S1 Suspended Particle Matter (SPM) in Japanese air quality regulation

In Japan, Suspended Particulate Matter (SPM) is defined as airborne particles with a diameter smaller than or equal to 10 μm.

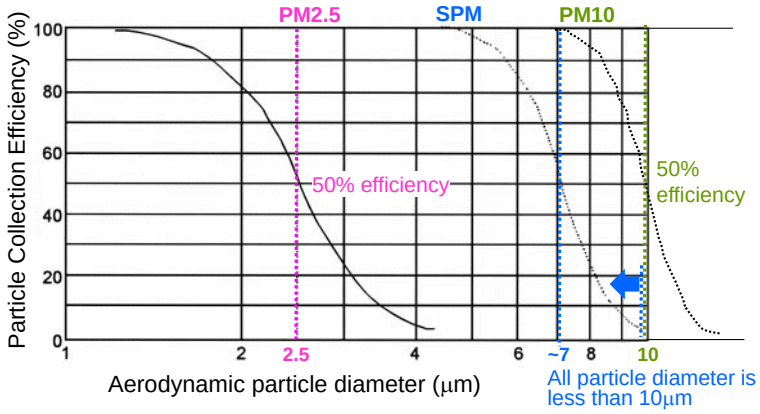


Figure S1. Definition of $PM_{2.5}$, SPM and PM_{10}

PM_{10}($PM_{2.5}$) is defined as particulate matter with a diameter of 10(2.5)μm collected with 50% efficiency by a PM_{10} ($PM_{2.5}$) sampling collection device.

S2. Vehicle category and emission regulation in Japan

Table S2. Vehicle category and emission regulation in Japan*

Vehicle Category			Calender Year																																
Fuel	Class	GVW/Engine Displacement	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gasoline & LPG	PC	660cc < Engine Displacement	S53														NST							New-LongTerm							H30				
	Mini car	Engine Displacement ≦ 660cc	S53														New-ShortTerm							New-LongTerm							H30				
	LDT	GVW ≦ 1700kg	S53														NST							New-LongTerm							H30				
	MDT	1700kg < GVW ≦ 2500kg	S53														NST							New-LongTerm							H30				
		2500kg < GVW ≦ 3500kg	S53														NST							New-LongTerm							H30				
	HDT	3500kg < GVW	S53														NST							New-LongTerm											
Diesel	PC	Vehicle Weight < 1265kg	H2			H6			ST				LongTerm				NST				NLT			Post-New-LongTerm							H30				
	PC	1265kg ≦ Vehicle Weight		H4		H6			ShortTerm				LongTerm				NST				NLT			Post-New-LongTerm							H30				
	LDT	GVW ≦ 1700kg	S63						ShortTerm				LongTerm				NST				NLT			Post-New-LongTerm							H30				
	MDT	1700kg < GVW ≦ 2500kg	S63						ShortTerm				LongTerm				NST				NLT			Post-New-LongTerm							H30				
		2500kg < GVW ≦ 3500kg	S63						ST				LongTerm				NST				NLT			Post-New-LongTerm							H30				
	HDT	3500kg < GVW ≦ 12000kg		H1					ShortTerm				LongTerm				NST				NLT			Post-New-LongTerm							H28				
		12000kg < GVW		H1					ShortTerm				LongTerm								NLT			Post-New-LongTerm							H28				
Motor cycles	Mini 1	1st-class motor-driven cycle	No Regultation												H10								H18				H24				H28				
	Mini 2	2nd-class motor-driven cycle	No Regultation														H11						H19				H24				H28				
	Small	125cc < Disp 250cc	No Regultation												H10								H18				H24				H28				
	Middle	250cc < Disp.	No Regultation														H11						H19				H24				H28				

Vehicle Category
- PC: Passenger Car
- LDT: Light Duty Truck
- MDT: Midium Duty Truck
- HDT: Heavy Duty Truck
- GVW: Gross Vehicle Weight
- Disp.: Engine Displacement

Emission Regulation
- S53: 1978 Regulation
- S63: 1988 Regulation
- H1: 1989 Regulation
- H2: 1990 Regulation
- H4: 1992 Regulation
- H6: 1994 Regulation
- H10: 1998 Regulation
- H11: 1999 Regulation
- H18: 2006 Regulation
- H19: 2007 Regulation
- H24: 2012 Regulation
- H28: 2016 Regulation
- H30: 2018 Regulation

- ST: Short Term Regulation
- LT: Long Term Regulation
- NST: New Short Term Regulation
- NLT: New Long Term Regulation
- PNLT:Post New Long Term Regulation

* Ministry of Land, Infrastructure, Transport and Tourism, Exhaust gas regulations for new cars. https://www.mlit.go.jp/jidosha/jidosha_tk10_000002.html (in Japanese) (accessed on 1 June 2021)

S3. 103 Vehicle Category for JEI-VEM

Table S3. 103 Vehicle Category for JEI-VEM

No.	Vehicle Type		Usage	Fuel Type	Weight Class	No. of vehicles owned (2010)
1	1	Light Passenger Car	Private	G	–	17,482,451
2			Buisiness	G	–	12,377
3	2	Passenger Car	Private	G	–	39,099,930
4				D	IW≦1.25t	64,869
5					IW＞1.25t	988,354
6			Buisiness	G	–	29,908
7				D	IW≦1.25t	109
8					IW＞1.25t	6,342
9				LPG	–	229,064
10	3	Bus	Private	G	1.7t＜GVW≦2.5t	183
11					2.5t＜GVW≦3.5t	5,173
12					3.5t＜GVW	2,839
13				D	1.7t＜GVW≦2.5t	159
14					2.5t＜GVW≦3.5t	11,543
15					3.5t＜GVW≦5.0t	32,059
16					5.0t＜GVW≦8.0t	51,959
17					8.0t＜GVW≦12t	10,746
18					12t＜GVW	5,743
19			Buisiness	G	1.7t＜GVW≦2.5t	10
20					2.5t＜GVW≦3.5t	303
21					3.5t＜GVW	1,154
22				D	1.7t＜GVW≦2.5t	2
23					2.5t＜GVW≦3.5t	932
24					3.5t＜GVW≦5.0t	1,796
25					5.0t＜GVW≦8.0t	16,920
26					8.0t＜GVW≦12t	21,433
27					12t＜GVW	65,324
28	4	Light Truck	Private	G	–	8,849,122
29			Buisiness	G	–	321,561
30	5	Small Truck	Private	G	GVW≦1.7t	742,543
31					1.7t＜GVW≦2.5t	661,320
32					2.5t＜GVW≦3.5t	439,134
33					3.5t＜GVW	5,515
34				D	GVW≦1.7t	60,161
35					1.7t＜GVW≦2.5t	281,843
36					2.5t＜GVW≦3.5t	850,984
37					3.5t＜GVW≦5.0t	676,136
38					5.0t＜GVW	112,786
39			Buisiness	G	GVW≦1.7t	5,235
40					1.7t＜GVW≦2.5t	5,527
41					2.5t＜GVW≦3.5t	7,084
42					3.5t＜GVW	413
43				D	GVW≦1.7t	716
44					1.7t＜GVW≦2.5t	3,150
45					2.5t＜GVW≦3.5t	19,304
46					3.5t＜GVW≦5.0t	28,272
47					5.0t＜GVW	6,731

Fuel Type G: Gasoline
D: Diesel

No.	Vehicle Type		Usage	Fuel Type	Weight Class	No. of vehicles owned (2010)
48	6	Truck	Private	G	GVW≦1.7t	2,849
49					1.7t＜GVW≦2.5t	28,890
50					2.5t＜GVW≦3.5t	77,197
51					3.5t＜GVW	19,083
52				D	GVW≦2.5t	14,511
53					2.5t＜GVW≦3.5t	125,887
54					3.5t＜GVW≦5.0t	183,660
55					5.0t＜GVW≦8.0t	838,205
56					8.0t＜GVW≦12t	11,062
57					12t＜GVW≦25t	133,933
58					25t＜GVW	4,892
59			Buisiness	G	GVW≦1.7t	4
60					1.7t＜GVW≦2.5t	70
61					2.5t＜GVW≦3.5t	3,762
62					3.5t＜GVW	20,108
63				D	GVW≦2.5t	93
64					2.5t＜GVW≦3.5t	3,222
65					3.5t＜GVW≦5.0t	63,791
66					5.0t＜GVW≦8.0t	360,008
67					8.0t＜GVW≦12t	9,487
68					12t＜GVW≦25t	318,786
69					25t＜GVW	84,067
70	7	Special Purpose Vehicle	Private	G	–	149,027
71					GVW≦1.7t	7,148
72					1.7t＜GVW≦2.5t	38,911
73					2.5t＜GVW≦3.5t	106,463
74					3.5t＜GVW	10,323
75				D	–	24,543
76					GVW≦1.7t	4,479
77					1.7t＜GVW≦2.5t	15,499
78					2.5t＜GVW≦3.5t	102,555
79					3.5t＜GVW≦5.0t	91,118
80					5.0t＜GVW≦8.0t	286,917
81					8.0t＜GVW≦12t	17,886
82					12t＜GVW	57,803
83			Buisiness	G	–	11,648
84					GVW≦1.7t	681
85					1.7t＜GVW≦2.5t	3,076
86					2.5t＜GVW≦3.5t	4,040
87					3.5t＜GVW	4,430
88				D	–	348
89					GVW≦1.7t	19
90					1.7t＜GVW≦2.5t	591
91					2.5t＜GVW≦3.5t	5,273
92					3.5t＜GVW≦5.0t	9,379
93					5.0t＜GVW≦8.0t	122,641
94					8.0t＜GVW≦12t	4,353
95					12t＜GVW	109,115
96	8	Motorcycle	Private	G	Less than 50cc, 2st	3,511,593
97					Less than 50cc, 4st	4,019,079
98					Less than 125cc, 2st	423,593
99					Less than 125cc, 4st	1,087,847
100					Less than 250cc, 2st	359,859
101					Less than 250cc, 4st	1,633,080
102					Over 250cc, 2st	0
103					Over 250cc, 4st	1,524,176

S4. Remote sensing device (RSD) measurement

RSD is a device that measures the emissions of vehicles traveling on the road in real time with the configuration shown in Figure S4-1

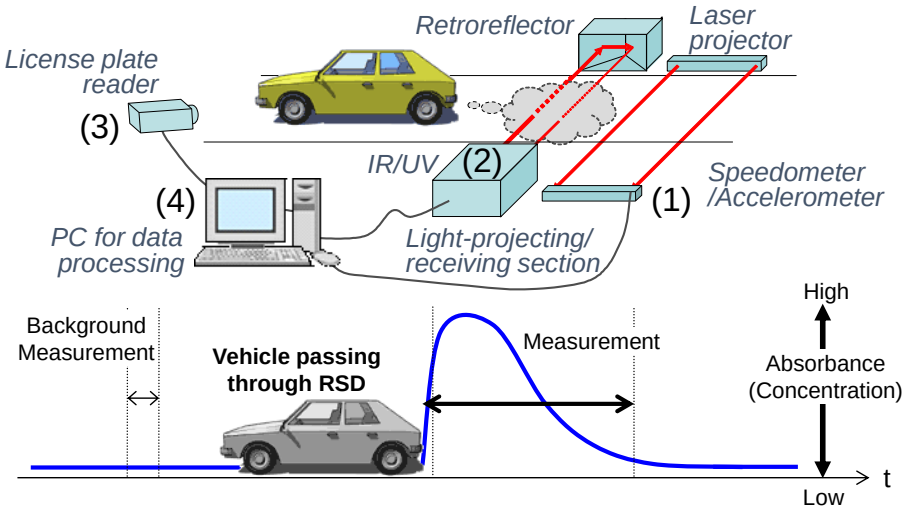


Figure S4-1 RSD On-road Set-up and Measurement

Table S4. JCAP/JATOP RSD measurement cases

Period	Place	Sample	Valid data
Oct 2002	Umi-no Koen Park	30,225	19,111 (63.2%)
Feb-Mar 2004	Umi-no Koen Park	53,608	36,327 (67.8%)
Jul-Aug 2004	Route No.4 Koga	66,296	17,649 (26.6%)
May-Jun 2006	Umi-no Koen Park	64,164	41,730 (65.0%)
Nov 2007	Umi-no Koen Park	59,417	27,233 (45.8%)
Feb 2008	Nakane Rittai	71,872	47,225 (65.7%)

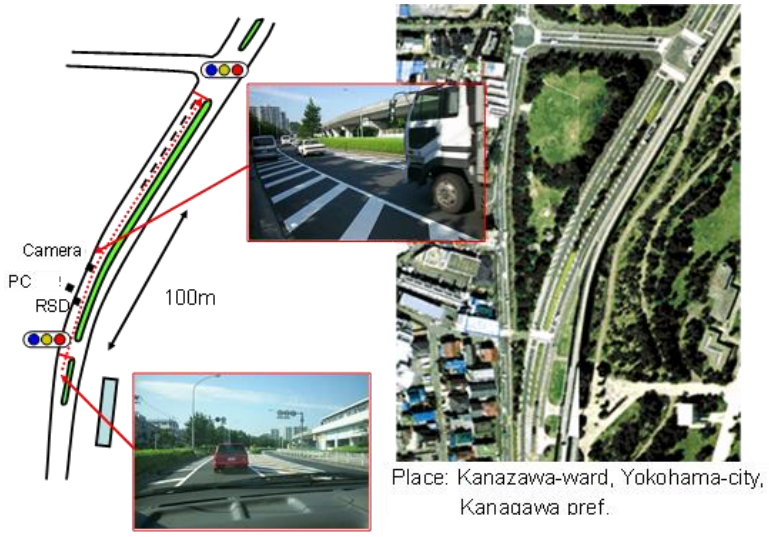


Figure S4-2. Umi-no-Koen Park

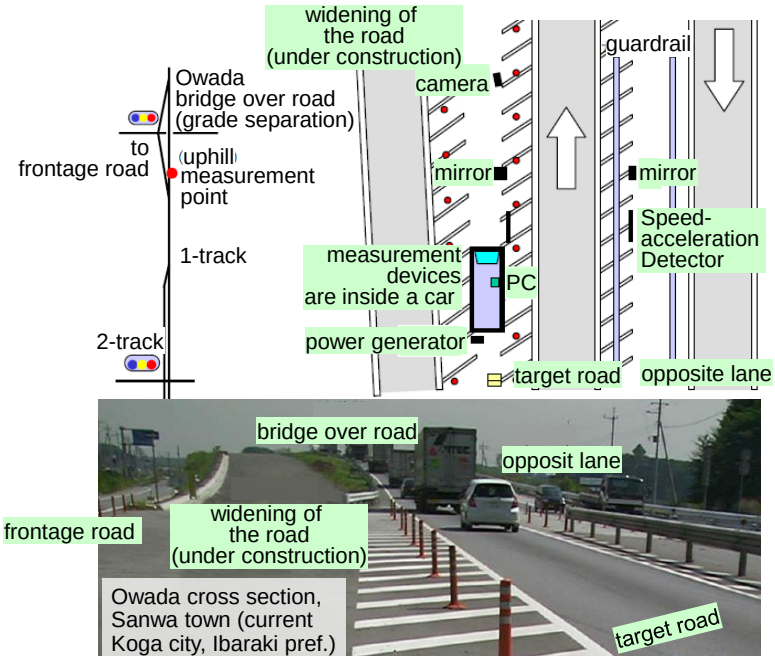


Figure S4-3. Route No.4 Koga

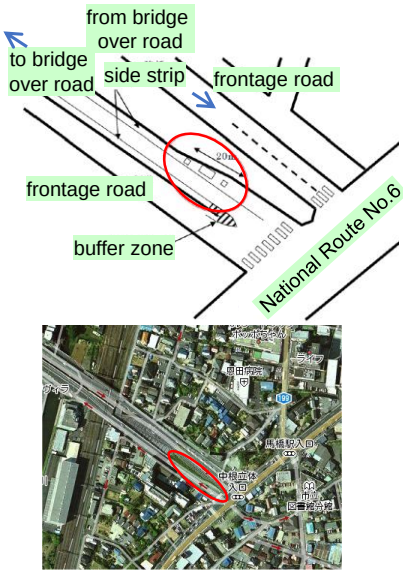


Figure S4-4. Nakane Rittai

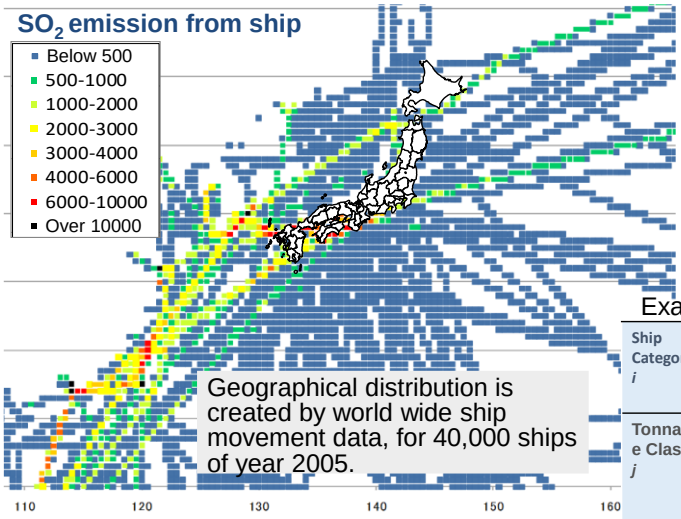
S5. Ship Emission

Figure S5 shows the ship emission of NOx. Emissions are applied based on the volume of vessel traffic on domestic and external routes. This inventory has been created by the National Maritime Research Institute's original program* SAPA-CTM, SAPA-MEET and SAPA-GIS.

$$Q_S = \sum_i \sum_j A_{ij} \times E_{Sij}$$

For Ocean-going vessels,
Domestic vessels,
Fishing vessels(domestic only)

Qs: Emission amount of Pollutant *S* (kg/hour).
Aij: Fuel consumption of **Ship Category *i***, ***T*onnage *j***, (t-fuel/hour) or (kWh)
Esij: Emission factor of pollutant *S* for **Ship Category *i***, ***T*onnage *j***, ***F*uel type *m***, (kg/t-furl) or (kg/kWh)



Geographical distribution is created by world wide ship movement data, for 40,000 ships of year 2005.

- ✓ Fuel consumption for each ship category and tonnage is estimated by a bottom up approach and adjusted by **national total energy consumption** as a top down approach.
- ✓ Fuel type for domestic vessels is defined by ship category and tonnage.

Example of ocean-going vessels' category

Ship Category *i*	Cargo carrier, Bulk carrier, Car carrier, Container ship, RO/RO ship, Tanker, Ferry, Cruise ship, Combination carrier, LPG/LNG tanker
Tonnage Class *j*	0～100GT 100～200GT 200～500GT 500～1,000GT 1,000～2,000GT 2,000～5,000GT 5,000～10,000GT 10,000～20,000GT 20,000～50,000GT 50,000～100,000GT 100,000～200,000GT 200,000GT～

Figure S5. Overview of ship emission inventory estimation method and SO_2 emission results

***** Software Information Center, Japan, Program Registration number: PNo.9995-1 (2011.4.21) https://www.softic.or.jp/touroku/list/list2011fh.html (in Japanese) (accessed on 1 June 2021)

S6. Secondary organic aerosol (SOA) model results

1) Concept

The secondary organic aerosol reaction is obtained as follows.

$$\Delta M0 = Y \cdot \Delta ROG$$

Where $\Delta M0$: Formed Aerosol Concentration

Y : Aerosol Yield as a function of Aerosol Conc. (Decided based on Chamber Experiments)

ΔROG : Reacted ROG Concentration

Aerosol yields for each ROG component are measured and modeled by smog chamber experiments. Figure S6-1and S6-2 show an outline of the chamber used.

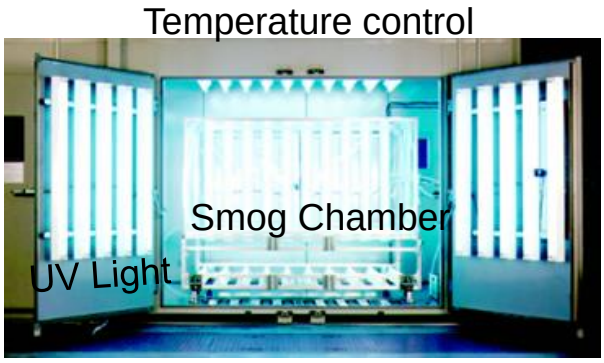


Figure S6-1. Smog chamber experiments

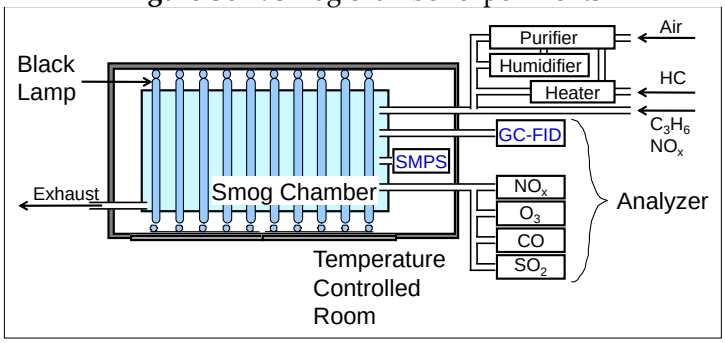


Figure S6-2. Outline of the chamber experiments

2) Modification of the Secondary Organic Aerosol Model

Based on the results of the photochemical chamber experiment, the secondary organic aerosol (SOA) formation model mounted on the air quality model (CMAQ) is modified and improved as below.

a) We updated the reaction parameters when secondary organic compounds (SOA) are generated from plant-derived VOCs (only NO non-coexistence reactions peculiar to forests are extracted).

b) A further pathway was added for the reaction product to react with OH. (Figure S6-3).

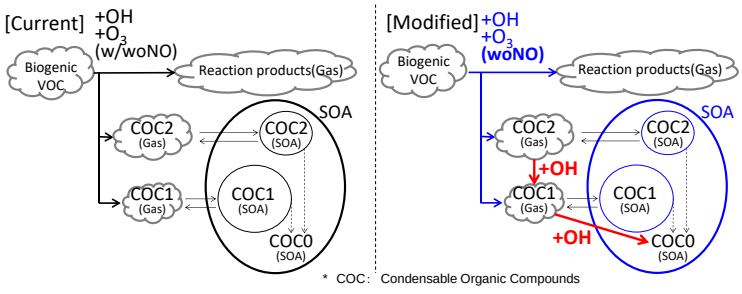


Figure S6-3. Reaction product pathway (Current and Modified)

Figure S6-4 shows comparison of SOA generation ability Y with default (SOA generation model with CMAQ)

(1) Biogenic VOC reaction: High ability to generate SOA at OA concentration at the level of the actual atmosphere.

(2) Product reaction process: The ability to generate SOA is further increased by adding a reaction pathway.

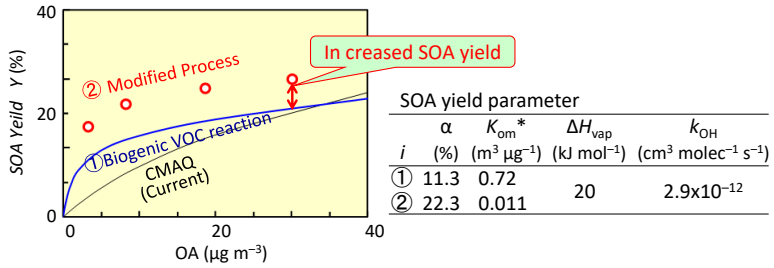


Figure S6-4. Comparison of SOA generation ability Y

Figure S6-5 shows the results of evaluating the reproducibility of OA concentration by incorporating the improved SOA model. Due to the improvement of the SOA generation model, the Biogenic SOA (BSOA) concentration increased by 50% on average annually. → Direction to improve the underestimation of OA. However, the difference from the observed values is large, and further research such as updating the SOA generation model and emission inventory is required.

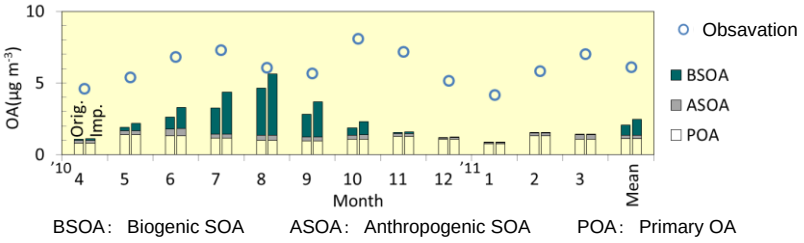


Figure S6-5. Results of OA reproducibility by the modified SOA model

S7. Reproducibility of the JATOP III Urban Air Quality Model

In the JCAP/JATOP Urban Air Quality Model study, dispersion (NME), overestimation or underestimation (NMB), and Peak conc. (UPA, ozone only), which US EPA have defined, are used as evaluation indexes for concentration reproducibility.
Figure S7-1 shows the reproducibility of the JATOP III Urban Air Quality Model of $PM_{2.5}$ and ozone. The reproducibility of the weight concentration of $PM_{2.5}$ is good in both components, but the EC and OA of the component concentration are still at a level that cannot be said to be sufficient.

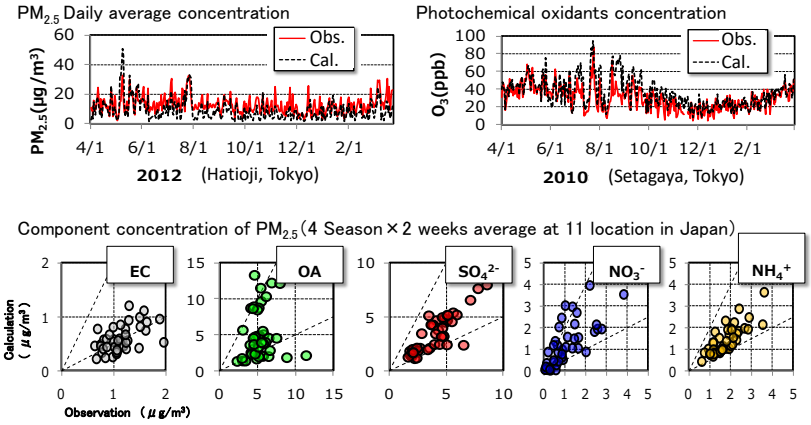


Figure S7-1. Reproducibility results of the JATOP III Urban Air Quality Model

Figure S7-2 shows the results of the evaluation index for each $PM_{2.5}$ component. Although the indicators have improved from JATOP II to JATOP III, the results are insufficient for EC and OA, and the reproducibility of each component is an issue for the future.

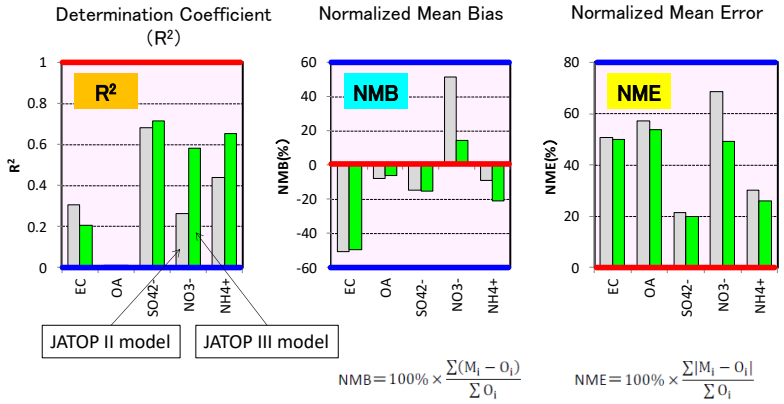


Figure S7-2. Evaluation index results for each $PM_{2.5}$ component

S8. Transient Emission Inventory Model for the Roadside Air Quality Model

Figure S8-1 shows the calculation procedure of the Transient Emission Inventory Model.
A two-dimensional map of speed and driving force is created from emission test data from the chassis dynamometer. The JMEC 03 test cycle is used to measure emission.

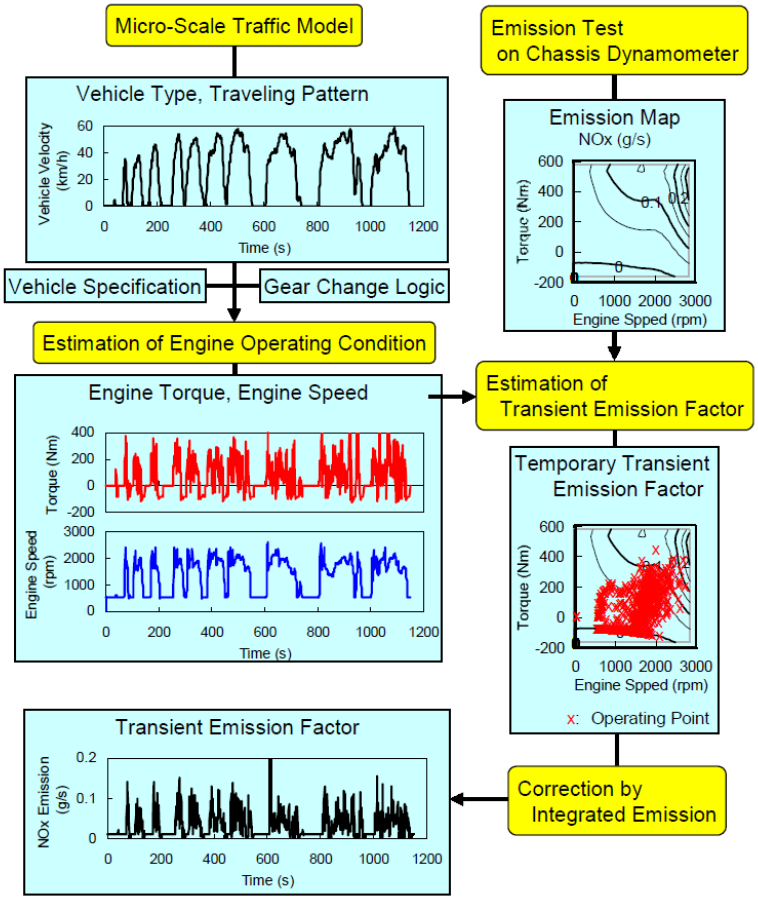


Figure S8-1. Calculation procedure of the Transient Emission Inventory

To incorporate the effect of road grade and load, driving force F is provided by the following equation.

$$F=(1+\gamma)\ m\alpha+\mu mg+mg\ (\sin\theta)\ +\lambda AV2$$

Where, γ : Inertia weight ratio
α : Vehicle Acceleration
μ : Rolling resistance coefficient
m : Vehicle weight
g : Acceleration of gravity
θ : Road grade
λ : Air resistance coefficient
A : Frontal projected area of vehicle
V : Vehicle speed

A traffic flow model (Paramics®) calculates a temporal vehicle speed at each point on 10m mesh. From the transient emission map, the emission amount corresponding to the vehicle speed/acceleration for each point (10m mesh) is calculated.

Emission inventory is constructed by accumulating emissions from vehicles with all traffic volume per hour for each road point.

Figure S8-2 shows a comparison of emission test results with load and road grade varied to simulation results. This comparison shows the change of vehicle load and road grade. The results show generally good reproducibility of this model.

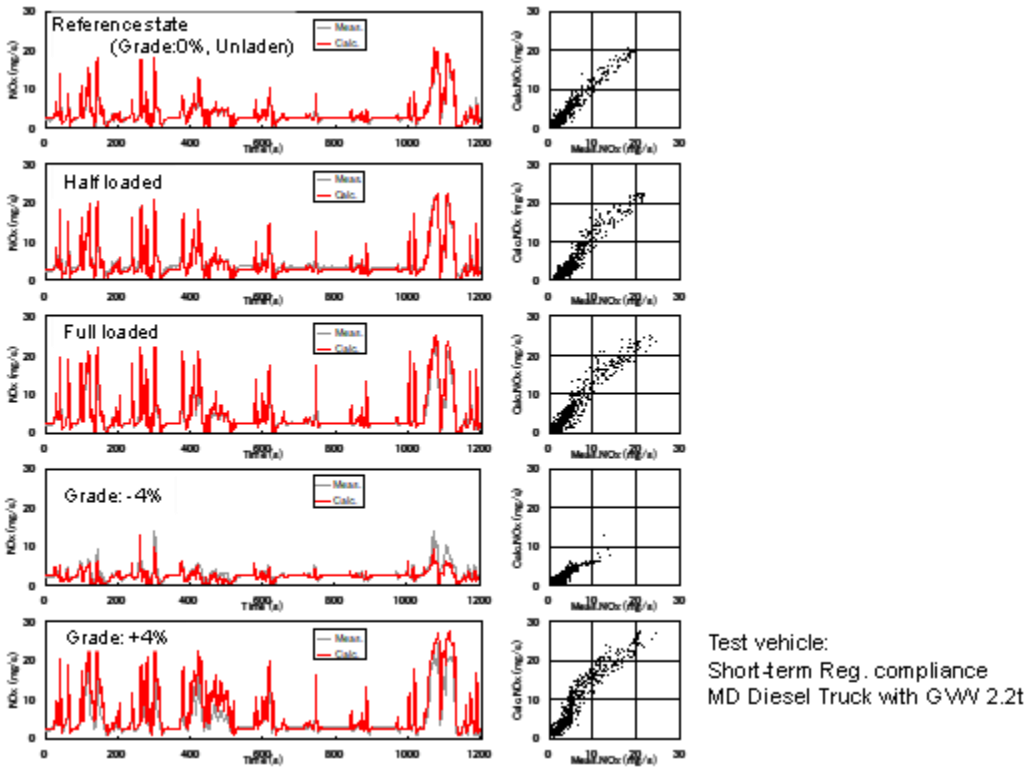


Figure S8-2. Comparison of emission test results with load and road grade

Emission inventory is constructed by accumulating emissions from vehicles with all traffic volume per hour for each road point. (Figure S8-3)

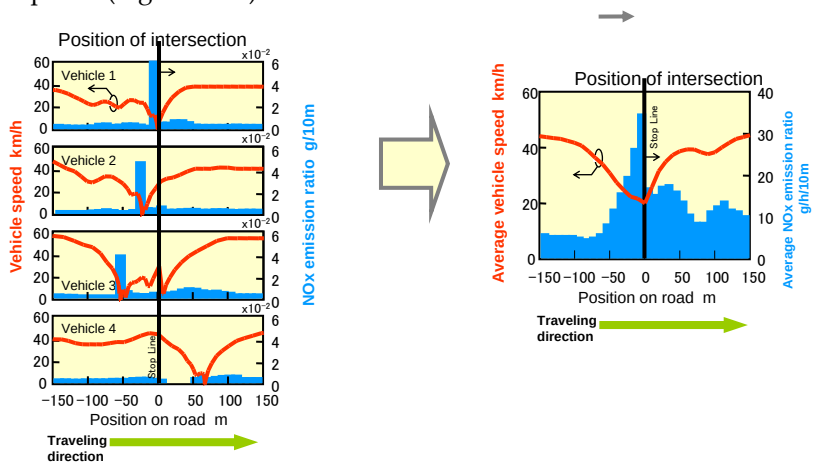
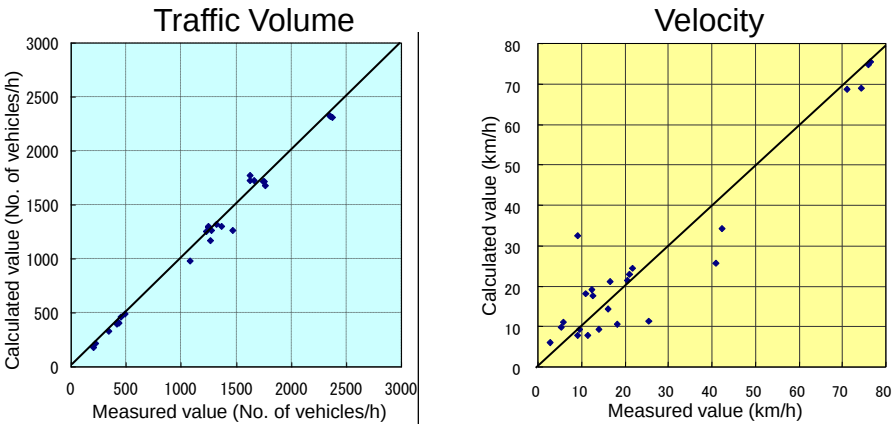


Figure S8-3. Transient emission inventory

S9. Micro-scale Traffic Flow Model

"Paramics®" is used as the micro traffic flow model. Figure S9 shows the reproducibility results at the Kamiuma intersection. The reproducibility of vehicle traffic and vehicle velocity are generally good.



Reproducibility evaluation

Item	Number of Links	Correlation coefficient	RMSE
Link traffic volume	26 links	0.995	5.7%
Link average velocity	22 links	0.947	29.3%

Figure S9. Reproducibility of micro traffic flow model, "Paramics®".

S10. Tracer gas analysis for the Roadside Air Quality Model (Yoshikawa, 2003a)

A concentration diffusion experiment with tracer gas has been performed to confirm reproducibility. Figure S10-1 shows the experimental conditions. Nine flow cases along the road are selected for measurement to confirm main canyon flow. SF6 was used as the tracer gas. The experiment date was from February 29th to March 3rd, 2000.

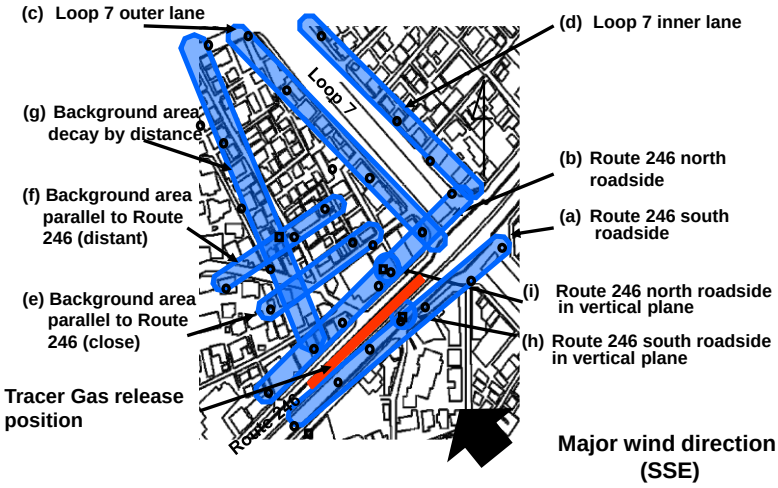


Fig. S10-1. Tracer gas flow measurement conditions. Small circles show tracer gas sampling points.

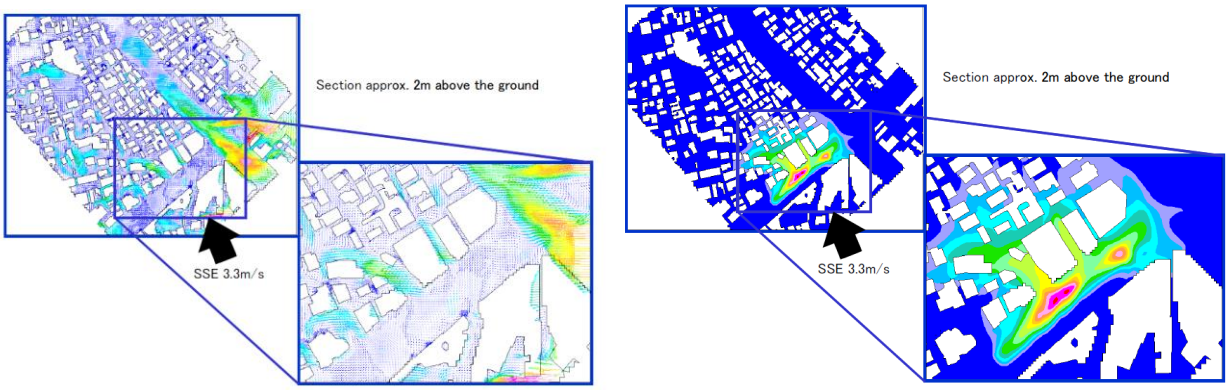


Figure S10-2. Calculated wind field (left) and tracer concentration field (right), section approx. 2m above the ground with the JCAP II Roadside Air Quality Model.

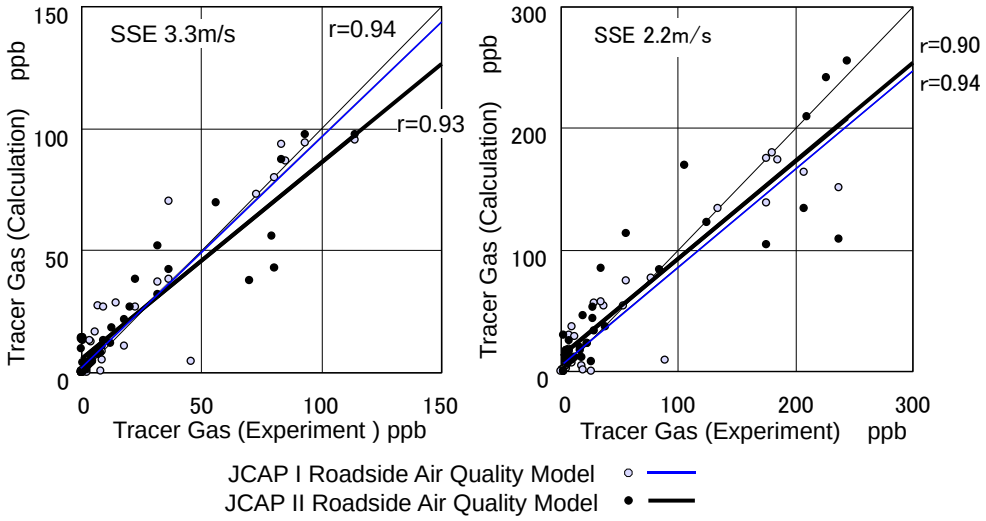


Figure S10-3. Correlation between experiment and calculation

S11. Changes in monthly average concentration of NO_2 at the five top Roadside Air Quality Monitoring Stations in Tokyo.

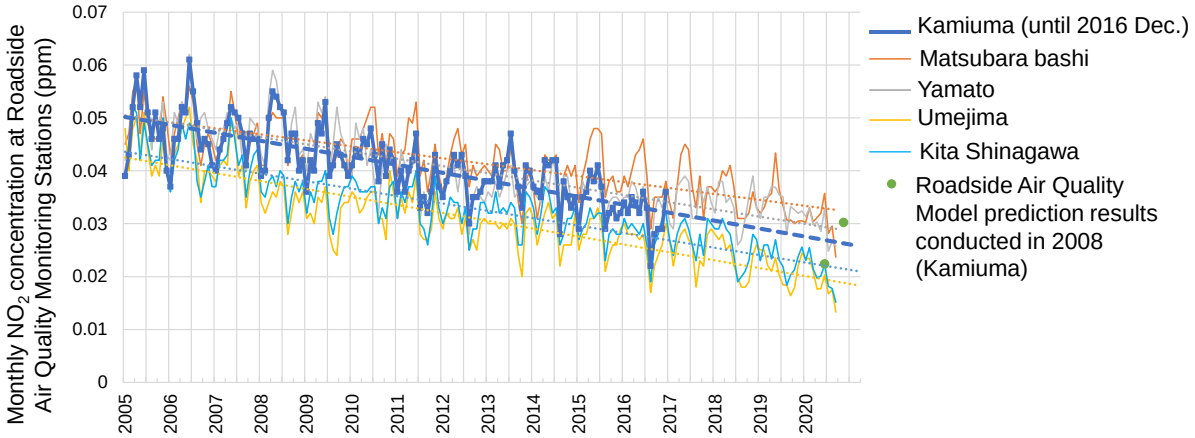


Figure S11-1. Changes in monthly average concentration of NO_2 at the five top Roadside Air Quality Monitoring Stations in Tokyo.

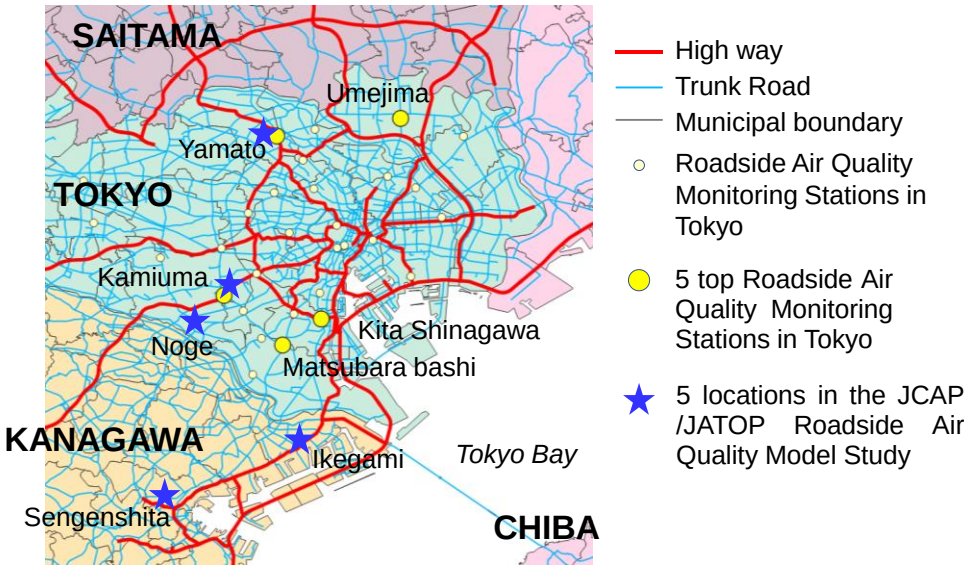
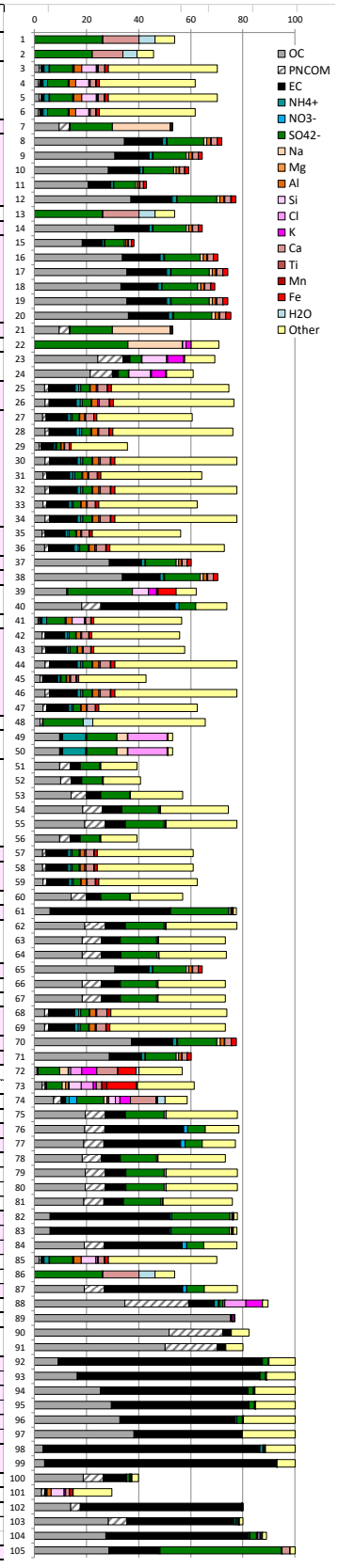


Figure S11-2. Locations of the five top Roadside Air Quality Monitoring Stations in Tokyo

S12. PM and VOC profile from anthropogenic emissions

Table S12-1 $PM_{2.5}$/TSP and $PM_{2.5}$ profile for CMAQ aero6.

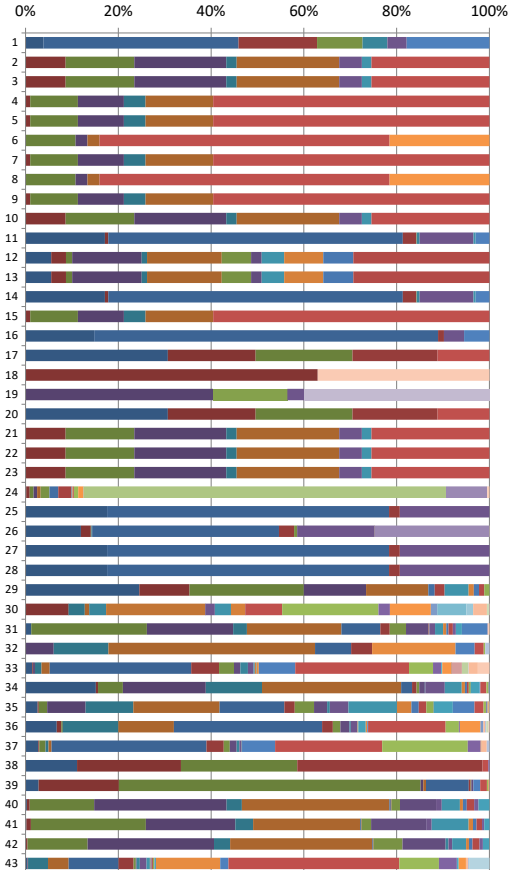
No.	Industry / Activity / Source	Fuel or Process	SPM/TSP	$PM_{2.5}$/TSP	Reference
1	Manufacturing Industry	Coke	0.72	0.54	speciate: Coke Calciner - Composite (ID: 91173) [S12-1]
2	Mining Industry	Coke	0.90	0.46	
3	Thermal Power Plant	Coal	0.86	0.70	speciate: Bituminous Combustion - Composite (ID: 91104) [S12-1]
4	Manufacturing Industry	Coal	0.83	0.62	
5	Mining Industry	Coal	0.94	0.70	
6	Construction Industry	Coal	0.83	0.62	
7	Municipal Solid Waste		0.80	0.50	PM2.5EI, Municipal Solid Waste [S12-2]
8	Thermal Power Plant	Heavy Oil	0.87	0.72	PM2.5EI, Heavy Oil A Grade [S12-2]
9	Manufacturing Industry	Heavy Oil, Grade B &C	0.83	0.64	
10	Mining Industry	Heavy Oil, Grade C	0.96	0.59	
11	Construction Industry	Heavy Oil, Grade C	0.93	0.43	
12	Fishing Industry	Heavy Oil, Grade C	0.95	0.77	
13	Manufacturing Industry	Oile Coke	0.72	0.54	speciate: Coke Calciner - Composite (ID: 91173) [S12-1]
14	Manufacturing Industry	Asphalt	0.83	0.64	PM2.5EI, Heavy Oil A Grade [S12-2]
15	Construction Industry	Heavy Oil, Grade A	0.89	0.38	PM2.5EI, Heavy Oil A Grade [S12-2]
16	Manufacturing Industry	Heavy Oil, Grade A	0.81	0.70	
17	Agriculture and Forestry	Heavy Oil, Grade A	0.94	0.74	
18	Mining Industry	Heavy Oil, Grade A	0.92	0.69	
19	Fishing Industry	Heavy Oil, Grade A	0.94	0.74	
20	District heating	Heavy Oil	0.95	0.75	
21	Industrial Waste		0.76	0.43	PM2.5EI, Municipal Solid Waste [S12-2]
22	Manufacturing Industry	Black Liquor	0.87	0.71	speciate: Pulp & Paper Mills - inventory speciation (ID: 91144) [S12-1]
23	Manufacturing Industry	Wood Scrap	0.86	0.69	speciate: Wood Fired Boiler - inventory speciation (ID: 91114) [S12-1]
24	Thermal Power Plant	Wood	0.81	0.61	
25	Manufacturing Industry	Blast Furnace Gas	0.89	0.75	PM2.5EI, City Gas [S12-2]
26	Thermal Power Plant	Blast Furnace Gas	0.90	0.77	
27	Manufacturing Industry	City Gas	0.81	0.61	PM2.5EI, City Gas [S12-2]
28	Thermal Power Plant	City Gas	0.89	0.76	
29	Construction Industry	City Gas	0.87	0.36	
30	District heating	City Gas	0.96	0.78	
31	Gasworks	City Gas	0.84	0.64	
32	Agriculture and Forestry	City Gas	0.89	0.78	
33	Mining Industry	City Gas	0.83	0.63	
34	Fishing Industry	City Gas	0.89	0.78	
35	Manufacturing Industry	Coke-oven Gas	0.77	0.56	PM2.5EI, City Gas [S12-2]
36	Thermal Power Plant	Coke-oven Gas	0.88	0.73	
37	Manufacturing Industry	Coal Tar	0.78	0.60	PM2.5EI, Heavy Oil A Grade [S12-2]
38	Thermal Power Plant	Crude Oil	0.87	0.70	PM2.5EI, Heavy Oil A Grade [S12-2]
39	Manufacturing Industry	Basic Oxygen Furnace Gas	0.81	0.62	speciate: Steel Production - Basic Oxygen Furnace (ID: 283033) [S12-1]
40	Thermal Power Plant	Basic Oxygen Furnace Gas	0.90	0.74	
41	Manufacturing Industry	Coal	0.78	0.57	speciate: Bituminous Combustion - Composite (ID: 91104) [S12-1]
42	Manufacturing Industry	LPG	0.77	0.56	PM2.5EI, City Gas [S12-2]
43	Thermal Power Plant	LPG	0.75	0.58	
44	Agriculture and Forestry	LPG	0.89	0.78	
45	Construction Industry	LPG	0.95	0.43	
46	Fishing Industry	LPG	0.89	0.78	
47	Mining Industry	LPG	0.83	0.63	
48	Manufacturing Industry	Refinery Gas	0.84	0.66	speciate: Petroleum Industry -Avg (ID: 91145) [S12-1]
49	Manufacturing Industry	Waste tire	0.61	0.40	speciate: Tire Burning (ID: 3283) [S12-1]
50	Waste Disposal	Industrial waste	0.61	0.40	
51	Agriculture and Forestry	Kerosene Oil	0.87	0.39	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
52	Construction Industry	Kerosene Oil	0.89	0.41	
53	Manufacturing Industry	Kerosene Oil	0.77	0.57	
54	District heating	Kerosene Oil	0.95	0.75	
55	Mining Industry	Kerosene Oil	0.94	0.78	
56	Fishing Industry	Kerosene Oil	0.87	0.39	
57	Manufacturing Industry	LNG	0.81	0.61	PM2.5EI, City Gas [S12-2]
58	Manufacturing Industry	Natural Gas	0.81	0.61	PM2.5EI, City Gas [S12-2]
59	Mining Industry	Natural Gas	0.83	0.63	
60	Manufacturing Industry	Jet Fuel	0.77	0.57	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
61	District heating	RDF	0.94	0.78	PM2.5EI, Municipal Solid Waste [S12-2]
62	Mining Industry	Light Oil	0.94	0.78	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
63	Thermal Power Plant	Light Oil	0.88	0.73	
64	Fishing Industry	Light Oil	0.92	0.74	
65	Manufacturing Industry	Lubricant Oil	0.83	0.64	PM2.5EI, Heavy Oil A Grade [S12-2]
66	Manufacturing Industry	Gasoline	0.86	0.73	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
67	Manufacturing Industry	Naphtha	0.86	0.73	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
68	Thermal Power Plant	NGL, Condensate	0.88	0.74	PM2.5EI, City Gas [S12-2]
69	Manufacturing Industry	NGL, Condensate	0.86	0.73	
70	District heating	Recycled Oil	0.96	0.78	PM2.5EI, Heavy Oil A Grade [S12-2]
71	Manufacturing Industry	Ultraheavy Oil, Paraffine Oil	0.78	0.60	PM2.5EI, Heavy Oil A Grade [S12-2]
72	Iron and Steel industry	Blast Furnace Steelmaker		0.57	speciate 91179, 91139, 91133, 91173 [S12-1]
73	Iron and Steel industry	Other maker		0.61	speciate 91157, 91123, 91153 [S12-1]
74	Cement Industry			0.58	specuate: Cement Production - Composite (ID: 91127) [S12-1]
75	Residential	Kerosene Oil	0.90	0.78	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
76	Residential	LPG	0.90	0.78	PM2.5EI, City Gas [S12-2]
77	Residential	City Gas	0.91	0.77	PM2.5EI, City Gas [S12-2]
78	Commercial/Institutional	Gasoline	0.86	0.73	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
79	Commercial/Institutional	Jet Fuel	0.90	0.78	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
80	Commercial/Institutional	Kerosene Oil	0.90	0.78	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
81	Commercial/Institutional	Light Oil	0.94	0.76	speciate: Distillate Oil Combustion - Composite (ID: 91115) [S12-1]
82	Commercial/Institutional	Heavy Oil, Grade A	0.85	0.78	PM2.5EI, Heavy Oil A Grade [S12-2]
83	Commercial/Institutional	Heavy Oil, Grade C	0.96	0.78	PM2.5EI, Heavy Oil A Grade [S12-2]
84	Commercial/Institutional	LPG	0.90	0.78	PM2.5EI, City Gas [S12-2]
85	Commercial/Institutional	Coal	0.94	0.70	speciate: Bituminous Combustion - Composite (ID: 91104) [S12-1]
86	Commercial/Institutional	Coke	0.72	0.54	speciate: Coke Calciner - Composite (ID: 91173) [S12-1]
87	Commercial/Institutional	City Gas	0.91	0.78	PM2.5EI, City Gas [S12-2]
88	Field Burning of Agricultural Residue		0.96	0.90	speciate: Agricultural Burning - Composite (ID: 91103) [S12-1]
89	Cigarette Smoke		1.00	0.77	speciate: Draft Cigarette Smoke - Composite (ID: 91006) [S12-1]
90	Cooking	Homemade		0.82	speciate: Potato Deep Frying - Composite (ID: 91175) [S12-1]
91	Cooking	Food Services & Drinking Places		0.80	
92	Diesel Vehicle	Passenger Car	1.00	1.00	JATOP [S12-3]
93	Diesel Vehicle	Van	1.00	1.00	JATOP [S12-3]
94	Diesel Vehicle	Bus	1.00	1.00	JATOP [S12-3]
95	Diesel Vehicle	Light Duty Truck	1.00	1.00	JATOP [S12-3]
96	Diesel Vehicle	Heavy Duty Truck	1.00	1.00	JATOP [S12-3]
97	Diesel Vehicle	Special Purpose Vehicle	1.00	1.00	JATOP [S12-3]
98	Gasoline Vehicle	Running	1.00	1.00	PM2.5EI, Gasoline Vehicle Exhaust Gas [S12-4]
99	Gasoline Vehicle	Starting	1.00	1.00	
100	Tire Ware		$PM_{2.5}$/SPM 0.4		speciate: Tire Dust - Composite (ID: 91150) [S12-1]
101	Road Dust		$PM_{2.5}$/SPM 0.2		speciate: Paved Road Dust - inventory speciation (ID91108) [S12-1]
102	Construction Machine	Diesel Engine	0.91	0.80	speciate: HDDV Exhaust - inventory speciation (ID: 91106) [S12-1]
103	Folk Lift & Agriculture Machine	Diesel Engine	0.91	0.80	speciate: LDDV Exhaust - inventory speciation (ID: 91162) [S12-1]
104	Air Plane		0.95	0.89	speciate: Aircraft Exhaust (ID: 3861) [S12-1]
105	Ship		1.00	1.00	Ocean Policy Research Foundation [S12-5]



The part colored in pink indicates based on measurement data unique to Japan.

Table S12-2 VOC profile from Combustion Sources expressed by SAPRC07 components.

NO	Fixed/Mobile Combustion Source, Fuel	Reference
1	Crude Oil	speciate: #9 [S12-1]
2	NGL	speciate: #3 [S12-1]
3	Naptha	speciate: #3 [S12-1]
4	Kerosene Oil	speciate: #2 [S12-1]
5	Light Oil	speciate: #2 [S12-1]
6	Heavy Oil, for Thermal Powe Plant	speciate: #1 [S12-1]
7	Heavy Oil for other than Thermal Power Plant	speciate: #2 [S12-1]
8	Heavy Oil Grade C	speciate: #1 [S12-1]
9	Ultraheavy Oil, Paraffine Oil	speciate: #2 [S12-1]
10	LPG	speciate: #3 [S12-1]
11	Oil Coke	speciate: #11 [S12-1]
12	Coal	speciate: #1178 [S12-1]
13	Coal	speciate: #1178 [S12-1]
14	Coke	speciate: #11 [S12-1]
15	Coal Tar	speciate: #2 [S12-1]
16	Coke-oven Gas	speciate: #5 [S12-1]
17	Blast Furnace Gas	speciate: #4 [S12-1]
18	Basic Oxygen Furnace Gas	speciate: #0016 [S12-1]
19	Electric Furnace	speciate: #0014 [S12-1]
20	Refinery Gas	speciate: #4 [S12-1]
21	Natural Gas	speciate: #3 [S12-1]
22	LNG	speciate: #3 [S12-1]
23	City Gas	speciate: #3 [S12-1]
24	Black Liquor	speciate: #8808 [S12-1]
25	Waste tire	speciate: #122 [S12-1]
26	Wood	speciate: #1084 [S12-1]
27	RDF	speciate: #122 [S12-1]
28	Waste Incinerator	speciate: #122 [S12-1]
29	Field Burning of Agricultural Residue	speciate: #5564 [S12-1]
30	Cigarette Smoke	Tokyo Met.Gov [S12-6]
31	Fork Lift & Agricultural Machine/Gasoline Engines	speciate: #4738 [S12-1]
32	Fork Lift & Agricultural Machine/Diesel Engines	speciate: #1201 [S12-1]
33	Air Plane	speciate: #1098 [S12-1]
34	Gasoline Vehicle/Running	JATOP [S12-3]
35	Gasoline Vehicle/Starting	JATOP [S12-3]
36	Diesel Vehicle/Running	JATOP [S12-3]
37	Diesel Vehicle/Starting	JATOP [S12-3]
38	LPG Vehicle/Running	JATOP [S12-3]
39	LPG Vehicle/Starting	JATOP [S12-3]
40	Gasoline Vehicle/Hot Soak Loss	JATOP [S12-3]
41	Gasoline Vehicle/Diurnal Breathing Loss	JATOP [S12-3]
42	Gasoline Vehicle/Running Loss	JATOP [S12-3]
43	Ship	JATOP [S12-3]



☐ The part colored in pink indicates based on measurement data unique to Japan.

SAPRC07 Components

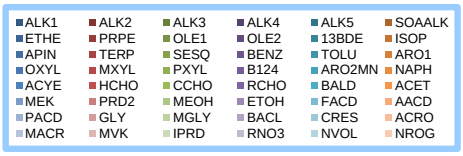
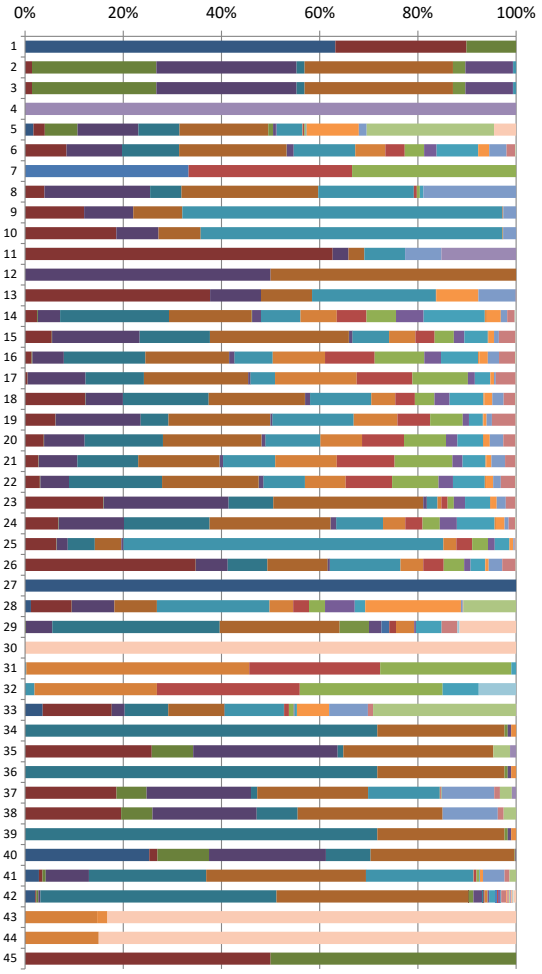


Table S12-3 VOC profile from Evaporative Sources expressed by SAPRC07 components.

NO	Evaporative Emission Sources	Reference
1	Natural Gas Production	MOEJ [S12-7]
2	Crude Oil Refining	MOEJ [S12-7]
3	Fuel Evaporative Emission, Petroleum Products	MOEJ [S12-7]
4	Food Manufacturing Process (Fermentation)	MOEJ [S12-7]
5	Chemical Production	MOEJ [S12-7]
6	Paint Production	MOEJ [S12-7]
7	Fishing Net Antifoulant	MOEJ [S12-7]
8	Converting Solvent	MOEJ [S12-7]
9	PSAs* & Releasing Agents, for Papers	MOEJ [S12-7]
10	PSAs* & Releasing Agents, for Plastics	MOEJ [S12-7]
11	Adhesive for Laminate	MOEJ [S12-7]
12	Dampening Water	MOEJ [S12-7]
13	Coating Solvent	MOEJ [S12-7]
14	Paint/Building	MOEJ [S12-7]
15	Paint/Building Material	MOEJ [S12-7]
16	Paint/Structure	MOEJ [S12-7]
17	Paint/Ship Building	MOEJ [S12-7]
18	Paint/New Vehicle	MOEJ [S12-7]
19	Paint/Automobile Repair	MOEJ [S12-7]
20	Paint/Electrical Machine	MOEJ [S12-7]
21	Paint/Machine	MOEJ [S12-7]
22	Paint/Metalware	MOEJ [S12-7]
23	Paint/Woodwork	MOEJ [S12-7]
24	Paint/for Domestic Use	MOEJ [S12-7]
25	Paint/Pavement-marking	MOEJ [S12-7]
26	Paint/Others	MOEJ [S12-7]
27	Paint Stripping Solvent	MOEJ [S12-7]
28	Cleaning Thinner	MOEJ [S12-7]
29	Asphalts	MOEJ [S12-7]
30	Fumigant	MOEJ [S12-7]
31	Agricultural Chemicals	MOEJ [S12-7]
32	Pesticide Chemicals	MOEJ [S12-7]
33	Adhesive (except Laminate)	MOEJ [S12-7]
34	Print/Lithographic Printing Ink	MOEJ [S12-7]
35	Print/Resin Letterpress Printing	MOEJ [S12-7]
36	Print/Metal Printing Ink	MOEJ [S12-7]
37	Print/Gravure Ink	MOEJ [S12-7]
38	Print/Other Ink	MOEJ [S12-7]
39	Print/News Paper Ink	MOEJ [S12-7]
40	Industrial Detergent/Cleaner	MOEJ [S12-7]
41	Rubber Solvent	MOEJ [S12-7]
42	Dry-cleaning Solvent	MOEJ [S12-7]
43	Moth Crystals	PRTR [S12-8]
44	Air Refresher	PRTR [S12-8]
45	Aerosol Spray	JATOP [S12-3]
	*PSAs: Pressure-sensitive Adhesive	



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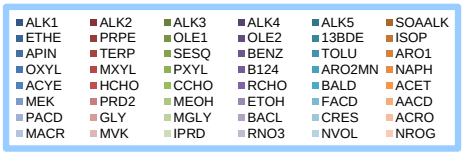
SAPRC07 Components



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