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Local Climate Zone Study for Sustainable Megacities Development by Using Improved WUDAPT Methodology – A Case Study in Guangzhou

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Abstract

High density urban development in the past has not only changed natural landscape into artificial constructions and pavements, but also brought along many environmental problems like air pollution, urban heat island (UHI) and dust haze, which can affect the public health condition. There are limited applied urban climatic studies in urban planning and development. One of key reasons is there is a missing link between urban development and its corresponding impact on local climatic conditions. The concept of Local Climate Zone scheme has been developed to fit into this gap[1]. It introduces a standardized scientific way to describe the land cover and its thermal performance on the UHI. Since 2012, The World Urban Database and Access Portal Tools (WUDAPT) have been developed to call for international efforts and collaborations on world-wide LCZ studies. Its level 0 method can quickly collect urban morphology information and create LCZ maps[2]. However, it's time consuming to use WUDAPT to classify cities globally as WUDAPT is designed at city scale. This paper aims to improve the current methodology to classify more cities in a shorter time and also achieve a more accurate result. In this paper, Guangzhou is selected as case study since it has complex urban morphology and can represent as typical megacity in China. The study firstly reviews the concept of LCZ and WUDAPT. Secondly, the level 0 method of WUDAPT is used to initially classify LCZs of Guangzhou. For enhancing the efficiency of the existing WUDAPT, an improved methodology is developed to use WUDAPT to classify a region and extract the cities inside the region. Thirdly, the relevant quality checking work of the two methodologies is also conducted to detect the accuracy of the two methodologies. The improved outputs can be applied to numerical modellings and local planning implementation[3]. Because the future trend of urbanization in China is towards megacity development, the lessons learnt from the study can be applied to other megacities and regions for better climatic-spatial planning in future.

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1. Introduction

The rapid urbanization in China has led to a serial of environmental problems, especially the urban heat island (UHI) phenomenon. Excessive heat in cities has impact on the sensation of thermal comfort, health and performance of inhabitants and affects their daily or leisure activities. Because of this, it is important and necessary to understand the urban development and its corresponding impact on local climatic conditions. For this purpose, the concept of Local Climate Zone has been developed to quantify the correlation between urban morphology and UHI[1]. The World Urban Database and Portal Tool (WUDAPT) is a newly developed approach to recognize the LCZ classification. WUDAPT has been created to collect requisite urban morphology and activity data globally, and provided the information in a form suitable for climate science by using a straightforward methodology as well as open and free software and data[2] .

However, the existing WUDAPT method is developed for urban climate study at city scale. It will take an excess of time to classify numerous cities one by one by the method[4, 5, 6]. Thus it is significant to improve the existing WUDAPT methodology to generate the LCZ maps in a more effective and quicker way. If WUDAPT can classify a large region then extract cities inside separately, the efficiency will be much improved. Whether WUDAPT is still suitable to classify several cities at one time has not been studied yet. This paper aims to check the feasibility of WUDAPT for regional study and provide a more efficient WUDAPT methodology for individual city. The LCZ map of either the whole region or the cities in the region can be generated based on the results. Thus the efficiency of LCZ classification can be greatly improved, which is significant for urban climate study.

2. Review

2.1 Local Climate Zone (LCZ)

Steward and Oke developed LCZ to redefine and quantify the UHI effect[1]. Each LCZ aims to have homogenous air temperature and is defined by both qualitative and quantitative properties. One of the major advantages of LCZ is the new perspective of urban heat island, looking into the temperature differentiation among LCZ classes rather than the traditional "urban" and "rural" classes. It emphasized the importance of intra-urban temperature comparison among different urban classes, to analyze the influence of heterogeneous urban morphology on local climate formation. LCZ has 17 standard types including two subsets: 10 built types and 7 land cover types.

2.2 The World Urban Database and Access Portal Tools (WUDAPT)

This method is designed to be universal, simple and objective which targets to be part of a global protocol to derive information about form and function of cities. With free satellite images and free software of Google Earth (GE) and SAGA-GIS. It applies globally available Landsat satellite images as an input data.

2.3 The problems in existing WUDAPT methodology

WUDAPT aims to classify cities globally and generate a world urban morphology database. Worldwide urban climate researchers have applied WUDAPT for LCZ studies. Currently 31 Chinese cities have been classified while there are 333 prefecture-level cities in China that are still needed to be classified[7]. It is a time-consuming process filled with image preprocessing and selecting training samples for each city. It is even a bulky workload to analyze cities globally. The existing methodology, therefore, has to be improved.