An Overview and Evaluation of the Real-Time Air Quality Model Forecasting at NCDAQ

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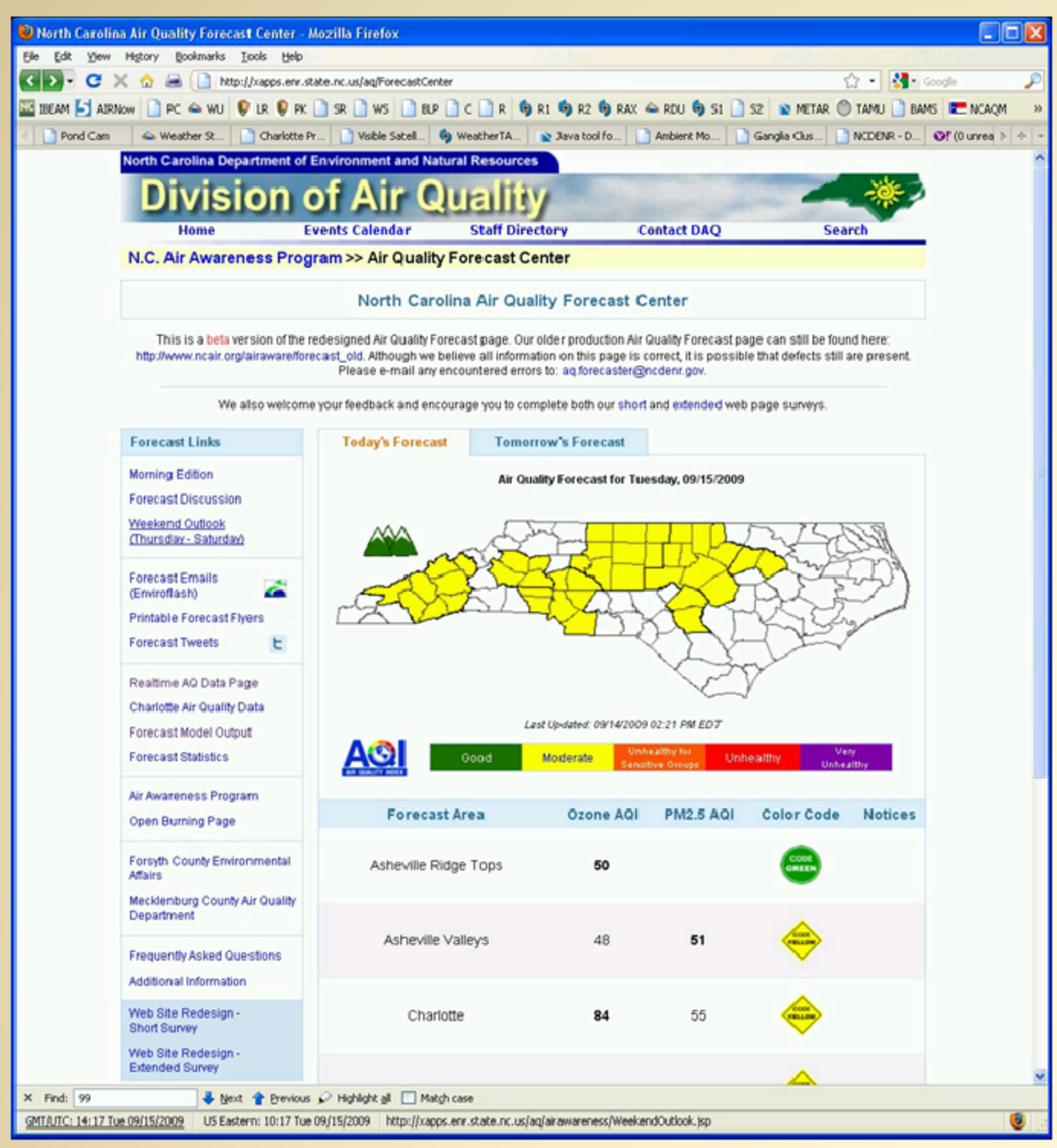
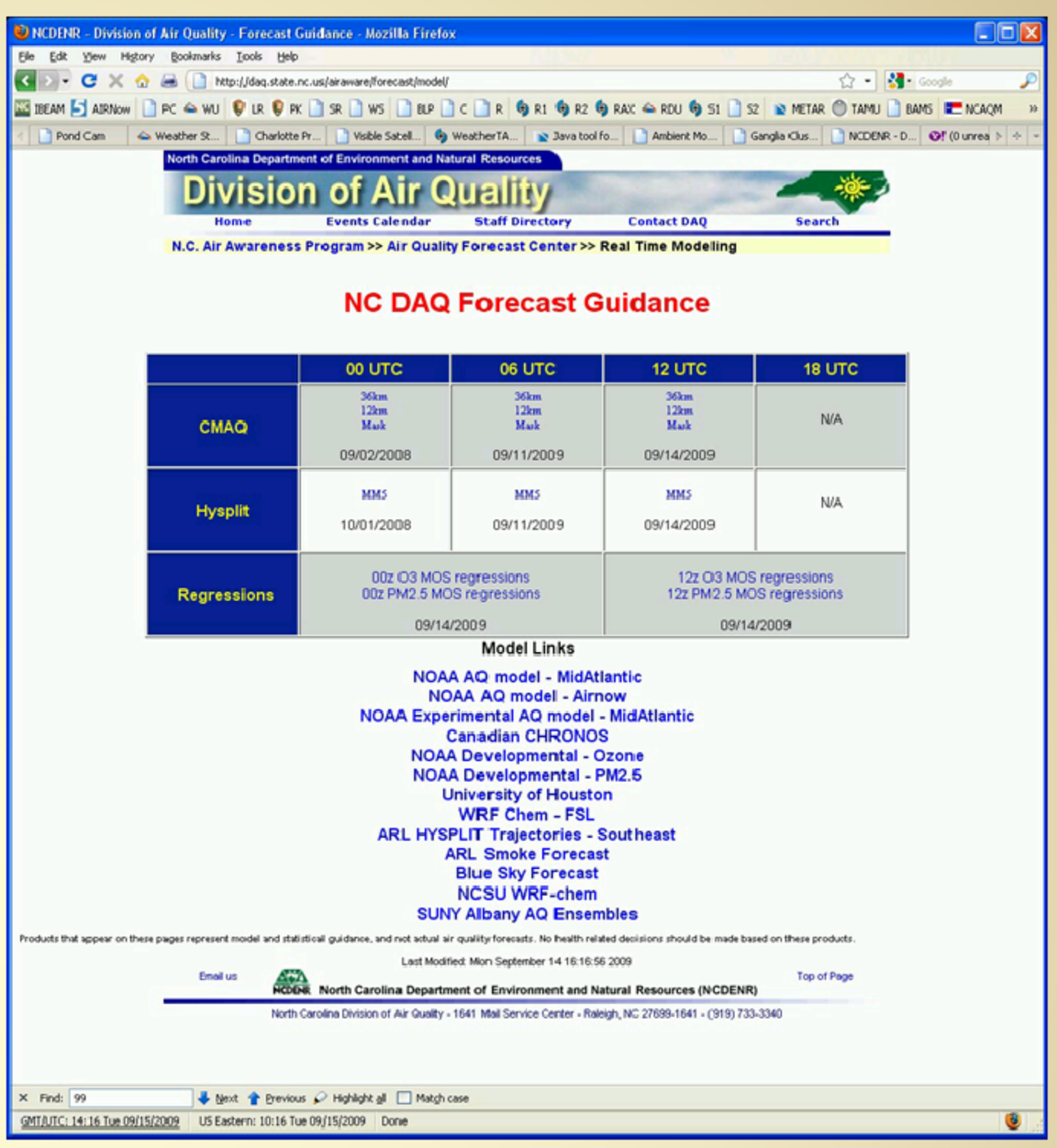
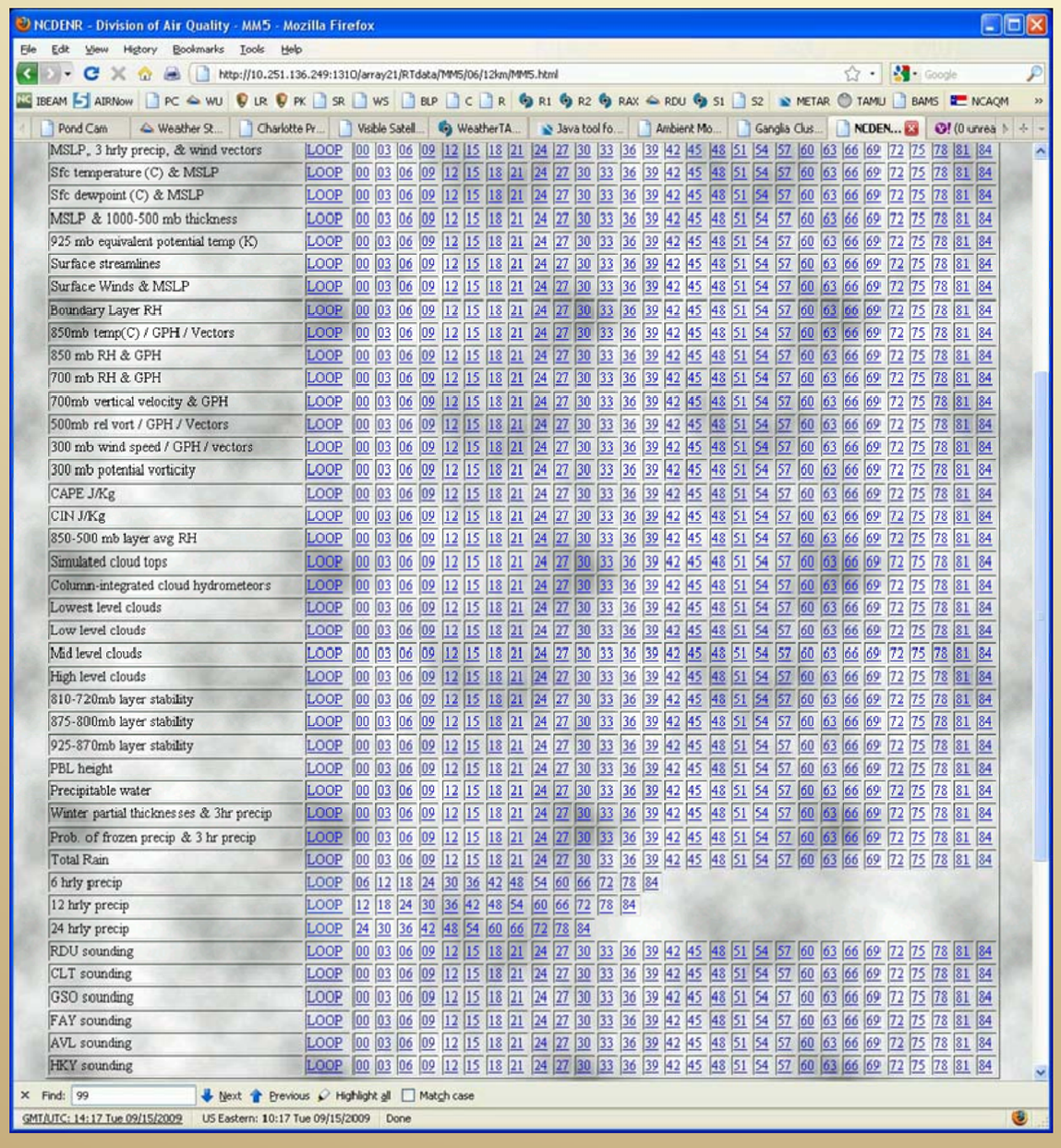
NCDAQ RT-AQ Model

- **MM5** *(06Z & 12Z)*
  - VISTAS RPO modeling 36km/12km domains
  - Physics:
    - Eta PBL
    - KF2 CP
    - Mixed Phase MP
    - RRTM
  - NAM boundary conditions with MADIS additions
- **CMAQ** *(06Z & 12Z)*
  - VISTAS / ASIP modeling configuration
  - CB4 chemistry with Environ SOA modifications
  - 2009 static / offline emissions
    - Typical summer day shifted monthly
  - Initial conditions are from previous model run

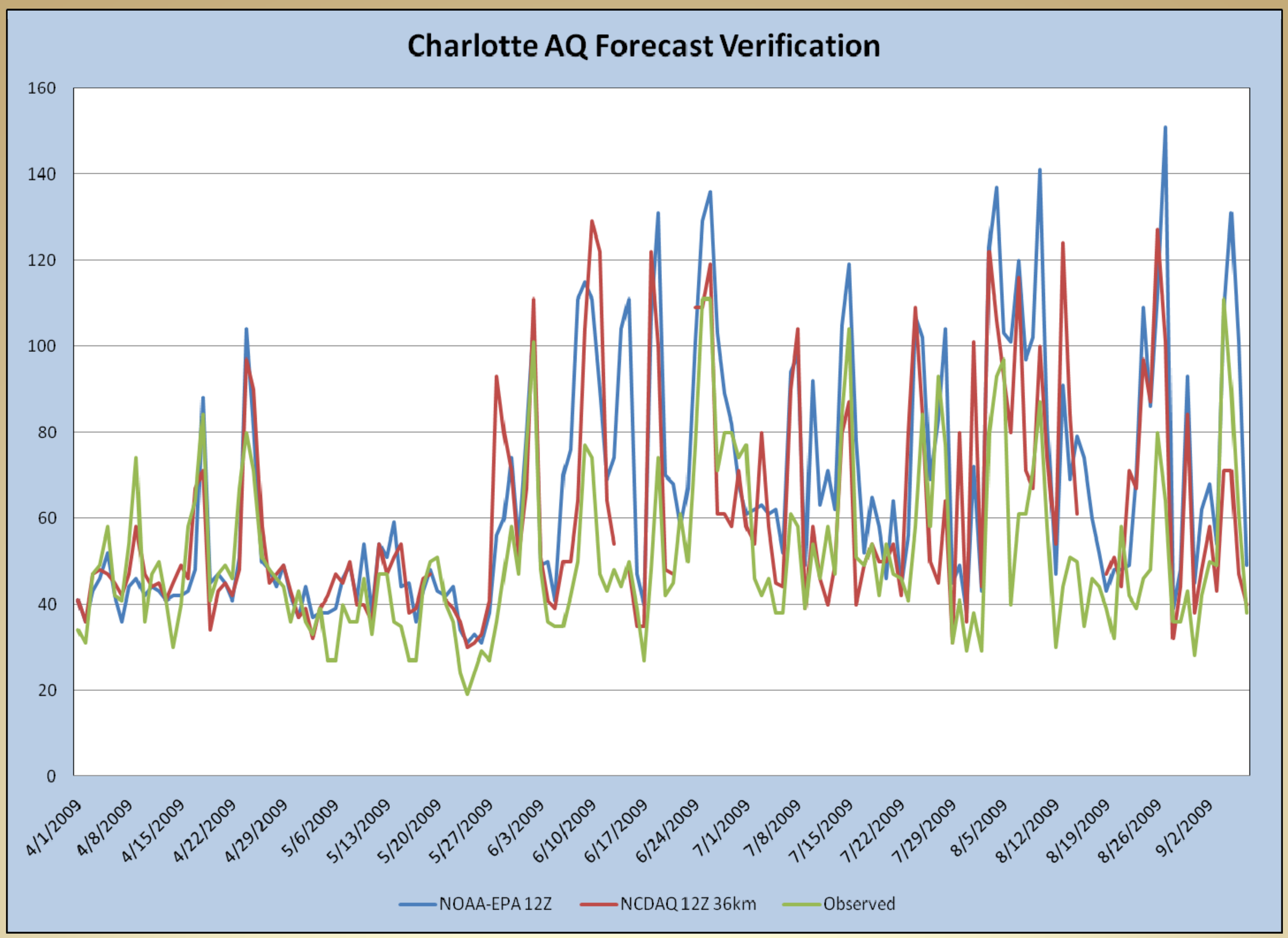




http://www.ncair.org/airaware/forecast/model



- Working on release our full suite of MM5 results on our external web server
- Eventual Transition to WRF in the next year


Charlotte AQ Forecast Verification
160
140
120
100
80
60
40
20
0
4/1/2009
4/8/2009
4/15/2009
4/22/2009
4/29/2009
5/6/2009
5/13/2009
5/20/2009
5/27/2009
6/3/2009
6/10/2009
6/17/2009
6/24/2009
7/1/2009
7/8/2009
7/15/2009
7/22/2009
7/29/2009
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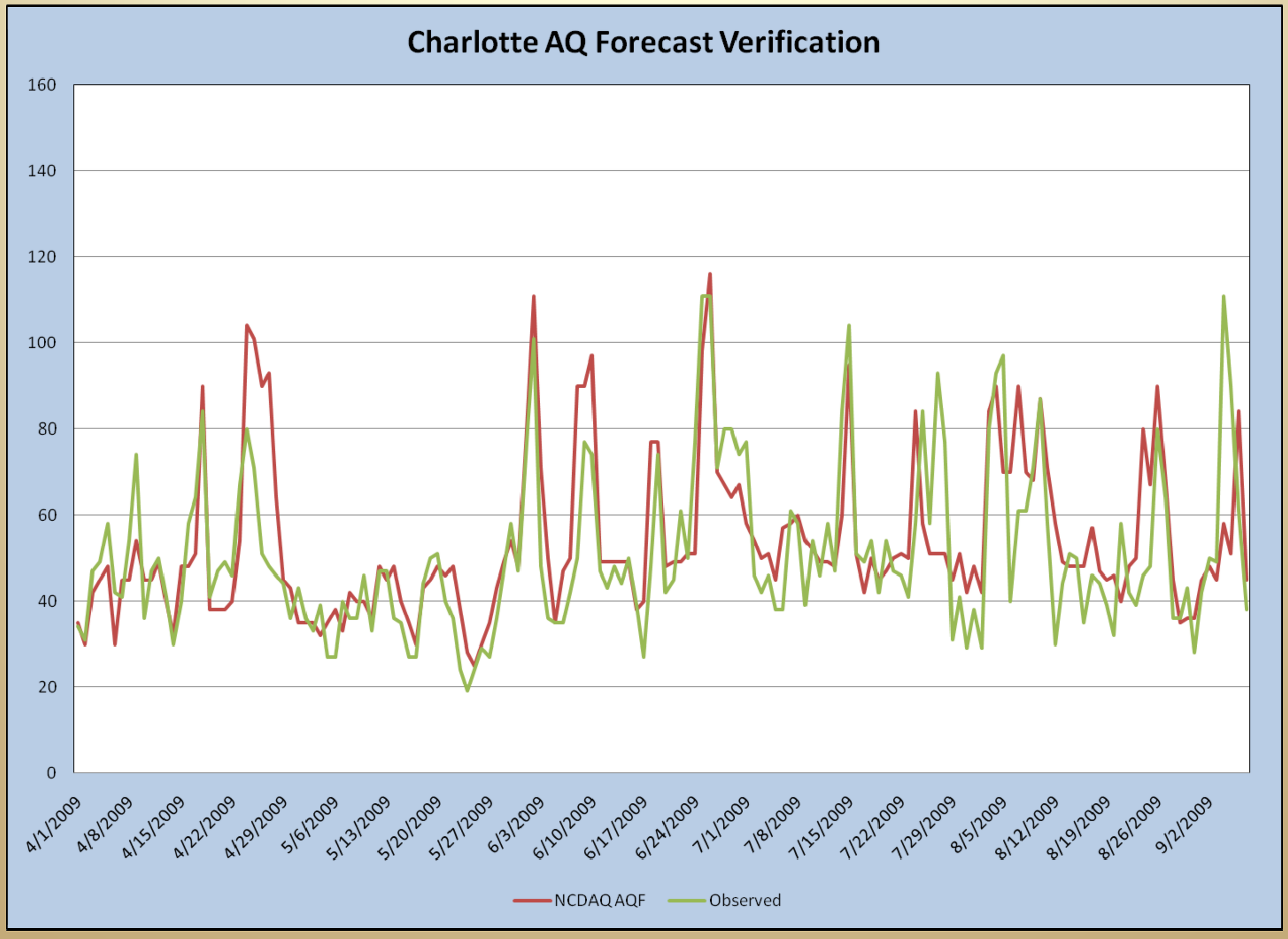
8/26/2009
9/2/2009
NOAA-EPA 12Z
NCDAQ 12Z 36km
Observed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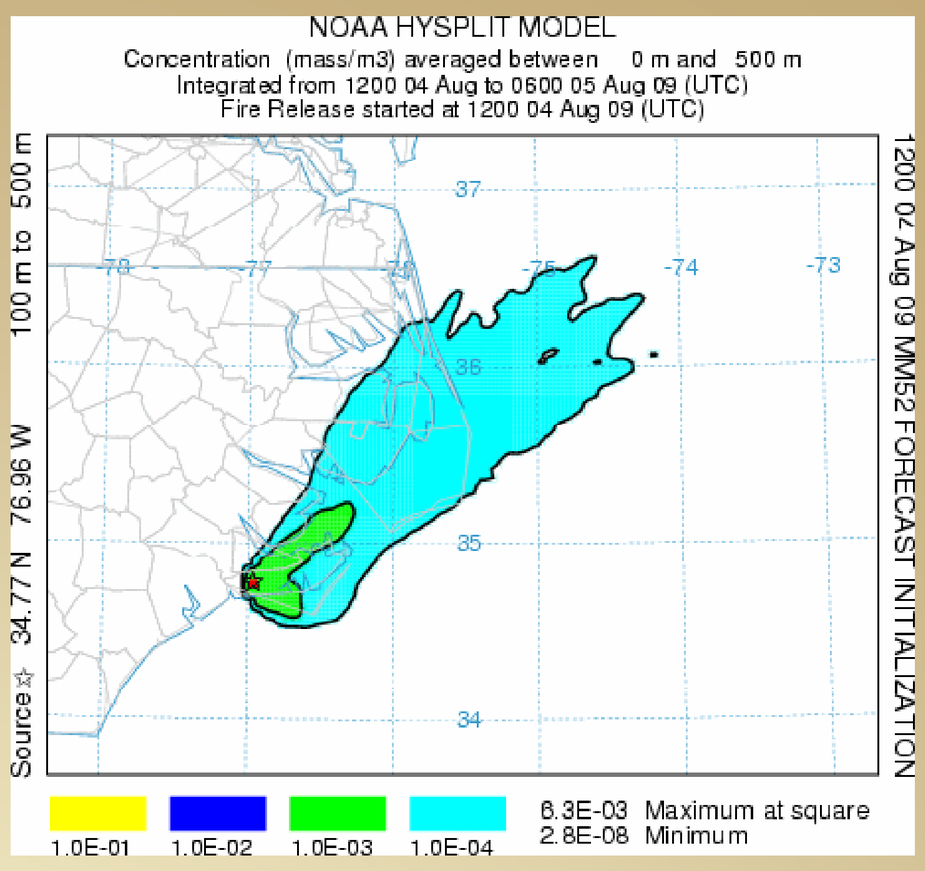
7/29/2009
8/5/2009
8/12/2009
8/19/2009
8/26/2009
9/2/2009
NCDAQ AQF
Observed

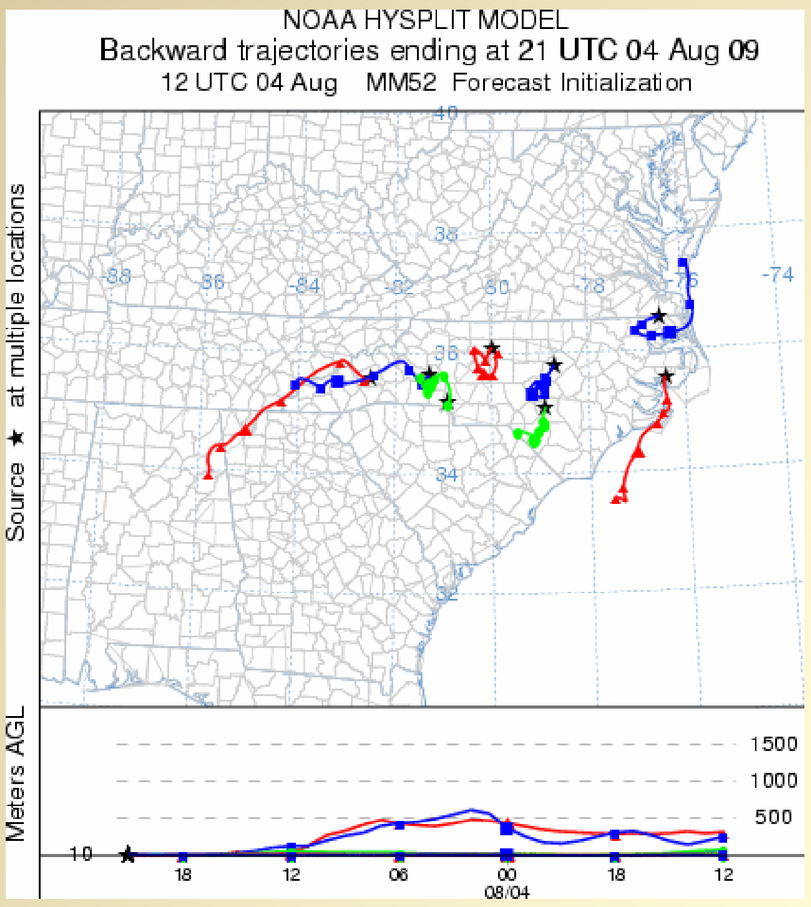
Action Day Statistics

Accuracy (Action Days)	AVL	CLT	FAY	HKY	RDU	RWI	Average
NOAA 12Z Day2	100.0	83.8	98.8	95.6	89.4	98.1	94.3
NOAA 06Z Day1	100.0	79.2	99.4	94.3	89.3	98.7	93.5
NCDAQ 12Z 12km Day2	100.0	88.5	99.2	100.0	96.7	100.0	97.4
NCDAQ 06Z 12km Day1	99.2	84.3	99.2	99.2	93.7	99.2	95.8
NCDAQ 12Z 36km Day2	100.0	89.5	99.3	99.3	98.0	100.0	97.7
NCDAQ 06Z 36km Day1	100.0	89.9	99.3	99.3	96.6	100.0	97.5
NC AQF	100.0	96.9	99.4	100.0	98.8	100.0	99.2

Bias (Action Days)	AVL	CLT	FAY	HKY	RDU	RWI	Average
NOAA 12Z Day2	#DIV/0!	6.20	1.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NOAA 06Z Day1	#DIV/0!	7.60	2.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NCDAQ 12Z 12km Day2	#DIV/0!	4.33	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NCDAQ 06Z 12km Day1	#DIV/0!	5.50	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NCDAQ 12Z 36km Day2	#DIV/0!	3.40	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NCDAQ 06Z 36km Day1	#DIV/0!	4.25	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NC AQF	#DIV/0!	0.80	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!



- Charlotte is highlighted seeing as it was the only area to experience any frequency of Action Days in 2009



Code Yellow Day Statistics

Accuracy (Code Yellow Only)	AVL	CLT	FAY	HKY	RDU	RWI	Average
NOAA 12Z Day2	69.4	58.8	79.4	73.8	66.9	76.3	70.7
NOAA 06Z Day1	74.8	61.6	73.0	71.1	62.9	78.6	70.3
NCDAQ 12Z 12km Day2	91.8	62.3	86.9	79.5	77.9	88.5	81.1
NCDAQ 06Z 12km Day1	90.6	64.6	84.3	84.3	75.6	88.2	81.2
NCDAQ 12Z 36km Day2	90.8	68.0	82.4	86.9	73.2	85.6	81.2
NCDAQ 06Z 36km Day1	91.9	68.9	83.1	82.4	77.7	87.2	81.9
NC AQF	91.3	80.0	82.5	83.1	81.9	87.5	84.4

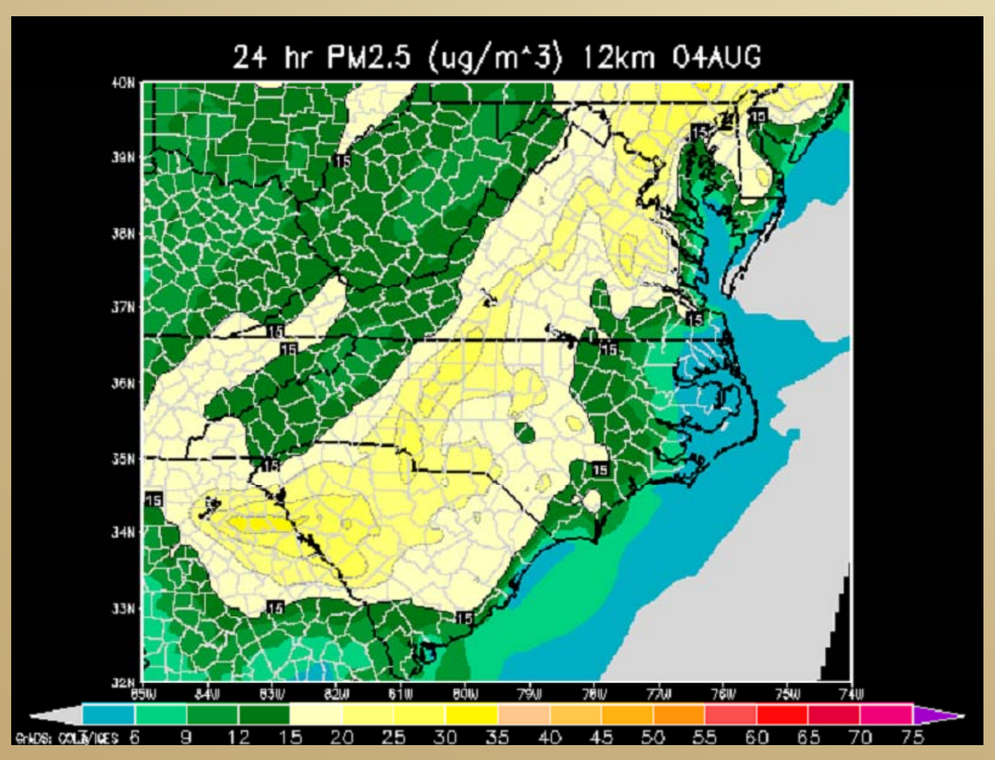
Bias (Code Yellow Only)	AVL	CLT	FAY	HKY	RDU	RWI	Average
NOAA 12Z Day2	7.14	1.20	1.76	2.14	1.71	2.47	2.74
NOAA 06Z Day1	6.14	1.06	2.08	2.24	1.83	2.60	2.66
NCDAQ 12Z 12km Day2	1.40	1.11	1.00	1.33	1.20	0.82	1.14
NCDAQ 06Z 12km Day1	1.33	1.08	1.44	1.67	1.42	1.27	1.37
NCDAQ 12Z 36km Day2	1.57	1.15	0.56	1.19	1.26	1.00	1.12
NCDAQ 06Z 36km Day1	2.00	1.22	1.13	1.67	1.29	1.38	1.45
NC AQF	1.57	1.16	0.76	1.33	1.37	1.00	1.20

- Given the infrequency of Action Days in 2009, Code Yellow Days were selected as a surrogate statistical measure

Hit Count

Action Day Count (O/R/P)	AVL	CLT	FAY	HKY	RDU	RWI
NOAA 12Z Day2	0	31	1	7	17	3
NOAA 06Z Day1	0	38	2	9	17	2
NCDAQ 12Z 12km Day2	0	13	0	0	4	0
NCDAQ 06Z 12km Day1	1	22	0	1	8	1
NCDAQ 12Z 36km Day2	0	17	0	1	3	0
NCDAQ 06Z 36km Day1	0	17	0	1	5	0
NC AQF	0	4	0	0	2	0
Observed	0	5	1	0	0	0

- Count of Code Orange or higher *(>75ppb)* ozone predictions and observations per NCDAQ Forecast Region
- Only Charlotte *(CLT)* and Fayetteville *(FAY)* observed Code Orange ozone in 2009
- There were no Code Red or Purple days



AQI Deltas

Average AQI Delta	AVL	CLT	FAY	HKY	RDU	RWI	Average
NOAA 12Z Day2	12.0	15.6	6.0	11.0	14.3	8.5	11.2
NOAA 06Z Day1	10.9	19.0	8.2	12.7	16.7	10.2	12.9
NCDAQ 12Z 12km Day2	5.1	10.1	2.5	3.9	6.9	3.3	5.3
NCDAQ 06Z 12km Day1	5.1	13.6	3.5	5.3	9.2	4.6	6.9
NCDAQ 12Z 36km Day2	4.3	9.2	-0.3	5.5	5.6	2.4	4.5
NCDAQ 06Z 36km Day1	4.5	12.4	2.1	6.5	7.0	3.5	6.0
NC AQF	2.8	2.5	1.1	5.1	3.5	3.0	3.0

Maximum AQI Delta	AVL	CLT	FAY	HKY	RDU	RWI	Max
NOAA 12Z Day2	52.0	87.0	46.0	74.0	72.0	58.0	87.0
NOAA 06Z Day1	53.0	84.0	43.0	71.0	69.0	67.0	84.0
NCDAQ 12Z 12km Day2	47.0	71.0	46.0	29.0	63.0	33.0	71.0
NCDAQ 06Z 12km Day1	71.0	108.0	53.0	68.0	70.0	38.0	108.0
NCDAQ 12Z 36km Day2	31.0	80.0	26.0	53.0	66.0	30.0	80.0
NCDAQ 06Z 36km Day1	47.0	100.0	53.0	87.0	67.0	27.0	100.0
NC AQF	43.0	45.0	36.0	43.0	41.0	27.0	45.0

Minimum AQI Delta	AVL	CLT	FAY	HKY	RDU	RWI	Min
NOAA 12Z Day2	-33.0	-28.0	-52.0	-29.0	-25.0	-34.0	-52.0
NOAA 06Z Day1	-30.0	-26.0	-30.0	-28.0	-23.0	-31.0	-31.0
NCDAQ 12Z 12km Day2	-31.0	-51.0	-54.0	-24.0	-47.0	-31.0	-54.0
NCDAQ 06Z 12km Day1	-30.0	-34.0	-50.0	-24.0	-47.0	-30.0	-50.0
NCDAQ 12Z 36km Day2	-28.0	-48.0	-57.0	-29.0	-43.0	-31.0	-57.0
NCDAQ 06Z 36km Day1	-29.0	-31.0	-46.0	-29.0	-39.0	-28.0	-46.0
NC AQF	-33.0	-53.0	-57.0	-29.0	-46.0	-32.0	-57.0

- Another useful metric evaluates the AQI Deltas for each of the products
- These Deltas are not binned into categories and are not cutoff at a certain lower threshold
- Maximum and minimum deltas only point out the worst performing predictions from the whole summer

Color Code Matrices

NOAA 12Z Day 2 Prediction

		Prediction				
		G	Y	O	R	
Observed	G	61	38	6	0	105
	Y	8	22	19	1	50
	O	0	0	5	0	5
	R	0	0	0	0	0
		69	60	30	1	

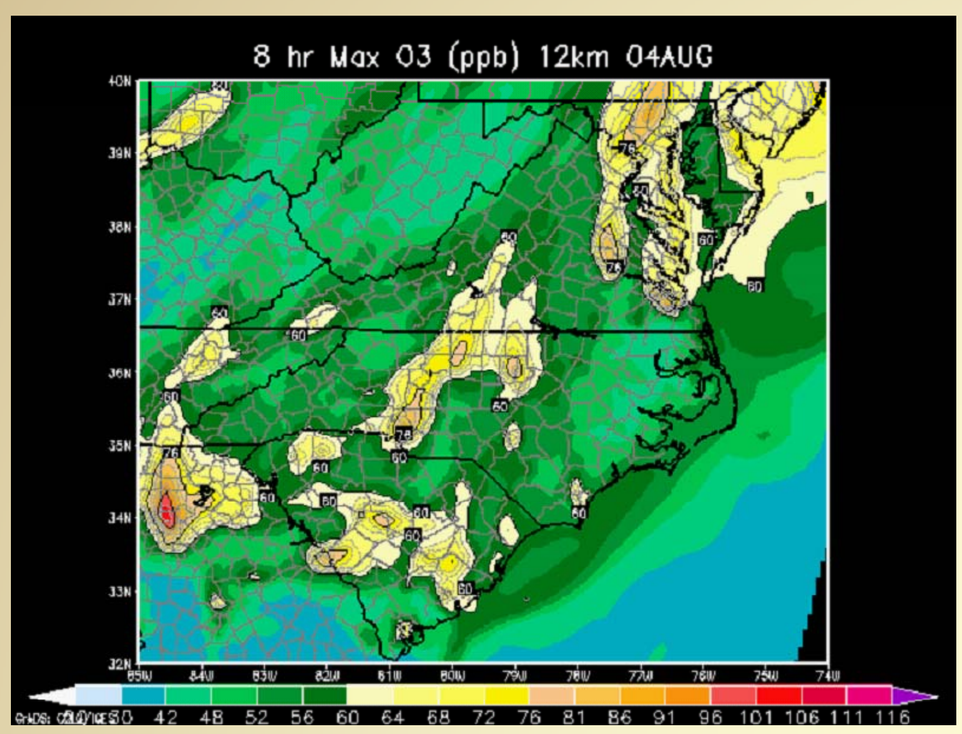
NCDAQ 12Z 36km Day 2 Prediction

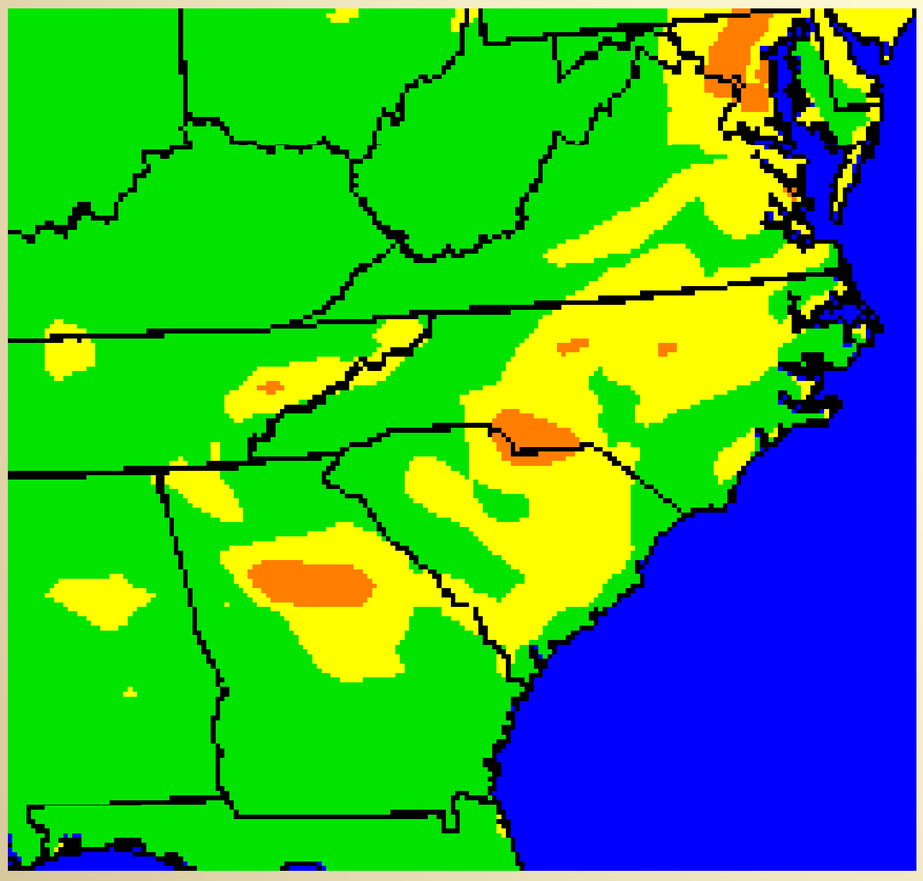
		Prediction				
		G	Y	O	R	
Observed	G	70	26	4	0	100
	Y	11	27	10	0	48
	O	0	2	3	0	5
	R	0	0	0	0	0
		81	55	17	0	

NCDAQ Air Quality Forecasts

		Prediction				
		G	Y	O	R	
Observed	G	88	17	0	0	105
	Y	10	38	2	0	50
	O	0	3	2	0	5
	R	0	0	0	0	0
		98	58	4	0	

- Great method to look and performance across the spectrum of Color Codes
- Helpful in understanding bias in the daily predictions
- The results shown here are for Charlotte from April 1st through September 7th, 2009





Evaluation Summary

- **NOAA** *(NAM/CMAQ)*
  - Reliably available all summer
  - Significant over-predictions starting around June 5th
    - 31 *(12Z)* / 38 *(06Z)* to 5 *(Observed)* Action Days in Charlotte
    - 17 *(12Z)* / 17 *(06Z)* to 0 *(Observed)* Action Days in Raleigh-Durham
  - Incredible POD but this traded off with horrible a FAR
  - Better performance outside of the major metropolitan regions in North Carolina, with the exception of Asheville
  - The 12Z Day 2 predictions usually better than that of the 06Z Day 1 predictions
  - The 06Z Day 1 predictions typical higher than and not as trusted as the 12Z Day 2 predictions, especially when considering a forecast upgrade
- **NCDAQ** *(MM5/CMAQ)*
  - General over-predictions on the higher ozone days
    - 12 *(12Z)* / 22 *(06Z)* to 5 *(Observed)* Action Days in Charlotte
    - 4 *(12Z)* / 8 *(06Z)* to 0 *(Observed)* Action Days in Raleigh-Durham
  - Decent performance statewide including emission dense and sparse areas
  - The 12Z Day 2 predictions usually better than that of the 06Z Day 1 predictions
  - The 06Z Day 1 predictions typical higher than and not as trusted as the 12Z Day 2 predictions, especially when considering a forecast upgrade

Thoughts For The Future

- The emission landscape is dramatically changing year by year with significant reductions coming in the near future… or already occurring in states like North Carolina.
- Unforeseen events such as this most recent economic recession significantly impact emissions.
- The replacement CAIR rule and Greenhouse Gas legislation will further reduce precursor pollution in the next decade.
- Rapidly updating emissions inventories will be required