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Classifying urban climate zones (UCZs) based on statistical analyses

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ABSTRACT

The objective of this study is the classification of urban climate zones (UCZs) based on statistical approaches, to provide key information for the establishment of spatial planning in order to create pleasant thermal environments in urban spaces. There are four parts in this paper: First, analysis was conducted of time points for summer and winter to classify UCZs in Seoul, South Korea. The air temperatures of these points were then analyzed using data of 246 Automatic Weather Stations (AWS). Second, information of urban spatial elements was selected based on literature review. Third, to classify urban climate zones influential urban spatial elements were identified using step-wise regression analysis between air temperature and urban spatial elements. Finally, the UCZs of the study area were classified by applying K-mean clustering analysis, and each spatial characteristic of the UCZs was identified. Based on the statistical analysis results, this study delineated clearer UCZs boundaries by applying influential urban spatial elements. These results offer integrated information of urban climate principles that can be utilized by urban planners, architects, and landscape planners. The outcomes can also be applied to spatial planning to reduce the negative effects of heat islands in summer and winter as well.

1. Introduction

The urban heat island effect can cause air temperatures in a city's interior areas to be significantly warmer (approximately 2–3 °C) than in rural hinterlands (Landsberg, 1981). The main causes of the urban heat island phenomenon include trapping of short and long wave radiation between buildings, decreasing of long-wave

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radiative heat losses due to building construction, increasing storage of sensible heat in the construction materials, anthropogenic heat released from human activities, and reduction of evapotranspiration potential (Rizwan et al., 2008; Oke, 1982). Efforts to mitigate the detrimental impacts of urban heat islands have been attempted in the urban planning field through physical controls including planting and vegetation (Tong et al., 2005; Ca et al., 1998), albedo management on the ground level and on roof tops (Takebayashi and Moriyama, 2007; Rosenfeld et al., 1998), and ventilation improvement (Wong et al., 2010; Gál and Unger, 2009). In order to achieve effective urban heat island mitigation, it is necessary to understand and apply urban climatic information in urban planning. In this regard, the urban climate zone (UCZ) concept is useful in urban thermal environment planning because it offers integrated information on climate characteristics and related spatial elements (Scherer et al., 1999). UCZs are homogeneously classified areas that distinguish climate characteristics based on built types and land cover types (Oke, 2006). In addition, the UCZ takes as its starting point a graphical description of the background climate of an urban area and examines how urban development may modify the climatic environment in terms of worsening or improvement. Studies on UCZs have been conducted as fundamental research to understand urban weather phenomena. For instance, Chandler (1965) classified urban areas in London into three types namely climate, topography, and building forms. Meanwhile, Auer (1978) classified urban areas into 12 types considering the characteristics of vegetation and buildings using urban land use information. Moreover, Ellefsen (1991) introduced the UTZ (Urban Terrain Zone) concept with 17 categories, while Oke (2006) presented the UCZ concept that considers urban structure, land cover, materials, human activities, and climate control capabilities of vegetation. In addition, Houet and Pigeon (2011) verified that Oke's UCZ could be differentiated according to air and surface temperatures. They also found that the climatic characteristics of UCZs could vary from winter to summer.

Building upon existing UCZ concepts, Stewart and Oke (2012) unveiled the LCZ (Local Climate Zone) concept to classify urban areas more concretely in which a more detailed LCZ delineates a combination of 7 land cover types and 10 building types, and urban areas are classified as a dominant combination on the local scale. Because the LCZ is useful in identifying urban spatial elements affecting the urban thermal environment, related research has been conducted in a number of countries including Japan, China (Hong Kong), France, Hungary, and the U.S.

Subsequently, various countries (over 15) around the world have applied these concepts to develop urban climatic maps that can be categorized as urban climatic analysis maps or urban climatic planning recommendation maps (Ren, 2015).

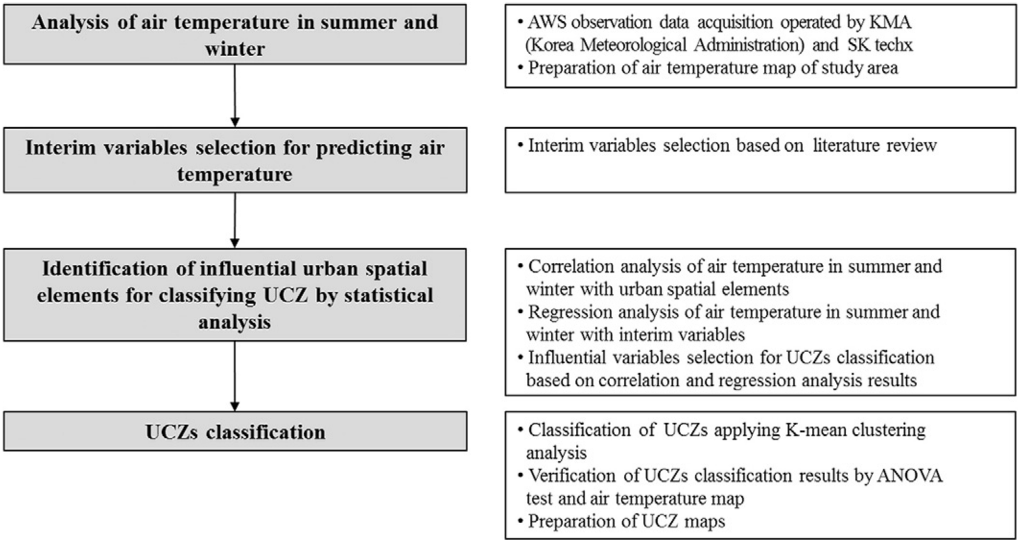

Fig. 1. Study workflow.

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