



4th International Conference on Countermeasures to Urban Heat Island (UHI) 2016

Urban Micro-climate Research in High Density Cities: Case Study in Nanjing

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Abstract

What kind of high density urban form presents a better micro-climate environment in summer days is the main question of this study. The micro-climate of three different urban form were simulated using the software ENVI-met. Parameters including building density, floor area ratio, green plot ratio, pavement area, building height are concerned in the simulation. By comparing and analyzing the air temperature (T_a), solar radiation, mean radiation temperature (T_{mrt}) and wind speed, the micro-climate performance in three cases are presented. The alternative thermal index physiological equivalent temperature (PET) is also used to evaluate the outdoor thermal comfort in the three cases.

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Peer-review under responsibility of the organizing committee of the 4th IC2UHI2016

Keywords: urban micro-climate; urban form; ENVI-met; urban heat island; high density; Nanjing

1. Introduction

The rapid urbanization in China is characterized by the expansion of urban area and the increasing of building density and height, which has significantly changed the sky view factor, solar reflectivity, heat capacity and roughness of the land surfaces. The phenomenon that air temperature in urban areas being significantly higher than that in rural areas is commonly termed as urban heat island (UHI) effect [1]. UHI effect can be observed all over the world, Gedzelman found that the maximum heat island intensity in New York was about 8.0°C [2]. It was reported that the

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annual mean air temperature in the centre of Tokyo city increased by 3°C remarkably during the last century. The UHI does not only impact the urban environment but also increases the mortality and the economic burden. A study in Netherland demonstrated that each degree increase in the air temperature above the comfortable range caused an mortality increase of 2.72% [3]. The Department of Power in U.S. reported that government spent about 10 billion dollars on mitigating the UHI every year [4]. Considering that over 50% Chinese people are living in the city now, it is easy to understand why this topic is receiving more and more attention.

Many researchers have focused on the factors such as urban population, albedo of the ground surface, urban vegetation which makes contribution to UHI. Asphalt's albedo value is about 0.1 on average and the concrete is 0.3 or 0.4, the low albedo cause the material temperature rise rapidly when exposed to solar radiation [5]. It is reported that proper vegetation can reduce the air temperature by 5°C in Singapore [6]. Dimoudi reported that the wind speed in the pedestrians' level inside the urban canyon is the 1/3-1/4 of the suburban area [7].

Few researches have been conducted to compare the micro-climate conditions in different high density cities. The micro-climate conditions in High density urban are concerned by the urban designers and citizens. The next section will present the progress of the UHI in Nanjing and highlight the location of the high surface temperature areas. Section 3 and Section 4 show the method and results of the case study. After the discussion of the main results, the research reports which kind of high density form is the reasonable choose to mitigate the Urban heat island in Nanjing.

2. Urban Heat Island in Nanjing

Nanjing the capital of Jiangsu province is situated in the Yangtze River Delta with the latitude of E31°14" to 32°37" and longitude of N118°22" to 119°14". Under the influence of the East Asia Monsoon, Nanjing has a humid subtropical climate. The annual mean air temperature in Nanjing is 15.9°C. Nanjing is usually referred to the "Furnace-like City" for the high air temperatures during the summer, even though the greenery coverage of Nanjing is about 44%, which is highest among those of all the cities in Jiangsu Province. Fig. 1 shows that July and August are the hottest months and the average maximum temperature is 32°C [8] while January is the coldest month with the average minimum temperature of -1°C. The average temperature difference between summer and winter is about 10°C. The average UHI intensity of Nanjing is about 0.5°C, reaching approximately 6°C in extreme cases. From 1960 to 2009, with the development of the urban scale, calculated by annual air temperature, the UHI intensity increased by 0.109°C/10a [9].

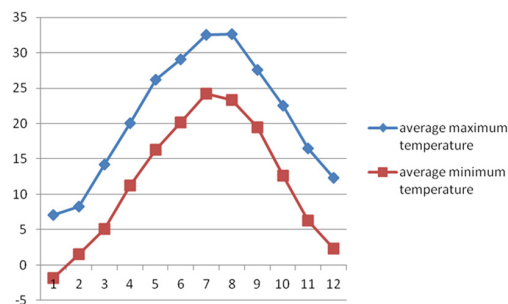


Fig. 1. Average monthly maximum and minimum air temperature in Nanjing (1951-2008)

The land surface temperature collected from satellite imagery clearly shows the UHI effect in Nanjing (Fig. 2). The main urban area shows the highest land surface temperature from 28 to 32°C. In contrast, the Yangzi river and Zijing mountain shows the lowest surface temperature about 23°C. The mean surface temperature of the rural area is about 26°C.

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