



Connecticut Department of Energy and Environmental Protection



Cold Season 2013-2014 PM2.5 Connecticut Exceedance Days Through February 20th, 2014

June 5, 2014

Michael Geigert

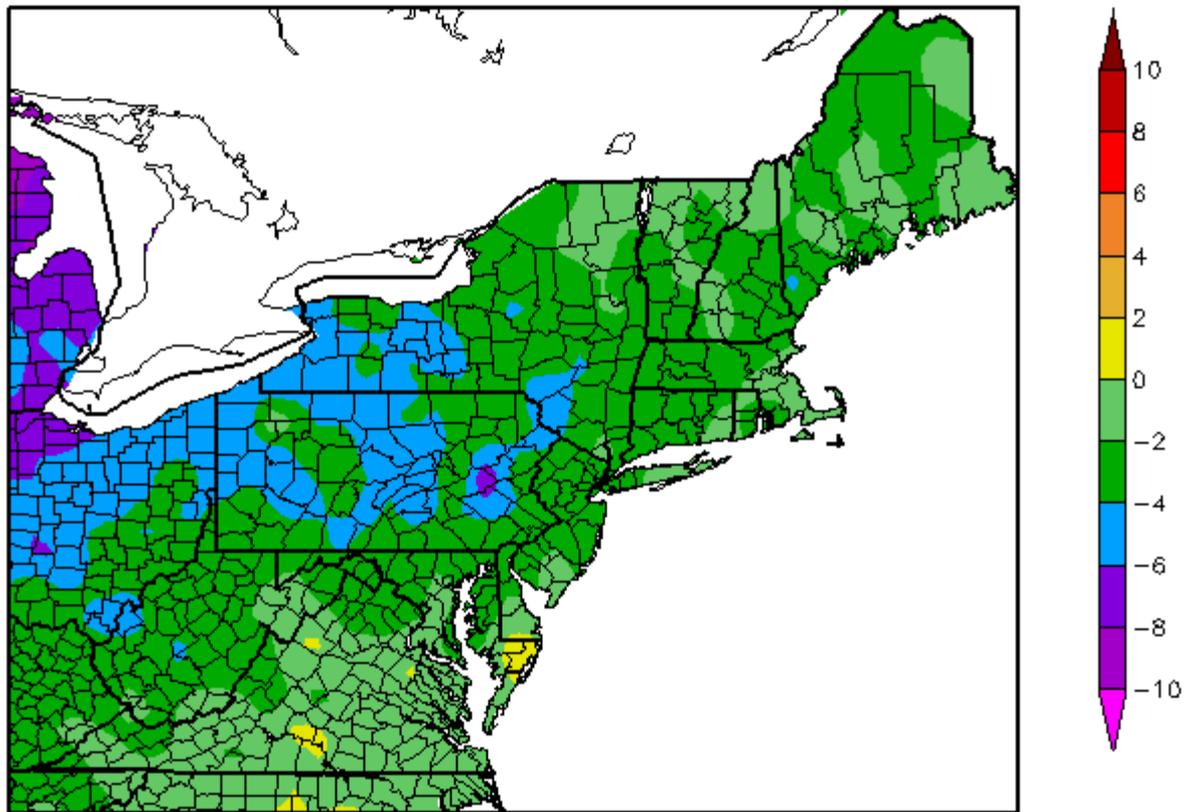
Siprac Meeting



Connecticut Department of Energy and Environmental Protection

- Winter of 2013-2014 colder than normal

Departure from Normal Temperature (F)
12/1/2013 – 2/28/2014



PM2.5 Sampling

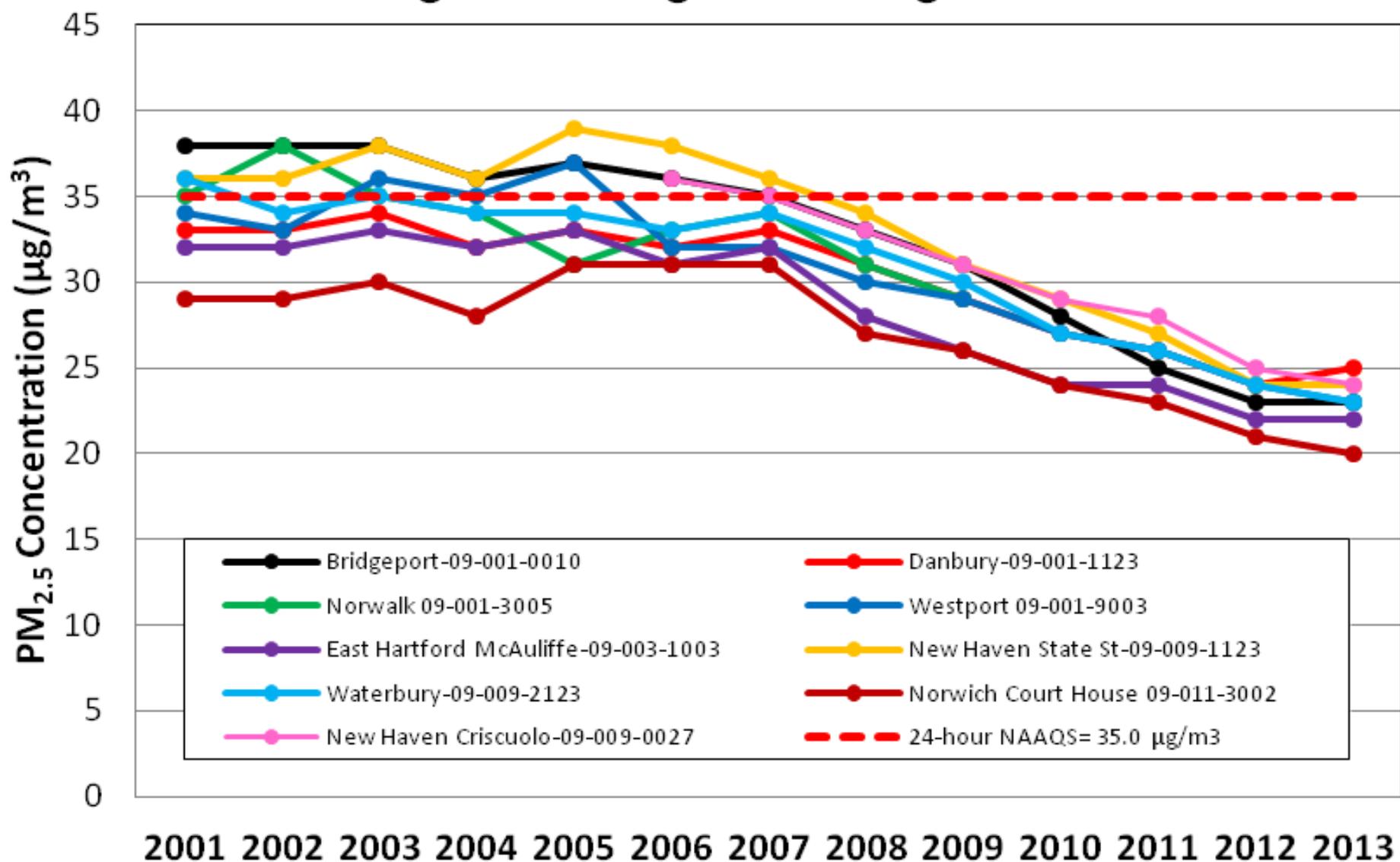


DEEP operates 9 PM2.5 FRM (filter based) sites in the air monitoring network using Thermo Partisol®-Plus 2025/2025i sequential air samplers. Two of the sites, Criscuolo Park in New Haven and McAuliffe Park in East Hartford, operate on a daily sample schedule while all the other sites operate on a 1-in-3 day sample schedule.



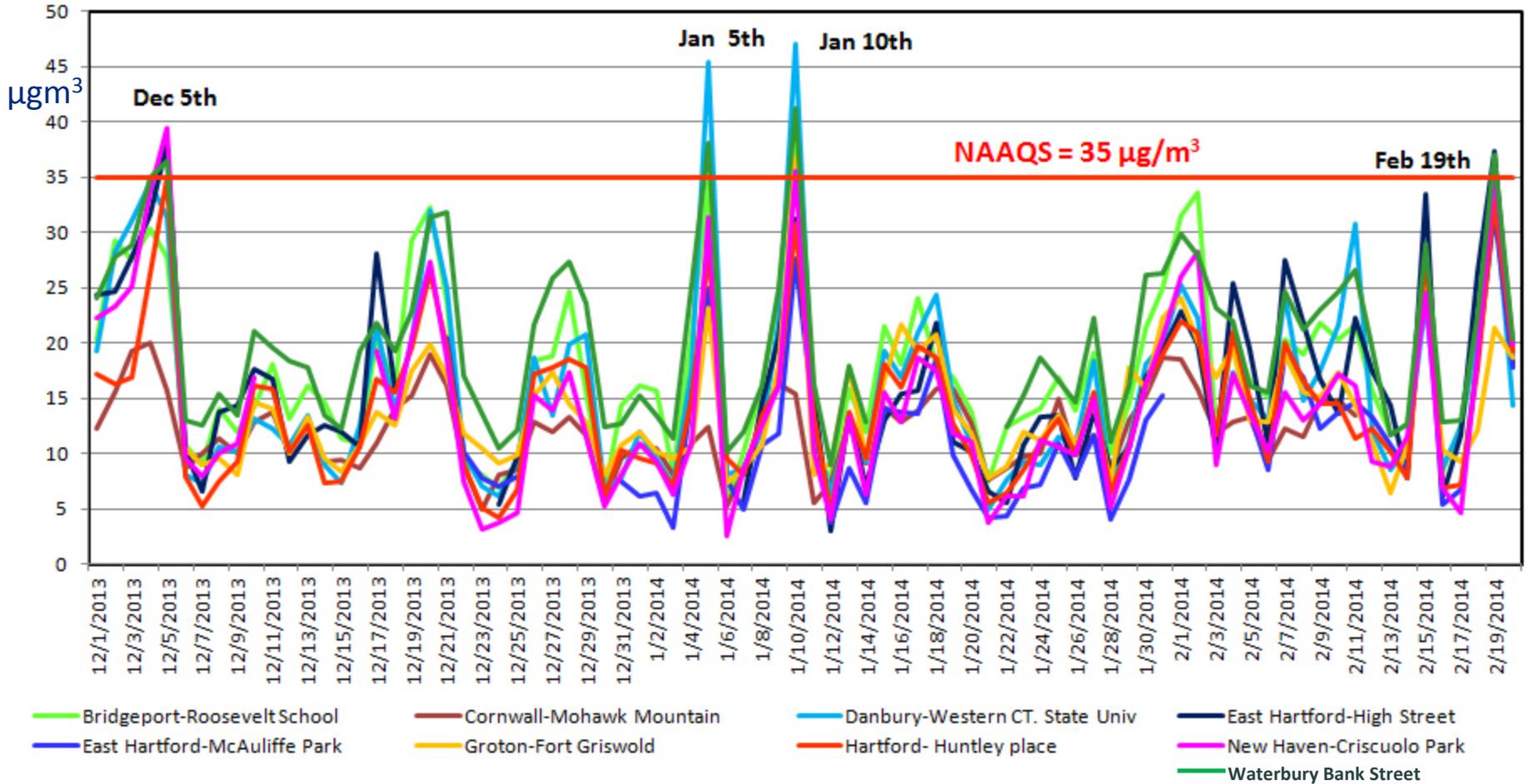
DEEP operates eleven continuous PM monitors at nine sites. This network includes continuous MetOne BAM 1020PM2.5 samplers at each of the nine sites, and paired continuous MetOne 1020 BAM PM10/ PM10-2.5 samplers at the two Ncore sites (New Haven and Cornwall). All BAM monitors are operated year-round and the hourly data is reported to AQS and is used for air quality index (AQI) reporting

PM_{2.5} 24-Hr Design Values of Connecticut's Longest Running Monitoring Sites



- 4 days where continuous PM2.5 monitors over NAAQS

Continuous PM2.5 Data December 1, 2013- February 20, 2014



PM2.5 FRM Sampling Day Calendars

December

Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

January

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

February

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

3-Day schedule is shown in orange, green, and purple

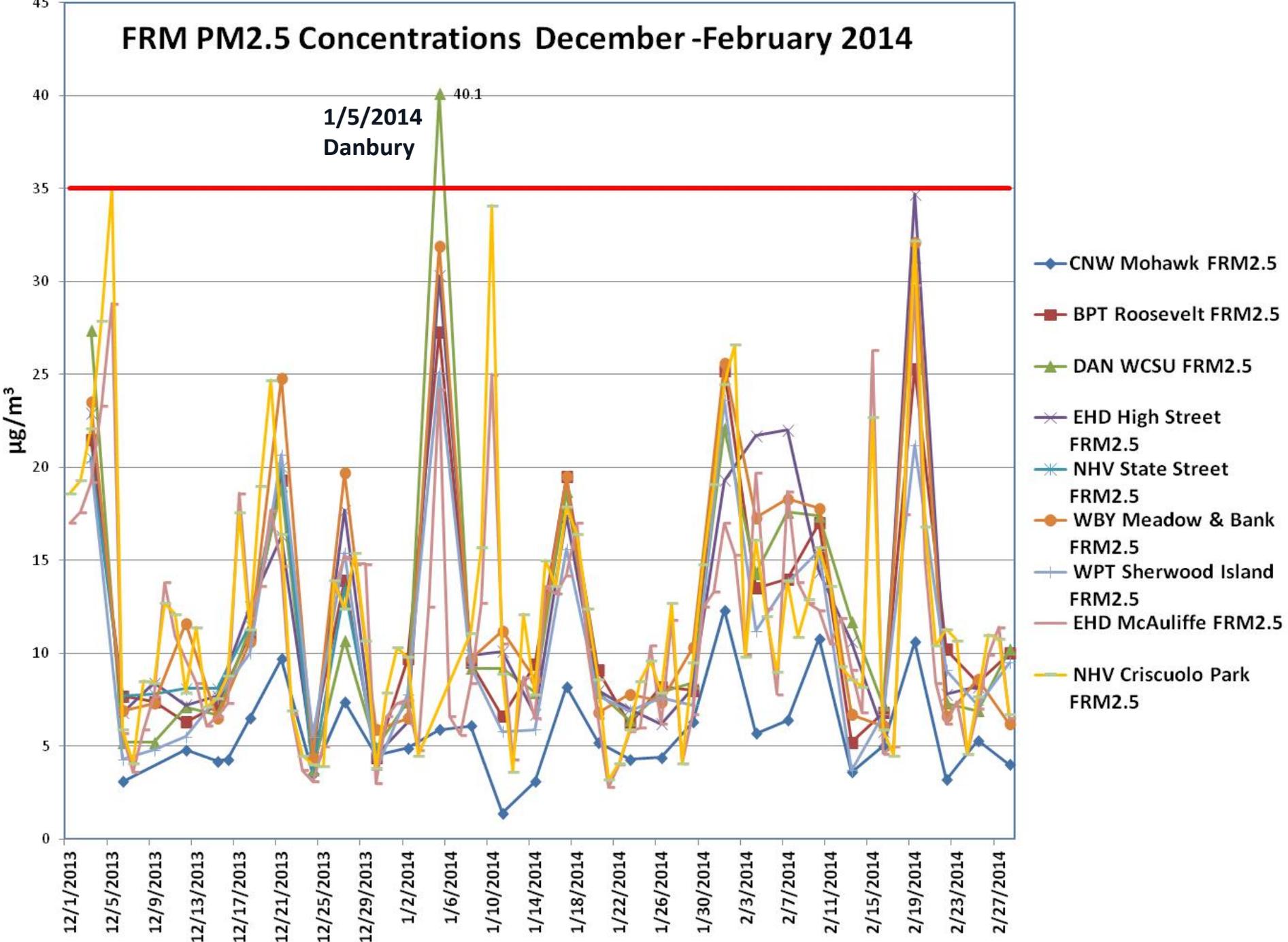
6-Day schedule is shown in green and purple

12-Day schedule is shown in purple

January 5th and February 19th 2014 were FRM sampling day coincident (every 3)

- Therefore all sites with FRMs will risk an exceedance day on January 5th and Feb 19th, 2014
- Note that starting in 2014: Bridgeport, Groton and Waterbury BAMS are now FEM!

FRM PM2.5 Concentrations December -February 2014



1/5/2014
Danbury

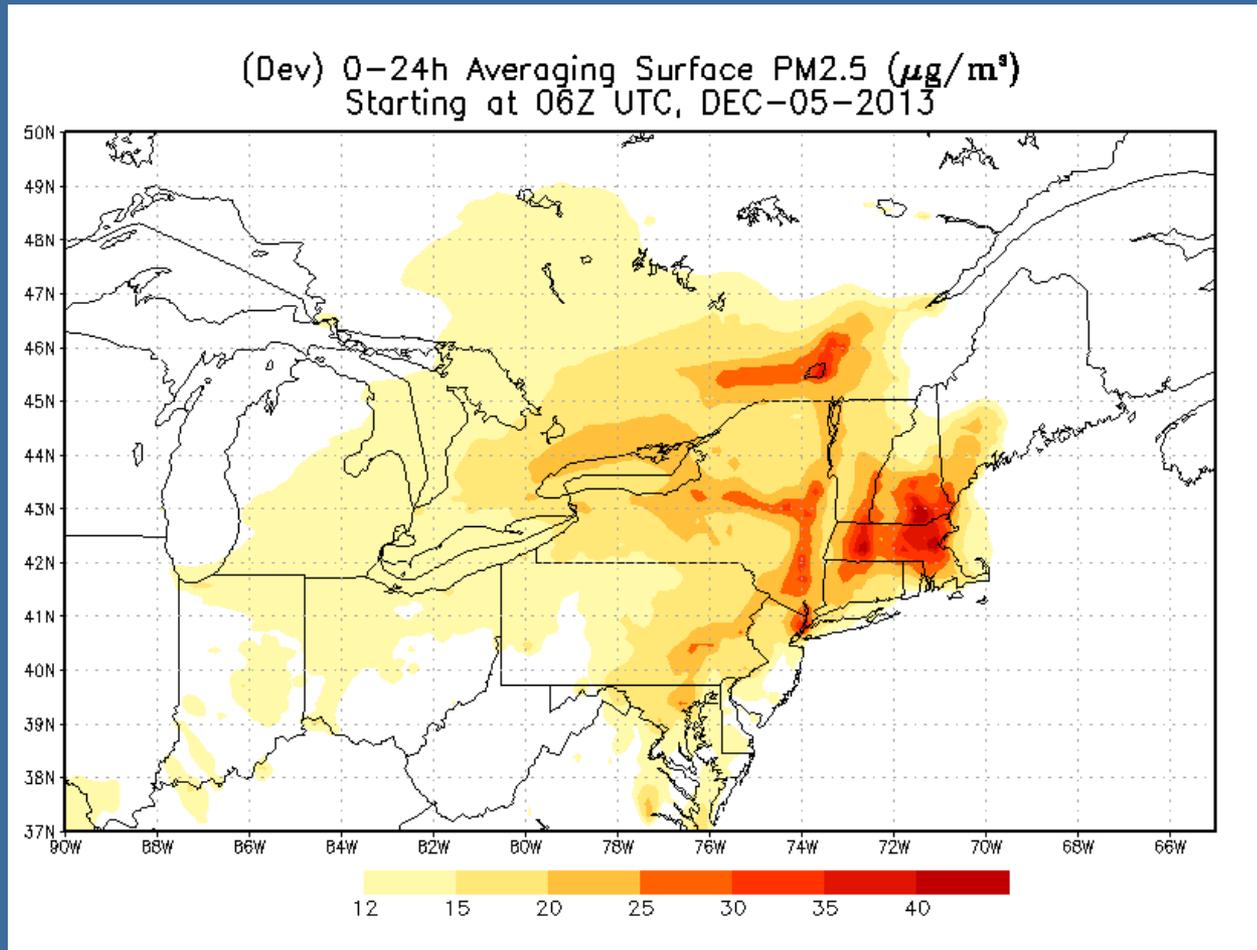
40.1

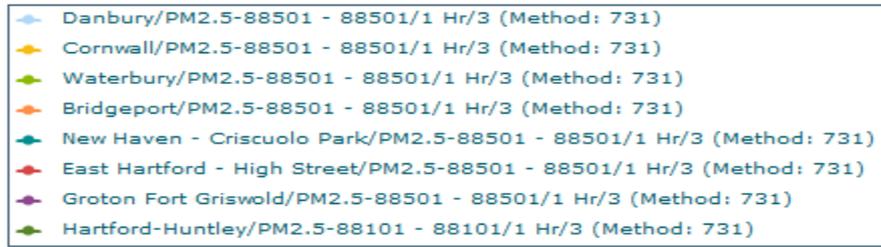
µg/m³

- ◆ CNW Mohawk FRM2.5
- BPT Roosevelt FRM2.5
- ▲ DAN WCSU FRM2.5
- ✕ EHD High Street FRM2.5
- ✱ NHV State Street FRM2.5
- WBY Meadow & Bank FRM2.5
- ⊕ WPT Sherwood Island FRM2.5
- ⊖ EHD McAuliffe FRM2.5
- ⚡ NHV Criscuolo Park FRM2.5

December 5, 2013 event

As modeled by NOAA PM2.5 model- same day
Under predicted by $10 \mu\text{g}/\text{m}^3$

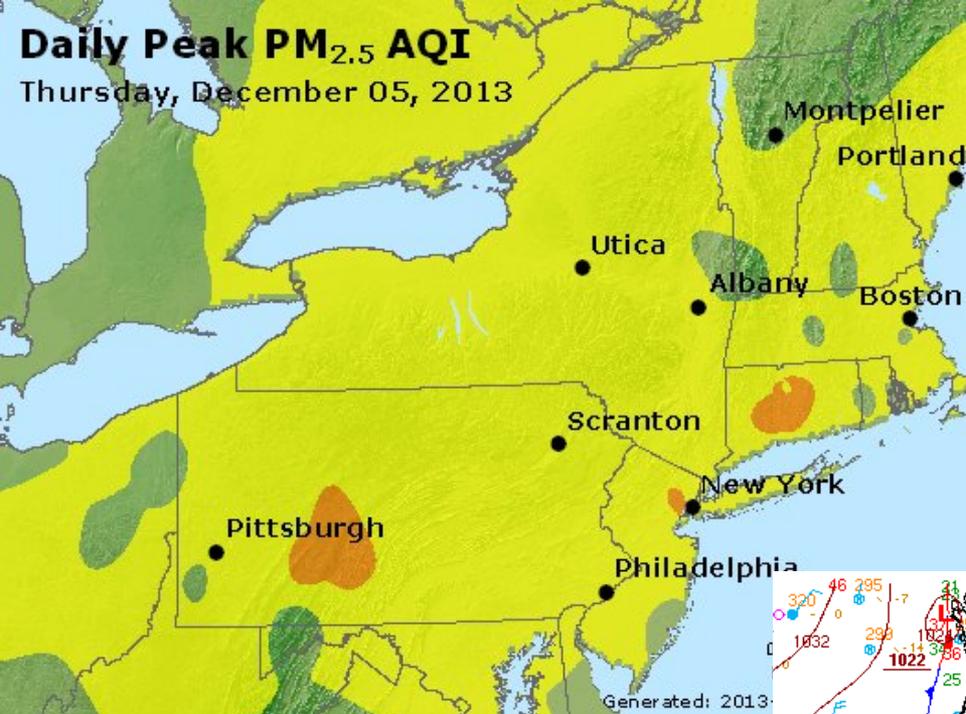




Site/Site AQS/Param/POC	Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Bridgeport/090010010/PM2.5-88501/3	12/05/13	25	31	29	33	32	36	36	37	36	36	40	33	29	25	18	24	25	15	21	18	20	24	20	23	27.75
Cornwall/090050005/PM2.5-88501/3	12/05/13	38	33	37	23	26	23	8	11	15	17	10	16	12	12	18	7	10	12	11	12	9	6	5	5	15.67
Danbury/090011123/PM2.5-88501/3	12/05/13	32	34	30	27	28	33	31	32	38	35	44	48	40	37	40	39	27	14	24	24	24	20	26	26	31.38
East Hartford -/090032006/PM2.5-88501/3	12/05/13	34	29	27	23	26	25	23	30	31	32	28	32	40	47	43	46	56	59	59	63	66	52	22	21	38.08
Groton Fort Gri/090110124/PM2.5-88501/3	12/05/13	34	30	33	28	28	25	24	31	27	29				22				16	11	12	12	12	11	6	21.72
Hartford-Huntle/090030025/PM2.5-88101/3	12/05/13	22	25	20	23	24	19	19	20	29	31	27	27	38	36	37	47	44	52	56	61	68	50	43	21	34.96
New Haven - Cri/090090027/PM2.5-88501/3	12/05/13	43	42	34	30	33	30	35	31	33	35	33	37	40	51	49	52	53	57	54	52	53	31	17	21	39.42
Waterbury/090092123/PM2.5-88501/3	12/05/13	31	33	33	32	29	35	32	41	39	38	39	42	46	56	47	47	35	35	36	38	37	28	24	20	36.38

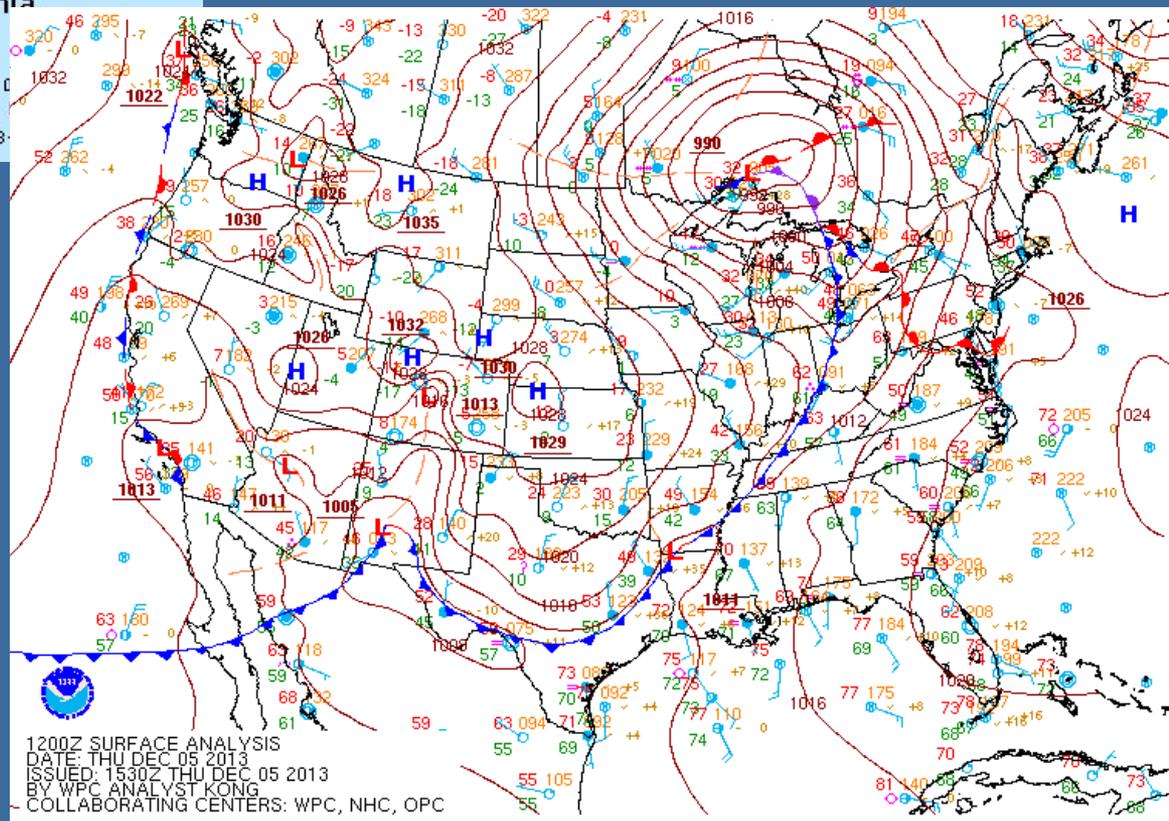
Daily Peak PM_{2.5} AQI

Thursday, December 05, 2013



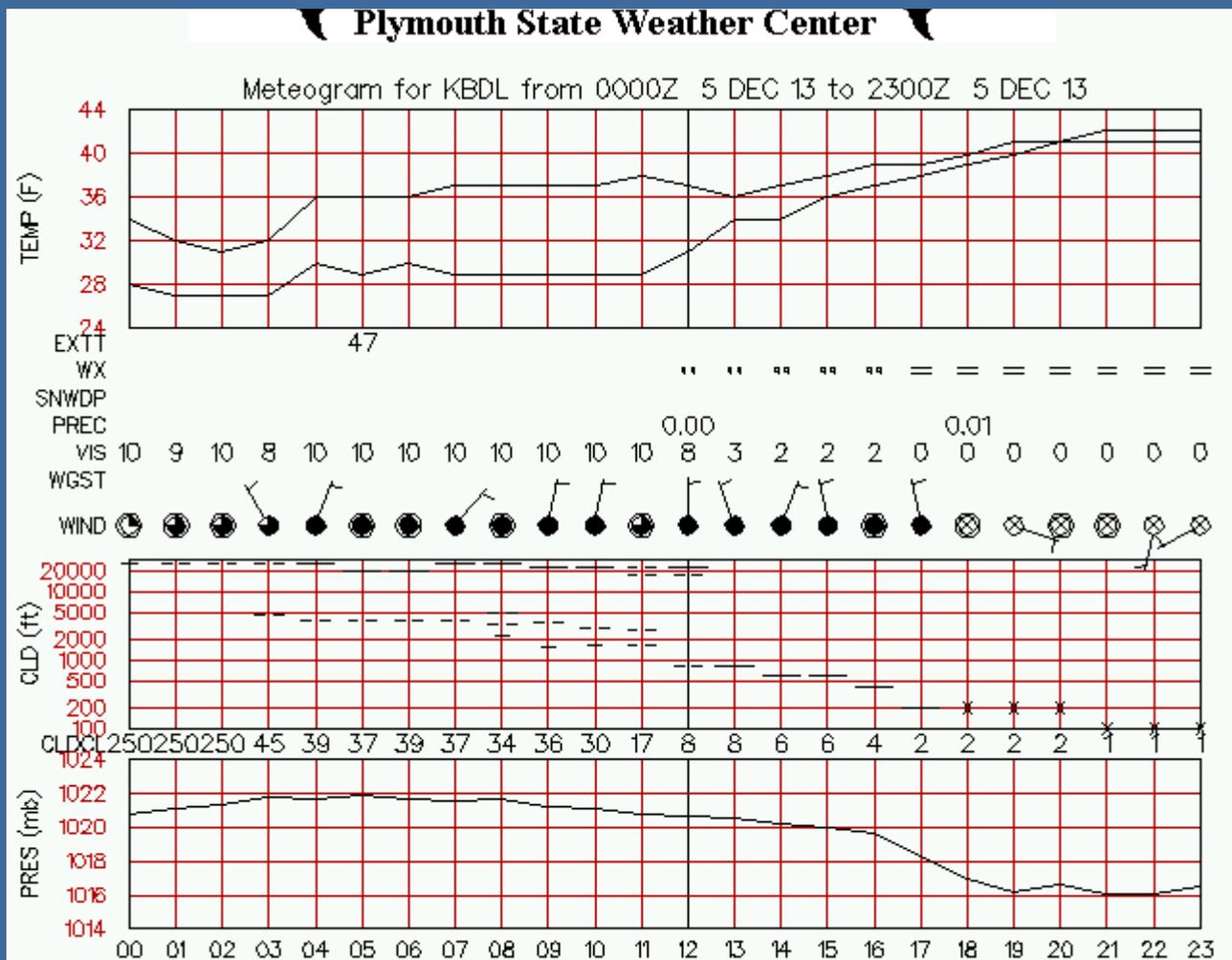
Synoptic Conditions:
Weak high pressure, light winds with inversion conditions. Warm front approaching.

Widespread MODERATE PM_{2.5} event over the northeast with several site exceedances.



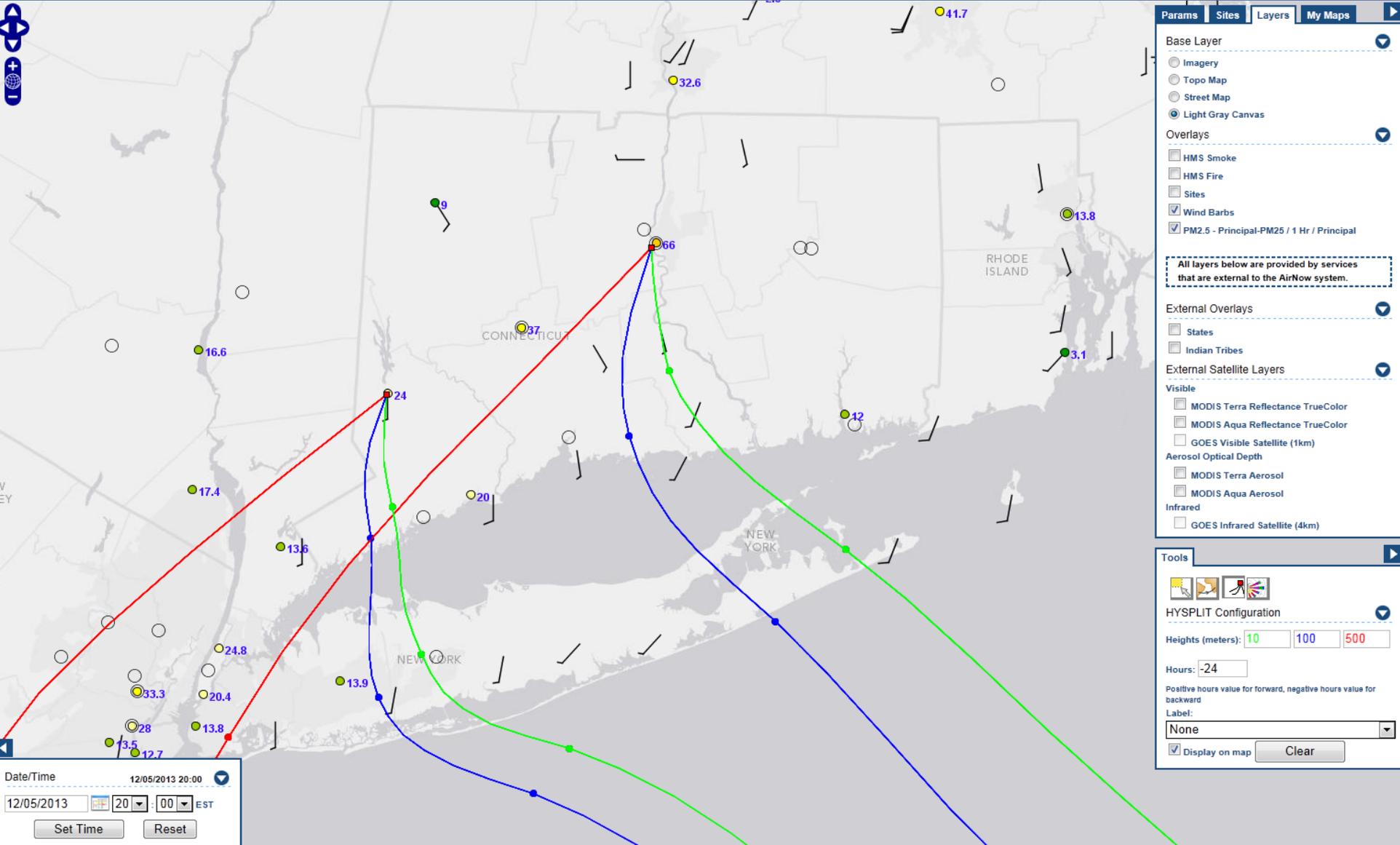
Hourly weather data from Bradley Airport (from 7pm day before)

- Light winds
- Low cloud base
- Fog and drizzle



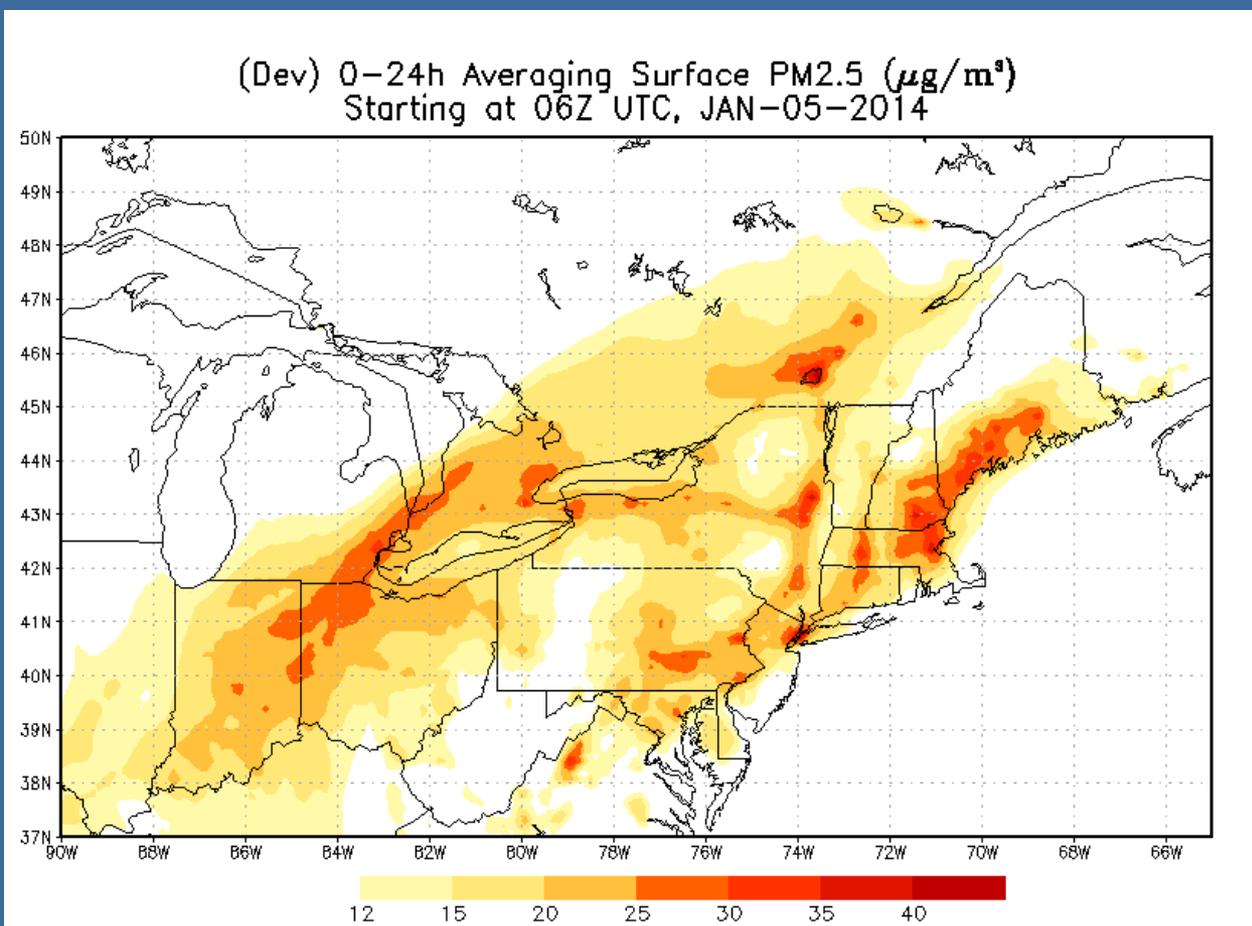
24-hour 3-level Back-Trajectory Analysis from 8pm, Dec 5, 2013

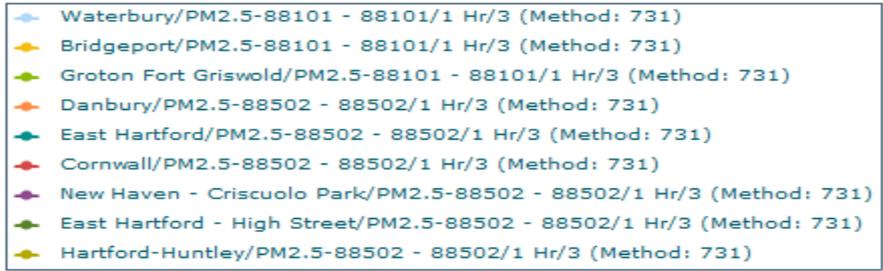
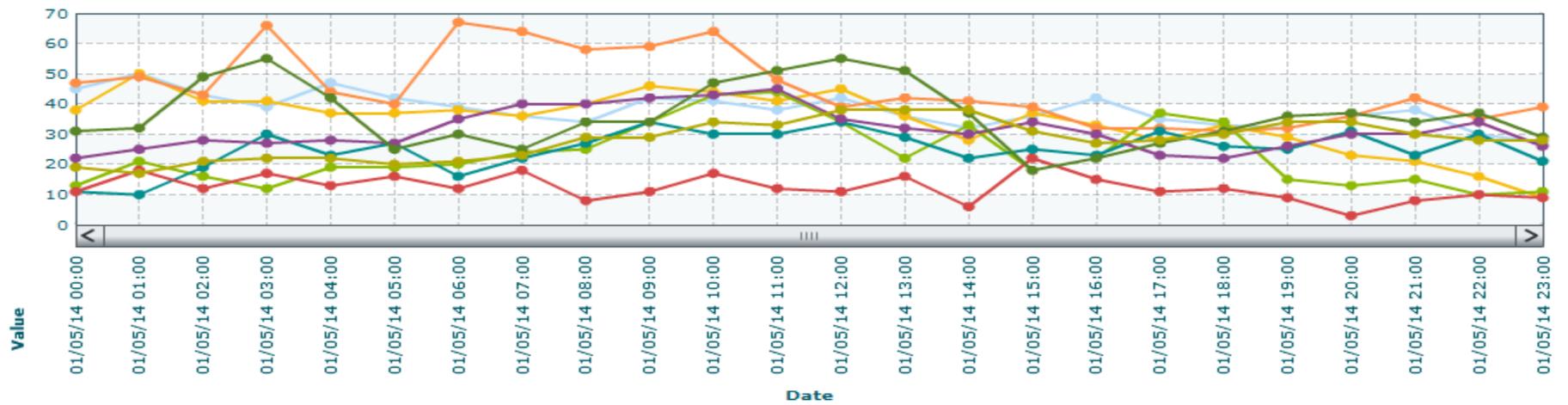
- Low level maritime flow- too light to ventilate atmosphere



January 5, 2014 event

As modeled by NOAA PM2.5 model- same day
Under predicted by $15 \mu\text{g}/\text{m}^3$

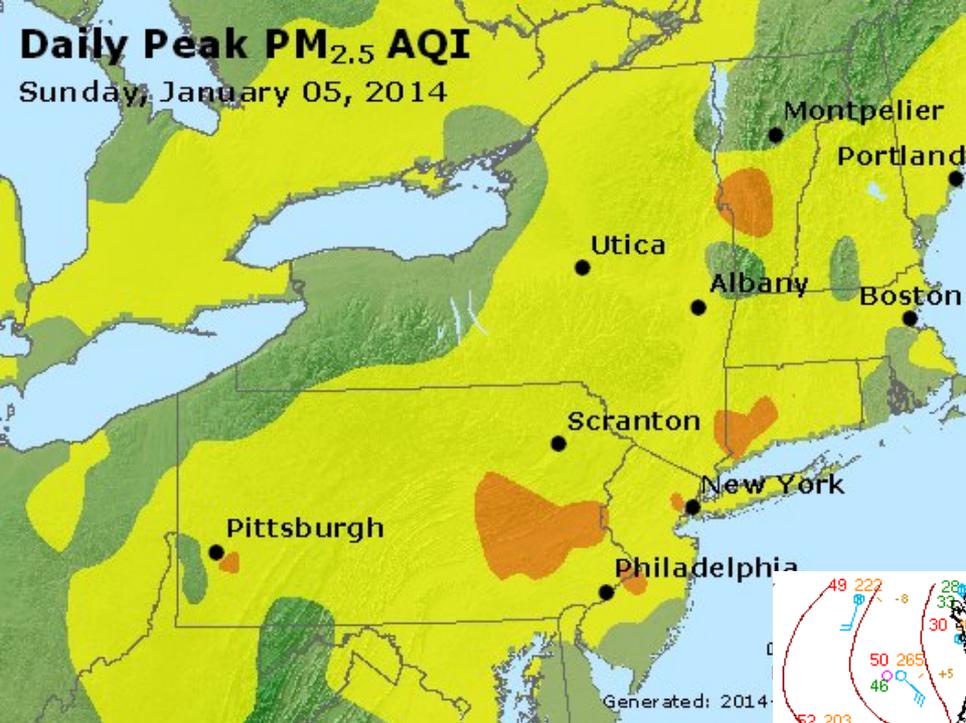




Site/Site AQS/Param/POC	Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Bridgeport/090010010/PM2.5-88101/3	01/05/14	38	50	41	41	37	37	38	36	40	46	44	41	45	36	28	37	33	28	33	29	23	21	16	9	34.46
Cornwall/090050005/PM2.5-88502/3	01/05/14	11	18	12	17	13	16	12	18	8	11	17	12	11	16	6	22	15	11	12	9	3	8	10	9	12.38
Danbury/090011123/PM2.5-88502/3	01/05/14	47	49	43	66	44	40	67	64	58	59	64	48	39	42	41	39	32	32	31	32	36	42	35	39	45.38
East Hartford - /090032006/PM2.5-88502/3	01/05/14	31	32	49	55	42	25	30	25	34	34	47	51	55	51	37	18	22	27	31	36	37	34	37	29	36.21
East Hartford/090031003/PM2.5-88502/3	01/05/14	11	10	19	30	23	27	16	22	27	34	30	30	34	29	22	25	23	31	26	25	31	23	30	21	24.96
Groton Fort Gri/090110124/PM2.5-88101/3	01/05/14	13	21	16	12	19	19	20	24	25	34	43	44	34	22	33	18	22	37	34	15	13	15	10	11	23.08
Hartford-Huntle/090030025/PM2.5-88502/3	01/05/14	19	17	21	22	22	20	21	23	29	29	34	33	38	38	38	31	27	28	30	34	34	30	28	28	28.08
New Haven - Cri/090090027/PM2.5-88502/3	01/05/14	22	25	28	27	28	27	35	40	40	42	43	45	35	32	30	34	30	23	22	26	30	30	34	26	31.42
Waterbury/090092123/PM2.5-88101/3	01/05/14	45	50	43	39	47	42	39	36	34	42	41	38	42	36	32	36	42	35	33	32	36	38	30	27	38.13

Daily Peak PM_{2.5} AQI

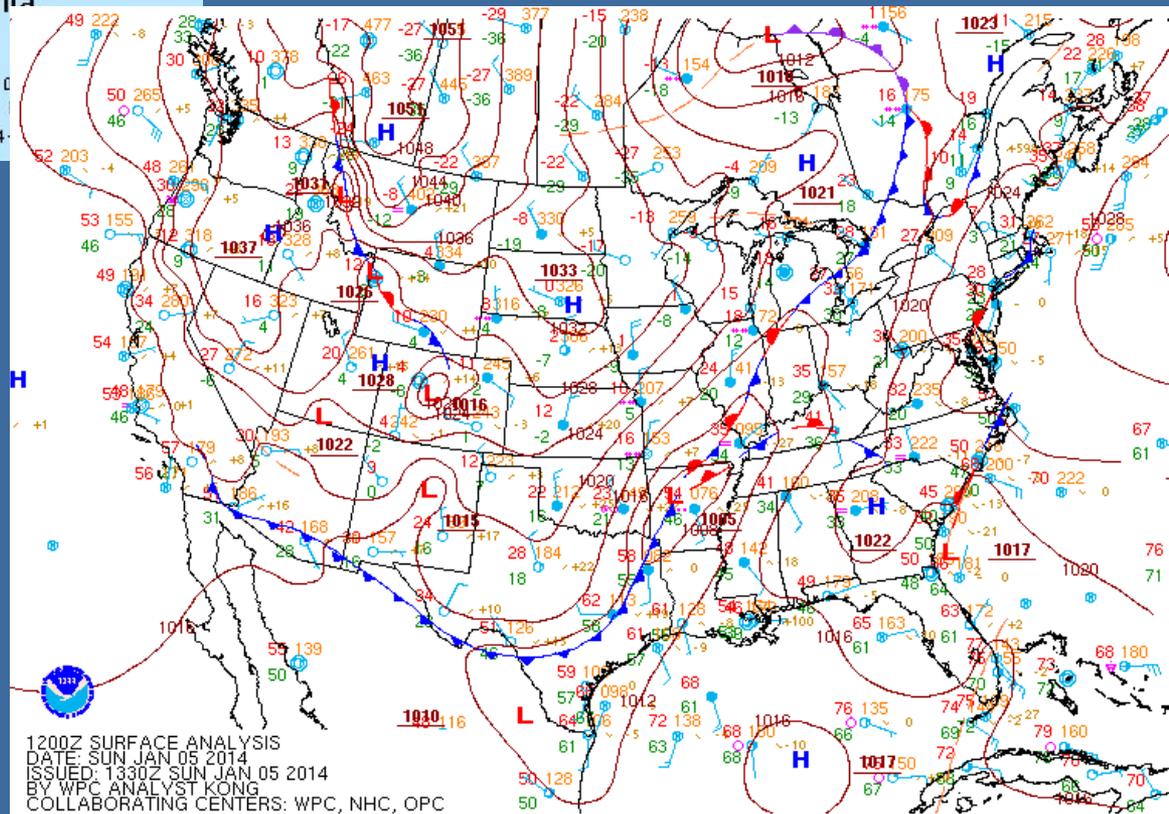
Sunday, January 05, 2014



Synoptic Conditions:

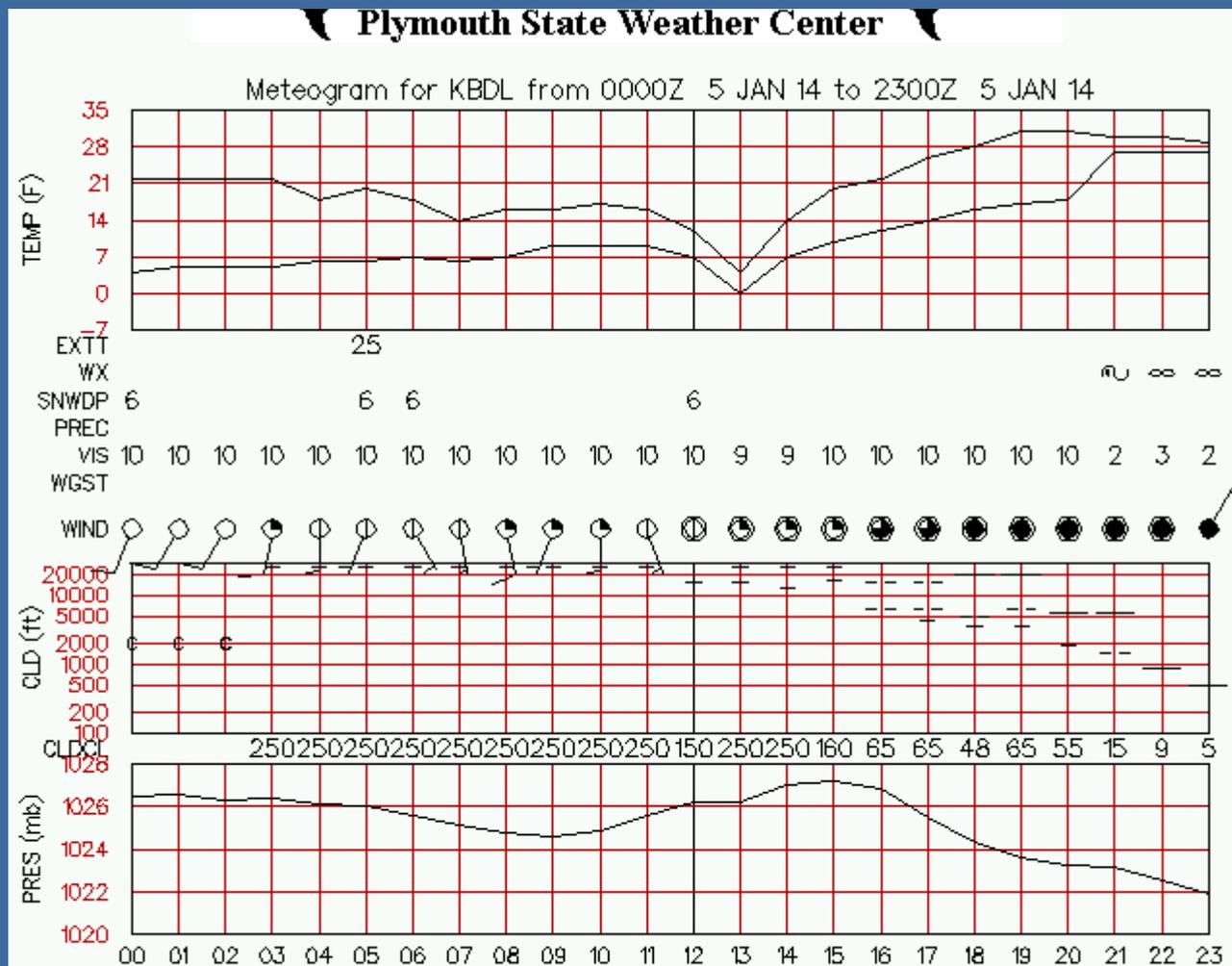
Cold high pressure departing, mostly calm winds with inversion conditions. Weak pressure gradient.

Widespread MODERATE PM_{2.5} event over the northeast with numerous site exceedances.



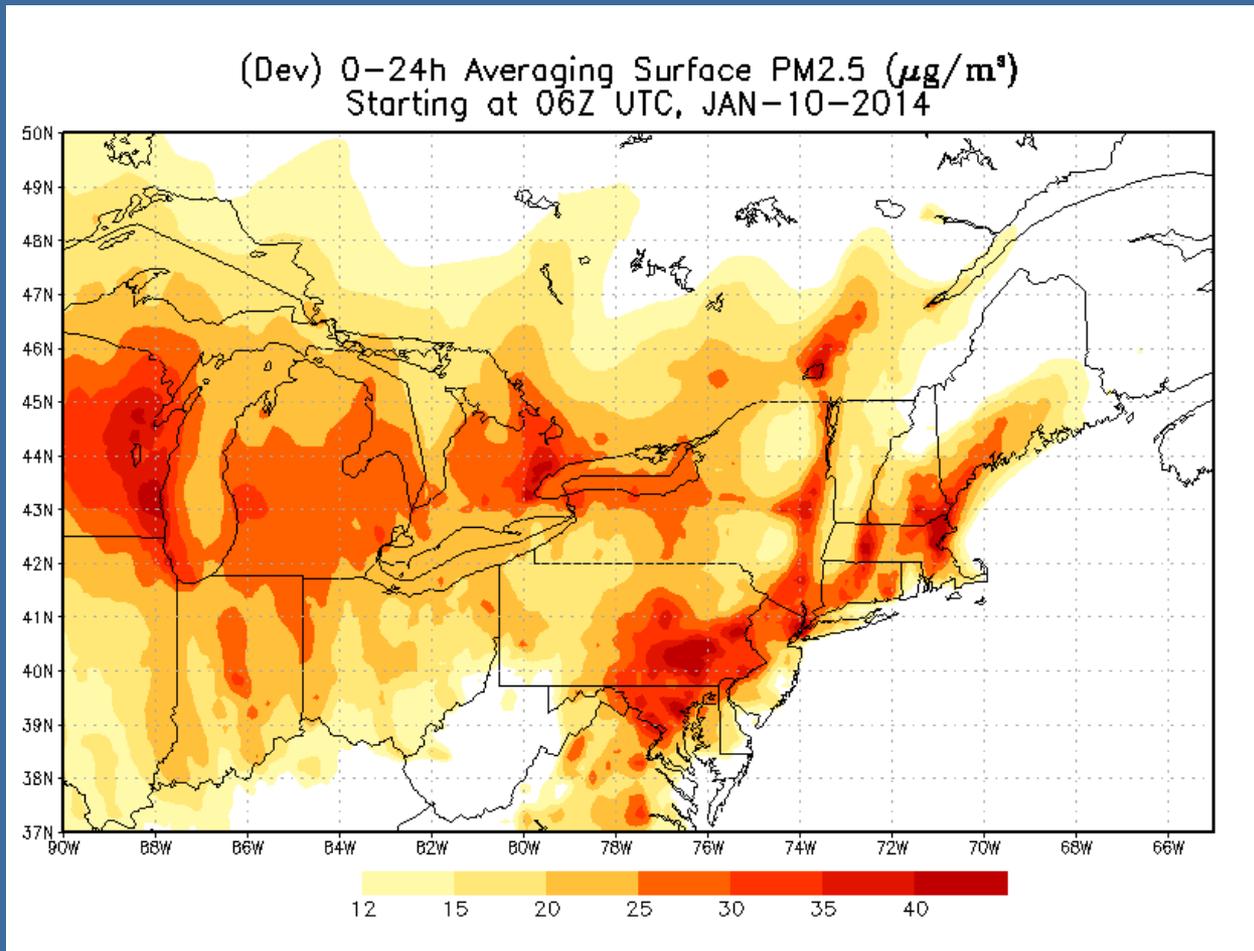
Hourly weather data from Bradley Airport (from 7pm day before)

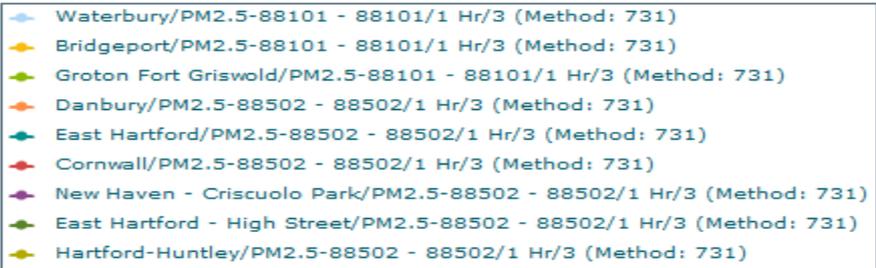
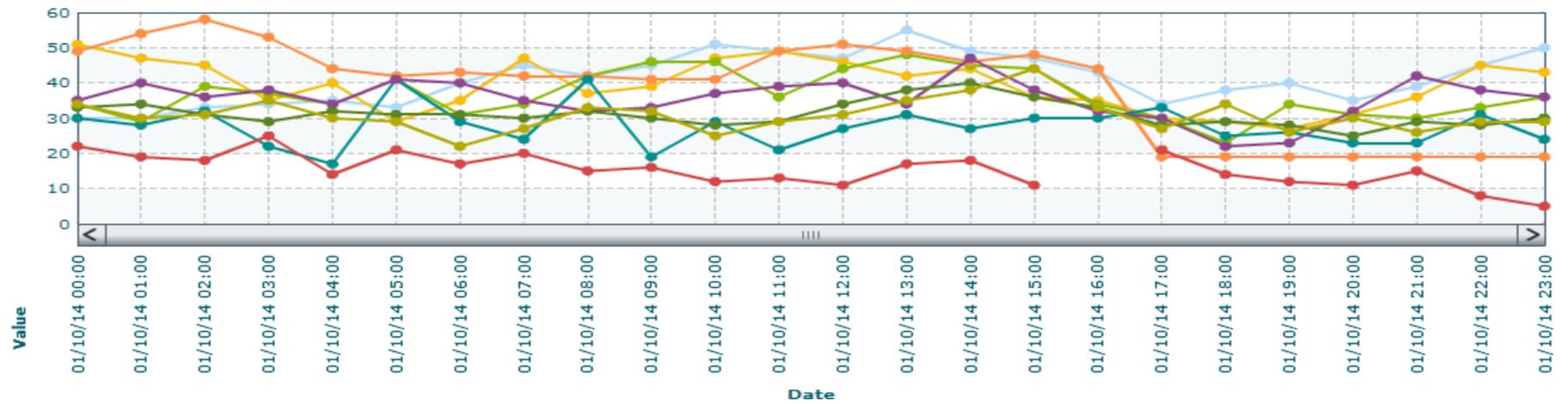
- Nearly calm winds
- Temperature inversion
- Late day fog



January 10, 2014 event

As modeled by NOAA PM2.5 model- same day
Under predicted by $10 \mu\text{g}/\text{m}^3$

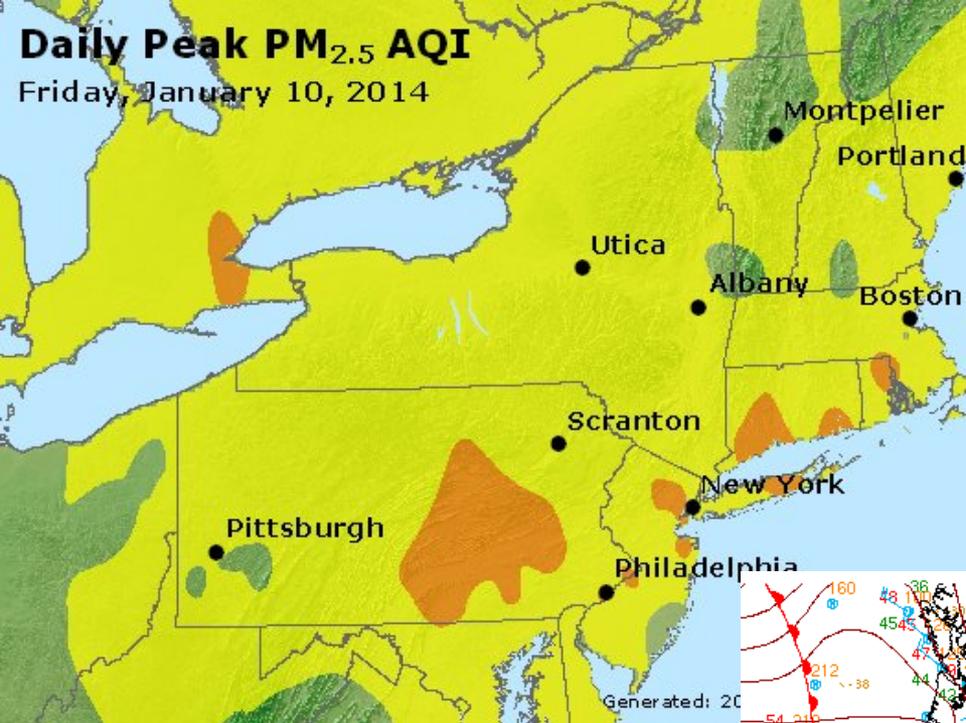




Site/Site AQS/Param/POC	Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg	
Bridgeport/090010010/PM2.5-88101/3	01/10/14	51	47	45	35	40	29	35	47	37	39	47	49	46	42	44	36	35	30	29	27	31	36	45	43	39.38	
Cornwall/090050005/PM2.5-88502/3	01/10/14	22	19	18	25	14	21	17	20	15	16	12	13	11	17	18	11		21	14	12	11	15	8	5	15.43	
Danbury/090011123/PM2.5-88502/3	01/10/14	49	54	58	53	44	42	43	42	42	41	41	49	51	49	46	48	44	19	46.82							
East Hartford -/090032006/PM2.5-88502/3	01/10/14	33	34	31	29	32	31	31	30	32	30	28	29	34	38	40	36	33	28	29	28	25	29	28	30	31.17	
East Hartford/090031003/PM2.5-88502/3	01/10/14	30	28	32	22	17	41	29	24	41	19	29	21	27	31	27	30	30	33	25	26	23	23	31	24	27.63	
Groton Fort Gri/090110124/PM2.5-88101/3	01/10/14	34	29	39	37	34	41	31	34	42	46	46	36	44	48	45	44	34	30	23	34	31	30	33	36	36.71	
Hartford-Huntle/090030025/PM2.5-88502/3	01/10/14	34	30	31	35	30	29	22	27	33	32	25	29	31	35	38	44	33	27	34	26	30	26	29	29	30.79	
New Haven - Cri/090090027/PM2.5-88502/3	01/10/14	35	40	36	38	34	41	40	35	32	33	37	39	40	34	47	38	32	30	22	23	32	42	38	36	35.58	
Waterbury/090092123/PM2.5-88101/3	01/10/14	30	30	33	34	35	33	40	45	42	45	51	49	47	55	49	47	43	34	38	40	35	39	45	50	41.21	

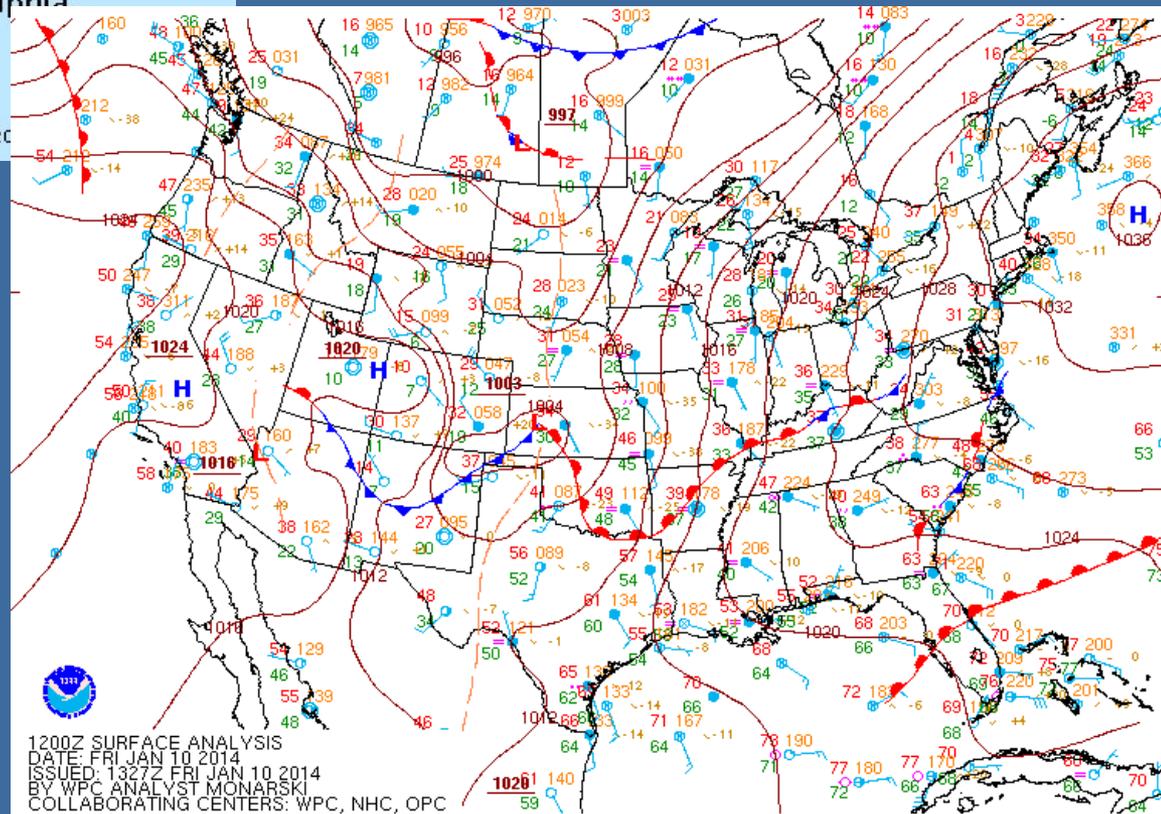
Daily Peak PM_{2.5} AQI

Friday, January 10, 2014



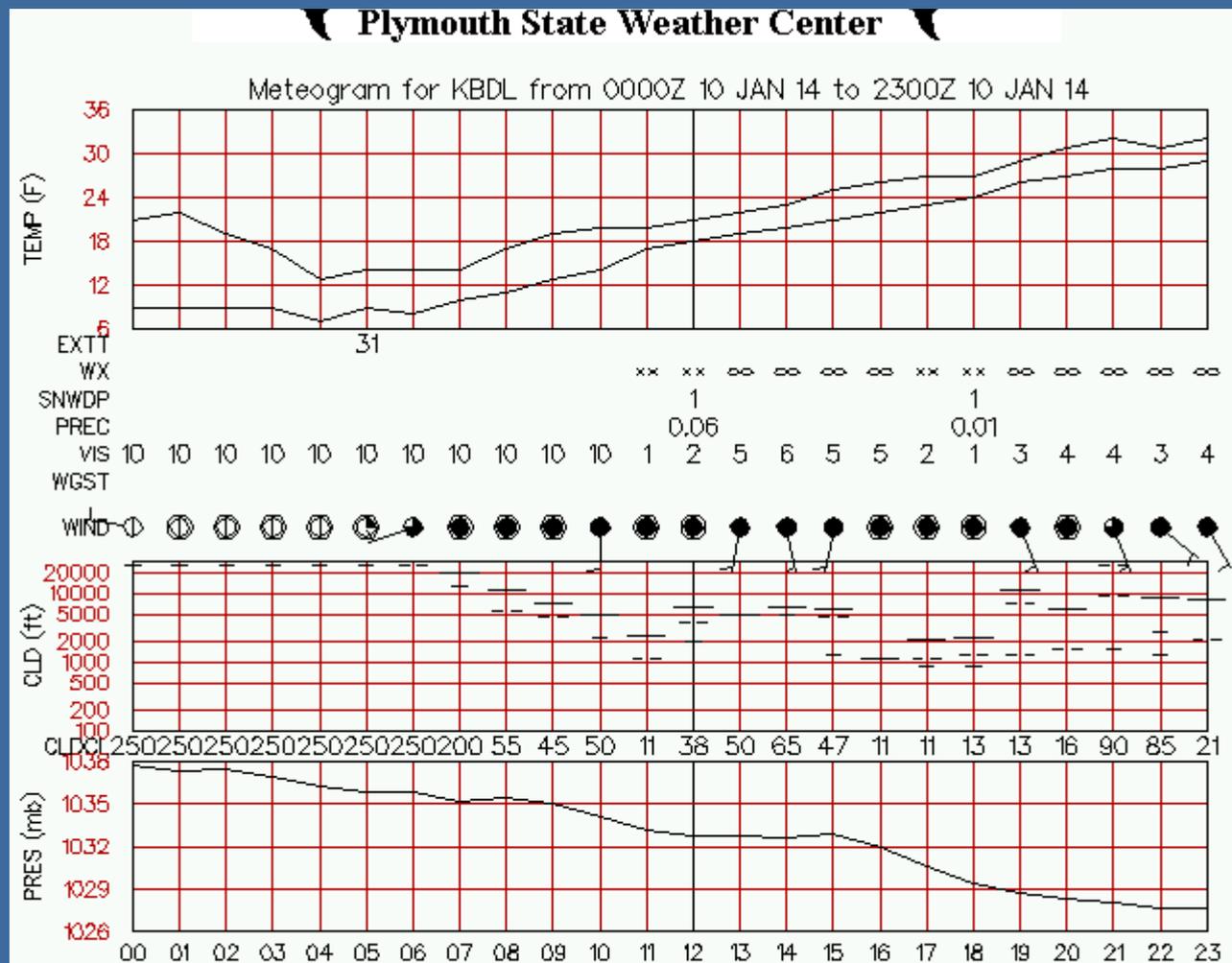
Synoptic Conditions:
Cold high pressure departing,
approaching warm front with periods
of light snow. Low cloud base with fog
produced low inversion.

Widespread MODERATE
PM_{2.5} event over the
northeast with numerous site
exceedances.



Hourly weather data from Bradley Airport (from 7pm day before)

- Nearly calm winds
- Light snow and fog
- Low level inversion as warmer air aloft traps colder air

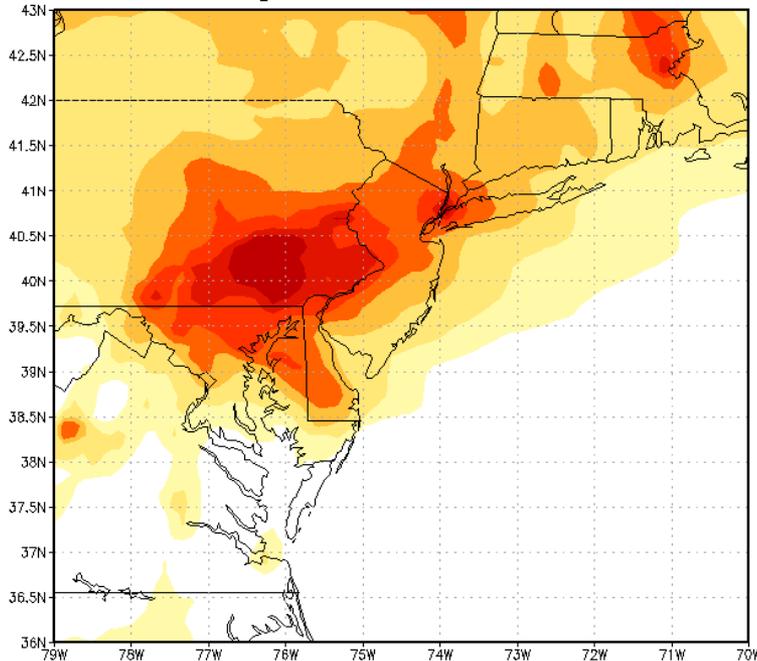


February 19, 2014 event

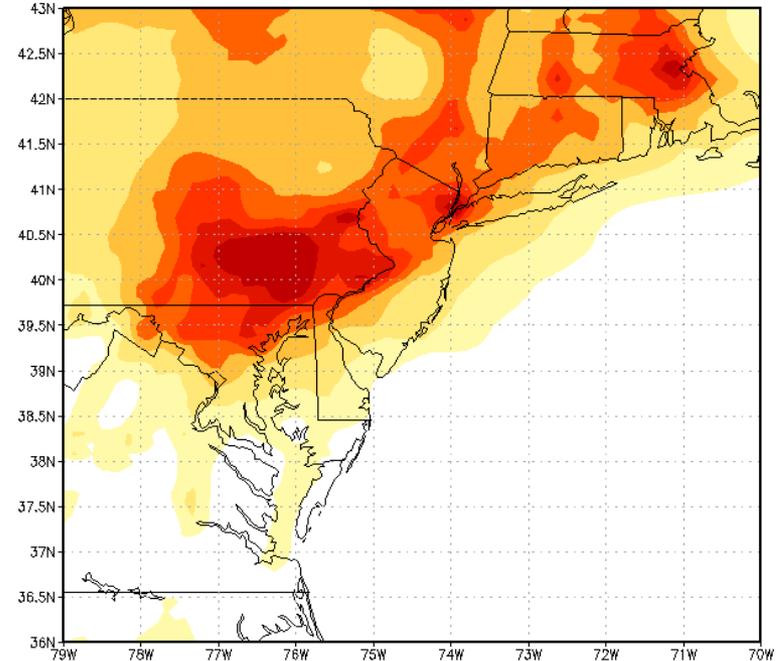
As modeled by NOAA PM2.5
model- previous day under
predicted by $10 \mu\text{g}/\text{m}^3$

As modeled by NOAA PM2.5
model- same day under
predicted by $5 \mu\text{g}/\text{m}^3$

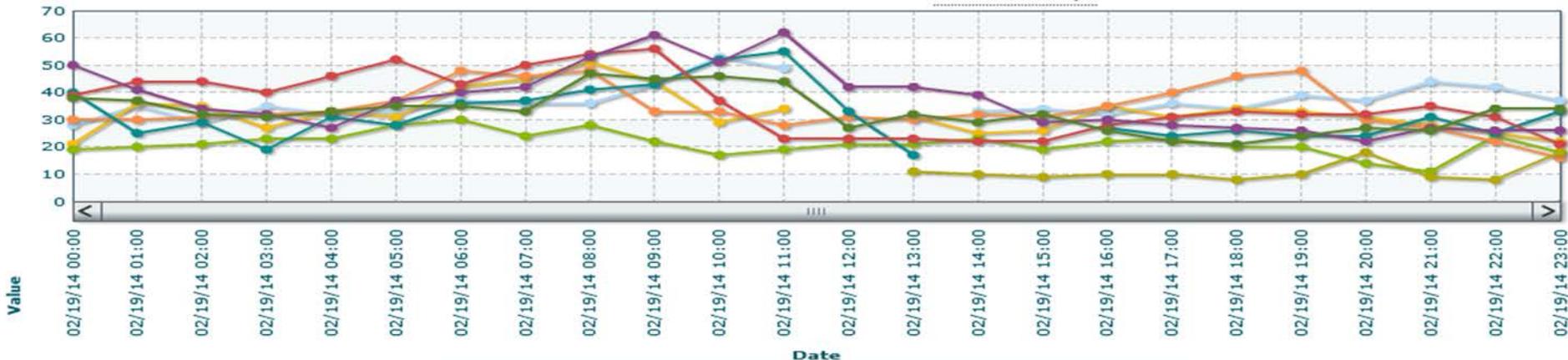
(Dev) 25–48h Averaging Surface PM2.5 ($\mu\text{g}/\text{m}^3$)
Starting at 06Z UTC, FEB-18-2014



(Dev) 0–24h Averaging Surface PM2.5 ($\mu\text{g}/\text{m}^3$)
Starting at 06Z UTC, FEB-19-2014



Reset Line Graph

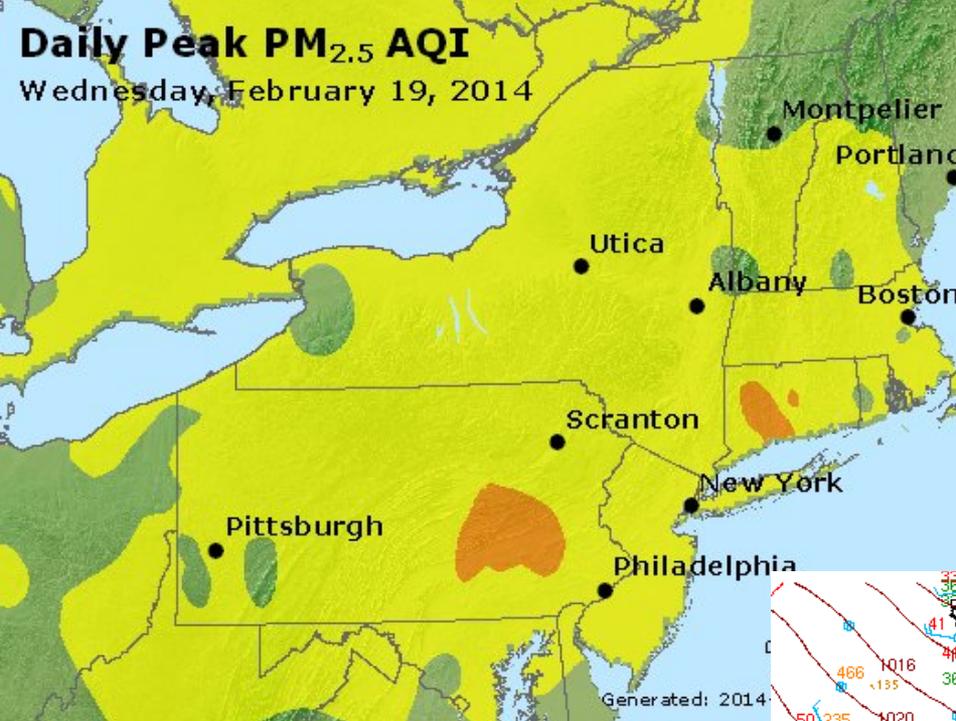


- Waterbury/PM2.5-88101 - 88101/1 Hr/3 (Method: 731)
- Bridgeport/PM2.5-88101 - 88101/1 Hr/3 (Method: 731)
- Groton Fort Griswold/PM2.5-88101 - 88101/1 Hr/3 (Method: 731)
- Danbury/PM2.5-88502 - 88502/1 Hr/3 (Method: 731)
- East Hartford/PM2.5-88502 - 88502/1 Hr/3 (Method: 731)
- New Haven - Criscuolo Park/PM2.5-88502 - 88502/1 Hr/3 (Method: 731)
- East Hartford - High Street/PM2.5-88502 - 88502/1 Hr/3 (Method: 731)
- Hartford-Huntley/PM2.5-88502 - 88502/1 Hr/3 (Method: 731)
- Cornwall/PM2.5-88502 - 88502/1 Hr/3 (Method: 731)

Site/Site AQS/Param/POC	Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Bridgeport/090010010/PM2.5-88101/3	02/19/14	21	36	35	27	33	31	42	45	51	44	29	34		31	25	26	35	31	34	33	31	28	25	22	32.57
Cornwall/090050005/PM2.5-88502/3	02/19/14														11	10	9	10	10	8	10	18	9	8	18	11
Danbury/090011123/PM2.5-88502/3	02/19/14	30	30	31	32	33	37	48	46	48	33	33	28	31	30	32	31	35	40	46	48	30	27	22	16	34.04
East Hartford -/090032006/PM2.5-88502/3	02/19/14	50	41	34	32	27	37	40	42	53	61	51	62	42	42	39	29	30	28	27	26	22	27	26	26	37.25
East Hartford/090031003/PM2.5-88502/3	02/19/14	40	25	29	19	31	28	36	37	41	43	52	55	33	17			27	24	26	24	24	31	25	33	31.82
Groton Fort Gri/090110124/PM2.5-88101/3	02/19/14	19	20	21	23	23	28	30	24	28	22	17	19	21	21	23	19	22	23	20	20	14	11	24	18	21.25
Hartford-Huntle/090030025/PM2.5-88502/3	02/19/14	38	37	32	31	33	35	35	33	47	45	46	44	27	32	29	32	26	22	21	24	27	26	34	34	32.92
New Haven - Cri/090090027/PM2.5-88502/3	02/19/14	39	44	44	40	46	52	43	50	54	56	37	23	23	23	22	22	28	31	33	32	32	35	31	21	35.88
Waterbury/090092123/PM2.5-88101/3	02/19/14	28	35	29	35	32	33	37	36	36	43	53	49			33	34	32	36	34	39	37	44	42	37	37

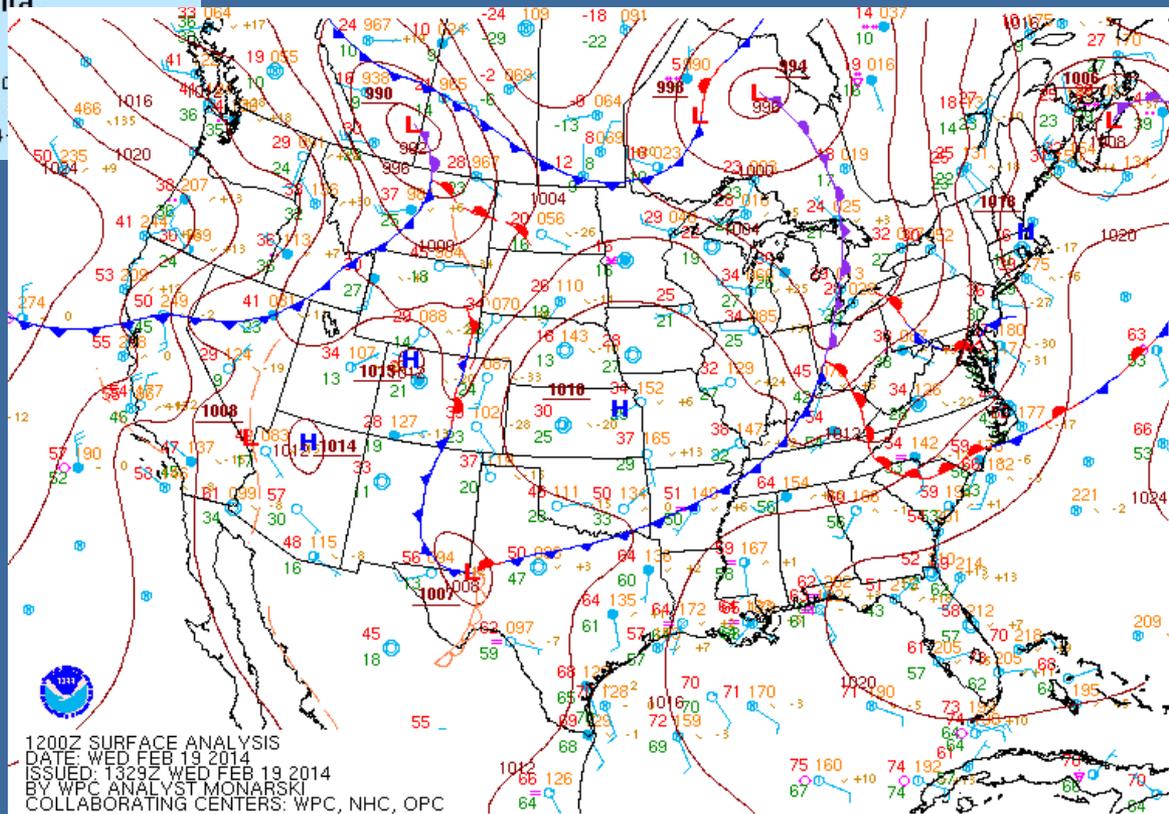
Daily Peak PM_{2.5} AQI

Wednesday, February 19, 2014



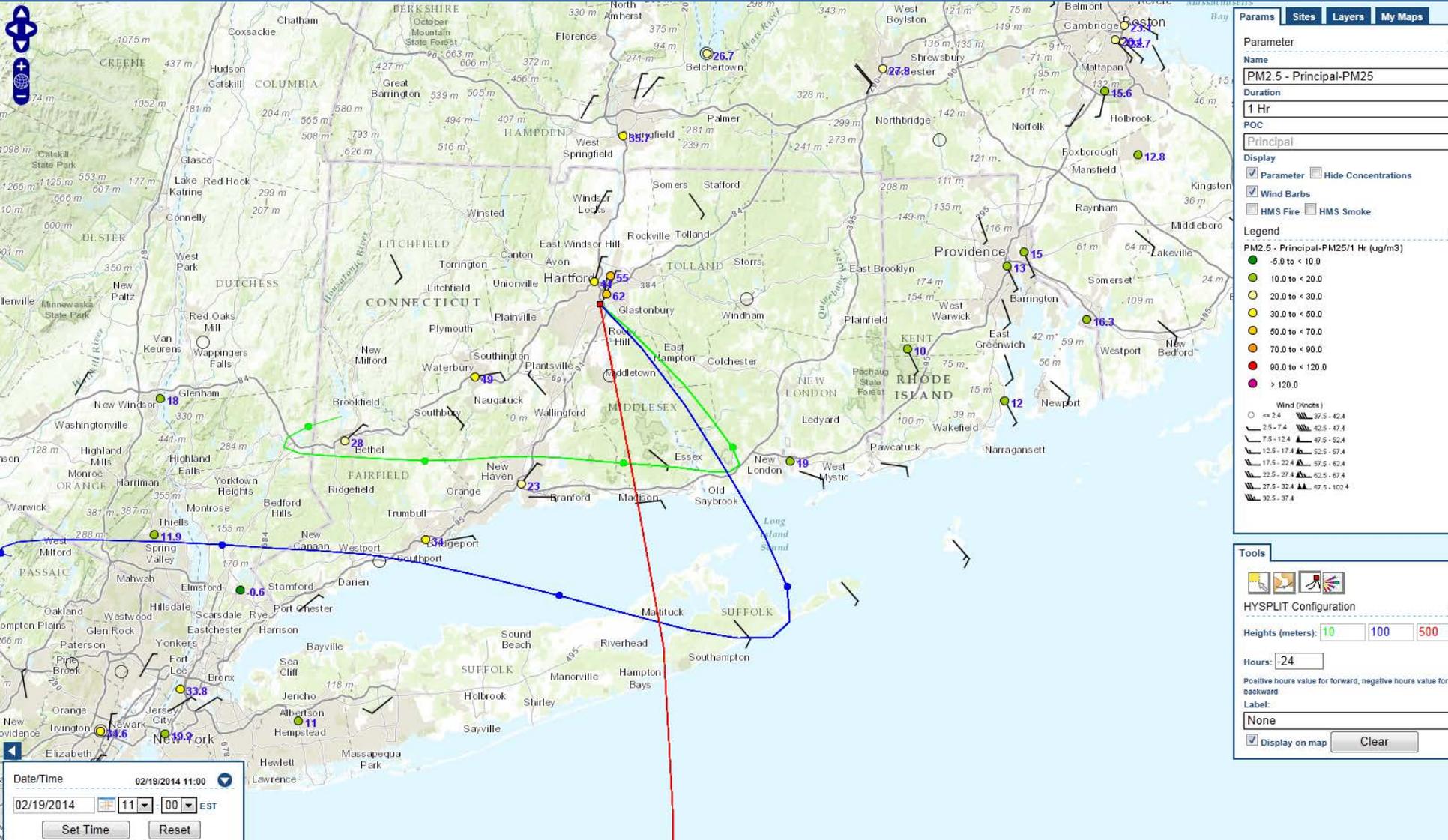
Synoptic Conditions:
Warm front approaching with weak high pressure moving off shore

Widespread MODERATE PM_{2.5} event over the northeast with pockets of exceedances.



24-hour 3-level Back-Trajectory Analysis from 12 pm, Feb 19, 2014

- High Trajectory from Atlantic Ocean to Hartford
- Low level winds were light and variable

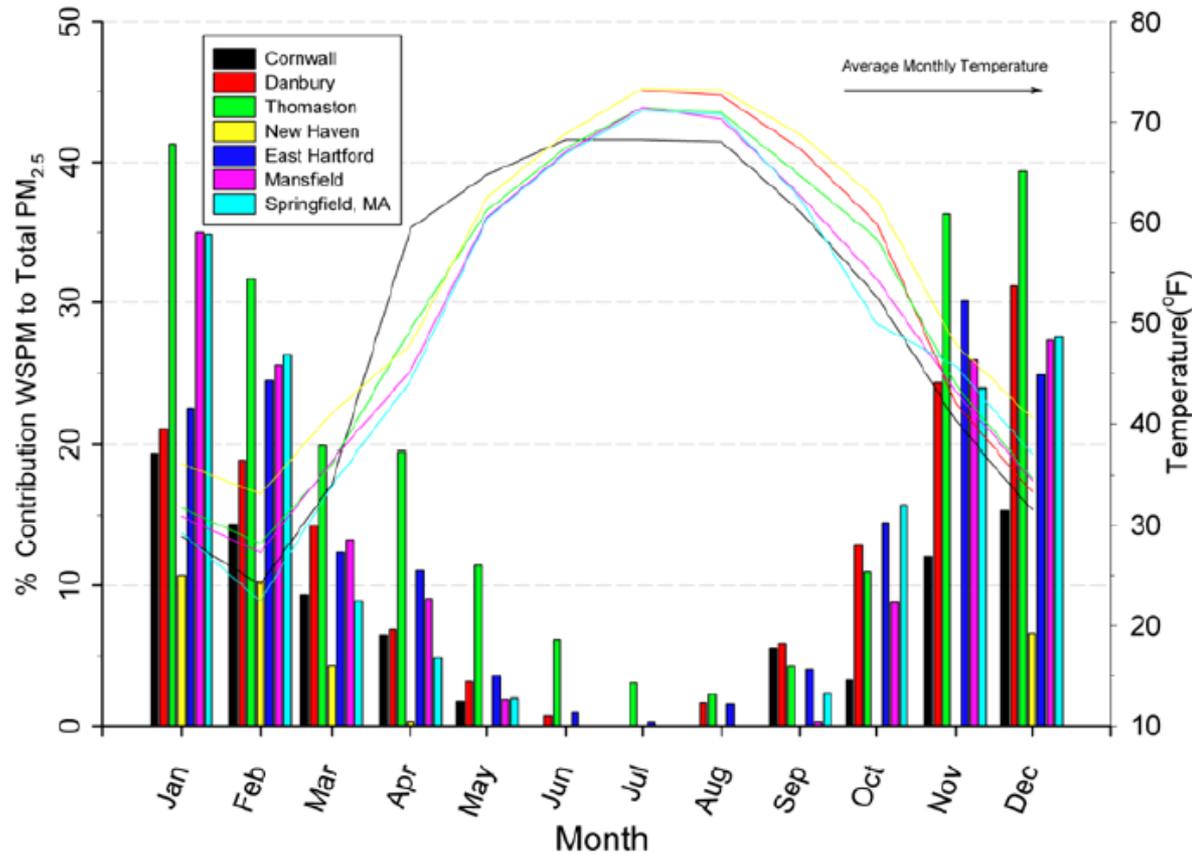


What about Wood smoke?

The CTDEEP conducted an ambient air monitoring study from **September 2006 through April 2008** that characterized the contribution of particulate matter from wood burning sources. Monitoring was conducted at seven sites and modeling was applied to the data collected to apportion the sources and quantify wood smoke particulate matter (WSPM) concentrations.

This study confirmed that the 2-channel Aethalometer™ (Magee Scientific) does provide a real-time wood smoke indicator. Using modeling, **a scaling factor (x7.8)** was derived to quantify wood smoke concentrations. This scaling factor was somewhat variable from site to site; however, a reasonable approximation of WSPM concentrations could be determined.

Figure ES-1: Average Monthly Percent Contribution of WSPM to Total PM_{2.5}

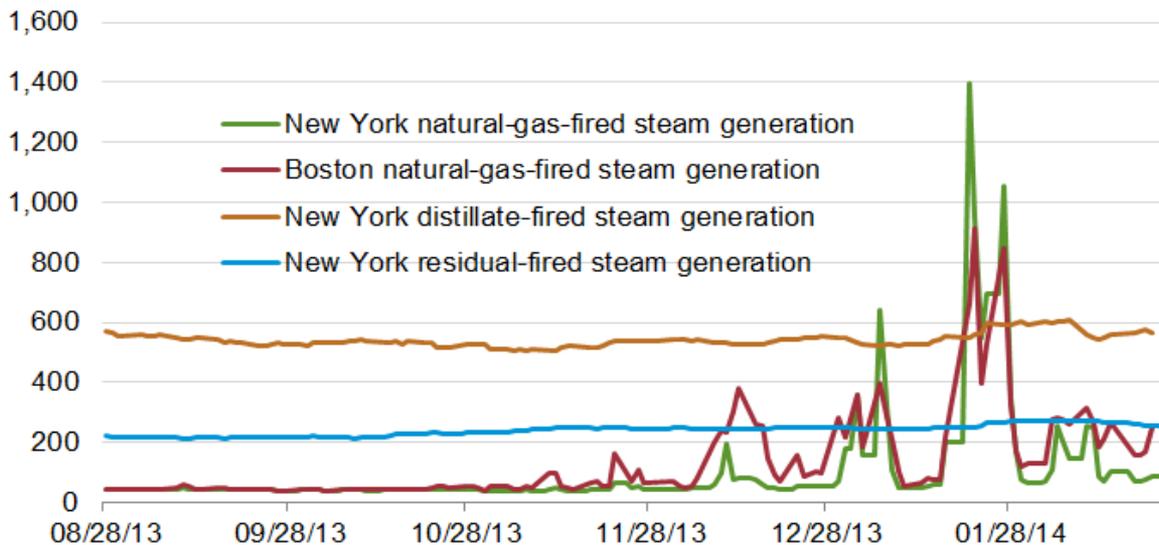


Wood smoke Contribution at New Haven

DeltaC[ug/...		Dec 5	DeltaC[ug/...		Jan 5	DeltaC[ug/m3 ...		Jan10	DeltaC[ug/m3 ...		Feb 19
Report Type: Stationreport			Report Type: Stationreport			Report Type: Stationreport			Report Type: Stationreport		
Date Time: 12/5/2013 12:00 AM-12/5/2013 11:00 PM			Date Time: 1/5/2014 12:00 AM-1/5/2014 11:00 PM			Date Time: 1/10/2014 12:00 AM-1/10/2014 11:00 PM			Date Time: 2/19/2014 12:00 AM-2/19/2014 11:00 PM		
Date & Time	DeltaC ug/m3 stp		Date & Time	DeltaC ug/m3 stp		Date & Time	DeltaC ug/m3 stp		Date & Time	DeltaC ug/m3 stp	
12/5/2013 12:00 AM	1.832		1/5/2014 12:00 AM	1.774		1/10/2014 12:00 AM	3.076		2/19/2014 12:00 AM	2.452	
12/5/2013 1:00 AM	1.623		1/5/2014 1:00 AM	1.987		1/10/2014 1:00 AM	3.259		2/19/2014 1:00 AM	2.803	
12/5/2013 2:00 AM	1.418		1/5/2014 2:00 AM	2.388		1/10/2014 2:00 AM	3.513		2/19/2014 2:00 AM	3.384	
12/5/2013 3:00 AM	1.352		1/5/2014 3:00 AM	1.766		1/10/2014 3:00 AM	3.760		2/19/2014 3:00 AM	4.777	
12/5/2013 4:00 AM	1.168		1/5/2014 4:00 AM	1.607		1/10/2014 4:00 AM	3.737		2/19/2014 4:00 AM	5.860	
12/5/2013 5:00 AM	1.069		1/5/2014 5:00 AM	2.081		1/10/2014 5:00 AM	2.873		2/19/2014 5:00 AM	3.184	
12/5/2013 6:00 AM	0.905		1/5/2014 6:00 AM	3.377		1/10/2014 6:00 AM	1.907		2/19/2014 6:00 AM	3.664	
12/5/2013 7:00 AM	0.841		1/5/2014 7:00 AM	3.678		1/10/2014 7:00 AM	1.520		2/19/2014 7:00 AM	3.400	
12/5/2013 8:00 AM	1.878		1/5/2014 8:00 AM	2.878		1/10/2014 8:00 AM	1.177		2/19/2014 8:00 AM	2.372	
12/5/2013 9:00 AM	0.899		1/5/2014 9:00 AM	2.427		1/10/2014 9:00 AM	0.968		2/19/2014 9:00 AM	2.393	
12/5/2013 10:00 AM	0.901		1/5/2014 10:00 AM	2.500		1/10/2014 10:00 AM	1.192		2/19/2014 10:00 AM	1.282	
12/5/2013 11:00 AM	0.789		1/5/2014 11:00 AM	1.469		1/10/2014 11:00 AM	1.020		2/19/2014 11:00 AM	0.725	
12/5/2013 12:00 PM	0.852		1/5/2014 12:00 PM	0.930		1/10/2014 12:00 PM	1.061		2/19/2014 12:00 PM	0.634	
12/5/2013 1:00 PM	0.970		1/5/2014 1:00 PM	0.898		1/10/2014 1:00 PM	1.460		2/19/2014 1:00 PM	0.471	
12/5/2013 2:00 PM	1.011		1/5/2014 2:00 PM	1.000		1/10/2014 2:00 PM	1.585		2/19/2014 2:00 PM	0.472	
12/5/2013 3:00 PM	1.186		1/5/2014 3:00 PM	0.798		1/10/2014 3:00 PM	1.089		2/19/2014 3:00 PM	0.268	
12/5/2013 4:00 PM	1.194		1/5/2014 4:00 PM	0.753		1/10/2014 4:00 PM	1.411		2/19/2014 4:00 PM	0.823	
12/5/2013 5:00 PM	0.982		1/5/2014 5:00 PM	1.040		1/10/2014 5:00 PM	1.117		2/19/2014 5:00 PM	0.866	
12/5/2013 6:00 PM	1.114		1/5/2014 6:00 PM	1.222		1/10/2014 6:00 PM	1.094		2/19/2014 6:00 PM	0.912	
12/5/2013 7:00 PM	1.433		1/5/2014 7:00 PM	1.310		1/10/2014 7:00 PM	1.289		2/19/2014 7:00 PM	0.949	
12/5/2013 8:00 PM	0.460		1/5/2014 8:00 PM	1.190		1/10/2014 8:00 PM	1.180		2/19/2014 8:00 PM	0.978	
12/5/2013 9:00 PM	-0.023		1/5/2014 9:00 PM	1.176		1/10/2014 9:00 PM	1.165		2/19/2014 9:00 PM	1.076	
12/5/2013 10:00 PM	0.037		1/5/2014 10:00 PM	1.057		1/10/2014 10:00 PM	1.412		2/19/2014 10:00 PM	0.605	
12/5/2013 11:00 PM	0.052		1/5/2014 11:00 PM	0.104		1/10/2014 11:00 PM	1.595		2/19/2014 11:00 PM	0.482	
Minimum	-0.023		Minimum	0.104		Minimum	0.968		Minimum	0.268	
MinDate	9:00 PM		MinDate	11:00 PM		MinDate	9:00 AM		MinDate	3:00 PM	
Maximum	1.878		Maximum	3.678		Maximum	3.760		Maximum	5.860	
MaxDate	8:00 AM		MaxDate	7:00 AM		MaxDate	3:00 AM		MaxDate	4:00 AM	
Avg	0.998		Avg	1.642		Avg	1.811		Avg	1.868	
Num		7.8µg	Num		12.8µg	Num		14.1µg	Num		14.6µg
Data[%]		20%	Data[%]		41%	Data[%]		39%	Data[%]		41%
STD			STD			STD			STD		

Figure 1. Northeast power market fuel choices

dollars per megawatthour

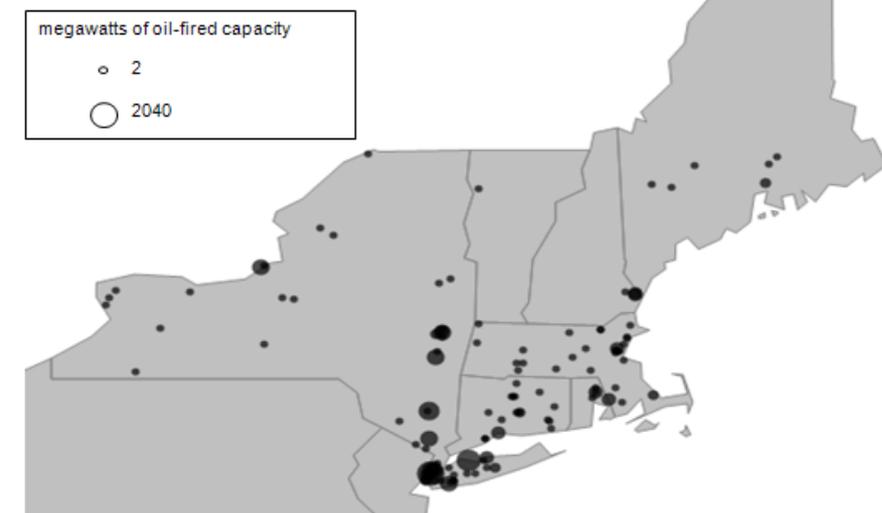


Another factor to consider is fuel switching from natural gas to residual fuel oil during days of high demand. This may effect inventory inputs to the models.

Source: U.S. Energy Information Administration based on Bloomberg, LP.

Note: Assumes a 12,733 British thermal unit per kilowatthour (Btu/kWh) heat rate for an oil-fired steam generator and a 11,576 Btu/kWh heat rate for a natural-gas-fired steam generator. Data through February 24, 2014.

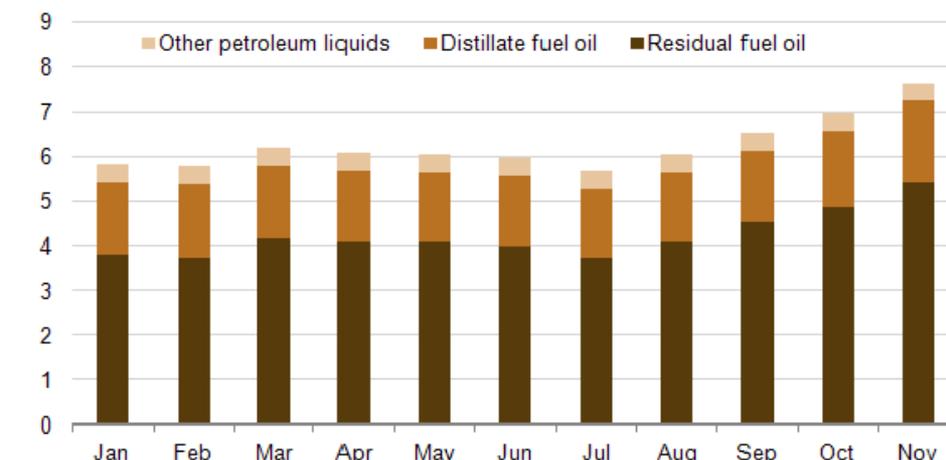
Figure 2. Petroleum liquids and natural gas fuel-switchable units in the Northeast, 2012



Source: U.S. Energy Information Administration, Form EIA860, Annual Electric Generator Report.

Figure 3. Stocks of petroleum liquids held at electric power plants in the Northeast, 2013

million barrels

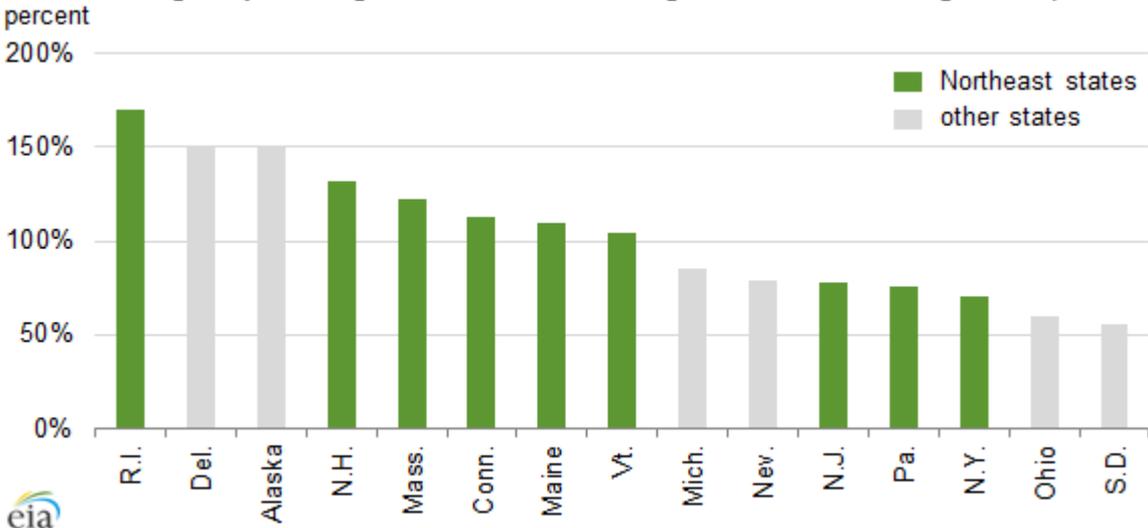


Source: U.S. Energy Information Administration, Electric Power Monthly.

Note: Other petroleum liquids include jet fuel, kerosene and waste oil.



States with highest percentage increase in homes using wood as main heating source (2005-12)



Source: U.S. Census Bureau, 2005 and 2012 American Community Survey
Note: Northeast states represent the Northeast Census region

- Wood as a main heating source in homes has gained popularity in many areas of the country in recent years, but the increase is most notable in the Northeast. All nine states in the New England and the Middle Atlantic Census divisions saw at least a 50% jump from 2005 to 2012 in the number of households that rely on wood as the main heating source. As the use of fuel oil and kerosene in this region has declined in recent years, many households have turned to lower-cost alternatives, including wood.
- In total, about 2.5 million households (2.1%) across the country use wood as the main fuel for home heating, up from 1.9 million households (1.7%) in 2005. An additional 9 million households (7.7%) use wood as a secondary heating fuel. This combination of main and secondary heating accounts for about 500 trillion British thermal units (Btu) of wood consumption per year in the residential sector, or about the same as propane consumption and slightly less than fuel oil consumption.
- Heating stoves are the most common equipment used by households that rely on wood as the main source of heat, and fireplaces are the most common choice for secondary wood heating. Most households still burn split logs, although [wood pellet](#) use has risen in recent years. And while households in higher income brackets are more likely to use wood, those at lower income levels who burn wood consume more on average

Conclusions

- These events had light surface winds and low level inversions in common.
- Only January 5th, 2014 event had multi-level southwest flow over NYC area that may have involved transport.
- Wood smoke has a significant contribution to total PM_{2.5} (increase in Hydronic wood heaters?)
- Due to fluctuations in natural gas prices, fuel switching to oil may also have contributed.





- Questions?
- Answers?

