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Influence of neighbourhood information on 'Local Climate Zone' mapping in heterogeneous cities

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ABSTRACT

Local climate zone (LCZ) mapping is an emerging field in urban climate research. LCZs potentially provide an objective framework to assess urban form and function worldwide. The scheme is currently being used to globally map LCZs as a part of the World Urban Database and Access Portal Tools (WUDAPT) initiative. So far, most of the LCZ maps lack proper quantitative assessment, challenging the generic character of the WUDAPT workflow. Using the standard method introduced by the WUDAPT community difficulties arose concerning the built zones due to high levels of heterogeneity. To overcome this problem a contextual classifier is adopted in the mapping process. This paper quantitatively assesses the influence of neighbourhood information on the LCZ mapping result of three cities in Belgium: Antwerp, Brussels and Ghent. Overall accuracies for the maps were respectively 85.7 ± 0.5, 79.6 ± 0.9, 90.2 ± 0.4%. The approach presented here results in overall accuracies of 93.6 ± 0.2, 92.6 ± 0.3 and 95.6 ± 0.3% for Antwerp, Brussels and Ghent. The results thus indicate a positive influence of neighbourhood information for all study areas with an increase in overall accuracies of 7.9, 13.0 and 5.4%. This paper reaches two main conclusions. Firstly, evidence was introduced on the relevance of a quantitative accuracy assessment in LCZ mapping, showing that the accuracies reported in previous papers are not easily achieved. Secondly, the method presented in this paper proves to be highly effective in Belgian cities, and given its open character shows promise for application in other heterogeneous cities worldwide.

1. Introduction

Urban areas cover only 3% of the Earth's land surface but are one of the most important human habitats (Mills, 2007). Already more than 50% of the world population is concentrated in these areas and this number will likely rise to 66% by 2050 (Zhou et al., 2011; United Nations, 2012). The increasing urban population and global warming will put more pressure on this fragile system, resulting in unhealthy living conditions, such as the occurrence of more and severe heat waves (Aertsens et al., 2012; World meteorological organisation, 2013). Until now, no global urban classification directly relevant for urban climate modelling exists. Across the United States a national land cover database exists, including 16 different land cover classes, from which 4 are urban oriented (Homer et al., 2011). The European CORINE land cover database contains 44 land cover classes, of which only three are urban areas (Kleeschulte and Büttner, 2006). More recently the Urban Atlas has been developed, but this classification is only available for EU countries (Danylo et al., 2016). The Urban Atlas is a combination of land cover and land use classes. It is a very useful tool to study urban sprawl and urban fringes because of the high spatial resolution (SR). However, it is not developed to study the urban climate, because thermal behaviour is mainly depending on land cover and urban structure. Another data set which is often used in urban climate research is the European Soil Sealing Data Set which typically provides a percentage imperviousness for a raster of 20 m or 100 m SR (EEA, 2017; Wouters et al., 2016). But similarly to the CORINE land cover database and the Urban Atlas, this dataset does not cover countries outside the EU. In Germany urban structure types (Stadtstrukturtypen, UST) are commonly used to support effective sustainable urban planning. Maps on UST are based on morphology and function (Pauleit and Duhme, 2000). There is, however, neither a consistent and standardized framework nor a coordinated strategy for nation-wide mapping of UST. Many of the above-mentioned classification schemes contain features, which can be applied in urban climate research, but none of them is

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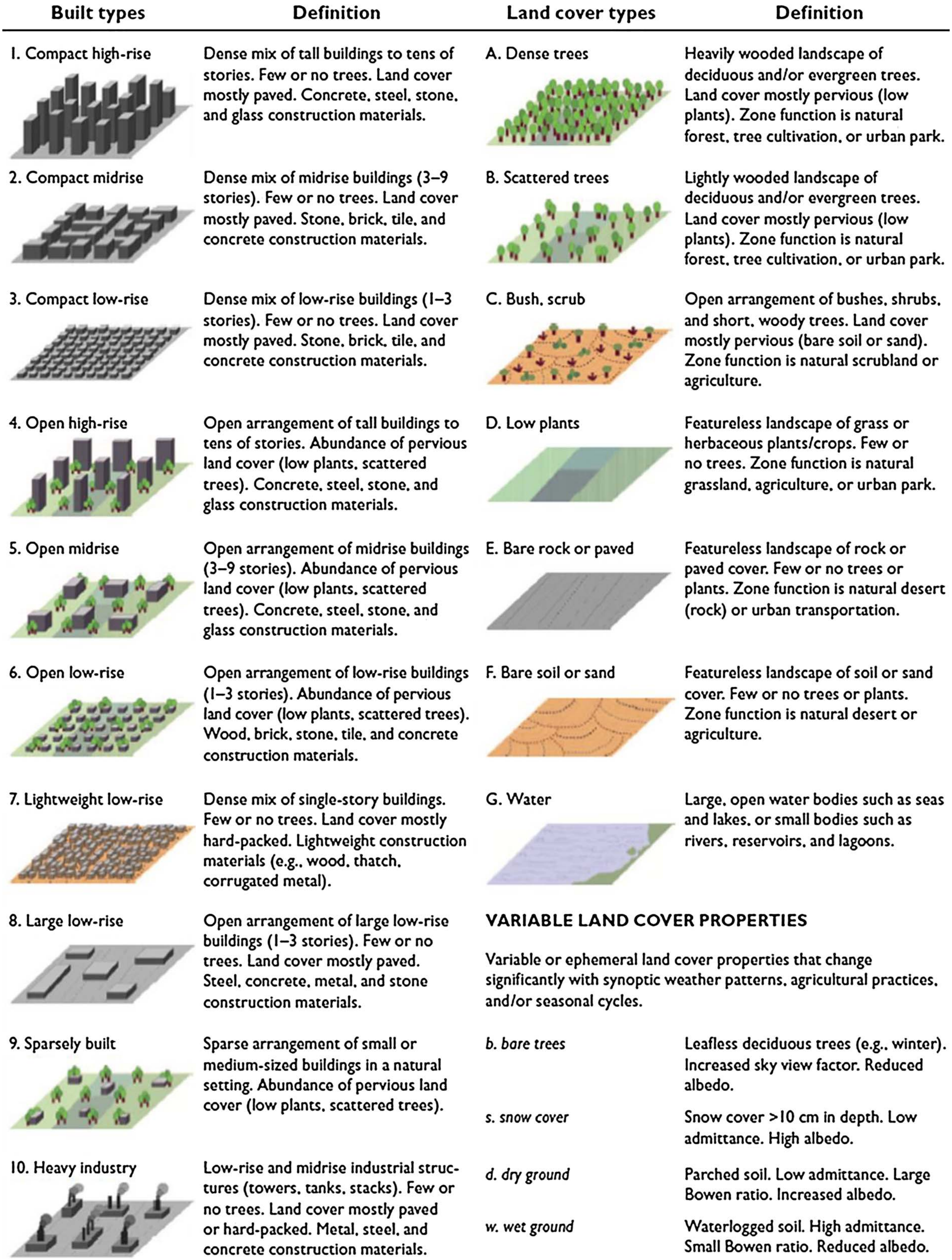

Fig. 1. Local climate zone scheme (Stewart and Oke, 2012). © Copyright (2012) American Meteorological Society. Permission to use figure.

comprehensive with regard to urban variation on global scale. A number of global datasets (Potere et al., 2009; ESA, 2017; Esh, 2017; ESA, 2017; Elvidge et al., 2007; Pesaresi et al., 2013) are available but none of these includes climatic properties and rural landscape classes, nor offer the necessary level of detail significantly hampering applicability at the local scale. Most of the mentioned classifications however do not use a set of surface climate properties (physical properties of surface structure, cover, fabric and metabolism) to define their classes (Stewart and Oke, 2012; Oke, 2004). In addition, when the rural landscape is not included in the classification, the system is not well suited for UHI research, because there is no reference site. The generic character of the local climate zone (LCZ) classification scheme (Fig. 1)