Supplement of

Updates and evaluation of NOAA's online-coupled air quality model version 7 (AQMv7) within the Unified Forecast System

Wei Li[1,2], Beiming Tang[1,2], Patrick C. Campbell[1,2], Youhua Tang[1,2], Barry Baker[1], Zachary Moon[1,3], Daniel Tong[1,2], Jianping Huang[4], Kai Wang[4,5], Ivanka Stajner[4], Raffaele Montuoro[4], Robert C. Gilliam[6]

[1]Air Resources Laboratory, NOAA/OAR, College Park, MD, USA

[2]Cooperative Institute for Satellite Earth System Studies, George Mason University, Fairfax, VA, USA

[3]Earth Resources Technology, Inc.

[4]Environmental Modeling Center, NOAA/NWS/NCEP, College Park, MD, USA

[5]Lynker, Leesburg, VA, USA

[6]US Environmental Protection Agency, Research Triangle Park, NC, USA

Corresponding author: Wei Li (wli31@gmu.edu)
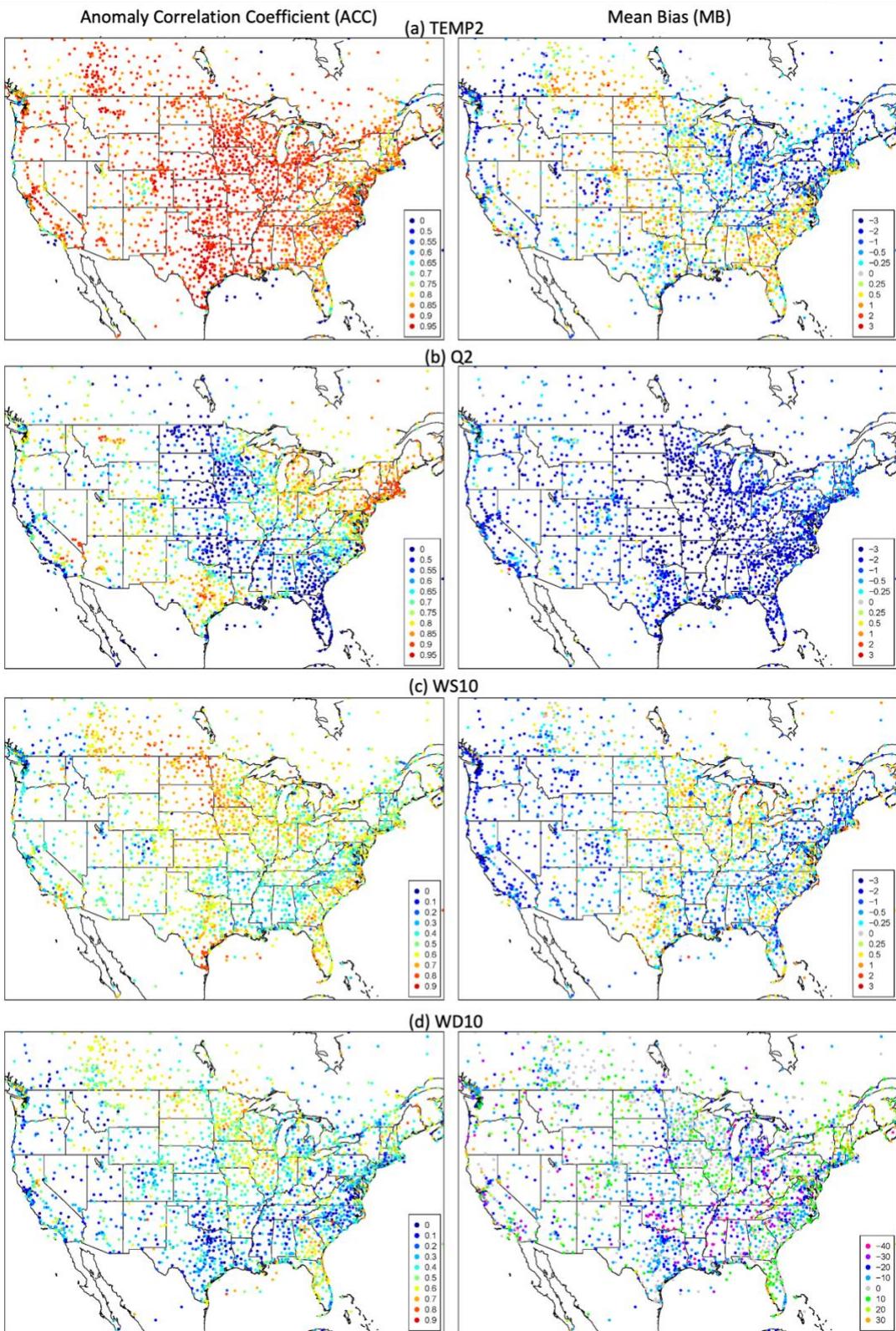
Figure S1: Anomaly correlation coefficient (ACC; left column) and mean bias (MB) between GFSv16.3 simulated and observed TEMP2 (a; °C), Q2(b; g/kg), WS10 (c; m/s), and WD10 (d; degree) at the surface.
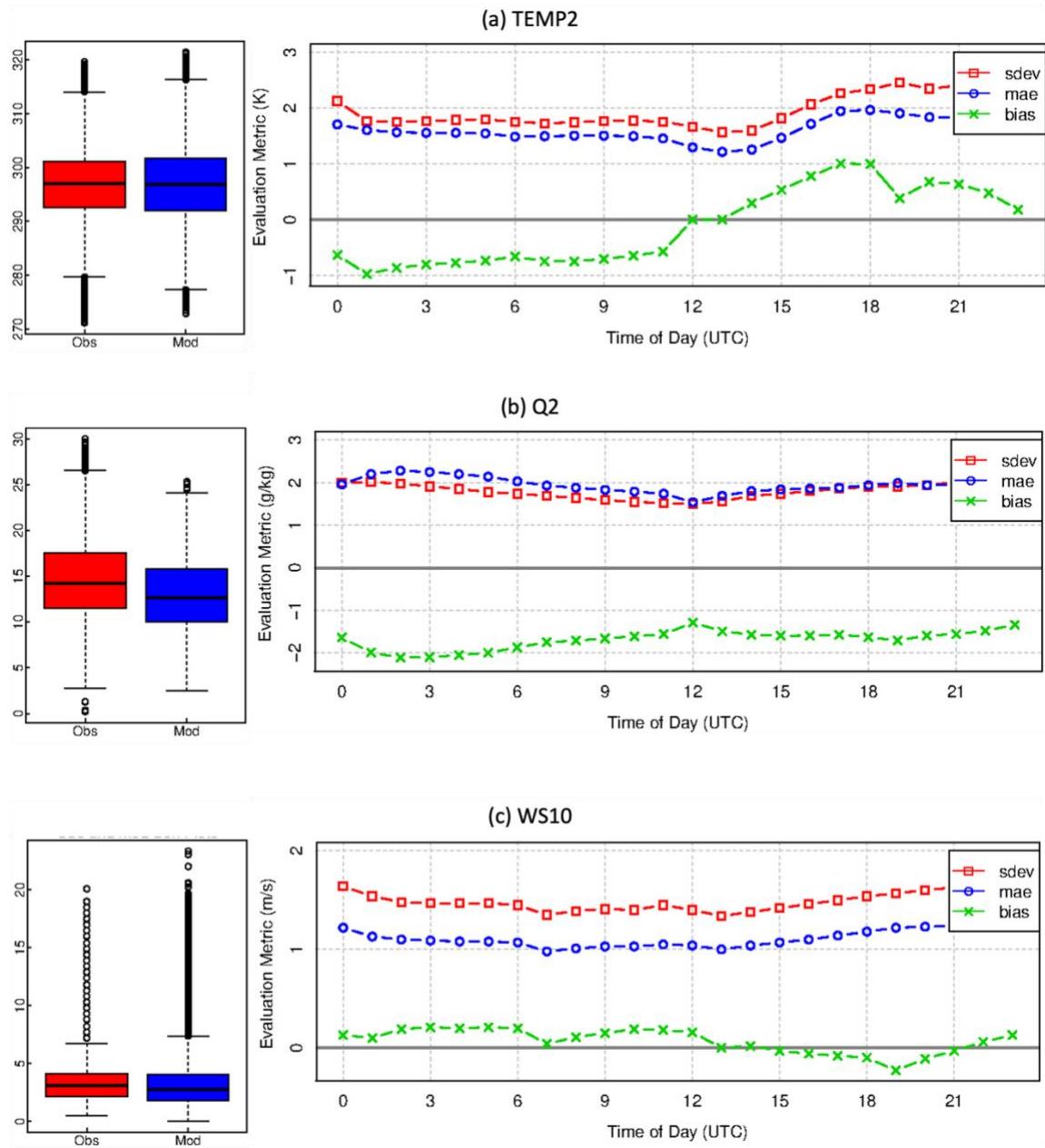
Figure S2: Boxplot (left column) and diurnal changes in three evaluation statistics (right column), including standard deviation (sdev; red), mean absolute error (mae; blue), and mean bias (gree), between GFSv16.3 simulated and observed TEMP2 (a; K), Q2(b; g/kg), and WS10 (c; m/s) at the surface across the eastern US (100°W east).
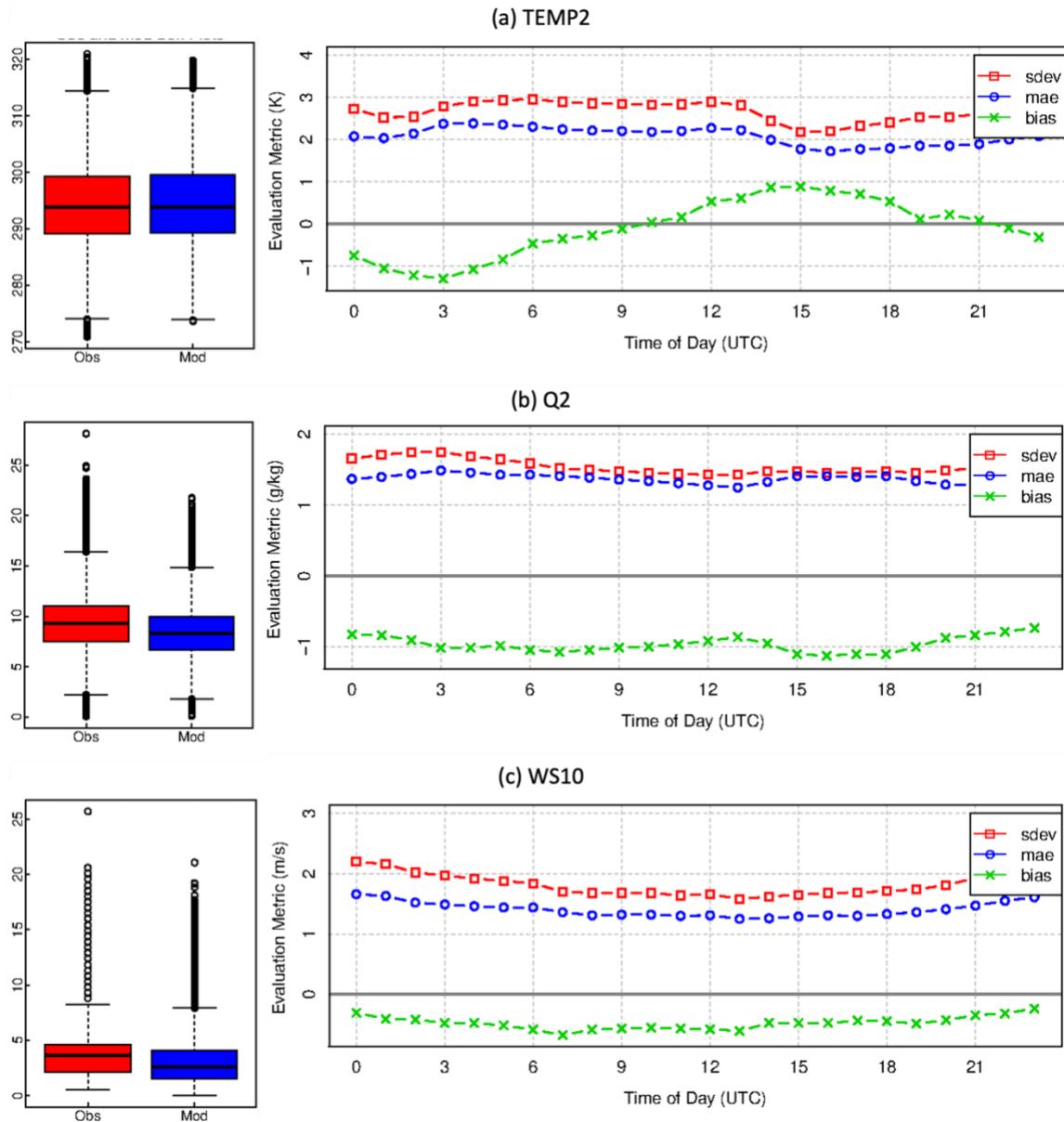
Figure S3: Same as Figure S2 but for the western US (100°W west).

Table S1: Evaluation statistics of TEMP2 (K), Q2(g/kg) and WS10 (m/s) from the GFSv16.3 simulation at the surface in August 2023.

Region	Variables	CORR	ACC	MB	NMB (%)	MAE	NME (%)	RMSE
CONUS	TEMP2	0.95	0.95	-0.03	-0.06	1.73	3.27	2.29
	Q2	0.92	0.87	-1.41	-4.72	1.70	5.66	2.25
	WS10	0.65	0.56	-0.15	-0.57	1.24	4.72	1.68
Eastern US (100°W east)	TEMP2	0.95	0.95	0	0	1.60	3.19	2.08
	Q2	0.89	0.81	-1.65	-5.55	1.91	6.40	2.45
	WS10	0.63	0.54	0.05	0.19	1.12	4.78	1.50
Western US (100°W west)	TEMP2	0.93	0.93	0.02	0.06	2.07	4.12	2.76
	Q2	0.83	0.77	-0.98	-3.48	1.37	4.87	1.83
	WS10	0.63	0.54	-0.48	-1.86	1.41	5.47	1.89
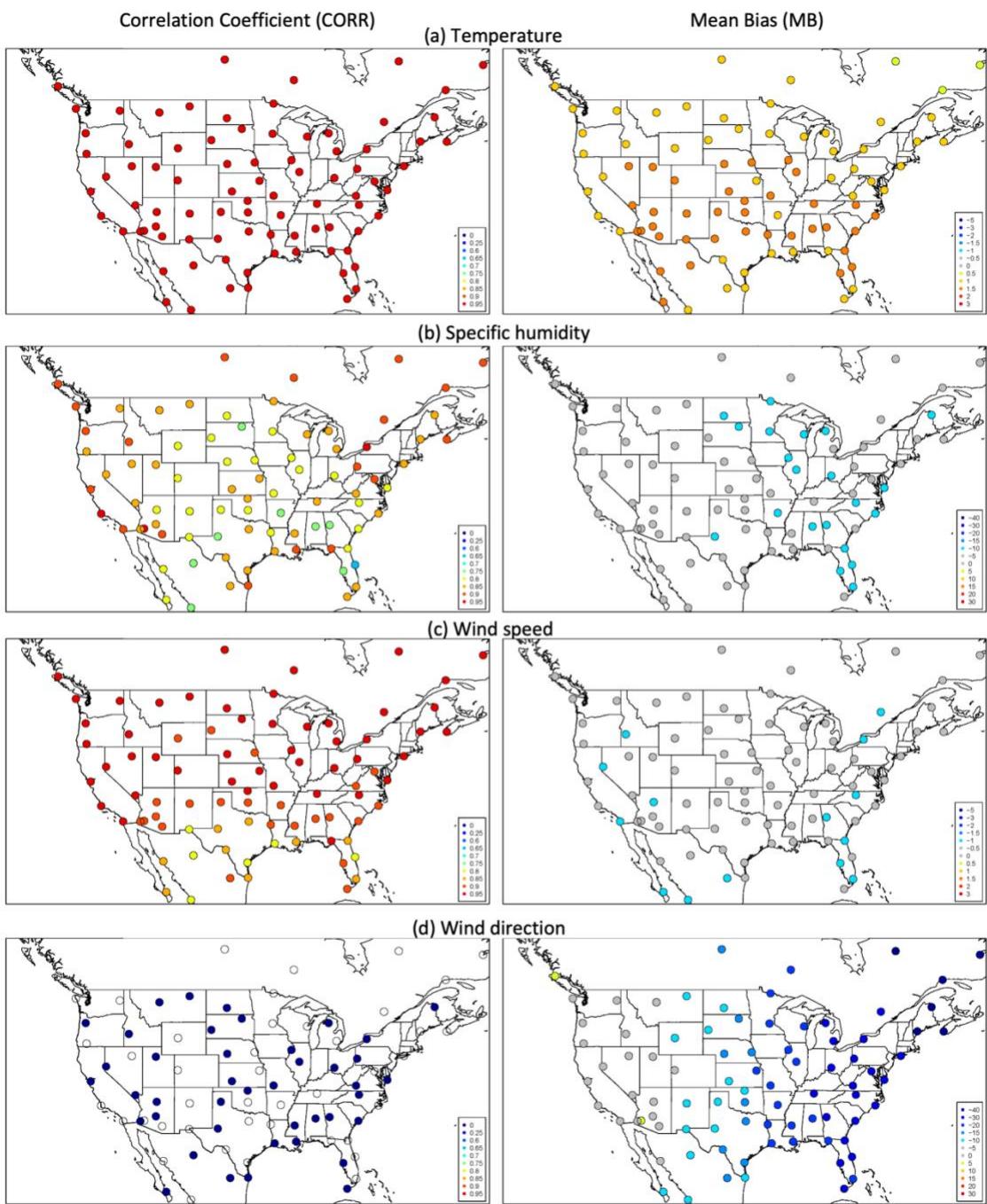
Figure S4: Correlation coefficient (CORR; left column) and mean bias (MB) between GFSv16.3 simulated and observed vertical distributions of temperature (a; °C), specific humidity (b; g/kg), wind speed (c; m/s), and wind direction (d; degree).
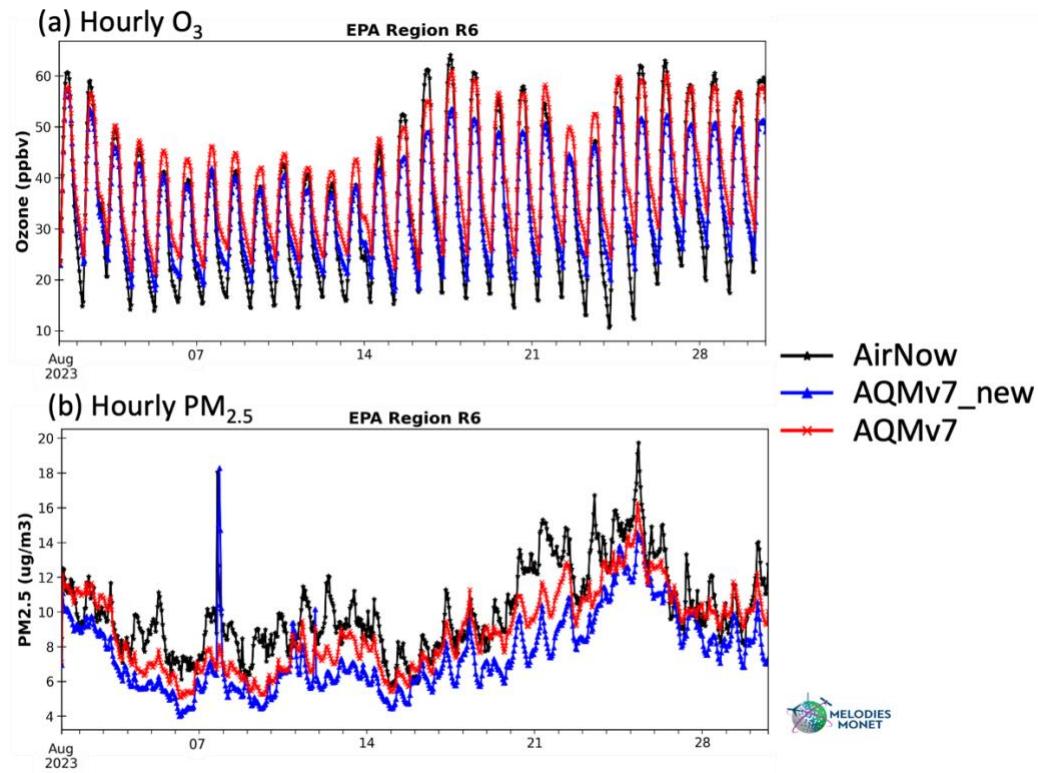
Figure S5: Hourly time series of O₃ and PM₂.₅ average over Region 6.

Table S2: MDA8 O₃ evaluation statistics of the AQMv7 and AQMv7_new simulations against the AirNow network in the CONUS and different regions in August 2023. The bold numbers in AQMv7_new indicates an improvement relative to those in AQMv7.

Region	Model	MB (ppb)	NMB (%)	MdnB (ppb)	NMdnB (%)	R^2	RMSE (ppb)	IOA
CONUS	AQMv7	4.99	11.44	4.79	11.15	0.52	10.18	0.80
	AQMv7_new	**1.37**	**3.15**	**1.04**	**2.41**	0.50	**9.13**	**0.83**
Region 1 (northeast)	AQMv7	6.68	17.91	5.95	16.26	0.45	10.08	0.73
	AQMv7_new	**4.14**	**11.09**	**3.56**	**9.72**	**0.47**	**8.43**	**0.79**
Region 2 (NY-NJ)	AQMv7	7.45	18.56	6.33	15.98	0.47	10.97	0.73
	AQMv7_new	**4.98**	**12.40**	**3.76**	**9.50**	0.46	**9.54**	**0.77**
Region 3 (mid-Atlantic)	AQMv7	7.08	16.16	7.09	16.24	0.40	10.18	0.68
	AQMv7_new	**2.60**	**5.93**	**2.40**	**5.51**	0.39	**7.52**	**0.77**
Region 4 (southeast)	AQMv7	9.32	22.74	9.16	22.34	0.58	11.53	0.71
	AQMv7_new	**4.39**	**10.71**	**4.18**	**10.20**	0.54	**8.33**	**0.80**
Region 5 (upper Midwest)	AQMv7	5.27	12.21	4.75	11.14	0.45	9.72	0.76
	AQMv7_new	**1.14**	**2.64**	**0.52**	**1.22**	**0.49**	**7.63**	**0.83**
Region 6 (south)	AQMv7	1.25	2.52	1.13	2.23	0.66	8.55	0.86
	AQMv7_new	-4.64	-9.35	-4.42	-8.74	0.66	9.86	0.82
Region 7 (central Great Plain)	AQMv7	5.82	12.95	4.98	11.24	0.32	9.82	0.68
	AQMv7_new	**0.53**	**1.17**	**-0.30**	**-0.67**	0.30	**7.69**	**0.73**
Region 8 (northern Great Plain)	AQMv7	0.59	1.18	0.19	0.38	0.28	8.40	0.69
	AQMv7_new	-3.35	-6.72	-4.06	-8.13	**0.35**	8.59	**0.71**
Region 9 (southwest)	AQMv7	3.00	6.02	2.59	5.18	0.58	9.76	0.84
	AQMv7_new	**0.96**	**1.93**	**0.73**	**1.45**	**0.59**	**9.50**	**0.87**
Region 10 (northwest)	AQMv7	3.81	9.06	3.07	7.35	0.56	9.53	0.84
	AQMv7_new	**2.51**	**5.96**	**0.62**	**1.49**	0.50	10.06	0.83

Table S3: Same as Table S2 but for daily PM$_{2.5}$.

Region	Model	MB (ppb)	NMB (%)	MdnB (ppb)	NMdnB (%)	R^2	RMSE (ppb)	IOA
CONUS	AQMv7	-0.09	-0.84	0.67	8.34	0.16	22.34	0.55
	AQMv7_new	-1.47	-12.94	**-0.48**	**-5.97**	0.16	**21.91**	0.55
Region 1 (northeast)	AQMv7	1.62	23.84	1.79	31.63	0.46	3.20	0.77
	AQMv7_new	**-0.01**	**-0.12**	**0.23**	**4.12**	0.37	**3.03**	0.76
Region 2 (NY-NJ)	AQMv7	2.75	32.44	2.59	34.58	0.46	4.23	0.75
	AQMv7_new	**1.71**	**20.25**	**1.57**	**20.92**	0.40	**4.16**	**0.76**
Region 3 (mid-Atlantic)	AQMv7	2.47	26.41	2.10	25.44	0.42	5.12	0.73
	AQMv7_new	**0.95**	**10.20**	**0.44**	**5.39**	0.41	**4.65**	**0.77**
Region 4 (southeast)	AQMv7	0.55	5.60	0.74	8.41	0.44	3.31	0.80
	AQMv7_new	-1.15	-11.80	-0.91	-10.37	0.39	3.57	0.75
Region 5 (upper Midwest)	AQMv7	2.57	21.88	1.95	17.93	0.37	7.57	0.71
	AQMv7_new	**-0.54**	**-4.58**	**-0.42**	**-3.83**	0.35	**5.89**	**0.76**
Region 6 (south)	AQMv7	-1.22	-12.03	-0.99	-10.10	0.41	3.79	0.77
	AQMv7_new	-2.50	-24.72	-2.60	-26.61	0.36	4.5	0.70
Region 7 (central Great Plain)	AQMv7	1.90	18.78	1.78	19.36	0.18	5.91	0.62
	AQMv7_new	**-0.34**	**-3.32**	**-0.12**	**-1.27**	0.13	**5.43**	0.61
Region 8 (northern Great Plain)	AQMv7	-1.32	-15.29	-0.62	-9.95	0.13	9.18	0.56
	AQMv7_new	-1.51	-17.50	-0.79	-12.68	0.11	9.55	0.53
Region 9 (southwest)	AQMv7	-0.05	-0.70	0.41	6.37	0.21	7.24	0.57
	AQMv7_new	-0.45	-5.90	**0.01**	**0.12**	0.21	7.27	0.56
Region 10 (northwest)	AQMv7	-3.56	-20.70	0.16	2.24	0.20	37.60	0.61
	AQMv7_new	-4.35	-25.30	**-0.10**	**-1.41**	**0.21**	**35.86**	**0.63**