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Investigating Surface Heat Island in the Pearl River Delta Region and Its Relationship with the Local Land Cover Change from the 1990s to the 2010s

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Abstract: With rapid urbanization, land surfaces have been modified dramatically, mainly converting from pervious vegetated surfaces to impervious surfaces (Mallick, Kant, & Bharath, 2008). Such land cover change can intensify the Urban Heat Island (UHI) effect, which may affect heat-related health impact, especially in summer time. The Pearl River Delta Region (PRD) in China has experienced fast urbanization and prominent land cover changes since the 1980s. However, referring to "the PRD region reform and development plan (2009-2020)", its regional urbanization will continue, and local development will be further intensified. The potential consequences of such high-density urban setting may cause local thermal environment deteriorated. Understanding of the historical local land cover, land surface temperature (LST) changes, and their relationship will help city planners to implement scientific planning. Thus, there is an urgent need to investigate the spatial-temporal variation of surface urban heat island (SUHI) in the PRD region from the 1990s to the 2010s.

According to literature, the influence of land cover change, especially urban expansion, on LST in the PRD region is a popular topic. Notable and uneven urban growth is found to raise the surface temperature in the urbanized area in this region (Qian & Ding, 2005; Weng, 2001). However, these studies are usually based on a rough classification of land use, which is not able to investigate the fine-scale variations. In addition, historical land use data are not readily available in China. The World Urban Database and Access Portal Tool (WUDAPT) provides land use data based on the Local Climate Zone (LCZ) classification system which includes 17 classes, ten (LCZ 1-10) are built types and seven (LCZ A-G) are land cover types. WUDAPT employs free time-series satellite images and machine learning algorithm to generate LCZ maps (Bechtel et al., 2015). Although WUDAPT product was applied to land cover change analysis and climatic modelling, few studies incorporate WUDAPT product into the analysis of LST and its relationship with land cover change.

This study aims to explore the historical LST change and its relationship to local land cover change in the PRD region, based on the WUDAPT product. First, historical LCZ maps and LST maps of this region were generated. LCZ maps were generated by following the WUDAPT method which includes the processing of Landsat images, selection of training samples, and classification by the LCZ classification tool in SAGA GIS (Bechtel et al., 2015). In the meanwhile, based on the 1km-resolution Moderate Resolution Imaging Spectroradiometer (MODIS) images, LST maps in summer time (from June to August) were produced by using the split-window algorithm which has high accuracy, especially over homogeneous land surfaces. Secondly, to illustrate the dynamic conversion among different land use types during the study period, land cover transformation matrix was used in the detection of changing

direction and amount of different LCZ types. Then, Moran' I index, as the common evaluation index for spatial autocorrelation, was employed to detect disperse, random or cluster pattern of different LCZ types in the PRD region. Finally, the relationship between LCZ and LST changes was analyzed by calculating the LST value of each LCZ class from the 1990s to the 2010s.

The results show there are significant land cover and LST changes in the PRD region from the 1990s to the 2010s (Figure 1-2), and land cover change affects LST correspondingly (Figure 3). First, among different LCZs' transformation, there is a constant conversion of areas of natural land cover types into areas of built types. Among built types, compact LCZs (LCZ 1-3) are mainly converted from open LCZs (LCZ 4-6) as well as LCZ D (low plants); for land cover types, transformations occur mainly among different land cover types, and between built types and land cover types. Moreover, spatial autocorrelation analysis indicates that different LCZ types are distributed in a cluster pattern with a strengthening trend from the 1990s to the 2010s. Secondly, LST changes show notable spatial and temporal pattern (Figure 2). Spatially, hot spots are usually located at built-up areas, particularly downtown areas in the PRD region. There are no clear borders in the LST distribution between cities, revealing the formation of a metropolitan region. Temporally, the average LST in the PRD region rises by 1.77℃ from the 1990s to the 2010s. Lastly, the change pattern of LST echoes that of LCZ. LST values of all LCZ types increase during the study period, showing an overall intensified SUHI (Figure 3). Particularly, the LST increase of built types are larger than that of land cover types, and LST differences among different built types become smaller from the 1990s to the 2010s. This finding is consistent with the enlarged built-up areas, especially compact LCZs, and shrunk natural land cover areas.

This study presents an application of WUDAPT product for analyzing SUHI, land cover change, and their relationship. It also proves the impact of land cover change on LST which should be considered when urban planners implement climatic-sensitive planning for the future PRD development.

Figure:

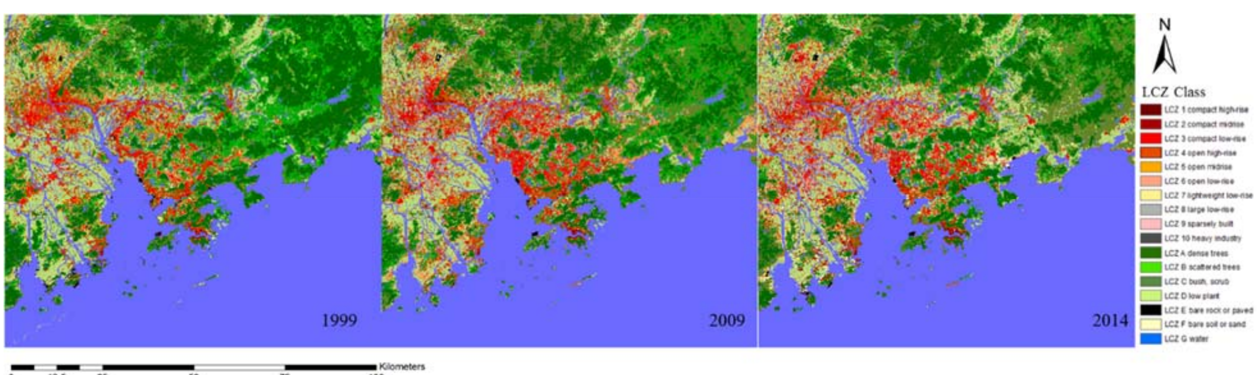

Figure 1. Historical LCZ maps of the PRD region

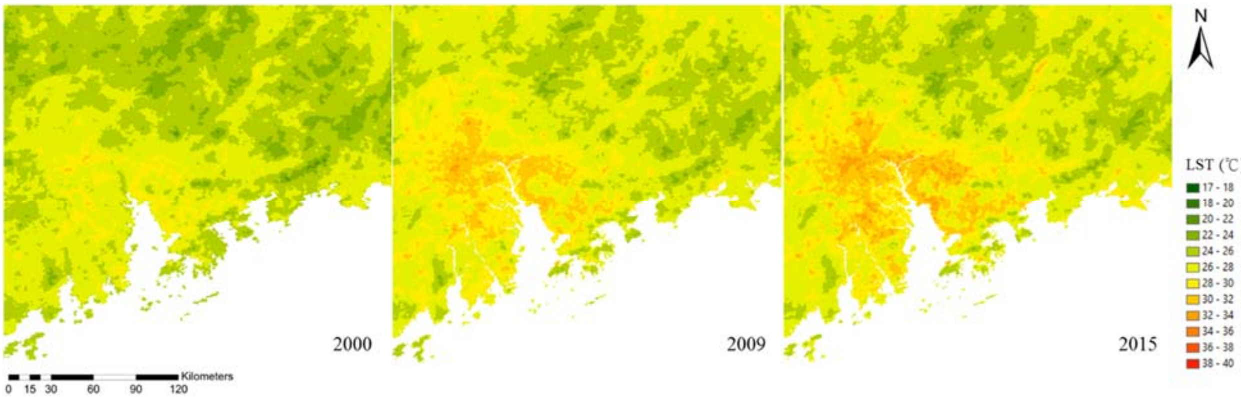

Figure 2. Historical LST maps of the PRD region

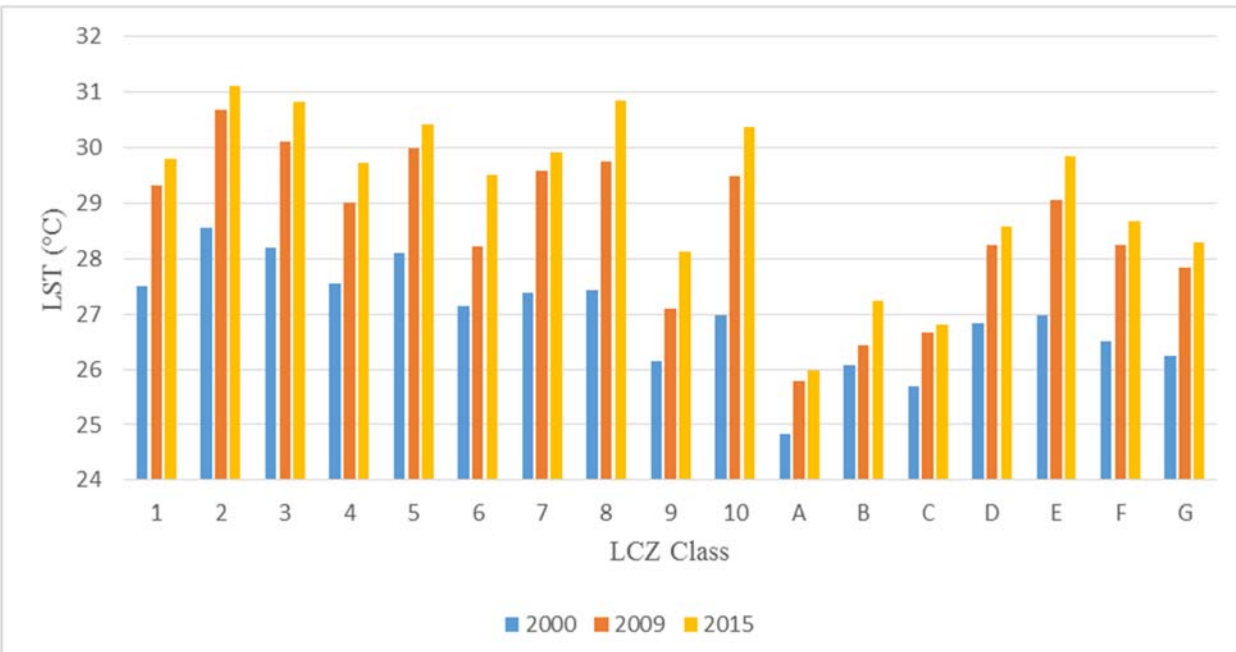

Figure 3. LST values of each LCZ class in the PRD region

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