Supplement Materials

Table S1: Ground-level MDA8 ozone statistics over the model domain and geographic regions for June 2019. Bold numbers indicate better performance for each case.

Region	Case	Record	OBS [ppb]	MOD [ppb]	MB [ppb]	NMB [%]	RMSE [ppb]	NME [%]	R
Domain	CNTRL	34151	46.1	47.5	**1.4**	**3.0**	**8.5**	**14.2**	0.72
	LGTNO	34151	46.1	47.8	1.7	3.6	8.5	**14.2**	**0.73**
NE	CNTRL	5358	43.9	47.8	**3.9**	**8.9**	**8.3**	**14.8**	0.72
	LGTNO	5358	43.9	48.1	4.2	9.5	8.4	14.9	**0.73**
SE	CNTRL	5871	41.4	44.2	**2.8**	**6.8**	**8.1**	**15.7**	**0.79**
	LGTNO	5871	41.4	44.7	3.3	8.0	8.3	16.0	**0.79**
UM	CNTRL	8370	46.1	45.7	-0.4	-0.8	7.5	12.8	0.65
	LGTNO	8370	46.1	46.1	**0.0**	**0.0**	**7.4**	**12.6**	**0.66**
LM	CNTRL	3319	42.8	43.8	**1.0**	**2.2**	9.6	17.2	**0.73**
	LGTNO	3319	42.8	44.2	1.4	3.3	**9.5**	**17.1**	**0.73**
RM	CNTRL	5868	53.1	54.5	**1.4**	**2.6**	8.6	11.9	0.49
	LGTNO	5868	53.1	54.7	1.6	3.0	**8.5**	**11.8**	**0.50**
PC	CNTRL	5342	48.1	48.4	**0.2**	**0.5**	9.7	15.7	**0.74**
	LGTNO	5342	48.1	48.4	0.3	0.6	**9.7**	**15.6**	**0.74**

Table S2: Ground-level MDA8 ozone statistics over the model domain and geographic regions for July 2019. Bold numbers indicate better performance for each case.

Region	Case	Record	OBS [ppb]	MOD [ppb]	MB [ppb]	NMB [%]	RMSE [ppb]	NME [%]	R
Domain	CNTRL	35188	44.6	45.6	**1.0**	**2.2**	**8.3**	**14.4**	**0.75**
	LGTNO	35188	44.6	46.1	1.4	3.2	8.4	14.5	**0.75**
NE	CNTRL	5462	45.6	48.4	**2.8**	**6.2**	**8.2**	**13.9**	**0.78**
	LGTNO	5462	45.6	48.8	3.2	7.1	8.4	14.3	0.77
SE	CNTRL	5975	39.9	44.1	**4.2**	**10.4**	**8.0**	**15.9**	0.77
	LGTNO	5975	39.9	44.9	5.0	12.4	8.4	16.8	**0.77**
UM	CNTRL	8618	44.6	44.8	**0.3**	**0.6**	**7.2**	**12.7**	**0.72**
	LGTNO	8618	44.6	45.3	0.7	1.5	7.2	**12.7**	**0.72**
LM	CNTRL	3542	38.3	42.4	**4.1**	**10.6**	**8.2**	**17.3**	0.82
	LGTNO	3542	38.3	42.8	4.5	11.6	8.3	17.6	**0.83**
RM	CNTRL	6009	50.2	48.6	-1.6	-3.2	8.1	12.2	0.55
	LGTNO	6009	50.2	49.1	**-1.1**	**-2.2**	**7.8**	**11.8**	0.57
PC	CNTRL	5552	46.8	44.7	-2.2	-4.7	**10.5**	**17.0**	**0.80**
	LGTNO	5552	46.8	44.7	**-2.1**	**-4.6**	**10.5**	**17.0**	**0.80**

Table S3: Ground-level MDA8 ozone statistics over the model domain and geographic regions for September 2019. Bold numbers indicate better performance for each case.

Region	Case	Record	OBS [ppb]	MOD [ppb]	MB [ppb]	NMB [%]	RMSE [ppb]	NME [%]	R
Domain	CNTRL	33872	42.8	44.3	**1.6**	**3.6**	7.5	13.7	0.77
	LGTNO	33872	42.8	44.6	1.8	4.2	**7.5**	**13.6**	**0.78**
NE	CNTRL	5263	39.6	42.9	**3.3**	**8.3**	**7.6**	**15.4**	0.79
	LGTNO	5263	39.6	42.9	3.4	8.5	7.6	15.5	**0.80**
SE	CNTRL	5706	45.1	46.0	**0.9**	**2.1**	6.7	**11.3**	0.75
	LGTNO	5706	45.1	46.3	1.2	2.6	**6.6**	**11.3**	**0.76**
UM	CNTRL	8488	40.0	41.1	**1.1**	**2.8**	**6.4**	**12.7**	**0.81**
	LGTNO	8488	40.0	41.3	1.3	3.2	**6.4**	**12.7**	**0.81**
LM	CNTRL	3341	42.9	44.0	**1.1**	**2.6**	7.5	14.0	0.74
	LGTNO	3341	42.9	44.5	1.5	3.6	**7.5**	**13.9**	**0.75**
RM	CNTRL	5835	45.6	47.4	**1.8**	**3.9**	7.7	13.3	0.70
	LGTNO	5835	45.6	47.8	2.2	4.9	**7.5**	**13.0**	**0.72**
PC	CNTRL	5211	44.6	45.8	**1.2**	**2.8**	9.6	16.7	**0.77**
	LGTNO	5211	44.6	45.9	1.4	3.0	**9.5**	**16.6**	**0.77**

15   **Table S4: Ground-level daily mean NO$_x$ statistics over the model domain and geographic regions for June 2019. Bold numbers indicate better performance for each case.**

Region	Case	Record	OBS [ppb]	MOD [ppb]	MB [ppb]	NMB [%]	RMSE [ppb]	NME [%]	R
Domain	CNTRL	10650	7.94	6.75	**-1.19**	**-14.90**	**7.64**	**55.30**	**0.54**
	LGTNO	10650	7.94	6.75	**-1.19**	**-14.90**	**7.64**	**55.30**	**0.54**
NE	CNTRL	1580	10.18	8.27	**-1.92**	**-18.80**	**9.27**	**55.50**	**0.50**
	LGTNO	1580	10.18	8.27	**-1.92**	**-18.80**	**9.27**	**55.50**	**0.50**
SE	CNTRL	1081	10.06	6.93	**-3.12**	**-31.10**	**8.55**	**51.30**	**0.57**
	LGTNO	1081	10.06	6.93	-3.13	**-31.10**	**8.55**	**51.30**	**0.57**
UM	CNTRL	1173	10.12	7.45	**-2.67**	**-26.40**	**7.77**	**46.20**	**0.56**
	LGTNO	1173	10.12	7.45	**-2.67**	**-26.40**	**7.77**	**46.20**	**0.56**
LM	CNTRL	1618	6.93	7.01	0.08	1.11	**6.92**	**58.70**	**0.46**
	LGTNO	1618	6.93	7.01	**0.08**	**1.10**	**6.92**	**58.70**	**0.46**
RM	CNTRL	2552	4.30	4.03	-0.27	-6.32	**4.24**	**53.40**	**0.74**
	LGTNO	2552	4.30	4.03	**-0.27**	**-6.28**	**4.24**	**53.40**	**0.74**
PC	CNTRL	2646	8.89	7.94	**-0.95**	**-10.70**	**8.97**	**60.80**	**0.41**
	LGTNO	2646	8.89	7.94	-0.95	**-10.70**	**8.97**	**60.80**	**0.41**

Table S5: Ground-level daily mean NO$_x$ statistics over the model domain and geographic regions for July 2019. Bold numbers indicate better performance for each case.

Region	Case	Record	OBS [ppb]	MOD [ppb]	MB [ppb]	NMB [%]	RMSE [ppb]	NME [%]	R
Domain	CNTRL	10790	7.87	7.15	**-0.72**	**-9.16**	**7.68**	**56.20**	**0.54**
	LGTNO	10790	7.87	7.15	-0.72	-9.18	**7.68**	**56.20**	**0.54**
NE	CNTRL	1540	10.04	9.35	**-0.70**	**-6.94**	**8.91**	**57.60**	**0.50**
	LGTNO	1540	10.04	9.34	-0.70	-6.98	**8.91**	**57.60**	**0.50**
SE	CNTRL	1064	10.18	7.74	**-2.44**	**-24.00**	**8.19**	**50.50**	**0.54**
	LGTNO	1064	10.18	7.73	-2.45	-24.10	**8.19**	**50.50**	**0.54**
UM	CNTRL	1191	9.53	7.25	**-2.28**	**-24.00**	**7.40**	**45.70**	**0.56**
	LGTNO	1191	9.53	7.25	-2.29	**-24.00**	**7.40**	**45.70**	**0.56**
LM	CNTRL	1633	6.05	7.05	1.00	16.60	6.83	**66.20**	**0.43**
	LGTNO	1633	6.05	7.05	**1.00**	**16.50**	6.82	**66.20**	**0.43**
RM	CNTRL	2631	4.23	3.86	-0.37	-8.72	**3.87**	**51.20**	**0.77**
	LGTNO	2631	4.23	3.86	**-0.37**	**-8.67**	**3.87**	**51.20**	**0.77**
PC	CNTRL	2755	9.54	8.79	**-0.75**	**-7.83**	**9.75**	**60.50**	**0.45**
	LGTNO	2755	9.54	8.79	**-0.75**	**-7.83**	**9.75**	**60.50**	**0.45**

Table S6: Ground-level daily mean NO$_x$ statistics over the model domain and geographic regions for September 2019. Bold numbers indicate better performance for each case.

Region	Case	Record	OBS [ppb]	MOD [ppb]	MB [ppb]	NMB [%]	RMSE [ppb]	NME [%]	R
Domain	CNTRL	10545	9.21	7.99	**-1.22**	**-13.20**	**8.61**	**53.60**	**0.57**
	LGTNO	10545	9.21	7.99	**-1.22**	**-13.20**	**8.61**	**53.60**	**0.57**
NE	CNTRL	1552	11.14	10.20	**-0.94**	**-8.44**	**9.74**	**56.20**	**0.51**
	LGTNO	1552	11.14	10.20	**-0.94**	**-8.44**	**9.74**	**56.20**	**0.51**
SE	CNTRL	1012	11.42	7.87	**-3.55**	**-31.10**	**9.78**	**52.40**	**0.61**
	LGTNO	1012	11.42	7.86	**-3.55**	**-31.10**	**9.78**	**52.40**	**0.61**
UM	CNTRL	1153	11.04	8.86	**-2.18**	**-19.80**	**8.59**	**45.50**	**0.57**
	LGTNO	1153	11.04	8.85	**-2.18**	**-19.80**	**8.59**	**45.50**	**0.57**
LM	CNTRL	1708	7.27	8.76	**1.49**	20.50	**7.34**	**62.40**	**0.51**
	LGTNO	1708	7.27	8.76	**1.49**	**20.40**	7.34	**62.40**	**0.51**
RM	CNTRL	2591	5.14	4.38	-0.77	**-14.90**	**5.86**	**51.70**	**0.72**
	LGTNO	2591	5.14	4.38	**-0.77**	**-14.90**	**5.86**	**51.70**	**0.72**
PC	CNTRL	2569	11.61	9.37	**-2.24**	**-19.30**	**10.20**	**53.20**	**0.53**
	LGTNO	2569	11.61	9.37	**-2.24**	**-19.30**	**10.20**	**53.20**	**0.53**

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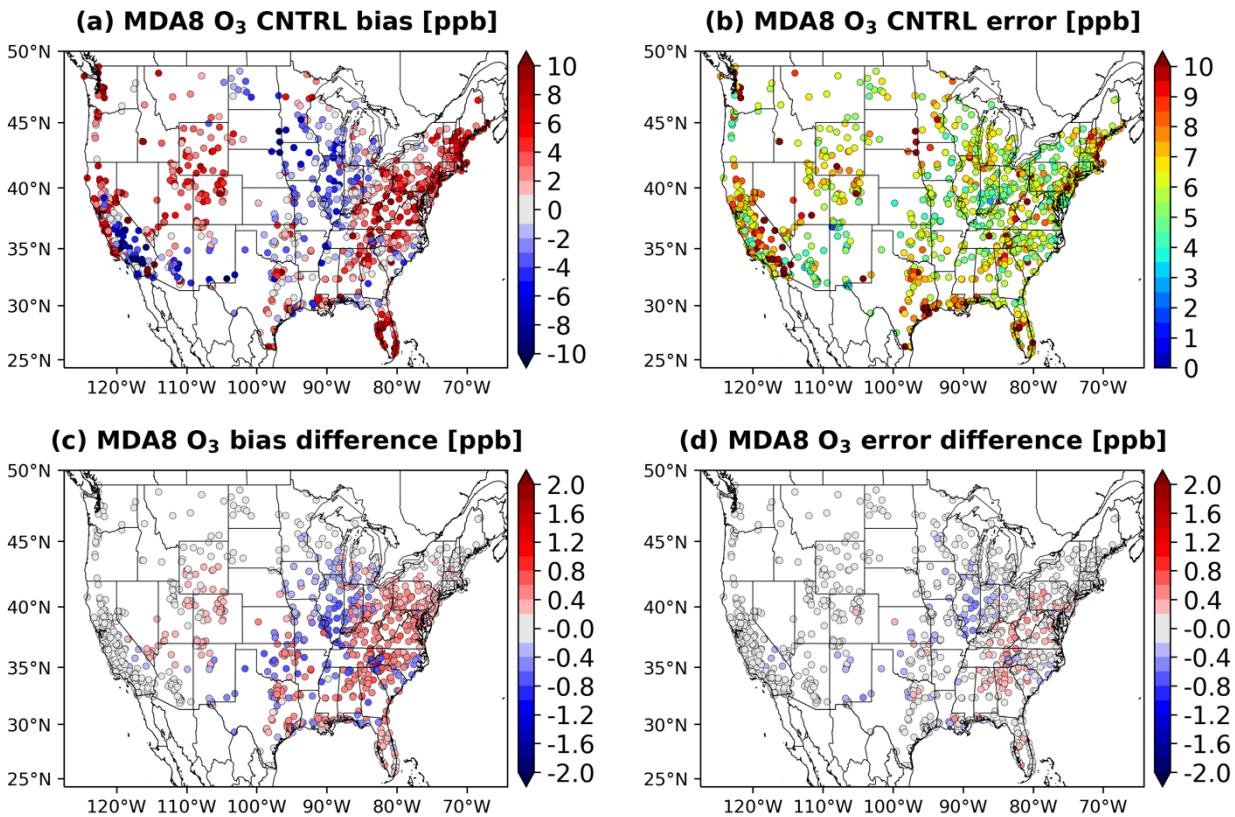
Figure S1: Spatial distribution of ground-level MDA8 ozone statistics for June 2019. (a) Mean bias of the CNTRL; (b) mean error of the CNTRL; (c) absolute mean bias difference between the LGTNO and the CNTRL; (d) mean error difference between the LGTNO and the CNTRL. In (c) and (d), negative and positive values represent improved and degraded statistics when including the NO_x emission, respectively.

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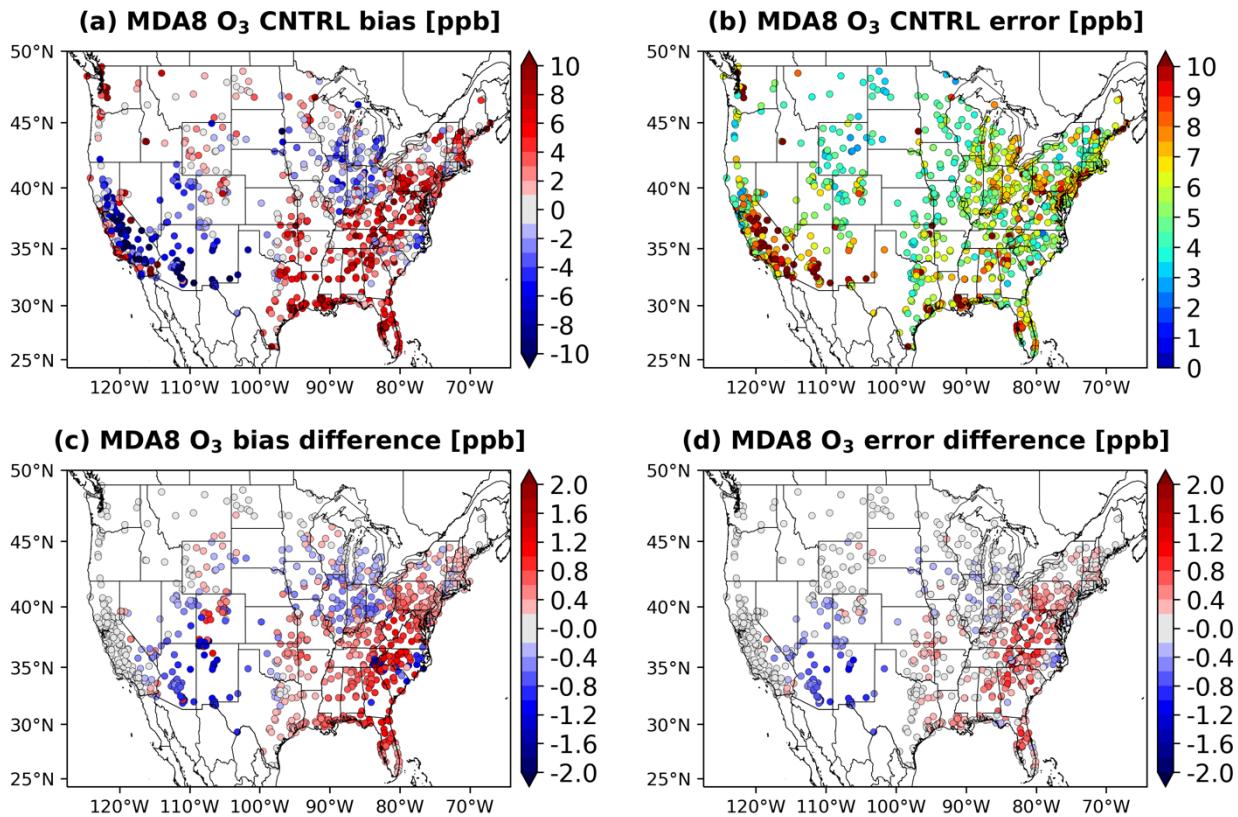
35   **Figure S2: Spatial distribution of ground-level MDA8 ozone statistics for July 2019. (a) Mean bias of the CNTRL; (b) mean error of the CNTRL; (c) absolute mean bias difference between the LGTNO and the CNTRL; (d) mean error difference between the LGTNO and the CNTRL. In (c) and (d), negative and positive values represent improved and degraded statistics when including the NOx emission, respectively.**
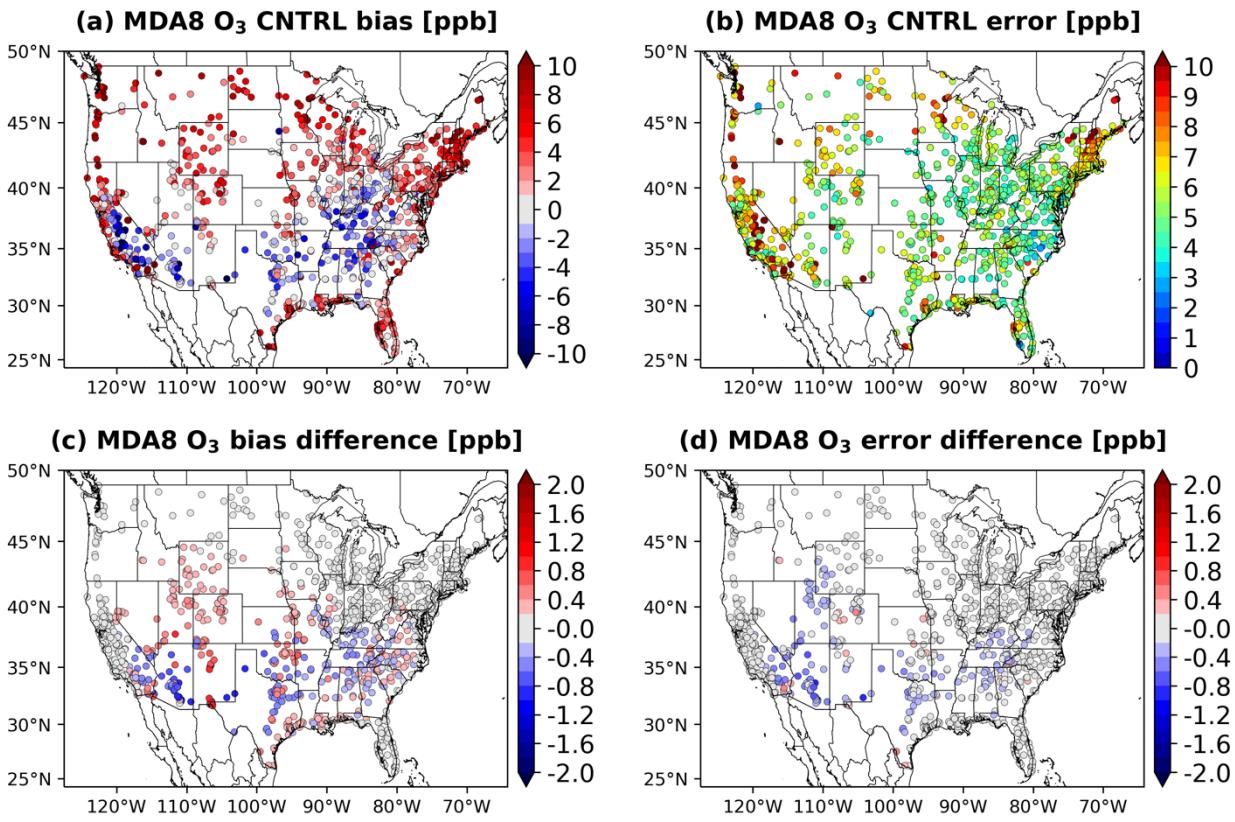
Figure S3: Spatial distribution of ground-level MDA8 ozone statistics for September 2019. (a) Mean bias of the CNTRL; (b) mean error of the CNTRL; (c) absolute mean bias difference between the LGTNO and the CNTRL; (d) mean error difference between the LGTNO and the CNTRL. In (c) and (d), negative and positive values represent improved and degraded statistics when including the NO$_x$ emission, respectively.

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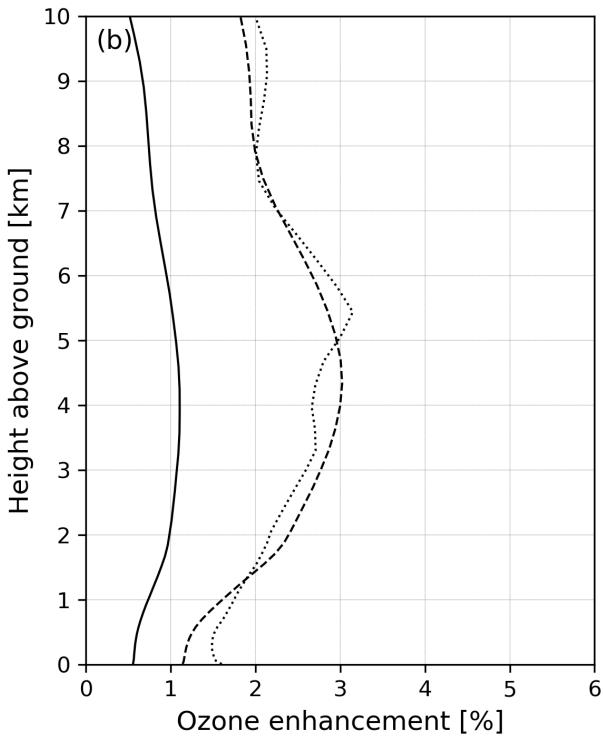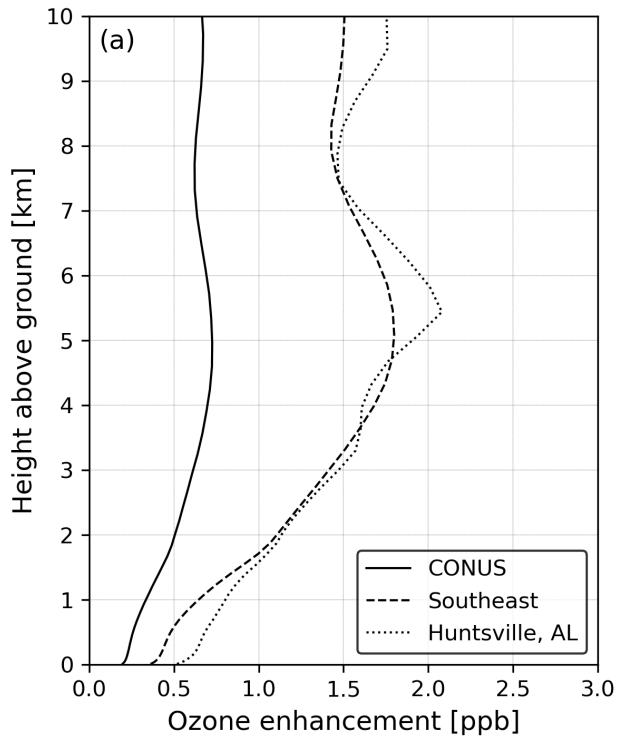
Figure S4: Vertical distribution of average ozone enhancement due to lightning NO$_x$ emission during june 2019 for the CONUS, the southeast U.S. (arbitrarily selected 25–40°N, 75–95°W for computation), and Huntsville, AL. (a) Ozone enhancement in ppb; (b) ozone enhancement in percent.

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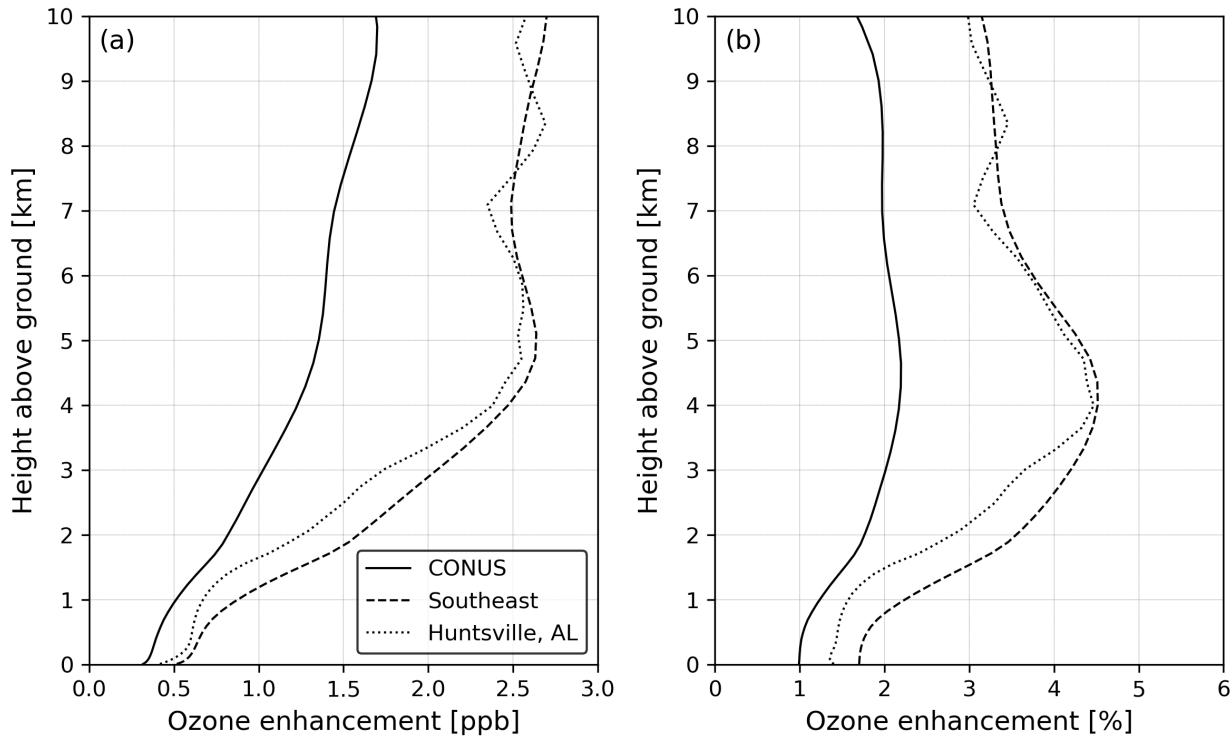
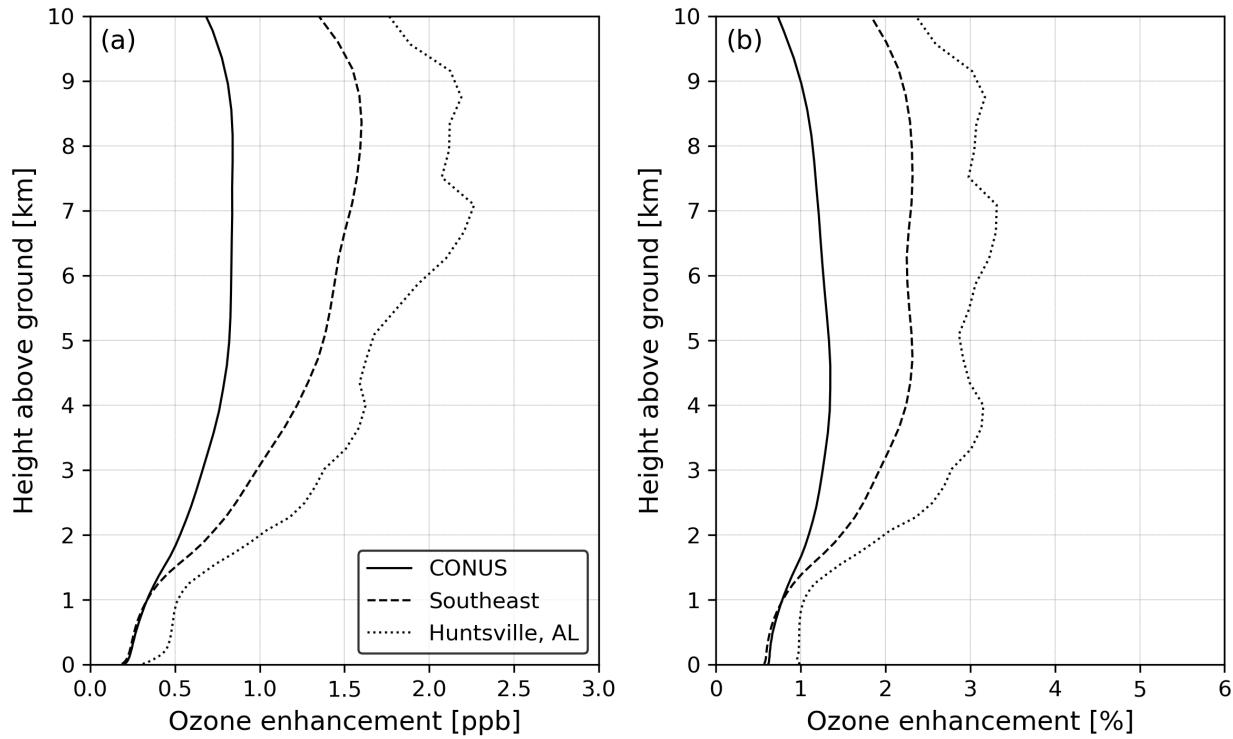


Figure S5: Vertical distribution of average ozone enhancement due to lightning NO$_x$ emission during July 2019 for the CONUS, the southeast U.S. (arbitrarily selected 25–40°N, 75–95°W for computation), and Huntsville, AL. (a) Ozone enhancement in ppb; (b) ozone enhancement in percent.

60   **Figure S6: Vertical distribution of average ozone enhancement due to lightning NO$_x$ emission during September 2019 for the CONUS, the southeast U.S. (arbitrarily selected 25–40°N, 75–95°W for computation), and Huntsville, AL. (a) Ozone enhancement in ppb; (b) ozone enhancement in percent.**

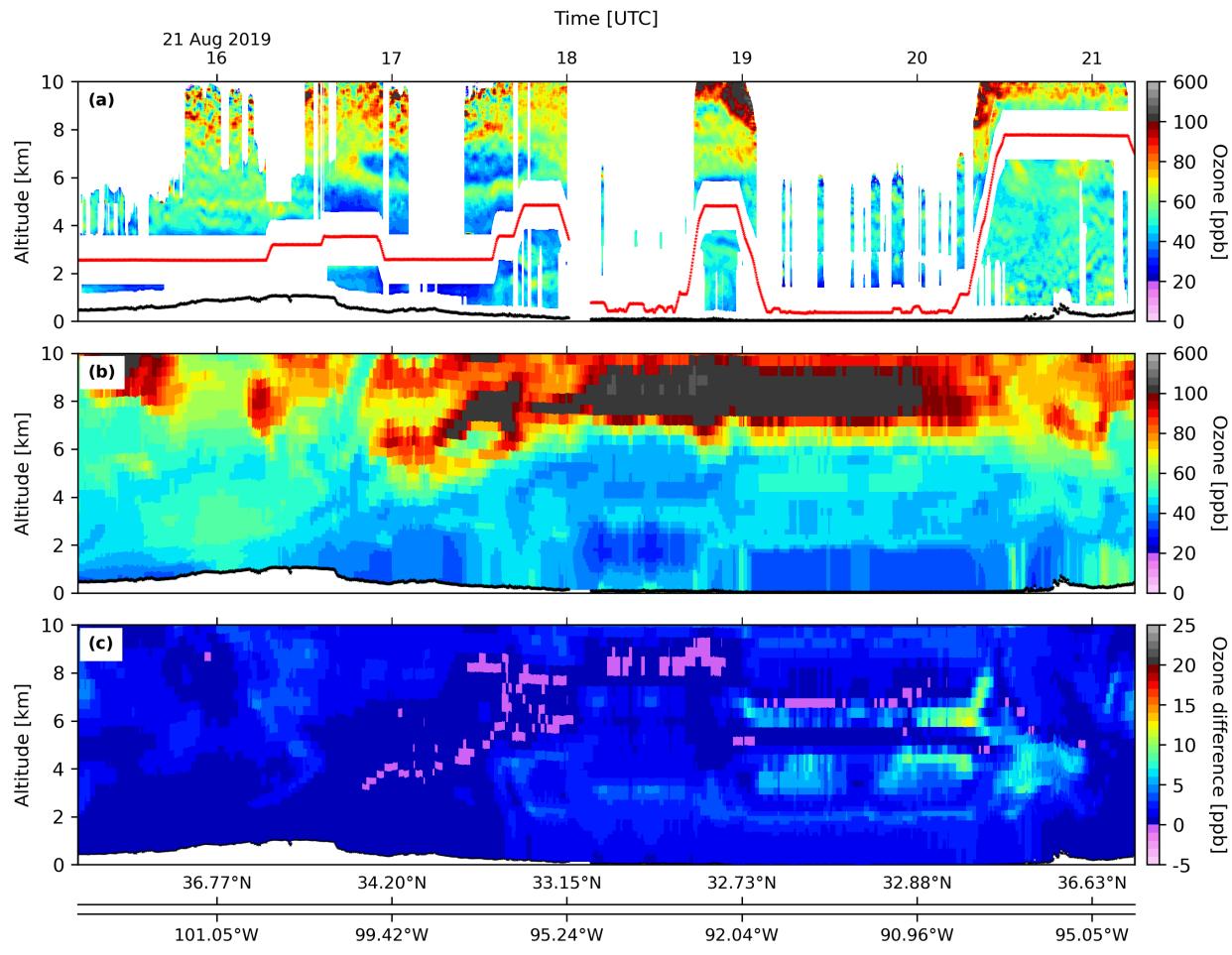



Figure S7: Time-height cross sections of lidar-measured and model-simulated ozone mixing ratio along the FIREX-AQ flight track on 21 August 2019. (a) Lidar-measured ozone profiles; (b) simulated ozone mixing ratio by the CNTRL model run; (c) ozone difference between the LGTNO and the CNTRL.

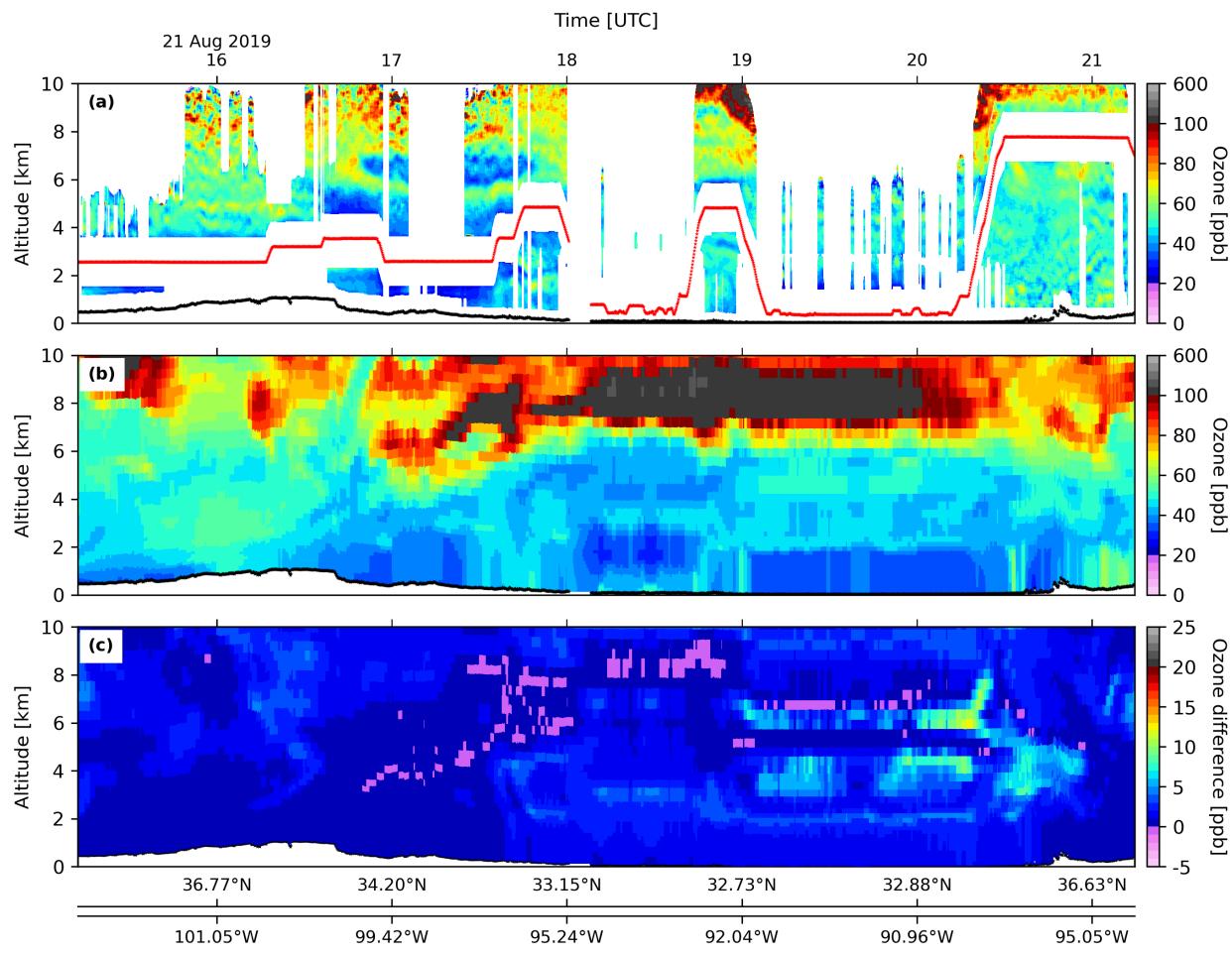



Figure S8: Time-height cross sections of lidar-measured and model-simulated ozone mixing ratio along the FIREX-AQ flight track on 23 August 2019. (a) Lidar-measured ozone profiles; (b) simulated ozone mixing ratio by the CNTRL model run; (c) ozone difference between the LGTNO and the CNTRL.

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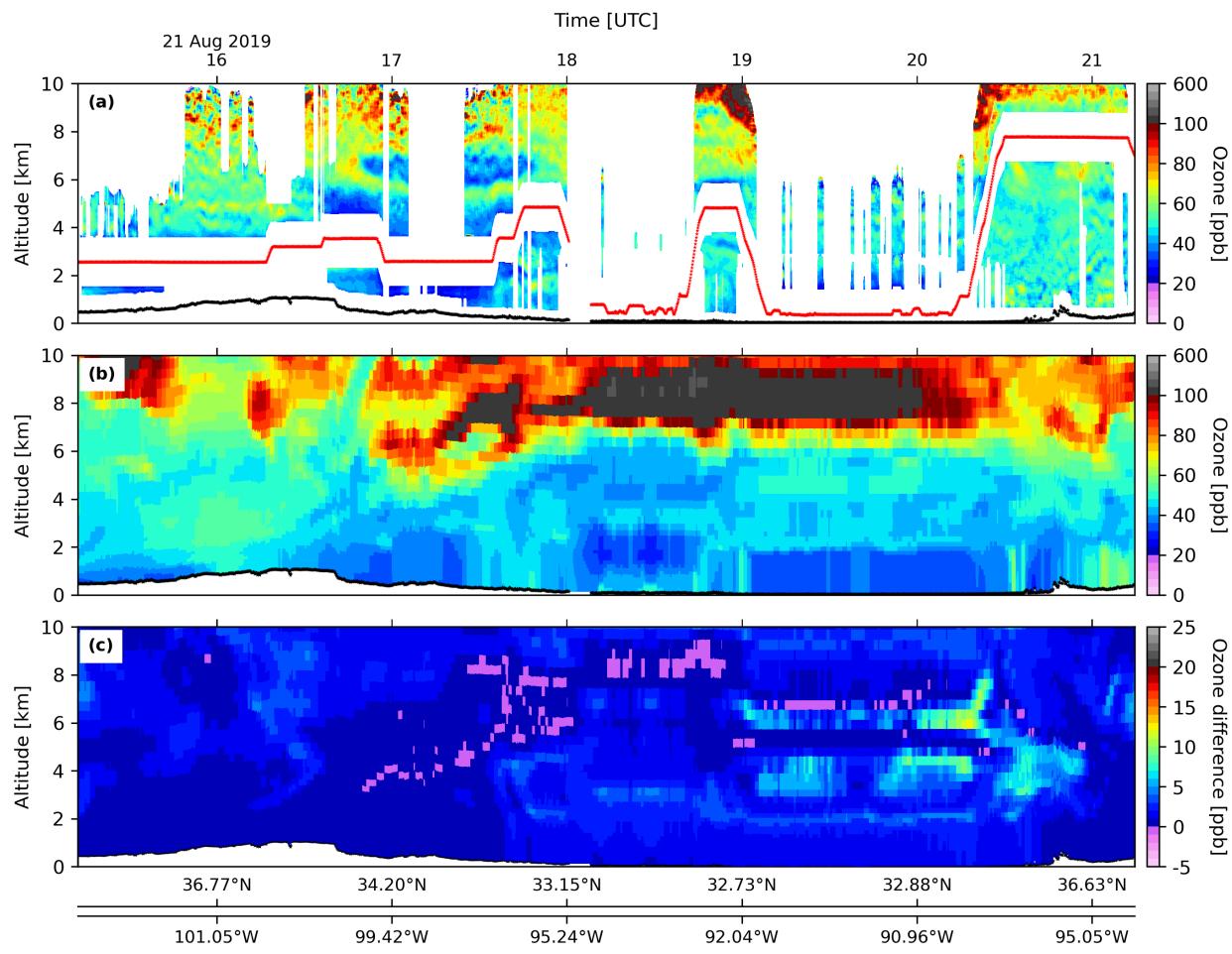
Figure S9: Time-height cross sections of lidar-measured and model-simulated ozone mixing ratio along the FIREX-AQ flight track on 26 August 2019. (a) Lidar-measured ozone profiles; (b) simulated ozone mixing ratio by the CNTRL model run; (c) ozone difference between the LGTNO and the CNTRL.