Appendix E

Additional Model Evaluation Summaries

This appendix provides additional information on the operational model performance evaluation of the HAPs simulated for this 2017 AirToxScreen. The model evaluation included both the hybrid air toxics and non-hybrid air toxics. The hybrid evaluation compared the HAPs for which there are valid ambient data (i.e., completeness criteria protocol) to compare against CMAQ, AERMOD and the hybrid model predictions. Likewise, the HAP non-hybrid evaluation used similar observational completeness criteria constraints to compare against HAPs estimated by adding AERMOD to remote ambient concentrations (where available) that are assumed to reflect background conditions. It should be noted when pairing observed to model data there are spatial scale differences between CMAQ, AERMOD and the hybrid model predictions. A CMAQ concentration represents a 12-km grid-cell volume-averaged value. The AERMOD model concentration represents a specific point within the modeled domain. The hybrid model concentration combines the AERMOD point concentration gradients with the 12-km CMAQ grid-cell volume average. The ambient observed measurements are made at specific spatial locations (latitude/longitude). Several annual graphical presentations and statistics of model performance were calculated and prepared. Graphical presentations include:

1) Box and whisker plots which show the distribution and the bias of the predicted and observed data,

2) Box and whisker plots which show the model-to-monitor ratios, and

3) Regional maps which show the mean bias and error calculated at individual monitoring sites.

E.1 Ambient Monitoring Data Preparation

EPA has created annual average concentrations for year 2017 using data in the Ambient Monitoring Archive for HAPs. These data primarily come from AQS; however, they also come from special studies and various other networks that may not have been included in AQS. All annual averages are in units of micrograms per cubic meter ($\mu g/m^3$) using local meteorological data where available or standard conditions otherwise. An annual average is created for each unique pollutant/monitoring site/sampling duration used the following procedures:

1) There must be at least 3 valid quarters of monitoring data for the year. A quarter is considered valid if it contains at least 7 daily averages.

2) Hourly monitoring data are averaged to daily (and sub hourly data are averaged to hourly) using the following criteria translating to the ceiling of 75% completeness:

Sampling Duration	Averaging To	Minimum Count
5 MINUTES	HOURLY	9
10 MINUTES	HOURLY	5
15 MINUTES	HOURLY	3
30 MINUTES	HOURLY	2
150 MINUTES	DAILY	8
90 MINUTES	DAILY	12
1 HOUR	DAILY	18
2 HOUR	DAILY	9
3 HOURS	DAILY	6
4 HOUR	DAILY	5
5 HOUR	DAILY	4
6 HOUR	DAILY	3
8 HOUR	DAILY	3
12 HOUR	DAILY	2
24 HOURS	DAILY	1

3) The median Regression on Order Statistic (ROS) is the annual average used, requiring at least 80% of daily averages to be above the method detection limit (MDL).

4) Some pollutants were summed to better reflect the AirToxScreen modeled pollutant. This occurred for PAH groups (summed individual PAHs belonging to the PAH groups), xylenes (summed m/p with o-xylene), and 1,3-dichloropropylene (summed cis and trans).

The data used in the model evaluation are provided in the Supplemental Data folder.

E.2 Model Performance Statistics

The Atmospheric Model Evaluation Tool (AMET) was used to conduct the 2017 AirToxScreen HAP evaluation (Appel et al., 2011). There are various statistical metrics available and used by the science community for model performance evaluation. For a robust evaluation, the principal evaluation statistics used to evaluate model performance are based on the following metrics: two bias metrics, mean bias and normalized mean bias; three error metrics, mean error and normalized mean error, root mean square error and correlation coefficient. These metrics are defined below.

Common Variables:

M = predicted concentration
O = observed concentration
X = predicted or observed concentration
σ = standard deviation

I. Mean Bias, Mean Error, and Root Mean Square Error (μg/m3)

Mean Bias = $\frac{1}{n}\sum_{1}^{n}(M-O)$

Mean Error = $\frac{1}{n}\sum_{1}^{n}|M-O|$

Root Mean Square Error = $\sqrt{\frac{\sum_{1}^{n}(M-O)^2}{n}}$

Mean Bias (MB) quantifies the tendency of the model to over- or under-estimate values while **Mean Error (ME)** and **Root Mean Square Error (RMSE)** measure the magnitude of the difference between modeled and observe values regardless of whether the modeled values are higher or lower than observations.

II. Normalized Mean Bias and Error (unitless)

Normalized Mean Bias = $\frac{\sum_{1}^{n}(M-O)}{\sum_{1}^{n}(O)}$

Normalized mean bias (NMB) is used as a normalization to facilitate a range of concentration magnitudes. This statistic averages the difference (model - observed) over the sum of observed values. NMB is a useful model performance indicator because it avoids over inflating the observed range of values, especially at low concentrations.

Normalized Mean Error = $\frac{\sum_{1}^{n}|M-O|}{\sum_{1}^{n}(O)}$

Normalized mean error (NME) is also similar to NMB, where the performance statistic is used as a normalization of the mean error. NME calculates the absolute value of the difference (model - observed) over the sum of observed values.

III. Correlation Coefficient (unitless)

$$\text{Correlation} = \frac{1}{(n-1)}\sum_{1}^{n}\left(\left(\frac{O-\overline{O}}{\sigma_o}\right)*\left(\frac{M-\overline{M}}{\sigma_m}\right)\right)$$

Correlation coefficient (r) provides an indication of the strength of linear relationship and is signed positive or negative based on the slope of the linear regression.

E.3 Hybrid Evaluation

An annual operational model performance evaluation for HAPs used in the hybrid model calculation was conducted in order to estimate the ability of the hybrid model as well as compare to the predictions from the CMAQ and AERMOD modeling systems to replicate the 2017 HAP observed ambient concentrations. Inclusion of all three model results is intended to demonstrate the merged attributes of the hybrid model used for this 2017 AirToxScreen. Statistical assessments of each model versus observed pairs were paired in time and space and aggregated on an annual basis. Table E-1 provides a list of HAPs evaluated in the hybrid model performance evaluation and the number of pairs (based on completeness criteria of observations, Section E.2). Please note that although carbonyl sulfide is listed in the hybrid HAPs that were evaluated, carbonyl sulfide was excluded in the model evaluation given the data uncertainty and sampling. Figure E-1 shows the 2017 HAP monitoring locations. In this section, paired average annual model to monitor site comparisons are presented for the hybrid model along with CMAQ and AERMOD. The annual model performance results for the hybrid HAPs are presented below in Table E-2. Boxplots showing model distribution (units of $\mu g/m^3$) and bias differences (units of $\mu g/m^3$) as compared to ambient observations are presented in this statistical analysis. These boxplots display boxed interquartile ranges of 25^{th} to 75^{th}, along with whiskers from the 5^{th} to 95^{th} quartiles. Also plotted on these boxplots are summary statistics of correlation (r), RMSE, NMB, NME, MB and ME. Another box and whisker plot displaying model-to-monitor ratio comparison for each of the hybrid HAPs is shown in Figure E-88. This model-to-monitor ratio metric is simply the modeled concentration divided by the annual median observed concentration per monitoring site. A model-to monitor ratio close to 1 for a specific HAP at a monitoring site indicates a high level of confidence in the modeling results for that HAP and monitoring site. Similarly, an average model-to-monitor ratio of several monitoring sites closer to 1 can indicate a high level of confidence in the modeling results. In addition, regional spatial maps which show the mean bias and error calculated at individual monitoring sites are shown in this section for certain HAPs.

CMAQ as well as hybrid model predictions of annual formaldehyde, acetaldehyde and benzene showed relatively small to moderate bias and error percentages when compared to observations. AERMOD showed larger biases and errors, these underestimates are expected for secondarily formed HAPs (e.g., -86.1% for acetaldehyde and -87.3% for formaldehyde) given the exclusion of atmospheric chemistry.

Technical issues in the HAPs data consist of (1) uncertainties in monitoring methods; (2) limited measurements in time/space to characterize ambient concentrations ('local in nature'); (3) commensurability issues between measurements and model predictions; (4) emissions and science uncertainty issues may also affect model performance; and (5) limited data for estimating intercontinental transport that effects the estimation of boundary conditions (i.e., boundary estimates for some species are much higher than predicted values inside the domain).

Table E-1. List of hybrid HAPs evaluated

Model Air Toxic	Measured Air Toxic	No. of Sites
Acetonitrile	ACET_NITRILE_24_HOURS	56
Acrolein	ACROLEIN_24_HOURS	28
Acrylonitrile	ACRY_NITRILE_24_HOURS	6
Acetaldehyde	ALD2_24_HOURS	119
Arsenic	ARSENIC_PM10_24_HOURS	39
	ARSENIC_PM25_24_HOURS	271
	ARSENIC_TSP_24_HOURS	51
Benzene	BENZENE_1_HOUR	27
	BENZENE_24_HOURS	245
	BENZENE_5_MINUTES	7
Beryllium	BERYLLIUM_PM10_24_HOURS	33
	BERYLLIUM_TSP_24_HOURS	35
Ethylene dibromide	BR2_C2_12_24_HOURS	10
1,3-Butadiene	BUTADIENE13_1_HOUR	25
	BUTADIENE13_24_HOURS	144
Benzo-a-pyrene	BaP_PM10_24_HOURS	24
Cadmium	CADMIUM_PM10_24_HOURS	39
	CADMIUM_PM25_24_HOURS	136
	CADMIUM_TSP_24_HOURS	49
Carbon tetrachloride	CARBONTET_24_HOURS	227
	CARBONTET_1_HOUR	3
Carbonyl sulfide	CARBSULFIDE_5_MINUTES	7
Chloroform	CHCL3_24_HOURS	209
Vinyl chloride	CL_ETHE_24_HOURS	89
Chlorine	CL2_PM10_24_HOURS	2
	CL2_PM2_5_24_HOURS	291
Ethylene dichloride	CL2_C2_12_24_HOURS	140
Methylene chloride	CL2_ME_24_HOURS	227
	CL2_ME_5_MINUTES	7
Trichloroethylene	CL3_ETHE_24_HOURS	89
1,1,2,2-Tetrachloroethane	CL4_ETHANE_24_HOURS	36
Tetrachloroethylene	CL4_ETHE_24_HOURS	157
	CL4_ETHE_5_MINUTES	7

Model Air Toxic	Measured Air Toxic	No. of Sites
Chromium Compounds (only hexavalent chromium was modeled)	CR_VI_PM10_24_HOURS	19
1,4-Dichlorobenzene(p)	DICL_BENZENE_24_HOURS	102
1,3-Dichloropropene	DICL_PROPENE_24_HOURS	2
Ethyl benzene	ETHYLBENZENE_1_HOUR	27
	ETHYLBENZENE_24_HOURS	222
Formaldehyde	FORM_24_HOURS	119
Hexane	HEXANE_1_HOUR	26
	HEXANE_24_HOURS	125
Lead Compounds	LEAD_PM10_24_HOURS	43
	LEAD_PM25_24_HOURS	286
	LEAD_TSP_24_HOURS	176
Manganese Compounds	MANGANESE_PM10_24_HOURS	43
	MANGANESE_PM25_24_HOURS	289
	MANGANESE_TSP_24_HOURS	75
Methyl chloride	METHCHLORIDE_24_HOURS	196
	METHCHLORIDE_5_MINUTES	7
Naphthalene	NAPHTHALENE_24_HOURS	35
Nickel Compounds	NICKEL_PM10_24_HOURS	40
	NICKEL_PM25_24_HOURS	285
	NICKEL_TSP_24_HOURS	62
Polycyclic Organic Matter	PAH_000E0_24_HOURS	32
Polycyclic Organic Matter	PAH_176E3_24_HOURS	21
Polycyclic Organic Matter	PAH_176E4_24_HOURS	32
Polycyclic Organic Matter	PAH_176E5_24_HOURS	32
Polycyclic Organic Matter	PAH_880E5_24_HOURS	34
Propylene dichloride	PROPYL_DICL_24_HOURS	61
Styrene	STYRENE_1_HOUR	27
	STYRENE_24_HOURS	161
Toluene	TOLUENE_1_HOUR	27
	TOLUENE_24_HOURS	241
Xylene	XYLENE_24_HOURS	222
	XYLENE_1_HOUR	27

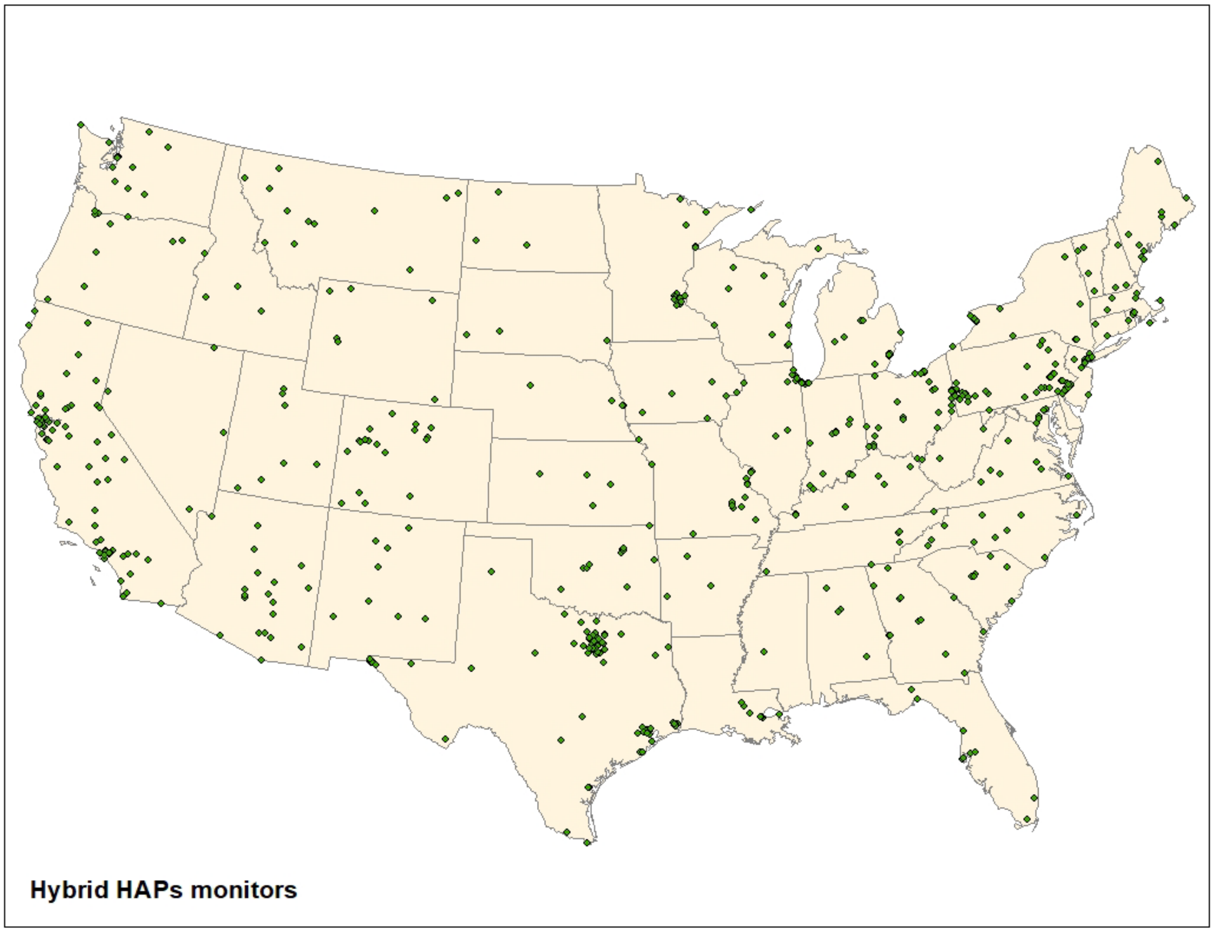


Figure E-1. 2017 monitoring locations for the hybrid HAPs evaluation

Table E-2. 2017 annual air toxics performance statistics for the Hybrid, CMAQ, and AERMOD models

Air Toxic Species	Model	MB (µg/m³)	ME (µg/m³)	NMB (%)	NME (%)
Acetonitrile (ACET_NITRILE_24_HOURS)	Hybrid	-1.1	1.2	-98.5	99.1
	CMAQ	-1.1	1.2	-98.6	99.2
	AERMOD	-1.1	1.2	-99.8	99.8
Acrolein (ACROLEIN _24_HOURS)	Hybrid	-0.6	0.6	-95.1	95.1
	CMAQ	-0.6	0.6	-95.4	95.4
	AERMOD	-0.6	0.6	-96.9	96.9
Acrylonitrile (ALD2_24_HOURS)	Hybrid	-0.1	0.1	-68.7	68.7
	CMAQ	-0.1	0.1	-97.0	97.0
	AERMOD	-0.1	0.1	-82.3	82.3
Acetaldehyde (ALD2_24_HOURS)	Hybrid	-0.4	0.4	-26.5	32.9
	CMAQ	-0.4	0.4	-27.7	33.9
	AERMOD	-1.1	1.1	-86.1	86.3

Air Toxic Species	Model	MB (µg/m³)	ME (µg/m³)	NMB (%)	NME (%)
Arsenic (ARSENIC_PM10_24_HOURS)	Hybrid	0.0	0.0	-83.0	83.0
	CMAQ	0.0	0.0	-85.5	85.5
	AERMOD	0.0	0.0	-85.5	85.5
Arsenic (ARSENIC_PM25_24_HOURS)	Hybrid	0.0	0.0	>100.0	>100.0
	CMAQ	0.0	0.0	82.7	>100.0
	AERMOD	0.0	0.0	65.6	>100.0
Arsenic (ARSENIC_TSP_24_HOURS)	Hybrid	0.0	0.0	-79.1	86.4
	CMAQ	0.0	0.0	-82.9	87.2
	AERMOD	0.0	0.0	-84.6	86.7
Benzene (BENZENE_24_HOURS)	Hybrid	-0.1	0.3	-19.3	46.9
	CMAQ	-0.2	0.3	-31.4	45.4
	AERMOD	-0.3	0.4	-43.8	61.3
Benzene (BENZENE_1_HOUR)	Hybrid	-0.2	0.2	-37.4	39.8
	CMAQ	-0.2	0.2	-38.2	38.6
	AERMOD	-0.3	0.3	-58.7	58.7
Benzene (BENZENE_5_MINUTES)	Hybrid	-0.01	0.1	-7.5	42.3
	CMAQ	-0.1	0.1	-42.2	45.1
	AERMOD	-0.1	0.1	-58.3	85.7
1,3-Butadiene (BUTADIENE13_24_HOURS)	Hybrid	-0.02	0.0	-35.1	59.3
	CMAQ	-0.03	0.0	-46.6	62.8
	AERMOD	-0.01	0.0	-19.7	61.3
1,3-Butadiene (BUTADIENE13_1_HOUR)	Hybrid	-0.1	0.1	-57.0	59.6
	CMAQ	-0.1	0.1	-55.1	56.3
	AERMOD	-0.04	0.04	-42.6	48.7
Beryllium (BERYLLIUM_PM10_24_HOURS)	Hybrid	0.0	0.0	-12.5	>100
	CMAQ	0.0	0.0	-14.3	>100
	AERMOD	0.0	0.0	-1.9	>100
Beryllium (BERYLLIUM_TSP_24_HOURS)	Hybrid	0.0	0.0	-44.6	90.5
	CMAQ	0.0	0.0	-45.2	90.0
	AERMOD	0.0	0.0	-34.6	>100
Ethylene dibromide (BR2_C2_12_24_HOURS)	Hybrid	-0.1	0.1	-100	100
	CMAQ	-0.1	0.1	-100	100
	AERMOD	-0.1	0.1	-100	100
Benzo-a-pyrene (BaP_PM10_24_HOURS)	Hybrid	0.0	0.0	>100	>100
	CMAQ	0.0	0.0	>100	>100
	AERMOD	0.0	0.0	>100	>100
Cadmium (CADMIUM_PM10_24_HOURS)	Hybrid	0.0	0.0	-41.6	69.0
	CMAQ	0.0	0.0	-44.4	75.3
	AERMOD	0.0	0.0	-53.0	83.5
Cadmium (CADMIUM_PM25_24_HOURS)	Hybrid	0.0	0.0	-93.7	93.7
	CMAQ	0.0	0.0	-95.4	95.4
	AERMOD	0.0	0.0	-95.4	95.4

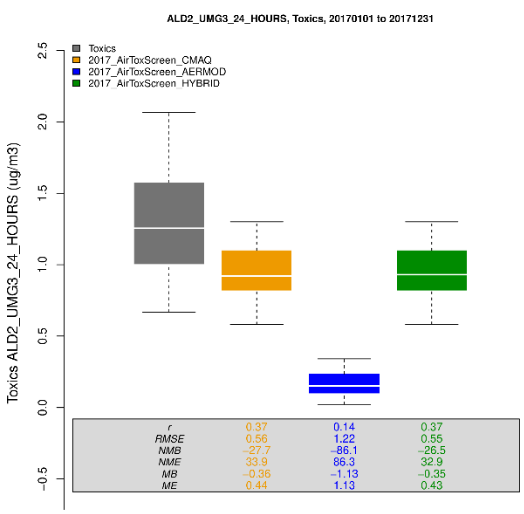
Air Toxic Species	Model	MB (µg/m³)	ME (µg/m³)	NMB (%)	NME (%)
Cadmium (CADMIUM_TSP_24_HOURS)	Hybrid	0.0	0.0	-73.8	75.6
	CMAQ	0.0	0.0	-77.2	78.7
	AERMOD	0.0	0.0	-79.7	80.6
Carbon Tetrachloride (CARBONTET_24_HOURS)	Hybrid	-0.02	0.1	-4.6	10.5
	CMAQ	-0.5	0.5	-99.9	99.9
	AERMOD	-0.5	0.5	-99.9	99.9
Carbon Tetrachloride (CARBONTET_1_HOUR)	Hybrid	-0.1	0.1	-14.3	16.1
	CMAQ	-0.6	0.6	-100	100
	AERMOD	-0.2	0.2	-36.9	38.7
Chloroform (CHCL3_24_HOURS)	Hybrid	0.0	0.1	-2.9	64.4
	CMAQ	-0.04	0.1	-30.3	42.9
	AERMOD	-0.1	0.1	-91.8	93.4
Vinyl Chloride (CL_ETHE_24_HOURS)	Hybrid	0.1	0.1	>100	>100
	CMAQ	0.0	0.1	5.9	>100
	AERMOD	0.1	0.1	>100	>100
Chlorine (CL2_PM10_24_HOURS)	Hybrid	-0.1	0.1	-100	100
	CMAQ	-0.1	0.1	-99.8	99.8
	AERMOD	-0.1	0.1	-100	100
Chlorine (CL2_PM2_5_24_HOURS)	Hybrid	-0.02	0.0	-94.7	100
	CMAQ	-0.02	0.0	94.3	99.6
	AERMOD	-0.02	0.0	-95.9	>100
Ethylene Dichloride (CL2_C2_12_24_HOURS)	Hybrid	-0.03	0.1	-42.7	>100
	CMAQ	-0.1	0.1	-93.2	94.0
	AERMOD	-0.02	0.1	-27.9	>100
Methylene Chloride (CL2_ME_24_HOURS)	Hybrid	-0.1	0.2	-35.4	47.7
	CMAQ	-0.2	0.2	-44.1	46.3
	AERMOD	-0.4	0.4	-97.3	97.3
Methylene Chloride (CL2_ME_5_MINUTES)	Hybrid	-0.1	0.1	-30.9	30.9
	CMAQ	-0.1	0.1	-55.4	55.4
	AERMOD	-0.2	0.2	-66.8	66.8
Trichloroethylene (CL3_ETHE_24_HOURS)	Hybrid	0.0	0.0	17.4	65.3
	CMAQ	0.0	0.0	9.0	67.1
	AERMOD	0.0	0.0	11.1	65.9
1,1,2,2-Tetrachloroethane (CL4_ETHANE_24_HOURS)	Hybrid	-0.1	0.0	-98.2	98.2
	CMAQ	-0.1	0.0	-98.7	98.7
	AERMOD	-0.1	0.0	-98.2	98.2
Tetrachloroethylene (CL4_ETHE_24_HOURS)	Hybrid	-0.03	0.1	-34.5	60.4
	CMAQ	-0.03	0.1	-38.5	60.5
	AERMOD	-0.1	0.1	-53.4	69.9
Tetrachloroethylene (CL4_ETHE_5_MINUTES)	Hybrid	0.0	0.0	-24.1	37.5
	CMAQ	-0.01	0.0	-54.4	54.4
	AERMOD	-0.01	0.0	-66.6	80.0
Chromium Compounds	Hybrid	0.0	0.0	-40.3	>100

Air Toxic Species	Model	MB (µg/m³)	ME (µg/m³)	NMB (%)	NME (%)
(CR_VI_PM10_24_HOURS)	CMAQ	0.0	0.0	-56.7	>100
	AERMOD	0.0	0.0	-29.8	>100
1,4-Dichlorobenzene(p) (DICL_BENZENE_24_HOURS)	Hybrid	-0.3	0.3	-99.5	99.5
	CMAQ	-0.3	0.3	-99.5	99.5
	AERMOD	-0.3	0.3	-99.4	99.4
1,3-Dichloropropene (DICL_PROPENE_24_HOURS)	Hybrid	-0.1	0.1	-100	100
	CMAQ	-0.1	0.1	-100	100
	AERMOD	-0.1	0.1	-100	100
Ethyl benzene (ETHYLBENZENE_24_HOURS)	Hybrid	-0.1	0.2	-46.5	64.3
	CMAQ	-0.1	0.2	-53.7	67.3
	AERMOD	-0.1	0.2	-42.3	60.7
Ethyl benzene (ETHYLBENZENE_1_HOUR)	Hybrid	-0.1	0.1	-32.4	37.0
	CMAQ	-0.1	0.1	-36.5	39.2
	AERMOD	-0.04	0.1	-27.5	34.1
Formaldehyde (FORM_24_HOURS)	Hybrid	-1.2	1.2	-47.3	48.7
	CMAQ	-1.2	1.2	-48.1	49.2
	AERMOD	-2.2	2.2	-87.3	87.3
Hexane (HEXANE_24_HOURS)	Hybrid	-0.3	0.4	-52.3	60.7
	CMAQ	-0.4	0.4	-59.0	66.9
	AERMOD	-0.3	0.4	-50.3	60.2
Hexane (HEXANE_1_HOUR)	Hybrid	-0.5	0.5	-66.3	66.3
	CMAQ	-0.5	0.5	-64.4	64.4
	AERMOD	-0.5	0.5	-60.8	60.8
Lead (LEAD_PM10_24_HOURS)	Hybrid	0.0	0.0	-65.5	66.7
	CMAQ	0.0	0.0	-66.6	66.6
	AERMOD	0.0	0.0	-81.0	81.0
Lead (LEAD_PM25_24_HOURS)	Hybrid	0.0	0.0	-35.5	79.4
	CMAQ	0.0	0.0	-58.1	65.0
	AERMOD	0.0	0.0	-40.7	>100.0
Lead (LEAD_TSP_24_HOURS)	Hybrid	0.0	0.0	5.5	>100.0
	CMAQ	-0.01	0.0	-87.5	88.4
	AERMOD	0.0	0.0	42.4	>100.0
Manganese Compounds (MANGANESE_PM10_24_HOURS)	Hybrid	0.0	0.0	-58.8	89.9
	CMAQ	-0.01	0.0	-84.9	84.9
	AERMOD	-0.01	0.0	-77.4	82.8
Manganese Compounds (MANGANESE _PM25_24_HOURS)	Hybrid	0.0	0.0	-7.5	90.8
	CMAQ	0.0	0.0	-33.4	72.8
	AERMOD	0.0	0.0	-13.8	>100
Manganese Compounds (MANGANESE _TSP_24_HOURS)	Hybrid	-0.03	0.0	-80.8	83.9
	CMAQ	-0.03	0.0	-92.3	92.6
	AERMOD	-0.03	0.0	-86.6	87.6
Methyl Chloride (METHCHLORIDE_24_HOURS)	Hybrid	0.2	0.5	17.5	44.8
	CMAQ	0.1	0.2	5.1	22.2

Air Toxic Species	Model	MB (µg/m³)	ME (µg/m³)	NMB (%)	NME (%)
	AERMOD	-1.1	1.1	-99.5	99.5
Methyl Chloride (METHCHLORIDE_5_MINUTES)	Hybrid	-0.1	0.1	-9.7	11.6
	CMAQ	-0.6	0.6	-50.6	51.1
	AERMOD	-0.7	0.7	-59.3	59.3
Naphthalene (NAPHTHALENE_24_HOURS)	Hybrid	0.0	0.0	30.2	59.1
	CMAQ	0.0	0.0	24.1	57.8
	AERMOD	0.0	0.0	22.0	68.0
Nickel Compounds (NICKEL_PM10_24_HOURS)	Hybrid	0.0	0.0	-11.4	69.6
	CMAQ	0.0	0.0	-13.6	61.3
	AERMOD	0.0	0.0	-26.5	69.5
Nickel Compounds (NICKEL _PM25_24_HOURS)	Hybrid	0.0	0.0	93.4	>100
	CMAQ	0.0	0.0	61.1	>100
	AERMOD	0.0	0.0	53.0	>100
Nickel Compounds (NICKEL _TSP_24_HOURS)	Hybrid	0.0	0.0	-53.5	59.0
	CMAQ	0.0	0.0	-79.9	83.0
	AERMOD	0.0	0.0	-61.6	66.1
Polycyclic Organic Matter (PAH_000E0_24_HOURS)	Hybrid	0.0	0.0	-19.4	65.9
	CMAQ	0.0	0.0	-22.7	65.5
	AERMOD	0.0	0.0	49.4	>100
Polycyclic Organic Matter (PAH_176E3_24_HOURS)	Hybrid	0.0	0.0	>100	>100
	CMAQ	0.0	0.0	>100	>100
	AERMOD	0.0	0.0	-13.2	86.2
Polycyclic Organic Matter (PAH_176E4_24_HOURS)	Hybrid	0.0	0.0	>100	>100
	CMAQ	0.0	0.0	>100	>100
	AERMOD	0.0	0.0	>100	>100
Polycyclic Organic Matter (PAH_176E5_24_HOURS)	Hybrid	0.0	0.0	>100	>100
	CMAQ	0.0	0.0	>100	>100
	AERMOD	0.0	0.0	>100	>100
Polycyclic Organic Matter (PAH_880E5_24_HOURS)	Hybrid	0.0	0.0	75.8	>100
	CMAQ	0.0	0.0	72.1	>100
	AERMOD	0.0	0.0	40.0	100.0
Propylene Dichloride (PROPYL_DICL_24_HOURS)	Hybrid	-0.03	0.0	-97.8	98.6
	CMAQ	-0.03	0.0	-99.5	99.5
	AERMOD	-0.03	0.0	-98.4	98.4
Styrene (STYRENE_24_HOURS)	Hybrid	-0.1	0.1	-99.7	99.7
	CMAQ	-0.1	0.1	-99.7	99.7
	AERMOD	-0.1	0.1	-56.3	91.8
Styrene (STYRENE_1_HOUR)	Hybrid	-0.1	0.1	-98.6	98.6
	CMAQ	-0.1	0.1	-98.9	98.9
	AERMOD	0.0	0.1	36.1	96.4
Toluene (TOLU_24_HOURS)	Hybrid	-0.2	0.5	-17.7	43.2
	CMAQ	-0.3	0.5	-25.8	44.9
	AERMOD	-0.2	0.5	-15.8	43.1

Air Toxic Species	Model	MB (µg/m³)	ME (µg/m³)	NMB (%)	NME (%)
Toluene (TOLU_1_HOUR)	Hybrid	-0.3	0.3	-28.8	32.2
	CMAQ	-0.3	0.3	-30.8	34.7
	AERMOD	-0.3	0.3	-27.4	30.9
Xylene (XYLENE_24_HOURS)	Hybrid	-0.2	0.4	-27.3	57.2
	CMAQ	-0.3	0.4	-37.3	57.5
	AERMOD	-0.1	0.4	-15.4	53.4
Xylene (XYLENE_1_HOUR)	Hybrid	-0.2	0.3	-40.9	44.4
	CMAQ	-0.3	0.3	-43.9	46.6
	AERMOD	-0.2	0.2	-32.6	39.4

(a)



(b)

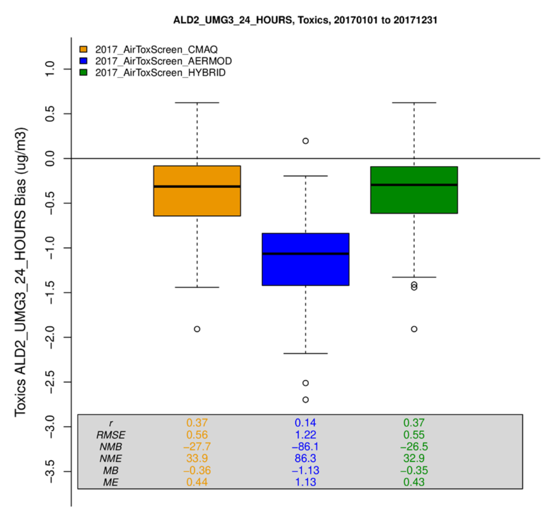


Figure E-2. Acetaldehyde boxplots of (a) distribution (µg/m³) and (b) bias difference (µg/m³) for CMAQ, AERMOD, and Hybrid models compared to ambient observations

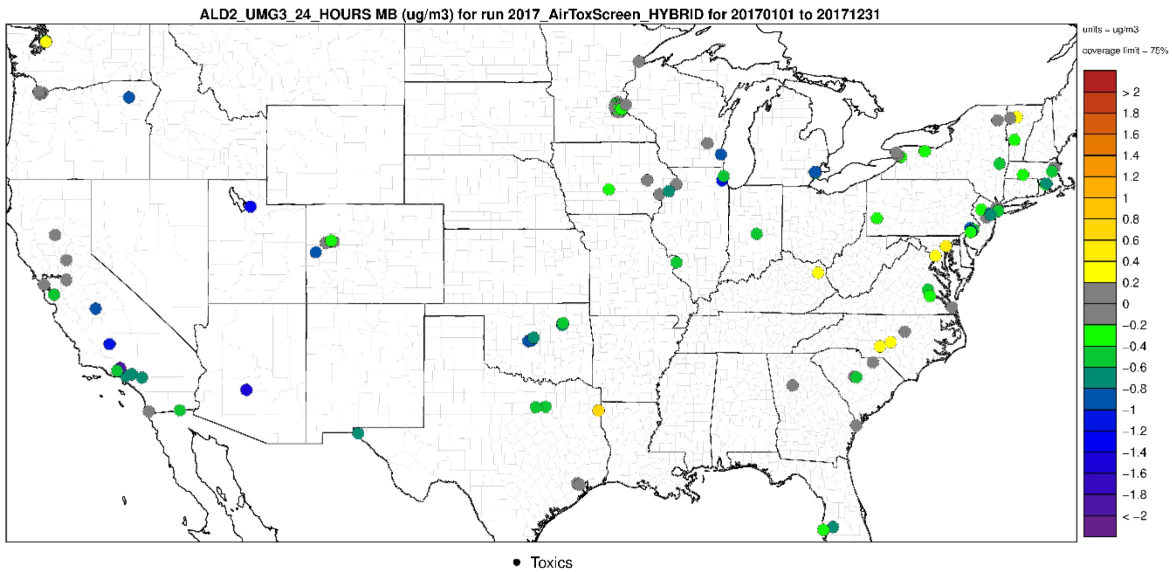


Figure E-3. Mean Bias (%) for acetaldehyde at 2017 monitoring sites in the Hybrid modeling domain

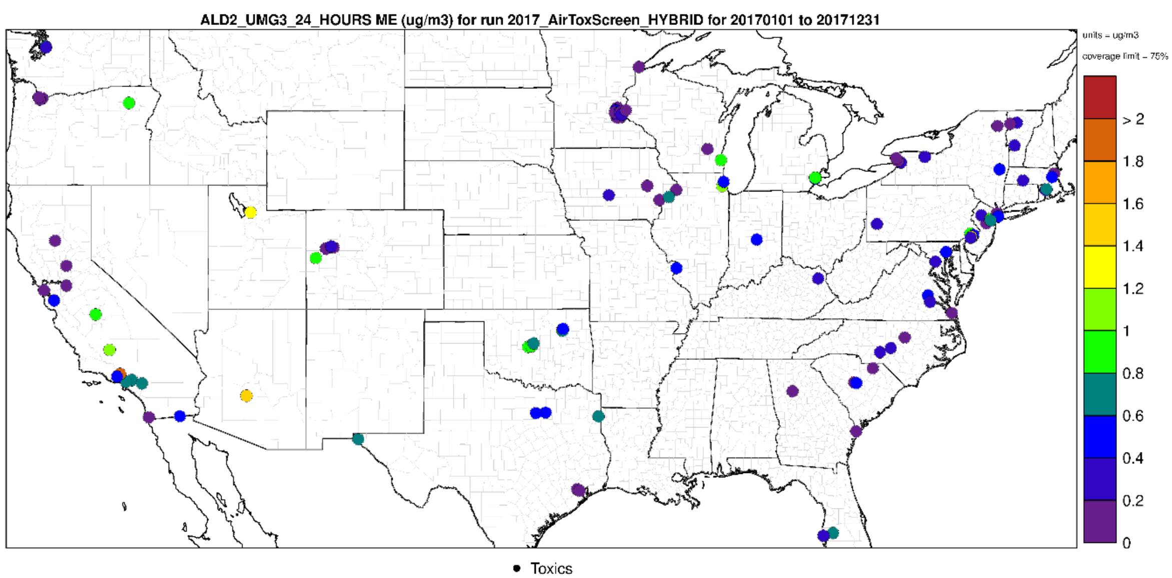


Figure E-4. Mean Error (%) for acetaldehyde at 2017 monitoring sites in the Hybrid modeling domain

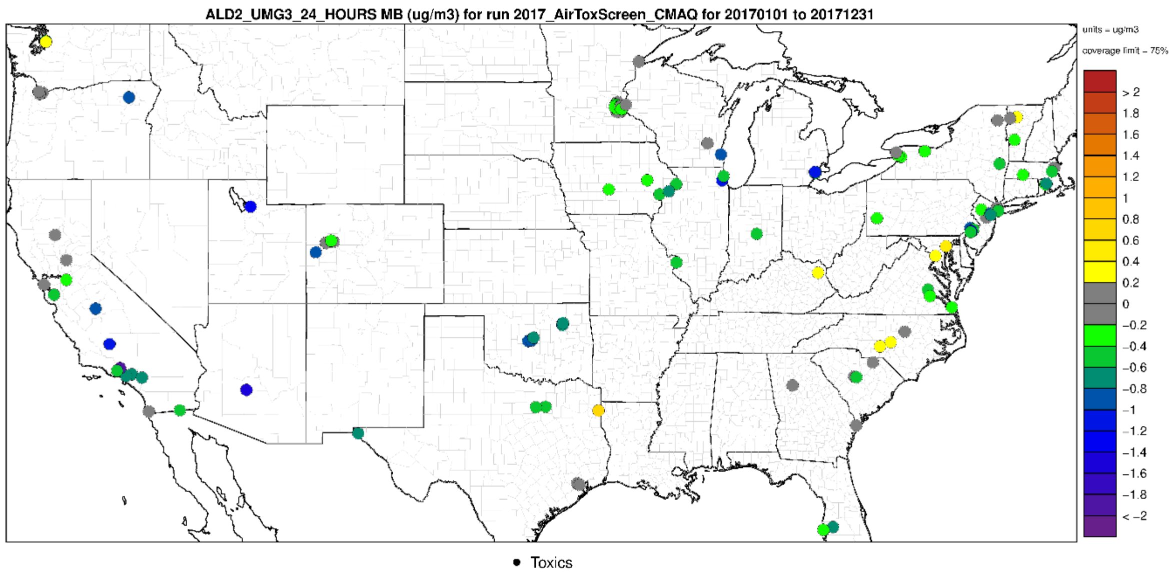


Figure E-5. Mean Bias (%) for acetaldehyde at 2017 monitoring sites in the CMAQ modeling domain

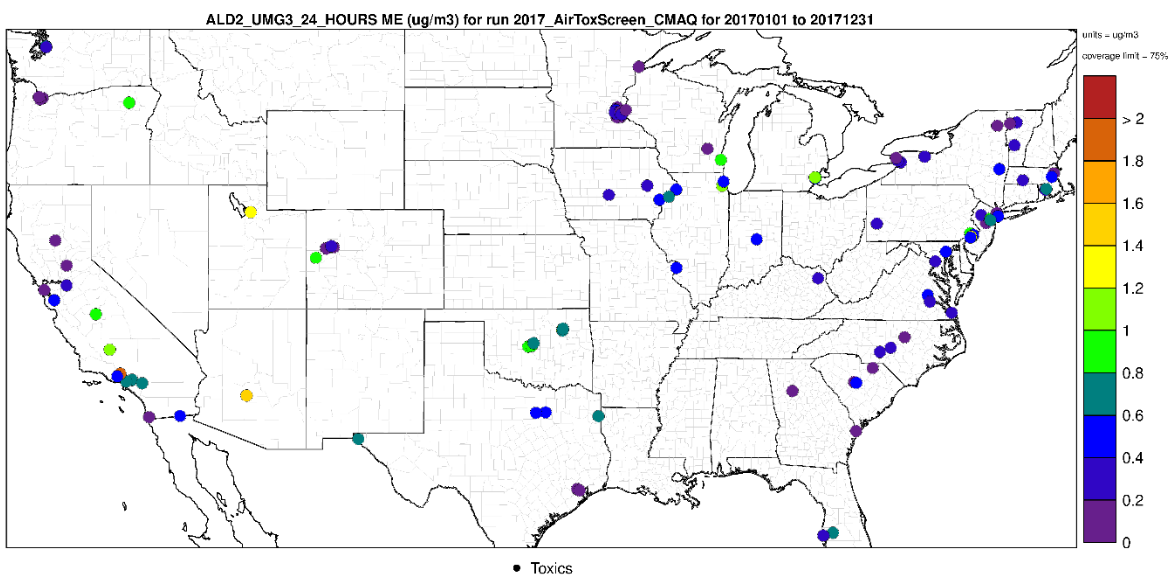


Figure E-6. Mean Error (%) for acetaldehyde at 2017 monitoring sites in the CMAQ modeling domain

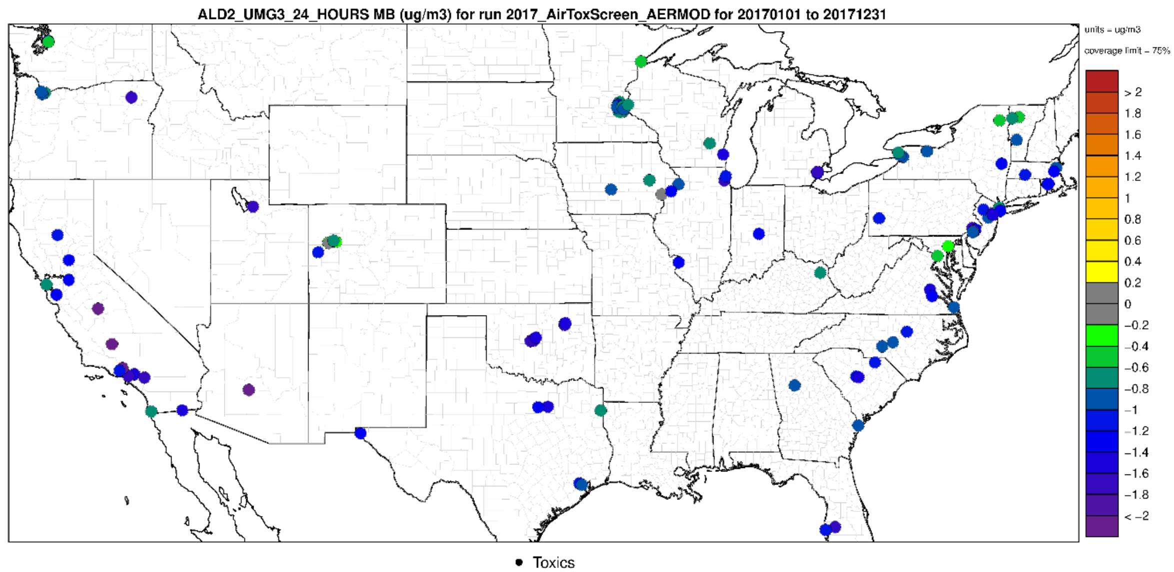


Figure E-7. Mean Bias (%) for acetaldehyde at 2017 monitoring sites in the AERMOD modeling domain

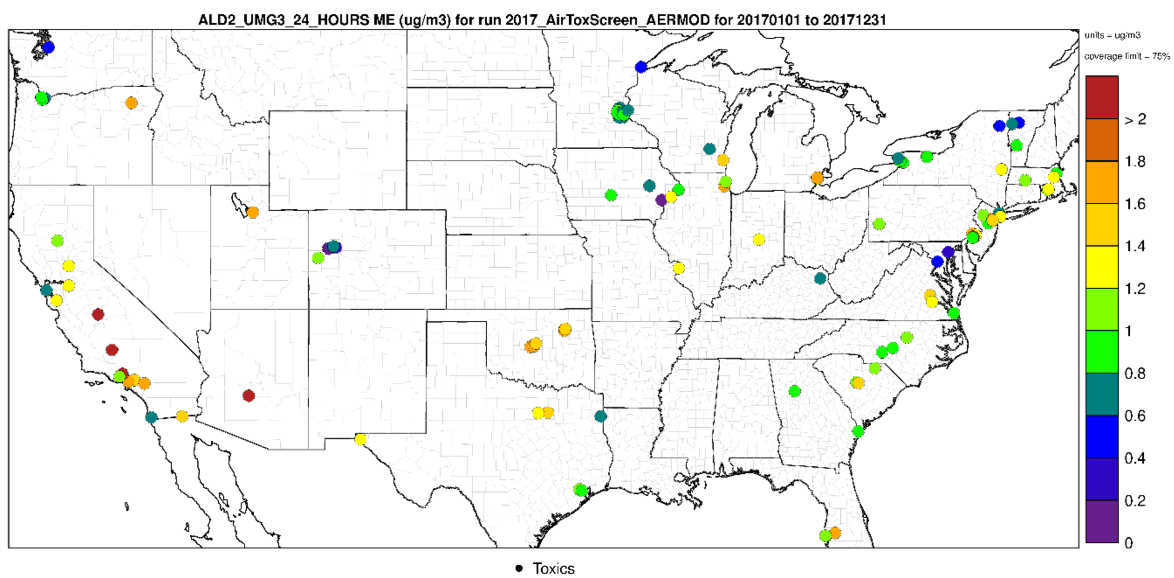


Figure E-8. Mean Error (%) for acetaldehyde at 2017 monitoring sites in the AERMOD modeling domain

(a) (b)

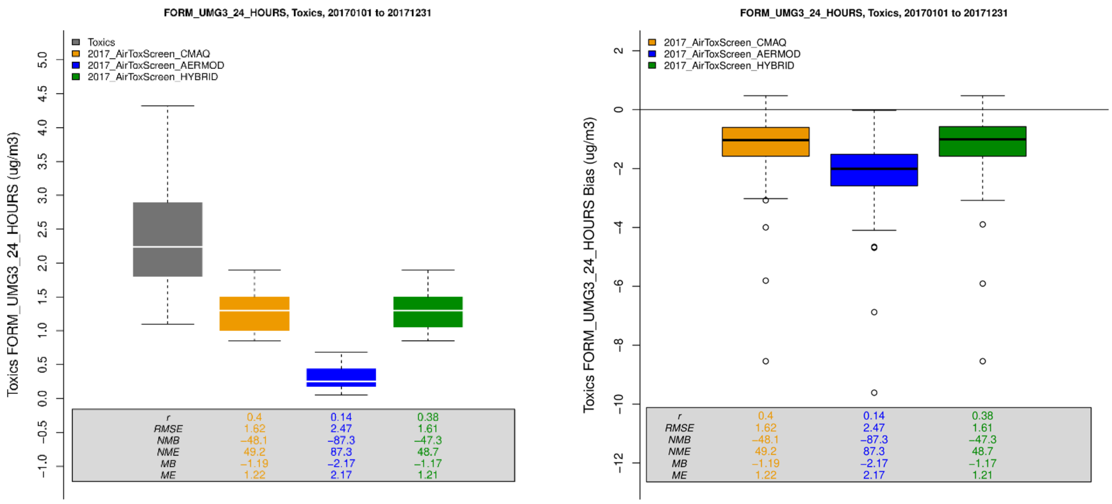


Figure E-9. Formaldehyde boxplots of (a) distribution ($\mu g/m^3$) and (b) bias difference ($\mu g/m^3$) for CMAQ, AERMOD, and Hybrid models compared to ambient observations

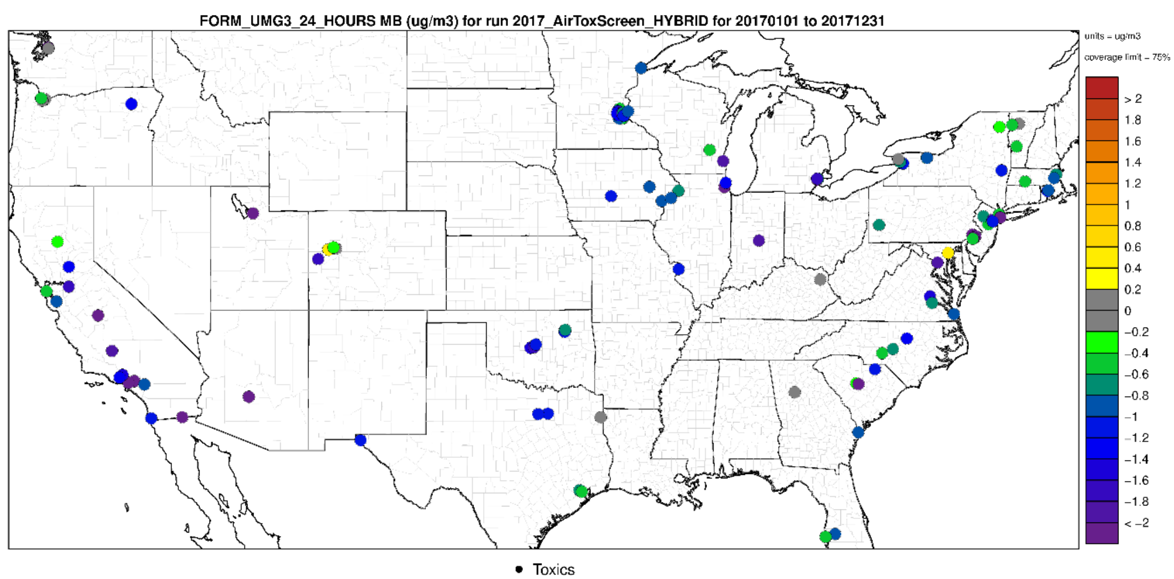


Figure E-10. Mean Bias (%) for formaldehyde at 2017 monitoring sites in the Hybrid modeling domain

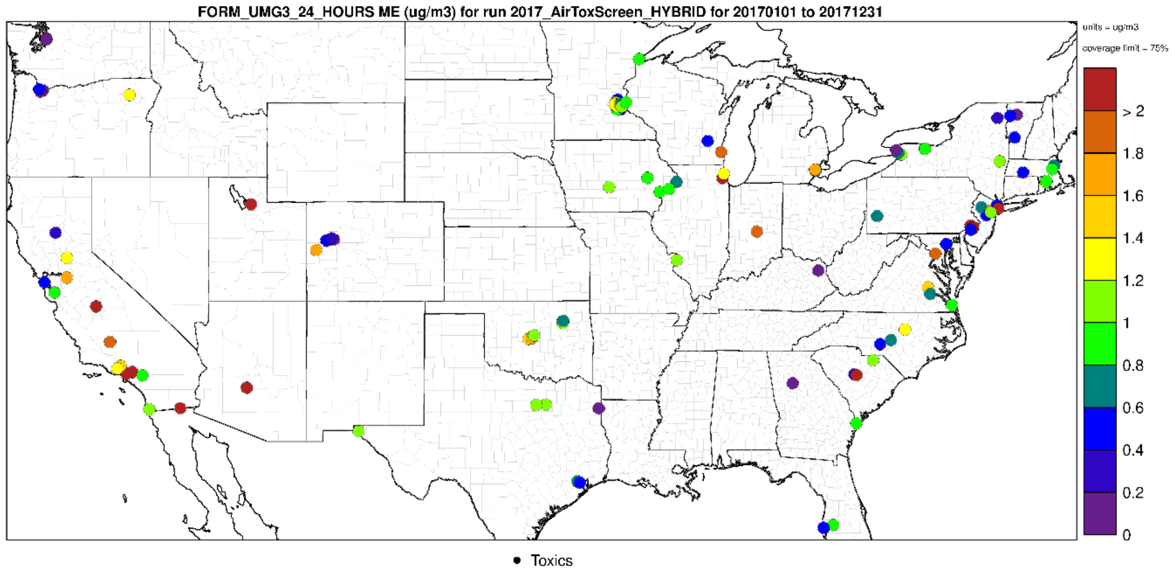


Figure E-11. Mean Error (%) for formaldehyde at 2017 monitoring sites in the Hybrid modeling domain

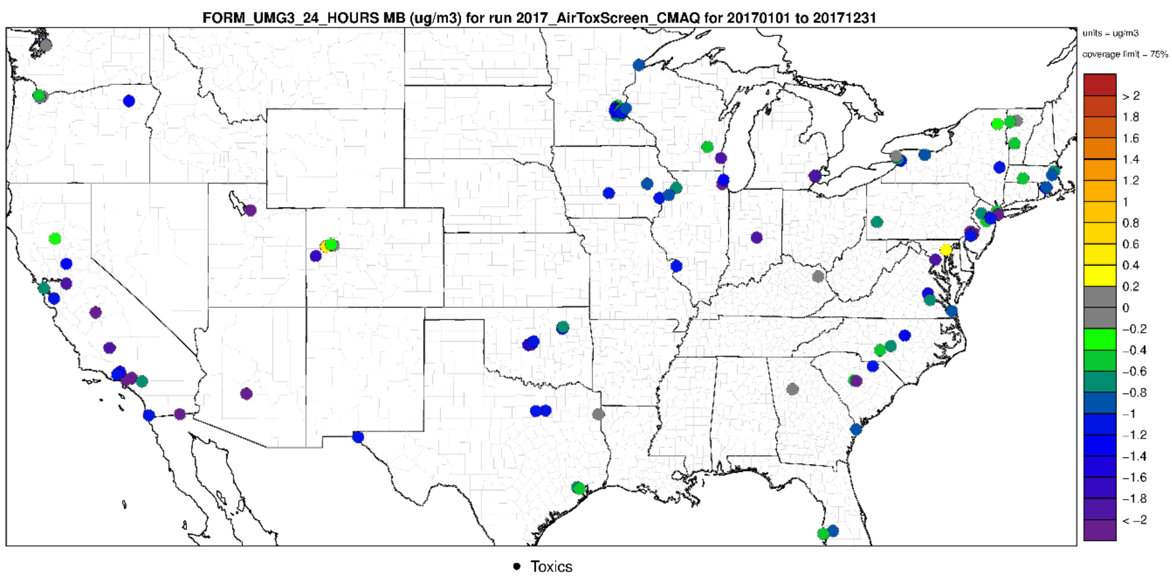


Figure E-12. Mean Bias (%) for formaldehyde at 2017 monitoring sites in the CMAQ modeling domain

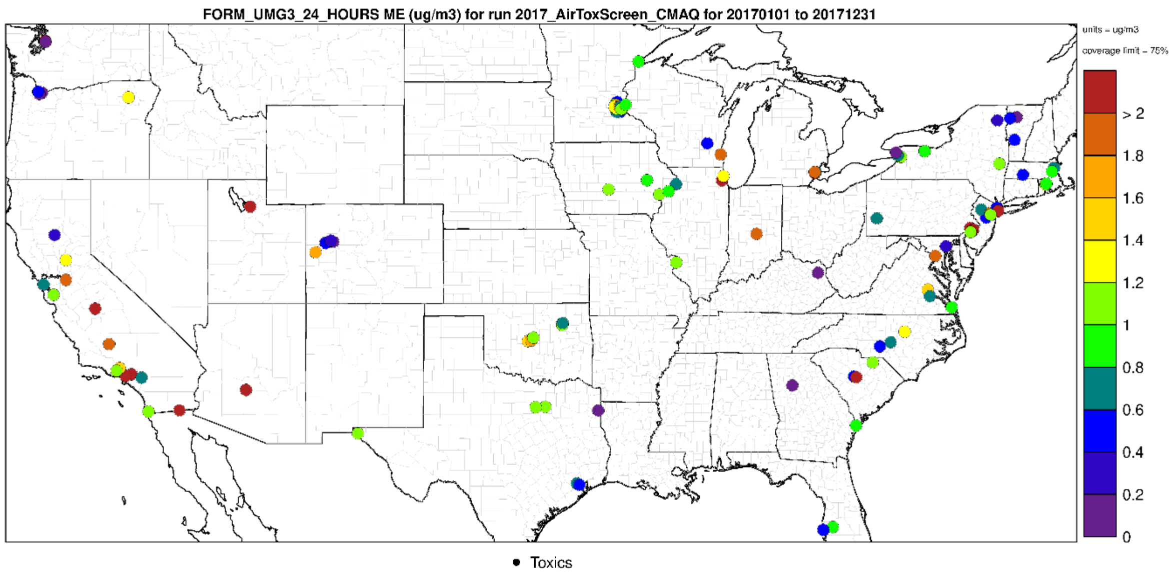


Figure E-13. Mean Error (%) for formaldehyde at 2017 monitoring sites in the CMAQ modeling domain

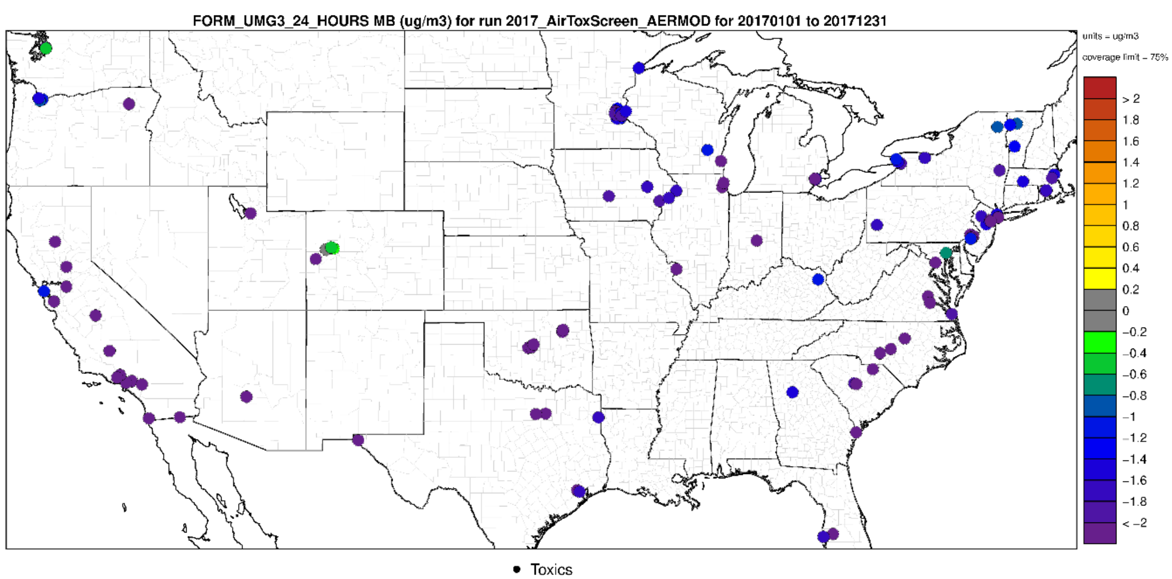


Figure E-14. Mean Bias (%) for formaldehyde at 2017 monitoring sites in the AERMOD modeling domain

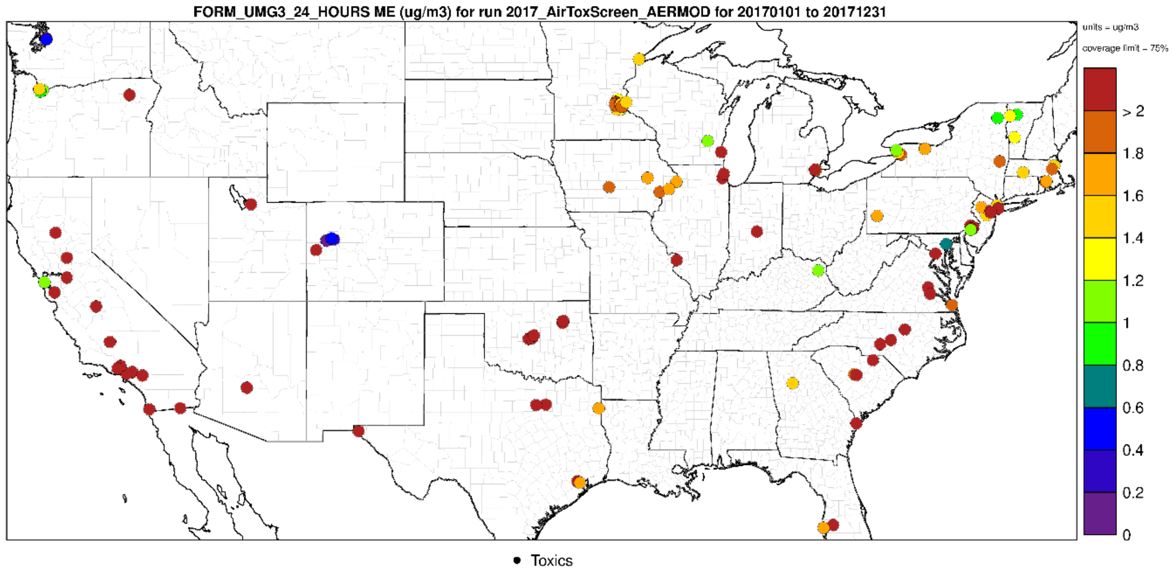


Figure E-15. Mean Error (%) for formaldehyde at 2017 monitoring sites in the AERMOD modeling domain

(a) (b)

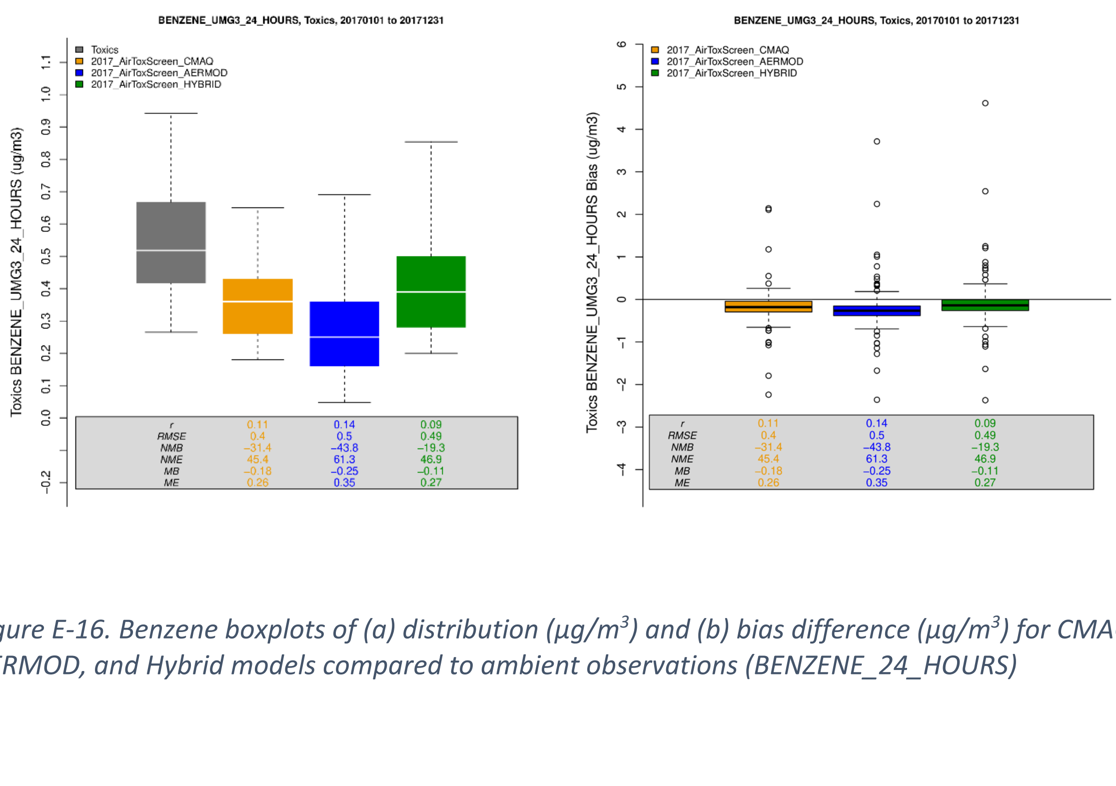


Figure E-16. Benzene boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (BENZENE_24_HOURS)

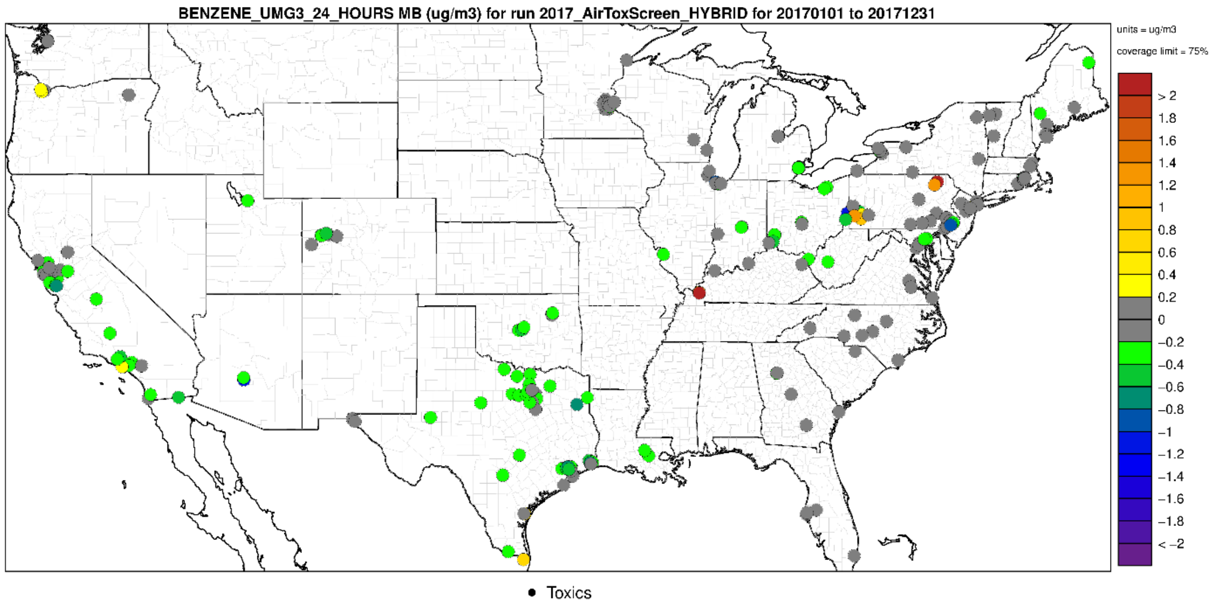


Figure E-17. Mean Bias (%) for benzene at 2017 monitoring sites (BENZENE_24_HOURS) in the Hybrid modeling domain

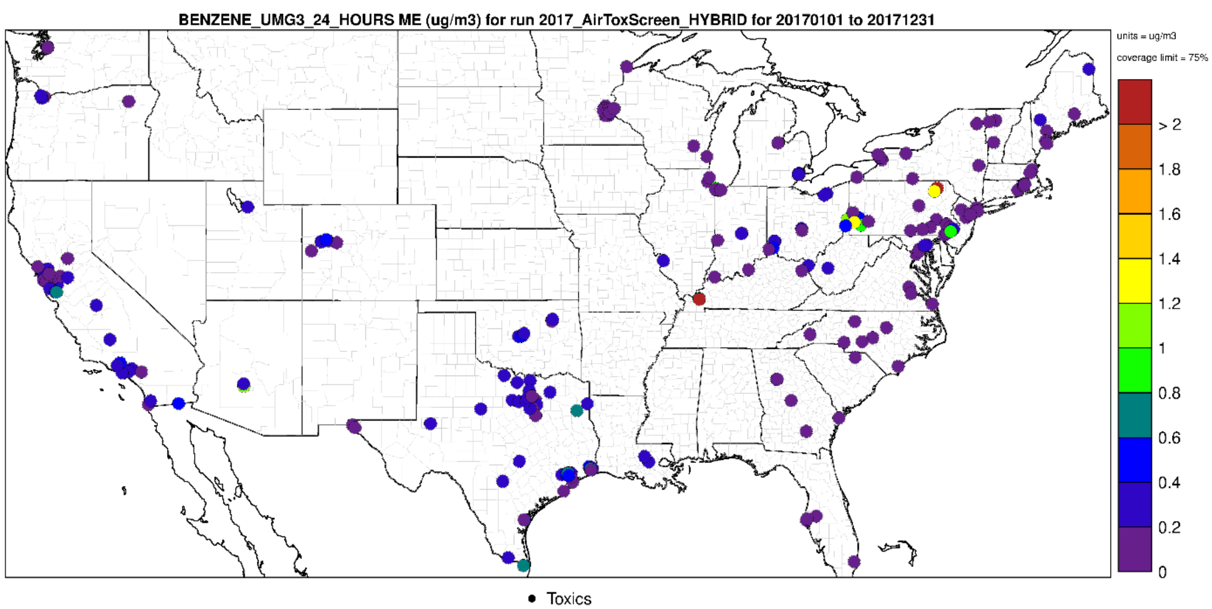


Figure E-18. Mean Error (%) for benzene at 2017 monitoring sites (BENZENE_24_HOURS) in the Hybrid modeling domain

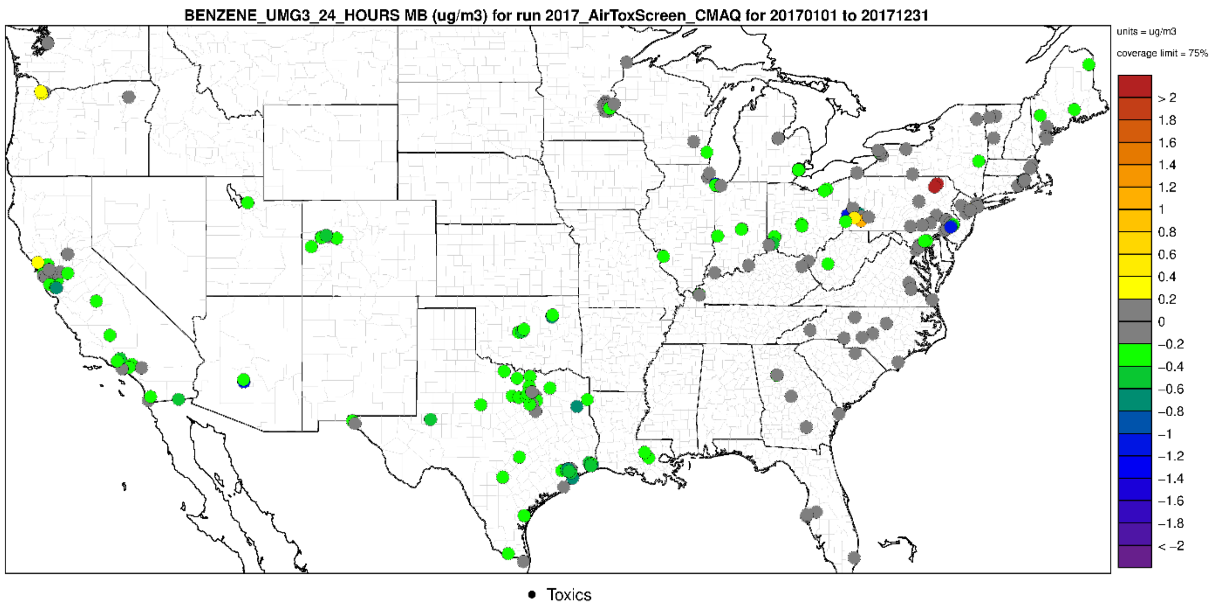


Figure E-19. Mean Bias (%) for benzene at 2017 monitoring sites (BENZENE_24_HOURS) in the CMAQ modeling domain

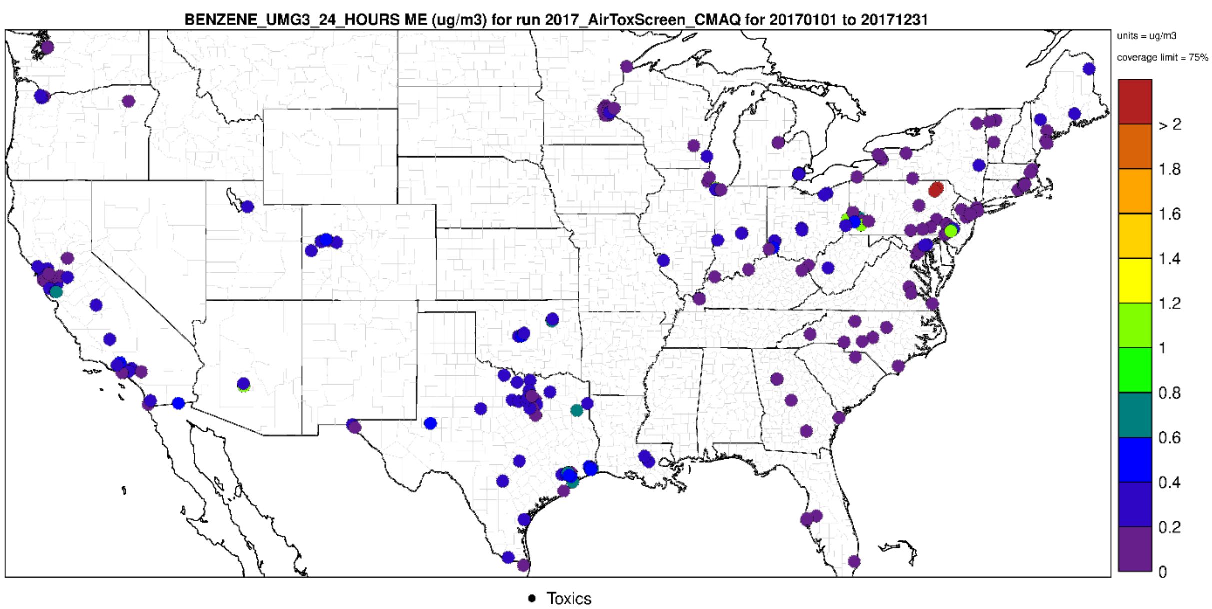


Figure E-20. Mean Error (%) for benzene at 2017 monitoring sites (BENZENE_24_HOURS) in the CMAQ modeling domain

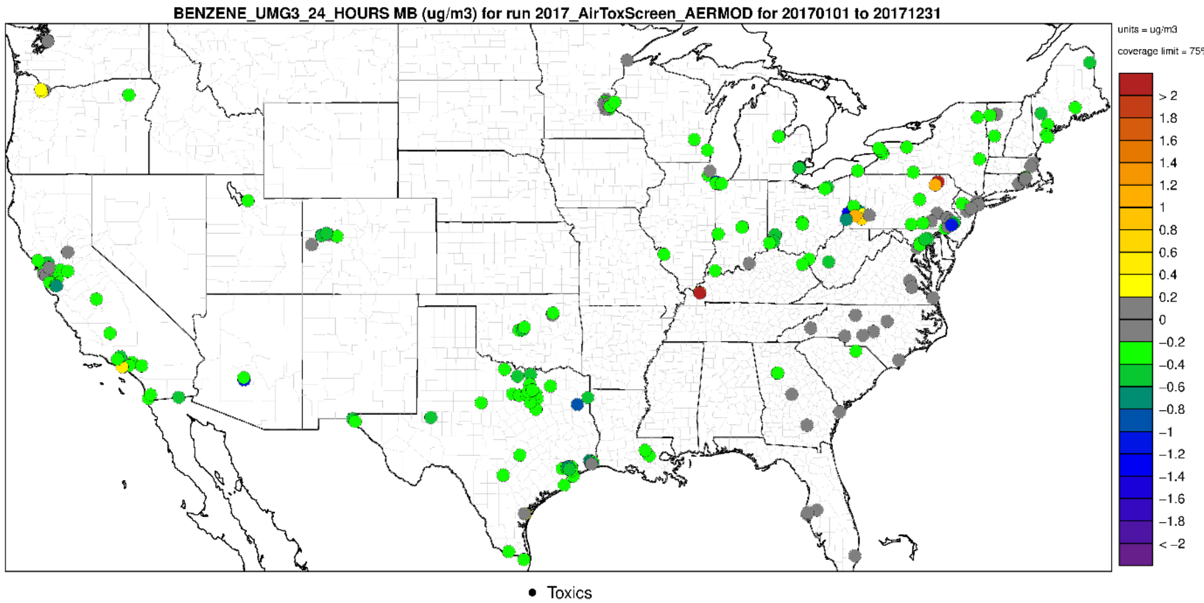


Figure E-21. Mean Bias (%) for benzene at 2017 monitoring sites (BENZENE_24_HOURS) in the AERMOD modeling domain

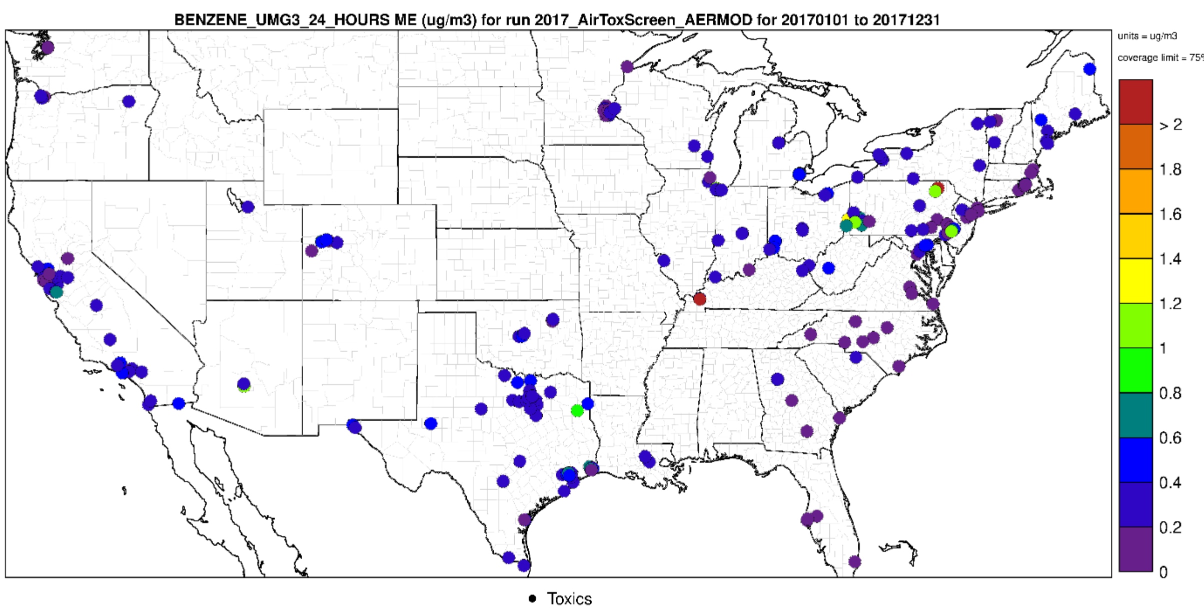


Figure E-22. Mean Error (%) for benzene at 2017 monitoring sites (BENZENE_24_HOURS) in the AERMOD modeling domain

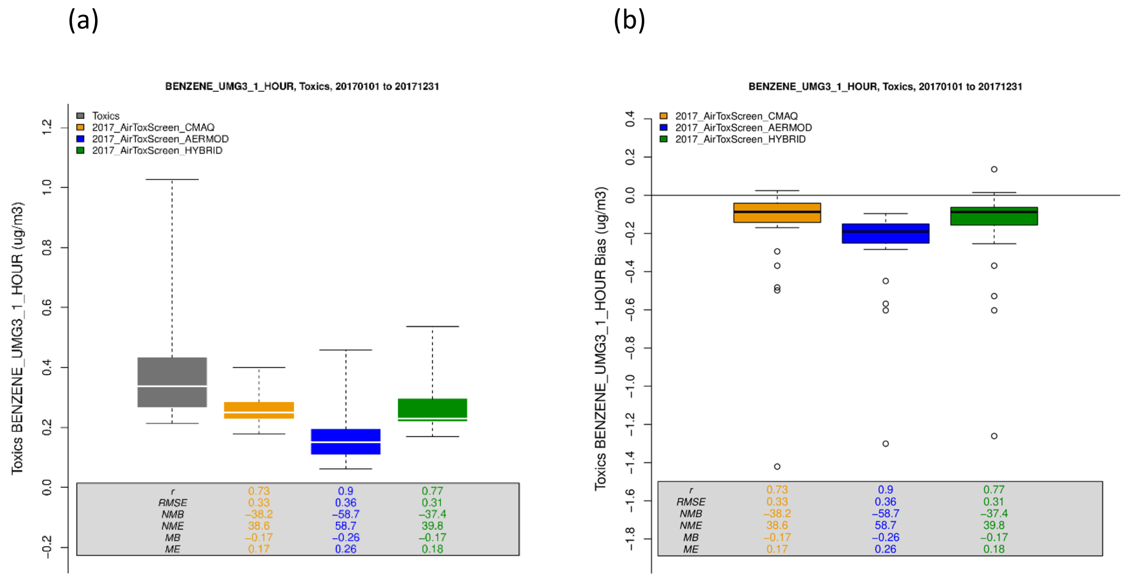


Figure E-23. Benzene boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (BENZENE_1_HOUR)

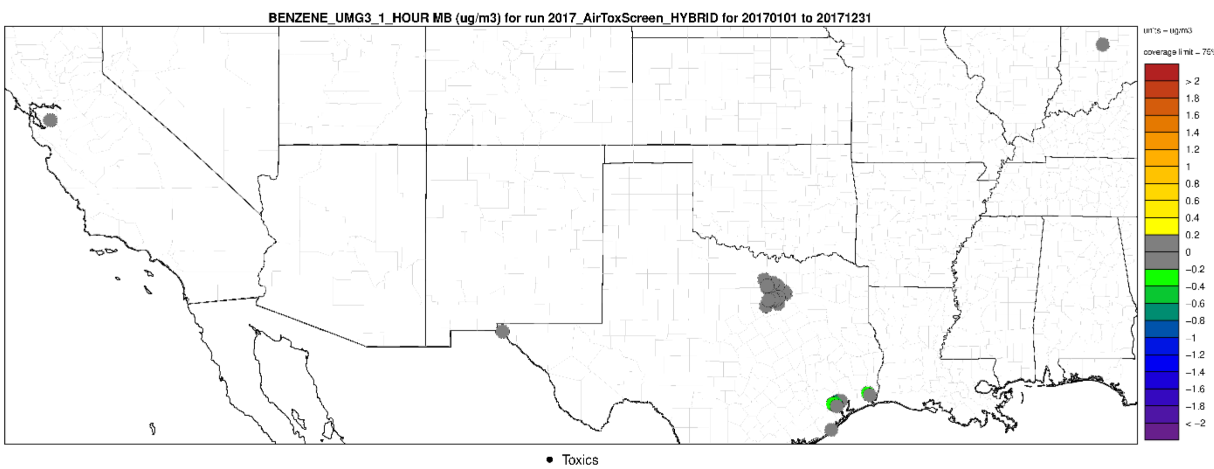


Figure E-24. Mean Bias (%) for benzene at 2017 monitoring sites (BENZENE_1_HOUR) in the Hybrid modeling domain

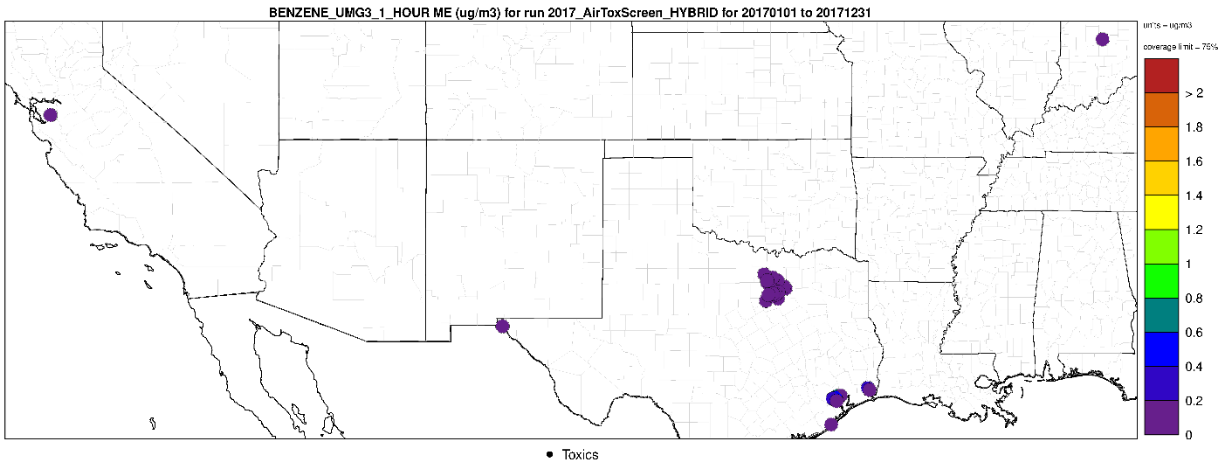


Figure E-25. Mean Error (%) for benzene at 2017 monitoring sites (BENZENE_1_HOUR) in the Hybrid modeling domain

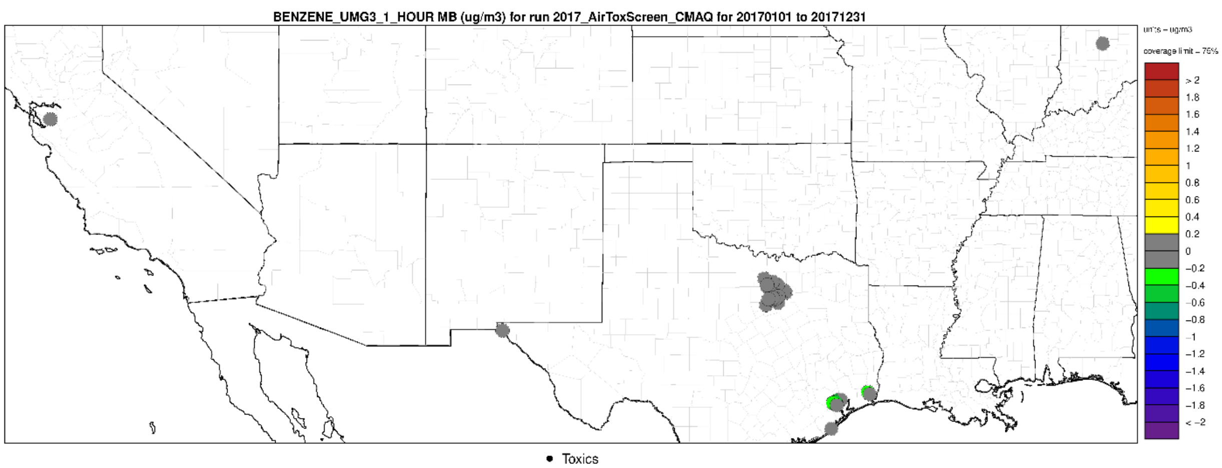


Figure E-26. Mean Bias (%) for benzene at 2017 monitoring sites (BENZENE_1_HOUR) in the CMAQ modeling domain

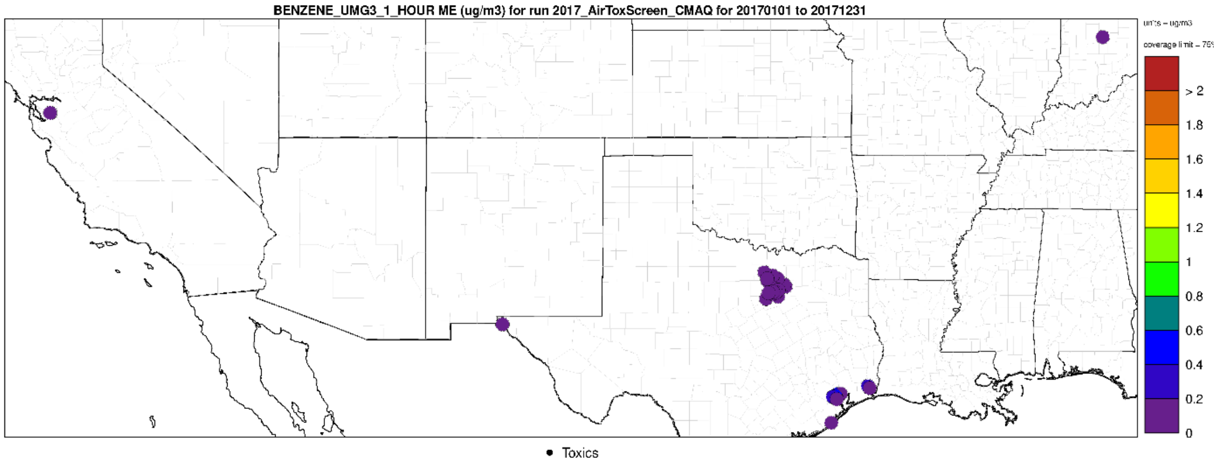


Figure E-27. Mean Error (%) for benzene at 2017 monitoring sites (BENZENE_1_HOUR) in the CMAQ modeling domain

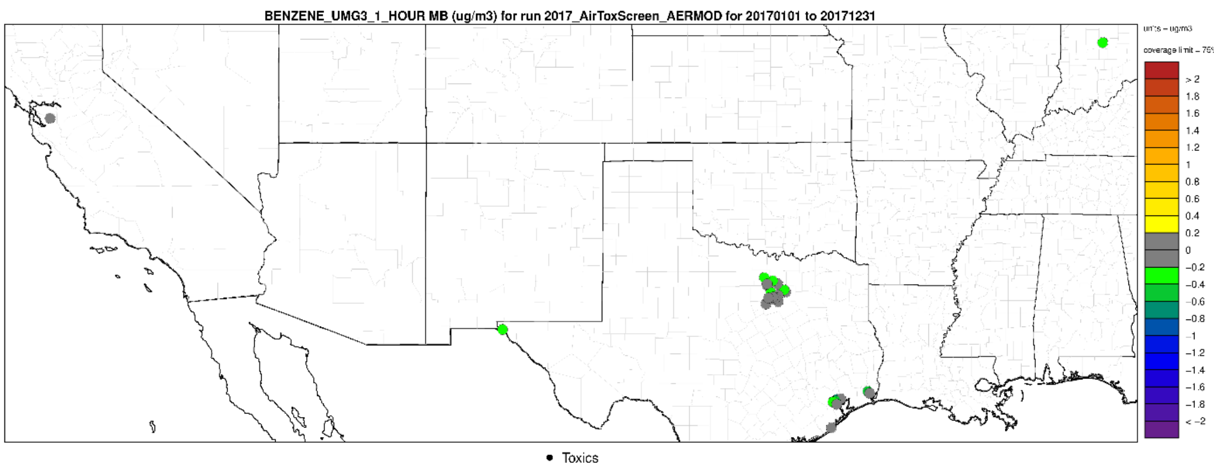


Figure E-28. Mean Bias (%) for benzene at 2017 monitoring sites (BENZENE_1_HOUR) in the AERMOD modeling domain

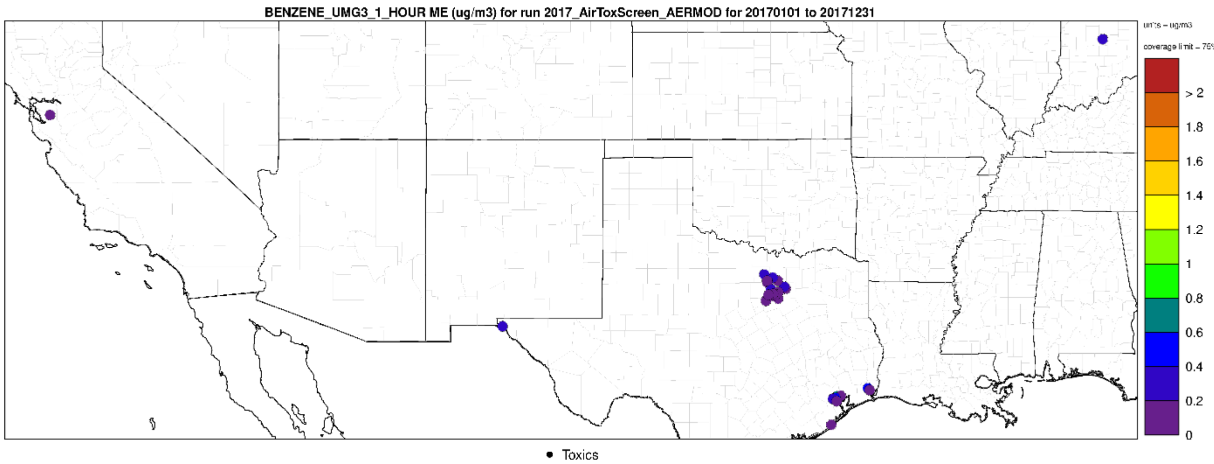


Figure E-29. Mean Error (%) for benzene at 2017 monitoring sites (BENZENE_1_HOUR) in the AERMOD modeling domain

(a) (b)

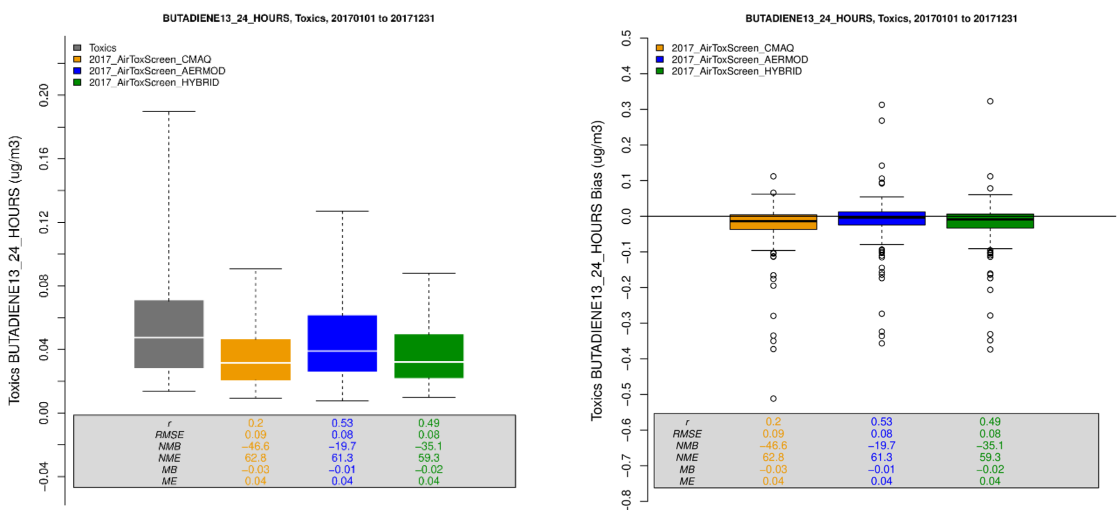


Figure E-30. 1,3-Butadiene boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (BUTADIENE13_24_HOURS)

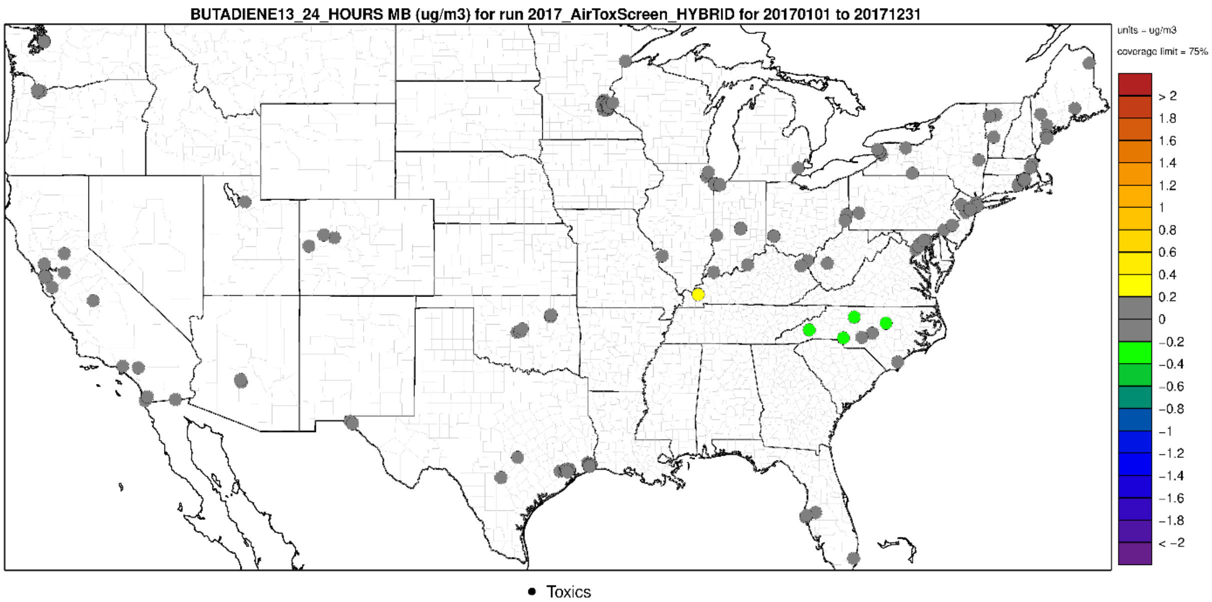


Figure E-31. Mean Bias (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_24_HOURS) in the Hybrid modeling domain

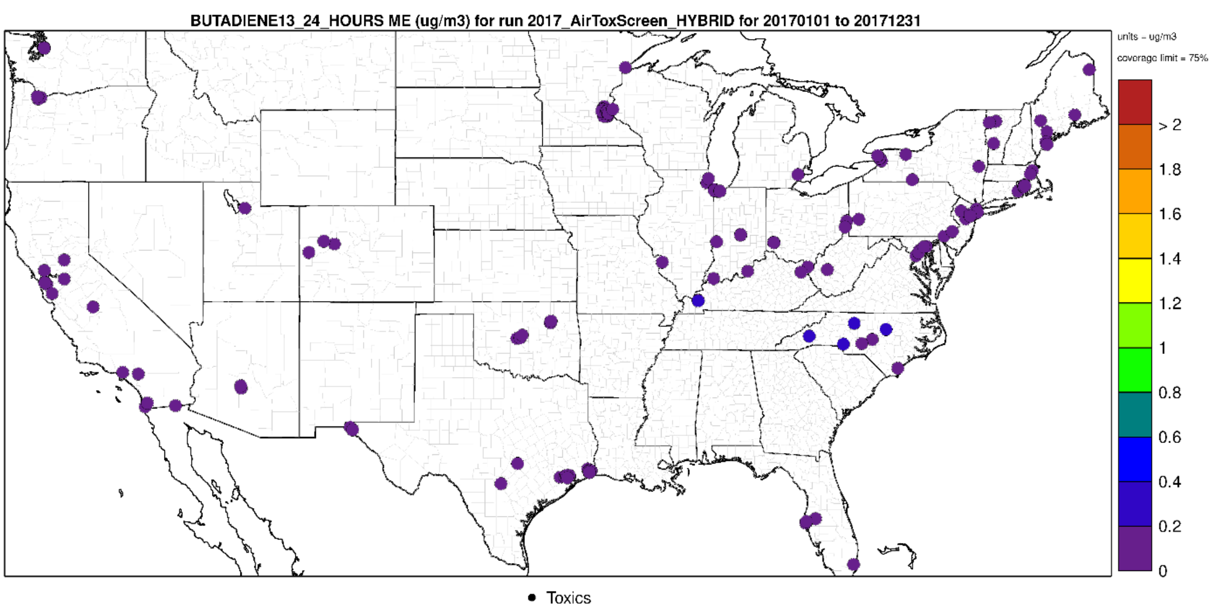


Figure E-32. Mean Error (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_24_HOURS) in the Hybrid modeling domain

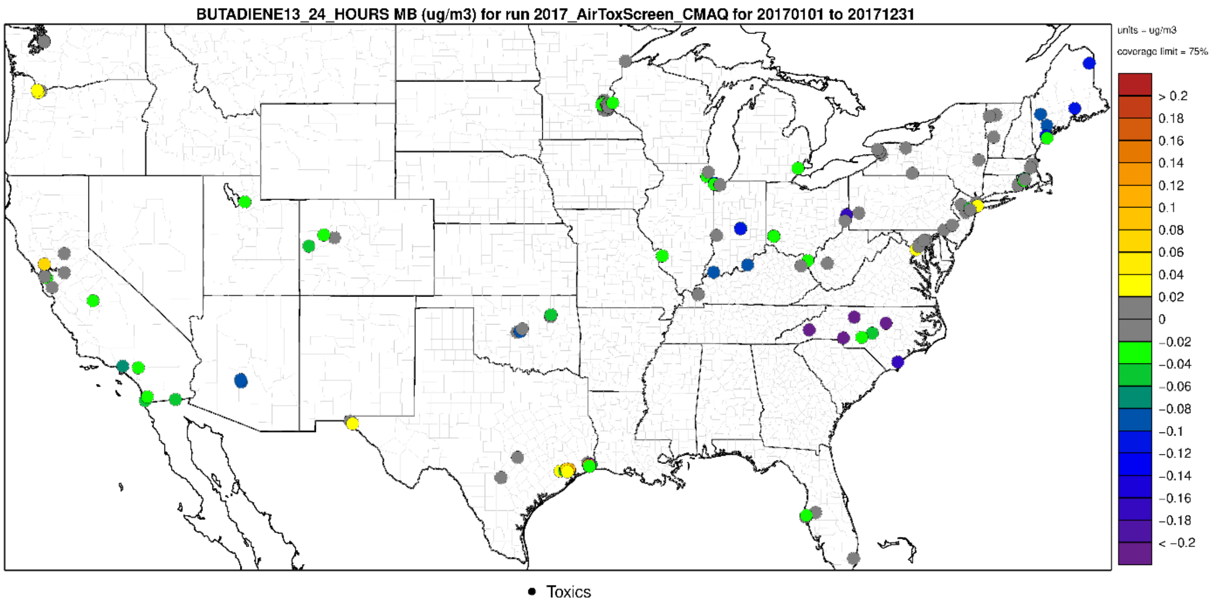


Figure E-33. Mean Bias (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_24_HOURS) in the CMAQ modeling domain

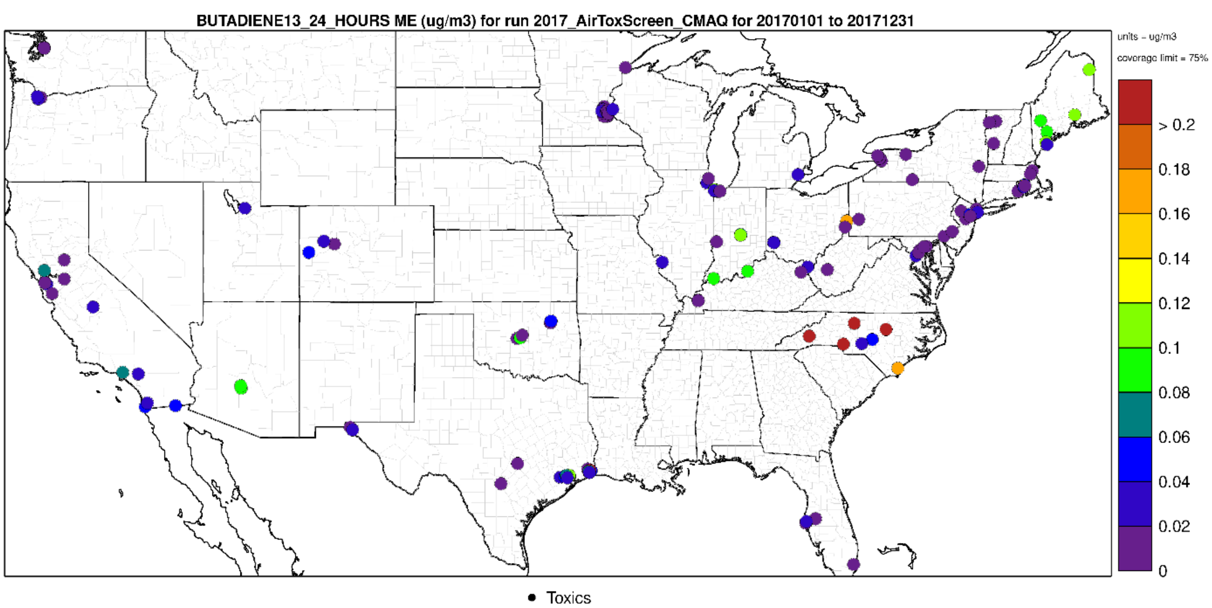


Figure E-34. Mean Error (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_24_HOURS) in the CMAQ modeling domain

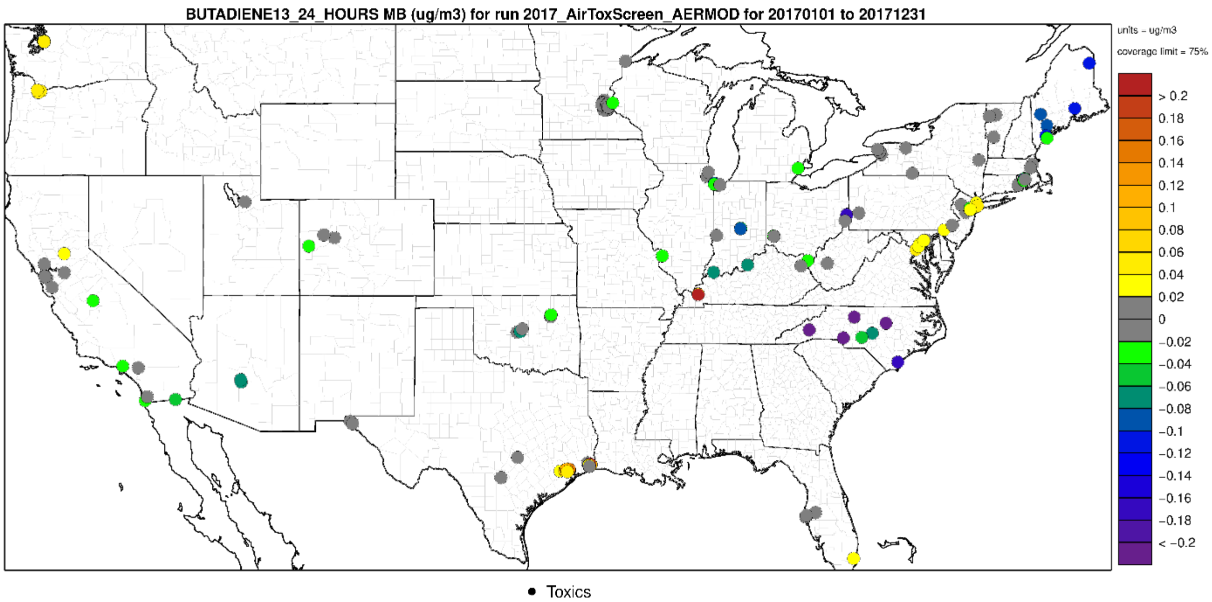


Figure E-35. Mean Bias (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_24_HOURS) in the AERMOD modeling domain

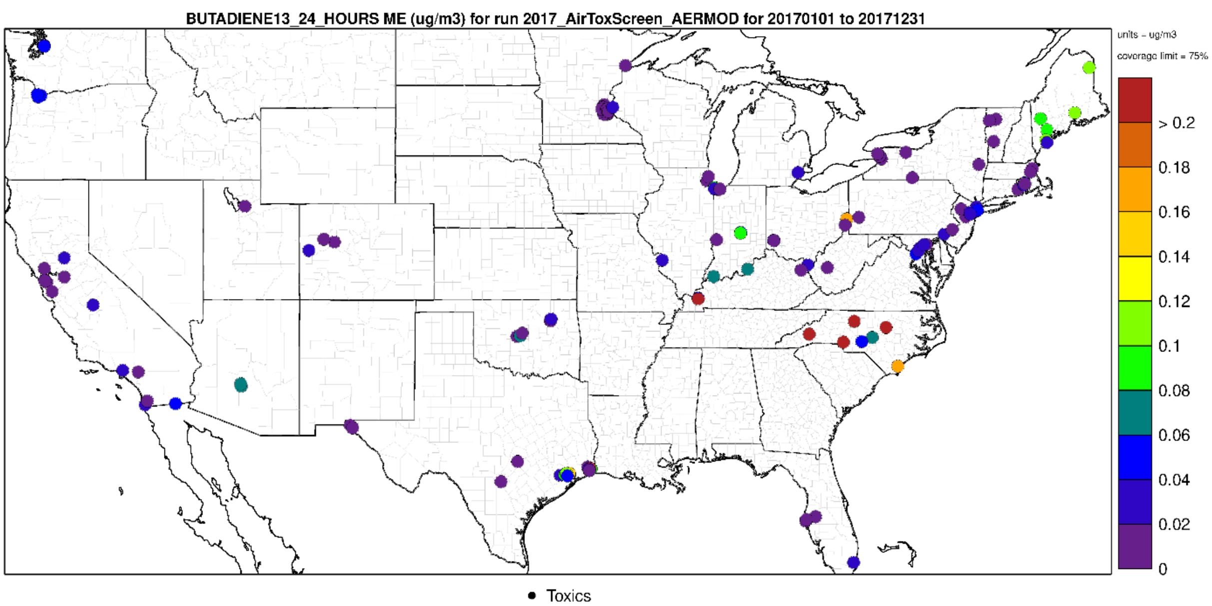


Figure E-36. Mean Error (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_24_HOURS) in the AERMOD modeling domain

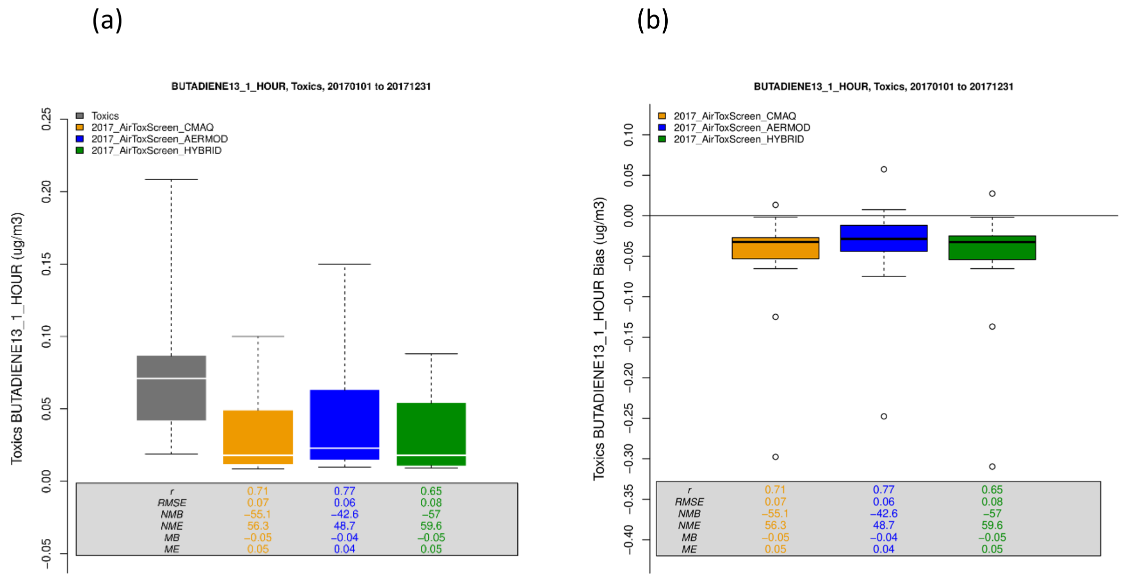


Figure E-37. 1,3-Butadiene boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (BUTADIENE13_1_HOUR)

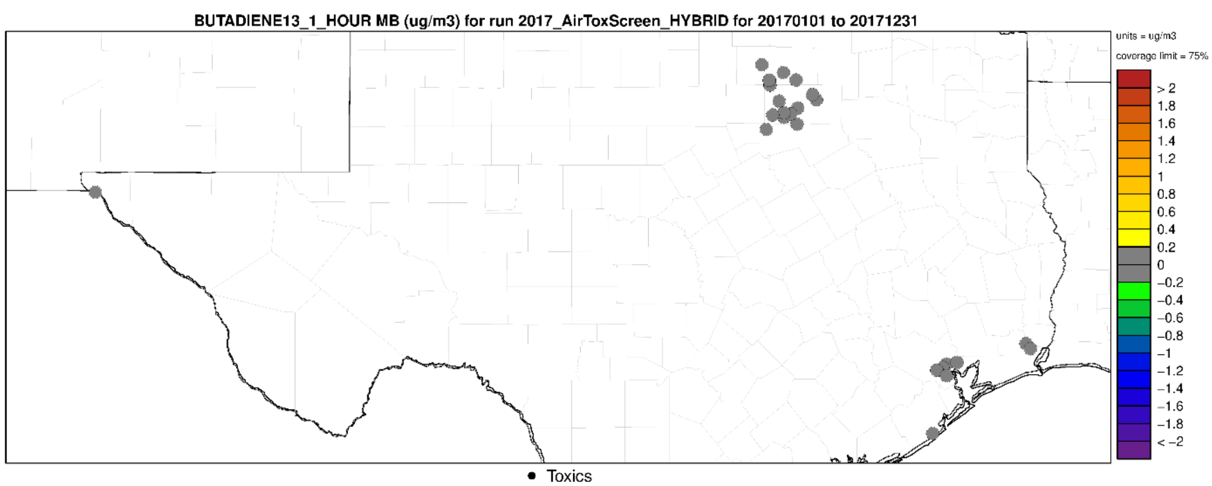


Figure E-38. Mean Bias (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_1_HOUR) in the Hybrid modeling domain

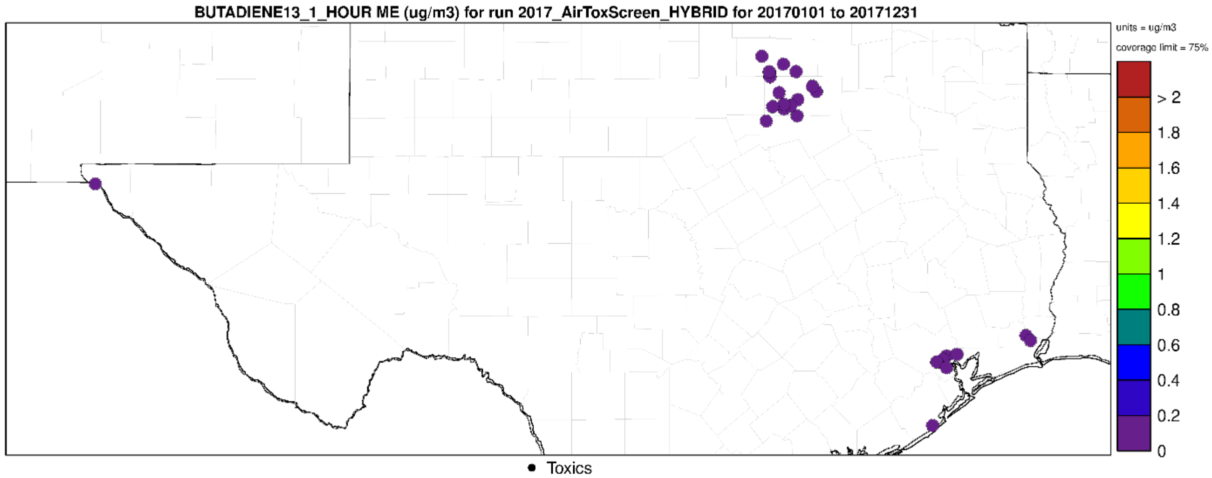


Figure E-39. Mean Error (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_1_HOUR) in the Hybrid modeling domain

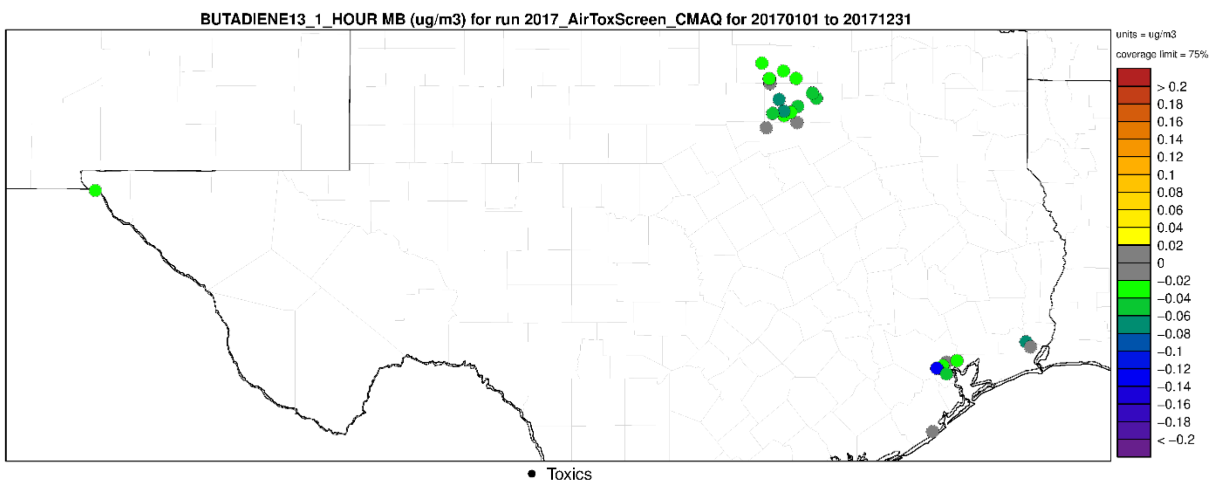


Figure E-40. Mean Bias (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_1_HOUR) in the CMAQ modeling domain

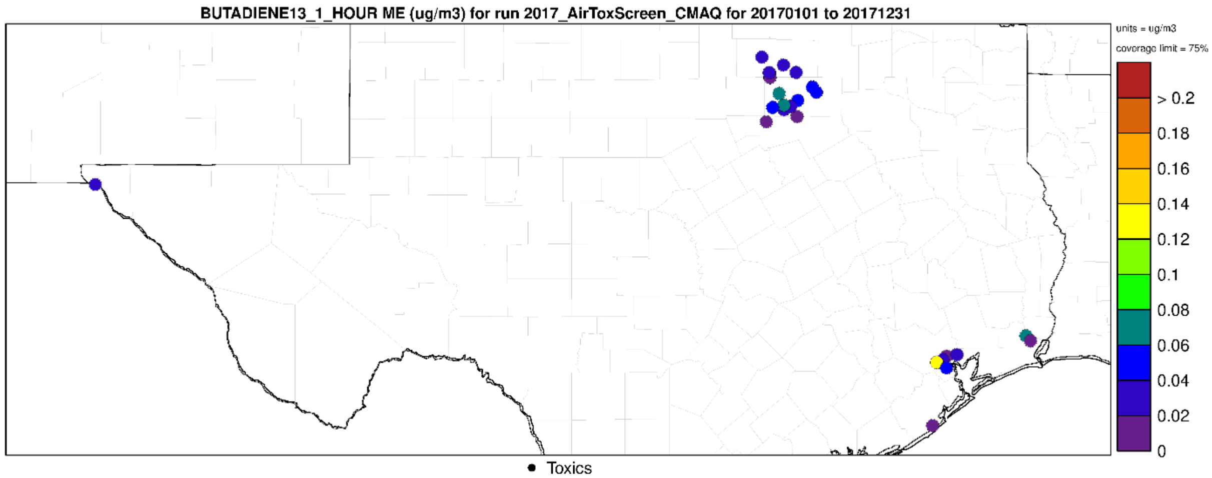


Figure E-41. Mean Error (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_1_HOUR) in the CMAQ modeling domain

Figure E-42. Mean Bias (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_1_HOUR) in the AERMOD modeling domain

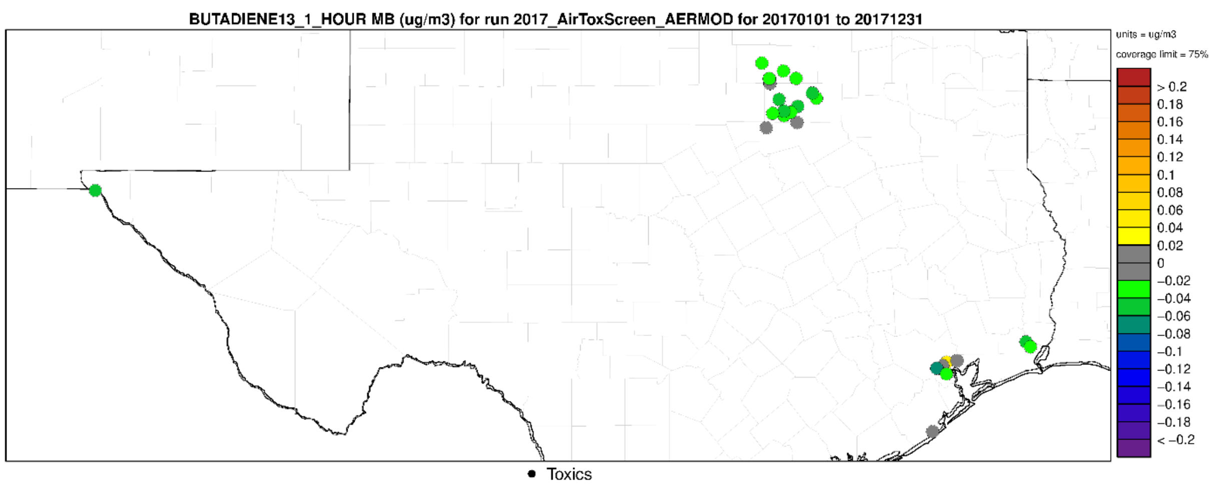


Figure E-42. Mean Bias (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_1_HOUR) in the AERMOD modeling domain

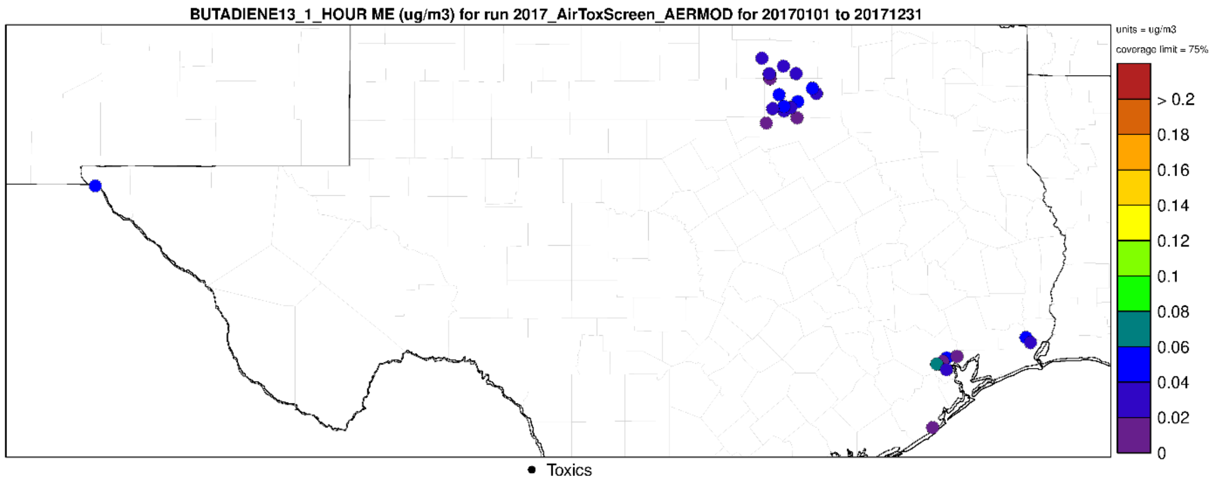


Figure E-43. Mean Error (%) for 1,3-butadiene at 2017 monitoring sites (BUTADIENE13_1_HOUR) in the AERMOD modeling domain

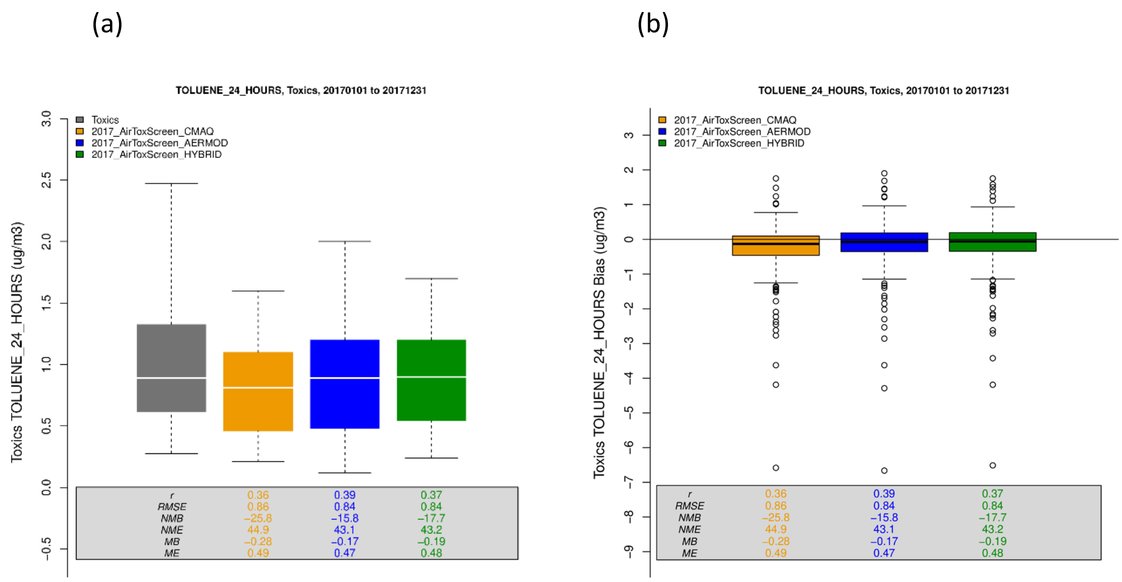


Figure E-44. Toluene boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (TOLU_24_HOURS)

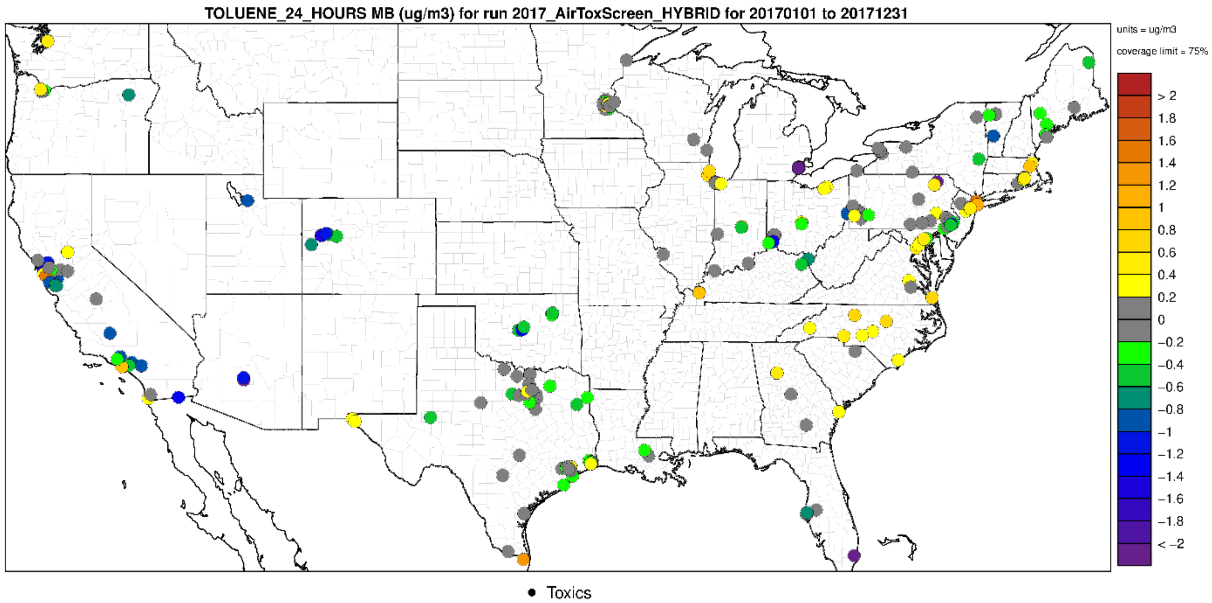


Figure E-45. Mean Bias (%) for toluene at 2017 monitoring sites (TOLU_24_HOURS) in the Hybrid modeling domain

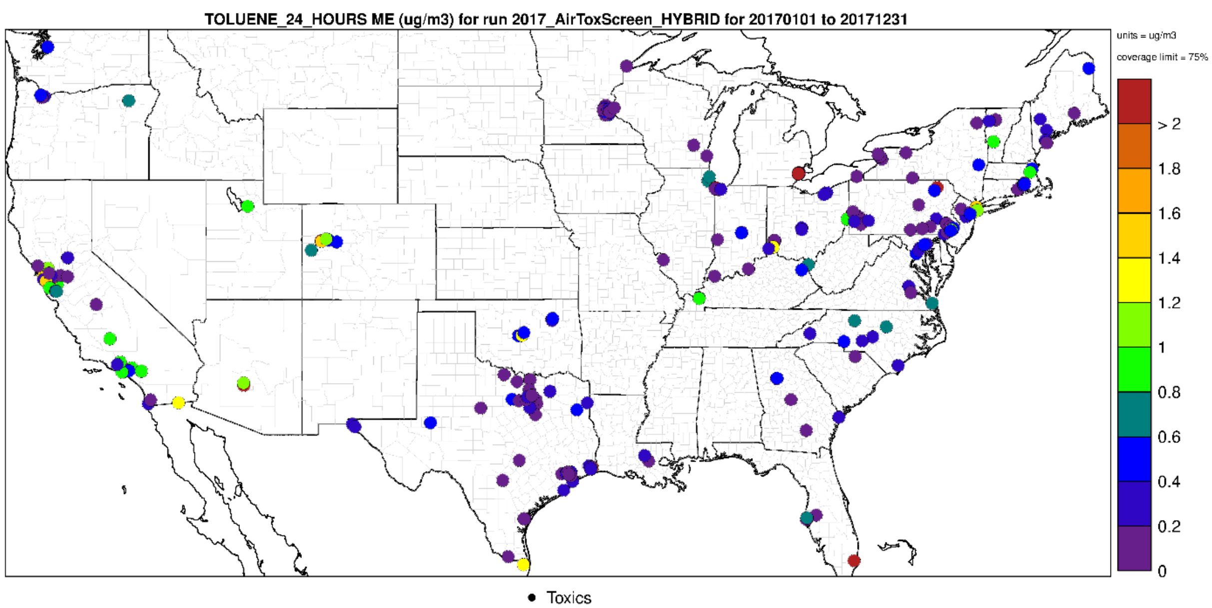


Figure E-46. Mean Error (%) for toluene at 2017 monitoring sites (TOLU_24_HOURS) in the Hybrid modeling domain

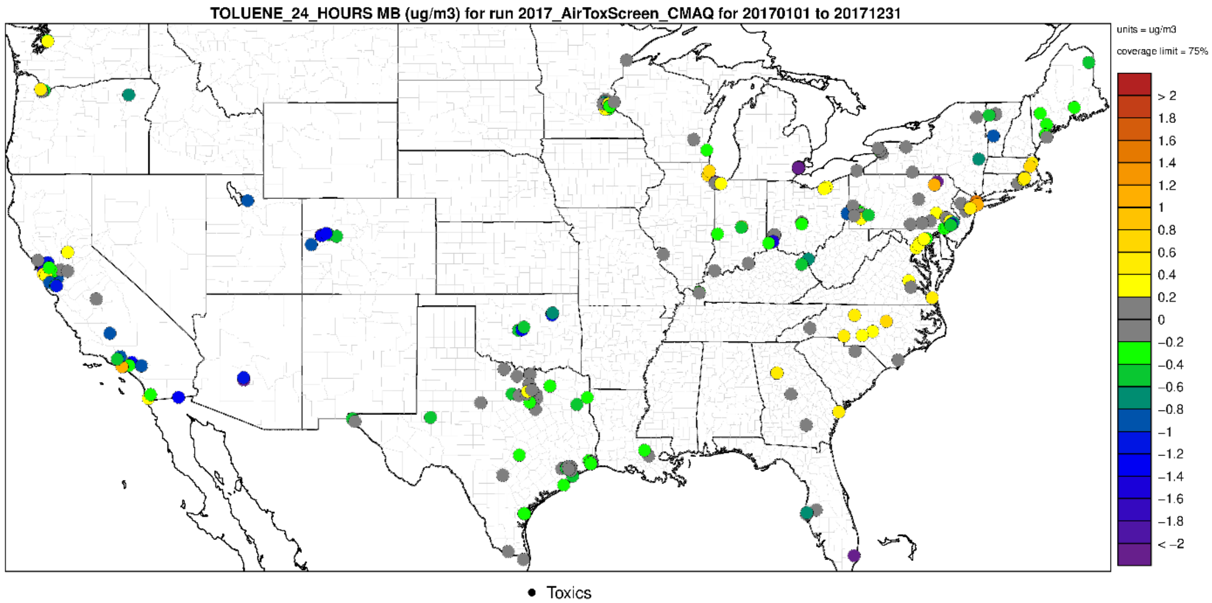


Figure E-47. Mean Bias (%) for toluene at 2017 monitoring sites (TOLU_24_HOURS) in the CMAQ modeling domain

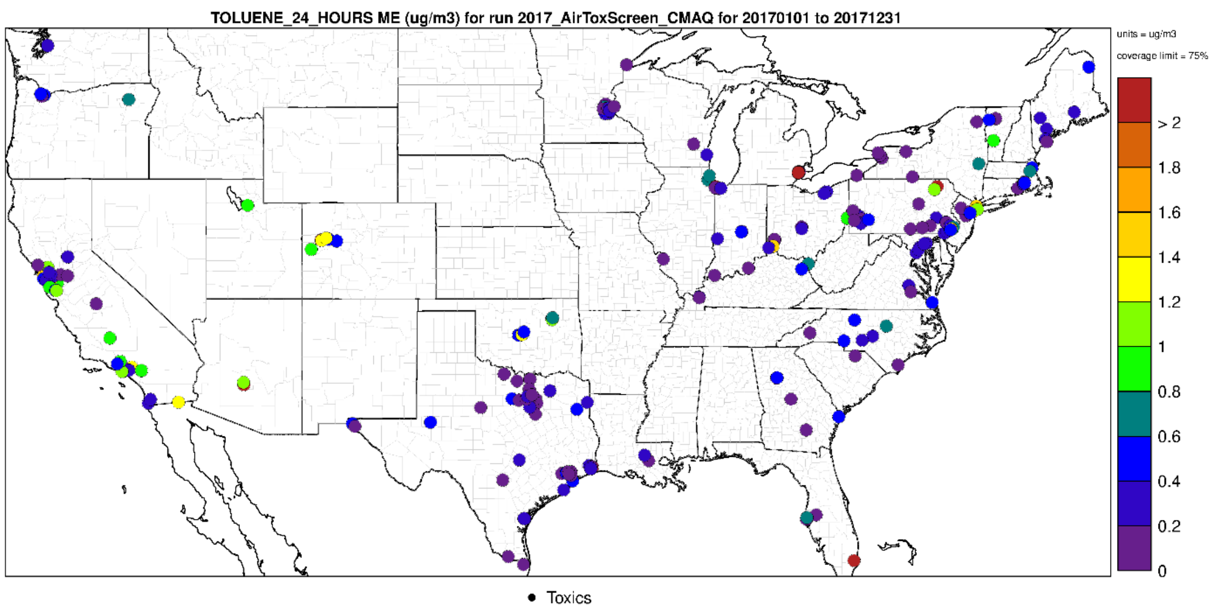


Figure E-48. Mean Error (%) for toluene at 2017 monitoring sites (TOLU_24_HOURS) in the CMAQ modeling domain

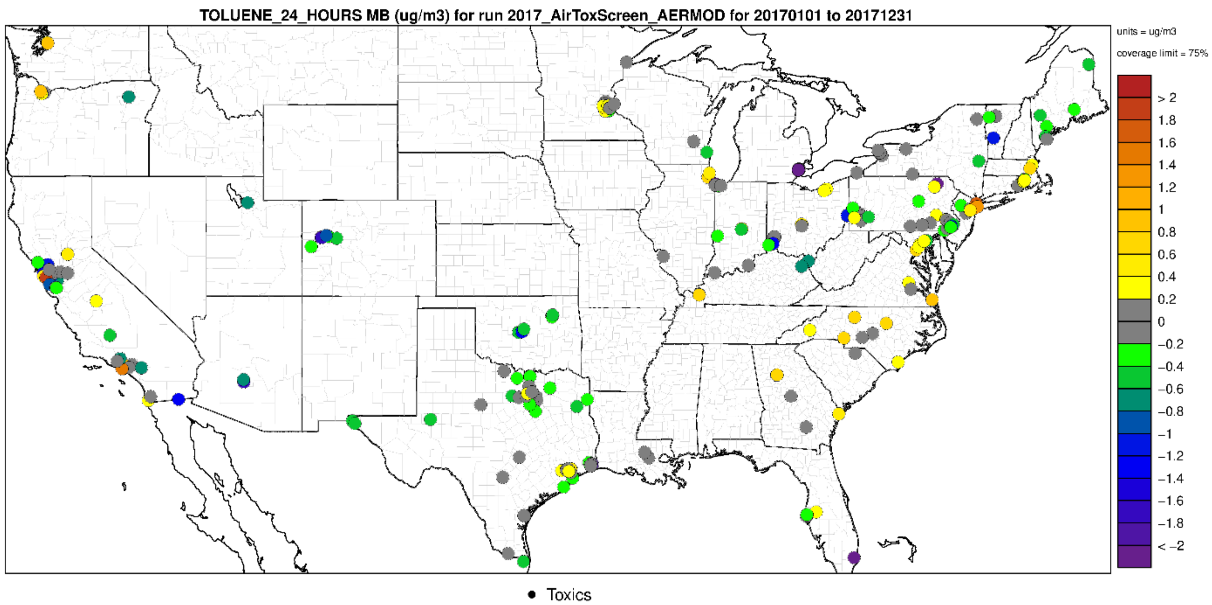


Figure E-49. Mean Bias (%) for toluene at 2017 monitoring sites (TOLU_24_HOURS) in the AERMOD modeling domain

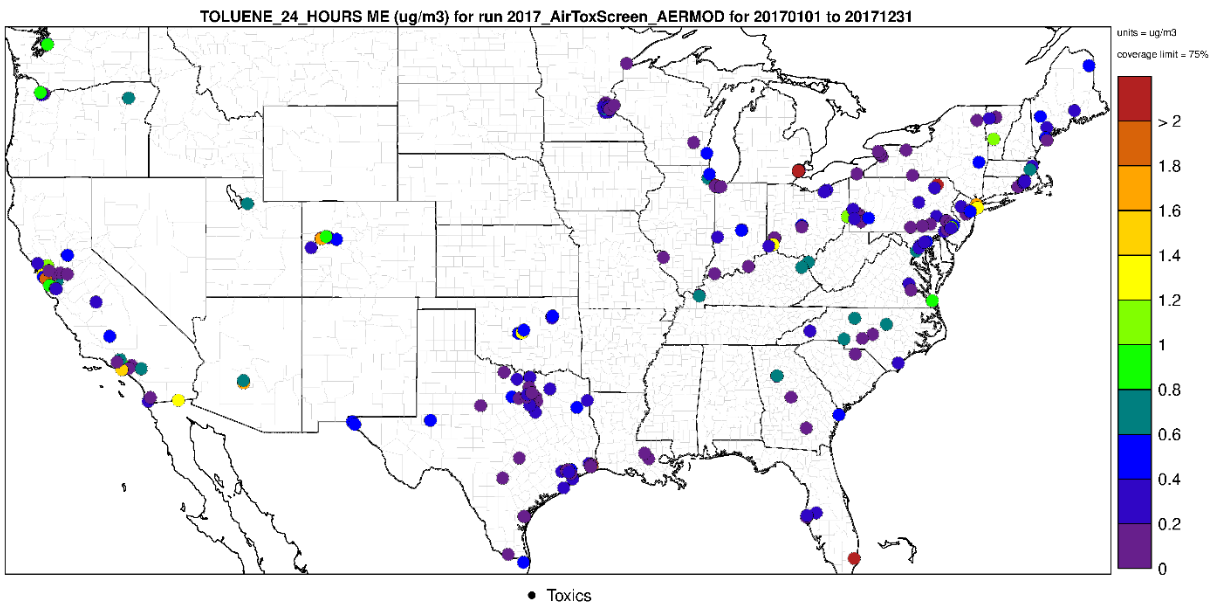


Figure E-50. Mean Error (%) for toluene at 2017 monitoring sites (TOLU_24_HOURS) in the AERMOD modeling domain

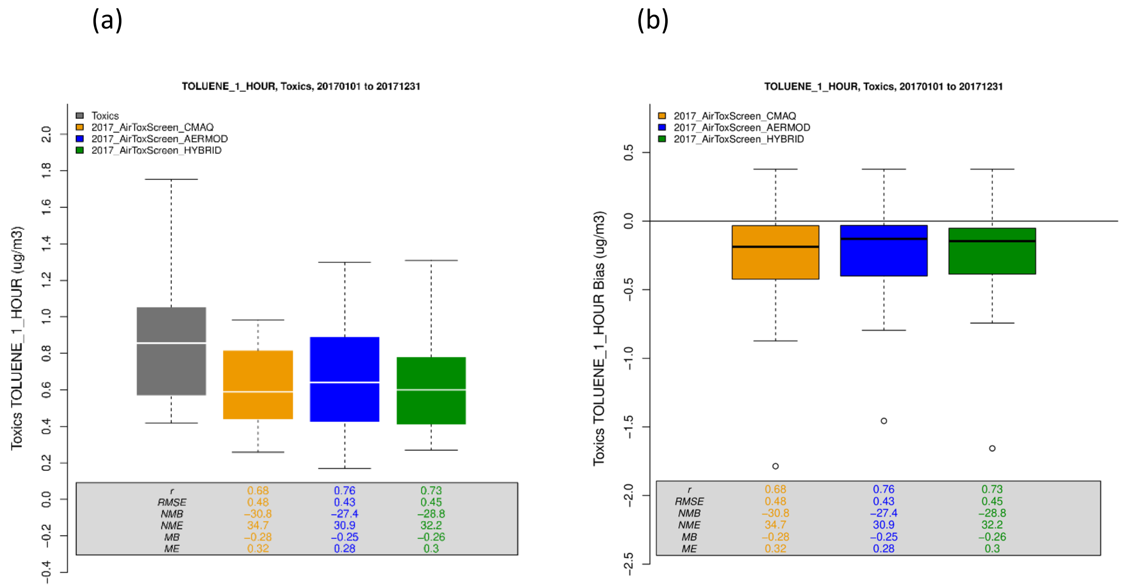


Figure E-51. Toluene boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (TOLU_1_HOUR)

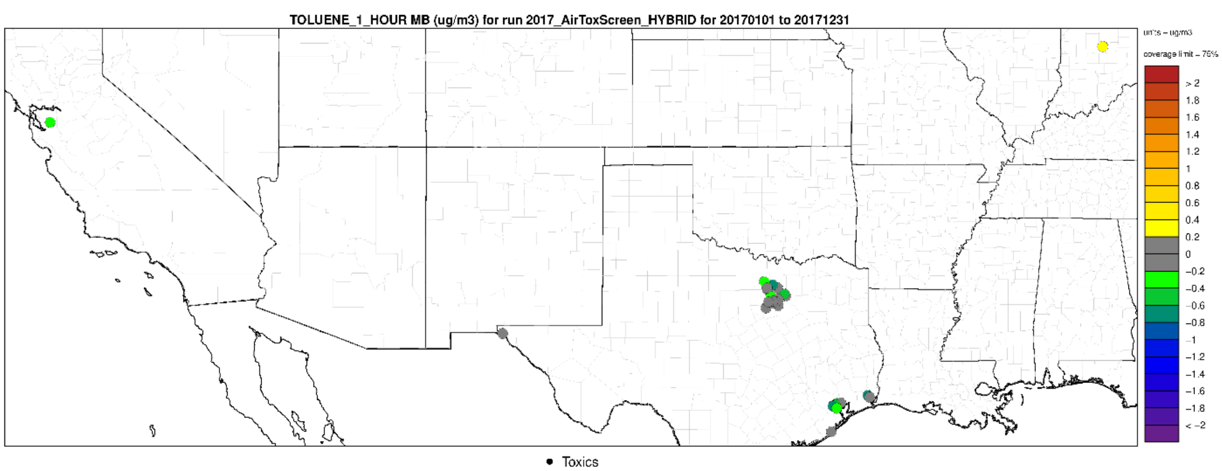


Figure E-52. Mean Bias (%) for toluene at 2017 monitoring sites (TOLU_1_HOUR) in the Hybrid modeling domain

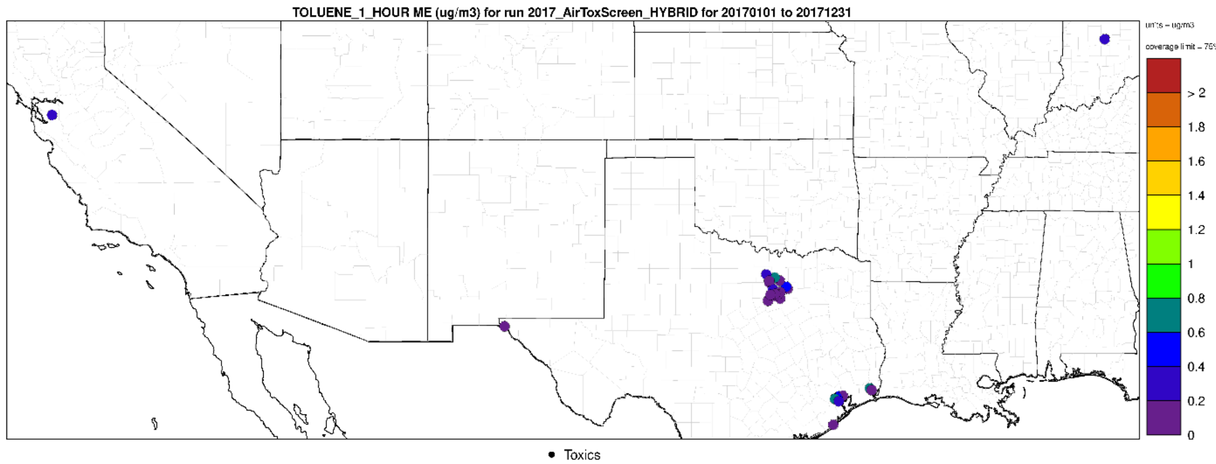


Figure E-53. Mean Error (%) for toluene at 2017 monitoring sites (TOLU_1_HOUR) in the Hybrid modeling domain

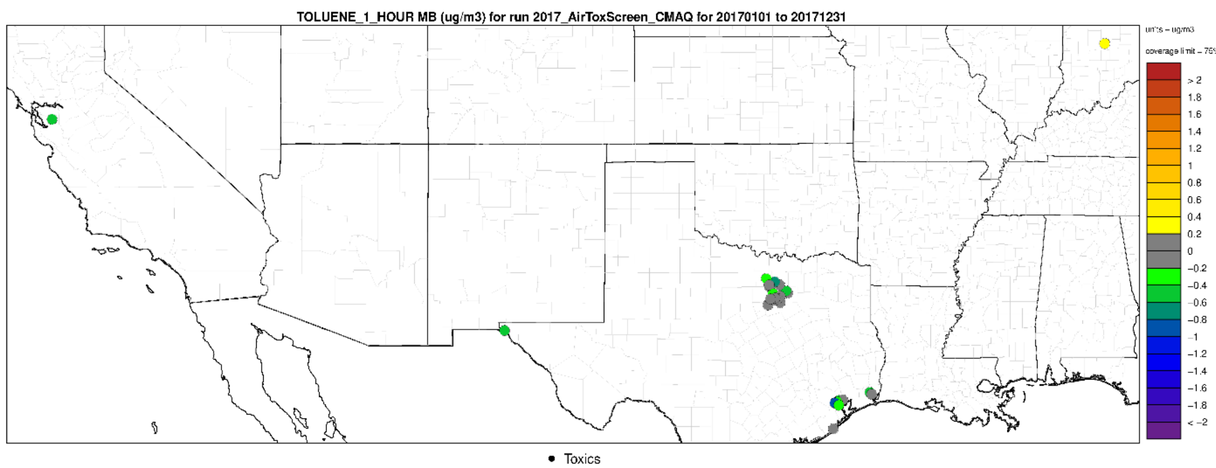


Figure E-54. Mean Bias (%) for toluene at 2017 monitoring sites (TOLU_1_HOUR) in the CMAQ modeling domain

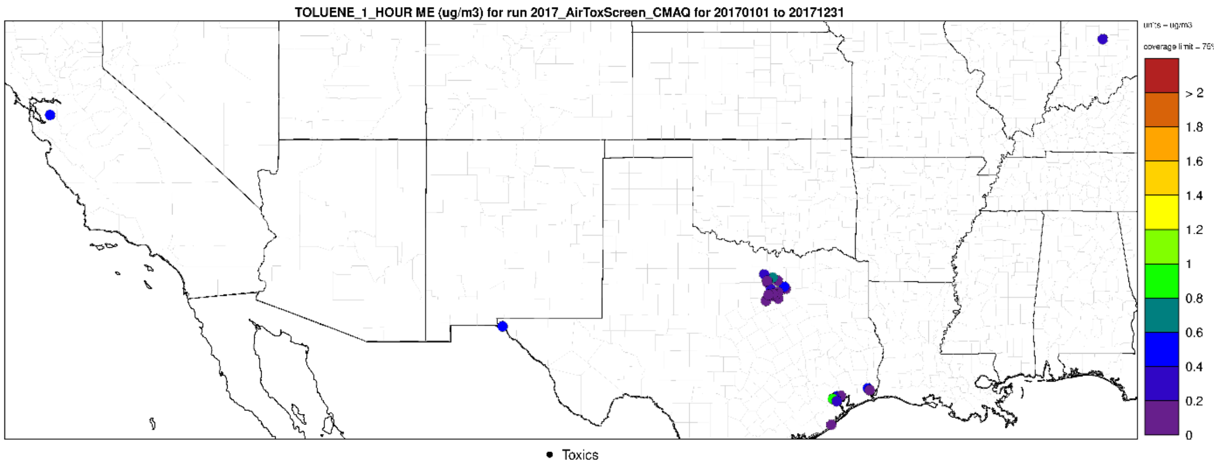


Figure E-55. Mean Error (%) for toluene at 2017 monitoring sites (TOLU_1_HOUR) in the CMAQ modeling domain

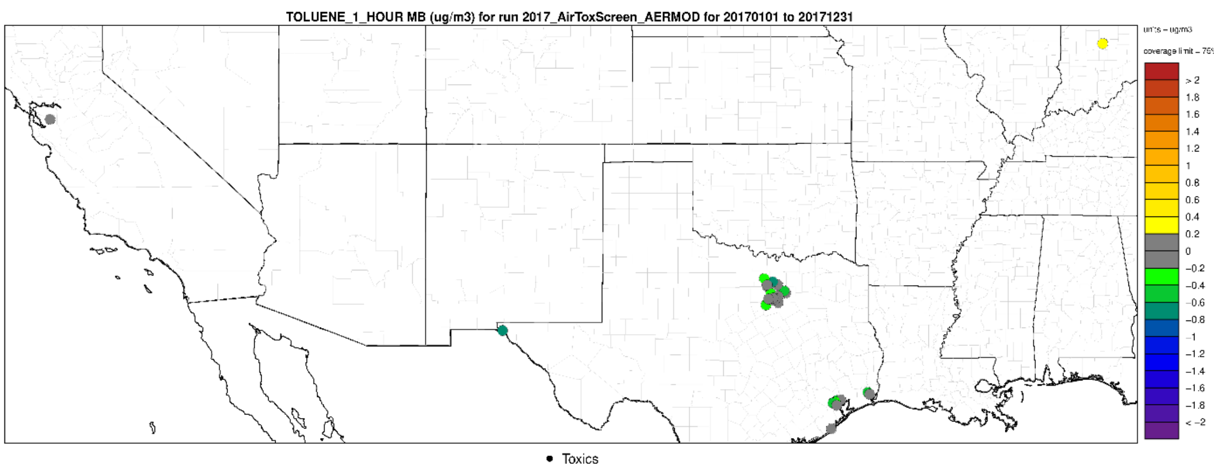


Figure E-56. Mean Bias (%) for toluene at 2017 monitoring sites (TOLU_1_HOUR) in the AERMOD modeling domain

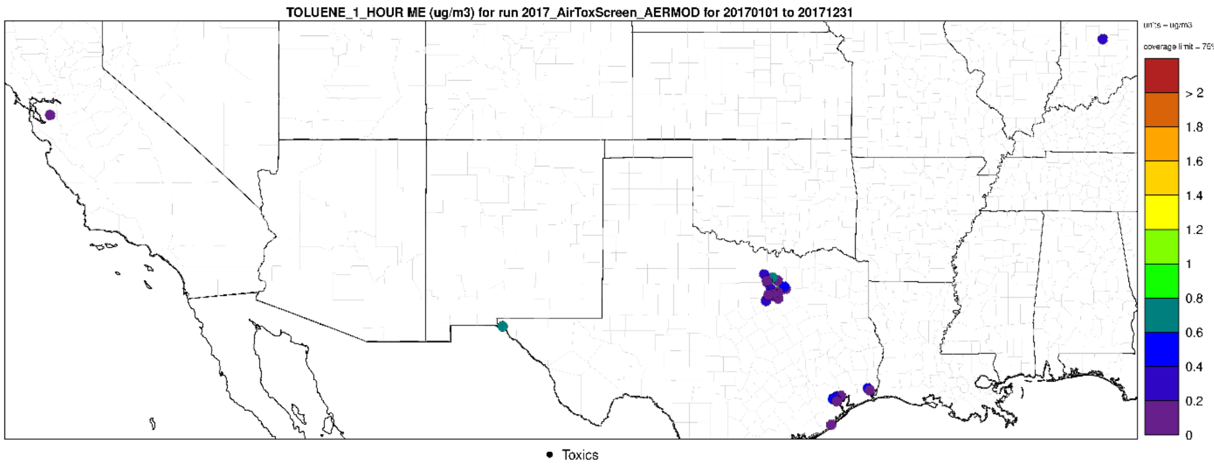


Figure E-57. Mean Error (%) for toluene at 2017 monitoring sites (TOLU_1_HOUR) in the AERMOD modeling domain

(a) (b)

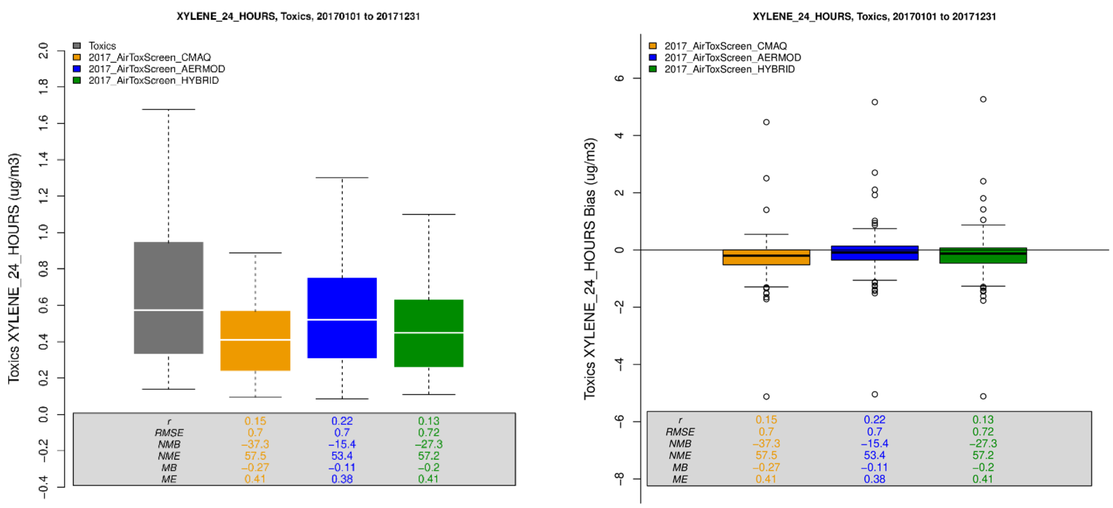


Figure E-58. Xylene boxplots of (a) distribution (μg/m^3) and (b) bias difference (μg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (XYLENE_24_HOURS)

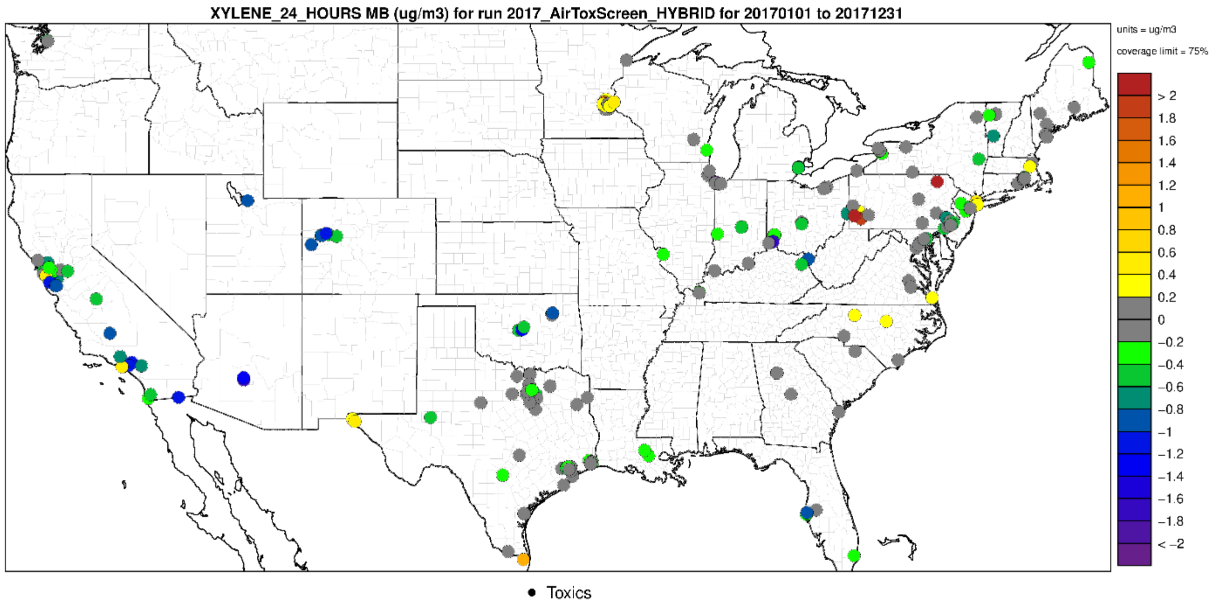


Figure E-59. Mean Bias (%) for xylene at 2017 monitoring sites (XYLENE_24_HOURS) in the Hybrid modeling domain

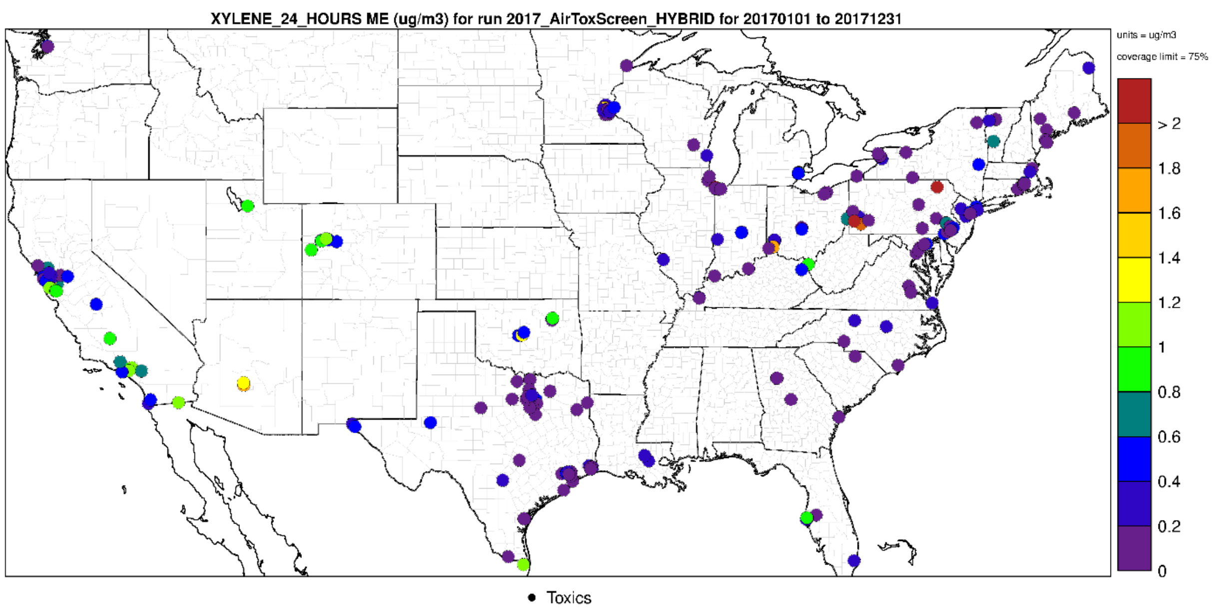


Figure E-60. Mean Error (%) for xylene at 2017 monitoring sites (XYLENE_24_HOURS) in the Hybrid modeling domain

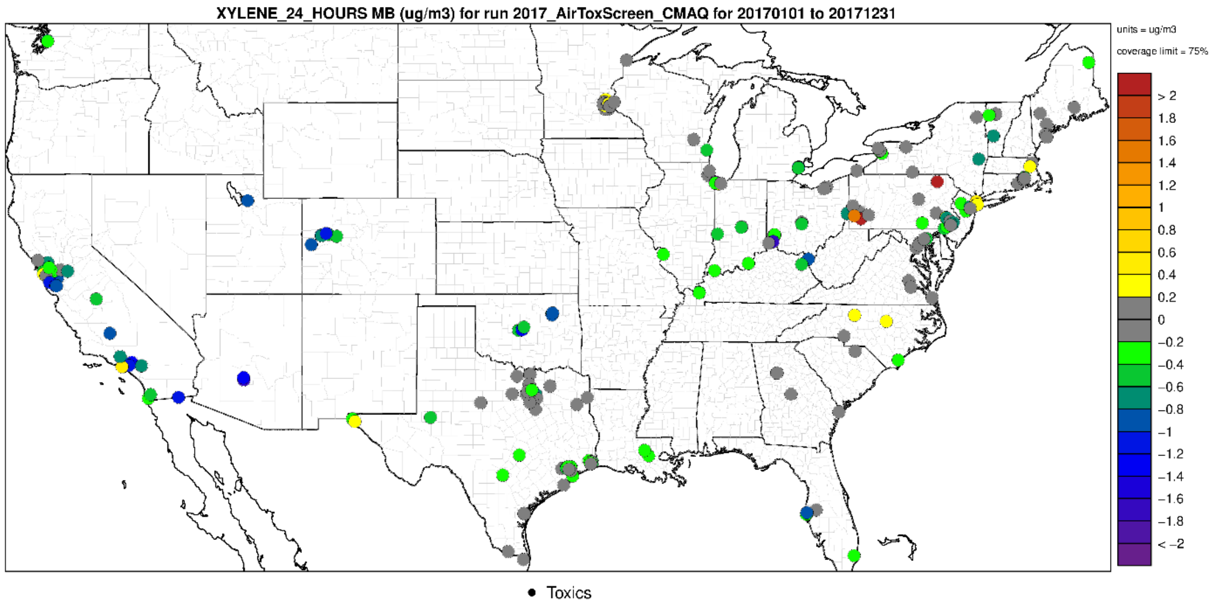


Figure E-61. Mean Bias (%) for xylene at 2017 monitoring sites (XYLENE_24_HOURS) in the CMAQ modeling domain

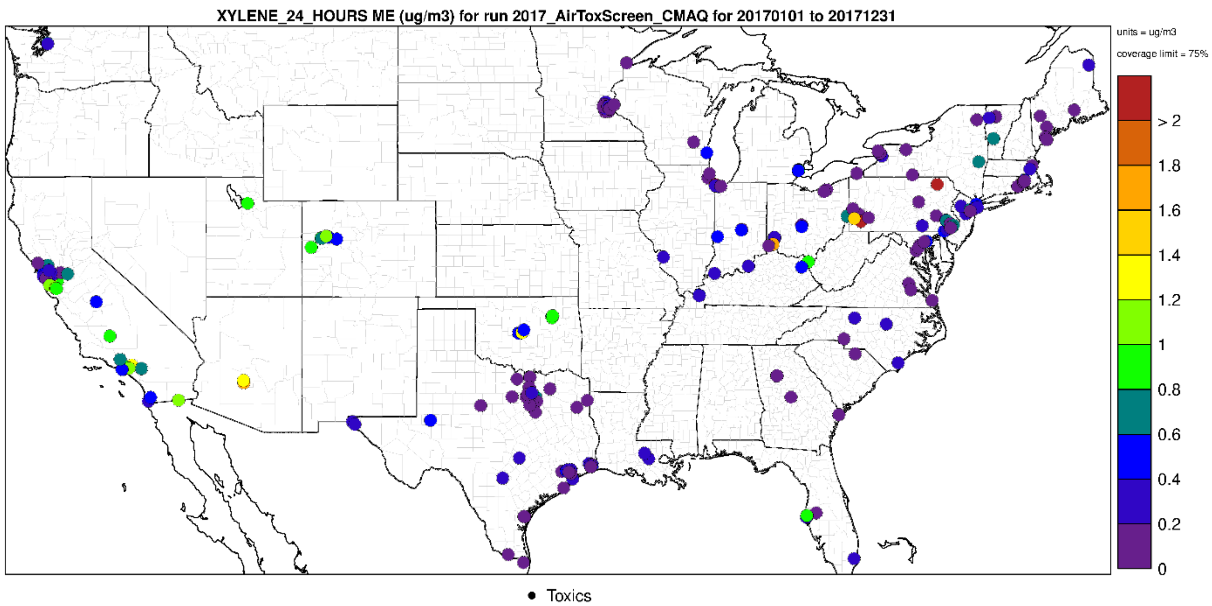


Figure E-62. Mean Error (%) for xylene at 2017 monitoring sites (XYLENE_24_HOURS) in the CMAQ modeling domain

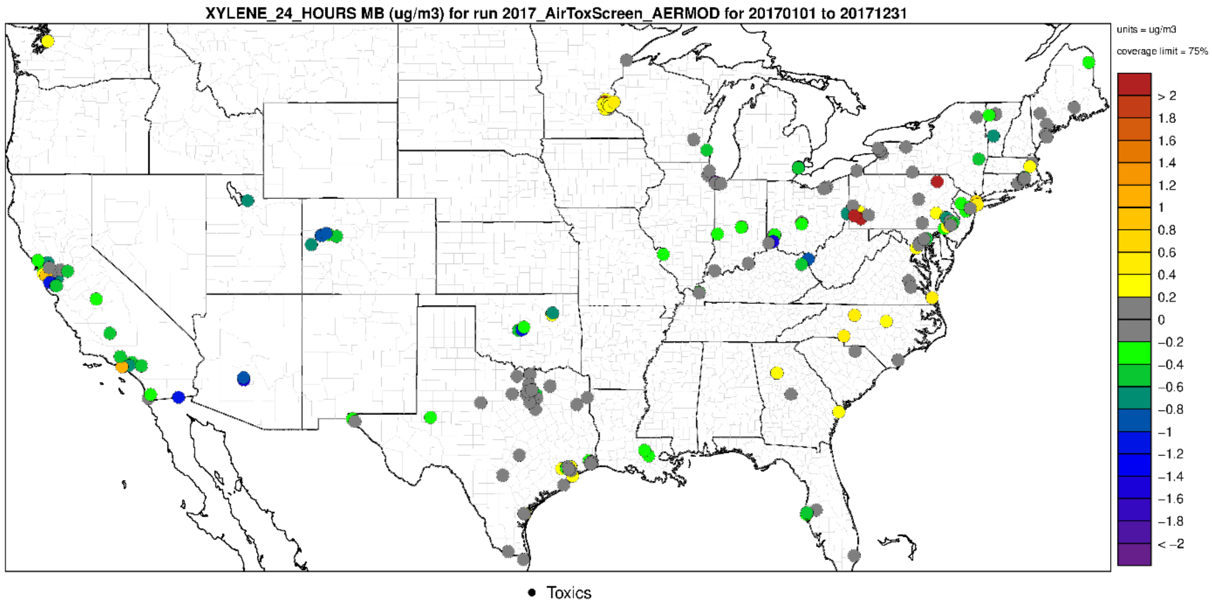


Figure E-63. Mean Bias (%) for xylene at 2017 monitoring sites (XYLENE_24_HOURS) in the AERMOD modeling domain

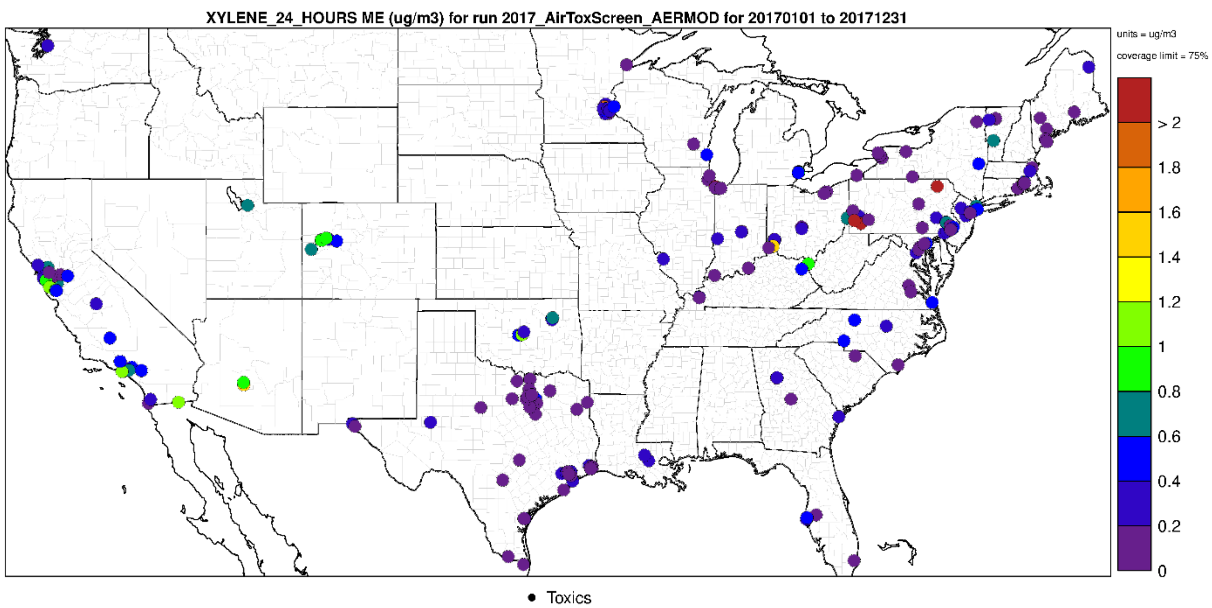


Figure E-64. Mean Error (%) for xylene at 2017 monitoring sites (XYLENE_24_HOURS) in the AERMOD modeling domain

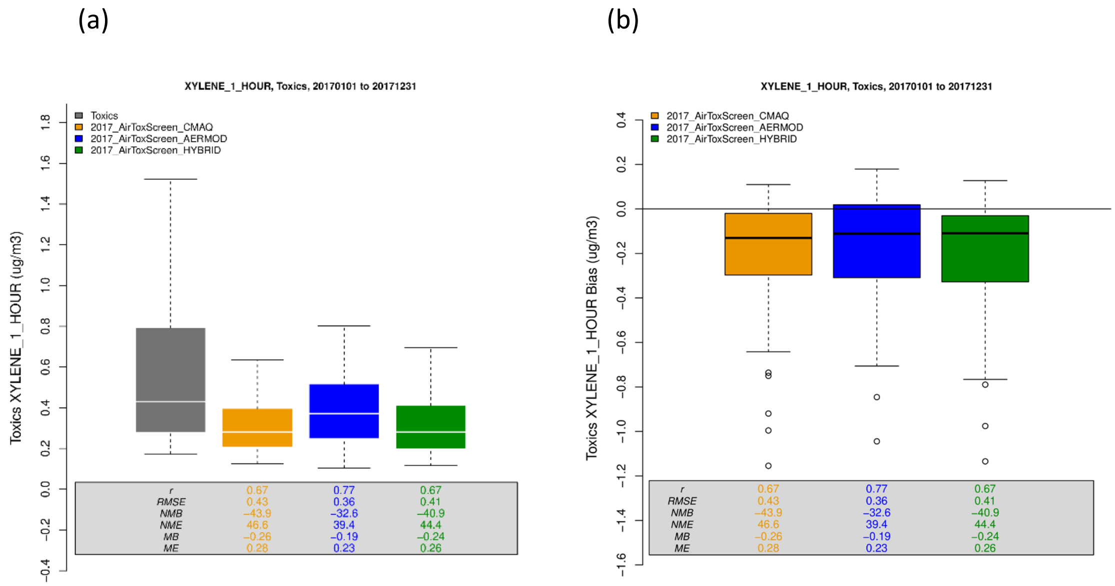


Figure E-65. Xylene boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (XYLENE_1_HOUR)

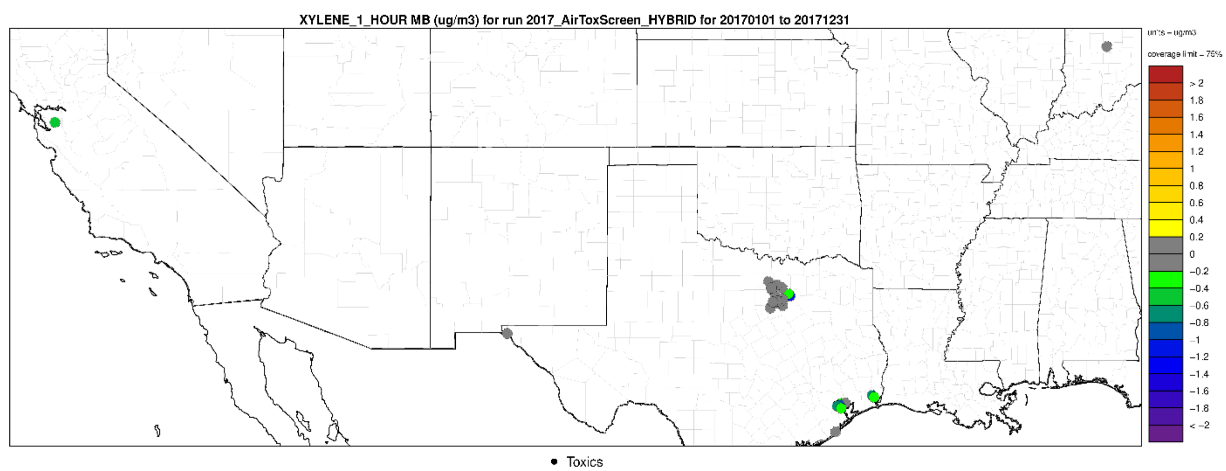


Figure E-66. Mean Bias (%) for xylene at 2017 monitoring sites (XYLENE_1_HOUR) in the Hybrid modeling domain

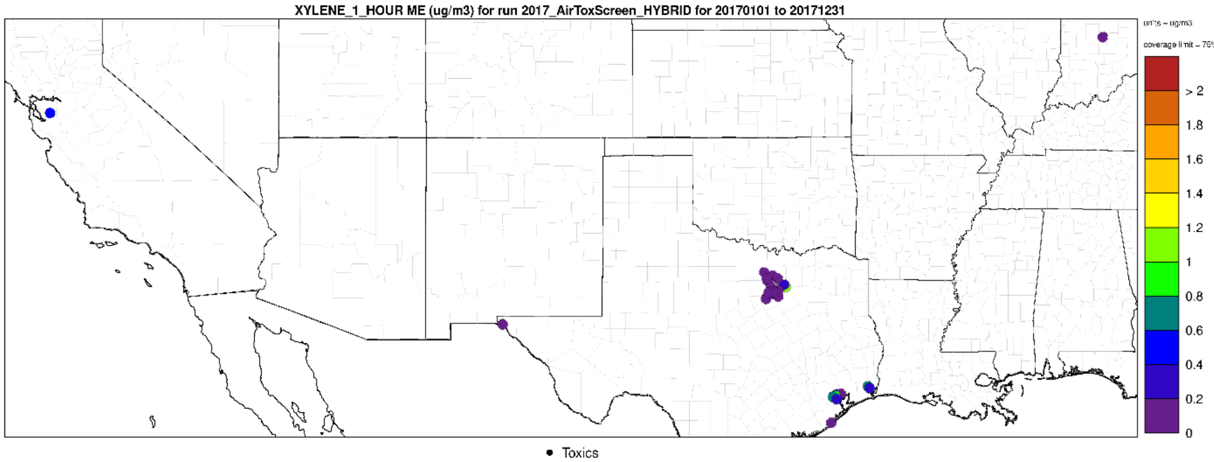


Figure E-67. Mean Error (%) for xylene at 2017 monitoring sites (XYLENE_1_HOUR) in the Hybrid modeling domain

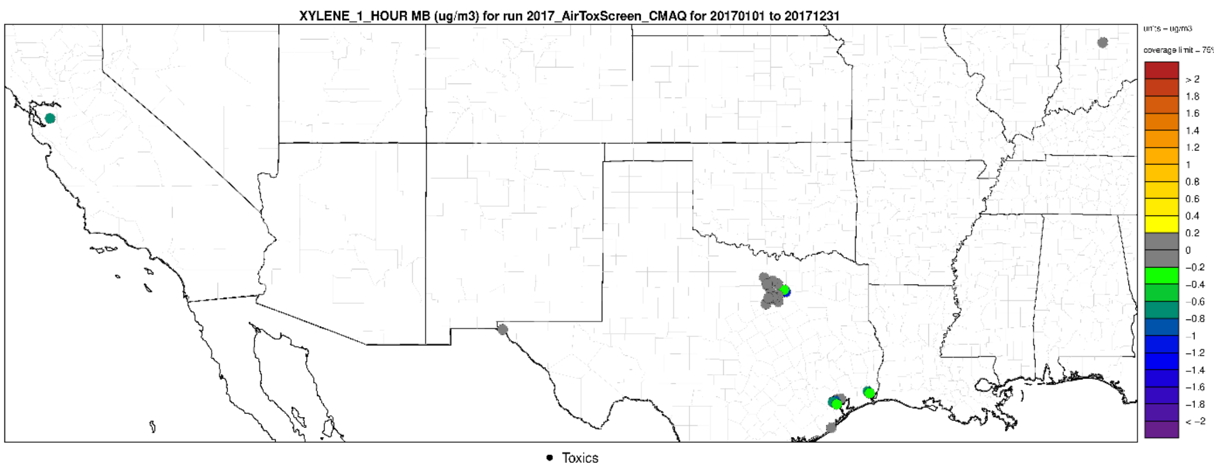


Figure E-68. Mean Bias (%) for xylene at 2017 monitoring sites (XYLENE_1_HOUR) in the CMAQ modeling domain

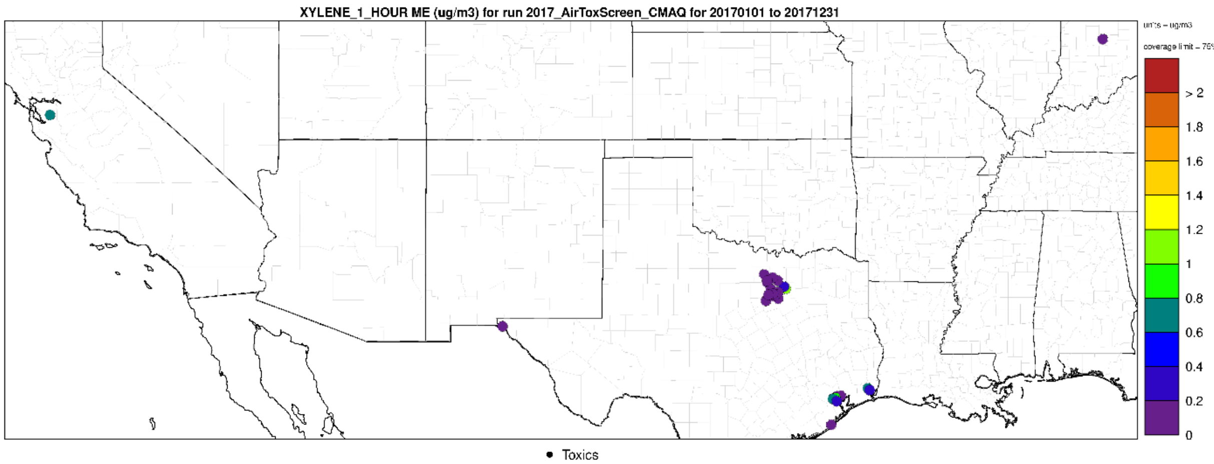


Figure E-69. Mean Error (%) for xylene at 2017 monitoring sites (XYLENE_1_HOUR) in the CMAQ modeling domain

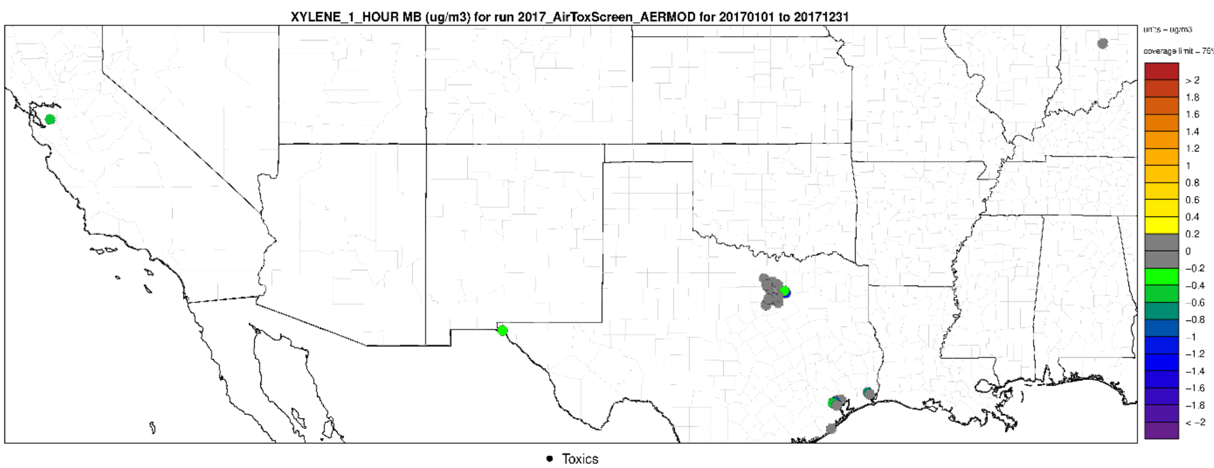


Figure E-70. Mean Bias (%) for xylene at 2017 monitoring sites (XYLENE_1_HOUR) in the AERMOD modeling domain

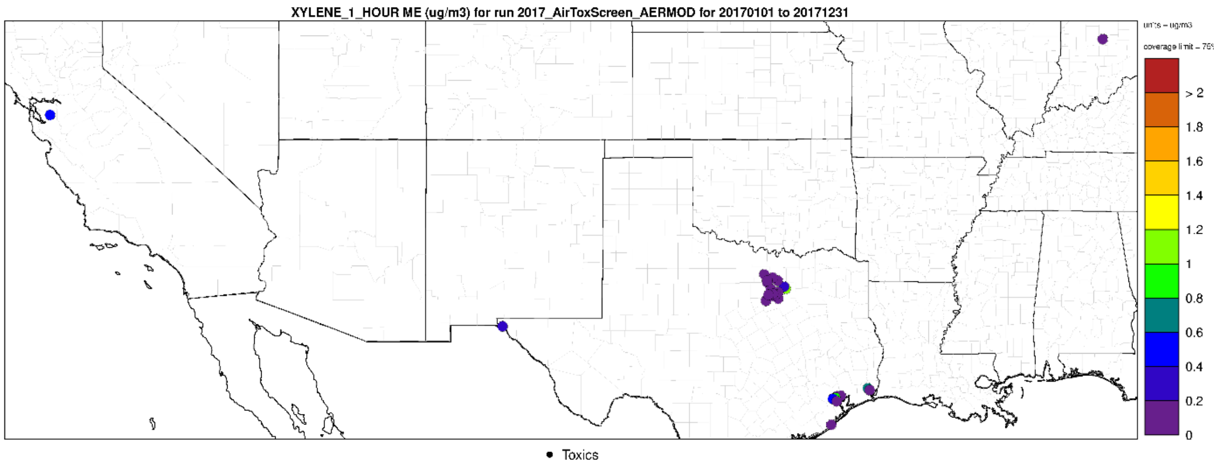


Figure E-71. Mean Error (%) for xylene at 2017 monitoring sites (XYLENE_1_HOUR) in the AERMOD modeling domain

(a) (b)

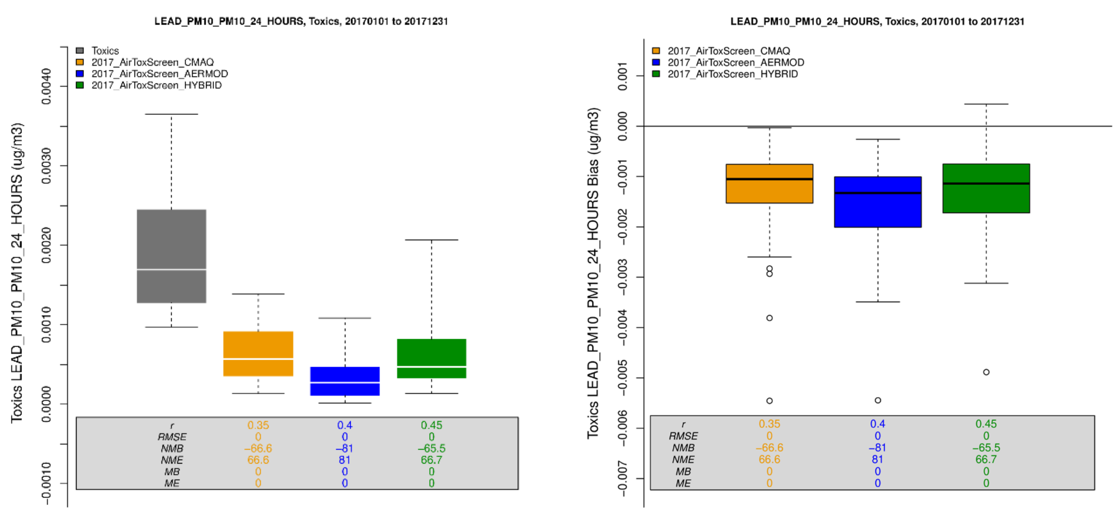


Figure E-72. Lead PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (LEAD_PM10_24_HOURS)

(a) (b)

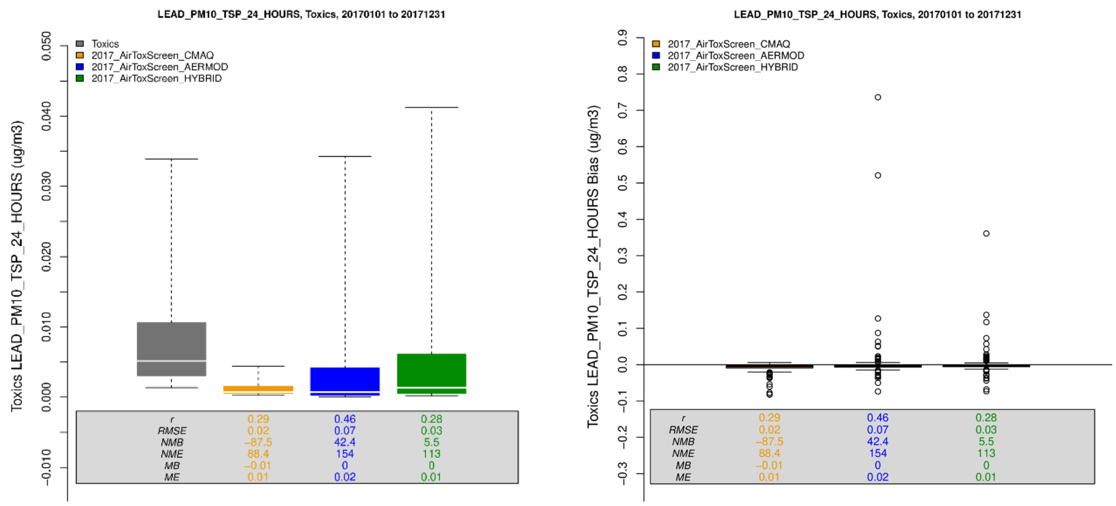


Figure E-73. Lead PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (LEAD_TSP_24_HOURS)

(a) (b)

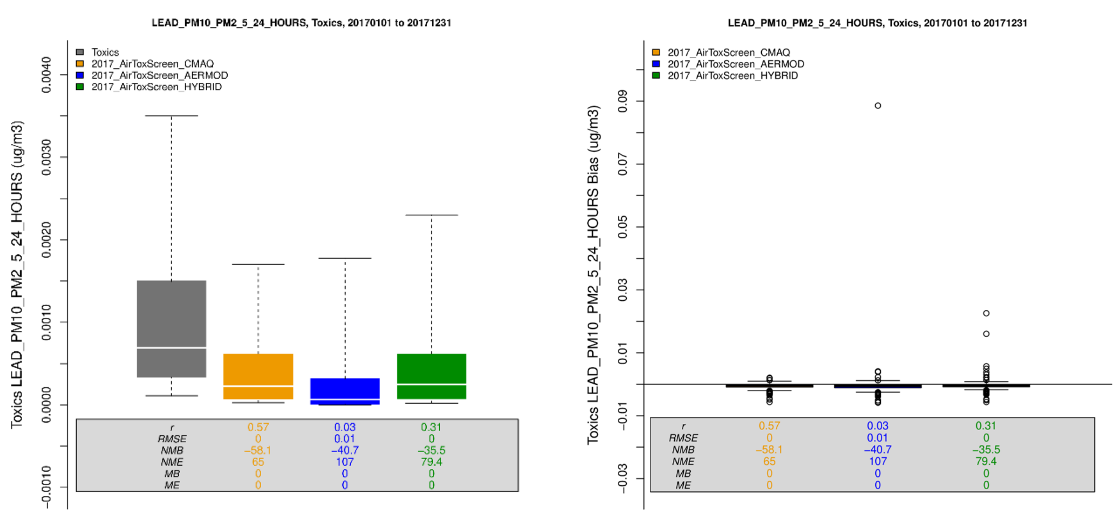


Figure E-74. Lead PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (LEAD_PM25_24_HOURS)

(a) (b)

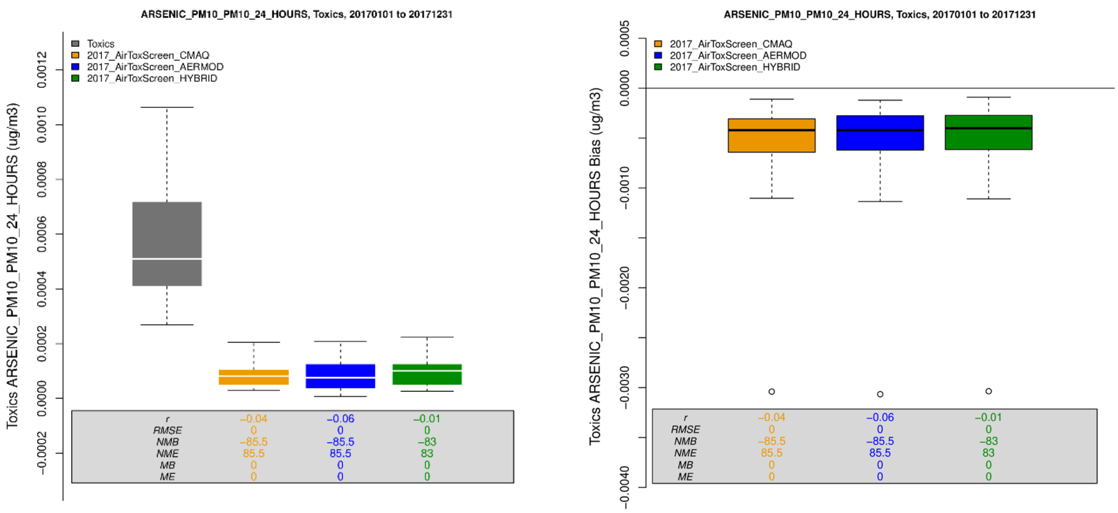


Figure E-75. Arsenic PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (ARSENIC_PM10_24_HOURS)

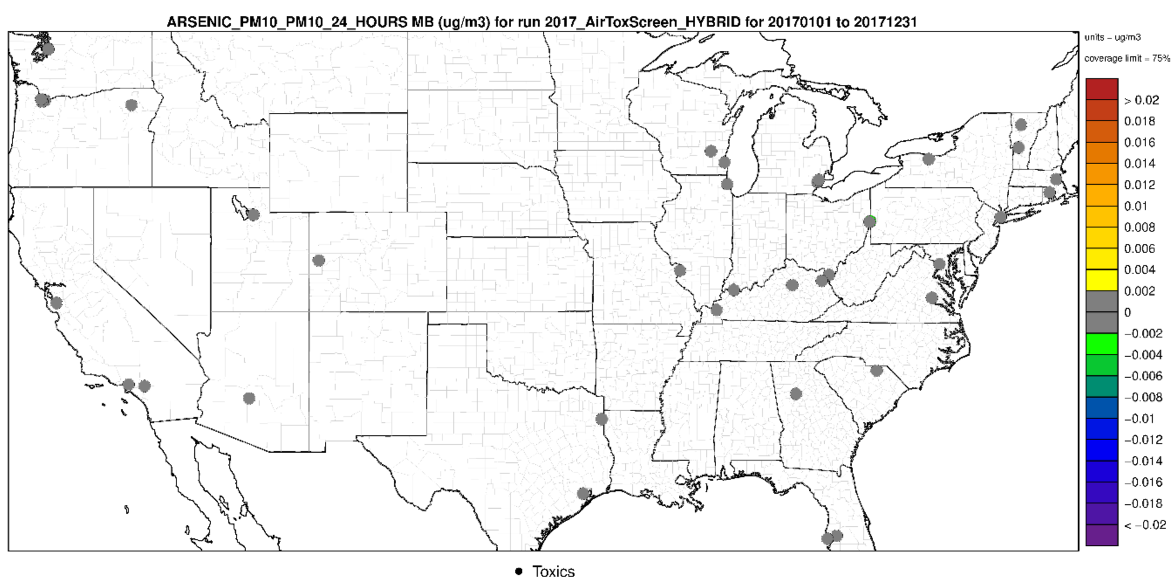


Figure E-76. Mean Bias (%) for arsenic PM10 at 2017 monitoring sites (ARSENIC_PM10_24_HOURS) in the Hybrid modeling domain

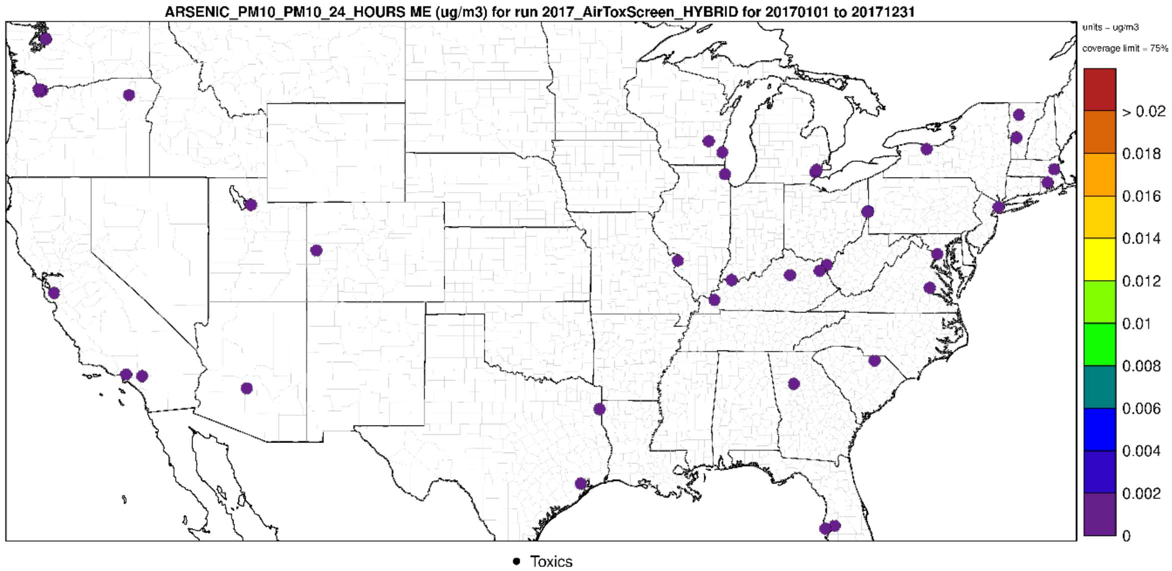


Figure E-77. Mean Error (%) for arsenic PM10 at 2017 monitoring sites (ARSENIC_PM10_24_HOURS) in the Hybrid modeling domain

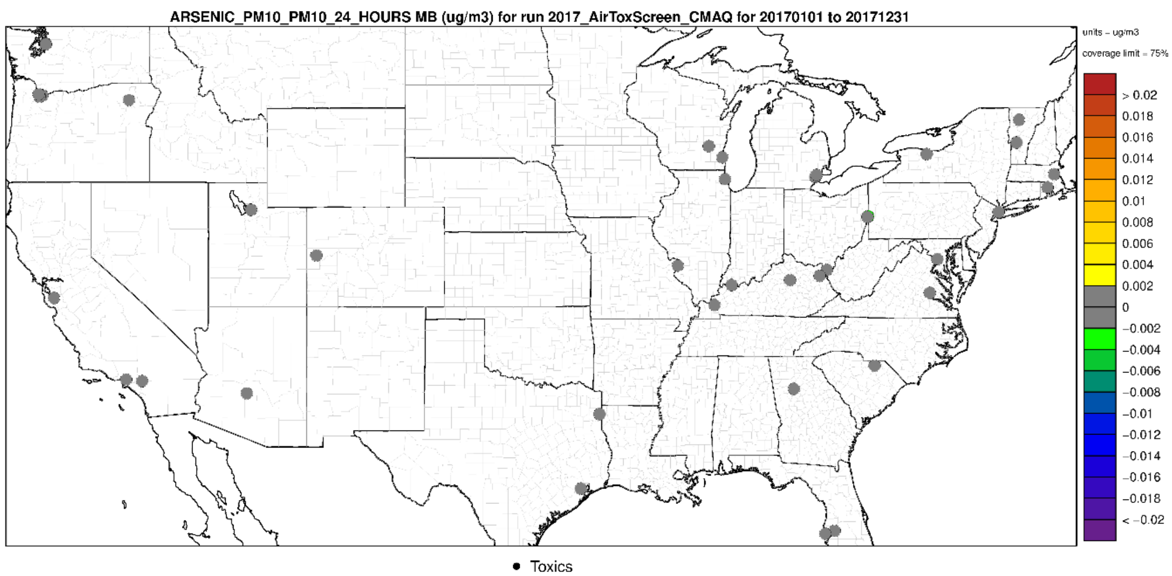


Figure E-78. Mean Bias (%) for arsenic PM10 at 2017 monitoring sites (ARSENIC_PM10_24_HOURS) in the CMAQ modeling domain

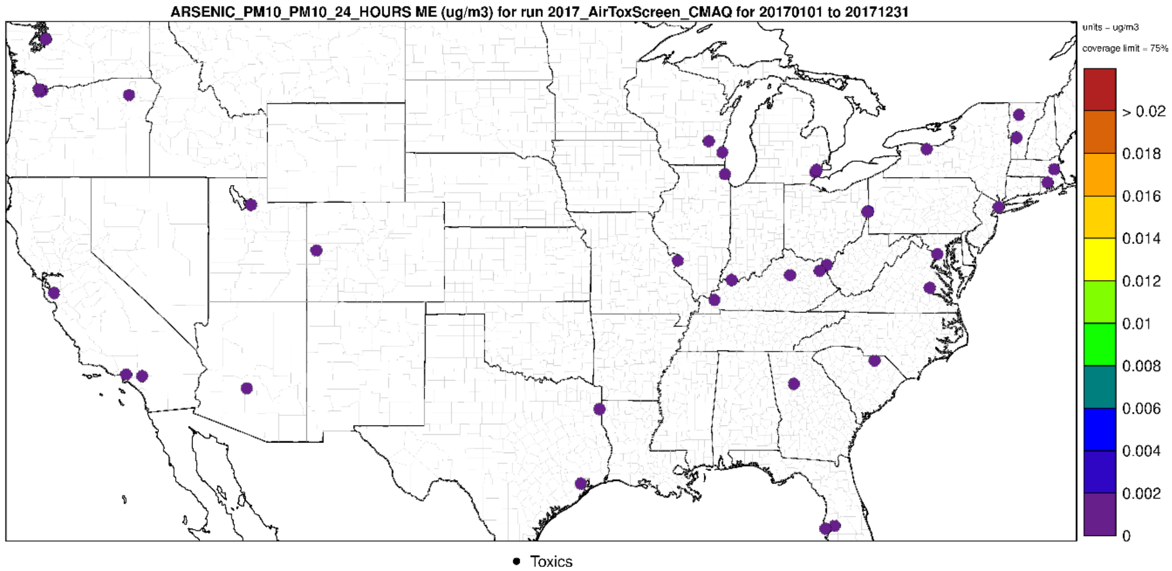


Figure E-79. Mean Error (%) for arsenic PM10 at 2017 monitoring sites (ARSENIC_PM10_24_HOURS) in the CMAQ modeling domain

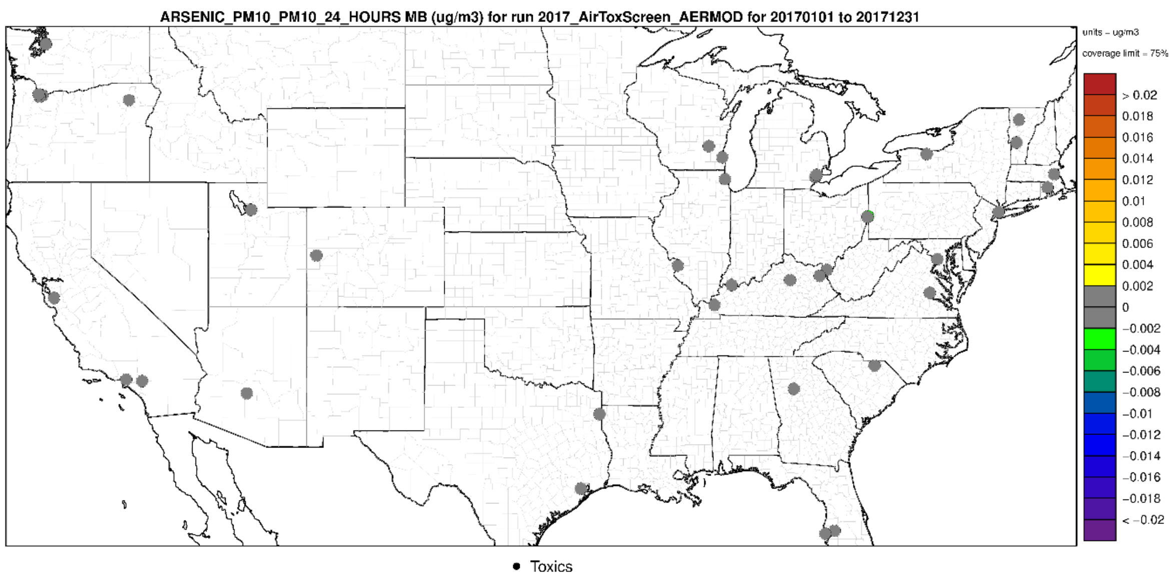


Figure E-80. Mean Bias (%) for arsenic PM10 at 2017 monitoring sites (ARSENIC_PM10_24_HOURS) in the AERMOD modeling domain

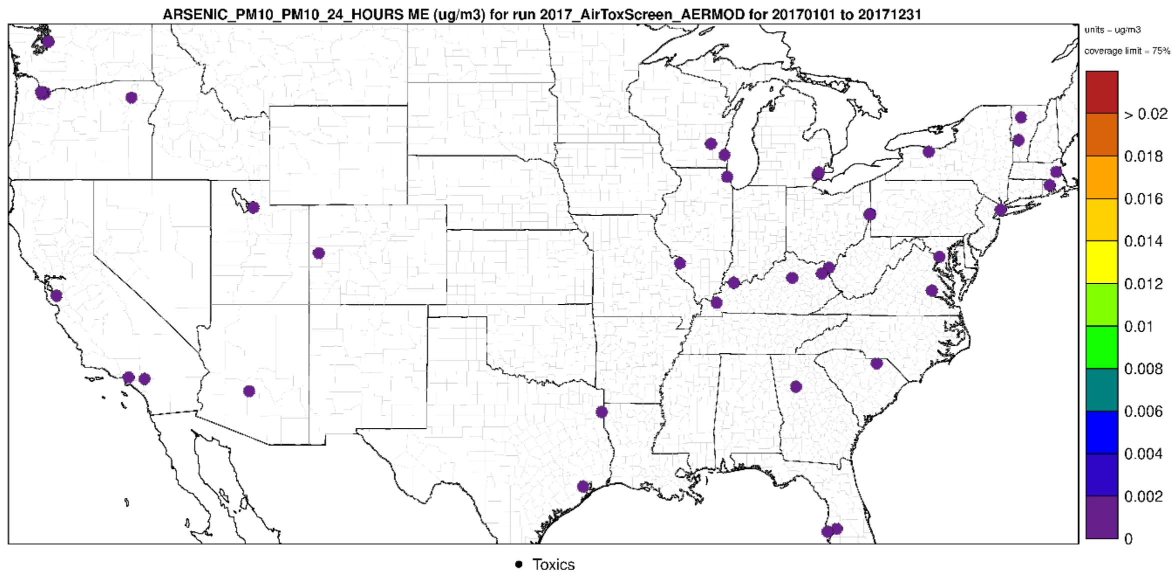


Figure E-81. Mean Error (%) for arsenic PM10 at 2017 monitoring sites (ARSENIC_PM10_24_HOURS) in the AERMOD modeling domain

(a) (b)

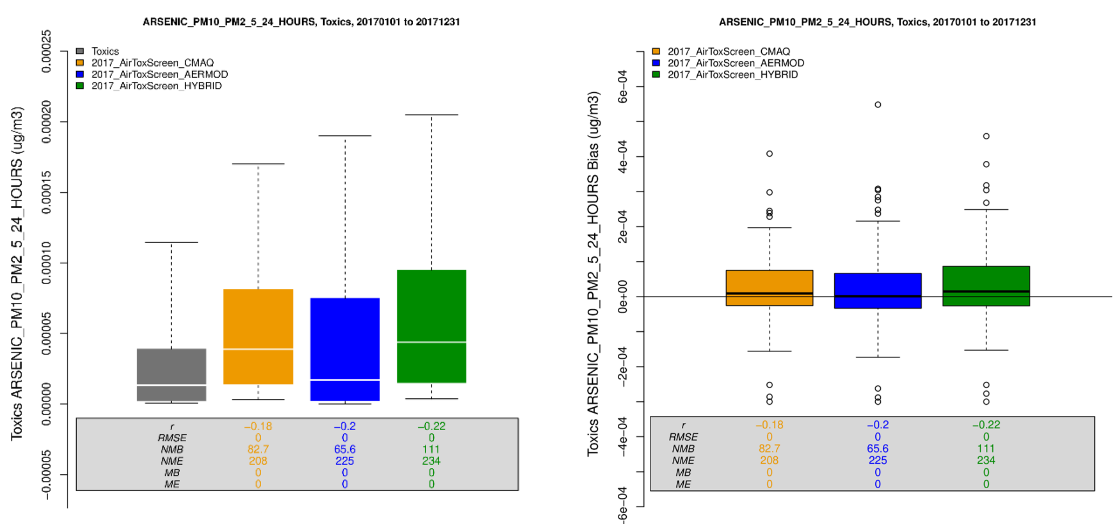


Figure E-82. Arsenic PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (ARSENIC_PM25_24_HOURS)

(a) (b)

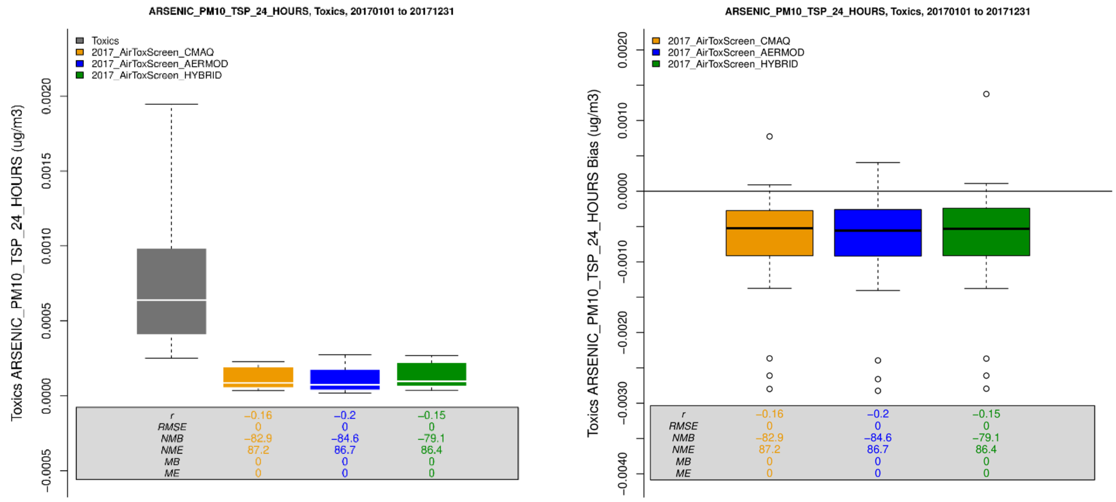


Figure E-83. Arsenic PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (ARSENIC_TSP_24_HOURS)

(a) (b)

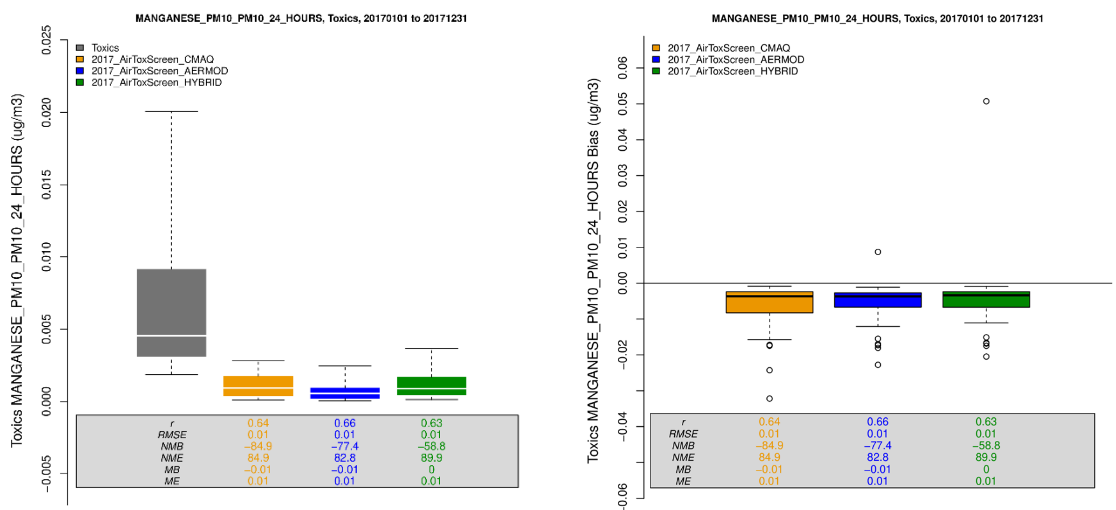


Figure E-84. Manganese PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (Manganese_PM10_24_HOURS)

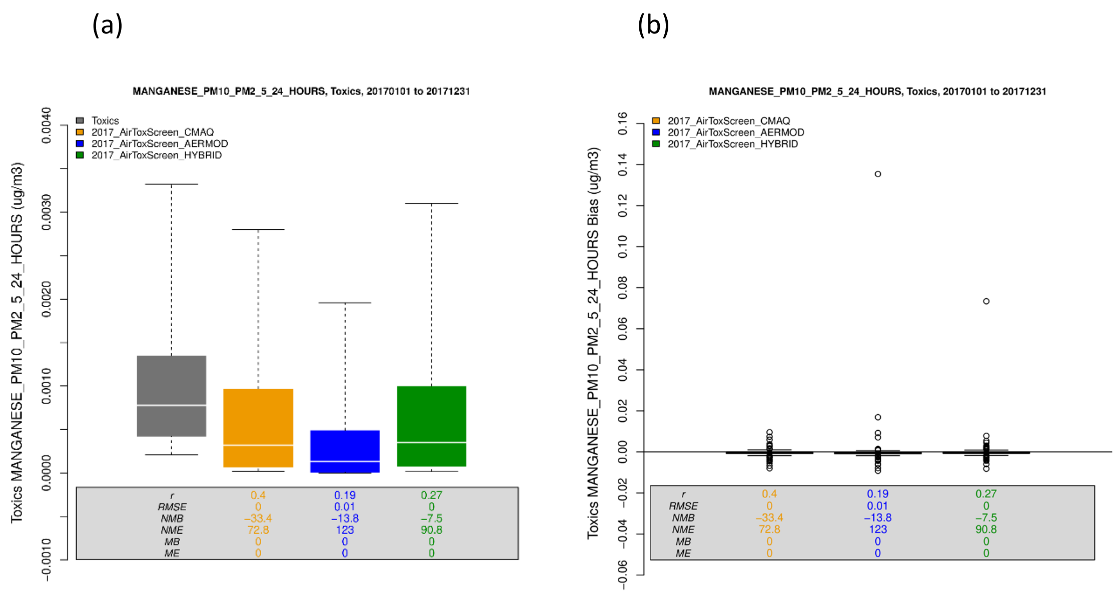


Figure E-85. Manganese PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (Manganese_PM25_24_HOURS)

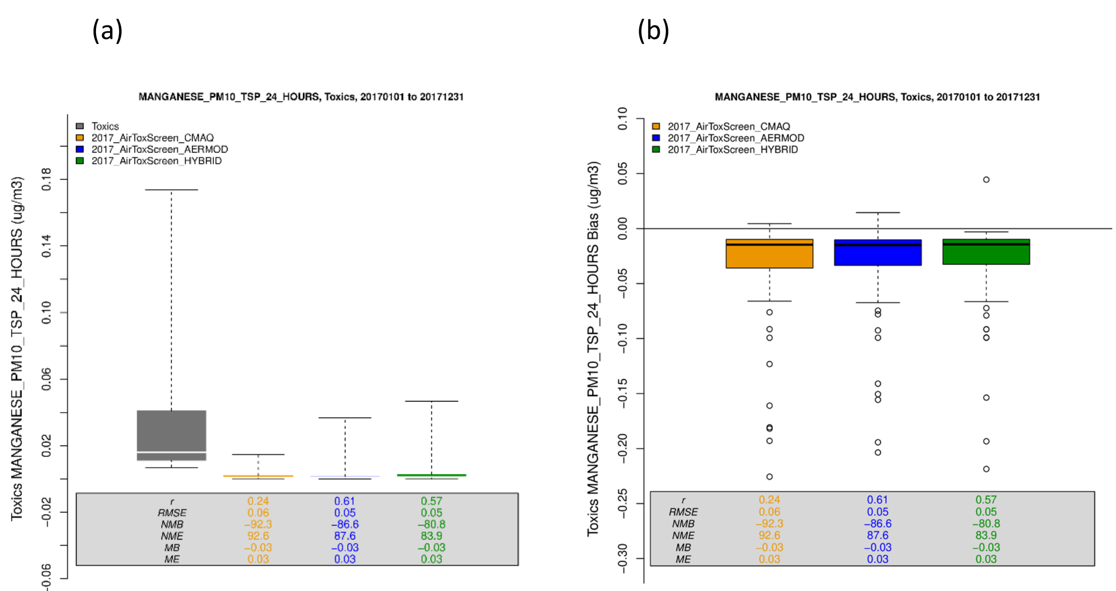
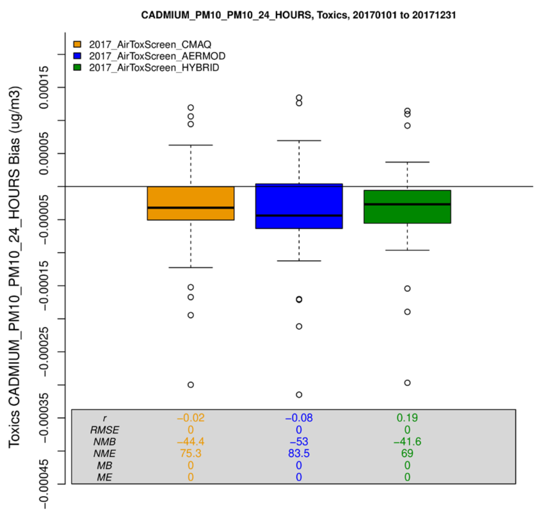
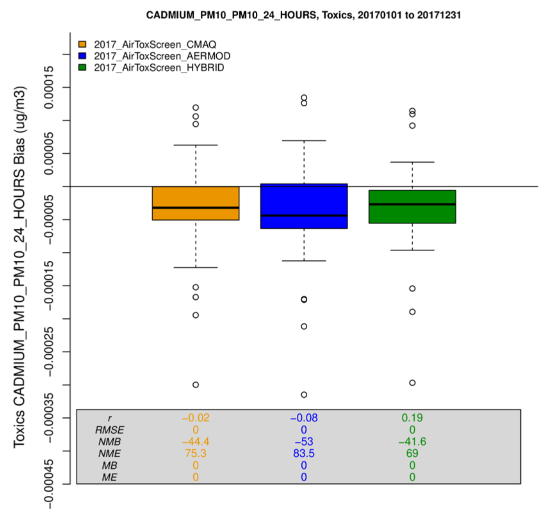


Figure E-86. Manganese PM10 boxplots of (a) distribution (µg/m^3) and (b) bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations (Manganese_TSP_24_HOURS)

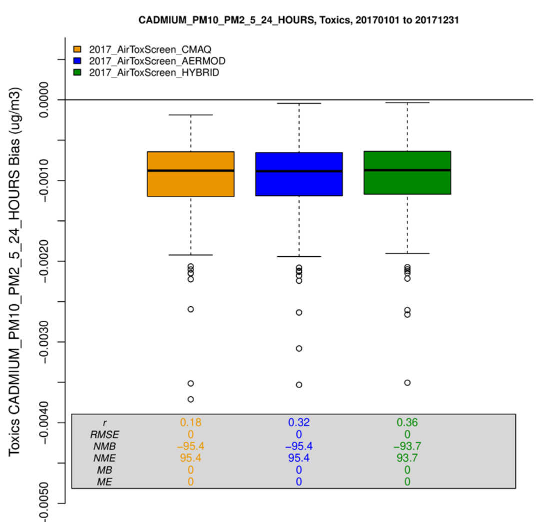
(a) Acetonitrile (AECT_NITRILE_24_HOURS)



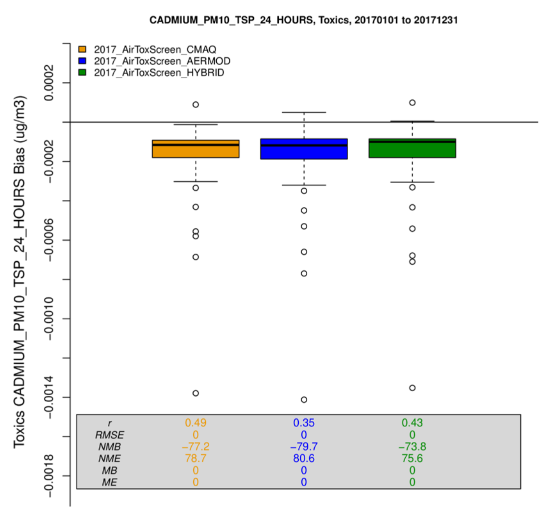
(b) Cadmium (PM10_24_HOURS)



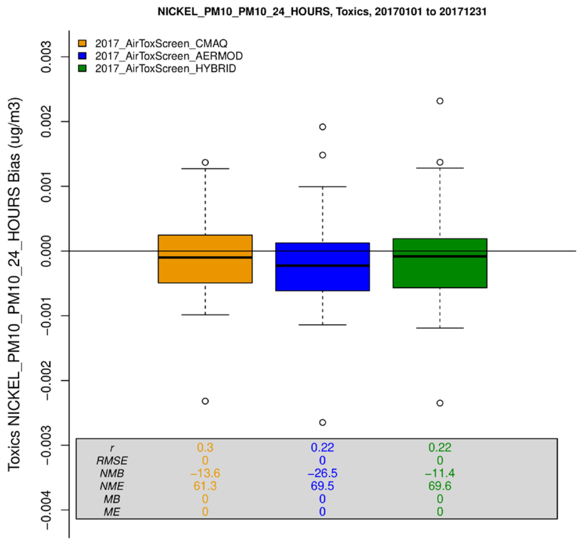
(c) Cadmium (PM25_24_HOURS)



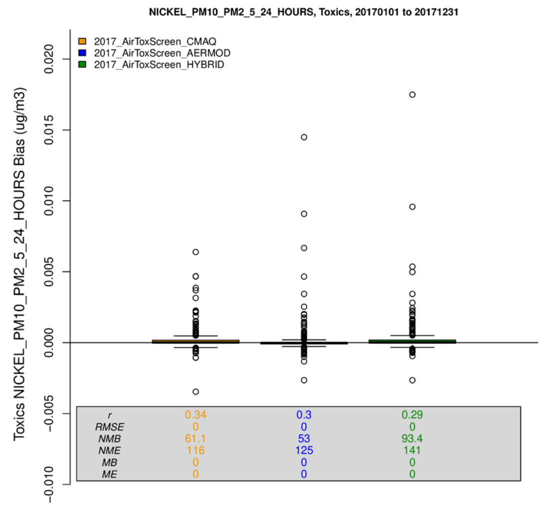
(d) Cadmium (TSP_24_HOURS)



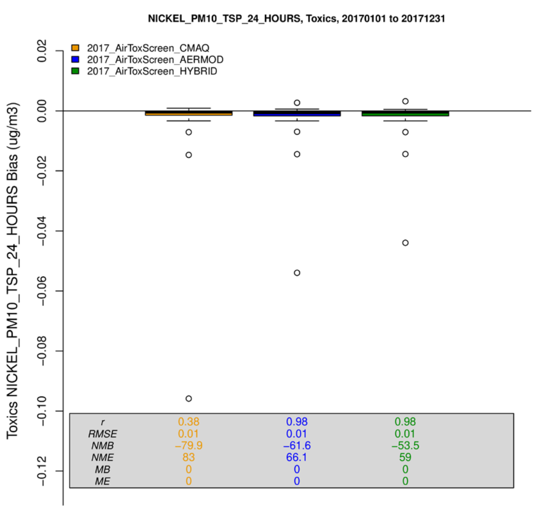
(e) Nickel (PM10_24_HOURS)



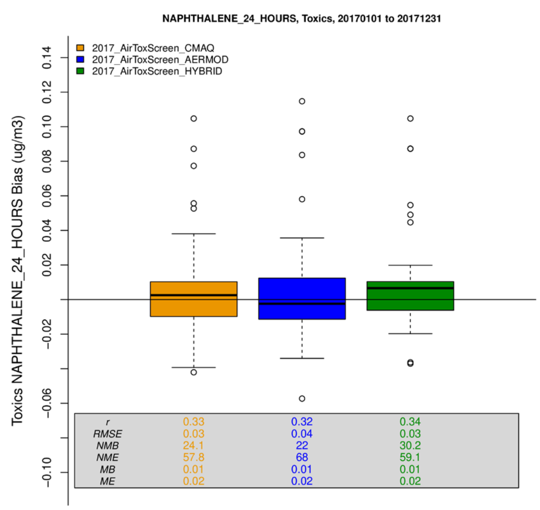
(f) Nickel (PM25_24_HOURS)



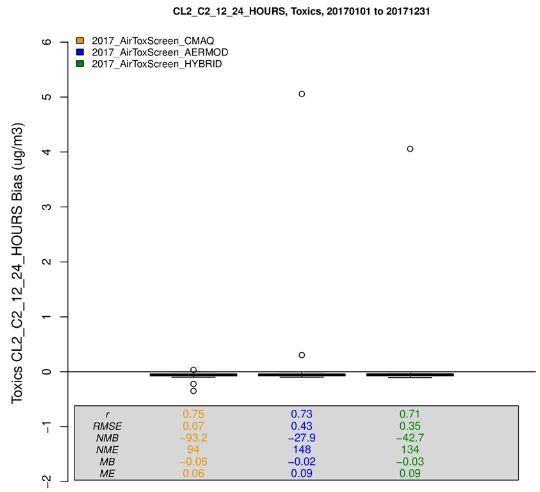
(g) Nickel (TSP_24_HOURS)



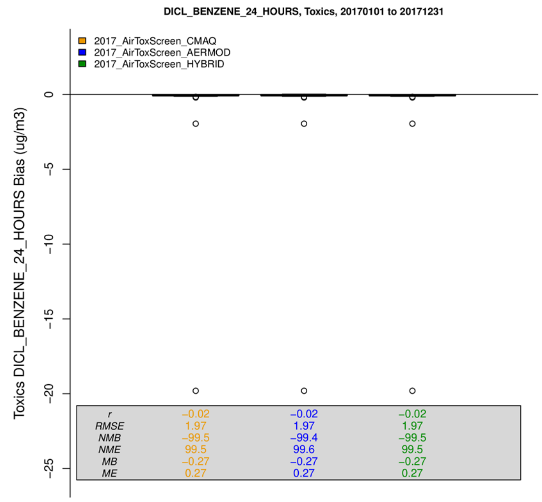
(h) Naphthalene (24_HOURS)



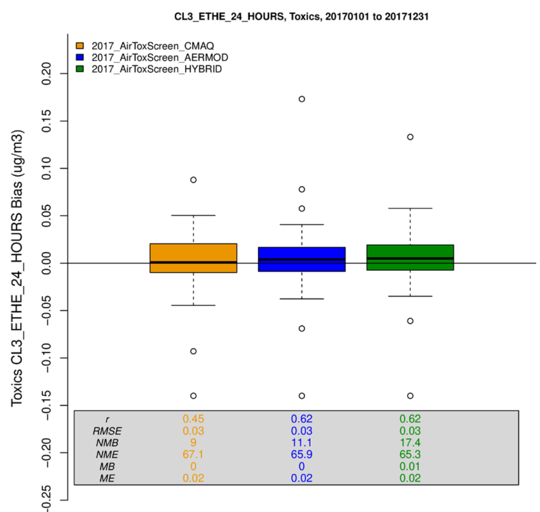
(i) 1,2- Dichloroethane (24_HOURS)



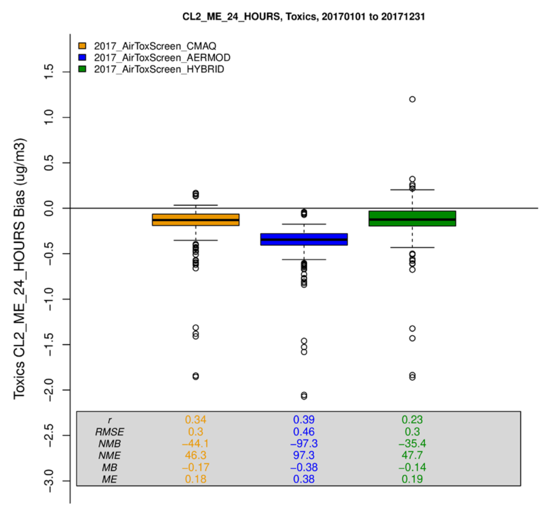
(j) Dichlorobenzene (24_HOURS)



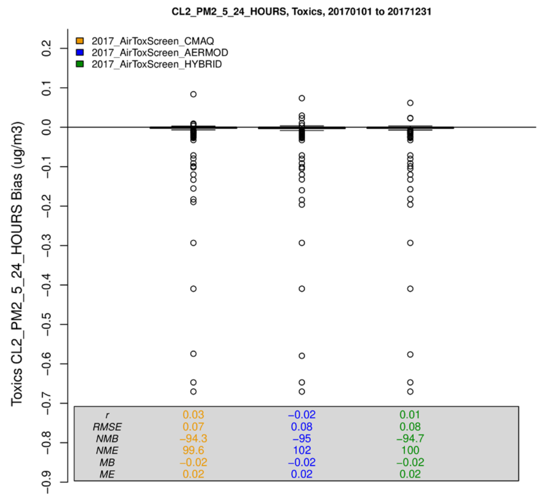
(k) Trichloroethylene (24_HOURS)



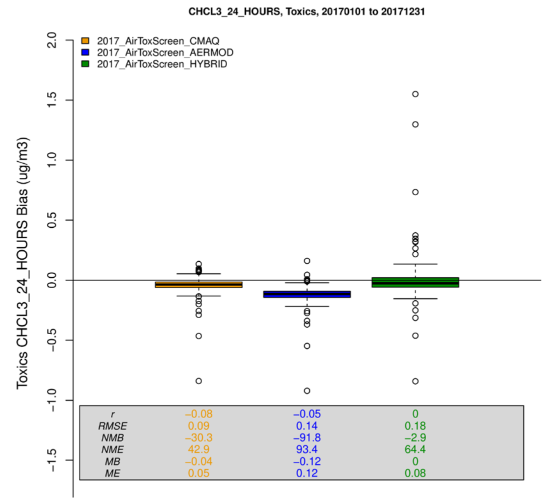
(l) Methylene Chloride (24_HOURS)



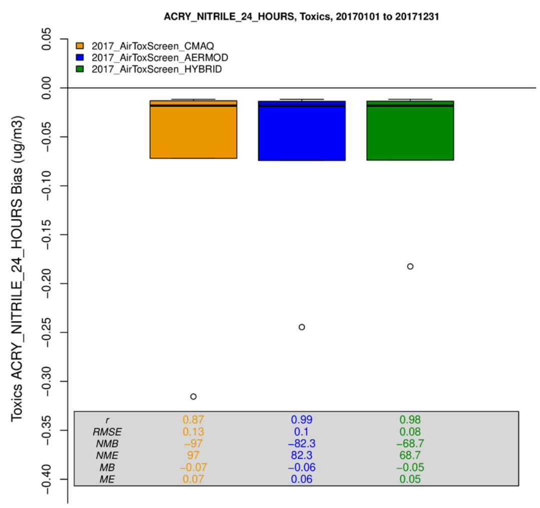
(m) Chlorine (PM25_24_HOURS)



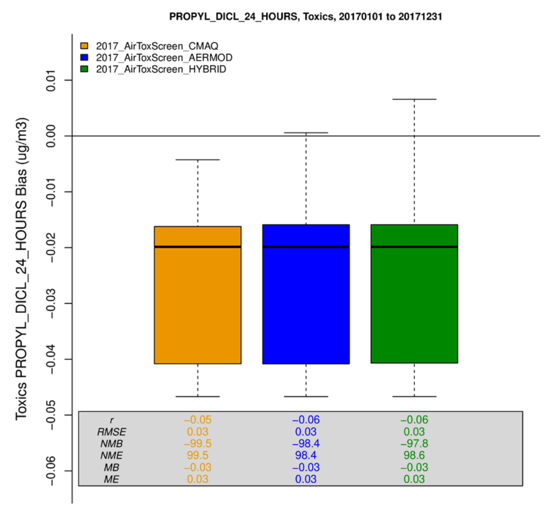
(n) Chloroform (24_HOURS)



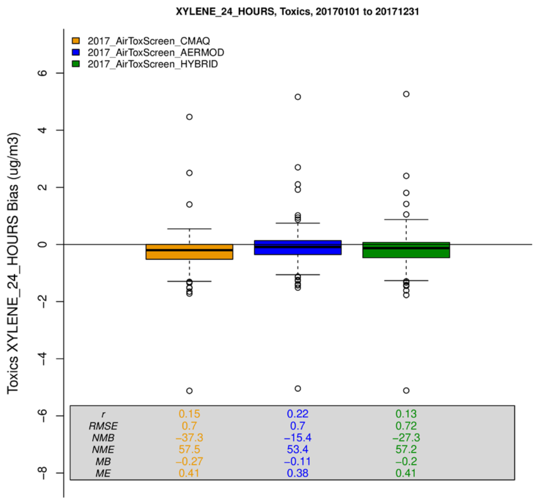
(o) Acrylonitrile (24_HOURS)



(p) Propylene dichloride (24_HOURS)



(q) Xylene (24_HOURS)



(r) Xylene (1_HOUR)

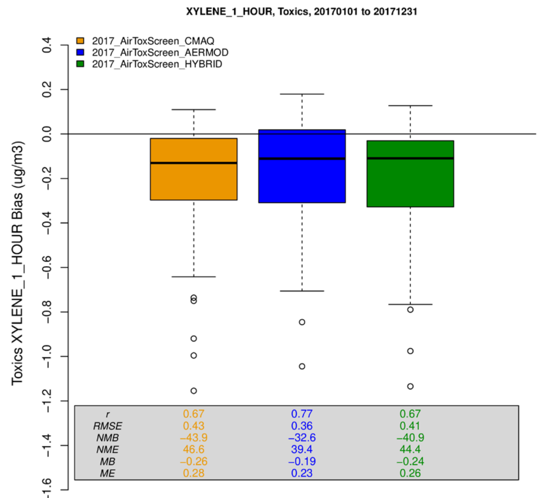


Figure E-87. Boxplots of bias difference (µg/m^3) for CMAQ, AERMOD, and Hybrid models compared to ambient observations for (a) Acetonitrile (24_HOURS), (b) Cadmium (PM10_24_HOURS), (c) Cadmium (PM25_24_HOURS), (d) Cadmium (TSP_24_HOURS), (e) Nickel (PM10_24_HOURS), (f) Nickel (PM25_24_HOURS), (g) Nickel (TSP_24_HOURS), (h) Naphthalene (24_HOURS), (i) 1,2- Dichloroethane (24_HOURS), (j) Dichlorobenzene (24_HOURS), (k) Trichloroethylene (24_HOURS), (l) Methylene Chloride (24_HOURS), (m) Chlorine (24_HOURS), (n) Chloroform (24_HOURS), (o) Acrylonitrile (24_HOURS), (p) Propylene dichloride (24_HOURS), (q) Xylene (24_HOURS) and (r) Xylene (1_HOUR)

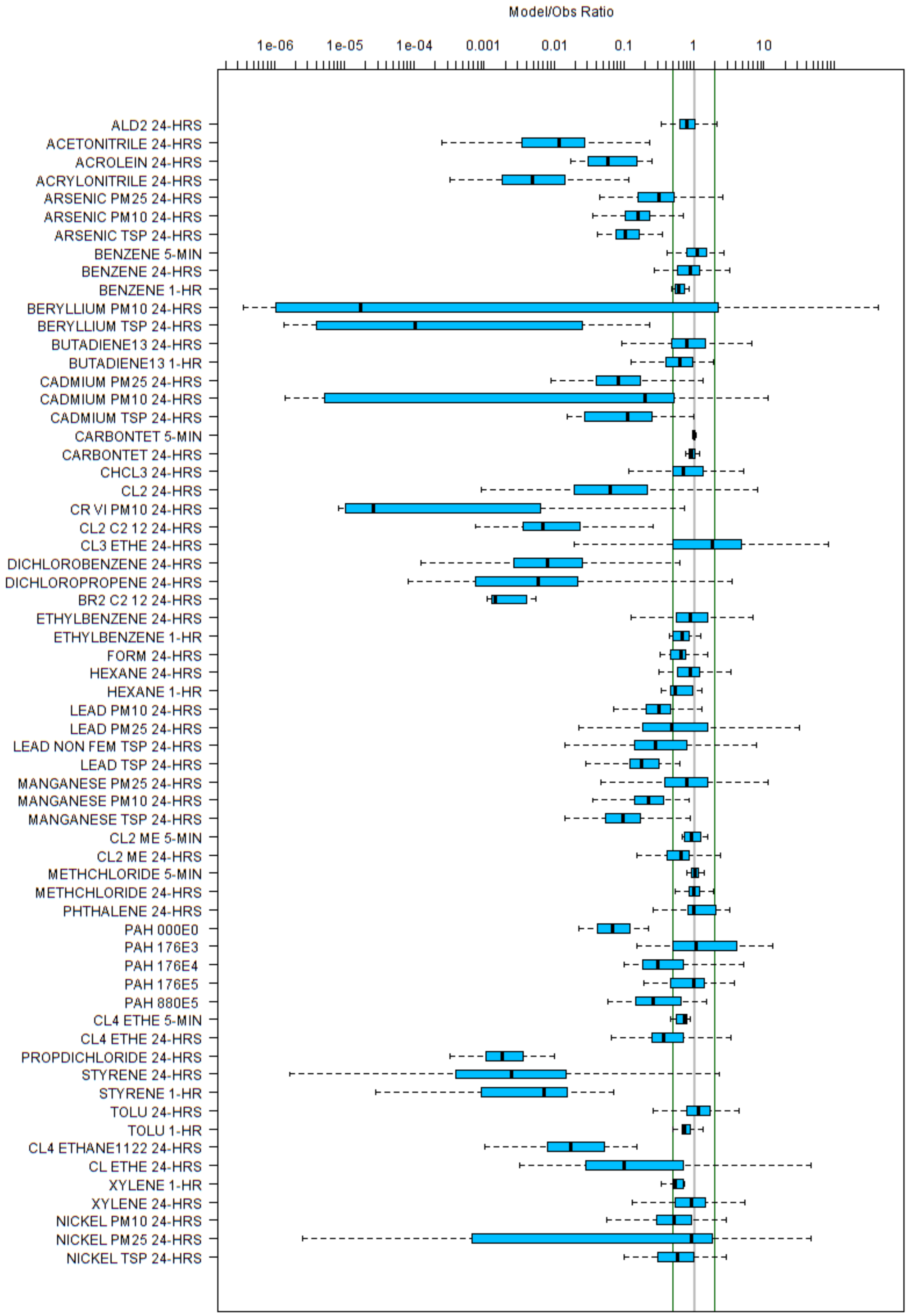


Figure E-88. 2017 Model-to-Monitor ratio comparisons of Hybrid HAPs

E.4 Non-hybrid Evaluation

An annual operational model performance evaluation for HAPs used in the non-hybrid model calculation was conducted in order to estimate the ability of the AERMOD model to replicate the 2017 HAP observed ambient concentrations. Statistical assessments of each model versus observed pairs were paired in time and space and aggregated on an annual basis. Table E-3 provides a list of HAPs evaluated in the hybrid model performance evaluation and the number of pairs (based on completeness criteria of observations, Section E.1) used in the annual median. Figure E-89 shows the 2017 non-hybrid HAP monitoring locations. In this section, paired average annual model to monitor site comparisons are presented.

Table E-3. List of non-hybrid HAPs evaluated

Model Air Toxic	Measured Air Toxic	No. of Sites
Antimony	ANTIMONY_PM25_24_HOURS	139
	ANTIMONY_PM10_24_HOURS	23
	ANTIMONY_TSP_24_HOURS	22
Cobalt	COBALT_PM25_24_HOURS	137
	COBALT_PM10_24_HOURS	29
	COBALT_TSP_24_HOURS	24
Selenium	SELENIUM_PM25_24_HOURS	286
	SELENIUM_PM10_24_HOURS	26
	SELENIUM_TSP_24_HOURS	10
Methyl Bromide (Bromomethane)	METHYLBROM_5_MINUTES	7
	METHYLBROM_24_HOURS	111
Methyl Chloroform (1,1,1-Trichloroethane)	MTHYLCHLRF_5_MINUTES	7
	MTHYLCHLRF_24_HOURS	120
	MTHYLCHLRF_1_HOUR	2
Carbon disulfide	CARBNDISULF_24_HOURS	57
Methyl Isobutyl Ketone (4-Methyl-2-pentanone)	MIBK_24_HOURS	61
Propanal (Propionaldehyde)	PROPIONAL_24_HOURS	95
Cumene (Isopropylbenzene)	CUMENE_24_HOURS	29
	CUMENE_1_HOUR	27
	CUMENE_3_HOURS	1
2,2,4-Trimethylpentane	TRMEPN224_24_HOURS	84
	TRMEPN224_1_HOUR	27
	TRMEPN224_3_HOURS	1
Bromoform (Tribromomethane)	BROMOFORM_24_HOURS	17
Chlorobenzene	CHLROBZNE_24_HOURS	75
1,2,4-Trichlorobenzene	TRICBZ124_24_HOURS	47
Benzyl Chloride (alpha-Chlorotoluene)	BENZYLCHLO_24_HOURS	22
Hexachloro-1,3-butadiene	HEXCHLRBT_24_HOURS	20
Methyl tert-butyl ether	MTBE_24_HOURS	20
p-Dioxane (1,4-Dioxane)	P_DIOXANE_24_HOURS	10

Model Air Toxic	Measured Air Toxic	No. of Sites
Vinyl Acetate	VINYLACET_24_HOURS	18
Ethyl Chloride (Chloroethane)	ETHYLCHLRD_24_HOURS	56
Ethylidene Dichloride (1,1-Dichloroethane)	ETHIDDICHLD_24_HOURS	43
Methyl Methacrylate	MMETACRYLAT_24_HOURS	11
Vinylidene Chloride (1,1-Dichloroethylene)	VINYLIDCLOR_24_HOURS	30
Methyl Iodide	MTHYLIODIDE_24_HOURS	2
1,1,2-Trichloroethane	TRICLA112_24_HOURS	31

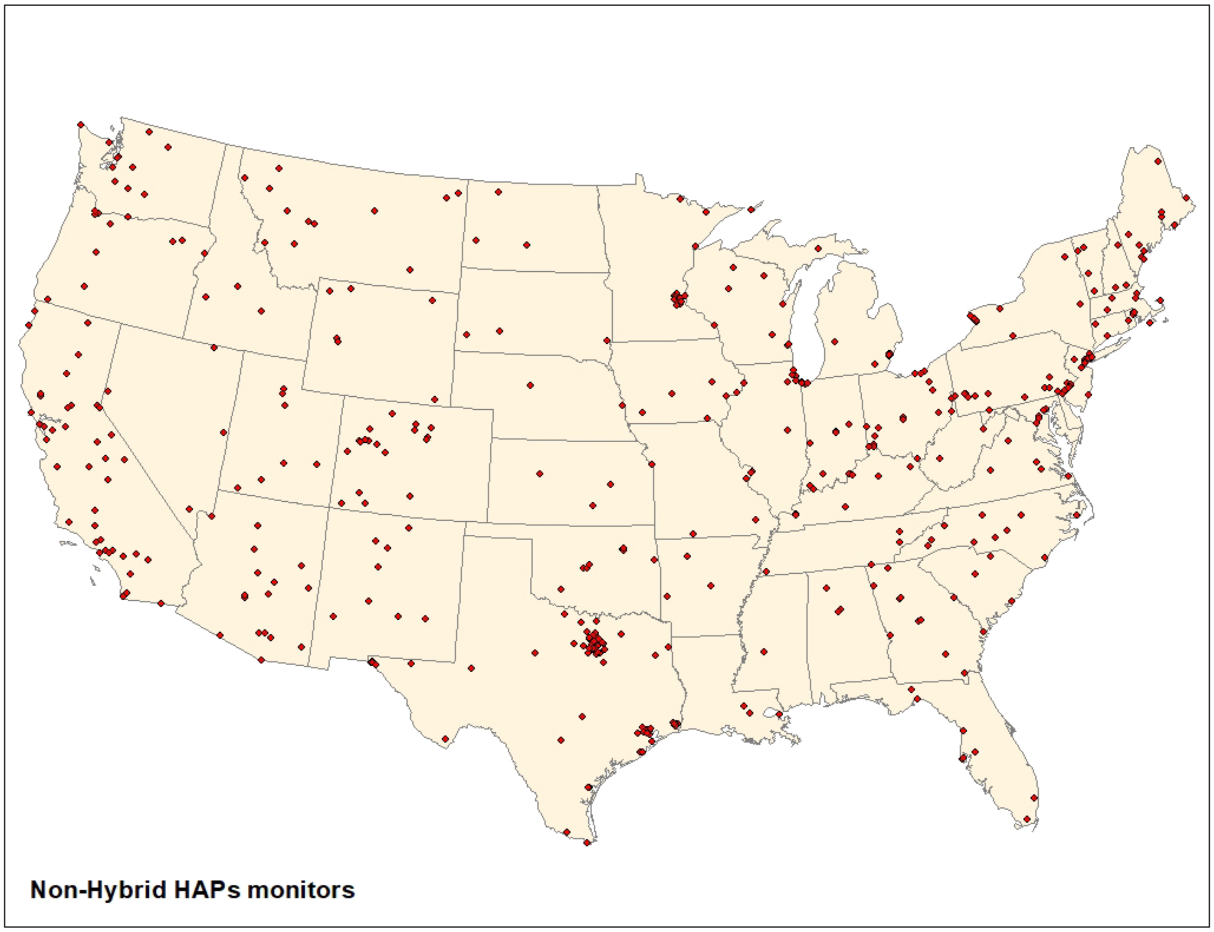


Figure E-89. 2017 monitoring locations for the non-hybrid HAPs evaluation

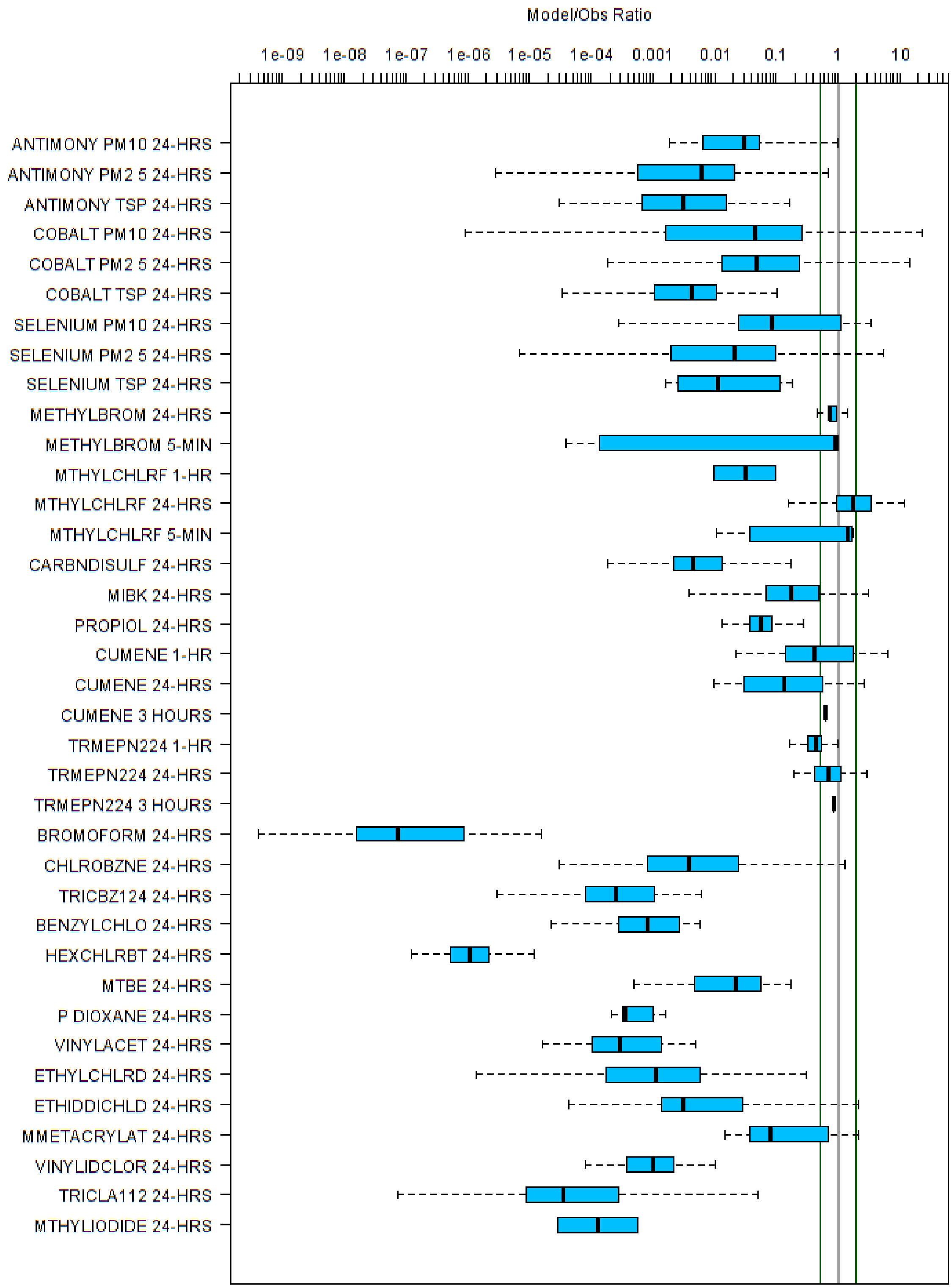


Figure E-90. 2017 Model-to-Monitor ratio comparisons of non-Hybrid HAPs

E.5 References

Appel, K.W., Gilliam, R.C., Davis, N., Zubrow, A., and Howard, S.C.: Overview of the Atmospheric Model Evaluation Tool (AMET) v1.1 for evaluating meteorological and air quality models, *Environ. Modell. Softw.*,26, 4, 434-443, 2011. (http://www.cmascenter.org/)