An Evaluation of the 2003 Release of Models-3 CMAQ

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CMAQ Model Peer Review Meeting
R.T.P., NC
December 17, 2003

INTRODUCTION

The 2003 Release of CMAQ featured many changes:

- updated science
- corrected implementations
- efficiency enhancements
- bug fixes

Largest impacts involved the aerosol modeling, especially:

- aerosol nitrate

  modeling updated with more recent science

- secondary organic aerosols (SOA)

  modeling now allows for reversible semi-volatility

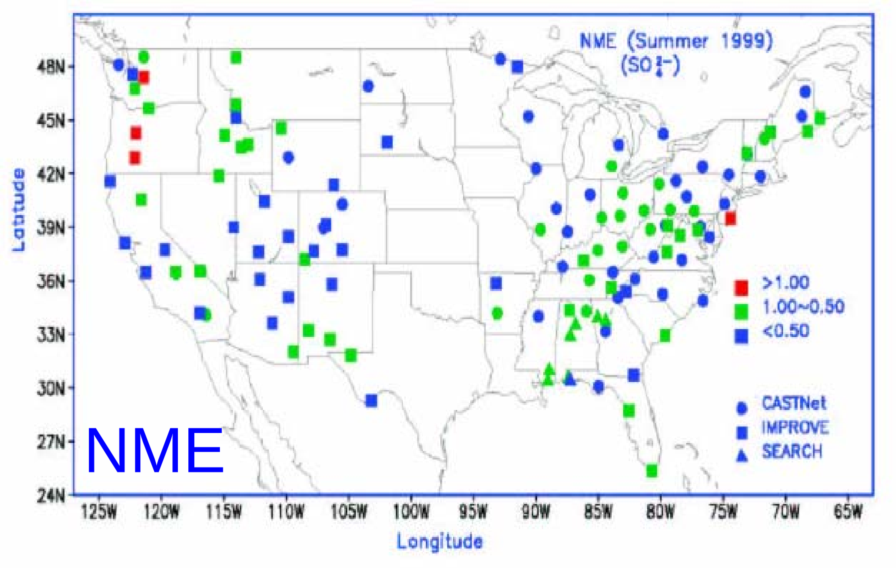
In order to quantify these changes and characterize its performance, the 2003 Release of CMAQ has been evaluated:

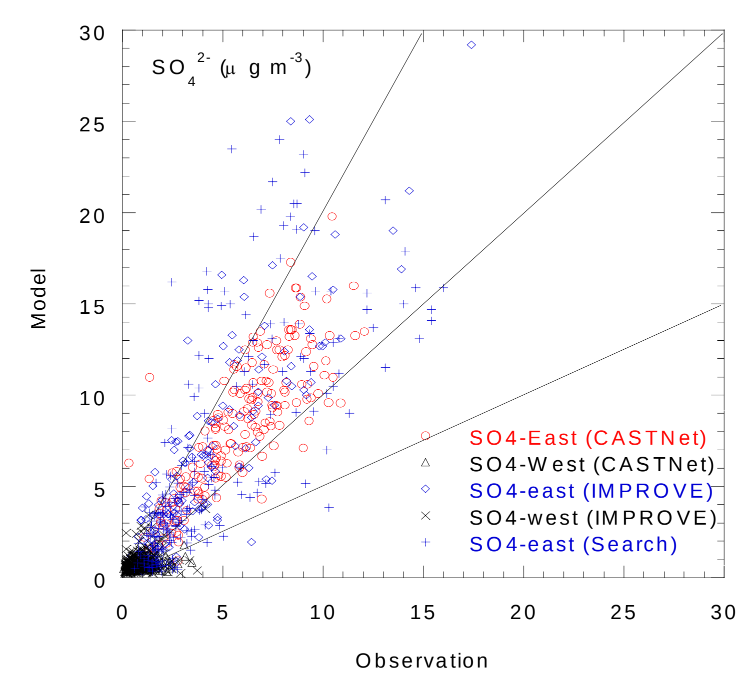
Over two simulation periods:	Summer 1999 (four weeks) Winter 2002 (six weeks)
For ambient air concentrations:	Sulfate Nitrate Ammonium Nitric Acid $PM_{2.5}$ Organic Carbon Ozone
Against data from five networks:	IMPROVE CASTNet STN *(only winter 2002)* AIRS SEARCH

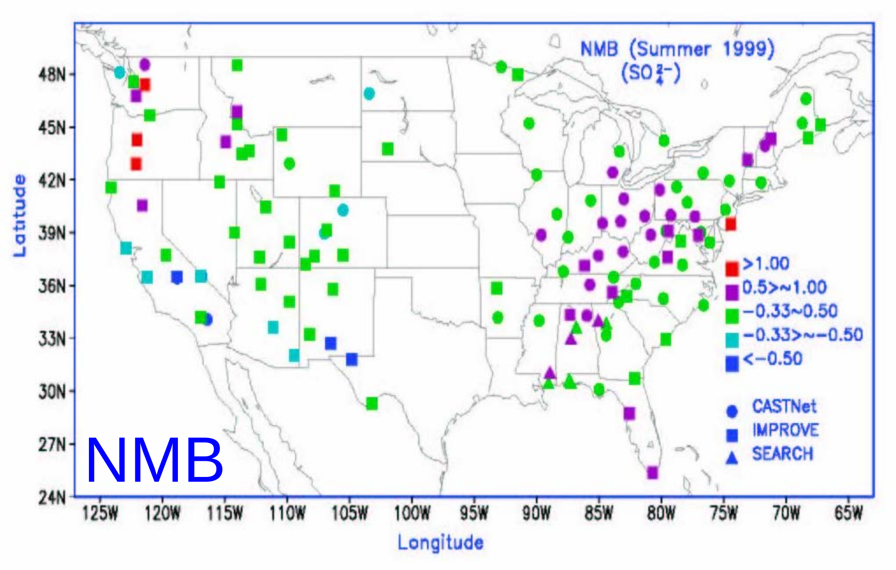
CMAQ Simulation Attributes

Emissions:	Gas-phase emissions are based on the 1999 EPA NEI.	
	Primary anthropogenic $PM_{2.5}$ emissions are speciated.	
	Mobile emissions are based on MOBILE5b.	
	Biogenic emissions are based on BEIS 3.11.	
Chemistry:	SAPRC99 gas-phase chemistry mechanism.	
Meteorology:	Derived from MM5 and processed through MCIP (2.2).	
Resolution:	Horizontal:	Contiguous U.S. Domain.
		32 km by 32 km grids(Summer)
		36 km by 36 km grids (Winter)
	Vertical:	Set on a sigma coordinate.
		21 layers (Summer)
		24 layers (Winter)

Sulfate - June 15 – July 16, 1999

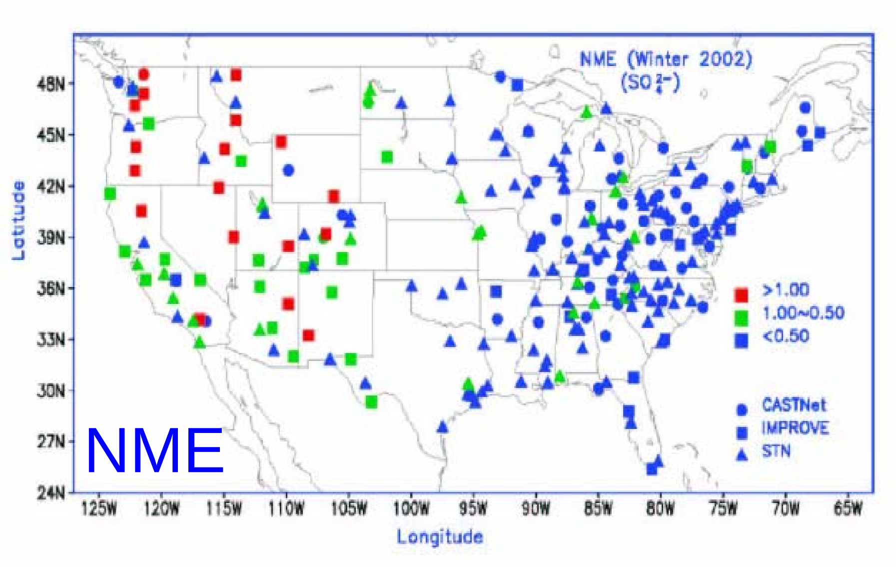


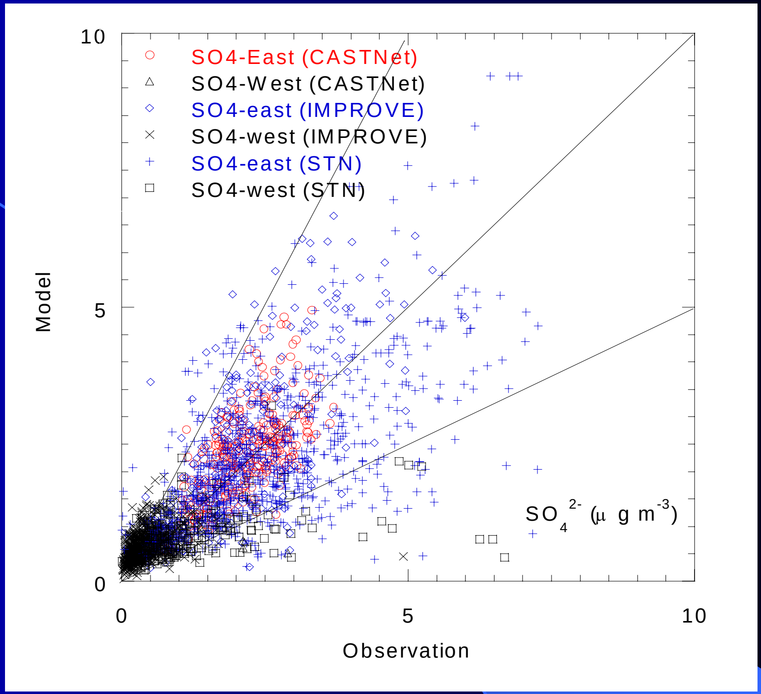


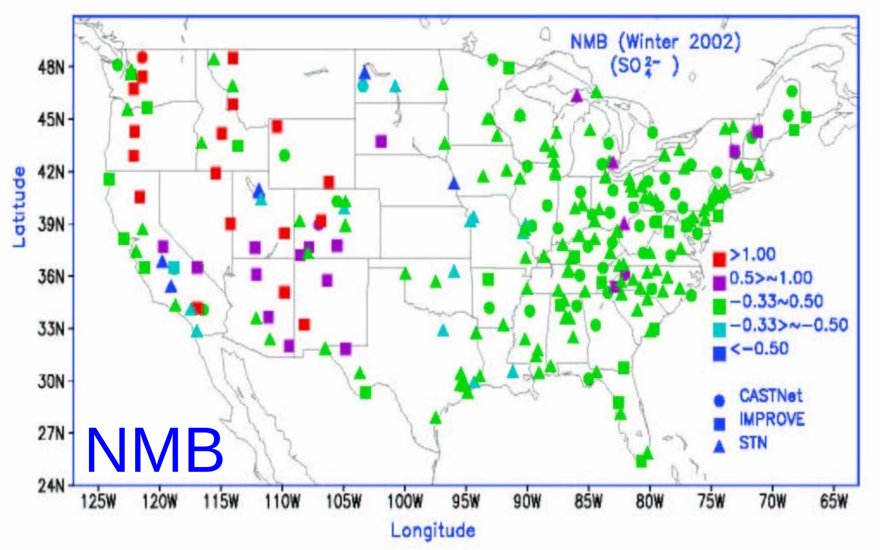


CASTNet		IMPROVE	
n	264	n	490
R	0.90	R	0.90
MB	1.74	MB	0.75
NMB(%)	38.0	NMB(%)	38.4
RMSE	2.89	RMSE	2.37
NME(%)	46.4	NME (%)	61.9

Sulfate - Jan. 4 - Feb.19, 2002

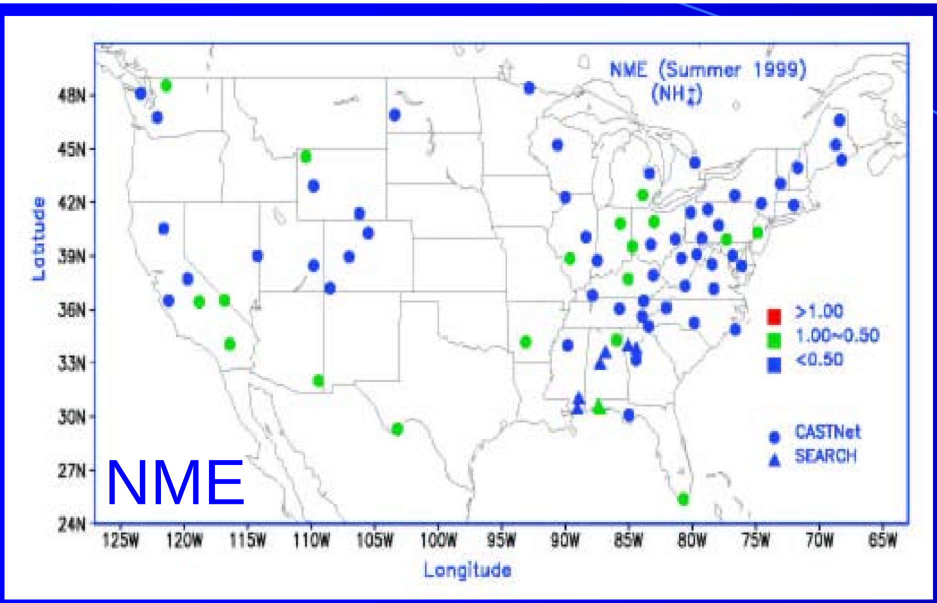


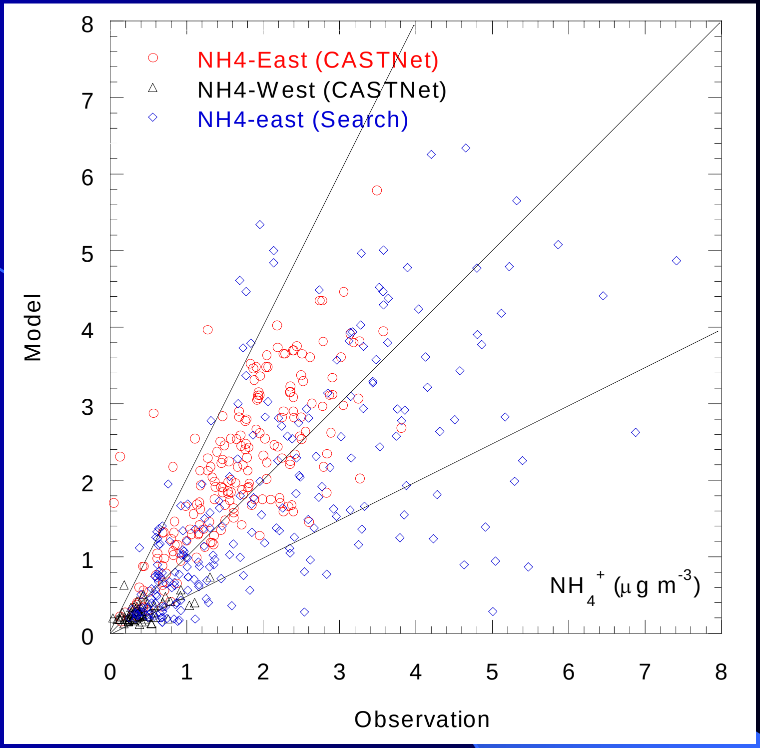


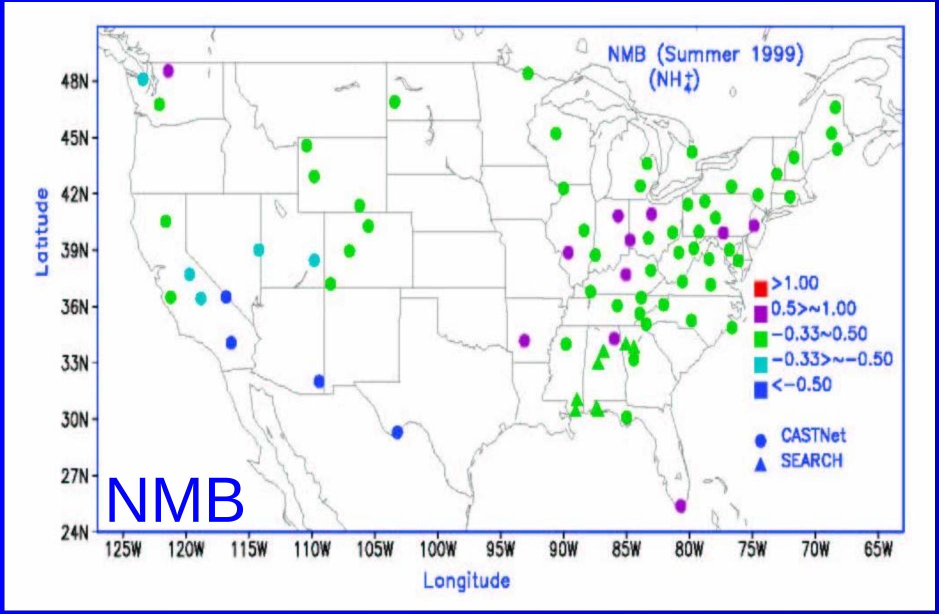


CASTNet		IMPROVE		STN	
n	407	n	728	n	1149
R	0.83	R	0.85	R	0.66
MB	0.15	MB	0.29	MB	-0.26
NMB(%)	9.2	NMB(%)	31.5	NMB(%)	-12.0
RMSE	0.60	RMSE	0.72	RMSE	1.16
NME(%)	25.7	NME(%)	53.1	NME(%)	35.9

Ammonium - June 15 – July 16, 1999

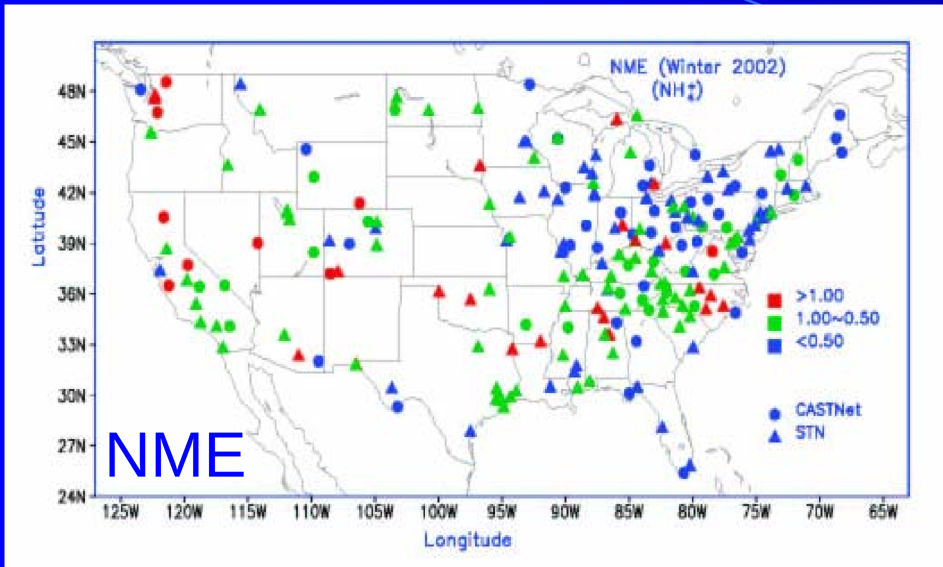


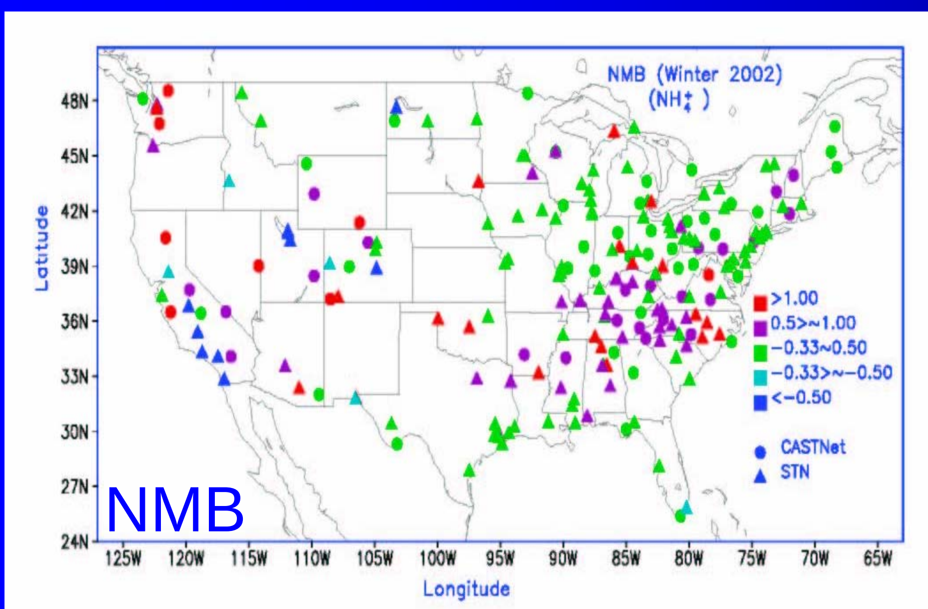


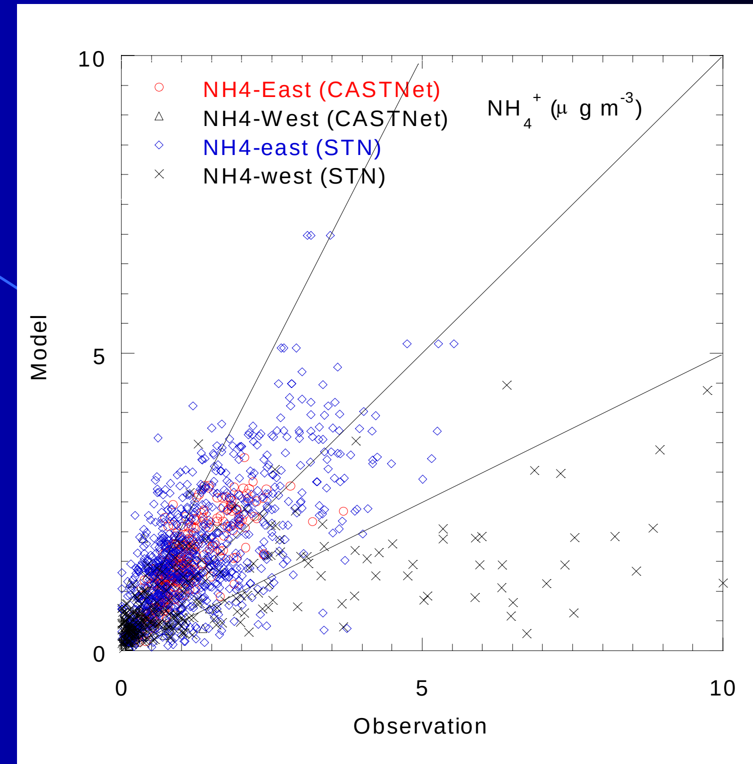


CASTNet	
n	264
R	0.86
MB	0.31
NMB(%)	22.7
RMSE	0.70
NME(%)	36.5

Ammonium - Jan. 4 - Feb.19, 2002

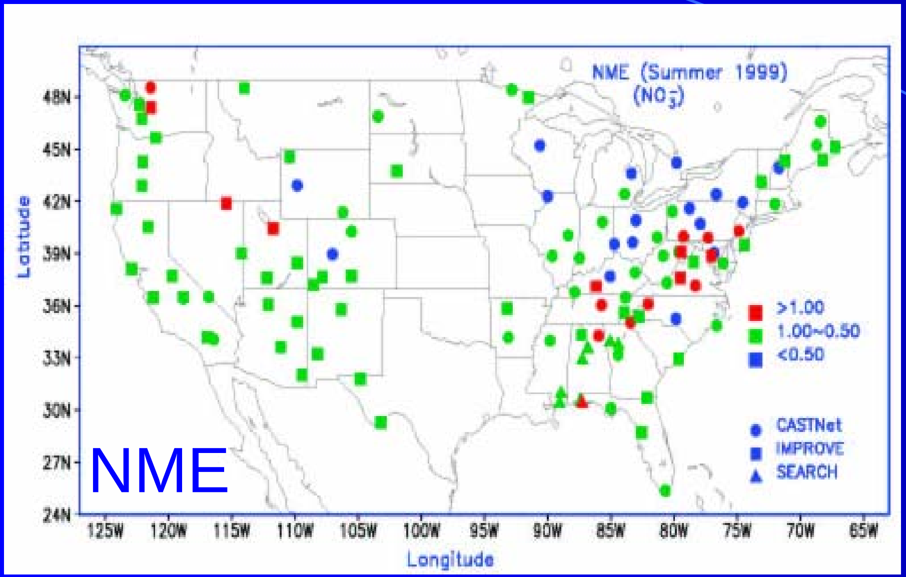


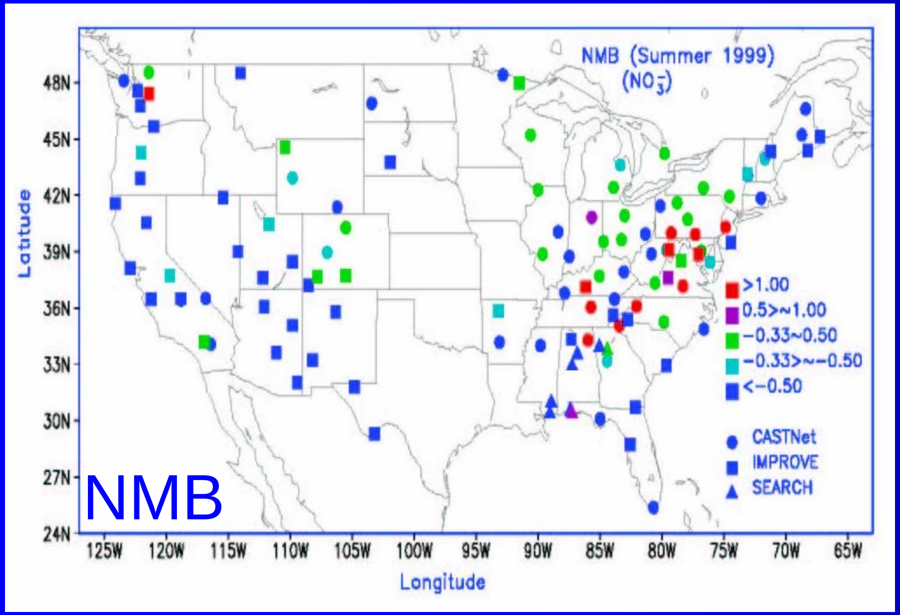


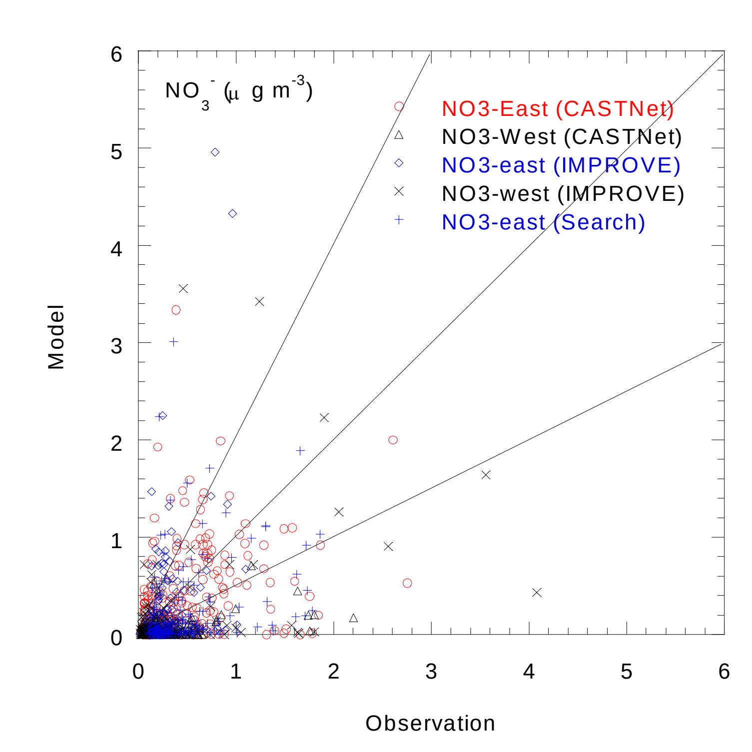


CASTNet		STN	
n	407	n	1149
R	0.85	R	0.41
MB	0.33	MB	0.07
NMB(%)	40.0	NMB(%)	5.2
RMSE	0.51	RMSE	1.46
NME(%)	47.2	NME(%)	57.7

Nitrate - June 15 – July 16, 1999

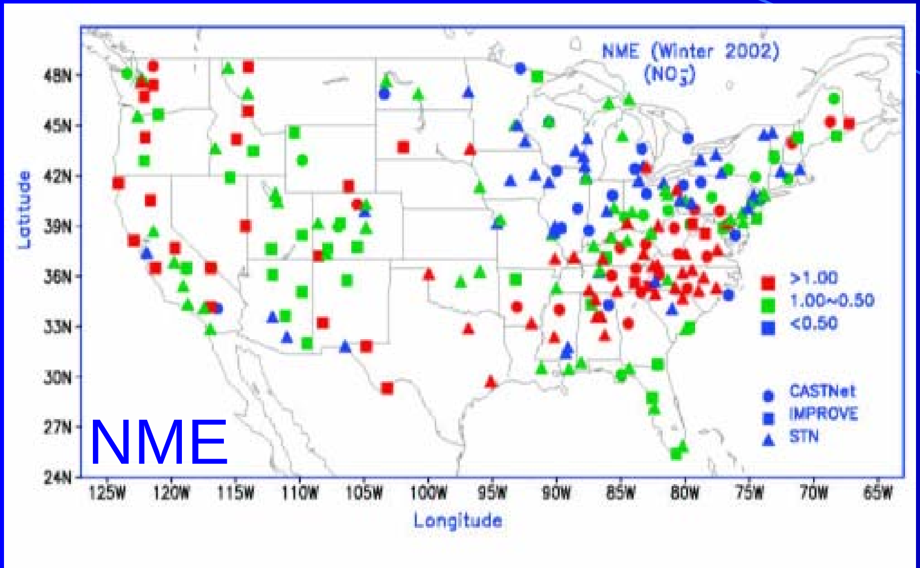


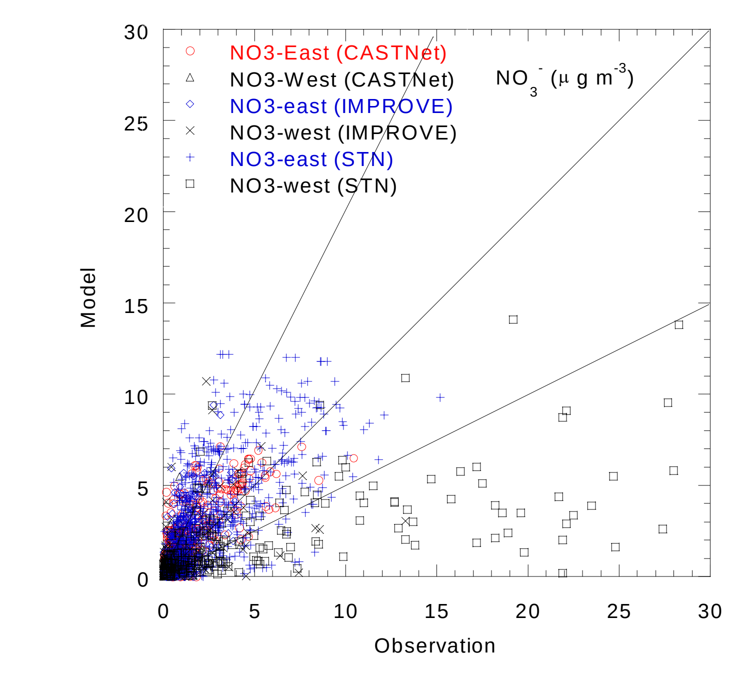


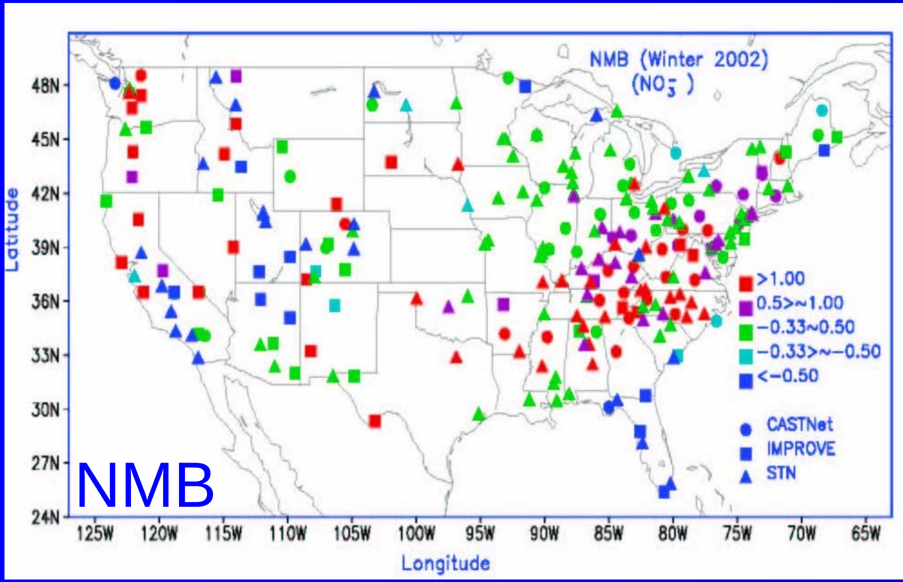


CASTNet		IMPROVE	
n	264	N	415
R	0.27	R	0.36
MB	-0.15	MB	-0.11
NMB(%)	-30.8	NMB(%)	-39.1
RMSE	0.57	RMSE	0.51
NME(%)	75.7	NME(%)	95.0

Nitrate - Jan. 4 - Feb.19, 2002

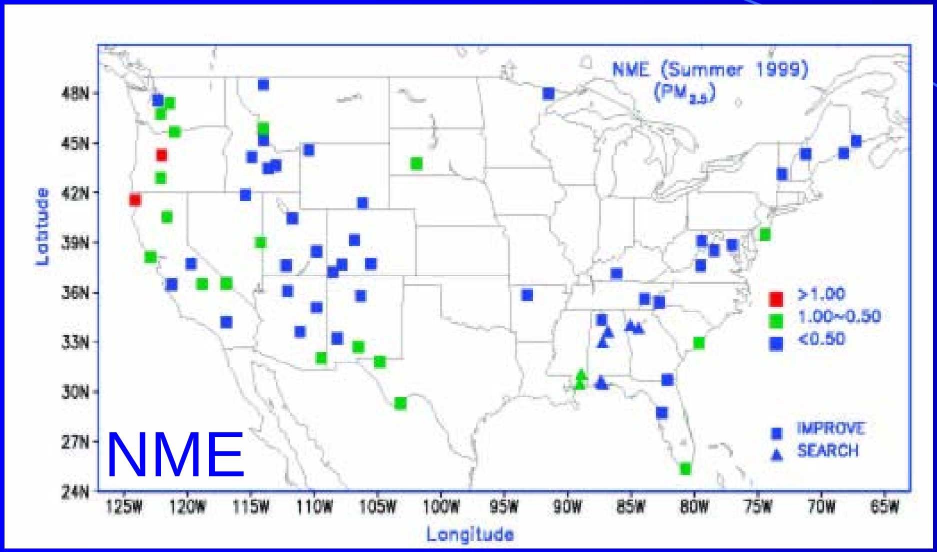


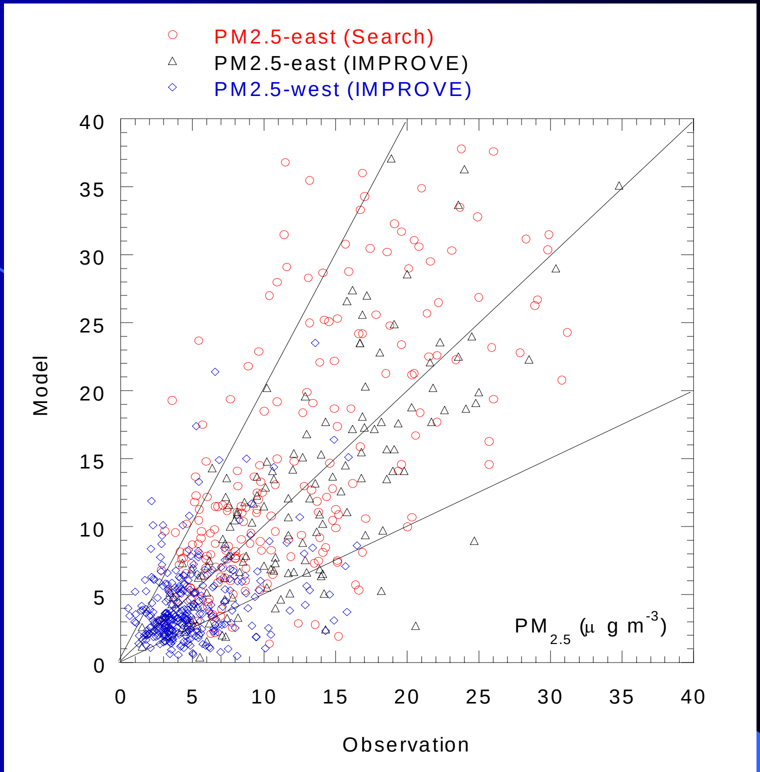


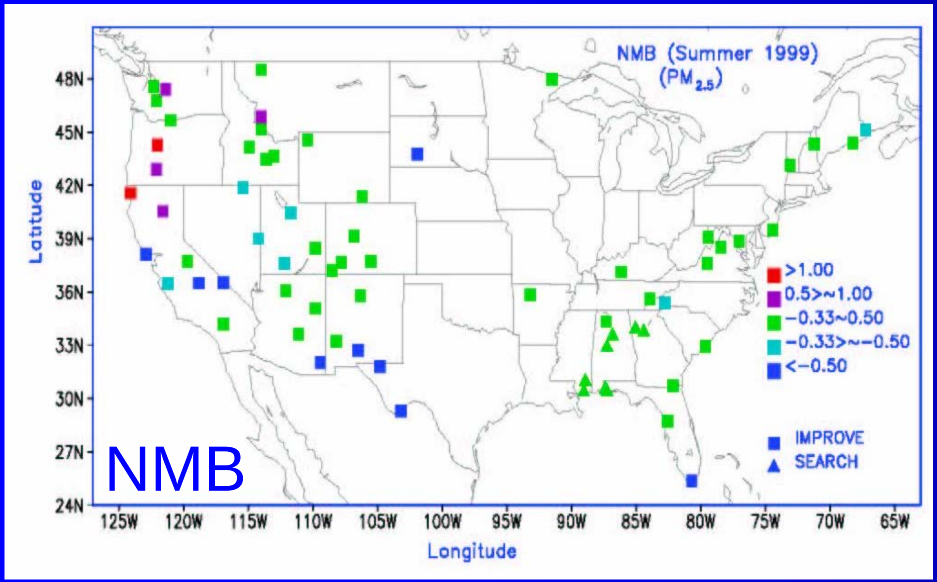


CASTNet		IMPROVE		STN	
n	407	n	688	n	1044
R	0.76	R	0.54	R	0.39
MB	0.64	MB	0.20	MB	-0.27
NMB(%)	46.8	NMB(%)	28.9	NMB(%)	-8.0
RMSE	1.36	RMSE	1.26	RMSE	4.37
NME(%)	70.4	NME(%)	96.5	NME(%)	66.9

PM 2.5 - June 15 – July 16, 1999

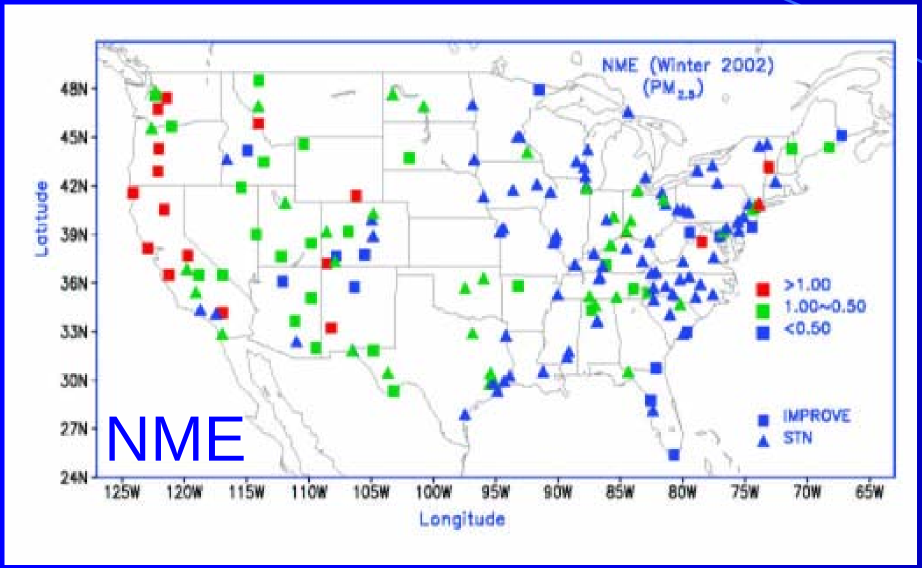


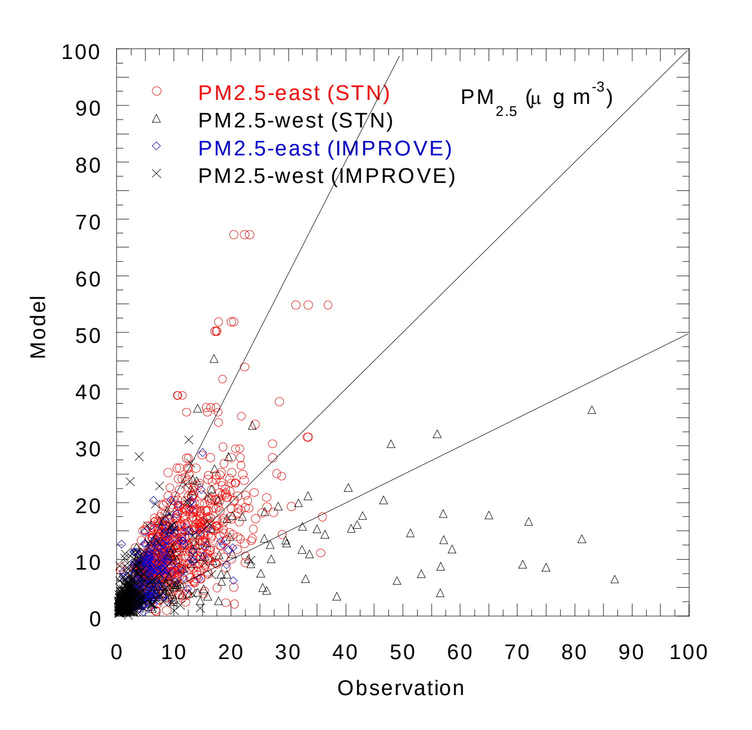


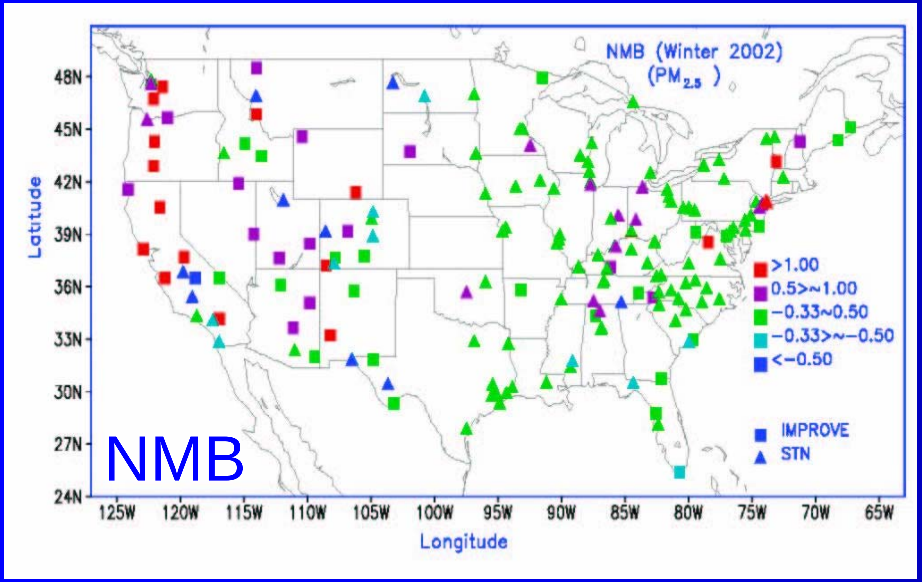


IMPROVE	
n	457
R	0.71
MB	-0.73
NMB(%)	-9.8
RMSE	4.70
NME(%)	40.3

$PM_{2.5}$ - Jan. 4 - Feb.19, 2002

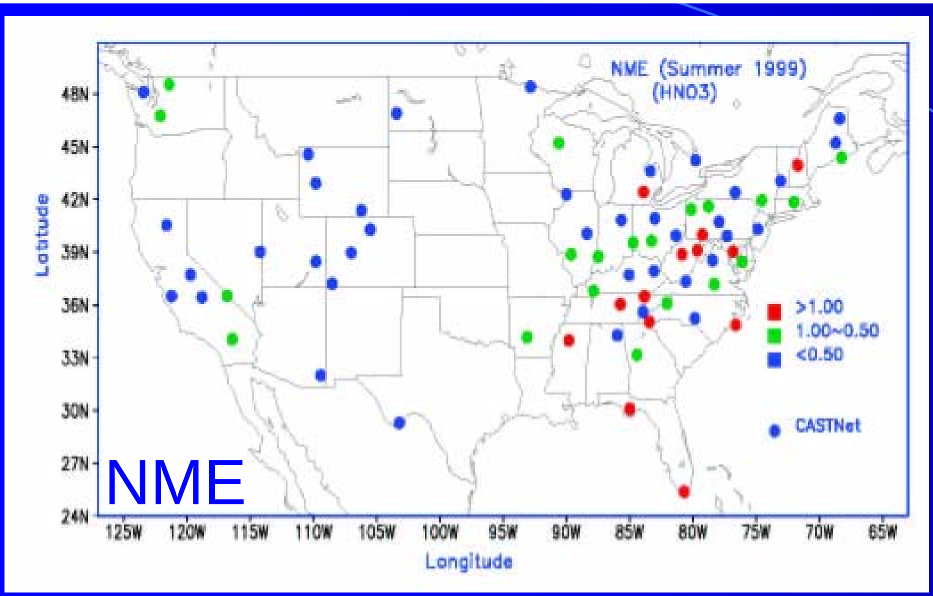


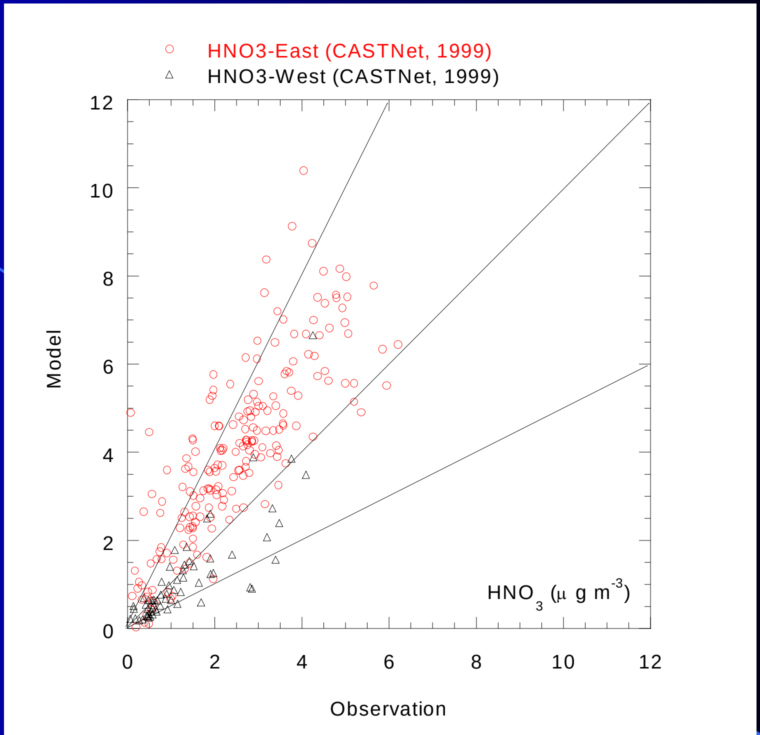


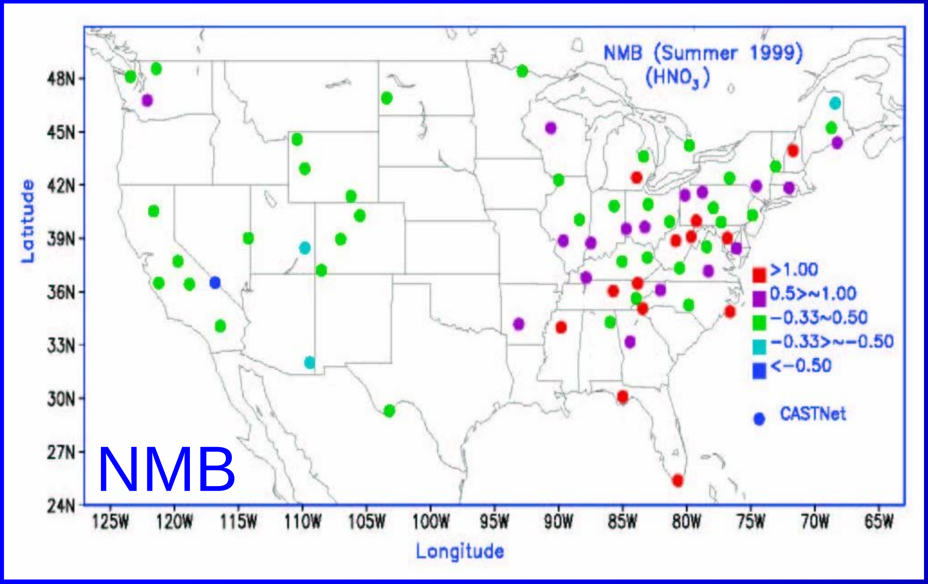


IMPROVE		STN	
n	714	n	927
R	0.68	R	0.37
MB	1.49	MB	0.51
NMB(%)	40.3	NMB(%)	4.1
RMSE	3.81	RMSE	10.45
NME(%)	68.9	NME(%)	50.0

Nitric Acid - June 15 – July 16, 1999

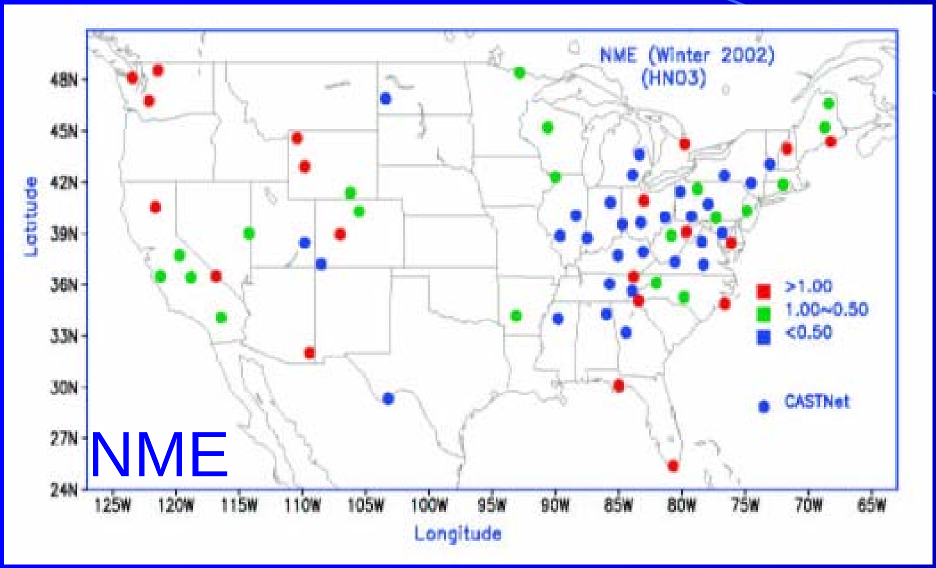


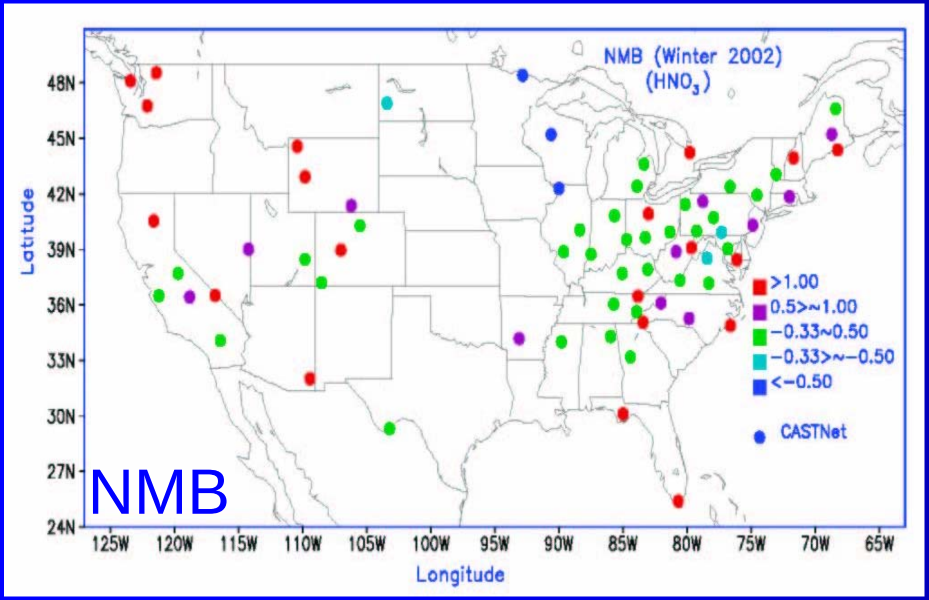


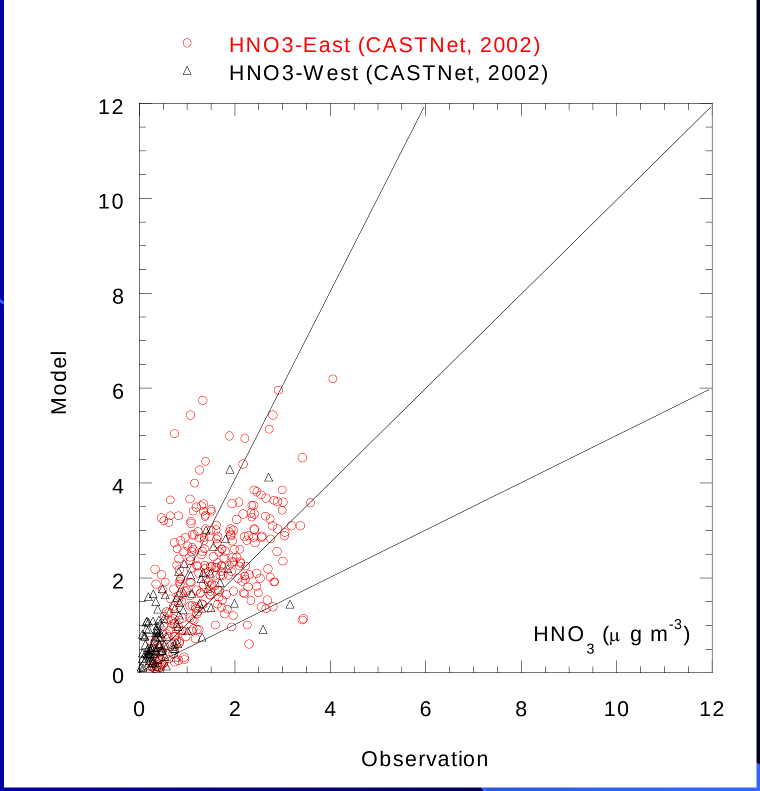


CASTNet	
n	264
R	0.79
MB	1.11
NMB(%)	49.0
RMSE	1.77
NME(%)	58.7

Nitric Acid - Jan. 4 - Feb.19, 2002

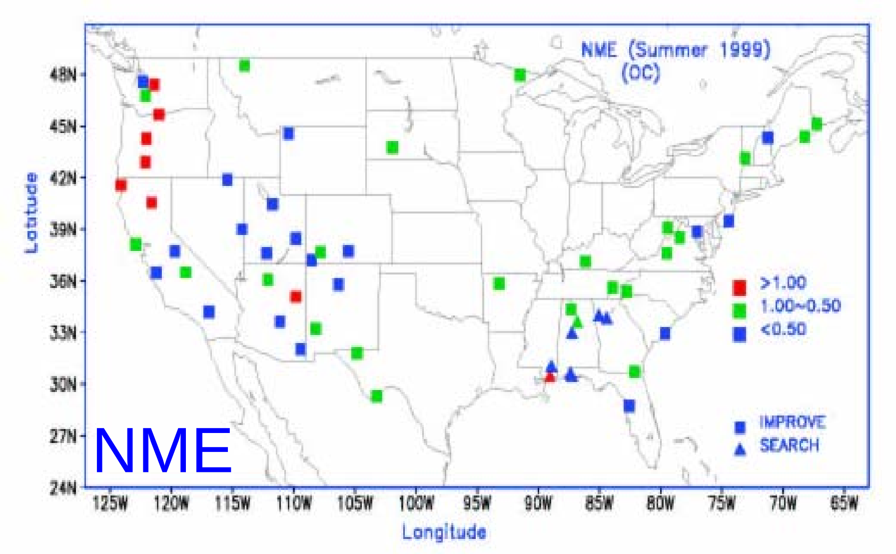


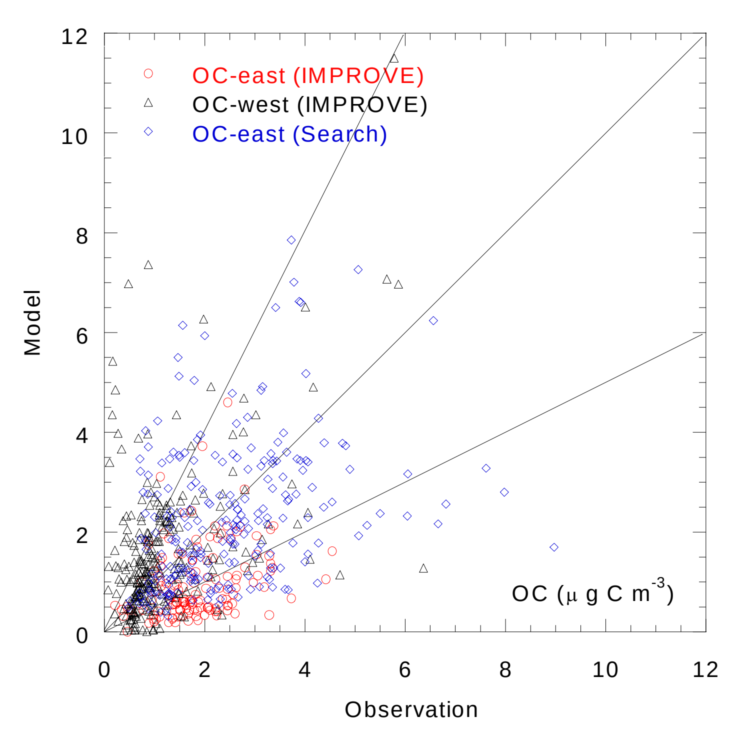


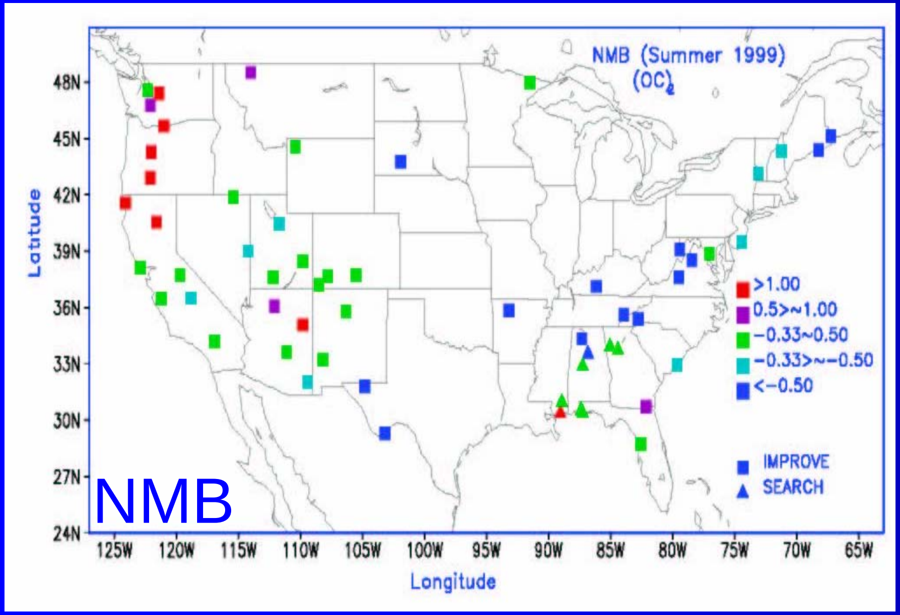


CASTNet	
n	407
R	0.64
MB	0.55
NMB(%)	44.2
RMSE	1.07
NME(%)	61.3

OC - June 15 – July 16, 1999

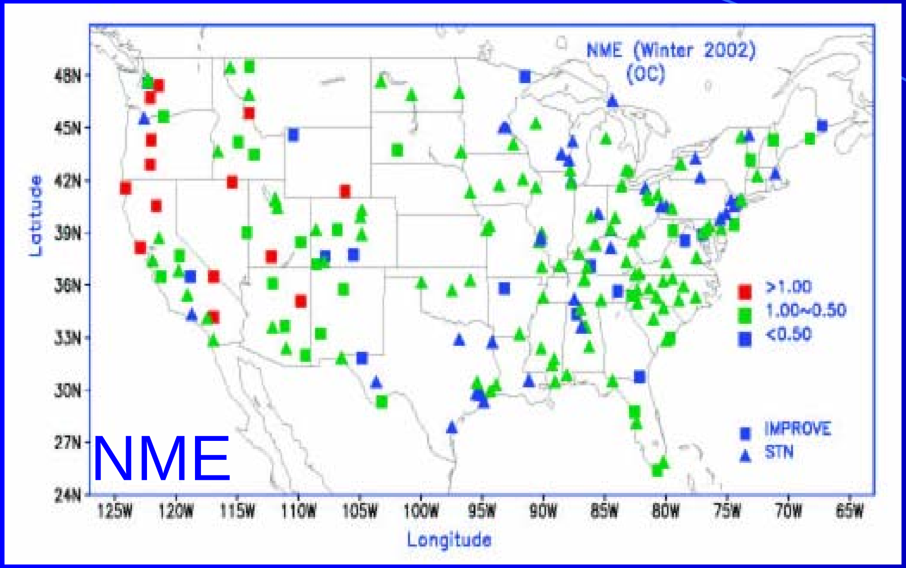


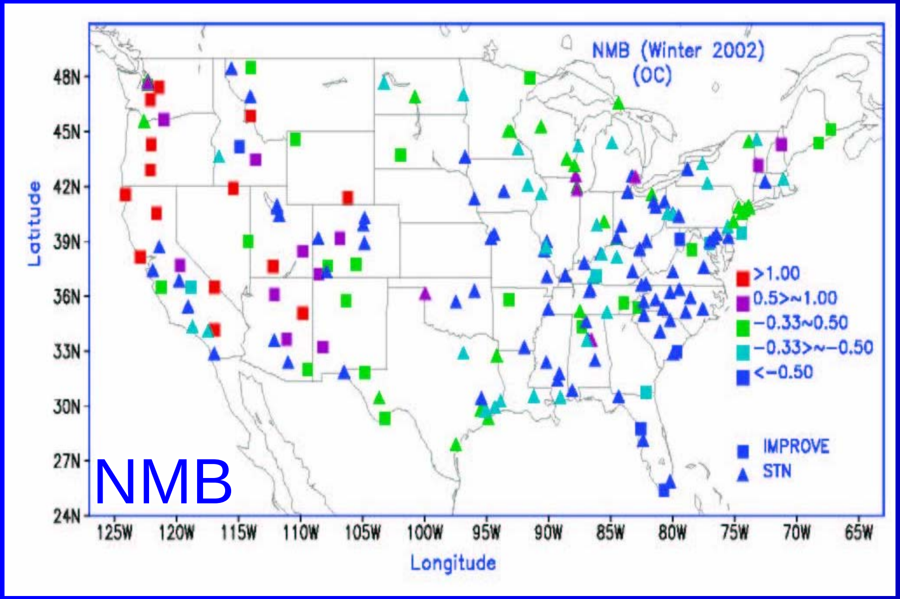


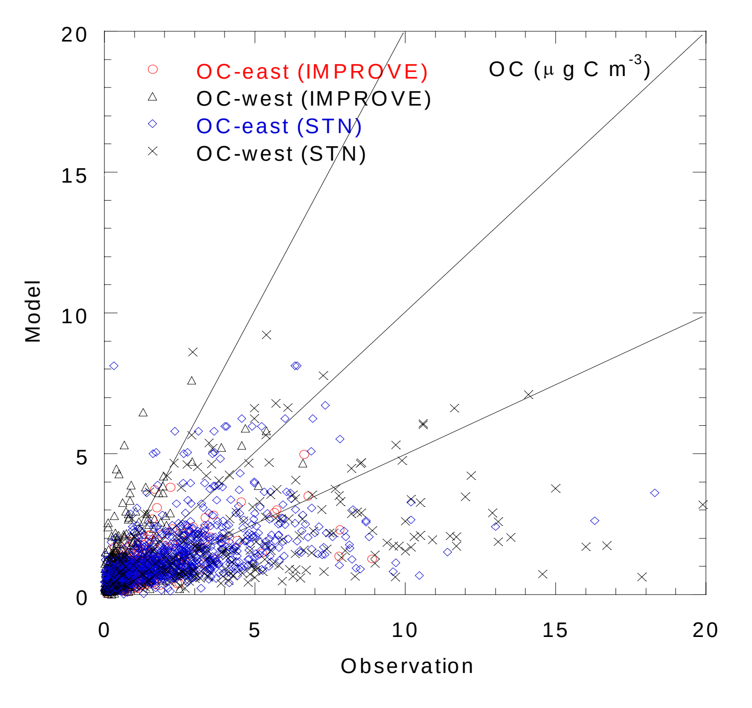


IMPROVE	
n	396
R	0.32
MB	-0.02
NMB(%)	-1.5
RMSE	1.35
NME(%)	67.2

OC- Jan. 4 - Feb.19, 2002



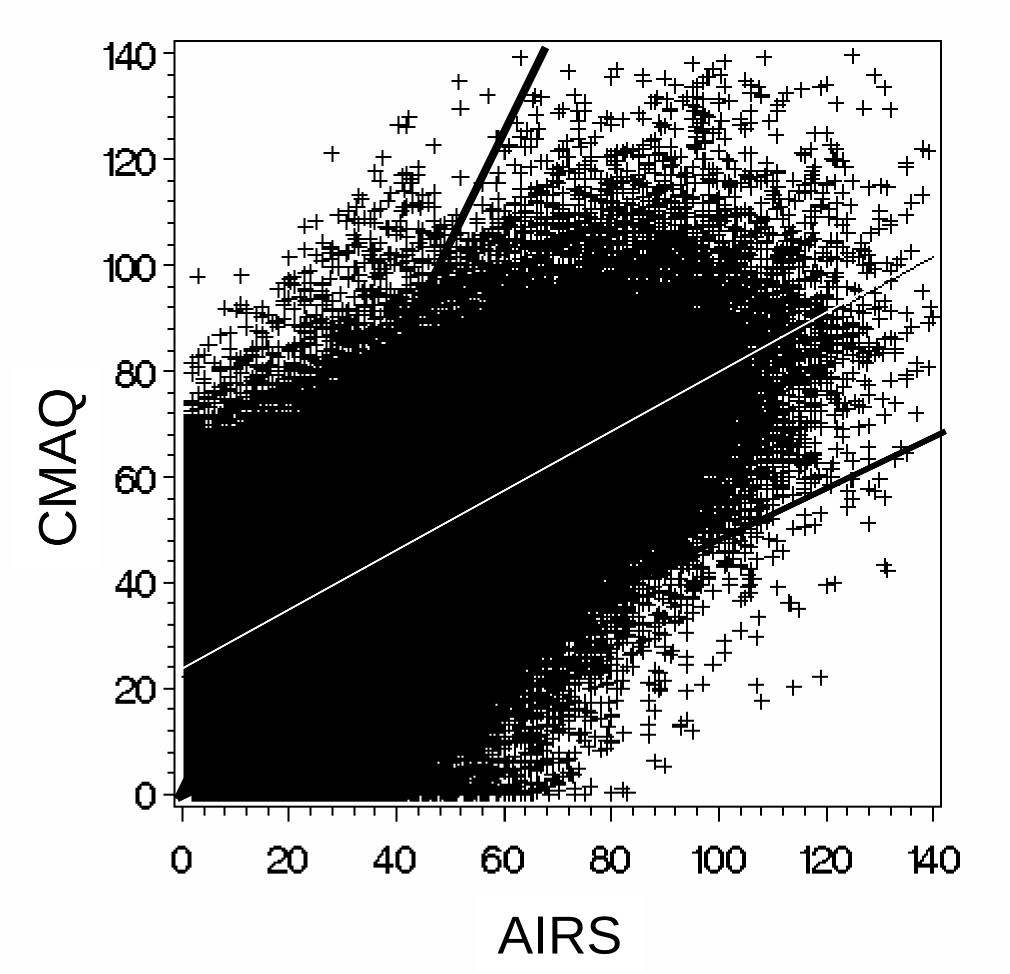




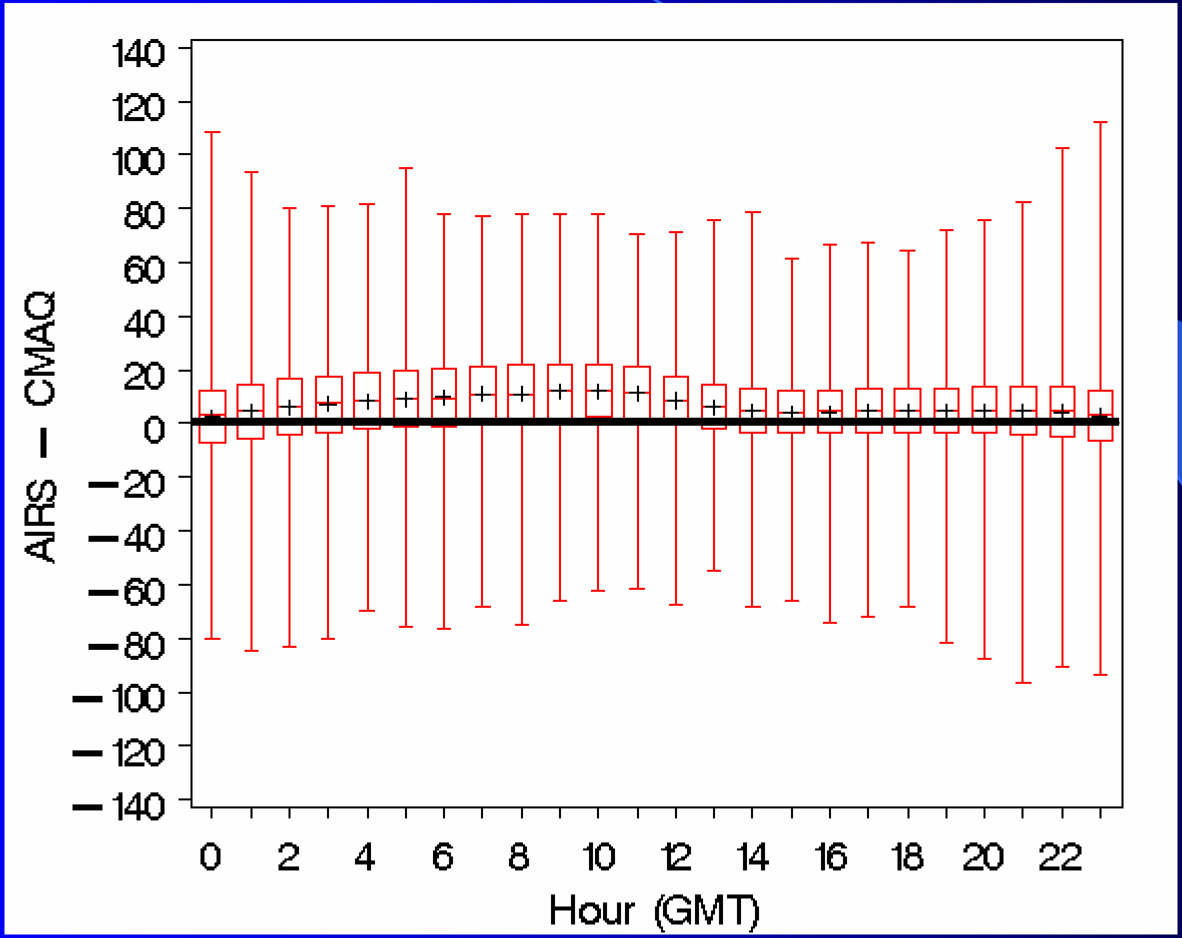
IMPROVE		STN	
n	731	n	1106
R	0.56	R	0.47
MB	0.14	MB	-1.64
NMB(%)	17.2	NMB(%)	-50.0
RMSE	0.93	RMSE	3.32
NME(%)	70.0	NME(%)	60.4

Hourly Ozone June 15 – July 16, 1999

AIRS	
n	531,496
R	0.69
MB	6.8
NMB(%)	18.8
RMSE	16.7
NME(%)	36.4



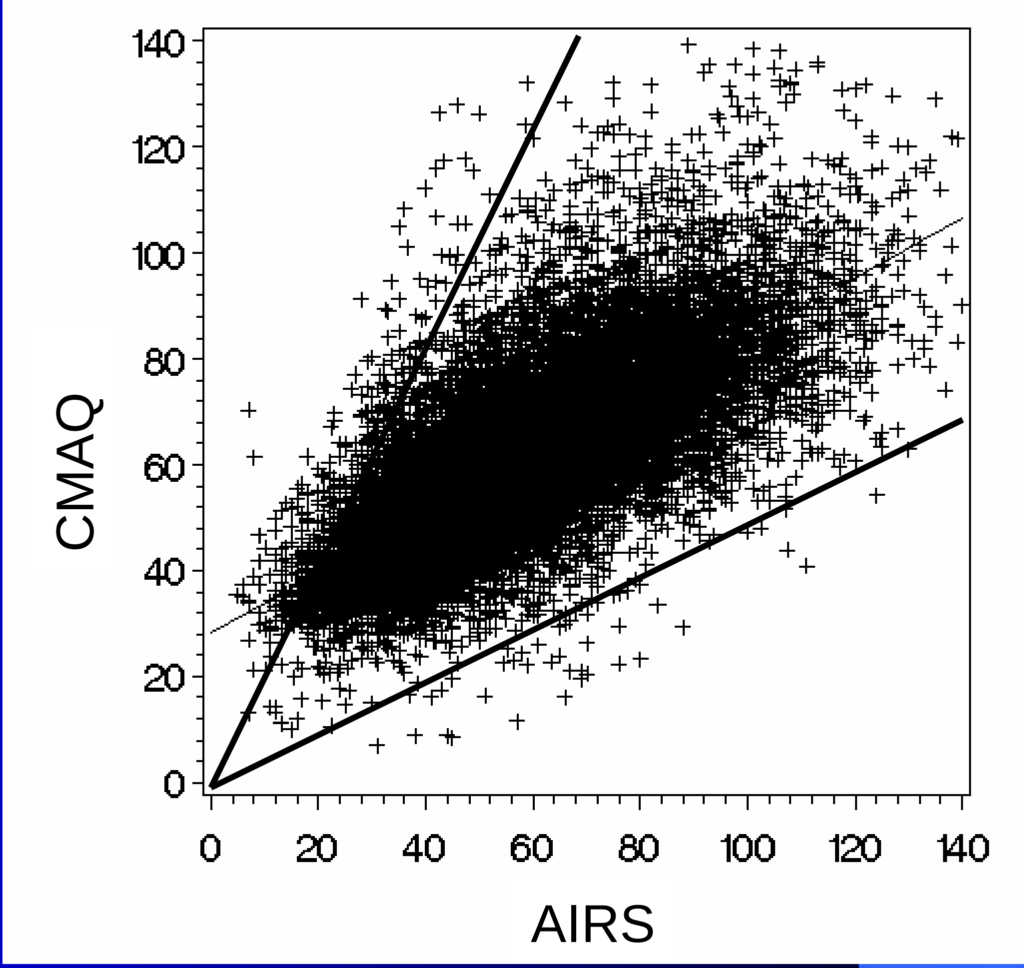
Hourly Ozone June 15 – July 16, 1999



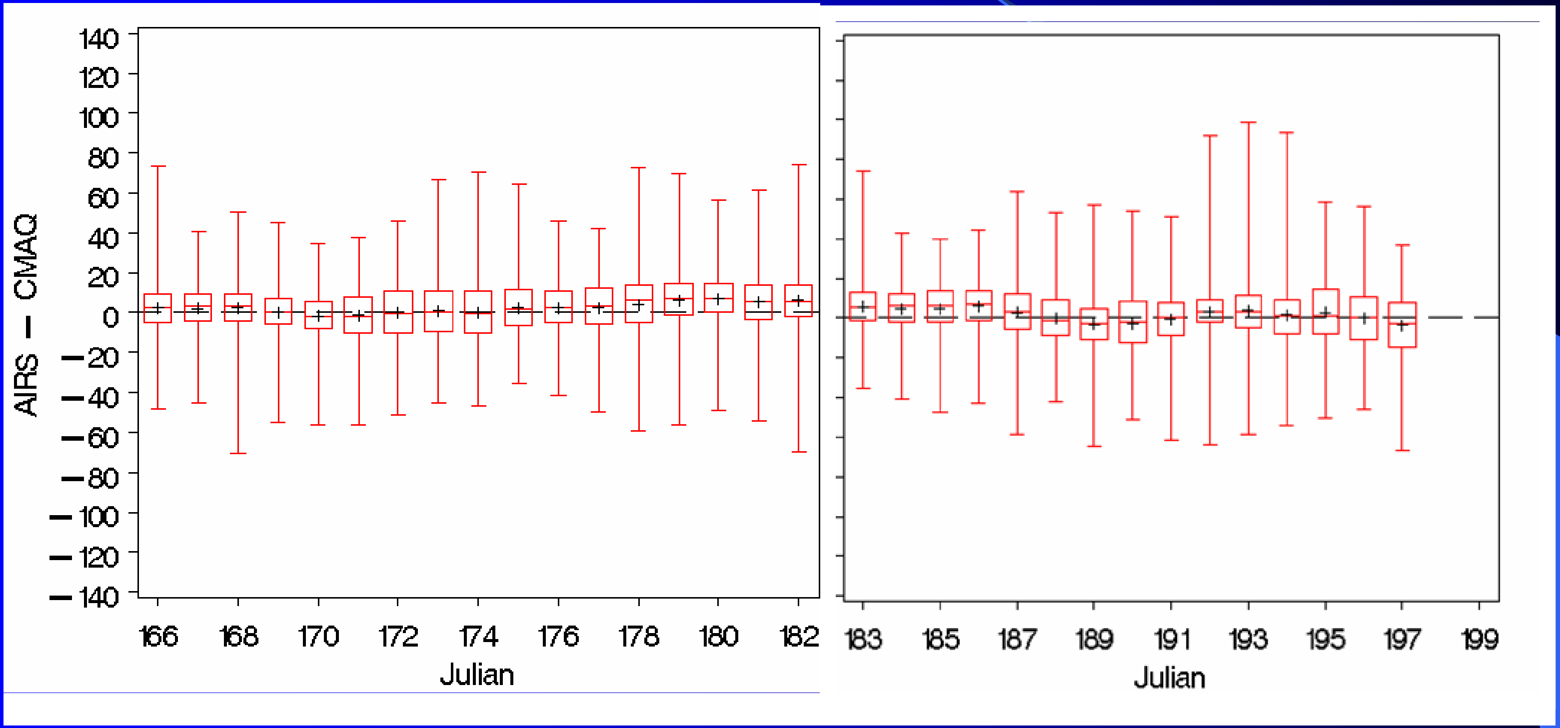
Boxplots of Bias Over Hours

Max. 1- hr Ozone June 15 – July 16, 1999

AIRS	
n	23,196
R	0.72
MB	2.3
NMB(%)	3.8
RMSE	14.5
NME(%)	18.8



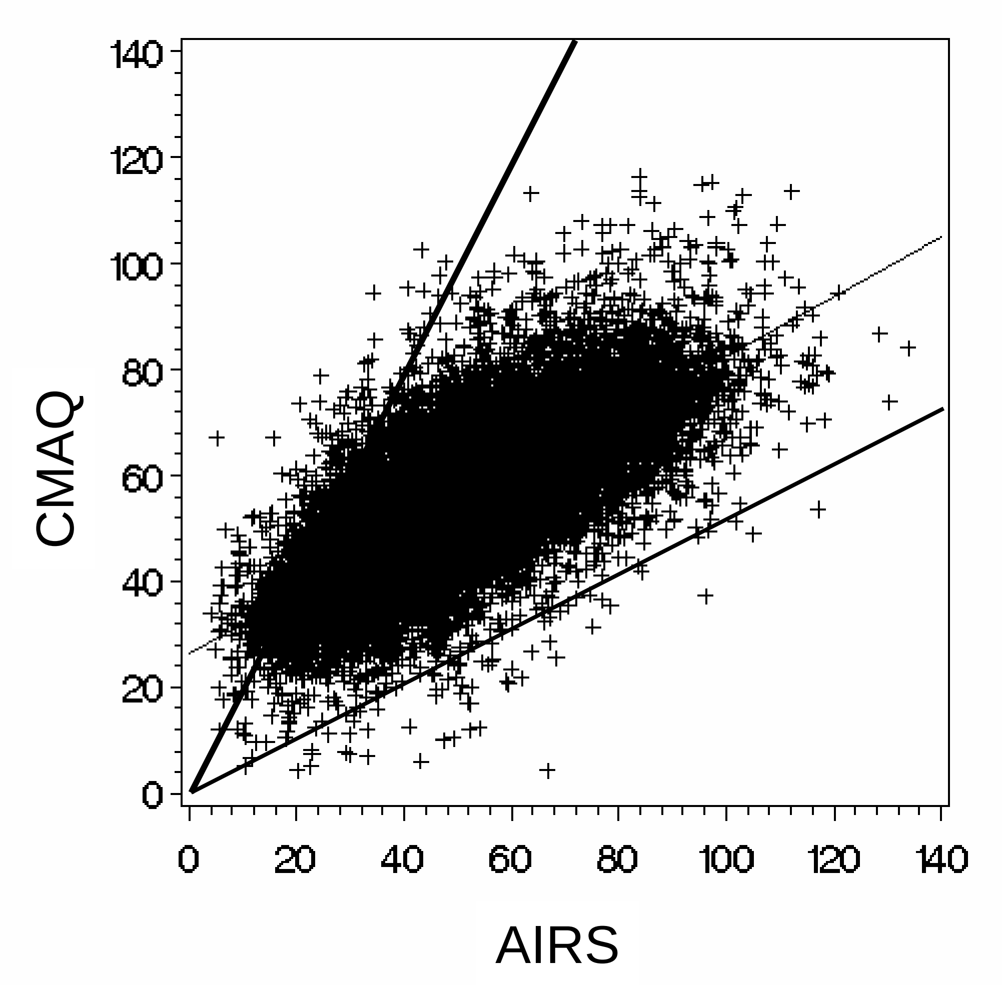
Max. 1- hr Ozone June 15 – July 16, 1999



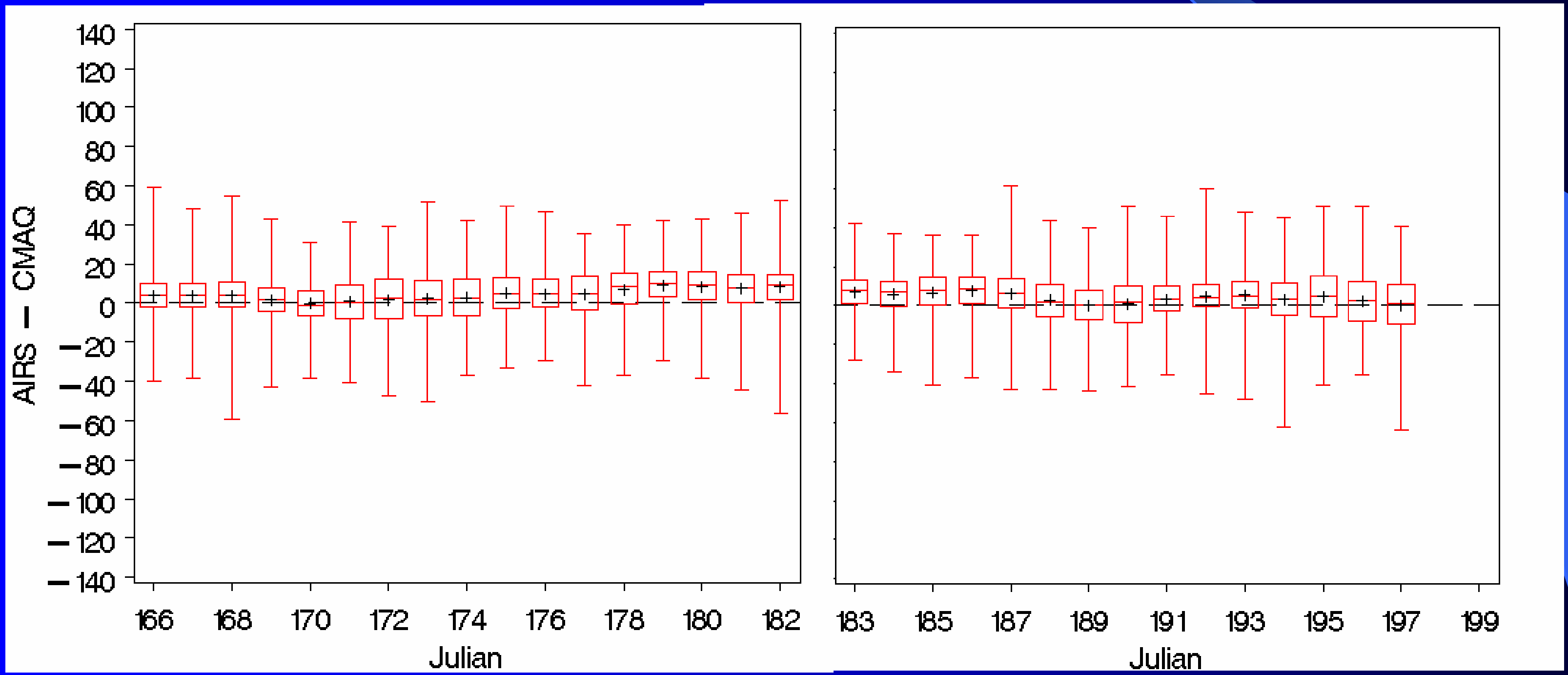
Boxplots of Bias Over Days

Max. 8- hr Ozone June 15 – July 16, 1999

AIRS	
n	23,196
R	0.75
MB	4.3
NMB(%)	8.7
RMSE	12.8
NME(%)	20.2



Max. 8- hr Ozone June 15 – July 16, 1999



Boxplots of Bias Over Days

SUMMARY

The 2003 Release of CMAQ featured many changes, the largest of which impacted:

- aerosol nitrate
- secondary organic aerosols (SOA)

resulting in substantially lower concentrations of aerosol nitrates and SOAs bringing them more in line with observations.

Other species continue to be simulated reasonably well:

- majority of correlations are greater than 0.70
- majority of model simulations are within 2:1

- majority NMB within ±35%
- majority NME less than 50%

(*depending on the specie and observational network*.)

FUTURE WORK

The 2004 Release of CMAQ will be available at the beginning of ’04 and will be used to perform a one year simulation (2001).

A comprehensive evaluation of that year long simulation will examine the performance of the individual components of the Models-3 CMAQ including:

Meteorology Model
Emissions Model
CMAQ

This comprehensive evaluation will include statistics similar to those presented here, as well as new, innovative statistical techniques examining:

Spatial
Temporal

characteristics of the model and how they relate to observations.