

# ON THE ASSESSMENT OF SURFACE URBAN HEAT ISLAND: SIZE, URBAN FORM, AND SEASONALITY

Abstract of the dissertation submitted by Bin Zhou

To what extent cities can be made sustainable under the mega-trends of urbanization and climate change remains a matter of unresolved scientific debate. Our inability in answering this question lies partly in the deficient knowledge regarding pivotal human-environment interactions. Regarded as the most well documented anthropogenic climate modification, the urban heat island (UHI) effect – the warmth of urban areas relative to the rural hinterland – has raised great public health concerns globally. Worse still, heat waves are being observed and are projected to increase in both frequency and intensity, which further impairs the well-being of urban dwellers. Albeit with a substantial increase in the number of publications on UHI in the recent decades, the diverse urban-rural definitions applied in previous studies have remarkably hampered the general comparability of results achieved. In addition, few studies have attempted to synergize the land use data and thermal remote sensing to systematically assess UHI and its contributing factors.

Given these research gaps, this work presents a general framework to systematically quantify the UHI effect based on an automated algorithm, whereby cities are defined as clusters of maximum spatial continuity on the basis of land use data, with their rural hinterland being defined analogously. By combining land use data with spatially explicit surface skin temperatures from satellites, the surface UHI intensity can be calculated in a consistent and robust manner. This facilitates monitoring, benchmarking, and categorizing UHI intensities for cities across scales. In light of this innovation, the relationship between city size and UHI intensity has been investigated, as well as the contributions of urban form indicators to the UHI intensity.

This work delivers manifold contributions to the understanding of the UHI, which have complemented and advanced a number of previous studies. Firstly, a log-linear relationship between surface UHI intensity and city size has been confirmed among the 5,000 European cities. The relationship can be extended to a log-logistic one, when taking a wider range of small-sized cities into account. Secondly, this work reveals a complex interplay between UHI intensity and urban form. City size is found to have the strongest influence on the UHI intensity, followed by the fractality and the anisometry. However, their relative contributions to the surface UHI intensity depict a pronounced regional heterogeneity, indicating the importance of considering spatial patterns of UHI while implementing UHI adaptation measures.

Lastly, this work presents a novel seasonality of the UHI intensity for individual clusters in the form of hysteresis-like curves, implying a phase shift between the time series of UHI intensity and background temperatures. Combining satellite observation and urban boundary layer simulation, the seasonal variations of UHI are assessed from both screen and skin levels. Taking London as an example, this work ascribes the discrepancies between the seasonality observed at different levels mainly to the peculiarities of surface skin temperatures associated with the incoming solar radiation. In addition, the efforts in classifying cities according to their UHI characteristics highlight the important role of regional climates in determining the UHI.

This work serves as one of the first studies conducted to systematically and statistically scrutinize the UHI. The outcomes of this work are of particular relevance for the overall spatial planning and regulation at meso- and macro levels in order to harness the benefits of rapid urbanization, while proactively minimizing its ensuing thermal stress.