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A NEW URBAN HEAT ISLAND MONITORING SYSTEM IN TOKYO

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Abstract

A new urban heat island monitoring system "METROS"(Metropolitan Environmental Temperature and Rainfall Observation System), which is composed of 20 high-powered real-time meteorological data acquisition stations and 100 automated temperature/humidity data loggers, have been established in Tokyo since July, 2002. The detailed temporal and spatial patterns of urban heat islands in Tokyo were clarified based on METROS for the first time. The results will also contribute to the verification of local-scale numerical simulations in the heat island phenomena in Tokyo.

Key words: urban heat island, meteorological observation, Tokyo

1. INTRODUCTION

Annual mean temperatures in central Tokyo have increased 3 degrees Celsius for the last 100 years, which is around five times as fast as that of global warming. Also a comparison of annual mean temperature trend of Tokyo with that of New York shows continuous warming of Tokyo since 1950's (Figure 1).

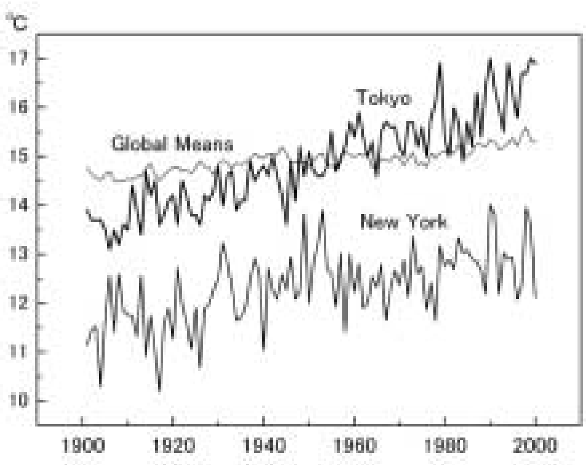

Figure 1. Annual mean temperatures for the last millennium
(Global mean temperature during 1961-90 is assumed to be 15 degrees)

In summer, although daily minimum temperatures might be highest in central Tokyo as a typical heat island pattern, daily maximum temperatures often appears in the northwestern residential area of Tokyo metropolis where only 4 AMeDAS (Automated Meteorological Data Acquisition System) stations are settled by JMA (Japan Meteorological Agency). In order to clarify both temporal and spatial variations of urban heat islands in Tokyo, we settled a new urban heat island monitoring system called METROS in Tokyo metropolitan area since July 2002 with the financial support of Tokyo Metropolitan Government. Although In 1997-1999, we made same kind of meteorological monitoring in Tokyo metropolis (Mikami et al., 2000), only temperature data were acquired and analyzed. Here we show some results of acquired data analysis in the last summer season.

2. METEOROLOGICAL MONITORING SYSTEM

The METROS is composed of 120 automated meteorological observation stations as shown in Figure 2. One is 20 high-powered real time data acquisition stations which observe temperature, humidity, wind direction/velocity,

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precipitation and air pressure with the interval of 10 minutes. As the main purpose of this system is to capture the prevailing wind fields above urban canopy layers which would affect daily maximum temperature patterns in Tokyo metropolis, meteorological equipments are settled on the rooftop of buildings. The other is 100 automated temperature/humidity data logging system which are settled in the screen shelter of primary schools and get data in every ten minutes.

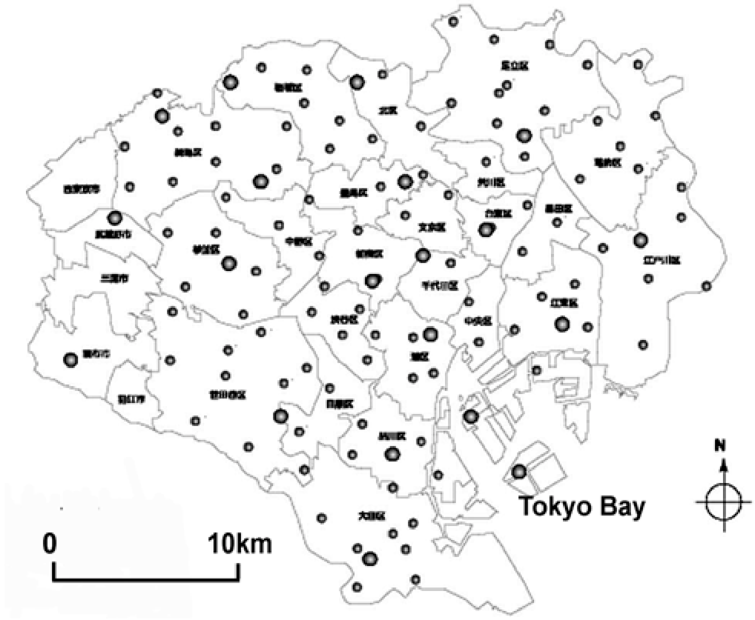

Figure 2. Location of 120 METROS stations
(Large circles show 20 high-powered stations)

3. TEMPERATURE PATTERNS IN TOKYO

3.1. Maximum and minimum temperature patterns

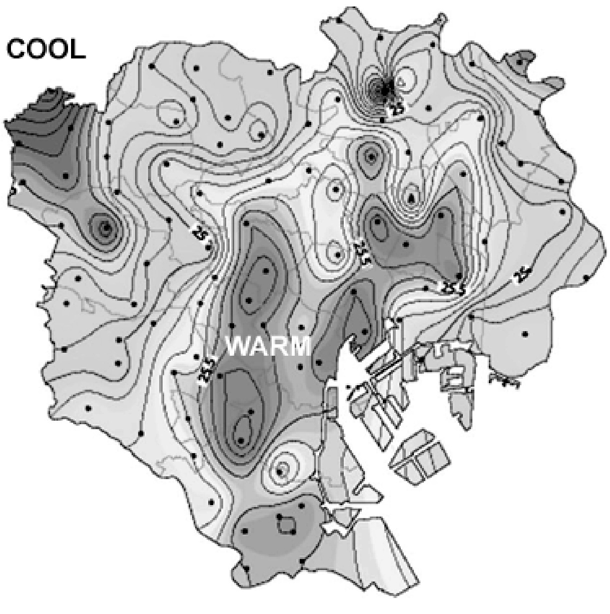

Figure 3. Daily minimum temperature patterns in Tokyo (July 20 – August 31, 2002)

Figure 3 shows daily mean minimum temperature patterns in Tokyo metropolis (23 Wards) during July 20 – August 31, 2002. Isothermal map describes detailed heat island structure in Tokyo. The warmest area of more than 25.5 degrees appears in central Tokyo separately, whereas cooler area can be seen in the northwest.

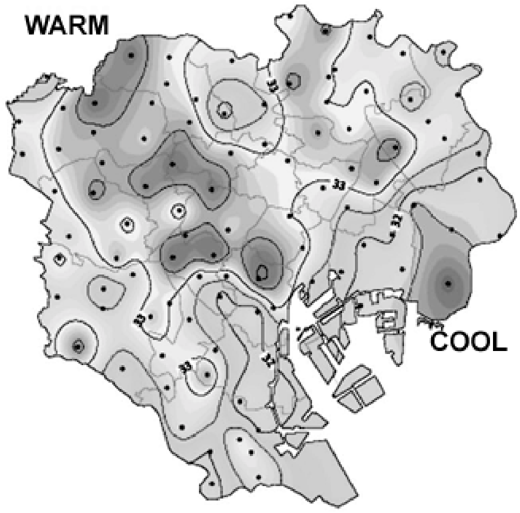

Figure 4. Daily mean maximum temperature Patterns in Tokyo (July 20 – August 31, 2002)

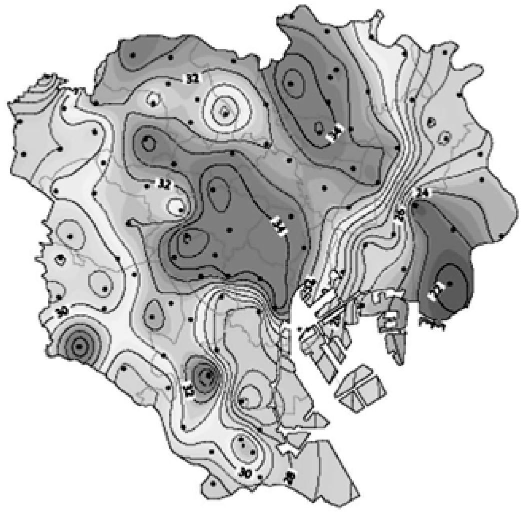

Figure 5. Ratio (%) of daily mean maximum temperature exceeding 30 degrees (July 20 – August 31, 2002)

In the afternoon of typical summer days, southeastern coastal area becomes cool affected by the sea breeze blowing from Tokyo Bay as shown in Figure 4. By contrast, northwest of Tokyo where the mean daily minimum temperature is the lowest forms warmest area extending from south east. However, the ratio of daily mean maximum temperatures exceeding 30 degrees (Figure 5) shows somewhat different spatial patterns from daily mean maximum temperatures. As indicated in Figure 5, the area in central Tokyo where the ratio is exceeding 34 % (more than 8 hours) is overlapped with high minimum temperature area shown in Figure 3.

3.2. Principal component analysis

In order to clarify the spatial and temporal variation in temperature patterns, we applied a principal component analysis to the temperature anomalies from 100 METROS temperature averages during the period from July 20 to August 31, 2002.

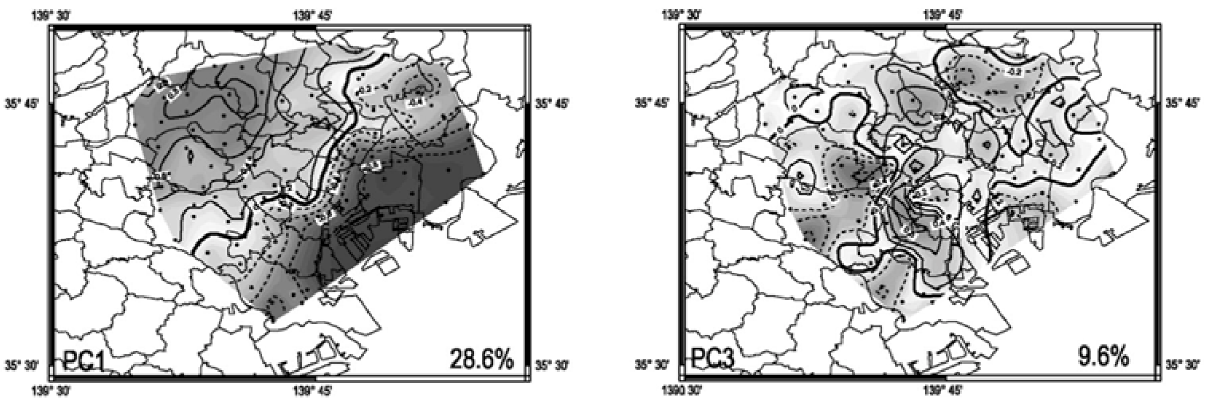

Figure 6. Factor loadings of Principal Component s (PC 1: left panel and PC 3: right panel)

The spatial pattern of Principal Components Figure 6) and their time variations (Figure 7) were examined. The Principal Component 1 shows reverse signs in the northwest and the southeast coastal area with a clear diurnal cycle of negative values from midnight to early morning and positive values in the afternoon (Figure 7). The contrast between northwest and southeast corresponds to the daily maximum and minimum temperature patterns as pointed out in the previous section. On the other hand, Principal Component 3 shows rather complicated patterns with positive area extending from the southwest bayside toward northwest. As the time series of PC 3 shows negative signs from morning to afternoon, it might be connected to the prevailing sea breeze from Tokyo Bay.

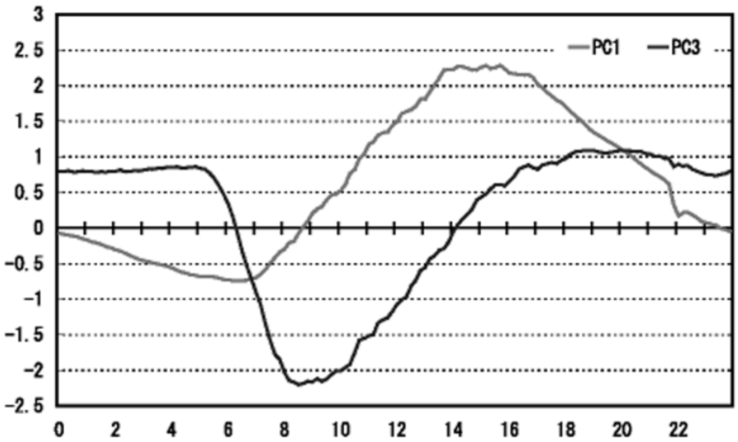

Figure 7. Time series of Principal Component 1 and 3

4. CONCLUSION

Temporal and spatial variations in the urban heat islands of Tokyo have been clarified using the 120 data taken from METROS stations in Tokyo. Daily mean maximum and minimum temperatures show different spatial patterns during summer season. During the night, warmest area appears in central Tokyo separately, whereas the warmer area stands in northwest to central Tokyo. Comparison with the prevailing wind system will bring dynamic climatological explanations for urban heat island structures in Tokyo.

References

Mikami,T., Kannari, A., Yamazoe, Y., Suzuki, C., Kimura, K. and Kubo, S., 2000, Investigation of urban heat island in Tokyo Metropolis based on the ground monitoring system, *WMO/TD*, **1026**, 194-495.