Land Surface Temperature Analysis by Using Local Climate Zone - Case Studies for San Francisco Bay Area Cities

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Introduction

The study of urban heat island (UHI) effect has long been limited by non-standardized definition and inadequate description of the classification of field sites. To standardize UHI study world-widely, Stewart and Oke (2012) developed a culturally-neutral framework for describing urban morphology named Local Climate Zones (LCZ).

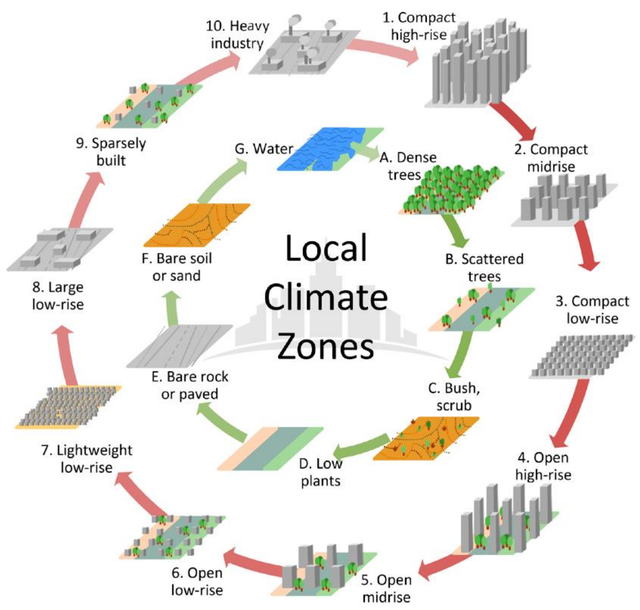

Figure 1. Local Climate Zone Framework (Stewart and Oke, 2012)

There are many studies for evaluating the performance of LCZ scheme by using air temperature data. But the relationship between land surface temperature (LST) and LCZ scheme is still remain uncertain.
The key research question is to investigate whether each LCZ class can portray a characteristic land surface temperature regime.
Two major cities, San Francisco and San Jose, in San Francisco Bay Area were chosen as case studies

Methods and Materials

(1) LCZ maps were firstly extracted following the World Urban Database and Access Portal Tools (WUDAPT) method. (Figure 2)

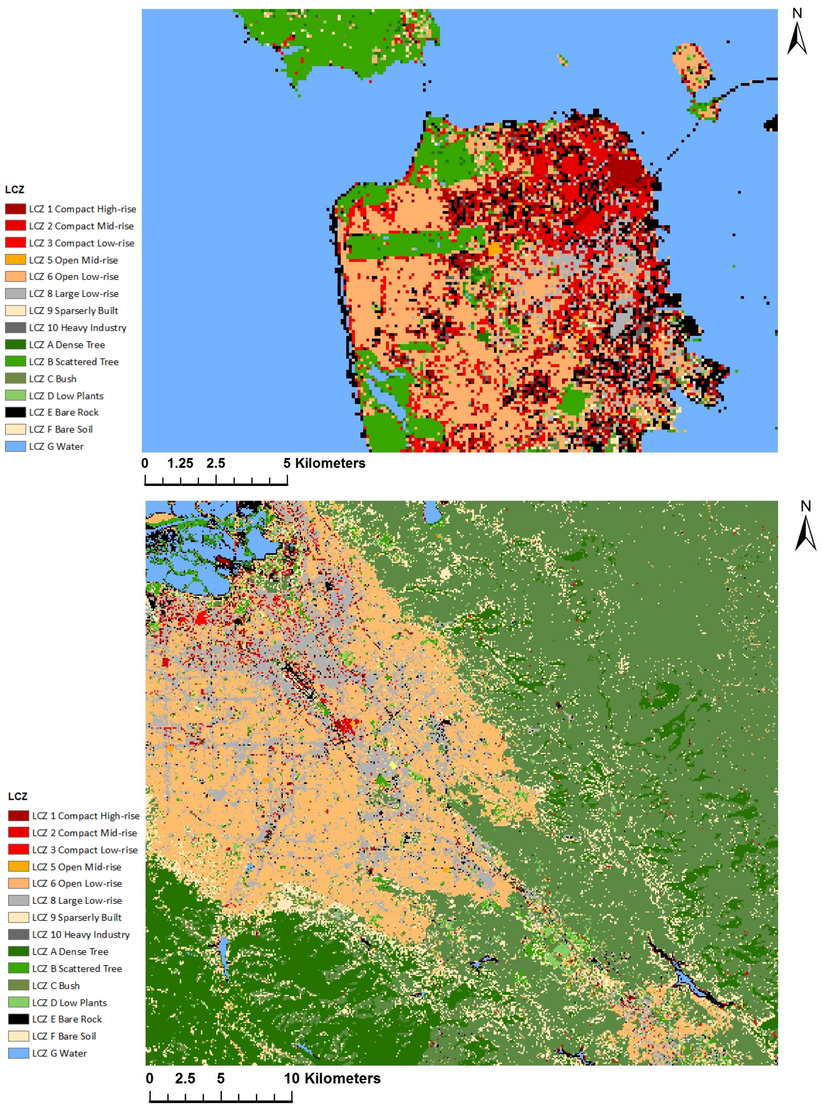

Figure 2. LCZ maps of San Francisco (top) and San Jose (bottom)

(2) Secondly, Landsat 8 images were used for deriving **LST** by split-window algorithm.
In order to analyze the relationship between LST and LCZ, we calculated the LST of two cities in typical summer and winter time from 2015 to 2017, respectively (Figure 3).

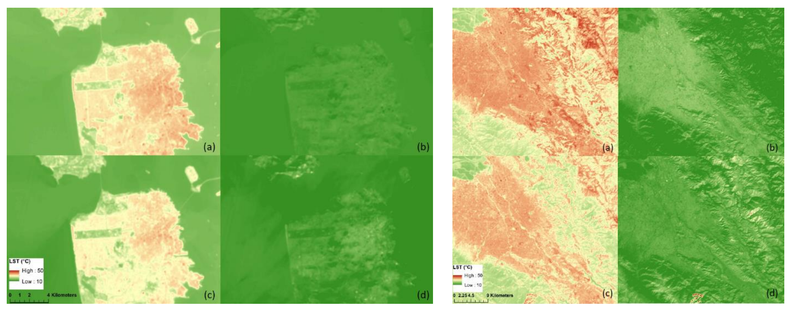

Figure 3. LST map of San Francisco (left) and San Jose (right) (a) summer 2015, (b) winter, 2016, (c) summer, 2017, (d) winter, 2016

(3) To understand the relationship between LST and LCZ, further **quantitative analyses** have been done to explore the relationship between these two parameters.

The **Box-plots** were used as the graphic display method to present the distribution and the range of differences of LST among LCZ categories (Figure 4)

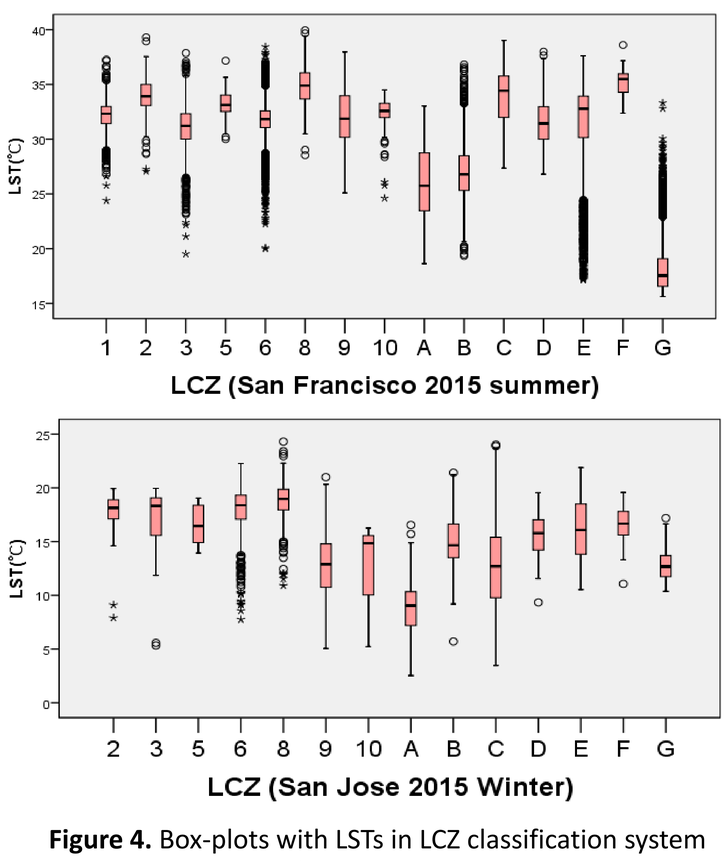

Figure 4. Box-plots with LSTs in LCZ classification system (two samples)

Differences between mean LST of each LCZ class were analyzed by **one-way analysis of variance (ANOVA)** test. When the ANOVA test indicated there is significant differences in LST, the Tukey-Kramer **multiple comparison analysis** was then applied to determine which LCZ classes share similar characteristics of mean LST and which LCZ classes are different.

The results of multiple comparison are presented in matrix format showing if there is statistically significance for each pair (Figure 5).
If the multiple comparison results suggest that there is significant difference between the mean LST of this pair, which is a "positive" result in this research. Otherwise is a "negative" result.

1511	1	2	3	5	6	8	9	10	A	B	C	D	F
1	-												
2		-											
3			-										
5				-									
6	×				-								
8						-							
9		×		×			-						
10				×				-					
A									-				
B										-			
C		×				×	×				-		
D					×							-	
F	×		×	×	×			×				×	-

2015 Winter

82.05% (64/78) of all tests show significant differences

1706	1	2	3	5	6	8	9	10	A	B	C	D	F
1	-												
2		-											
3			-										
5				-									
6					-								
8						-							
9							-						
10	×							-					
A									-				
B										-			
C			×								-		
D			×									-	
F		×		×		×							-

2017 Summer

91.03% (71/78) of all tests show significant differences

Figure 5. Results of Tukey's test for all combinations of LCZs in San Francisco (two examples)

"Although the LCZ concept was originally designed for air temperature, the results of this study proved that different LCZ has different LST features."

Results & Conclusions

The key findings of this study are summarized as follows:

Characteristics can be observed in **Box-plot graphs**:

- Different LCZs show different land surface temperature signatures
- Large Low-rise has the highest LST in built-up categories followed by Compact Building types. Bush & scrub has the highest temperature in natural categories

Results of **ANOVA test** and **multiple comparisons**:

- The feature of LSTs differ significantly between LCZ categories for most of the situation
- Better performance of distinguishing LST of LCZs are found for LCZs that are structurally different
- The sample size of each LCZ category also has influence on final results
- Seasonal differences of LST using LCZ classification scheme can be observed. The temperature differences are more significant in summer and more homogenous in winter

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