Appendix 8D

Technical Support Documents from

Bureau of Air Quality Analysis and Research

Division of Air Resources

New York State Department of Environmental Conservation

Albany, NY 12233

TSD-1

Meteorological Modeling of 2002 using Penn State/NCAR 5th Generation Mesoscale Model (MM5)

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Meteorological Modeling using Penn State/NCAR 5th Generation Mesoscale Model (MM5)

Version 3.6 of MM5 was used to generate annual 2002 meteorology for the Mid-Atlantic Northeast Visibility Union (MANE-VU) through the Modeling Committee of Ozone Transport Commission (OTC). Prof. Dalin Zhang of the University of Maryland (UMD) performed the MM5 simulations in consultation with NYSDEC staffs. The model was applied in Lambert conformal map projection and utilized MPP Version developed for clusters. The two-way nested domain consisted of a coarse (36km) and fine (12km) mesh corresponding to 149x129 and 175x175 grids, respectively, in this application (see Figure 1).

The Lambert projection used in this work followed the Regional Planning Organization (RPO) national domain setup with the center at (40°N, 97°W) and parallels at 33°N and 45°N. Map projection parameters in reference to the projection center point are as follows: Southwest corner for the 36 km grid is at (-2664km, -2304km) and the northeast corner at (2664km, 2304km). In the case of the 12km grid, the southwest corner is at (252km, -900km) and the northeast corner at (2340km, 1188km). In the vertical direction, the terrain following σ-coordinate system was used with the pressure at each σ-level determined from a reference state that is estimated using the hydrostatic equation from a given sea-level pressure and temperature with a standard lapse rate. There are 30 unevenly spaced σ levels, giving 29 vertical layers, with higher resolution within the planetary boundary layer (PBL). The σ levels are:

1.0000, 0.9974, 0.9940, 0.8980, 0.9820, 0.9720, 0.9590, 0.9430, 0.9230, 0.8990, 0.8710, 0.8390, 0.8030, 0.7630, 0.7180, 0.6680, 0.6180, 0.5680, 0.5180, 0.4680, 0.3680, 0.3180, 0.2680, 0.2180, 0.1680, 0.1230, 0.0800, 0.0400, 0.0000

The surface layer was set at about 10m, the level at which surface winds were typically observed, and the model top was set at 50hPa with a radiative top boundary condition. The time steps for the 36km and 12km domains were 75 and 25 seconds, respectively.

The important model physics options used for this MM5 simulation include:

- Kain-Fritsch (1993) convective scheme for both 36- and 12-km domains
- Explicit moisture scheme (without the mixed phase) containing prognostic equations for cloud water (ice) and rainwater (snow) (Dudhia 1989; Zhang 1989)
- Modified version of the Blackadar planetary boundary layer (PBL) scheme (Zhang and Anthes 1982; Zhang and Zheng 2004)
- Simple radiative cooling scheme (Grell et al. 1994)
- Multi-layer soil model to predict land surface temperatures using the surface energy budget equation (Dudhia 1996)

Note that the Blackadar PBL scheme has been modified in order to correct the phase shift of surface wind speed and temperature diurnal cycle, following a study that compared five different PBL schemes: the Gayno-Seaman TKE scheme (Shafran et al. 2000), Burk-

Thompson (1989), Blackadar (Zhang and Anthes 1982), MRF (Hong and Pan 1996), and Mellor-Yamada-Jajic (Mellor and Yamada 1974; Jajic 1990, 1994). The details of the study can be found at Zhang and Zheng (2004).

Nudging Processes

The MM5 provides options for nudging observations for each domain during the model integration process (Stauffer and Seaman, 1990; Stauffer et al. 1991). The Eta analyses of upper-air winds, temperature and water-vapor mixing ratio as well as their associated surface fields were used for nudging every 6 hours, and the Eta surface wind fields blended with surface wind observations were used to nudge every 3 hours. While only the surface winds were nudged, their influences could extend into the PBL as well (see Stauffer et al. 1991). Based on UMD's prior experience in numerical experiments, the following nudging coefficients have been used:

- Upper-air wind fields: 5. 0E-4s^{-1} for Domain 1 (36km), and 2. 5E-4s^{-1} for Domain 2 (12km);
- Upper-air temperature fields: 1.0E-5s^{-1} for both Domains;
- Surface winds: 5. 0s^{-1}E-4s^{-1} for Domain 1, and 2.5E-4s^{-1} for Domain 2; and
- Surface temperature and moisture: not nudged due to instability consideration.

ASSESSMENT

National Weather Service (NWS) and CASTNet data – Surface temperature, Wind Speed, and Humidity

NWS (TDL) and CASTNet (www.epa.gov/castnet/) surface measurements of temperature, wind speed, and humidity (note there were no humidity measurements for CASTNet) were used to compare with the MM5 outputs. The evaluation was performed with METSTAT program developed by Environ Corporation (www.camx.com/files/metstat.15feb05.tar.gz) When comparing to NWS data, the METSTAT interpolates the first layer MM5 (at 10m height) temperature and humidity data to a height of 2m, the level that corresponds to the NWS measurement of these parameters, but no interpolation was made for wind speed and direction. In the case of CASTNet surface measurements, no interpolations were made as CASTNet data were reported at 10m height. In this analysis, no exclusion was made for calm conditions. The reported calm winds (zero wind speed measured) were treated *as is* in this evaluation effort. The METSTAT calculated standard statistical measures – average, bias, error and index of agreement between the measured and predicted parameters. Table 1 summarizes the MM5 average bias for each month for wind speed, wind direction, temperature, and humidity by comparing data from NWS and CASTNet networks. The humidity data is only available for NWS network. In general, there is no systematic bias between winter and summer seasons for MM5 in terms of wind speed, wind direction and temperature. However, MM5 showed dry bias in the summer and wet bias in the winter when compared with humidity data from NWS.

Figure 2a and 2b display the time series comparison of wind speed between MM5 and measured data from NWS and CASTNet networks for winter months (January, February and December) and summer months (June, July and August), respectively. MM5 underpredicted NWS and overpredicted CASTNet daytime peak wind speed, while MM5 appears to track quite well the nighttime wind speed minimum for CASTNet and overpredicted nighttime wind speed minimum for the NWS data. MM5 performed quite well in capturing magnitude and diurnal timing for temperature from both NWS and CASTNet data (Figures 3a and 3b). It should be pointed out that there are differences in how the meteorological information is collected and reported by the two networks and as computed in MM5. The CASTNet measurements are based on hourly averaged wind speed while NWS reports 2min average at 10min before the hour, whereas MM5 predictions are reflective of the last time-step of the hour of computation. In the case of humidity (Figure 4), MM5 tracked the NWS observed humidity trend well, but exhibits dry bias for summer season and wet bias for winter season and misses the observed semi-diurnal cycles. Comparisons for the whole year of 2002 including bias and root mean square error from both NWS and CASTNet are available on request from NYSDEC.

The above assessment is based on domain-wide averages to provide an overall response of the model. Another way of assessing the model is to examine the spatial distribution of correlation between the measured and predicted parameters at each monitor. Figures 5a and 5b display such a comparison for wind speed and temperature over winter months and summer months, respectively. For the wind speed (Figure 5a), the correlation is in the range of 0.8 to 0.9 for winter months and 0.7 to 0.8 for summer months. For the temperature (Figure 5b), the correlation is above 0.95 for summer months, slightly higher than winter months. The correlation for humidity (Figure 5c) is in the range of 0.8 to 0.9 for both winter and summer months. These correlations indicate that MM5 simulation has captured both the diurnal and synoptic scale variations. Detailed plots of this comparison are available on request from NYSDEC.

Vertical Profiler – Winds

The Wind-Profiler network measurements along the U. S. East Coast (www.madis-fsl.org/cap) were used to evaluate the vertical profiles from MM5. There are twelve wind-profiler measurement stations from which data were available for comparison. For convenience of comparison, the wind-profiler measurements were interpolated to the MM5 vertical levels. The approach used was simple interpolation between two adjacent wind-profiler layers to the MM5 vertical level, and was limited to that reported by the profiler measurement. The focus of the comparison was to assess if MM5 was able to capture the measured vertical structure, and for this we used the observed Low Level Jet (LLJ) as an indicator. The comparison was performed for June, July and August 2002. In general it is found that MM5 captures the profiler measured vertical wind field structure reasonably well. Figure 6 displays an example of the MM5 and wind profiler comparison for the August 2002 episode at Richmond, VA and Concord, NH. MM5 predicted weaker LLJ winds compared to those based on the wind-profiler measurements. The detailed plots of this comparison are available on request from NYSDEC.

Cloud Cover – Satellite cloud image

Cloud information derived from satellite image data (www.atmos.umd.edu/~srb/gcip/webgcip.htm) were used to assess the MM5 prediction of cloud cover. The 0.5^{o} by 0.5^{o} resolution of the satellite data were interpolated into the 12km MM5 grid for comparison. The MM5 total cloud fraction was estimated by MCIP based on the MM5's low cloud, middle cloud and high cloud predictions. In general, MM5 seems to capture the satellite cloud pattern well but underestimates the satellite cloud fraction (see Figure 7a and 7b as examples), which may in part be due to the coarse resolution of the satellite cloud data.

Precipitation comparison

The monthly total observed precipitation data were constructed from 1/8-degree daily precipitation analysis data (http://data.eol.ucar.edu/codiac/dss/id=21.093) produced by Climate Prediction Center, based on 7,000-8,000 hourly/6-hourly gauge reports and radar). The MM5 monthly total precipitation was estimated from the MM5 predicted convective and non-convective rainfall and summed up for each month. In general, MM5 captured the observed spatial patterns (see examples of Figures 8a and 8b). For winter months, MM5 performed well for February (Figure 8a) but underpredicted for November. For the summer months, MM5 performed well for May and September, but no so well for June, July and August (See Figure 8b), that may reflect the summertime convective rain activities are not captured by MM5.

Calm Conditions

Calm conditions are defined as observed wind speed of zero knots and wind direction as 0^{o}. It would be useful to assess how MM5 performs under observed calm conditions, because of potential pollutant buildup that could occur under such conditions. Table 2a and 2b list the summary of the percentage of calm condition at each hour for the February and August 2002, respectively from the NWS data within the 12km domain. It is apparent from the Table that the calm conditions occur primarily during the night and early morning hours, from 23Z (7 p.m. EDT) to 15Z (11 a.m. EDT) with a peak at around 10Z (6 a.m. EDT). August had much higher percentage of calm condition than February. To assess MM5 performance, the observed and MM5 predicted wind speeds were divided into calm and non-calm according to observed wind speed. In general MM5 underpredicted the observed non-calm conditions for both February and August (Table 2a and 2b). Figure 9 displays such a comparison of the MM5 predicted wind speed to the observed wind speed under the calm and non-calm conditions for the month of August 2002. For the "calm" group, the average wind speed for MM5 varies from 1 m/s during the night and early morning hours and over 1.5 m/s during the day. MM5 is over-predicting during observed calm wind conditions. There are local minima every 3 hours, due to the surface observed wind speed nudging in MM5. In contrast under the non-calm conditions, MM5 underpredicts by about 0.5 m/s for all hours with noticeable local maximum happening at the nudging hours. The MM5 nudging process would pull predictions toward the measured data, while the underprediction of MM5 for the non-calm conditions may due to the adopted PBL scheme in this simulation.

Summary

In this study, we performed an assessment of the MM5 simulation to measured data, both with the surface measurement networks as well as with information from the vertical wind profilers and satellite cloud images. While there are no specific recommended procedures identified for this assessment, similar approaches have been used elsewhere (Dolwick 2005, Baker 2004, and Johnson 2004). Traditionally, the NWS surface measurements are used for such a comparison. Since NWS data had been used through nudging processes in developing the MM5 simulation, the comparisons should not be far removed from each other. In this study, we extended the evaluation by using CASTNet measurements that were not used in the nudging of MM5 simulation. Thus comparison with CASTNet data provides for an independent assessment and should complement the comparison with NWS data. We also compared the MM5 results with the wind profiler data and cloud data derived from satellite images to diagnose if the MM5 simulation is yielding the right dynamics in the vertical. The analyses shows that in general, the performance of the MM5 is reasonable both at the surface and in the vertical, thereby providing confidence in the use of these data in the CMAQ simulations.

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Table 1: Average bias of wind speed, wind direction, temperature, and humidity of MM5 in comparing with observed data from TDL and CASTNet networks for each *month* in 2002

Month	Wind Speed (TDL / CASTNet)	Wind Direction (TDL / CASTNet)	Temperature (TDL / CASTNet)	Humidity TDL
January	-0.53 / 0.34	3.12 / 2.54	-1.18 / -1.25	0.45
February	-0.56 / 0.31	3.31 / 0.88	-1.00 / -0.65	0.48
March	-0.59 / 0.31	3.48 / 1.93	-0.72 / -0.35	0.52
April	-0.55 / 0.38	3.61 / 2.49	-0.48 / -0.52	0.52
May	-0.52 / 0.44	3.53 / 2.33	-0.18 / 0.67	-0.02
June	-0.56 / 0.28	3.89 / 3.33	-0.12 / 1.03	-0.33
July	-0.58 / 0.31	3.62 / 1.44	-0.34 / 0.34	-0.55
August	-0.61 / 0.24	2.74 / 2.34	-0.42 / 0.32	-0.23
September	-0.54 / 0.30	3.31 / 3.01	-0.54 / 0.76	0.03
October	-0.56 / 0.32	2.81 / 1.39	-0.79 / -0.56	0.15
November	-0.57 / 0.37	2.28 / 2.35	-1.35 / -1.25	0.34
December	-0.59 / 0.39	3.41 / 2.69	-1.20 / -1.17	0.34

Table 2a: Measured calm and non-calm occurrences over the modeling domain during *February* 2002 based on NWS data

Hour (UTC)	Obs Not Calm	Obs Calm	Obs Total	Percent Calm (%)	TDL Avg WinSpd Not Calm	MM5 Avg WinSpd Not Calm
0	17266	2711	19977	13.6	4.28	3.84
1	17270	3324	20594	16.1	4.30	3.82
2	17051	3421	20472	16.7	4.30	3.75
3	16878	3499	20377	17.2	4.32	3.79
4	16401	3513	19914	17.6	4.33	3.78
5	16127	3532	19659	18.0	4.28	3.75
6	15914	3645	19559	18.6	4.26	3.81
7	15841	3703	19544	18.9	4.23	3.75
8	15784	3783	19567	19.3	4.20	3.71
9	15752	3857	19609	19.7	4.19	3.73
10	15630	3932	19562	20.1	4.18	3.70
11	15911	4020	19931	**20.2**	4.16	3.72
12	16451	4104	20555	20.0	4.21	3.82
13	16844	3891	20735	18.8	4.28	3.86
14	17779	2945	20724	14.2	4.62	4.00
15	18741	1822	20563	8.9	4.98	4.37
16	18740	1337	20077	6.7	5.21	4.66
17	19079	1106	20185	5.5	5.38	4.83
18	19158	954	20112	4.7	5.46	4.93
19	19380	880	20260	4.3	5.49	4.91
20	19545	883	20428	4.3	5.47	4.75
21	19648	859	20507	4.2	5.33	4.46
22	19576	1027	20603	5.0	5.03	4.02
23	18941	1772	20713	8.6	4.57	3.79

Table 2b: Measured calm and non-calm occurrences over the modeling domain during *August* 2002 based on NWS data

Hour (UTC)	Obs Not Calm	Obs Calm	Obs Total	Percent Calm (%)	TDL Avg WinSpd Not Calm	MM5 Avg WinSpd Not Calm
0	18209	3924	22133	17.7	3.14	2.56
1	16531	6026	22557	26.7	2.85	2.45
2	15604	6929	22533	30.8	2.79	2.33
3	14983	7245	22228	32.6	2.81	2.33
4	14309	7540	21849	34.5	2.80	2.28
5	14073	7735	21808	35.5	2.79	2.24
6	13934	7949	21883	36.3	2.78	2.29
7	13792	8040	21832	36.8	2.76	2.23
8	13542	8273	21815	37.9	2.75	2.22
9	13542	8385	21927	38.2	2.74	2.28
10	13708	8591	22299	**38.5**	2.72	2.25
11	14139	8693	22832	38.1	2.74	2.25
12	15297	7690	22987	33.5	2.89	2.33
13	17336	5192	22528	23.0	3.14	2.41
14	18522	3439	21961	15.7	3.39	2.63
15	18755	2617	21372	12.2	3.60	2.98
16	19169	2015	21184	9.5	3.79	3.15
17	19555	1617	21172	7.6	3.97	3.22
18	19982	1430	21412	6.7	4.08	3.38
19	20149	1389	21538	6.4	4.16	3.43
20	20565	1288	21853	5.9	4.14	3.41
21	20518	1383	21901	6.3	4.06	3.41
22	20672	1556	22228	7.0	3.88	3.12
23	20231	2292	22523	10.2	3.56	2.74

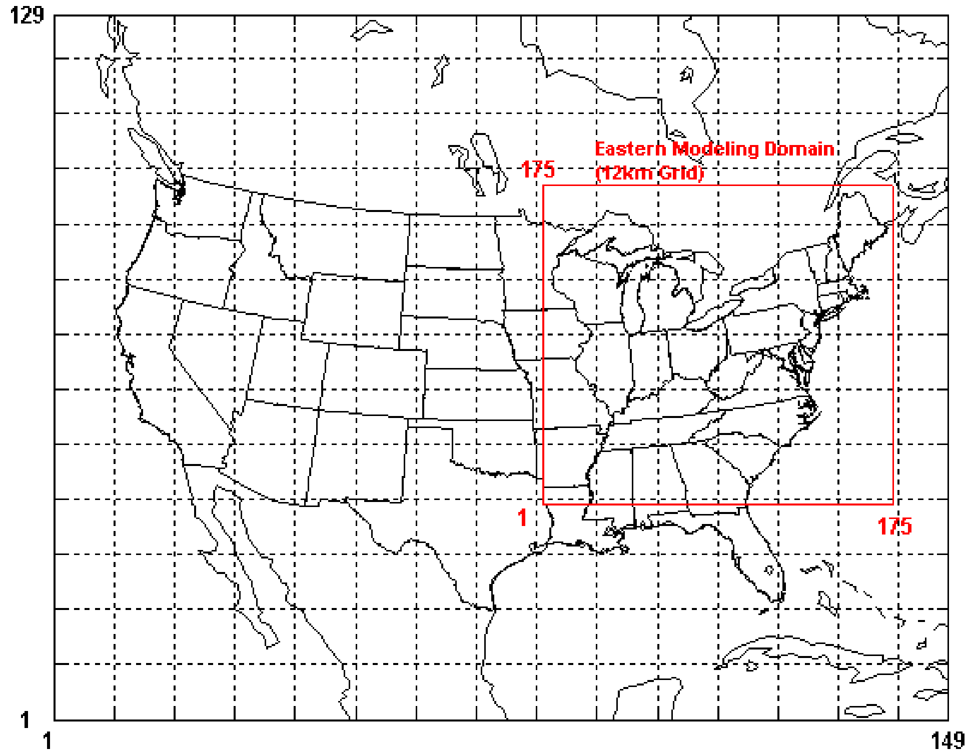
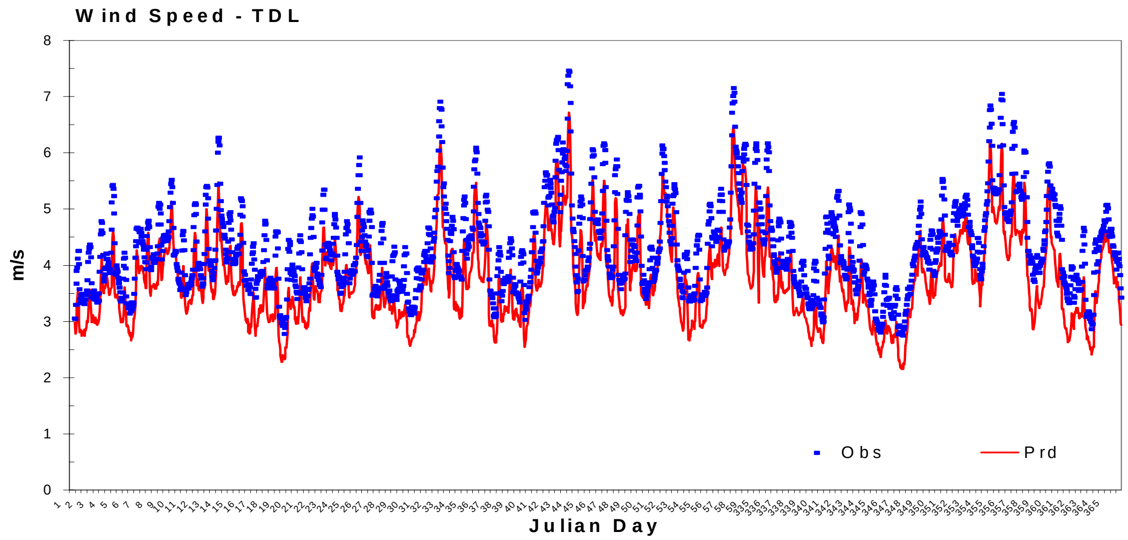


Figure 1: OTC MM5 modeling domain with areal extent of 12km and 36km grids



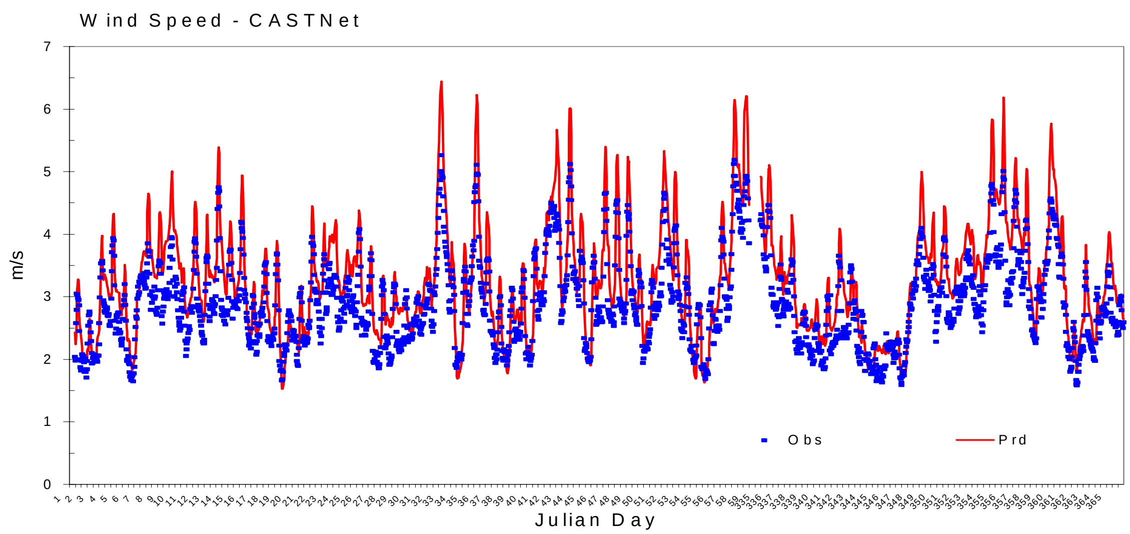
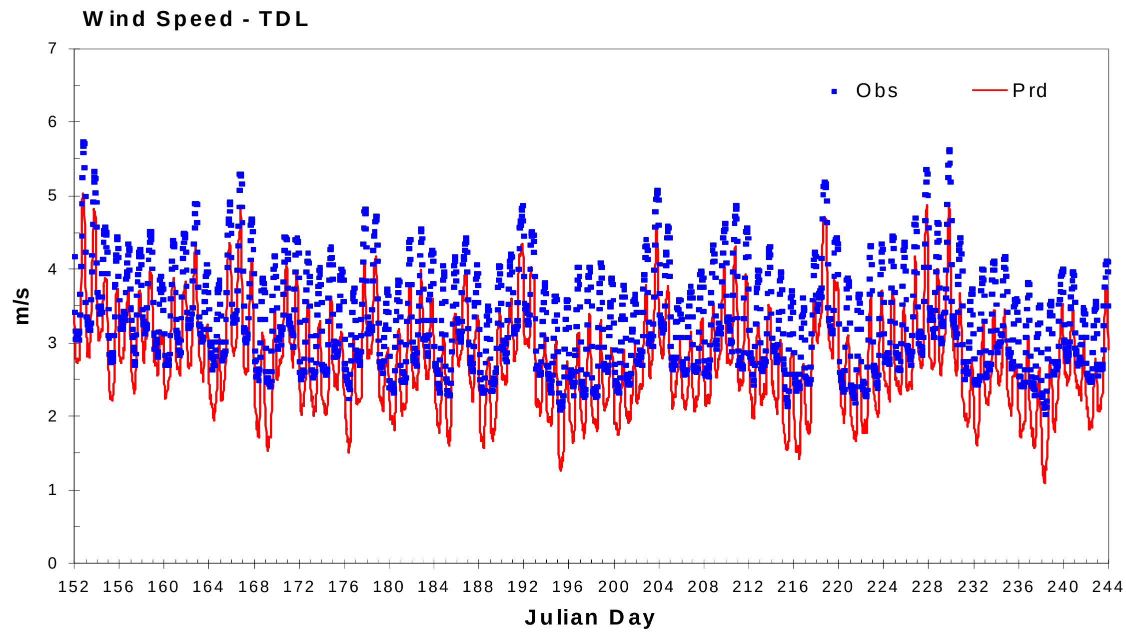


Figure 2a: Wind speed comparison for winter months - January, February, and December, 2002. The upper panel is the comparison between MM5 and NWS data, and the lower panel is the comparison between MM5 and CASTNet data.



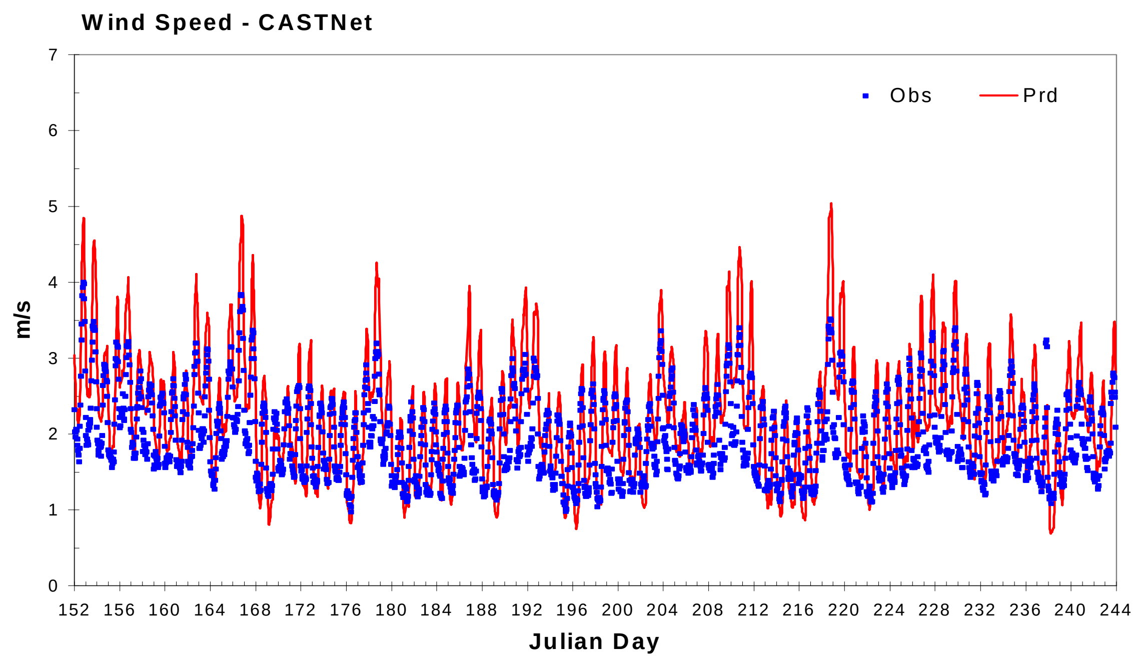
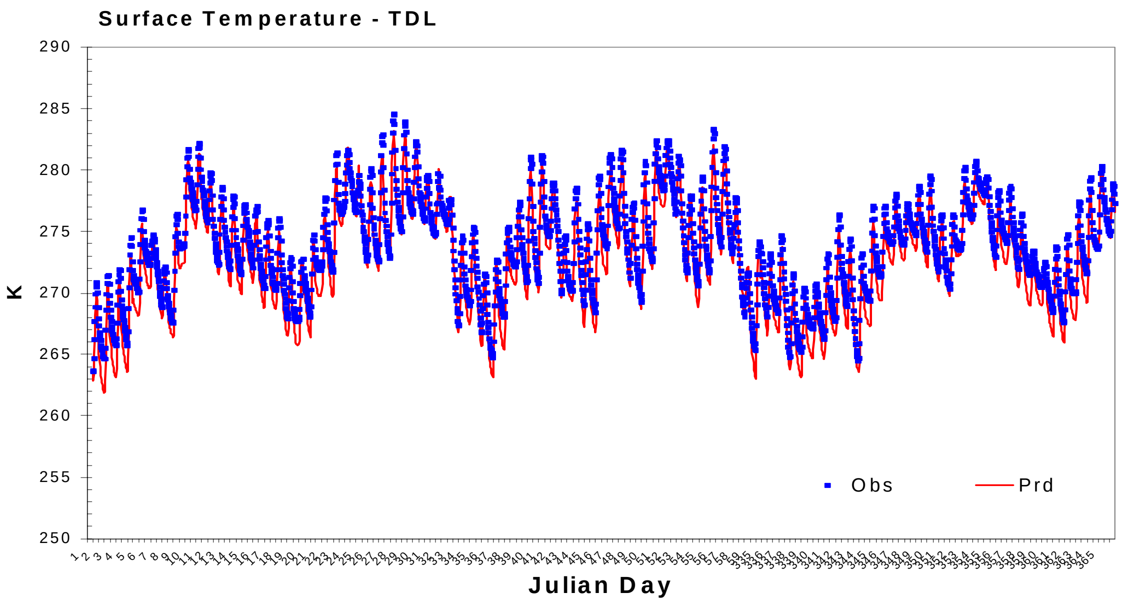


Figure 2b: Wind speed comparison for summer months - June, July, and August, 2002. The upper panel is the comparison between MM5 and NWS data, and the lower panel is the comparison between MM5 and CASTNet data.



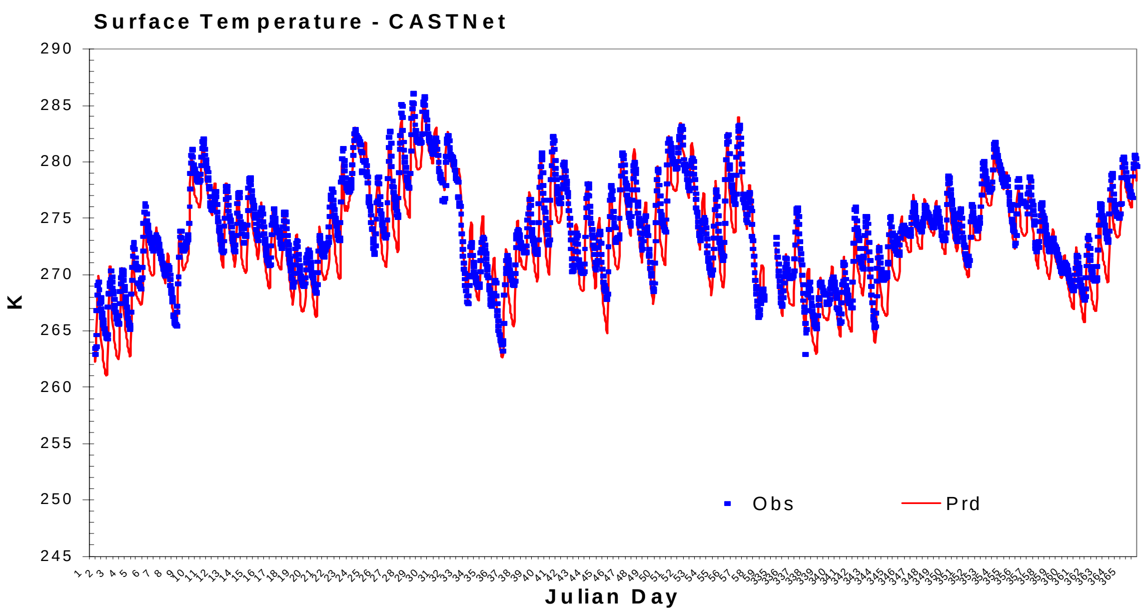
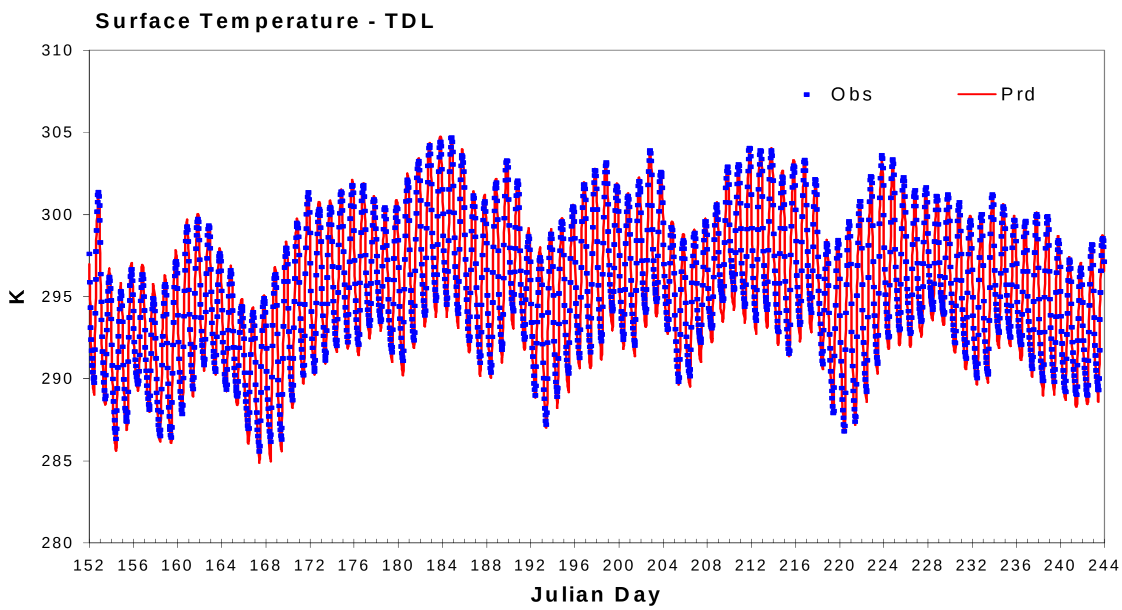


Figure 3a: Temperature comparison for winter months - January, February, and December, 2002. Upper panel is the comparison between MM5 and NWS data, and the lower panel is the comparison between MM5 and CASTNet data.



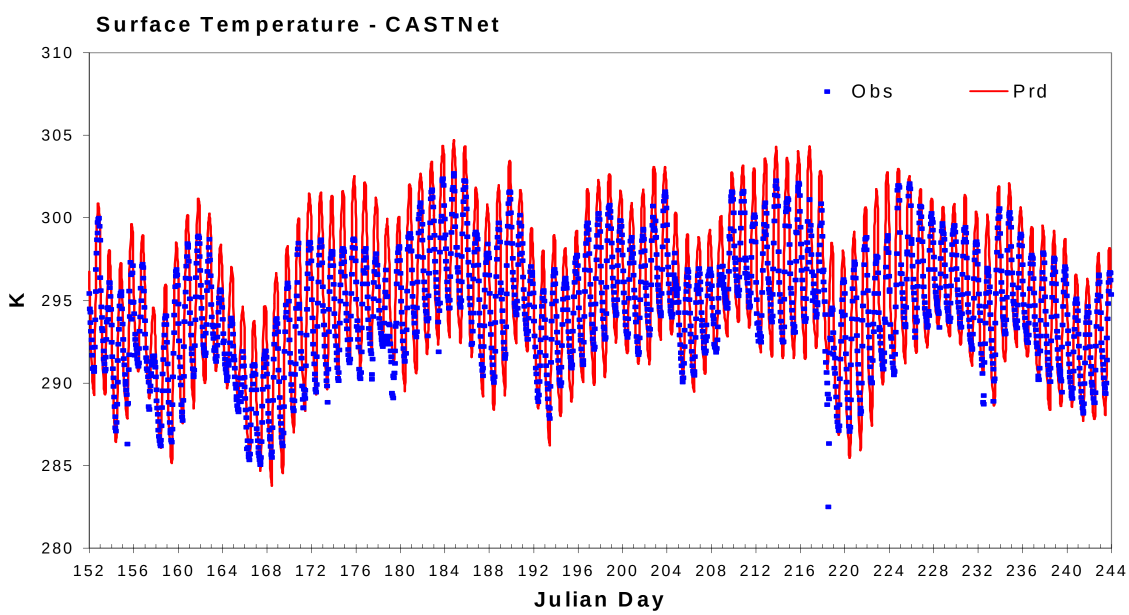
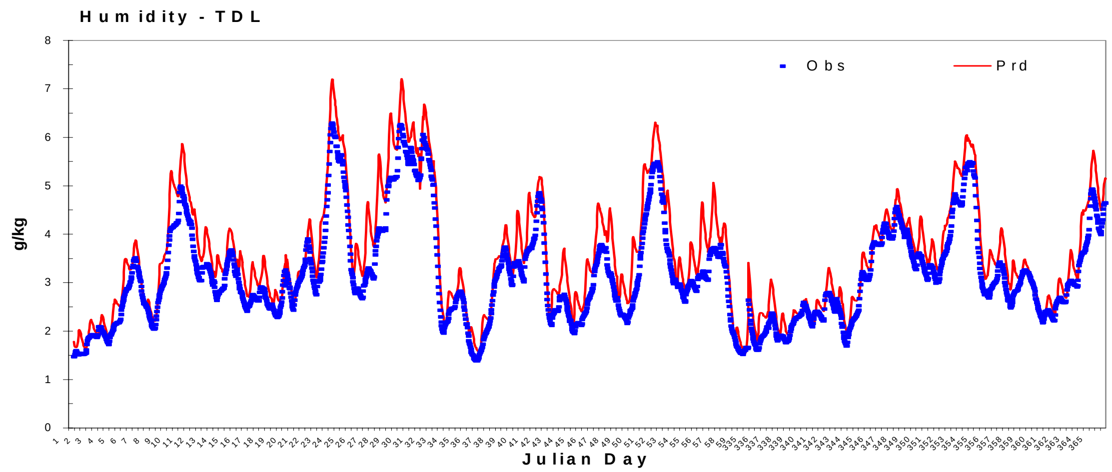


Figure 3b: Temperature comparison for summer months - June, July, and August, 2002. The upper panel is the comparison between MM5 and NWS data, and the lower panel is thew comparison between MM5 and CASTNet data.



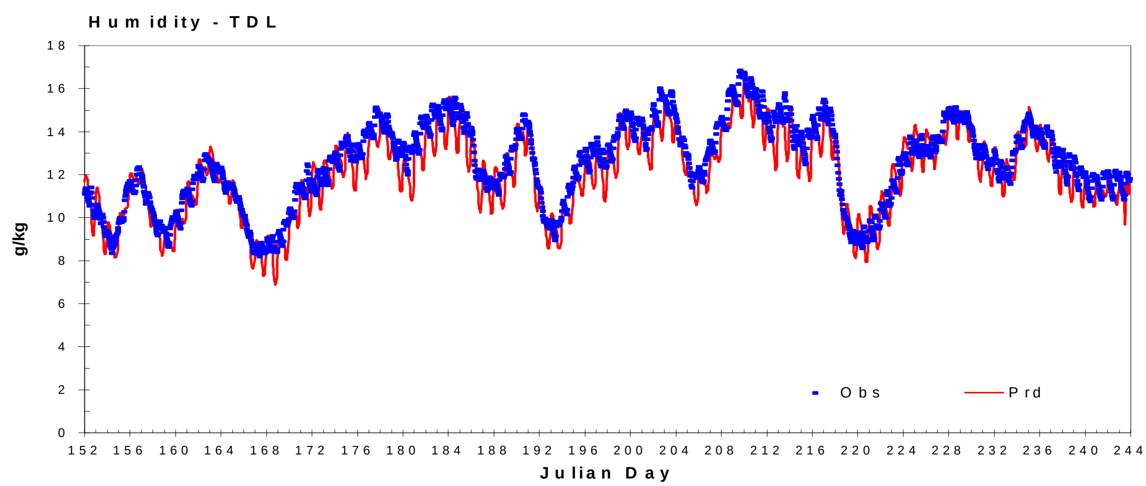
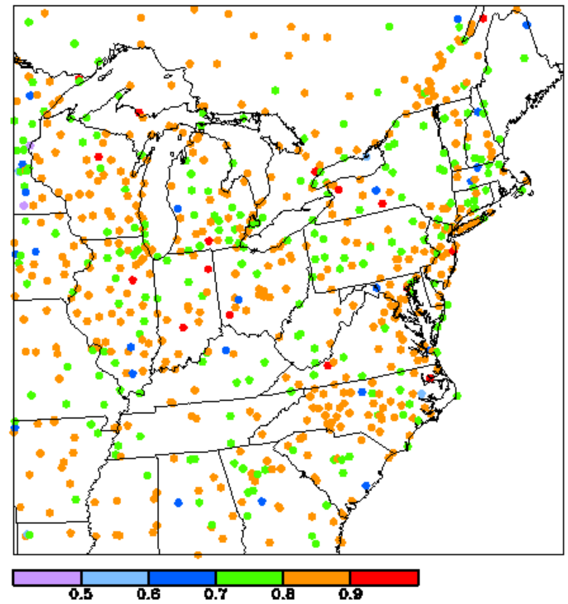


Figure 4: Humidity comparison for winter months - January, February, and December, 2002, (top panel), and summer months - June, July, and August, 2002 (bottom panel).

MM5 Sfc Wind Speed Correlation with TDL Jan to Mar 2002



MM5 Sfc Wind Speed Correlation with TDL May to Sept 2002

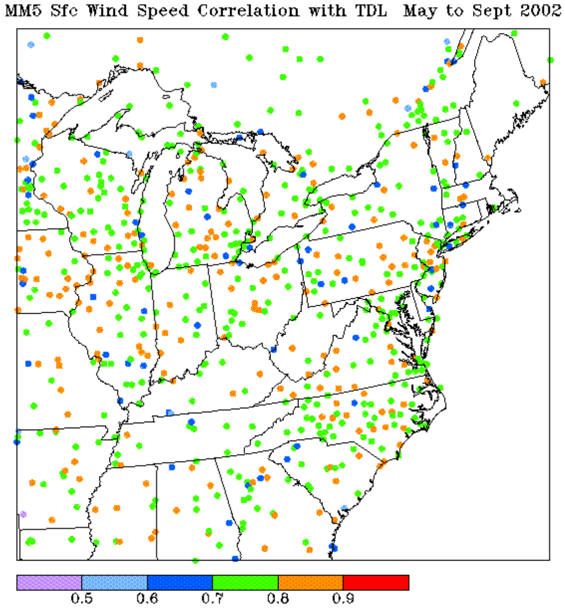


Figure 5a: Spatial correlation estimates between MM5 and NWS data for wind speed for winter months – January to March, 2002 (top panel) and summer months - May to September, 2002 (bottom panel).

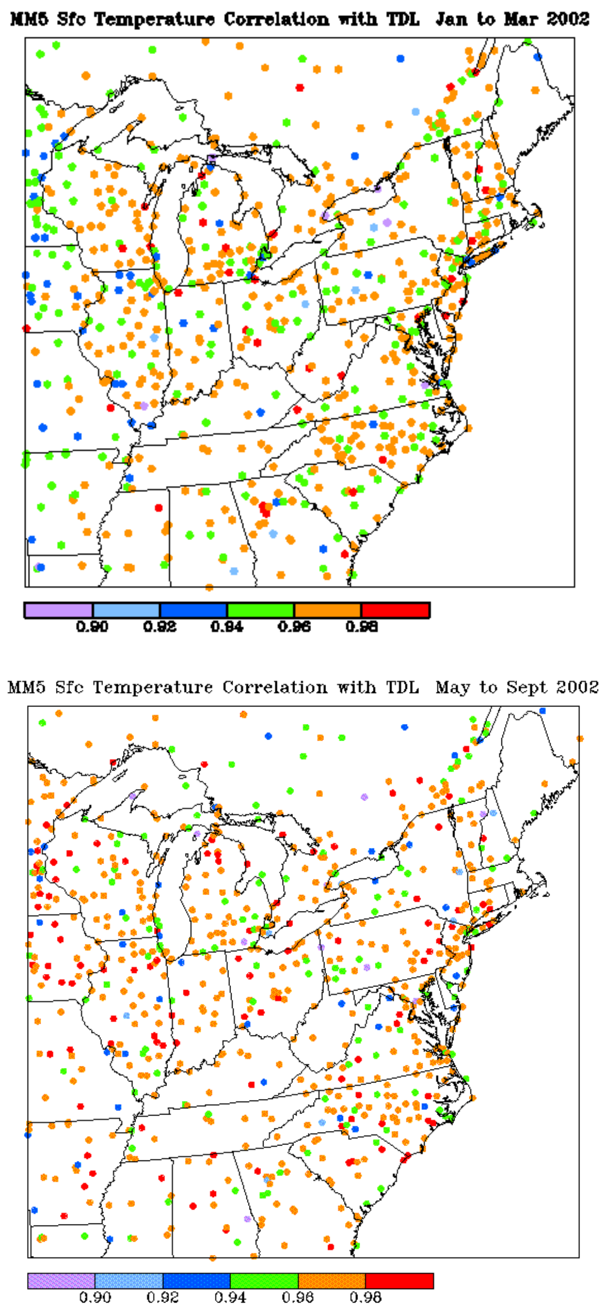


Figure 5b: Spatial distribution of correlation coefficients for Temperature between MM5 and NWS data for winter months – January to March, 2002 (top panel), and summer months - May to September, 2002 (bottom panel).

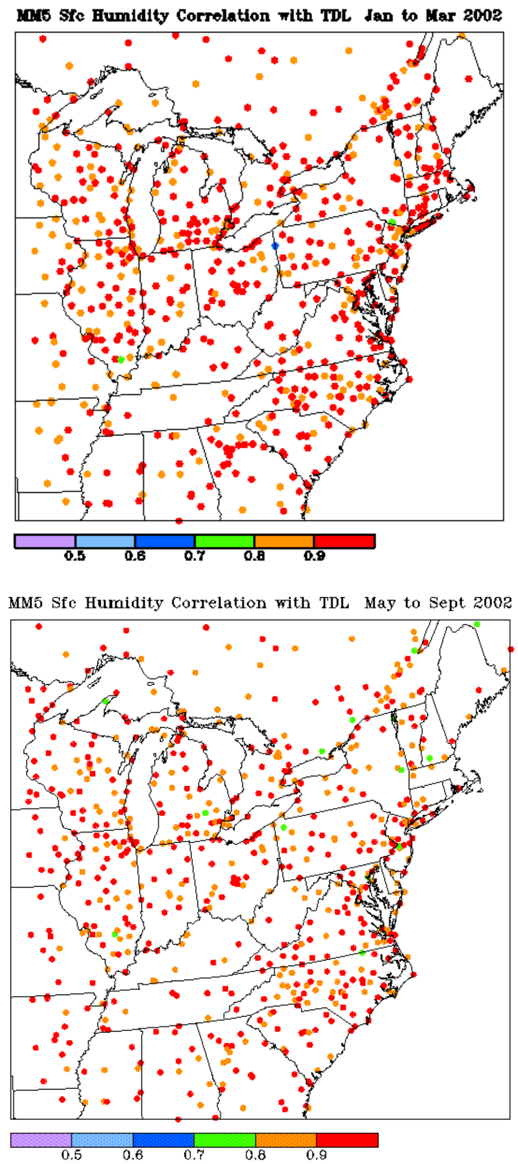
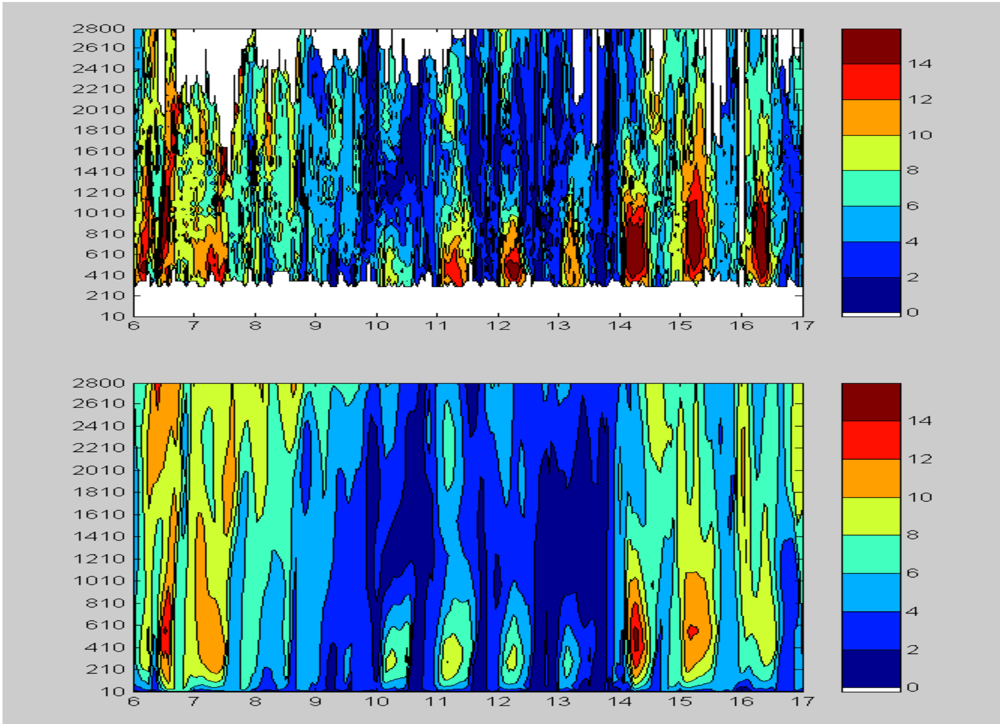


Figure 5c: Spatial distribution of correlation coefficients for Humidity between MM5 and NWS data for winter months – January to March, 2002 (top panel), and summer months - May to September, 2002 (bottom panel).

Richmond, VA



Concord, NH

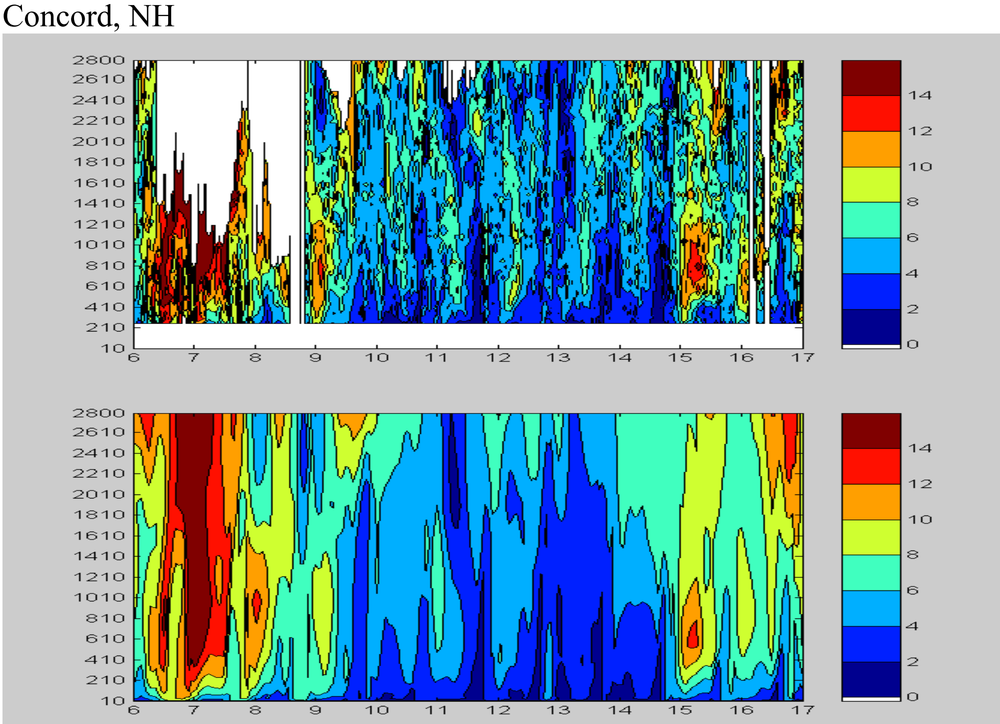


Figure 6: MM5 and Wind profiler comparison for August 6 to 17, 2002 at Richmond, VA and Concord, NH. The upper and lower panes at each station are for MM5 and profiler, respectively. The abscissa represents day and the ordinate the height (m).

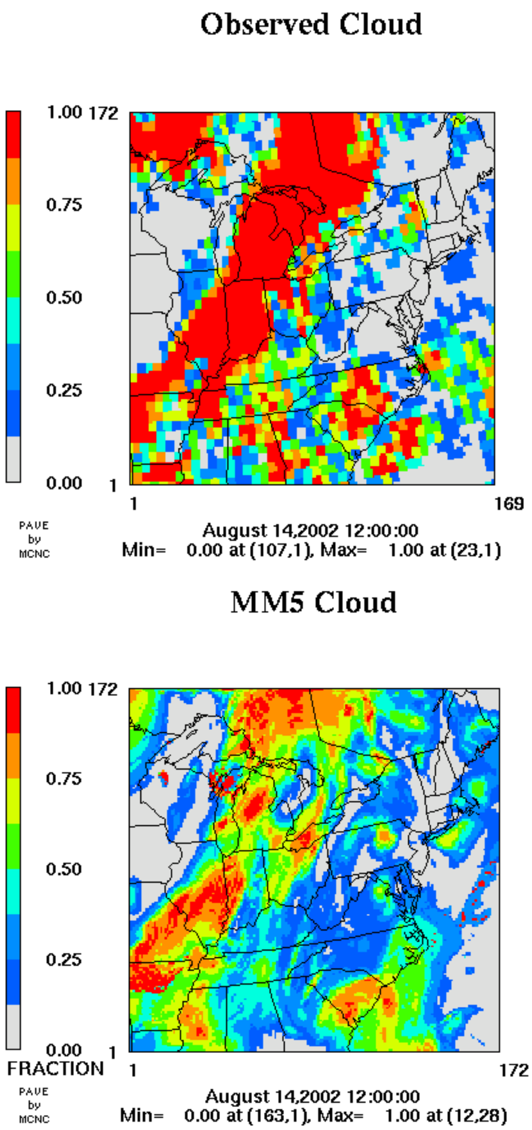


Figure 7a: Observed Satellite and MM5 cloud images for *August* 14, 2002 at 0700 EST

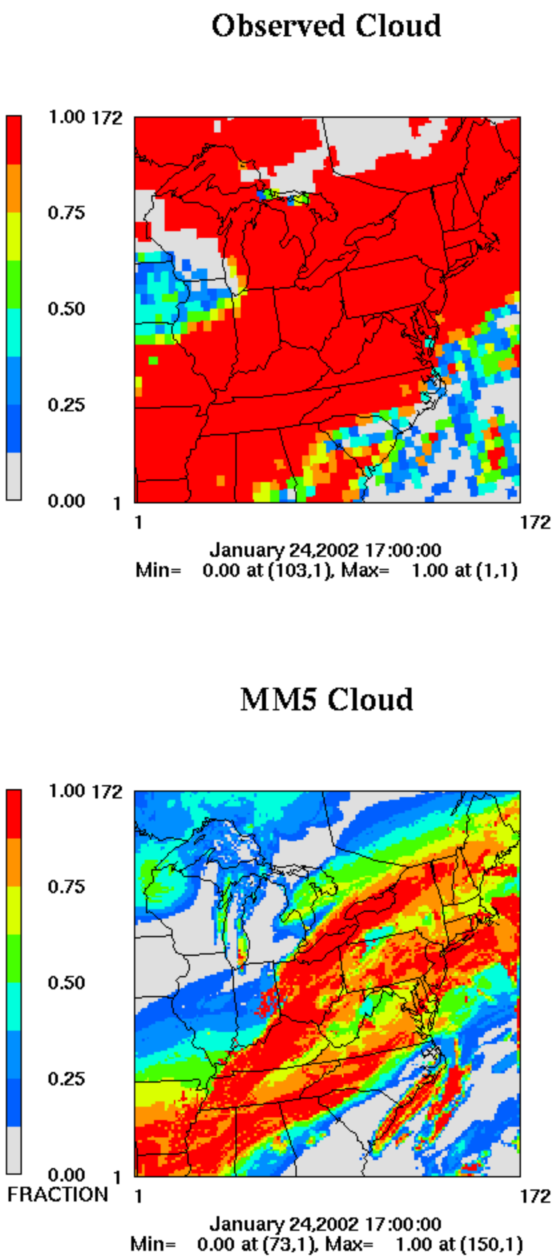


Figure 7b: Observed Satellite and MM5 cloud images for *January* 24, 2002 at 1200 EST

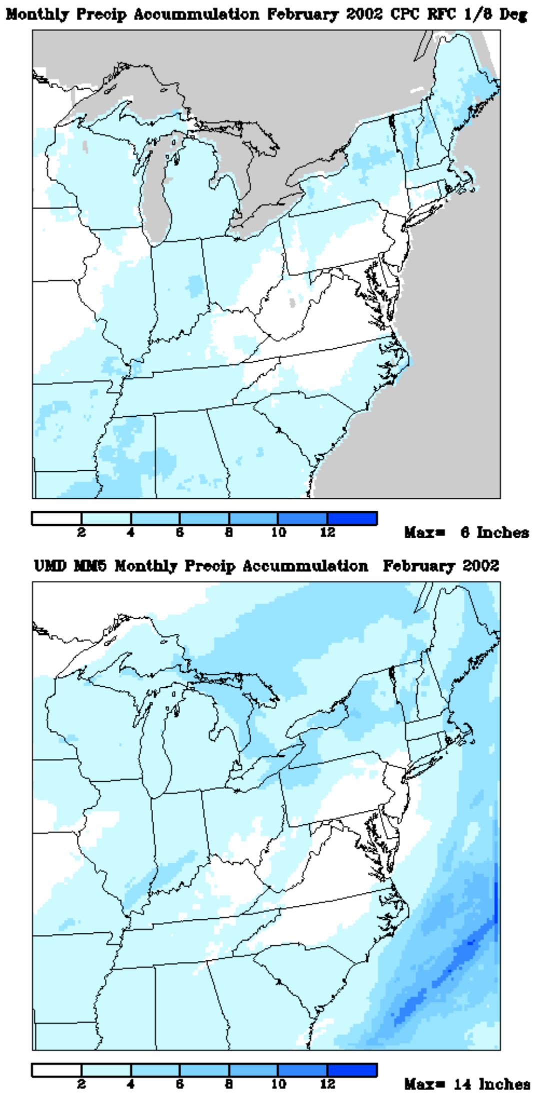
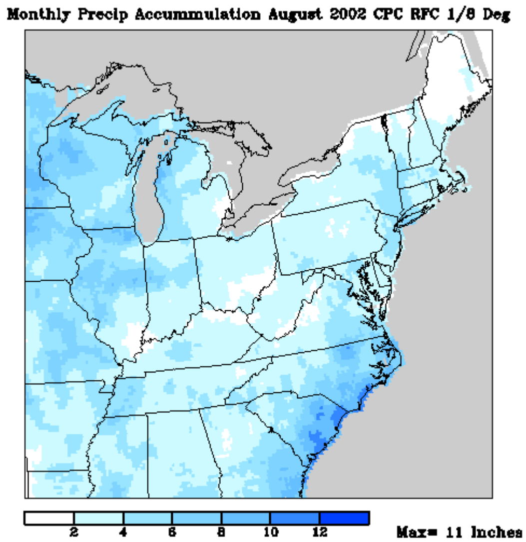


Figure 8a: Measured and MM5 predicted precipitation over the domain for the month of *February* 2002.



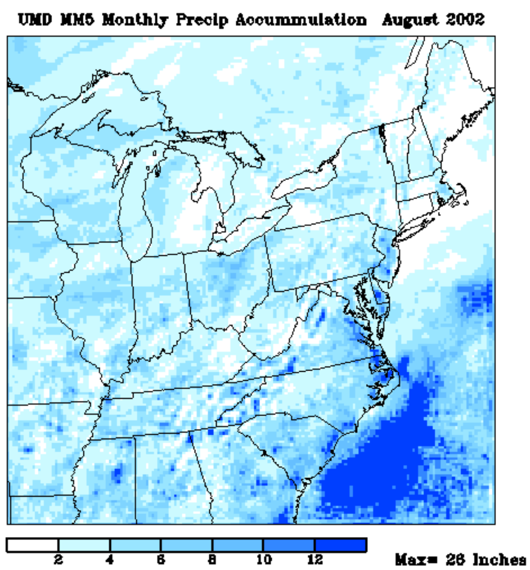


Figure 8b: Measured and MM5 predicted precipitation over the domain for the month of *August* 2002

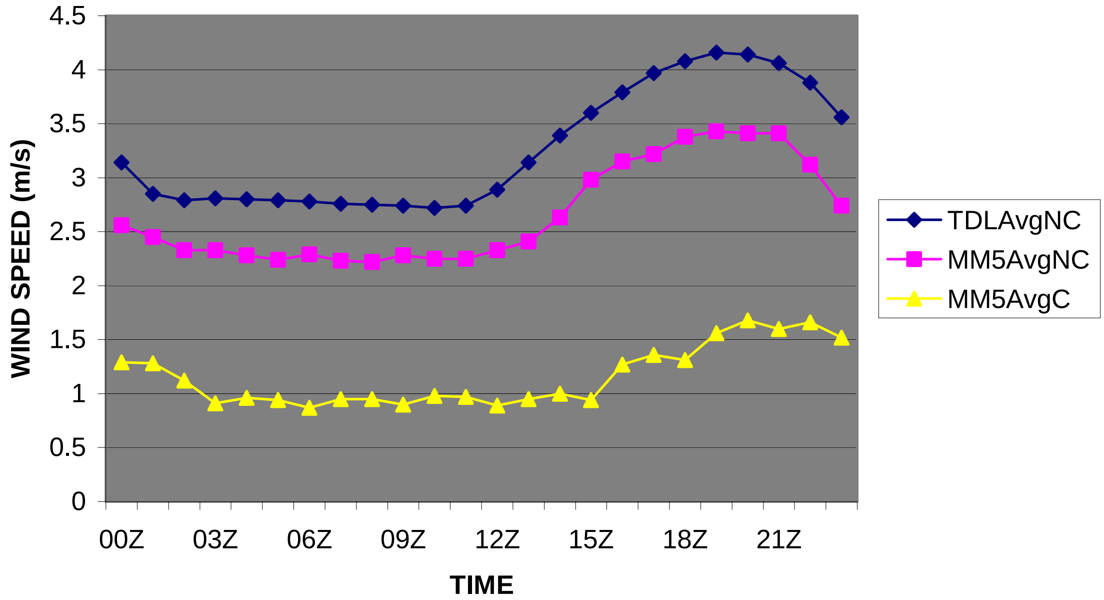


Figure 9: Comparison of averaged wind speed between MM5 and observed under calm (C) and non-calm (NC) conditions.

TSD-2a

Processing of 2002 Biogenic Emissions for OTC / MANE-VU Regional and Urban Modeling

Bureau of Air Quality Analysis and Research

Division of Air Resources

New York State Department of Environmental Conservation

Albany, NY 12233

September 19, 2006

Biogenic emissions for the time period from January 1, 2002 – December 31, 2002 were calculated by NYSDEC using the Biogenic Emissions Inventory System (BEIS) version 3.12 integrated within SMOKE2.1. General information about BEIS is available at http://www.epa.gov/AMD/biogen.html while documentation about biogenic emissions processing within SMOKE2.1 is available at http://cf.unc.edu/cep/empd/products/smoke/version2.1/html/ch06s10.html and http://cf.unc.edu/cep/empd/products/smoke/version2.1/html/ch06s17.html . Note that the SMOKE documentation refers to BEIS3.09 and has not yet been updated for BEIS3.12. This affects the number of species modeled as well as the use of different speciation profiles. However, the general processing approach has not changed from BEIS3.09 to BEIS3.12. In short, this processing approach is as follows and was utilized by NYSDEC for its biogenic emission processing for 8-hr ozone and $PM_{2.5}$ modeling:

1. **Normbeis3** reads gridded land use data and emissions factors and produces gridded normalized biogenic emissions for 34 species/compounds. The gridded land use includes 230 different land use types. Both summer and winter emissions factors for each species/compound are provided for each of the 230 land use types. On output, **Normbeis3** generates a file `B3GRD` which contains gridded summer and winter emission fluxes for the modeling domain that are normalized to 30 °C and a photosynthetic active radiation (PAR) of 1000 μmol/m^2s. In addition, gridded summer and winter leaf area indices (LAI) are also written to `B3GRD`.

2. **Tmpbeis3** reads the gridded, normalized emissions file `B3GRD` and meteorological data from the MCIP-processed MM5 meteorological fields generated by the University of Maryland for MANE-VU/OTC modeling. Specifically, the following MM5/MCIP meteorological variables are used by **Tmpbeis3** to compute hour-specific, gridded biogenic emissions from the normalized emission fluxed contained in `B3GRD`: layer-1 air temperature (“TA”), layer-1 pressure (“PRES”), total incoming solar radiation at the surface (“RGRND”), and convective (“RC”) and non-convective (“RN”) rainfall. Additionally, the emissions for the 34 species/compounds modeled by

BEIS3.12 are converted to CO, NO, and the CB-IV VOC species utilized in CMAQ via the use of the BEIS3.12-CB-IV speciation profile. In adition, an optional seasonal switch file, `BIOSEASON`, was utilized to decide whether to use summer or winter emissions factors for any given grid cell on any given day. This file was generated by the SMOKE2.1 utility **Metscan** based on MM5 layer-1 air temperatures to determine the date of the last spring frost and first fall frost at each grid cell. Summer emission factors are used by **Tmpbeis3** for the time period between the last spring frost and first fall frost at any given grid cell, and winter emission factors are used for the remaining time period. Documentation for the **Metscan** utility is available at http://cf.unc.edu/cep/empd/products/smoke/version2.1/html/ch05s07.html . An animated GIF file showing the `BIOSEASON` file used by NYSDEC can be found at ftp://ftp.dec.state.ny.us/dar/air_research/chogrefe/biog_reports/b3season_movie.gif

3. For reporting purposes, the hourly, speciated, gridded emissions were aggregated to the county level for each day. For any given grid cell, emissions are distributed among the counties intersecting this grid cell in proportion to the area of each of these counties within the grid cell. The area gridding surrogates needed for this aggregration are based on a file obtained from EPA via http://www.epa.gov/ttn/chief/emch/spatial/new/bgpro.12km_041604.us.gz followed by windowing for the MANE-VU/OTC modeling domain.

Table 1 County and State totals of estimated biogenic emissions (tpy)

State	FIPS	County	NO [TPY]	CO [TPY]	VOC [TPY]
Connecticut	009001	Fairfield	52	894	7150
	009003	Hartford	88	915	8537
	009005	Litchfield	98	1261	12221
	009007	Middlesex	54	615	5587
	009009	New Haven	80	876	7544
	009011	New London	74	906	8960
	009013	Tolland	55	651	5999
	009015	Windham	60	772	8019
Connecticut		**TOTAL**	560	6889	64017
Deleware	010001	Kent	308	1354	15912
	010003	New Castle	143	875	8834
	010005	Sussex	539	2045	21595
Deleware		**TOTAL**	990	4274	46342
DC	011001	Washington	30	150	1726
DC		**TOTAL**	30	150	1726
Maine	023001	Androscoggin	35	885	8204
	023003	Aroostook	741	15531	140877
	023005	Cumberland	49	1298	11528
	023007	Franklin	72	3269	32111
	023009	Hancock	66	2950	27090
	023011	Kennebec	73	1425	12849
	023013	Knox	30	689	6680
	023015	Lincoln	32	849	8072
	023017	Oxford	79	3224	34189
	023019	Penobscot	211	7249	63128
	023021	Piscataquis	146	8638	80748
	023023	Sagadahoc	37	526	4504
	023025	Somerset	173	8413	77850
	023027	Waldo	57	1833	18125
	023029	Washington	144	6459	58678
	023031	York	73	1698	15571
Maine		**TOTAL**	2018	64936	600203
Maryland	024001	Allegany	63	661	8664
	024003	Anne Arundel	79	945	12786
	024005	Baltimore	166	847	8102
	024009	Calvert	59	798	10048

	024011	Caroline	202	648	7907
	024013	Carroll	189	822	7853
	024015	Cecil	86	654	10093
	024017	Charles	78	1079	15042
	024019	Dorchester	134	829	10337
	024021	Frederick	204	1123	10964
	024023	Garrett	102	930	11391
	024025	Harford	141	911	9053
	024027	Howard	75	562	4460
	024029	Kent	177	498	4761
	024031	Montgomery	134	813	6786
	024033	Prince Georges	87	732	10214
	024035	Queen Annes	222	684	7146
	024037	St Marys	99	886	10793
	024039	Somerset	58	498	5796
	024041	Talbot	131	495	5225
	024043	Washington	112	781	7538
	024045	Wicomico	124	796	10304
	024047	Worcester	158	1121	13079
	024510	Baltimore	54	235	1762
Maryland		**TOTAL**	2934	18350	210104
Massachusetts	025001	Barnstable	261	668	5905
	025003	Berkshire	73	1182	11029
	025005	Bristol	107	753	7142
	025007	Dukes	115	252	1728
	025009	Essex	55	794	7128
	025011	Franklin	61	1031	9424
	025013	Hampden	51	904	9201
	025015	Hampshire	61	820	7056
	025017	Middlesex	68	1085	11630
	025019	Nantucket	56	159	1362
	025021	Norfolk	49	615	5513
	025023	Plymouth	170	1197	11876
	025025	Suffolk	26	177	1351
	025027	Worcester	103	1955	23612
Massachusetts		**TOTAL**	1257	11594	113957
New Hampshire	033001	Belknap	25	693	6915
	033003	Carroll	40	1512	14981
	033005	Cheshire	49	1019	10099
	033007	Coos	72	3239	33668
	033009	Grafton	91	2442	23151
	033011	Hillsborough	48	1337	14503
	033013	Merrimack	48	1314	13566
	033015	Rockingham	39	1120	10080
	033017	Strafford	25	686	6617
	033019	Sullivan	45	943	8314

New Hampshire		**TOTAL**	482	14306	141894
New Jersey	034001	Atlantic	135	1225	18890
	034003	Bergen	37	239	2455
	034005	Burlington	151	1827	25255
	034007	Camden	68	491	7751
	034009	Cape May	90	566	7763
	034011	Cumberland	122	773	10699
	034013	Essex	57	199	1831
	034015	Gloucester	119	556	8444
	034017	Hudson	26	125	701
	034019	Hunterdon	81	706	5743
	034021	Mercer	85	475	4889
	034023	Middlesex	98	456	5267
	034025	Monmouth	125	1152	15423
	034027	Morris	63	604	7288
	034029	Ocean	128	1871	27063
	034031	Passaic	41	339	3841
	034033	Salem	123	535	8304
	034035	Somerset	49	518	5548
	034037	Sussex	67	718	7768
	034039	Union	21	168	2191
	034041	Warren	125	517	4505
New Jersey		**TOTAL**	1813	14058	181618
New York	036001	Albany	59	730	6253
	036003	Allegany	129	1218	9526
	036005	Bronx	25	100	657
	036007	Broome	107	879	7861
	036009	Cattaraugus	148	1654	13540
	036011	Cayuga	227	986	7928
	036013	Chautauqua	202	1260	8144
	036015	Chemung	88	521	3911
	036017	Chenango	149	1120	7833
	036019	Clinton	138	1631	13341
	036021	Columbia	96	896	8484
	036023	Cortland	101	616	4280
	036025	Delaware	133	1672	13435
	036027	Dutchess	90	1096	10288
	036029	Erie	165	1127	6898
	036031	Essex	94	2547	20888
	036033	Franklin	228	2337	17197
	036035	Fulton	90	764	5275
	036037	Genesee	201	645	3993
	036039	Greene	47	886	8182
	036041	Hamilton	78	2092	16056
	036043	Herkimer	175	1783	12846
	036045	Jefferson	251	1754	12503

	036047	Kings	15	60	309
	036049	Lewis	154	1693	12116
	036051	Livingston	222	888	6048
	036053	Madison	149	1049	7528
	036055	Monroe	223	990	6237
	036057	Montgomery	106	579	4715
	036059	Nassau	81	408	2859
	036061	New York	16	76	473
	036063	Niagara	335	940	5182
	036065	Oneida	214	1515	10021
	036067	Onondaga	171	929	6259
	036069	Ontario	178	767	6024
	036071	Orange	110	1065	13024
	036073	Orleans	195	635	3314
	036075	Oswego	119	1277	7911
	036077	Otsego	157	1190	7958
	036079	Putnam	32	473	5243
	036081	Queens	20	105	543
	036083	Rensselaer	96	894	7316
	036085	Richmond	47	173	1292
	036087	Rockland	26	300	4006
	036089	St. Lawrence	376	3876	28960
	036091	Saratoga	76	1125	9010
	036093	Schenectady	39	377	3032
	036095	Schoharie	95	737	5496
	036097	Schuyler	87	438	3193
	036099	Seneca	127	438	3305
	036101	Steuben	267	1475	12085
	036103	Suffolk	368	1328	12886
	036105	Sullivan	76	1325	12538
	036107	Tioga	102	730	5400
	036109	Tompkins	96	576	4128
	036111	Ulster	82	1493	15714
	036113	Warren	46	1396	11568
	036115	Washington	183	1109	8355
	036117	Wayne	270	920	5940
	036119	Westchester	35	549	5347
	036121	Wyoming	194	720	3813
	036123	Yates	107	507	4017
New York		**TOTAL**	8313	63436	492483
Pennsylvania	042001	Adams	186	892	8926
	042003	Allegheny	182	948	6727
	042005	Armstrong	108	940	9955
	042007	Beaver	69	600	4895
	042009	Bedford	128	1249	14127
	042011	Berks	280	1377	14146
	042013	Blair	91	729	7579

042015	Bradford	224	1265	9423
042017	Bucks	144	954	8399
042019	Butler	149	1032	8602
042021	Cambria	128	805	6545
042023	Cameron	25	627	7563
042025	Carbon	53	585	8121
042027	Centre	158	1344	16886
042029	Chester	264	1176	10474
042031	Clarion	85	848	10743
042033	Clearfield	149	1368	13267
042035	Clinton	71	1230	18191
042037	Columbia	106	802	9080
042039	Crawford	204	1297	10839
042041	Cumberland	193	816	9505
042043	Dauphin	116	799	8502
042045	Delaware	35	410	3250
042047	Elk	49	949	8921
042049	Erie	199	1107	8273
042051	Fayette	156	1087	9277
042053	Forest	26	577	7122
042055	Franklin	271	1057	10296
042057	Fulton	93	744	9341
042059	Greene	91	830	6966
042061	Huntingdon	135	1093	12606
042063	Indiana	144	1078	9156
042065	Jefferson	101	865	7362
042067	Juniata	79	588	8263
042069	Lackawanna	58	586	5569
042071	Lancaster	464	1299	9565
042073	Lawrence	114	503	3755
042075	Lebanon	155	623	5827
042077	Lehigh	149	594	6040
042079	Luzerne	75	1013	13215
042081	Lycoming	152	1457	16633
042083	Mc Kean	57	1044	7113
042085	Mercer	175	865	7114
042087	Mifflin	107	620	7508
042089	Monroe	75	773	8856
042091	Montgomery	106	812	6736
042093	Montour	85	321	3306
042095	Northampton	144	506	4416
042097	Northumberland	92	570	6340
042099	Perry	113	804	10216
042101	Philadelphia	29	194	1420
042103	Pike	37	757	9946
042105	Potter	89	1129	9027
042107	Schuylkill	123	1050	15001
042109	Snyder	88	538	6373

	042111	Somerset	221	1251	11228
	042113	Sullivan	45	684	5112
	042115	Susquehanna	126	978	6448
	042117	Tioga	176	1313	10942
	042119	Union	71	541	6435
	042121	Venango	72	855	9086
	042123	Warren	76	1031	7352
	042125	Washington	166	1068	7429
	042127	Wayne	89	862	5954
	042129	Westmoreland	199	1297	10589
	042131	Wyoming	60	551	4634
	042133	York	366	1393	12758
Pennsylvania		**TOTAL**	8645	59945	585271
Rhode Island	044001	Bristol	40	90	441
	044003	Kent	41	328	3471
	044005	Newport	37	183	1646
	044007	Providence	39	591	6901
	044009	Washington	54	572	6775
Rhode Island		**TOTAL**	211	1764	19233
Vermont	050001	Addison	186	922	6274
	050003	Bennington	43	896	7349
	050005	Caledonia	58	1149	10239
	050007	Chittenden	74	606	3633
	050009	Essex	61	1315	11795
	050011	Franklin	208	971	5927
	050013	Grand Isle	50	490	3506
	050015	Lamoille	36	727	5627
	050017	Orange	57	1182	10120
	050019	Orleans	120	1570	12842
	050021	Rutland	102	1257	9867
	050023	Washington	47	1099	9502
	050025	Windham	42	1232	10898
	050027	Windsor	57	1330	10796
Vermont		**TOTAL**	1142	14745	118376
Virginia	051001	Accomack	187	959	9472
	051003	Albemarle	140	1246	12533
	051005	Alleghany	35	522	7369
	051007	Amelia	70	915	10717
	051009	Amherst	80	905	10823
	051011	Appomattox	76	830	10447
	051013	Arlington	17	64	531
	051015	Augusta	135	1049	13291
	051017	Bath	46	771	11636
	051019	Bedford	189	1279	13052
	051021	Bland	41	515	7097

051023	Botetourt	74	780	10211
051025	Brunswick	98	1458	18254
051027	Buchanan	32	722	9557
051029	Buckingham	76	1287	18830
051031	Campbell	112	1078	12933
051033	Caroline	73	1173	16020
051035	Carroll	132	634	6885
051036	Charles City	93	415	4711
051037	Charlotte	84	1219	14277
051041	Chesterfield	69	802	10686
051043	Clarke	56	369	4009
051045	Craig	39	538	7314
051047	Culpeper	105	894	10720
051049	Cumberland	56	814	10677
051051	Dickenson	20	550	6910
051053	Dinwiddie	82	1207	16511
051057	Essex	58	671	7403
051059	Fairfax	111	533	5538
051061	Fauquier	150	1166	14084
051063	Floyd	47	593	6493
051065	Fluvanna	54	775	10756
051067	Franklin	119	1297	15933
051069	Frederick	64	588	8798
051071	Giles	38	508	4918
051073	Gloucester	32	510	5945
051075	Goochland	47	670	10392
051077	Grayson	60	627	8260
051079	Greene	57	434	5727
051081	Greensville	63	735	9009
051083	Halifax	201	1852	22730
051085	Hanover	91	950	12493
051087	Henri	81	427	5468
051089	Henry	59	805	9772
051091	Highland	44	608	8579
051093	Isle Of Wight	178	813	8049
051095	James City	41	314	3989
051097	King And Queen	77	673	7615
051099	King George	62	540	6111
051101	King William	102	712	7846
051103	Lancaster	33	311	3669
051105	Lee	97	680	7221
051107	Loudoun	137	942	8999
051109	Louisa	78	1142	16780
051111	Lunenberg	88	1108	13611
051113	Madison	70	598	7305
051115	Mathews	27	367	4025
051117	Mecklenburg	145	1478	18507
051119	Middlesex	42	480	5561

051121	Montgomery	70	501	5366
051125	Nelson	67	979	12465
051127	New Kent	35	600	8240
051131	Northampton	90	263	2019
051133	Northumberland	88	778	9298
051135	Nottoway	74	894	10670
051137	Orange	98	759	8265
051139	Page	77	540	6705
051141	Patrick	75	884	10255
051143	Pittsylvania	203	1806	22102
051145	Powhatan	47	675	10194
051147	Prince Edward	69	942	12042
051149	Prince George	73	572	6484
051153	Prince William	38	718	10979
051155	Pulaski	61	450	6510
051157	Rappahannock	61	521	7141
051159	Richmond	63	383	4548
051161	Roanoke	63	427	5278
051163	Rockbridge	101	813	9710
051165	Rockingham	189	1020	12959
051167	Russell	56	703	7975
051169	Scott	95	753	9943
051171	Shenandoah	117	757	10570
051173	Smyth	78	603	7159
051175	Southampton	177	1306	15588
051177	Spotsylvania	46	911	12575
051179	Stafford	27	637	8344
051181	Surry	85	784	10024
051183	Sussex	102	1267	16362
051185	Tazewell	77	639	7477
051187	Warren	44	438	6310
051191	Washington	142	632	6822
051193	Westmoreland	101	777	9357
051195	Wise	35	462	5685
051197	Wythe	109	596	7803
051199	York	35	271	3423
051510	Alexandria	38	145	1065
051515	Bedford	22	101	604
051520	Bristol	37	135	1220
051530	Buena Vista	6	43	381
051540	Charlottesville	18	98	528
051550	Chesapeake	71	666	8477
051560	Clifton Forge	27	61	436
051570	Colonial Heights	35	88	662
051580	Covington	24	114	1605
051590	Danville	55	343	3405
051595	Emporia	19	234	3300
051600	Fairfax	18	96	1518

	051610	Falls Church	16	98	1120
	051620	Franklin	66	142	1041
	051630	Fredericksburg	14	250	3012
	051640	Galax	45	94	519
	051650	Hampton	24	127	1112
	051660	Harrisonburg	73	143	746
	051670	Hopewell	26	79	711
	051678	Lexington	8	62	620
	051680	Lynchburg	45	250	2135
	051683	Manassas	17	86	743
	051685	Manassas Park	17	50	268
	051690	Martinsville	19	190	1625
	051700	Newport News	63	231	2187
	051710	Norfolk	42	197	2692
	051720	Norton	13	120	1305
	051730	Petersburg	58	171	1419
	051735	Poquoson	17	122	1351
	051740	Portsmouth	34	285	3215
	051750	Radford	27	76	609
	051760	Richmond	29	239	3517
	051770	Roanoke	33	91	770
	051775	Salem	14	61	568
	051790	Staunton	69	205	1550
	051800	Suffolk	118	964	11269
	051810	Virginia Beach	186	924	8724
	051820	Waynesboro	43	120	895
	051830	Williamsburg	3	38	446
	051840	Winchester	42	117	772
Virginia		**TOTAL**	9267	80615	981848

TSD-2b

Processing of 2002 Anthropogenic Emissions: OTC Regional and Urban 12km Base Year Simulation

Bureau of Air Quality Analysis and Research
Division of Air Resources
New York State Department of Environmental Conservation
Albany, NY 12233

March 19, 2007

Overview

All emissions processing for the revised 2002 OTC regional and urban 12 km base case simulations was performed with SMOKE2.1 compiled on a Red Hat 9.0 Linux operating system with the Portland group fortran compiler version 5.1. The emissions processing was performed on a month-by-month and RPO-by-RPO basis, i.e. SMOKE processing was performed for each month for each of the RPOs (MANE-VU, VISTAS, CENRAP, MRPO) individually as well as for Canada. For each month/RPO combination, a separate SMOKE ASSIGNS file was created, and the length of the episode in each of these ASSIGNS files was set to the entire month. Also, as discussed in Section 3, there was no difference between "episode-average" temperatures and "monthly-average" temperatures for the Mobile6 simulations that used the option of temperature averaging.

This document is structured as follows: A listing of all emission inventories is given in Section 2, organized by RPO and source category. Section 3 discusses the Mobile6 processing approach employed for the different RPOs, while Section 4 describes the processing of biogenic emissions with BEIS3.12. Finally, Sections 5 through7 describe the temporal allocation, speciation, and spatial allocation of the emissions inventories, respectively.

Emission Inventories

<u>MANE-VU</u>

Version 3 of the MANE_VU inventory was utilized to generate CMAQ-ready emissions. This emissions inventory data were obtained from the MANEVU archive in April 2006.

Area Sources

- Files: MANEVU_AREA_SMOKE_INPUT_ANNUAL_SUMMERDAY_040606.txt and MANEVU_AREA_SMOKE_INPUT_ANNUAL_WINTERDAY_040606.txt prepared by PECHAN, downloaded from **ftp.marama.org** (username mane-vu, password exchange)
- Fugitive dust correction: This was applied as county-specific correction factors for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; the correction factor file gcntl.xportfrac.txt was obtained from EPA's CAIR NODA ftp site http://www.airmodelingftp.com (password protected).; this adjustment was performed using the SMOKE programs cntlmat and grwinven to generate an adjusted IDA inventory file used for subsequent SMOKE processing

Nonroad Sources

- File: MANEVU_NRD2002_SMOKE_030306 prepared by PECHAN; downloaded from **ftp.marama.org** (username mane-vu, password exchange)

Mobile Sources

- VMT/Speed: MANEVU_2002_mbinv_02022006_addCT.txt prepared by PECHAN and NESCAUM; downloaded from http://bronze.nescaum.org/Private/junghun/MANE-VU/onroad_ver3_update/MANEVU_V3_update.tar

Point Sources

- Files: MANEVU_Point_SMOKE_INPUT_ANNUAL_SUMMERDAY_041006.txt and MANEVU_Point_SMOKE_INPUT_ANNUAL_WINTERDAY_041006.txt prepared by PECHAN were downloaded from **ftp.marama.org** (username mane-vu, password exchange)

- Fugitive dust correction: This was applied as county-specific correction factors for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; the correction factor file gcntl.xportfrac.txt was obtained from EPA's CAIR NODA ftp site http://www.airmodelingftp.com (password protected).; this adjustment was performed using the SMOKE programs cntlmat and grwinven to generate an adjusted IDA inventory file used for subsequent SMOKE processing
- Corrected the omission of 2,100 tons/year VOC emissions from several point sources in NJ. NJDEP provided updated IDA files on June 30 that were used for modeling.

CENRAP

The inventory data were obtained from the CENRAP ftp site in March 2006 and reflect version BaseB of the CENRAP inventory.

Area Sources

- Files:
  - CENRAP_AREA_SMOKE_INPUT_ANN_STATES_081705.txt
  - CENRAP_AREA_MISC_SMOKE_INPUT_ANN_STATE_071905.txt
  - CENRAP_AREA_BURNING_SMOKE_INPUT_ANN_TX_NELI_071905.txt
  - CENRAP_AREA_MISC_SMOKE_INPUT_NH3_MONTH_{MMM}_072805.txt where {MMM} is JAN, FEB, … DEC
  - CENRAP_AREA_SMOKE_INPUT_NH3_MONTH_{MMM}_071905.txt where {MMM} is JAN, FEB, … DEC
- Fugitive dust correction: This was applied as county-specific correction factors for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; the correction factor file gcntl.xportfrac.txt was obtained from EPA's CAIR NODA ftp site http://www.airmodelingftp.com (password protected).; this adjustment was performed using the SMOKE programs cntlmat and grwinven to generate an adjusted IDA inventory file used for subsequent SMOKE processing
- Note about area and nonroad source SMOKE processing for the CENRAP region: All area source inventories (both annual and month-specific) were processed in one step through SMOKE. SMK_AVEDAY_YN was set to N, so seasonal profiles were used to apportion the annual inventories numbers by month. This setting was also used for the nonroad processing performed in a separate step. This was necessary since the month-specific files had zero in their 'average-day' column and the annual total column reflects the "monthly emissions as annual totals" as per header line. Therefore, seasonal profiles are used to apportion both the annual and month-specific files. As described below, we utilized the temporal profiles and cross-reference files generated by CENRAP. However, we did not verify that this approach indeed leads to the intended monthly allocation of ammonia and nonroad emissions.

Nonroad Sources

- Files:
  - CENRAP_NONROAD_SMOKE_INPUT_ANN_071305.txt
  - CENRAP_NONROAD_SMOKE_INPUT_MONTH_{MMM}_071305.txt where {MMM} is JAN, FEB, … DEC

Mobile Sources

- VMT/Speed files:
  - mbinv02_vmt_cenrap_ce.ida
  - mbinv02_vmt_cenrap_no.ida
  - mbinv02_vmt_cenrap_so.ida
  - mbinv02_vmt_cenrap_we.ida

Point Sources

- File: CENRAP_POINT_SMOKE_INPUT_ANNUAL_DAILY_072505.txt
- Fugitive dust correction: This was applied as county-specific correction factors for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; the correction factor file gcntl.xportfrac.txt was obtained from EPA's CAIR NODA ftp site http://www.airmodelingftp.com (password protected).; this adjustment was performed using the SMOKE programs cntlmat and grwinven to generate an adjusted IDA inventory file used for subsequent SMOKE processing.

VISTAS

All VISTAS emission files were obtained from the Alpine Geophysics ftp site. They reflect version BaseG of the VISTAS inventory with the exception of fire emissions which reflect BaseF and BaseD. These files were downloaded between February and August, 2006.

Area Sources

- Files:
  - arinv_vistas_2002g_2453922_w_pmfac.txt
  - ida_ar_fire_2002_vistaonly_basef.ida
- Note: the header lines of these files indicate that the fugitive dust correction was already applied, so no further correction was performed.

Nonroad Sources

- Files:
  - nrinv_vistas_2002g_2453908.txt
  - marinv_vistas_2002g_2453972.txt

Mobile Sources

- VMT/Speed file: mbinv_vistas_02g_vmt_12jun06.txt

Point Sources

- Files:
  - Annual:
    - egu_ptinv_vistas_2002typ_baseg_2453909.txt
    - negu_ptinv_vistas_2002typ_baseg_2453909.txt
    - ptinv_fires_{MM}_typ.vistas.ida where {MM} is 01, 02, 03, etc. depending on the month; these annual point fire files were

        - generated as part of the VISTAS BaseD inventory and were obtained in January 2005
    - Hour-specific:
        - pthour_2002typ_baseg_{MMM}_28jun2006.ems where {MMM} is jan, feb, mar, etc.
        - pthour_fires_{MM}_typ.vistas.ida where {MM} is 01, 02, 03, etc. depending on the month; these hourly point fire files were generated as part of the VISTAS BaseD inventory and were obtained in January 2005
- Note: No fugitive dust correction was performed for these files.

MRPO

MRPO emissions for SMOKE modeling were generated by Alpine Geophysics through a contract from MARAMA to convert the MRPO BaseK inventory from NIF to IDA format. The files were downloaded from the MARAMA ftp site **ftp.marama.org** (username mane-vu, password exchange) between April and June 2006.

Area Sources

- Files:
    - Annual:
        - arinv_mar_mrpok_2002_27apr2006.txt
        - arinv_other_mrpok_2002_20jun2006.txt
    - Month-specific:
        - arinv_nh3_2002_mrpok_{mmm}_3may2006.txt where {mmm} is jan, feb, etc.
        - dustinv_2002_mrpok_{mmm}_23may2006.txt where {mmm} is jan, feb, etc.
- Fugitive dust correction: This correction was performed only to the arinv_other_mrpok_2002_20jun2006.txt file using county-specific correction factors for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; the correction factor file gcntl.xportfrac.txt was obtained from EPA's CAIR NODA ftp site http://www.airmodelingftp.com (password protected).; this adjustment was performed using the SMOKE programs cntlmat and grwinven to generate an adjusted IDA inventory file used for subsequent SMOKE processing.
- Note about area source SMOKE processing: SMOKE processing was performed separately for the annual and month-specific files. For the annual inventory processing, SMK_AVEDAY_YN was set to N, so seasonal profiles were used to apportion the annual inventories numbers by month. For the month-specific inventory processing, this variable was set to Y so that no seasonal profiles would be applied and the inventory numbers in the 'average day' column would be used. To save a SMOKE processing step, the annual "marine" inventory "arinv_mar_mrpok_2002_27apr2006.txt" was processed together with the annual "other area source" inventory "arinv_other_mrpok_2002_20jun2006.txt" even though it technically is part of the nonroad inventory.

Nonroad Sources

- Files: nrinv_2002_mrpok_{mmm}_3may2006.txt where {mmm} is jan, feb, etc.

Mobile Sources

- VMT/Speed file: mbinv_mrpo_02f_vmt_02may06.txt

Point Sources

- Files: ptinv_egu_negu_2002_mrpok_1may2006.txt
- Fugitive dust correction: This correction was performed only to the arinv_other_mrpok_2002_20jun2006.txt file using county-specific correction factors for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; the correction factor file gcntl.xportfrac.txt was obtained from EPA's CAIR NODA ftp site http://www.airmodelingftp.com (password protected).; this adjustment was performed using the SMOKE programs cntlmat and grwinven to generate an adjusted IDA inventory file used for subsequent SMOKE processing.

Canada

Area Sources

- File: AS2000_SMOKEready.txt obtained from ftp://ftp.epa.gov/EmisInventory/canada_2000inventory
- Fugitive dust correction: We applied "divide-by-four" correction for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; this adjustment was performed outside SMOKE with in-house Fortran programs. No county/province-specific correction factors were available for Canada

Nonroad Sources

- File: NONROAD2000_SMOKEready.txt obtained from ftp://ftp.epa.gov/EmisInventory/canada_2000inventory

Mobile Sources

- File: MOBILE2000_SMOKEready.txt obtained from ftp://ftp.epa.gov/EmisInventory/canada_2000inventory
- Fugitive dust correction: applied "divide-by-four" correction for SCC's listed at http://www.epa.gov/ttn/chief/emch/invent/index.html#dust; this adjustment was performed outside of SMOKE with in-house Fortran programs. No county/province-specific correction factors were available for Canada.

Point Sources

There has long been difficulty in obtaining an up-to-date Canadian criteria emissions inventory for point sources. This is due largely to confidentiality rights afforded to Canadian facilities. Thus far, the most recent inventory of Canadian point sources is rooted in the 1985 NAPAP data and is close to two decades old. Because there are a number of high emitting industrial facilities in southern Canada it is of particular importance to have a reasonably accurate inventory of these sources especially when modeling air quality over the Northeast and Midwest United States. Toward this end, an effort was made to obtain more recent Canadian point source data and incorporate it into an inventory database, which could then be used for the 2002 OTC air quality modeling.

Perhaps the most accurate and publicly accessible source of Canadian pollutant data is now available from the National Pollutant Release Inventory (NPRI) database. This database contains 268 substances. Facilities that manufacture, process or otherwise use one of these substances and that meet reporting thresholds are required to report these emissions to Environment Canada on an annual basis. The NPRI data are available at Environment Canada's website and can be found at the link http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm. The page hosts an on-line search engine where one can locate emissions by pollutant or location. In addition, the entire database is available for download as an MS Access or Excel file. The NPRI database contains numerous pages with a rather comprehensive list of information. Detailed information is available about each facility, including location, activity and annual emissions. In addition, facilities having stacks with a height of 50 meters or more are required to report stack parameters.

Unfortunately, one of the limitations of the NPRI database for modeling purposes is that the data are only available at the facility level. Emissions models require process level information, so in order to use this data, a few generalizations had to be made. Each facility has a Standard Industrial Classification (SIC) code associated with it; however, emissions models require Source Classification Codes (SCC's). SCC's are of critical importance as the emissions models use these codes for assignment of temporal and speciation profiles. SIC codes describe the general activity of a facility while SCC codes describe specific processes taking place at each facility. While no direct relationship exists between these two codes, a general albeit subjective association can be made.

For the purposes of creating a model-ready inventory file it was necessary to obtain the whole NPRI database. After merging all the necessary components from the NPRI database required in the SMOKE inventory file, the SIC code from each facility was examined and assigned an SCC code. In most cases, only a SCC3 level code was assigned with confidence. While this is admittedly a less than desirable process, it does allow for the use of the most recent emissions from the NPRI database to be used in modeling. Furthermore, having some level of SCC associated with these emissions will ensure that they will be assigned a temporal and speciation profile by the model, other than the default. Once the model-ready inventory file was developed, it was processed through SMOKE.

Mobile6 Processing

MANE-VU

Mobile6 input files

- Month-specific input files were prepared by PECHAN and NESCAUM and were downloaded from http://bronze.nescaum.org/Private/junghun/MANE-VU/onroad_ver3_update/MANEVU_V3_update.tar
- Added the line "REBUILD EFFECTS :0.10" to each file before the SCENARIO record to override the Mobile6 default setting of 0.9 (90%) for the "chip reflash" effectiveness

SMOKE/Mobile6 auxiliary files

- SMOKE/Mobile6 auxiliary files were prepared by PECHAN and NESCAUM and were downloaded from http://bronze.nescaum.org/Private/junghun/MANE-VU/onroad_ver3_update/MANEVU_V3_update.tar

Temperature averaging

- Following the setting in the MANEVU_2002_mvref.txt files, the following procedures were used by SMOKE for temporal and spatial temperature averaging in the calculation of emission factors:
    - Spatial averaging: temperatures were averaged over all counties that share a common reference county (i.e. Mobile6 input file)
    - Temporal averaging for May – September emissions processing: no temporal averaging was used, i.e. day-specific temperatures were used to calculate emission factors for each day.
    - Temporal averaging for non-summer-months emissions processing: Temporal averaging over the duration of the episode (i.e. the entire month, see introduction) was used, i.e. monthly average temperatures were used to calculate the emission factors.

CENRAP

Mobile6 input files

- Mobile6 input files for the CENRAP region for January and July were contained in the files central_M6_{MMM}.zip, north_M6_{MMM}.zip, south_M6_{MMM}.zip, west_M6_{MMM}.zip where {MMM} is either jan or jul. July input files were used for April – September processing, while January input files were used for the remaining months
- All files were downloaded from the CENRAP ftp site in March 2006.

SMOKE/Mobile6 auxiliary files

- SMOKE/Mobile6 auxiliary files were contained in the files central_M6_RD.zip, north_M6_RD.zip, south_M6_RD.zip, and west_M6_RD.zip. The SMOKE MCREF, MVREF, and MCODES files were contained in the file MOBILESMOKE_Inputs.zip. The MCREF and MVREF files were combined for the different regions ("central", "east", "west", "north")
- All files were downloaded from the CENRAP ftp site in March 2006.

Temperature averaging

- The following procedures were used by SMOKE for temporal and spatial temperature averaging in the calculation of emission factors according to the setting in the mvref files:
    - Spatial averaging: no spatial averaging of temperatures, i.e. the temperatures for the reference county is used to calculate emission factors for all counties that share this reference county (i.e. Mobile6 input file)
    - Temporal averaging: Temporal averaging over the duration of the episode (i.e. the entire month, see introduction) was used, i.e. monthly average temperatures were used to calculate the emission factors.

VISTAS

Mobile6 input files

- Month-specific Mobile6 input files were obtained from the Alpine Geophysics ftp site in July 2006. They reflect version BaseG of the VISTAS inventory.

SMOKE/Mobile6 auxiliary files

- SMOKE/Mobile6 auxiliary files utilized were obtained from the Alpine Geophysics ftp site in July 2006. They reflect version BaseG of the VISTAS inventory.

Temperature averaging

- The following procedures were used by SMOKE for the temporal and spatial temperature averaging in the calculation of emission factors according to the setting in the mvref_baseg.36k.ag.txt file:
    - Spatial averaging: temperatures averaged over all counties that share a common reference county (i.e. Mobile6 input file)
    - Temporal averaging: Temporal averaging over the duration of the episode (i.e. the entire month, see introduction) was used, i.e. monthly average temperatures were used to calculate the emission factors.

MRPO

Mobile6 input files

- Month-specific Mobile6 input files for SMOKE modeling were generated by Alpine Geophysics through a contract from MARAMA. They are based on version BaseK of the MRPO inventory. The files were downloaded from the MARAMA ftp site **ftp.marama.org** (username mane-vu, password exchange) in May 2006.

SMOKE/Mobile6 auxiliary files

- SMOKE/Mobile6 auxiliary files for SMOKE modeling were generated by Alpine Geophysics through a contract from MARAMA. They are based on version BaseK of the MRPO inventory. The files were downloaded from the MARAMA ftp site **ftp.marama.org** (username mane-vu, password exchange) in May 2006.

Temperature averaging

- The following procedures were used by SMOKE for the temporal and spatial temperature averaging in the calculation of emission factors according to the setting in the mvreg_mrpo_basek.txt file:
    - Spatial averaging: temperatures averaged over all counties that share a common reference county (i.e. Mobile6 input file)
    - Temporal averaging: Temporal averaging over the duration of the episode (i.e. the entire month, see introduction) was used, i.e. monthly average temperatures were used to calculate the emission factors.

Biogenic Emission Processing

Hourly gridded biogenic emissions for the 12 km and 36 km modeling domains were calculated by BEIS3.12 through SMOKE, using MCIP-processed MM5 fields for temperature (“TA”, layer-1 temperature), solar radiation (“RGRND”), surface pressure (“PRES”), and precipitation (“RN” and “RC”). A ‘seasonal switch’ file was generated by the SMOKE utility metscan to determine whether winter or summer emission factors should be used for any given grid cell on any given day. Winter emission factors are used from January 1st through the date of the last frost and again from the data of the first frost in fall through December 31st. Summer emission factors are used for the time period in between. This calculation is performed separately for each grid cell.

Temporal Allocation

MANE-VU

Area and nonroad sources

- Generated as part of the MANE-VU version 1 inventory
- amptpro.m3.us+can.manevu.030205.txt
- amptref.m3.manevu.012405.txt
- downloaded from **ftp.marama.org** (username mane-vu, password exchange) in January 2005

Mobile sources

- MANEVU_2002_mtpro_02022006_addCT.txt
- MANEVU_2002_mtref_02022006_addCT.txt
- prepared by PECHAN and NESCAUM and downloaded from http://bronze.nescaum.org/Private/junghun/MANE-VU/onroad_ver3_update/MANEVU_V3_update.tar

Point Sources

- Based on the same files as for the MANE-VU area and nonroad temporal files listed above, but added the CEM-based 2002 state-specific temporal profiles and cross-references for EGU sources for the MANE-VU states that were generated by VISTAS for their BaseD modeling and obtained in February 2005.
- No CEM-based hour-specific EGU emissions were utilized

CENRAP

The following temporal profiles and cross-reference files were used:

- Area and nonroad sources:
  - amptpro.m3.us+can.cenrap.010605_incl_nrd.txt
  - amptref.m3.cenrap.010605_add_nh3_and_nrd.txt
- Mobile sources:
  - mtpro.cenrap.v3.txt
  - mtref.cenrap.v3.txt
- Point sources:
  - ptpro.{QQ}.cenrap_egus_cem.00-03avg.121205.txt where {QQ} is Q1 for January/February/March, Q2 for April/May/June, etc.
  - ptref.{QQ}.cenrap_egus_cem.00-03avg.121205.txt where {QQ} is Q1 for January/February/March, Q2 for April/May/June, etc.
- All files were downloaded from the CENRAP ftp site in March 2006.

VISTAS

The following month-specific temporal profiles and cross-reference files were used:

- Area and nonroad sources:
  - atpro_vistas_basef_15jul05.txt
  - atref_vistas_basef_15jul05.txt
- Mobile sources:
  - mtpro_vistas_basef_04jul05.txt
  - mtref_us_can_vistas_basef_04jul05.txt
- Point sources:
  - ptpro_typ_{MMM}_vistasg_28jun2006.txt where {MMM} is jan, feb, mar, etc.
  - ptref_typ_vistas_baseg_28jun2006.txt
- These files were obtained from the Alpine Geophysics ftp site. They reflect version BaseG of the VISTAS inventory for the point source allocation files and version BaseF for the area, nonroad, and mobile source allocation files. These files were downloaded between February and July, 2006.

MRPO

The following month-specific temporal profiles and cross-reference files were used for all source categories:

- amptpro_typ_us_can_{MMM}_vistas_27nov04.txt where {MMM} is jan, feb, mar, etc.
- amptref_2002_us_can_vistas_17dec04.txt
- These files were obtained from VISTAS in January 2005 and reflect their BaseD modeling. No updated temporal profiles or cross-reference files were developed for use with the MRPO BaseK inventory.

Canada

For Canada, the SMOKE2.1 default temporal profiles and cross-reference files (amptpro.m3.us+can.txt and amptref.m3.us+can.txt) were utilized.

Speciation

The same speciation profiles (gspro.cmaq.cb4p25.txt) and cross-references (gsref.cmaq.cb4p25.txt) were utilized for all regions and all source categories. Different versions of these files were obtained (SMOKE2.1 default, EPA-CAIR modeling, VISTAS, CENRAP and MANE-VU) and compared. After comparing the creation dates and header lines of these files, it was determined that the EPA-CAIR and MANE-VU files had the most recent updates, and consequently the final speciation profile and cross-reference files used for all regions and source categories was based on the EPA-CAIR files with the addition of MANE-VU specific updates.

Spatial Allocation

U.S.

The spatial surrogates for the 12km domain were extracted from the national grid 12km U.S. gridding surrogates posted at EPA's website at
http://www.epa.gov/ttn/chief/emch/spatial/newsurrogate.html
The gridding cross-references were also obtained from this website, but for the processing of MANE-VU area source emissions, MANE-VU specific cross-reference entries posted on the MARAMA ftp site were added.

Canada

The spatial surrogates for Canadian emissions for the 12km domain were extracted from the national grid 12km Canadian gridding surrogates posted at EPA's website at
http://www.epa.gov/ttn/chief/emch/spatial/newsurrogate.html
The gridding cross-references were also obtained from this website.

Reference:

Pechan: (2006) Technical Support document for 2002 MANE-VU SIP Modeling inventories, version 3. Prepared by E. H. Pechan & Associates, Inc. 3622 Lyckan Parkway, Suite 2005, Durham, NC 27707.

TSD-2c

$PM_{2.5}$ modeling using the SMOKE/CMAQ system over the Ozone Transport Region (OTR)

Bureau of Air Quality Analysis and Research

Division of Air Resources

New York State Department of Environmental Conservation

Albany, NY 12233

February 1, 2006

Air Quality Modeling Domain

The modeling domain utilized in this application represented a sub-set of the inter-RPO's continental modeling domain that covered the entire 48-state region with emphasis on the Ozone Transport Region. The OTC modeling domain at 12km horizontal mesh is displayed in Figure 1 is part of the 36km continental domain that is designed to provide boundary conditions (BCs). The particulars of the two modeling domains are:

The 36km domain covered the continental US by a 149 by 129 mesh in the east-west and north-south directions, respectively. The domain is based on Lambert Conformal Projection with the center at (97ºW 40ºN) and parallels at 33ºN and 45ºN. As evident from Figure 1, the 12km domain utilized in this analysis covers most areas of the eastern US and has 172 by 172 mesh in the horizontal. Both domains utilize 22 layers in the vertical extending to about 16km with 16 layers placed within the lower 3km.

Photochemical Modeling -- CMAQ

The CMAQ (version 4.5.1) with CB4 chemistry, aerosol module for $PM_{2.5}$ and RADM cloud scheme was utilized in this study. Photochemical modeling was performed with the CCTM software that is part of the CMAQ modeling package. Version 4.5.1 of this modeling software was obtained from the CMAS modeling center at http://www.cmascenter.org. The following module options were used in compiling the CCTM executable:

- Horizontal advection: yamo
- Vertical advection: yamo
- Horizontal diffusion: multiscale
- Vertical diffusion: eddy
- Plume-in-Grid: non operational
- Gas phase chemical mechanism: CB-4
- Chemical solver: EBI
- Aerosol module: aero3
- Process analysis: non operational

The following computational choices were made during compilation:

- Compiler version: PGI 6.0
- Fortran compiler flags:-Mfixed -Mextend -Bstatic -O2 -module ${MODLOC} -I.
- C compiler flags: -v -O2 -I${MPICH}/include
- IOAPI library: version 3.0
- NETCDF library: version 3.6.0
- Parallel processing library version: mpich 1.2.6
- Static compilation on 32-bit system

The following choices were made for running the executable:

- Number of processors: 8
- Domain decomposition for parallel processing: 4 columns, 2 rows
- Number of species written to the layer-1 hourly-average concentration output (ACONC) file: 39 (O3, NO, CO, NO2, HNO3, N2O5, HONO, PNA, PAN, NTR, NH3, SO2, FORM, ALD2, PAR, OLE, ETH, TOL, XYL, ISOP, ASO4I, ASO4J, ANO3I, ANO3J, ANH4I, ANH4J, AORGAI, AORGAJ, AORGPAI, AORGPAJ, AORGBI, AORGBJ, AECI, AECJ, A25I, A25J, ACORS, ASEAS, ASOIL)
- Each daily simulation was performed for 24 hours starting at 05:00 GMT (00:00 EST)

The following postprocessing steps were performed using utility tools from the "ioapi" software package obtained from
http://www.baronams.com/products/ioapi/AA.html#tools:

- Extract and combine the following species for each hour for the first 16 model layers from the full 3-D instantaneous concentration output file: O3, CO, NO, NO2, NOY_1 (=*NO + NO2 + PAN + HNO3*), NOY_2 (=*NO + NO2 + PAN + HNO3 + HONO + N2O5 + NO3 + PNA + NTR*), HOX (=*OH + HO2*), VOC (=*2*ALD2 + 2*ETH + FORM + 5*ISOP + 2*OLE + PAR + 7*TOL + 8*XYL*), ISOP, PM2.5 (=*ASO4I + ASO4J + ANO3I + ANO3J + ANH4I + ANH4J + AORGAI + AORGAJ + 1.167*AORGPAI + 1.167*AORGPAJ + AORGBI + AORGBJ + AECI + AECJ + A25I + A25J*), PM_SULF (=*ASO4I + ASO4J*), PM_NITR (=*ANO3I + ANO3J*), PM_AMM (=*ANH4I + ANH4J*), PM_ORG_SA (=*AORGAI + AORGAJ*), PM_ORG_PA (=*1.167*AORGPAI + 1.167*AORGPAJ*), PM_ORG_SB(=*AORGBI + AORGBJ*), PM_ORG_TOT (=*AORGAI + AORGAJ + 1.167*AORGPAI + 1.167*AORGPAJ + AORGBI + AORGBJ*), PM_EC (=*AECI + AECJ*), PM_OTH (=*A25I + A25J*), PM_COARS (=*ACORS + ASEAS + ASOIL*), SO2, HNO3, NH3, H2O2
- Extract all species for all model layers for the last hour of each daily instantaneous concentration output file to enable "hot" restarts of modeling simulations
- Create daily files of hourly running-average 8-hr ozone concentrations with time stamps assigned to the first hour of the averaging interval

The following files are archived on LTO2 computer tapes (each tape holds approximately 200 Gb of data) for each day:

- Aerosol/visibility file
- Layer-1 hourly-average concentration output file (contains 39 species)
- Dry deposition file
- Wet deposition file
- Extracted 16-layer species file
- Restart file (last hour of full 3-D instantaneous concentration file)
- Hourly 8-hr concentration file

Photolysis Rates

One of the inputs to CMAQ is the photolysis rates. In this study, photolysis rate lookup tables were generated for each day of 2002 with the JPROC software that is part of the CMAQ modeling package. This software was obtained from the CMAS modeling center at http://www.cmascenter.org. Rather than using climatological ozone column data, daily ozone column measurements from the NASA Earthprobe TOMS instrument were downloaded from ftp://toms.gsfc.nasa.gov/pub/eptoms/data/ozone/Y2002/ and used as input to the JPROC processor. It should be noted that TOMS data were missing for the time period from August 3 – 11, 2002. The missing period was filled as follows-- TOMS data file for August 2 was used as JPROC input for August 3rd through August 7th, and the TOMS data file for August 12th was used as JPROC input for August 8th through August 11th.

Boundary Conditions (BCs)

The boundary conditions for the 12km grid were extracted from the 36km CMAQ simulation. The 36km simulation utilized boundary conditions that were based on a one-way nest approach to GEOS-CHEM global model outputs (Moon and Byun 2004, Baker 2005). As stated above, the intent of the 36km CMAQ simulation was to provide the BCs for the 12km model that would be more reflective of the emissions and meteorology rather than to use either clean or arbitrary pollutant fields. Also, in this study the CMAQ simulations utilized a 15-day ramp-up period, thereby minimizing the propagation of the boundary fields into the areas of concern. A report on the setup and application of the 36km CMAQ and the extraction of the BCs is available from NYSDEC.

Meteorological data

The meteorological data for this study was based on MM5 modeling (see Meteorological Modeling, 2007). The MM5 fields are then processed by MCIP version 3.0, a utility available as part of the CCTM software from CMAS Modeling Center (see http://www.cmascenter.org) to provide CMAQ model-ready inputs.

Emissions

The emissions data for 2002 were generated by individual states within the OTR and were assembled and processed through the Mid Atlantic Northeast Visibility Union (MANE-VU), a Regional Planning Organization (RPO). These emissions were then processed by NYSDEC using SMOKE processor to provide CMAQ compatible inputs (Anthro-Emissions 2006). The 2002 emissions for the non-OTR areas within the modeling domain were obtained from the corresponding RPOs and were processed using SMOKE, in a manner similar to that of the OTR.emissions. Details of this processing are outlined in the report (Pechan 2007), and the hourly biogenic emissions (Bio-Emissions, 2006)

CMAQ simulations

CMAQ simulations were performed using the one-way nesting approach in which we perform the continental CMAQ simulation at 36km grid spacing. For this simulation we utilized clean initial conditions with boundary conditions extracted from the simulation of GEOS-CHEM global chemical model. The interface program used in this application was developed by University of Huston (Moon and Byun 2004), which was applied to obtain hourly 36km boundary concentrations from GEOS-CHEM outputs. The CMAQ 36km simulation was initiated from December 15, 2001 with the first 15 days as spin up period and terminated on December 31, 2002. The simulation utilized the 2002 emissions data available from the RPOs and 2002 MM5 meteorological fields developed by the University of Maryland (TSD-1a). The hourly boundary fields for the 12km CMAQ domain were obtained by application of BCON program to the 3-D concentration fields generated by the 36km CMAQ simulation.

The 12km simulations for both base and future year were assigned the boundary conditions based on the 36km CMAQ simulation and clean initial conditions. The annual simulation was parsed out between different member states or their contractors of the OTR, so as to expedite the process of completing the simulation in a limited time. The approach used is as follows: The annual simulation was parsed out into five parts and each modeling center identified below initiated and completed the simulation, extracted the outputs which were then combined to provide the annual simulation. There was considerable exchange of information in the setup and execution of the modeling system between the centers using benchmark runs to ensure consistency and uniformity between the centers. The process was followed both for the base year 2002 and for the future year 2009. Details on CMAQ setup and run scripts are available from NYSDEC.

Modeling Center	Simulation period	Analysis period
MDE/UMD	Dec 15, 2001 to Feb 28, 2002	Jan 01, 2002 to Feb 28, 2002
NJDEP/Rutgers	Feb 15, 2002 to May 14, 2002	Mar 01, 2002 to May 14, 2002
NYSDEC	May 01, 2002 to Sep 30, 2002	May 15, 2002 to Sep 30, 2002
VA DEQ	Sep 15, 2002 to Oct 30, 2002	Oct 01, 2002 to Oct 30, 2002
NESCAUM	Oct 15, 2002 to Dec 31, 2002	Nov 01, 2002 to Dec 31, 2002

References

Baker, K.: (2005) http://www.ladco.org/tech/photo/present/ozone.pdf

Moon, N. and D. Byun: (2004) A simple user’s guide for “geos2cmaq”code: Linking CMAQ with GEOS-CHEM. Version 1.0. Institute for Multidimensional Air quality Studies (IMAQS), University of Houston, Houston TX.

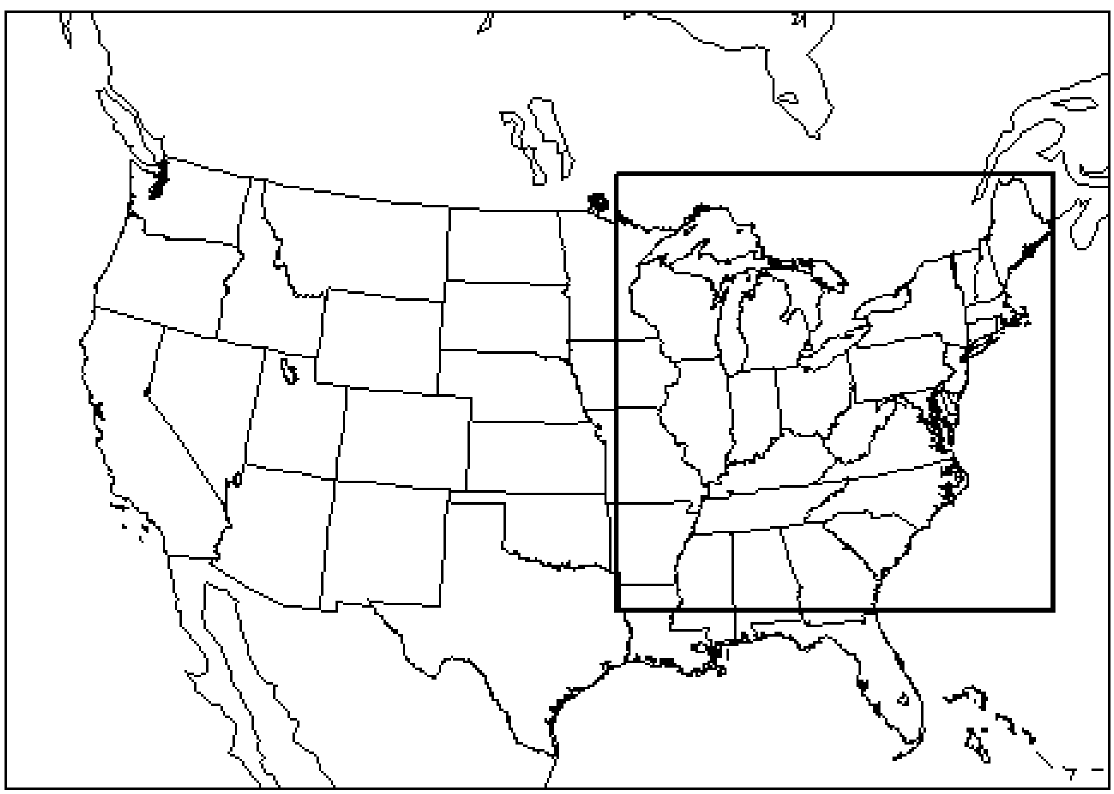
Meteorological Modeling: (2007) Meteorological Modeling of 2002 using Penn State/NCAR 5th Generation Mesoscale Model (MM5). TSD-1a

Pechan: (2006) Technical Support document for 2002 MANE-VU SIP Modeling inventories, version 3. Prepared by E. H. Pechan & Associates, Inc. 3622 Lyckan Parkway, Suite 2005, Durham, NC 27707.

Bio-Emissions: (2006) Processing of Biogenic Emissions for OTC/MANE-VU Modeling. TSD-1b

Anthro-Emissions: (2006) Emission Processing for the Revised 2002 OTC Regional and Urban 12 km Base Case Simulations. TSD-1c

Figure 1 Display of 36- and 12km air quality modeling domains.



TSD- 3a

Analysis of Ambient $PM_{2.5}$ Mass and Speciation

for the New York Metropolitan Area through 2006

Bureau of Air Quality Analysis and Research
Division of Air Resources
New York State Department of Environmental Conservation
Albany, NY 12233

December 14, 2007

Introduction

With the promulgation of the annual and daily $PM_{2.5}$ national ambient air quality standards (NAAQS) in 1997, the New York State Department of Environmental Conservation (NYSDEC) initiated monitoring this pollutant on a statewide basis beginning in 1998/1999. A majority of the monitoring efforts to date have involved 24-hour, filter-based Federal Reference Method (FRM) samplers. Most of the FRM samplers operate on a 1-in-3-day schedule, although a few monitors operate on a daily basis. Also, as per network design requirements, several FRM sites have collocated duplicate samplers.

The $PM_{2.5}$ NAAQS is mass-based, but ambient $PM_{2.5}$ has a complex morphology and chemical composition. In order to obtain information on species composition, the NYSDEC also has operated Speciation Trends Network (STN) monitors at several locations across the state. Similar to the FRM network, the STN samplers operate on a 1-in-3-day schedule. The STN program provides for the concentration of major ions, carbon compounds, and trace elements, which generally constitute the bulk of $PM_{2.5}$ mass.

Although time series of ambient $PM_{2.5}$ mass and species are relatively short compared to other criteria pollutants, such as ozone, it is nonetheless important to examine temporal and seasonal trends in the data, in addition to characterize current ambient levels. Here we present such trends on a composite basis over the New York portion of the New York City $PM_{2.5}$ non-attainment area (NYC NAA), corresponding to Bronx, Kings, Nassau, New York, Orange, Queens, Richmond, Suffolk and Westchester Counties. All data used in this analysis are publicly available on the NYSDEC Division of Air Resources' ambient $PM_{2.5}$ monitoring website (please see http://www.dec.ny.gov/chemical/8539.html).

FRM data

Table 1 lists the site locations and sampling periods between 1999-2006 for all FRM monitors in the three NYSDEC sub-regions that cover parts of the NYC NAA: Region 1 (Long Island; 6 sites), Region 2 (New York City; 19 sites), and Region 3 (Lower Hudson River Valley; 3 sites). The analysis included Dutchess County for completeness, even though it is not part of the NYC NAA area. Seven of the Region 2 sites have collocated duplicate monitors. Three of the sites also operated daily for at least part of the time. A map of the FRM locations is shown in Figure 1.

Figure 2 displays the composite average FRM mass by NYSDEC region, using all valid data from 1999-2006. The averages presented in Figure 2 do not represent design values for attainment/regulatory purposes; however, the annual NAAQS of 15 $\mu g\ m^{-3}$ is shown for reference. This figure illustrates that on average, $PM_{2.5}$ is higher in Region 2 than the surrounding areas. Whereas the average levels in New York City range from about 13-15 $\mu g\ m^{-3}$, the average levels in the surrounding counties is about 10-12 $\mu g\ m^{-3}$.

One other feature evident in Figure 2 is that $PM_{2.5}$ levels in the most recent few years are generally lower than levels measured in 1999-2001.

Figure 3 displays the composite seasonal/quarterly variations in FRM mass by NYSDEC region, again using all valid data from 1999-2006. In Regions 1 and 3 there appears to be a warm season maximum; this corresponds to the time of maximum photochemical activity and secondary particulate formation. In Region 2 the $PM_{2.5}$ levels are high in during both the warm and cold seasons. The high levels during the colder months are likely indicative of local sources in the New York City, such as space heating, as well as the effects of large urban emissions being mixed through a shallow atmospheric boundary layer.

Tables 2 and 3 display the annual average and 98th percentiles of FRM mass, respectively, from 2000-2006. Only those years with at least 75% valid samples are included in these tables. Note that some of the values presented in Tables 2 and 3 correspond to years that do not necessarily have four complete quarters. Similar to Figure 2, Table 2 indicates than on an average basis $PM_{2.5}$ levels are generally lower in the most recent years compared to earlier years. In particular, average $PM_{2.5}$ levels in 2006 were generally the lowest in this seven-year period. The 98th percentiles presented in Table 3 are related to the daily $PM_{2.5}$ NAAQS, which consists of the average of the 98th percentile values over three consecutive years. Currently the daily NAAQS is 65 $\mu g\ m^{-3}$, and Table 3 shows that all sites in the New York metropolitan area have been well below this level.

Table 4 lists the linear trends in $PM_{2.5}$ mass at longest-running sites FRM sites in the New York metropolitan area. These sites operated from 1999/2000 through 2006, and the trends reported in Table 4 are based on quarterly average values at each site. Only those quarters with at least 10 valid data points were included in the linear trend estimates. Consistent with the composite averages presented earlier, $PM_{2.5}$ mass appears to be decreasing at each of these longest-running sites, by ~0.1-0.5 $\mu g\ m^{-3}\ yr^{-1}$.

STN data

Table 5 lists the site locations and sampling periods of the STN monitors. Each of these sites is collocated with an FRM monitor. The STN samplers collect five ions – sulfate (SO_4), nitrate (NO_3), ammonium (NH_4), potassium (K), and sodium (Na) – nearly 50 trace elements, and various carbon species – elemental carbon (EC) and organic carbon (OC). For this analysis, we assume that $PM_{2.5}$ is primarily composed of only SO_4, NO_3, NH_4, EC, OC, and major crustal species (major oxides of Al, Ca, Fe, Si, and Ti; e.g. US EPA, 2007), and hereafter refer to the sum of these species as the "reconstructed mass." Although the $PM_{2.5}$ NAAQS is strictly mass-based, here we attempt to approximate the average species composition of the ambient $PM_{2.5}$ in NYC.

We adjusted the OC value by subtracting a constant, monitor-specific blank, and applying a multiplicative factor of 1.8 to account for the non-carbon composition (O, H, etc.). In various EPA documents, a blank of 1.40 $\mu g\ m^{-3}$ for MetOne SASS instruments

(Canal Street Post Office, N.Y. Botanical Gardens) and 0.93 μg m^{-3} for R&P 2300 ACCU instruments (I.S. 52, Queens College II/P.S. 219) is assumed (e.g., http://www.epa.gov/airtrends/aqtrnd03/pdfs/2_chemspecofpm25.pdf). We then calculated the composite average of each of these components across all four STN sites for all valid data points, as well as for just the winter (December-February) and summer (June-August) periods.

Figure 4 displays the annual, wintertime, and summertime average major $PM_{2.5}$ speciation levels. On an overall annual basis, SO_4 and OC account for about 27% and 35%, respectively, of the reconstructed mass in New York City, roughly twice the contribution of NO_3. During the winter months, OC is the largest contributor to the reconstructed mass (34%), while SO_4 and NO_3 also account for about 20%. The relative importance of NO_3 is higher during the winter months because NO_3 volatilization is much lower during the colder months. During the summer months, SO_4 and OC levels are considerably higher than during the winter months, and account for about 70% of the reconstructed mass. The smallest components of reconstructed mass correspond to EC and crustal mass (~4-8%). On average, the reconstructed mass in New York City is about 18.2 μg m^{-3} during the summer months, and about 15.2 μg m^{-3} during the winter months.

Summary

The FRM data collected across the New York metropolitan area over the past seven years suggest that $PM_{2.5}$ levels are generally higher in the core urban areas compared to the surrounding suburban counties. While this is a rather short time period, it appears that $PM_{2.5}$ levels have been decreasing across the entire metropolitan area since the early 2000's. In terms of species composition, SO_4 and OC are the most important species, especially during the summer months, while NO_3 is also an important species during the winter months. It appears that emissions control programs that target precursors of SO_4, NO_3, and OC will be needed to further reduce $PM_{2.5}$ levels across the metropolitan area.

Reference

United States Environmental Protection Agency (US EPA), 2007. Guidance on the use of models and other analyses for demonstrating attainment of air quality goals for ozone, $PM_{2.5}$, and regional haze. Office of Air Quality Planning and Standards, 253 pp., EPA-454/B-07-002.

Table 1. Listing of FRM sites, 1999-2006. Some locations have primary ("P") and duplicate ("D") samplers. Dates with an asterix denote daily sampling for at least part of the period.

NYSDEC Region	Site Name	County	Dates
1	Eisenhower Park	Nassau	1/1999 – 12/1999
1	Hempstead	Nassau	1/1999 – 12/2006
1	Briarcliffe	Nassau	2/2000 – 3/2003
1	Roslyn	Nassau	7/2000 – 3/2003
1	Roslyn Heights	Nassau	1/1999 – 3/2000
1	Babylon	Suffolk	1/1999 – 12/2006
2	Mabel Dean H.S.	New York	1/1999 – 6/2001*
2	J.H.S. 45	New York	P: 1/2000 – 12/2006 D: 1/2006 – 12/2006
2	P.S. 59	New York	P: 1/1999 – 12/2006 D: 1/1999 – 12/2005
2	P.S. 19	New York	10/2001 – 12/2006
2	Canal Street Post Office	New York	P: 1/1999 – 12/2006 D: 8/1999 – 9/2001
2	I.S. 155	Bronx	P: 1/1999 – 7/1999 D: 1/1999 – 7/1999
2	Morrisania II	Bronx	1/1999 – 12/2006
2	N.Y. Botanical Gardens	Bronx	1/1999 – 12/2006
2	I.S. 52	Bronx	P: 9/1999 – 12/2006* D: 9/1999 – 12/2006
2	Greenpoint	Kings	P: 1/1999 – 12/2000 D: 1/1999 – 7/1999
2	P.S. 321	Kings	1/1999 – 3/2003
2	P.S. 314	Kings	4/2000 – 1/2003
2	J.H.S. 126	Kings	1/2001 – 12/2006
2	Queensboro Community College	Queens	1/1999 – 12/2000
2	P.S. 29	Queens	P: 7/1999 – 1/2003 D: 8/1999 – 1/2003
2	P.S. 214	Queens	4/2000 – 3/2003
2	Queens College II/P.S. 219	Queens	1/2001 – 4/2006*
2	Susan Wagner H.S.	Richmond	1/1999 – 12/2006
2	Port Richmond Post Office	Richmond	12/1999 – 12/2006
3	Poughkeepsie	Dutchess	7/1999 – 3/2003
3	Newburgh	Orange	2/2000 – 12/2006
3	Mamaroneck	Westchester	2/2000 – 12/2006

Table 2. Annual average $PM_{2.5}$ levels for sites with at least 75% valid samples in a given year, 2000-2006. Incomplete years are left blank.

Site Name	2000	2001	2002	2003	2004	2005	2006
Hempstead	12.29	12.86	11.35	12.37	11.28	12.38	10.91
Briarcliffe	12.73	12.44	11.27				
Roslyn		12.25	11.28				
Babylon	12.66	13.02	11.43	11.78	10.68	12.09	10.41
Mabel Dean H.S.	16.71						
J.H.S. 45 (P)	15.52	15.18	14.12	14.35	13.12	14.51	12.63
J.H.S. 45 (D)							12.77
P.S. 59 (P)	18.42	17.95	15.88		15.63	16.96	14.60
P.S. 59 (D)	18.38	18.01	16.22		15.76	16.81	
P.S. 19			15.62	15.94	15.10	15.59	13.79
Canal Street Post Office (P)	17.57	17.13	15.42	15.76	14.43	15.45	12.76
Canal Street Post Office (D)	17.36						
Morrisania II	16.73	15.92	15.34	15.58	14.39	16.38	14.40
N.Y. Botanical Gardens	14.30	14.35	13.46	13.35	12.80	13.87	12.72
I.S. 52 (P)	15.10	15.65	14.25	14.76	13.72	13.78	12.84
I.S. 52 (D)	15.35	14.74	14.46	14.82	13.53	14.82	12.88
Greenpoint	16.30						
P.S. 321	14.88	15.06	13.28				
P.S. 314		16.29	13.95				
J.H.S. 126		15.24	14.04	14.19	14.06	15.08	12.97
Queensboro Community College		13.04					
P.S. 29 (P)	14.08	13.52					
P.S. 29 (D)	13.86	13.73					
P.S. 214		14.00	13.11				
Queens College II/P.S. 219			12.78	13.48	12.16	12.18	
Susan Wagner H.S.	12.44	13.00	10.84		11.35	12.15	10.45
Port Richmond Post Office	14.31	14.46	13.83		13.33	14.36	12.03
Poughkeepsie	11.31	11.18	10.73				
Newburgh	11.90	11.58	11.07	11.84	10.48	12.14	9.81
Mamaroneck	12.62	12.93	11.76	12.14	11.33	12.46	11.11

Table 3. The 98th percentile of $PM_{2.5}$ levels for sites with at least 75% valid samples in a given year, 2000-2006. Incomplete years are left blank.

Site Name	2000	2001	2002	2003	2004	2005	2006
Hempstead	32.1	31.2	31.9	39.3	30.8	35.1	33.0
Briarcliffe	34.0	32.5	30.7				
Roslyn		32.2	30.3				
Babylon	31.8	34.1	30.9	38.8	30.9	34.3	31.9
Mabel Dean H.S.	42.9						
J.H.S. 45 (P)	40.8	35.8	35.5	46.2	38.0	36.6	37.6
J.H.S. 45 (D)							37.8
P.S. 59 (P)	41.7	40.4	35.6		41.1	40.1	40.7
P.S. 59 (D)	42.1	39.8	35.5		41.4	39.5	
P.S. 19			35.8	48.5	38.9	36.5	36.8
Canal Street Post Office (P)	41.4	38.2	33.6	46.2	39.1	39.5	35.9
Canal Street Post Office (D)	41.0						
Morrisania II	40.1	36.7	35.2	44.8	38.2	37.7	41.5
N.Y. Botanical Gardens	39.0	35.0	33.4	38.2	31.3	36.6	39.8
I.S. 52 (P)	40.5	38.9	40.6	39.1	33.9	36.8	38.7
I.S. 52 (D)	40.3	35.2	36.8	46.0	38.2	38.0	38.1
Greenpoint	41.7						
P.S. 321	42.0	34.6	31.2				
P.S. 314		36.5	31.9				
J.H.S. 126		34.9	33.8	46.2	36.9	38.1	37.7
Queensboro Community College		32.8					
P.S. 29 (P)	35.7	36.2					
P.S. 29 (D)	38.0	35.8					
P.S. 214		36.8	33.0				
Queens College II/P.S. 219			37.4	39.0	33.4	34.0	
Susan Wagner H.S.	33.0	31.4	24.3		33.5	32.1	32.0
Port Richmond Post Office	39.8	31.9	39.3		31.3	37.2	36.2
Poughkeepsie	30.8	27.6	31.2				
Newburgh	29.8	27.8	30.5	31.3	27.4	29.6	31.7
Mamaroneck	34.9	33.5	32.5	36.8	33.5	32.8	34.4

Table 4. Trends in $PM_{2.5}$ mass at the longest running FRM monitors, based on quarterly averages from 1999-2006, in $\mu g\ m^{-3}\ yr^{-1}$. Only those quarters with at least 10 valid samples are included in this trend estimate.

Site Name	Trend ($\mu g\ m^{-3}\ yr^{-1}$)
Hempstead	-0.12
Babylon	-0.34
J.H.S. 45	-0.42
P.S. 59	-0.30
Canal Street Post Office	-0.50
Morrisania II	-0.27
N.Y. Botanical Gardens	-0.15
I.S. 52 (P)	-0.33
I.S. 52 (D)	-0.23
Susan Wagner H.S.	-0.13
Port Richmond Post Office	-0.20
Newburgh	-0.20
Mamaroneck	-0.20

Table 5. Listing of Speciation Trends Network (STN) sites, 2000-2006. All sites are located in NYSDEC Region 2.

Site Name	County	Dates
Canal Street Post Office	New York	8/2002 – 12/2006
N.Y. Botanical Gardens	Bronx	2/2000 – 12/2005
I.S. 52	Bronx	1/2001 – 12/2006
Queens College II/P.S. 219	Queens	4/2001 – 12/2006

Figure 1. Map of FRM sites.

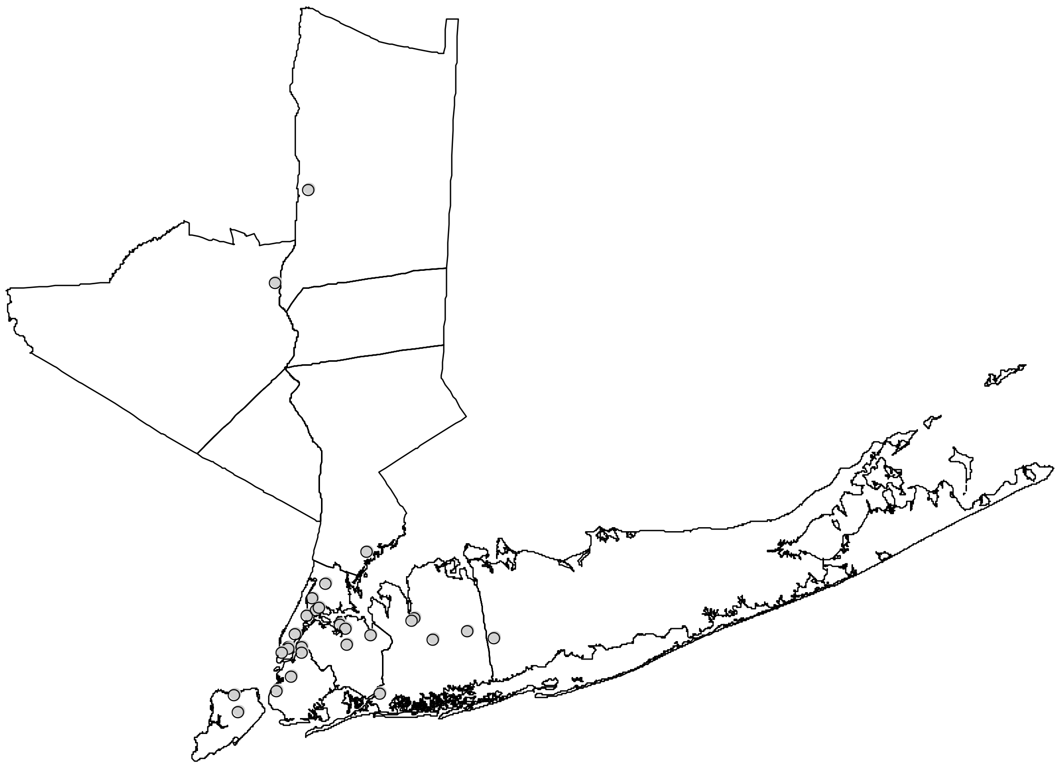


Figure 2. Annual average $PM_{2.5}$ mass at FRM sites by NYSDEC Region.

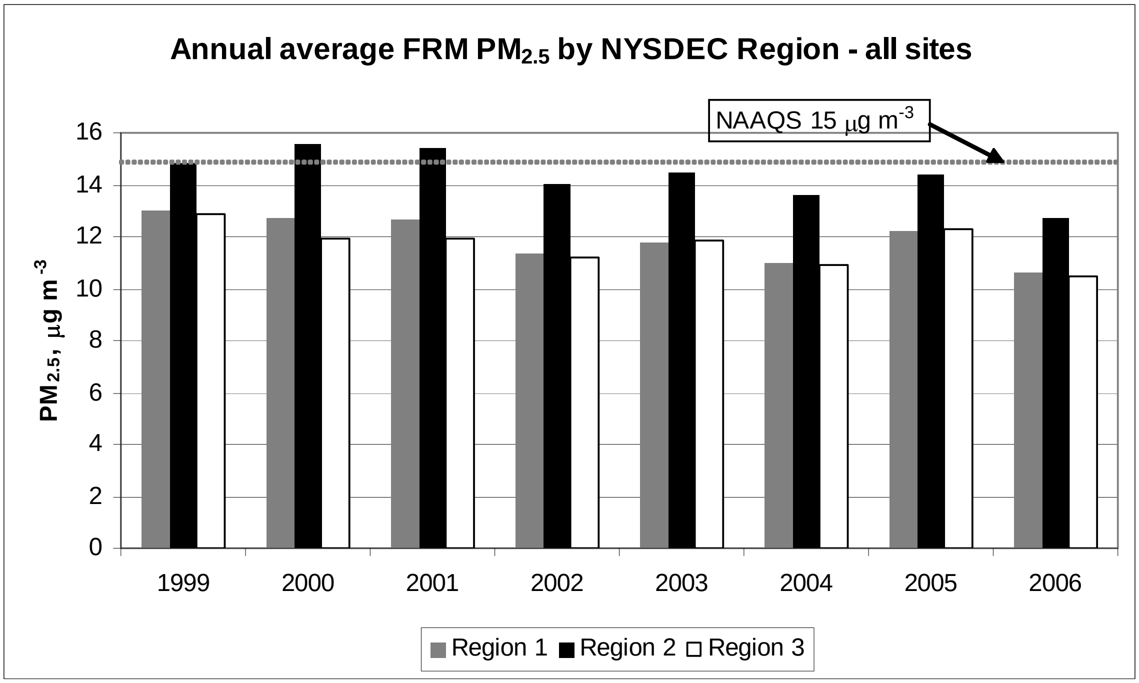


Figure 3. Seasonal variation in $PM_{2.5}$ mass at FRM sites, by NYSDEC Region.

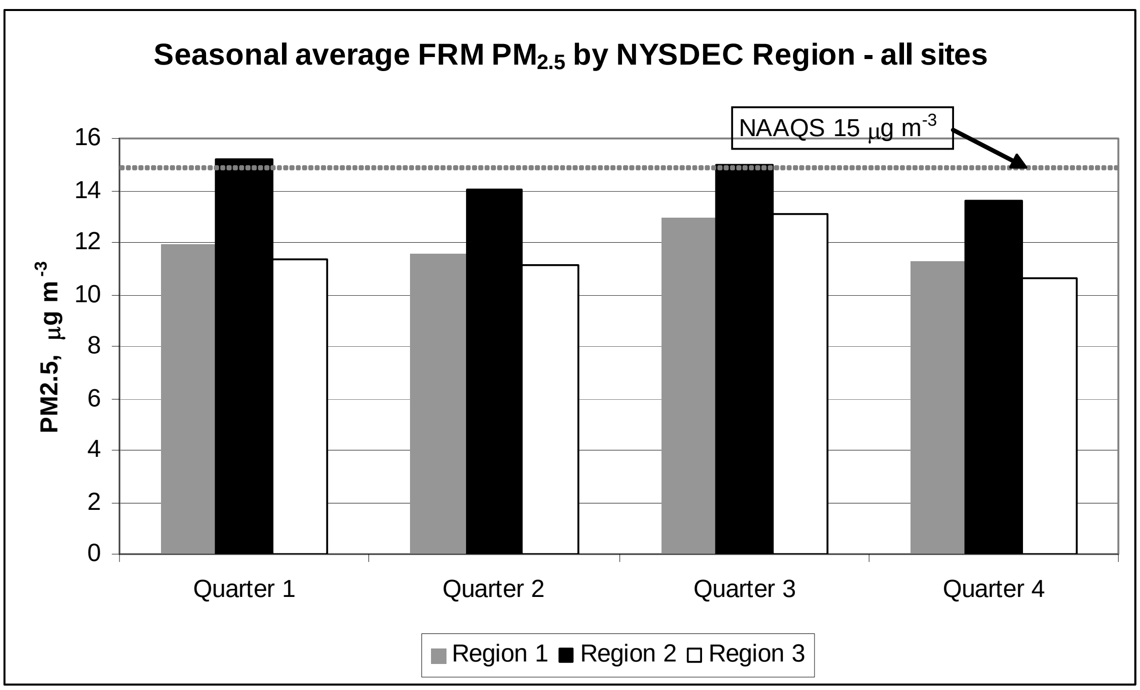
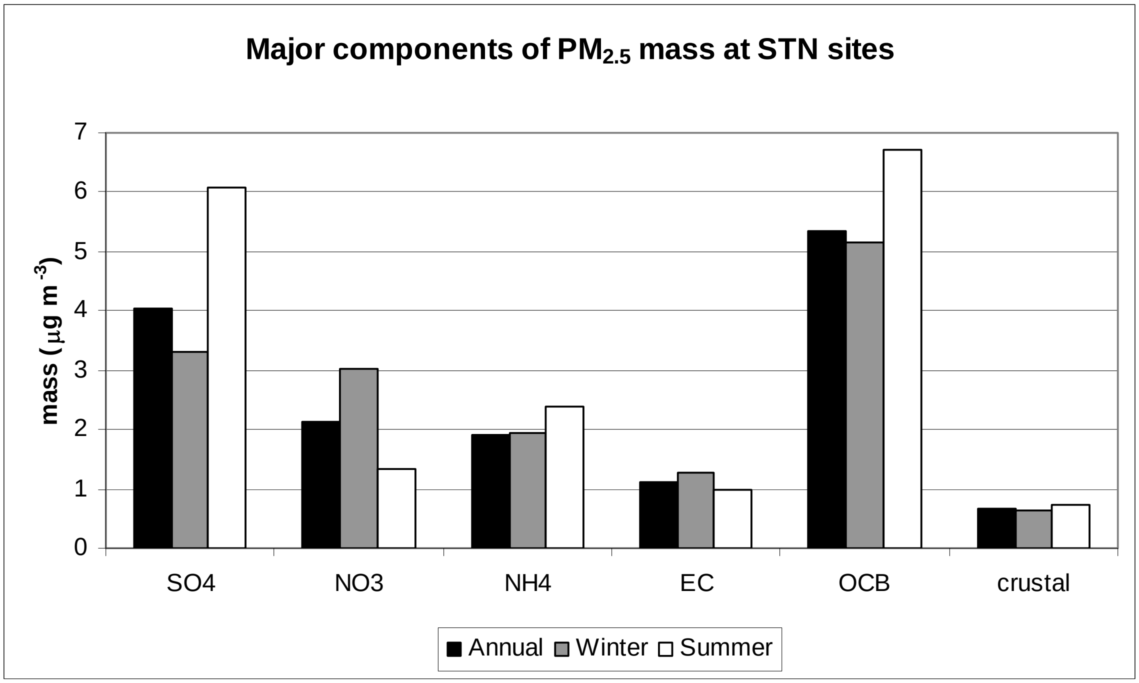


Figure 4. Average $PM_{2.5}$ speciation – annual, winter (DJF), and summer (JJA).



TSD- 3b

Analysis of Ambient $PM_{2.5}$ Mass:

CT and NJ portions of the New York City Metropolitan Non-attainment Area through 2006

Bureau of Air Quality Analysis and Research
Division of Air Resources
New York State Department of Environmental Conservation
Albany, NY 12233

December 27, 2007

Introduction

In this report we provide ambient data analysis for those monitors in Connecticut (two counties) and New Jersey (10 counties) that are part of the New York City non-attainment area (NYC NAA) for $PM_{2.5}$. The analysis presented here supplements TSD-3a (2007), which examined $PM_{2.5}$ air quality for the FRM monitors in New York only.

Database

The analysis is based upon the Federal Reference Method (FRM) data covering the period of 1999 to 2006, which were extracted from the EPA Air Quality System (AQS) data on December 26, 2007. To be consistent with the analysis reported in TSD-3a (2007), we excluded the data from July 6-9, 2002 that was associated with large-scale Canadian forest fires.

Connecticut

The Connecticut portion of the NYC NAA had 14 sites at various times during this period; five of these sites have collocated duplicate monitors and two of the sites had every day sampling for at least a portion of the time. It should be noted that the New Haven/Stiles St. monitor was designated as a "special purpose" monitor, and as such cannot be used to make an attainment or non-attainmment designation. The stations are listed in Table 1 along with their operational dates.

New Jersey

The New Jersey portion of the NYC NAA had 15 monitoring sites at various times during this period; three of these sites have collocated duplicate monitors and two of the sites had every day sampling for at least a portion of the time. Information on these monitors is listed in Table 1.

Analysis

A very cursory analysis was performed on these data, similar to what was done for the NY sites in TSD-3a (2007). The annual average estimates are listed in Table 2. Only those monitors with at least 75% valid samples in a given year are shown in Table 2, and blank cells indicate that either the sampler was not in operation or it did not meet the 75% criteria. In general the CT monitors are below the level of the annual $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) of 15 $\mu g\ m^{-3}$, with the exception of the New Haven/Stile Street special purpose monitoring site. In the case of NJ, there is obvious year-to-year variation at some of the sites, and a few of the monitors are above the level of the annual $PM_{2.5}$ NAAQS. However, this estimated annual average should not be confused with that based on the regulatory process that requires estimation of the annual average based upon individual quarterly data.

Table 3 lists the 98th percentile of the $PM_{2.5}$ concentration at each of these monitors, and again, only those years that had 75% valid samples are shown. The 24-hour NAAQS for $PM_{2.5}$ is 65μg m^{-3}, and only once did a site exceed 50μg m^{-3} – Elizabeth Lab in 2001.

Trends

We also used these data to estimate the annual trends at the longest-running sites. For this analysis we computed quarterly averages at these sites, and considered quarters to be complete if there were at least 10 valid samples. Table 4 lists the estimated linear trends on an annual basis. All monitors except for the New Haven/Stiles Street special purpose monitor show a downward trend, varying between 0.05μg m^{-3} and 0.49μg m^{-3}, indicating general improvement in $PM_{2.5}$ air quality over the region and consistent with what was reported in TSD-3a (2007) for the NY monitors.

Reference

TSD-3a, 2007. Analysis of Ambient $PM_{2.5}$ Mass and Speciation: New York portion of the New York Metropolitan Nonattainment Area through 2006

Table 1. Listing of FRM sites, 1999-2006. Some locations have primary ("P") and duplicate ("D") samplers. Dates with an asterix denote daily sampling for at least part of the period. The New Haven/Stiles St. monitor was designated as "special purpose," and is included here for completeness only (*in italics*).

State	AQS ID	Site Name	County	Dates
CT	090010010	Bridgeport/Roosevelt School	Fairfield CT	P: 1/1999 – 12/2006 D: 1/1999 – 1/2003
	090010113	Bridgeport/Edison School	Fairfield CT	9/2000 – 12/2003
	090011123	Danbury WCSU	Fairfield CT	1/1999 – 12/2006
	090012124	Stamford H.S.	Fairfield CT	1/1999 – 12/2004
	090013005	Norwalk Health Dept.	Fairfield CT	3/2000 – 12/2006
	090019003	Westport/Sherwood Island	Fairfield CT	1/1999 – 12/2006
	090090018	*New Haven/Stiles St.*	*New Haven CT*	*P: 1/1999 – 9/2005** *D: 1/1999 – 1/2003*
	090090026	New Haven/Woodward Firehouse	New Haven CT	4/2003 – 12/2006
	090090027	New Haven/Criscuolo Park	New Haven CT	P: 1/2004 – 12/2006* D: 2/2005 – 12/2006
	090091123	New Haven/State St.	New Haven CT	P: 1/1999 – 12/2006 D: 1/1999 – 2/2005
	090092008	New Haven/Ag. Center	New Haven CT	4/2003 – 12/2006
	090092123	Waterbury/Bank St.	New Haven CT	P: 1/1999 – 12/2006 D: 1/1999 – 12/2006
	090098003	West Haven Toll	New Haven CT	4/2003 – 12/2004
	090099005	Hamden Mill Basins	New Haven CT	7/1999 – 12/2003
NJ	340030003	Fort Lee Library	Bergen NJ	1/1999 – 12/2006
	340130011	Newark/St. Charles	Essex NJ	1/1999 – 12/1999
	340130015	Newark/Willis Center	Essex NJ	4/1999 – 12/2006
	340130016	Newark Lab	Essex NJ	P: 8/2001 – 5/2003 D: 8/2001 – 5/2003
	340171003	Jersey City Firehouse	Hudson NJ	P: 1/1999 – 12/2006 D: 12/1999 – 12/2006
	340172002	Union City	Hudson NJ	1/1999 – 3/2002, 7/2005 – 12/2006
	340210008	Trenton	Mercer NJ	1/1999 – 12/2006
	340218001	Washington Crossing	Mercer NJ	1/1999 – 12/2006
	340230006	New Brunswick	Middlesex NJ	1/1999 – 12/2006
	340270004	Morristown Ambulance Squad	Morris NJ	5/1999 – 12/2006
	340273001	Chester	Morris NJ	1/1999 – 12/2006
	340310005	Paterson	Passaic NJ	1/1999 – 12/2006
	340390004	Elizabeth Lab	Union NJ	P: 1/1999 – 12/2006* D: 1/1999 – 12/2006
	340390006	Elizabeth/Mitchell Bldg.	Union NJ	1/1999 – 12/2006
	340392003	Rahway	Union NJ	12/1999 – 12/2006*

Table 2. Annual average $PM_{2.5}$ levels for sites with at least 75% valid samples in a given year, 2000-2006. Incomplete years are left blank.

Site Name	2000	2001	2002	2003	2004	2005	2006
Bridgeport/Roosevelt School (P)	13.88	13.71	12.72	12.98	12.92	14.32	12.51
Bridgeport/Roosevelt School (D)	15.63	13.49	11.82				
Bridgeport/Edison School		12.77	12.88	12.27			
Danbury WCSU	12.70	13.22	12.51	13.37	11.25	13.44	12.17
Stamford H.S.	12.90	13.01	12.81	13.51	11.78		
Norwalk Health Dept.	12.86	13.41	12.58	12.96	12.23	13.32	11.77
Westport/Sherwood Island	13.03	12.15	11.49	11.63	11.06	12.18	10.69
New Haven/Stiles St. (P)	*15.94*	*16.88*	*16.00*	*16.91*	*15.40*		
New Haven/Stiles St. (D)	*18.78*	*18.60*	*16.19*				
New Haven/Woodward Firehouse					11.56	13.05	11.72
New Haven/Criscuolo Park (P)					12.21	13.62	12.21
New Haven/Criscuolo Park (D)						14.01	12.81
New Haven/State St. (P)	14.07	14.32	13.03	13.59	12.66	13.88	12.63
New Haven/State St. (D)		14.58	12.38	15.49	12.39		
New Haven/Ag. Center					11.14	11.73	10.76
Waterbury/Bank St. (P)	13.61	13.98	13.23	12.64	12.04	14.00	11.98
Waterbury/Bank St. (D)	14.82	14.21	12.75	14.09	11.97	14.14	12.26
West Haven Toll					12.91		
Hamden Mill Basins	11.49	11.88	11.09	12.29			
Fort Lee Library	14.57	13.85	12.99	13.34	12.05	14.65	11.82
Newark/Willis Center	15.60	13.06	13.16	13.84	13.17	14.35	12.12
Newark Lab (P)			14.12				
Newark Lab (D)			14.05				
Jersey City Firehouse (P)	16.78	14.01	14.34	14.81	13.66	15.10	13.35
Jersey City Firehouse (D)			13.99	16.26	12.93	16.07	14.67
Union City	17.08	15.54					13.83
Trenton	14.71	14.46	12.94	13.41	12.48	12.90	12.19
Washington Crossing	12.05		11.35	12.18	10.96	12.27	10.06
New Brunswick	13.00	12.72	11.12	12.91	11.11	13.33	10.77
Morristown Ambulance Squad	12.88		11.48	12.16	11.27	12.33	10.12
Chester	11.09		10.46	10.77	9.99	10.77	9.01
Paterson	13.56		12.90	13.26	12.60	13.44	11.88
Elizabeth Lab (P)		15.53	14.56	15.96	15.08	15.24	14.16
Elizabeth Lab (D)	18.49	15.42	14.78	16.97	14.19	16.65	14.72
Elizabeth/Mitchell Bldg.	15.20	12.88	13.11	13.97	12.68	14.33	12.36
Rahway	14.10	12.77	12.04	13.24	12.53	13.91	11.92

Table 3. The 98th percentile of $PM_{2.5}$ levels for sites with at least 75% valid samples in a given year, 2000-2006. Incomplete years are left blank.

Site Name	2000	2001	2002	2003	2004	2005	2006
Bridgeport/Roosevelt School (P)	41.5	40.1	32.9	39.6	34.2	38.3	36.7
Bridgeport/Roosevelt School (D)	42.8	40.6	34.0				
Bridgeport/Edison School		32.1	33.2	40.4			
Danbury WCSU	32.9	35.2	30.7	37.3	27.5	33.4	33.8
Stamford H.S.	36.3	37.4	34.5	41.5	32.2		
Norwalk Health Dept.	35.3	35.7	34.3	42.9	35.2	34.9	35.9
Westport/Sherwood Island	33.4	34.5	30.8	44.0	30.9	35.2	31.3
New Haven/Stiles St. (P)	*39.5*	*40.6*	*40.4*	*44.0*	*34.9*		
New Haven/Stiles St. (D)	*44.8*	*43.0*	*34.5*				
New Haven/Woodward Firehouse					31.5	36.4	36.5
New Haven/Criscuolo Park (P)					33.2	38.2	36.7
New Haven/Criscuolo Park (D)						39.1	31.6
New Haven/State St. (P)	37.2	39.5	32.4	40.6	36.2	40.8	38.1
New Haven/State St. (D)		40.6	32.3	38.9	29.9		
New Haven/Ag. Center					32.1	32.8	33.9
Waterbury/Bank St. (P)	34.4	35.4	32.6	37.7	30.4	34.1	35.6
Waterbury/Bank St. (D)	36.0	34.9	33.5	32.8	26.1	35.9	35.2
West Haven Toll					30.8		
Hamden Mill Basins	34.7	32.1	29.4	44.0			
Fort Lee Library	36.4	34.4	33.0	38.9	31.0	40.5	38.2
Newark/Willis Center	41.6	32.1	32.3	39.8	34.9	40.4	39.9
Newark Lab (P)			34.6				
Newark Lab (D)			39.9				
Jersey City Firehouse (P)	39.5	34.1	34.3	46.4	37.4	37.9	41.0
Jersey City Firehouse (D)			36.8	41.1	29.1	38.3	38.9
Union City	39.3	39.5					
Trenton	43.1	35.4	35.4	40.5	33.3	33.6	36.2
Washington Crossing	31.5		32.2	34.9	28.0	33.0	29.5
New Brunswick	34.5	34.1	26.0	45.0	35.5	33.8	32.8
Morristown Ambulance Squad	30.2		29.7	36.8	31.1	32.9	30.4
Chester	29.4		30.0	35.7	29.8	33.4	28.3
Paterson	35.4		34.9	39.8	31.0	40.5	33.4
Elizabeth Lab (P)		39.7	41.7	37.0	40.5	42.5	39.8
Elizabeth Lab (D)	46.6	50.3	39.3	41.2	36.5	39.8	41.9
Elizabeth/Mitchell Bldg.	36.0	33.8	30.0	40.9	33.1	38.6	38.7
Rahway	38.0	30.4	31.1	35.2	36.6	38.2	37.5

Table 4. Trends in $PM_{2.5}$ mass at the longest running FRM monitors, based on quarterly averages from 1999-2006, in μg m^{-3} yr^{-1}. Only those quarters with at least 10 valid samples are included in this trend estimate.

Site Name	Trend (μg m^{-3} yr^{-1})
Bridgeport/Roosevelt School (P)	-0.07
Danbury WCSU	-0.05
Norwalk Health Dept.	-0.18
Westport/Sherwood Island	-0.19
New Haven/Stiles St. (P)	*+0.02*
New Haven/State St. (P)	-0.19
New Haven/State St. (D)	-0.32
Waterbury/Bank St. (P)	-0.16
Waterbury/Bank St. (D)	-0.13
Fort Lee Library	-0.25
Newark/Willis Center	-0.37
Jersey City Firehouse (P)	-0.34
Jersey City Firehouse (D)	-0.25
Trenton	-0.27
Washington Crossing	-0.14
New Brunswick	-0.11
Morristown Ambulance Squad	-0.49
Chester	-0.21
Paterson	-0.06
Elizabeth Lab (P)	-0.27
Elizabeth Lab (D)	-0.43
Elizabeth/Mitchell Bldg.	-0.30
Rahway	-0.15

TSD-4

Future Year Emissions Inventory for Regional and Urban Modeling over the OTR

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February 22, 2007

Following the designation of an area as non-attainment for the criteria pollutant Ozone, the Clean Air Act requires submission of an implementation plan, commonly referred to as State Implementation Plan (SIP), demonstrating as to how that area will be meeting the NAAQS in the time period established by the Act. Several areas of the OTR were designated as being in nonattainment for 8-hr ozone (see http://www.epa.gov/ozonedesignations/) with a maximum attainment date of June 2009 and June 2010. However, given that ozone precursors also contribute to $PM_{2.5}$ and other logistics, it was recommended and agreed by the member states that the future year for demonstrating attainment would be 2009. Therefore the OTR states initiated the development of emissions inventories reflecting growth and control from 2002 to 2009 as well as for 2012 and 2018. The 2018 inventory was in response to the need for submission of regional haze SIP, and the 2012 as a next step in the event that attainment for ozone was not feasible in 2009.

Future year emissions inventories within the OTR

The OTR states through MANE-VU contracted MACTEC Federal Programs (called Contractor) develop the 2009, 2012 and 2018 inventories based upon 2002 inventories that the states had previously developed for use in the base year model work. The Contractor in consultation with the states developed the necessary growth and control factors and applied to the 2002 inventory. It should be noted that emissions for mobile sources and the electric energy generating units (EGUs) was not part of the Contractor's effort. The states provided VADEQ and NESCAUM appropriate MOBILE 6 input files along with the projected VMTs, which coupled with the hourly gridded temperature information was used to generate mobile source emissions. As for the emissions from the EGU sector, the inter-RPO work group utilized the Integrated Planning Model (IPM) to develop the state and unit-level emissions. Details on these topics can be found in MACTEC (2007) for non-EGU sectors and in ICF (2005a, 2005b) for the EGU sector. These inventories are identified as 2009 on the way (2009OTW), since they reflect all emission control measures that were promulgated or would become effective on or before 2009.

In addition to these OTW inventories, states have also requested the development of what is termed as beyond on the way (BOTW) inventories for 2009, 2012, and 2018. These inventories are to be based on additional OTC model rules, which would result in reduction in emissions from specific source categories. Details on the development of these controls and the corresponding inventories can be found in MACTEC (2007).

Future year emission inventories outside the OTR

MANE-VU obtained inventories for 2009OTW and 2018OTW as part of the inter-RPO workgroup. However, only MRPO provided emissions for 2012OTW. For the VISTAS region, 2012 emissions were obtained by interpolating area, nonroad, and non-EGU emissions between 2009 and 2018. For mobile sources, VMT were interpolated between 2009 and 2018 and the 2012 emissions were calculated with MOBILE6 using these interpolated VMT and 2012 emission factors. For the CENRAP region, no 2012 emissions were generated, and therefore the 2009 emissions were used in the 2012 CMAQ simulation.

Canadian Emissions

In the case of Canadian emissions, 2010 and 2020 area, non-road, and mobile source emissions were obtained from USEPA (ftp://ftp.epa.gov/EmisInventory/canada_2000inventory/).
Primary $PM_{2.5}$ and PM_{10} emissions for the SCCs listed in http://www.epa.gov/ttn/chief/emch/invent/tf_scc_list2002nei_v2.xls were divided by a factor of 4 to account for the fugitive dust transport fraction correction. EGU point source emissions for 2010 and 2020 were obtained from Environment Canada (Bloomer, 2006), while non-EGU point source emissions were assumed to be the same as those developed for 2002 and described elsewhere (see TSD-1c). The 2010 inventories were used in preparing CMAQ input files for the 2009OTW, 2009BOTW, and 2012BOTW scenarios.

Emissions processing – Application of SMOKE

The 2009OTW, 2009BOTW, and 2012 BOTW inventories were processed by VADEQ and NYSDEC using a template similar to that was used for processing 2002 base year emissions (see TSD-1d, TSD-1j) for the 12 km domain. In particular, all gridding and speciation profiles and cross-reference files as well as all temporal allocation profiles and cross-reference files used in the 2002 processing were also used for future year processing. For each day, the following files were prepared:

2009OTW:

- MANE-VU
  - 2009 OTW V3 area source (VADEQ)
  - 2009 V3 nonroad source (VADEQ)
  - 2009 mobile source (NYSDEC)
  - 2009 OTW V3 non-EGU point source (VADEQ)
  - 2009 IPM2.1.9. EGU point source (VADEQ)
  - 2009 EGU point source, IPM2.1.9. non-fossil fuel units (VADEQ)
- VISTAS
  - 2009 BaseG area source (VADEQ)
  - 2009 BaseG nonroad source (VADEQ)

    - 2009 BaseG non-EGU point source (VADEQ)
    - 2009 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (VADEQ)
    - 2009 BaseG low-level fires (VADEQ)
    - 2009 BaseG elevated source fires (VADEQ)
- MRPO
    - 2009 BaseK area source (NYSDEC)
    - 2009 BaseK area source NH3/dust (NYSDEC)
    - 2009 BaseK nonroad source (NYSDEC)
    - 2009 non-EGU point source (VADEQ)
    - 2009 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (VADEQ)
- CENRAP
    - 2009 BaseB area source (VADEQ)
    - 2009 BaseB nonroad source (VADEQ)
    - 2009 non-EGU point source (VADEQ)
    - 2009 IPM2.1.9. EGU point source (VADEQ)
- VISTAS/MRPO/CENRAP ("non-MANE-VU RPOs")
    - 2009 mobile sources for all non-MANE-VU RPOs as implemented in VISTAS 2009 BaseG processing (VADEQ)
- Canada
    - 2010 area sources (NYSDEC)
    - 2010 nonroad sources (NYSDEC)
    - 2010 mobile sources (NYSDEC)
    - point sources (2002 non-EGU point sources; 2010 EGU point sources from IPM) (NYSDEC)
- Biogenics
    - Same as for 2002 base case, calculated with hourly MM5 meteorological fields for 2002 (NYSDEC)

2009 BOTW:

As above for 2009 OTW, with the following two exceptions:

- MANE-VU
    - 2009 BOTW V3 area source (NYSDEC)
    - 2009 BOTW V3 non-EGU point source (NYSDEC)

2012 BOTW:

- MANE-VU
    - 2012 OTW V3 area source (NYSDEC)
    - 2012 V3 nonroad source (NYSDEC)
    - 2012 mobile source (NYSDEC)
    - 2012 OTW V3 non-EGU point source (NYSDEC)
    - 2012 IPM2.1.9. EGU point source (NYSDEC)
    - 2009 EGU point source, IPM2.1.9. non-fossil fuel units (VADEQ)
- VISTAS

- 2012 BaseG area source (interpolated between 2009 BaseG and 2018 BaseG) (NYSDEC)
- 2012 BaseG nonroad source (interpolated between 2009 BaseG and 2018 BaseG) (NYSDEC)
- 2012 BaseG mobile source (interpolated VMT between 2009 BaseG and 2018 BaseG) (NYSDEC)
- 2012 BaseG non-EGU point source (interpolated between 2009 BaseG and 2018 BaseG) (NYSDEC)
- 2012 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (NYSDEC)
- 2009 BaseG low-level fires (VADEQ)
- 2009 BaseG elevated source fires (VADEQ)

- MRPO
    - 2012 BaseK area source (NYSDEC)
    - 2012 BaseK area source NH3/dust (NYSDEC)
    - 2012 BaseK nonroad source (NYSDEC)
    - 2012 BaseK nonroad source (NYSDEC)
    - 2012 non-EGU point source (NYSDEC)
    - 2012 IPM2.1.9. EGU point source (incl. post-IPM adjustments) (NYSDEC)
- CENRAP
    - 2009 BaseB area source (VADEQ)
    - 2009 BaseB nonroad source (VADEQ)
    - 2009 mobile source (based on VISTAS 2009 BaseG processing) (NYSDEC)
    - 2009 non-EGU point source (VADEQ)
    - 2009 IPM2.1.9. EGU point source (VADEQ)
- Canada
    - 2010 area sources (NYSDEC)
    - 2010 nonroad sources (NYSDEC)
    - 2010 mobile sources (NYSDEC)
    - point sources (2002 non-EGU point sources; 2010 EGU point sources from IPM) (NYSDEC)
- Biogenics
    - Same as for 2002 base case, calculated with hourly MM5 meteorological fields for 2002

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TSD-1c (2006) Emissions Processing for 2002 OTC Regional and Urban 12km Base year simulation

TSD-1d (2006) 8-h Ozone Modeling using the SMOKE/CMAQ system

TSD-1j (2007) Emission processing for OTC 2009 OTW/OB 12km CMAQ Simulations

TSD-5

Baseline and Future $PM_{2.5}$ Design Values in the New York City Metropolitan Non-Attainment Area

Bureau of Air Quality Analysis and Research

Division of Air Resources

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Introduction

Baseline $PM_{2.5}$ design values for a given area are based solely on measured Federal Reference Method (FRM) data, whereas air quality model-based results utilizing emissions from a target future year are needed to project $PM_{2.5}$ design values to determine future attainment status of that area. The modeling guidance (USEPA, 2007a) states that the results from the regulatory applications of air quality models are not to be used in an absolute sense; rather, they are to be used to estimate the effects of changes in emissions on pollutant levels in a relative sense. For a single pollutant like ozone, the future design value at a given location is the product of the current observed value and the ratio of the future-to-current model predictions. The ratio of the future-to-current model prediction is also known as the relative response factor (RRF). Unlike ozone, $PM_{2.5}$ is comprised of a variety of ions, trace elements, and carbon species. To demonstrate future attainment of air quality standards for $PM_{2.5}$, one needs to project how each of the major species changes between the baseline and future model yeasr; that is, it is necessary to estimate speciated RRF values. In this report we present an overview of the calculation of the baseline $PM_{2.5}$ design values and speciated RRFs for monitors in the 22-county New York City non-attainment area (NYC NAA), which when combined yield future year $PM_{2.5}$ design values across the NYC NAA.

Baseline $PM_{2.5}$ design values

The first step in the modeled attainment test for the annual National Ambient Air Quality Standard (NAAQS) is to compute the baseline design values at each FRM site in the NYC NAA. The baseline design value is based on a five-year weighted average of observations from 2000-2004 to straddle the baseline emissions/modeling year of 2002 (EPA, 2007a). This calculation is to be performed utilizing data on a quarterly basis. In other words, for each quarter the baseline concentration is the average of the concentrations from the corresponding quarters of the three year periods of 2000-2002, 2001-2003, and 2002-2004. Table 1 lists the baseline design values, based on the EPA's official quarterly averages (EPA, 2007b), at each FRM site across the NYC NAA having at least two years of sampling data during this five-year period. We note that one monitor – P.S. 59 (360610056) in New York County – had recorded one anomalously high average concentration of 25.2 $\mu g\ m^{-3}$ during the third quarter of 2003. Examination of the data shows that for this quarter there were only five valid data points at the beginning of the quarter, and the monitor was subsequently shut down because of construction activity at the site. Because this short time period is not representative of air quality over the entire quarter, in this analysis this quarter was treated as missing, and this is reflected in Table 1. Attachment 1 provides a more detailed analysis of this particular issue.

Current species concentrations

The next step in the modeled attainment test is to determine the current species composition at each FRM monitor, based on measured species data. The $PM_{2.5}$ species composition is highly complex, but if the goal of air quality management decisions is to reduce $PM_{2.5}$, it is necessary to know the dominant chemical species. Some of FRM monitors in the NYC NAA are collocated with Speciation Trends Network (STN) monitors that collect major ions, including sulfate (SO_4), nitrate (NO_3), and ammonium (NH_4); carbon species, including elemental carbon (EC) and organic carbon (OC); and about 50 trace elements. At sites where both STN and FRM data are available, it is possible to relate the total FRM mass with the mass of individual species; however, during the 2000-2004 period, in the NYC NAA there were only two sites in CT, three in NJ, and four in NY that had collocated STN and FRM monitors. At those FRM sites that do not have collocated STN monitor, we assumed that the speciation data from the nearest STN monitor is sufficient to characterize the FRM site. Table 1 also lists the nearest STN site that is to be associated with the FTM site in the NYC NAA for computing the current species concentrations.

It is known that FRM monitor filters do not retain semi-volatile species such as ammonium nitrate and some organics with high efficiency, particularly during the warmer months. Hence, one cannot simply add up the major species from the STN monitor and expect to relate this identically to the total mass from the FRM monitor. It is necessary to adjust some of the STN data to estimate the species composition of mass measured by the FRM monitor. According to the modeling guidance (USEPA, 2007a) the mass from the FRM monitor can be expressed as:

$PM_{2.5}$ = "retained nitrate mass" + "ammoniated sulfate mass" + "ammonium associated with sulfate and retained nitrate" + "particle-bound water" + "other primary $PM_{2.5}$" + "blank mass" + "carbonaceous mass" [Eq. 1]

where $PM_{2.5}$ refers to the total mass measured at each FRM site; "retained nitrate mass" and "ammonium associated with sulfate and retained nitrate" refer only to the fractions of NO_3 and NH_4, respectively, that are not volatilized; "ammoniated sulfate mass" refers to the SO_4 that is measured by the STN; "particle-bound water" refers to water that is associated with the hygroscopic ammonium sulfate and nitrate, and can be estimated as a polynomial function of retained ammonium, sulfate, and nitrate; "other primary $PM_{2.5}$" refers to unspeciated, inert $PM_{2.5}$ such as soil/crustal elements (here assumed to be the sum of major crustal oxides – Si, Ca, Fe, and Ti); "blank mass" refers to passively collected contamination, assumed to be 0.5 $\mu g\ m^{-3}$; and "carbonaceous mass" refers to EC and an estimate of retained OC. Because of uncertainties in the measured OC, the modeling guidance suggests that organic mass be computed as the difference between the measured FRM mass and the sum of the other species listed above.

To compute the current species concentrations at each FRM site in the NYC NAA, we used the EPA's official database of STN data (EPA, 2007b) covering the period 2002-2004. This database also includes the adjusted speciation data needed to compute the various retained species. For each quarter, the average species composition was computed; this was a simple arithmetic average, not a weighted average like the FRM mass. Table 2 lists the current species composition, as defined in Equation 1 above. Note that in the case of retained NH_4, the actual measured data were not used here, due to uncertainties in its measurement. The modeling guidance suggests that NH_4 can be estimated according to degree of neutralization (DON) of sulfate:

$$NH_4 = DON \times SO_4 + 0.29 \times NO_3r \qquad \text{[Eq. 2]}$$

Where NO_3r refers to retained nitrate. As will be shown in a later section, using the DON – which also is included in the official EPA database – will allow the future NH_4 value to depend only on SO_4 and NO_3, since reductions in emissions generally are targeting precursors of SO_4 and NO_3. The formulas for particle-bound water (PBW) and other primary $PM_{2.5}$ (OPP) are listed in the modeling guidance (USEPA, 2007a).

Relative Response Factors

As stated in the Introduction, the air quality modeling results are to be used in a relative sense to compute future $PM_{2.5}$ design values. For each species *i*, the future concentration of each species (CF_i) is the product of the baseline concentration (CB_i) and the corresponding RRF_i:

$$CF_i = CB_i \times RRF_i \qquad \text{[Eq. 3]}$$

As with the measured data to obtain current FRM mass and species composition, the model results are used on a quarterly basis. For each quarter and species, we computed the quarterly average concentration for the base and future year simulations. The RRF is the ratio of the quarterly average future-to-base year values. For this analysis, at each FRM site we considered the average of the surrounding nine grid cells and not just the grid cell that corresponds to that FRM site.

The RRF values for SO_4, NO_3r, OC, EC, and OPP were based on application of CMAQ model (TSD-2c, 2007) for 2002 and 2009. Table 3 lists the appropriate CMAQ variables that were used to estimate the speciated RRF values. For NH_4, we used the future values of SO_4 and NO_3r to obtain the future year value, as per Equation 2. For PBW, we used the future year SO_4, NO_3r, and NH_4 values and the polynomial formulation listed in the modeling guidance (USEPA, 2007a). Finally, the blank concentration of 0.5 $\mu g\ m^{-3}$ is assumed to remain constant in the future year.

Future $PM_{2.5}$ design values

Table 4 lists the baseline and future design values for the annual NAAQS at each FRM location in the NYC NAA. In 2009 all sites except for one – P.S. 59 (360610056) in New York County, NY – are projected to be in attainment of the NAAQS, since the future design values are below 14.5 $\mu g\ m^{-3}$. The P.S. 59 site has a projected future concentration of 15.3 $\mu g\ m^{-3}$, meaning that corroboratory analyses are needed for a weight of evidence (WOE) determination to demonstrate attainment at this monitor. It should be noted that on the average the design values across the NYC NAA were reduced by about 1.6 $\mu g\ m^{-3}$, ranging from 1.2-2.2 $\mu g\ m^{-3}$, in 2009 compared to baseline design values. Attachment 2 details the WOE analyses that support the assertion that the entire NYC NAA is projected to be in attainment of the $PM_{2.5}$ NAAQS by 2009.

References

United States Environmental Protection Agency (USEPA), 2007a. Guidance on the use of models and other analyses for demonstrating attainment of air quality goals for ozone, $PM_{2.5}$, and regional haze. EPA-454/B-07-002, Research Triangle Park, NC.

United States Environmental Protection Agency (USEPA), 2007b. Electronic mail correspondence from Kenneth Fradkin, EPA Region 2, on 17 August, 2007 contains two data files used here to demonstrate attainment of the annual $PM_{2.5}$ NAAQS: Annual-official-FRM-99-06-v1.zip (official quarterly average FRM mass) and STN-only-02-04-R2.zip (daily speciation data).

TSD-2c, 2007. $PM_{2.5}$ modeling using the SMOKE/CMAQ system over the Ozone Transport Region (OTR)

Table 1. Base year $PM_{2.5}$ design values across the NYC NAA based on weighted averages over 2000-2004, and the nearest STN monitor to each FRM monitor. Base year design values listed in bold are above the annual NAAQS.

FRM site	Base year Design Value, $\mu g\ m^{-3}$	Nearest STN monitor
090010010	13.1	090019003
090010113	12.6	090019003
090011123	12.8	090019003
090012124	12.9	090019003
090013005	12.9	090019003
090019003	11.8	090019003
090091123	13.7	090091123
090092123	13.1	090091123
090099005	11.6	090091123
340030003	13.7	360050110
340171003	14.9	360610062
340172002	**16.0**	360610062
340210008	13.9	340230006
340218001	11.9	340230006
340230006	12.5	340230006
340270004	12.4	340273001
340273001	11.1	340273001
340310005	13.2	360050083
340390004	**15.7**	340390004
340390006	13.5	340390004
340392003	13.1	340390004
360050080	**15.8**	360050110
360050083	13.8	360050083
360050110	14.7	360050110
360470052	**15.1**	360610062
360470076	14.2	360610062
360470122	14.8	360610062
360590008	12.2	360810124
360610056	**16.9**	360610062
360610062	**16.3**	360610062
360610079	14.7	360050110
360610128	**15.9**	360610062
360710002	11.5	090019003
360810124	13.3	360810124
360850055	14.0	340390004
360850067	12.1	340390004
361030001	12.1	360810124
361191002	12.3	360050083

Table 2. Current species composition in μg m^{-3} across the NYC NAA, based on speciation data from the nearest STN monitor. "SO_4" is sulfate; "NO_3r" is retained nitrate; "OM" is organic mass; "PBW" is particle-bound water; "NH_4" is ammonium associated with SO_4 and NO_3r; and "OPP" is other primary $PM_{2.5}$, assumed to equal the sum of major crustal oxides (Si, Ca, Fe, and Ti).

FRM site	SO_4	NO_3r	OM	EC	PBW	NH_4	OPP
090010010	3.98	0.61	4.09	0.86	1.18	1.34	0.56
090010113	3.81	0.61	3.93	0.83	1.14	1.29	0.53
090011123	3.85	0.60	3.97	0.84	1.15	1.30	0.54
090012124	3.90	0.59	4.02	0.85	1.16	1.31	0.55
090013005	3.89	0.61	4.00	0.85	1.16	1.31	0.55
090019003	3.56	0.52	3.73	0.76	1.06	1.18	0.50
090091123	4.26	0.69	3.67	1.00	1.46	1.63	0.51
090092123	4.05	0.68	3.52	0.96	1.38	1.55	0.49
090099005	3.62	0.57	3.06	0.84	1.24	1.38	0.43
340030003	4.10	0.95	3.32	1.04	1.37	1.70	0.66
340171003	4.40	1.28	3.38	1.33	1.46	1.92	0.68
340172002	4.71	1.41	3.59	1.43	1.56	2.07	0.73
340210008	4.68	0.85	3.32	0.75	1.52	1.77	0.52
340218001	4.01	0.68	2.86	0.63	1.30	1.50	0.44
340230006	4.19	0.73	2.98	0.66	1.36	1.57	0.46
340270004	4.52	0.62	2.91	0.45	1.44	1.59	0.36
340273001	4.04	0.53	2.61	0.39	1.29	1.41	0.32
340310005	3.80	0.82	3.49	1.26	1.26	1.50	0.61
340390004	4.40	1.02	4.03	1.74	1.47	1.83	0.67
340390006	3.76	0.91	3.46	1.50	1.25	1.58	0.57
340392003	3.67	0.84	3.38	1.46	1.22	1.52	0.56
360050080	4.73	1.17	3.84	1.23	1.57	1.99	0.77
360050083	3.95	0.92	3.61	1.34	1.31	1.57	0.64
360050110	4.39	1.08	3.56	1.14	1.46	1.84	0.71
360470052	4.45	1.28	3.42	1.34	1.47	1.94	0.68
360470076	4.20	1.22	3.20	1.26	1.39	1.83	0.64
360470122	4.36	1.26	3.32	1.31	1.44	1.90	0.67
360590008	3.85	0.82	2.97	0.69	1.29	1.55	0.55
360610056	4.98	1.50	3.81	1.51	1.65	2.19	0.77
360610062	4.81	1.40	3.66	1.45	1.59	2.10	0.74
360610079	4.41	1.05	3.58	1.13	1.47	1.84	0.71
360610128	4.68	1.39	3.59	1.42	1.55	2.05	0.72
360710002	3.46	0.49	3.65	0.74	1.03	1.14	0.49
360810124	4.22	0.92	3.24	0.75	1.41	1.70	0.60
360850055	3.93	0.87	3.62	1.56	1.31	1.63	0.60
360850067	3.39	0.75	3.10	1.34	1.13	1.40	0.51
361030001	3.82	0.81	2.95	0.68	1.28	1.53	0.55
361191002	3.52	0.78	3.23	1.18	1.17	1.39	0.57

Table 3. Model variables from CMAQ used to compute speciated RRF values.

$PM_{2.5}$ species, $\mu g\ m^{-3}$	**CMAQ variables, $\mu g\ m^{-3}$**
SO_4	ASO4I + ASO4J
NO_3r	ANO3I + ANO3J
OC	AORGPAI + AORGPAJ + AORGAI + AORGAJ + AORGBI + AORGBJ
EC	AECI + AECJ
OPP	A25I + A25J

Table 4. Base year and future (2009) $PM_{2.5}$ design values across the NYC NAA. Concentrations listed in bold are above the annual NAAQS.

FRM site	Base Year Design Value $\mu g\ m^{-3}$	Future $PM_{2.5}$ Design Value $\mu g\ m^{-3}$
090010010	13.1	11.5
090010113	12.6	11.2
090011123	12.8	11.2
090012124	12.9	11.4
090013005	12.9	11.3
090019003	11.8	10.4
090091123	13.7	11.7
090092123	13.1	11.2
090099005	11.6	9.9
340030003	13.7	12.1
340171003	14.9	13.3
340172002	**16.0**	14.3
340210008	13.9	11.8
340218001	11.9	10.1
340230006	12.5	10.4
340270004	12.4	10.4
340273001	11.1	9.3
340310005	13.2	11.4
340390004	**15.7**	13.5
340390006	13.5	11.8
340392003	13.1	11.4
360050080	**15.8**	14.2
360050083	13.8	12.4
360050110	14.7	13.3
360470052	**15.1**	13.6
360470076	14.2	12.8
360470122	14.8	13.3
360590008	12.2	11.0
360610056	**16.9**	**15.3**
360610062	**16.3**	14.4
360610079	14.7	13.3
360610128	**15.9**	14.3
360710002	11.5	10.3
360810124	13.3	12.1
360850055	14.0	12.3
360850067	12.1	10.6
361030001	12.1	10.7
361191002	12.3	10.9

Attachment 1

Analysis of the FRM data at PS 59 in New York (Manhattan) County, NY

New York State DEC
Division of Air Resources

Background

The New York State DEC analyzed the measurements of $PM_{2.5}$ mass data across the New York City metropolitan non-attainment area for use in estimating the future design values, which are based on air quality modeling of the 2002 base and 2009 future years. The EPA Guidance (US EPA, 2007) requires the use of the measured data from the five-year period around the base year (2000-2004) to estimate the current design value (DVc). Although the Modeled Attainment Test Software (MATS) has not yet been released, the New York State DEC has been able to compute preliminary baseline and future $PM_{2.5}$ levels, based on discussions with EPA/OAQPS. These preliminary calculations suggest that, except for one monitor – PS 59 [AQS ID 36-061-0056] in New York (Manhattan) County, NY – the region will be at or below the annual $PM_{2.5}$ NAAQS. If the official FRM data received from OAQPS are used 'as-is,' PS 59 will be *slightly* above the prescribed level of the annual $PM_{2.5}$ NAAQS. This is despite the fact that on average, $PM_{2.5}$ levels have been decreasing at this site by nearly ~0.4-0.5 $\mu g\ m^{-3}\ yr^{-1}$ since 1999. In the following we investigate the cause for this dichotomy, and note that the measurements taken during the third quarter of 2003 play an important role in the estimated $PM_{2.5}$ DVc and the potential future status of nonattainment at this location.

PS 59 monitoring location

The FRM unit is located on the roof of PS 59 in New York County and has been operational since 1999. Appendix A provides the location and description of the monitoring site. The FRM sampler was collocated with a duplicate sampler, as part of the network design requirements. Both monitors were shut down for most of the third quarter of 2003 due to roof repairs. Appendix B provides the correspondence from New York City School Construction Authority indicating the working hours of construction activities at the location with the requirement that the *roof-main work to be completed by August 25, 2003*. Ambient monitoring was resumed at this site in October 2003. So for the third quarter in 2003 there were only the first five samples out of a possible 31 were available.

Duplicate Monitors and Analysis

Appendix C describes the analysis associated with the primary and duplicate measurements, which shows that there is very good agreement between the two monitors, except for one outlier, which is found to be not associated with the period in question – 3rd quarter of 2003. The estimated correlation coefficient (r^2=0.9867) and the almost zero intercept (0.0081) suggest either of the monitors could be used in the analysis. It should also be noted that from a monitoring perspective the site meets the criteria for data completeness in 2003 based on the remainder of the measurements. Yet, examination of the data on a quarterly average basis indicates that an average based on these five data points is not necessarily representative of air quality over the entire quarter at this location in addressing model-based attainment. The reason for examining the data by quarter arises from the modeling guidance (US EPA, 2007) that calls for a weighted five-year running quarterly average to compute baseline concentration levels.

In the following two sections we will present a case that a more appropriate quarterly concentration value be used for this quarter at this site, rather than one based on only the five values, in estimating the DVc.

Observed $PM_{2.5}$ mass in New York County, 2003

Figure 1 displays the time series of $PM_{2.5}$ mass at the four New York County FRM monitors in 2003 – PS 59 (360610056), Canal Street (360610062), JHS 45 (360610079), and PS 19 (360610128). Each site tends to track the others rather well over the entire year. Considering only those days for which valid measurements are available for all four sites, there were a total of 64 days out of a possible 121 days which were used to estimate the annual arithmetic average at each site: PS 59, 17.11 $\mu g\ m^{-3}$; Canal Street, 15.69 $\mu g\ m^{-3}$ JHS 45, 14.75 $\mu g\ m^{-3}$ and PS 19, 16.18 $\mu g\ m^{-3}$. These averages, not to be confused with the regulatory definition, indicate that in 2003 the PS 59 monitor is on avergae about 1 to 2 $\mu g\ m^{-3}$ higher than the other sites.

Figures 2a-d display the quarterly average concentrations covering the five year span of 2000 to 2004 for these four monitors. With the exception of the third quarter of 2003 (Figure 2c) the quarterly average concentrations are quite comparable at these four monitors. As evident from Figure 2c however, the estimated quarterly average for PS 59 is more than 8 $\mu g\ m^{-3}$ higher than the other three sites, whose third quarter averages based on 20 to 29 samples were in the 16-17 $\mu g\ m^{-3}$ range.

Current and baseline $PM_{2.5}$ levels at PS 59

To compute baseline $PM_{2.5}$ levels at this site, we started with the data file that was provided to the New York State DEC by Region 2 on August 17, 2007. The file labeled "Annual-official-FRM-99-06-v1.csv" lists the EPA's official quarterly averages at each FRM site across the country for the period 1999-2006, as well as the corresponding attainment status and completion codes.

Base year $PM_{2.5}$ levels were computed three ways. The first method (method A) includes the FRM data from the anomalous third quarter of 2003. The other two methods involve data substitution; method B substitutes the third quarter average (16.70 $\mu g\ m^{-3}$) from a nearby site (PS 19, ~3.5 km south of PS 59), while method C substitutes the average of the third quarter values from the other years (16.51 $\mu g\ m^{-3}$; 2000-2002 and 2004). The third quarter of 2003 at PS 19 and the average of the third quarters from the other years at PS 59 are considered complete for attainment/non-attainment purposes and are more likely to reflect the average air quality at or near this site.

If method A is used the base DVc is 17.37 $\mu g\ m^{-3}$, while the methods B and C result in a DVc of 16.90 $\mu g\ m^{-3}$ and 16.89 $\mu g\ m^{-3}$, respectively. Hence, if the 'anomalous quarter' from 2003 is used in this calculation (method A), the base year DVc is about 0.5 $\mu g\ m^{-3}$ higher than the other methods that used substitution. Preliminary calculations of the future 2009 design value are estimated to be about 15.7 $\mu g\ m^{-3}$ using method A, and about 15.3 $\mu g\ m^{-3}$ based on either method B or C.

Summary

The above analysis has demonstrated that the use of quarterly average based on the measured data 'as-is' has significant consequences for $PM_{2.5}$ non-attainment status at the PS 59 monitor. A quarterly average that covers only five days for the third quarter of 2003 is not consistent with the measurements available at other monitor locations in New York County. It is recommended that this quarterly average be re-calculated using either the substitution of a third quarter concentration from a nearby monitor such as PS 19, or the substitution of the composite average of the third quarters from the other years at that monitor.

Reference

US EPA, 2007. Guidance on the use of models and other analyses for demonstrating attainment of air quality goals for ozone, $PM_{2.5}$, and regional haze. Office of Air Quality Planning and Standards, 253 pp., EPA-454/B-07-002.

Figure 1. Time series of $PM_{2.5}$ mass at the four FRM sites in New York County in 2003.

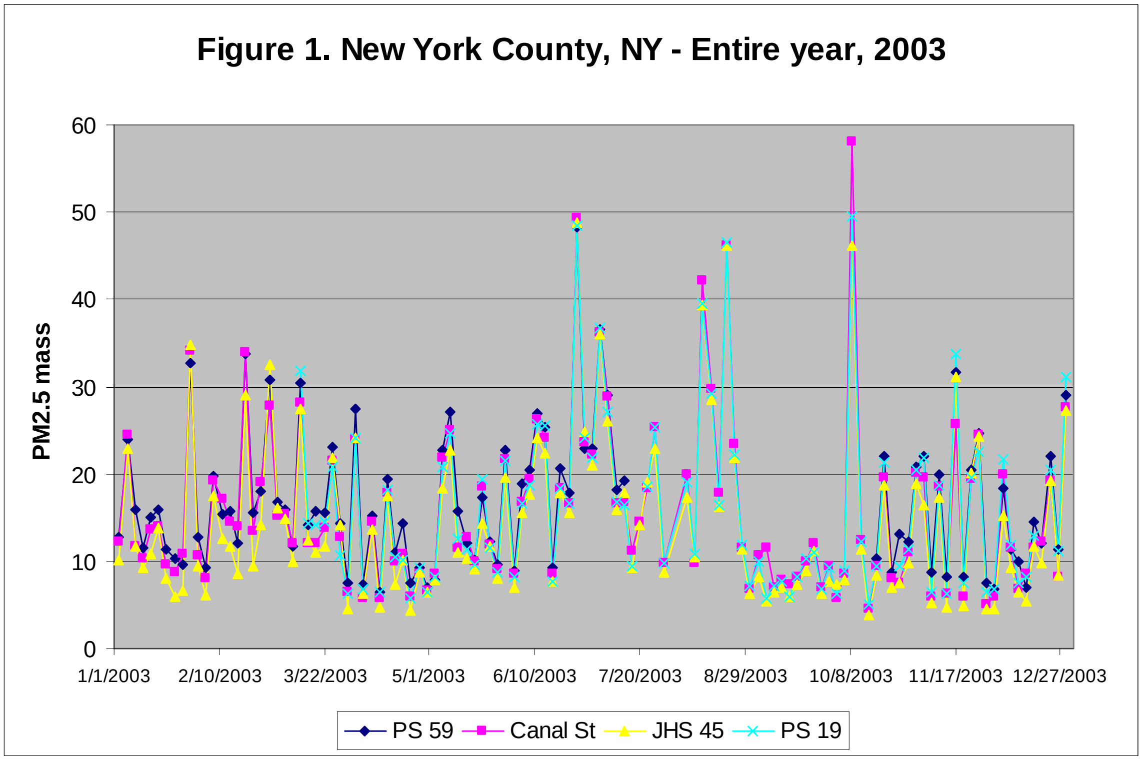
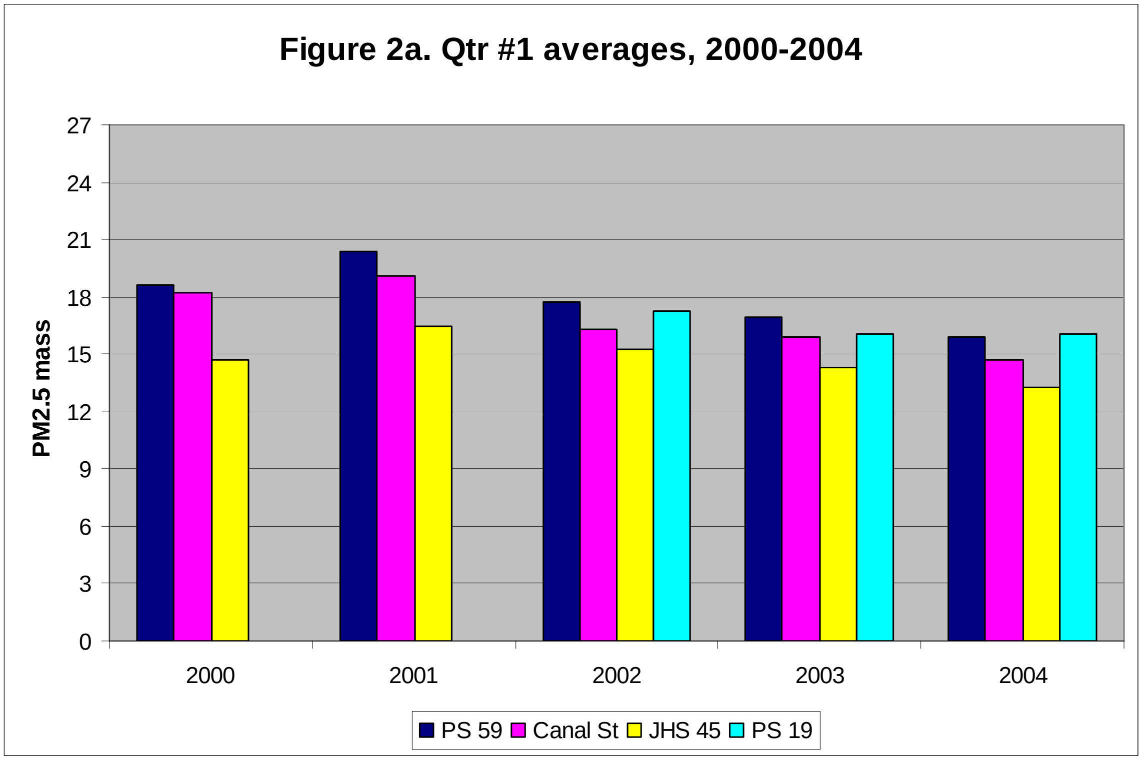


Figure 2. Comparison of quarterly averages at the four FRM monitors in New York County, 2000-2004. (a) Quarter #1, (b) Quarter #2, (c) Quarter #3, and (d) Quarter #4.



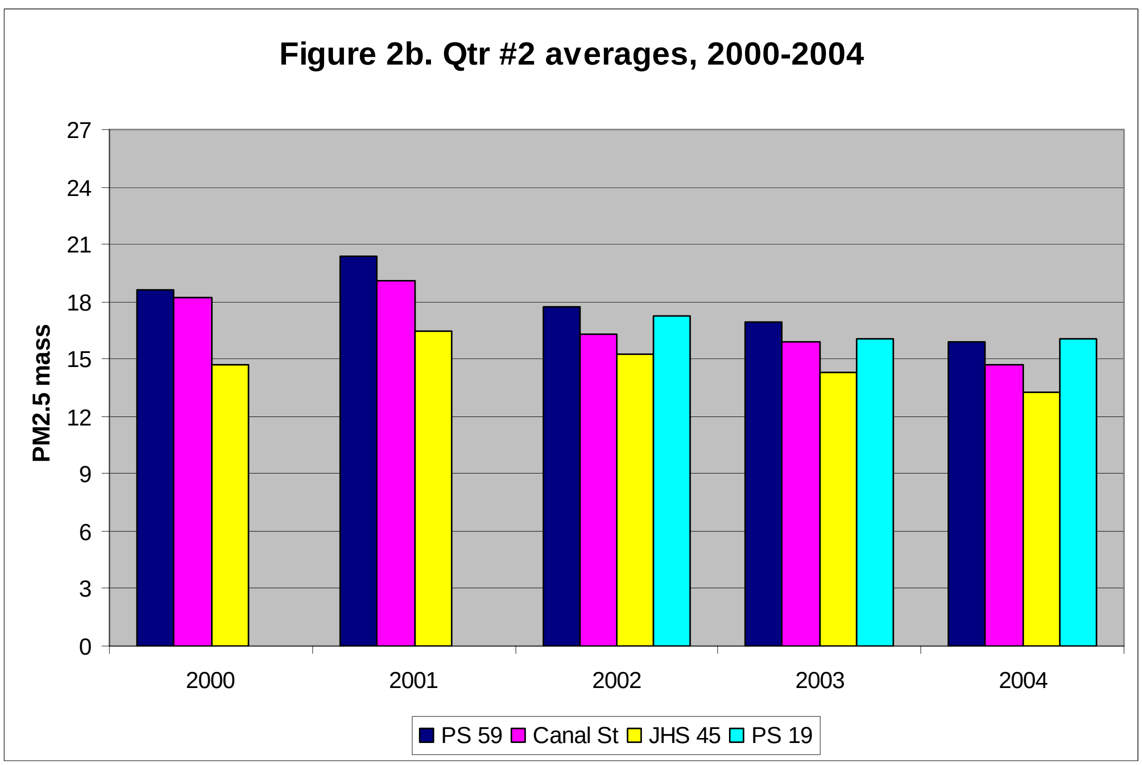
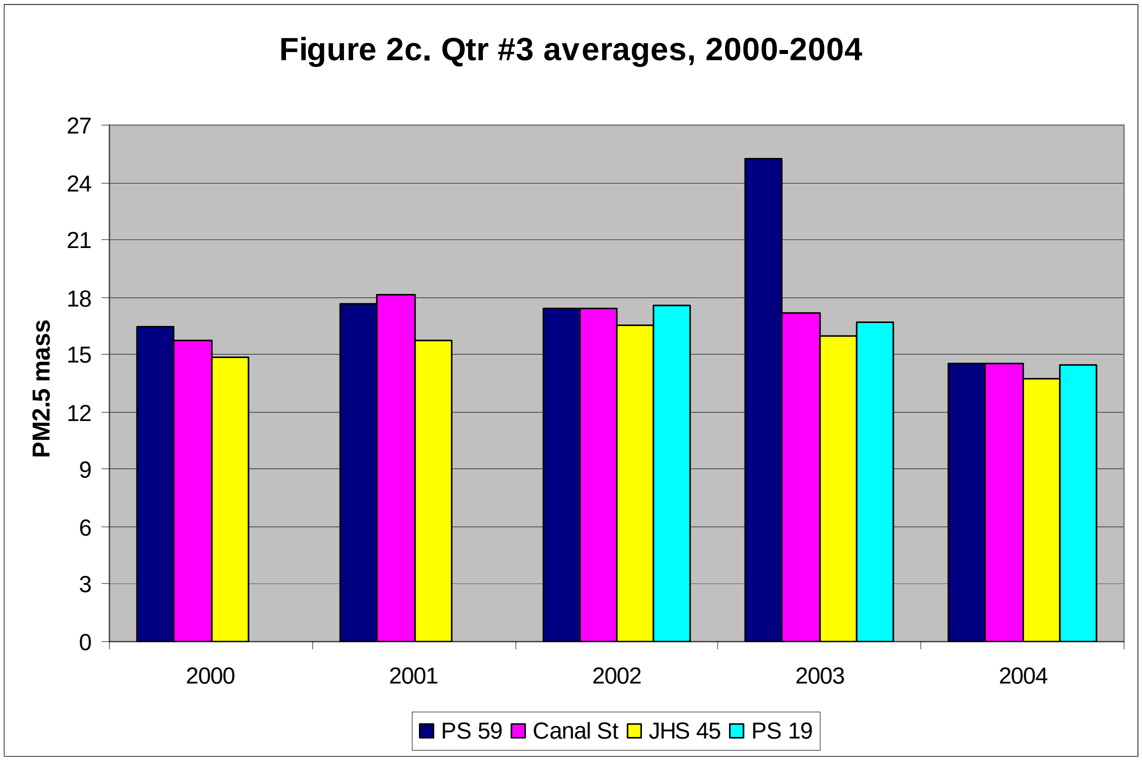
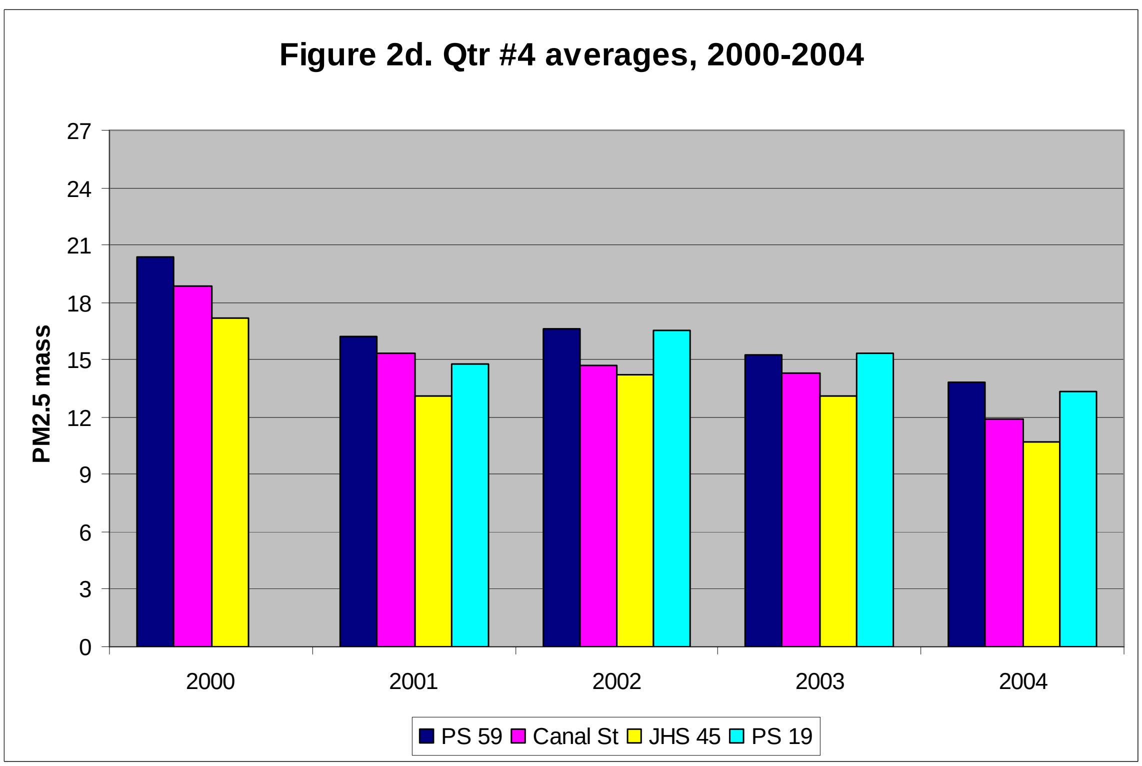


Figure 2 (continued).





Appendix A

PS 59
36-061-0056

New York City Department of Education
Public School 59
228 East 57th Street
New York, NY 10022

PS 59

Address: New York City Department of Education
Public School 59
228 East 57th Street
New York, NY 10022

AQS Number: 36-061-0056
DEC Number: 7093-10
County: New York
Statistical Area: New York City Metropolitan Area
Coordinates: 40.7591 N 73.9666 W

PS 59 was established in midtown Manhattan in July 1985. In 1999 duplicate Federal Reference Method fine particulate samplers were added. In December 2005, one of the $PM_{2.5}$ samplers was changed to a FRM PM_{10} sampler at the request of EPA to evaluate midtown Manhattan PM_{10} levels. The collocated $PM_{2.5}$ sampler was moved to JHS 45 (36-061-0079) at the same time.

The parameters monitored are indicated in the following table:

Parameter	Sampling Method	Analysis Method	Schedule
Sulfur Dioxide	Pulsed Fluorescence TEI 43C Method 060		Continuous
Oxides of Nitrogen	Gas Phase Chemiluminescence TEI 42C Method 074		Continuous
Carbon Monoxide	Gas Filter Correlation TEI 48C Method 054		Continuous
$PM_{2.5}$	R&P 2025 Method 118	Gravimetric RTI Laboratory	1 day in 3
PM_{10}	R&P 2025 Method 127	Gravimetric RTI Laboratory	1 day in 3
Toxics	Summa Canister	GC/MS	1 day in 6

Appendix B

NEW YORK CITY SCHOOL
CONSTRUCTION AUTHORITY

PS59M
3/25/03

March 25, 2003
Revised

Ms. Leslie Zackman, Principal
P.S.59M
228 East 57th Street
New York, NY

Re: Phasing Letter for the Upcoming Project:
LLW# 023607, Design# 006802 Roof Replacements

Dear Ms. Zackman:

As discussed with me, the following items pertaining to the Construction and Phasing Plan were reviewed:

1. **School Hours**

- Normally School hours are Monday through Friday from 8:20 AM to 3:00 PM.
- After School program from 3:00PM to 6:00PM.
- No Saturday or Sunday classes.
- School will not be in session during the Summer of 2003.

2. **Standardized Testing Period**

- The Contractor must allow fifteen non-sequential days during each School year for testing during normal School time during which no work will be allowed.
- The Contractor's work schedule shall account for these days and under no circumstances will the Contractor be granted an extension of time for the completion of this project.

3. **Work Hours for the Project**

- All physical work can be performed weekdays from 6:00 PM to 7:00 AM. Non-disturbing work will be allowed to commence at 3: 00 PM. On Saturdays and Sundays, working hours shall be 8:00 AM to 10:00 PM. The Contractor shall obtain and pay for all Custodial and Dept. of Building Permits required to perform work during non-school hours. These permit requests shall be made a minimum of 5 days in advance of the work period.

30 - 30 Thomson Avenue
Long Island City, NY 11101-3045
TEL 718 472-8000
FAX 718 472-8840
Web Site: www.nycsca.org

RBV
RT2

- Contractor must **not** perform ACM (Asbestos) removals, hot tar roofing, demolition, unloading of materials & equipment, and any operation that may impact the educational process of the School facility or any part of it, between the School hours of 8:00 AM to 6:00 PM. Work requiring shutdown of the School facility or any part of it must be preceded by two (2) week notice, and must be performed during non-school hours.

4. Use of School Stairs/Entrances

- The East 57th St. main entrance west door and stairway for the Contractor's use will be permitted for construction purposes. Only one entrance & stairway shall be used depending where the work is being performed, and for any changes prior approval is to be obtained from the Custodian.

5. Employee Identification

- All the employees working at this project must wear visible photo identification badges that identifies name of the employee, name of the company.. All workers are required to sign in and out in the School's security log book.

6. Use of School Facilities

- The Contractor's employees shall not use any School facilities except as follows:
- The Contractor will not be allowed to use any bathrooms, and shall furnish temporary toilet facilities for his usage. Temporary water can be obtained from existing hose bibs that may be operable. Temporary electric will be properly taken from the appropriate School power panels.
- No loitering in the School will be allowed.
- Absolutely no School equipment is to be used.
- There is no available space in the Basement for construction personnel offices and storage.
- Storage of materials and equipment will be permitted in the Children Playground only within fenced in areas within erected sidewalk sheds.

7. Use of Dumpster

- Custodian and Project Officer will review and approve the location of dumpsters in the adjacent street roadways. Proper DOT permits to be obtained by the Contractor.

8. Construction Trailers

- The Contractor will locate at least two (2) office trailers on E.56th St. One of which will be for the Project Officer.

9. Security Guards

RS
LTV

- A minimum of 0ne(1) uniformed security guard must be present on the site at all times, seven (7) days per week. Security guards must have access to electronic communication with their headquarters and/or with the police department to address any emergencies.

10. **Site Safety Plan and Permits**

- An approved Site Safety Plan will be posted before construction will commence.
- All Construction Permits will be posted, and copies will be given to the Custodian.

11. **Phasing**

- All construction work scheduling to be coordinated in tandem with roofing work at HS of Art & Design.
- The Contractor is to phase his "Scope of Work" to insure that the * School can be used during school hours. Our intent is to first commence work at both the main roof and existing play terrace roof at the 2nd floor In case of unusual conditions the Contractor will give at least two (2) weeks advanced notice, and must receive approval from the Authority and Principal for the closing of any part of the School.
- Job progress meetings will be held every two (2) weeks for coordinating purposes. Written minutes of these meetings will be distributed to the Principal and Custodian.

LTZ
RBS

* INCLUDES 2ND FL. TERRACE PLAYGROUND.

LTZ
RBS
• ROOF-MAIN TO BE COMPLETED BY AUG. 25, 2003 WITH 2ND FL TERRACE PLAYGROUND SHORTLY THEREAFTER. ** SAFE ACCESS TO BE MAINTAINED INTO AND OUT OF THE SCHOOL AT ALL TIMES.

** INCLUDES USE ALSO.

Sincerely,

Robert B. Spear

Robert B. Spear
Project Officer

Concur: Leslie Zackman Date: 3/26/03
Leslie Zackman, Principal

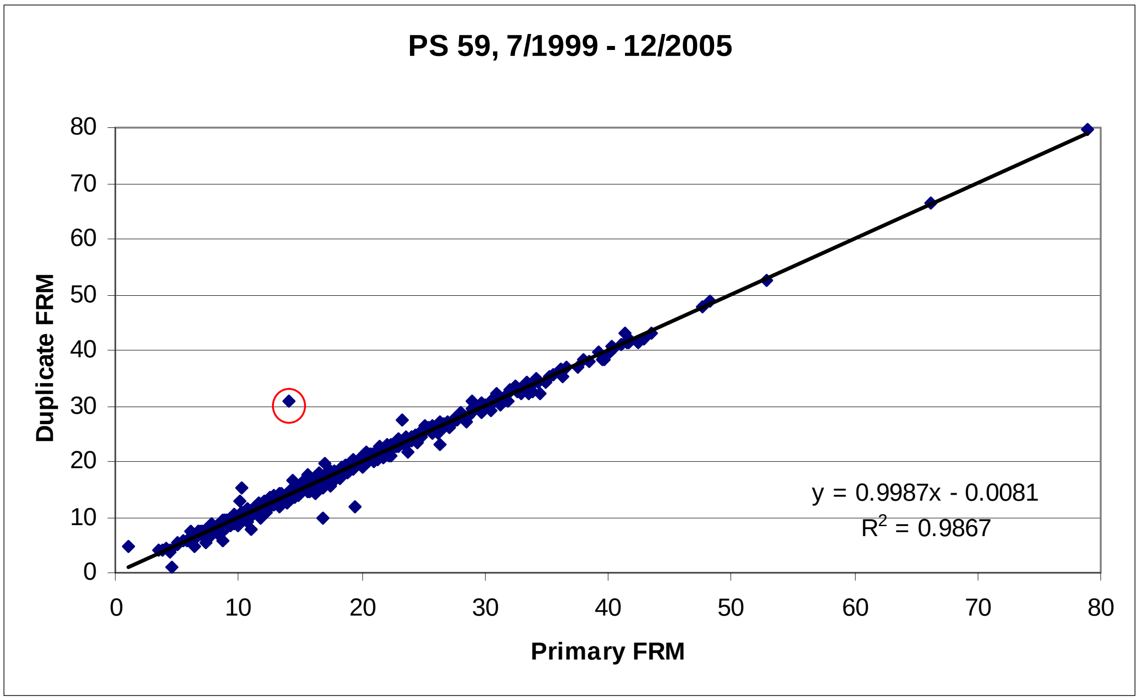
Concur:__________ Date:________
Shelley Harwayne, District 2 Superintendent

Cf: Dan Reddan, VPPM&O, Silviu Herscher, Sr. Dir., Christopher Mitchell, SPO
Michael Mirisola, PSM, Kevin Zodi, Custodian/Engineer

RBS

Comparison of data from the primary and duplicate FRM monitors at PS 59

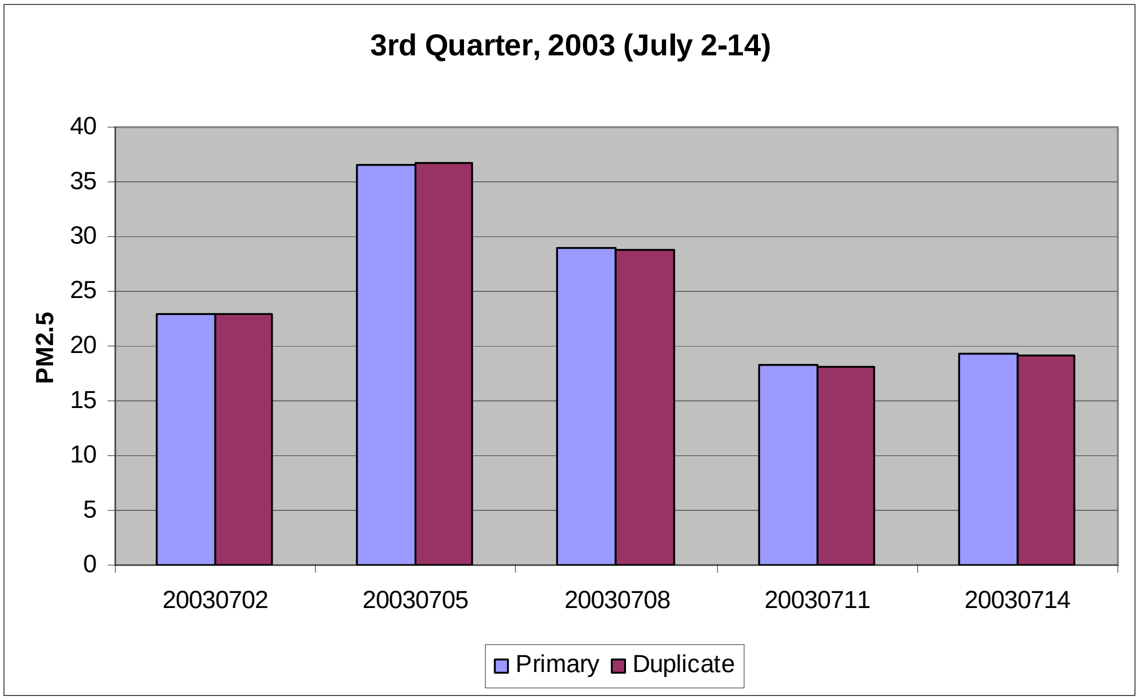
- Both sites started in July 1999; the primary monitor continues to operate but the duplicate monitor was shut down at the end of 2005
- Data were extracted from AQS on December 3, 2007
- There are 644 days during this 6.5 year period with both sets of data available



The overall arithmetic average at the primary monitor is 17.07 μg m^{-3}, while at the duplicate monitor it is 17.04 μg m^{-3}. The average difference ("primary-duplicate") is 0.03 μg m^{-3} and the standard deviation of the difference is 1.05 μg m^{-3}. The central 95% of the differences between the two monitors ranges from -1.2 μg m^{-3} to +1.5 μg m^{-3}. Of the 644 days, there appears to be only one day for which the two monitors differed substantially - January 31, 2001 with the primary and duplicate monitors reporting 14.1 μg m^{-3}, and 30.8 μg m^{-3}, respectively.

Two time periods of interest are considered to highlight the comparability between the two monitors -- July 6-9, 2002 period (very high values due to the Canadian wildfires), and the third quarter of 2003 (only the first five samples were available). On July 7, 2002 – the only FRM sampling day during the wildfire period – the primary FRM recorded 79.0 μg m^{-3}, while the duplicate FRM recorded 79.8 μg m^{-3}. Hence, even on this very high loading day the monitors were within 0.8 μg m^{-3} (1%) of each other.

As per the 3rd quarter of 2003, the following plot displays the data for both monitors that were operational only for five sampling days. Recall that the monitors were shut down for the rest of the quarter. On each of these days the two monitors agree to within 0.2 μg m^{-3}. The averages over these five days were 25.22 μg m^{-3} (primary) and 25.16 μg m^{-3} (duplicate).



Attachment 2

Weight of evidence (WOE) in support of modeled attainment of the $PM_{2.5}$ NAAQS in the New York City non-attainment area

The EPA modeling guidance (US EPA, 2007), in conjunction with ambient Federal Reference Method (FRM) $PM_{2.5}$ mass data from 2000-2004 and baseline and future air quality modeling results, has been applied to determine the attainment status of the New York City non-attainment area (NYC NAA) with respect to the annual National Ambient Air Quality Standard (NAAQS). The application of the EPA guidance for estimating the future design values based on the use of relative response factor (RRF) has resulted in one monitor – P.S. 59 (360610056), located in New York County, NY – to exceed the annual $PM_{2.5}$ NAAQS level of 15 μg m^{-3}. The estimated future $PM_{2.5}$ design value at this monitor, based on this procedure, is 15.3μg m^{-3}. This value falls within the uncertainty range of ±0.5 μg m^{-3} of the annual $PM_{2.5}$ NAAQS, and supplemental analyses are needed for this monitor be considered to be in attainment. In the following sections we provide information to suggest that there is high degree of potential that estimated future design value will be below the annual NAAQS.

Monitoring network in New York County and surroundings

For most of the 2000-2004 period New York County, NY had 4 FRM monitors, but only one Speciation Trends Network (STN) monitor collocated with the FRM at the Canal Street site (360610062) to provide information on composition of the baseline $PM_{2.5}$ species. Figure 1 displays the location of the four monitors as well as monitors in the surrounding counties. Table 1 lists the dates of operation of the FRM monitors in New York County; the base year design value for 2002, which is a weighted average of the measurements in the 2000 to 2004 period; and the nearest STN monitor. It should be noted that not all monitors in New York County were assigned the same STN monitor, because the approach selected was to use the nearest neighborhood monitor to link the FRM and STN. In the case of the J.H.S.45 (36061007) FRM monitor in New York County, the nearest STN monitor is the Bronx County I.S.52 site (360050110), and this site is also included in Table 1.

The current speciation levels estimated at these monitors are listed in Table 2. Only two of these sites – Canal Street and I.S.52 – have collocated STN monitors, while the species composition at the other FRM sites are only estimates based on the speciation data from a nearby monitor. Examination of the speciation data at Canal Street and I.S.52 suggests that there may be fairly substantial gradients in $PM_{2.5}$ species composition over the non-attainment area, on the order of several tenths of a μg m^{-3}. Thus the estimates listed for the other monitors should only be considered approximate, and in some cases may not necessarily be representative of species composition at these monitors. This is certainly a limitation that needs to be taken into consideration when projecting the future design values using the model results and the current speciation levels.

Although the air quality modeling results are to be used in a relative sense, it is instructive to examine the changes in $PM_{2.5}$ mass that the model predicts in an absolute sense to see the direct impacts of emissions reductions. We examined the CMAQ-predicted average $PM_{2.5}$ mass over the nine-grid cells that surround each of these FRM monitors (see Table 3) in the base (2002) and future (2009) years. Note that CMAQ predicts a consistent reduction of about 16% over each FRM monitor in New York County. Although not shown here, future $PM_{2.5}$ concentrations at each FRM location across the 22-county NYC NAA are predicted by CMAQ to decrease by 12-18%.

<u>Estimate of future design values</u>

Table 4 lists the base year and projected future design values based on the EPA Guidance. The only monitor that is projected to be above 15μg m^{-3} in 2009 is P.S.59 (360610056). In fact, none of the other monitors in the 22-county metropolitan non-attainment area is projected to exceed the lower end of the margin of safety range of 14.5μg m^{-3}. This suggests that on an overall basis the planned emissions reductions are projected to improve the $PM_{2.5}$ air quality over the NYC NAA.

Noting that there is only one other monitor (360610062) that is above 16μg m^{-3} besides 360610056, and that it is collocated with STN providing an estimated future design value of 14.4μg m^{-3} that is below the annual $PM_{2.5}$ NAAQS. If a simple linear extrapolation is used to compare these two monitors, then the projected future design value for P.S.59 would be 14.9μg m^{-3} and thus below the annual $PM_{2.5}$ NAAQS. Also, the change estimated based on the guidance between 2009 and 2002 at 360610062 is 1.9μg m^{-3}, whereas at 360610056 the decrease is only 1.6μg m^{-3}.

<u>Other data analysis</u>

A recent study by Qin et al. (2006) suggest that sum of sulfate and nitrate comprise about 40% or more of the $PM_{2.5}$ mass in the NYC metropolitan area, and that 70% or more of the $PM_{2.5}$ measured in NYC results from transport into the region. Based on results from source apportionment modeling using Positive Matrix Factorization (PMF), the authors determined that the largest single source factor affecting NYC is "secondary sulfate" associated with SO_2 emissions from upwind regions. It is clear that emission reductions in upwind states will be needed to further reduce $PM_{2.5}$ in the NYC NAA.

In an earlier chapter (TSD-3a), we showed that $PM_{2.5}$ levels appear to be decreasing across the NYC NAA. Although the data records for $PM_{2.5}$ are somewhat short, we estimated that $PM_{2.5}$ mass is decreasing by about 0.1-0.5μg m^{-3} yr^{-1}. At the P.S.59 site $PM_{2.5}$ mass measurements are decreasing by about 0.3μg m^{-3} yr^{-1} during 1999-2006. In addition to $PM_{2.5}$ mass, several criteria pollutants are also measured at the P.S.59 site. We examine the trends in SO_2 and NO_2 from 1993 to 2006 using the seasonal Kendall test, and found that ambient levels are declining at rates of 3.4% yr^{-1} and 1.7% yr^{-1}, respectively. This again points to the potential that this area would be meeting the annual NAAQS, given that there are various measures under consideration that are aimed at decreasing the emissions of $PM_{2.5}$ precursors.

Summary

In summary, the above analysis shows that, based upon the EPA guidance only one monitor in the New York $PM_{2.5}$ nonattainment area falls slightly above the level of the annual NAAQS, but still within the framework of uncertainty. The analysis suggests that lack of collocated speciation monitors and use of speciation information from the nearest neighborhood monitor may have contributed to the estimate of $PM_{2.5}$ being above the level of NAAQS at the P.S.59 monitor. Examining the trends in precursors as well as measured $PM_{2.5}$ at P.S.59 suggests a downward path and that coupled with the observation that the contribution to the secondary species is from upwind regions rather than local, favors strongly that this monitor will also be in attainment similar to the rest of them in the region. Analysis based on the only other monitor (360610062) with similar $PM_{2.5}$ concentrations is projected to be below the level of the annual NAAQS, suggests that P.S.59 (360610056) would also be similarly be below the level of the annual NAAQS.

Reference

Qin, Y., Kim., E., Hopke, P. K., 2006. The concentrations and sources of $PM_{2.5}$ in metropolitan New York City. Atmospheric Environment 40, S312-S332.

TSD-3a (2007) Analysis of Ambient $PM_{2.5}$ Mass and Speciation for the New York metropolitan area through 2006. NYSDEC, Division of Air Resources, Albany, NY 12233.

United States Environmental Protection Agency (US EPA), 2007. Guidance on the use of models and other analyses for demonstrating attainment of air quality goals for ozone, $PM_{2.5}$, and regional haze. Office of Air Quality Planning and Standards, 253 pp., EPA-454/B-07-002.

Table 1. Information for the five FRM monitors considered in this analysis: site name and ID, dates of operation during 2000-2004, base year $PM_{2.5}$ design value, and the nearest STN monitor.

Site Name	FRM site	Operational periods during 2000-2004	Base year Design Value, $\mu g\ m^{-3}$	Nearest STN monitor
P.S.59	360610056	1st qtr 2000 – 4th qtr 2004	16.9	360610062
Canal St	360610062	1st qtr 2000 – 4th qtr 2004	16.3	360610062
J.H.S.45	360610079	1st qtr 2000 – 4th qtr 2004	14.7	360050110
P.S.19	360610128	3rd qtr 2001 – 4th qtr 2004	15.9	360610062
I.S.52	360050110	1st qtr 2000 – 4th qtr 2004	14.7	360050110

Table 2. Current $PM_{2.5}$ species composition at each site: sulfate (SO_4), retained nitrate (NO_3r), organic carbon (OC), elemental carbon (EC), particle-bound water (PBW), retained ammonium (NH_4), and other primary $PM_{2.5}$ (OPP).

FRM site	SO_4	NO_3r	OC	EC	PBW	NH_4	OPP
360610056	4.98	1.50	3.81	1.51	1.65	2.19	0.77
360610062*	4.81	1.40	3.66	1.45	1.59	2.10	0.74
360610079	4.41	1.05	3.58	1.13	1.47	1.84	0.71
360610128	4.68	1.39	3.59	1.42	1.55	2.05	0.72
360050110*	4.39	1.08	3.56	1.14	1.46	1.84	0.71

* FRM Monitor with collocated STN

Table 3. Annual average $PM_{2.5}$ mass over the nine grid cells surrounding each monitor from the base year (2002) and future year (2009) CMAQ simulations, as well as the absolute and percent reductions.

FRM site	2002 avg., $\mu g\ m^{-3}$	2009 avg., $\mu g\ m^{-3}$	Change ($\mu g\ m^{-3}$)	Change (%)
360610056	24.28	20.51	-3.77	-15.5
360610062	23.70	19.80	-3.90	-16.5
360610079	24.28	20.51	-3.77	-15.5
360610128	23.66	20.01	-3.65	-15.4
360050110	24.28	20.51	-3.77	-15.5

Table 4. Base and future year $PM_{2.5}$ design values.

FRM site	Base Year Design Value, $\mu g\ m^{-3}$	Future $PM_{2.5}$ Design Value, $\mu g\ m^{-3}$
360610056	16.9	15.3
360610062	16.3	14.4
360610079	14.7	13.3
360610128	15.9	14.3
360050110	14.7	13.3

Figure 1.