Urban Cool Island in Daytime
―Analysis by Using Thermal Image and Air Temperature Measurements―

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Abstract

We found that an urban heat island appeared clearly on night In Okayama City. The heat island intensity (i.e., the temperature difference between urban and rural areas) was 3.0-4.0 degree C. during the summer. Especially, the heat island appears clearly for 2100-2400 JST. On the other hand, during the daytime, the air temperature of urban central area was 1.0-2.0 degree C. lower than that of residential areas. This phenomenon can be considered as the “urban cool island”. At the same time, the urban surface temperature was lower than the residential surface temperature. The horizontal scale was 2-3km.

Key words: Urban Heat Island, Urban Cool Island, Surface Temperature,

1. Introduction

In recent years, the urban heat island becomes an object of public concern. Its feature changes greatly with the urban scale and structure. Urban heat island phenomena, which are known as high temperature occurrences in the central part of city, would be estimated to become in a large city (e.g.,Robert, 1968). A large number of investigations have been theoretically and observationally given on the problems of urban heat island. We constructed the weather observation network in Okayama City, Japan. Therefore, the comparison among our observation results helps to clarify the mechanism of urban climate.

2. Meteorological observations

We constructed an observation network in Okayama City (700,000 people), Japan (Fig.1). The observation network data were obtained during the following period: the surface temperature measurements by the helicopter on Aug.5 and 7; air temperature (2.0m) from Jul.30-Sep.10 in 2008. The Air temperature and sky view factor (Fig. 2) are measured in the 60 observation points.

3. Methods

The values measured temperature sensors were corrected an error. Temperature value was accurate to ±0.2℃. Temperatures were averaged to 20 min. The heat island intensity and cool island intensity ($\Delta T_{u\text{-}r}$) is defined as urban-rural maximum temperature difference as shown by as follows: (Oke, 1973).

$$\Delta T_{u\text{-}r} = T_u - T_r \qquad (1)$$

T_u explain the maximum temperature in urban area. T_r explain the maximum temperature in rural area. Our study uses the difference between mean temperature of the inside points, A-C (X-Z), and the outside points, a-c (x-y). In this paper, Japanese Standard Time (JST) is used unless otherwise noted.

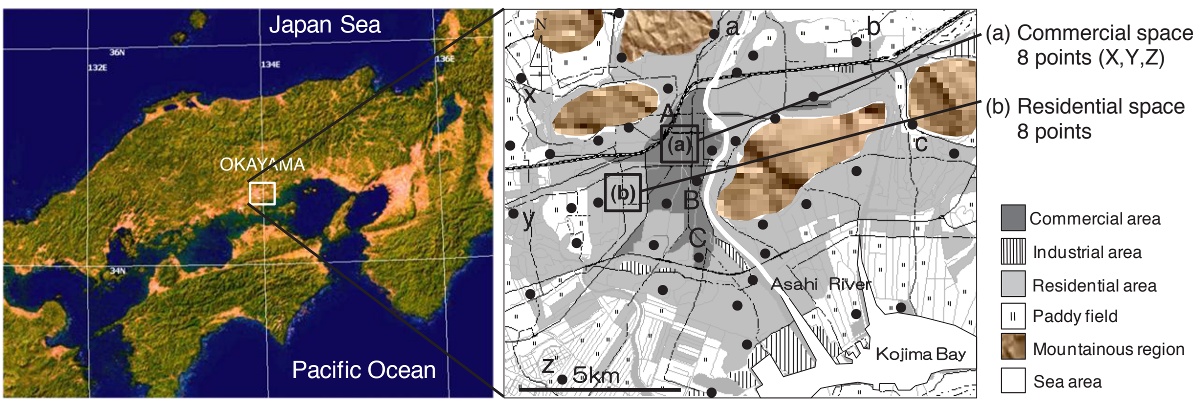

Fig. 1 Map showing the locations of the observation points in Okayama City, Japan ●: observation points. Urban area points (A-C) and rural area points (a-c) are used for the estimation of the heat island intensity. Urban area points (X-Z) and rural area points (x-z) are used for the estimation of the cool island intensity.

4. Results

4.1. Typical temperature distribution and Temporal change of heat island intensity

Figure 2(a) shows temporal change of heat island intensity. The heat island intensity of Okayama City indicate tendency to be large from 1800 to 0600 JST and to be small from 0900 to 1500. Especially, a heat island clearly appears about 3.0-4.0 degree C. for 2200-0100 JST (Fig.3a). The heat island intensity of Okayama City is significantly small in the daytime, while that clearly appeared clearly in nighttime.

4.2. Typical temperature distribution and Temporal change of cool island intensity

Figure 2(b) shows temporal change of cool island intensity. The cool island intensity of Okayama City indicate tendency to be large from 0800 to 1800 JST and to be small from 2100 to 0600. Especially, a cool island clearly appears about 1.0-2.0 degree C. for 1000-1200 JST (Fig.3b). The cool island intensity of Okayama City is significantly small in the nighttime, while that clearly appeared clearly in daytime. In the daytime, the urban temperature was often lower than the rural temperature in Okayama City (i.e., the urban cool island).

4.3. Temporal change of temperature in commercial and residential space

We constructed an observation network in commercial and residential space (Fig.1). The Air temperature and sky view factor (Fig. 4a,b) are measured in the 8 observation points. Figure 5 shows temporal variation of the spatially averaged (a) air temperature, (b) standard deviation, from observations at the sites.

The Standard deviation of commercial space indicate tendency to be large from 1000 to 0800 JST and to be small from 2100 to 0600.

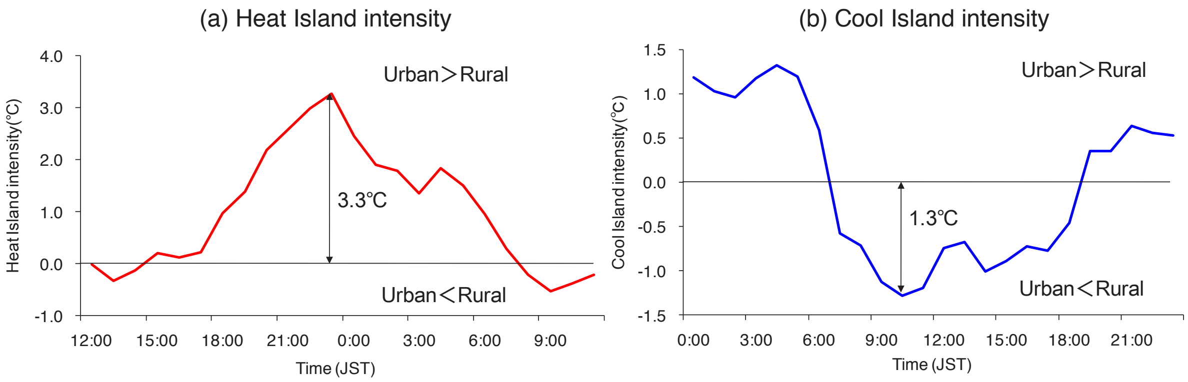

Fig. 2 Temporal change of (a) heat island intensity, Aug.13-14 , (b) cool island intensity, Aug.11.

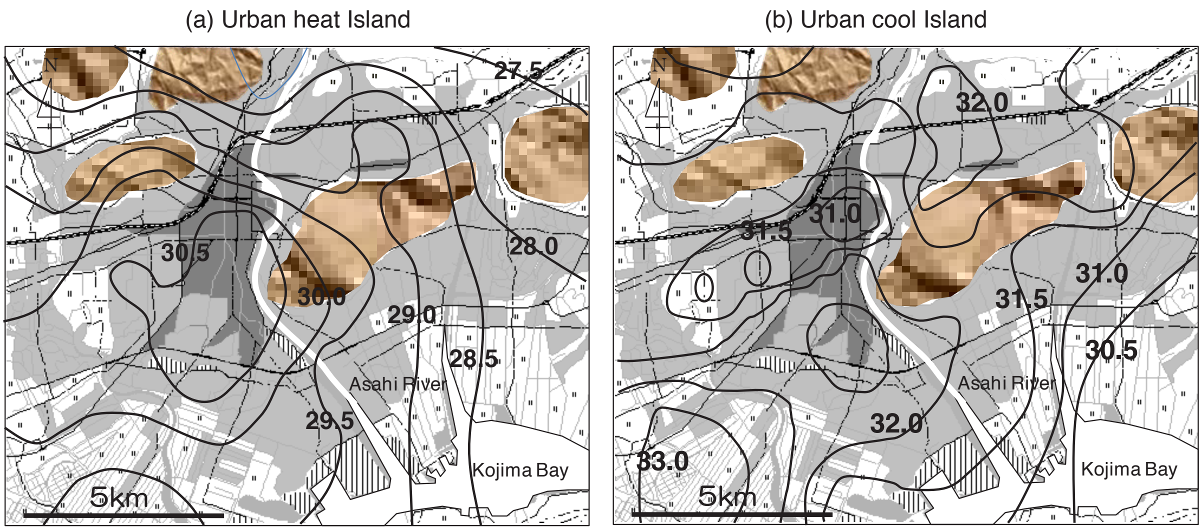

Fig. 3 Temperature distribution. (a) Urban heat island in nighttime, 2300 JST, Aug. 13 , (b) Urban cool island in daytime, 1000 JST, Aug. 11. Numerals indicate air temperature (℃).

Fig. 4 Map of the observation points in (a) commercial and (b) residential spaces
○: observation points. Numerals indicate sky view factor.

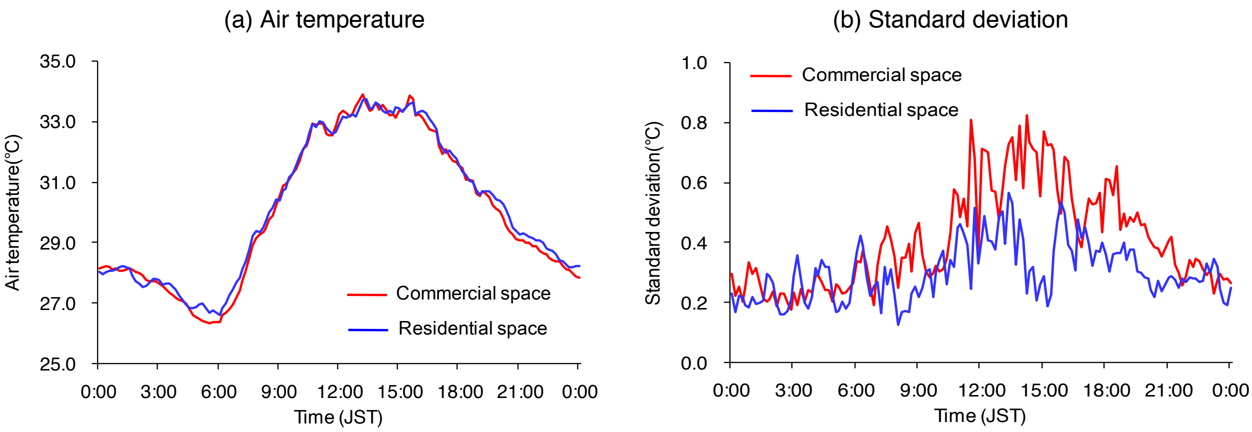

Fig. 5 Temporal variation of the spatially averaged (a) air temperature, (b) standard deviation, from observations at the sites.

4.4. Relationship between sky view factor and air temperature in commercial and residential space

The spatial distribution of the mean minimum air temperature well corresponds to that of the sky view factor. The sky view factor was small in the inside of all commercial space, and become to be large in residential. Scatter diagram of the minimum, maximum and mean air temperature to the sky view factor is shown in Figure 6, 7.

The minimum air temperature the negative high correlation appears in commercial space (r=-0.69). On the other hand, residential space has not a negative high correlation (r=-0.02) at the minimum air temperature. The commercial and residential space has not a negative high correlation (r=-0.11, r=-0.09) at the maximum air temperature.

4.5. Relationship between surface temperature and air temperature

The urban surface temperature was lower than the residential surface temperature. We are analyze the relationship between surface temperature and air temperature in Okayama City now.

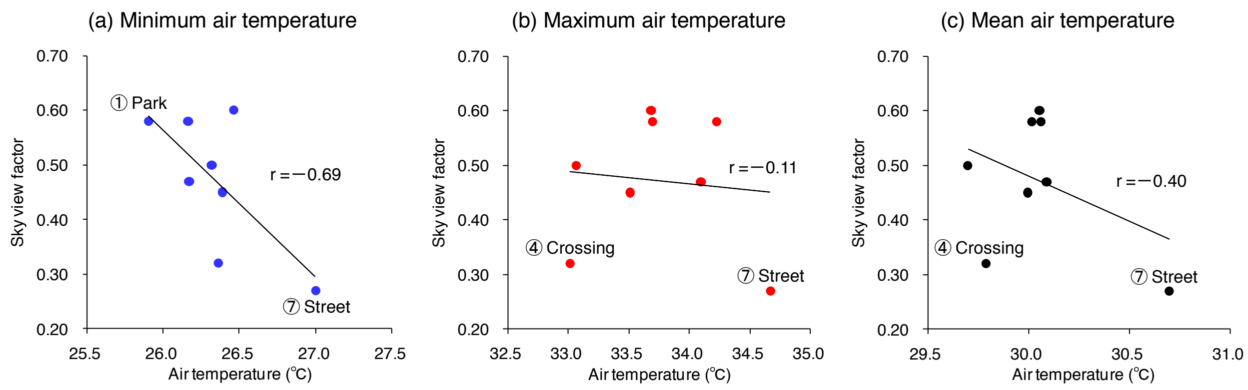

Fig. 6 Scatter diagrams of the sky-view factor and the (a) minimum air temperature, (b) maximum air temperature, (c) mean air temperature, in commercial space. The value of symbol r represents the correlation coefficient.

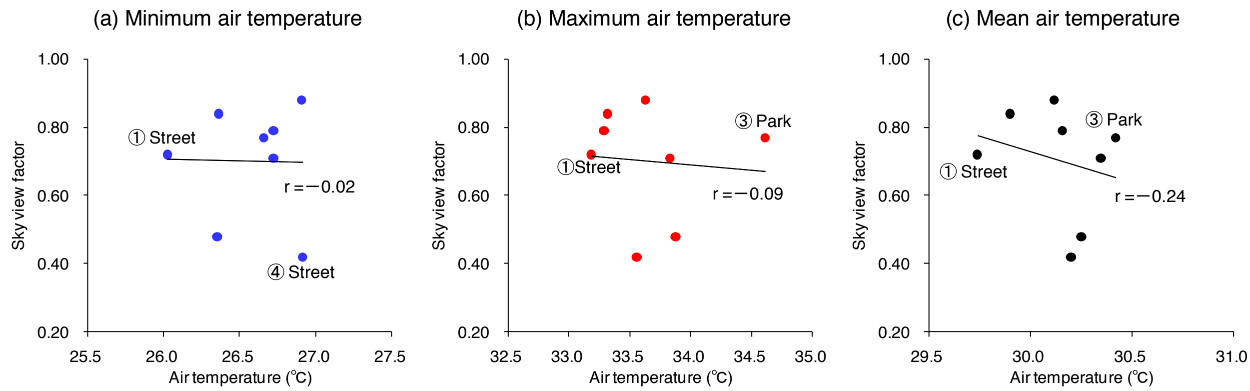

Fig. 7 Scatter diagrams of the sky-view factor and the (a) minimum air temperature, (b) maximum air temperature, (c) mean air temperature, in residential space. The value of symbol r represents the correlation coefficient.

5. Conclusions

We constructed an observation network in Okayama City (700,000 people), Japan. We found that an urban heat island appeared clearly on nighttime In Okayama City. The heat island intensity (i.e., the temperature difference between urban and rural areas) was 3.0-4.0 degree C. during the summer. Especially, the heat island appears clearly for 2200-0100 JST.

On the other hand, during the daytime, the air temperature of urban central area was 1.0-2.0 degree C. lower than that of rural areas. This phenomenon can be considered as the “urban cool island”. At the same time, the urban surface temperature was lower than the residential surface temperature. The horizontal scale was 2-3km.

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