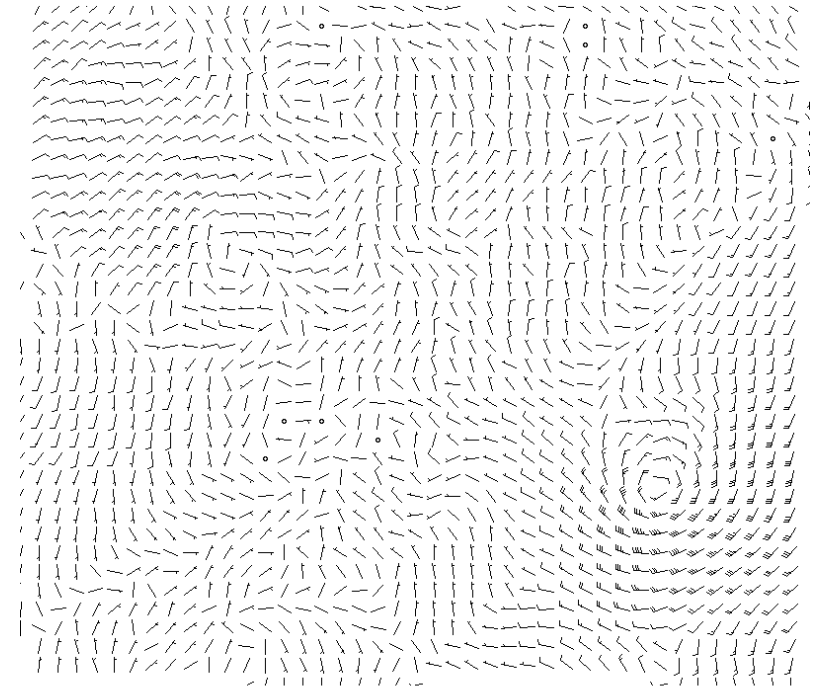


# An Operational Evaluation of The Eta-CMAQ Air Quality Forecast Model: Summer 2005



**Brian Eder<sup>1</sup>**  
**Daiwen Kang<sup>2</sup>**  
**Rohit Mathur<sup>1</sup>**  
**Shaocai Yu<sup>2</sup>**  
**Kenneth Schere<sup>1</sup>**

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



<sup>1</sup> In partnership with the National Exposure Research Laboratory, U.S. EPA, RTP, NC 27711

<sup>2</sup> On assignment from Science and Technology Corporation, Hampton, VA 23666

## 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

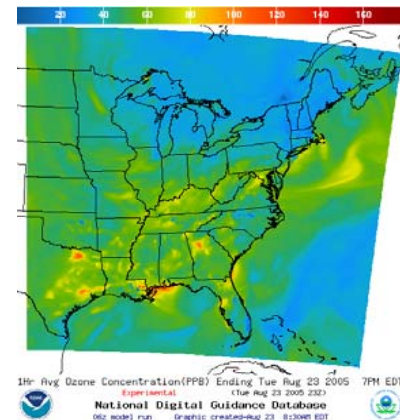
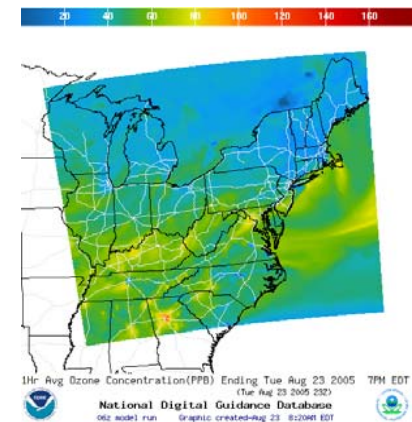
The initial deployment of the operational AQFS began last September, providing 48 hour simulations of hourly, maximum 1- and 8-hour **ozone** concentrations in the Northeastern US.

# 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/>



**National Oceanic and Atmospheric Administration**  
**National Weather Service**  
WORKING TOGETHER TO SAVE LIVES

weather.gov



[Site Map](#) [News](#) [Organization](#) [Search](#)

Local forecast by "City, St"

**Warnings**  
Current By State...

**Observations**  
Radar  
Satellite  
Snow Cover  
Surface Weather...

**Forecasts**  
Local  
Graphical  
Aviation  
Marine  
Hurricanes  
Severe Weather  
Fire Weather  
Climate...

**Forecast Models**  
Numerical Models  
Statistical Models...

**Weather Safety**  
Weather Radio  
Hazard Assmt...

**Education/Outreach**

**Information Center**  
Past Weather  
Glossary  
Publications...

**Careers**

**Contact Us**  
FAQ  
Comments...

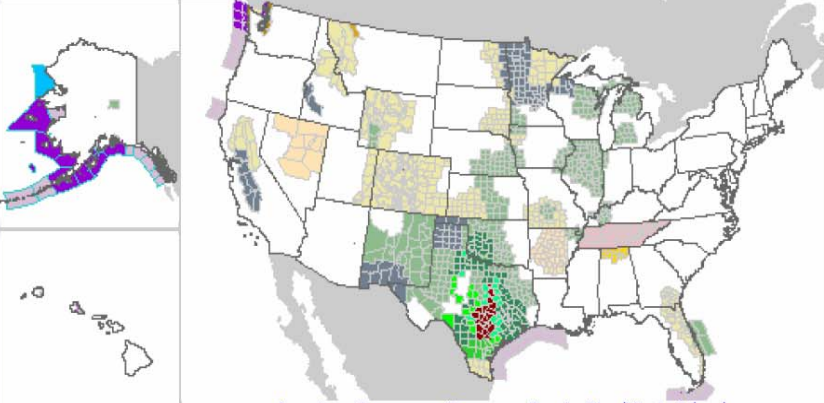
### Comment on Strategic Plan for NOAA's National Weather Service

A draft of the National Weather Service's Strategic Plan for 2005-2010 is available for public comment. This Strategic Plan lays out the path that NOAA's NWS will take to accomplish its mission, advance its vision, and integrate its core values throughout the organization. The theme of this plan "Working Together to Save Lives" reflects NWS's commitment to work with all of its partners to provide the services America needs. We are interested in your comments.

[Details...](#)

[Warnings & Forecasts](#) [Graphical Forecasts](#) [National Maps](#) [Radar](#) [Rivers](#) [Air Quality](#) [Satellite](#)

[Click On Map Below To Zoom In.](#)



American Samoa · Guam · Puerto Rico/Virgin Islands

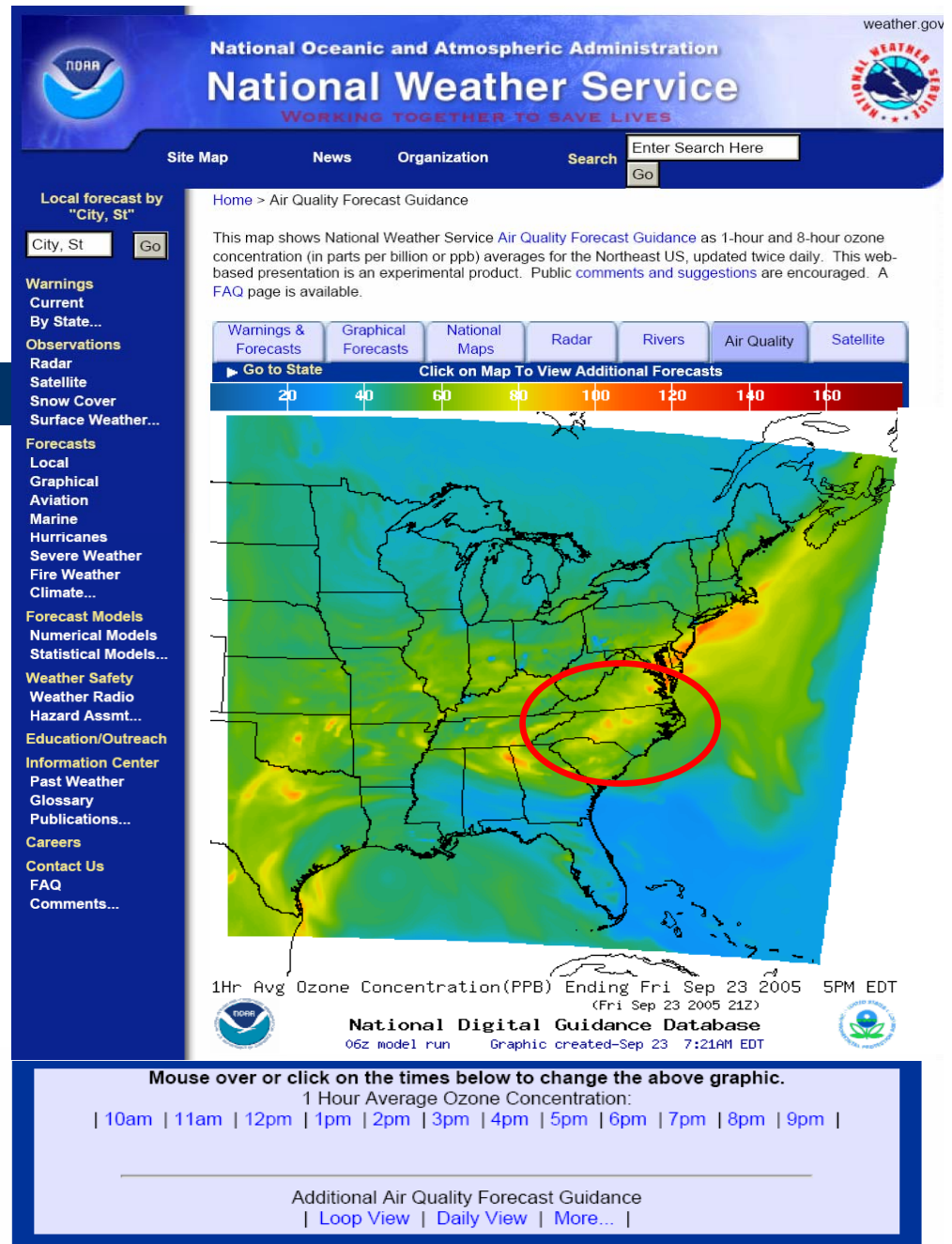
Flash Flood Warning	Flood Warning	High Wind Warning
Flash Flood Statement	Gale Warning	Flash Flood Watch
High Surf Advisory	Heavy Freezing Spray Warning	Small Craft Advisory
Dense Fog Advisory	Marine Weather Statement	Coastal Flood Watch
Flood Watch	High Wind Watch	Civil Emergency Message
Flood Statement	Special Weather Statement	Short Term Forecast
Hazardous Weather Outlook	Child Abduction Emergency	

(WED) 11.17.2004 10:11:26 AM (EST)

[24 Hour Loop](#) | [12 hour Loop](#)

# Operation

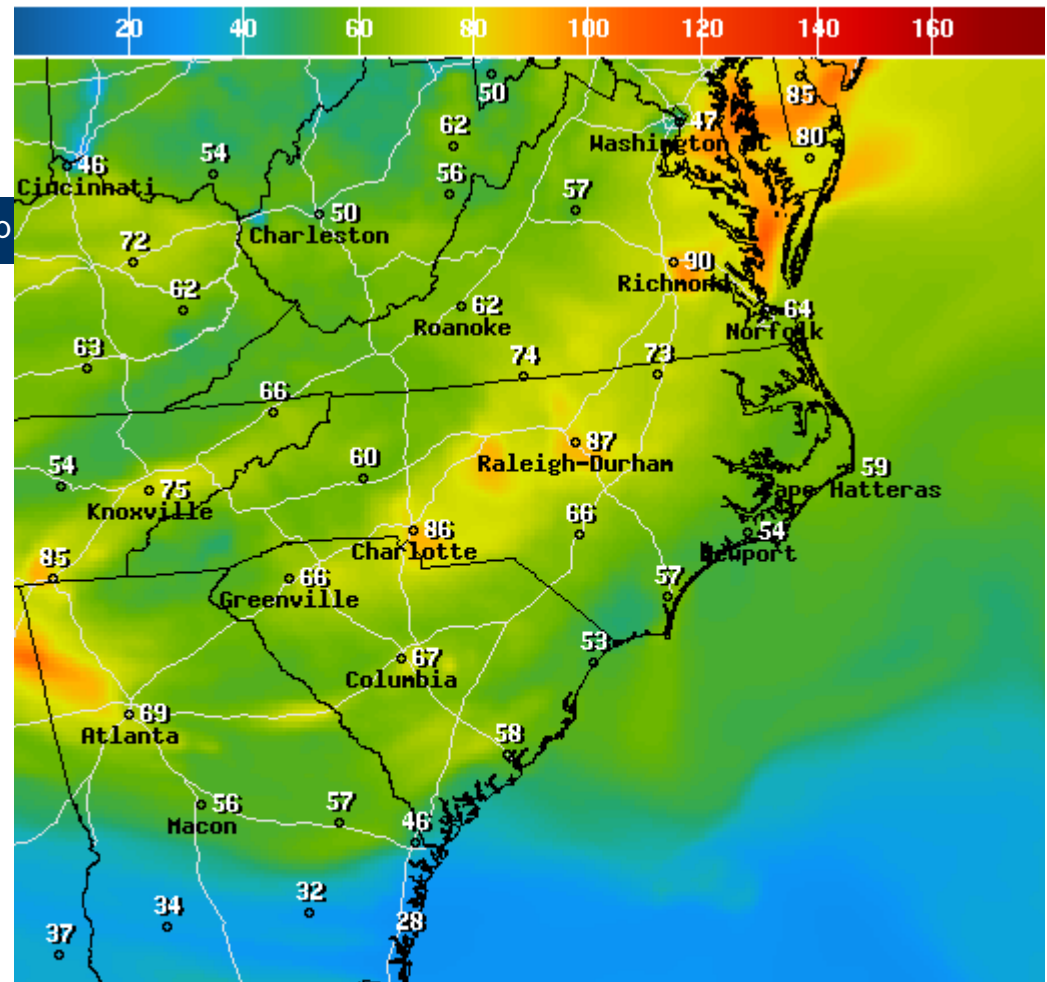
<http://www.nws.noaa.gov/aq>





# Operation

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



1Hr Avg Ozone Concentration(PPB) Ending Fri Sep 23 2005 5PM EDT  
(Fri Sep 23 2005 21Z)



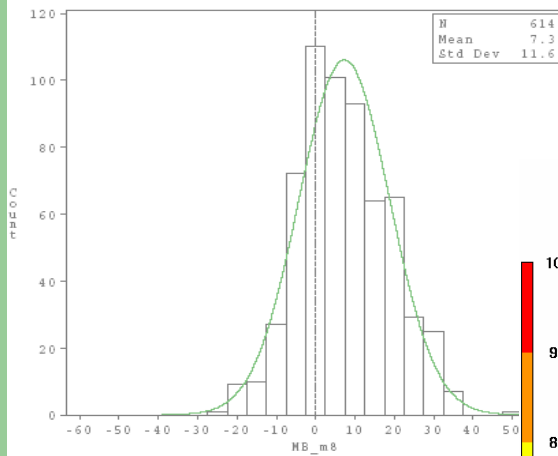
**National Digital Guidance Database**

06z model run

Graphic created-Sep 23 7:22AM EDT

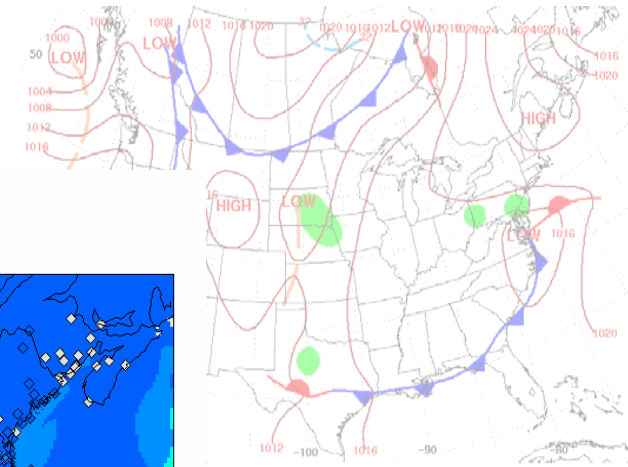
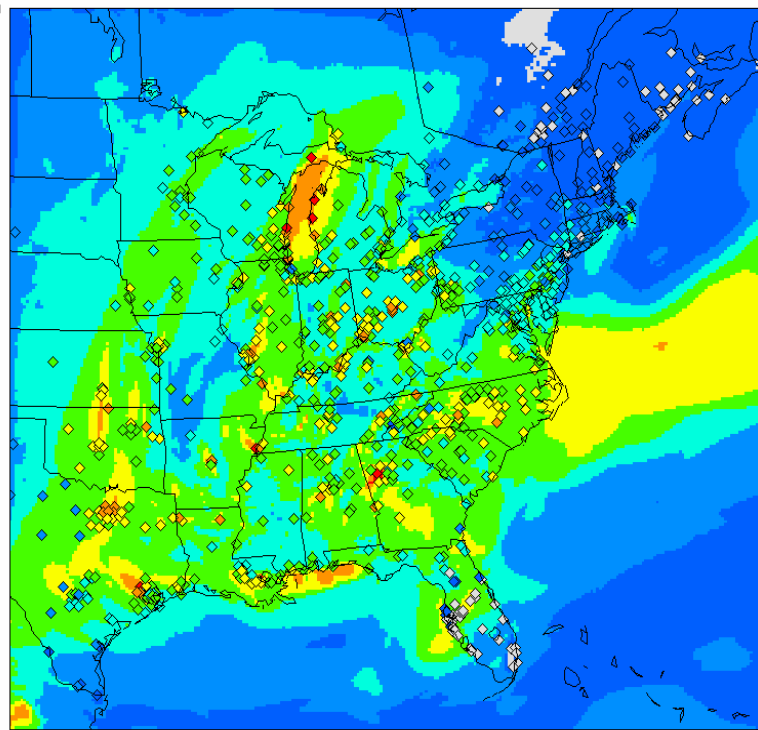


# Evaluation

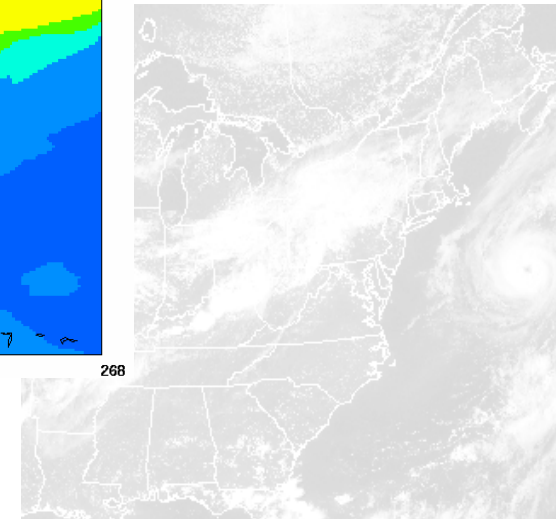
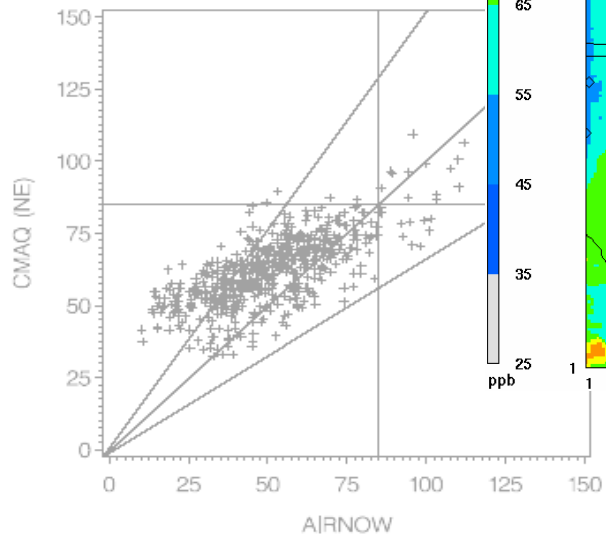


## Max. 8-Hour Ozone

June 22



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



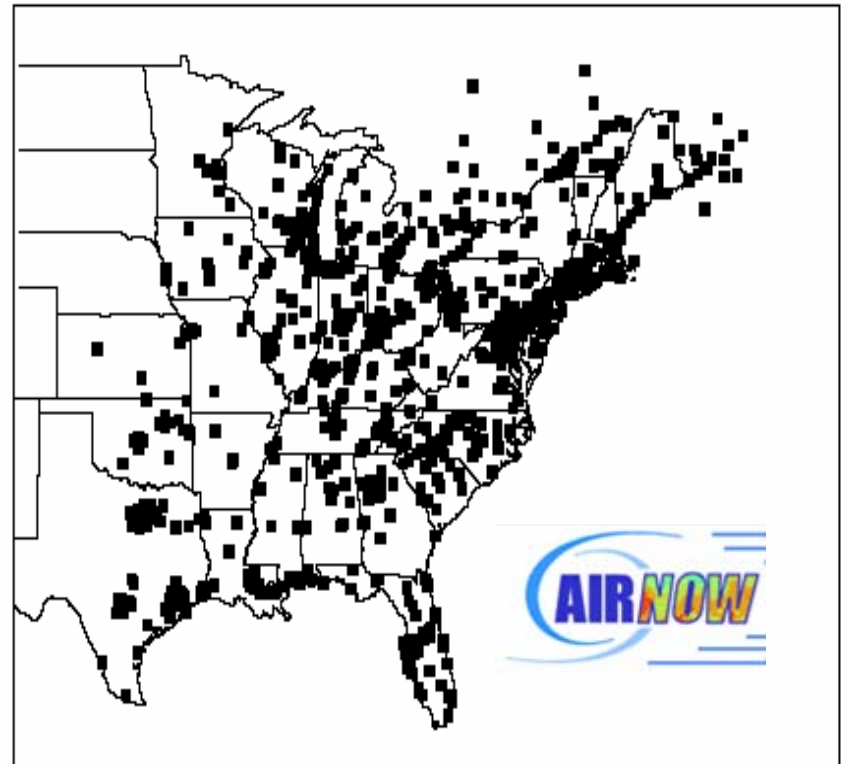


# Evaluation

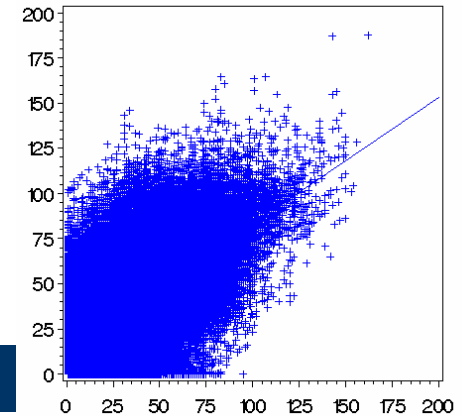
## O<sub>3</sub> (ppb) from EPA's AIRNOW network



- More than 800 stations  
(mostly urban)
- ~ Four month period  
(M, J, J, A,)
- Hourly O<sub>3</sub>  
Max. 1-hour O<sub>3</sub>  
Max. 8-hour O<sub>3</sub> (presented)



## Discrete Forecast / Evaluation



[Observed] *versus* [Forecast]

### Statistics

- Summary

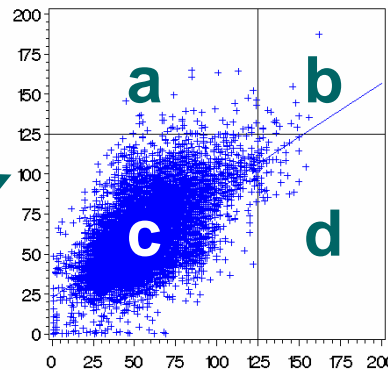
- Biases: 
$$MB = \frac{1}{N} \sum_{1}^N (\text{Model} - \text{Obs})$$
$$NMB = \frac{\sum_{1}^N (\text{Model} - \text{Obs})}{\sum_{1}^N (\text{Obs})} \cdot 100\%$$

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

## Category Forecast / Evaluation

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

Forecast Exceedance	Yes	No
	<b>a</b>	<b>b</b>
No	<b>c</b>	<b>d</b>
		Observed Exceedance
		No      Yes



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

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

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

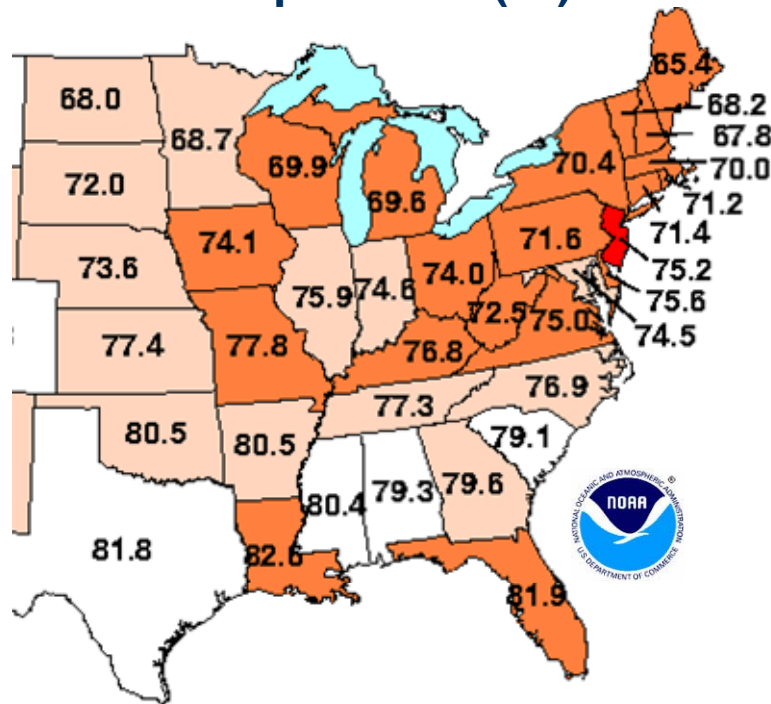
$$CSI = \left( \frac{b}{a + b + d} \right) \cdot 100\%$$

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

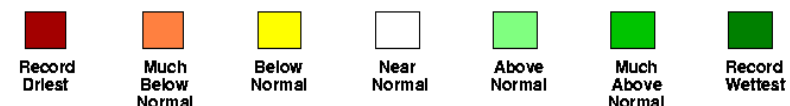
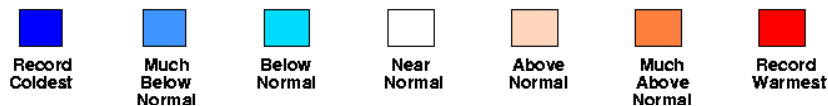
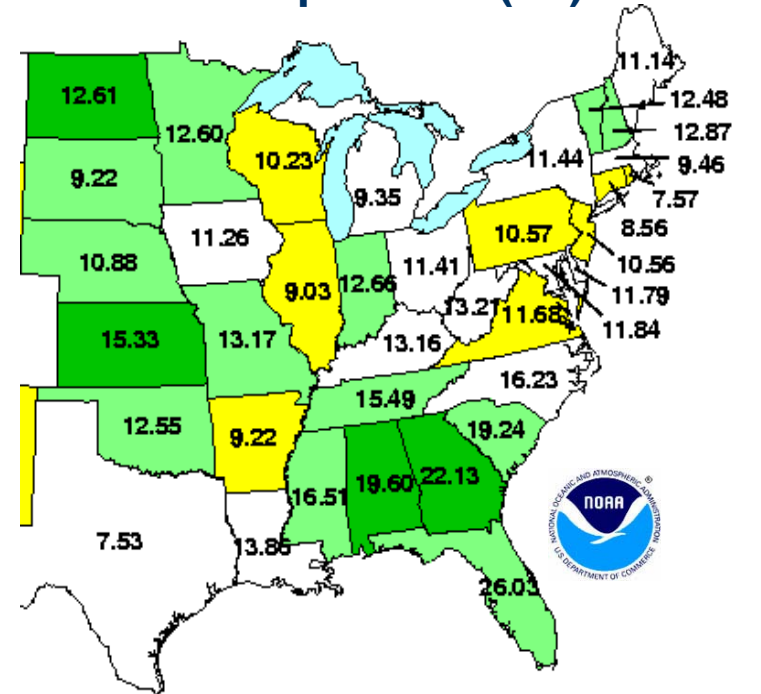
# Evaluation

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

### Temperature (°F)



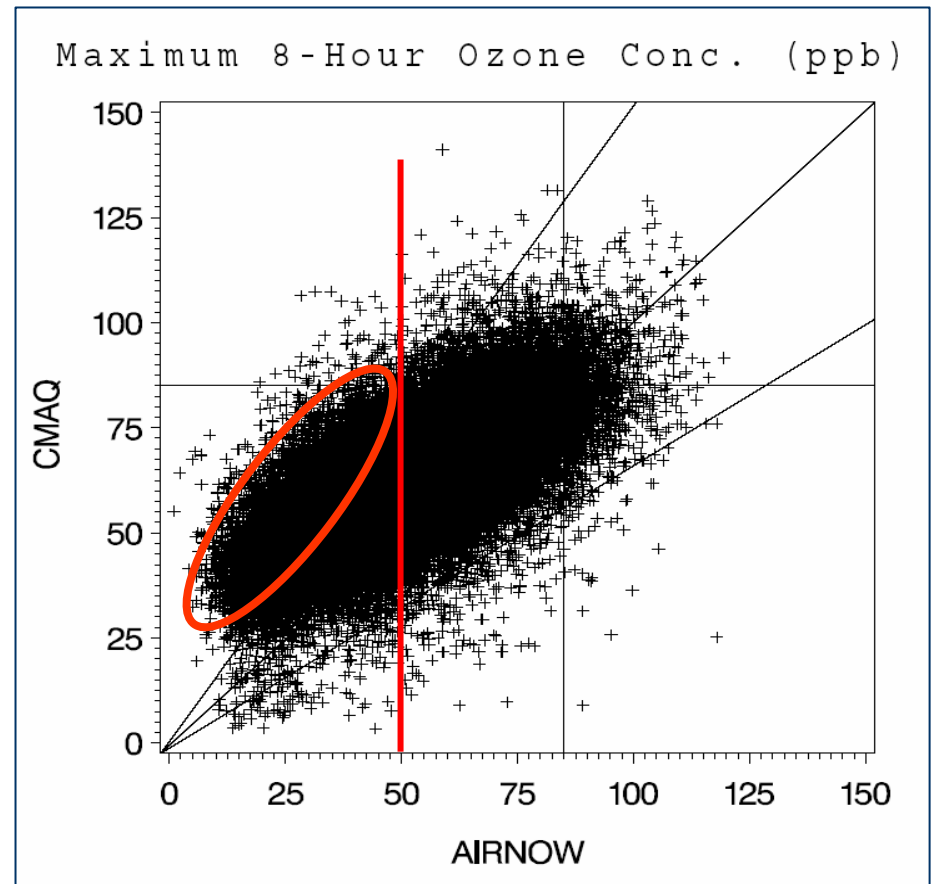
### Precipitation (In.)



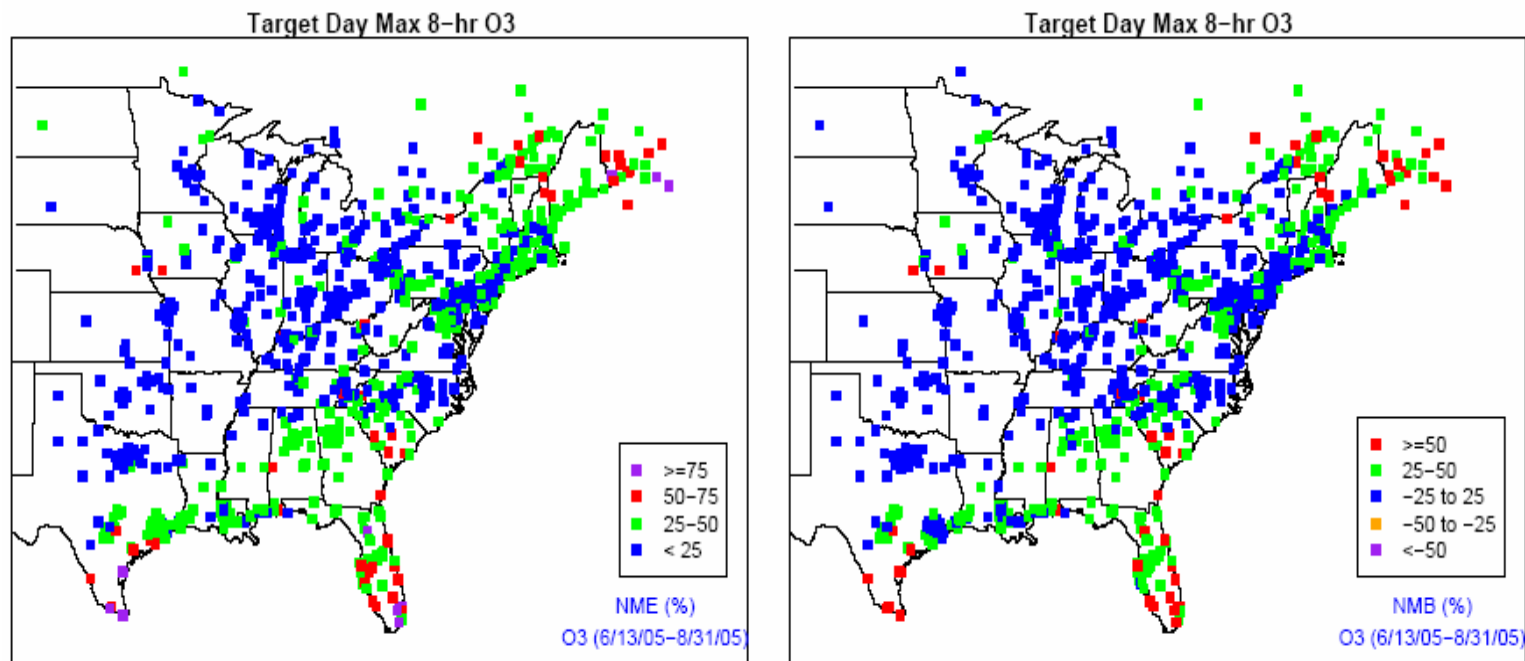
## Seasonal Scatterplot

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

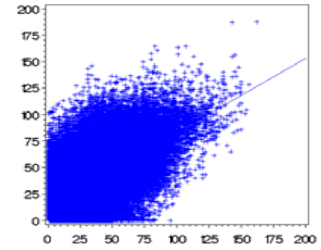


## Seasonal Summary



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.

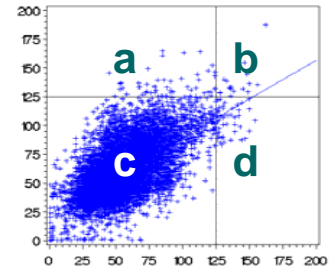




## Monthly Summary - Discrete

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

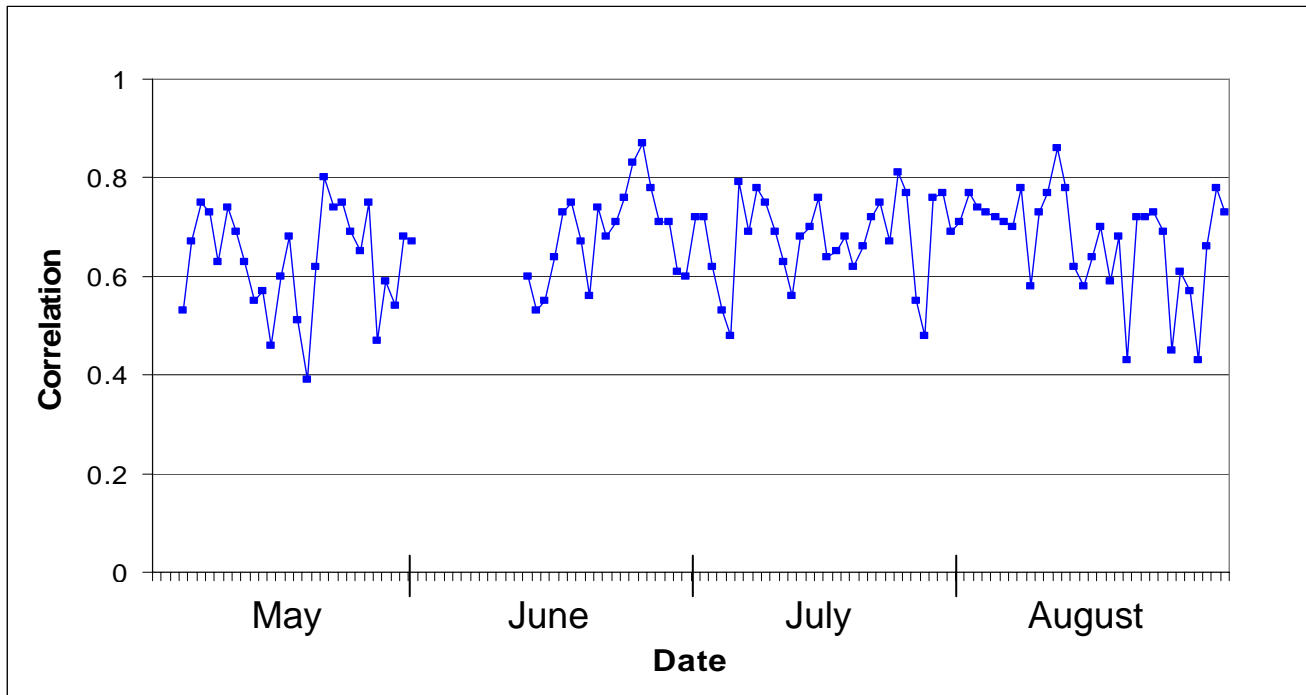


## Monthly Summary - Categorical

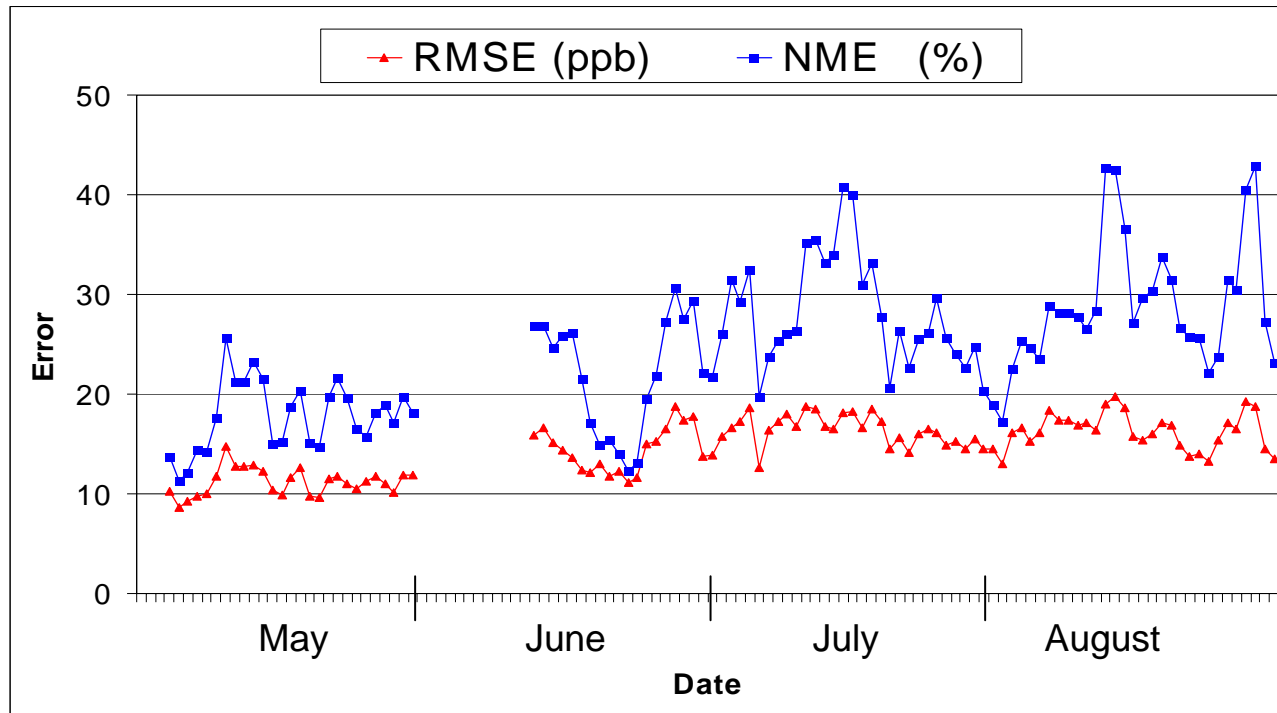
Month	A (%)	B	FAR (%)	CSI (%)	POD (%)
May <sup>@</sup>	99.4	0.30	69.4	7.5	9.0
June <sup>*</sup>	94.3	1.04	59.2	26.2	42.6
July	96.1	2.39	84.2	12.6	37.9
August	95.7	2.4	81.0	15.6	46.5

<sup>@</sup> May 5-31, <sup>\*</sup>June 13-30

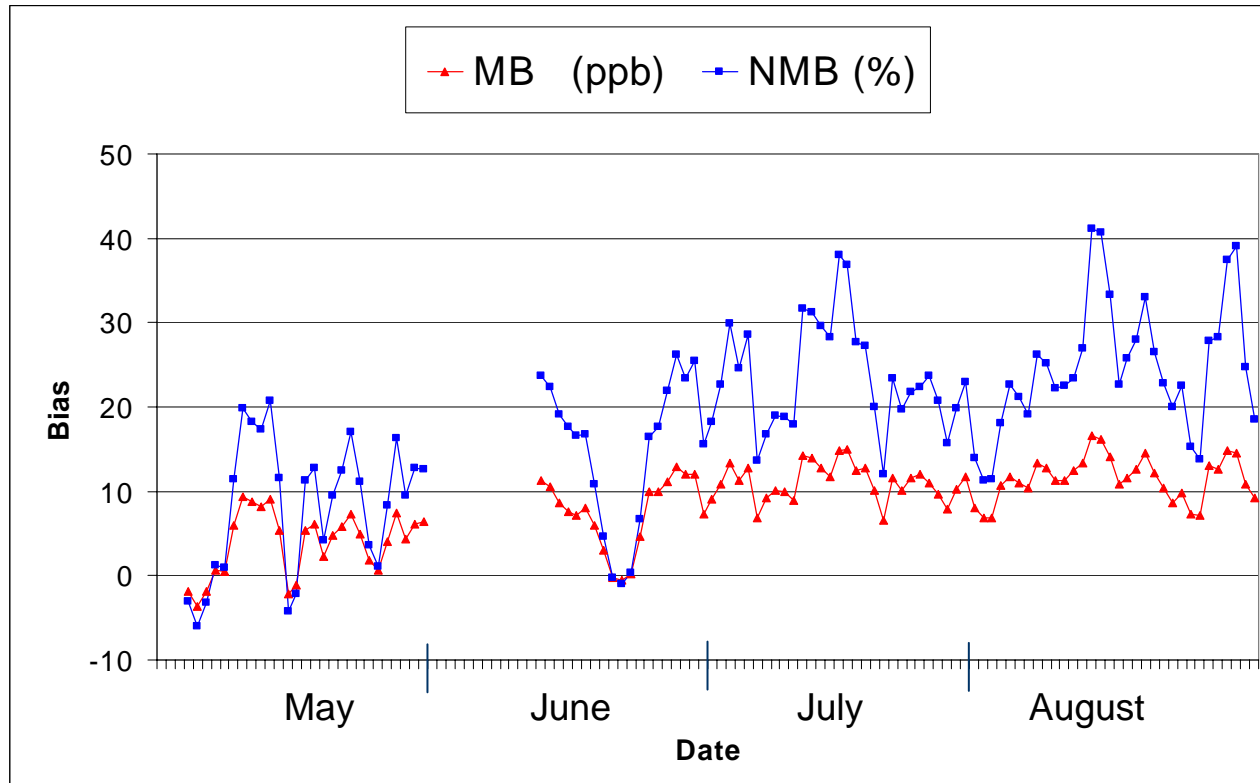
## Daily, Domain Wide Correlations



## Daily, Domain Wide Error



## Daily, Domain Wide Bias



## 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

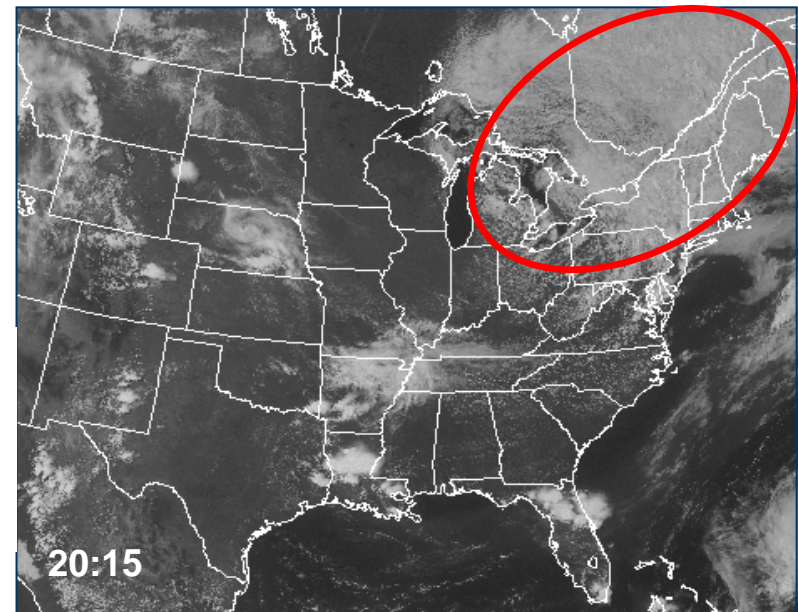
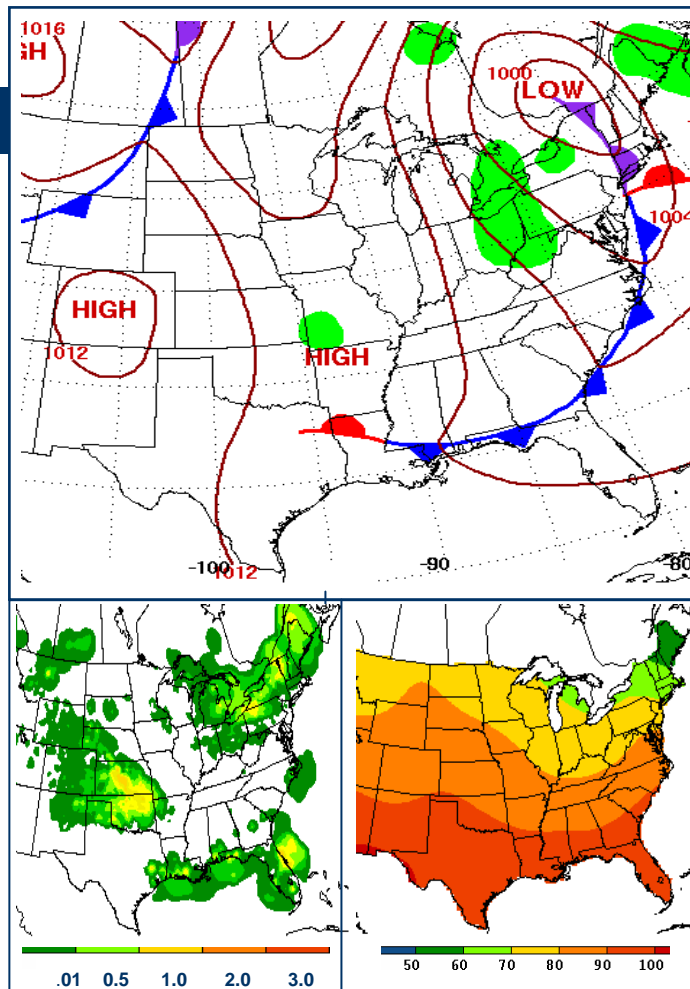
16 - 17 June

23 - 24 June



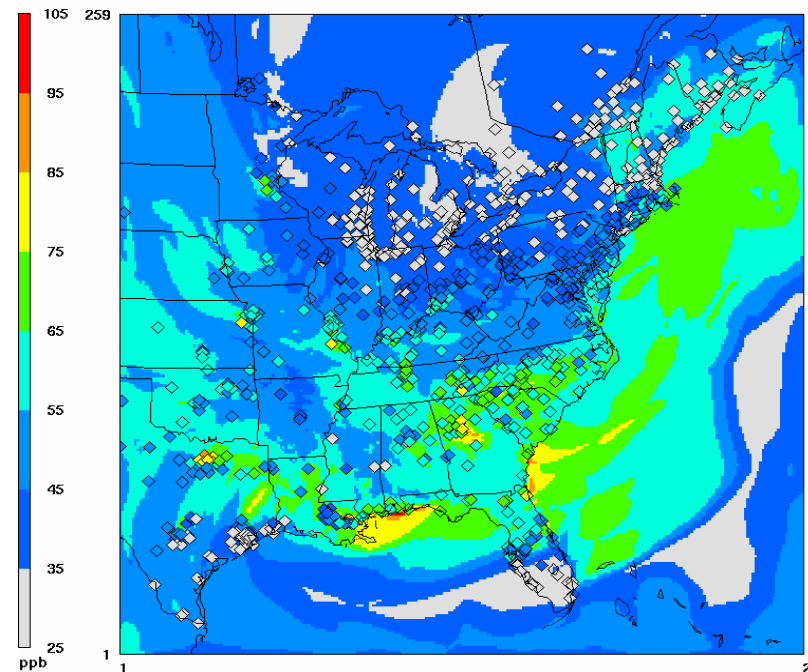
# Synoptic Scale Meteorology

## 16 June 2005



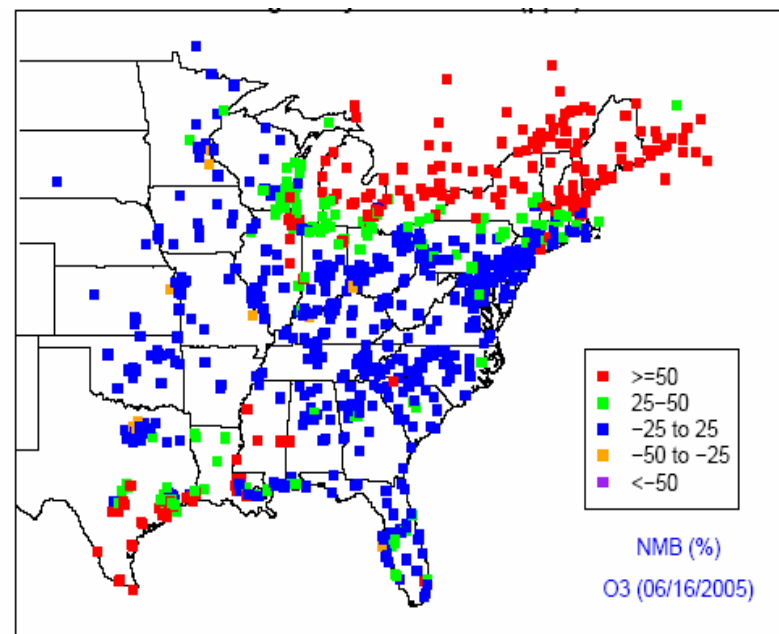
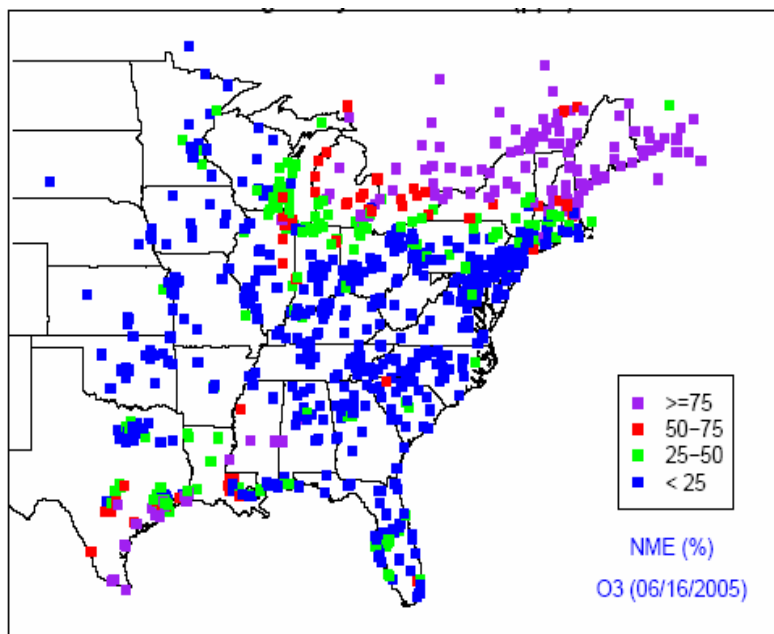
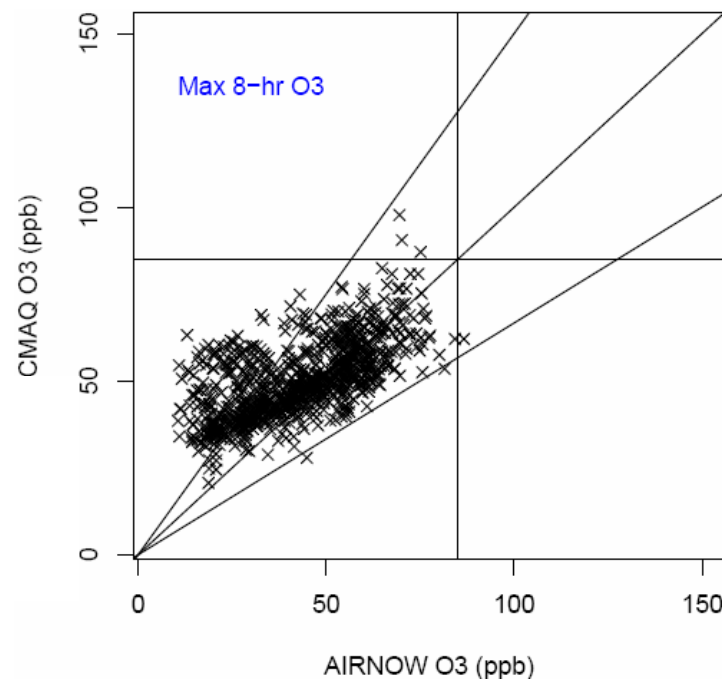
Max. 8-Hour Ozone

June 16



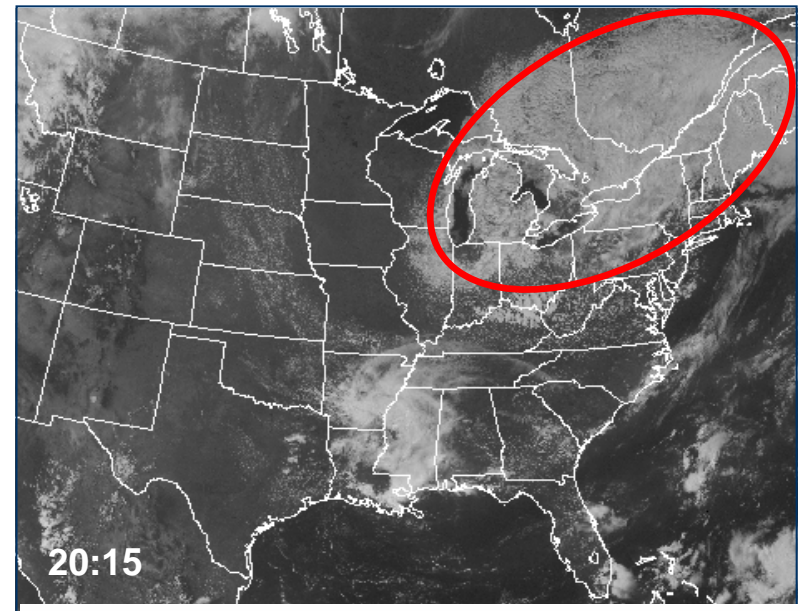
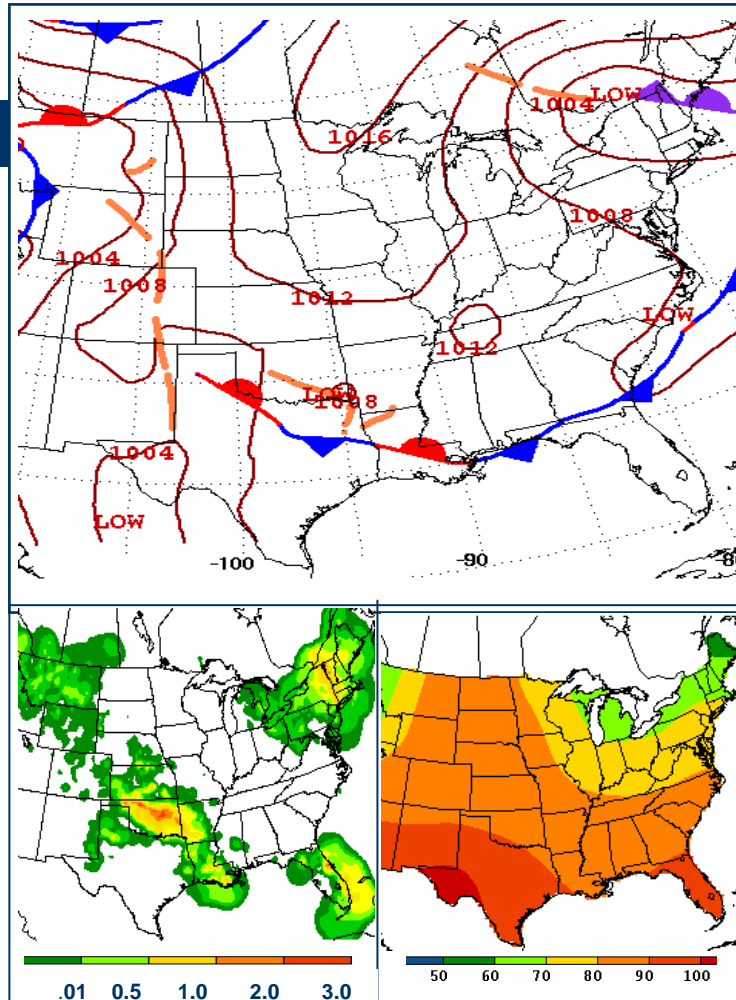
# 48 Hour Max. 8-Hour Ozone Forecast Valid: 16 June

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



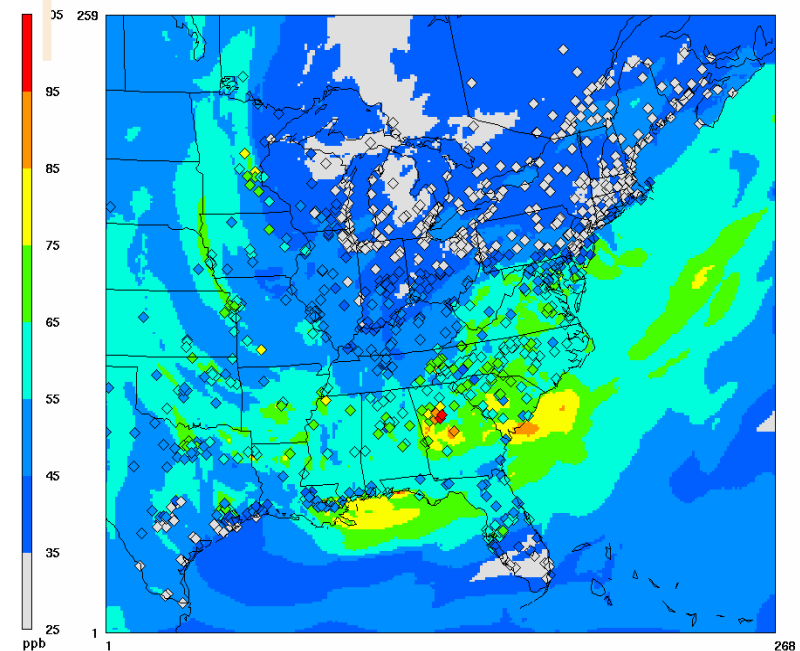
# Synoptic Scale Meteorology

## 17 June 2005



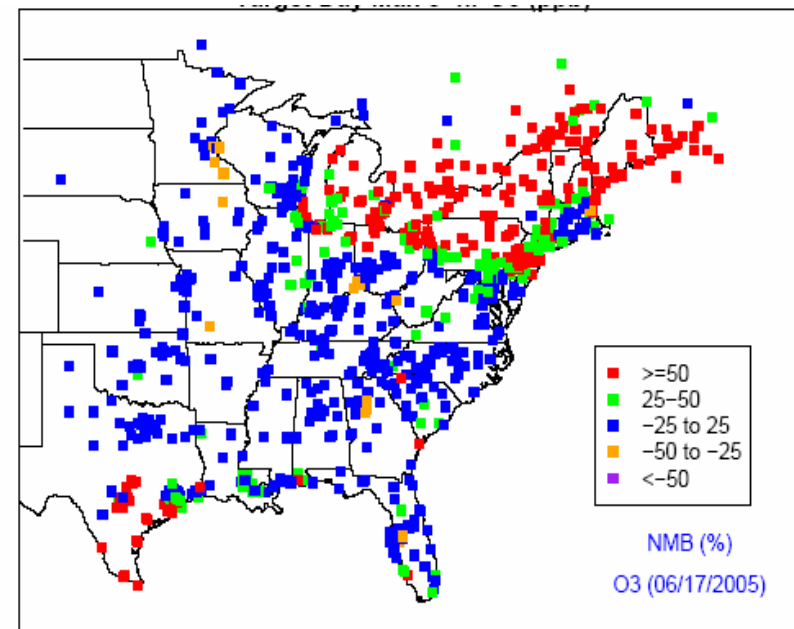
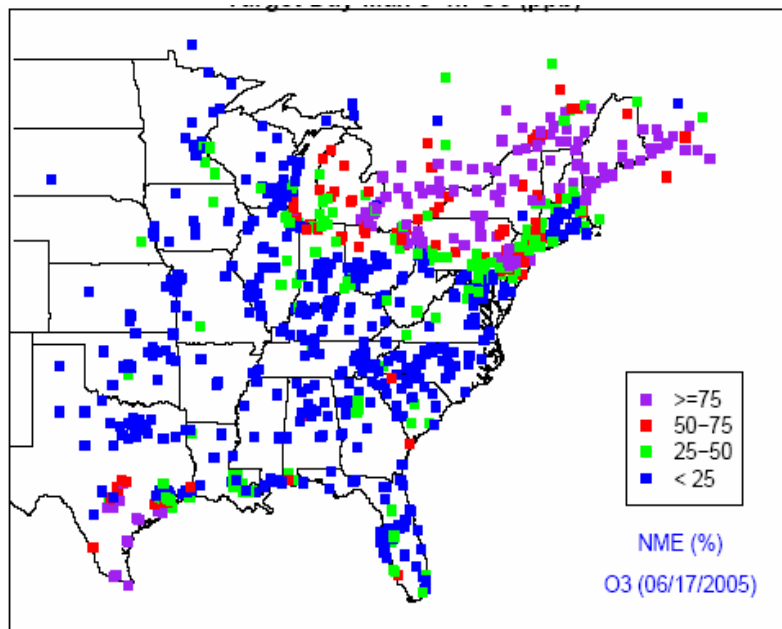
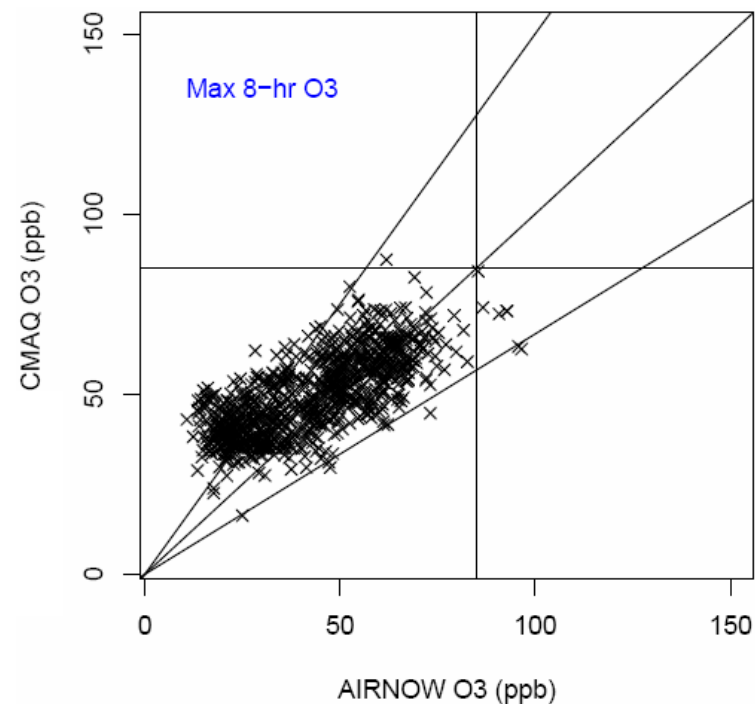
Max. 8-Hour Ozone

June 17



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

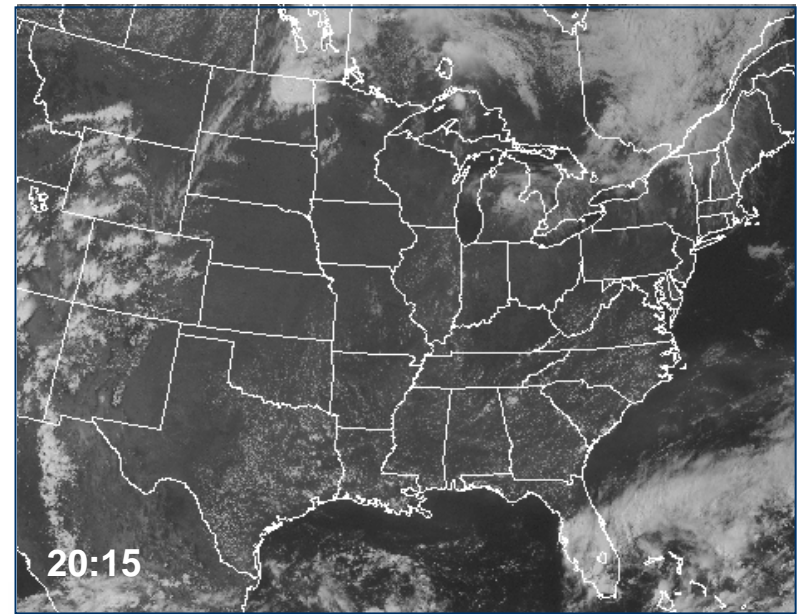
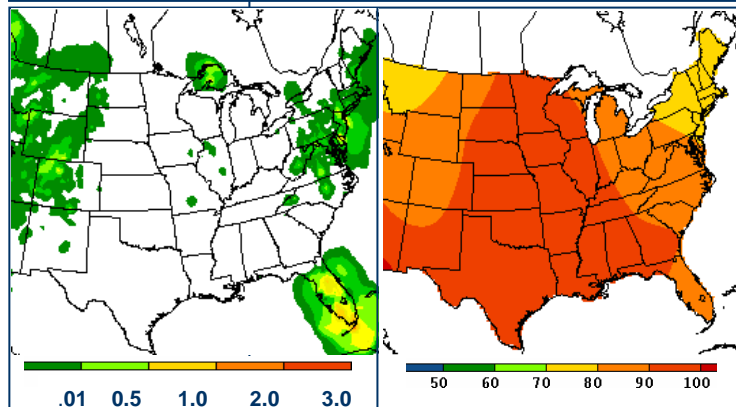
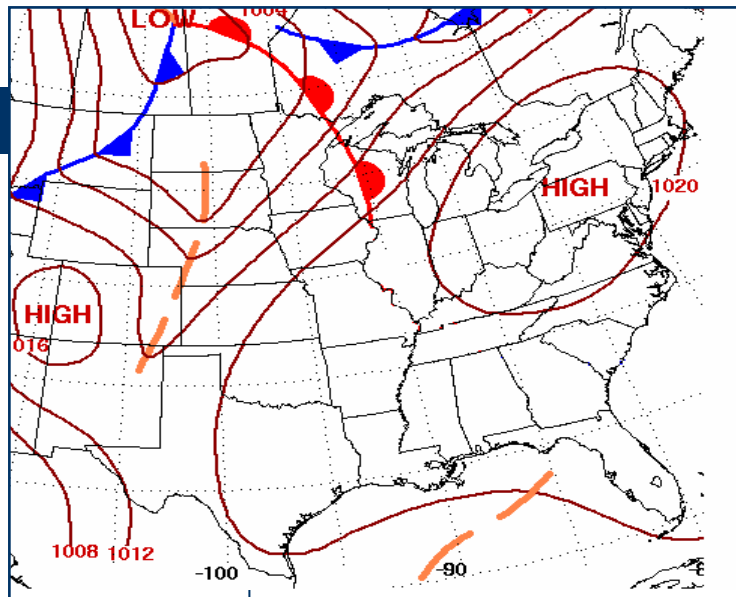
Obs Mean	Model Mean	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)
42.5	49.6	0.73	7.1	16.7	13.7	26.2



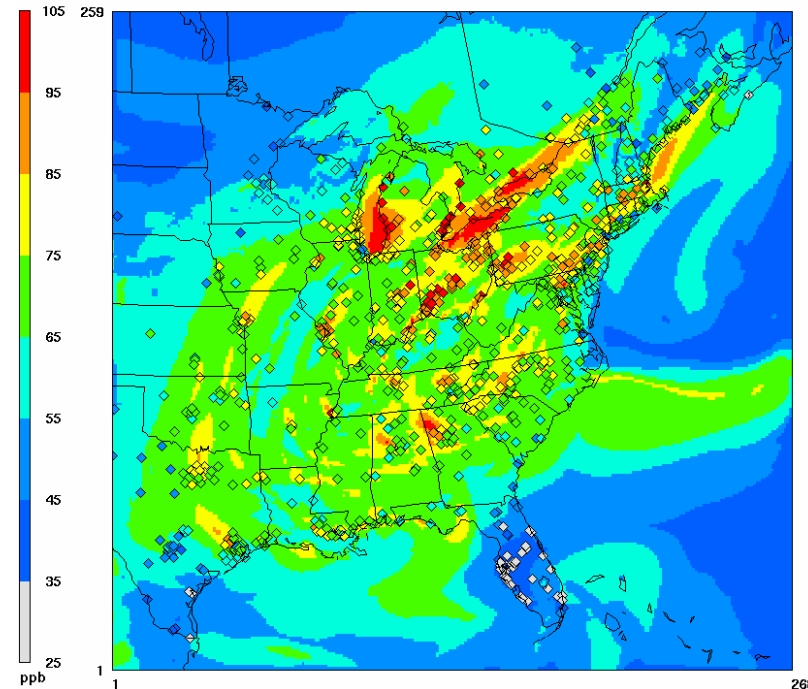


# Synoptic Scale Meteorology

## 23 June 2005

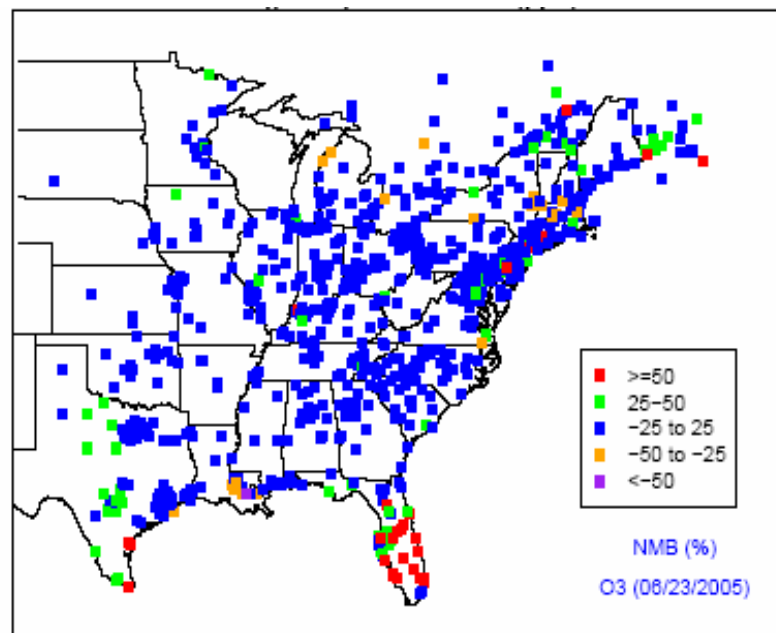
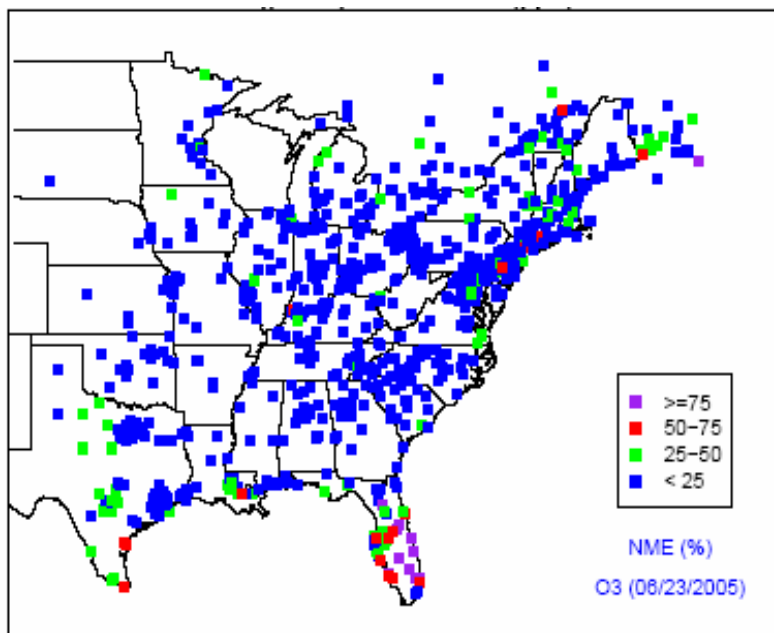
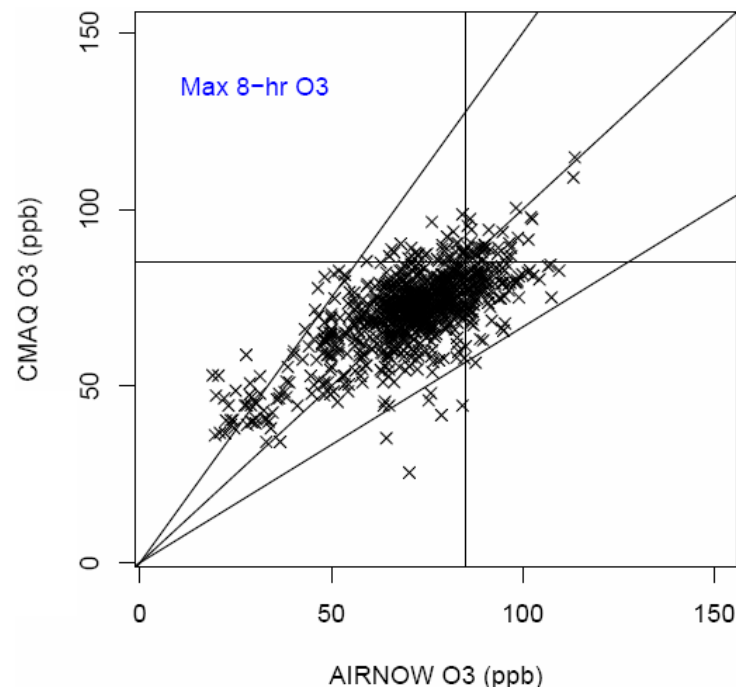


June 23



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

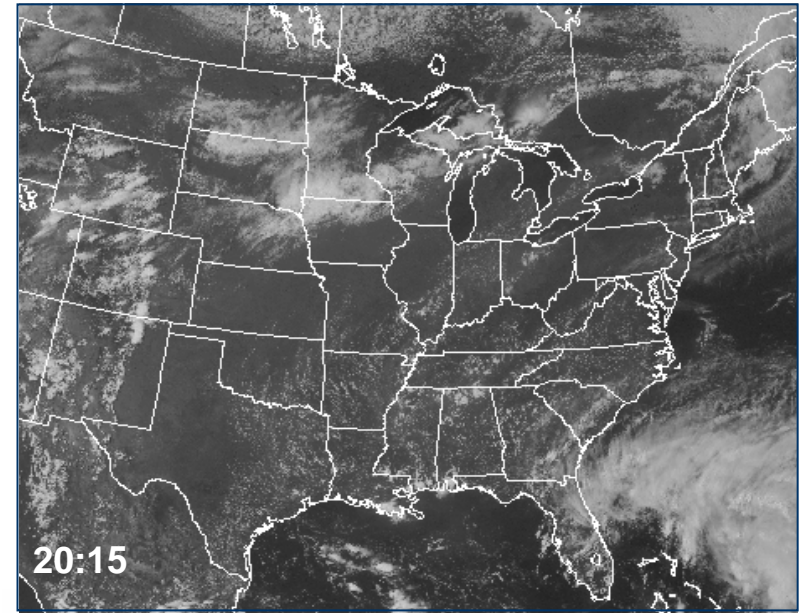
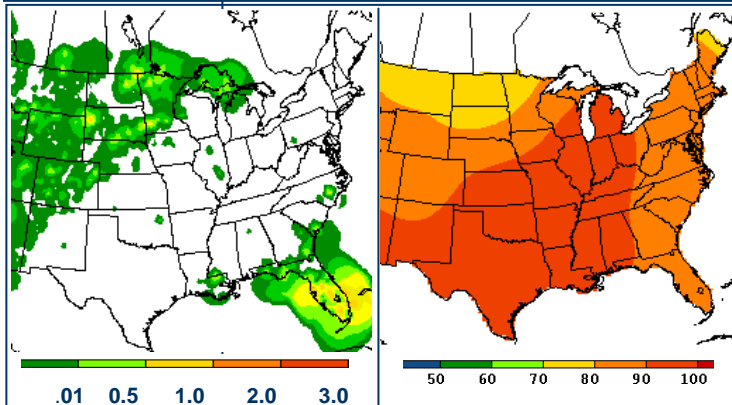
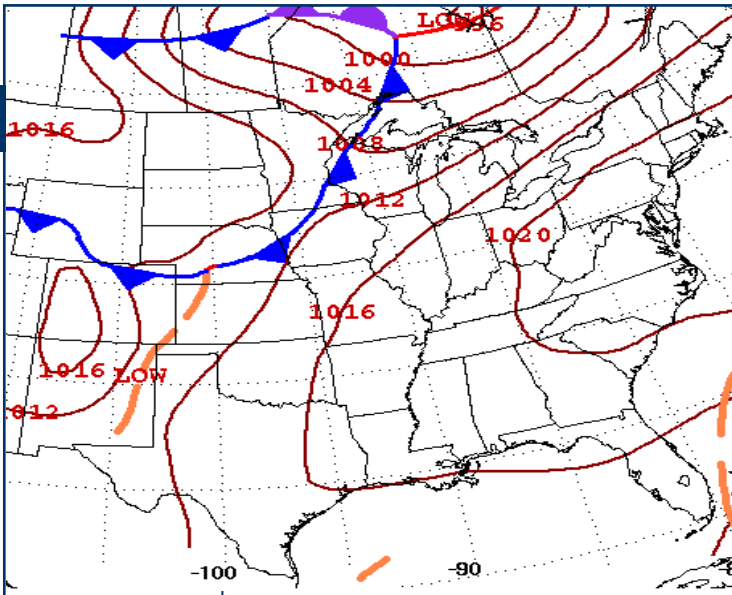
Obs Mean	Model Mean	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)
70.7	70.9	0.71	0.2	0.3	11.2	12.2





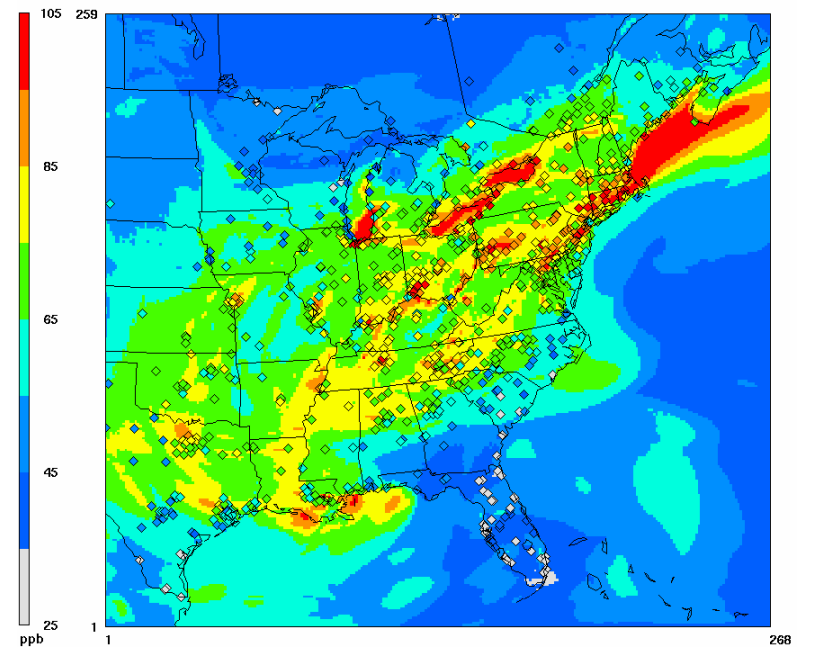
# Synoptic Scale Meteorology

## 24 June 2005



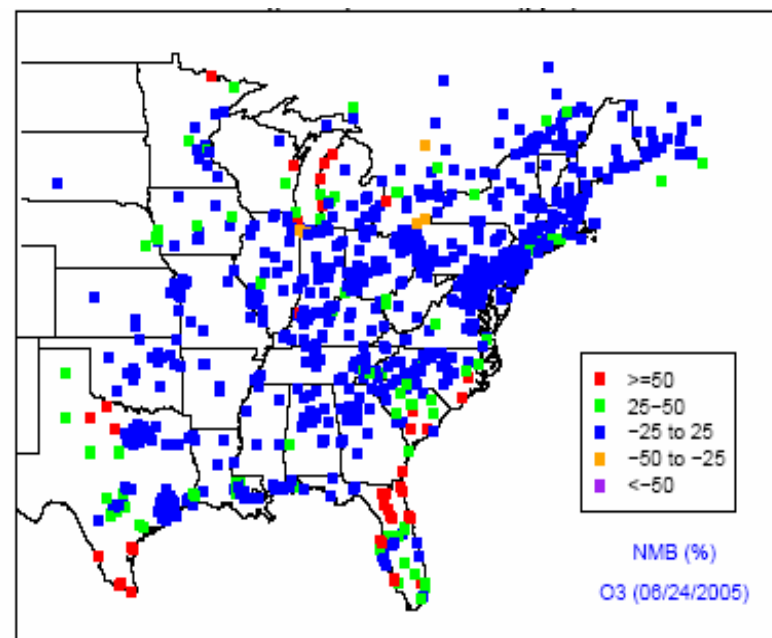
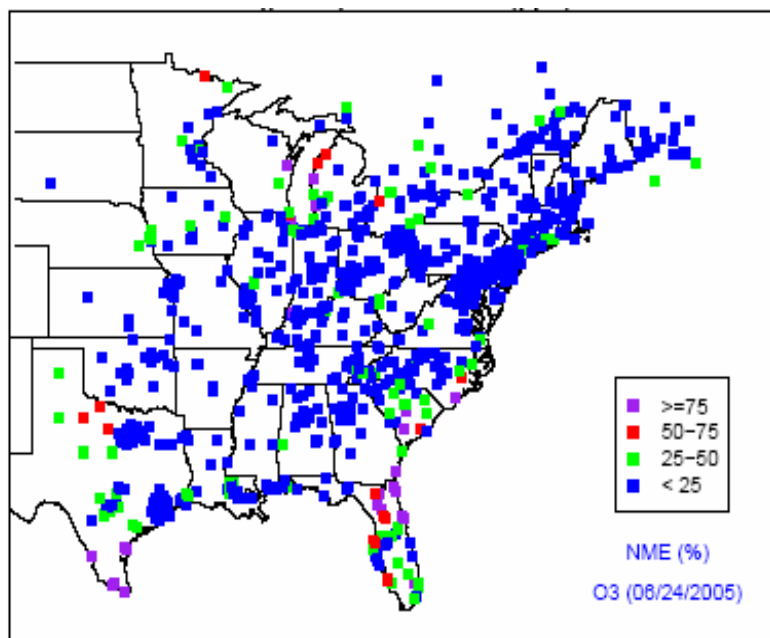
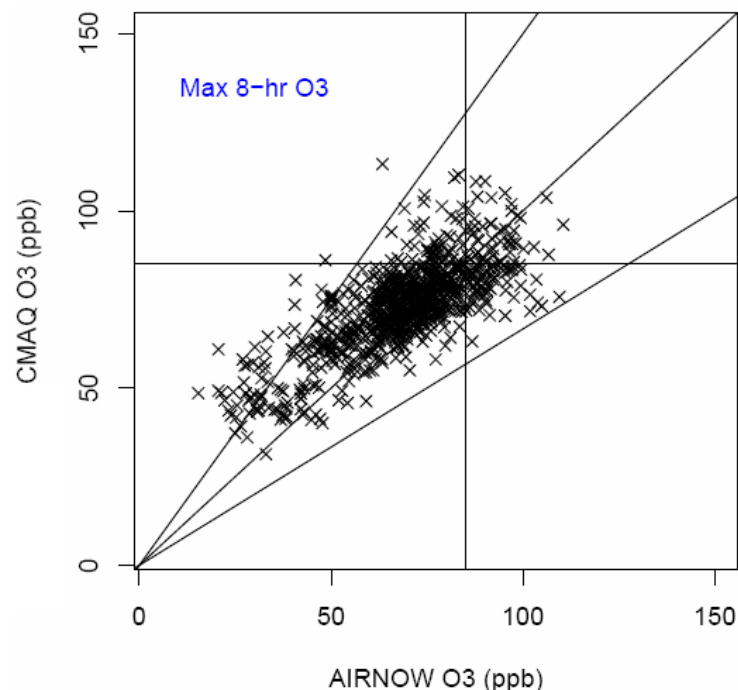
Max. 8-hour Ozone

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](mailto:eder@hpcc.epa.gov)

919.541.3994 (v)

919.541.1379 (f)

<http://www.epa.gov/asmdnerl/>

**Disclaimer** - The research presented here was performed under the Memorandum of Understanding between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and under agreement number DW13921548. This work constitutes a contribution to the NOAA Air Quality Program. Although it has been reviewed by EPA and NOAA and approved for publication, it does not necessarily reflect their policies or views.