAGEMENT STRUCTURE

2.1 OTR Oversight Committee (Appendix B)

OTC Air Directors will serve as the OTR Oversight Committee. The Air Directors will ensure that 2002 and 2009 CAA emission inventories are prepared for each OTC state in the OTR Modeling Domain, and will also be responsible for obtaining emission inventories for the non OTR States that are part of the OTR Modeling Domain. The Air Directors will oversee the design of ozone control strategies for the OTR, and will make the final decision on any funding needed to develop the OTC SIP Quality Modeling System. The Air Directors will review all OTC SIP Quality Modeling System documentation before it is released to interested parties. The state members of the OTC Modeling Committee will keep Air Directors informed of the development of the OTC SIP Quality Modeling System.

2.2 OTR Photochemical Modeling Workgroup (Appendix B)

OTR Photochemical Modeling Workgroup will be responsible for preparing the modeling assessment of the ozone NAAQS in the OTR. The Workgroup will be responsible for collecting and processing model input data, setting up all model input files, performing model runs, and interpreting and documenting the results of the modeling analyses for the OTR domain.
The Workgroup will prepare and submit all OTC SIP quality modeling system documentation to the OTC Air Directors.

2.3 OTR Meteorological Modeling Workgroup (Appendix B)

The OTR Meteorological Modeling Workgroup will be responsible for preparing and assessing MM5 meteorological fields for the OTR Modeling Domain. This Workgroup will also work with the OTR Photochemical Modeling Workgroup to prepare all meteorological input files for the OTC SIP quality modeling system.

2.4 OTR Emission Inventory Development Workgroup (Appendix B)

The OTR Emission Inventory Development Workgroup will be responsible for obtaining and developing guidance for preparing 2002 and 2009 state emission inventories for all states in the OTR. The OTC Air Directors will be responsible for obtaining emission inventories for non-OTR states in the OTR Modeling Domain. The Mid-Atlantic Regional Air Management Association (MARAMA) and the Mid-Atlantic /Northeast Visibility Union (MANE-VU) organizations will provide funding for contractors and work with OTR states to help prepare state-of-the-art 2002 emission files, 2009 CAA emission files and 2009 Control Strategy emission files for the OTR Modeling Domain.

2.5 OTR Control Strategy Development Workgroup (Appendix B)

The OTR Control Strategy Development Workgroup will be responsible for designing an ozone control strategy for the OTR Domain that will attain the ozone NAAQS by 2009 in moderate non-attainment areas and 2012 in serious non-attainment areas. The Workgroup will work with the

OTC stationary /area source committee and the OTC mobile source committee to design an effective ozone control strategy for the OTR domain.

3 OTR MODELING DOMAIN

3.1 Description

The OTR modeling domain (see Figure 1) follows the national grid adopted by the Regional Haze Regional Planning Organizations (RPOs), but with focus on the eastern U.S. The areal extent of the domain was selected such that the northeastern areas of Maine are inside the domain. Based upon the existing computer resources, the southern and western boundaries were limited to the region shown in Figure 1. At a horizontal grid resolution of 12 km, there are 172 grids in the east-west and 172 grids in north-south direction. Details of the modeling system setup can be found at ftp://ftp.dec.state.ny.us/dar/air_research/gsistla/otc-mm5-cmaq-grid-def.doc

3.2 Horizontal Grid Size

Following EPA and as noted above, a 12 km grid resolution will be used for the domain. A coarser mesh may not be appropriate for urban area applications. Modeling at a higher resolution than 12 km will not be performed at this time; to do would require improvements in the modeling system in terms of the physical and chemical formulation as well as the need for development of emissions at a higher spatial resolution than that for the currently available county-level estimates.

3.3 Number of Vertical Layers

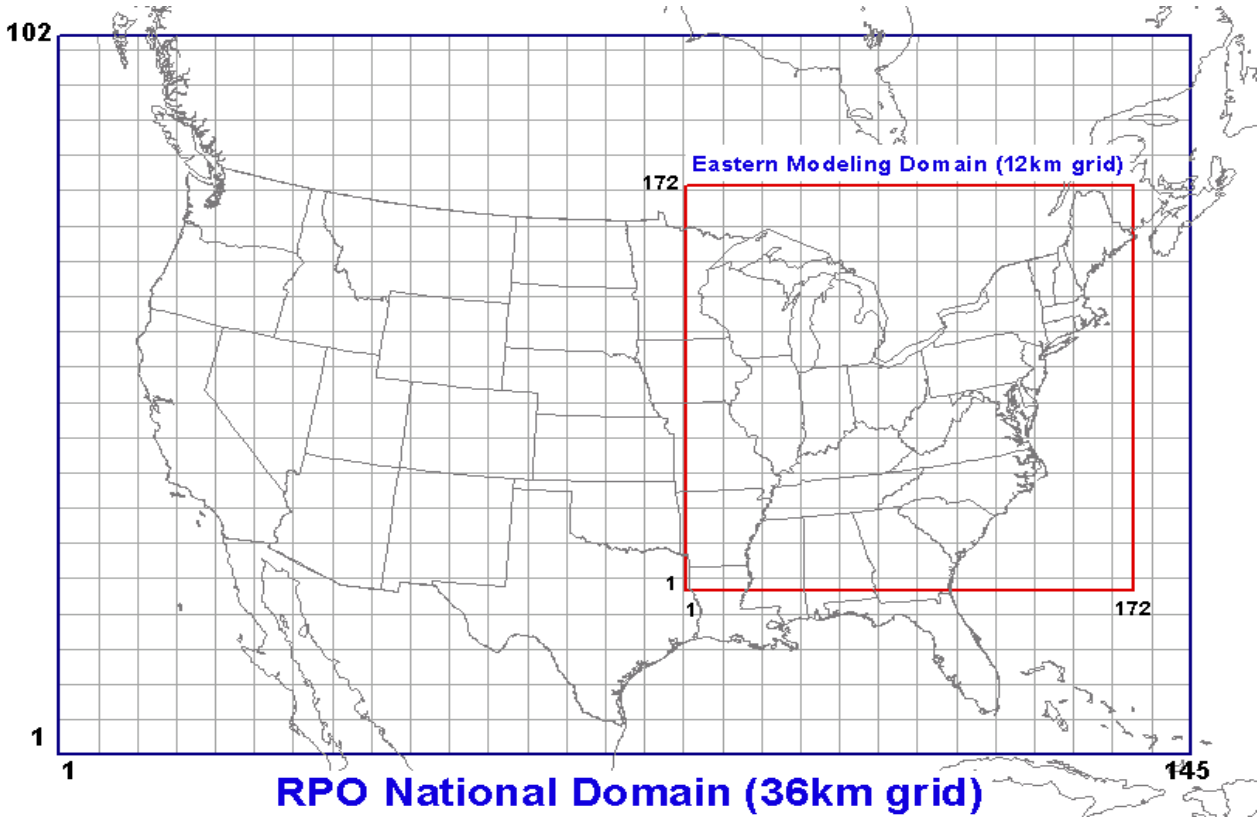
Similar to the horizontal grid spacing which is fixed by the default set forth in the design of the meteorological model, in this case 12 km, the definition of the vertical structure could also be adopted one-to-one based upon the meteorological model which has 29 layers. However, given the computational resources and runtime needs the number of vertical layers in the photochemical model was limited to 22, of which the lower 16 layers (approximately 3km) were set one-to-one with those of the meteorological model.

4 OZONE EPISODES

4.1 Episode Selection Criteria

Since it would be impractical to model every violation day, EPA has recommended targeting a select group of episode days for ozone attainment demonstrations. Such episode days should be (1) meteorologically representative of typical high ozone exceedance days in the domain, and (2) so severe that any control strategies predicted to attain the ozone NAAQS for that episode day would also result in attainment for all other exceedance days.

Figure 1: OTC Modeling Domain with areal extent of 12km and 36km grids



4.2 Proposed Episode Selection Procedure

While the above-suggested approach is perhaps feasible for isolated urban areas, such an approach may not be meaningful given the areal extent of concern and the modeling domain. Also, selection of episodes from different years would require the generation of the meteorological fields and emissions database, which would be an extremely difficult proposition given the modeling domain. The 2002 ozone season had a significant number of exceedance days (the spatial distribution of the daily 1-hr and 8-hr maxima over the eastern U. S. can be examined at the site ftp://ftp.state.ny.us/dar/air_research/htdocs/index.html). It was decided that the 5-month ozone season of 2002 would be simulated with the OTC SIP Quality Modeling System which will involve investigating numerous ozone episodes and would provide for better assessment of the simulated pollutant fields. The Environ report "Determination of Representativeness of 2002 Ozone Season for Ozone Transport Region SIP Modeling" demonstrated that 2002 episode days are (1) meteorologically representative of typical high ozone exceedance days in the domain, and (2) are probably so severe that control strategies predicted to attain the ozone NAAQS for those episode day would also result in attainment for all other exceedance days.

5 METEOROLOGICAL FIELDS

5.1 MM5 Meteorological Fields

The MM5 setup has been described by Zhang (2000) for generating meteorological fields based on a modified Blackadar scheme for the boundary layer. Since there are a variety of options that can be exercised in the application of MM5, initial testing was performed for a high ozone event of 2002 with the most commonly used default options as well as with modified boundary layer schemes (Zhang and Zheng 2004). A set of options was selected and used by Prof. Zhang of UMD in consultation with NYDEC Staff for running MM5 for the 2002 5-month ozone season.

5.2 Quality Assurance of Meteorological Fields

As a part of this effort, the simulated meteorological fields will be compared to data collected under CASTNET as well as with observations from the National Weather Service (NWS). Prior experience has shown that these approaches provide for an independent assessment of the simulated meteorological conditions. Also, data from any other special measurements will be sought and compared with the simulated fields. This analysis should provide a degree of confidence in the simulated meteorological fields and their use in photochemical grid modeling. This work will be coordinated through the meteorological model work group.

6 BASE CASE EMISSION INVENTORIES FOR 2002

6.1 2002 Base Case Emission Inventories for OTC states

Each state in the OTR Domain will prepare a 2002 base year emission Inventory that include VOC, NO_x, and CO for a typical ozone summer day. States are to follow EPA guidance documents for this base year inventory, which is due to EPA by June 1, 2004. Note this inventory may also qualify as the consolidated emissions regulatory report (CERR).

Emissions for all categories will be estimated for each county and state and the seasonal factors will facilitate spatial and temporal adjustments for modeling. Point and area source data will be submitted by individual states to EPA for uploading to EPA's National Emission Inventory (NEI) database using the required EPA format. MOBILE6.2 input files and VMT data will be submitted to NEI so that EPA can generate on-road mobile emissions for each state by county in a format that can be easily gridded and speciated. Similarly, off-road input files will be sent to EPA for running the latest NONROAD model.

It is anticipated that these state inventories will follow the EPA prescribed approach and should be formatted in a consistent manner. While this protocol deals with 8-hr ozone issues, the inventory would also contain the necessary information for exercising the particulate option of the photochemical model. This would be of help in those cases where the one-atmosphere

option is to be exercised in the assessment. Biogenic emissions will be estimated with EPA's BEIS-3 emissions model.

6.2 2002 Base Case Emission Inventories for All Other States in the OTR Domain

A 2002 base year emission inventory that includes VOC, NO_x, and CO for a typical ozone summer day will be obtained for all non-OTC states in the OTR domain. It is anticipated that these inventories will be developed following EPA guidance, and will be formatted in a consistent manner.

7 BASE CASE EMISSION INPUT FILES FOR 2002

7.1 Preparation of 2002 Emission Input Files for the OTR Domain

Emissions data will be processed using SMOKE. The surrogate data files for the OTR grid have been previously developed by NY DEC and will be used in this study. For those pollutants that depend upon ambient temperature, MM5 layer-1 gridded temperature fields will be used.

7.2 Quality Assurance of 2002 Emission Input Files for the OTR Domain

The processing of the emissions data will include several quality checks before the data are exercised in the simulations. Prior experience has shown that considerable time and resources are often invested in developing the gridded emissions data. While there are many avenues to improve or correct the data, based upon consensus of the OTC Photochemical Modeling Workgroup, a definite closure of the emissions processing will be adhered to and any further changes or corrections will be archived and incorporated at a later date. In performing this work, close attention will be paid to the emissions within the OTR and, if necessary, corrections will be incorporated on the advice of the OTC Photochemical Modeling Workgroup.

Biogenic emissions will be prepared for each episode day using BEIS-3. The temperature data from MM5 layer-1 will be used along with cloud cover information obtained from MM5.

8 AIR QUALITY DATA

8.1 Initial Conditions

Prior experience has shown that a 3-day ramp-up period is sufficient to establish pollutant levels that are encountered in the beginning of the ozone episode. In this application clean conditions will be assumed for the 1st hour of the simulation along with the emissions and boundary conditions as described below. Since the application was to be in one-atmosphere mode using a common platform, it was determined that a longer ramp-up period of 15 days was needed because experiments indicated that some of the $PM_{2.5}$ species from the initial conditions (IC) were retained for ramp-up periods of 10 days or less. Thus the CMAQ model run will start on May 1, 2002; the first 15 days are assumed to be ramp-up days and will not used for performance evaluation purposes.

8.2 Boundary Conditions

In prior studies attempts were made to include any available information from ozonesondes and monitors that are near the western and northern boundaries of the modeling domain. For this study, similar attempts will be made to obtain pollutant data at the boundaries.

For boundary conditions, NY DEC will run CMAQ with the continental 36 km grid using GEOS-CHEM simulation data for 2002. The GEOS-CHEM information will be obtained by NESCAUM from Prof. Daniel Jacob's group of Harvard University. Hour by hour boundary conditions will then be extracted from the continental 36 km CMAQ run results and used for the OTR 12 km modeling domain.

8.3 Ambient Air Quality Data

Ambient air quality data will be extracted from the EPA AQS archive for ozone, CO, NO_x, and total and speciated hydrocarbons reported as part of the PAMS network. Also, data from CASTNET will be obtained. Since the OTR modeling domain extends over two time zones, while the model simulations are reflective of a single time zone, EST, there will be a need to ”correct” the clock and assemble the ambient air quality database. Any special measurements that are relevant to this study during the summer of 2002 will also be acquired, including upper air measurements.

9 DIAGNOSTIC ANALYSES

9.1 Quality Assurance Tests of Input Components

Before proceeding with modeling, all air quality, emissions, and meteorological data will be reviewed to ensure completeness, accuracy, and consistency. Any errors, missing data or inconsistencies will be addressed using appropriate methods that are consistent with standard practices.

9.2 Diagnostic Tests

Attempts will be made to perform diagnostic tests to ensure that the simulated ozone patterns are in agreement with observed patterns over the entire simulation period. While it is unrealistic to expect day-to-day agreement between the measured and predicted data, close attention will be paid to the changes in pattern of the measured ozone levels and the ability of the model to capture such changes.

10 MODEL PERFORMANCE EVALUATION

10.1 Performance Criteria

This is an area that will likely require dialog among member states. While there are many statistical tests that can be applied to predicted ozone concentrations, it is important to define a priori some of the conditions of the analysis and the targets of evaluation. Also, it is important to define the areal extent for which the assessment needs to be done to address the performance of the model. Statistical tests are to be applied to the precursor data as well, recognizing that all tests applied to the ozone data may or may not be valid.

As part of the model assessment, qualitative analysis will also be performed by comparing predicted and measured pollutant fields to establish if the spatial patterns are captured by the modeling system. This is a critical step, since the measured concentrations may fall into a neighboring grid cell (but not at the measured location itself) and may be found to be in good agreement.

Another area that is quite important is the predictive ability of the model with respect to height. Recognizing that the pollutants trapped above the mixed layer during the overnight hours would mix down during the daytime, comparison will be made between measurements and model predictions. Special attention will be paid to elevated monitoring stations, such as the television tower near Durham, North Carolina; the Sears Tower in Chicago, Illinois, and monitors located at elevated rural stations at Whiteface Mountain, NY.

10.2 Statistical Performance Measures

The recommended EPA procedures will be used to calculate the recommended performance measures. At a minimum, the following three statistical performance measures will be used to assess CAMx model performance for each episode.

- Unpaired highest-prediction accuracy

  This measure quantifies the difference between the highest observed eight-hour value in the domain and the highest predicted value in the domain. The acceptable performance range is plus or minus 15-20 percent.

- Normalized bias

  This measure indicates the degree to which simulated eight-hour values are over or under-predicted. The acceptable performance range is plus or minus 5-15 percent.

- Gross error of all pairs above 40 ppb

  This measure indicates the average discrepancy between predicted and observed values and provides an overall assessment of model performance. The acceptable performance range is 30-35 percent.

11 CAA EMISSION INVENTORIES FOR 2009

11.1 CAA Emission Inventories for OTR States for 2009

Each OTC state in the OTR Domain will prepare a 2009 CAA emission inventory that is consistent with the regulations and rules adopted or expected to be in-place. The inventory will be developed consistent with EPA guidance. The states will develop the information on growth factors and controls used in the development of the inventory. Each state will submit a report on the development of these future year inventories.

Since the electric energy generation and use are highly inter-connected, coupled with the existing rules on trading and banking of pollutants, it is expected that an inventory consistent with this information would be developed for all electric energy generation units using models such as IPM.

Recognizing that any prediction of future emissions are subject to changes, the OTC Modeling Committee would develop a decision framework on obtaining these emissions to be consistent with the OTC SIP quality modeling system schedule (Appendix A).

11.2 CAA Emission Inventories for all non-OTR States for 2009

A 2009 CAA emission inventory that includes VOC, NO_x, and CO for a typical ozone summer day will be obtained for all non-OTC states in the OTR. It is anticipated that these inventories will be developed following EPA guidance, and will be formatted in a consistent manner.

12 CAA EMISSION INPUT FILES FOR 2009 FOR THE OTR DOMAIN

12.1 CAA Emission Input Files for OTR Domain for 2009

2009 CAA emissions data will be processed using SMOKE. For pollutants that depend on ambient temperature, MM5 layer-1 gridded temperature fields will be used to estimate hourly emission rates. The biogenic emission input files prepared for the base 2002 will be used as a surrogate for 2009 biogenic emissions. These emissions data will be processed using the quality assurance checks described in section 7.2.

It should be noted that the CAA means all on the books and on the way control measures (OTB/OTW) scheduled to be in effect by 2009.

13 OTR DOMAIN OZONE CONTROL STRATEGY

13.1 OTC CALGRID System Screening Runs

A series of CALGRID screening runs will be performed to investigate the level of emissions reductions needed both within and outside of the OTR. This will help identify potential emission reductions scenarios that can be used for CMAX future year SIP modeling runs.

13.2 OTC SIP Modeling Platform Runs

OTC SIP modeling platform CAA runs for 2009 will be reviewed to help determine the level of emissions reductions needed to attain the ozone NAAQS. VOC and NOX sensitivity runs will also be performed to help identify potential emission reductions scenarios that can be used to lower ozone levels in the OTR.

13.3 Analysis of Available Air Quality and Emission Databases

A review of air quality and emission databases (for example, EPA Clear Skies and Transport Rule emission files) will be performed to help identify potential source sectors of ozone precursors. Analysis of available EPA modeling results will also be performed to help identify potential source sectors of ozone precursors in, and upwind, of the OTR domain.

13.4 Ozone Control Strategy for the OTR Domain

The OTR Control Strategy Development Team will review CALGRID results, other available databases**,** and EPA databases, to help identify potential control programs. The Team will work with OTR states and the OTC stationary, area and mobile source committees to design ozone control strategies for the OTR Domain with the goal of meeting regulatory target dates.

14 OZONE CONTROL STRATEGY EMISSION INPUT FILES

14.1 Ozone Control Strategy Emission Input Files for the OTR Domain for 2009

Emissions files for the selected ozone control strategy for the OTR Domain for 2009 will be prepared in a consistent manner as per schedule. If necessary, additional IPM simulations may be performed to obtain EGU emission estimates.

15 OZONE PREDICTIONS FOR 2009

15.1 Initial Conditions

The initial conditions at the startup will be “clean”. The OTR Modeling Team will use the 2002 initial condition files as a surrogate for initial conditions for 2009 modeling runs.

15.2 Boundary conditions

EPA will be consulted for guidance in estimating boundary conditions for 2009 or, under default, would utilize those adapted for the Base 2002 base year simulation. It should be noted that the default option was used for the 2009 CMAQ simulation.

15.3 CAA Ozone Predictions for 2009

The model will be run with the CAA emission files developed for 2009. Tile plots, difference plots, and model statistics will be prepared to help characterize the extent of any remaining non-attainment areas predicted in the OTR in 2009.

15.4 Ozone Control Strategy Predictions for 2009.

The model will be run with OTR control strategy emission files prepared for 2009. Tile plots, difference plots and model statistics will be prepared to help characterize the extent of any remaining non-attainment areas predicted in the OTR for the year 2009.

16 DOCUMENTATION

A report titled "Assessment of the Ozone National Ambient Air Quality Standards in the Ozone Transport Region will be prepared by the OTR Modeling Team". The report would cover model performance evaluation, and an evaluation of the OTR control strategy runs for 2009. This technical document will be made available to all interested parties and will be used by the member States in their SIP submission documentation as needed.

17 REFERENCES

Environ (2006): Determination of Representativeness of 2002 Ozone Season for Ozone Transport Region SIP Modeling

Dalin Zhang (2000): Development of meteorological database for summer 1997 using MM5 at 12 km resolution in Photochemical Model Simulations

Dalin Zhang and William Zheng (2004): Diurnal cycles of surface winds and temperatures as simulated by five boundary-layer parameterizations, Journal of Appl. Meteorology 43, 157-169

Gopal Sistla (1999): Development of a surrogate database for use in Regional/Urban-scale Modeling at 4 km spatial resolution (see http://envpro.ncsc.org/emcenter/)

Wick Havens (2000): Development of an Emissions Inventory for Regional/Urban-scale Modeling, MARAMA-RTC (see http://www.marama.org/)

APPENDIX A

Workgroups for the Development and Application of the OTC SIP Quality Modeling System for Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region

OTC Photochemical Modeling Workgroup

State Lead	Gopal Sistla
OTC contact	Tom Frankiewicz
Chair OTC Modeling Committee	Barbara Kwetz

Delaware	Mohammed Majeed
DC	Rama Tangirala
Maine	Tom Downs
Maryland	Mike Woodman
Massachusetts	Steve Dennis
New Hampshire	Jeff Underhill
New York	Gopal Sistla
Pennsylvania	Tim Leon Gurrero
NESCAUM	Gary Kleiman
EPA	Invited for selected discussions

OTC Meteorological Modeling Workgroup

State Lead	Mike Woodman
OTC contact	Tom Frankiewicz
Connecticut	Dave Wackter
Delaware	Mohammed Majeed
DC	Rama Tangirala
Maine	Tom Downs
Maryland	Tad Aburn Matt Seybold Mike Woodman Jeff Stehr
Massachusetts	Rich Fields
New Hampshire	Jeff Underhill
New Jersey	Alan Dresser
New York	Gopal Sistla
Pennsylvania	Tim Leon Gurrero
Vermont	Paul Wishinski
Virginia	Kirit Chaudhar
MARAMA	Serpil Kayin
NESCAUM	Gary Kleiman
EPA	Invited for selected discussions

OTC Emission Inventory Development Workgroup

State Lead	Ray Malenfant
OTC contact	Tom Frankiewicz
Connecticut	Bill Simpson
Delaware	Dave Fees
DC	Rama Tangirala
Maine	Dave Wright
Maryland	Roger Thgunell
Massachusetts	Ken Santlal
New Hampshire	Mike Fitzgerald Andy Bodnarik
New Jersey	Joan Held
New York	Jim Ralston
Pennsylvania	Dean Van Orden
Rhode Island	Karen Slattery
Vermont	Jeff Merrell
Virginia	Tom Ballou
MARAMA	Serpil Kayin
EPA	Invited for selected discussions

OTC/MANE-VU Control Strategies Workgroup

State Lead	Jeff Underhill
OTC contact	Tom Frankiewicz
Connecticut	Dave Wackter Kurt Kebschull
Delaware	Ray Malenfant Mohammed Majeed
Maine	Jeff Crawford Tom Downs
Maryland	Tad Aburn Matt Seybold Mike Woodman Jeff Stehr
Massachusetts	Eileen Hiney Steve Dennis
New Hampshire	Jeff Underhill Andy Bodnarik
New Jersey	Bob Stern Ray Papalski Alan Dresser Robert Huizer
New York	Gopal Sistla
Pennsylvania	Wick Havens Tim Leon Gurrero
Rhode Island	Barbara Morin
Vermont	Paul Wishinski
Virginia	Kirit Chaudhar
MARAMA	Serpil Kayin Megan Schuster
NESCAUM	Leah Weiss Gary Kleiman
EPA	Invited for selected discussions

APPENDIX B

Work Plan for the Development and Application of the OTC SIP Quality Modeling System.

Work plan for the Development and Application of the OTC SIP Quality Modeling System†

Task No.	Activity or Task	Initial Target Date	Organization(s) Performing Task	Remarks & Status Notes & Revisions
	Initial Planning			
1	Prepare a Work plan and a Modeling Protocol for the development of the OTC SIP quality modeling system to address ozone non-attainment problems in the OTR.	Nov 03	NY, MA	Completed
	Meteorology			
2 3 4	Complete MM5 modeling for 2002 (May thru Sep) Episode evaluation and assessment Evaluate MM5 data and process for photochemical models.	Dec 04 Dec 04 Mar 05	MD (UMCP), NY Contract Support MD (UMCP), NY	In progress In progress Inn progress
	Emissions Inventories			
5	Prepare 2002 emission inventories for MANEVU states in the OTR Domain.	Jan 05	MARAMA	
6	Obtain 2002 emission inventories for non-MANEVU states in the OTR Domain.	Jan 05	MARAMA	
7	Prepare 2009 CAA emission inventories for MANEVU states in the OTR Domain.	Aug 05	MARAMA	
8	Obtain 2009 CAA emission inventories for non-MANEVU states in the OTR Domain.	Aug 05	MARAMA	
	Emission Input files			
9	Prepare 2002 emission files for the OTR domain with SMOKE and /or EMS2001, and QA emissions data.	Nov 04	NY	Delayed until Jan 05
10	Prepare 2009 CAA emission files for the OTR domain with SMOKE and /or EMS2001, and QA emissions data.	Nov 05	NY	
11	Prepare 2009 emission files for OTR control strategy with SMOKE and /or EMS2001, and QA emissions data.	Nov 05	NY	

Task No.	Activity or Task	Initial Target Date	Organization(s) Performing Task	Remarks & Status Notes & Revisions
	Modeling			
12	Complete 2002 model performance evaluation for OTR Domain.	May 05	NY	
13	Test model sensitivity to NOx, VOC reductions and potential control measure options.	Sep 05	NY	
14	Complete modeling runs for 2009 CAA scenarios.	Jan 06	NY	
15	Complete modeling runs for 2009 OTR control strategy	Jan 06	NY	
	OTR Control Strategy Development			
16	Perform screening runs with OTC CALGRID modeling system	Mar 05	OTR Control Strategy Development Workgroup	
17	Review air quality and emission databases to help identify potential sources of ozone in the OTR.	Jul 05	OTR Control Strategy Development Workgroup	
18	Design Control Strategy for the OTR Domain	Sep 05	OTR Control Strategy Development Workgroup	
	Reports			
19	Complete technical support documents presenting regional OTR modeling and air quality/emission database analyses. (These two documents will provide technical support for state ozone SIPs.	Jun 06	NY, other OTC states	This will allow states nine months to prepare SIP revisions due in April 2007.
	Management			
20	Day-to-day management and coordination.	on-going	OTC Modeling Committee	
21	Provide direction, oversight, and obtain any necessary funding.	on-going	OTC Air Directors	

† To be used as needed for Ozone SIPs in the OTR. Based on EPA draft guidance, Ozone SIPs expected submission by April 2007.

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Emission Processing for OTC 2009 OTW/OTB 12km CMAQ Simulations

Office of Air Data Analysis
Air Division
Virginia Department of Environmental Quality
Richmond, VA

February 19, 2007

Overview

The OTC 2009 OTW/OTB emission modeling was conducted at the Virginia Department of Environmental Quality (DEQ). The modeling followed and retained the framework of the previous (original) OTC 2002/2009 emission modeling done by the New York State Department of Environmental Conservation (NYSDEC). Several changes and corrections had been made throughout the entire modeling period. Virginia DEQ was in close contact with NYSDEC which provided many premerged netCDF files for inclusion in the merging process to obtain final SMOKE outputs for CMAQ simulations.

Emissions for all source categories were processed by SMOKE2.1. The SMOKE programs downloaded from Community Modeling and Analysis System (CMAS) website have been compiled for LINUX system and ready for usage. If existing compiled codes returned errors, such as in the case of large MCIP files, compiled versions provided by NYSDEC and available at Ozone Research Center's (ORC) ftp sites were used instead.

Data Sources

The majority of raw input data files were provided to DEQ by Greg Stella of AlpineGeophysics through its ftp site at alpinegeophysics.com. Different versions of 2009 SMOKE emission modeling have been conducted over the years by AlpineGeophysics. The version of input data files used for OTC 2009 OTW/OTB emission modeling was labeled as BaseG of the AlpineGeophysics.

In some source categories, primarily in MANEVU and Canada regions, several changes and corrections in emissions were made at various stage of SMOKE modeling, causing the outputs using AlpineGeophysics files to be discarded. SMOKE modeling of those categories (described below) was performed by NYSDEC which made netCDF outputs available at Ozone Research Center's ftp site at ozoneresearch.org. In such cases, DEQ used the premerged netCDF files directly for final merging.

SMOKE Processing

The OTC 12km regional and urban scale modeling domain encompasses four RPOs: VISTAS, MANEVU, CENRAP, and MRPO. Part of Canada also falls in the modeling domain.

The OTC 2009 OTW/OTB emissions were processed roughly on a month-by-month and RPO-by-RPO basis. SMOKE modeling was conducted for each month for each of the four individual RPOs as well as for Canada (completed by NYSDEC), except for mobile source category, which was done by two sub-RPOs: one for MANEVU and the other for the combination of VISTAS, CENRAP, and MRPO. A separate SMOKE ASSIGNS file was created for each RPO and/or source category. The episode length in the ASSIGNS files varies from one month to the entire year.

Five major emission source categories (listed below) were included in the OTC 2009 OTW/OTB SMOKE modeling. Sub-categories were lumped into the major categories here for presentation purpose but were treated as separate categories in processing. For example, low-level wildfire was treated as area source, whereas high-level wildfire was modeled as point source. In addition, point source category was further divided into EGU and non-EGU. Minor sources such as non-fossil fuels and marine vessel were processed as well. Table~1 summarizes input files and other relevant information for each of the RPOs and Canada.

(1) Area (including low-level wildfire and NH3);
(2) Nonroad (including marine vessel);
(3) Point (including EGU, Non-EGU, non-fossil fuels and wildfires);
(4) Mobile;
(5) Biogenic.

For VISTAS region (only), AlpineGeophysics has developed annual, daily, or hourly emissions data for EGU and high-level wildfire source categories. SMOKE run script parameters of DAY_SPECIFIC_YN and/or HOUR_SPECIFIC_YN were turned on (to Y) and month-specific temporal profiles of BaseG were applied to make sure those more detailed inventory files were used to override annual emissions.

Mobile source emissions were divided into two groups for processing. The original input file (mbinv_vistas_09g_vmt_12jun06.txt) provided by AlpineGeophysics contains VMT data for all four RPOs. The MANEVU portion was first removed from the original file and the revised file (otherRPOs.mb.vmt.emis) which contains VMT data for the remaining three RPOs (VISTAS, CENRAP, MRPO) was then used as the input inventory for processing. The MANEVU portion removed from the original file was processed separately on its own as another group.

MOBILE6 Processing

As described above, mobile source emissions for three RPOs --- VISTAS, CENRAP, and MRPO --- were grouped and processed together. To estimate vehicle emission factors in MOBILE6, temperature averaging of space and time were specified in input file of mvref_vistas_2009g_26aug06.txt as follows:

(1) Spatial averaging: temperatures were averaged over all counties that share a common reference county;

(2) Temporal averaging: temperatures were averaged over the duration of the episode, which in present case is one month.

The averaging described above is consistent with the original OTC 2002/2009 emission processing done by NYSDEC. DEQ also processed MANEVU portion of mobile source. However, due to the inconsistency of temporal profile and cross-reference file used between DEQ's run and the original 2002/2009 run by NYSDEC, those outputs were discarded. NYSDEC re-processed the MANEVU portion and provided netCDF files to

DEQ for final merging. The re-processed MANEVU run by NYSDEC reflects updated mobile source information in New Jersey and Connecticut.

Speciations, Temporal and Spatial Allocations

For consistency, the OTC 2009 OTW/OTB input profiles for speciations, temporal, and spatial allocations remained the same as the original OTC 2002/2009 emission modeling done by NYSDEC, even though more up-to-date profiles (such as those marked with BaseG or later) were available at the AlpineGeophysics. No attempt was made to examine the effects of different versions of profiles on daily emissions.

Fugitive Dust Corrections

Fugitive dust emissions were corrected in SMOKE by two-step process. First, SMKINVEN and CNTLMAT were executed with two separate input files: (1) the original inventory file, and (2) a controlled matrix file of 2009 dust projection factors. A new inventory file containing adjusted emissions was created in SMKINVEN/CNTLMAT run. The new file was then used as the inventory input for regular SMOKE processing of SMKINVEN, SPCMAT, GRDMAT, TEMPORAL, LAYPOINT (for point source), and SMKMERGE. The source categories which went through this two-step process included non-EGU for VISTAS, MANEVU, CENRAP, and MRPO, and area sources for MANEVU and CENRAP.

Canadian and Biogenic Emissions

Canadian emissions of all four source categories (area, nonroad, point, mobile) and domain-wide biogenic emissions were processed by NYSDEC. Details on how emission modeling of these categories was conducted have been documented in ``Emission Processing for the Revised 2002 OTC Regional and Urban 12 km Base Case Simulations" by NYSDEC. DEQ obtained premerged netCDF files for these source categories from ORC ftp site and used them directly for final merging.

Premerged netCDF Files

In December 2006, NYSDEC made further adjustments to ammonia and dust emissions of MRPO region and ran through SMOKE with the adjusted emissions. Three of MRPO's source categories were affected: area, nonroad, and NH3. As a result, outputs generated by DEQ for the three affected MRPO's categories were discarded. Canadian emissions of all four source categories (area, nonroad, point and mobile) were also re-processed by NYSDEC with updated information. Seven newer versions, three for MRPO and four for Canada, of premerged netCDF files reflecting the adjustments were made available at ORC ftp site. The updated premerged netCDF files were used to replace earlier versions in the final merging process.

SMOKE Merging

A total of twenty-seven netCDF files were merged together to produce daily total emissions for use as inputs to CMAQ:

(1) Six for VISTAS (excluding mobile);
(2) Five for MANEVU (excluding mobile);
(3) Four for CENRAP (excluding mobile);
(4) Five for MRPO (excluding mobile);
(5) Two for mobile source emissions;
(6) Four for Canadian emissions;
(7) One for domain-wide biogenic emissions.

Table~1 lists the categories (indicated by sequential numbers) which were combined in the merging process.

BOTW Emissions

The differences between 2009 BOTW and 2009 OTW/OTB emissions lie in the area and non-EGU sources of MANEVU region where more controlled emissions are in effect for BOTW than for OTW/OTB. NYSDEC generated premerged netCDF files for BOTW run. To obtain 2009 OTC BOTW emissions, the two affected MANEVU source categories for OTW/OTB run were substituted and replaced by the new BOTW premerged files in the final merging process.

Table 1. 2009 OTW/OTB Emissions Processing Summary			
Category	**Files**	**Files Source**	**Notes**
VISTAS			
(1) Area	arinv_vistas_2009g 2453922 w pmfac.txt	Alpine Geophysics	
(2) Non-Road	nrinv_vistas_2009g 2453908.txt	Alpine Geophysics	
	marinv_vistas_2009g 2453972.txt	Alpine Geophysics	marine vessel emissions
(3) Non-EGU	negu_ptinv_vistas_2009_baseg_2453957.txt	Alpine Geophysics	
(4) EGU	egu_ptinv_vistas_2009_baseg_2453990.txt	Alpine Geophysics	annual emissions
	pthour_2009_baseg_mon_2453990.ems	Alpine Geophysics	hourly emissions, mon=may,jun,...
(5) Low Fire	area_level_res_vistas2002_baseg.ida	Alpine Geophysics	treated as area sources
(6) High Fire	ptinv.plume.vistasbaseg09.num.ida	Alpine Geophysics	treated as point sources; annual data
	ptday.plume.vistasbaseg09.num.ida	Alpine Geophysics	daily data; num=1,2,...
	pthour.plume.vistasbaseg09.num.ida	Alpine Geophysics	hourly data; num=1,2,...
(7) Mobile	otherRPOs.mb.vmt.emis	Revised from AlpineG	contains VISTAS/CENRAP/MRPO
MANE-VU			
(8) Area	MANEVU2009OTBAreaV3_1_woodburn.incl.IDA.txt	Alpine Geophysics	if BOTW, premerged netCDF for merging
(9) Non-Road	2009MANEVUNRNIFV3_0_NonRoad_IDA.NJ_x.txt	Alpine Geophysics	
(10) Non-EGU	manevu2009noneguv3_0_point_ida.txt	Alpine Geophysics	if BOTW, premerged netCDF for merging
(11) EGU	ptinv_egu_2009_manevu_10aug2006.txt	Alpine Geophysics	annual emissions
(12) Non-Fossil EGU	manevu_nonfossil_2009_19sept2006.txt	Alpine Geophysics	non-fossil fuel emissions
(13) Mobile	netCDF file	Alpine Geophysics	netCDF used for merging
CENRAP			
(14) Area	cenrap_area_burning_smoke_2009_input_ann_tx_neli_071905_2453959.txt	Alpine Geophysics	
	cenrap_area_misc_2009_smoke_input_ann_state_071905_2453959.txt	Alpine Geophysics	
	cenrap_area_misc_2009_smoke_output_nh3_annual_072805 rev_2453959.txt	Alpine Geophysics	
	arinv.cenrap_2009_09_xfact.ida.txt	Alpine Geophysics	
	cenrap_area_smoke_2009_output_nh3_annual_071905_rev_2453959.txt	Alpine Geophysics	
(15) Non-Road	cenrap_nonroad_smoke_2009_output_annual_071305_rev.txt	Alpine Geophysics	
(16) Non-EGU	ptinv_negu_cenrap2009_25aug2006.ida	Alpine Geophysics	
(17) EGU	ptinv_egu_2009_cenrap_10aug2006.txt	Alpine Geophysics	annual emissions
Mobile	otherRPOs.mb.vmt.emis	Revised from AlpineG	VISTAS/CENRAP/MRPO
MRPO			
(18) Area	arinv_other_mrpok_2009_10aug2006.txt	Alpine Geophysics	dust correction; premerged netCDF
	dustinv_mrpo_basef4_2009_10nov05.ida	Alpine Geophysics	
(19) NH3	nh3inv_2009_mrpok_ann_10aug2006.txt	Alpine Geophysics	dust correction; premerged netCDF
(20) Non-Road	nrinv_mrpo_g_09_2453958 adj.txt	Alpine Geophysics	dust correction; premerged netCDF
	arinv_mar_mrpok_2009_7aug2006.txt	Alpine Geophysics	
(21) Non-EGU	ptinv_negu_2009_mrpok_10aug2006.txt	Alpine Geophysics	
(22) EGU	ptinv_egu_2009_mrpok_10aug2006.txt	Alpine Geophysics	annual emissions
Mobile	otherRPOs.mb.vmt.emis	Revised from AlpineG	VISTAS/CENRAP/MRPO

Table 1. 2009 OTW/OTB Emissions Processing Summary			
Category	**Files**	**Files Source**	**Notes**
CANADA			
(23) Area	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
(24) Non-Road	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
(25) Point	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
(26) Mobile	netCDF file	NYSDEC; downloaded from OTC ftp site	premerged netCDF for merging
BIOGENIC			
(27) Biogenic	netCDF file	NYSDEC; downloaded from OTC ftp site	domain-wide emissions; premerged netCDF for merging

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Trends in Measured 1-h Ozone Concentrations over the OTR modeling domain

Bureau of Air Quality Analysis and Research

Division of Air Resources

New York State Department of Environmental Conservation

Albany, NY 12233

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Ozone Trend Analysis

Trends in raw and meteorologically adjusted 1-hour ozone were calculated at several AQS monitoring sites in the Northeast. A summary of the analysis is provided below, and a detailed description of the met-adjustment procedure is outlined in Milanchus et al. (1998) and references contained including those related to the Kolmogorov-Zurbenko (KZ) method used in this analysis to estimate trends.

Data

Ozone time series were obtained at many monitoring sites in the Northeastern United States. From these data, log of daily maximum one hour ozone were calculated. In addition, several meteorological variables were obtained from National Weather service stations in the Northeast. These included surface temperature, dew point and specific humidity with dew point depression being calculated. Daily maximum values were calculated for each of the meteorological variable times series. The time span of data considered for both ozone and meteorological variables was from 1985 to 2005. In addition, this analysis focused on the ozone season (April 15 through October 15) of each year.

Summary of Trend analysis

In calculating raw ozone trends, a KZ365,3 filter was applied to the log of daily maximum ozone time series to obtain the long-term trend component. A linear regression is then performed to get the trend estimate.

For the met-adjusted trends, the time series of ozone and meteorological variables must first be separated into the baseline and short-term time scales. A KZ15,5 was used for this separation. The effects of meteorology are then removed from these components independently. Applying the KZ15,5 filter to the raw data (log of daily maximum ozone and daily maximum met. variables) produces the baseline component. The short term component is then obtained by subtracting the baseline from the raw data. For this analysis, temperature and dew point depression were removed from the short-term component, while temperature and specific humidity were removed from the baseline component.

Once the baseline and short-term components are isolated a multiple least squares regression is performed on each component with the respective meteorological components. Next, the residuals from the multiple regression on the short-term are added to the residuals from the baseline to get the met-adjusted ozone time series. A KZ365,3 filter is then applied to the met-adjusted ozone to get the long-term component of met-adjusted ozone. A linear regression is then applied to the long-term met-adjusted ozone to get a trend estimate and 95% confidence interval. Trend values that are negative represent a decreasing trend in ozone, while positive values indicate an upward trend. In this

analysis, trends were calculated for 4 different time periods; 1985 to 2005, 1990 to 2005, 1995 to 2005 and 2000 to 2005. Only trends that were significant at the 95% confidence level were reported. Tables 1to 4 list the raw and met-adjusted trends for each of these time periods over the OTR. The total number of ozone monitors varied in these time periods, as there were often changes in the location of the monitor due to operational logistics. Figures 1a and 1b provide a graphical representation of the trends for the 1990 to 2005 time period.

Results

Trends in both raw and meteorologically adjusted ozone are found to vary substantially over different time periods and from location to location. Trends were calculated for all ozone monitors located within the modeling domain, although the following discussion is focused on the New York CMSA, and that similar analysis could be performed for other areas of the OTR. In general, there is a decreasing trend in raw ozone over the New York, New Jersey and Connecticut area for all the time periods considered. Monitors in New York tend to show more decreasing trends when consideration is given to the longer time period of 1985 to 2005, and less for the shorter period of 1995 to 2005. Only one monitor in New Jersey continues to show an increasing trend in raw ozone levels irrespective of the 3 time periods, while Connecticut has the highest number of monitors that display an increasing trend particularly for the 1990 to 2005 period.

When meteorologically adjusted ozone is considered, the general trend over the tri-state area is one of decreasing ozone. The majority of New York monitors show decreasing trends in met-adjusted ozone with the most being in the 1985 to 2005 and 1995 to 2005 time periods and the least during the 1990 to 2005 time period. As with raw ozone concentrations, New Jersey has only one monitor showing an upward trend and only for the 1990 to 2005 time period. Monitors in Connecticut show a general downward trend in met-adjusted ozone with the majority of these occurring in the 1985 to 2005 time period and the least in the 1990 to 2005 period. Although we see a fairly consistent decrease in both raw and meteorologically adjusted ozone, it is not uncommon to see trends of different magnitude or even trend directions in nearby monitors that is probably a reflection of differences in emissions and titration effects on ozone.

Reference:

Milanchus et al., (1998) “Evaluating the effectiveness of ozone management efforts in the presence of meteorological variability”, JA&WMA, 48, 201-215.

Table 1 Raw and Met-adjusted trends in 1-hr ozone concentrations over the OTR for 1985-2005 ozone seasons

STATE	AIRS ID	STATION	LOCATION	RAW TRENDS		MET-ADJUSTED TRENDS	
				Slope (%/yr)	95% CI	Slope (%/yr)	95% CI
CT	90010017	GREENWICH	GREENWICH POINT PARK	-0.118	0.015	-0.234	0.017
CT	90011123	DANBURY	TRAILER, W. CONNECTICUT STATE UNIVERSITY	0.041	0.019	-0.083	0.021
CT	90013007	STRATFORD	USCG LIGHTHOUSE , PROSPECT STREET	-0.558	0.017	-0.823	0.019
CT	90031003	E. HARTFORD	MCAULIFFEE PARK	0.395	0.019	0.422	0.014
CT	90070007	MIDDLETOWN	CONN. VALLEY HOSP., SHEW HALL, EASTERN D	-0.097	0.014	-0.197	0.011
CT	90093002	MADISON	HAMMONASSET STATE PARK	0.056	0.015		
CT	90110008	GROTON	UNIVERSITY OF CONNECTICUT, AVERY POINT	-0.758	0.015	-0.807	0.019
CT	90131001	STAFFORD	ROUTE 190, SHENIPSIT STATE FOREST	-0.176	0.015	-0.218	0.013
DC	110010025	NOT IN A CITY	TAKOMA SC. PINEY BRANCH RD & DAHLIA ST N	-0.464	0.022	-0.191	0.015
ME	230052003	CAPE ELIZABETH	TWO LIGHTS STATE PARK	-0.943	0.014	-0.847	0.013
ME	230312002	NOT IN A CITY	OCEAN AVE/PARSONS WAY, KENNEBUNKPORT	-0.794	0.016	-0.712	0.013
MD	240030014	NOT IN A CITY	QUEEN ANNE AND WAYSON ROADS	-0.904	0.024	-0.698	0.019
MD	240051007	COCKEYSVILLE	GREENSIDE DRIVE COCKEYSVILLE MD	-0.596	0.015	-0.326	0.010
MD	240053001	ESSEX	WOODWARD & DORSEY RDS ,ESSEX MD	-0.493	0.014	-0.221	0.012
MD	240130001	NOT IN A CITY	1300 W. OLD LIBERTY ROAD, WINFIELD,MD	-0.841	0.014	-0.566	0.010
MD	240170010	NOT IN A CITY	SO MD CORRECTIONAL CAMP, HUGHESVILLE	-0.780	0.020	-0.557	0.015
MD	240251001	EDGEWOOD	EDGEWOOD ARMY CHEM CENTER EDGEWOOD	-0.537	0.016	-0.296	0.016
MD	240313001	ROCKVILLE	LOTHROP E SMITH ENV.ED CENTER ROCKVILLE	-0.604	0.022	-0.441	0.018
MA	250010002	TRURO	FOX BOTTOM AREA-CAPE COD NAT'L SEA SHR	0.029	0.018	-0.312	0.020
MA	250051002	FAIRHAVEN	LEROY WOOD SCHOOL	-0.186	0.019	-0.301	0.020
MA	250130008	CHICOPEE	ANDERSON ROAD AIR FORCE BASE	-0.201	0.019	-0.072	0.016

MA	250154002	WARE	QUABBIN SUMMIT	-0.520	0.015	-0.576	0.014
NH	330050007	KEENE	RAILROAD STREET	-0.140	0.036	-0.360	0.005
NH	330190003	CLAREMONT	SOUTH STREET	0.390	0.068	0.210	0.037
NJ	340010005	NOT IN A CITY	BRIGANTINE WILDLIFE REFUGE,NACOTE CREEK	-0.999	0.020	-0.914	0.020
NJ	340070003	NOT IN A CITY	COPEWOOD E. DAVIS STS; TRAILER	-0.692	0.021	-0.729	0.020
NJ	340071001	NOT IN A CITY	ANCORA STATE HOSPITAL, ANCORA	-0.838	0.014	-0.752	0.016
NJ	340110007	NOT IN A CITY	LINCOLN AVE.&HIGHWAY 55,NE OF MILLVILLE	-0.767	0.014	-0.551	0.015
NJ	340150002	NOT IN A CITY	CLARKSBORO,SHADY LANE REST HOME	-0.686	0.011	-0.580	0.012
NJ	340170006	BAYONNE	VETERANS PARK ON NEWARK BAY	-0.988	0.014	-0.784	0.015
NJ	340190001	FLEMINGTON	RARITAN STP,RTE.613S, THREE BRIDGES	-0.326	0.013	-0.118	0.016
NJ	340210005	NOT IN A CITY	RIDER COLLEGE;LAWRENCE TOWNSHIP	-0.825	0.014	-0.753	0.012
NJ	340273001	NOT IN A CITY	BLDG.#1, BELL LABS, OFF ROUTE 513	-0.823	0.015	-0.645	0.017
NY	360010012	ALBANY	LOUDONVILLE RESERVOIR			0.169	0.010
NY	360150003	ELMIRA	SULLIVAN ST., WATER TR. PL.	-0.056	0.017	0.036	0.016
NY	360290002	AMHERST	AUDUBON GOLF COURSE, MAPLE ROAD	0.066	0.027	0.334	0.027
NY	360310002	NOT IN A CITY	SUMMIT,WHITEFACE MTN,WEATHER STATION	-0.319	0.012	-0.376	0.027
NY	360310003	NOT IN A CITY	BASE WHITEFACE MTN,ASRC,SUNY	-0.528	0.026	-0.441	0.025
NY	360450002	NOT IN A CITY	VADAI ROAD, PERCH RIVER, BROWNVILLE	-0.147	0.024	-0.255	0.024
NY	360631006	NOT IN A CITY	MIDDLEPORT STP, NORTH HARTLAND RD	-0.317	0.017	-0.059	0.017
NY	360850067	NEW YORK CITY	SUSAN WAGNER HS, ,	-0.643	0.018	-0.399	0.022
NY	360930003	SCHENECTADY	MT.PLEASANT HS,	-0.123	0.016	0.016	0.011
NY	361030002	BABYLON	EAST FARMINGDALE WATER DIST.,GAZZA BLVD.	-0.315	0.018	-0.678	0.014
NY	361030004	RIVERHEAD	39 SOUND AVENUE,RIVERHEAD	-0.163	0.051	-0.089	0.038
NY	361173001	NOT IN A CITY	WAYNE EDUCATIONAL CENTER, WILLIAMSON	-0.929	0.020	-0.618	0.016
NY	361192004	WHITE PLAINS	WHITE PLAINS PUMP STATION,ORCHARD STREET	-0.424	0.018	-0.330	0.018
PA	420030008	PITTSBURGH	BAPC 301 39TH STREET BLDG #7	0.148	0.034	0.678	0.031
PA	420030067	NOT IN A CITY	OLD OAKDALE ROAD SOUTH FAYETTE	0.879	0.037	1.204	0.035
PA	420070014	BEAVER FALLS	EIGHT STREET AND RIVER ALLEY	-0.251	0.016	0.121	0.015
PA	420110009	READING	UGI CO MONGANTOWN RD AND PROSPECT ST	-0.304	0.016	-0.269	0.014

PA	420130801	ALTOONA	2ND AVE & 7TH ST	-0.207	0.016	0.141	0.014
PA	420170012	BRISTOL (BORO)	ROCKVIEW LANE	-0.609	0.012	-0.522	0.015
PA	420210011	NOT IN A CITY	MILLER AUTO SHOP 1 MESSENGER ST	-0.020	0.018	0.327	0.017
PA	420430401	HARRISBURG	1833 UPS DRIVE HARRISBURG PA	-0.188	0.017	-0.130	0.013
PA	420431100	HERSHEY	SIPE AVE & MAE STREET	-0.297	0.017	-0.279	0.014
PA	420450002	CHESTER	FRONT ST & NORRIS ST	-0.585	0.014	-0.379	0.015
PA	420692006	SCRANTON	GEORGE ST TROOP AND CITY OF SCRANTON	-0.163	0.017	-0.218	0.017
PA	420710007	LANCASTER CITY	ABRAHAM LINCOLN JR HIGH GROFFTOWN RD	0.178	0.020	0.265	0.019
PA	420730015	NEW CASTLE	CROTON ST & JEFFERSON ST.	-0.091	0.014	0.112	0.014
PA	420770004	ALLENTOWN	STATE HOSPITAL REAR 1600 HANOVER AVE	-0.054	0.017	-0.056	0.018
PA	420791100	NANTICOKE	255 LOWER BROADWAY	-0.073	0.020	-0.110	0.024
PA	420791101	WILKES-BARRE	CHILWICK & WASHINGTON STS	0.132	0.017	0.089	0.016
PA	420850100	NOT IN A CITY	PA518 (NEW CASTLE ROAD) & PA418			0.164	0.013
PA	420910013	NORRISTOWN	STATE ARMORY - 1046 BELVOIR RD	-0.323	0.016	-0.142	0.017
PA	420990301	NOT IN A CITY	ROUTE 34 LITTLE BUFFALO STATE PARK	-0.274	0.017	-0.052	0.016
PA	421010014	PHILADELPHIA	ROXY WATER PUMP STA EVA-DEARNLEY STS	-0.991	0.012	-0.720	0.014
PA	421010024	PHILADELPHIA	GRANT-ASHTON ROADS PHILA NE AIRPORT	-0.408	0.024	-0.374	0.029
PA	421250005	CHARLEROI	CHARLER01 WASTE TREATMENT PLANT	0.060	0.023	0.386	0.022
PA	421250200	WASHINGTON	MCCARRELL AND FAYETTE STS	-0.273	0.017	0.094	0.017
PA	421330008	YORK	HILL ST.	-0.071	0.016	0.060	0.018
RI	440030002	NOT IN A CITY	W. ALTON JONES CAMPUS URI PARKERFIELD	-0.752	0.017	-0.888	0.018
VA	510130020	NOT IN A CITY	S 18TH AND HAYES ST	-0.529	0.015	-0.195	0.011
VA	510410004	NOT IN A CITY	BEACH,INTERSECTION OF CO.ROADS 655 & 654	-0.555	0.020	-0.122	0.018
VA	510590018	NOT IN A CITY	MT.VERNON 2675 SHERWOOD HALL LANE	-0.939	0.014	-0.530	0.013
VA	510595001	MC LEAN	LEWINSVILLE 1437 BALLS HILL RD	-0.540	0.014	-0.209	0.015
VA	510610002	NOT IN A CITY	RT651 C PHELPS WILDLIFE MANAGEMENT AREA	-1.145	0.019	-0.741	0.016
VA	510870014	NOT IN A CITY	2401 HARTMAN STREET MATH & SCIENCE CTR	-0.427	0.015		
VA	511130003	NOT IN A CITY	SHENANDOAH NP BIG MEADOWS	-0.031	0.021	0.067	0.018
VA	511611004	VINTON	EAST VINTON ELEMENTARY SCHOOL	-0.374	0.022	-0.180	0.019
VA	515100009	ALEXANDRIA	517 N SAINT ASAPH ST, ALEXANDRIA HEALTH	0.104	0.024	0.400	0.020
VA	518000004	SUFFOLK	TIDEWATER COMM. COLL.. FREDERIC CAMPUS	-0.287	0.024	0.072	0.020

Table 2 Raw and Met-adjusted trends in 1-hr ozone concentrations over the OTR for 1990-2005 ozone seasons

STATE	AIRS ID	STATION	LOCATION	RAW TRENDS		MET-ADJUSTED TRENDS	
				Slope (%/yr)	95% CI	Slope (%/yr)	95% CI
CT	090010017	GREENWICH	GREENWICH POINT PARK	0.165	0.022	0.202	0.024
CT	090011123	DANBURY	TRAILER, W. CONNECTICUT STATE UNIVERSITY	0.591	0.024	0.646	0.023
CT	090013007	STRATFORD	USCG LIGHTHOUSE , PROSPECT STREET	0.078	0.018	-0.123	0.019
CT	090031003	EAST HARTFORD	MCAULIFFEE PARK	0.046	0.027	0.208	0.018
CT	090070007	MIDDLETOWN	CONN. VALLEY HOSP., SHEW HALL, EASTERN D	0.225	0.017	0.171	0.012
CT	090093002	MADISON	HAMMONASSET STATE PARK	-0.203	0.022	-0.167	0.025
CT	090110008	GROTON	UNIVERSITY OF CONNECTICUT, AVERY POINT	-0.402	0.022	-0.295	0.026
CT	090131001	STAFFORD	ROUTE 190, SHENIPSIT STATE FOREST	-0.114	0.019	-0.104	0.015
DC	110010025	NOT IN A CITY	TAKOMA SC. PINEY BRANCH RD & DAHLIA ST N	-0.357	0.029	-0.088	0.021
ME	230052003	CAPE ELIZABETH	TWO LIGHTS STATE PARK	-0.858	0.021	-0.684	0.02
ME	230312002	NOT IN A CITY	OCEAN AVE/PARSONS WAY, KENNEBUNKPORT	-0.874	0.015	-0.746	0.013
MD	240030014	NOT IN A CITY	QUEEN ANNE AND WAYSON ROADS	-0.805	0.037	-0.518	0.032
MD	240051007	COCKEYSVILLE	GREENSIDE DRIVE COCKEYSVILLE MD	-0.805	0.021	-0.416	0.013
MD	240053001	ESSEX	WOODWARD & DORSEY RDS ,ESSEX MD	-0.396	0.020		
MD	240130001	NOT IN A CITY	1300 W. OLD LIBERTY ROAD, WINFIELD,MD	-0.940	0.019	-0.553	0.013
MD	240170010	NOT IN A CITY	SO MD CORRECTIONAL CAMP, HUGHESVILLE	-0.644	0.029	-0.501	0.025
MD	240251001	EDGEWOOD	EDGEWOOD ARMY CHEM CENTER EDGEWOOD	-0.555	0.020	-0.144	0.018
MD	240313001	ROCKVILLE	LOTHROP E SMITH ENV.ED CENTER ROCKVILLE	-0.730	0.035	-0.542	0.031
MA	250010002	TRURO	FOX BOTTOM AREA-CAPE COD NAT'L Sea shr	0.134	0.019	0.202	0.019
MA	250051002	FAIRHAVEN	LEROY WOOD SCHOOL	0.337	0.025	0.314	0.027
MA	250130008	CHICOPEE	ANDERSON ROAD AIR FORCE BASE	0.252	0.023	0.473	0.018

MA	250154002	WARE	QUABBIN SUMMIT	-0.793	0.016	-0.706	0.014
NH	330050007	KEENE	RAILROAD STREET	-0.150	0.072	-0.180	0.065
NH	330190003	CLAREMONT	SOUTH STREET	0.570	0.045	0.550	0.012
NJ	340010005	NOT IN A CITY	BRIGANTINE WILDLIFE REFUGE,NACOTE CREEK	-1.291	0.031	-1.308	0.031
NJ	340070003	NOT IN A CITY	COPEWOOD E. DAVIS STS; TRAILER	-0.089	0.025	-0.043	0.022
NJ	340071001	NOT IN A CITY	ANCORA STATE HOSPITAL, ANCORA	-0.720	0.017	-0.544	0.023
NJ	340110007	NOT IN A CITY	LINCOLN AVE.&HIGHWAY 55,NE OF MILLVILLE	-0.592	0.021	-0.257	0.022
NJ	340150002	NOT IN A CITY	CLARKSBORO,SHADY LANE REST HOME	-0.743	0.016	-0.473	0.018
NJ	340170006	BAYONNE	VETERANS PARK ON NEWARK BAY	-1.137	0.019	-0.782	0.022
NJ	340190001	FLEMINGTON	RARITAN STP,RTE.613S, THREE BRIDGES	-0.208	0.019	0.121	0.023
NJ	340210005	NOT IN A CITY	RIDER COLLEGE;LAWRENCE TOWNSHIP	-1.027	0.021	-0.828	0.019
NJ	340273001	NOT IN A CITY	BLDG.#1, BELL LABS, OFF ROUTE 513	-0.863	0.024	-0.575	0.029
NY	360010012	ALBANY	LOUDONVILLE RESERVOIR	-0.148	0.019	0.154	0.014
NY	360150003	ELMIRA	SULLIVAN ST., WATER TR. PL.			0.066	0.026
NY	360290002	AMHERST	AUDUBON GOLF COURSE, MAPLE ROAD	1.008	0.031	1.358	0.031
NY	360310002	NOT IN A CITY	SUMMIT,WHITEFACE MTN,WEATHER STATION	-0.447	0.016	-0.376	0.027
NY	360310003	NOT IN A CITY	BASE WHITEFACE MTN,ASRC,SUNY	-0.517	0.027	-0.441	0.025
NY	360450002	NOT IN A CITY	VADAI ROAD, PERCH RIVER, BROWNVILLE	0.626	0.027	0.533	0.029
NY	360631006	NOT IN A CITY	MIDDLEPORT STP, NORTH HARTLAND RD	0.213	0.020	0.529	0.019
NY	360850067	NEW YORK CITY	SUSAN WAGNER HS	-0.400	0.027		
NY	360930003	SCHENECTADY	MT.PLEASANT HS.	-0.043	0.021	0.255	0.015
NY	361030002	BABYLON	EAST FARMINGDALE WATER DIST.,GAZZA BLVD.	-0.927	0.016	-1.101	0.016
NY	361030004	RIVERHEAD	39 SOUND AVENUE,RIVERHEAD	-0.170	0.051	-0.089	0.038
NY	361173001	NOT IN A CITY	WAYNE EDUCATIONAL CENTER, WILLIAMSON	-0.841	0.033	-0.408	0.025
NY	361192004	WHITE PLAINS	WHITE PLAINS PUMP STATION,ORCHARD Str	-0.250	0.026	0.084	0.024
PA	420030008	PITTSBURGH	BAPC 301 39TH STREET BLDG #7	0.871	0.050	1.486	0.045
PA	420030067	NOT IN A CITY	OLD OAKDALE ROAD SOUTH FAYETTE	1.406	0.052	1.767	0.046
PA	420070014	BEAVER FALLS	EIGHT STREET AND RIVER ALLEY	-0.118	0.026	0.417	0.023
PA	420110009	READING	UGI CO MONGANTOWN RD AND PROSPECT ST	-0.143	0.024		

PA	420130801	ALTOONA	2ND AVE & 7TH ST	-0.274	0.024	0.190	0.021
PA	420170012	BRISTOL (BOROUG	ROCKVIEW LANE	-0.536	0.019	-0.322	0.024
PA	420210011	NOT IN A CITY	MILLER AUTO SHOP 1 MESSENGER ST	0.085	0.029	0.564	0.026
PA	420430401	HARRISBURG	1833 UPS DRIVE HARRISBURG PA	-0.142	0.027	0.048	0.018
PA	420431100	HERSHEY	SIPE AVE & MAE STREET	-0.251	0.026	-0.120	0.022
PA	420450002	CHESTER	FRONT ST & NORRIS ST	-0.464	0.021	-0.042	0.022
PA	420692006	SCRANTON	GEORGE ST TROOP AND CITY OF SCRANTON	-0.253	0.025	-0.097	0.026
PA	420710007	LANCASTER CITY	ABRAHAM LINCOLN JR HIGH GROFFTOWN RD	0.124	0.029	0.329	0.029
PA	420730015	NEW CASTLE	CROTON ST & JEFFERSON ST.	0.075	0.022	0.394	0.022
PA	420770004	ALLENTOWN	STATE HOSPITAL REAR 1600 HANOVER AVE	0.272	0.026	0.346	0.026
PA	420791100	NANTICOKE	255 LOWER BROADWAY	0.467	0.026	0.640	0.030
PA	420791101	WILKES-BARRE	CHILWICK & WASHINGTON STS	-0.327	0.022	-0.134	0.024
PA	420850100	NOT IN A CITY	PA518 (NEW CASTLE ROAD) & PA418	0.104	0.022	0.360	0.020
PA	420910013	NORRISTOWN	STATE ARMORY - 1046 BELVOIR RD	-0.404	0.026	0.125	0.027
PA	420990301	NOT IN A CITY	ROUTE 34 LITTLE BUFFALO STATE PARK	-0.284	0.027	-0.441	0.019
PA	421010014	PHILADELPHIA	ROXY WATER PUMP STA EVA-DEARNLEY STS	-0.773	0.017	0.430	0.037
PA	421250200	WASHINGTON	MCCARRELL AND FAYETTE STS	-0.091	0.027	0.444	0.027
PA	421330008	YORK	HILL ST.	0.296	0.021	0.535	0.023
RI	440030002	NOT IN A CITY	W. ALTON JONES CAMPUS URI PARKERFIELD	-0.166	0.019	-0.204	0.021
VA	510130020	NOT IN A CITY	S 18TH AND HAYES ST	-0.347	0.021	-0.109	0.016
VA	510410004	NOT IN A CITY	BEACH,INTERSECTION OF CO.ROADS 655 & 654	-0.454	0.031	-0.081	0.028
VA	510590018	NOT IN A CITY	MT.VERNON 2675 SHERWOOD HALL LANE	-0.631	0.020	-0.377	0.020
VA	510595001	MC LEAN	LEWINSVILLE 1437 BALLS HILL RD	-0.384	0.021	-0.091	0.021
VA	510610002	NOT IN A CITY	RT651 C PHELPS WILDLIFE MANAGEMENT AREA	-1.288	0.029	-1.044	0.023
VA	510870014	NOT IN A CITY	2401 HARTMAN STREET MATH & SCIENCE CTR	-0.645	0.021	-0.206	0.019
VA	511130003	NOT IN A CITY	SHENANDOAH NP BIG MEADOWS	-0.387	0.029	-0.319	0.024
VA	511611004	VINTON	EAST VINTON ELEMENTARY SCHOOL	-0.281	0.036	-0.199	0.027
VA	515100009	ALEXANDRIA	517 N SAINT ASAPH ST, ALEXANDRIA HEALTH	0.041	0.031	0.180	0.028
VA	518000004	SUFFOLK	TIDEWATER COMM. COLLEGE, FREDERIC CAMPUS	-0.825	0.025	-0.074	0.028

Table 3 Raw and Met-adjusted trends in 1-hr ozone concentrations over the OTR for 1995-2005 ozone seasons

STATE	AIRS ID	STATION	LOCATION	RAW TRENDS		MET-ADJUSTED TRENDS	
				Slope (%/yr)	95% CI	Slope (%/yr)	95% CI
CT	090010017	GREENWICH	GREENWICH POINT PARK			-0.288	0.033
CT	090011123	DANBURY	TRAILER, W. CONNECTICUT STATE UNIVERSITY	0.807	0.037	0.506	0.038
CT	090013007	STRATFORD	USCG LIGHTHOUSE , PROSPECT STREET	-0.037	0.034	-0.398	0.035
CT	090031003	EAST HARTFORD	MCAULIFFEE PARK	-0.843	0.036	-0.458	0.017
CT	090070007	MIDDLETOWN	CONN. VALLEY HOSP., SHEW HALL, EASTERN D	0.111	0.033	0.067	0.023
CT	090093002	MADISON	HAMMONASSET STATE PARK	-0.610	0.035	-0.913	0.040
CT	090110008	GROTON	UNIVERSITY OF CONNECTICUT, AVERY POINT	-0.887	0.040	-1.023	0.046
CT	090131001	STAFFORD	ROUTE 190, SHENIPSIT STATE FOREST	-0.259	0.038	-0.250	0.028
DC	110010025	NOT IN A CITY	TAKOMA SC. PINEY BRANCH RD & DAHLIA ST N	-0.917	0.051	-0.459	0.037
ME	230052003	CAPE ELIZABETH	TWO LIGHTS STATE PARK	-1.251	0.037	-1.135	0.034
ME	230312002	NOT IN A CITY	OCEAN AVE/PARSONS WAY, KENNEBUNKPORT	-0.828	0.029	-0.911	0.025
MD	240030014	NOT IN A CITY	QUEEN ANNE AND WAYSON ROADS	-1.987	0.060	-1.460	0.056
MD	240051007	COCKEYSVILLE	GREENSIDE DRIVE COCKEYSVILLE MD	-0.804	0.039	-0.350	0.026
MD	240053001	ESSEX	WOODWARD & DORSEY RDS ,ESSEX MD	-0.324	0.038	0.213	0.032
MD	240130001	NOT IN A CITY	1300 W. OLD LIBERTY ROAD, WINFIELD,MD	-1.212	0.033	-0.698	0.026
MD	240170010	NOT IN A CITY	SO MD CORRECTIONAL CAMP, HUGHESVILLE	-1.542	0.045	-1.171	0.042
MD	240251001	EDGEWOOD	EDGEWOOD ARMY CHEM CENTER EDGEWOOD	-0.737	0.040	-0.154	0.038
MD	240313001	ROCKVILLE	LOTHROP E SMITH ENV.ED CENTER ROCKVILLE	-1.873	0.056	-1.446	0.050
MA	250010002	TRURO	FOX BOTTOM AREA-CAPE COD NAT'L	-0.152	0.030	-0.267	0.030

			SEASHORE				
MA	250051002	FAIRHAVEN	LEROY WOOD SCHOOL	-0.145	0.025	-0.268	0.031
MA	250130008	CHICOPEE	ANDERSON ROAD AIR FORCE BASE	0.276	0.044	0.515	0.032
MA	250154002	WARE	QUABBIN SUMMIT	-0.215	0.026	-0.420	0.022
NH	330050007	KEENE	RAILROAD STREET	-0.140	0.097	-0.170	0.089
NH	330190003	CLAREMONT	SOUTH STREET	0.560	0.090	0.550	0.033
NJ	340010005	NOT IN A CITY	BRIGANTINE WILDLIFE REFUGE,NACOTE CREEK	-2.237	0.041	-2.354	0.044
NJ	340070003	NOT IN A CITY	COPEWOOD E. DAVIS STS; TRAILER	0.330	0.044	-0.278	0.040
NJ	340071001	NOT IN A CITY	ANCORA STATE HOSPITAL, ANCORA	-1.046	0.021	-1.292	0.031
NJ	340110007	NOT IN A CITY	LINCOLN AVE.&HIGHWAY 55,NE OF MILLVILLE	-0.653	0.034	-0.324	0.045
NJ	340150002	NOT IN A CITY	CLARKSBORO,SHADY LANE REST HOME	-0.850	0.027	-0.902	0.030
NJ	340170006	BAYONNE	VETERANS PARK ON NEWARK BAY	-0.987	0.035	-1.198	0.036
NJ	340190001	FLEMINGTON	RARITAN STP,RTE.613S, THREE BRIDGES	-0.250	0.026	-0.358	0.026
NJ	340210005	NOT IN A CITY	RIDER COLLEGE;LAWRENCE TOWNSHIP	-0.798	0.035	-1.098	0.034
NJ	340273001	NOT IN A CITY	BLDG.#1, BELL LABS, OFF ROUTE 513	-1.293	0.043	-1.491	0.040
NY	360010012	ALBANY	LOUDONVILLE RESERVOIR	-0.050	0.039	-0.339	0.021
NY	360150003	ELMIRA	SULLIVAN ST., WATER TR. PL.	-0.312	0.045	-0.373	0.042
NY	360290002	AMHERST	AUDUBON GOLF COURSE, MAPLE ROAD	1.091	0.050	1.203	0.047
NY	360310002	NOT IN A CITY	SUMMIT,WHITEFACE MTN,WEATHER STATION	-0.290	0.022	-0.058	0.025
NY	360310003	NOT IN A CITY	BASE WHITEFACE MTN,ASRC,SUNY	-0.479	0.049	-0.701	0.042
NY	360450002	NOT IN A CITY	VADAI ROAD, PERCH RIVER, BROWNVILLE	0.122	0.049	0.047	0.045
NY	360631006	NOT IN A CITY	MIDDLEPORT STP, NORTH HARTLAND RD	0.086	0.035	0.296	0.031
NY	360850067	NEW YORK CITY	SUSAN WAGNER HS	-1.031	0.030	-1.261	0.048
NY	360930003	SCHENECTADY	MT.PLEASANT HS.	0.180	0.042	-0.095	0.028
NY	361030002	BABYLON	EAST FARMINGDALE WATER DIST.,GAZZA BLVD.	-0.706	0.024	-0.958	0.031
NY	361030004	RIVERHEAD	39 SOUND AVENUE,RIVERHEAD	-1.590	0.057	-1.312	0.035
NY	361173001	NOT IN A CITY	WAYNE EDUCATIONAL CENTER, WILLIAMSON	-1.594	0.060	-1.184	0.042
NY	361192004	WHITE PLAINS	WHITE PLAINS PUMP STATION,ORCHARD ST	-0.352	0.048	-0.371	0.042
PA	420030008	PITTSBURGH	BAPC 301 39TH STREET BLDG #7	-1.114	0.042	-0.341	0.046

PA	420030067	NOT IN A CITY	OLD OAKDALE ROAD SOUTH FAYETTE	-0.675	0.053	-0.110	0.049
PA	420070014	BEAVER FALLS	EIGHT STREET AND RIVER ALLEY	-0.968	0.030	-0.262	0.035
PA	420110009	READING	UGI CO MONGANTOWN RD AND PROSPECT ST	-0.398	0.041	-0.310	0.027
PA	420130801	ALTOONA	2ND AVE & 7TH ST	-1.096	0.033	-0.451	0.035
PA	420170012	BRISTOL (BOROUG	ROCKVIEW LANE	-0.886	0.035	-1.164	0.035
PA	420210011	NOT IN A CITY	MILLER AUTO SHOP 1 MESSENGER ST	-0.681	0.050		
PA	420430401	HARRISBURG	1833 UPS DRIVE HARRISBURG PA	-0.378	0.053	-0.190	0.035
PA	420431100	HERSHEY	SIPE AVE & MAE STREET	-0.905	0.041	-0.839	0.036
PA	420450002	CHESTER	FRONT ST & NORRIS ST	-0.868	0.037	-0.762	0.034
PA	420692006	SCRANTON	GEORGE ST TROOP AND CITY OF SCRANTON	-0.902	0.042	-1.131	0.036
PA	420710007	LANCASTER CITY	ABRAHAM LINCOLN JR HIGH GROFFTOWN RD	-0.836	0.038	-1.101	0.028
PA	420730015	NEW CASTLE	CROTON ST & JEFFERSON ST.	-0.697	0.031	-0.529	0.029
PA	420770004	ALLENTOWN	STATE HOSPITAL REAR 1600 HANOVER AVE	-0.516	0.043	-0.557	0.042
PA	420791100	NANTICOKE	255 LOWER BROADWAY	-0.203	0.047	-0.375	0.050
PA	420791101	WILKES-BARRE	CHILWICK & WASHINGTON STS	-0.837	0.038	-1.076	0.031
PA	420850100	NOT IN A CITY	PA518 (NEW CASTLE ROAD) & PA418	-0.641	0.035	-0.518	0.023
PA	420910013	NORRISTOWN	STATE ARMORY - 1046 BELVOIR RD	-1.211	0.040	-1.094	0.037
PA	420990301	NOT IN A CITY	ROUTE 34 LITTLE BUFFALO STATE PARK	-0.937	0.041	-0.888	0.033
PA	421010014	PHILADELPHIA	ROXY WATER PUMP STA EVA-DEARNLEY STS	-1.056	0.027	-1.223	0.022
PA	421010024	PHILADELPHIA	GRANT-ASHTON ROADS PHILA NE AIRPORT	-0.337	0.054	-1.442	0.055
PA	421250005	CHARLEROI	CHARLER01 WASTE TREATMENT PLANT	-1.480	0.052	-0.892	0.058
PA	421250200	WASHINGTON	MCCARRELL AND FAYETTE STS	-0.876	0.044	-0.227	0.048
PA	421330008	YORK	HILL ST.	0.326	0.036	0.159	0.036
RI	440030002	NOT IN A CITY	W. ALTON JONES CAMPUS URI PARKERFIELD	0.044	0.031	-0.128	0.032
VA	510130020	NOT IN A CITY	S 18TH AND HAYES ST	-0.492	0.036		
VA	510410004	NOT IN A CITY	BEACH,INTERSECTION OF CO.ROADS 655 & 654	-1.333	0.039	-0.972	0.040
VA	510590018	NOT IN A CITY	MT.VERNON 2675 SHERWOOD HALL LANE	-0.659	0.036	-0.604	0.037
VA	510595001	MC LEAN	LEWINSVILLE 1437 BALLS HILL RD	-0.164	0.039	0.138	0.038
VA	510610002	NOT IN A CITY	RT651 C PHELPS WILDLIFE MANAGEMENT AREA	-2.029	0.050	-1.963	0.030
VA	510870014	NOT IN A CITY	2401 HARTMAN STREET MATH & SCIENCE CTR	-0.871	0.042	-0.659	0.036

VA	511130003	NOT IN A CITY	SHENANDOAH NP BIG MEADOWS	-1.406	0.044	-1.230	0.029
VA	511611004	VINTON	EAST VINTON ELEMENTARY SCHOOL	-1.186	0.063	-1.099	0.043
VA	515100009	ALEXANDRIA	517 N SAINT ASAPH ST, ALEXANDRIA HEALTH	-0.399	0.048	0.080	0.032
VA	518000004	SUFFOLK	TIDEWATER COMM. COLLEGE, FREDERIC CAMPUS	-0.822	0.047	-0.179	0.049

Table 3 Raw and Met-adjusted trends in 1-hr ozone concentrations over the OTR for 2000-2005 ozone seasons

STATE	AIRS ID	STATION	LOCATION	RAW TRENDS		MET-ADJUSTED TRENDS	
				Slope (%/yr)	95% CI	Slope (%/yr)	95% CI
CT	090010017	GREENWICH	GREENWICH POINT PARK	-0.749	0.096	-1.670	0.051
CT	090011123	DANBURY	TRAILER, W. CONNECTICUT STATE UNIVERSITY	0.750	0.090	-0.111	0.052
CT	090013007	STRATFORD	USCG LIGHTHOUSE , PROSPECT STREET	-0.313	0.088	-1.191	0.060
CT	090031003	EAST HARTFORD	MCAULIFFEE PARK	-0.170	0.110	-0.472	0.039
CT	090070007	MIDDLETOWN	CONN. VALLEY HOSP., SHEW HALL, EASTERN D	-0.333	0.093	-0.486	0.056
CT	090093002	MADISON	HAMMONASSET STATE PARK	-0.994	0.092	-1.786	0.078
CT	090110008	GROTON	UNIVERSITY OF CONNECTICUT, AVERY POINT	-1.237	0.064	-1.830	0.045
CT	090131001	STAFFORD	ROUTE 190, SHENIPSIT STATE FOREST	-0.230	0.110	-0.485	0.059
DC	110010025	NOT IN A CITY	TAKOMA SC. PINEY BRANCH RD & DAHLIA ST N	-0.484	0.081	-1.473	0.054
ME	230052003	CAPE ELIZABETH	TWO LIGHTS STATE PARK	-1.917	0.106	-1.030	0.084
ME	230312002	NOT IN A CITY	OCEAN AVE/PARSONS WAY, KENNEBUNKPORT	-1.108	0.086	-0.978	0.076
MD	240030014	NOT IN A CITY	QUEEN ANNE AND WAYSON ROADS	-2.268	0.103	-2.596	0.112
MD	240051007	COCKEYSVILLE	GREENSIDE DRIVE COCKEYSVILLE MD	-0.814	0.103	-1.377	0.059
MD	240053001	ESSEX	WOODWARD & DORSEY RDS ,ESSEX MD	-0.305	0.123	-0.757	0.080
MD	240130001	NOT IN A CITY	1300 W. OLD LIBERTY ROAD, WINFIELD,MD	-1.578	0.077	-1.961	0.016
MD	240170010	NOT IN A CITY	SO MD CORRECTIONAL CAMP, HUGHESVILLE MD	-1.881	0.058	-3.100	0.061
MD	240251001	EDGEWOOD	EDGEWOOD ARMY CHEM CENTER EDGEWOOD MD	-1.266	0.122	-1.552	0.089
MD	240313001	ROCKVILLE	LOTHROP E SMITH ENV.ED CENTER ROCKVILLE	-2.649	0.116	-3.603	0.108
MA	250010002	TRURO	FOX BOTTOM AREA-CAPE COD NAT'L SEASHORE	0.304	0.064	-0.542	0.054

MA	250051002	FAIRHAVEN	LEROY WOOD SCHOOL	-0.942	0.054	-0.961	0.067
MA	250130008	CHICOPEE	ANDERSON ROAD AIR FORCE BASE	-0.369	0.123	0.393	0.083
MA	250154002	WARE	QUABBIN SUMMIT	0.678	0.067		
NH	330050007	KEENE	RAILROAD STREET	0.479	0.093	0.214	0.075
NH	330190003	CLAREMONT	SOUTH STREET	0.361	0.093	0.112	0.081
NJ	340010005	NOT IN A CITY	BRIGANTINE WILDLIFE REFUGE,NACOTE CREEK	-2.644	0.090	-2.813	0.100
NJ	340070003	NOT IN A CITY	COPEWOOD E. DAVIS STS; TRAILER	-0.906	0.128	-2.066	0.089
NJ	340071001	NOT IN A CITY	ANCORA STATE HOSPITAL, ANCORA	-1.359	0.049	-1.871	0.061
NJ	340110007	NOT IN A CITY	LINCOLN AVE.&HIGHWAY 55,NE OF MILLVILLE	-1.517	0.092	-1.541	0.124
NJ	340150002	NOT IN A CITY	CLARKSBORO,SHADY LANE REST HOME	-1.279	0.076	-1.155	0.064
NJ	340170006	BAYONNE	VETERANS PARK ON NEWARK BAY	-1.603	0.077	-2.175	0.038
NJ	340190001	FLEMINGTON	RARITAN STP,RTE.613S, THREE BRIDGES	-0.384	0.073	-0.700	0.050
NJ	340210005	NOT IN A CITY	RIDER COLLEGE;LAWRENCE TOWNSHIP	-1.535	0.086	-2.178	0.075
NJ	340273001	NOT IN A CITY	BLDG.#1, BELL LABS, OFF ROUTE 513	-2.419	0.112	-2.929	0.104
NY	360010012	ALBANY	LOUDONVILLE RESERVOIR			-0.667	0.062
NY	360150003	ELMIRA	SULLIVAN ST., WATER TR. PL.	-2.157	0.100	-2.626	0.073
NY	360290002	AMHERST	AUDUBON GOLF COURSE, MAPLE ROAD	-0.579	0.099	-1.111	0.092
NY	360310002	NOT IN A CITY	SUMMIT,WHITEFACE MTN,WEATHER STATION	-0.206	0.051	-0.357	0.056
NY	360310003	NOT IN A CITY	BASE WHITEFACE MTN,ASRC,SUNY			-0.326	0.121
NY	360450002	NOT IN A CITY	VADAI ROAD, PERCH RIVER, BROWNVILLE	-1.208	0.148	-1.649	0.122
NY	360631006	NOT IN A CITY	MIDDLEPORT STP, NORTH HARTLAND RD	-0.158	0.095	-0.438	0.091
NY	360850067	NEW YORK CITY	SUSAN WAGNER HS, BRIELLE AVE.& MANOR RD,	-1.704	0.064	-2.593	0.076
NY	360930003	SCHENECTADY	MT.PLEASANT HS, NORWOOD AVE.& FOREST RD.	-0.716	0.117	-1.310	0.071
NY	361030002	BABYLON	EAST FARMINGDALE WATER DIST.,GAZZA BLVD.	-0.367	0.061	-0.482	0.080
NY	361030004	RIVERHEAD	39 SOUND AVENUE,RIVERHEAD	-0.714	0.128	-0.543	0.070
NY	361173001	NOT IN A CITY	WAYNE EDUCATIONAL CENTER, WILLIAMSON	-3.545	0.125	-2.090	0.082
NY	361192004	WHITE PLAINS	WHITE PLAINS PUMP STATION,ORCHARD STREET	-0.631	0.158	-1.199	0.115
NY	360130006	DUNKIRK	STP LAKESIDE BLD DUNKIRK	-1.019	0.048	-1.297	0.032

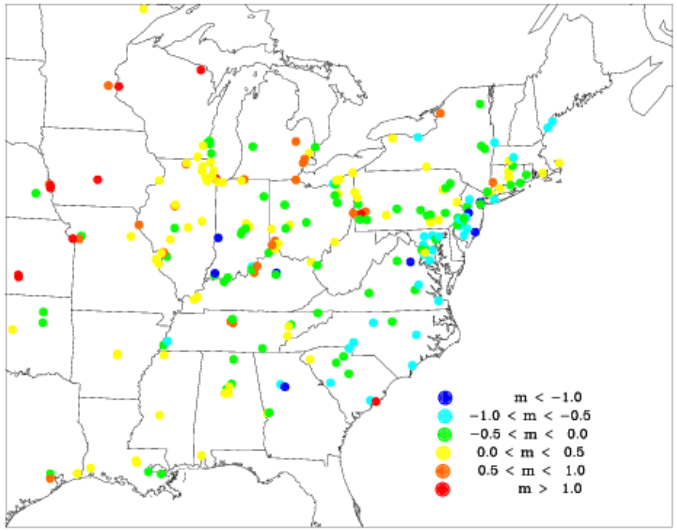
NY	360130011	NOT IN A CITY	TOWN OF WESTFIELD	-1.004	0.068	-0.714	0.071
NY	360270007	NOT IN A CITY	VILLAGE OF MILLBROOK	-1.980	0.125	-2.539	0.085
NY	360715001	NOT IN A CITY	1175 ROUTE 17K, MONTGOMERY	0.899	0.057	0.639	0.032
NY	360790005	NOT IN A CITY	NYSDEC FIELD HQTRS GYPSY TRAIL ROAD	-0.247	0.121	-0.739	0.079
PA	420030008	PITTSBURGH	BAPC 301 39TH STREET BLDG #7	-2.115	0.093	-2.154	0.090
PA	420030067	NOT IN A CITY	OLD OAKDALE ROAD SOUTH FAYETTE	-1.333	0.077	-1.409	0.030
PA	420070014	BEAVER FALLS	EIGHT STREET AND RIVER ALLEY	-1.497	0.061	-1.646	0.031
PA	420110009	READING	UGI CO MONGANTOWN RD AND PROSPECT ST	-0.237	0.105	-1.184	0.059
PA	420130801	ALTOONA	2ND AVE & 7TH ST	-1.356	0.073	-1.378	0.056
PA	420170012	BRISTOL (BOROUG	ROCKVIEW LANE	-2.197	0.086	-3.095	0.060
PA	420210011	NOT IN A CITY	MILLER AUTO SHOP 1 MESSENGER ST	-1.941	0.064	-2.058	0.044
PA	420430401	HARRISBURG	1833 UPS DRIVE HARRISBURG PA	0.709	0.122		
PA	420431100	HERSHEY	SIPE AVE & MAE STREET	-1.675	0.109	-2.838	0.071
PA	420450002	CHESTER	FRONT ST & NORRIS ST	-0.335	0.110	-0.091	0.050
PA	420692006	SCRANTON	GEORGE ST TROOP AND CITY OF SCRANTON	-1.071	0.121	-2.145	0.080
PA	420710007	LANCASTER CITY	ABRAHAM LINCOLN JR HIGH GROFFTOWN RD	-0.273	0.090	-1.212	0.031
PA	420730015	NEW CASTLE	CROTON ST & JEFFERSON ST.	0.131	0.072	0.182	0.072
PA	420770004	ALLENTOWN	STATE HOSPITAL REAR 1600 HANOVER AVE	-1.201	0.080	-2.283	0.056
PA	420791100	NANTICOKE	255 LOWER BROADWAY(NEXT TO LEON&EDDY'S)	-2.157	0.106	-3.038	0.084
PA	420791101	WILKES-BARRE	CHILWICK & WASHINGTON STS	-0.257	0.112	-1.430	0.081
PA	420850100	NOT IN A CITY	PA518 (NEW CASTLE ROAD) & PA418	-0.667	0.092	-0.680	0.059
PA	420910013	NORRISTOWN	STATE ARMORY - 1046 BELVOIR RD	-2.263	0.082	-2.191	0.033
PA	420990301	NOT IN A CITY	ROUTE 34 LITTLE BUFFALO STATE PARK	-0.838	0.115	-1.120	0.047
PA	421010014	PHILADELPHIA	ROXY WATER PUMP STA EVA-DEARNLEY STS	-0.741	0.077	-0.963	0.030
PA	421010024	PHILADELPHIA	GRANT-ASHTON ROADS PHILA NE AIRPORT	0.339	0.122	-2.539	0.169
PA	421250005	CHARLEROI	CHARLER01 WASTE TREATMENT PLANT	-1.514	0.068	-1.750	0.047
PA	421250200	WASHINGTON	MCCARRELL AND FAYETTE STS	-2.408	0.086	-2.456	0.059
PA	421330008	YORK	HILL ST.	0.370	0.076	-0.409	0.011
RI	440030002	NOT IN A CITY	W. ALTON JONES CAMPUS URI PARKERFIELD WE	-0.980	0.085	-1.434	0.074

VA	510130020	NOT IN A CITY	S 18TH AND HAYES ST	-0.310	0.101	-1.544	0.062
VA	510410004	NOT IN A CITY	BEACH,INTERSECTION OF CO.ROADS 655 & 654	-2.087	0.057	-2.585	0.055
VA	510590018	NOT IN A CITY	MT.VERNON 2675 SHERWOOD HALL LANE	-1.402	0.062	-1.770	0.041
VA	510595001	MC LEAN	LEWINSVILLE 1437 BALLS HILL RD	-0.939	0.100	-1.553	0.065
VA	510610002	NOT IN A CITY	RT651 C PHELPS WILDLIFE MANAGEMENT AREA	-2.613	0.077	-3.255	0.033
VA	510870014	NOT IN A CITY	2401 HARTMAN STREET MATH & SCIENCE CTR	-1.367	0.093	-2.160	0.053
VA	511130003	NOT IN A CITY	SHENANDOAH NP BIG MEADOWS	-1.848	0.060	-1.629	0.068
VA	511611004	VINTON	EAST VINTON ELEMENTARY SCHOOL	-3.062	0.081	-3.146	0.035
VA	515100009	ALEXANDRIA	517 N SAINT ASAPH ST, ALEXANDRIA HEALTH			-0.982	0.091
VA	518000004	SUFFOLK	TIDEWATER COMM. COLLEGE, FREDERIC CAMPUS	-2.007	0.049	-0.779	0.034

Linear Trends in Long-Term Daily Maximum

Ozone at AIRS Sites

(1990-2005, Raw Data)



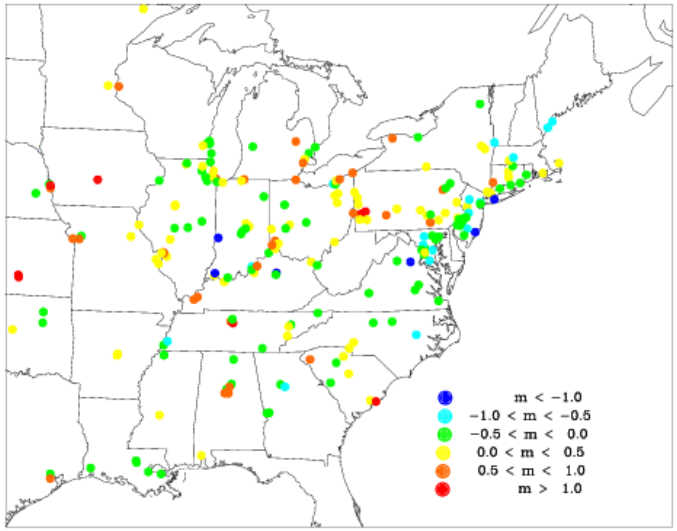
(Only trends significant at the 95% confidence level are shown.)

Figure 1a

Linear Trends in Long-Term Daily Maximum

Ozone at AIRS Sites

(1990-2005, Met-Adjusted Data)



(Only trends significant at the 95% confidence level are shown.)

Figure 1b

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