



Reduction of pollutant concentrations within the urban canopy and indoor environment

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Back ground & objective

Oxidants including ozone (O_3) are a major component of photochemical smog. The oxidants environmental quality standard value at air pollution monitoring stations (APMS) in Japan is under 0.06ppm, but the achievement ratio is exceptionally low, 0.26% in 2012 as shown in Fig. 1.

Outdoor O_3 concentrations can be reduced during transport processes within the urban canopy and within the indoor environment by surface removal and reactions between O_3 and other chemicals in the air, example nitrogen oxide (NO_x). When we investigate air pollution and damage to human health, it is useful to evaluate the relationship between outdoor and indoor pollutant concentrations and the degree to which pollutant concentrations are reduced during transport.

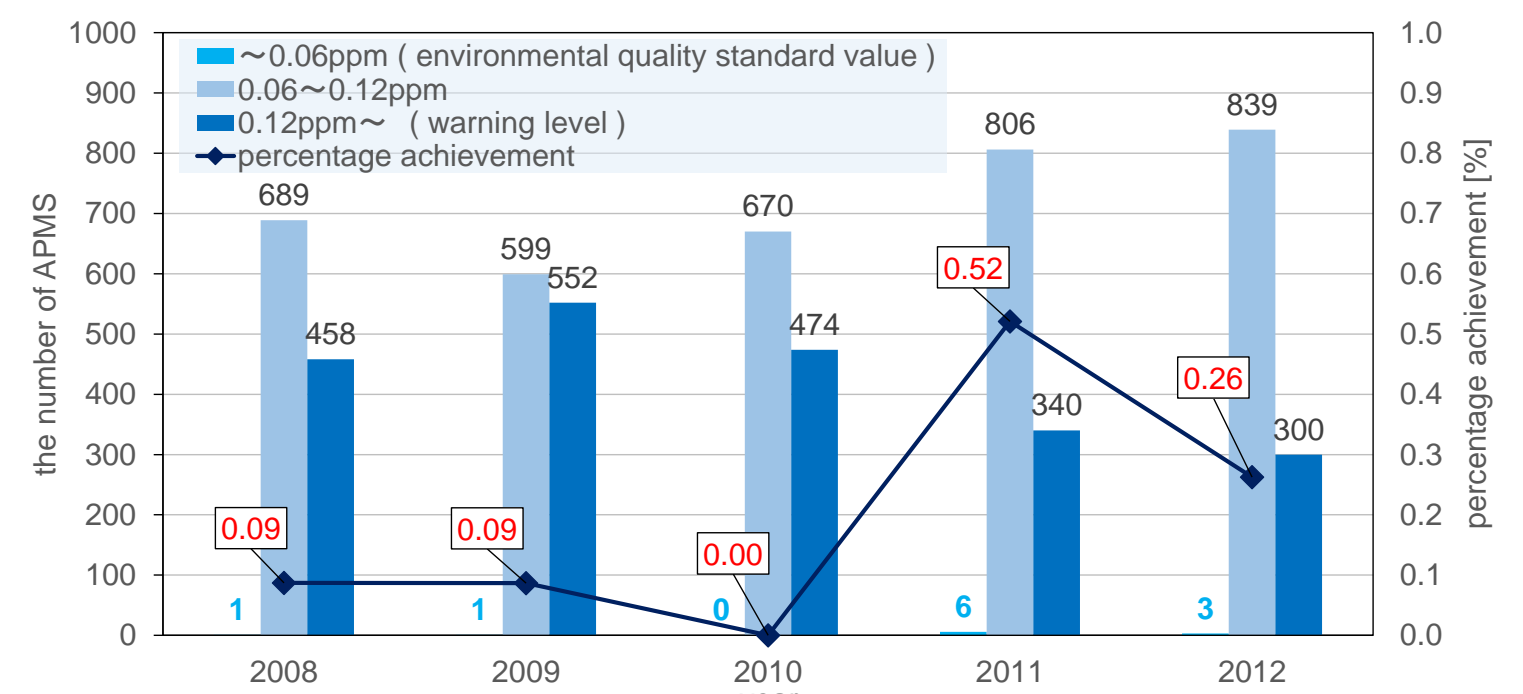
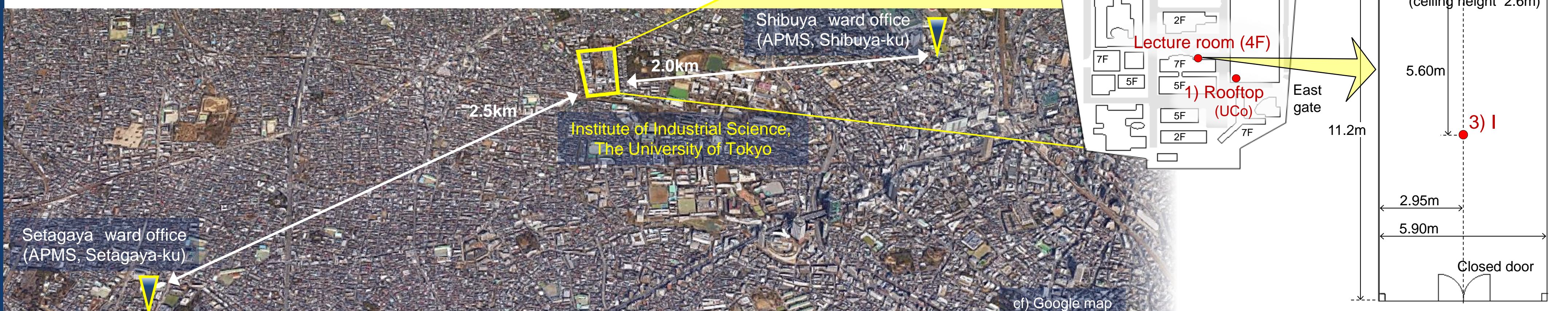


Fig. 1 Achievement ratio of the oxidants environmental quality standard value at APMS in Japan

Measurement

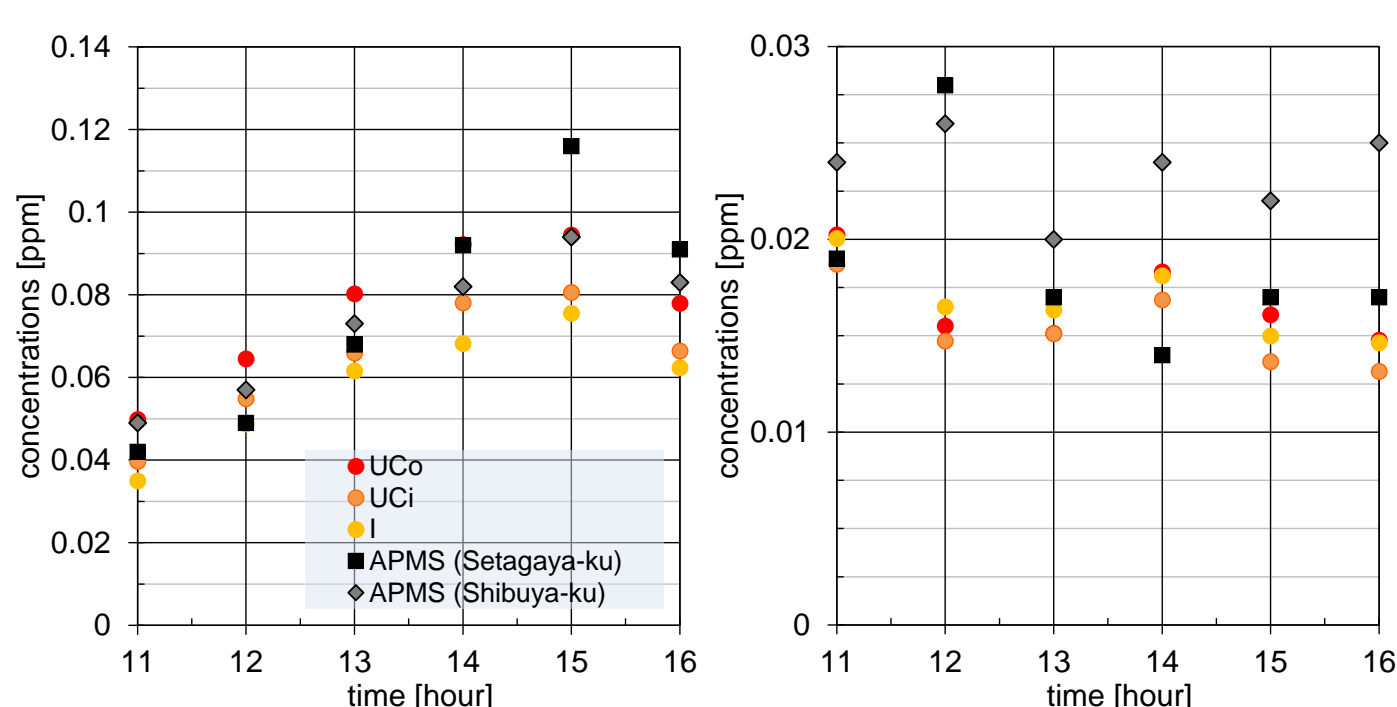
We carried out measurements of O_3 and NO_x concentrations at 3 points shown below simultaneously.

- Period : 5 days starting on July 7, 2014
- Measurement points : 3 points at our university campus in Tokyo
 - 1) On a building rooftop, assumed outside the urban canopy (UCo)
 - 2) Outside of the window at the lecture room, assumed inside the urban canopy (UCi)
 - 3) The center of the lecture room, assumed represent values in the indoor environment (I)
- Method : O_3 — non-dispersive ultraviolet absorption method
 NO_x (= NO_2 + NO) — chemiluminescence method

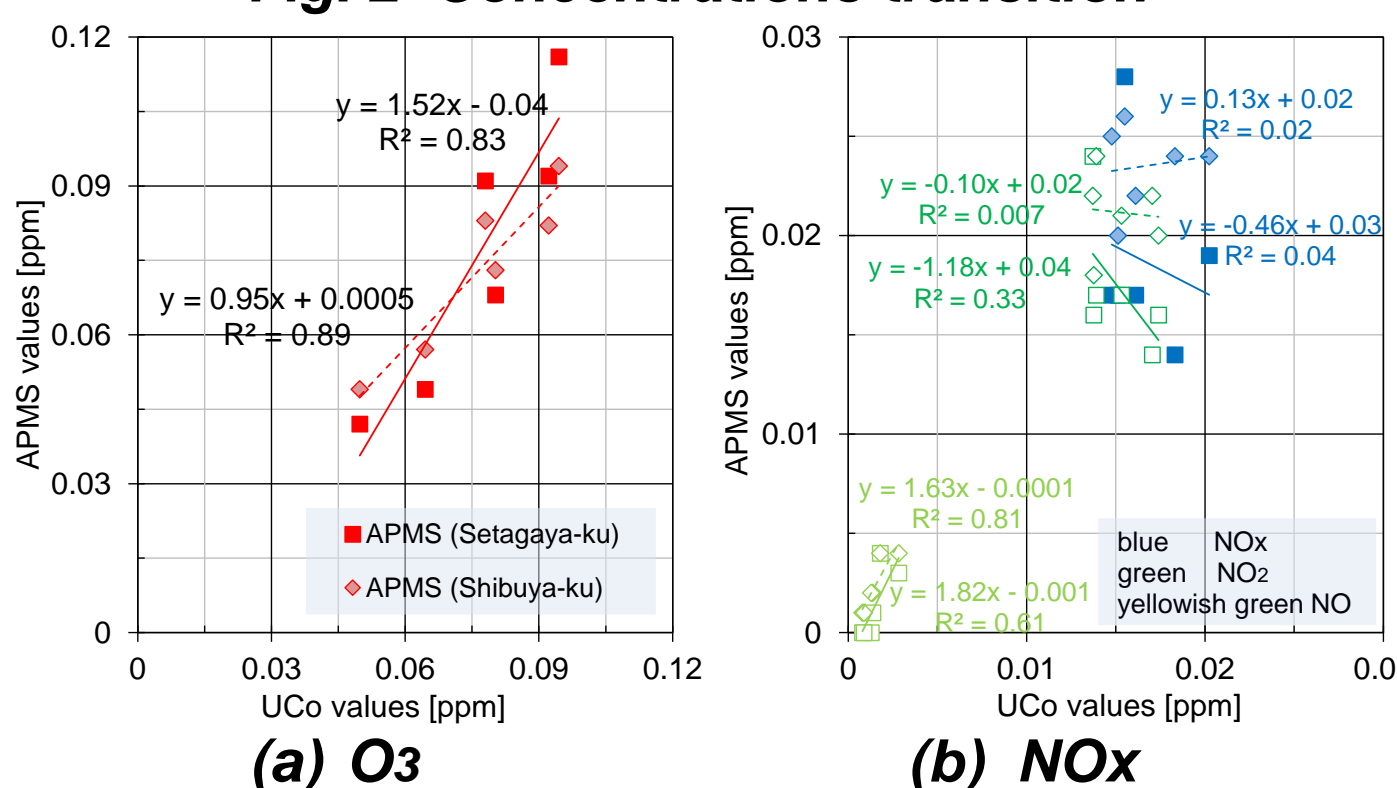


The local representativeness of a measured value at APMS

We compared measurements at 3 points with that at APMS on July 8, in order to investigate the local representativeness of the values at APMS.



(a) O_3 (b) NO_x
Fig. 2 Concentrations transition



(a) O_3 (b) NO_x
Fig. 3 Correlation between UCo and APMS values

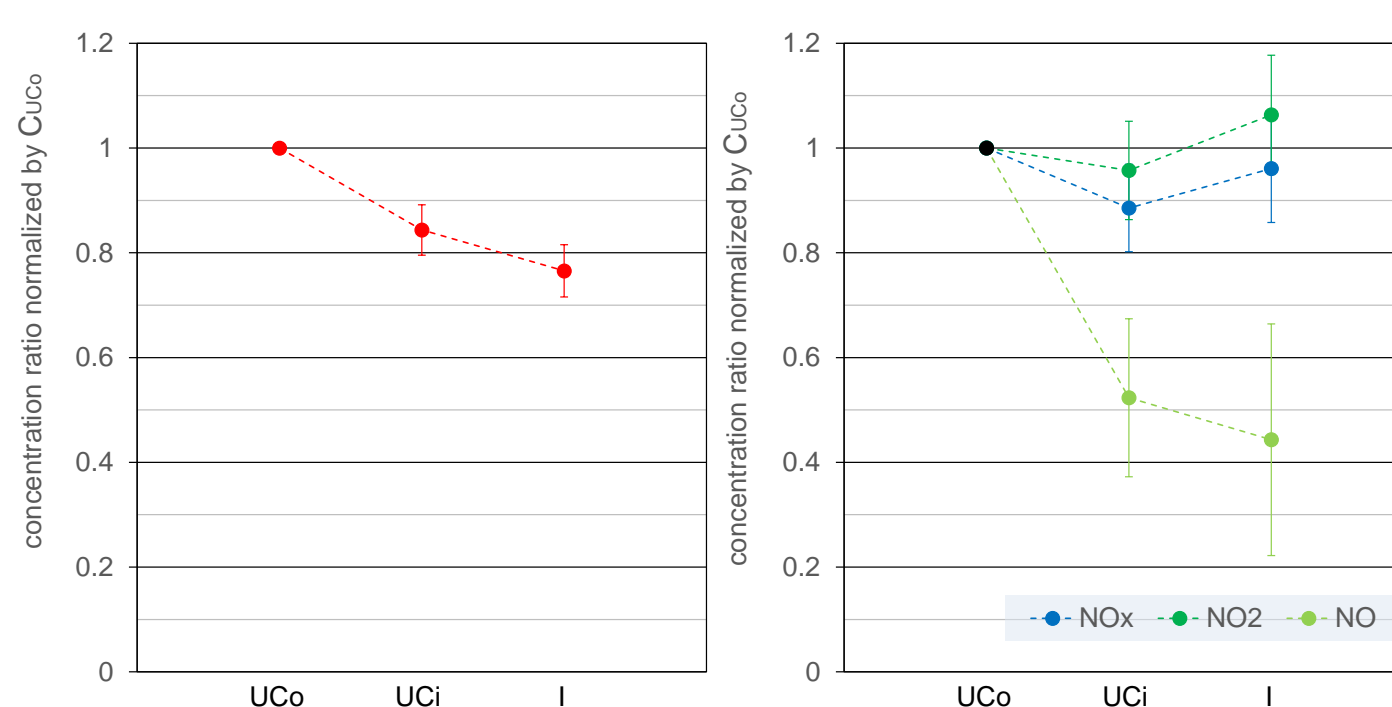
- ◆ The measured values at all points were above 0.06ppm, which value is the environmental quality standard value, in the daytime.
- ◆ The result about O_3 was a correlation between the values at UCo and APMS, but there was no correlation seen in the result about NO_x .
- ◆ There is a possibility that NO_x concentrations measured at APMS may not have representativeness of that area's environment.

Conclusion

- ◆ NO_x concentrations measured at air pollution monitoring stations may not have representativeness of that area's environment.
- ◆ O_3 concentrations were reduced during transport processes within the urban canopy and the indoor environment.

Variations of concentrations within the urban canopy

We calculated the ratio of concentrations outside and inside the urban canopy, as well as an indoor/outdoor (I/O) ratio, from the results of July 8.



(a) O_3 (b) NO_x
Fig. 4 Variations of concentrations within the urban canopy and the indoor environment

Table. 1 Concentrations ratio of measured values at 3 points

	C_{UCi} / C_{UCo}^*	C_i / C_{UCi}	C_i / C_{UCo}^{**}
O_3	0.84	0.91	0.77
NO_x	0.89	1.09	0.96
NO_2	0.96	1.11	1.06
NO	0.52	0.85	0.44

* the ratio of concentrations outside and inside the urban canopy

** the general I/O ratio

- ◆ The O_3 concentrations were reduced during transport processes within the urban canopy and within the indoor environment.
- ◆ However the NO_x concentrations were not reduced, the NO concentrations were reduced remarkably.
- ◆ It can be estimated that the chemical reaction from NO to NO_2 was promoted and one of factors of the reaction was O_3 .

Variations of concentrations within the urban canopy

On the last day of July 11, we opened and closed the window in the lecture room in order to analyze the reductive processes for O_3 and NO_x concentrations in the indoor environment (I). We also calculated the ventilation rate, which is considered to significantly affect the indoor environment, from the concentration variations at the time the window was opened.

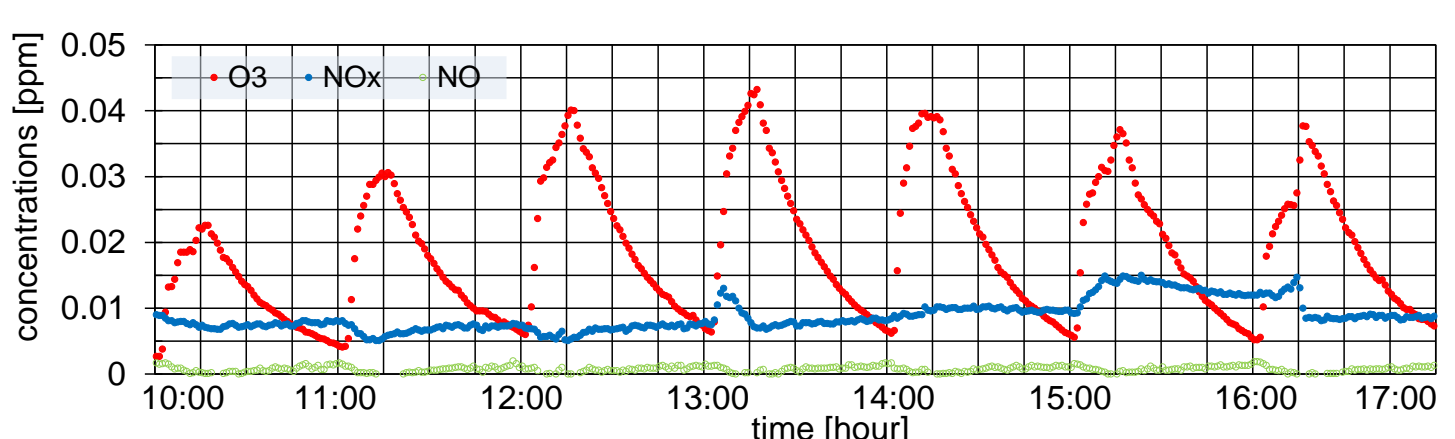


Fig. 5 Concentrations transition when opening/closing windows

Table. 2 Time constant (T) and ventilation rate

Trial frequency	Closing windows		Opening windows		Wind velocity (m/s)
	T^{***} (min)	$1/T \times 60$ (- / hour)	ventilation rate (- / hour)	ventilation rate (- / hour)	
1	26.3	2.28	6.60	3.82	
2	27.8	2.16	7.26	3.74	
3	25.0	2.40	5.40	3.42	
4	23.3	2.58	5.34	4.14	
5	23.3	2.58	7.32	5.06	
6	23.3	2.58	5.43	5.45	
7	25.0	2.40	6.36	4.37	

*** Time to take before concentrations become $1/e$ (natural logarithm) after closing windows

- ◆ The average of T was 24.9 minutes. The degree of reduction may be affected by not chemical reactions but surface removal.
- ◆ C_i / C_{UCo} ratio calculated from the ventilation rate when opening windows was about 0.72. The value was roughly equivalent to that from measurements.

- ◆ The indoor concentrations were above 0.06ppm when windows were opened as well as outdoor values.
- ◆ Closing windows, indoor values were reduced rapidly by surface removal.
- ◆ When we investigate damage to human health closely, selection and control of appropriate ventilation system needs to be examined.