

**Cities from Space:**  
**Influence of Rural to Urban Gradients on**  
**Remote Sensing of Urban Heat Island**

Submitted by  
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Doctor of Philosophy

School of Life Sciences, Faculty of Science  
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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.

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## Table of Contents

<b>Certificate of original authorship .....</b>	<b>ii</b>
<b>Acknowledgements .....</b>	<b>iii</b>
<b>Table of Contents .....</b>	<b>v</b>
<b>List of Figures.....</b>	<b>xi</b>
<b>List of Tables .....</b>	<b>xx</b>
<b>Summary.....</b>	<b>xxii</b>
<b>Chapter 1: Introduction .....</b>	<b>24</b>
1.1    General research background .....	25
1.1.1. Urbanisation and Landscape Change .....	27
1.1.2    Urban Thermal Climate Change .....	31
1.2    Geospatial Techniques for Mapping Urban Landscape Dynamics .....	37
1.2.1    Remote Sensing .....	37
1.2.2    Satellite data.....	38
1.2.3    Spectral Products / Indices Derived from Satellite Data .....	42
1.3    Australian Perspective .....	45
1.3.1    Climate variability in Australia.....	45
1.3.2    UHI in Australia.....	46
1.4    Current issues and corresponding thesis objectives .....	48
1.4.1    Study Area .....	50
1.4.2    Research Questions.....	51
1.4.3    Research Chapters.....	52
1.5    References .....	55

**Chapter 2: Spatial and Temporal Analysis of Land Surface Temperature in Urban  
– peri-urban Surroundings for Estimating and Quantifying the Urban Heat**

<b>Island.....</b>	<b>63</b>
Abstract .....	64
2.6 Introduction .....	65
2.7 Data and Methods.....	67
2.7.1 Land use land cover (LULC) & Digital elevation model (DEM) data .	67
2.7.2 Land Surface Temperature Data .....	69
2.7.3 LST patterns across urban and rural zones (2003 to 2017) .....	70
2.7.4 Spatial and temporal patterns in UHI from 2003 to 2017.....	70
2.7.5 UHI Inside the city.....	71
2.7.6 Workflow .....	71
2.8 Results .....	72
2.8.1 LST spatial patterns over Sydney and Melbourne.....	72
2.8.2 Urban and Rural LST Histogram.....	76
2.8.3 Quantifying UHI .....	80
2.8.4 UHI inside city.....	83
2.8.5 UHI and its rural reference .....	84
2.9 Discussion.....	86
2.9.1 Diurnal characteristics of UHI.....	87
2.9.2 Seasonal characteristics of UHI.....	88
2.9.3 UHI and Choice of Rural Class as Reference.....	88
2.9.4 Limitations .....	89
2.10 Conclusion.....	89
2.11 References .....	91

<b>Chapter 3: UHI Time Series Trends and their Drivers.</b>	<b>93</b>
Abstract	94
3.1 Introduction	95
3.2 Data and Methods	96
3.2.1 Satellite based greenness (EVI)	97
3.2.2 Urban Green Deficit (UGD)	97
3.2.3 Albedo	98
3.2.4 Delta Albedo	98
3.2.5 Urban Heat Island (UHI)	99
3.2.6 UHI trends and attributing these trends to its drivers	99
3.2.7 Rural LULC and its impacts on UHI variance	100
3.2.8 Workflow	100
3.3 Results	101
3.3.1 Seasonal and inter-annual variations in UHI	101
3.3.2 Influence of the non-urban, outside reference used to compute UHI.	105
3.3.3 Causes for the increasing UHI trends. Is it LST trends in the city? ...	107
3.3.4 Attributing UHI to Greening	109
3.3.5 Attributing to Albedo	114
3.3.6 BFAST results	119
3.4 Discussion	121
3.4.1 The inter-annual trends in UHI and their drivers	121
3.4.2 Greenness in rural zones	123
3.4.3 Albedo change and its influence on UHI trends	123
3.4.4 The role of rural class as reference	124
3.4.5 Past studies	125

3.4.6	Limitation.....	125
3.5	Conclusion.....	126
3.6	References .....	127
<b>Chapter 4: Interactions of vegetation phenology with UHI.....</b>		<b>129</b>
	Abstract .....	130
4.1	Introduction .....	132
4.2	Data and Methods.....	133
4.2.1	Plotting UHI and LST climatic averages .....	134
4.2.2	Generating inter-annual and seasonal patterns .....	134
4.3	Results .....	134
4.3.1	Seasonal Patterns UHI .....	134
4.3.2	Inter-annual Patterns - LST.....	136
4.3.3	Phenology curves for vegetation.....	137
4.4	Discussion.....	140
4.4.1	UHI and LST seasonality.....	140
4.4.2	Vegetation Phenology.....	141
4.5	Conclusion.....	142
4.6	References .....	143
<b>Chapter 5: Extreme Heat Waves and their influence on UHI.....</b>		<b>145</b>
	Abstract .....	146
5.1	Introduction .....	147
5.2	Data and Methods.....	150
5.2.1	Study Area .....	150
5.2.2	Synoptic Background.....	150
5.2.3	MODIS based LSTs and UHI.....	152

5.2.4	Himawari-8 .....	152
5.2.5	Himawari-8 derived LST Data .....	152
5.2.6	Ancillary Data .....	154
5.2.7	UHI Quantification and Contour Plots .....	154
5.2.8	Comparison of heat wave LST/UHI with average LST/UHI in summer 154	
5.2.9	Workflow .....	155
5.3	Results .....	156
5.3.1	Heat Wave as seen in MODIS .....	156
5.3.2	Himawari-8 Brightness Temperature (BT) Results .....	157
5.3.3	Himawari-8 derived LST .....	158
5.3.4	Himawari-8 LST results (9 to 12 February 2017) .....	159
5.3.5	Himawari-8 UHI results (9 to 12 February 2017) .....	165
5.3.6	LST/UHI variations inside the city .....	167
5.3.7	Comparing Average February with heat wave LST .....	170
5.3.8	Comparing Average February with heat wave UHI .....	171
5.4	Discussion.....	173
5.4.1	Himawari-8 LST/UHI (9 to 12-February 2017) .....	173
5.4.2	Comparing Average February with heat wave .....	174
5.4.3	Limitations .....	175
5.5	Conclusion.....	175
5.6	References .....	177
	<b>Conclusion and Future Directions.....</b>	<b>180</b>
6.1	Summary of Key results and conclusions .....	181
6.2	Future Research Directions .....	184

6.3	Final Conclusion.....	185
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## List of Figures

Figure 1.1. A generalised description of the UHI (modified from <a href="http://www.pmsilicone.com/urban-heat-island-effect/">http://www.pmsilicone.com/urban-heat-island-effect/</a> cited on 15//02/2016).....	25
Figure 1.2. Built up areas have less evapotranspiration and more.....	
runoff (left); while vegetated areas have more evapotranspiration and less runoff (modified from Gao et al. (2015).....	30
Figure 1.3. A flow chart showing urbanisation changing local climate and causing an UHI birth ( <a href="https://bloomington.in.gov/media/media/image/jpeg/12924.jpg">https://bloomington.in.gov/media/media/image/jpeg/12924.jpg</a> cited on 02/09/2015). ....	32
Figure 1.4. Shows fraction of radiations blocked and transmitted by atmosphere at various wavelengths in the electromagnetic spectral band. (Modified from <a href="https://christinatang1992.wordpress.com/tag/atmospheric-windows/">https://christinatang1992.wordpress.com/tag/atmospheric-windows/</a> dated 01-02- 2018) .....	38
Figure 1.5. The Number of Record Hot Days for Each Year from 1960 to 2010 across Australia and the average number of hot days per year for each decade; modified from Cleugh et al. (2011) .....	46
Figure 1.6. (a) Australia (b) East Australia showing Sydney and Melbourne (c) Greater Sydney Region boundary in white colour overlayed on mosaicked satellite image of Landsat dated 29 April and 15 August 2018 (d) Greater Melbourne region boundary in white colour overlayed on mosaicked satellite image of Landsat dated 20 January and 16 May 2018. ....	50

Figure 2.1. (a) SRTM DEM (30 m) overlaid by Greater city boundary for Sydney and (b) Melbourne, (c) Land Use Land Cover (LULC) map acquired from mesh boundaries data of Australian Bureau of Statistics (ABS) for Sydney (d) Land Use Land Cover (LULC) map acquired from mesh boundaries data of Australian Bureau of Statistics (ABS) for Melbourne.....	69
Figure 2.2. Workflow followed to implement the set objectives for chapter 2. ....	72
Figure 2.3. LST (day time and night time) averaged over Sydney for fifteen years (2003 – 2017) through January, April, July and October representing summer, autumn, winter and spring seasons respectively. The black colour polygon represents the urban boundary as per ABS (2016) data. ....	74
Figure 2.4. LST (day time and night time) averaged over Melbourne for fifteen years (2003 – 2017) through January, April, July and October representing summer, autumn, winter and spring seasons respectively. The black colour polygon represents the urban boundary as per ABS (2016) data. ....	75
Figure 2.5. Shows LST pixels distribution in urban and rural regions over Sydney in summer season. ....	76
Figure 2.6. Shows LST pixels distribution in urban and rural regions over Sydney in winter season. ....	77
Figure 2.8. Shows LST pixels distribution in urban and rural regions over Melbourne in summer season. ....	78
Figure 2.9. Shows LST pixels distribution in urban and rural regions over Melbourne in summer season. ....	81

Figure 2.10. UHI (diurnal) averaged over fifteen years (2003 – 2017) through January, April, July and October representing summer, autumn, winter and spring seasons respectively over Sydney.....	82
Figure 2.11. Shows LST pixel distribution in urban, forest and pasture regions over Sydney in summer season. ....	85
Figure 2.12. Shows LST pixels distribution in urban, forest and pasture regions over Sydney in winter season. ....	85
Figure 2.13. Shows LST pixels distribution in urban, forest and pasture regions over Melbourne in summer season. ....	86
Figure 2.14. Shows LST pixels distribution in urban, forest and pasture regions over Melbourne in winter season. ....	86
Figure 3.1. Work flow of the methodology followed in chapter 03.....	99
Figure 3.2. UHI trends over fifteen years from 2003 to 2017 Sydney.....	101
Figure 3.3. UHI trends over fifteen years from 2003 to 2017 over Melbourne.....	101
Figure 3.4. Pixel based slope with p-value <0.05 over Sydney (a) Day-time, where the black colour circle indicates areas with relatively steeper slopes; (b) Night-time, where red circle shows the pixels with relatively higher slope values.....	103
Figure 3.5. Pixel based slope with p-value <0.05 over Melbourne; (a) Daytime, where the black colour circle indicates areas with relatively steeper slopes; (b) Nighttime.....	103

Figure 3.6. Shows time series of UHI spatial with respect to various rural LULC classes, used as the reference, for the past fifteen years (2003 - 2017) (a) over Sydney and (b) over Melbourne. ....	106
Figure 3.7. Shows time series of LST in urban and rural LULC classes for past fifteen years (2003 - 2017) (a) over Sydney and (b) over Melbourne. . ....	107
Figure 3.8. (a) Shows time series of EVI in urban and rural LULC classes for past fifteen years (2003 - 2017) over Melbourne region (b) Pixel based trend over Melbourne with p-value < 0.05; the black polygon shows relatively higher slope value pixels in the region and red polygon shows pixels with dropping EVI values over selected period. . ....	109
Figure 3.9. (a) Shows time series of EVI in urban and rural LULC classes for past fifteen years (2003 - 2017) over Sydney region (b) Pixel based trend over Sydney with p-value < 0.05; the black polygon shows relatively higher slope value pixels in the region and red polygon shows pixels with dropping EVI values over selected period. . ....	110
Figure 3.10. Shows time series of UGD in urban and rural LULC classes for past fifteen years (2003 - 2017) (a) over Sydney and (b) over Melbourne. . ....	112
Figure 3.11. Shows cross plots of UHI day vs UGD for rural sub-classes over past fifteen years (2003 - 2017) (a) Sydney and (b) Melbourne. . ....	113
Figure 3.12. (a) Shows time series of albedo in urban and rural LULC classes for past fifteen years (2003 - 2017) over Sydney region (b) Pixel based trend over Sydney with p-value < 0.05. . ....	115

Figure 3.13. (a) Shows time series of albedo in urban and rural LULC classes for past fifteen years (2003 - 2017) over Melbourne region (b) Pixel based trend over Melbourne with p-value < 0.05. ....	116
Figure 3.14. Shows time series of delta albedo in urban and rural LULC classes for past fifteen years (2003 - 2017) (a) over Sydney and (b) over Melbourne. ....	117
Figure 3.15. Shows cross plots of UHI day vs delta albedo for rural sub-classes over past fifteen years (2003 - 2017) (a) Sydney and (b) Melbourne. ....	118
Figure 3.16. BFAST results for Sydney UHI time series at daytime and nighttime. ....	119
Figure 3.17. BFAST results for Melbourne UHI time series at daytime and nighttime. ....	119
Figure 4.1. Shows inter-annual variations in UHI with reference to selected adjacent rural LULC classes, which are ‘pasture’ and ‘forest’ over (a) Sydney and (b) Melbourne. ....	135
Figure 4.2. Shows inter-annual variations in LST over ‘urban’ and it’s adjacent rural LULC classes, which are ‘pasture’ and ‘forest’ over (a) Sydney and (b) Melbourne. ....	136
Figure 4.3. Shows inter-annual variations in EVI (satellite based greenness) over ‘urban’ and it’s adjacent rural LULC classes, which are ‘pasture’ and ‘forest’ over (a) Sydney and (b) Melbourne. ....	137
Figure 4.4. Shows inter-annual variations in UGD with reference to adjacent rural LULC classes, which are ‘pasture’ and ‘forest’ over (a) Sydney and (b) Melbourne. ...	138

Figure 5.1. (a) Shows the heat wave plot for Friday, Saturday and Sunday (10-12 February 2017), the figure is modified from <a href="http://www.bom.gov.au/">http://www.bom.gov.au/</a> dated 05 Oct 2017;	
(b) Count of days in which Sydney has been in a three-day heatwave during summer, where it can be seen 2017 summer has recorded one of the most of number of days as three-day heatwave after 1991, the figure is modified from <a href="http://www.bom.gov.au/">http://www.bom.gov.au/</a> dated 12 Nov 2018. ....	149
Figure 5.2. Work flow followed for Himawari-8 data analysis. ....	153
Figure 5.3. LST and UHI maps at diurnal scale over Sydney from derived from MODIS 08 day composites (10-02-2017). ....	154
Figure 5.4. Brightness Temperature (BT) results as seen in Himawari-8 data from 01 February to 14 February in 2017 over Sydney region during the heat wave event.....	155
Figure 5.5. (a) Cross plots, the solid line represents the correlation of 0.8305 between Himawari-8 derived LST and MODIS daily LST at 2 pm (b) images of MODIS derived LST and Himawari-8 LST MODIS LST dated 10 February 2017. ....	156
Figure 5.6. Himawari-08 derived LST means plotted from 09 February to 12 February, 2017 over urban, rural, pasture and forest LULC classes in Sydney region. ....	157
Figure 5.7. Normalised LST means from Himawari-8, plotted from 9 February to 12, 2017 over urban, rural, pasture and forest LULC classes in Sydney region. ....	157
Figure 5.8 (a) February 09, 2017 mean LST variation across Sydney urban and adjacent rural LULC classes (10 min gap); (b) LST spatial variations over Sydney region, the black polygon represents ABS urban boundary as extracted from its Mesh	

blocks LULC data (ABS, 2016) (hourly gap); (c) Histograms for urban and its two major rural LULC classes that are forest and pasture (hourly gap). .....159

Figure 5.9. (a) February 10, 2017 mean LST variation across Sydney urban and adjacent rural LULC classes (10 min gap); (b) LST spatial variations over Sydney region, the black polygon represents ABS urban boundary as extracted from its Mesh blocks LULC data (ABS, 2016) (hourly gap); (c) Histograms for urban and its two major rural LULC classes that are forest and pasture (hourly gap). .....160

Figure 5.10. (a) February 11, 2017 mean LST variation across Sydney urban and adjacent rural LULC classes (10 min gap); (b) LST spatial variations over Sydney region, the black polygon represents ABS urban boundary as extracted from its Mesh blocks LULC data (ABS, 2016) (hourly gap); (c) Histograms for urban and its two major rural LULC classes that are forest and pasture (hourly gap). .....161

Figure 5.11. UHI dynamics for February 09, 2017 (a) plot for mean UHI over Sydney urban and adjacent rural LULC classes; (b) images for UHI spatial variations over Sydney region, the black polygon represents ABS urban boundary as extracted from its Mesh blocks LULC data (ABS, 2016). .....162

Figure 5.12. Sydney UHI comparisons, derived from Himawari-8, resulting from the use of different rural class references. (a) plot for mean UHI over Sydney urban and adjacent rural LULC classes for February 10, 2017; (b) images for UHI spatial variations over Sydney region, the black polygon represents ABS urban boundary as extracted from its Mesh blocks LULC data (ABS, 2016). .....163

Figure 5.13. (a) Shows selected suburbs inside Sydney city (red colour polygons), which are 'Blacktown', 'Hornsby' and 'Sydney CBD' as seen in Satellite image of

Landsat-8 dated 08-09-2015; (b) the Himawari-8 derived LSTs recorded on 9 February 2017 with 10 min interval over selected suburbs; (c) the Himawari-8 derived LSTs recorded on 10 February 2017 with 10 min interval over selected suburbs. ....165

Figure 5.14. Shows UHI curve over selected suburbs inside the city of Sydney (a) on 9 February 2017; (b) 10 February 2017. ....167

Figure 5.15. Himawari-8 LST values over urban pixels in Sydney, plotted for the average February 2016 (orange colour) and February 9-13 heat wave event (green colour). ....168

Figure 5.16. Spatial variations in UHI with an hourly gap over Sydney (a) shows the average February 2016; (b) shows heat wave event days (09 – 13 February 2017) as seen in Himawari-08 data. ....169

Figure 5.17. Shows contour plots of UHI (a) on an average February 2016 day; (b) heat wave event days (09 – 13 February 2017) at 2 pm (Himawari-08 data). ....169



## List of Tables

Table 1.1 Examples of satellite and sensor systems relevant to applications. ....	40
Table 1.2 Selected satellite products relevant for urban monitoring studies. Blue, Red, Near-infrared (NIR) and Short-wave infrared (SWIR) indicate surface reflectance values in those wavebands and BT represents satellite brightness temperature.....	42
Table 2.1. Shows statistical significance of histograms.....	79
Table 2.2. UHI values inside city at different suburbs and parks.....	83
Table 3.1. Shows statistical significance and slope values of UHI variance over selected time for Sydney and Melbourne. ....	106
Table 3.2. Shows statistical significance and slope values of LST variance over selected time for Sydney and Melbourne urban and rural zones. ....	109
Table 5.1. Shows the constants given in equation (1) and their values as adopted from technical document, GEOS-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document for Land Surface Temperature by Yunyue et al. (2010). ....	151
Table 5.2. Shows the statistical analysis for selected suburbs inside the city.....	166



## **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.