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Impact of introducing electric vehicles on ground-level O_3 and $PM_{2.5}$ in the Greater Tokyo Area: yearly trends and the importance of changes in the urban heat island effect

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Text S1 *Additional information on numerical simulations*

Table S1: Latitude and longitude of the seven sites analyzed in model validation within this study.

Prefecture	City	Longitude	Latitude
Tokyo	Tokyo	139.75	35.69
Kanagawa	Yokohama	139.65	35.44
Chiba	Chiba	140.10	35.60
Saitama	Saitama	139.59	35.88
Tochigi	Utsunomiya	139.88	36.56
Gunma	Maebashi	139.07	36.38
Ibaraki	Mito	140.47	36.37

Table S2: Calculation settings for the WRF.

Model	**WRF-ARW v4.3.3**
Reanalysis	NCEP FNL (1 deg., 6 hr)
SST	NOAA SST (0.082 deg., 6 hr)
domains	220×170, 45 km (D1), 154×160 (D2), 64×70 (D3)
Minimum vertical pressure (p_top)	100 hPa
Grid nudging	k_zfac_uv = 10
	guv, gt, gq = 0.0001 (D1), 0.00005 (D2), 0.0000 (D3)
Microphysics	WRF Single-Moment 5-class scheme
Longwave radiation	RRTMG scheme
Shortwave radiation	RRTMG scheme
Planetary boundary layer	Mellor-Yamada Nakanishi and Niino Level 3 PBL scheme
Cloud Physics	Kain–Fritsch scheme
Urban physics	Urban-canopy model (UCM)

Table S3: Calculation settings for the CMAQ.

Model	**CMAQv5.3.3**
Boundary concentration (D1)	MOZART-4/GEOS5
Boundary concentration (D2)	Nested from D1
Boundary concentration (D3)	Nested from D2
Initial concentration (D1)	CMAQ default (profile)
Initial concentration (D2)	Nested from D1
Initial concentration (D3)	Nested from D2
Gas/Aerosol/Aqueous chemistry	saprc07tc/aero6/cloud_acm_ae6
Photolysis	phot_inline

Horizontal advection	Yamo
Vertical advection	wrf
Horizontal diffusion	hdiff/multiscale
Vertical diffusion	vdiff/acm
Dry deposition	m3dry

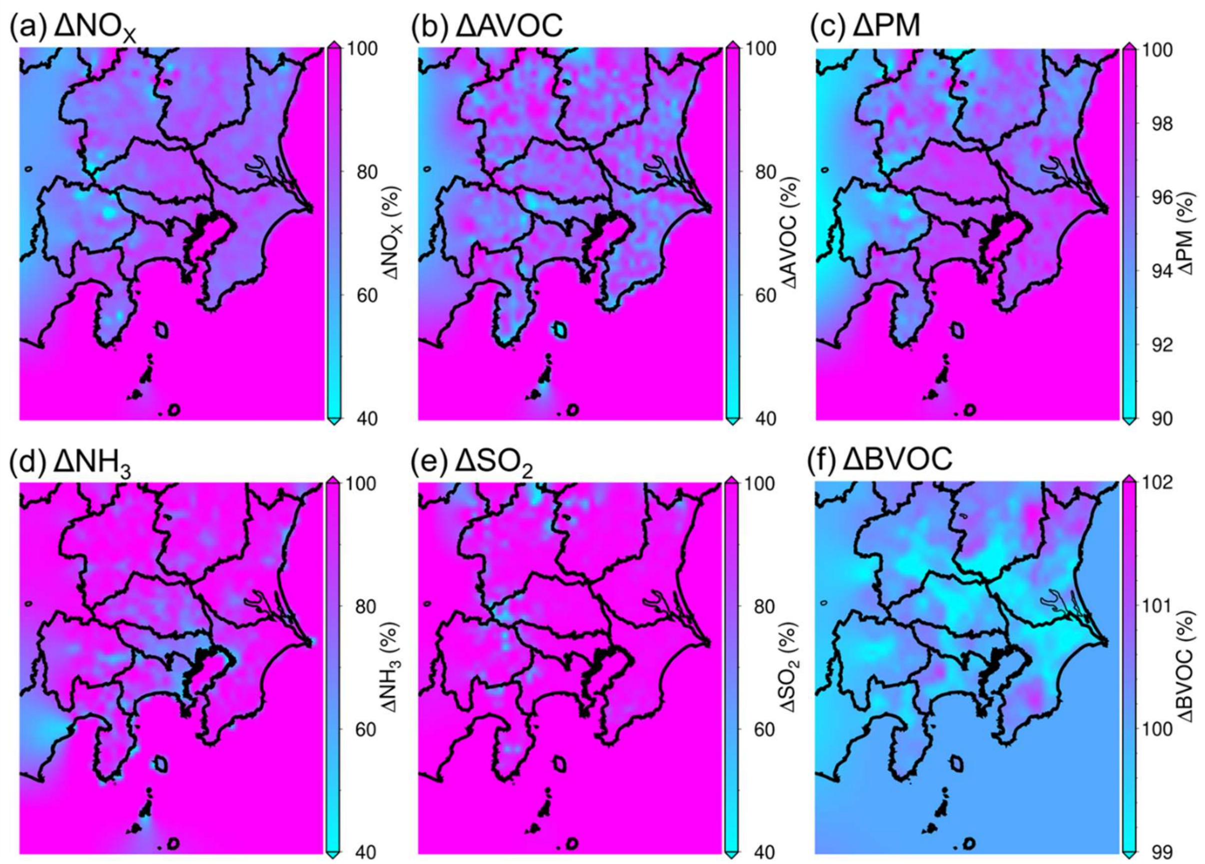

Fig. S1: Changes in annual emissions in ALL and BASE scenarios (ALL/BASE) in terms of: (a) NO_X, (b) anthropogenic VOCs (AVOC), (c) particulate matter (PM), (d) NH_3, (e) SO_2, and (f) biogenic VOCs (BVOC). The following would occur through introducing EVs and are included: a reduction in tailpipe exhaust and evaporative emissions, an increase in emissions from power plants owing to battery charging, and changes in BVOC emissions caused by a change in the UHI effect.

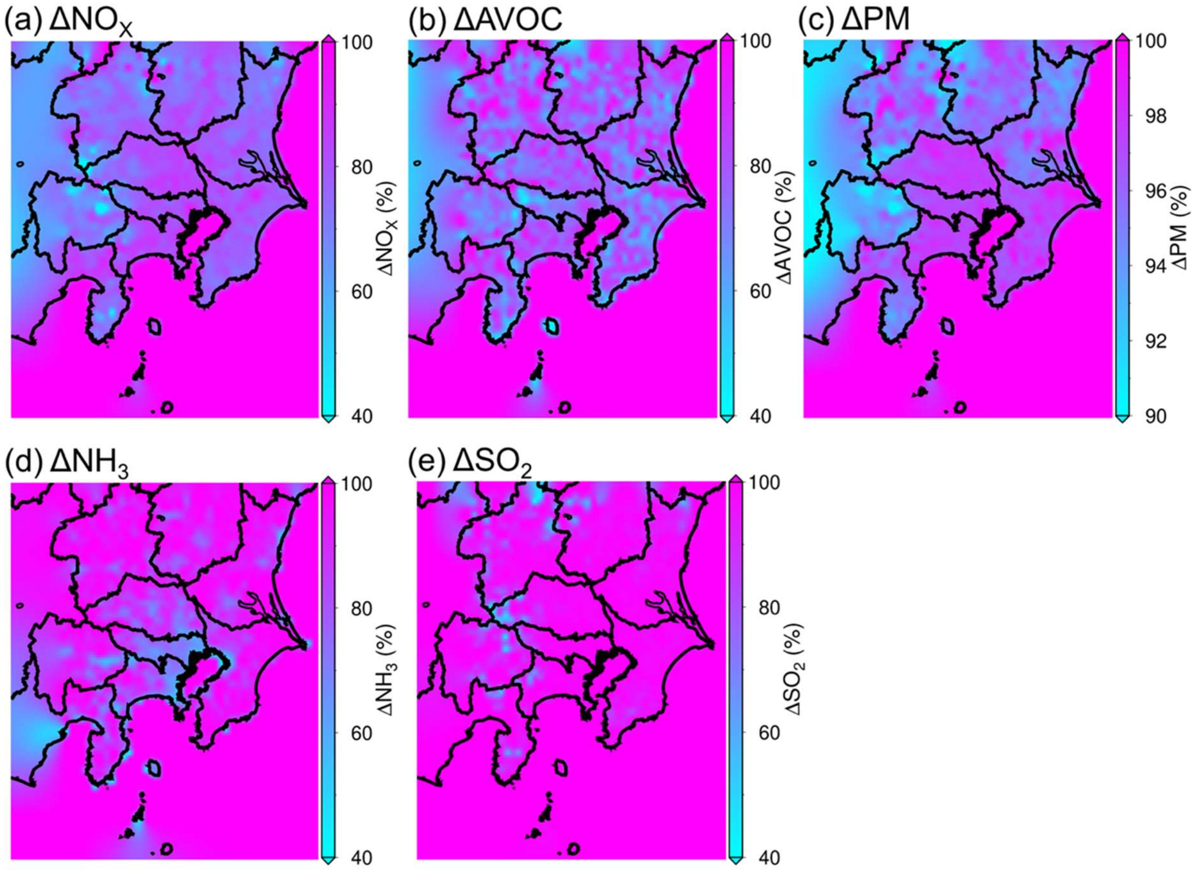

Fig. S2: Changes in annual emissions produced in S_{EV} and BASE scenarios (S_{EV}/BASE): (a) NO_X, (b) anthropogenic VOC (AVOC), (c) particulate matter (PM), (d) NH_3, and (e) SO_2.

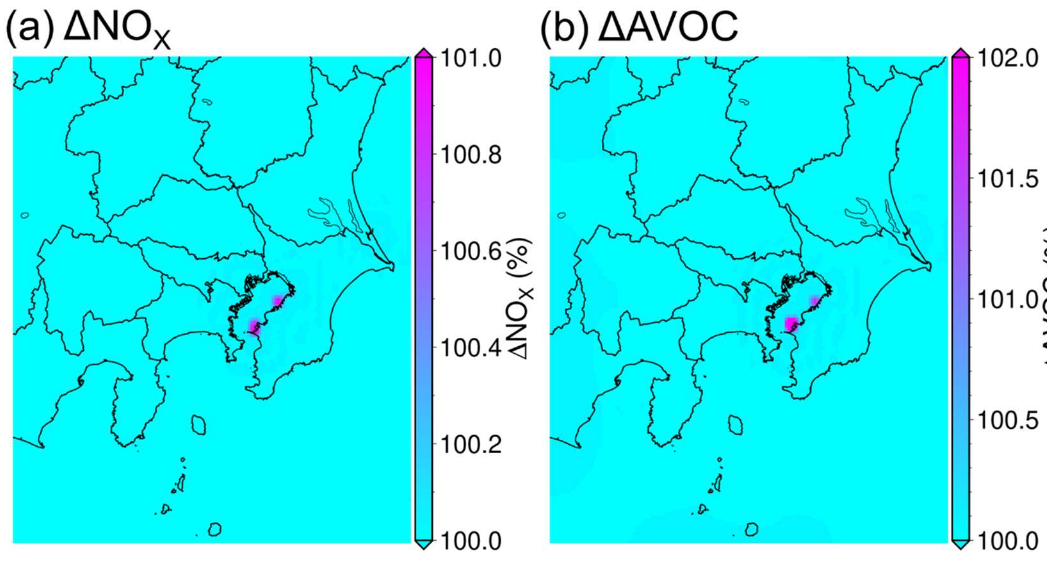

Fig. S3: Changes in annual emissions produced in S_{PP} and BASE scenarios (S_{PP}/BASES): (a) NO_X and (b) anthropogenic VOCs (AVOC). Significant changes in NO_X and AVOC emissions are observed.

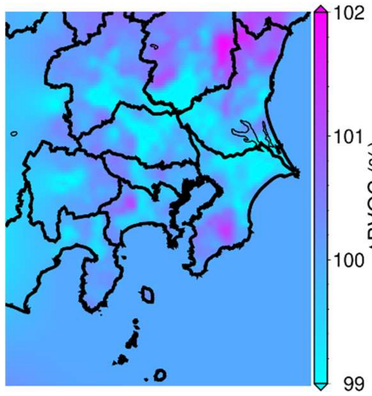

Fig. S4: Changes in annual BVOC emissions produced in S_{BVOC} and BASE scenarios (S_{BVOC}/BASE). BVOCs are defined as the sum of isoprene, monoterpenes, and sesquiterpenes. The change in BVOC emissions from the BASE scenario is caused by a change in the UHI effect owing to the introduction of BEVs.

Text S3 *Additional information to supplement results section*

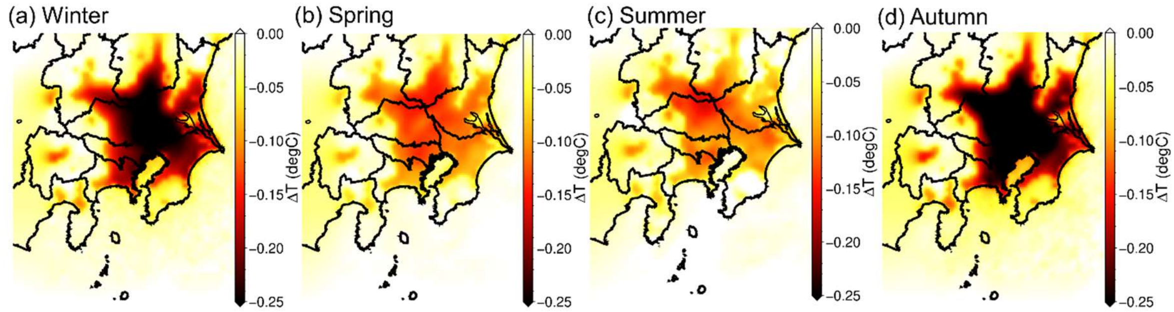

Fig. S5: Changes in ground temperature resulting from a decrease in the UHI effect owing to the introducing BEVs in the GTA.

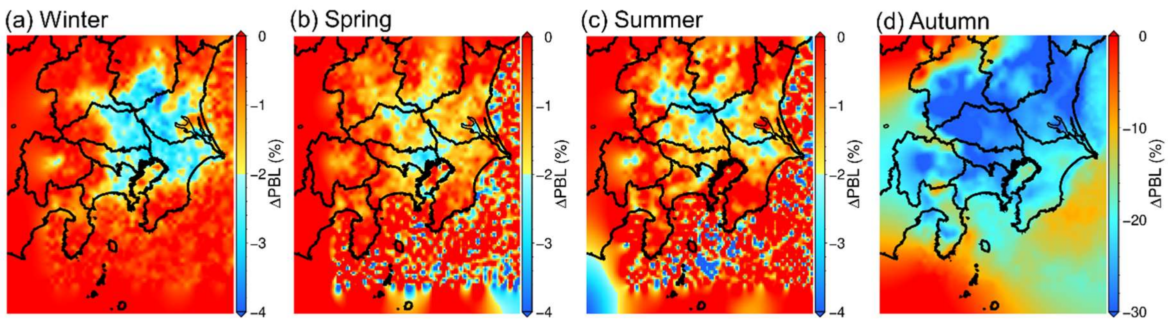

Fig. S6: Changes in the planetary boundary layer (PBL: %) from the ground surface to the free troposphere resulting from a decrease in the UHI effect owing to introducing BEVs in the GTA.

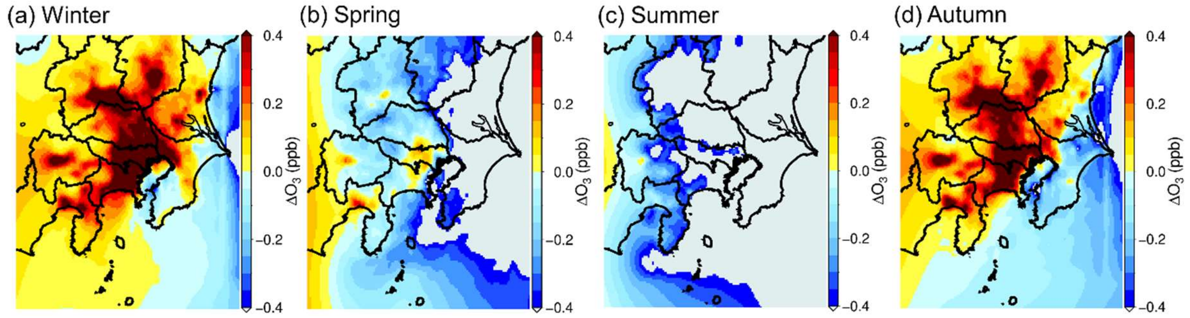

Fig. S7: Changes in O_3 concentration in four seasons following the introduction of BEVs in the GTA.

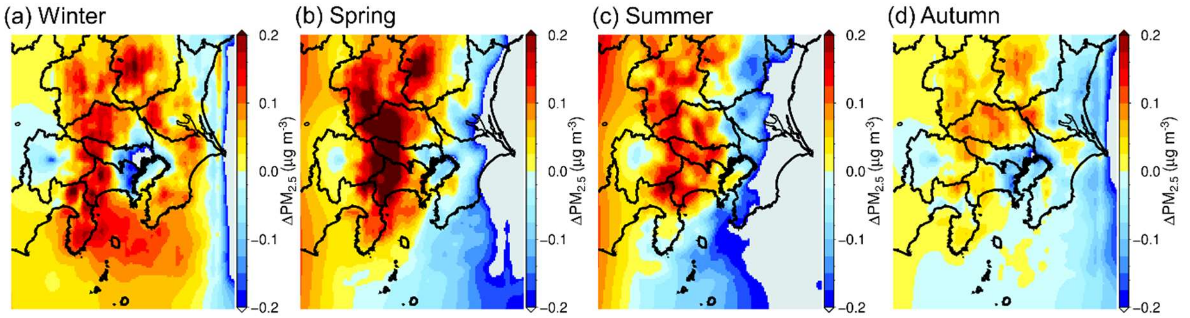

Fig. S8: Changes in $PM_{2.5}$ concentration in four seasons following the introduction of BEVs in the GTA.

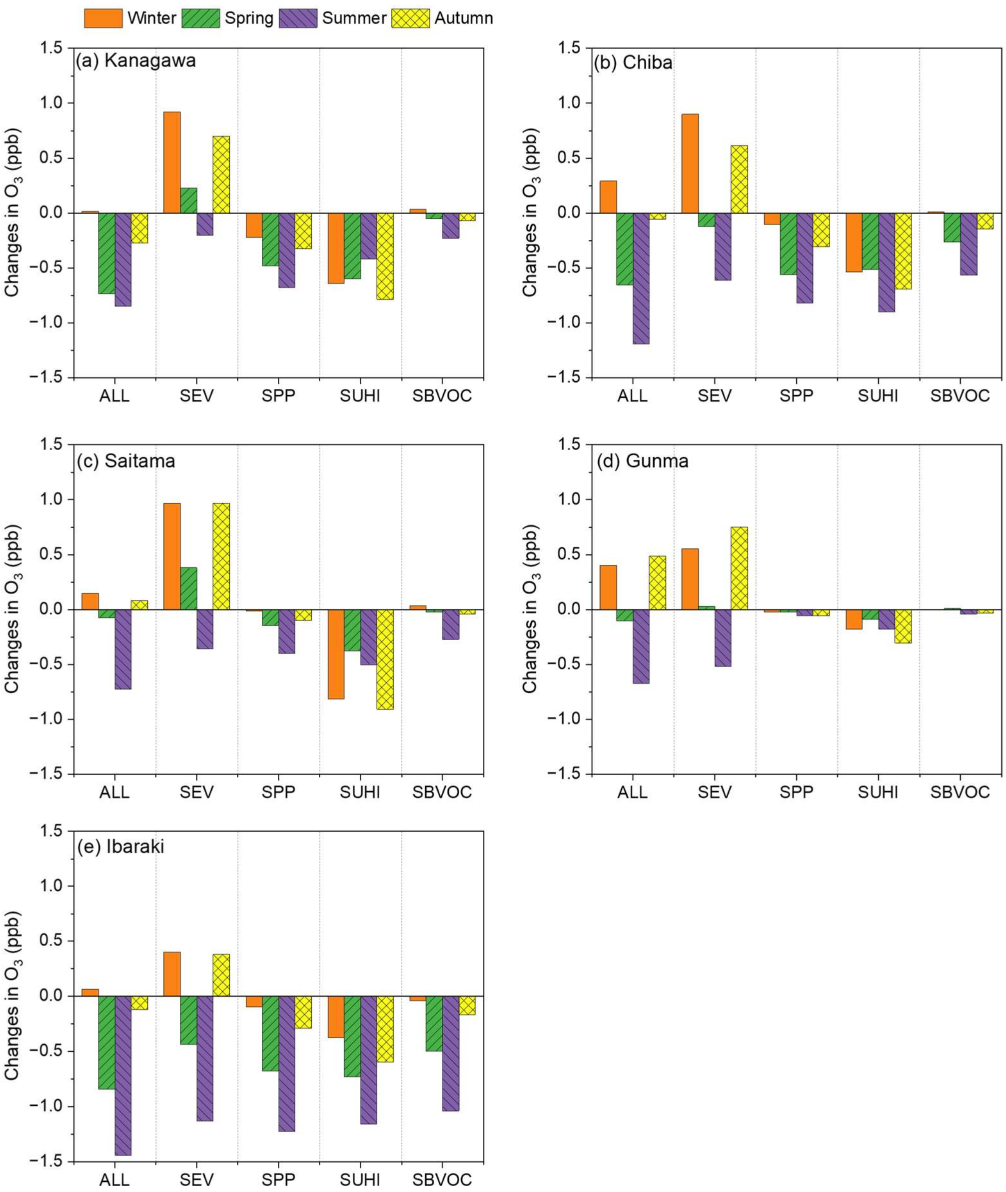

Fig. S9: Contributions of the five scenarios listed in Table 1 (of the main article) to the changes in O_3 in (a) Kanagawa, (b) Chiba, (c) Saitama, (d) Gunma, and (e) Ibaraki.

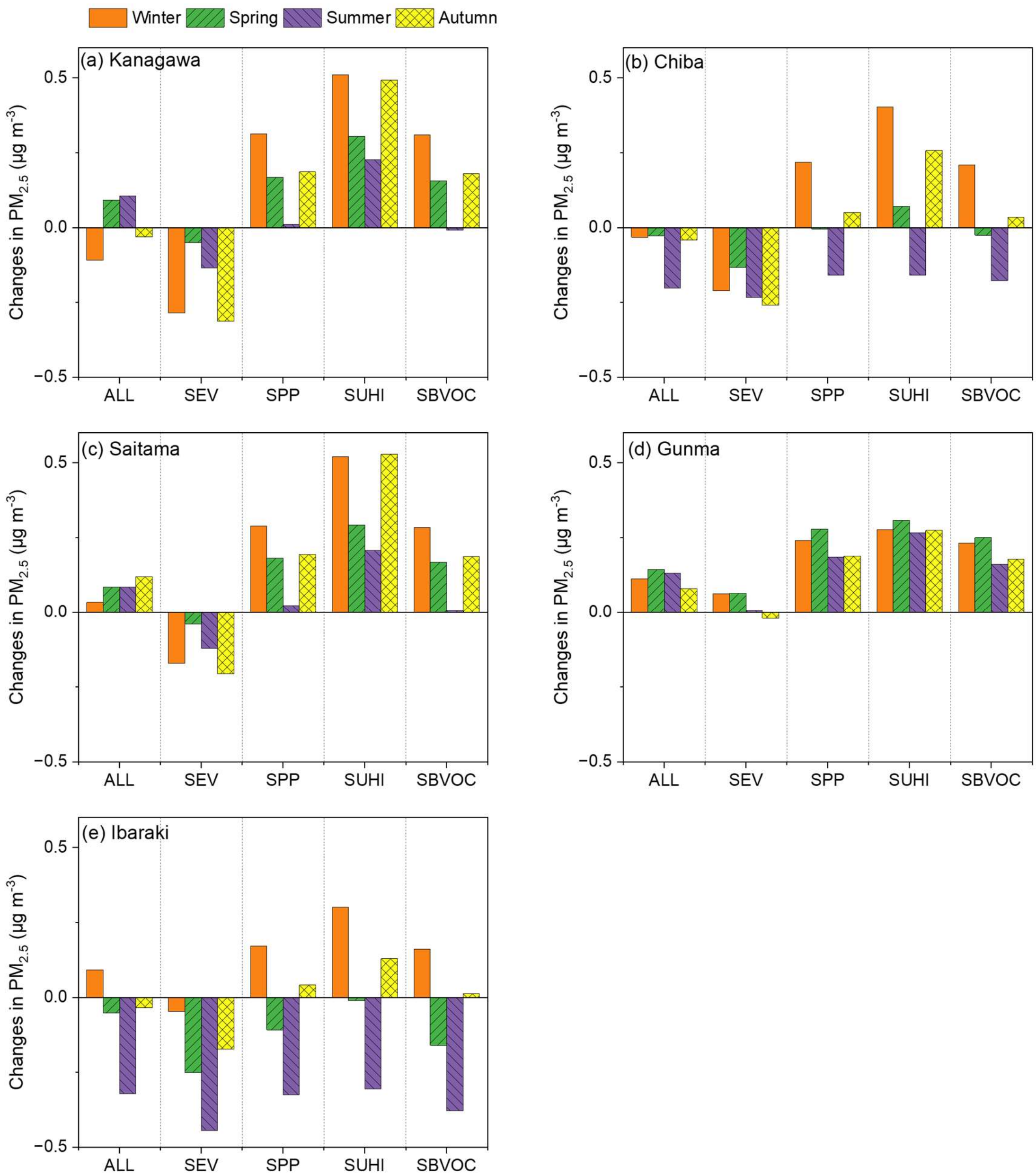

Fig. S10: Contributions of the five scenarios listed in Table 1 (of the main article) to the changes in $PM_{2.5}$ in (a) Kanagawa, (b) Chiba, (c) Saitama, (d) Gunma, and (e) Ibaraki.

Table S4: Concentrations of the species defined in the box modeling of SAPRC-07. Definitions of the species are listed in the previous work (Carter. Atmos. Environ. 44(40), 5324-5335, 2010.)

Species	Conc. (ppm)	Species	Conc. (ppm)	Species	Conc. (ppm)
CO	1.00E+00	B124	1.49E-03	MEK	2.95E-03
NO	3.47E-01	BENZ	3.54E-03	MGLY	3.59E-05
NO2	3.56E-02	CRES	4.78E-04	MVK	0.00E+00
SO2	3.66E-01	MXYL	4.18E-03	RCHO	7.15E-04
NH3	1.90E-01	NAPH	2.04E-04	AACD	6.71E-04
ALK1	8.93E-03	OXYL	2.41E-03	BACL	5.11E-04
ALK2	1.63E-02	PXYL	1.83E-03	ETOH	1.57E-02
ALK3	2.76E-02	TOLU	1.18E-02	FACD	3.77E-05
ALK4	3.75E-02	13BDE	3.53E-04	MEOH	5.25E-03
ALK5	1.17E-02	ACET	4.05E-03	PACD	1.85E-04
OLE1	2.66E-03	ACRO	1.15E-04	IPRD	5.70E-03
OLE2	6.76E-03	BALD	6.79E-05	PRD2	1.13E-03
ETHE	1.12E-02	CCHO	1.75E-03	ACYE	1.32E-03
ARO1	6.61E-03	GLY	5.68E-05	ISOP	3.06E-02
ARO2	4.73E-03	HCHO	1.39E-02	APIN	7.97E-06
ARO2MN	4.53E-03	MACR	4.71E-05	TERP	5.11E-03