Cities from Space:

Influence of Rural to Urban Gradients on Remote Sensing of Urban Heat Island

Submitted by

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Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This research is supported by the Australian Government Research Training Program.

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Abstract

The Urban Heat Island (UHI) effect occurs when urban areas have higher surface/ air temperature differences relative to surrounding rural reference areas. Most of the studies carried out in past are limited to a certain time in a year or a day, and lack a long term analysis. Moreover, the research potential of satellites and its modern tools remain largely untapped.

The overall goal of this thesis is to investigate and characterise the UHI in selected Australian cities with satellite data sets, particularly the Moderate Resolution Imaging Spectro-radiometer (MODIS). To achieve these objectives, (1) I, firstly investigated the inter-annual and seasonal characteristics of diurnal land surface temperature (LST) and UHI across urban and rural areas from 2003- to 2017; (2) then I assessed the long-term trends (significant/non-significant) in UHI and LST and their interactions/dependencies with its drivers/indicators (greenness, albedo); (3) furthermore I examined the phenology patterns for greenness and urban greenness deficit in relationship with the diurnal, seasonal, inter-annual characteristics in UHI; (4) lastly, I examined an extreme heat wave event in Sydney and its influence on UHI utilising the geostationary Himawari-8 satellite.

The temporal analysis on seasonal and inter-annual variations of UHI revealed maximum intensities in the daytime period for both the cities of Melbourne and Sydney. Melbourne and Sydney experienced the highest daytime UHI in the austral 'spring' and austral 'summer' season respectively. A nighttime UHI was present in both cities in the 'summer' season. Inter-annual trends in UHI revealed a significant increasing trend in daytime UHI (p-value < 0.01) for both selected cities despite no significant trends in daytime urban LST in both cities. The increasing UHI trends were primarily attributed to increasing greenness and declining temperatures in the rural zones surrounding both

cities. We found the choice of a rural reference class, whether forest, pasture, or mixed, significantly altered computed UHI values. Greenness and urban green deficit (UGD) showed an inverse relationship with daytime UHI, whereas albedo and delta albedo (urban minus rural albedo) did not show any correlation with UHI. During the extreme heatwave event, the UHI was seen to be more widespread and dominant in the city for a longer time than for an average day, while the intensity remained more or less similar.

This thesis highlights the value of remote sensing techniques (e.g. MODIS and Himawari-08 satellites) as essential tools for improved assessments and management of urban landscapes in selected Australian cities.