An innovative method to investigate the altering urban thermal environment by dynamic land cover change : A case study of Suwon, Republic of Korea

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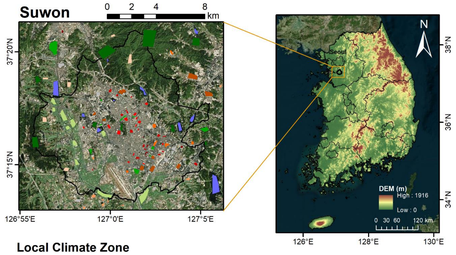
Introduction

- Understanding the impact of dynamic land cover changes on urban thermal environment is crucial as the thermal behavior of a city is related to land cover and urban form.
- Local Climate Zone (LCZ), which has been widely used for urban climate research, can divide urban areas into different types based on height and density (Stewart and Oke, 2012).
- Vertical expansion, the conversion of low-rise buildings to high-rises, is a feasible phenomenon in the process of rapid urbanization (Bounoua et al., 2018). However, many studies have focused on horizontal expansion, which typically involves the conversion of natural land cover to impervious surfaces.
- Furthermore, previous studies that analyzed the urban thermal environment using LCZs may have had uncertainties caused by the low classification accuracy of built types LCZs (OA_{urb}), which falls short of the target 85% accuracy required in remote sensing-based thematic classification (Anderson, 1976).
- We propose an innovative approach to derive reasonable urban thermal behavior by accounting for dynamic land cover changes and ensuring suitable classification accuracy.

Study Area and Data



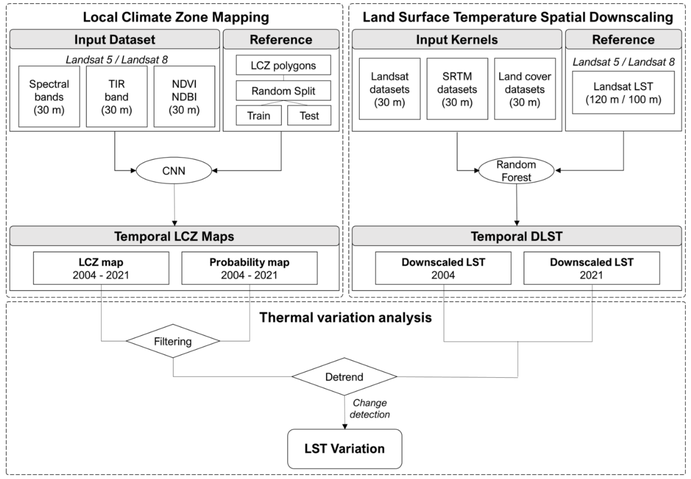
- The study area is Suwon (37°N, 127°E), located approximately 35 km south of Seoul, the capital of South Korea.
- Suwon has undergone **significant urbanization and population expansion**, with a notable increase from around 0.3 million inhabitants in 1980 to 1 million in 2000.
- This led to **extensive land cover changes**, with impervious materials expanding both horizontally and vertically.

Data

Source	Variables	Spatial (Temporal) resolution
Landsat 5	Spectral bands	30 m
	NDVI, NDBI	(16 days)
	Thermal band	120 m
		(16 days)
Landsat 8	Spectral bands	30 m
	NDVI, NDBI	(16 days)
	Thermal bands	100 m
		(16 days)
SRTM	Elevation, Slope, Aspect,	30 m
	Solar radiation, Latitude, Longitude	(-)
Land Cover Map	Percentage of urbanized area, forest area, agricultural area, waterbody	30 m (-)

Methodology

Flow Chart



The overall flow for exploring the thermal impact by dynamically changed intra-urban configuration consists of three main parts: 1) **temporal LCZ classification** using Convolutional Neural Networks, 2) **Land Surface Temperature (LST) downscaling** with Random Forest, and 3) **thermal variability analysis** by LCZ transformation.

Detrend

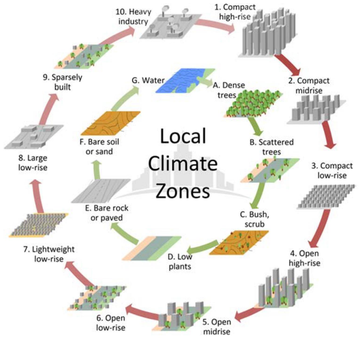
As for annual LST fluctuation, LST difference for the same LCZ class was normalized against all other LST differences using the following steps

$$\bar{\Delta}LST_{ij} = LST_{i(2021)} - LST_{j(2004)}$$

$$\Delta LST_i = LST_{i(2021)} - LST_{i(2004)}$$

$$NLST = \bar{\Delta}LST_{ij} - \Delta LST_i$$

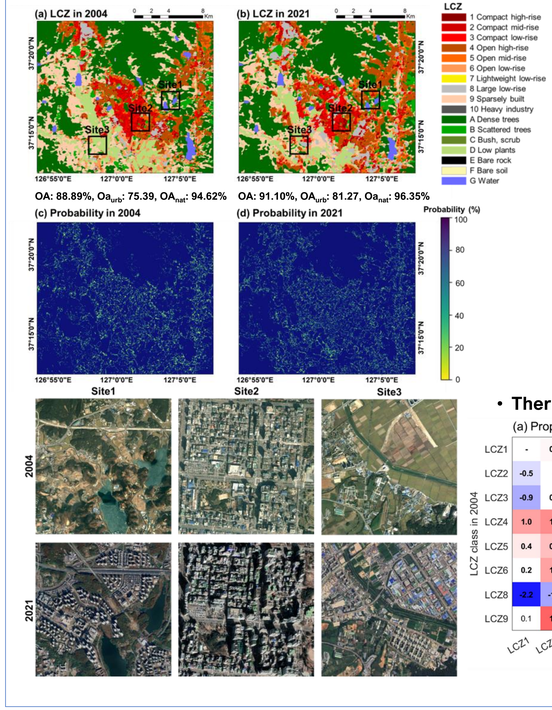
Local Climate Zone



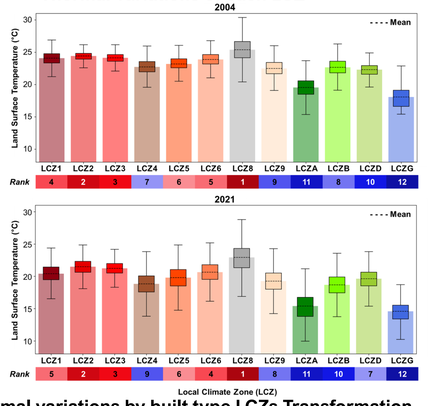
The LCZ scheme from Bechtel et al., 2017

Results and Discussion

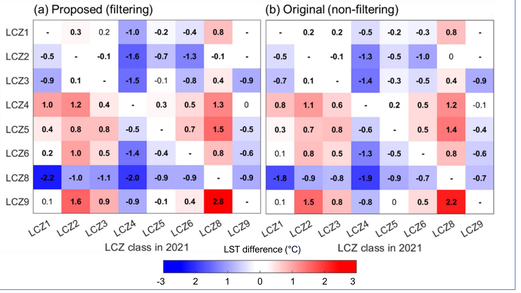
Temporal LCZ maps



Thermal variations of each LCZ



Thermal variations by built type LCZs Transformation



Conclusion

- The **LCZ maps** and spatially **downscaled LSTs facilitated an elaborate investigation** of the dynamic land cover changes.
- Thermal variations of varying intensity were observed, depending on the **height** and **density** of the building conversion within the city. Transition from LCZ8 (all LCZ classes except for LCZ8) to other LCZ classes (LCZ8) indicated the minimum (maximum) thermal variation.
- The application of the **filtering method** proposed in this study **contributed to deriving rational results** in thermal variation by **removing ambiguous LCZs** in classification.
- The proposed novel method is expected to be applicable to other cities and contribute to the advancement of urban thermal environment analysis.

References

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