

Evaluation of the offline-coupled GFSv15-FV3-CMAQv5.0.2 in support of the next-generation National Air Quality Forecast Capability over the Contiguous United States

Supplement

Table S1. Datasets used in this study

Database	Parameter	Data frequency	Number of sites / resolution
CASTNET	T2, RH2, WS10, WD10, Precipitation	Hourly	Up to 90 sites
CCPA	Precipitation	Hourly	0.125 degree
AirNow	O ₃ , PM _{2.5}	Hourly	Up to 1100 sites
METAR	T2, RH2, WS10, WD10, Precipitation	Hourly	~1900 sites
GPCP	Precipitation	Monthly	2.5 degree
MODIS_MOD04	Aerosol Optical depth	Monthly	1 degree

Table S2. Monthly performance statistics of meteorological variables

Datasets		CASTNET							METAR						
		Variable	Period	Mean Obs.	Mean Sim.	MB	RMSE	NMB, %	NME, %	Corr	Mean Obs.	Mean Sim.	MB	RMSE	NMB, %
T2, °C	Jan	-1.8	-2.2	-0.4	2.5	-23.2	-102.1	0.96	1.3	1.1	-0.1	2.4	-11.5	144.5	0.97
	Feb	-0.6	-1.2	-0.6	2.6	-88.8	-308.4	0.97	2.5	2.2	-0.2	2.6	-10.2	77.5	0.97
	Mar	3.5	2.7	-0.7	2.4	-20.6	53.2	0.97	6.2	5.8	-0.4	2.3	-6.2	28.2	0.97
	Apr	11.2	10.7	-0.5	2.3	-4.5	16.0	0.96	13.5	13.1	-0.3	2.3	-2.4	12.7	0.96
	May	15.0	14.7	-0.3	2.3	-2.1	11.7	0.96	17.5	17.2	-0.4	2.3	-2.2	9.7	0.96
	Jun	19.8	19.5	-0.3	2.4	-1.7	9.2	0.94	21.9	21.4	-0.5	2.4	-2.1	8.3	0.94
	Jul	22.9	22.9	-0.1	2.5	-0.2	8.2	0.91	24.6	24.4	-0.3	2.3	-1.1	7.1	0.92
	Aug	21.8	21.6	-0.2	2.4	-0.7	8.4	0.93	23.6	23.5	-0.1	2.3	-0.5	7.3	0.93
	Sept	19.5	19.2	-0.3	2.3	-1.7	9.0	0.95	21.7	21.6	-0.1	2.2	-0.6	7.5	0.95
	Oct	11.1	11.0	-0.2	2.7	-1.6	16.7	0.95	13.4	13.5	0.1	2.3	0.6	12.9	0.97
	Nov	4.0	3.8	-0.2	2.8	-4.9	48.5	0.94	6.2	6.5	0.2	2.5	3.8	29.4	0.96
	Dec	2.0	1.8	-0.3	2.8	-12.6	97.6	0.94	4.3	4.4	0.1	2.5	2.4	43.5	0.96
	DJF	-1.8	-2.2	-0.4	2.5	-23.2	-102.1	0.96	1.3	1.1	-0.1	2.4	-11.5	144.5	0.97
RH2, %	Jan	68.6	70.9	2.3	14.4	3.3	15.3	0.73	72.7	72.3	-0.4	13.1	-0.6	13.6	0.76
	Feb	69.3	74.0	4.6	14.3	6.7	14.8	0.76	74.1	75.6	1.5	14.0	2.0	13.9	0.75
	Mar	63.1	69.1	6.0	15.9	9.6	18.5	0.77	66.6	70.0	3.4	14.7	5.1	16.8	0.77
	Apr	59.9	63.3	3.4	13.3	5.7	16.4	0.85	66.0	68.9	2.9	13.8	4.4	15.9	0.82
	May	65.0	65.6	0.7	13.0	1.0	14.9	0.85	69.5	71.3	1.8	13.0	2.6	14.1	0.82
	Jun	56.4	55.6	-0.8	12.2	-1.4	15.9	0.88	66.4	68.0	1.6	13.7	2.5	15.6	0.82

	Jul	55.0	52.7	-2.3	12.4	-4.2	16.8	0.88	66.6	67.1	0.5	12.9	0.8	14.7	0.84
	Aug	53.7	51.6	-2.0	12.0	-3.8	16.4	0.89	68.0	66.8	-1.1	12.7	-1.7	14.1	0.85
	Sept	58.3	56.0	-2.3	11.7	-3.9	14.7	0.89	68.3	66.9	-1.4	12.3	-2.0	13.6	0.85
	Oct	56.5	54.4	-2.1	12.6	-3.7	16.2	0.89	67.8	65.6	-2.2	13.2	-3.2	14.5	0.85
	Nov	62.4	62.6	0.2	14.5	0.3	17.3	0.82	70.1	68.6	-1.5	14.1	-2.1	15.4	0.77
	Dec	69.3	71.1	1.9	14.3	2.7	15.1	0.75	87.8	88.0	0.2	9.5	0.2	8.0	0.60
WS10, m s ⁻¹	Jan	2.6	3.0	0.4	2.0	15.5	55.2	0.61	3.4	3.8	0.3	2.0	9.9	42.5	0.73
	Feb	2.7	3.4	0.6	2.2	22.8	56.9	0.57	3.5	3.8	0.3	2.0	8.2	42.6	0.71
	Mar	2.7	3.2	0.5	1.9	17.0	51.6	0.63	3.6	3.9	0.3	1.9	8.2	41.0	0.72
	Apr	2.9	3.6	0.7	2.2	24.9	57.3	0.58	3.8	4.2	0.4	2.1	11.0	41.3	0.71
	May	2.7	3.3	0.7	2.1	24.7	58.0	0.59	3.4	3.8	0.4	2.0	12.4	45.7	0.66
	Jun	2.6	3.2	0.6	2.1	23.0	60.6	0.51	3.1	3.5	0.5	2.0	14.8	49.3	0.63
	Jul	2.4	3.0	0.6	1.9	25.8	61.5	0.49	2.7	3.2	0.4	1.9	16.2	52.2	0.62
	Aug	2.3	2.8	0.6	1.8	24.8	60.6	0.52	2.6	3.1	0.5	1.9	20.6	57.0	0.59
	Sept	2.6	3.2	0.6	2.0	24.7	58.2	0.59	3.8	4.0	0.2	1.7	5.1	34.3	0.65
	Oct	2.7	3.2	0.5	2.2	20.6	59.7	0.53	4.1	4.3	0.2	1.9	5.1	33.0	0.69
	Nov	2.4	2.8	0.4	2.0	15.3	58.0	0.58	4.0	4.1	0.1	1.8	2.6	32.3	0.70
	Dec	2.4	2.8	0.4	1.9	18.7	58.2	0.57	3.1	3.6	0.4	1.9	14.4	45.8	0.70
Precip, mm hr ⁻¹	Jan	1.0	0.6	-0.5	1.6	-43.2	87.1	0.24	1.3	0.8	-0.6	2.9	-44.3	75.9	0.21
	Feb	1.0	0.6	-0.4	1.7	-41.7	86.5	0.25	1.3	0.6	-0.6	4.5	-48.9	78.4	0.11
	Mar	1.1	0.6	-0.5	1.7	-46.0	83.4	0.28	1.6	0.6	-1.0	12.5	-60.5	83.4	0.04
	Apr	1.1	0.5	-0.6	1.9	-54.2	88.4	0.28	1.7	0.8	-0.9	3.5	-51.0	85.2	0.18
	May	1.2	0.5	-0.7	2.3	-55.6	88.8	0.15	2.0	0.7	-1.2	4.9	-63.2	87.3	0.10
	Jun	2.0	0.5	-1.5	4.2	-74.5	93.0	0.09	2.4	0.7	-1.7	5.7	-70.7	89.7	0.07
	Jul	2.2	0.4	-1.8	4.8	-82.4	95.8	0.04	2.8	0.7	-2.1	7.3	-76.1	93.3	0.04
	Aug	2.3	0.5	-1.8	5.2	-77.2	93.1	0.17	2.7	0.6	-2.1	9.7	-77.3	92.1	0.03
	Sept	1.3	0.5	-0.8	2.4	-60.5	86.8	0.18	2.3	0.7	-1.6	13.7	-70.2	89.9	0.03
	Oct	1.5	0.7	-0.8	2.7	-52.4	88.0	0.25	1.9	0.9	-0.9	6.7	-49.9	82.8	0.10
	Nov	1.1	0.5	-0.5	1.9	-49.8	82.7	0.28	1.3	0.6	-0.7	6.1	-50.6	77.7	0.07
	Dec	1.0	0.6	-0.4	1.5	-44.2	83.7	0.32	1.4	0.8	-0.6	2.7	-40.4	77.7	0.18

Figure S1. Site locations within CONUS of (a) CASTNET and (b) METAR. (c) Ten regions within CONUS for regional analysis

Figure S2. Forecasted monthly accumulated precipitation by GFSv15-CMAQv5.0.2, overlaid observations from METAR

Figure S3. Monthly accumulated precipitation from CCPA

Figure S4. Monthly accumulated precipitation from GPCP

Figure S5. Time series of observed and predicted hourly precipitation at two CASTNET sites during July at (a) site YEL408 in Wyoming, and (b) site GRS420 in Tennessee

Figure S6. Spatial distribution of annual area emissions

Figure S7. Time series of daily maximum 8-hr O₃ in 10 regions within CONUS

Figure S8. Diurnal O₃ in: (a) O₃ season for regions 1 to 5; (b) Non-O₃ season for regions 1 to 5; (c) O₃ season for regions 6 to 10; (d) non-O₃ season for regions 6 to 10

Figure S9. Time series of 24-h avg PM_{2.5} in 10 regions within CONUS for regions 6 to 10; (d) Non-O₃ season for region 6 to 10. Solid curves are observed values and dash curves are predicted values

Figure S10. Monthly variation of domain-wide area emissions

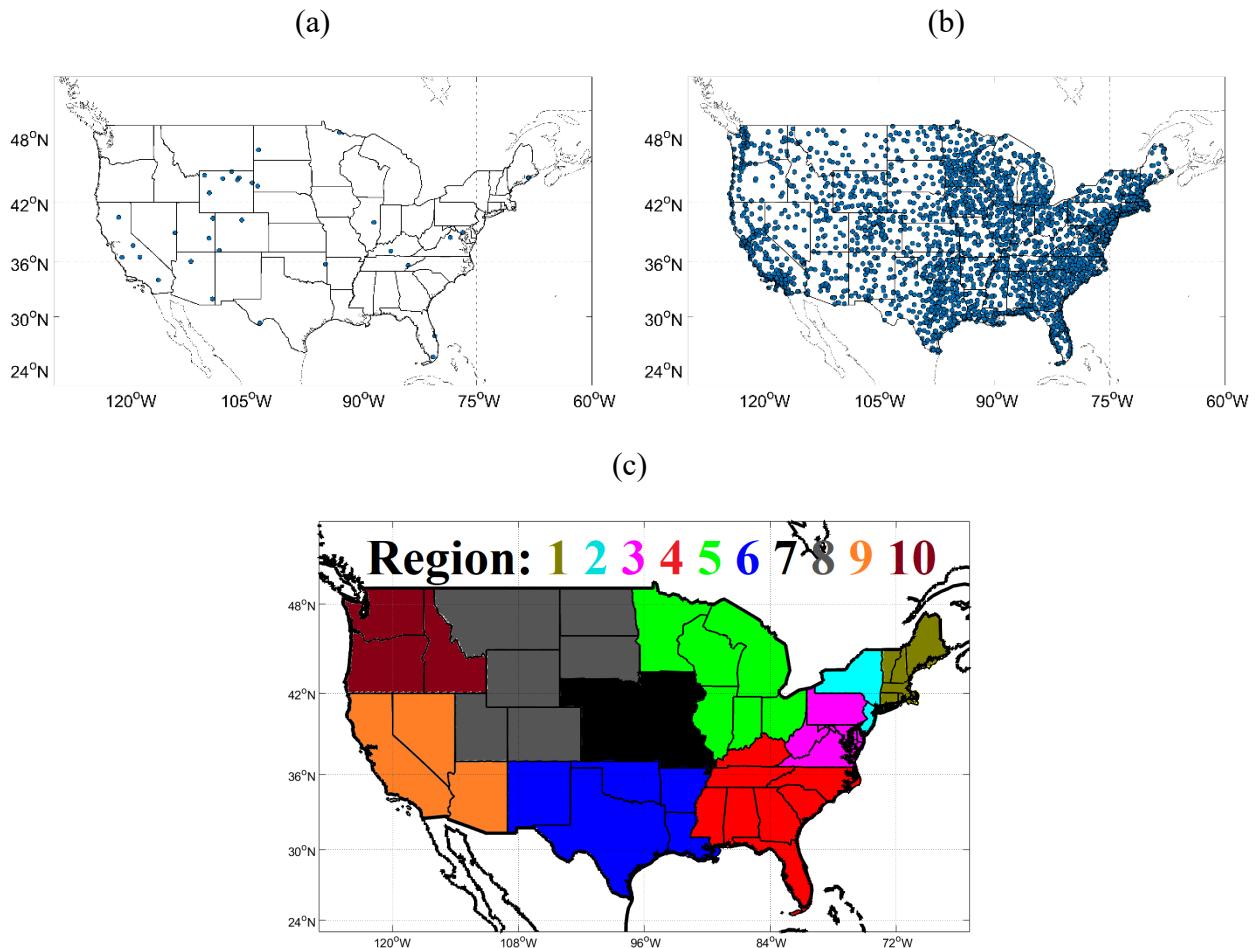


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within CONUS for regional analysis: (Region 1) Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; (Region 2) New Jersey, and New York; (Region 3) Delaware, Washington D.C, Maryland, Pennsylvania, Virginia, and West Virginia; (Region 4) Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee; (Region 5) Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin; (Region 6) Arkansas, Louisiana, New Mexico, Oklahoma, and Texas; (Region 7) Iowa, Kansas, Missouri, and Nebraska; (Region 8) Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming; (Region 9) Arizona, California, and Nevada; and (Region 10) Idaho, Oregon, and Washington

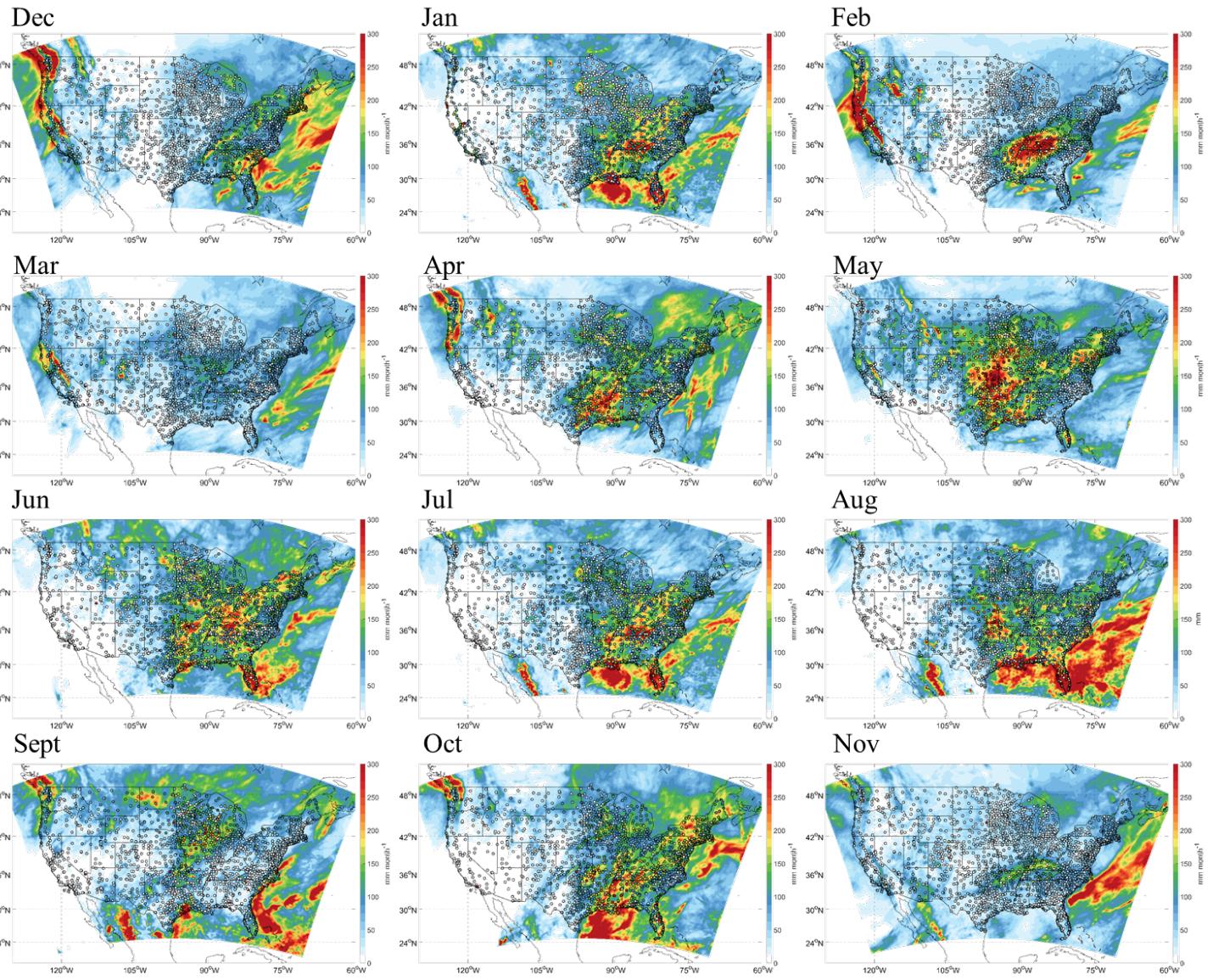


Figure S2. Forecasted monthly accumulated precipitation by GFSv15-CMAQv5.0.2, overlaid observations from METAR

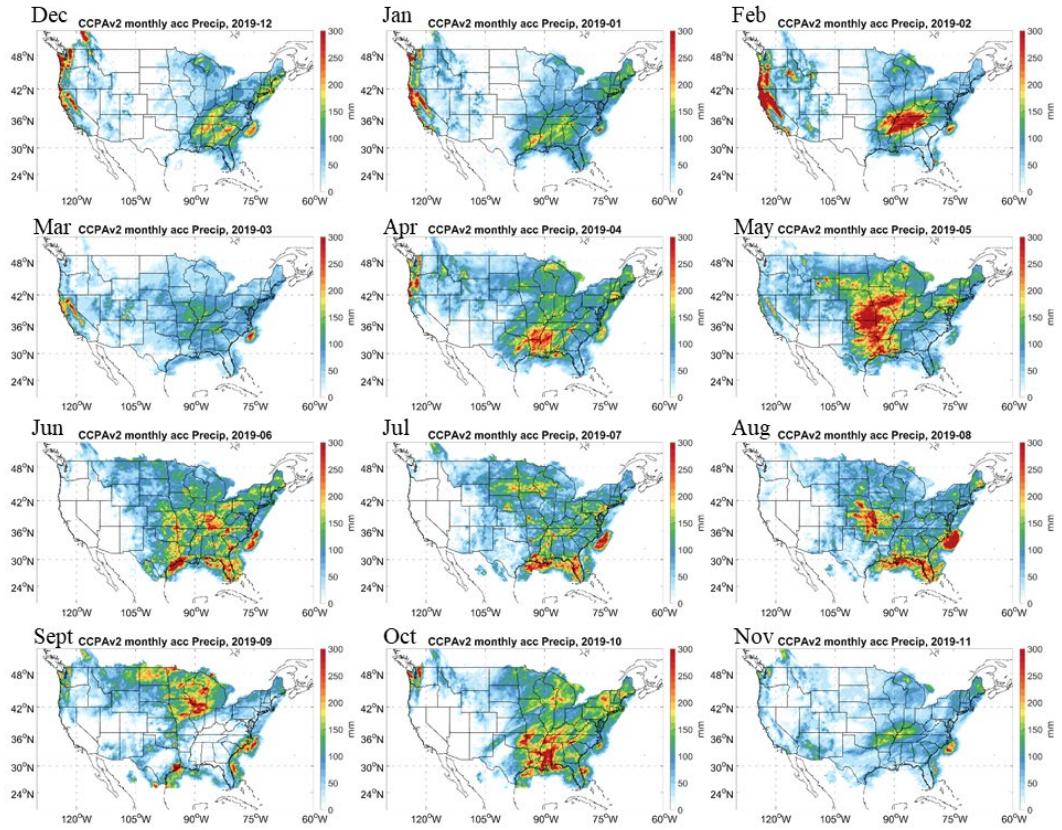


Figure S3. Monthly accumulated precipitation from CCPA.

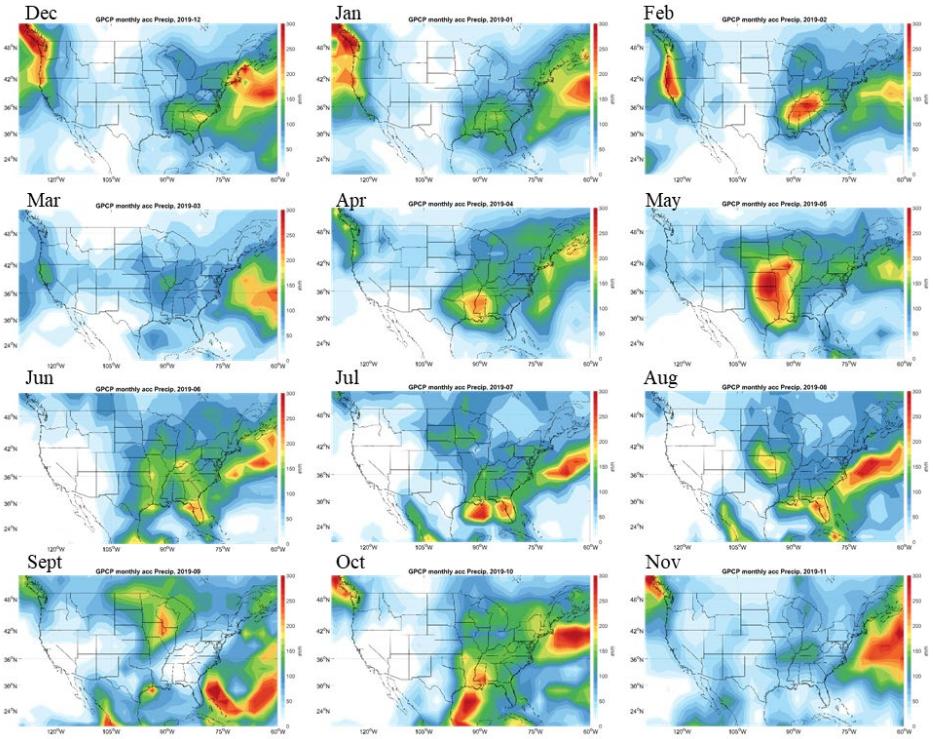


Figure S4. Monthly accumulated precipitation from GPCP.

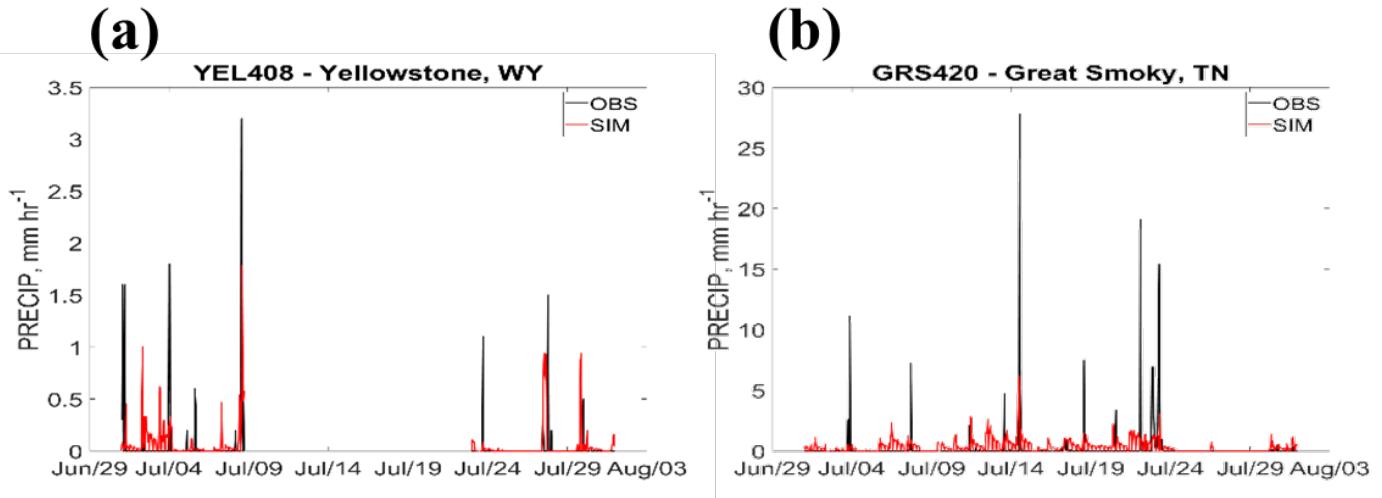


Figure S5. Time series of observed and predicted hourly precipitation at two CASTNET sites during July at (a) site YEL408 in Wyoming, and (b) site GRS420 in Tennessee

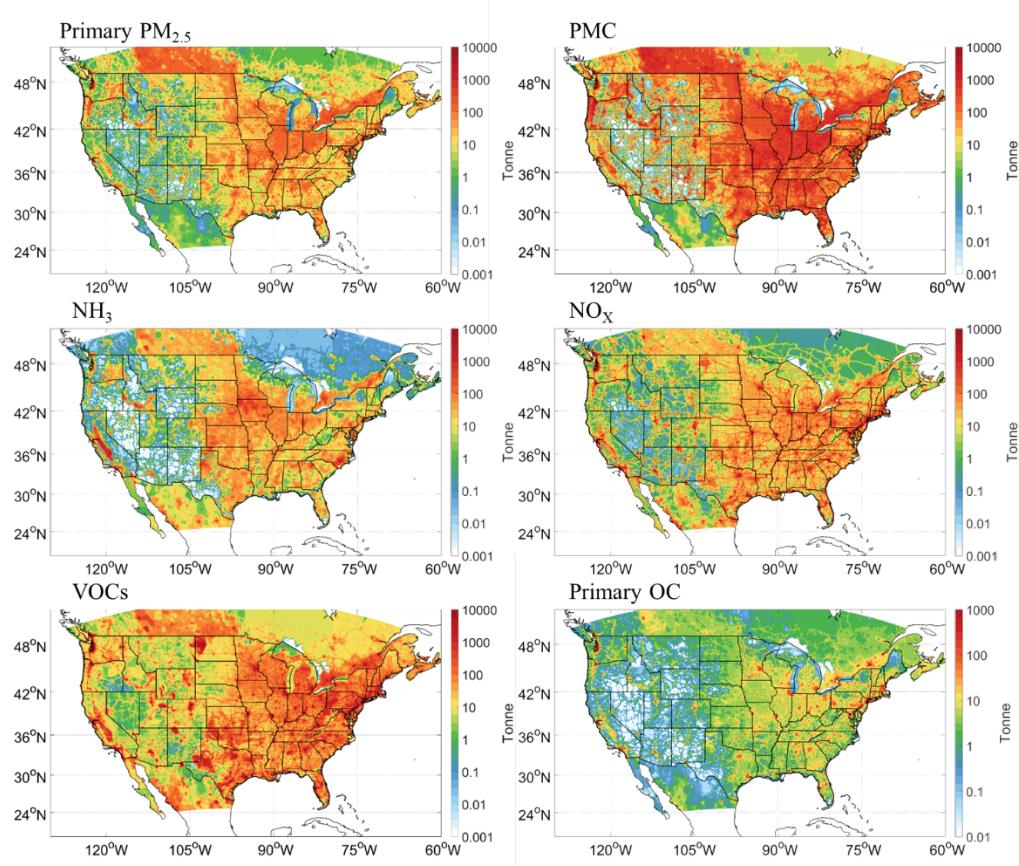


Figure S6. Spatial distribution of annual area emissions in anthropogenic sectors for primary PM_{2.5}, primary coarse mode PM (PMC), ammonia (NH₃), Nitrogen Oxide (NO_x), volatile organic compounds (VOCs), and primary organic carbon (POC).

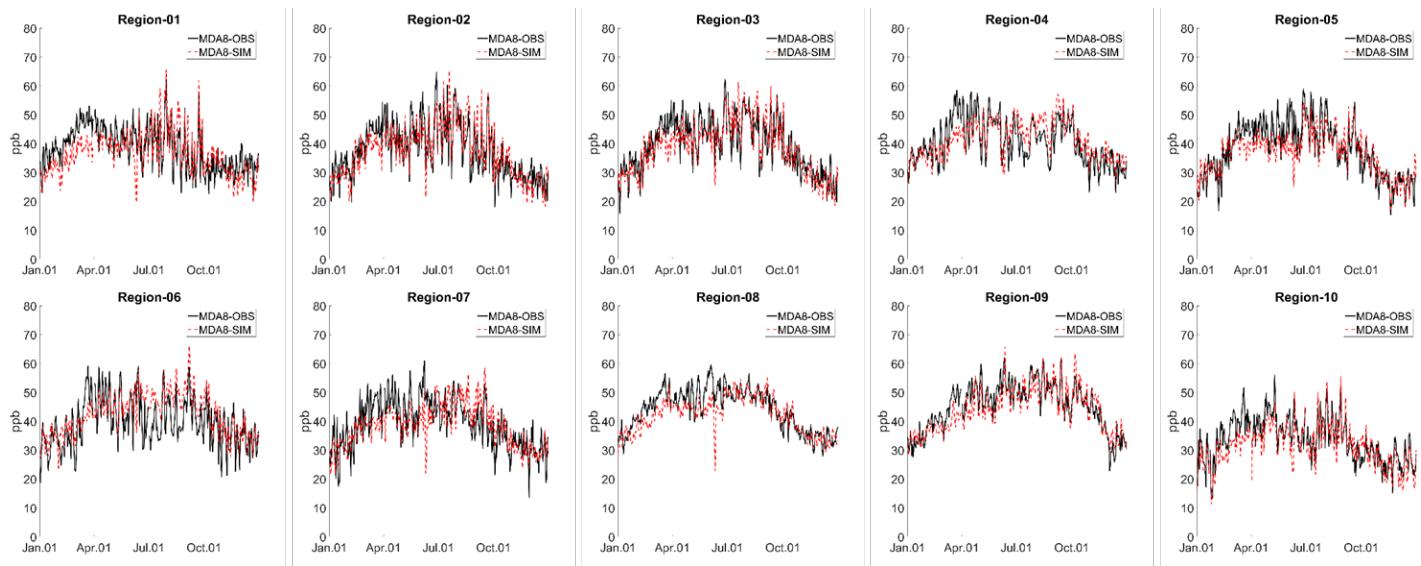


Figure S7. Time series of daily maximum 8-hr O₃ in 10 regions within CONUS

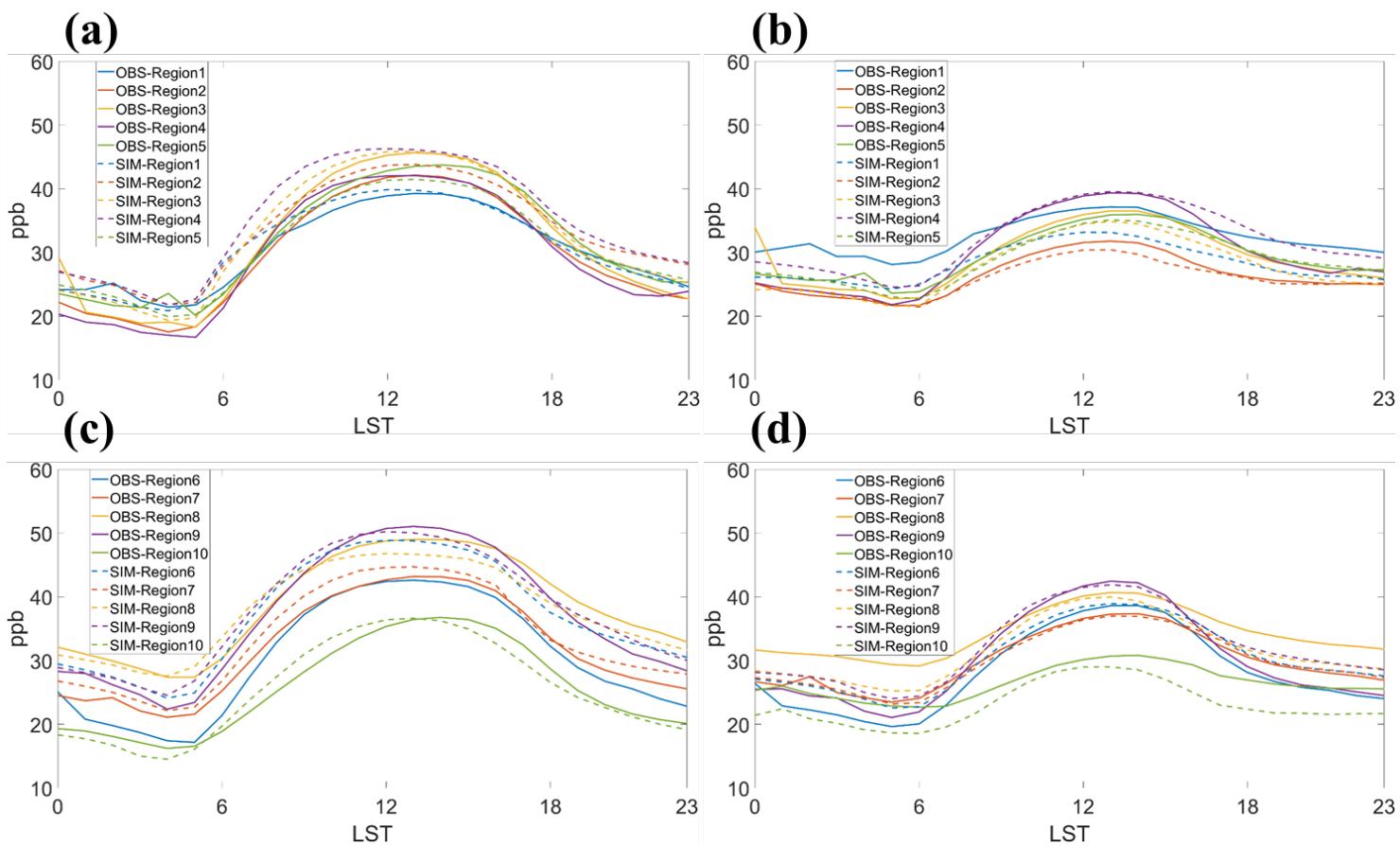


Figure S8. Diurnal O₃ in: (a) O₃ season for regions 1 to 5; (b) Non-O₃ season for regions 1 to 5; (c) O₃ season

for regions 6 to 10; (d) non-O₃ season for regions 6 to 10

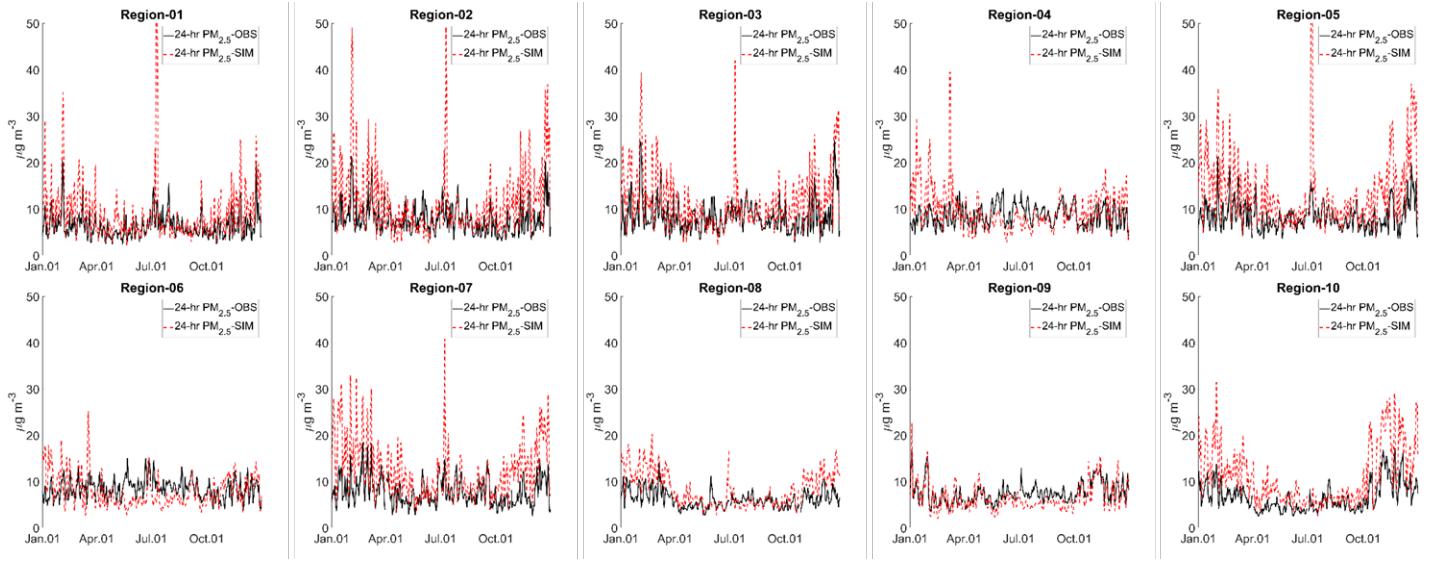


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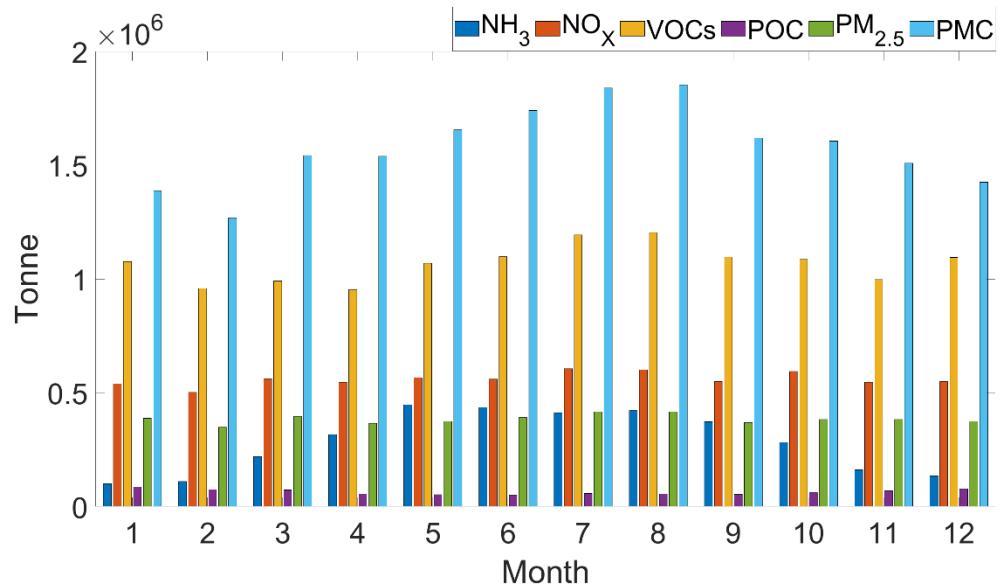


Figure S10. Monthly variation of domain-wide area emissions

References

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