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1. INTRODUCTION

The summer climate in Osaka city is very hot and humid, and probably the severest thermal environment of summer night in Japan. On the whole, the factors affecting to urban night air temperature are 1) the factors caused by urbanization and 2) meteorological factors.

1) the two major factors caused by urbanization are considered as the following.

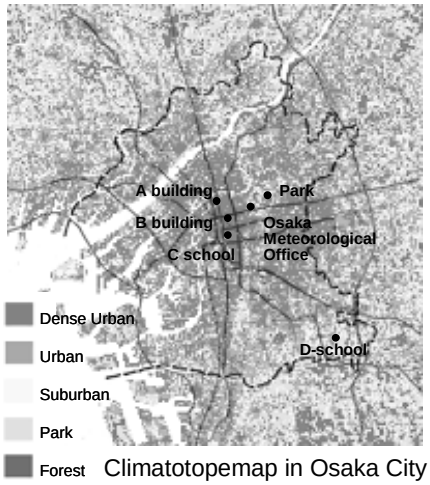
i) The increase of heat storage in earth surface materials because of land cover alterations (green covers to pavements, buildings and so on). It's effect depends on the weather condition, such as "fine" or "cloudy".

ii) The artificial heat released. It depends on the urban activities such as cars and buildings.2) Meteorological factors

i) In Osaka area, the strong sea breeze in daytime prevents air temperature rise and the weak land breeze in nighttime enhances the effects of urbanization.

ii) The cloudiness in the night prevents a radiative cooling.

The purpose of the investigation is to evaluate quantitatively the main causes on the high air temperature of a summer night. The urban effects are analyzed using the observed data through the comparison of air temperature variation 1) between the places in the urban center, in the large park and in the suburban area, and 2) between weekdays and holidays.



Location

1) A- and B- building: on the roof of office building, 32m high above ground level, measured as the typical air temperature variation of urban center

2) Park: in a flower garden in Osaka Castle Park (about 350m apart from surrounding roads)

3) Osaka meteorological office

4) an elementary school C: located at south part in the urban center

4) D-school: elementary school , 9km apart from urban center as the typical air temperature variation of suburban area

FIG. 1 LOCATION OF OBSERVATION POINTS

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2. OBSERVATION METHOD

The observation points of air temperature is shown in FIG. 1. The air temperature is all measured at 1.5m high above the ground using the wooden ventilated boxes from August 1999. The four points of city center are i) on the roof of two different office buildings (A and B). The elementary school (C) is located in the representative amusement area in Osaka city. Osaka meteorological office is located at south-wast side of Osaka castle park apart from 300m. 2) The point of a park is located in Osaka castle park. This park is the largest park in Osaka city near the central district. 3) the point of suburban area is the elementary school (D) where is about 9km west apart from city center.

3. COMPARISON OF PERIOD MEAN TEMPERATURE

Table 1 shows the observation results of August mean. As a whole, the effect depending on the places, was large at minimum temperature and small at maximum temperature. The minimum air temperature in urban center is 2-3 deg higher than in "park". However the maximum temperature in "park" is about 1.0 deg higher than in urban center. It was unexpected. The following reasons is presumed as the cause of this phenomenon. Osaka area has the sea in west direction. In daytime, it has the strong sea breeze all over the area. However the observation point in the park is located at the eastside of Osaka castle building, which is located on the hill. So the observation point in the park is in the shadow of sea breeze. On the other hand, the air temperature of the point in the city center might be lower in daytime because of the roughness effect by the tall buildings.

TABLE 1 COMPARISON OF PERIOD MEAN AIR TEMPERATURE

	August 3～31, 1999			August 1～31, 2000		
	Mean	Max	Min	Mean	Max	Min
Park (Tp)	28.6	33.8	24.6	29.1	35.2	24.8
Met. Office (Ts)	29.1	32.9	25.9	29.6	34.0	26.6
Ts-Tp	0.5	-0.9	1.3	0.5	-1.2	1.8
A-Building (Ta)	29.5	32.9	22.6	29.8	34.1	27.0
Ta-Tp	0.9	-0.9	2.0	0.7	-1.1	2.3
B-Building (Tb)	29.6	33.5	26.4	30.2	35.4	26.9
Tb-Tp	1.0	-0.3	1.8	1.1	0.2	2.2
C-School (Tc)	29.7	32.8	27.1	30.3	34.0	27.7
Tc-Tp	1.1	-1.0	2.5	1.2	-1.2	3.0
D-School (Td)	29.1	33.8	25.4	29.9	35.5	25.7
d-Tp(Suburban)	0.5	0.0	0.8	0.7	0.3	1.0

4. INFLUENCES ON WEATHER

The cloudiness data at the meteorological office was used for the distinction between fine and cloudy weather. Fine: cloudiness <0.8, cloudy: cloudiness >0.8, where, the daytime data of cloudiness were used 9, 12, 15,18h, the nighttime data were 21, 3, 6h.

FIG. 2 shows the diurnal variation of air temperature classified by the 4 weather patterns selected from the data of August, 1999. This F-C means that the daytime is fine and the nighttime is cloudy. There are 4 patterns. In daytime: Around the maximum, air temperature is almost same value. Further more, it seems that the effects of artificial heat released and the building cooling connecting with the thermal characteristics of building materials and cold air flow from inside of buildings is very complicated. The separating these effects from the heat storage effect of pavement surfaces may be impossible now for us.

In nighttime: The air temperature in “urban” is 2-3 degree higher than in “park”.

5. COMPARISON BETWEEN WEEKDAY AND HOLIDAY

FIG. 3 shows the comparison between weekdays and holidays. The air temperature variation of weekday and holiday cannot simply compare because of different days. The irregular variations in the evening of urban air temperature were appeared. This seems the effect of artificial heat from the condenser of cooling equipments and cars so on. There are a lot of night restaurants in the area as well as office buildings. This temperature variation is almost not appeared in the park data and holiday data of “urban” center. FIG. 4 shows on an average the comparison between weekday and holiday. Only the fine to fine weather case for three days was used for the comparison. The variation pattern of the air temperature difference from mean values for the three days is presented because of the different days data. The diurnal variations of the global solar radiation, the wind velocity and the cloudiness, which were observed by the Osaka Meteorological Office were examined for the comparison of different days. They had almost same tendency and values. Consequently, it was concluded that the comparison on the diurnal variation of mean values between weekdays and holidays is allowed.

In FIG. 4, the temperature gradient of holiday evening is larger than weekday. It seems also caused by artificial heat released; building cooling equipments and cars. However it appeared also in the pattern of park. The park is also influenced by the urban activities of weekday, local influence of traffic roads and overall influences of uban activities.

6. CONCLUSIONS

The diurnal air temperature variations were compared with the different places in Osaka area, and compared between weekday and holiday. The temperature difference in summer night between weekday and holiday was smaller than the temperature difference between at the city center and at the park. It seems that the main causes of the difference in summer night air temperature between at the city center and at the park are the heat storage of solar radiation on the pavements, rather than the artficial heat released.

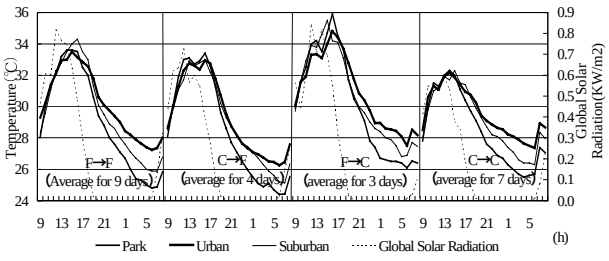

FIG. 2 HOURLY MEAN TEMPERATURE ACCORDING TO WEATER TYPE (August 3-31, 1999)

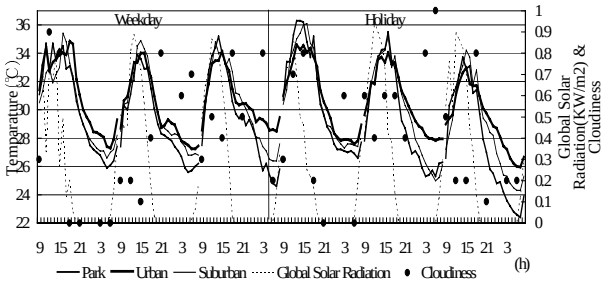

FIG. 3 COMPARISON BETWEEN WEEKDAY AND HOLIDAY (Weather type: F-F)

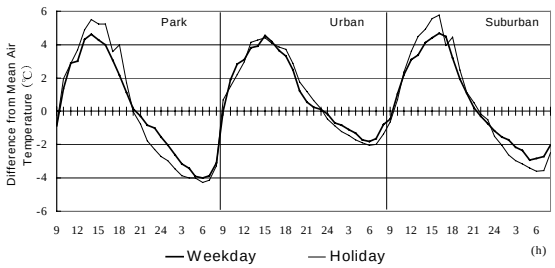

FIG. 4 COMPARISON BETWEEN WEEKDAY AND HOLIDAY (hourly mean value of three days, represented by the difference from daily mean air temperature)