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Spatial-Temporal Analysis of the Urban Heat Island of a Subtropical City by Using Mobile Measurement

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Abstract

Mobile temperature and humidity measurements have been performed along a 17-km transect in a local urban area in Shenzhen (China), during the period from August to December in 2013. The spatial-temporal distributions of Urban Heat Island intensity (UHII) show that the overall average UHII at different times vary between 0°C and 2°C. The daily average UHII change from 0°C to 3°C. The spatial distributions of UHII express obvious UHII differences as a whole. The correlation coefficients between spatial influential factors and the UHII reveal that the formation of UHII is influenced by both the urban surface characteristics and weather conditions.

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Keywords: Urban heat island; spatial-temporal; mobile measurement; influential factors

1. Introduction

The rapid urbanization in urban areas has affected both local and regional climates. Various forms of human activity and urban structure contribute to creating a special climate for urbanized regions [1]. The most known phenomenon is the urban heat island (UHI) which is usually expressed with the UHI intensity [2-3]. Much research has been done

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on this phenomenon by a variety of methods, including the use of climate data, satellite imagery, or mathematical modeling [4-7]. Many research results indicate that the UHI intensity has local geographical characteristics depending on the urban structure, intensity of building development, and ground surface materials [8-11]. In addition, the UHI intensity is also strongly related to weather variables [12-14]. Hence the patterns of UHI intensity have spatial-temporal characteristics by considering the spatial morphology of underlying surface and the weather conditions.

However, the current studies usually focus on several limited weather stations in built-up urban areas which could not reflect the overall distributions of UHI intensity in a regional area. The weather aspects usually consider the specific seasons through some specific meteorological data, which lack the long-term reliable data supporting. Additionally, the spatial influential factors affecting UHI intensity should be adopted from the view of urban planning to quantify the relationships between UHI phenomenon and urban spatial patterns.

This paper aims to quantitatively analyze the spatial-temporal characteristics of UHI in a local area in the highly urbanized city of Shenzhen. With a long-term mobile survey for air temperature in the study area, the UHI intensity values of different areas under different weather conditions are obtained. The influences of underlying surface spatial morphology are particularly discussed.

2. Area and Methodology

2.1. Study area

The economic special district in the city of Shenzhen (113°52'-114°21'E, 22°27'-22°39'N) led to its rapid growth from a small city into a megalopolis with millions of inhabitants during the past twenty years. Shenzhen is situated in the Pearl River Delta in south China with a typically subtropical monsoon climate. The annual mean air temperatures are around 23°C, with the average daily temperatures varying from 16°C to 23°C in the spring, from 25°C to 31°C in the summer, from 24°C to 31°C in the autumn, and from 14°C to 22°C in the winter.

Owing to the rapid urbanization in Shenzhen, the original natural underlying surfaces have been replaced by dense buildings and emerging activity space. This paper adopted the urban areas around the University Town of Shenzhen as the main study area. The whole research region has an area of 15km^2, containing diversified underlying surface types and a variety of building forms.

In order to conduct quantitative analysis of the study area, thirty blocks were divided according to the characteristics of land use types and building spatial distributions from the view of urban planning, as expressed in Fig. 1. The land use map shows that the blocks had different land use types, and the building spatial map displays the building spatial forms of blocks. The blocks from No.1 to No.8 were mainly filled with green land or public buildings. The blocks from No.9 to No.23 were mainly the industrial buildings, while the blocks from No.24 to No.30 were mainly the residential buildings.

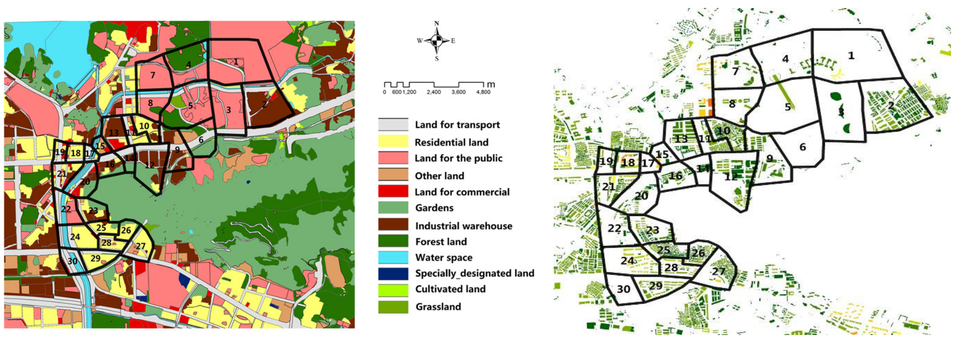

Fig. 1. Block divisions in the land use map (Left) and the building spatial map (Right).

With the data statistics of underlying surfaces and buildings in each block, the represented parameters of each block were obtained, including the total block area, the areas of the asphalt road, water space, grassland, forest land, bare