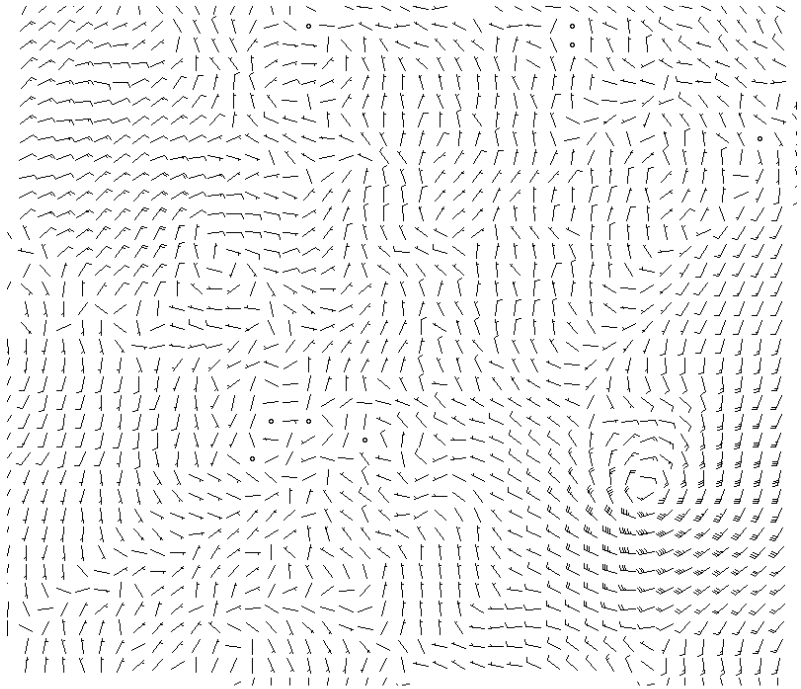
An Operational Evaluation of The Eta-CMAQ Air Quality Forecast Model: Summer 2005

Brian Eder[1]
Daiwen Kang[2]
Rohit Mathur[1]
Shaocai Yu[2]
Kenneth Schere[1]

Atmospheric Sciences Modeling Division
Air Resources Laboratory
NOAA, RTP, NC 27711



[1] In partnership with the National Exposure Research Laboratory, U.S. EPA, RTP, NC 27711

[2] On assignment from Science and Technology Corporation, Hampton, VA 23666

Background

NOAA and EPA have established a National AQF partnership.

NOAA and EPA have entered into a partnership to make full use of their respective capabilities and authorities in developing the AQF system.

- National Emissions Inventory (NEI)
- National air quality data bases (AIRNOW)
- Communication with State and local agencies

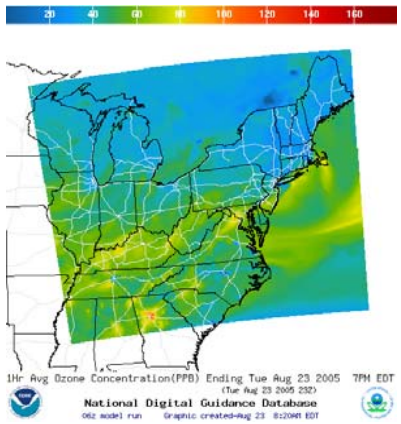
- Meteorological Model (Eta)
- Operations of the Eta-CMAQ AQF model
- Communication with NWS offices

The initial deployment of the operational AQFS began last September, providing 48 hour simulations of hourly, maximum 1- and 8-hour **ozone** concentrations in the Northeastern US.

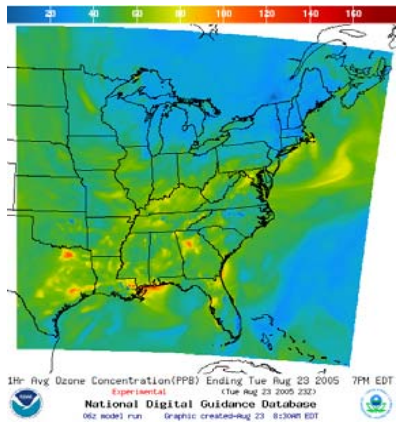
Background

Initial deployment and recent expansion of the AQFS

The smaller **northeastern** domain is considered *operational* and has been available since Sept. 2004.



The larger **eastern** domain, which is the **focus of this evaluation**, was considered *experimental*, until 1 Sept., when it too became operational.



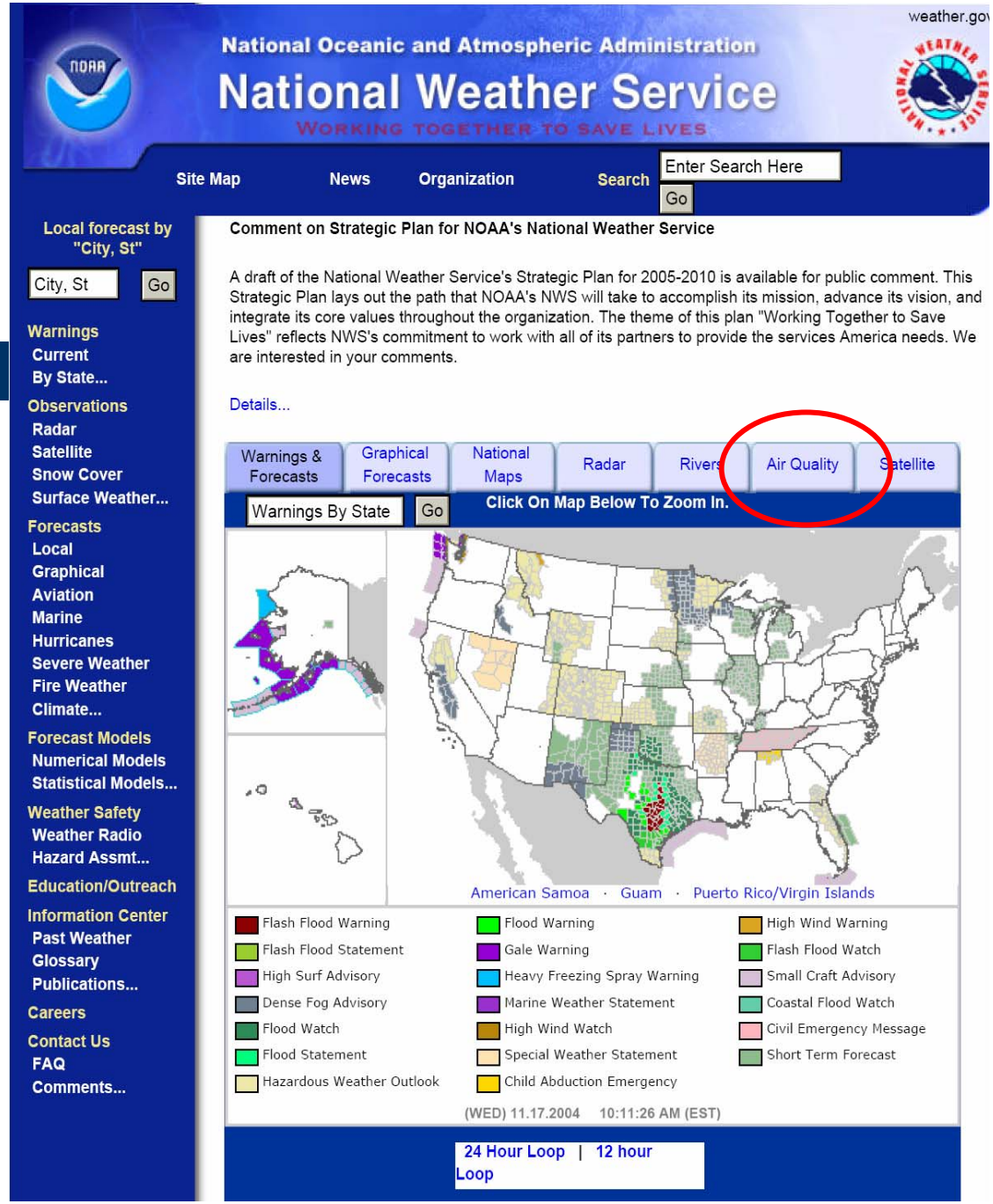
Air Quality Forecast System

- **Eta (NAM) Meteorology**
- **CMAQ Model**
  - SMOKE Emissions (*Offline*)
  - 12 km grid resolution
  - 22 Vertical Layers
  - 48 Hr. Ozone Simulations (12Z Init.)
- **Simulation Period**
  - 5 May – 31 August 2005*

**1-13 June omitted due to error with interpolation of GFS data*

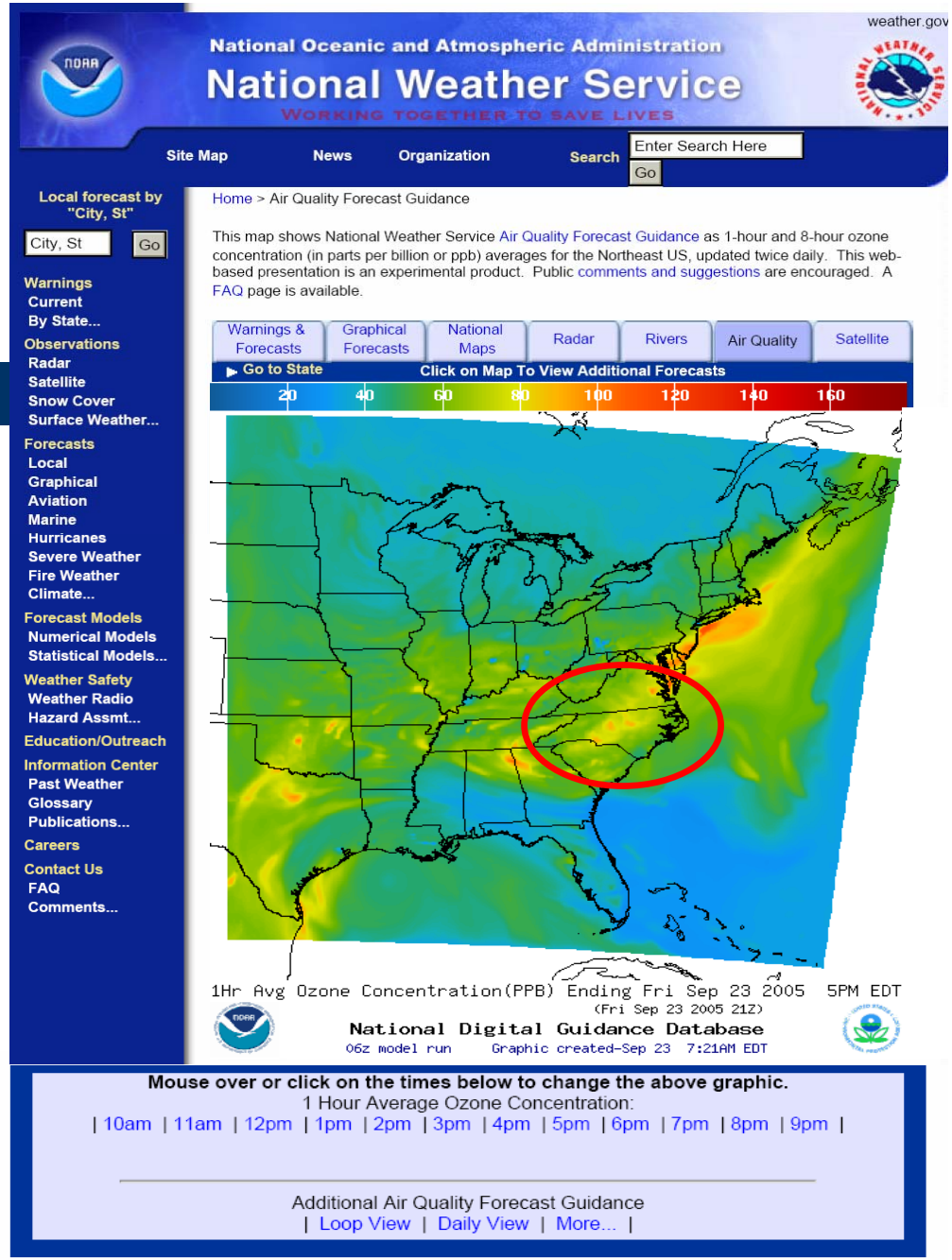
Operation

http://www.nws.noaa.gov/



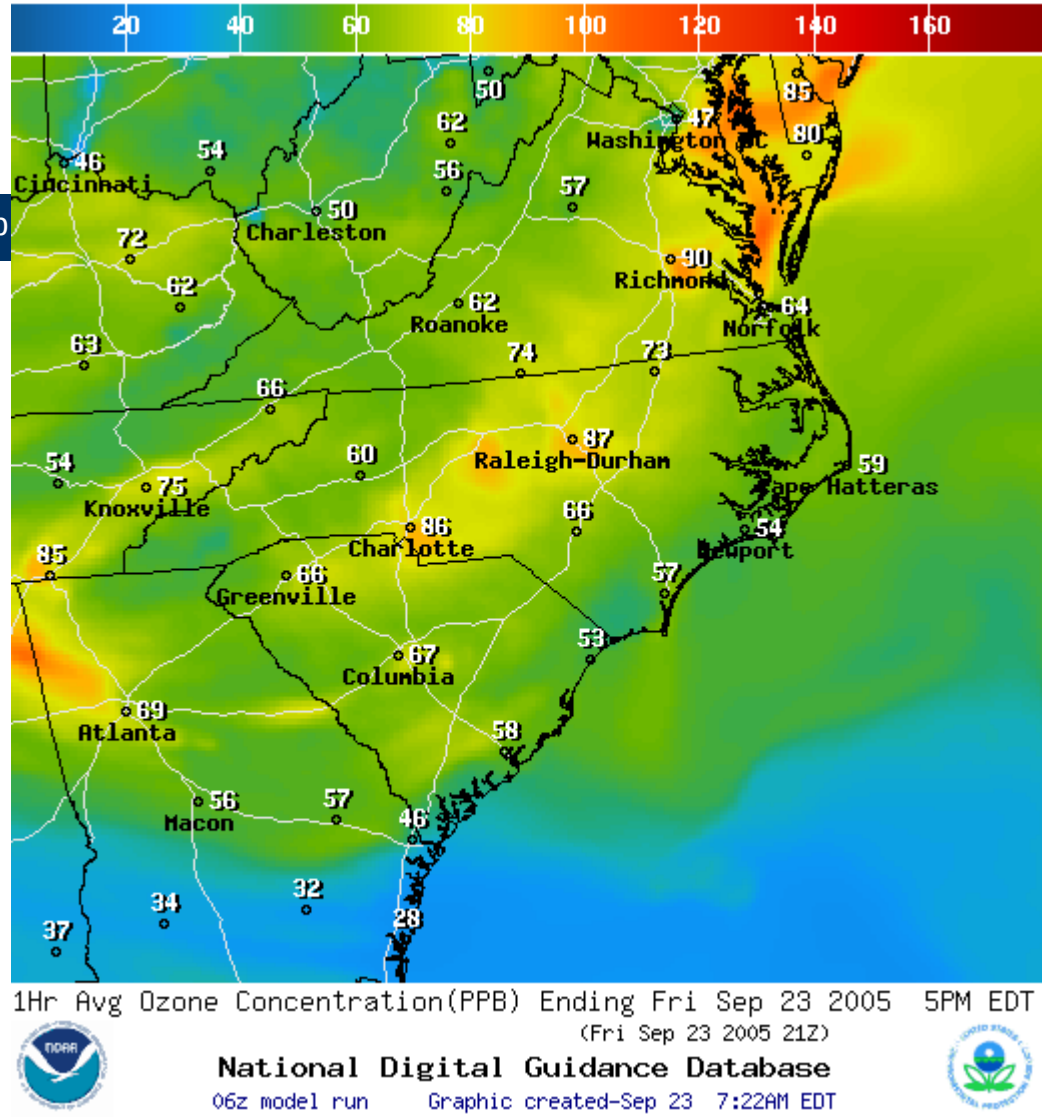
Operation

http://www.nws.noaa.gov/aq

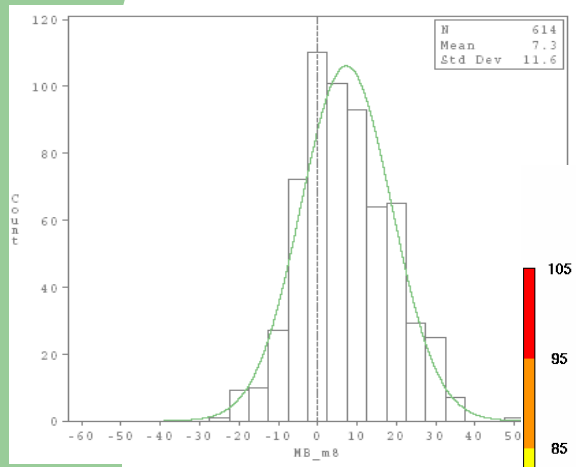


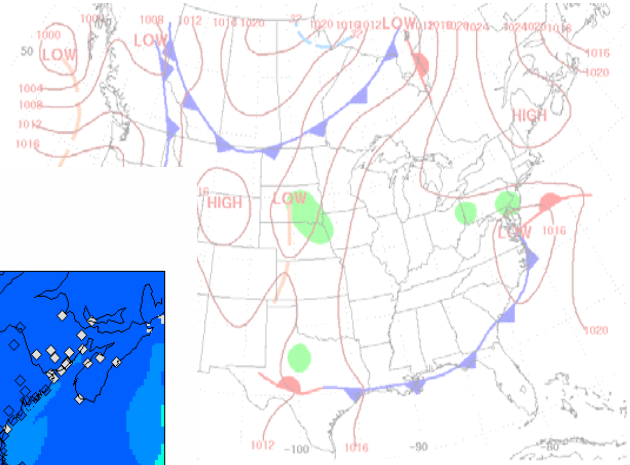
Operation

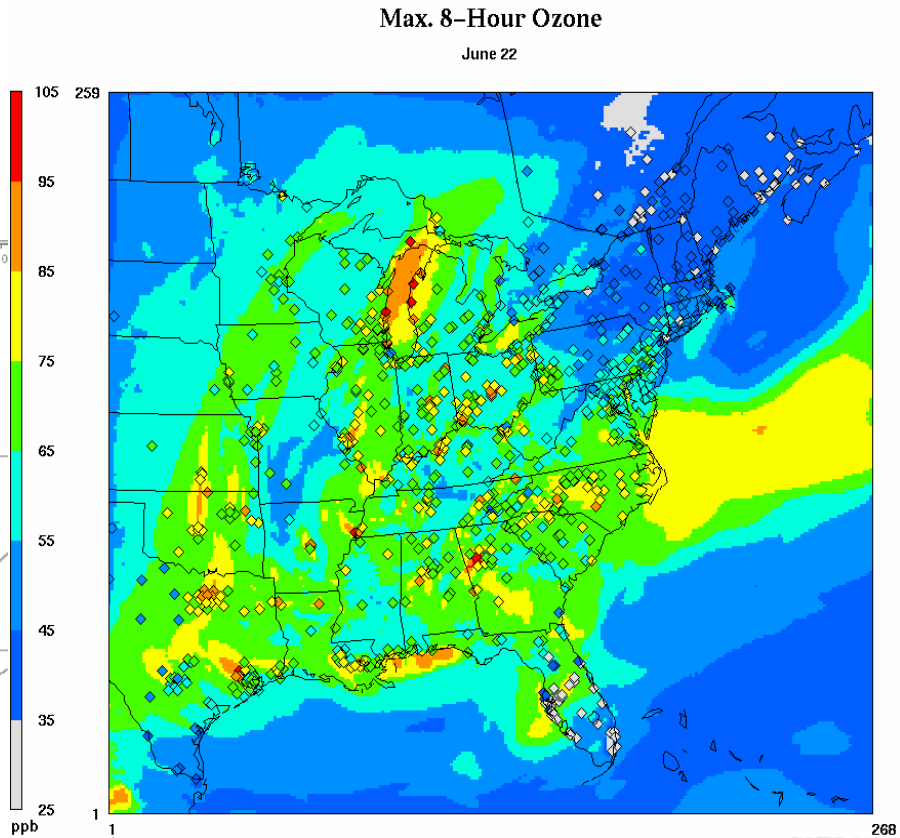
http://www.nws.noaa.gov/aq/sectors/midatlantic.php

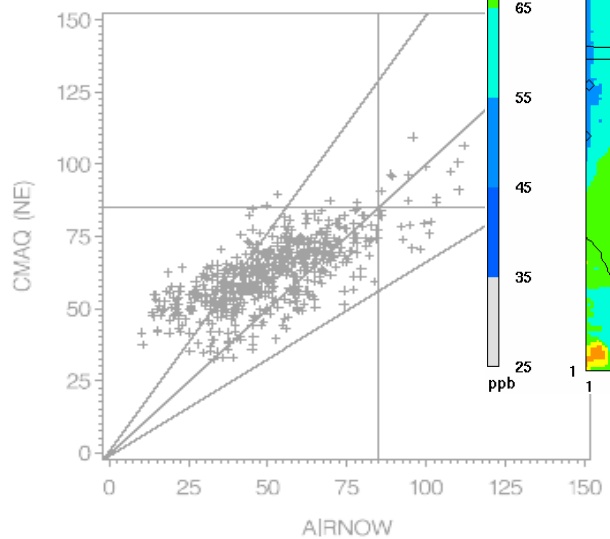


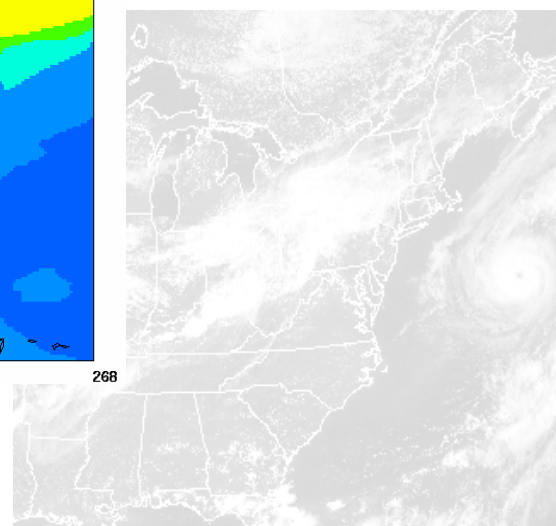
Evaluation


N 614
Mean 7.3
Std Dev 11.6
MB_m8


LOW
HIGH
Surface Weather Map at 7:00 A.M. E.S.T.


Max. 8-Hour Ozone
June 22
105
95
85
75
65
55
45
35
25
ppb
259
1
1
268


CMAQ (NE)
AIRNOW



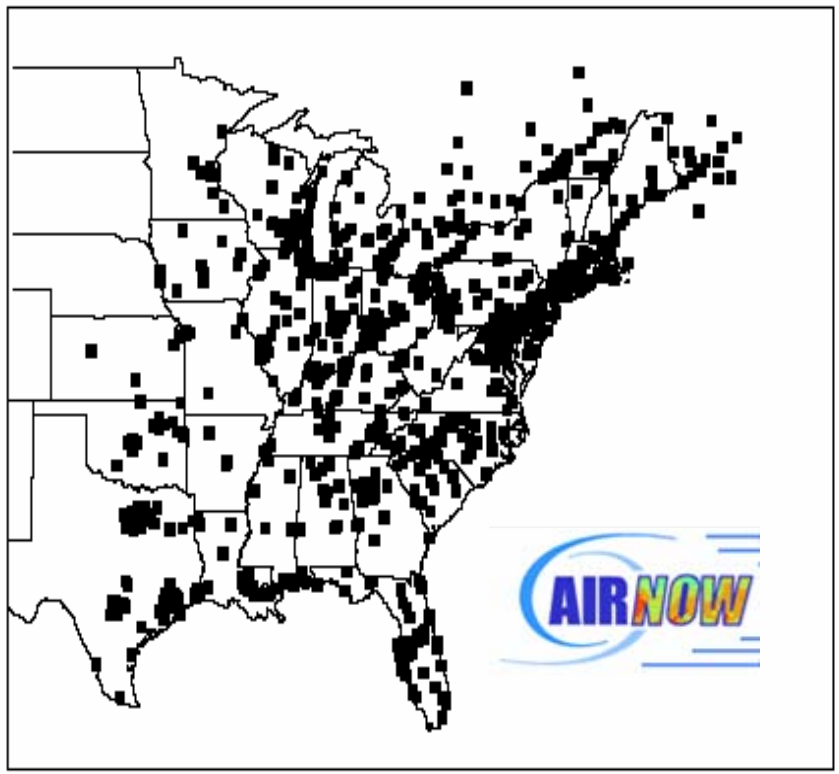
Evaluation

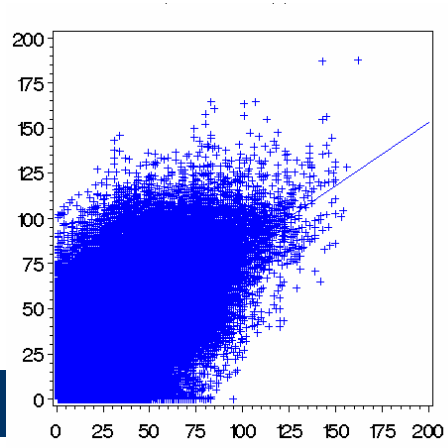
O_3 (ppb) from EPA's AIRNOW network

- More than 800 stations (mostly urban)

~ Four month period (*M*, *J*, J, A,)

- Hourly O_3
  Max. 1-hour O_3
  Max. 8-hour O_3 (presented)





Discrete Forecast / Evaluation

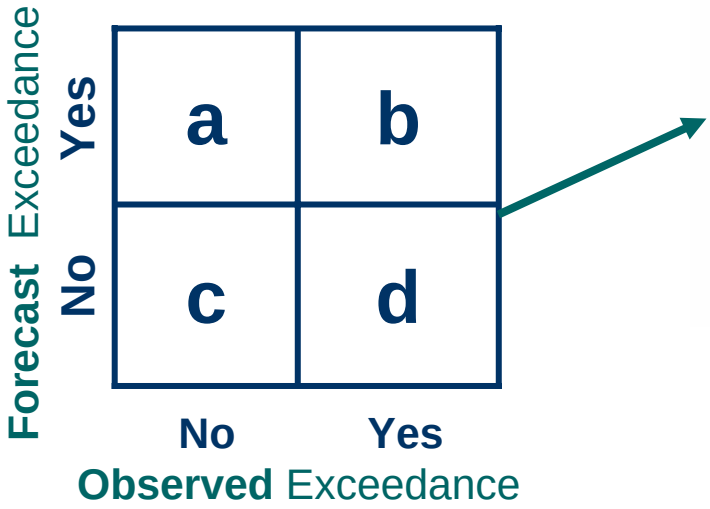
[Observed] *versus* [Forecast]

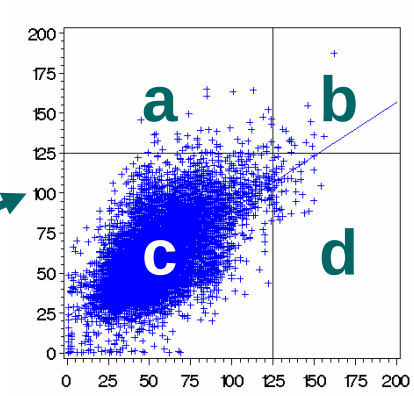
Statistics

- Summary
- Biases: $MB = \frac{1}{N}\sum_{1}^{N}(Model - Obs)$ $NMB = \frac{\sum_{1}^{N}(Model - Obs)}{\sum_{1}^{N}(Obs)} \cdot 100\%$
- Errors: $RMSE = \left(\frac{1}{N}\sum_{1}^{N}(Model - Obs)^2\right)^{0.5}$ $NME = \frac{\sum_{1}^{N}|Model - Obs|}{\sum_{1}^{N}(Obs)} \cdot 100\%$

Category Forecast / Evaluation

Observed Exceedances, Non-Exceedances
versus
Forecast Exceedances, Non-Exceedances





$$A = \left(\frac{b + c}{a + b + c + d}\right) \cdot 100\%$$

$$B = \left(\frac{a + b}{b + d}\right)$$

$$FAR = \left(\frac{a}{a + b}\right) \cdot 100\%$$

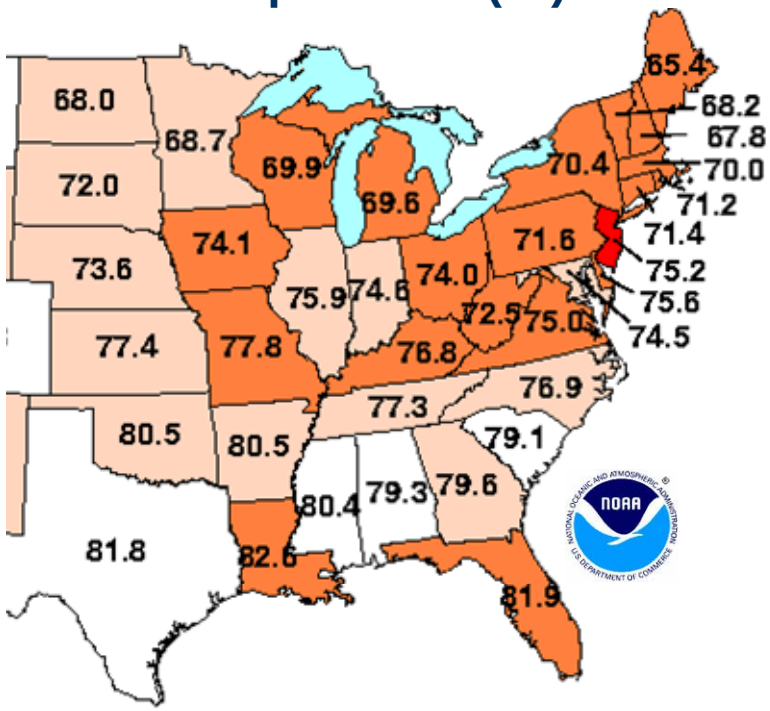
$$CSI = \left(\frac{b}{a + b + d}\right) \cdot 100\%$$

$$POD = \left(\frac{b}{b + d}\right) \cdot 100\%$$

Evaluation

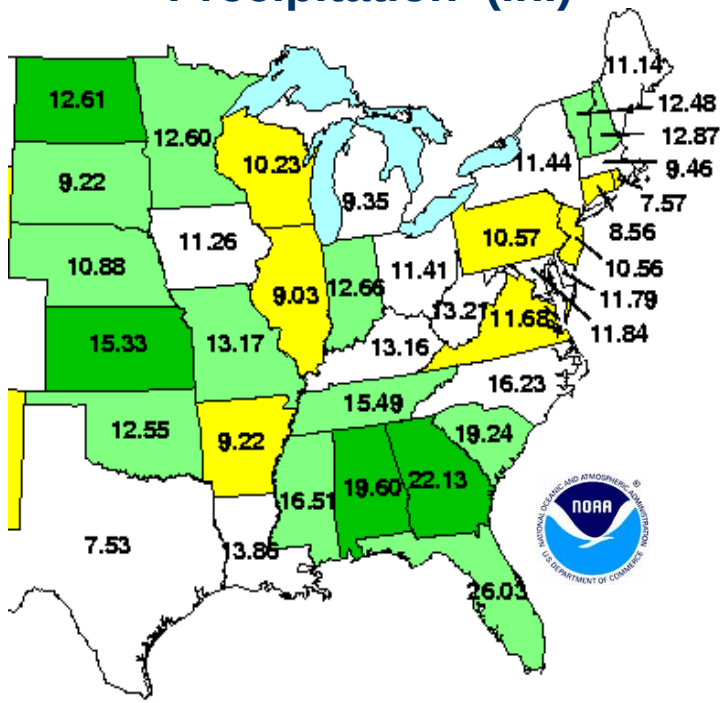
Meteorological Conditions for the Summer (J, J, A) 2005

Temperature (°F)



Record Coldest | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal | Record Warmest

Precipitation (In.)

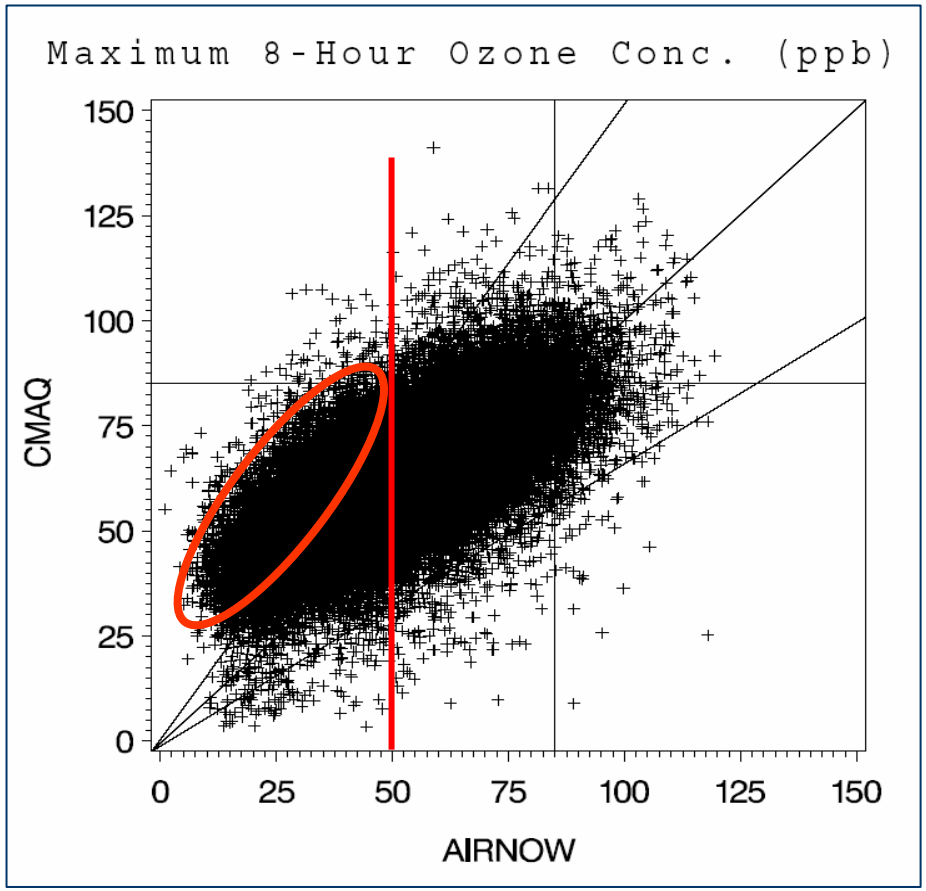


Record Driest | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal | Record Wettest

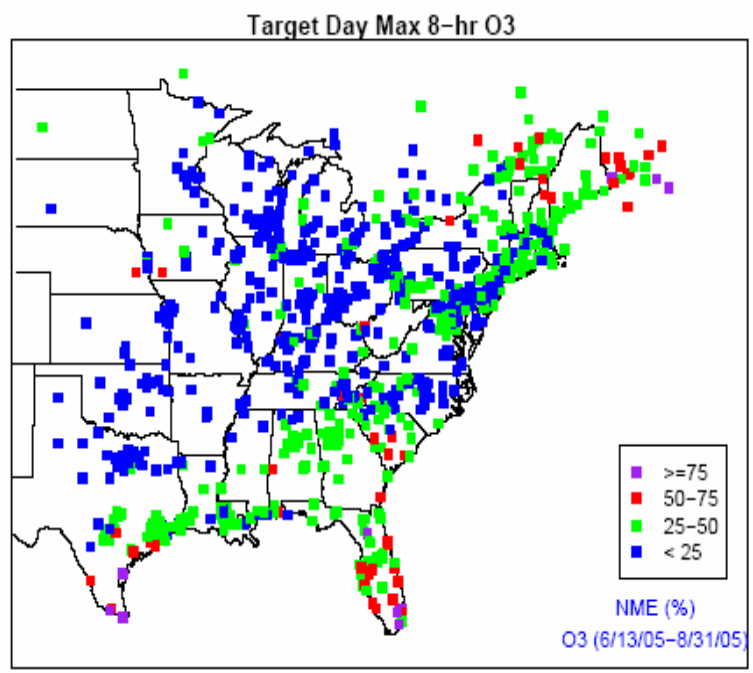
Seasonal Scatterplot

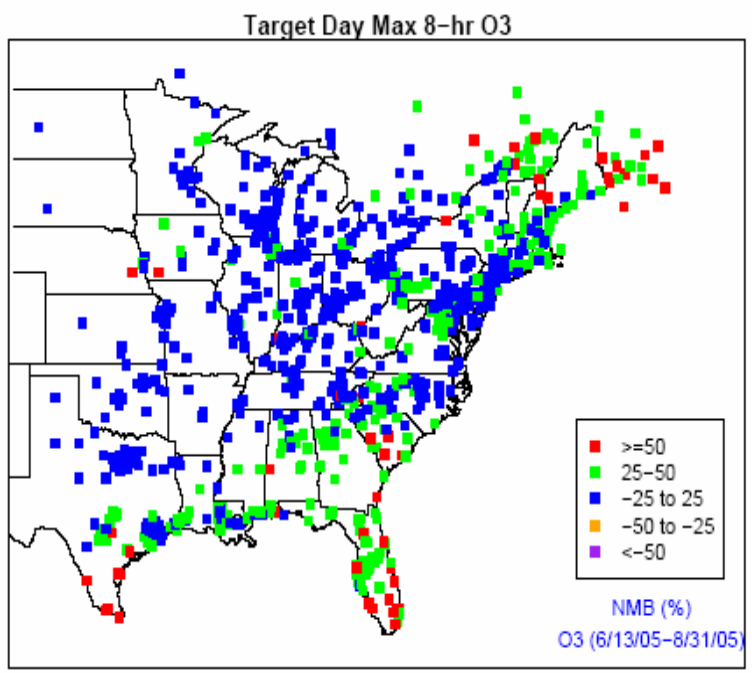
Vast majority of O_3 forecasts fall within a factor of 1.5 of the observations.

When the observed O_3 concentrations < 50 ppb, the AQFS tends to overprediction

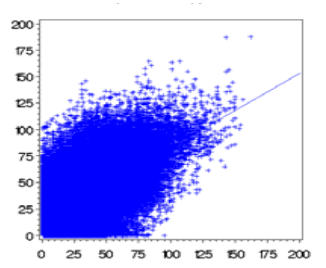


Seasonal Summary





Ozone was overpredicted in an area stretching from South Carolina, south to Florida and west to the Texas coast – this area corresponds fairly well with the area of *much above normal* summer precipitation.

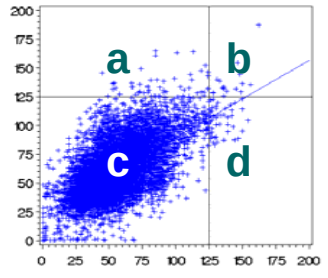


Monthly Summary - Discrete

Month	Obs. Mean Max. 8-hr (ppb)	Model Mean Max. 8-hr (ppb)	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)
May@	50.2	53.8	0.63	3.6	7.2	11.2	17.4
June*	54.3	61.5	0.75	7.2	13.3	14.5	20.7
July	48.0	59.1	0.69	11.1	23.0	16.4	27.8
August	48.2	59.7	0.72	11.5	23.9	16.4	28.1

@ May 5-31, *June 13-30

Evaluation

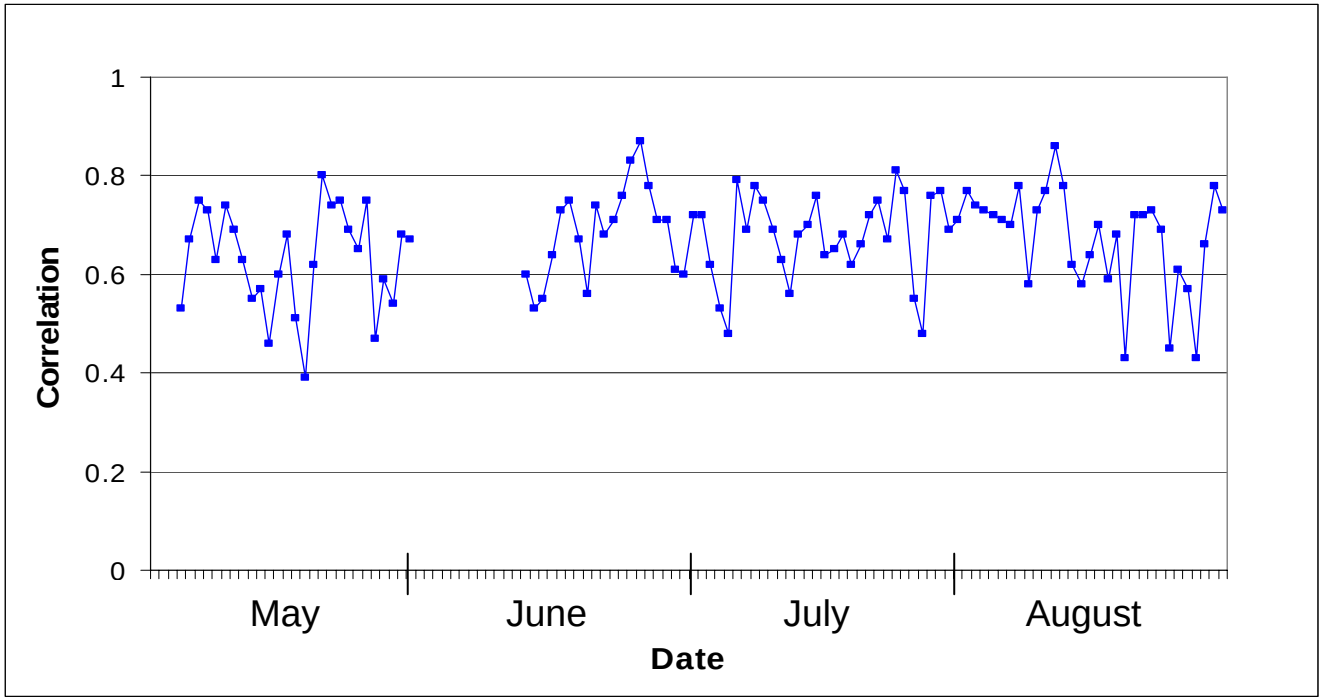


Monthly Summary - Categorical

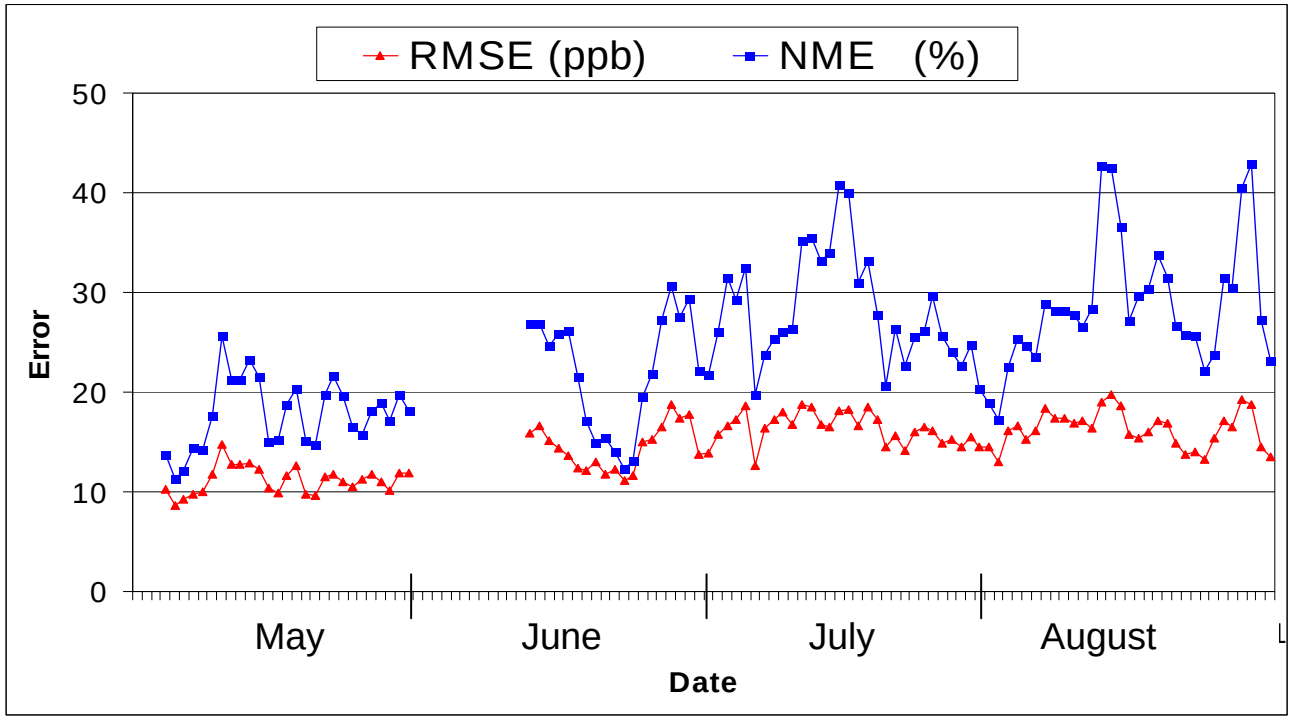
Month	A (%)	B	FAR (%)	CSI (%)	POD (%)
May@	99.4	0.30	69.4	7.5	9.0
June*	94.3	1.04	59.2	26.2	42.6
July	96.1	2.39	84.2	12.6	37.9
August	95.7	2.4	81.0	15.6	46.5

@ May 5-31, *June 13-30

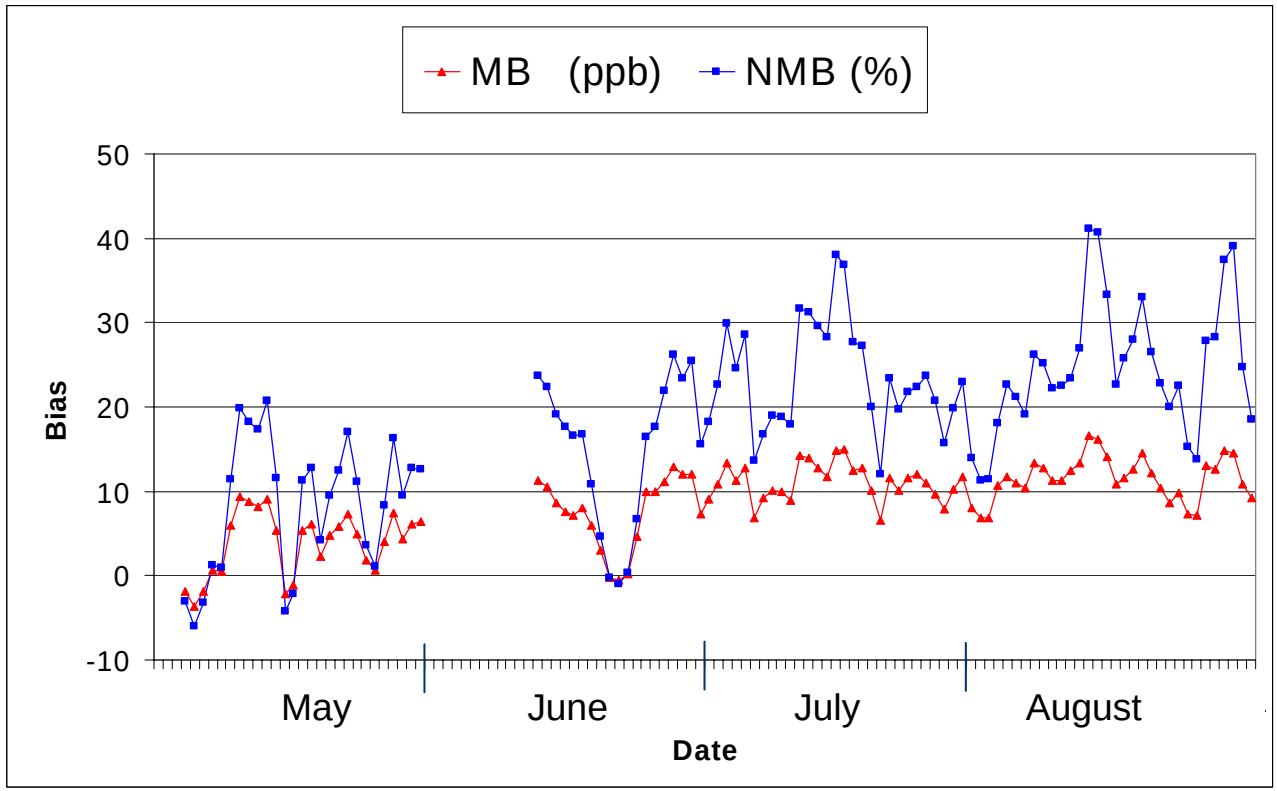
Daily, Domain Wide Correlations



Daily, Domain Wide Error



Daily, Domain Wide Bias



Evaluation

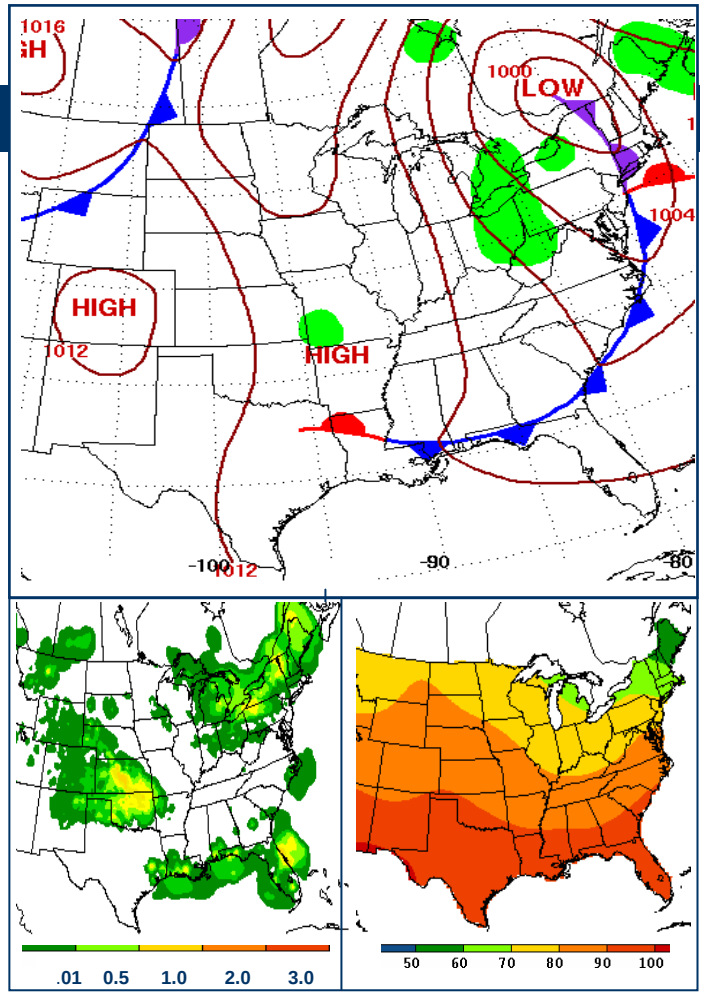
Daily summaries

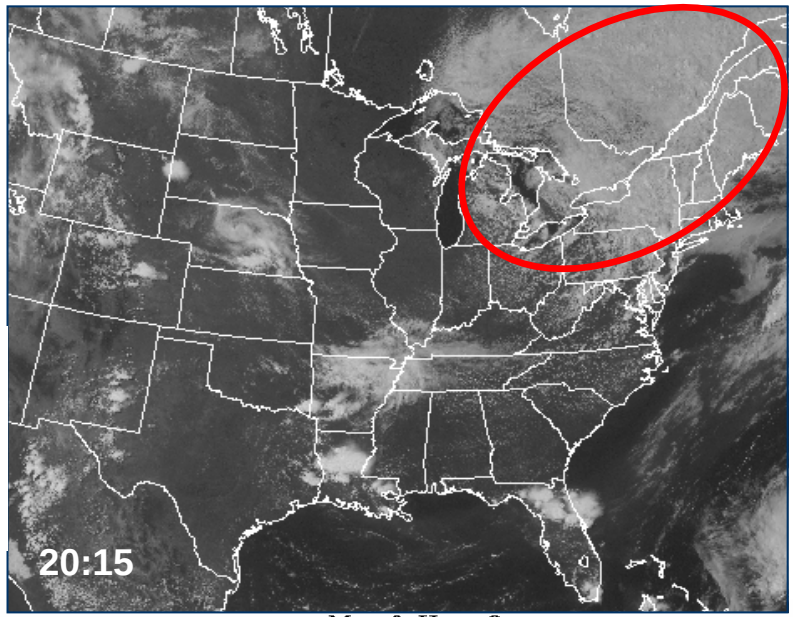
- During the summer, the performance of the AQFS was closely examined on a daily basis

  - We will examine two, two-day periods, illustrating both good and poor model performance

    16 - 17 June
    23 - 24 June

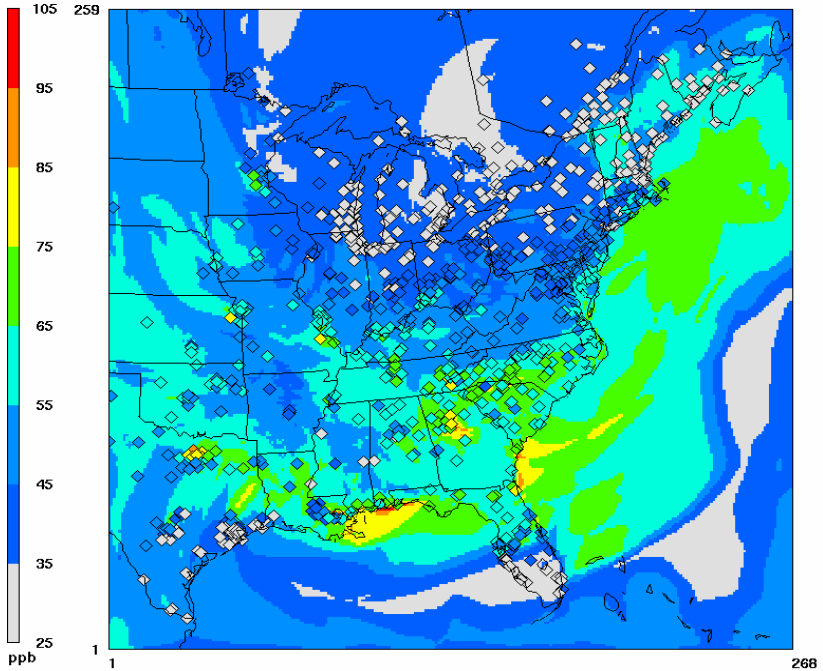
Synoptic Scale Meteorology
16 June 2005





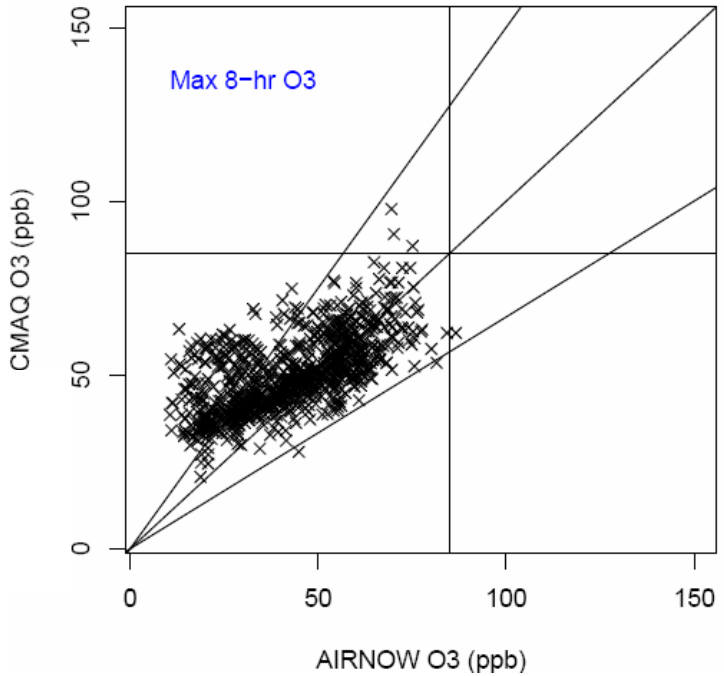
Max. 8-Hour Ozone

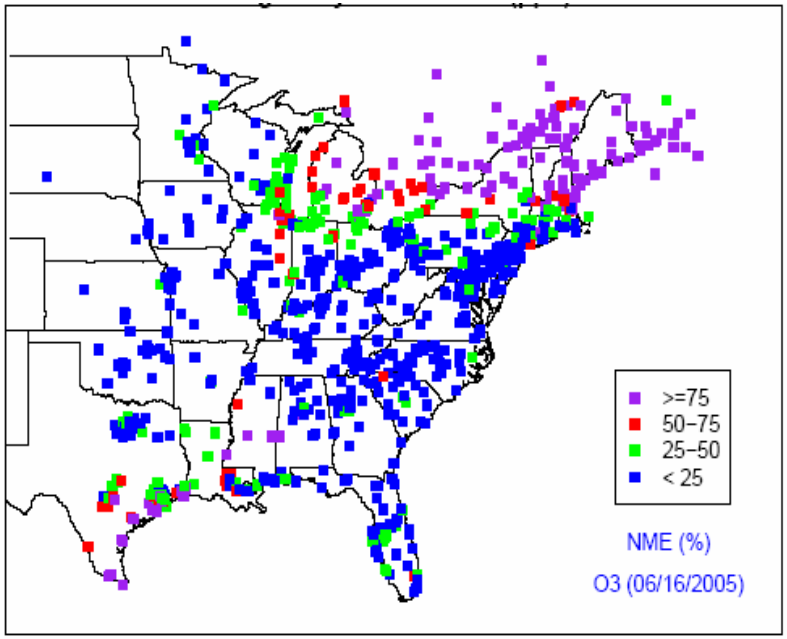
June 16

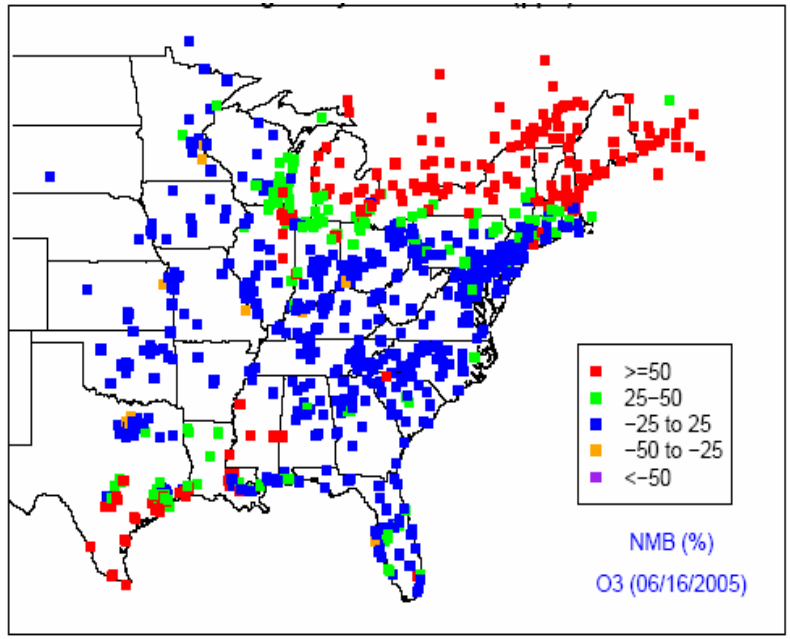


48 Hour Max. 8-Hour Ozone Forecast Valid: 16 June

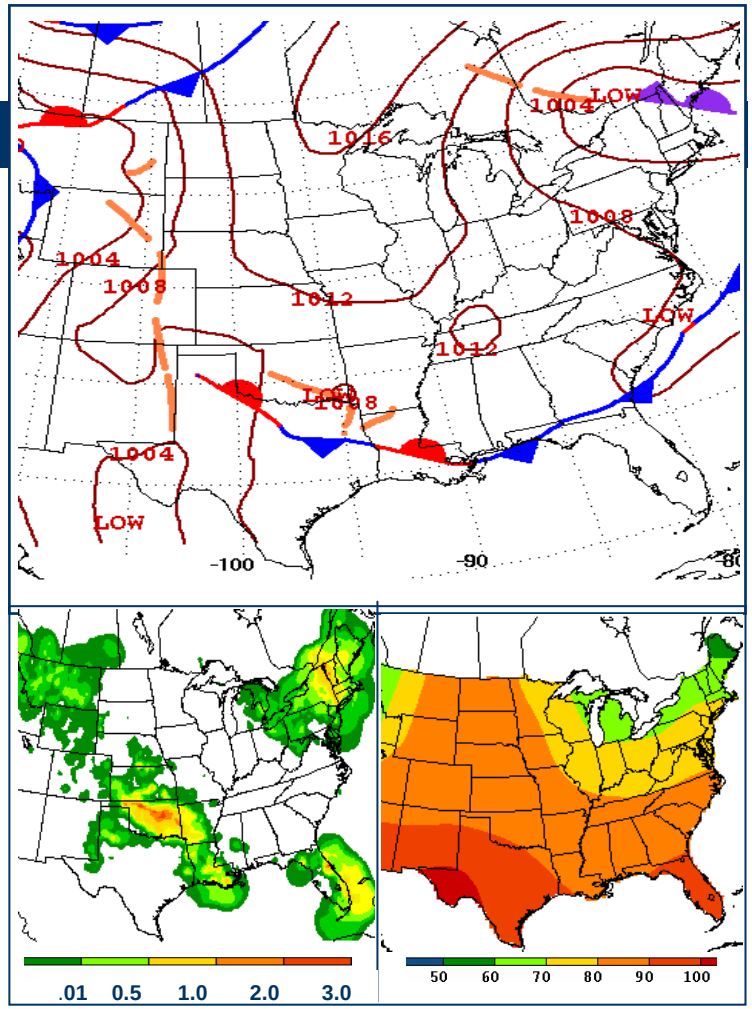
Obs Mean	Model Mean	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)
42.8	50.4	0.64	7.6	17.6	14.4	25.9

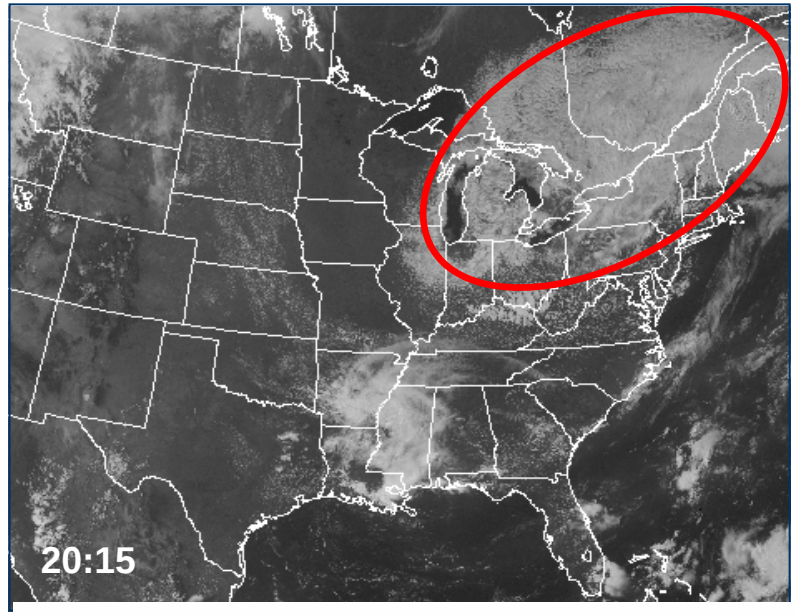


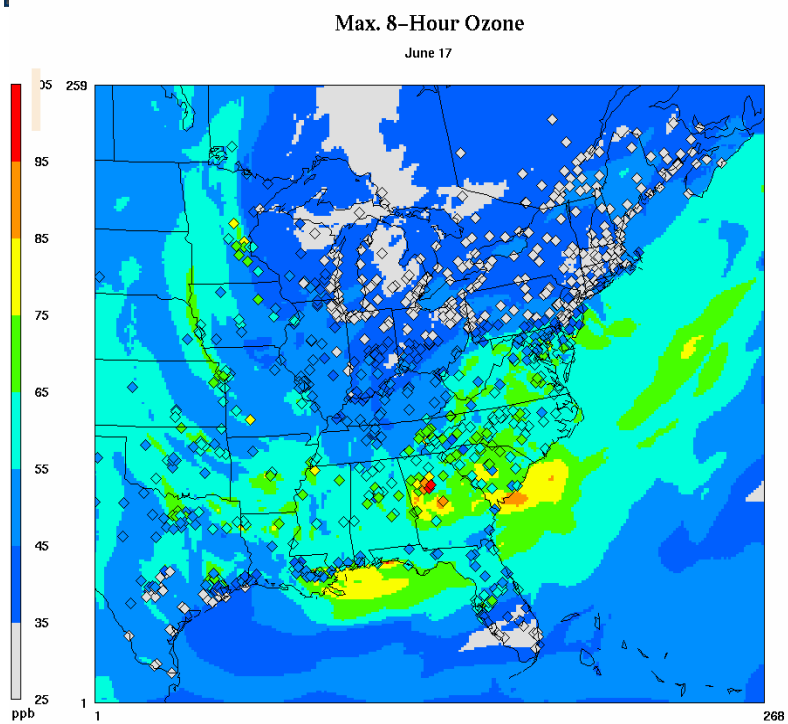




Synoptic Scale Meteorology
17 June 2005

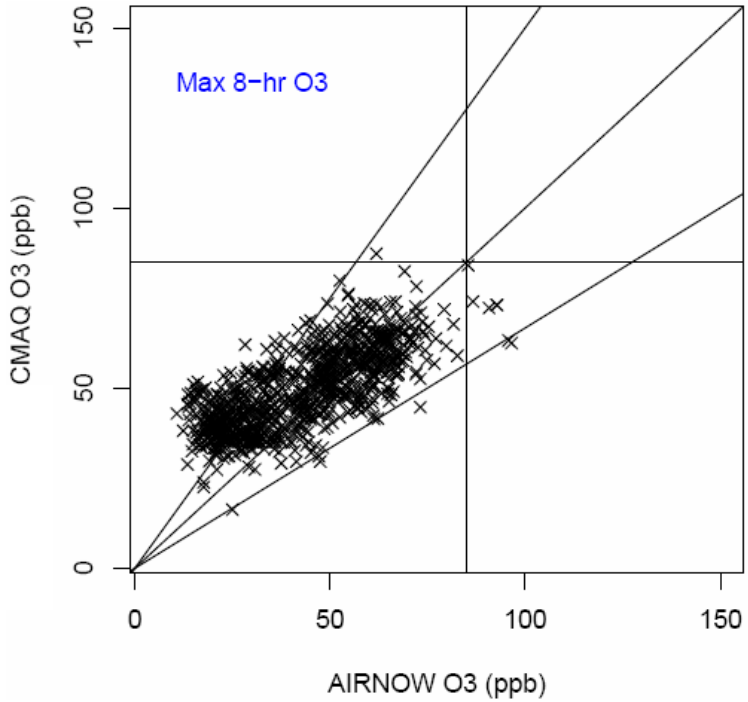


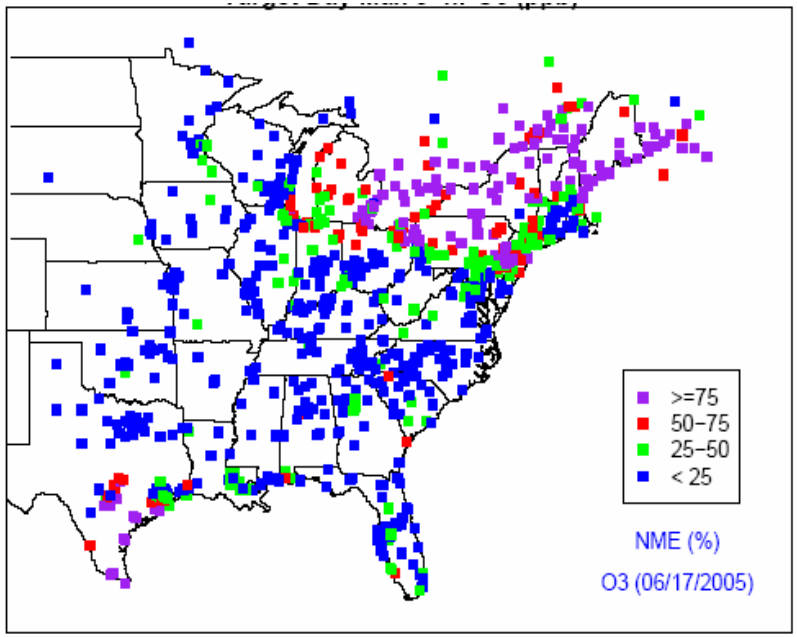


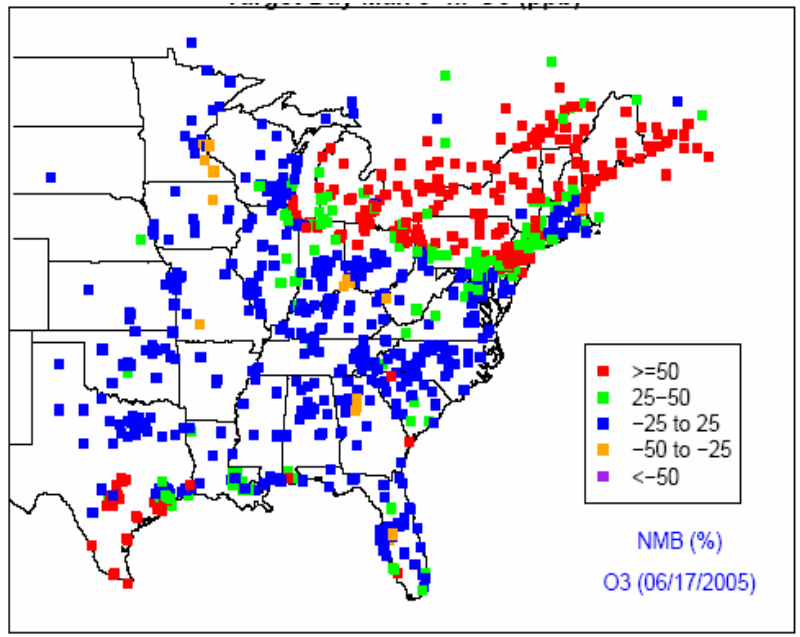


48 Hour Max. 8-Hour Ozone Forecast Valid: 17 June

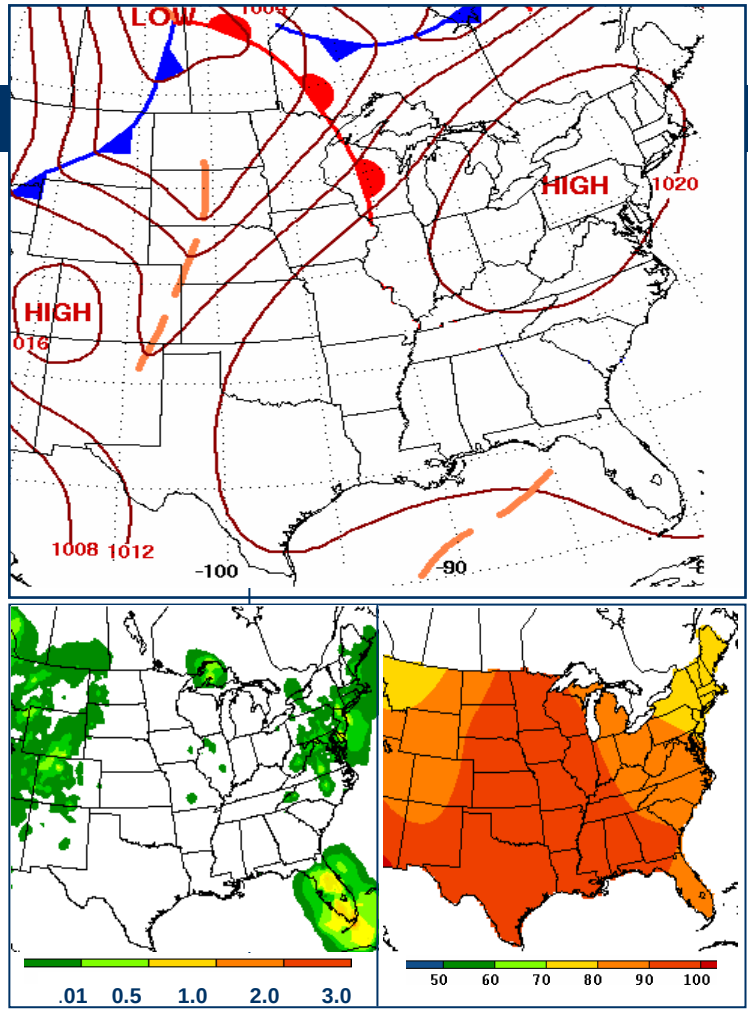
Obs Mean	Model Mean	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)
42.5	49.6	0.73	7.1	16.7	13.7	26.2

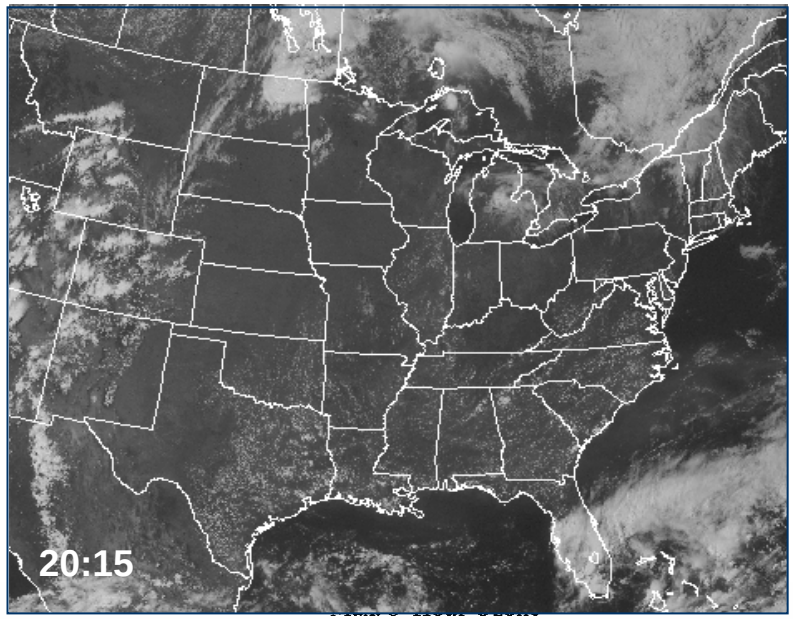




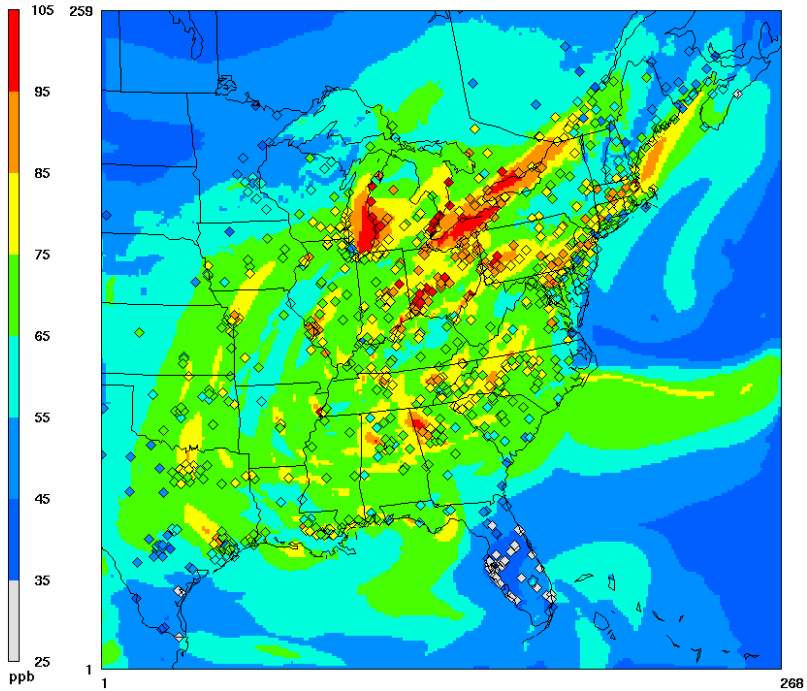


Synoptic Scale Meteorology
23 June 2005



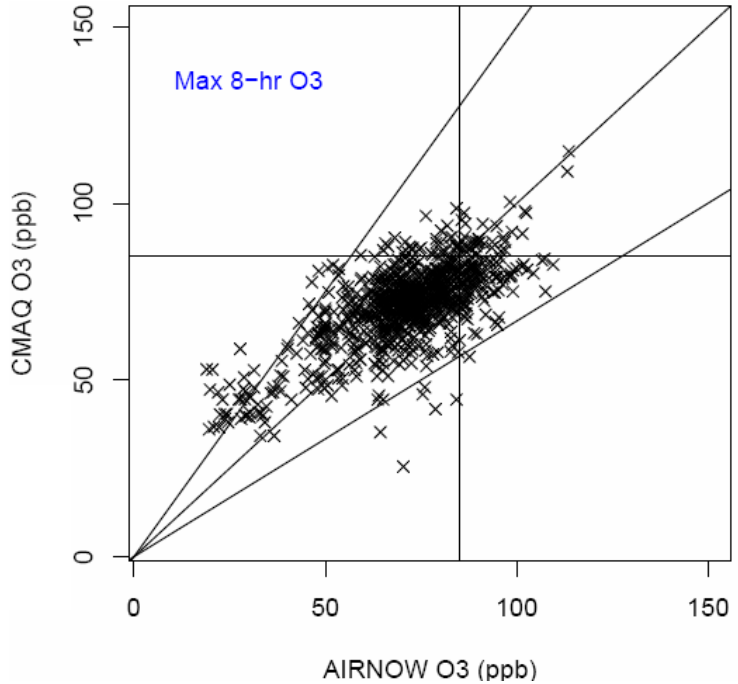


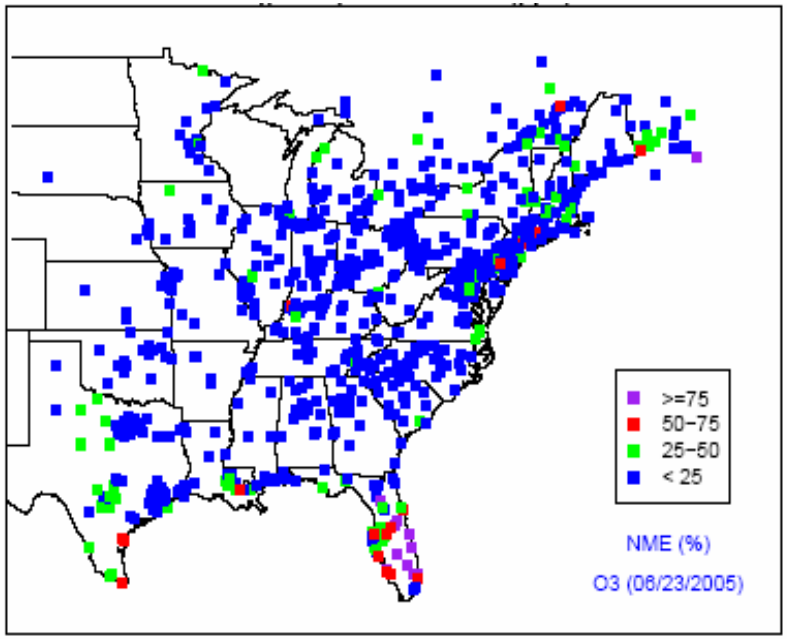
June 23

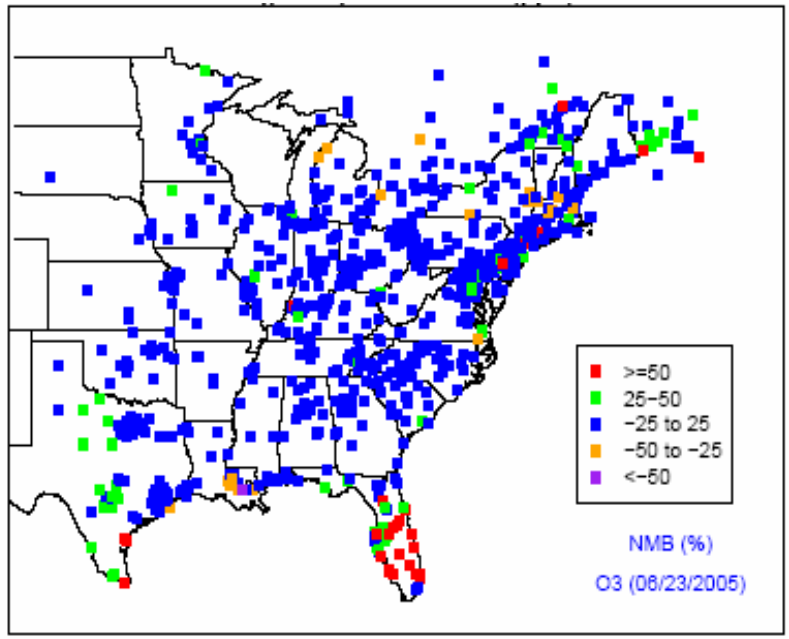


48 Hour Max. 8-Hour Ozone Forecast Valid: 23 June

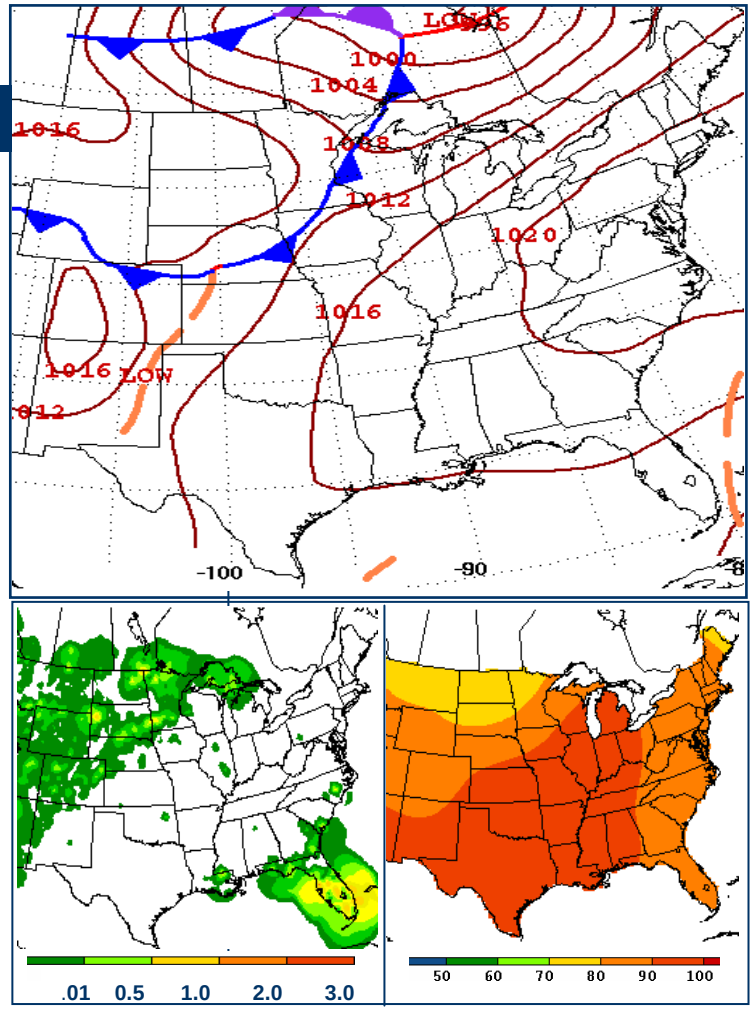
Obs Mean	Model Mean	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)
70.7	70.9	0.71	0.2	0.3	11.2	12.2

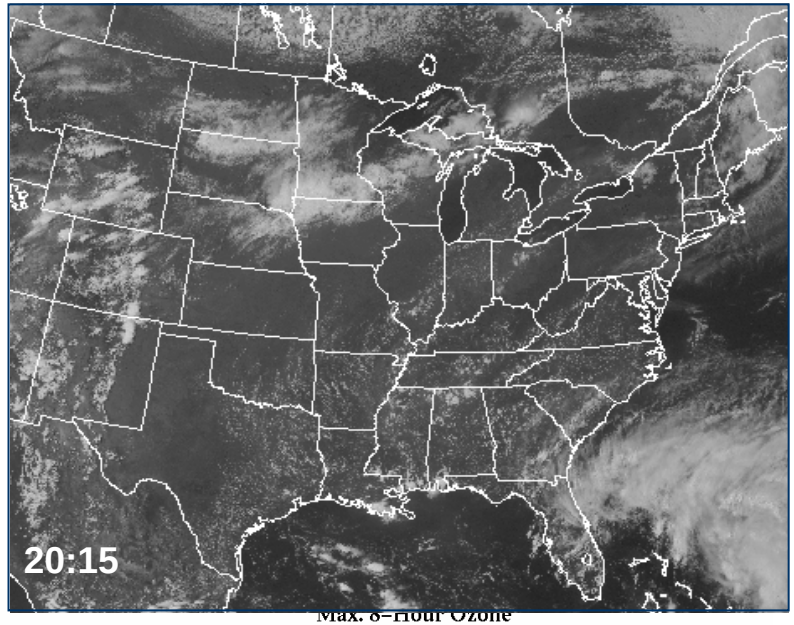






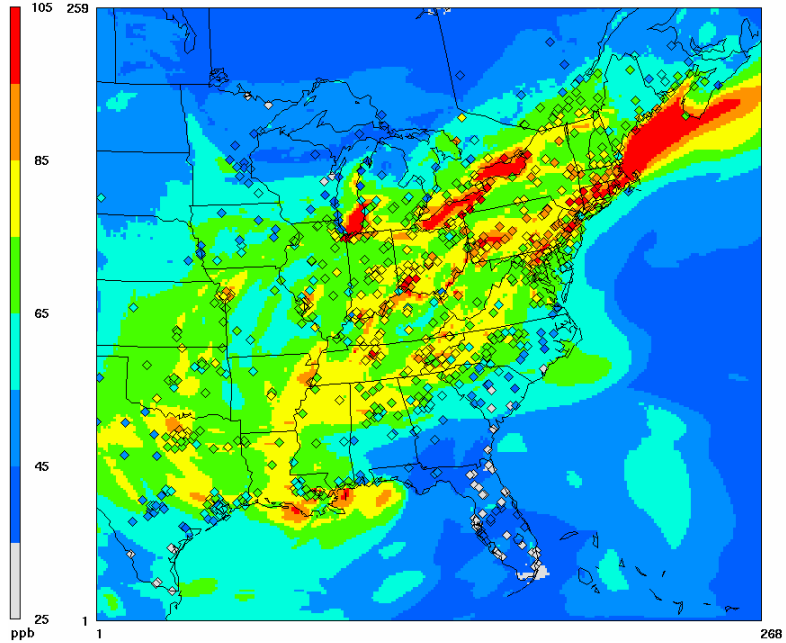
Synoptic Scale Meteorology
24 June 2005





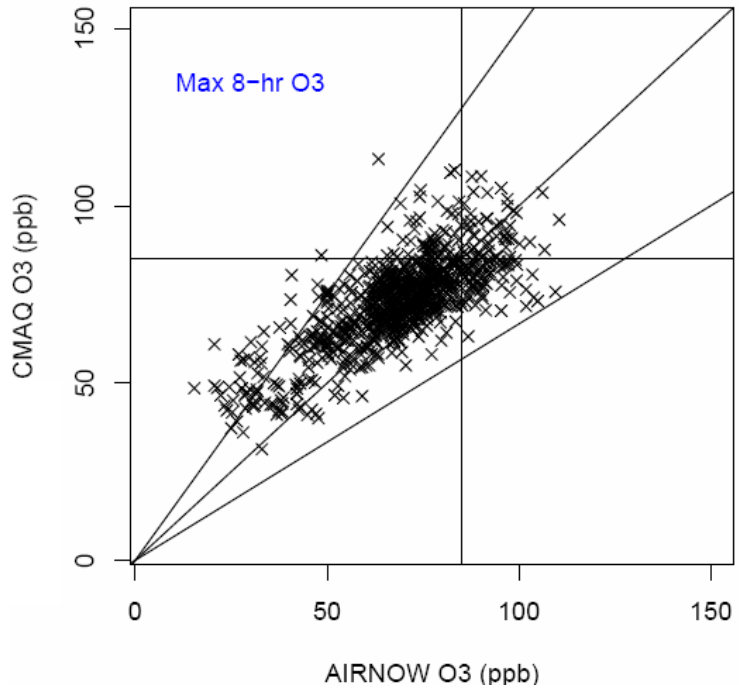
Max. 8-Hour Ozone

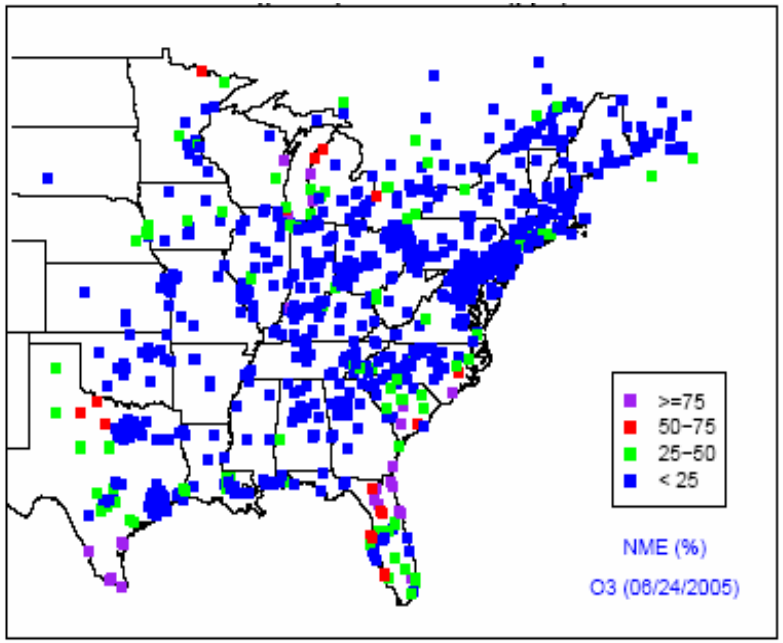
June 24

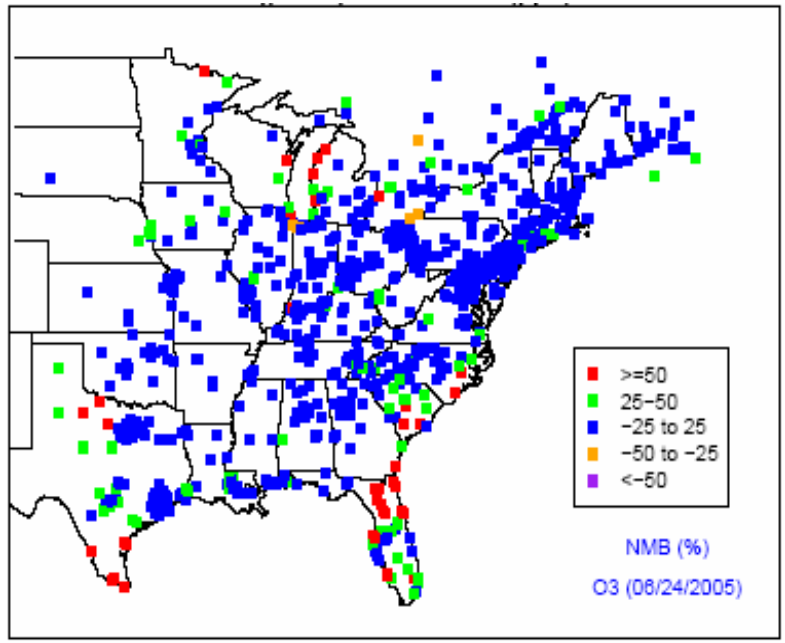


48 Hour Max. 8-Hour Ozone Forecast Valid: 24 June

Obs Mean	Model Mean	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)
68.3	73.2	0.76	4.6	6.7	11.7	13.1







Summary

The AQFS performed reasonably well in its second season.

- Performance was closely tied to meteorological conditions.
  - Better performance with clear skies and no precipitation:

    $r > 0.75$; NME < 20%; NMB < 15%

  - Poorer performance with cloud cover and precipitation occurred:

    $r < 0.60$; NME > 25%; NMB > 20%

Summary

Research is underway to address several modeling issues:

- cloud attenuation and mixing;
- boundary conditions.

Concurrent, experimental simulations performed on a continental domain using static boundary conditions and better cloud physics have resulted in a marked improvement in the AQFS's performance.

Thank you

Contact

Brian Eder
eder@hpcc.epa.gov

919.541.3994 (v)
919.541.1379 (f)
http://www.epa.gov/asmdnerl/

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