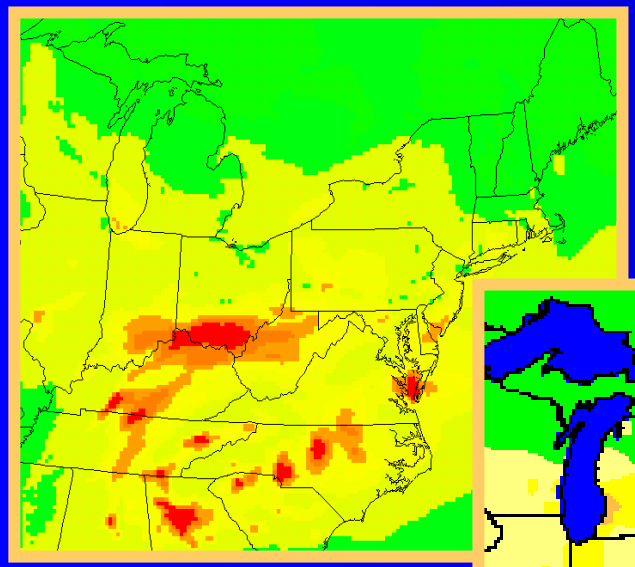
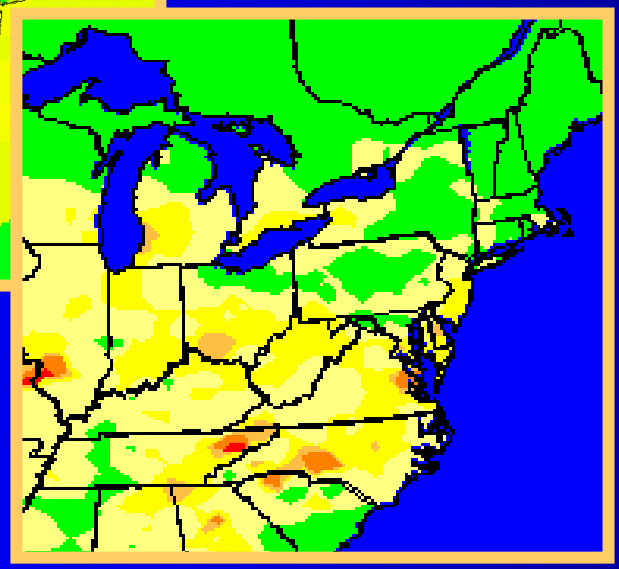
AN EVALUATION OF THE ETA-CMAQ AIR QUALITY FORECAST MODEL AS PART OF NOAA'S NATIONAL PROGRAM

CMAQ



AIRNOW



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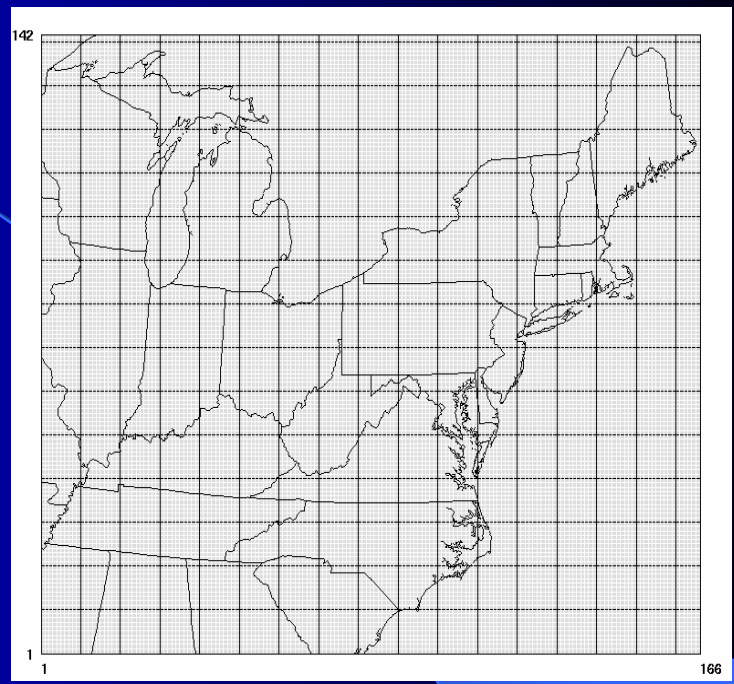
Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

Models-3 CMAQ

Domain



Forecast Configuration

- **Eta** Meteorology
- CBIV Mechanism
- SMOKE Emissions (*Offline*)
- 12 km grid resolution
- 22 Vertical Layers
- 48 Hr. Forecast (12Z Init.)

Simulation Period

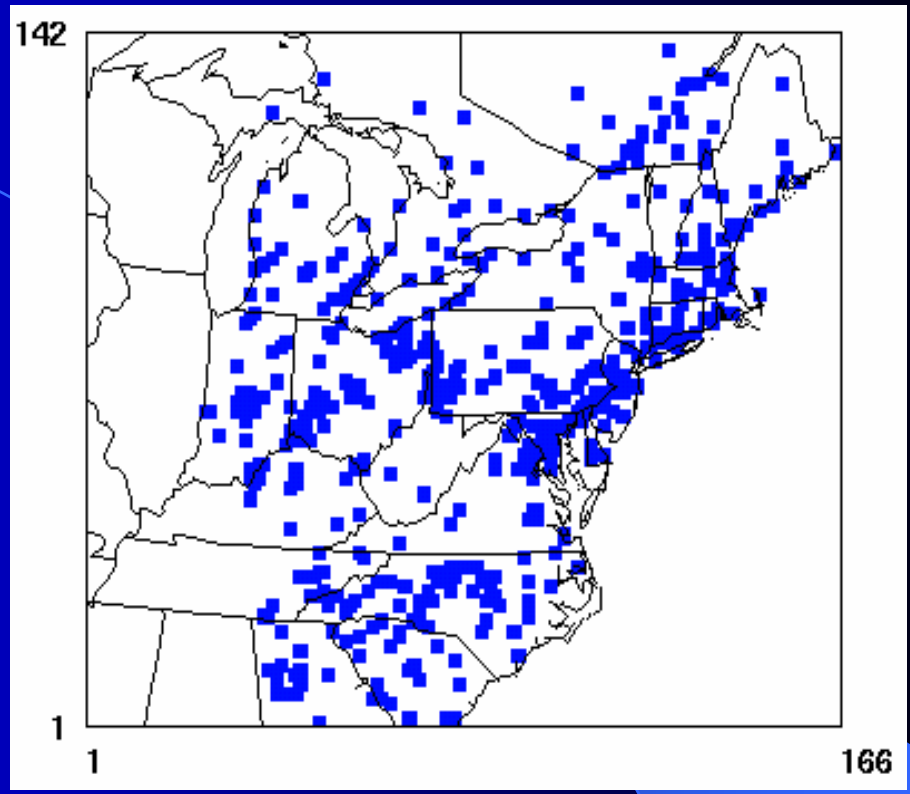
- 7 July – 30 September, 2003
- 12 – 19 August (Rerun with land-use correction)

This evaluation used:

- Hourly O_3 concentrations (ppb) from EPA's AIRNOW network

  521 stations

  7 July - 30 September



- A suite of statistical metrics for both:

  discrete forecasts and *categorical forecasts*

  for the:

  hourly, maximum 1-hr, maximum 8-hr O_3 simulations

Two Forecast / Evaluation Types

- **Discrete Forecasts**

[Observed] *versus* [Forecast]

- **Category Forecasts** (Two Category)

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

Discrete Forecast / Evaluation

Statistics

- Summary
- Regression

- Biases

$$MB = \frac{1}{N}\sum_{1}^{N}(Model - Obs)$$

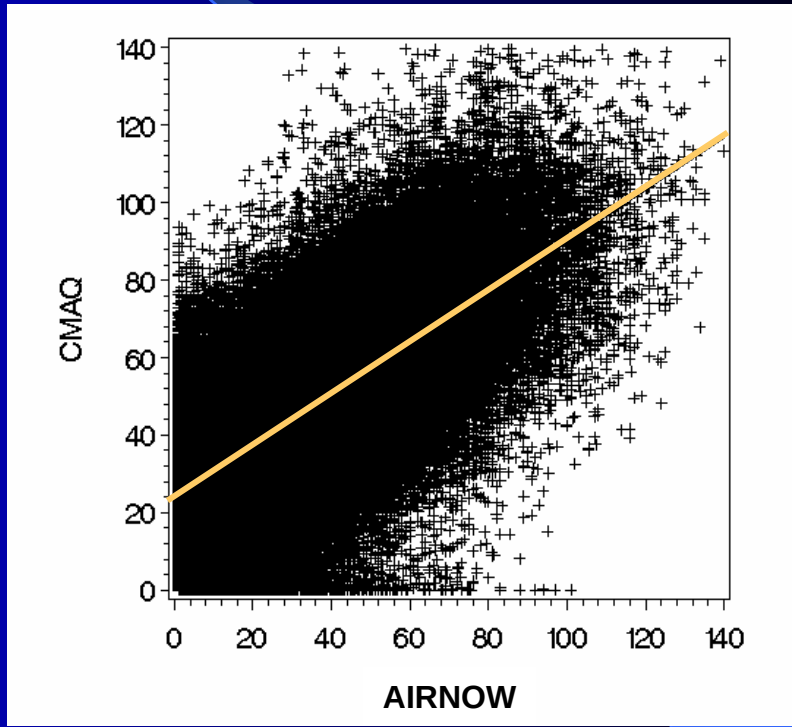
$$NMB = \frac{\sum_{1}^{N}(Model - Obs)}{\sum_{1}^{N}(Obs)} \cdot 100\%$$

- Errors

$$RMSE = \left(\frac{1}{N}\sum_{1}^{N}(Model - Obs)^2\right)^{0.5}$$

$$NME = \frac{\sum_{1}^{N}|Model - Obs|}{\sum_{1}^{N}(Obs)} \cdot 100\%$$

[Observed] *versus* [Forecast]



Category Forecast / Evaluation

- **Two Category Forecasts**

Observed Exceedances, Non-Exceedances

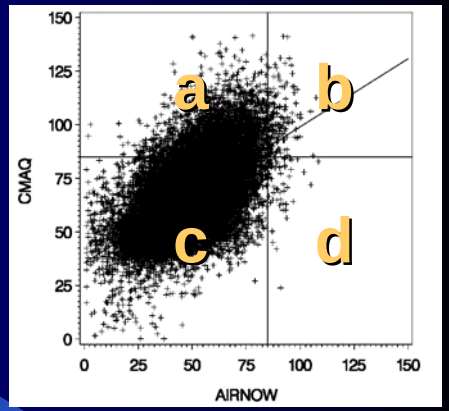
versus

Forecast Exceedances, Non-Exceedances

Category Forecast

Accuracy

Percent of forecasts that correctly predict event or non-event.



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

Bias

Indicates if forecasts are under-predicted (false negatives) or over-predicted (false positives)

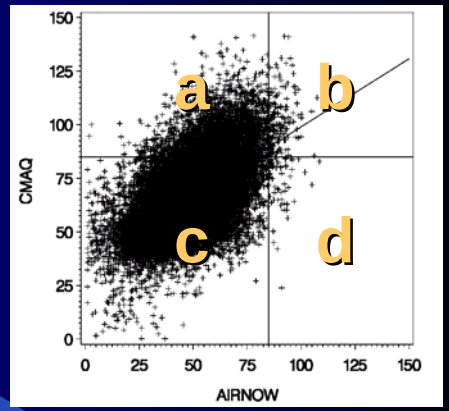
$$B = \left(\frac{a + b}{b + d} \right)$$

False Alarm Rate

Percent of times a forecast of high ozone did **not** occur

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

Category Forecast



Critical Success Index

How well the high ozone events were predicted.

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

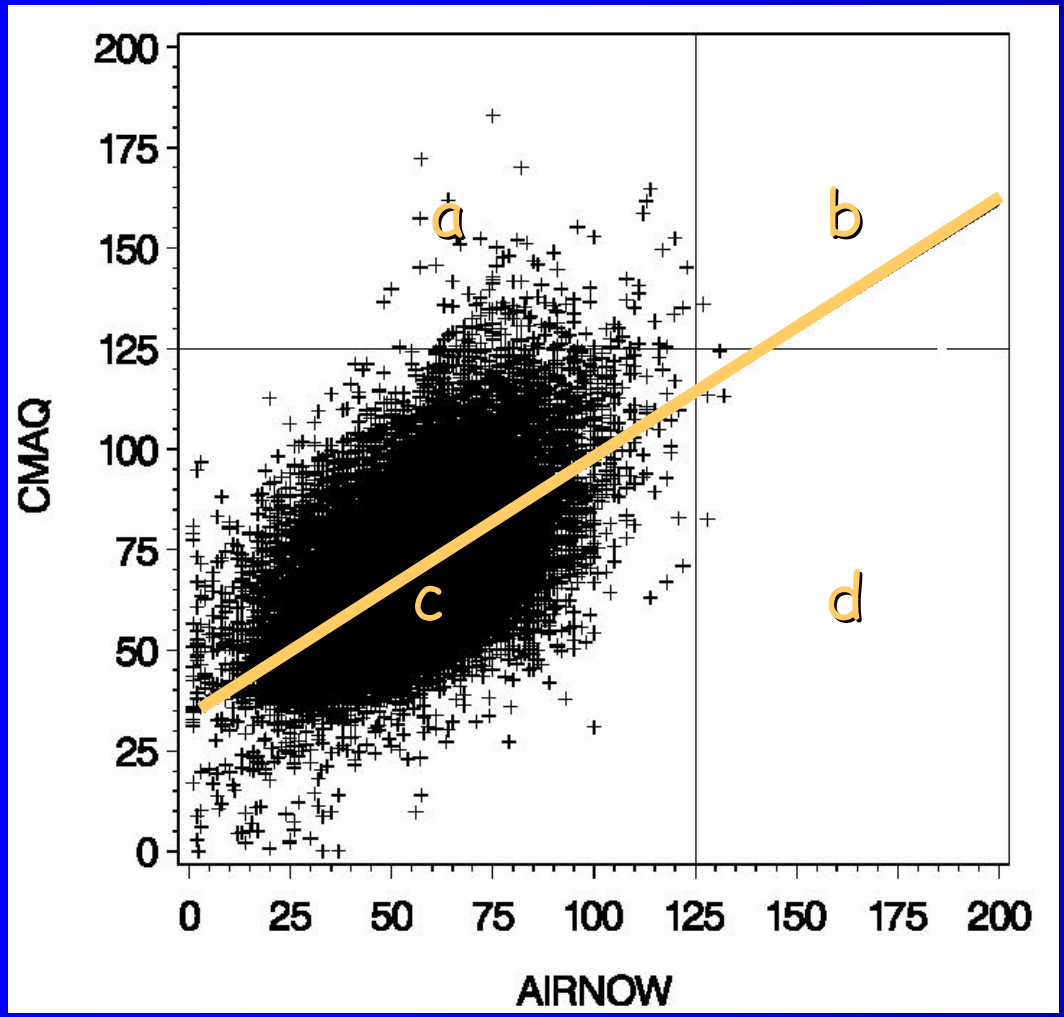
Probability Of Detection

Ability to predict high ozone events

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

Max 1-hr O_3

CMAQ = 34.5 + 0.63(AIRNOW)



7 July – 30 September

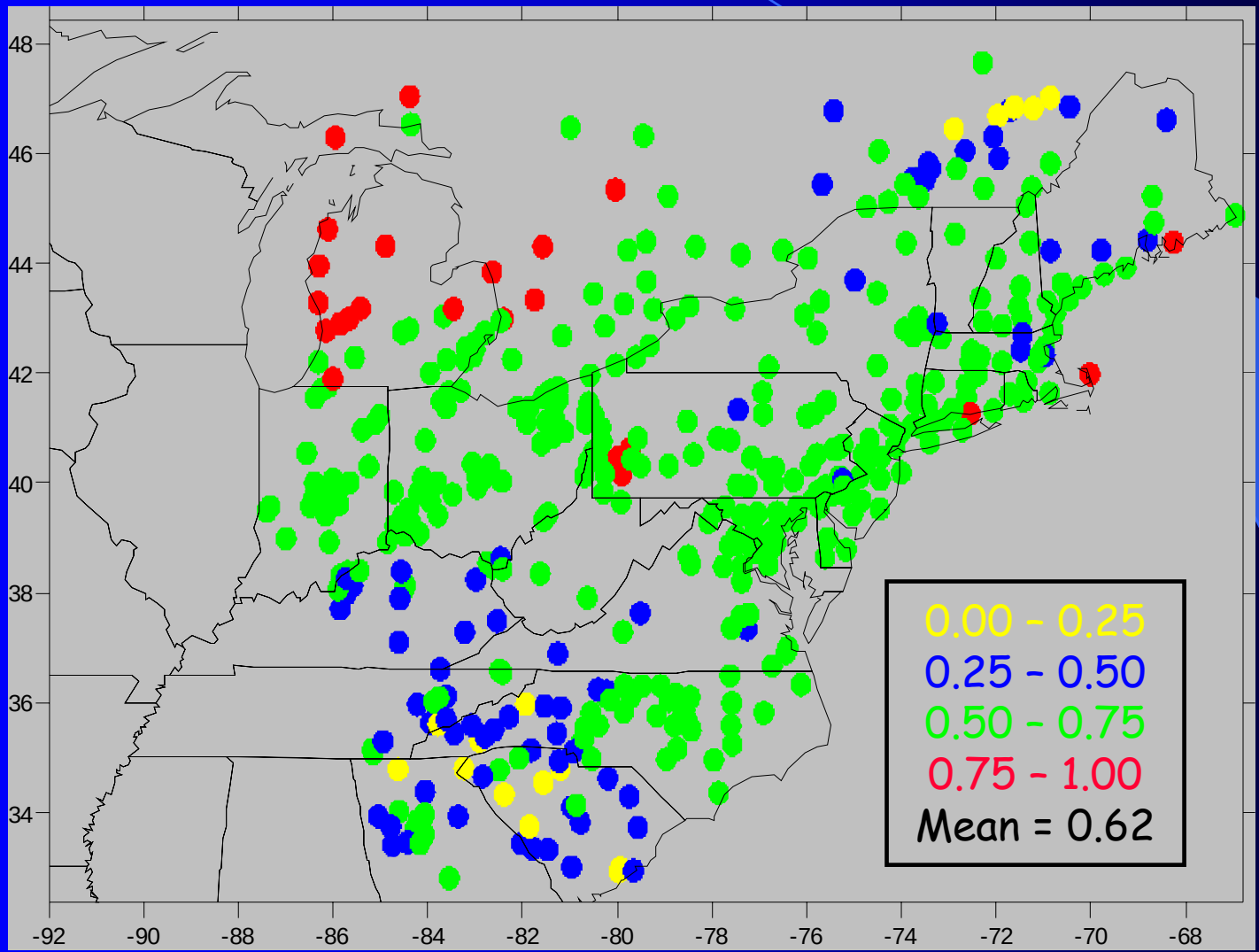
a=	154
b=	1
c=	36,023
d=	4
n=	36,182

Max 1- hr O_3

	Summary Statistics		Discrete Evaluation		Categorical Evaluation	
[ppb]	CMAQ	AIRNOW	CMAQ = 34.5 + 0.63 (AIRNOW)		Ozone ≥125 ppb	
Mean	68.1	53.1	r	0.62	A	99.6%
SD	17.3	16.7	N	36,814	B	26.0
CV	25.3	31.5				
Max	182.9	132	BIASES			
95th	99.2	81	MB	15.0	FAR	99.4%
75th	78.7	65	NMB	28.2%	CSI	0.6%
50th	66.0	53				
25th	55.6	41	ERRORS			
5th	44.2	27	RMSE	21.1	POD	16.7%
Min	0	1	NME	32.2%		

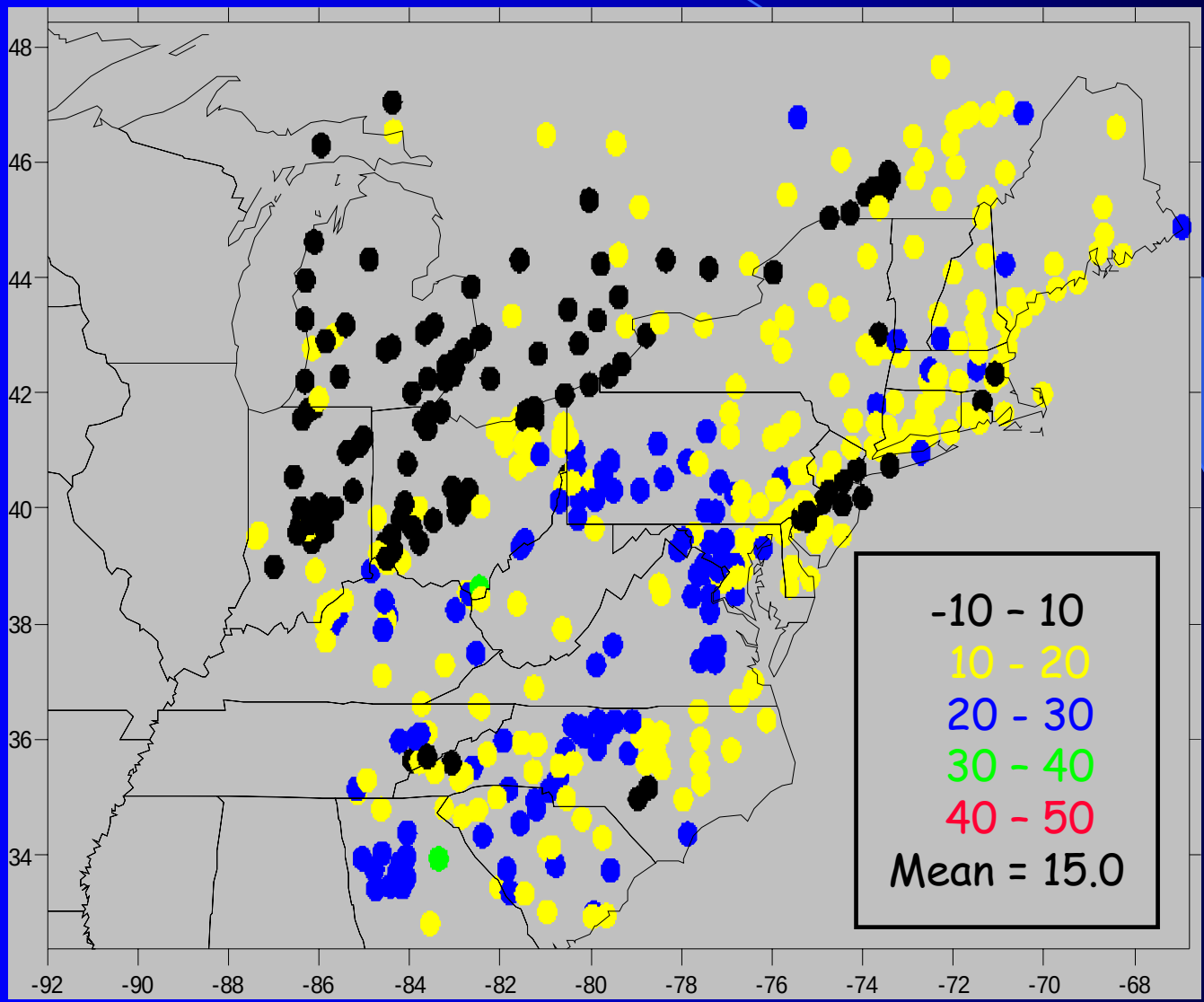
Spatial Evaluation

Max 1- hr O_3
Correlation



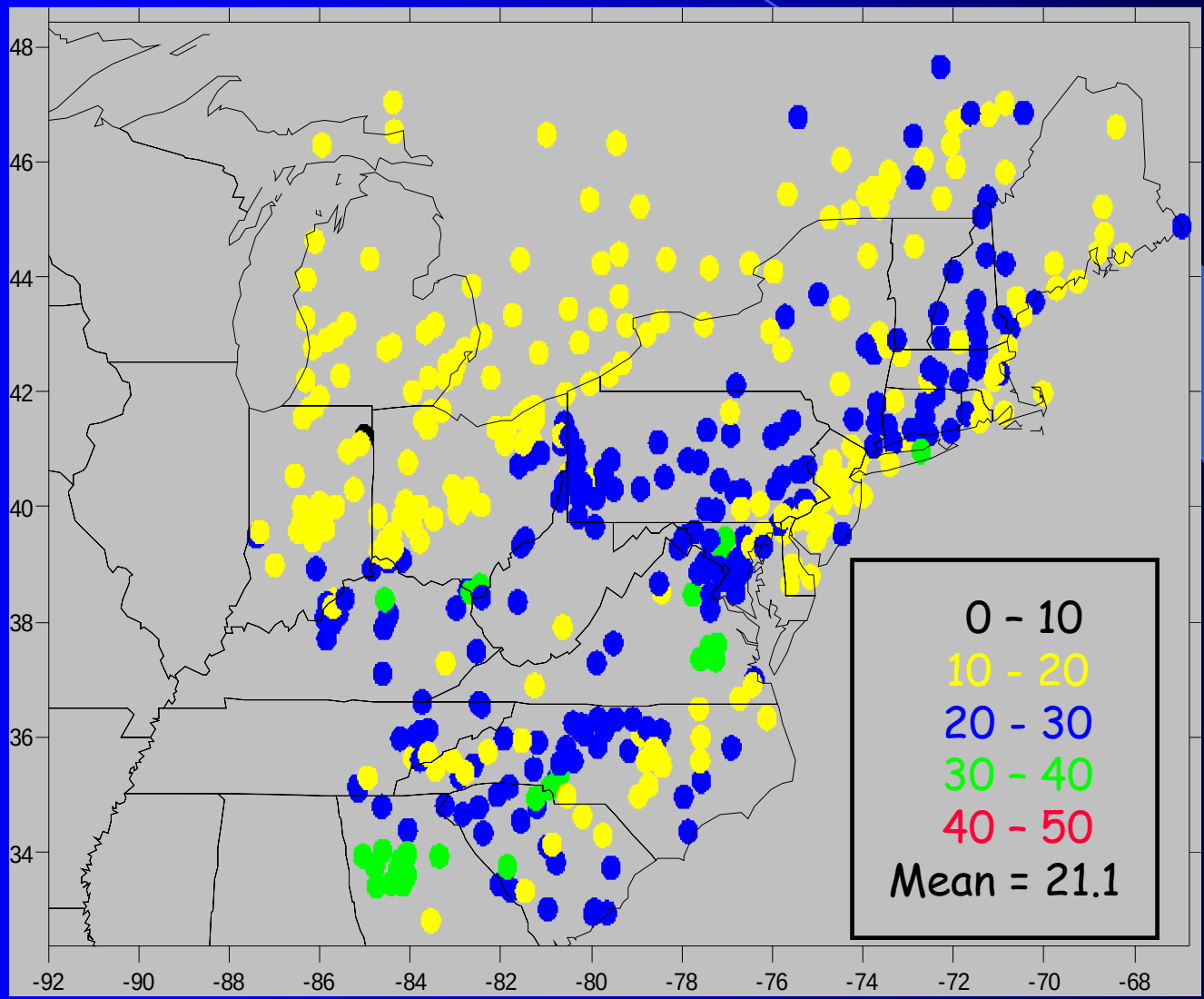
Spatial Evaluation

Max 1- hr O_3
Mean Bias



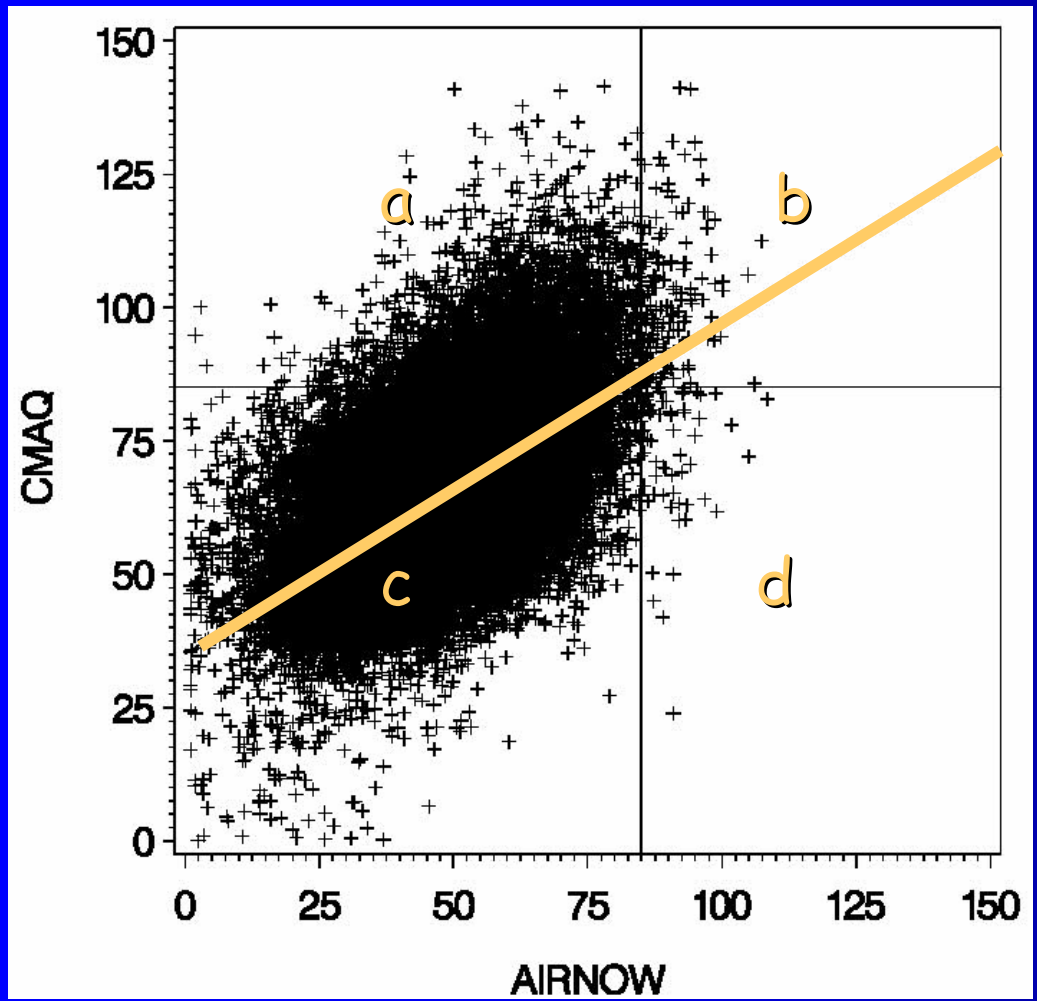
Spatial Evaluation

Max 1- hr O_3
Root Mean Square Error



Max 8-hr O_3

CMAQ = 35.1 + 0.62(AIRNOW)



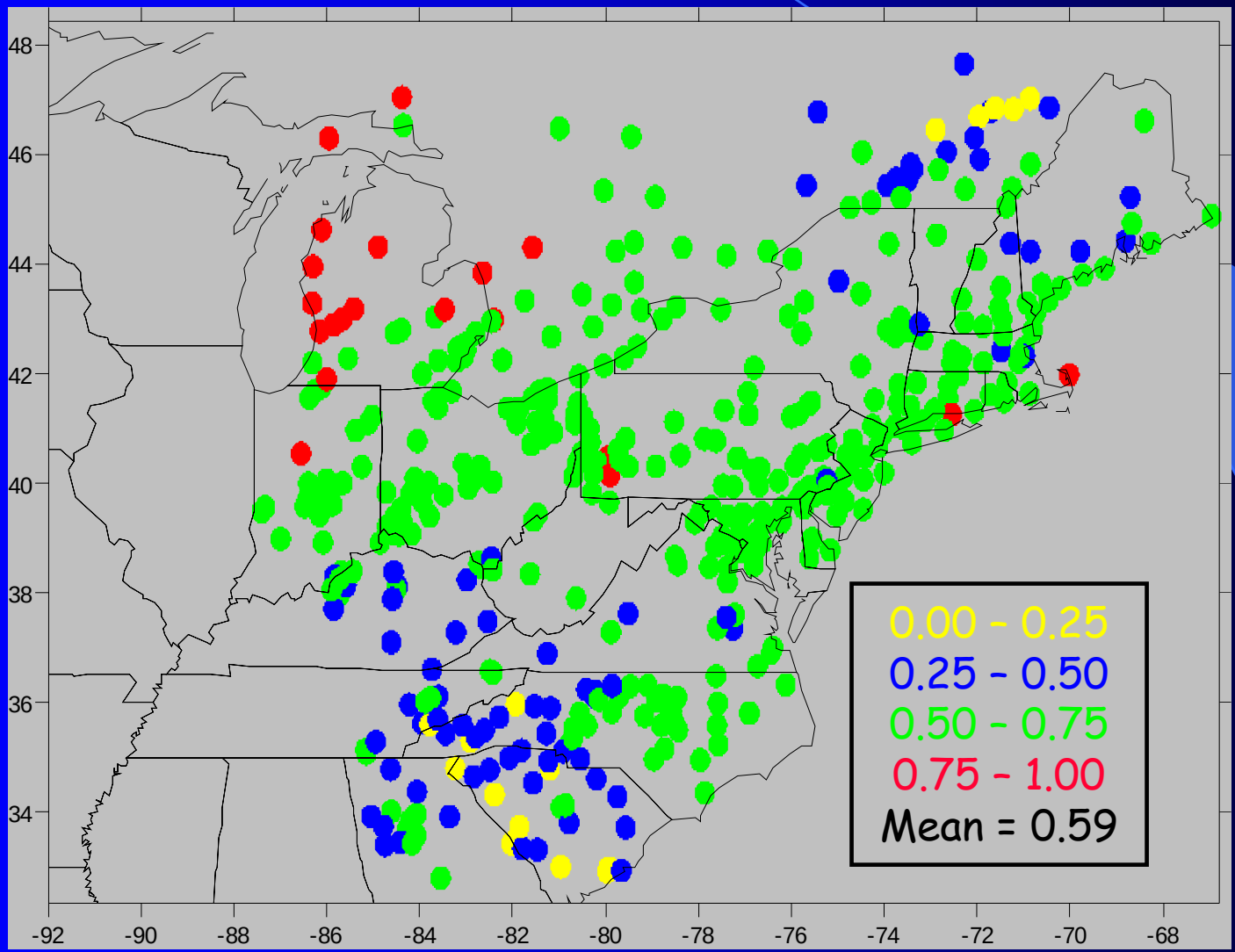
a=	3537
b=	152
c=	33,242
d=	67
n=	36,998

Max 8- hr O_3

	Summary Statistics		Discrete Evaluation		Categorical Evaluation	
[ppb]	CMAQ	AIRNOW	CMAQ = 35.1 + 0.62 (AIRNOW)		Ozone ≥ 85 ppb	
Mean	64.0	46.7	r	0.59	A	89.6%
SD	15.8	15.0	n	36,998	B	10.3
CV	24.6%	32.2%				
Max	162.2	108.4	BIASES			
95th	92.1	71.6	MB	17.4	FAR	96.0%
75th	73.9	57.2	NMB	37.3%	CSI	3.7%
50th	62.2	46.1				
25th	52.6	35.7	ERRORS			
5th	42.1	23.3	RMSE	22.2	POD	41.0%
Min	0	1	NME	39.9%		

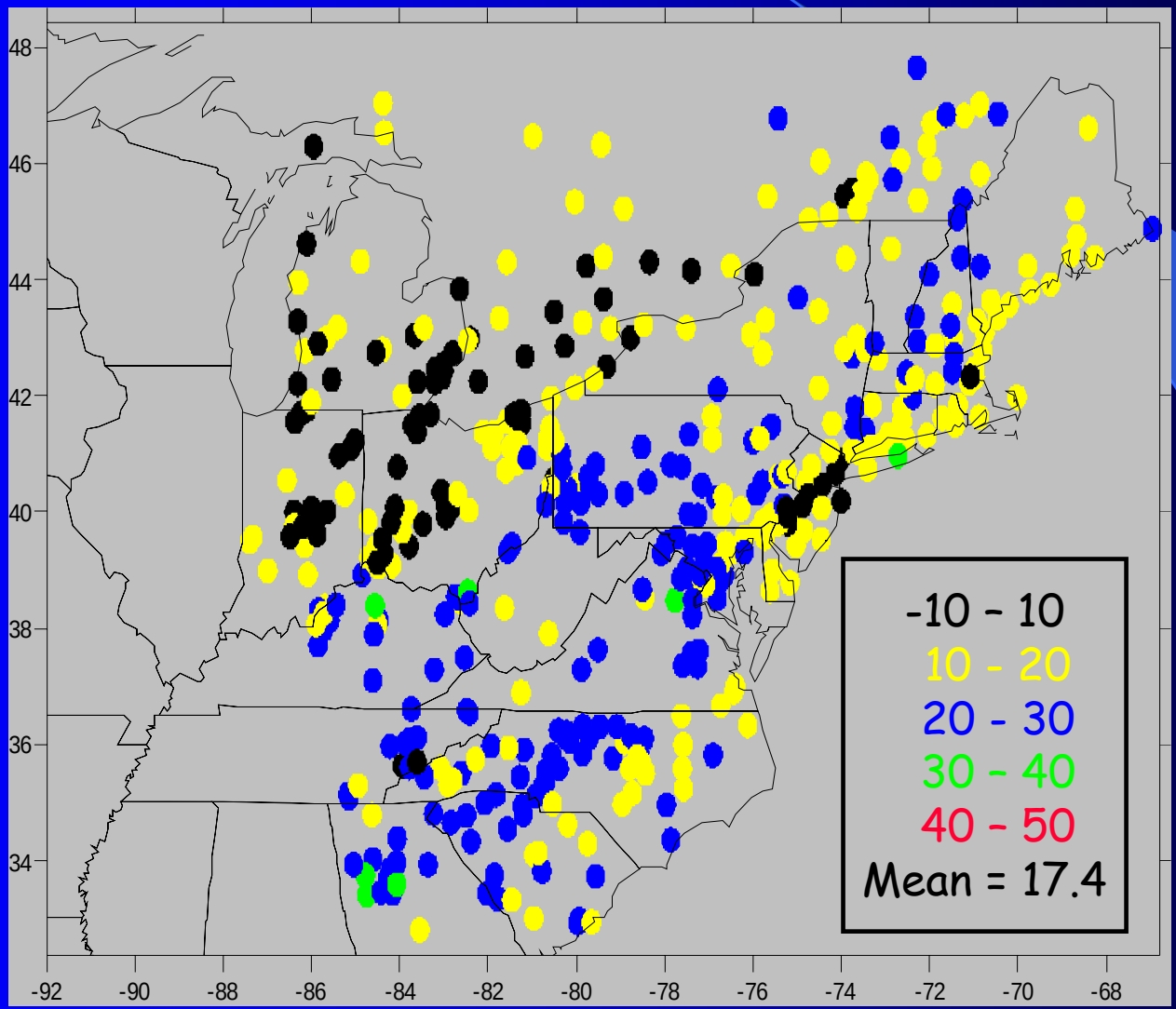
Spatial Evaluation

Max 8- hr O_3
Correlation



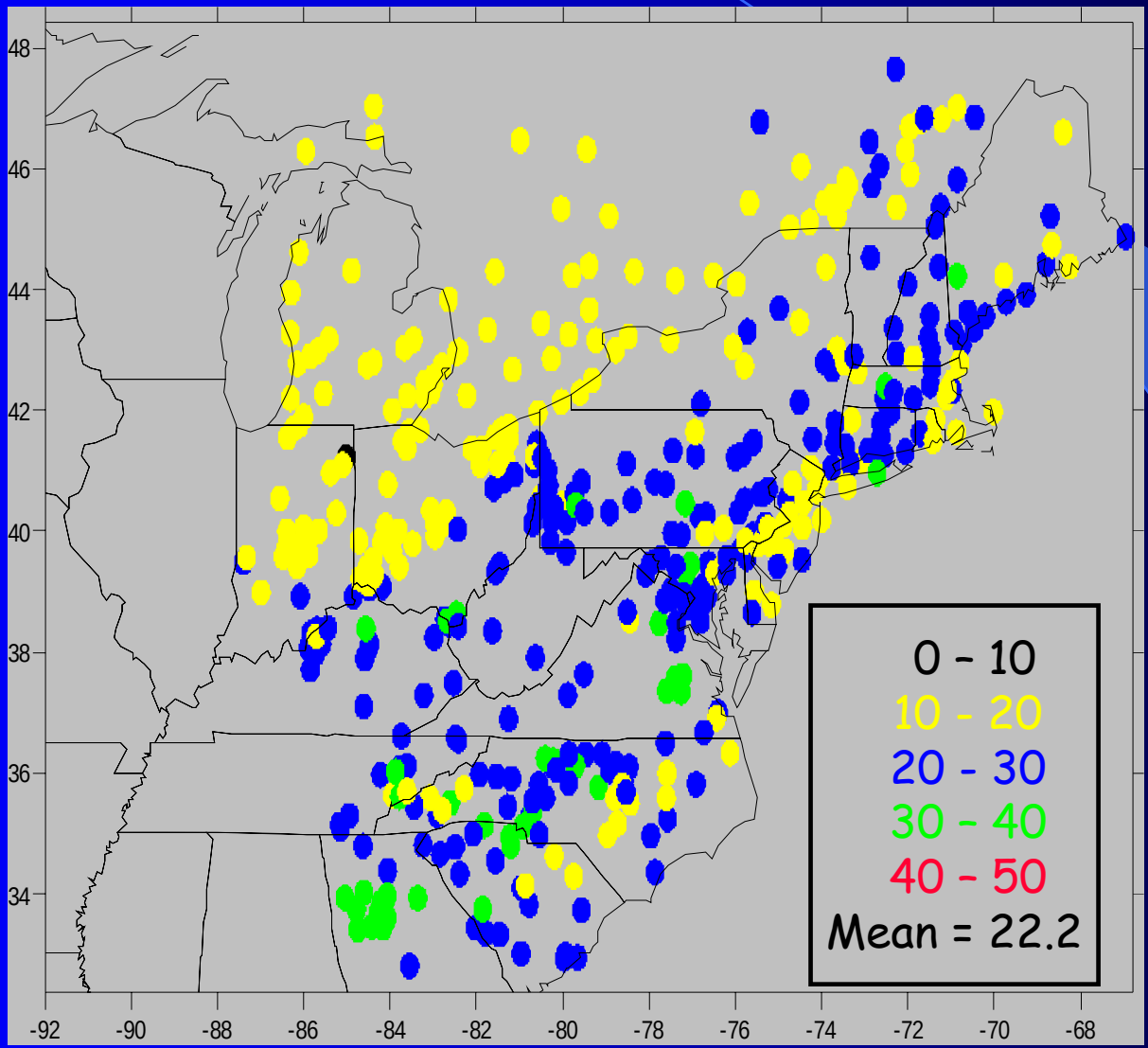
Spatial Evaluation

Max 8- hr O_3
Mean Bias



Spatial Evaluation

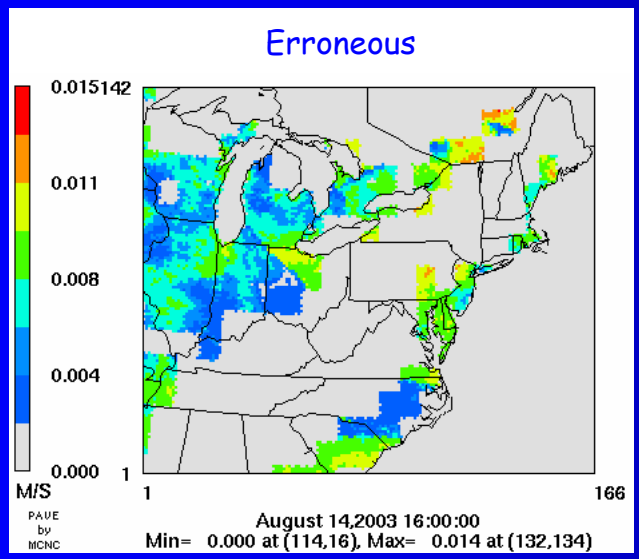
Max-8 hr O_3
Root Mean Square Error

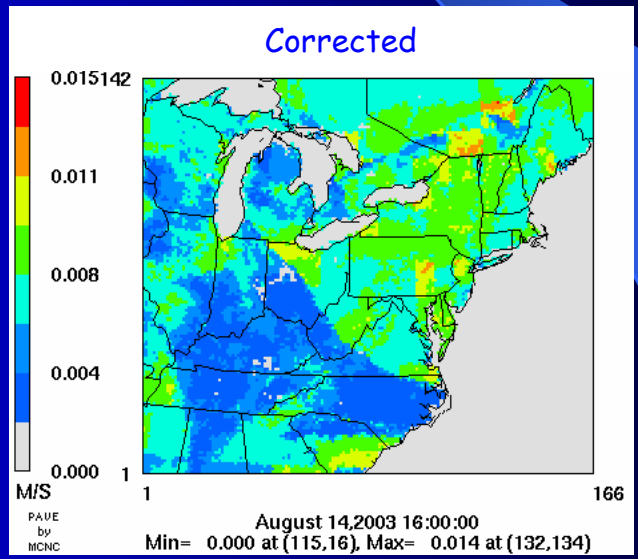


Land-Use Error

Approximately two months into the forecast period, AMDB discovered the the land-use fields associated with Eta were being post-processed incorrectly by NCEP. As a result:

- Most of the domain was classified as water.
- Dry deposition was greatly under simulated
- Concentrations were over predicted



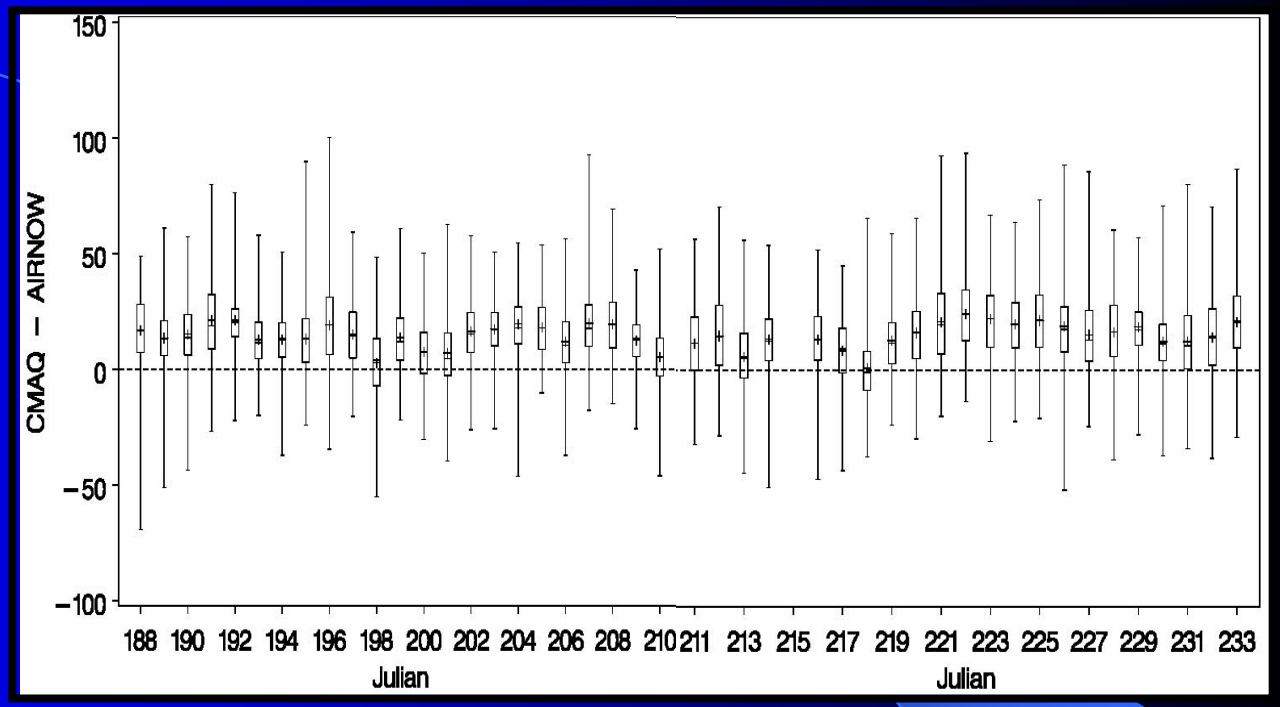


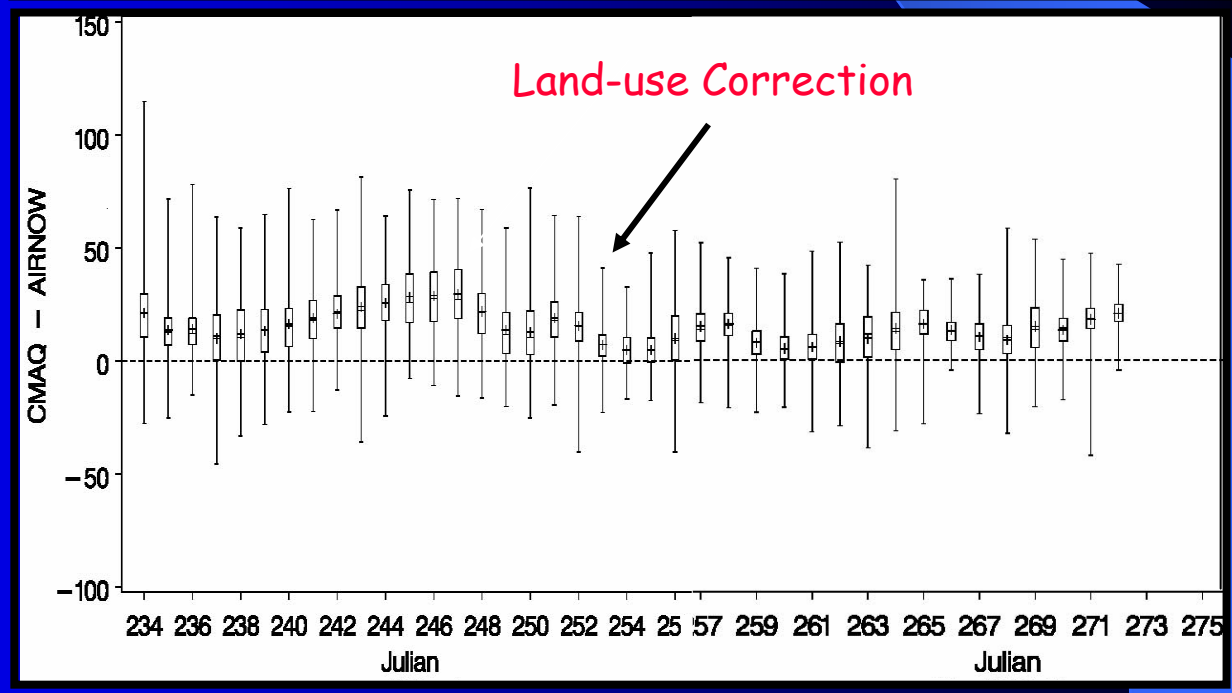
This error was corrected on Sept. 9th.

- An eight day period (12-19 August) was re-simulated.
- Positive biases were cut in half, errors reduced also.

Temporal Evaluation

– Max 1 hr O_3





Comparison Between Initial and Corrected Simulations

August 12 –19 2003

Max 1-hr O_3

Run	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)	A (%)	B	FAR (%)	CSI (%)	POD (%)
Initial	0.64	16.2	27.5	23.0	31.7	99.0	-	100.0	0.0	-
Corrected	0.66	7.6	13.0	16.6	21.7	99.6	-	100.0	0.0	-

Max 8-hr O_3

Run	r	MB (ppb)	NMB (%)	RMSE (ppb)	NME (%)	A (%)	B	FAR (%)	CSI (%)	POD (%)
Initial	0.62	19.2	37.2	24.6	39.9	76.2	-	100.0	0.0	-
Corrected	0.64	10.4	20.1	17.1	26.3	90.7	3.5	92.0	6.6	28.0

Summary

The Eta-CMAQ modeling system performed reasonably well, in this, its first attempt at forecasting ozone concentrations:

Correlation:	0.59 - 0.62
Bias:	15.1 ppb (28.2%) - 17.4 ppb (37.3%)
Error:	21.1 ppb (32.2%) - 22.2 ppb (39.9%)
Accuracy:	89.6 - 99.6%

An error was discovered in Eta's post processed land-use designation that resulted in the:

- under-estimation of dry deposition and
- hence over-simulation of concentrations

Once corrected, the positive biases and errors were greatly reduced when the model was re-run for an eight day period:

Correlation:	0.64 - 0.66
Bias:	7.6 ppb (13.0%) - 10.4 ppb (20.1%)
Error:	16.6 ppb (21.7%) - 17.1 ppb (26.3%)
Accuracy:	90.7 - 99.6%