

WRAP CMAQ 1996 revised Model Performance Evaluation Case

- These are preliminary results, as of August 18, 2003
- Includes all updates and corrections for CMAQ and input data sets discovered during the last two years:
 - CMAQ v4.2.2
 - MCIP v2.2 corrected layer averaging bug
 - Monthly adjusted NH₃ emissions
 - Corrected NH₃ deposition velocity
 - Many emissions updates & corrections
- 18 statistical measures employed in model performance evaluation

Summary Results

- 18 statistical measures employed in model performance evaluation; can be analyzed based on
 - *allsite_daily*
 - *allsite_yearly*
 - *allsite_monthly*
 - *onesite_daily*
 - *onesite_monthly*
 - *onesite_yearly*
- Data available from ~55 IMPROVE stations in modeling domain
- Data available from total of 104 days in 1996
 - Spring (26 days), Summer (27 days), Fall (26 days), and Winter (25 days)

Statistical measures used in model performance evaluation

Measure	Mathematical Expression	Notation
Accuracy of unpaired peak (<i>Au</i>)	$\frac{P_{peak}^u - O_{peak}}{O_{peak}}$	O_{peak} = peak observation; P_{peak}^u = unpaired peak prediction within 2 grid cells of peak observation site
Accuracy of paired peak (<i>Ap</i>)	$\frac{P - O_{peak}}{O_{peak}}$	P = paired in time and space peak prediction
Coefficient of determination	$\frac{\left[\sum_{i=1}^N (P_i - \bar{P})(O_i - \bar{O}) \right]^2}{\sum_{i=1}^N (P_i - \bar{P})^2 \sum_{i=1}^N (O_i - \bar{O})^2}$	P_i = prediction at time and location i ; O_i = observation at time and location i ; \bar{P} = arithmetic average of P_i , $i=1,2,\dots,N$; \bar{O} = arithmetic average of O_i , $i=1,2,\dots,N$
Normalized Mean Error (<i>NME</i>)	$\frac{\sum_{i=1}^N P_i - O_i }{\sum_{i=1}^N O_i}$	Reported as %
Root Mean Square Error (<i>RMSE</i>)	$\left[\frac{1}{N} \sum_{i=1}^N (P_i - O_i)^2 \right]^{1/2}$	
Fractional Gross Error (<i>FE</i>)	$\frac{2}{N} \sum_{i=1}^N \left \frac{P_i - O_i}{P_i + O_i} \right $	

Statistical measures used in model performance evaluation

Measure	Mathematical Expression	Notation
Mean Absolute Gross Error (MAGE)	$\frac{1}{N} \sum_{i=1}^N P_i - O_i $	
Mean Normalized Gross Error (MNGE); Mean Normalized Error (MNE)	$\frac{1}{N} \sum_{i=1}^N \frac{ P_i - O_i }{O_i}$	Reported as %
Mean Bias (MB)	$\frac{1}{N} \sum_{i=1}^N (P_i - O_i)$	
Mean Normalized Bias (MNB)	$\frac{1}{N} \sum_{i=1}^N \frac{(P_i - O_i)}{O_i}$	Reported as %
Mean Fractionalized Bias (Fractional Bias, MFB)	$\frac{2}{N} \sum_{i=1}^N \left(\frac{P_i - O_i}{P_i + O_i} \right)$	Reported as %
Normalized Mean Bias (NMB)	$\frac{\sum_{i=1}^N (P_i - O_i)}{\sum_{i=1}^N O_i}$	Reported as %

Statistical measures used in model performance evaluation

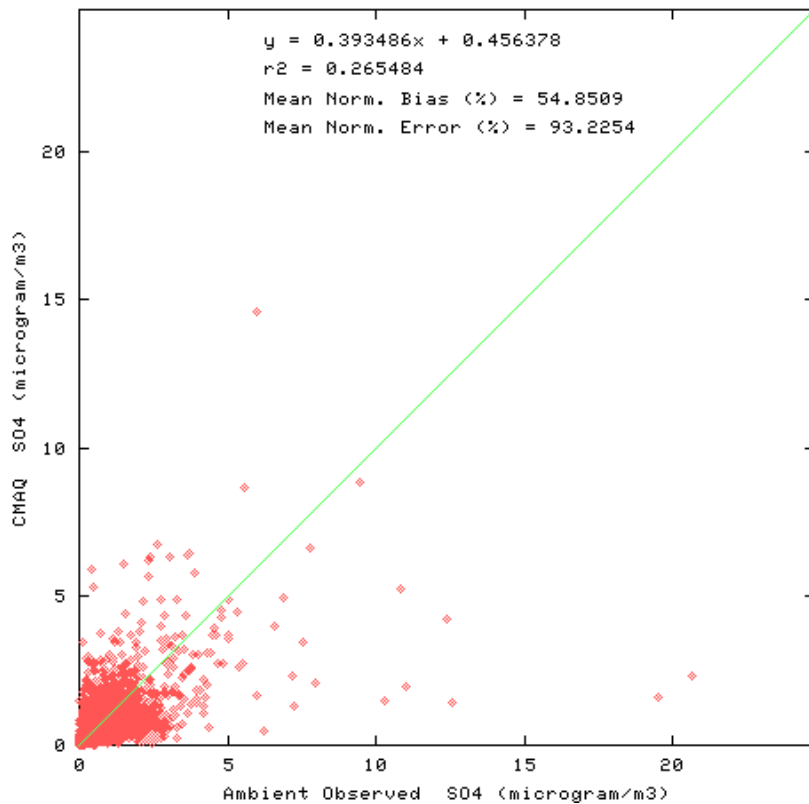
- In addition...
 - Mean observation
 - Mean prediction
 - Standard deviation (SD) of observation
 - Standard deviation (SD) of prediction
 - Correlation variance
 - Regression analysis (R^2)

All Sites Yearly Results

ALLSITE_ALLDAYS	SO4	NO3	OC	EC	SOIL	CM	PM25	RCFM	PM10	BEXT Recon
Mean Observation ($\mu\text{g}/\text{m}^3$)	0.85	0.34	1.45	0.25	0.71	5.54	4.59	3.95	10.06	22.59
Mean Predication ($\mu\text{g}/\text{m}^3$)	0.79	0.58	2.10	0.26	1.03	0.43	5.09	5.29	5.32	24.21
SD_Observation	0.98	0.69	1.69	0.31	1.01	5.36	4.02	3.36	8.07	18.87
SD_Prediction	0.75	1.22	2.91	0.47	1.77	0.44	5.53	5.86	5.33	24.80
Corr_Variance	0.77	1.38	8.12	0.17	4.15	54.48	30.04	31.93	94.99	599.07
Accuracy of Unpaired Peak	-0.79	-0.90	-0.81	-0.62	-0.97	-1.00	-0.80	-0.68	-0.97	-0.93
Accuracy of Paired Peak	-0.89	-0.91	-0.79	-0.22	-0.95	-1.00	-0.79	-0.74	-0.97	-0.81
Coefficient of Determination	0.27	0.15	0.14	0.28	0.00	0.02	0.15	0.16	0.06	0.16
Normalized Mean Error (%)	54.36	154.37	86.78	74.44	130.21	92.56	63.79	73.71	60.61	56.27
Root Mean Square Error	0.88	1.17	2.85	0.41	2.04	7.38	5.48	5.65	9.75	24.48
Fractional Gross Error	0.56	1.14	0.65	0.69	0.89	1.59	0.56	0.57	0.74	0.51
Mean Absolute Gross Error	0.46	0.52	1.26	0.18	0.92	5.13	2.93	2.91	6.10	12.71
Mean Normalized Gross Error (%)	93.23	365.59	148.19	121.76	344.39	88.98	81.46	100.23	59.91	71.47
Mean Bias	-0.06	0.24	0.65	0.02	0.32	-5.11	0.50	1.34	-4.74	1.63
Mean Normalized Bias (%)	54.85	291.01	118.51	64.67	306.10	-83.07	44.95	73.37	-26.68	35.04
Mean Fractionalized Bias (%)	2.55	-16.54	22.55	-16.93	30.43	-156.75	4.62	19.46	-57.38	-0.09
Normalized Mean Bias (%)	-6.84	72.73	45.08	6.96	45.54	-92.29	10.96	34.03	-47.09	7.20

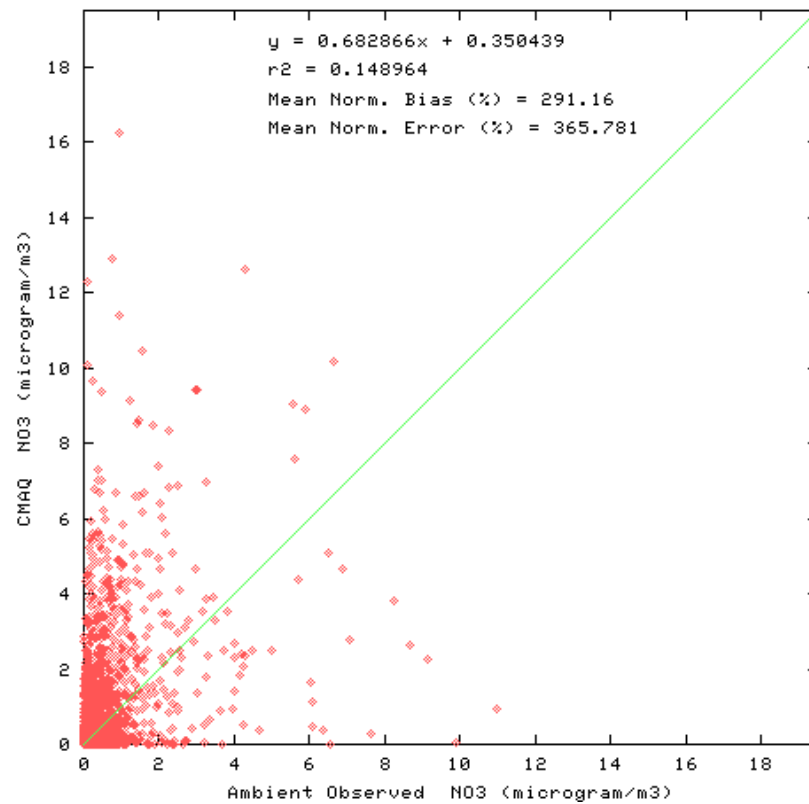
SO4

Ambient Observed vs. CMAQ SO4 at 55 stations for all days



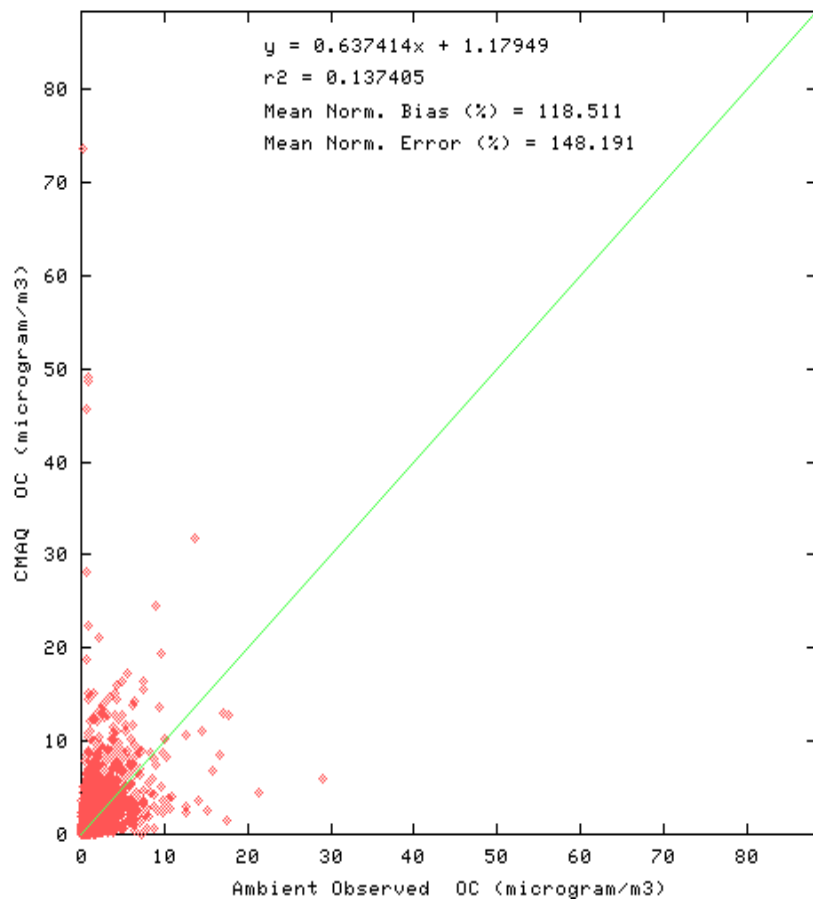
NO3

Ambient Observed vs. CMAQ NO3 at 55 stations for all days



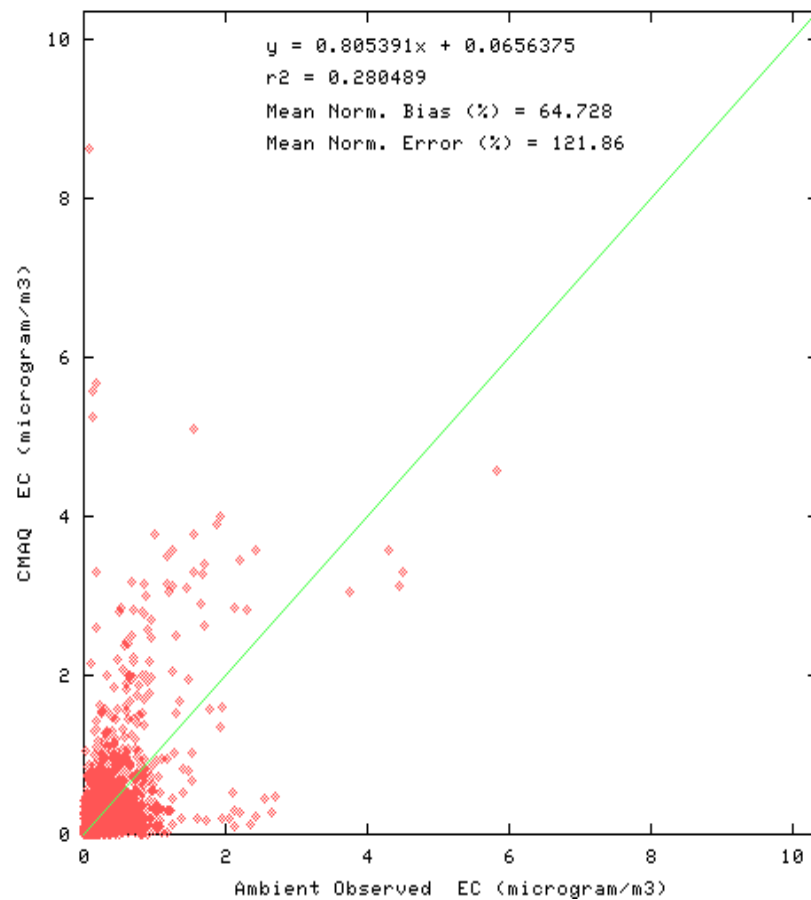
OC

Ambient Observed vs. CMAQ OC at 55 stations for all days



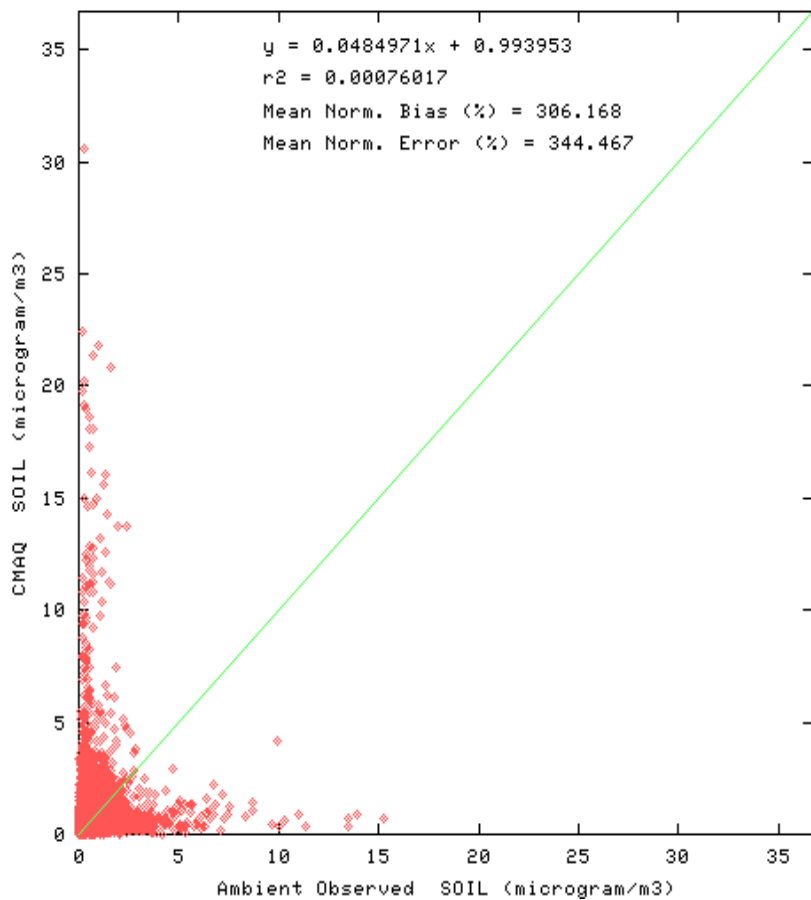
EC

Ambient Observed vs. CMAQ EC at 55 stations for all days



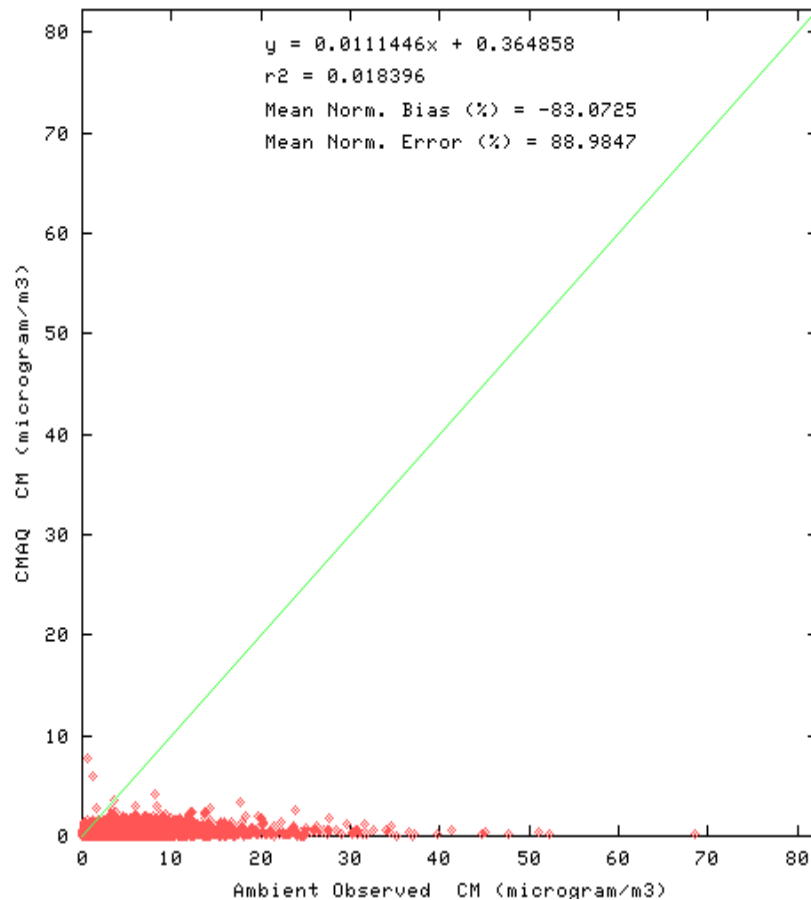
SOIL

Ambient Observed vs. CMAQ SOIL at 55 stations for all days



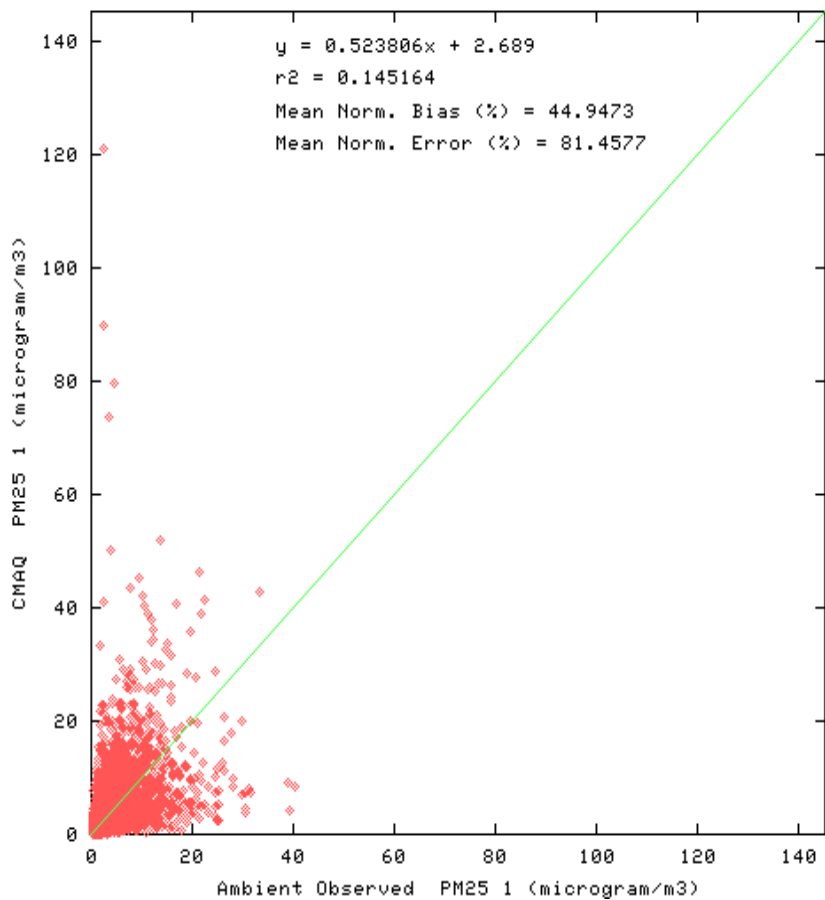
CM

Ambient Observed vs. CMAQ CM at 55 stations for all days



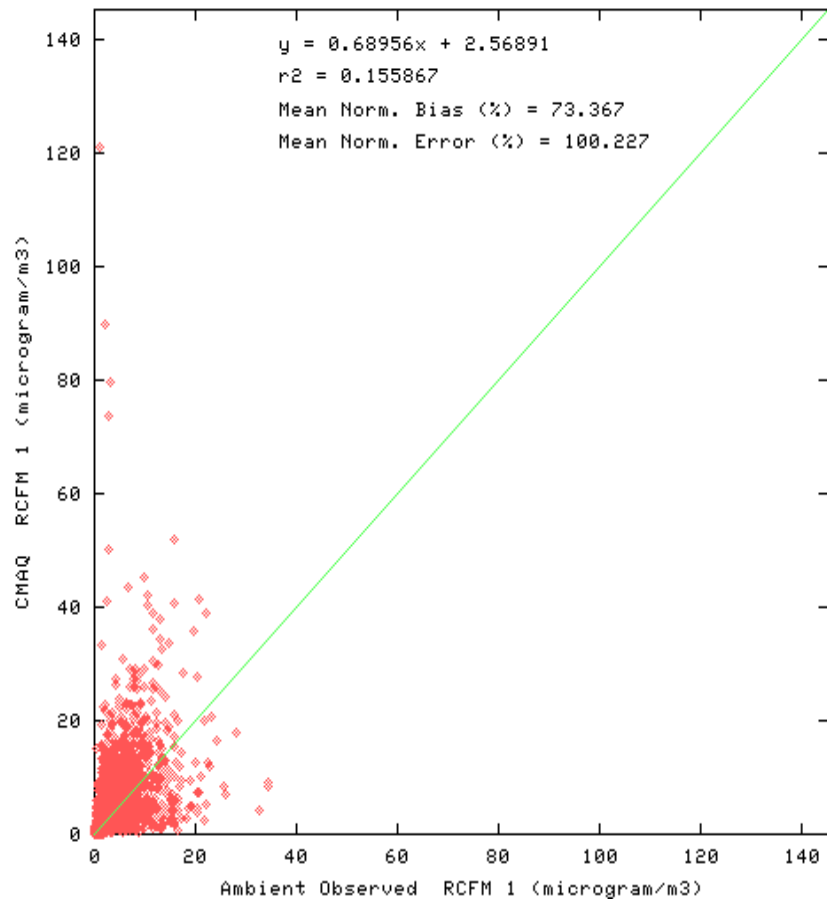
PM25

Ambient Observed vs. CMAQ PM25 1 at 55 stations for all days



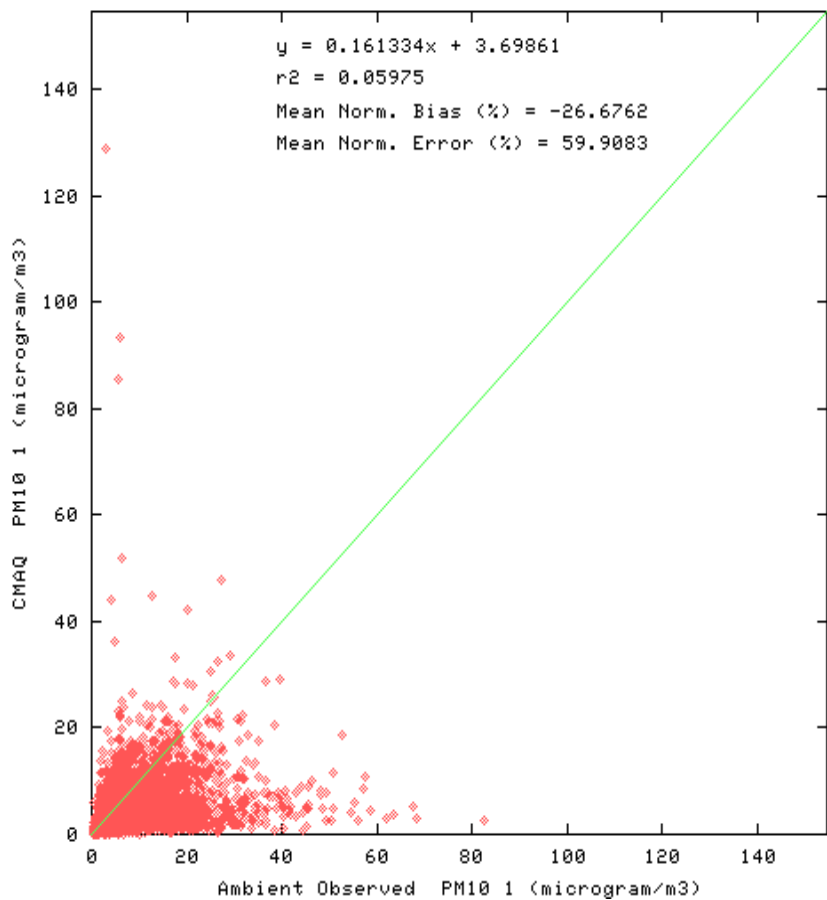
RCFM

Ambient Observed vs. CMAQ RCFM 1 at 55 stations for all days



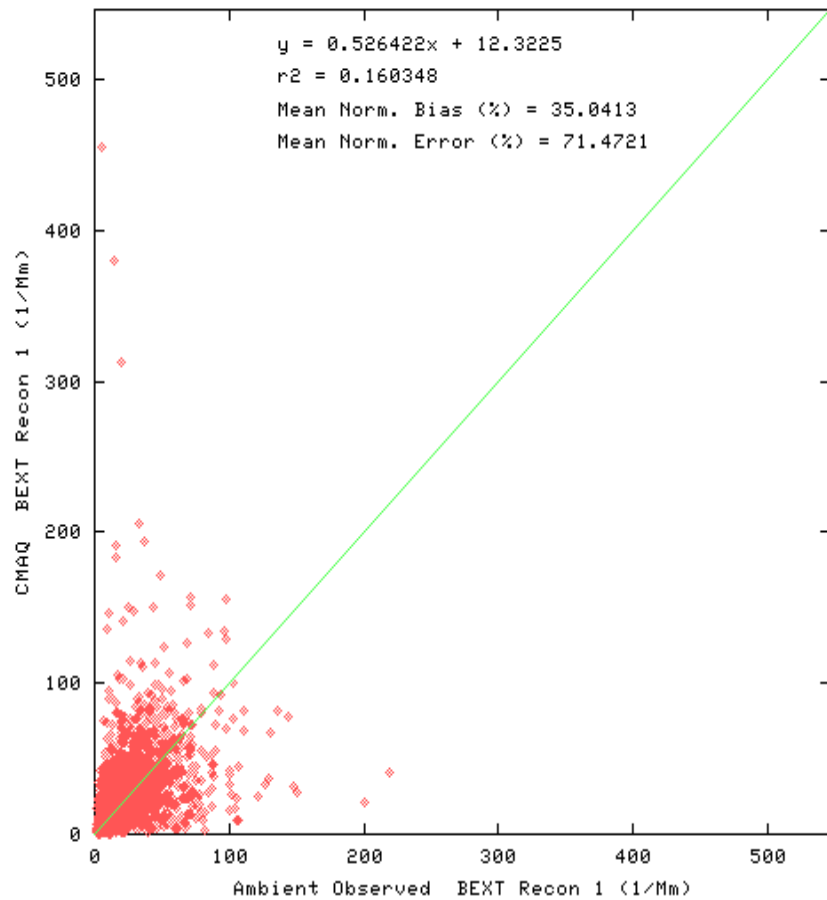
PM10

Ambient Observed vs. CMAQ PM10 1 at 55 stations for all days



BEXT

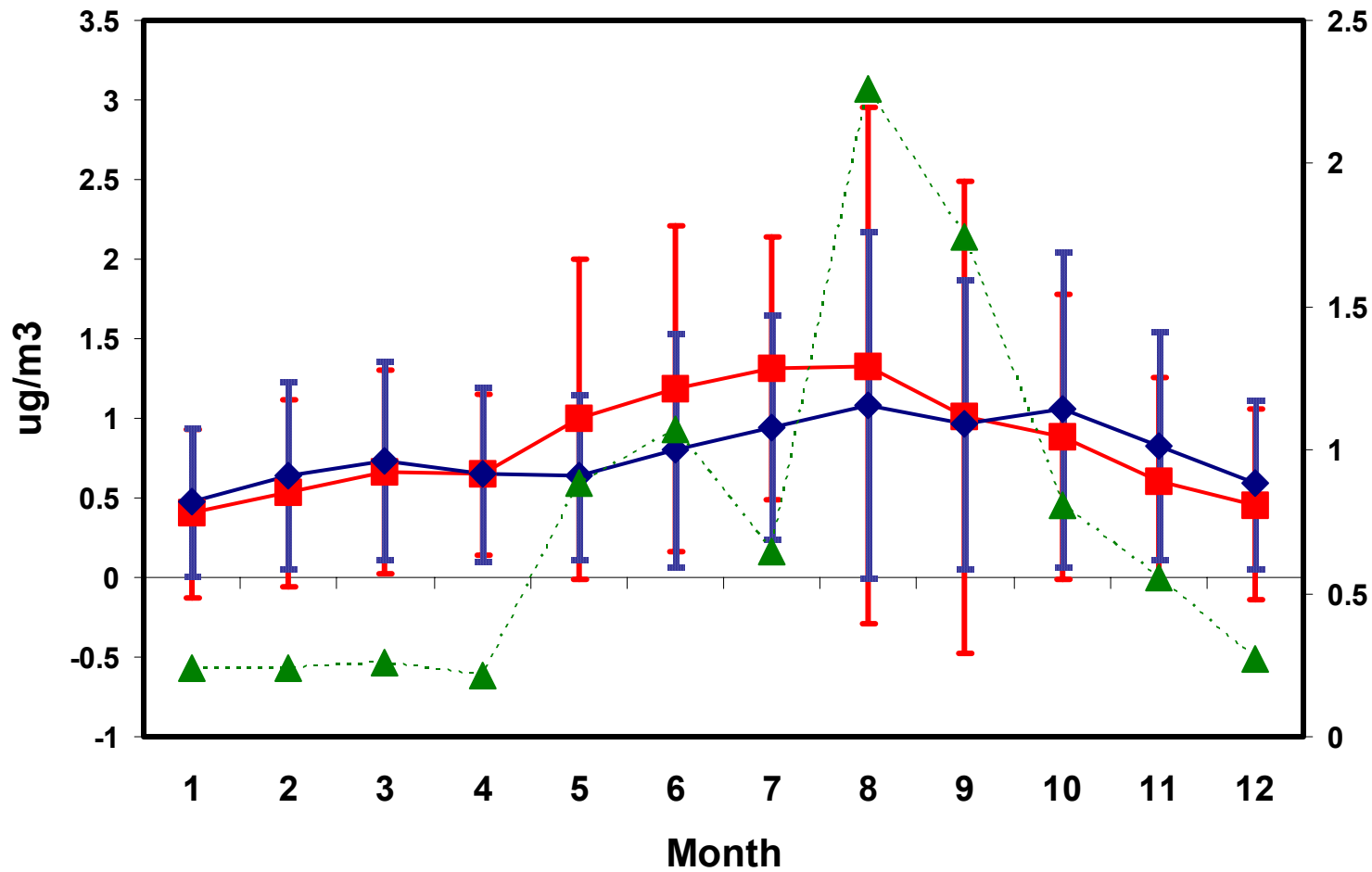
Ambient Observed vs. CMAQ BEXT Recon 1 at 55 stations for all da



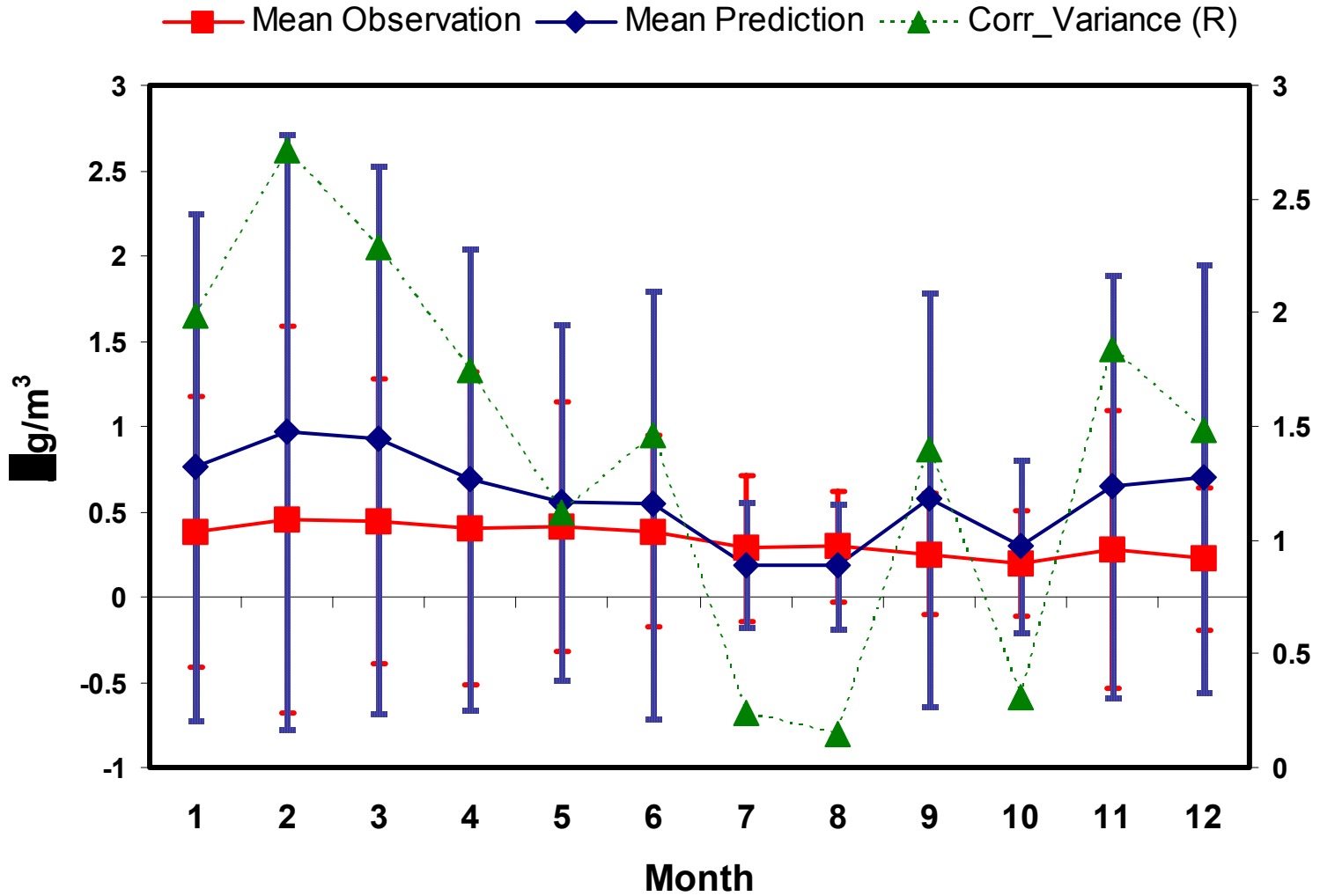
Selected Monthly Statistical Measures

SO4, Monthly Mean Conc. with SD

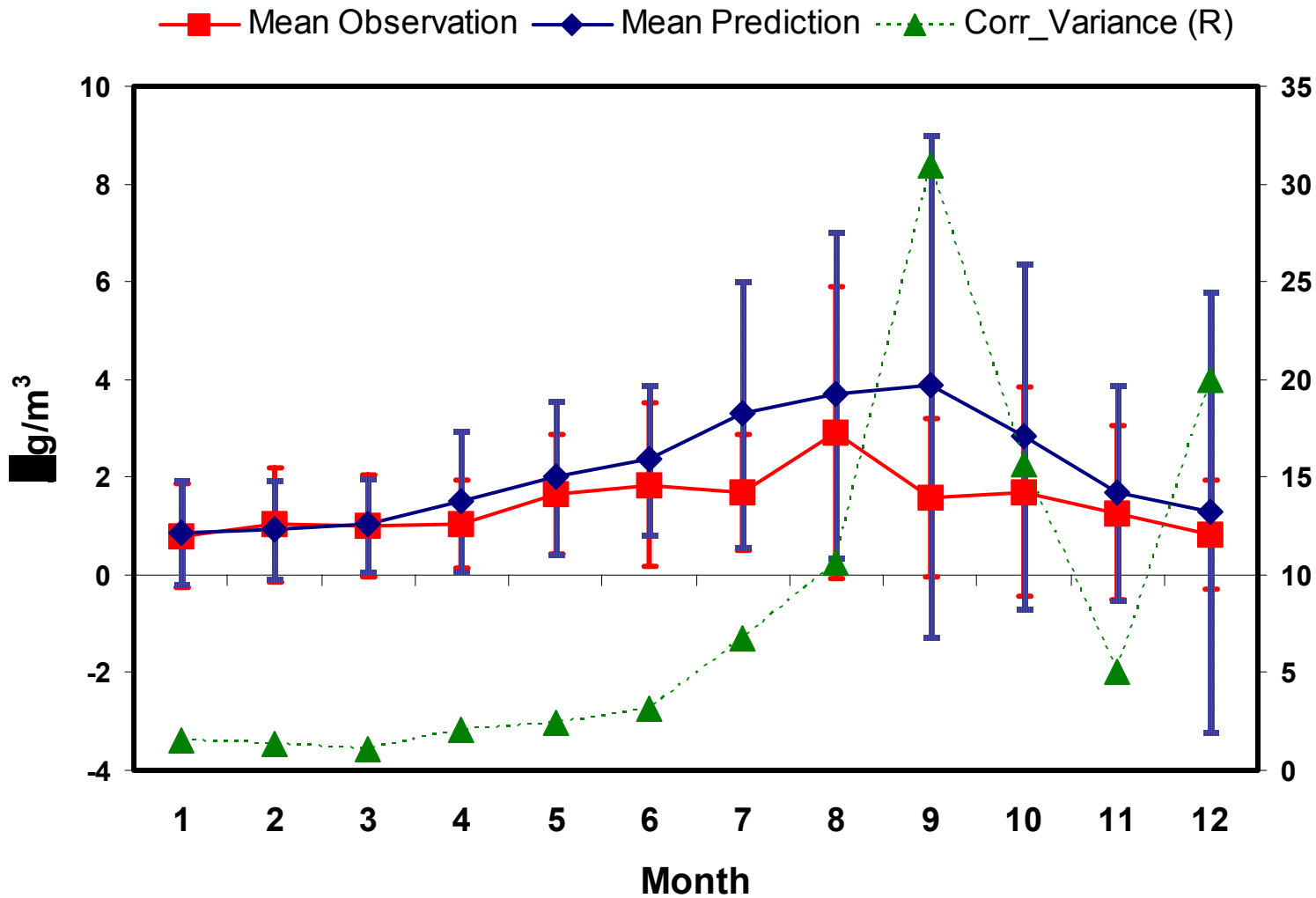
■ Mean Observation
 ◆ Mean Prediction
 ▲ Corr_Variance (R)



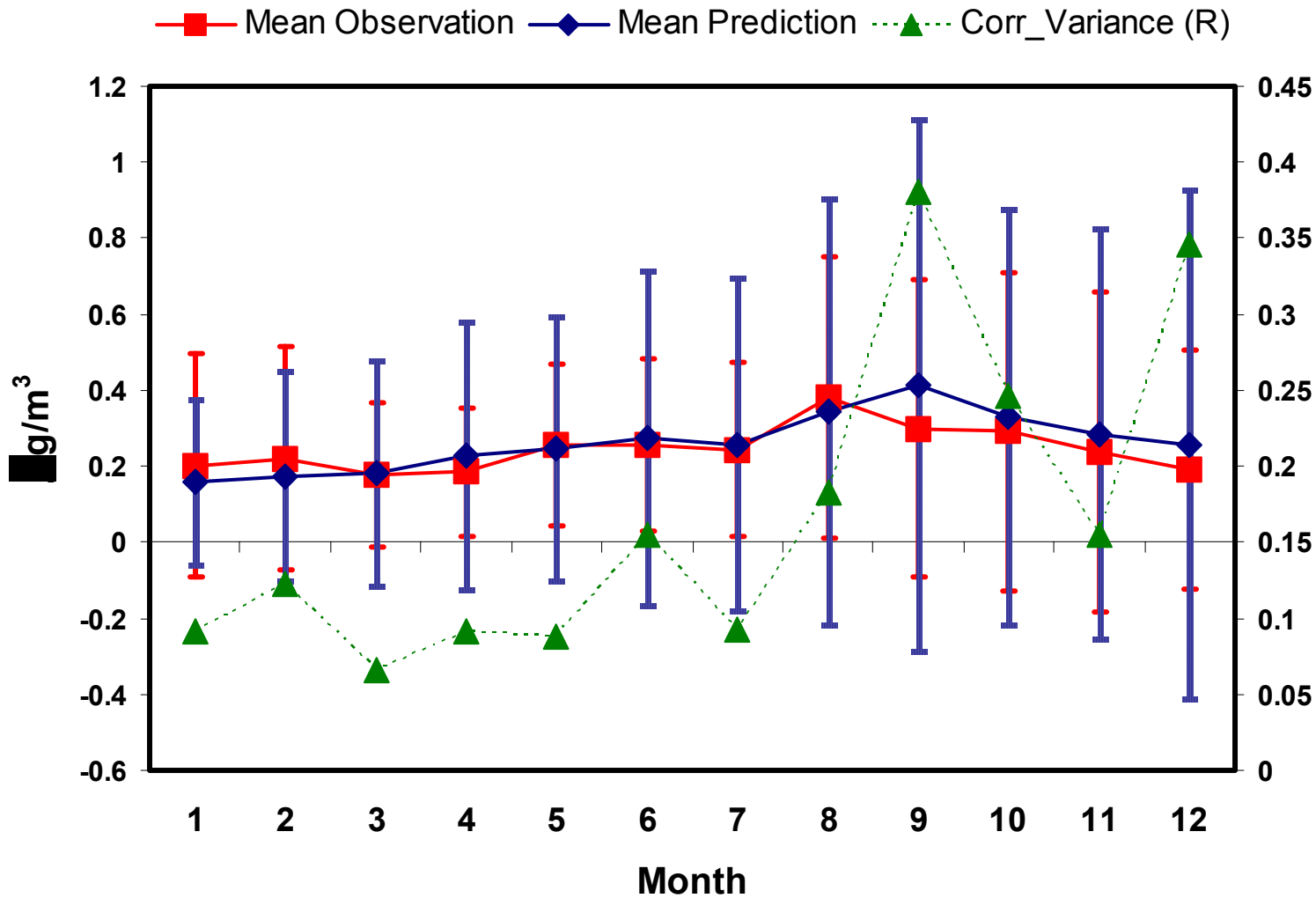
NO3, Monthly Mean Conc. with SD



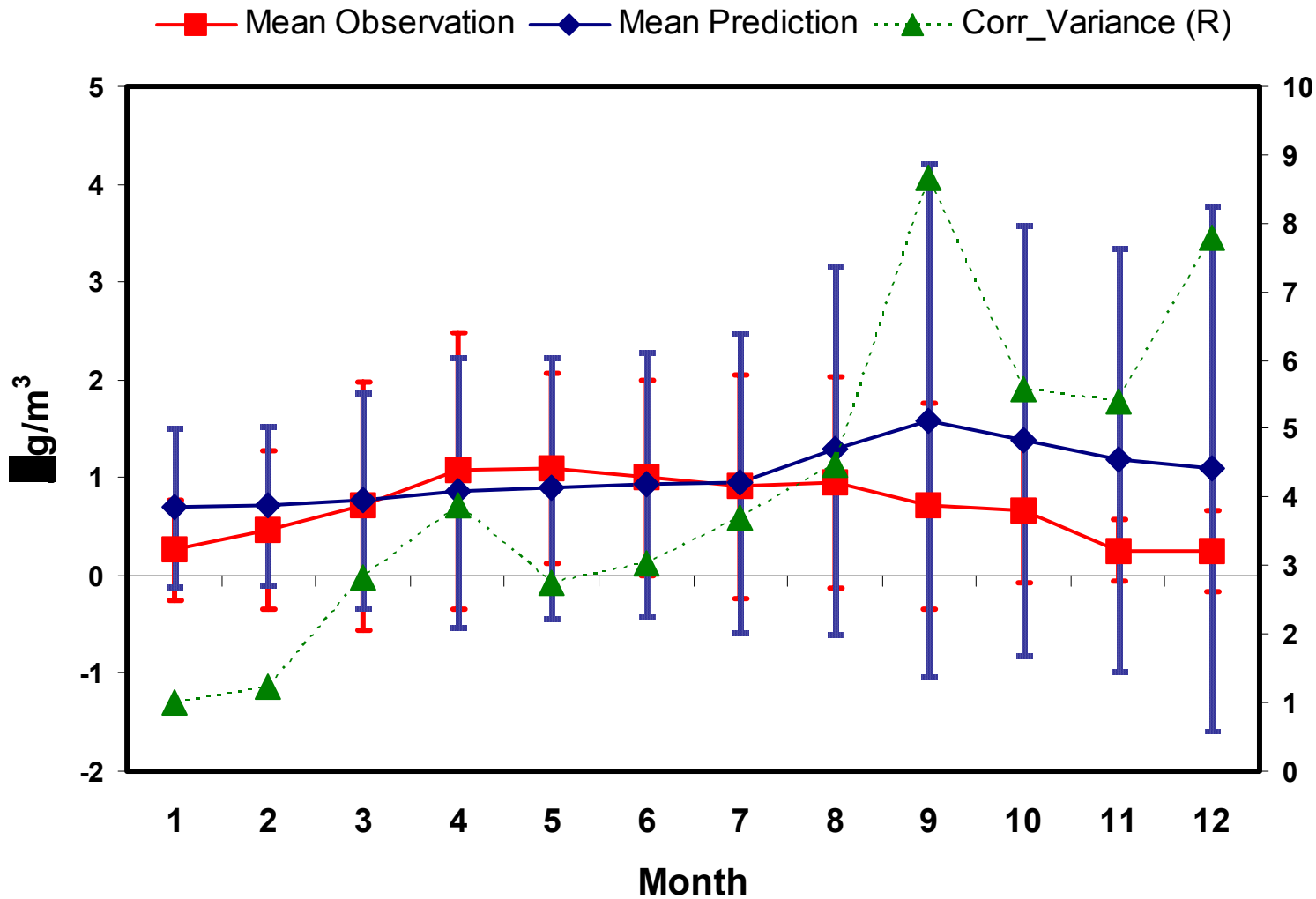
OC, Monthly Mean Conc. with SD



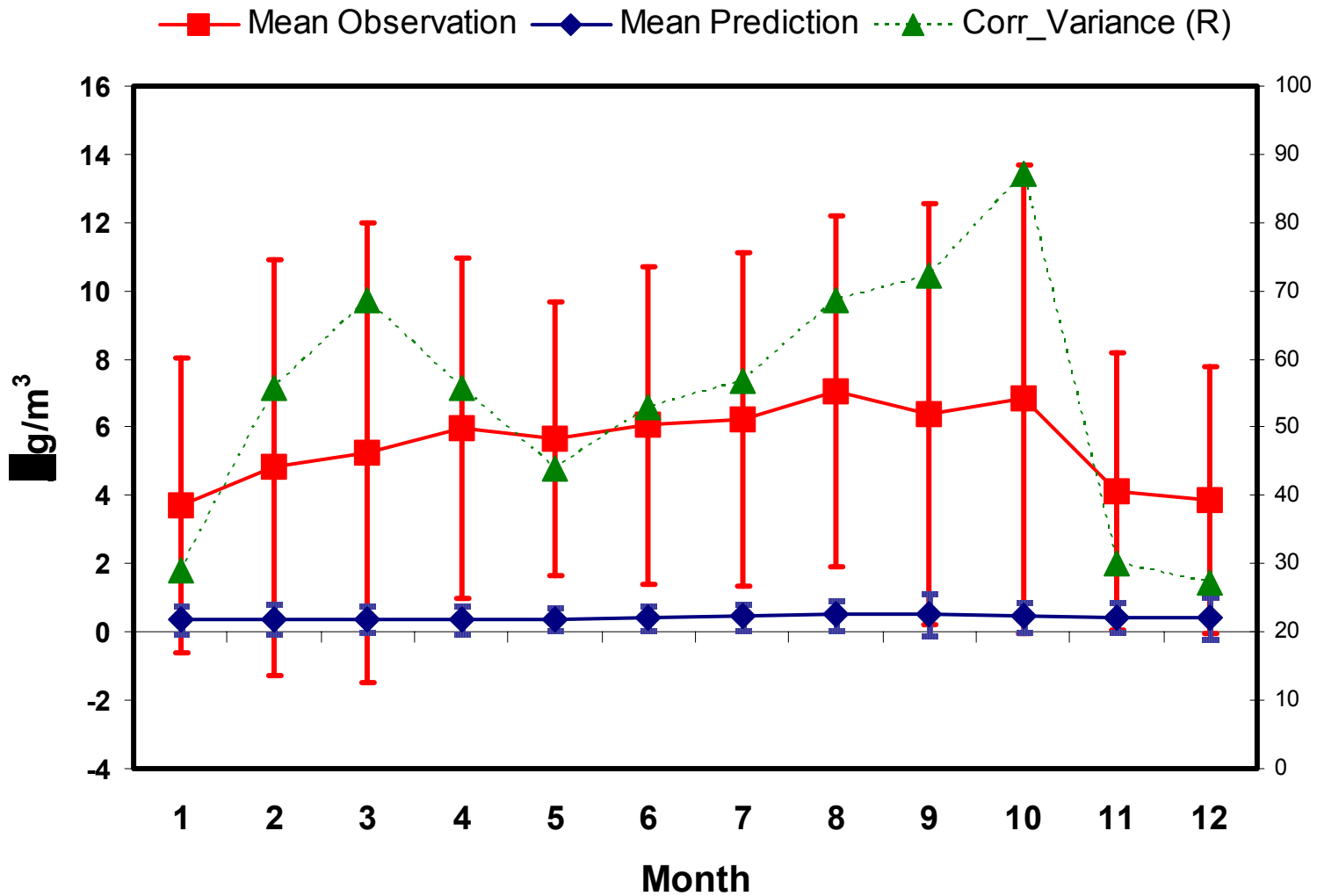
EC, Monthly Mean Conc. with SD



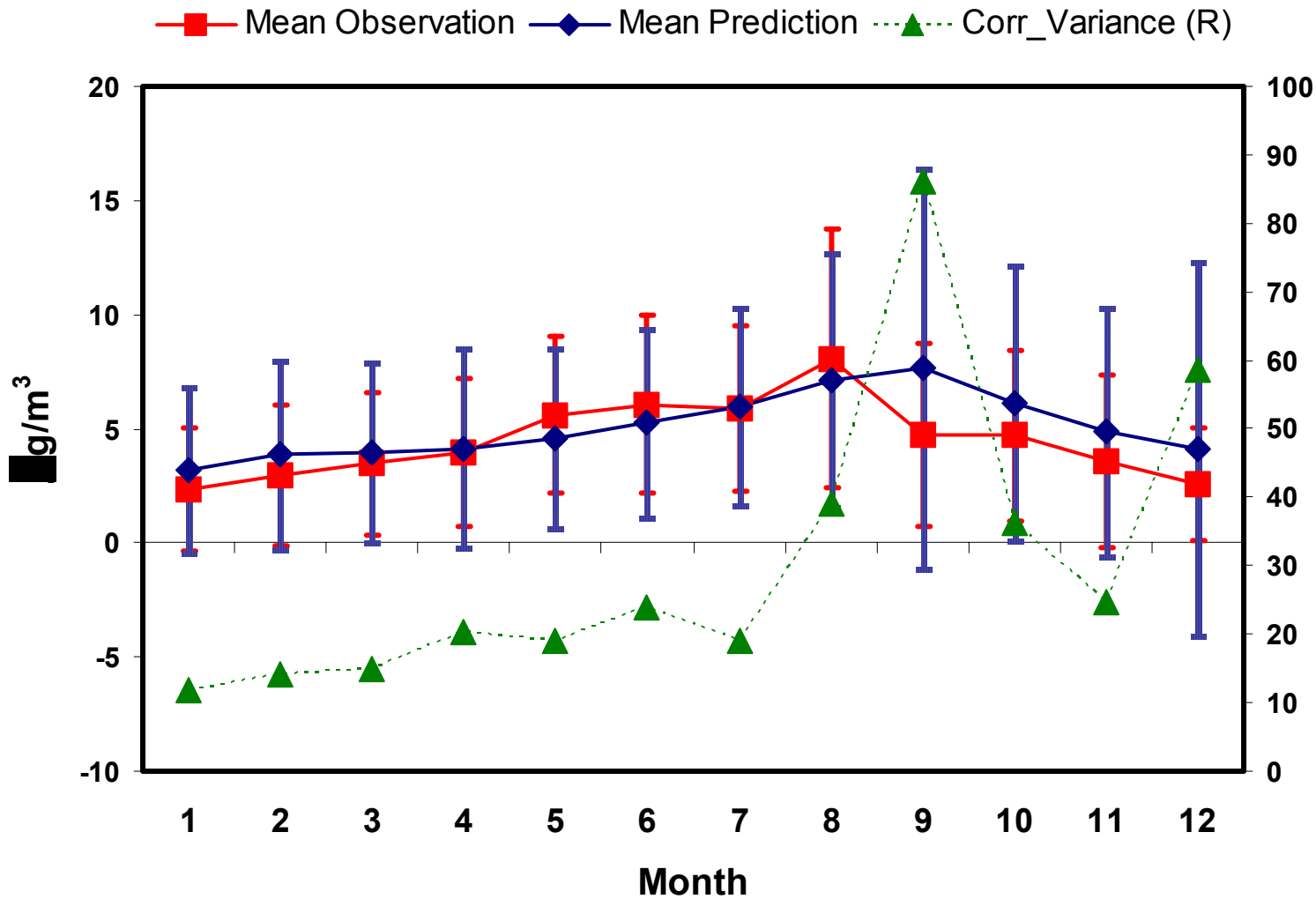
SOIL, Monthly Mean Conc. with SD



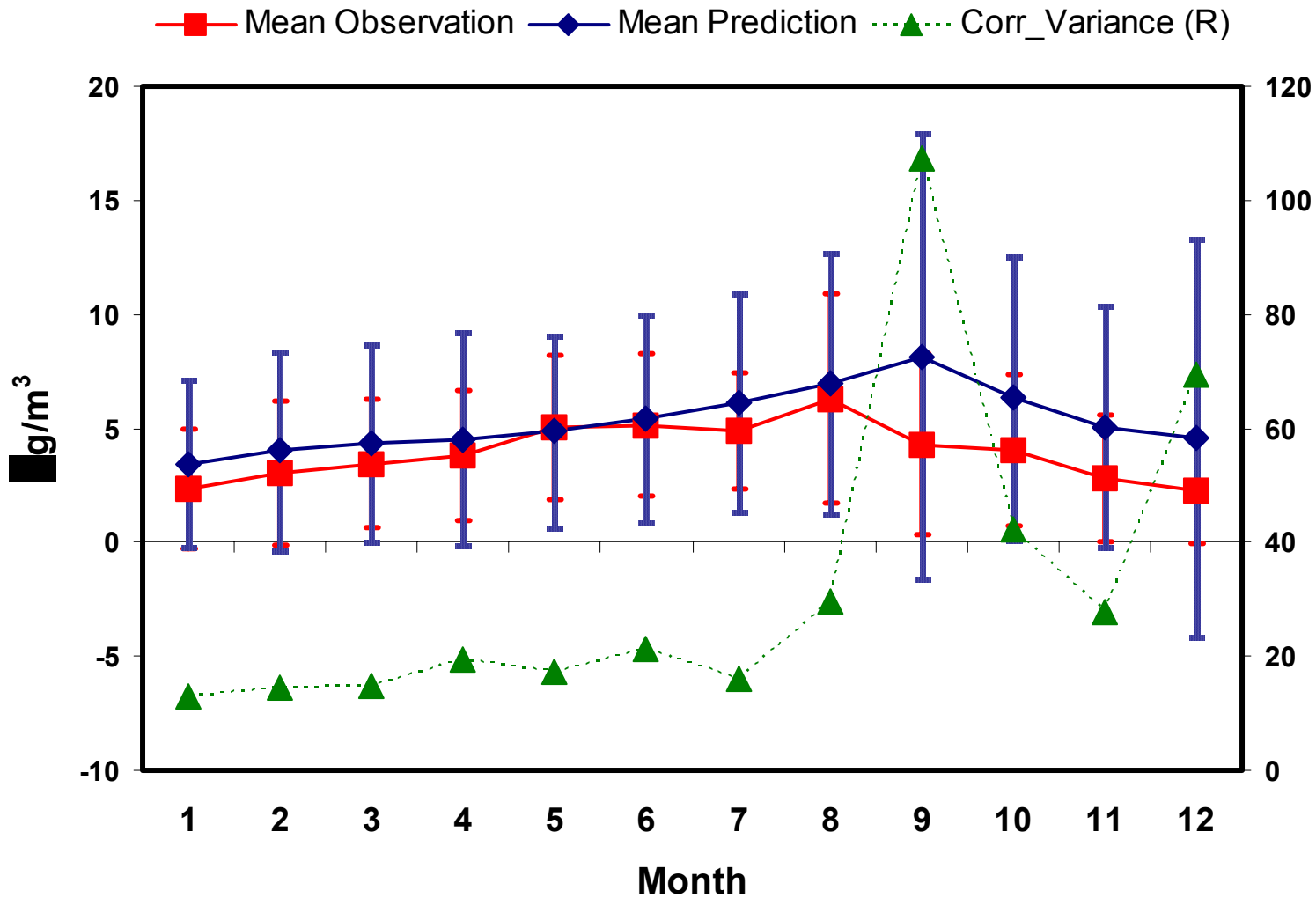
CM, Monthly Mean Conc. with SD



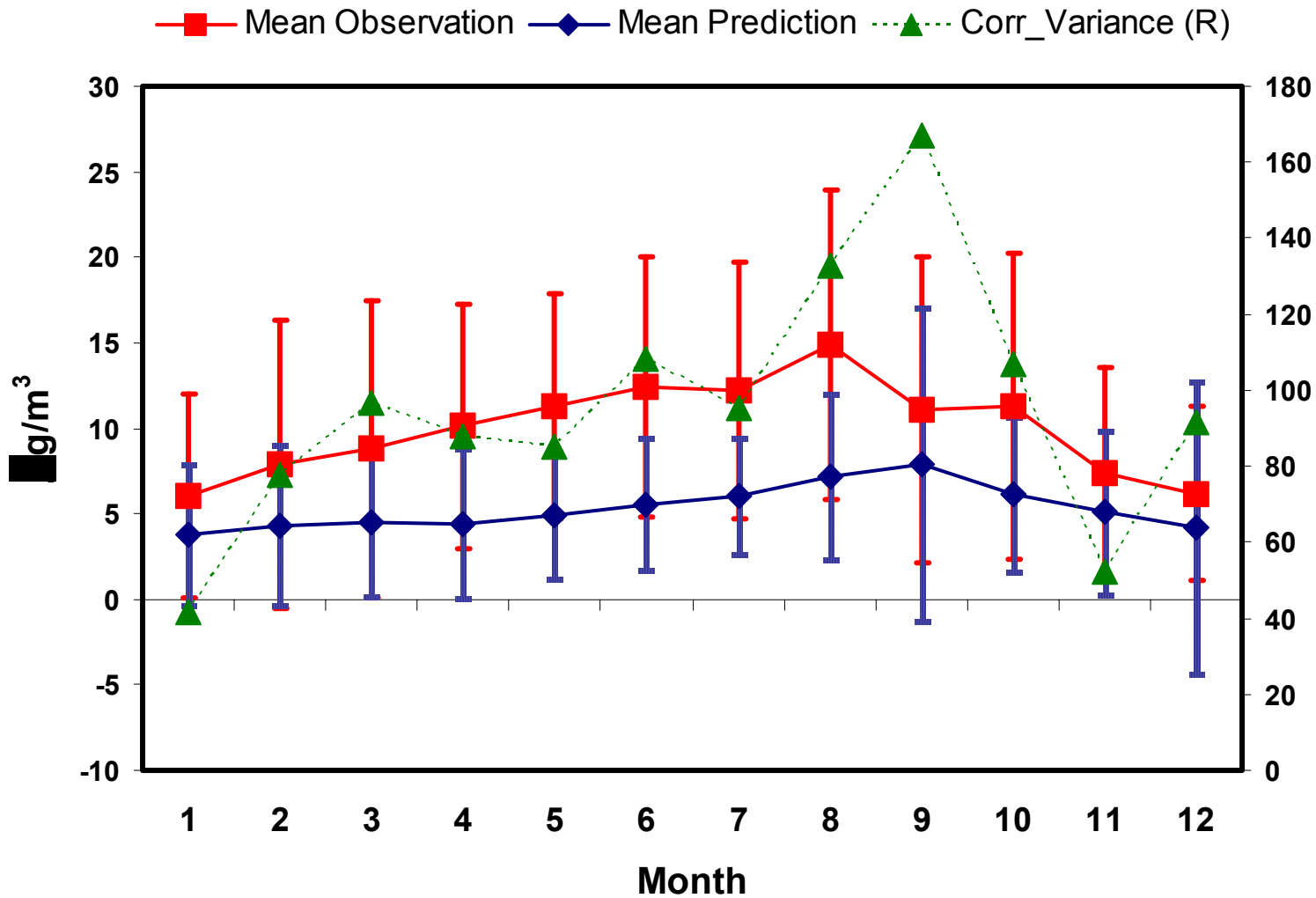
PM25, Monthly Mean Conc. with SD



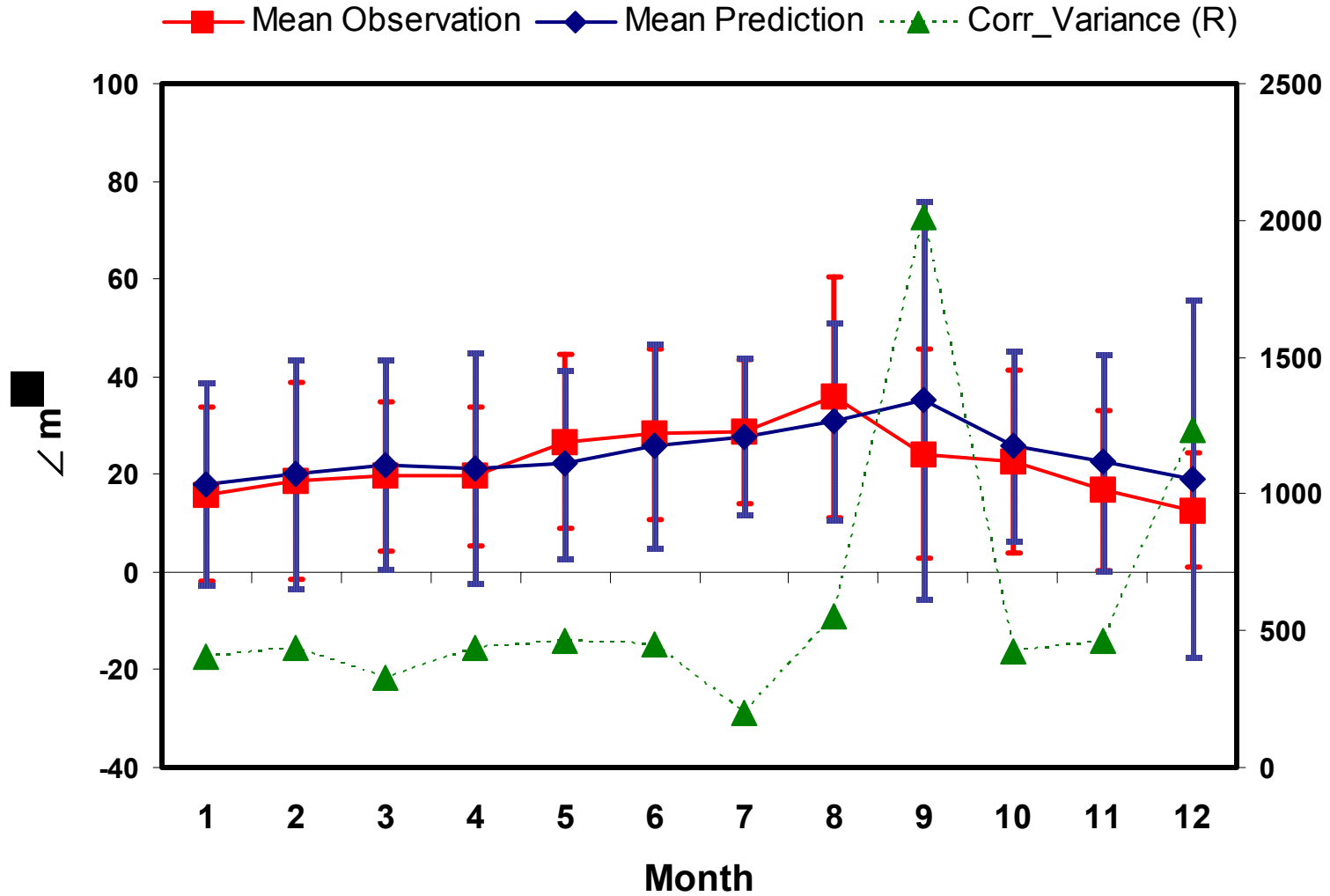
RCFM, Monthly Mean Conc. with SD



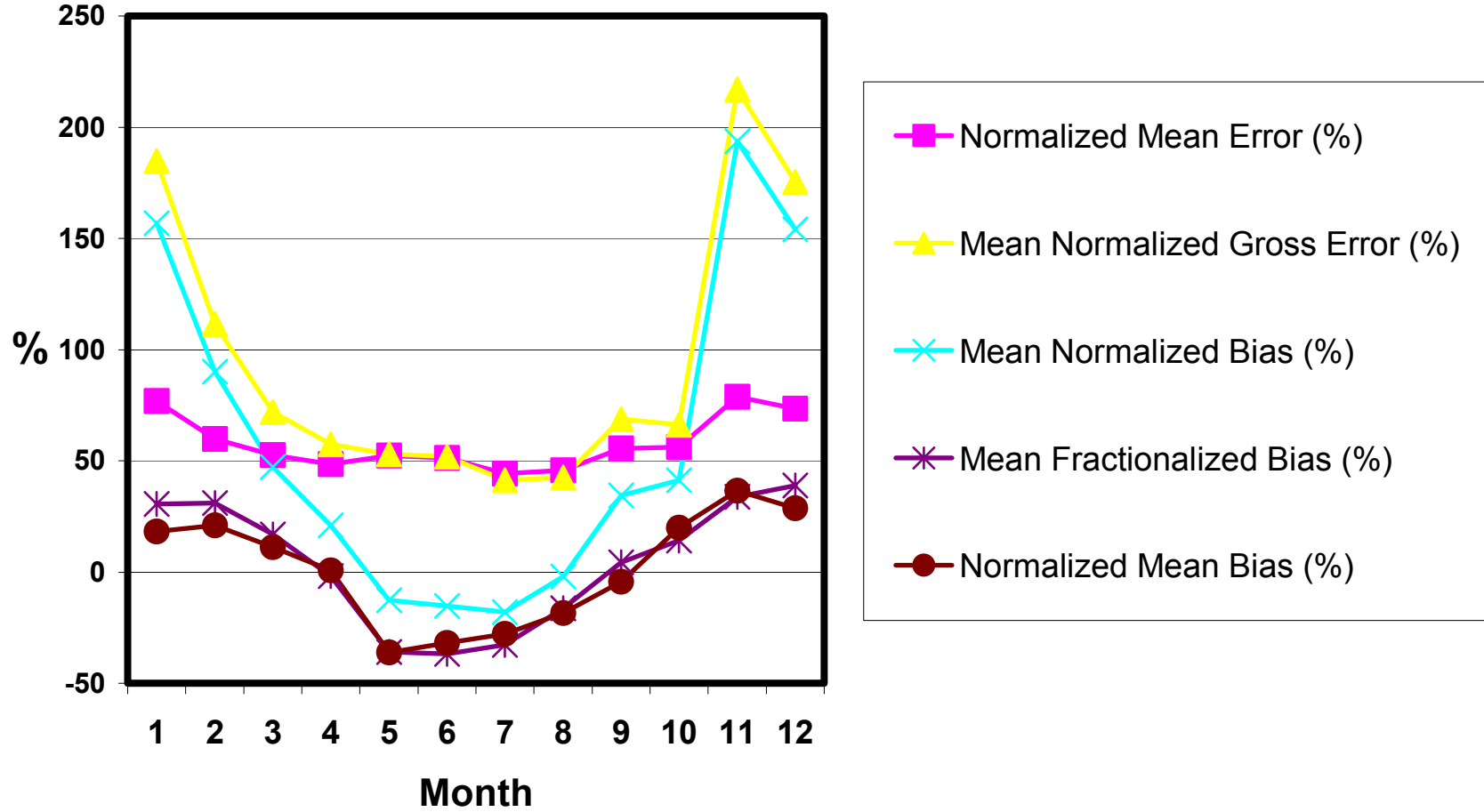
PM10, Monthly Mean Conc. with SD



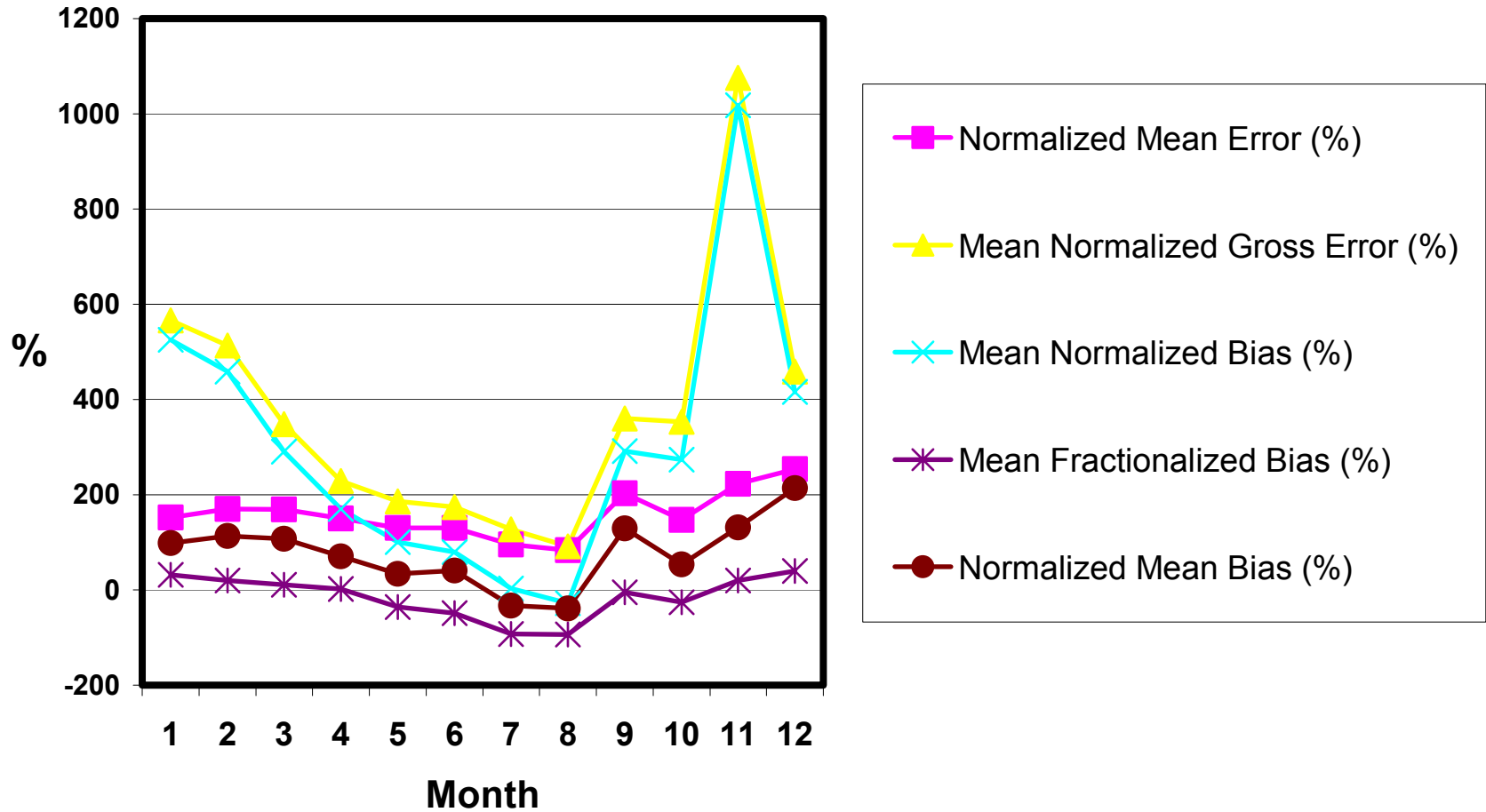
BEXT, Monthly Mean Conc. with SD



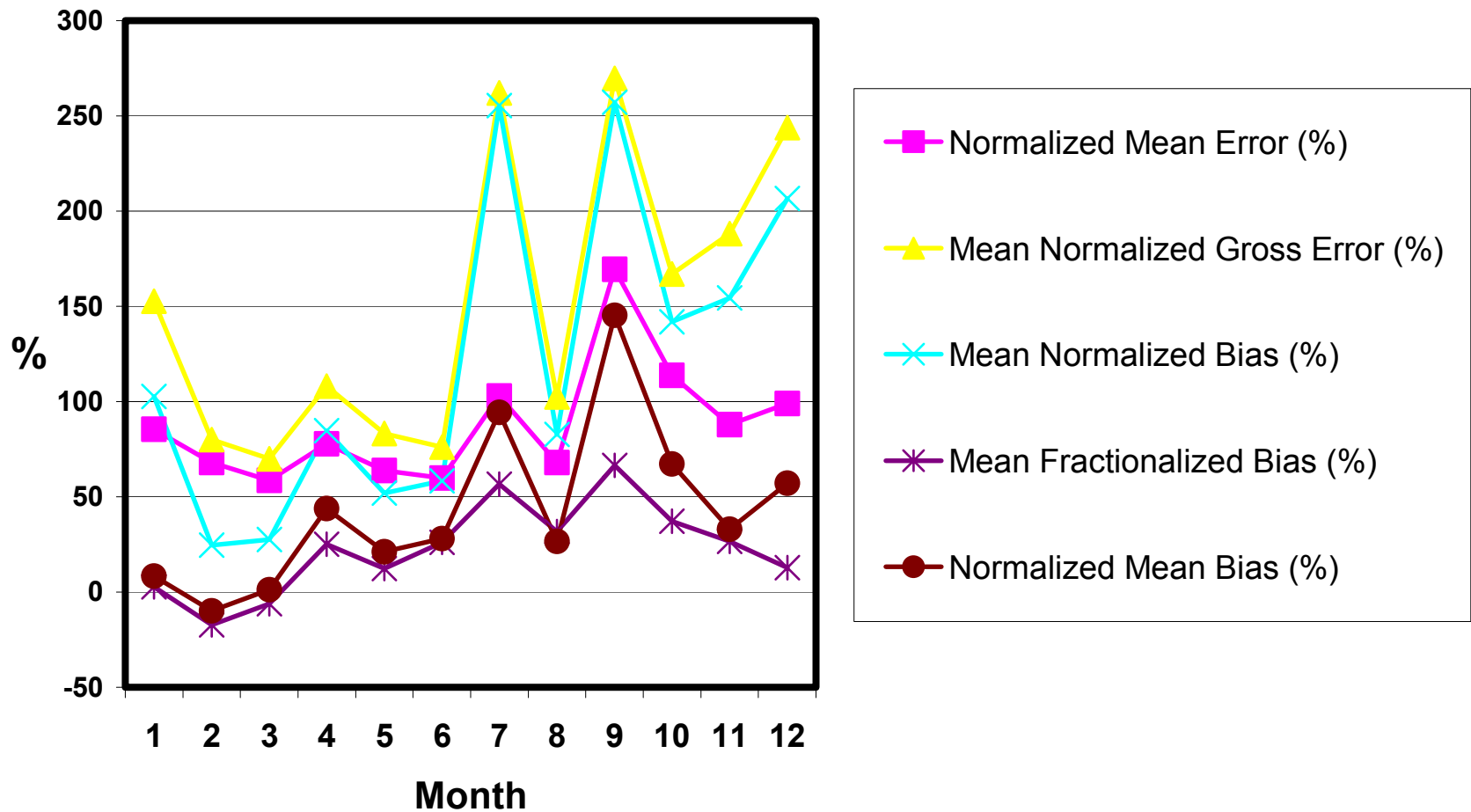
SO4, Monthly Statistical Measures



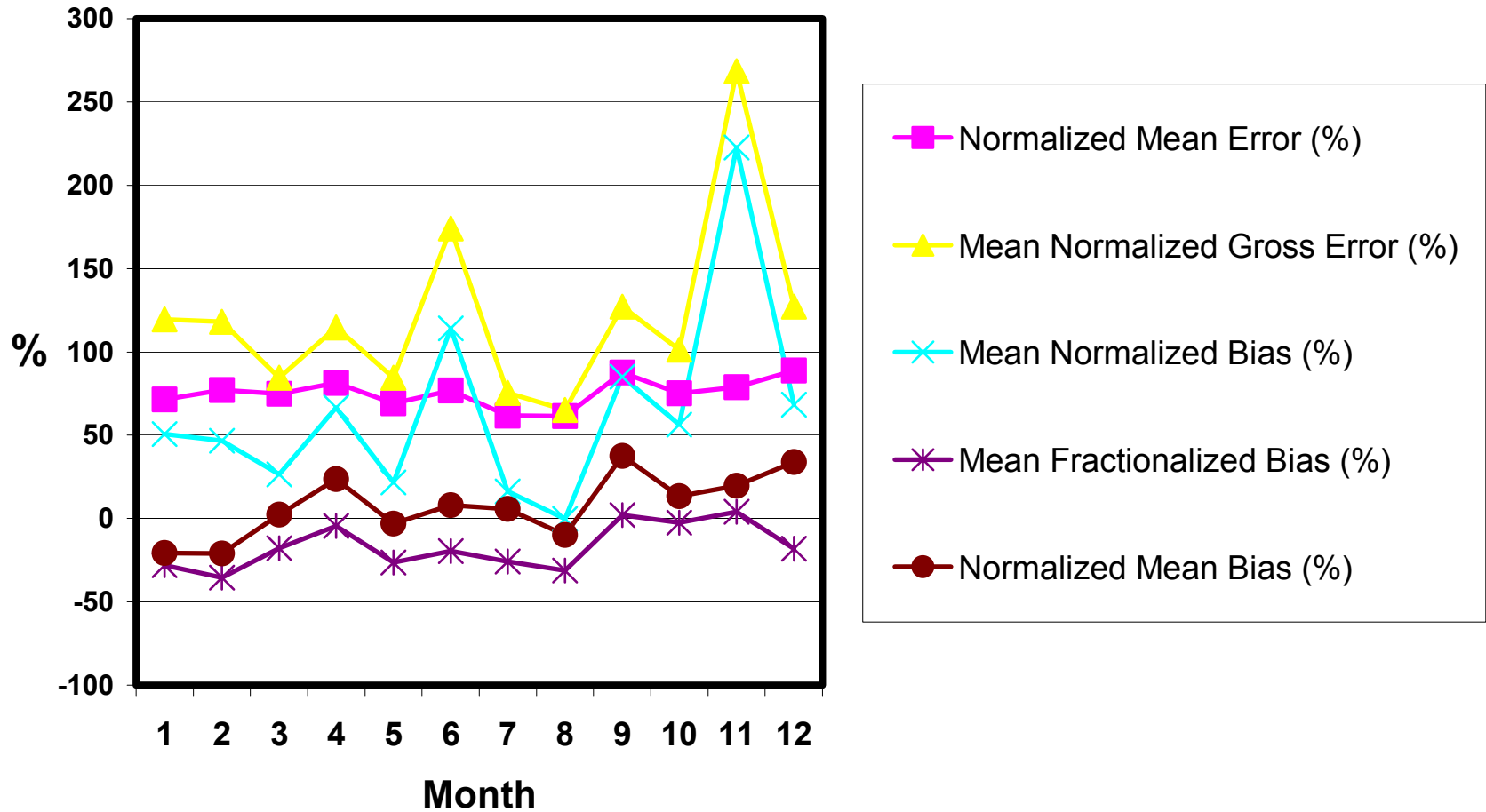
NO3, Monthly Statistical Measures



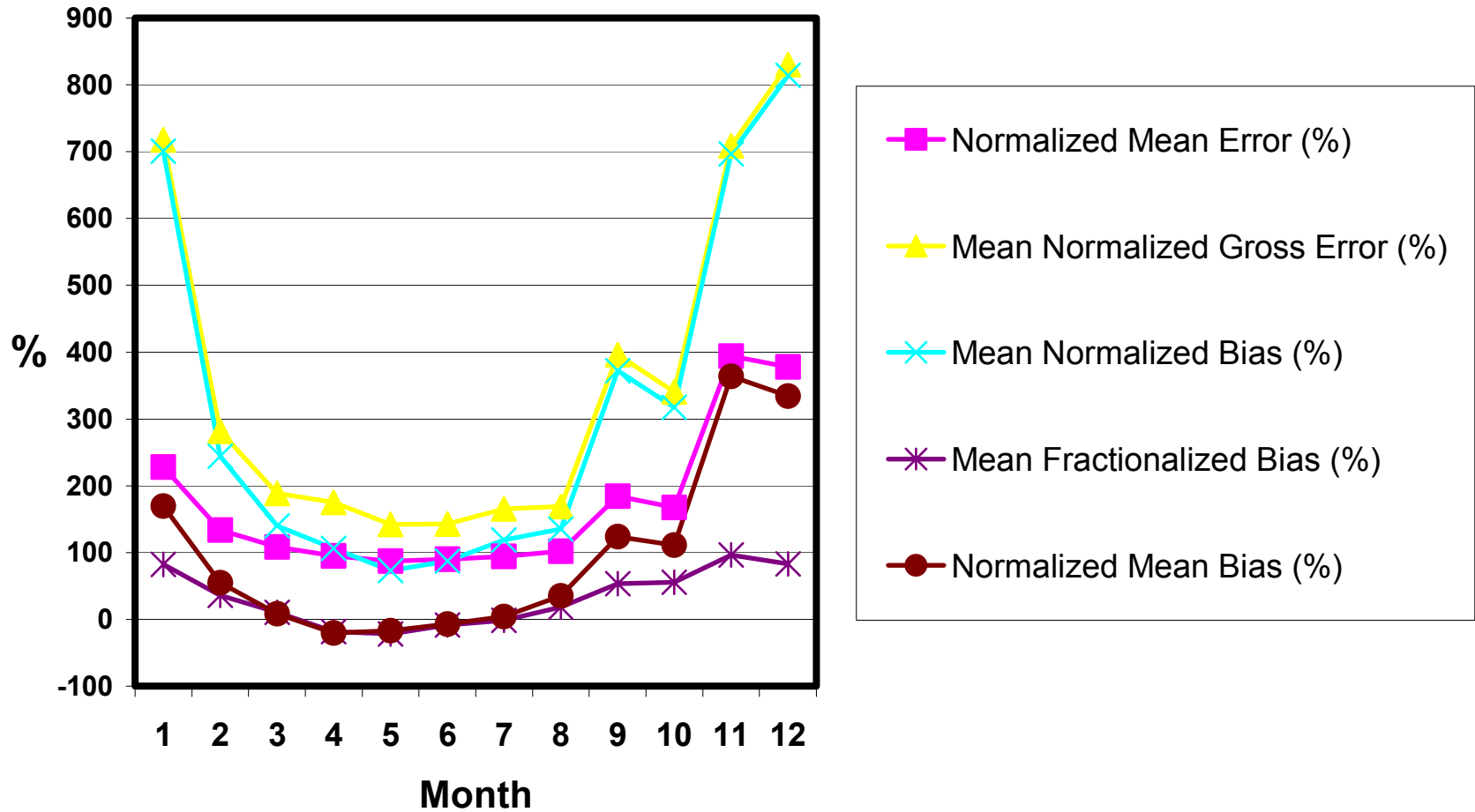
OC, Monthly Statistical Measures



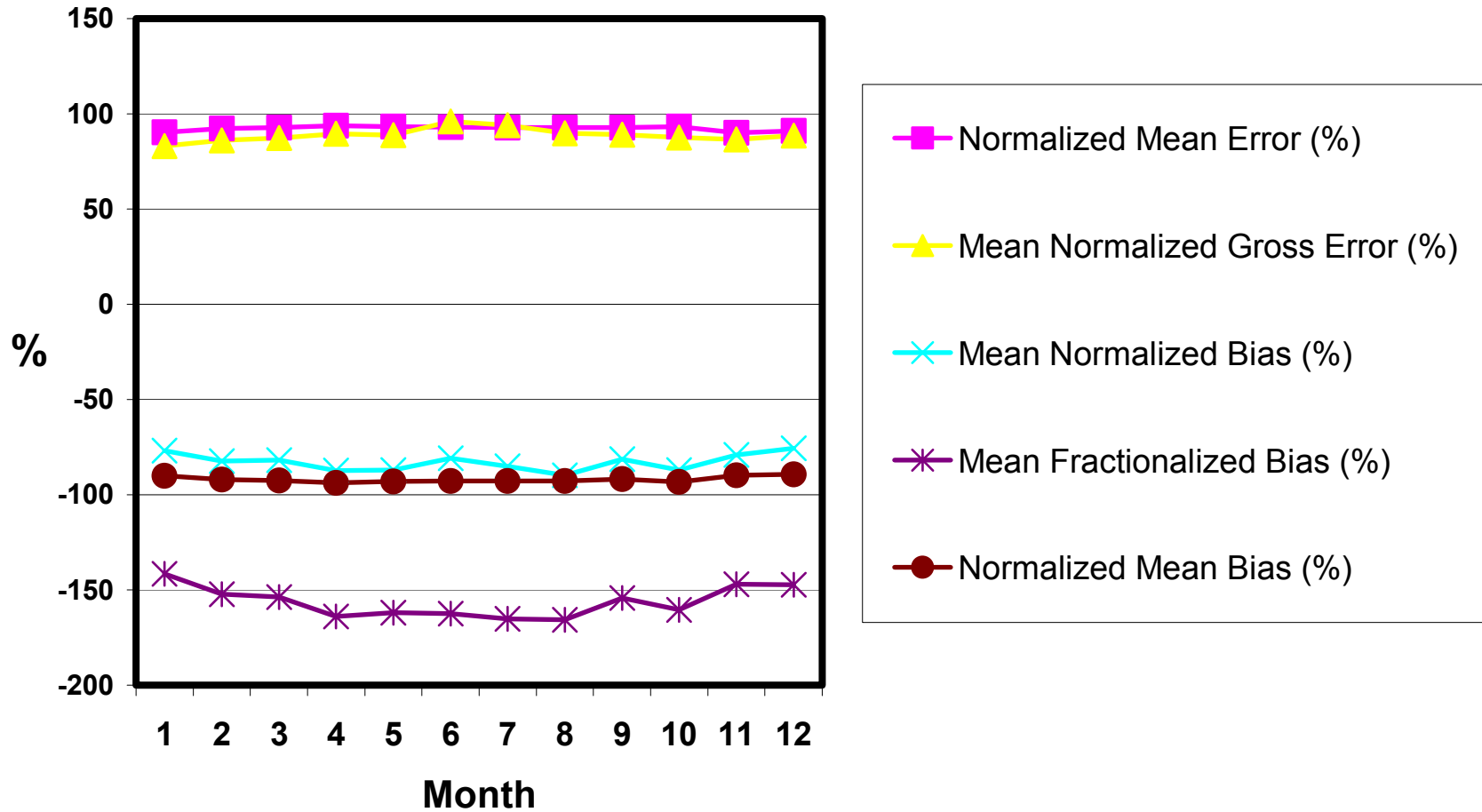
EC, Monthly Statistical Measures



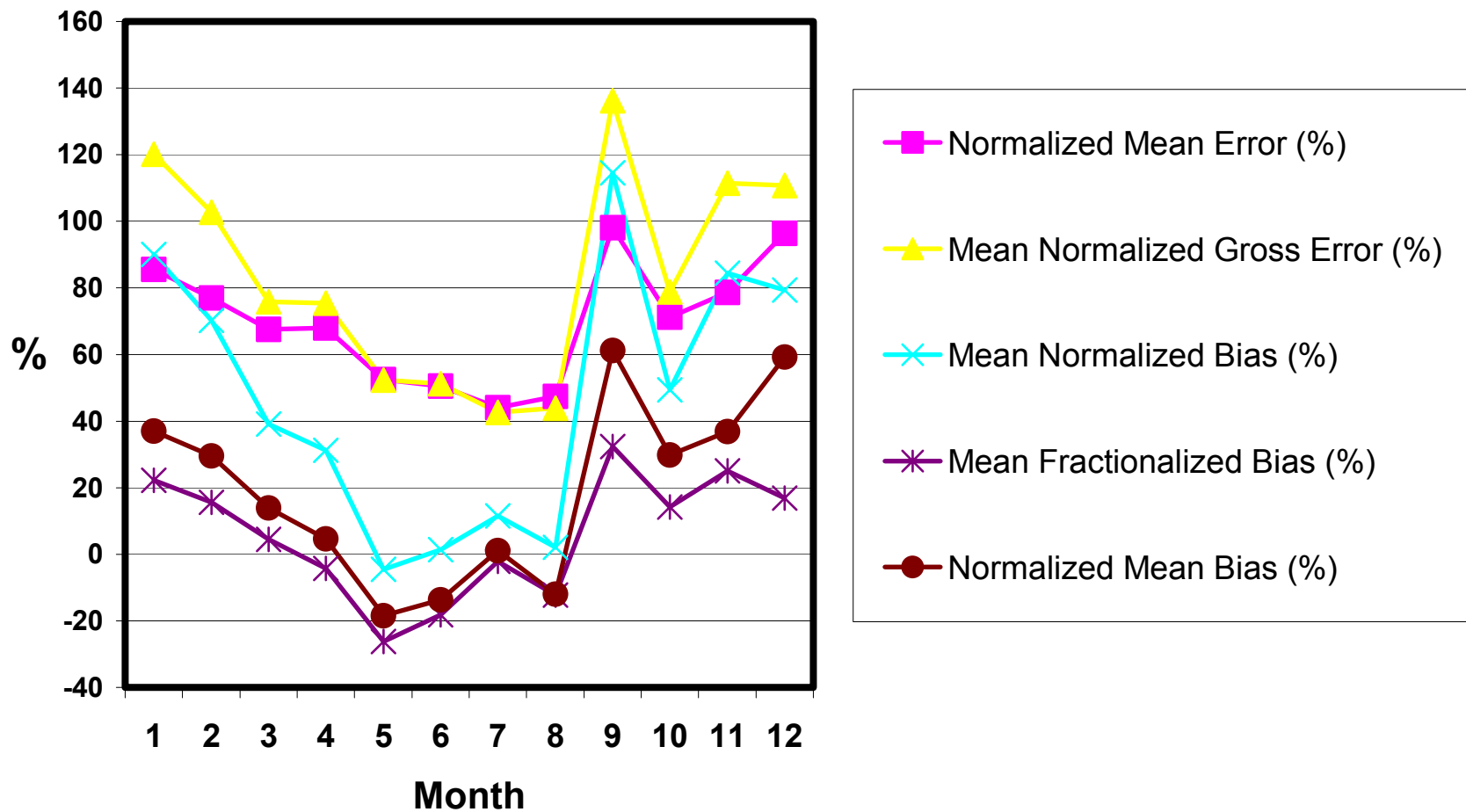
SOIL, Monthly Statistical Measures



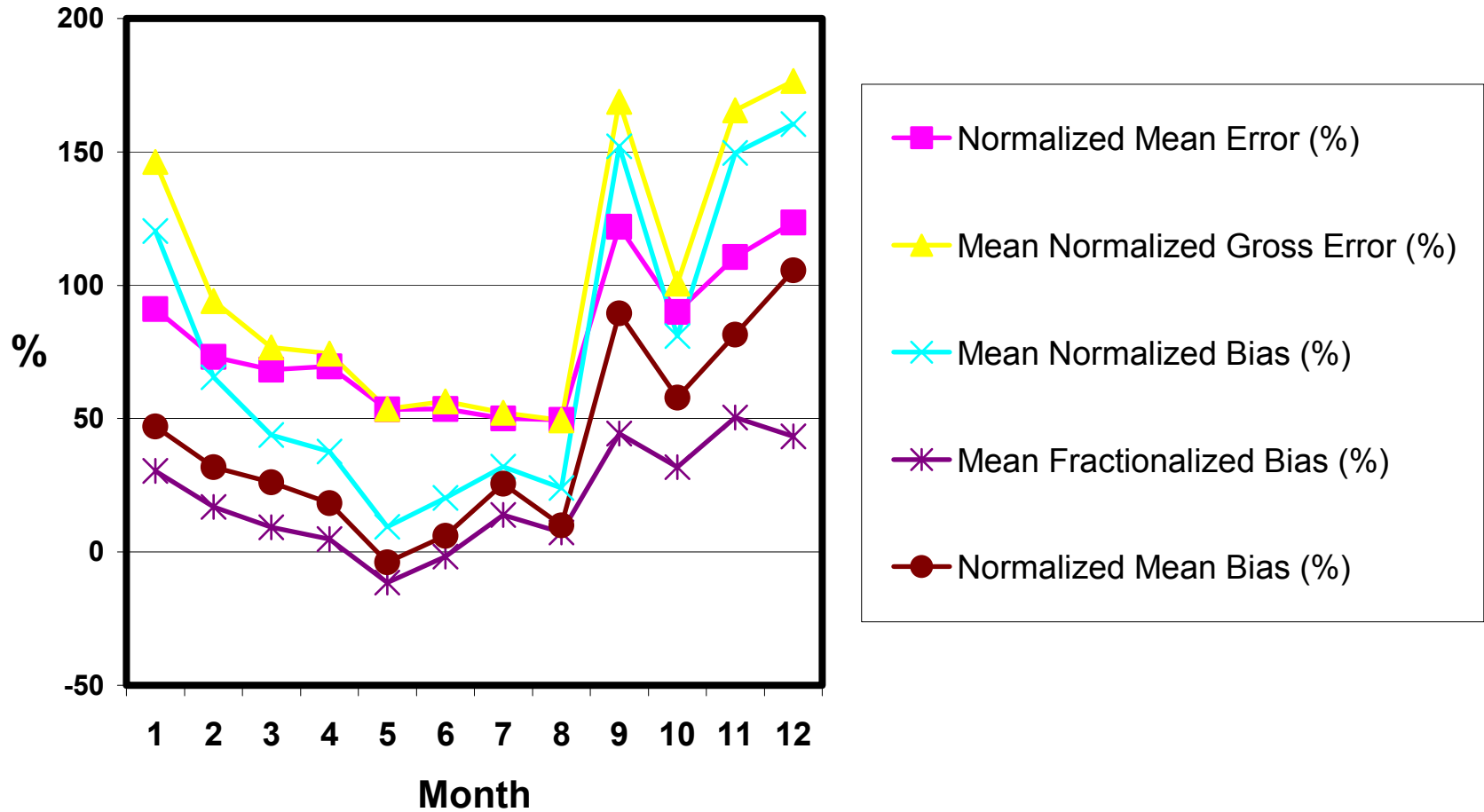
CM, Monthly Statistical Measures



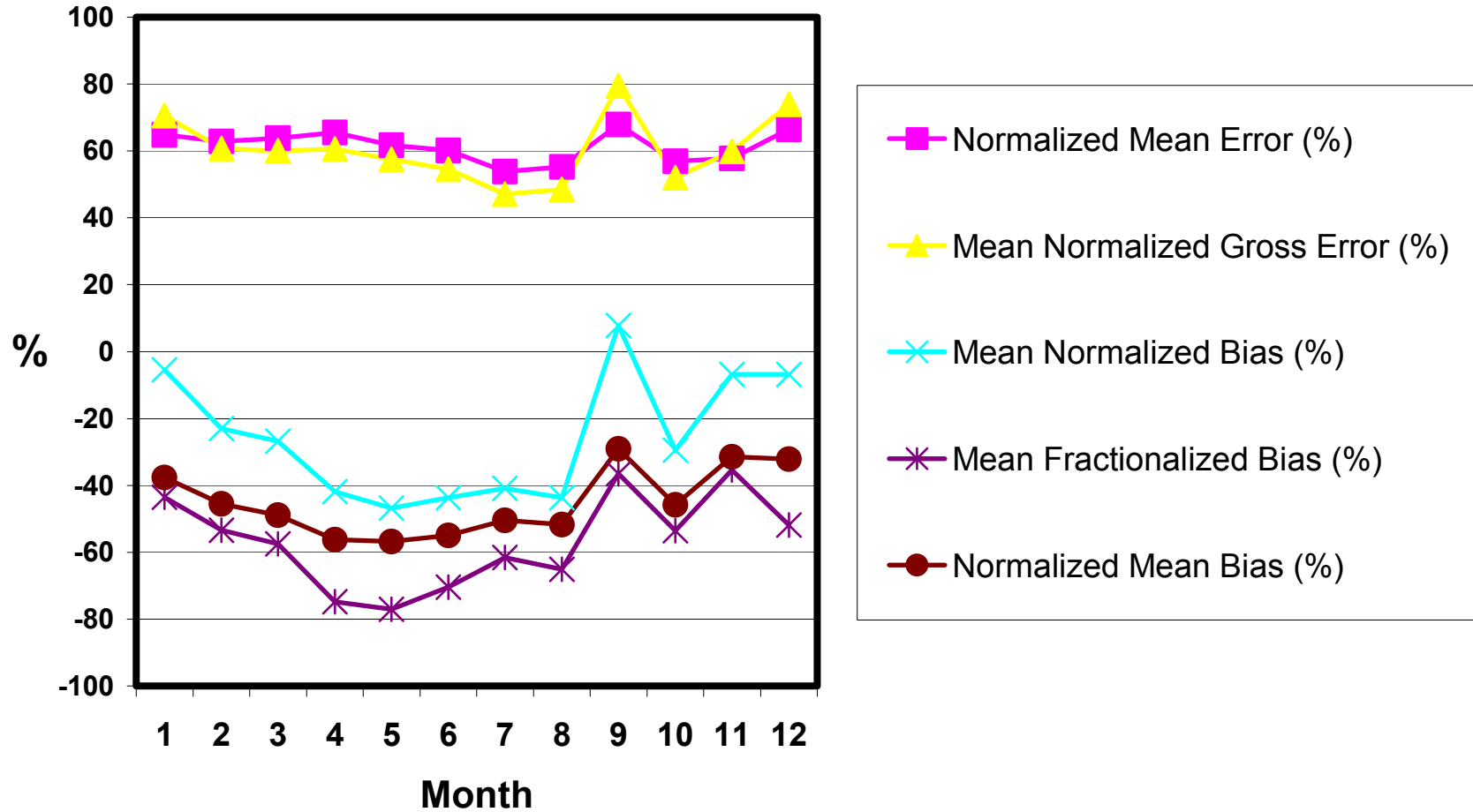
PM25, Monthly Statistical Measures



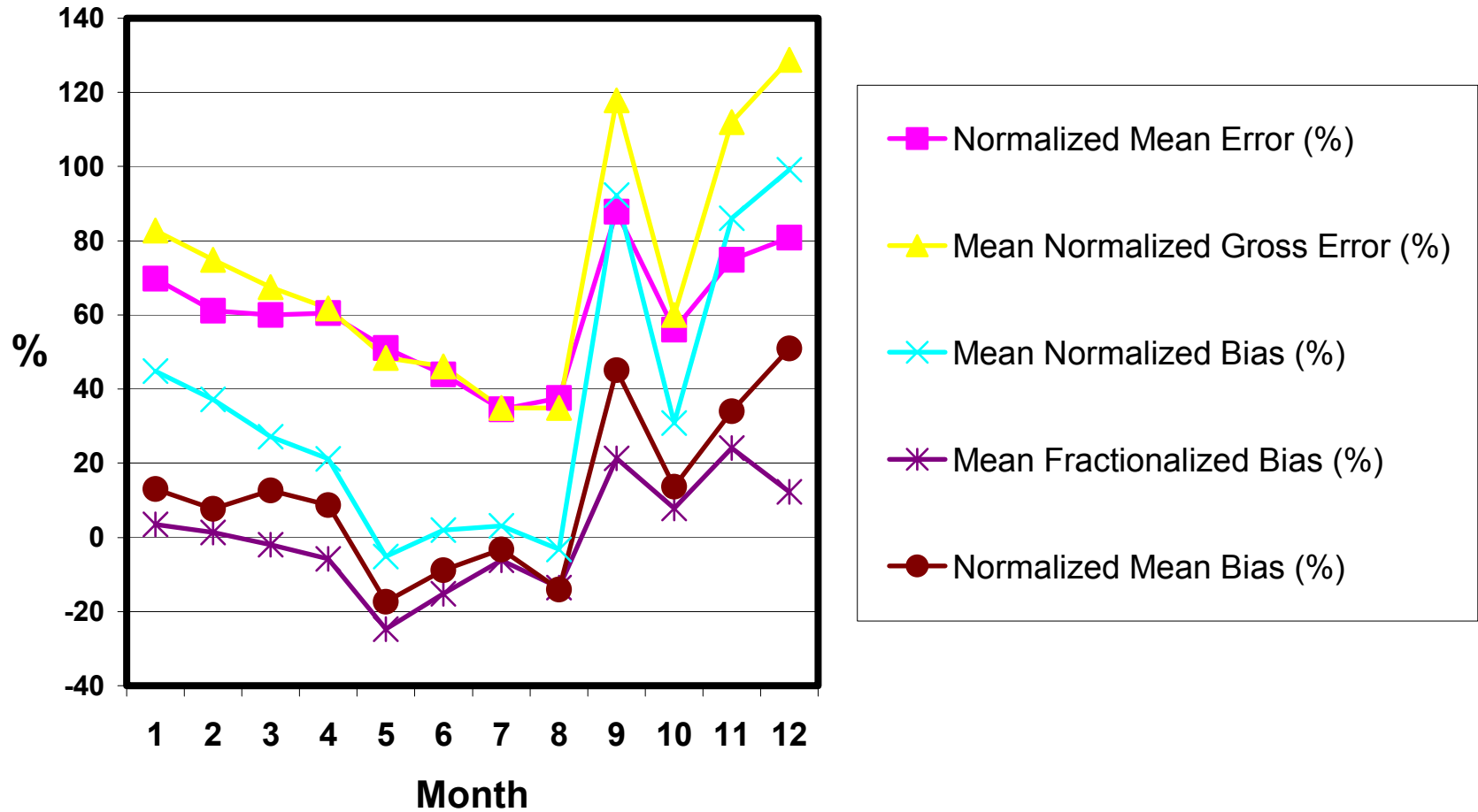
RCFM, Monthly Statistical Measures



PM10, Monthly Statistical Measures

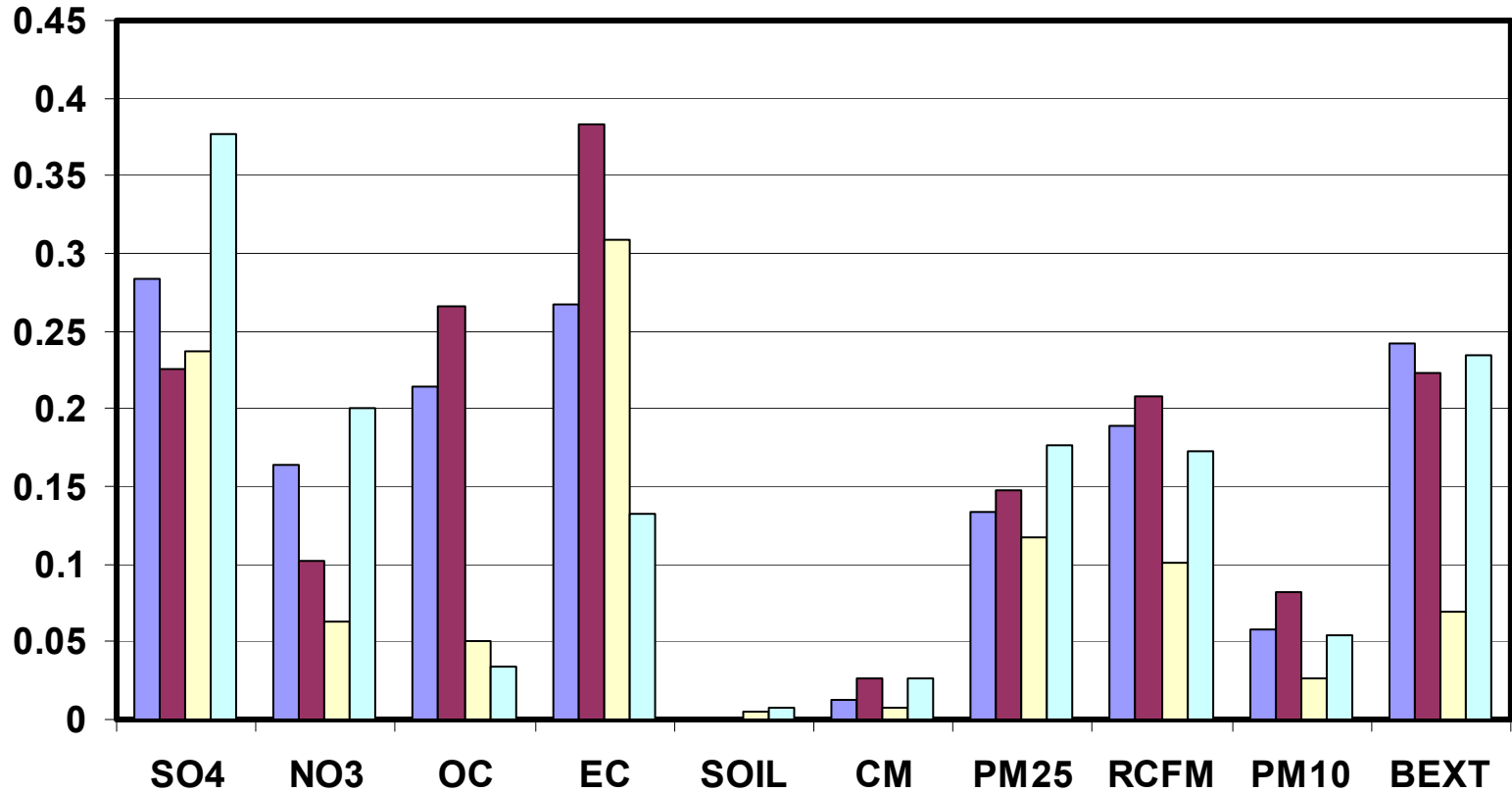


BEXT, Monthly Statistical Measures

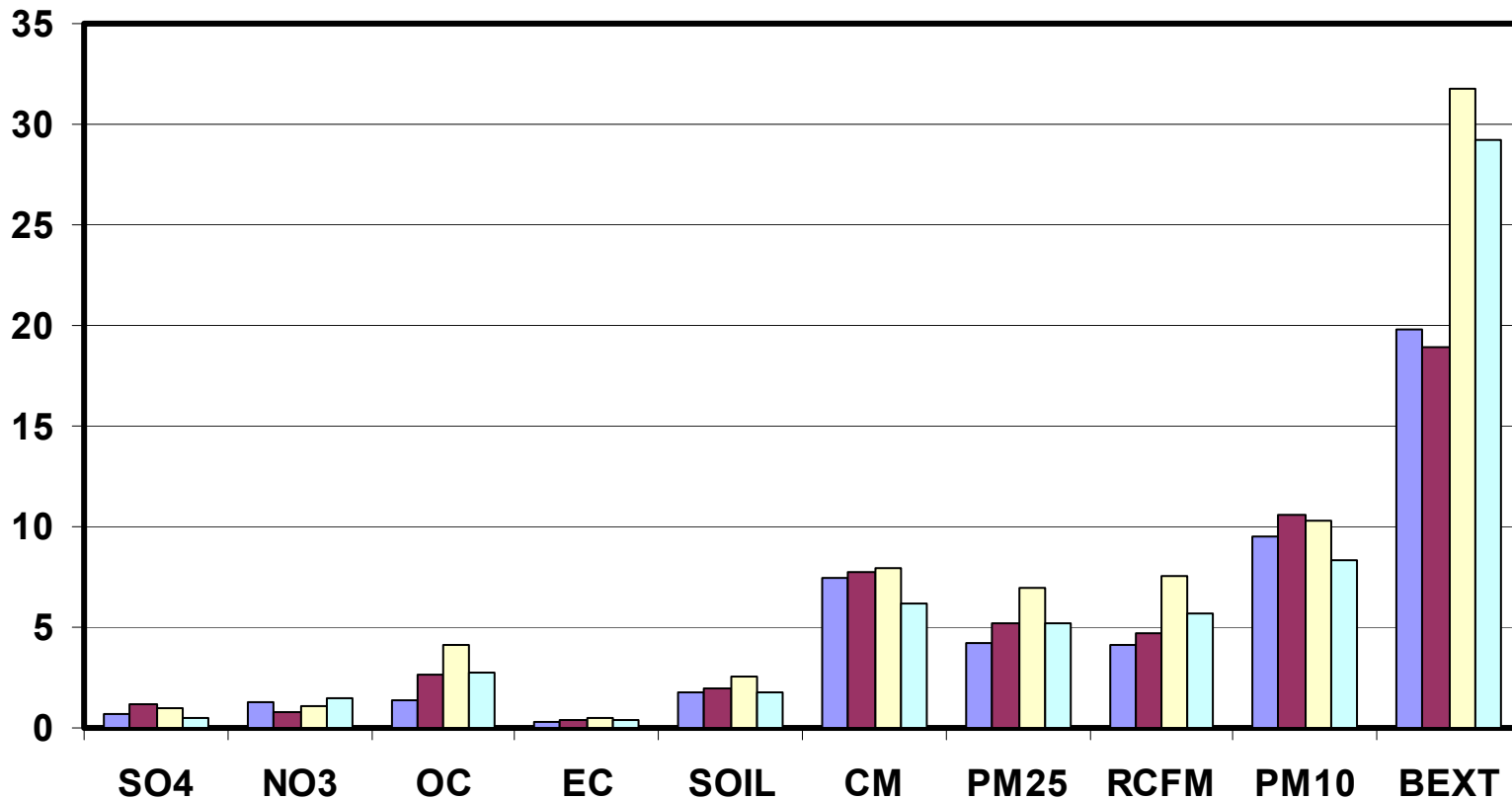


Seasonal Results

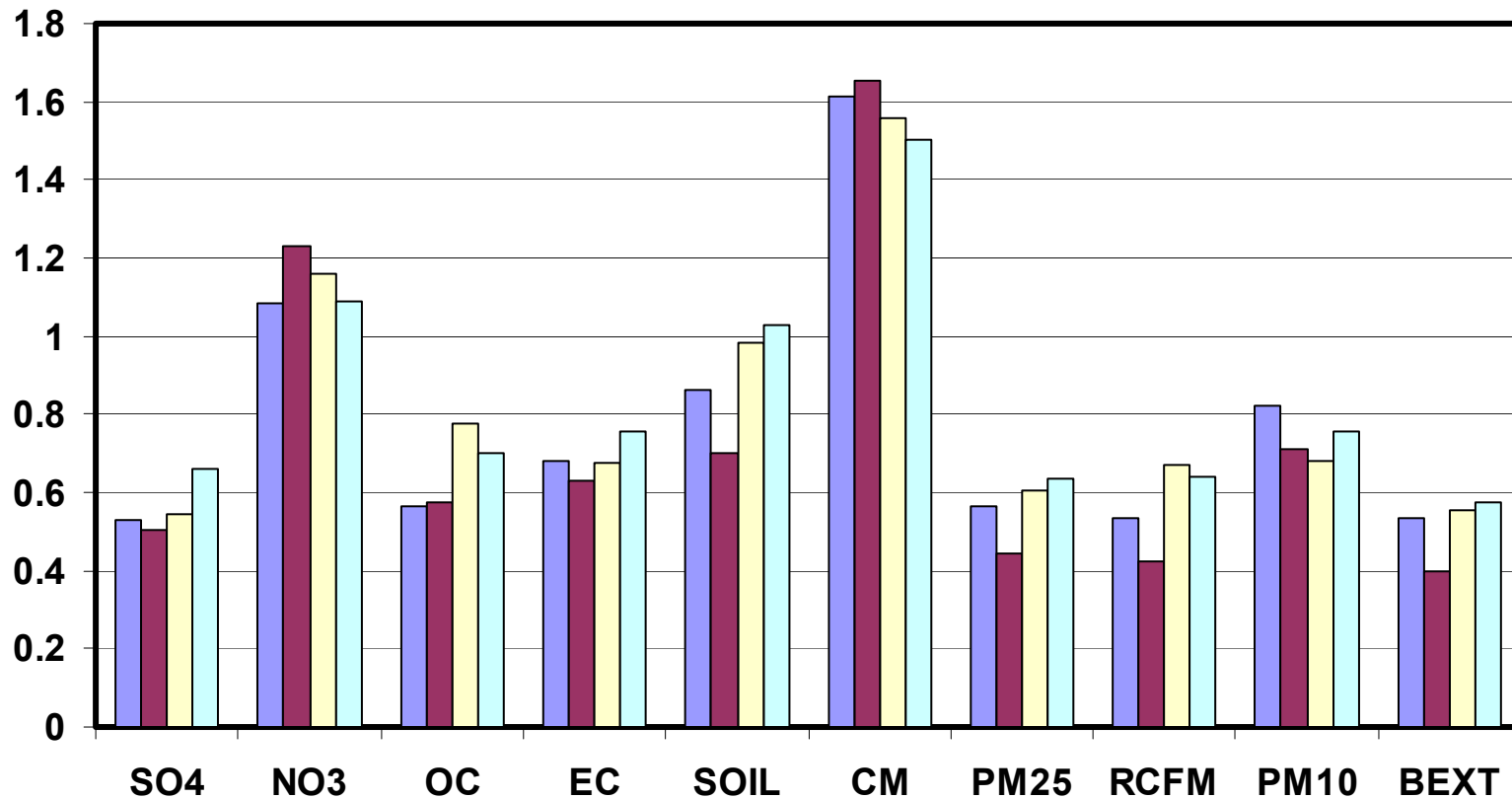
Coefficient of Determination



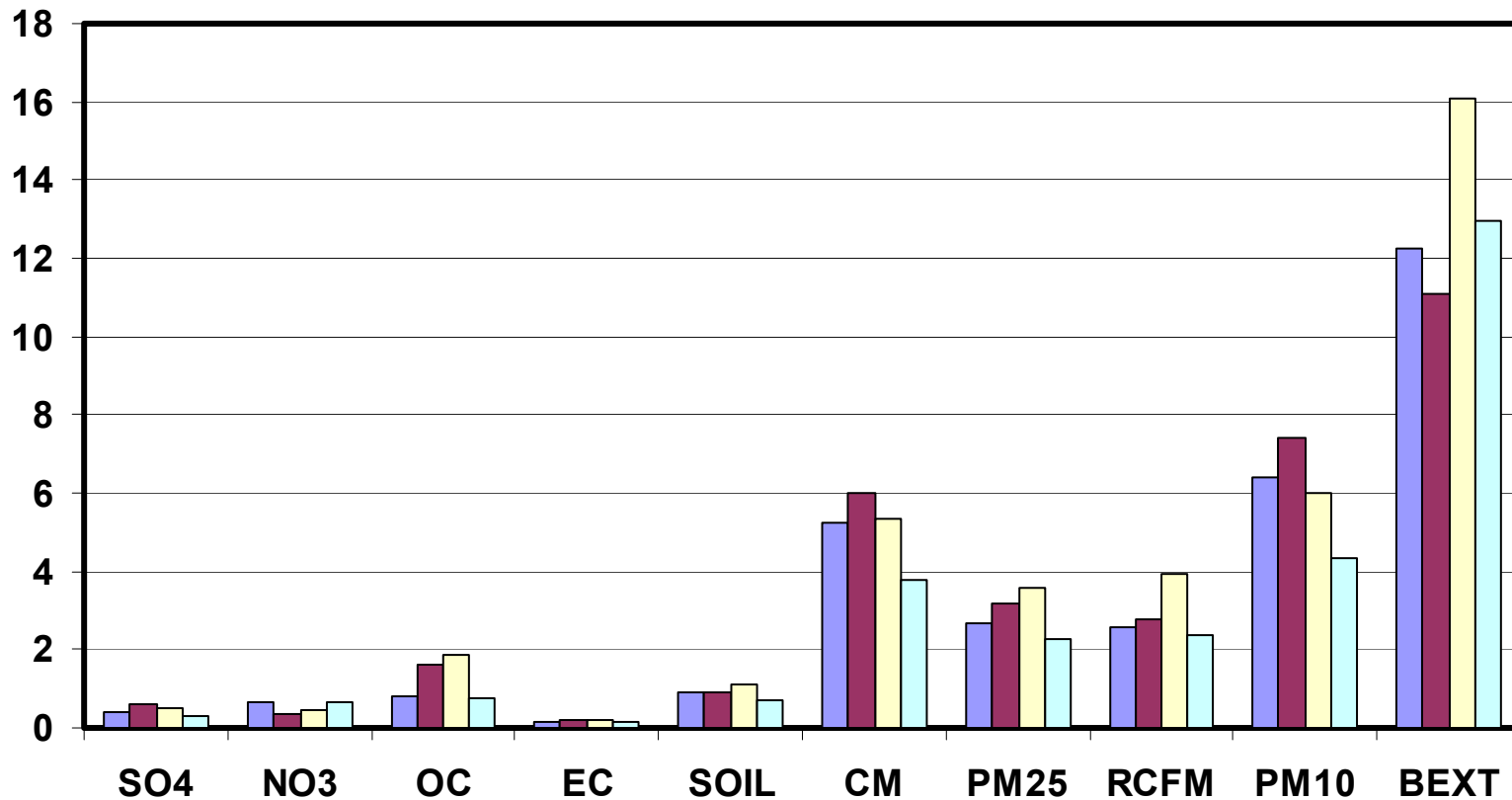
Root Mean Square Error



Fractional Gross Error



Mean Absolute Gross Error



Mean Bias

