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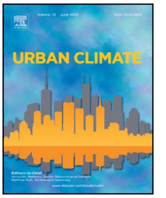

Analysis of the relationship between urban size and heat island intensity using WRF model

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ABSTRACT

In this study, the relationship between urban size and heat island intensity is analyzed using the meso-scale sWeather Research & Forecasting (WRF) model, and is applied to three different sized cities (Tokyo, Osaka, and Nagoya). Given that the urban areas of the study region spread inland, there were a number of high temperature points, with air temperature tending to be relatively higher in Tokyo. The spatial average air temperature in urban areas rise with the expansion of the urban size, since higher air temperature areas increase inland. In the case of calculating the heat island intensity using spatial average temperatures in urban areas, the heat island intensity is related to urban size.

1. Introduction

Urban heat island intensity is defined by the air temperature difference between an urban area and its surrounding suburbs. Oke (1973) revealed that urban heat island intensity is proportional to the logarithm of the population, based on observations in a number of cities in North America and Europe. Fukuoka (1983) and Park (1986) both showed the same relationship in Japanese and Korean cities and revealed that the slope of the relationship is steep for cities with more than 300,000 people. Sakakibara and Kitahara (2003) also showed a similar relationship for cities in Nagano Prefecture, Japan; however, the change in slope, such as that found by Fukuoka and Park, was not obtained.

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In these studies, population was used to indicate the degree of urbanization. An increase in population, for example, was associated with high-rise buildings and land use change, as well as with an expansion of the urban area. More specific indicators, such as urban area, artificial land coverage, and average building height, should be used to implement more effective heat island countermeasures. The mesoscale Weather Research & Forecasting (WRF) model (Skamarock et al., 2008), which is used generically worldwide, is effective for these studies (Iizuka et al., 2009; Kusaka et al., 2012; Moriyama et al., 2014). Therefore, this study used the WRF model to analyze the relationship between urban size and heat island intensity in three cities representing different sizes (Tokyo, Osaka, and Nagoya). The original definition of urban heat island intensity by Oke (1973) is the annual maximum air temperature difference. However, since the higher air temperature in the summer is noticed socially, which causes the deterioration of the thermal environment in outdoor space and the increase of energy consumption, the higher air temperature period of summer was selected as the objective period in this study.

Outline of calculations and calculation results are described in chapters 2 and 3. Conclusion is described in chapter 4. The objective of the study is to analyze the relationship between urban size and heat island intensity, by using WRF model. Present land use and potential natural vegetation are set for land use boundary condition.

2. Outline of calculations

The objective study areas are shown in Fig. 1. The outer square is domain 1 (3 km grid, 360 km square) and the inner filled square is domain 2 (1 km grid, 103 km square). The nesting technique was used in each region. The calculation results of air temperature at 2 m high and wind velocity at 10 m high in domain 2 were used for the analysis. Calculation conditions are shown in Table 1. The period for which calculations were done was from August 1–31, 2010. Based on digital national land information (spatial resolution of 100 m) and a normalized vegetation index created from Landsat7 ETM + data, urban areas were classified into three categories according to the previous study (Kitao et al., 2009): high-rise and high-density, middle-rise and moderate-density, and low-rise and low-density. Present land use and potential natural vegetation in Tokyo, Osaka, and Nagoya are shown in Fig. 2. Potential natural vegetation is an ecological concept referring to the vegetation that would be expected given environmental constraints (climate, geomorphology, geology) without human intervention or a hazard event. The concept has been developed in the mid 1950s by phytosociologist Reinhold Tüxen, partly expanding on the concept of climax. Image data was scanned and mapped. Frequency of urban land use at each

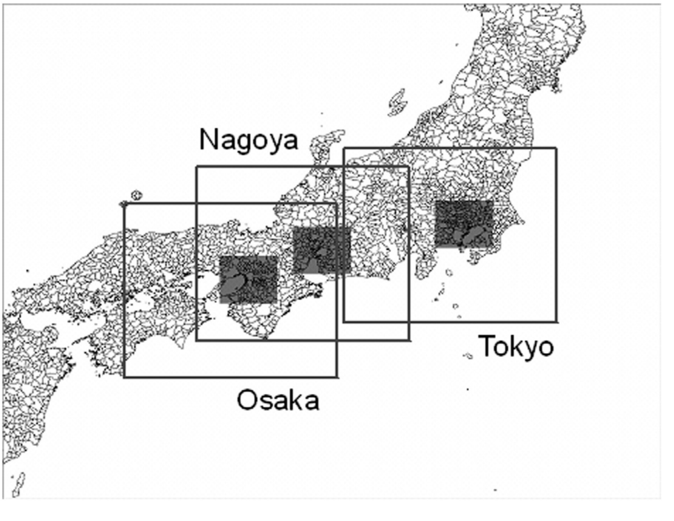

Fig. 1. Objective study areas.

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