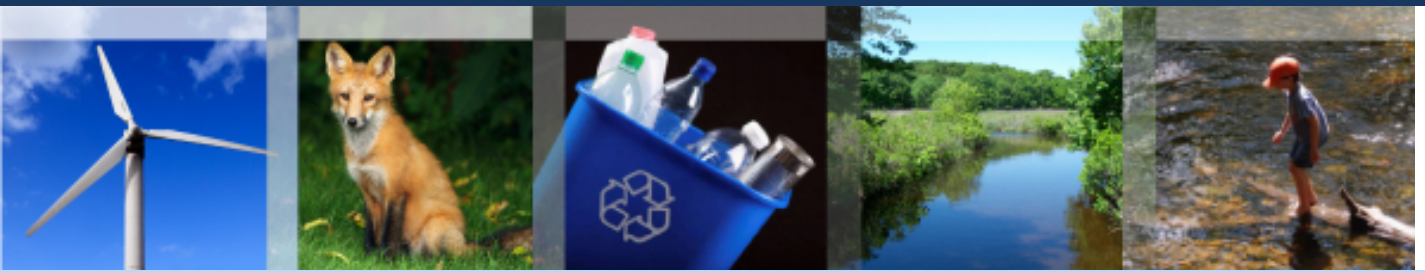
Connecticut Department of Energy and Environmental Protection



Connecticut Department of
ENERGY &
ENVIRONMENTAL
PROTECTION

2015 Ozone Season Forecasting Final Summary

Michael Geigert, Sam Sampieri & Jude Catalano

October 8, 2015

SIPRAC Meeting

Connecticut Department of Energy and Environmental Protection

2015 Ozone Season

22 Days over the 8-Hour Ozone NAAQS

Last Year: Only 8 Days

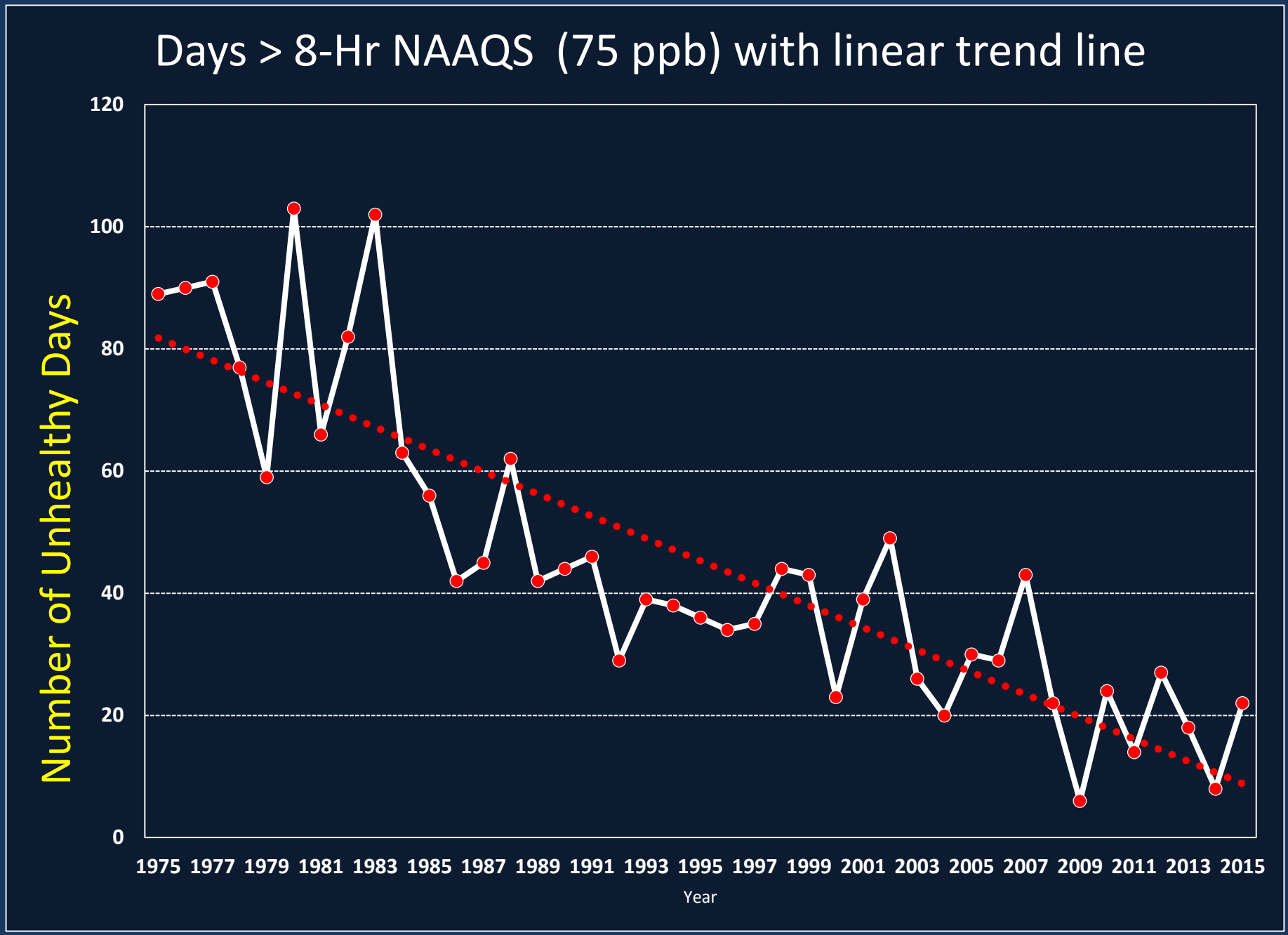
18 Days >=90° (BDL)This Summer (5 in September)

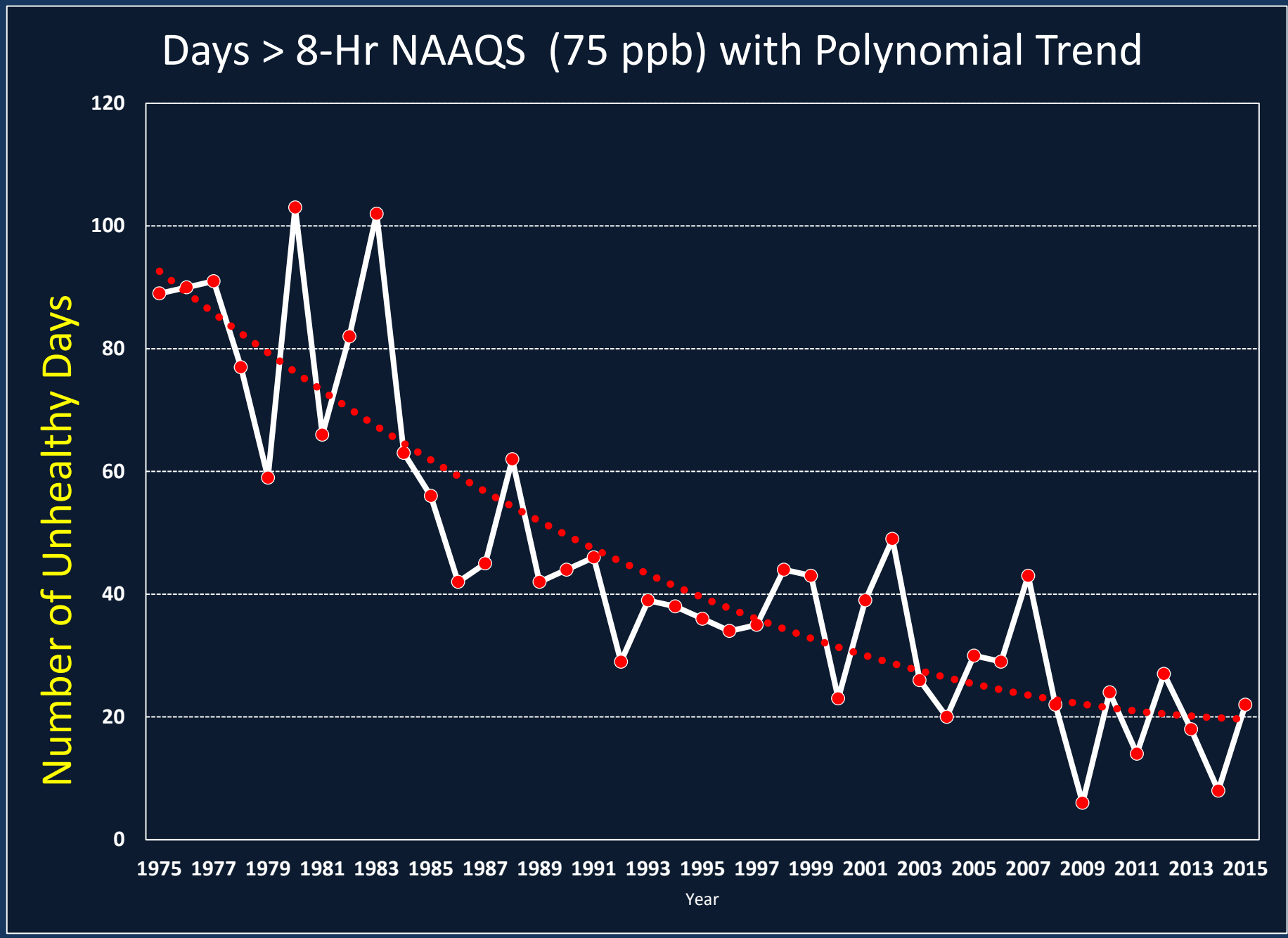
How did we do this year?

Actual Exceedences Days = 22
Forecast Exceedences Days = 15

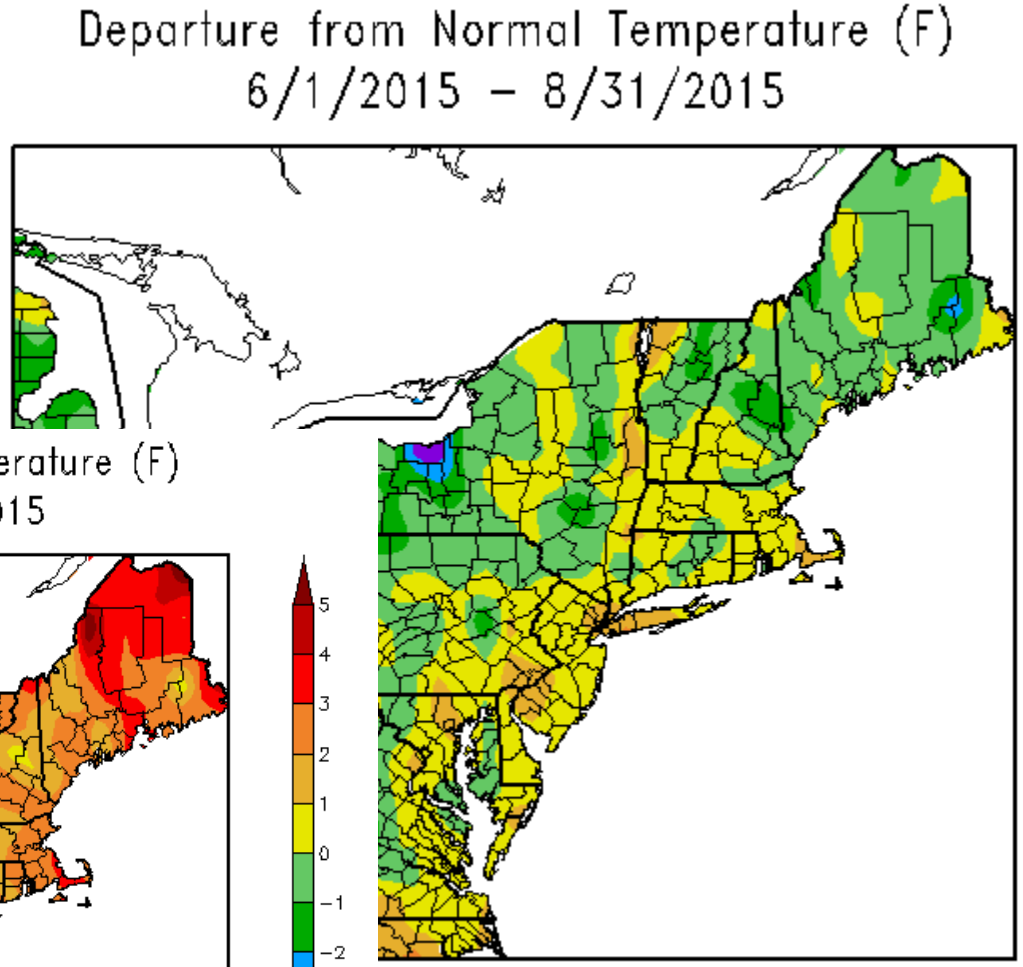
Month	Actual Dates	Forecast Dates
May	4, 8 26	8
June	11, 12	11
July	1, 19, 20, 21, & 29	12, 19, 21,28, 29
August	3, 4, 15, 17, 24, 30, 31	15, 16, 17, 18
September	2, 7, 8, 17, 18	2, 3, 8, 18
Total	22	15

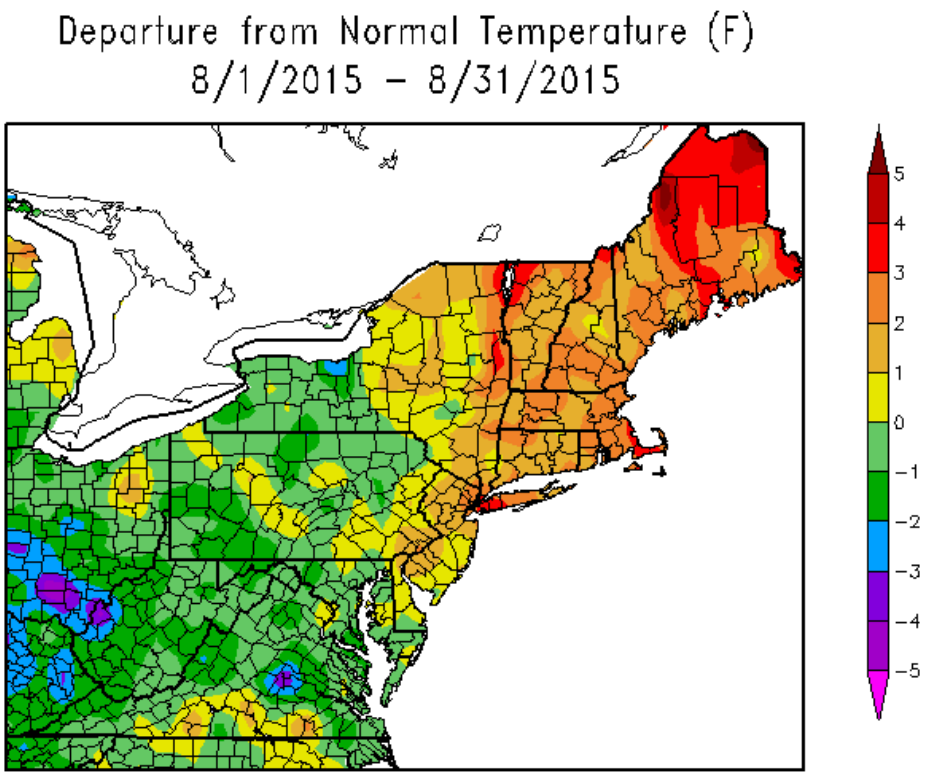
Days > 8-Hr NAAQS (75 ppb) with linear trend line




Days > 8-Hr NAAQS (75 ppb) with Polynomial Trend
Number of Unhealthy Days
120
100
80
60
40
20
0
1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Year

August Temperatures Above Normal



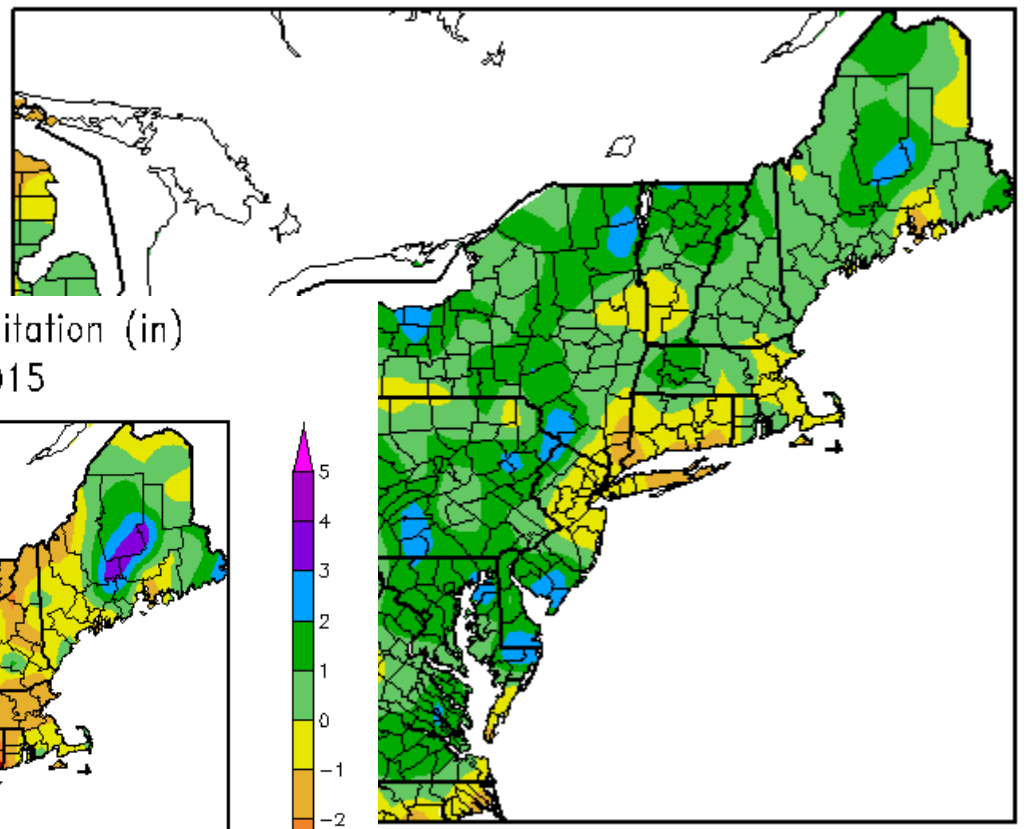


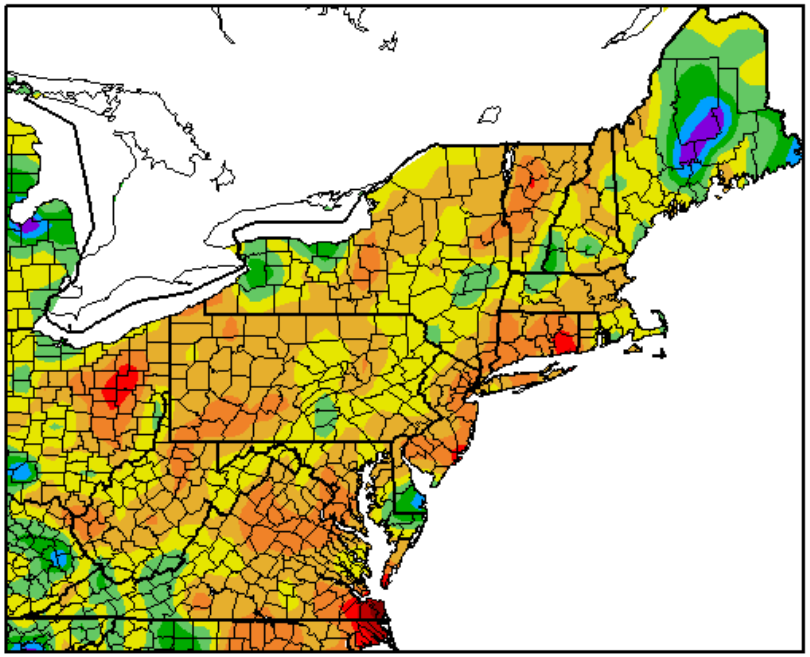
sional data. Regional Climate Centers

d Environmental Protection

Generated 9/2/2015 at HPRCC using provisional data. Regional Climate Centers

A Dry Summer / Especially August



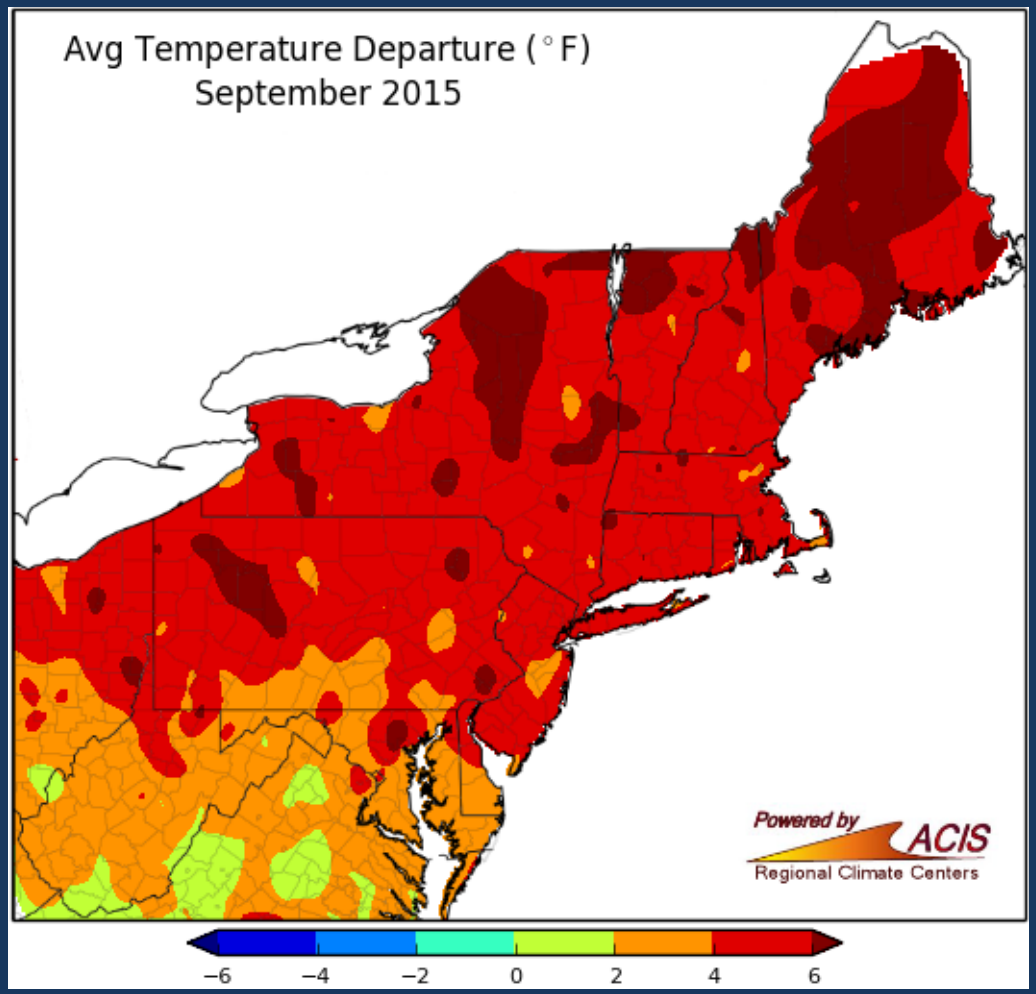


ional data. Regional Climate Centers

d Environmental Protection

Generated 9/2/2015 at HPRCC using provisional data. Regional Climate Centers

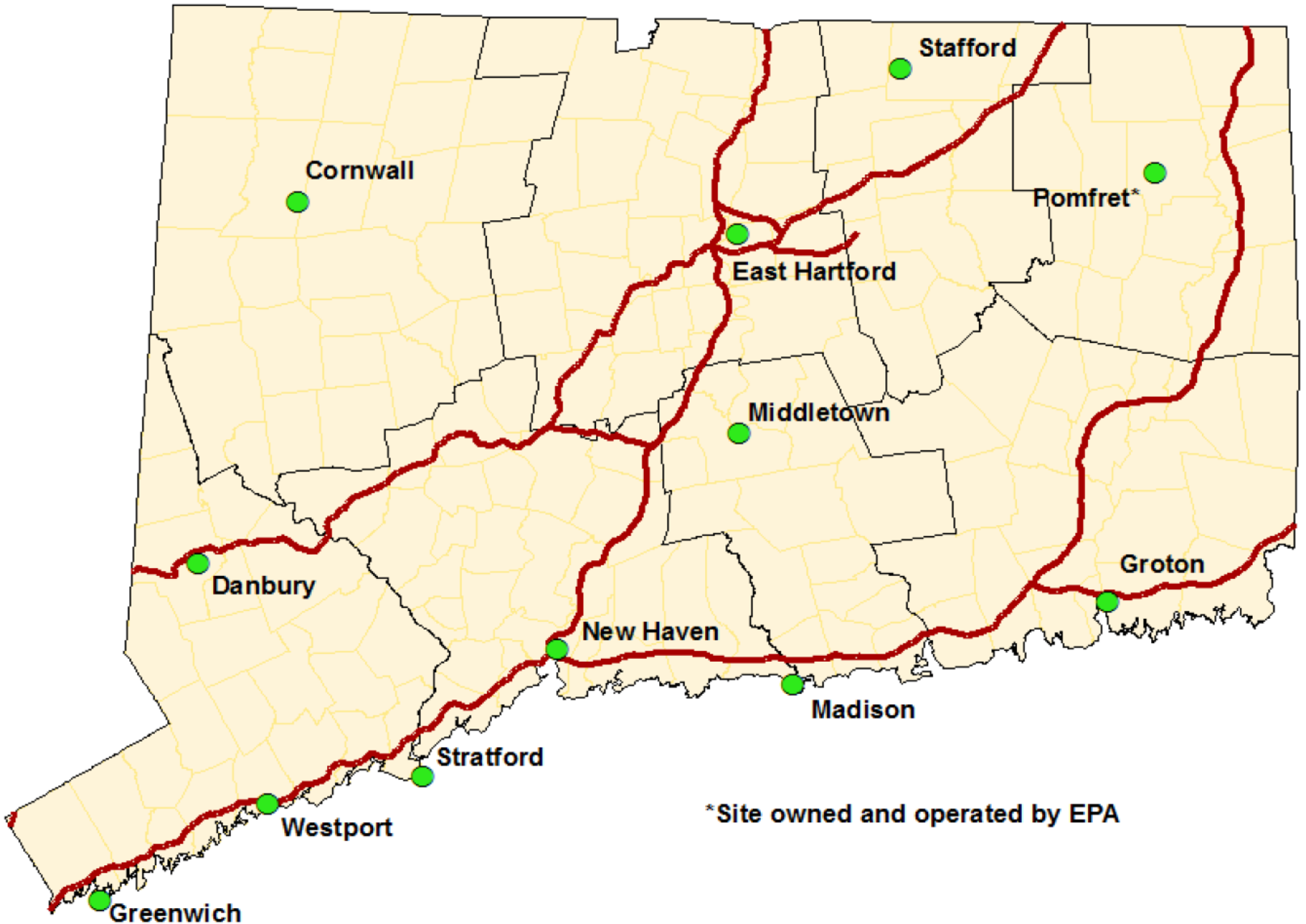
And then Comes September…



Analysis of 4 Ozone Events from 2015

- Early season event: May 4, 2015- Only one exceedance
- June 11, 2015: Widespread I-95 corridor
- July 12, 2015: Model over prediction
- September 17-18, 2015: Rare late season stagnation event

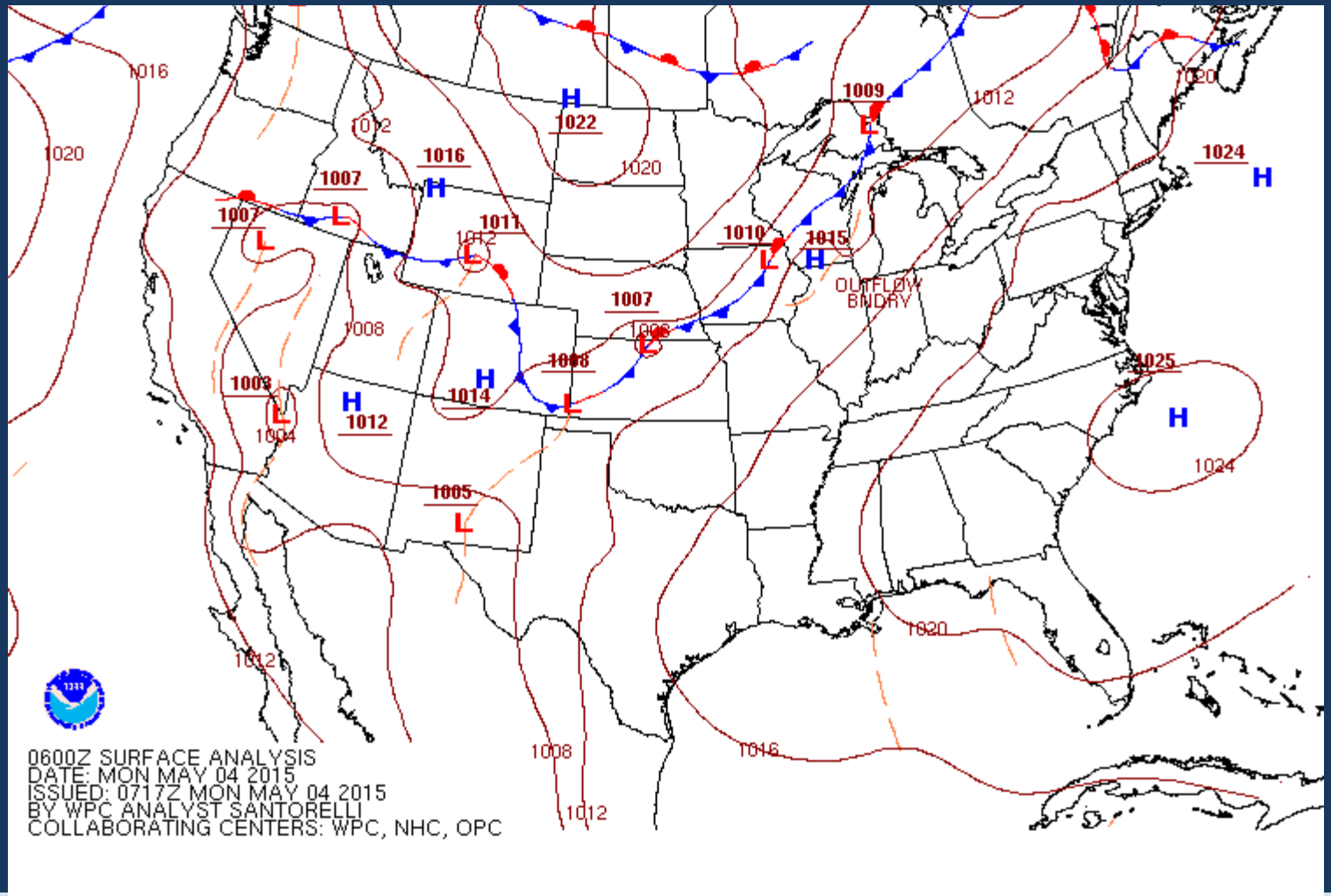
CT Ozone Monitors

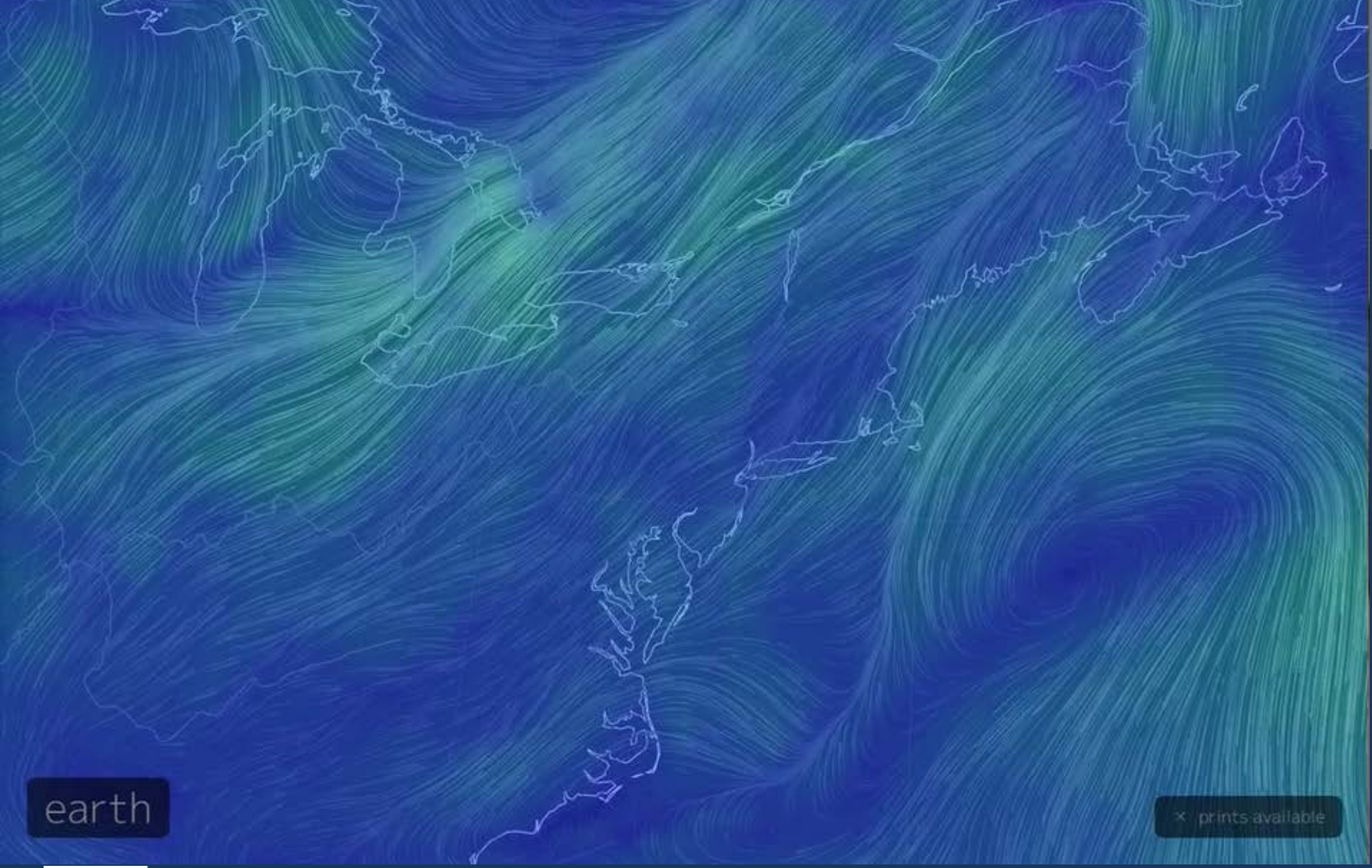


CT May 4, 2015 8-Hr Maximum Ozone Averages

Agency	Site	Site AQS	Param	Date (LST)	Unit	Max 8-hr
CT1	Cornwall	90050005	O3	5/4/2015	PPB	76
CT1	Danbury	90011123	O3	5/4/2015	PPB	71
CT1	East Hartford	90031003	O3	5/4/2015	PPB	70
CT1	Greenwich	90010017	O3	5/4/2015	PPB	61
CT1	Groton Fort Griswold	90110124	O3	5/4/2015	PPB	64
CT1	Madison-Beach Road	90099002	O3	5/4/2015	PPB	63
CT1	Middletown	90070007	O3	5/4/2015	PPB	69
CT1	New Haven - Criscuolo Park	90090027	O3	5/4/2015	PPB	56
CT1	Stafford	90131001	O3	5/4/2015	PPB	72
CT1	Stratford	90013007	O3	5/4/2015	PPB	63
CT1	Westport	90019003	O3	5/4/2015	PPB	61

Weak high pressure off the coast with southwest winds developing during the day





Note sea breeze convergence zone developing in afternoon

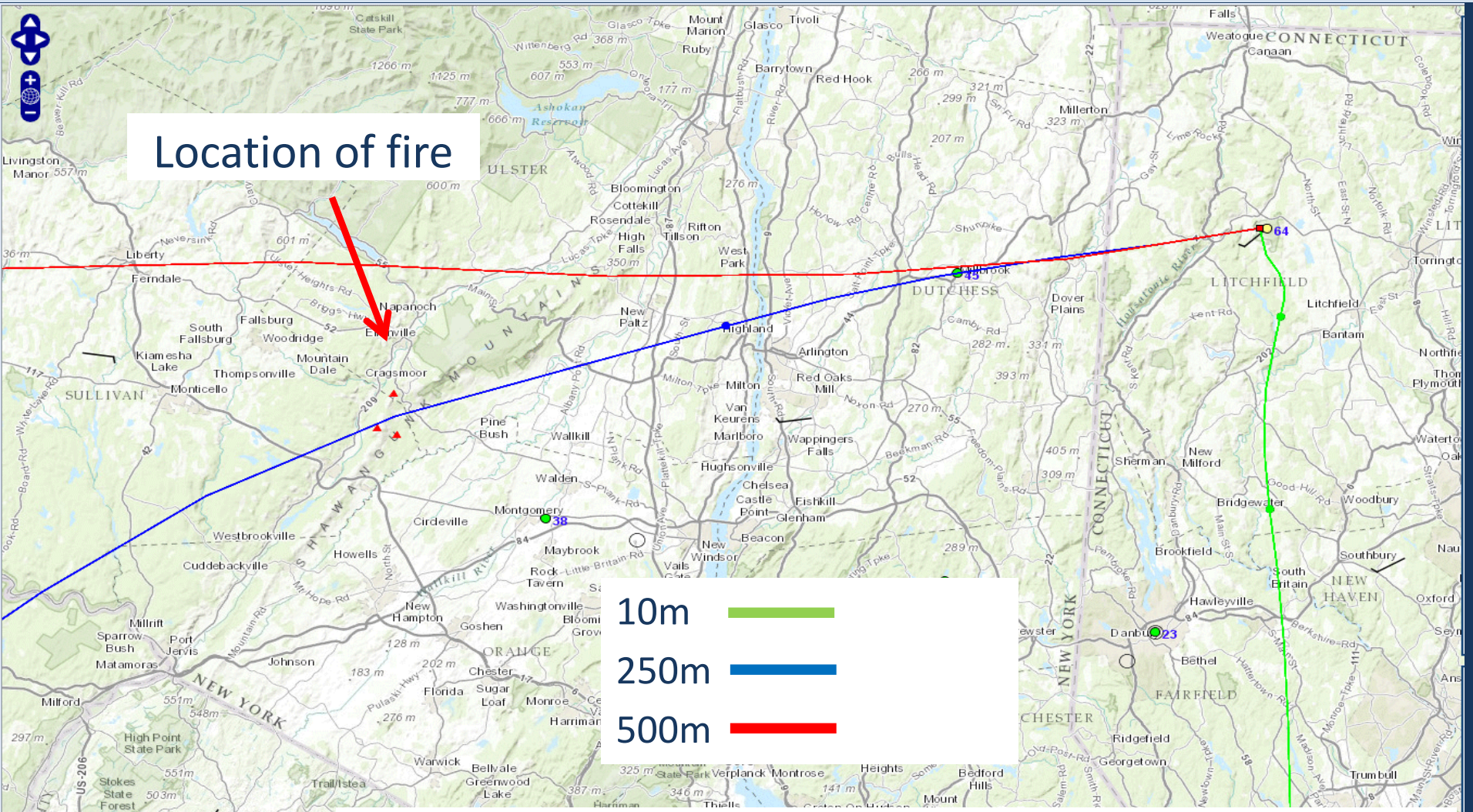
- Most areas in the northeast averaged moderate air quality on May 4th.
- Cornwall monitor was the only ozone exceedance.
- 8-hour average = 76 ppb
- Current NAAQS = 75 ppb

- Modeled ozone values are typically under-predicted by 5-10 ppb in the April- May timeframe (vegetation releasing Ozone Precursors such as VOC’s & Isoprene's?)
- This produces a challenge for forecasters early in the season, since exceedances can occur with temperatures well below 90° F. What is the new norm?? 85° F

- Did the NY wild fire contributed a few ppbs to the ozone levels at Cornwall on May 4th?
- Back trajectories suggest it may be possible for a few hours in the morning
- Forward trajectories suggest plume impacted northern England

The brush fire on the Shawangunk Ridge is seen Tuesday morning northeast of Ellenville, N.Y.

May 4th Event



Back Trajectories from Cornwall Monitor

8:00am to 6:00ppm

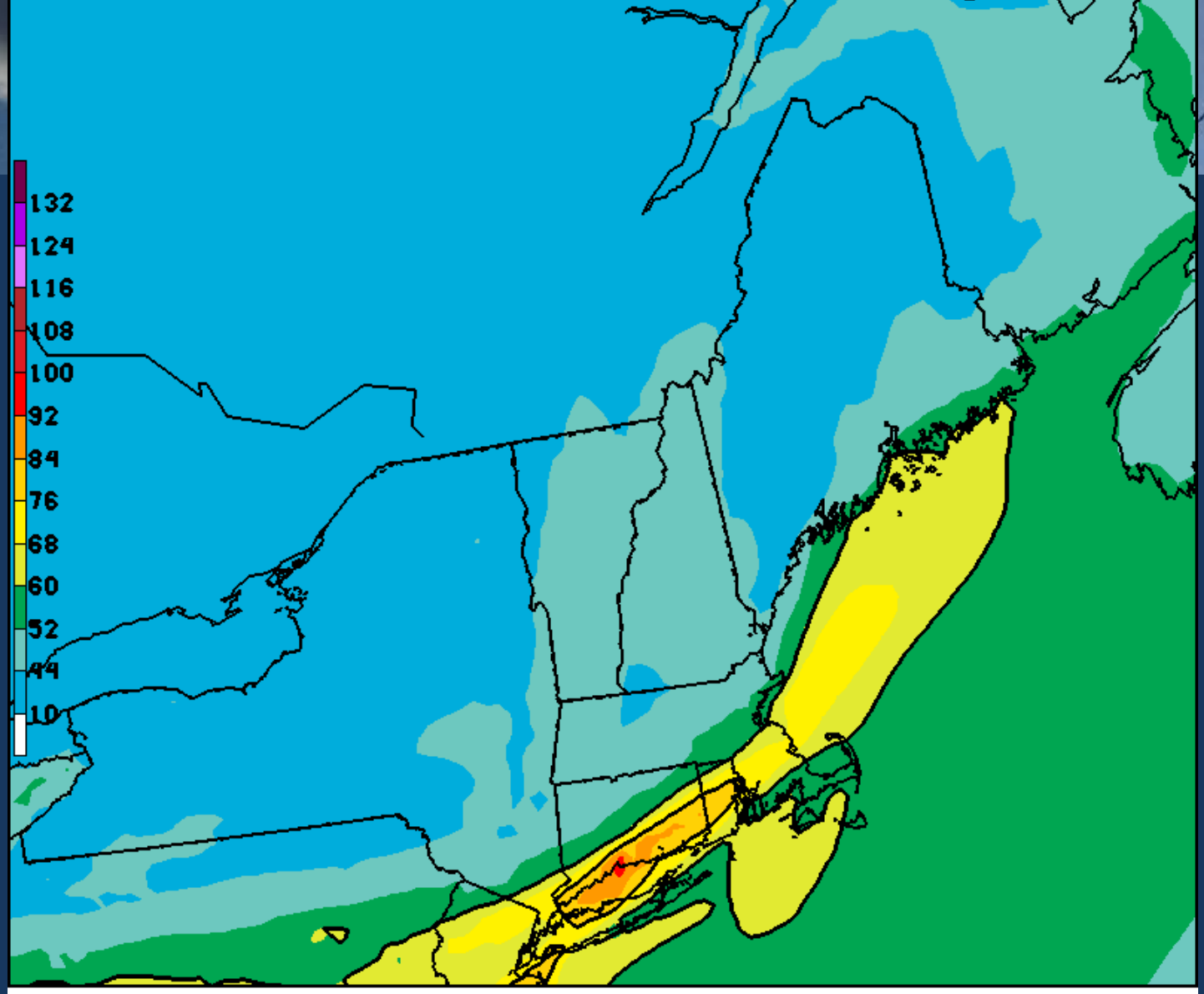
Forward Trajectories from Fire Location 6:00am to 12:00ppm

Conclusion

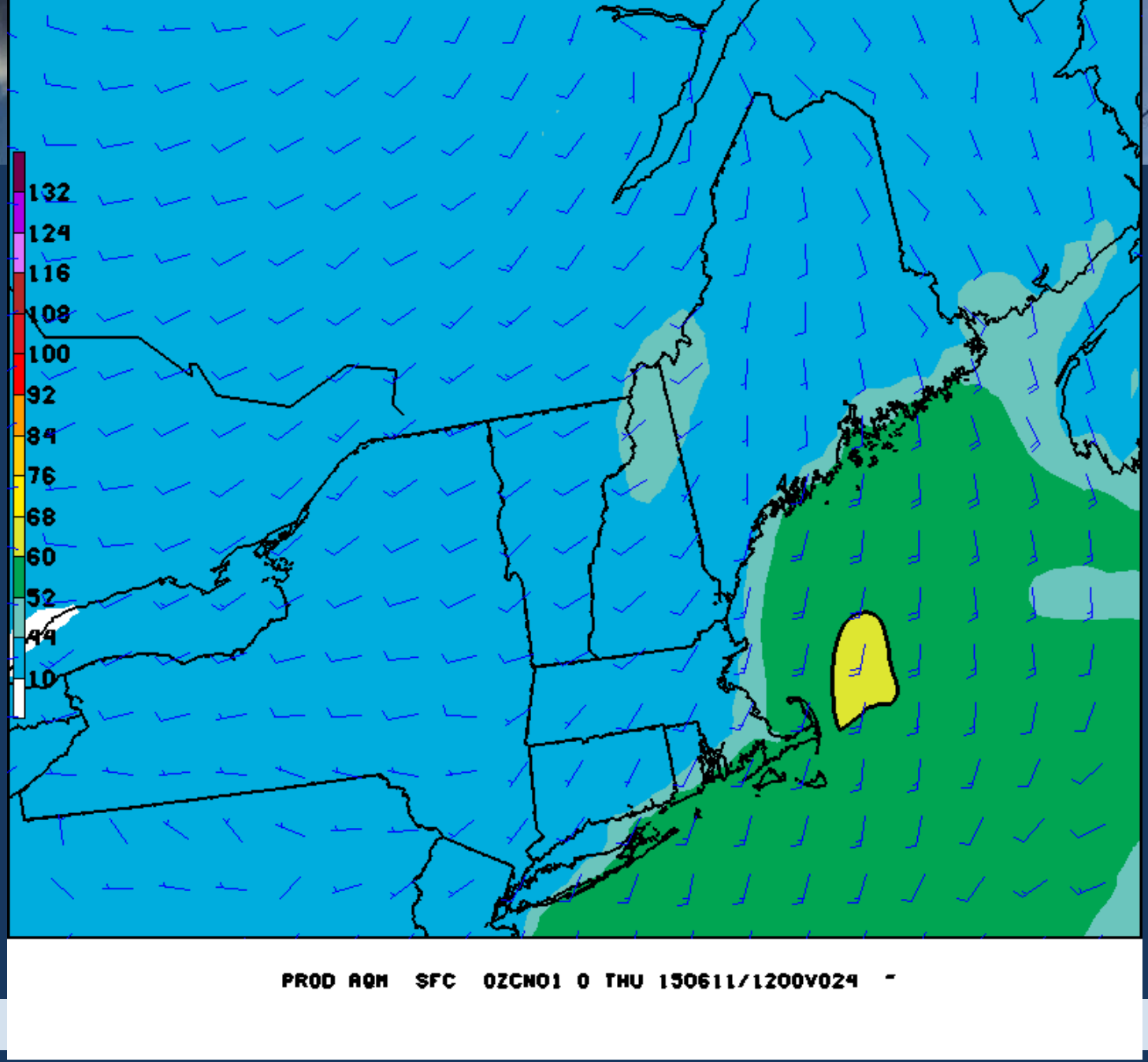
- Wide spread MODERATE ozone event on May 4th, 2015 for New England
- Warmest day of the year (high temp reached 87° at BDL), combined with southwest winds and sea breeze convergence aided in low level exceedance at Cornwall.
- Trajectories suggest that wild fire probably not the issue

June 11, 2015, 8-Hour Ozone Concentrations

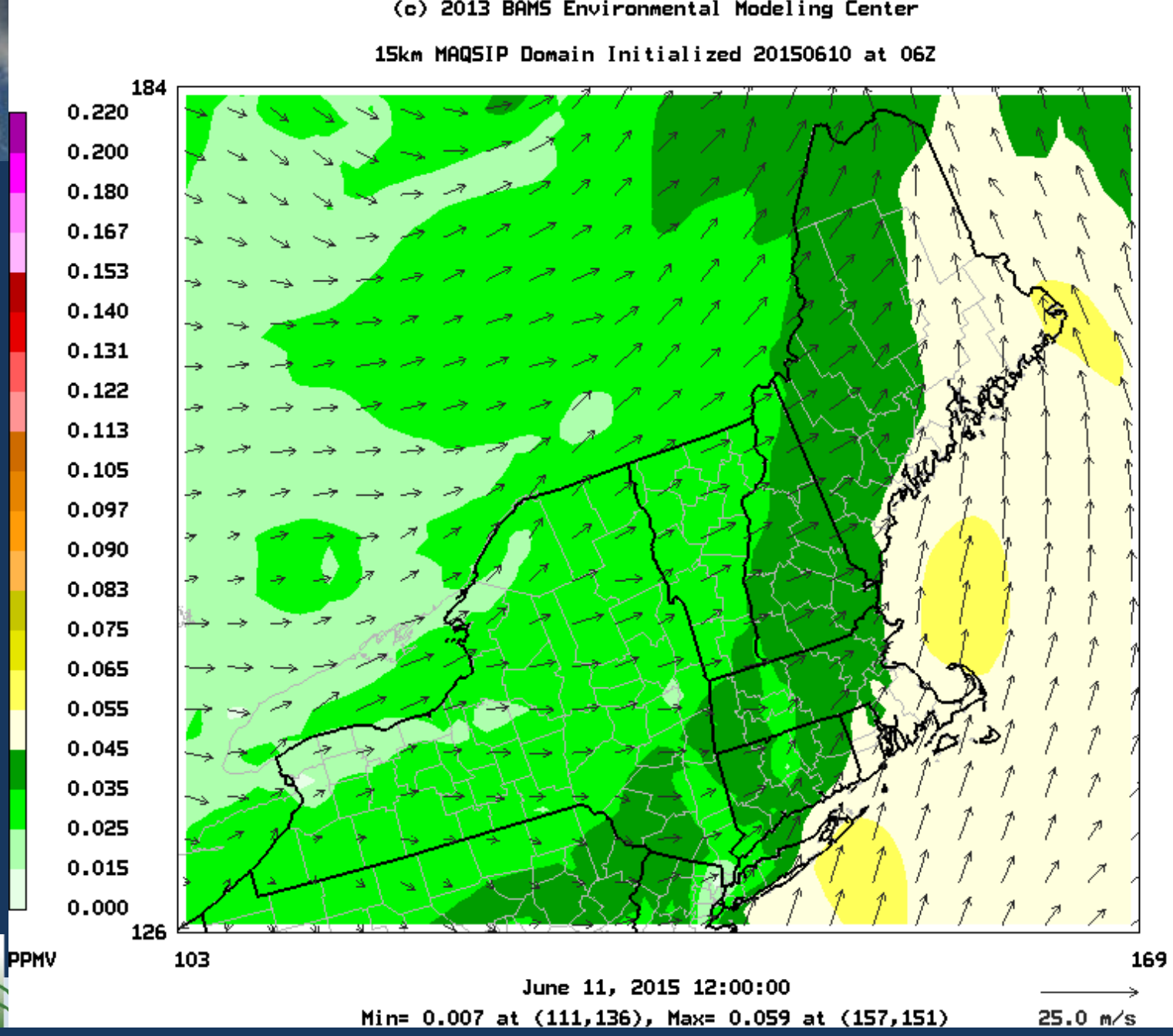
Agency	Site	Site AQS	Date (LST)	Unit	Max 8-hr
CT1	Cornwall	90050005	6/11/2015	PPB	56
CT1	Danbury	90011123	6/11/2015	PPB	68
CT1	East Hartford	90031003	6/11/2015	PPB	59
CT1	Greenwich	90010017	6/11/2015	PPB	86
CT1	Groton Fort Griswold	90110124	6/11/2015	PPB	86
CT1	Madison-Beach Road	90099002	6/11/2015	PPB	91
CT1	Middletown	90070007	6/11/2015	PPB	74
CT1	New Haven - Criscuolo Park	90090027	6/11/2015	PPB	93
CT1	Stafford	90131001	6/11/2015	PPB	57
CT1	Stratford	90013007	6/11/2015	PPB	95
CT1	Westport	90019003	6/11/2015	PPB	92



NOAA Ozone Model 8-hr Forecast

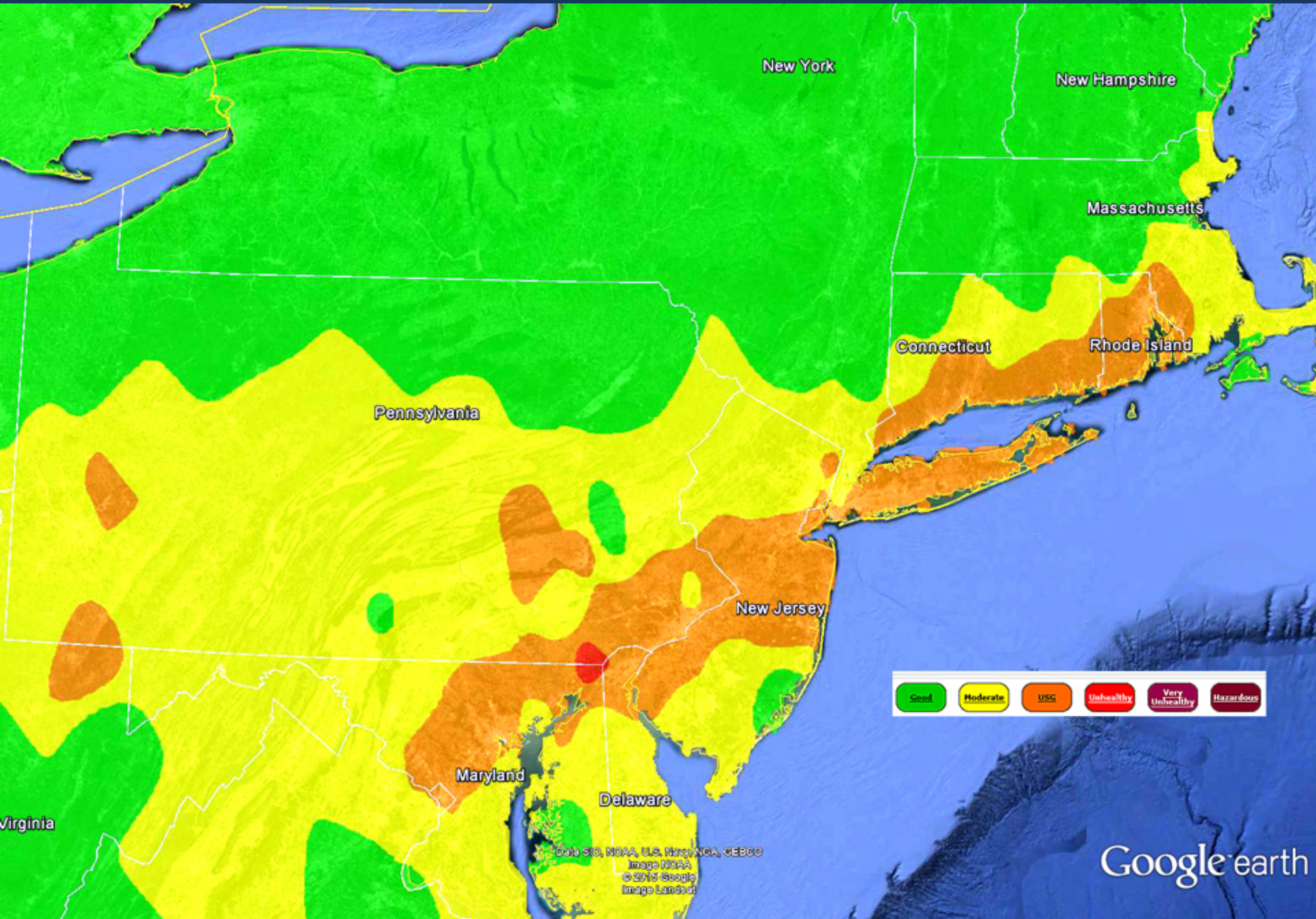


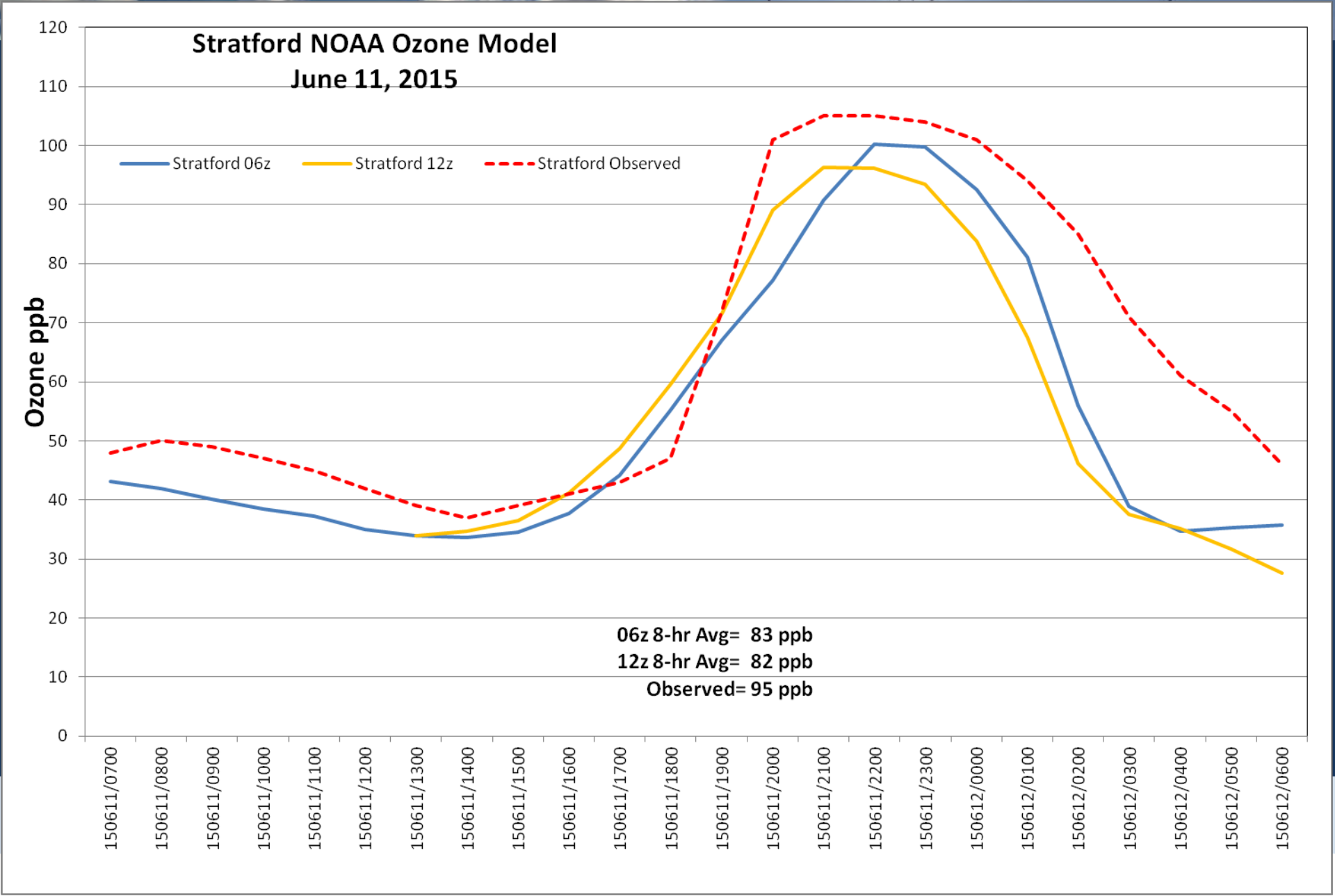
NOAA Ozone Model 8:00am -11:00pm



Barons Ozone Model 8:00am -8:00pm

AirNow 8-hr Ozone Observed AQI Map for June 11, 2015




Stratford NOAA Ozone Model
June 11, 2015
Stratford 06z
Stratford 12z
Stratford Observed
Ozone ppb
120
110
100
90
80
70
60
50
40
30
20
10
0
06z 8-hr Avg= 83 ppb
12z 8-hr Avg= 82 ppb
Observed= 95 ppb
150611/0700
150611/0800
150611/0900
150611/1000
150611/1100
150611/1200
150611/1300
150611/1400
150611/1500
150611/1600
150611/1700
150611/1800
150611/1900
150611/2000
150611/2100
150611/2200
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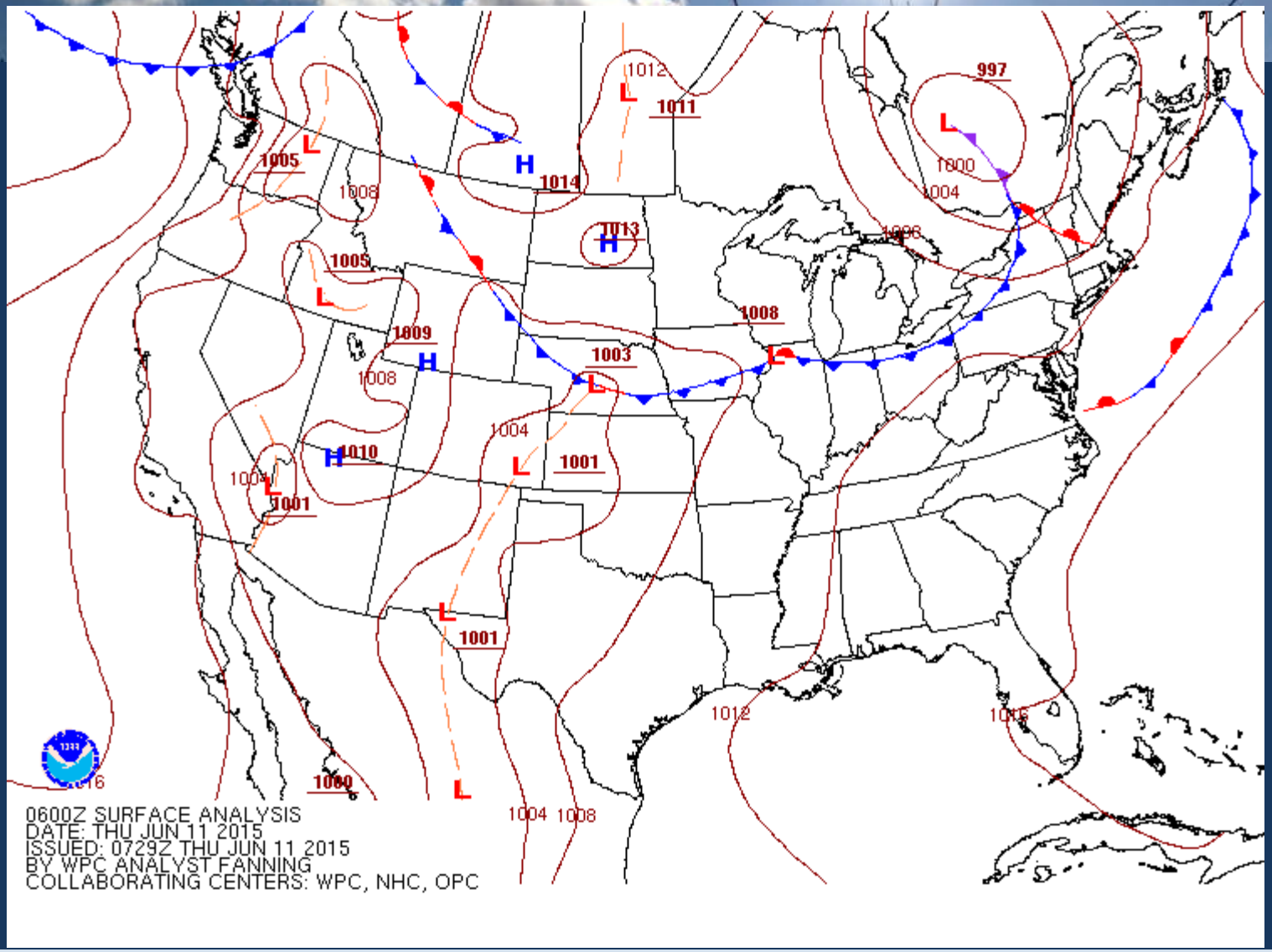
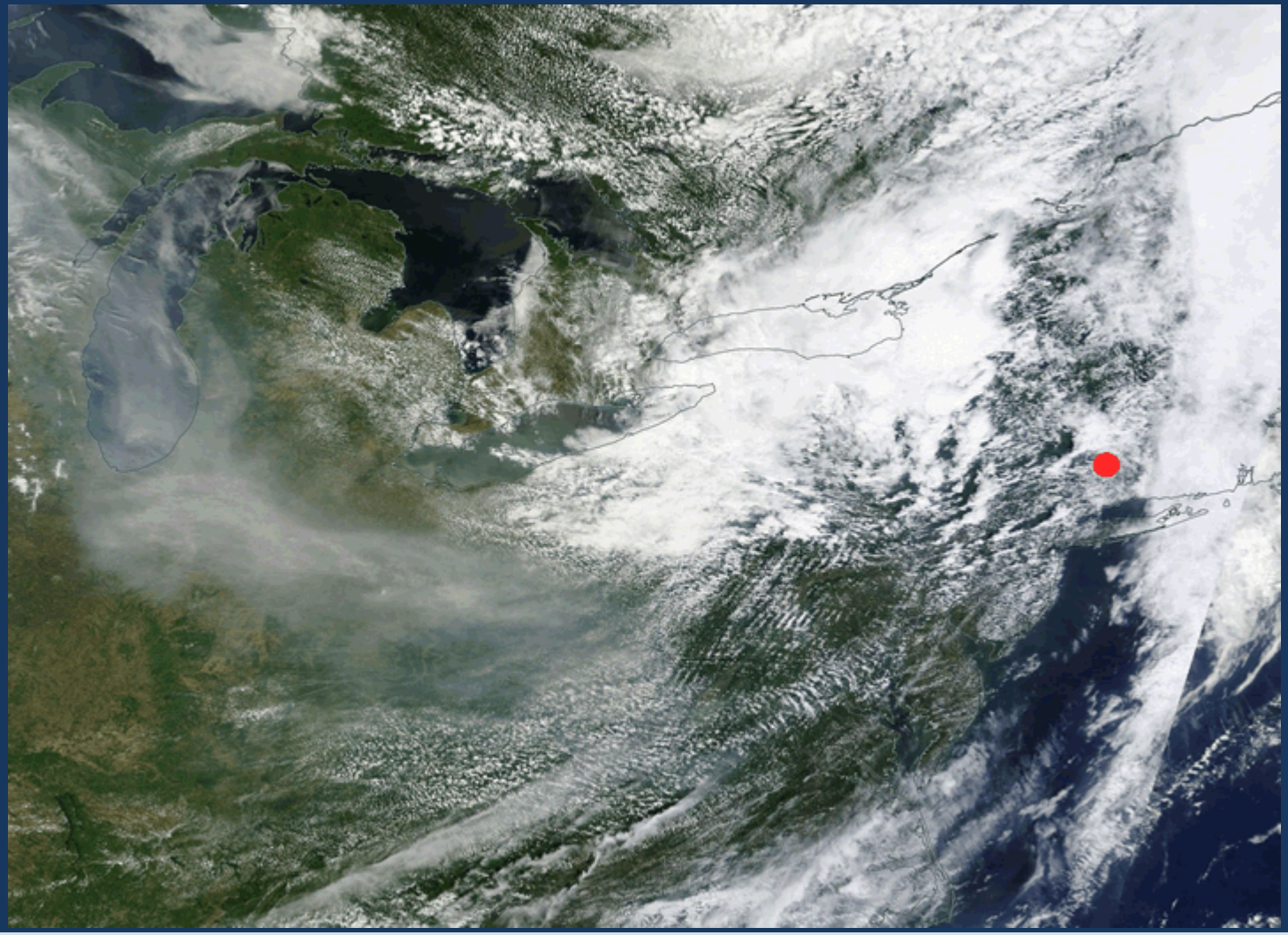
150612/0500
150612/0600



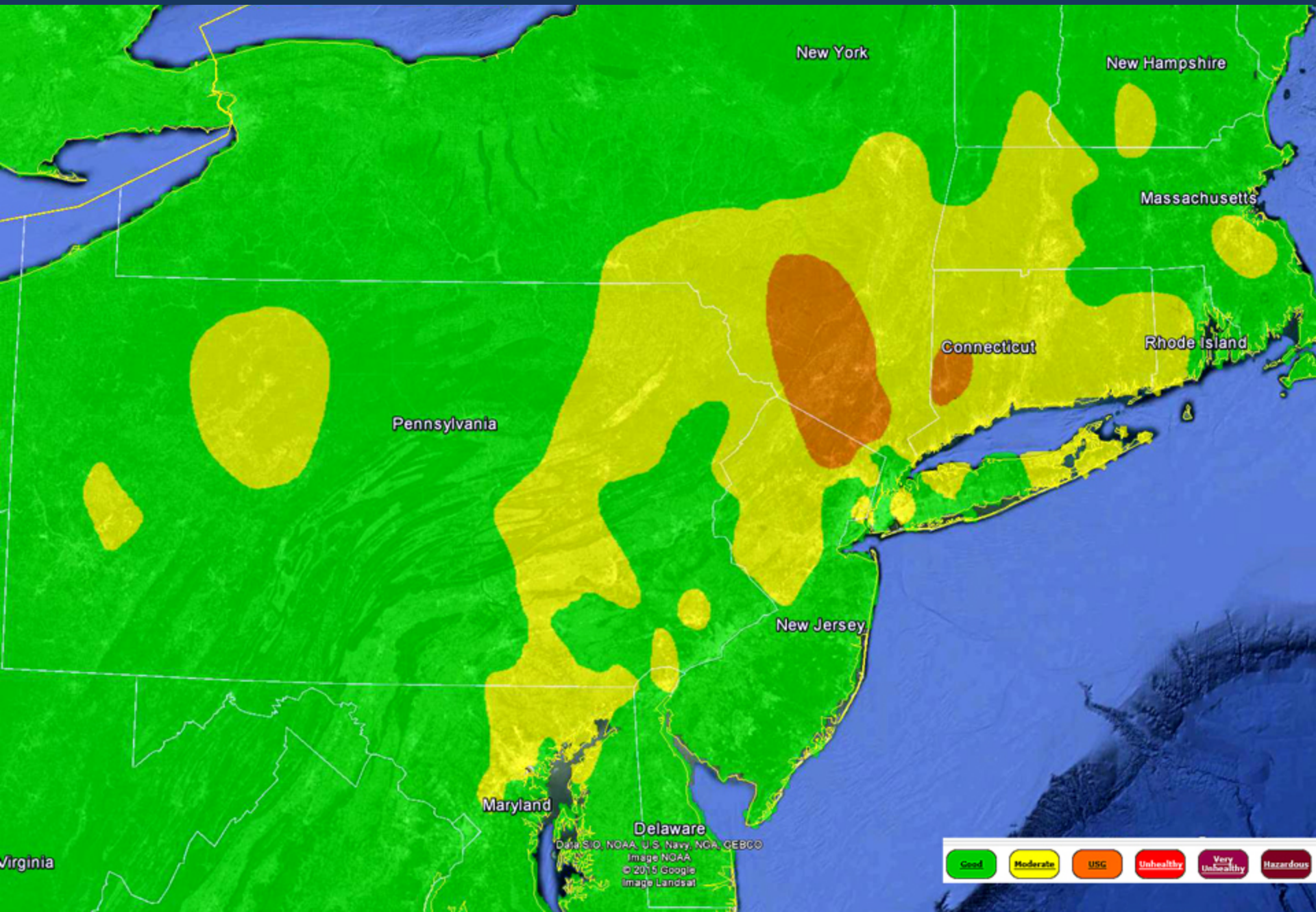
Connecticut Department of Energy and Environmental Protection

Aqua/Terra Images from June 9- June 11
Note the plume from Canadian wildfires

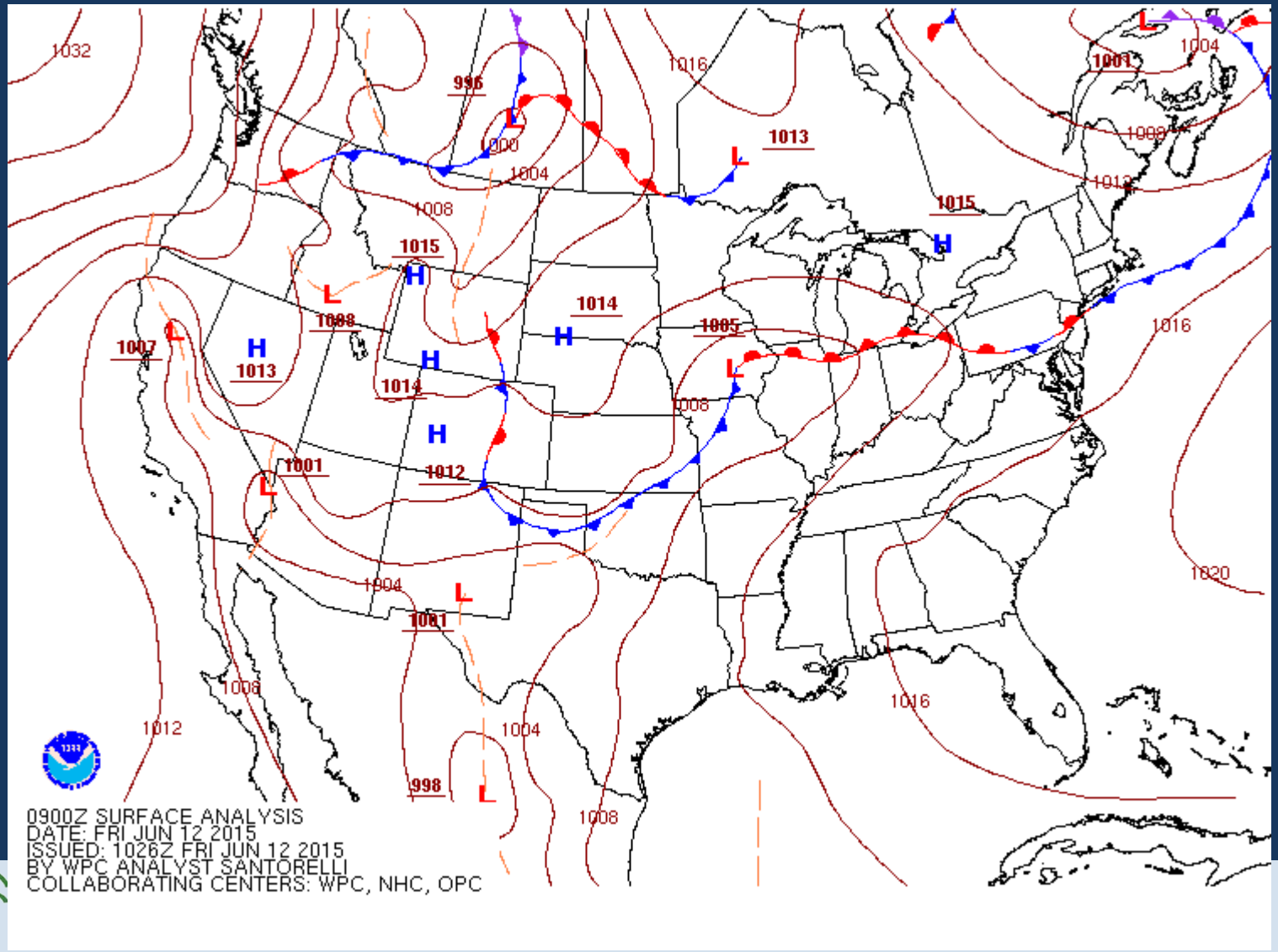


- Both Barons and NOAA models showed good agreement for Connecticut
- NOAA model shows exceedances along entire CT coast
- Observed 8-hour averages ranged from 86ppb Groton to 95 ppb Stratford
- One day event expected at the time

AirNow 8-hr Ozone Observed AQI Map for June 12, 2015



Surface Map Animation for June 12, 2015 Shows Warm Front Passage late in Day

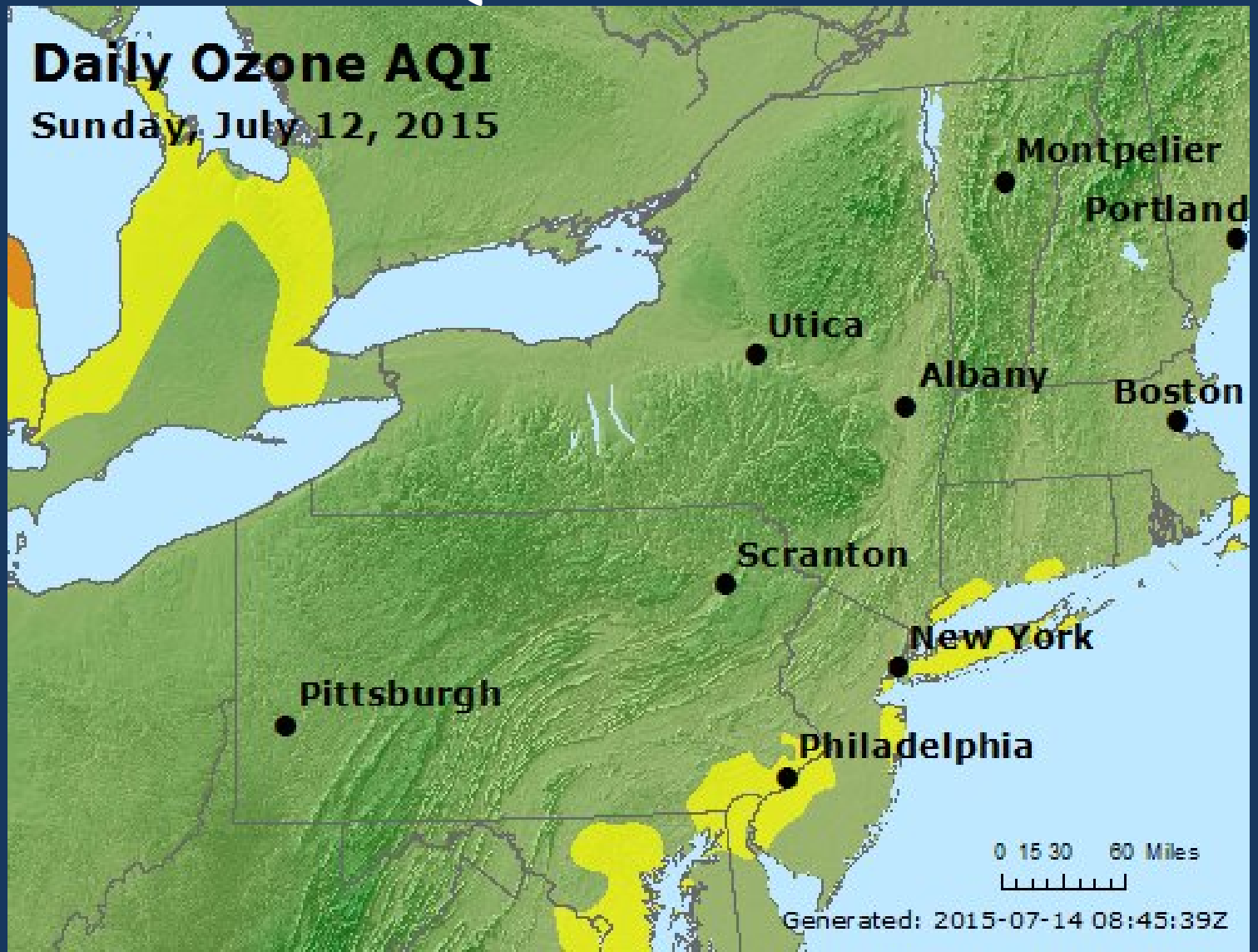


Conclusions for June 12, 2015

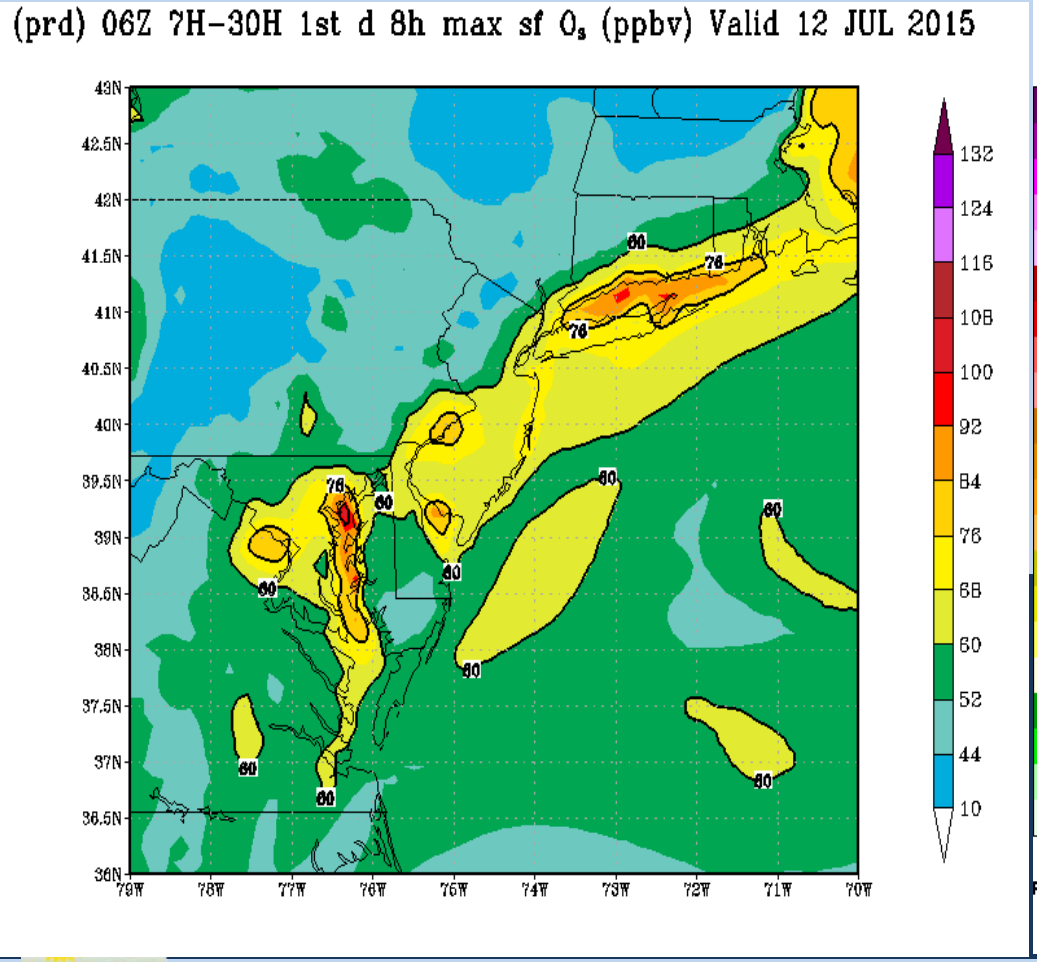
- NOAA model under-predicted ozone (GOOD to MODERATE) in CT, but predicted USG for southeast New York and northern New Jersey
- Low levels trajectories were local - off LIS, but at 1000 meters, transport was from southwest
- Warm front passage was sooner than modeled, resulting in MODERATE ozone forecasted, instead of MODERATE to USG.

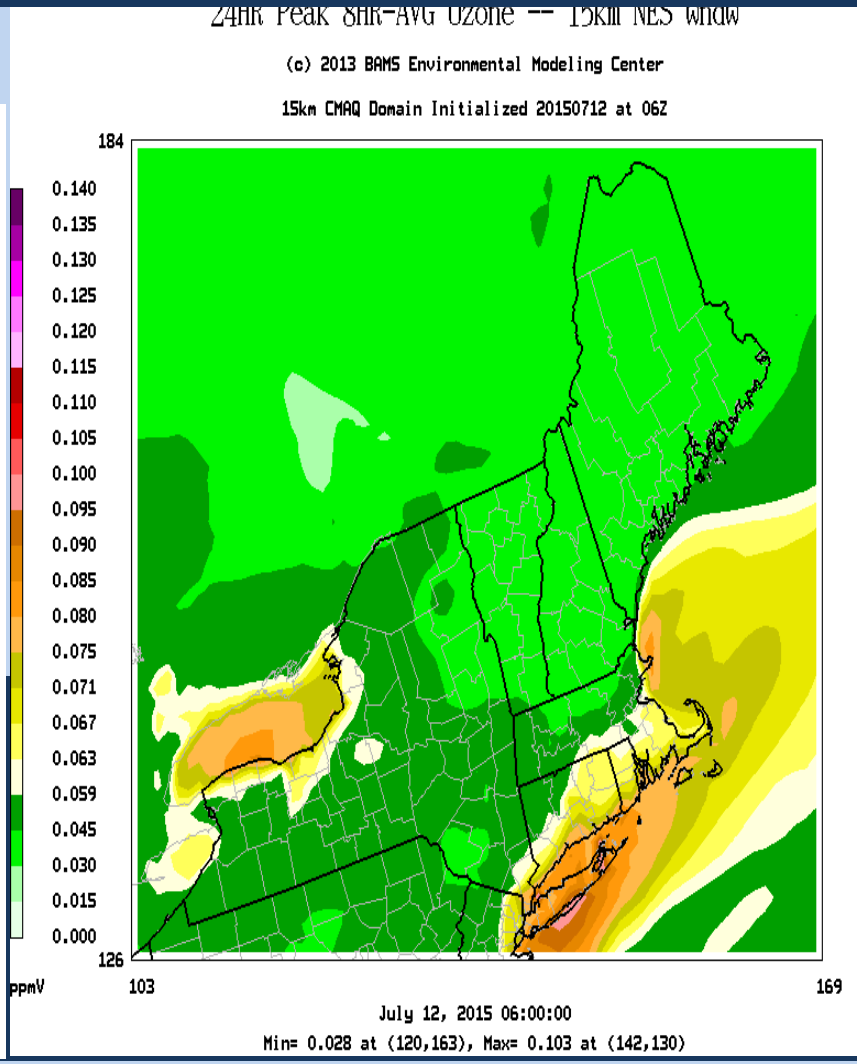
July 12, 2015 Over-Prediction

Ozone AQI for the Northeast



NOAA/BARONS Models: 06z July 12, 2015
Both Models Over predicted Coastal Exceedances

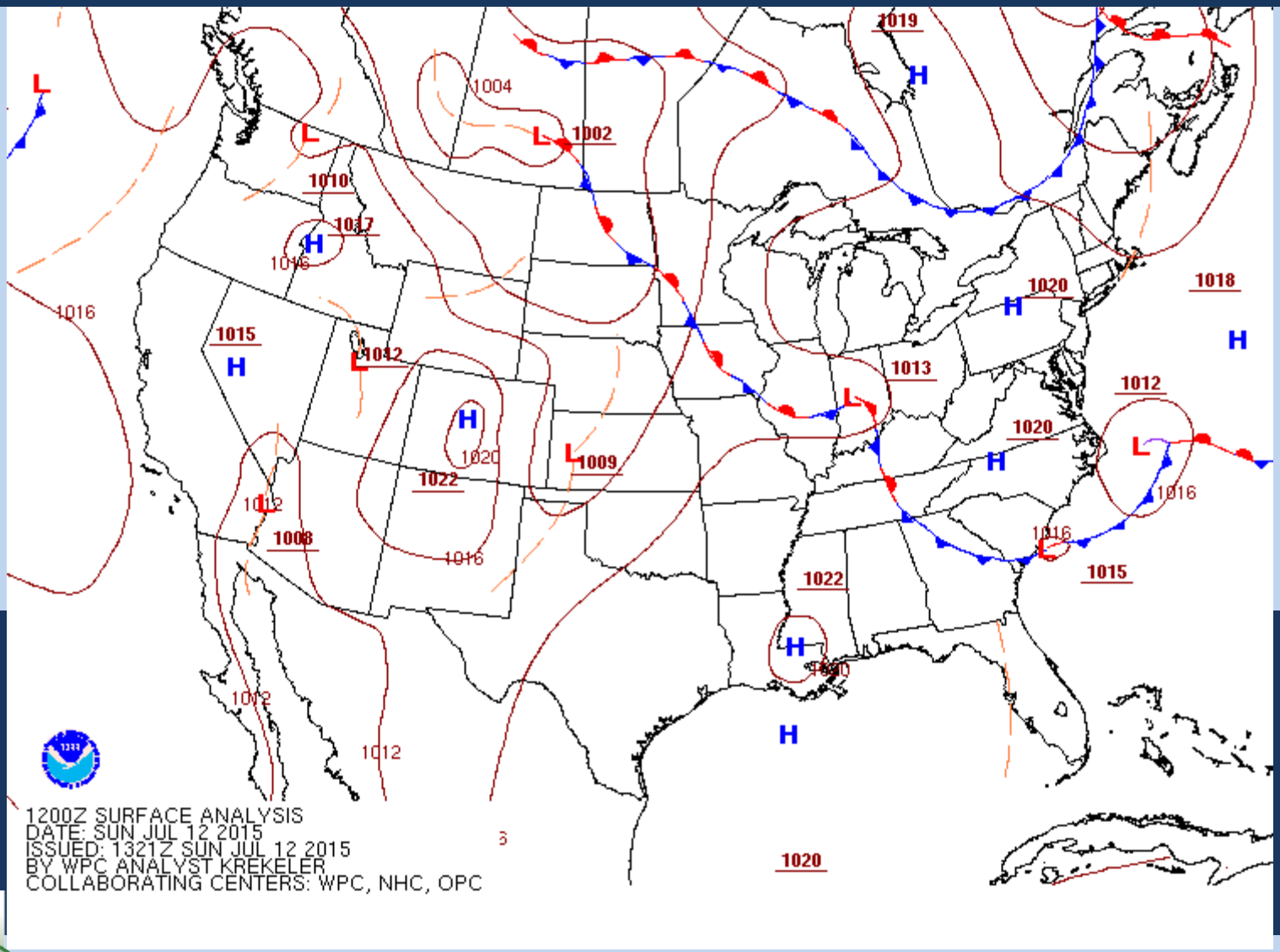


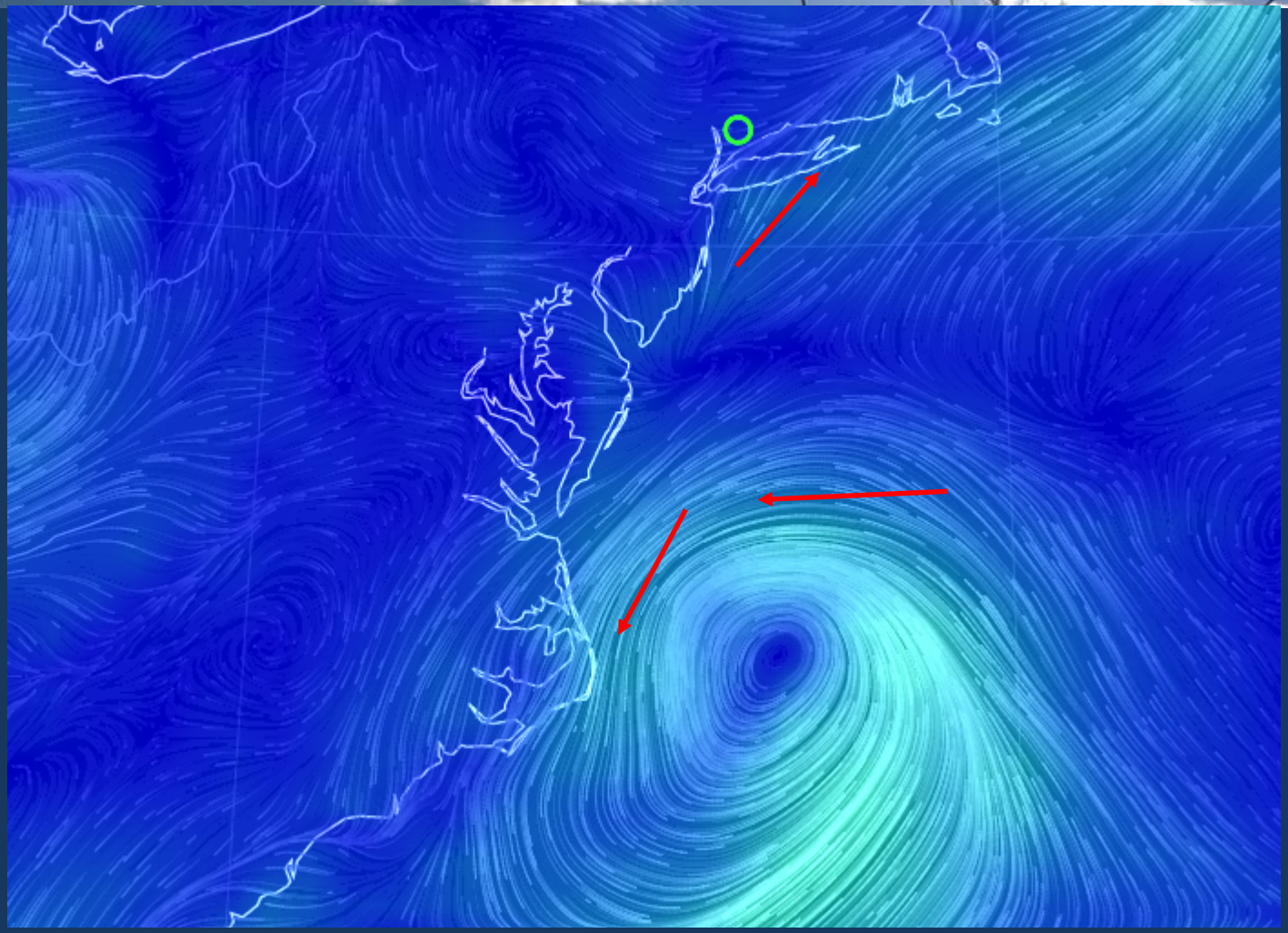


July 12, 2015 Ozone Forecast (ppb) and Observed Values

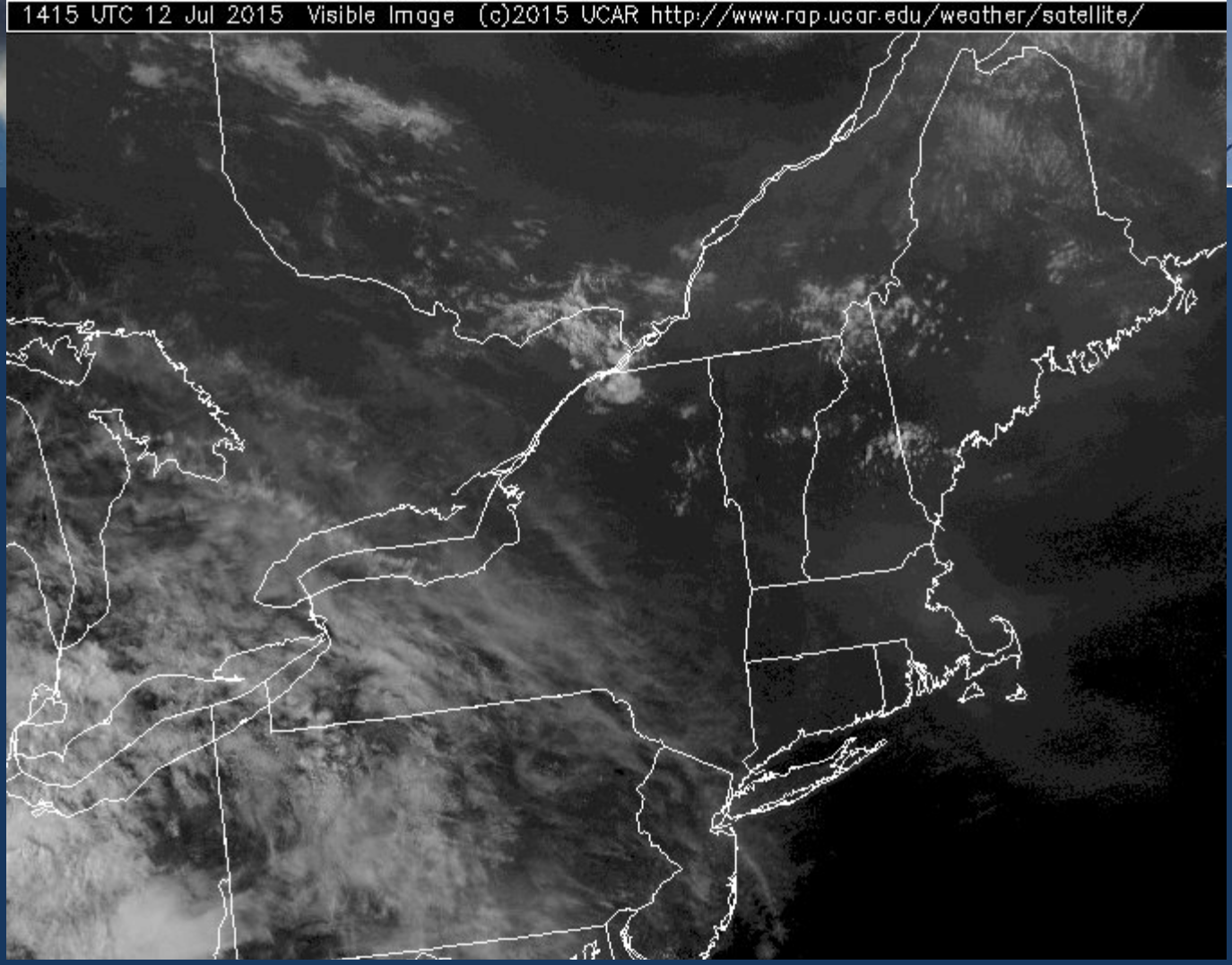
Site/Site AQS/Param/POC	Date (LST)	Max Observed	NOAA 06z	CTDEEP Forecast
Cornwall/090050005/O3/1	7/12/2015	48	46	62
Danbury/090011123/O3/1	7/12/2015	53	54	70
East Hartford/090031003/O3/1	7/12/2015	47	53	72
Greenwich/090010017/O3/1	7/12/2015	70	79	80
Groton Fort Gri/090110124/O3/1	7/12/2015	56	81	80
Madison-Beach R/090099002/O3/1	7/12/2015	65	93	80
Middletown/090070007/O3/1	7/12/2015	50	61	74
New Haven - Cri/090090027/O3/1	7/12/2015	44	81	80
Stafford/090131001/O3/1	7/12/2015	44	49	70
Stratford/090013007/O3/1	7/12/2015	62	90	80
Westport/090019003/O3/1	7/12/2015	63	80	80

Surface Map Animation Showing Ocean Low





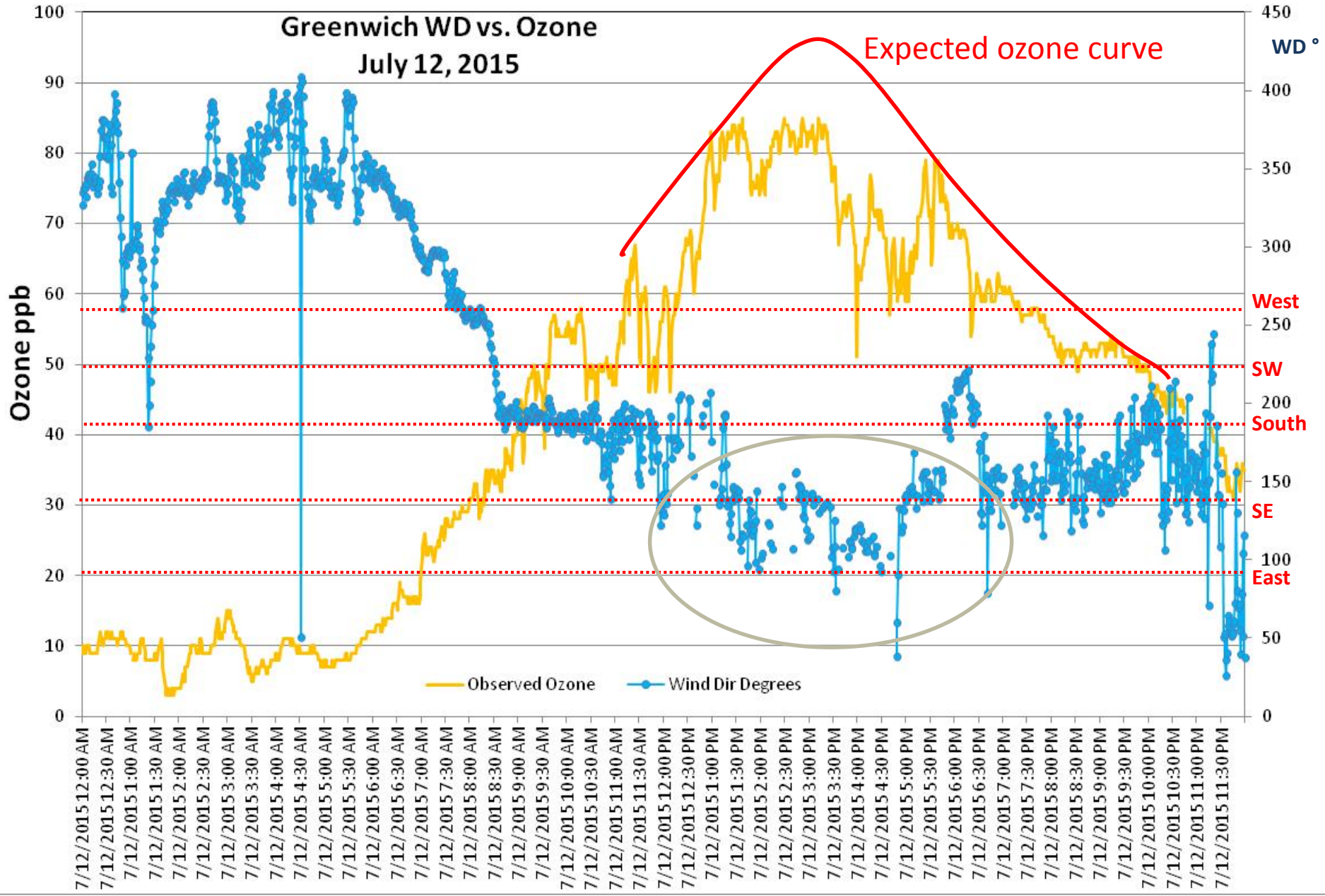
GFS 18z windstream analysis further exemplifies prevailing southwest winds over LIS while tropical system gets going to the south.



- Satellite shows high clouds streaming over the area
- Typically, this is not enough to limit ozone production

Wind Direction vs. Minute Ozone at Greenwich

Note the ozone ppb deviation from expected curve when wind shifted towards the east



Conclusions

- Irregularity of observed ozone curve suggests that expected sea-breeze was disrupted.
- NAM model was predicting influence of ocean ‘low’ by Monday, mixing in the maritime air
- It’s possible that ‘low’ developed sooner and stronger than forecast by NAM
- The Greenwich wind direction trace vs. ozone shows how sensitive it is to wind direction
- There is a need to better characterize the ozone over LIS

September 17, 2015

8-hour Average Maximum Ozone Concentrations (ppb)

- 39 OTC monitors > 75 ppb
- 8 CT monitors > 75 ppb
- 10 OTC monitors > 84 ppb
- 4 CT monitors > 84 ppb

Site (CT only)	Site AQS	Param	Date (LST)	Max_8-hr _O3
Greenwich	90010017	O3	9/17/2015	91
Danbury	90011123	O3	9/17/2015	72
Stratford	90013007	O3	9/17/2015	94
Westport	90019003	O3	9/17/2015	96
Cornwall	90050005	O3	9/17/2015	68
Middletown	90070007	O3	9/17/2015	84
New Haven	90090027	O3	9/17/2015	88
Madison-Beach	90099002	O3	9/17/2015	81
Groton Fort	90110124	O3	9/17/2015	77
Stafford	90131001	O3	9/17/2015	79
Abington	90159991	O3	9/17/2015	73

September 18, 2015

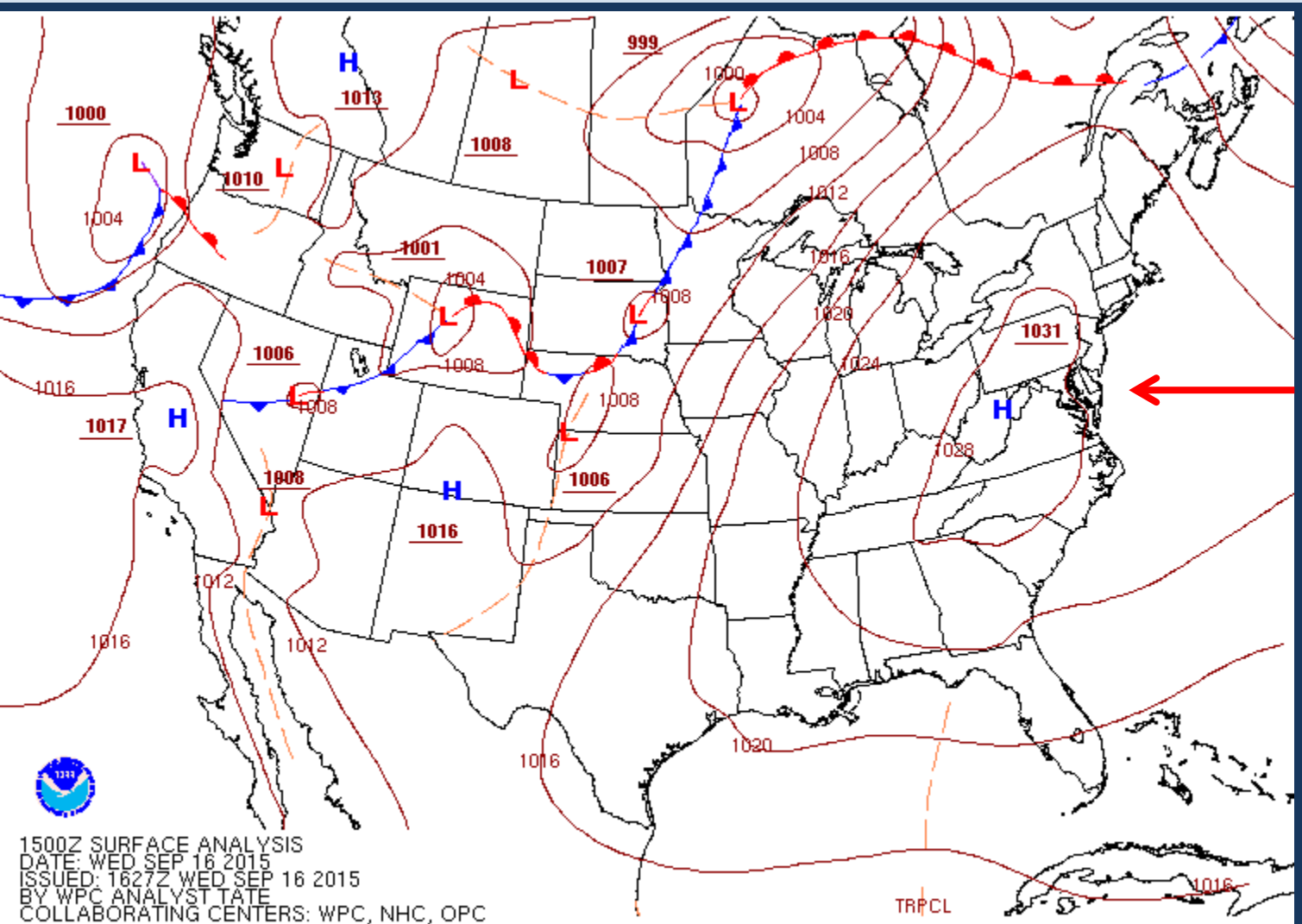
8-hour Average Maximum Ozone Concentrations (ppb)

- 35 OTC monitors > 75 ppb
- 11 CT monitors > 75 ppb
- 2 OTC monitors > 84 ppb
- 1 CT monitor > 84 ppb

Site (CT only)	Site AQS	Param	Date (LST)	Max 8-hr Ozone
Danbury	90011123	O3	9/18/2015	88
East Hartford	90031003	O3	9/18/2015	84
Stratford	90013007	O3	9/18/2015	84
Middletown	90070007	O3	9/18/2015	82
Westport	90019003	O3	9/18/2015	81
Abington	90159991	O3	9/18/2015	79
Cornwall	90050005	O3	9/18/2015	79
Madison-Beach	90099002	O3	9/18/2015	79
New Haven	90090027	O3	9/18/2015	79
Stafford	90131001	O3	9/18/2015	79
Greenwich	90010017	O3	9/18/2015	78
Groton Fort	90110124	O3	9/18/2015	71

Surface Analysis Animation

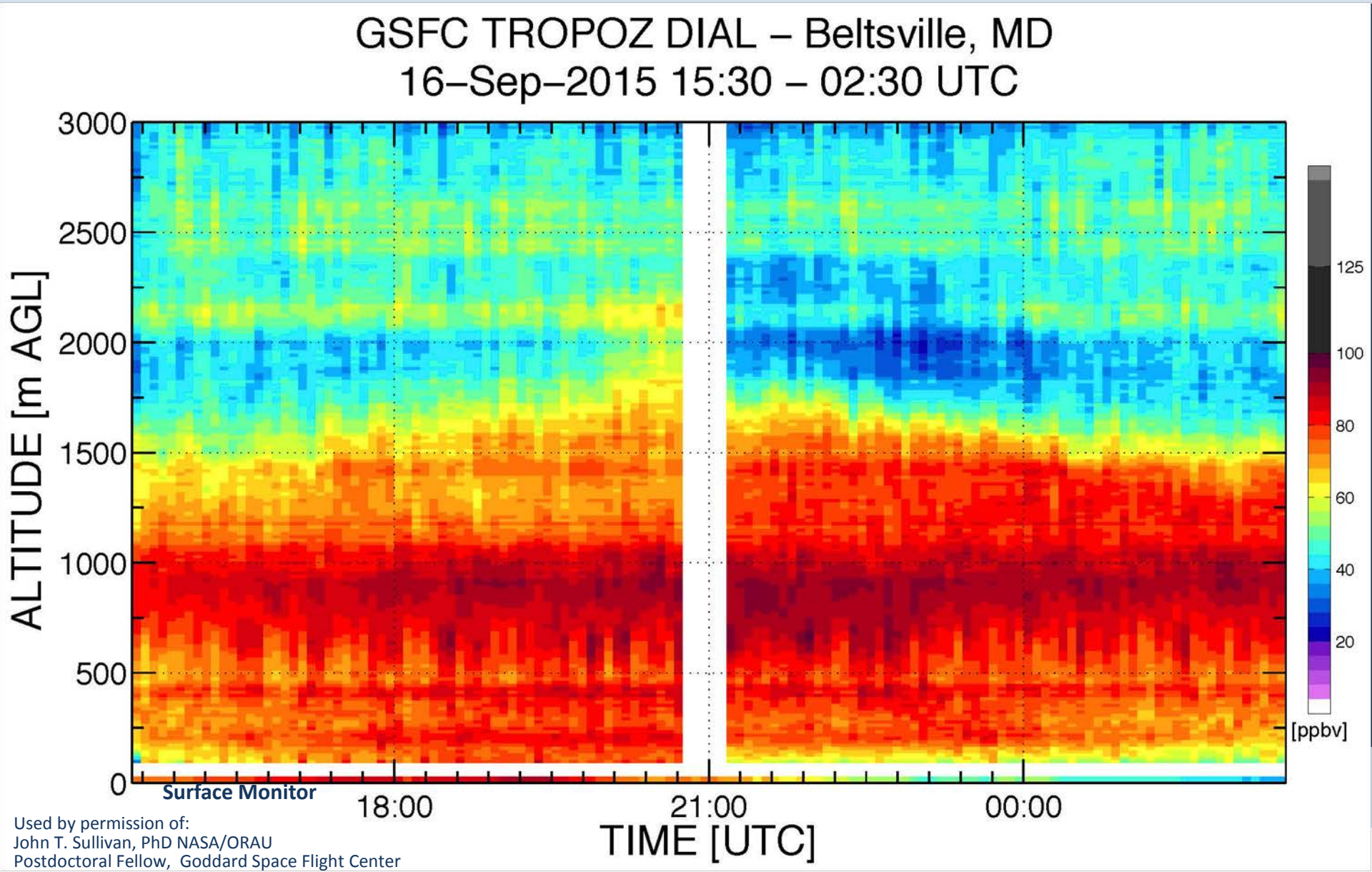
September 16, 11:00 am- September 19, 2:00 am



Note the nearly stationary high pressure center over the mid-Atlantic region.

This resulted in light winds and stagnant conditions that tended to trap pollutants in the boundary layer.

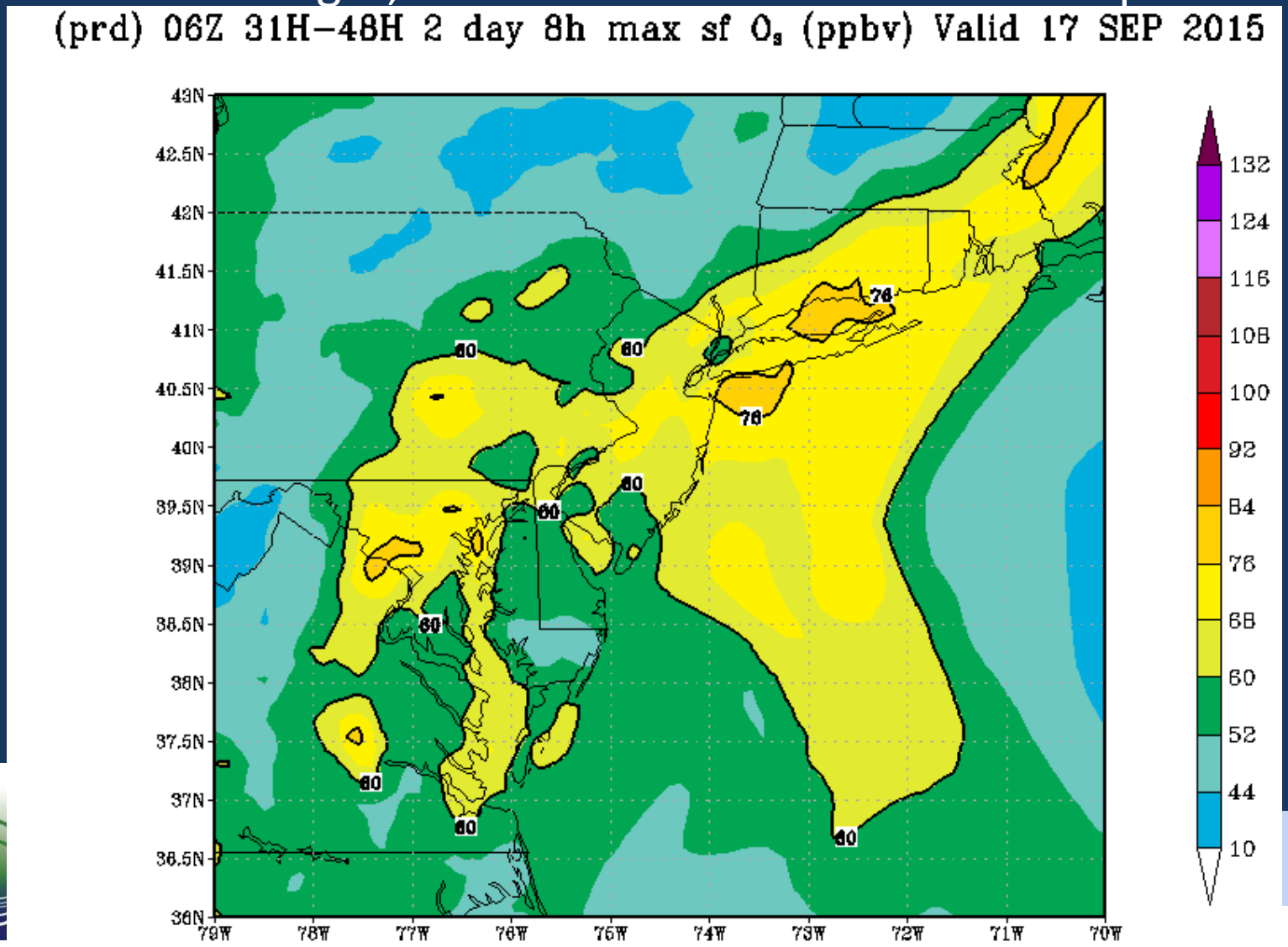
Ozone Lidar 11:30 am- 10:30 pm
September 16, 2015, Beltsville MD



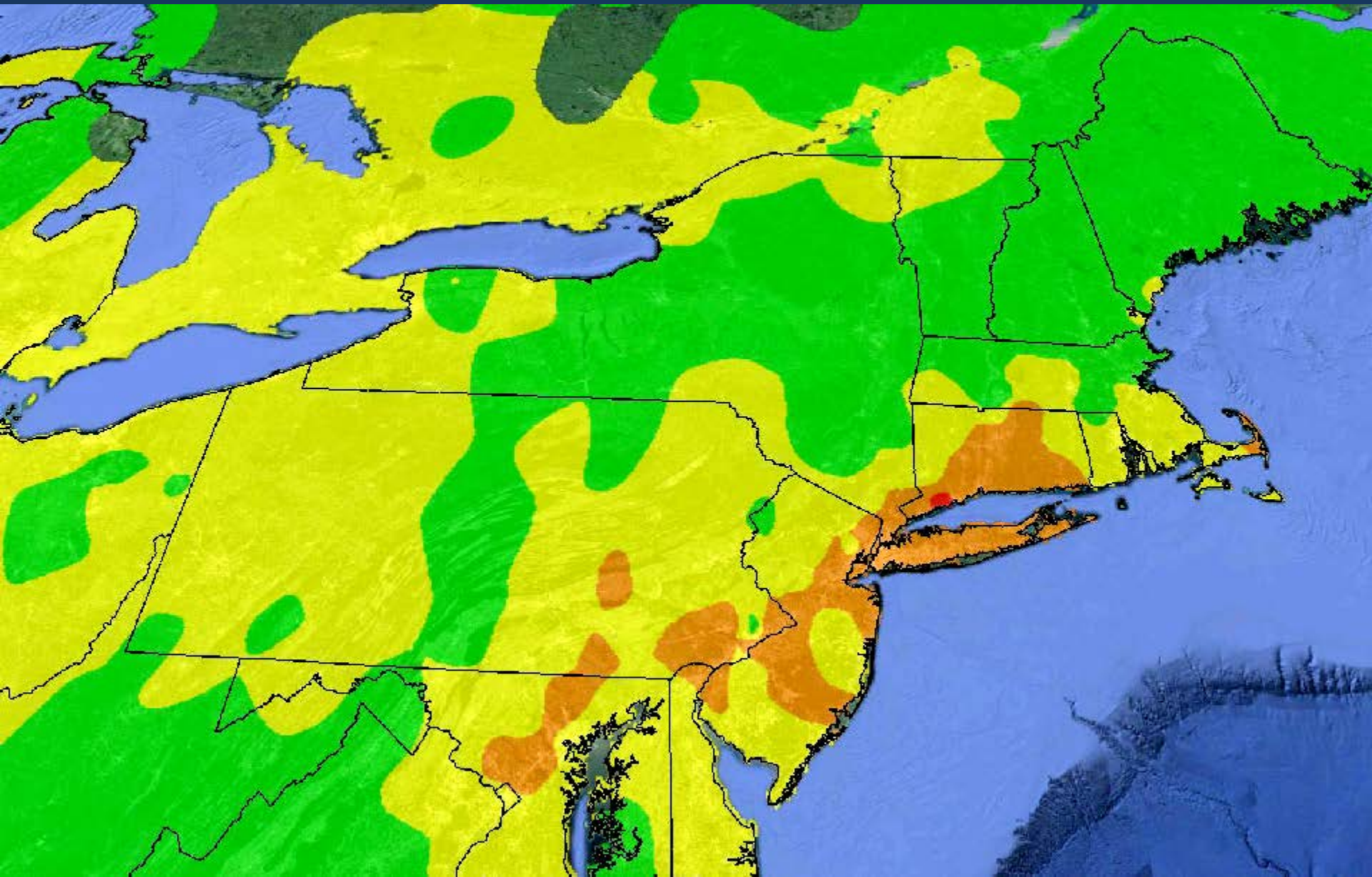
Used by permission of:
John T. Sullivan, PhD NASA/ORAU
Postdoctoral Fellow, Goddard Space Flight Center

September 17th

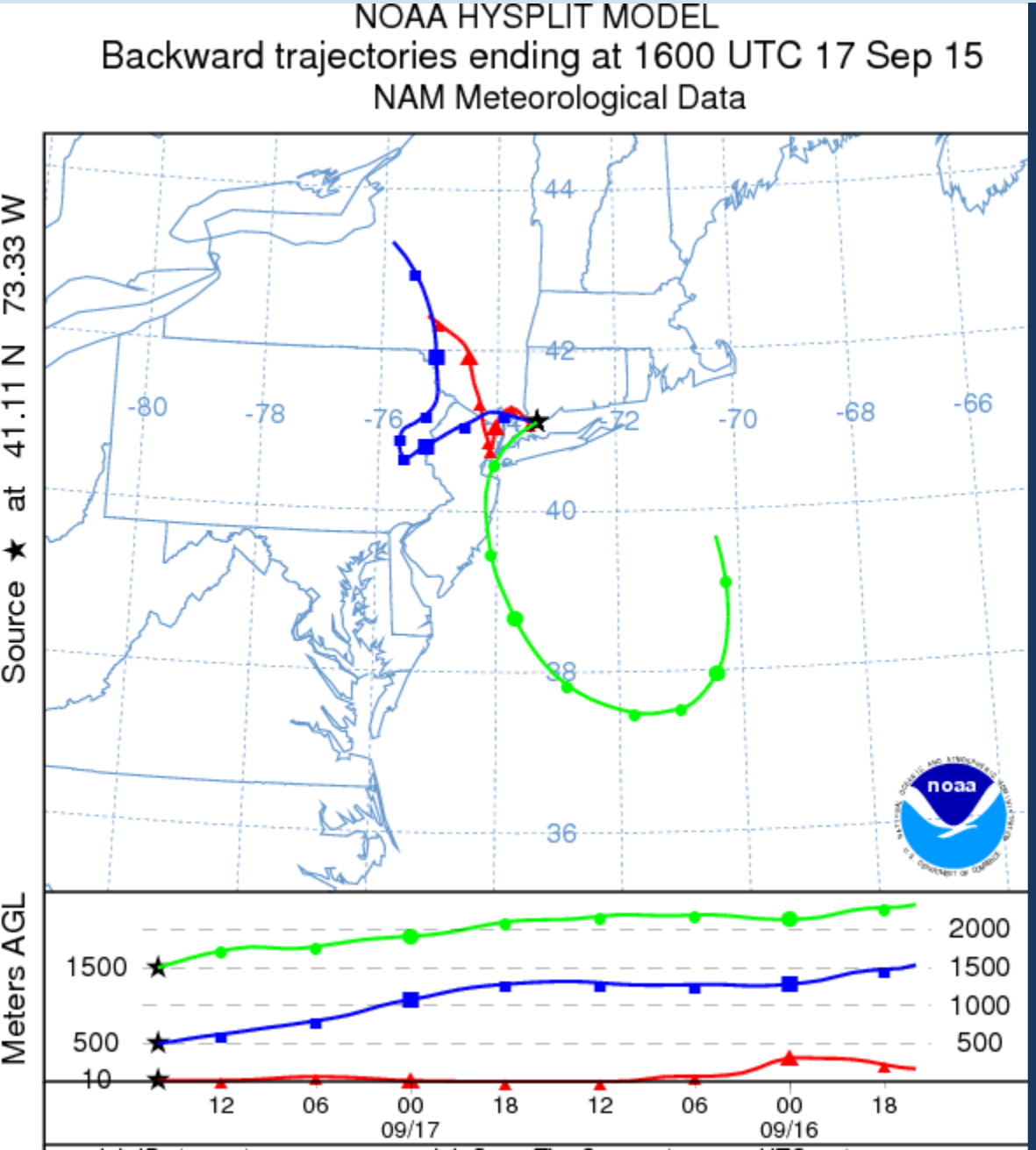
- Ozone Lidar levels ranged from 80-120 ppb on September 17th up to 1500 meters in height, but the NOAA model was under predicting



Peak Ozone AQI- September 17, 2015



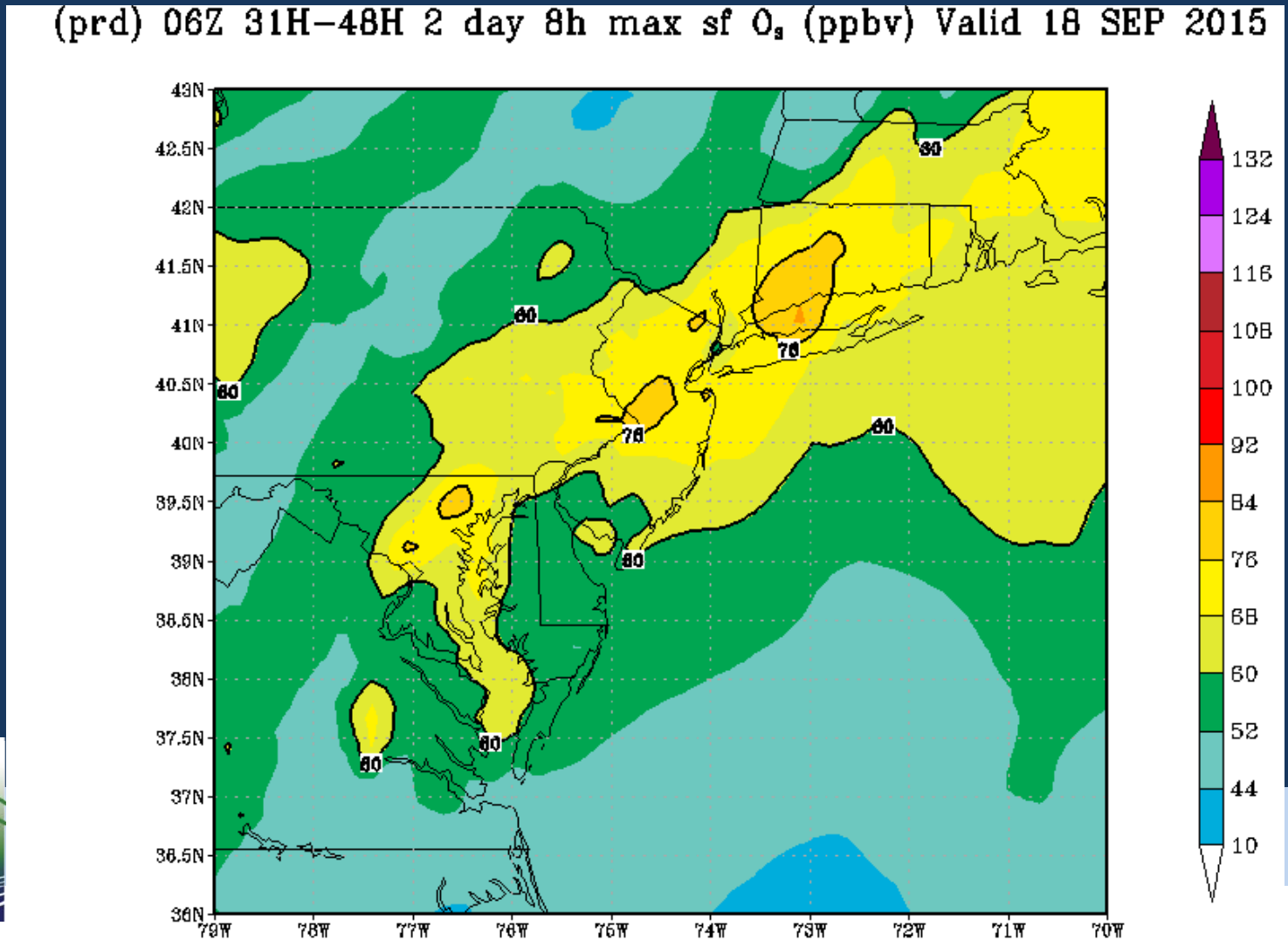
September 17, 2015 NAM 48-hr Back Trajectories



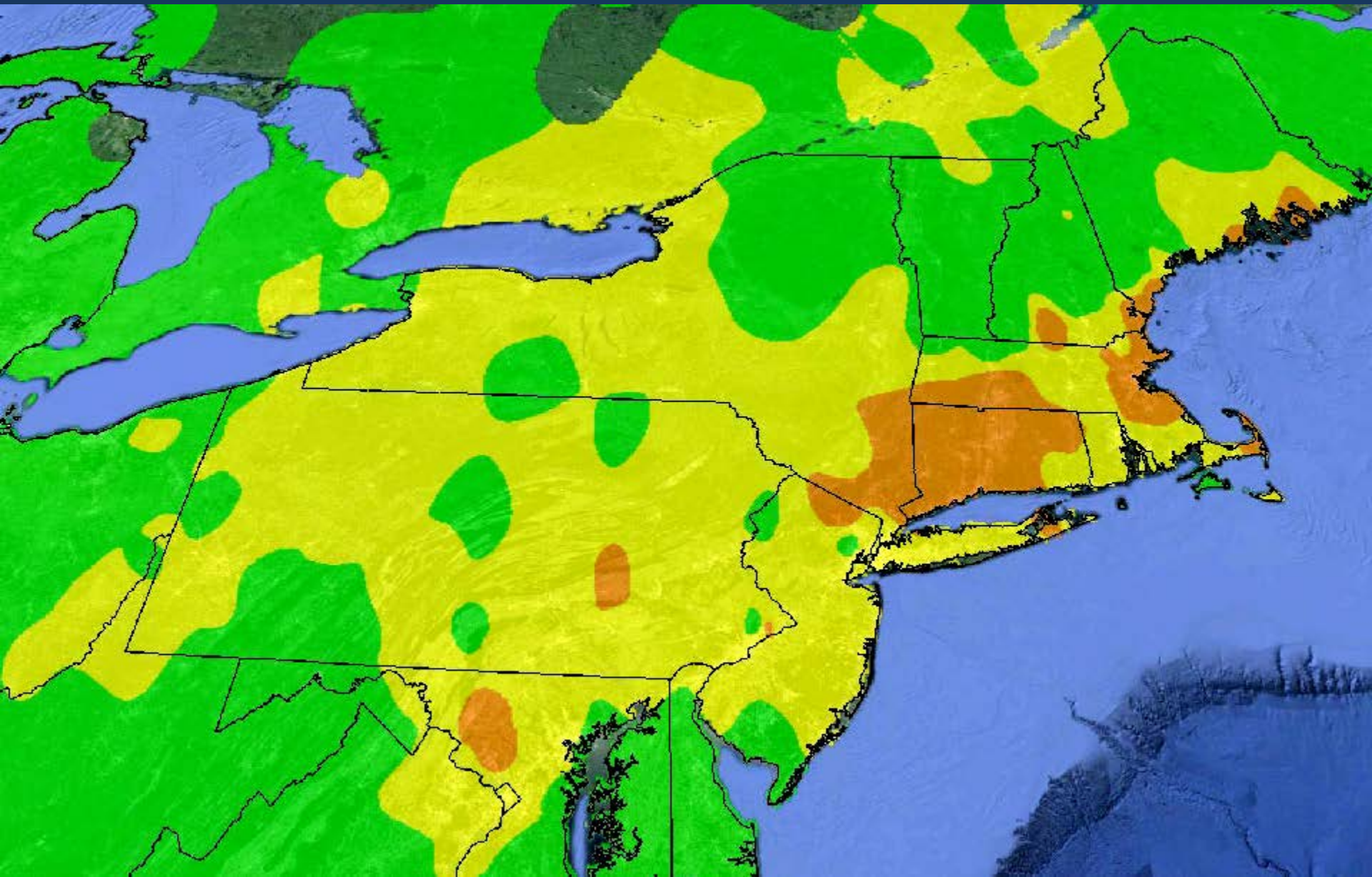
- These September 17 NAM 48-hour back trajectories tell a story of meandering lower level winds and the 1500 meter back-trajectory starting over the Atlantic.
- Clearly not a classic case of ‘Corridor’ transport

September 18th

- NOAA model was still under-predicting ozone, especially in New England.
-

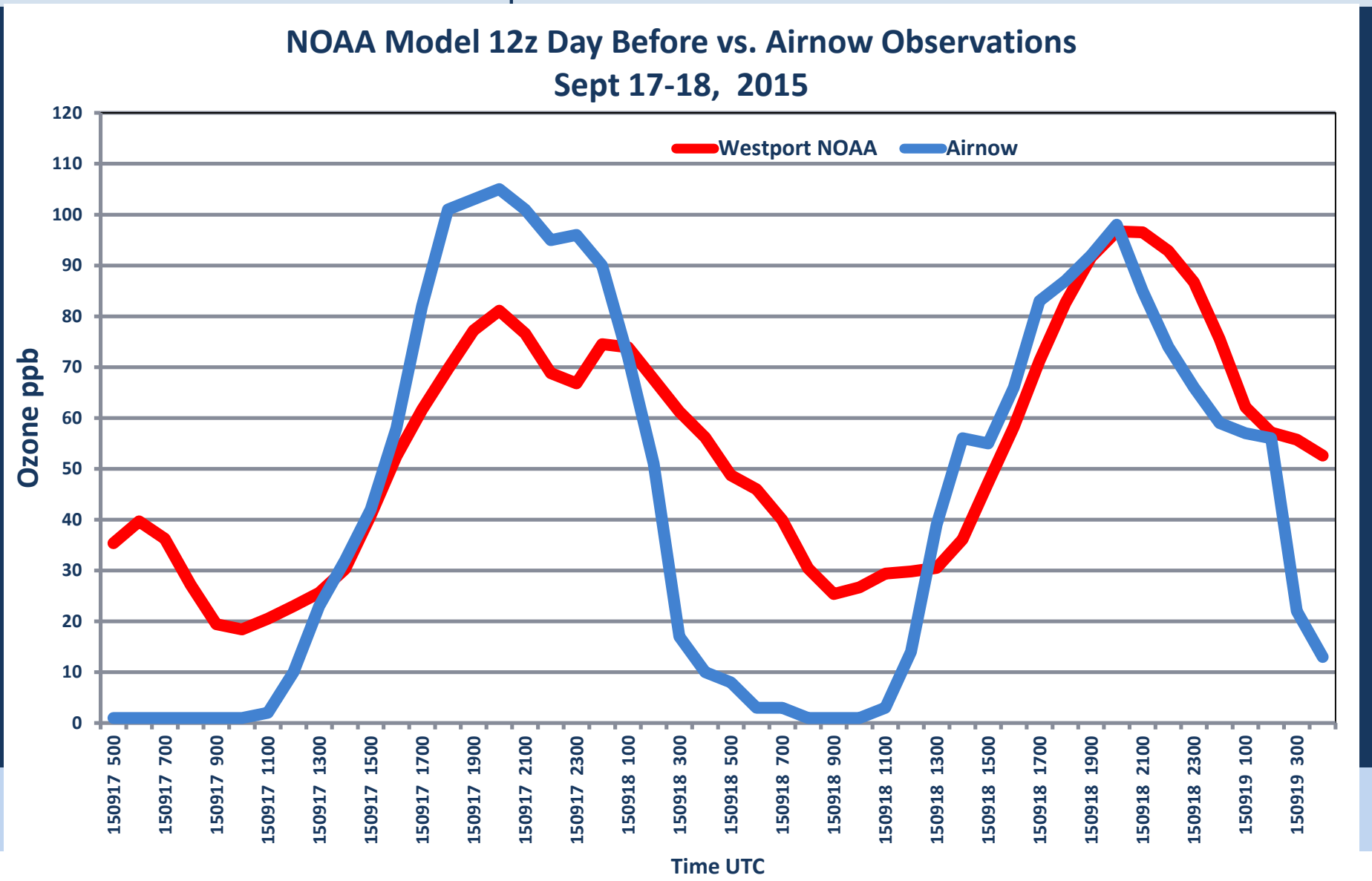


Peak Ozone AQI- September 18, 2015



Westport CT Modeled Ozone

- 12z day before model run forecast better than same day 06z
- Forecast for September 18th was much more accurate



Conclusions

- Evidence suggests that some southwest ozone transport into Connecticut was occurring, but a portion of the precursor buildup could have been ‘homegrown’.
- This was a rare September stagnation type of event that was under-predicted by the NOAA CMAQ model.
- This is an important case study for CMAQ/NAM model developers to improve the boundary layer parameters.

Questions?