6.6 DATA ANALYSIS ON "COOL SPOT" EFFECT OF GREEN CANOPY IN URBAN AREAS

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1. INTRODUCTION

In large cities such as Osaka, which are located in the southwest part of Japan, the urban heat island prevents peoples from deep sleeping in summer without using an air conditioner. Today measures to decrease it are hoped in these cities. It is well known that the air temperature under the large green canopy in a park is lower than the surrounding urban areas where buildings are concentrated. (e.g. Maruta,1972) This is because the trees shade the ground from solar radiation and the evaporation from leaves keeps the surface temperature of leaves lower. We called the space where the surface and the air temperature are lower than the surroundings "Cool Spot". One of the effective measures to decrease the local air temperature will be covering an area with many Cool Spots. The aim of this study is to investigate the relation between the cool spot effect and the size of cool spot, wind speed, ground surface temperature and eddy diffusivity.

2. METHODS OF MEASUREMENTS

Some sets of meteorological elements of air temperature, ground surface temperature and the others were measured in and around urban three green canopies in Osaka for four days in August 1992. The instruments used here are shown in table 2. The green areas are two parks and one green area beside a street. (Fig.1) The size of three cool spots is between tens to hundreds meters. (Table 1) The relation of the temperature difference between inside and outside of the cool spot, and variables of the length of cool spot, wind speed, the ground surface temperature and eddy diffusivity were examined. The wind speed over the cool spots and solar radiation are the data observed at the Osaka Meteorological Office.

3. MEASURED TEMPERATURE AND METEOROLOGICAL DATA

Measured temperature and meteorological data are shown in Table 3. The Us is the wind speed in cool spots at 1 meter in height, Uh is the wind speed at 15m in height that is over the cool spot. The Kz is the estimated eddy diffusivity using the OMG dispersion model.(Kono and Ito,1990) The Kz is the value over the cool spot and buildings. The ΔTs is the difference of the ground surface temperature between inside and outside of a cool spot. The ΔT is the difference of the air temperature too. Temperature and surface temperature were measured at several points and the averaged values of them were used for the analysis. The t is the travel time of air mass in the cool spot. It is simply defined that t =L1/2/Us where L1 is the length of a shorter side of a cool spot.

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TABLE 1 SIZE OF COOL SPOTS WHERE TEMPERATURE WAS MEASURED

Location		Area (L1 m×L2 m)	Height of Trees*(m)
A	Park	550×915	11
B	Park	175×375	15
C	Green area beside a street	60×150	12-15

*The trees in A, B and C are zelkova.

TABLE 2 INSTRUMENTS

Air temperature/ humidity	Assmann ventilated psychrometer	At height 1m above ground
Wind speed	Cup anemometer	At height 1m above ground
Surface temperature	Infrared thermometer	Average of several points

FIG.1 COOL SPOT (LOCATION C)

4. DATA ANALYSIS

We made simple 2-D models to explain the temperature difference ΔT between inside and outside of cool spot as a function of travel time ‘ t’ in a cool spot, the surface temperature difference ΔTs and eddy diffusivity in the vertical direction, Kz. The first assumption is that ΔT is proportional to the travel time t、because the temperature of air mass which enters into a cool spot will become lower in contact with the ground surface and tree leaves. The second assumption is that ΔT will be proportional to the surface temperature difference ΔTs. The relation between ΔT and diffusion is difficult to predict. When Kz increases, the ventilation of the cool spot will increase, however, at the same time in the cool spot, the heat flux from air to the ground will increase too. Thus following three models are used for analyzing the data:

(1) $\Delta T \propto \Delta Ts*t / Kz$

(2) $\Delta T \propto \Delta Ts*t / Us$

(3) $\Delta T \propto \Delta Ts*t * Kz$

5. RESULT AND CONCLUSION

The results are shown in Table 4. It shows that ΔT is strongly depend on the travel time ‘t’ in the cool spot and proportional to it. The range of travel time is between several tens to 1000 s.
The equation (1) explains the data best.

REFERENCES

Kono,H. S.Ito,1990, A micro-scale dispersion model for motor vehicle exhaust gas in urban area-OMG volume-source dispersion model Atmospheric Environment 24B, 2, 243-251.

Maruta, Y., 1972, The various Studies on Urban Climatology have Demonstrated the Following Finding., City Planning Review, 69/70,49-77.

TABLE3 TEMPERATURE AND METEOROLOGICAL DATA

Run	1	2	3	4	5	6	7	8
Date	Aug.17		Aug.20	Aug.21		Aug..22		Aug.23
Time	14-16	18-19	13-15	5-6	13-14	5-6	13-15	13-14
Location	B	B	A / B	A / B	A / B	A / B	A	C
Weather	Fair	Fair	Cloudy	Cloudy	Fair	Fair	Fair	Fair
Insolation (W/m^2)	641	72	186	0	683	0	688	602
Us(m/s)	0.6	0.8	0.5	0.3	1.1/ 0.6	0.3	1.0	1.2
Uh(m/s)	6.2	4.7	2.5	0.6	2.1	0.5	2.0	1.1
Kz(m^2/s)	1.7	1.3	0.66	0.33	1.6	0.31	1.5	0.87
ΔTs(℃)	17.6	7.3	5.2 / 5.8	2.1 / 1.3	16.9 /13.2	2.1/ 3.4	12.6	15.6
t(s)	290	220	1100 / 350	1830/590	500 / 290	1830 / 590	550	50
ΔT(℃)	**1.2**	**1.0**	**1.6 / 1.8**	**2.3 / 1.1**	**1.1 / 1.1**	**2.5 / 2.0**	**0.9**	**0.4**

TABLE 4 CORRELATIONS BETWEEN VARIABLES

	ΔTs	L1	1/Us	t	Kz	1/Kz	ΔTs*t /Kz	ΔTs*t /Us	ΔTs*t*Kz	ΔT
ΔTs	1.00									
L1	-0.17	1.00								
1/Us	-0.85	0.11	1.00							
t	-0.62	0.73	0.67	1.00						
Kz	0.88	-0.07	-0.82	-0.59	1.00					
1/Kz	-0.85	0.13	0.94	0.67	-0.93	1.00				
ΔTs*t / Kz	-0.52	0.78	0.60	0.96	-0.52	0.60	1.00			
ΔTs*t /Us	-0.25	0.78	0.42	0.84	-0.19	0.32	0.91	1.00		
ΔTs*t*Kz	-0.46	0.79	0.49	0.97	-0.46	0.51	0.96	0.86	1.00	
ΔT	**-0.69**	**0.44**	**0.79**	**0.82**	**-0.64**	**0.72**	**0.84**	**0.74**	**0.73**	1.00