VARIATIONS IN THE URBAN HEAT ISLAND INTENSITY AFFECTED BY GEOGRAPHICAL ENVIRONMENTS*

By Hye-Sook PARK**

(received March 5, 1987)

ABSTRACT

The main object of this research was to examine the urban influence and the topographical effects on the heat island intensity.

First, influences caused by the urban structures on the heat island intensity were discussed. The relationships between the maximum heat island intensity and the urban population are approximately linear and proportional, and regression lines can be represented as linear lines for American and European cities (Oke, 1973). By contrast, in Japanese and Korean cities the relationship changes at around 300,000 population. At that level the regression lines bend so that, in effect, there are lines in two directions, one for cities smaller than 300,000 population, another for larger cities. The increments of the maximum heat island intensity for cities with populations over 300,000 are larger than those for cities with populations under 300,000. That means that in Japan and Korea, the function and structure of cities above a population of 300,000 are different from those with smaller populations. In order to quantify and relate the differences of urban function and structure to the heat island intensity, the author has employed the urban population as an index of urban function and the sky view factor and the impermeable surface coverage ratio as indices of urban structure. Although the relationship between the sky view factor and the urban population did not alter remarkably at around 300,000 in population in Japanese and Korean cities, Japanese cities can be divided into two groups. One includes the cities which have a sky view factor that accords with their populations, the other the cities which have a larger sky view factor than expected from their populations. On the other hand, the relationships between the impermeable surface coverage ratio and the urban population were represented by a biphasic regression line for cities in both countries, with a slope transition occurring at the 500,000 population level. It is considered that the impermeable surface coverage ratio is probably not the only factor involved in this biphasic correlation, but is probably a key to understanding it.

As a next step, the physical meanings of each index were discussed based on the heat balance at the ground surface. The results are as follows. The sky view factor (an index of urban geometry) and the impermeable surface coverage ratio (an index of the thermal structure of the ground surface) are closely correlated with the radiation and heat balance at the ground surface which are related to radiative cooling during the clear and calm nights.

Second, the topographical factors of location on the coast, location on a plain inland from the coast, and location in a basin, which affected the heat island intensi-

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* A dissertation submitted in partial fulfilments for the degree of Doctor of Science in Doctoral Program in the University of Tsukuba.

** Address from April 1, 1987 is the Institute of Geoscience, the University of Tsukuba.

ty, were discussed. A basin city does not seem to be much influenced by advection. On the other hand, the advection by sea-breezes in a coastal city seems very strong all day long during daytime in summer. Particularly, the cooling amounts of temperature ($\Delta T_{t\text{-}s}$) and cooling rates ($\Delta T/\Delta t$) from sunset until sunrise in a basin city are higher than those of inland and coastal cities. These differences influence the nocturnal heat island intensity. Climatic analyses show that the heat island intensity is remarkably developed in winter nighttime, but is weak in summer daytime.

Furthermore, the heat island intensity is affected by the difference between the intensity of the nocturnal surface inversion in the urban area and the nocturnal surface inversion in the nearby rural area. In a basin city, the surface inversion layer is highly notable and is caused by radiative cooling, which produces a strong heat island intensity. On the other hand, in a coastal city, a surface inversion layer does not form because there is much advection effect caused by cool sea-breezes, and the heat island intensity is negative or slightly positive.

Finally, the urban influences and the topographical effects on the heat island intensity are summarized and schematic models are presented.