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Quantitaive Estimation of Surface Temperature Changes in the Tsukuba Science City

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1. Introduction

A lot of works have been done to investigate urbanization effects on surface temperature. Most common approach to this problem is to make temperature measurement in and around urbanized cities on some particular days or during some periods of a year. This method is, however, quite difficult in those cities which lie on geographically uneven land. Most populated areas in Japan develop on coast or at foot of a mountain so that the quantitative estimation of urban effects on temperature is hard. Another hindrance to the study is land use circumstances; obscure boundaries of urbanized area. The Tsukuba Science City (TSC) is one of the examples of the latter case.

The study of urban effects of the TSC was made for the first time by Yoshino et al. (1976) just after the completion of its construction. Although they intended to investigate unban effects due to anthropogenic alteration of surface condition, no quantitative discussion could be made. A description of the climate of the TSC was shown by Kawamura (1984). No mention was, however, made of quantitative estimation of surface temperature changes. In this report climatic temperature data obtained in and just outside of the TSC were used to investigate the temperature difference between urban and rural areas. Since the temperature measurement obtained outside of the TSC was made only for non-meteorological purpose, those data are presented to the meteorologist's eyes for the first time.

2. Descriptions of temperature observation sites

The Tsukuba Science City, about 15km by 2km stretch of institute sites, was constructed in the northern part of the Kanto plains, where about 50 institutes except one (Aerological Observatory, Tateno) were removed to from other part of Japan.

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The construction plan was announced by the cabinet in 1963. At the time forest and arable land were spread in the area of Tsukuba with small villages here and there. The official construction works done by the government started in October, 1968, and ended in March, 1980. It was June 1970 when the business of the TSC began for the first time by one of the institutes.

Aerological Observatory of the JMA, which is in the center of the TSC at present, has been operating its business for almost seventy years at Tateno. Formerly the site of the observatory was called as an isolated-island-on-land in the Kanto plains. After the completion of the new city constrution many institutes were constructed around it;within one kilometer Meteorological Research Institute of the JMA (184:number of personnel as for 1981), nine institutes of the Agency of Industrial Science and Technology (2244) and a high School:within two kilometers the National Institute for Environmental Studies (203) and four other institutes:

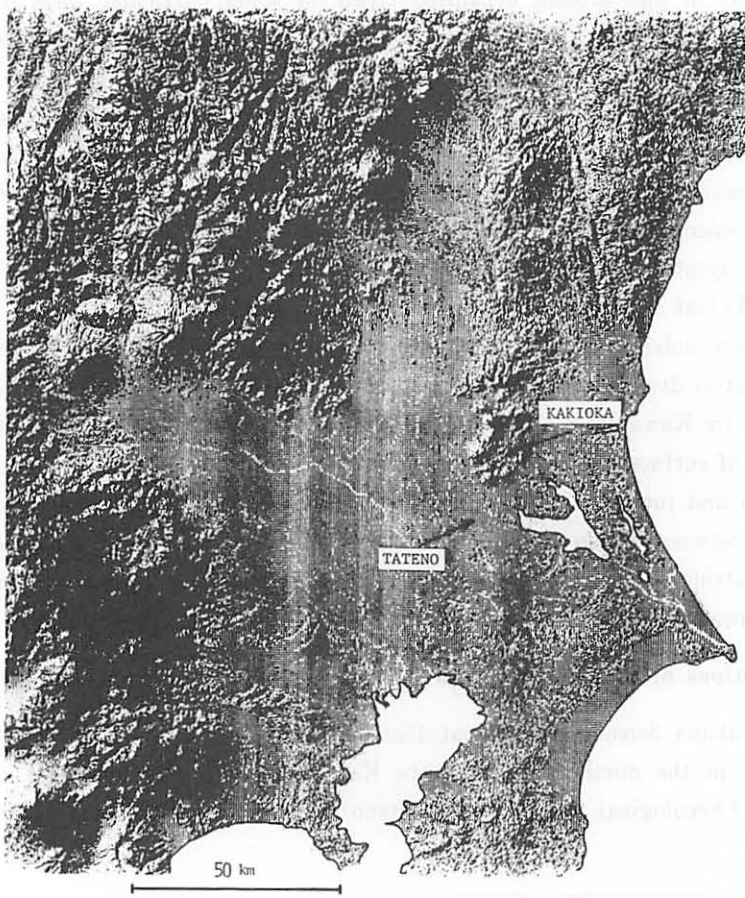

Fig. 1 : Temperature observation sites on a topograhic view of the Kanto plains. (by courtesy of the Geographical Survey Institute of Japan)

the University of Tsukuba 5 km north of the observatory. Temperature observation made at the Aerological Observatory provides us with climatological data of the TSC before and after its construction.

Another climatological data for about eighty years up to the present time areobtained at the Magnetic Observatory which is in a small village, Kakioka, 20km northeast of Tateno. This village is in a basin with diameter of 10km surrounded by mountains and is completely left behind urbanization. Although temperature observation at the Magnetic Observatory was made only for the temperature correction of magnetometers, it provides us with climatological temperature data for the present study. Laying an electric railroad, constrution of ferroconcrete buildings and big civil engineering works in vicinity of the Magnetic Observatory are prohibited or limited. Owing to this rule population of the village has not increased for these several scores years.

3. Results

Trends of monthly average maximum and minimum temperature differences between Tateno and Kakioka is shown in Fig 2. Before 1970 and after 1975 the monthly average values don't indicate any tendency of increase nor decrease except distinct seasonal change. During the period from 1970 to 1975 a tendency of increase or decrease is clealy shown;decrease in maximum temperature difference and increase

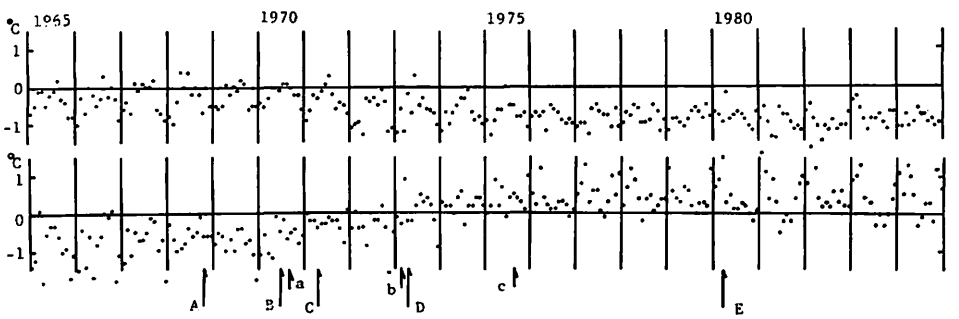

Fig. 2 : Trends of monthly average maximum (above) and minimum (below) temperature differences between Tateno and Kakioka (shown in Tateno minus Kakioka).
Shift of observation site at Tateno and Kakioka.
a : 35m at Kakioka b : 60m at Tateno c : 170m at Tateno
Commencement of the business of individual institute.
A National Institute for Reserach in Inorganic Materials (169, 1km)
B University of Tsukuba (−, 5 km)
C Meteorological Research Institute (184, 1km)
D Eight institutes of the Agency of Industrial Science and Technology (2224, 1km)
E National Research Insitute for Metals (70, 2km)
Numbers in parenthesis indicate the number of staff in 1981 and distance from Tateno.

in minimum temperature difference. Since this period corresponds to that of construction works of the TSC, it is considered that the temperature changes are due to urbanization of Tateno.

Fig 3 shows mean monthly average maximum and minimum temperature difference between the two observation sites for the periods before urbanization (1926−1970) and after urbanization (1975−1984). It is shown that before the construction of the TSC monthly average minimum temperature at Tateno was lower by 0.5～1.2℃ than at Kakioka and monthly average maximum temperature much the same between the two sites. This situation markedly changed after the construction of the TSC. Monthly average maximum and minimum temperature changes due to the construction of the TSC are shown in Table 1. These are derived from the difference between monthly average values for the two periods shown in Fig 3; increase in monthly average minimum temperature by about 2 ℃ in winter and by about 0.6℃ in summer: decrease in monthly average maximum

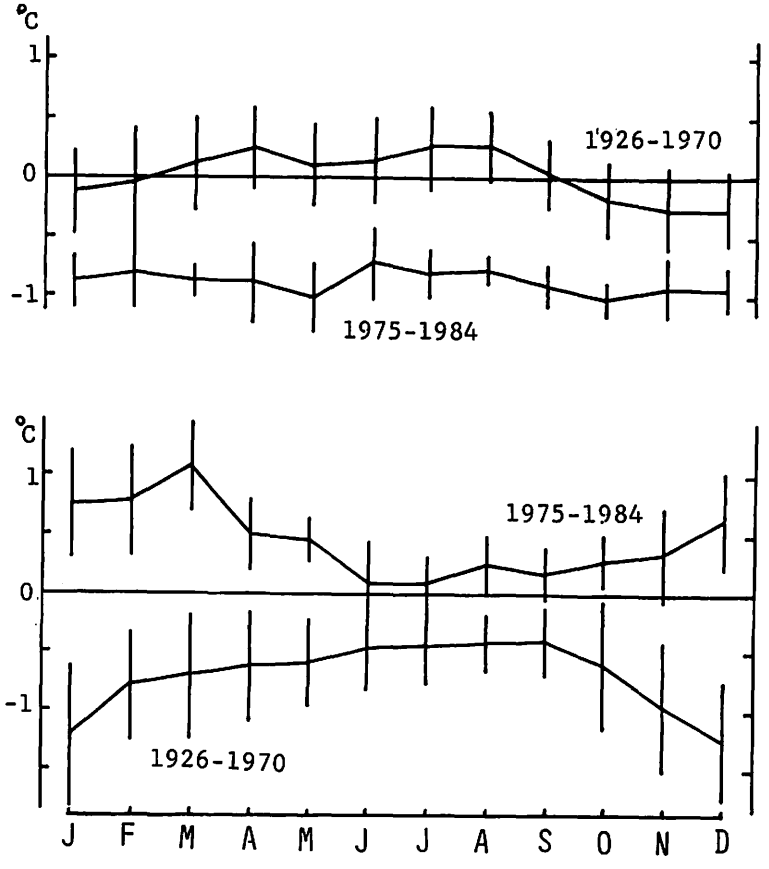

Fig. 3 : Mean monthly average maximum (above) and minimum (below) temperature differences between Tateno and Kakioka for the two periods (shown in Tateno minus Kakioka).

Table 1 Monthly average maximum and minimum temperature changes due to the construction of the TSC. Unit in ℃.

	Max.	Min.
Jan.	−0.7	2.0
Feb.	−0.8	1.6
Mar.	−1.0	1.8
Apr.	−1.1	1.2
May.	−1.1	1.0
Jun.	−0.8	0.6
Jul.	−1.1	0.6
Aug.	−1.0	0.7
Sept.	−0.9	0.6
Oct.	−0.8	0.9
Nov.	−0.7	1.3
Dec.	−0.7	1.9
Year	−0.9	1.2

temperature by 0.7～1.1℃.

In textbooks describing the atmospheric environment, heat islands in urban areas are often referred, and causes of increase in minimum temperature are explained by polluted urban atmosphere, effect of urban canyon, changes in surface condition and others as well as heat release (Oke, 1977). Minimum temperature increase shown in this study could be explained quite easely by the common theory. On the other hand maximum temperature decrease in urban area should be explained by some other reasons. This study suggests that increase in surface roughness factor would cause decrease in maximum temperature in daytime in the TSC.

Acknowledgment

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筑波研究学園都市における地上気温変化の量的推定

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概　要

筑波研究学園都市の建設によってもたらされた地上気温の変化について，地磁気観測所と高層気象台に於い行われてきた気温観測資料によって量的に推定した．高層気象台から近距離にある研究機関や大きな定員を擁する機関が業務を開始した1970年代の前半を境に，高層気象台の地上気温は，日最高気温は低下し，日最低気温は上昇した．月平均値では，日最低気温は冬期に約2℃上昇し，夏期に約0.6℃上昇している．日最高気温については，0.7～1.1℃の低下である．