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Quantifying the cooling effect of urban vegetation by mobile traverse method: A local-scale urban heat island study in a subtropical megacity

Chunhua Yan, Qiuping Guo, Hongyong Li, Linjun Li, Guo Yu Qiu

School of Environment and Energy, Peking University Shenzhen Graduate School, Shenzhen 518055, China

yanch@pku.edu.cn

INTRODUCTION

With the quick expansion of the urban size and population, the urban heat island intensity has rapidly increased and increasing vegetation is considered one of the most efficient ways to mitigate the urban heat island (UHI) effect due to the cooling effect of evapotranspiration. Considering the adverse consequences of the UHI effect on sustainable development and health problems among city dwellers, the effectiveness of urban vegetation on regulation of the UHI effect should be quantitatively evaluated and analyzed to satisfy the needs of urban planning and policy making. Therefore, in this study we analyzed an one-year field experiment data along an 8-km-long belt transect with various land use types and measured the air temperature at 2-h intervals in Shenzhen, a subtropical megacity in China to quantify the mechanism of the cooling effect of vegetation.

MATERIAL AND METHODS

- Mobile traverse observations were conducted along the 8-km transect for two year from July 2011 to July 2013 by an e-bike in continuous motion, at a speed of approximately 15 km h^{-1} (Fig. 1)
- Measurements were conducted at 2-hour intervals each day without rainy events, summed to 7011 repetitions in total.
- Along the transect, vegetated area ratio ranges from approximately 10% to 80%.

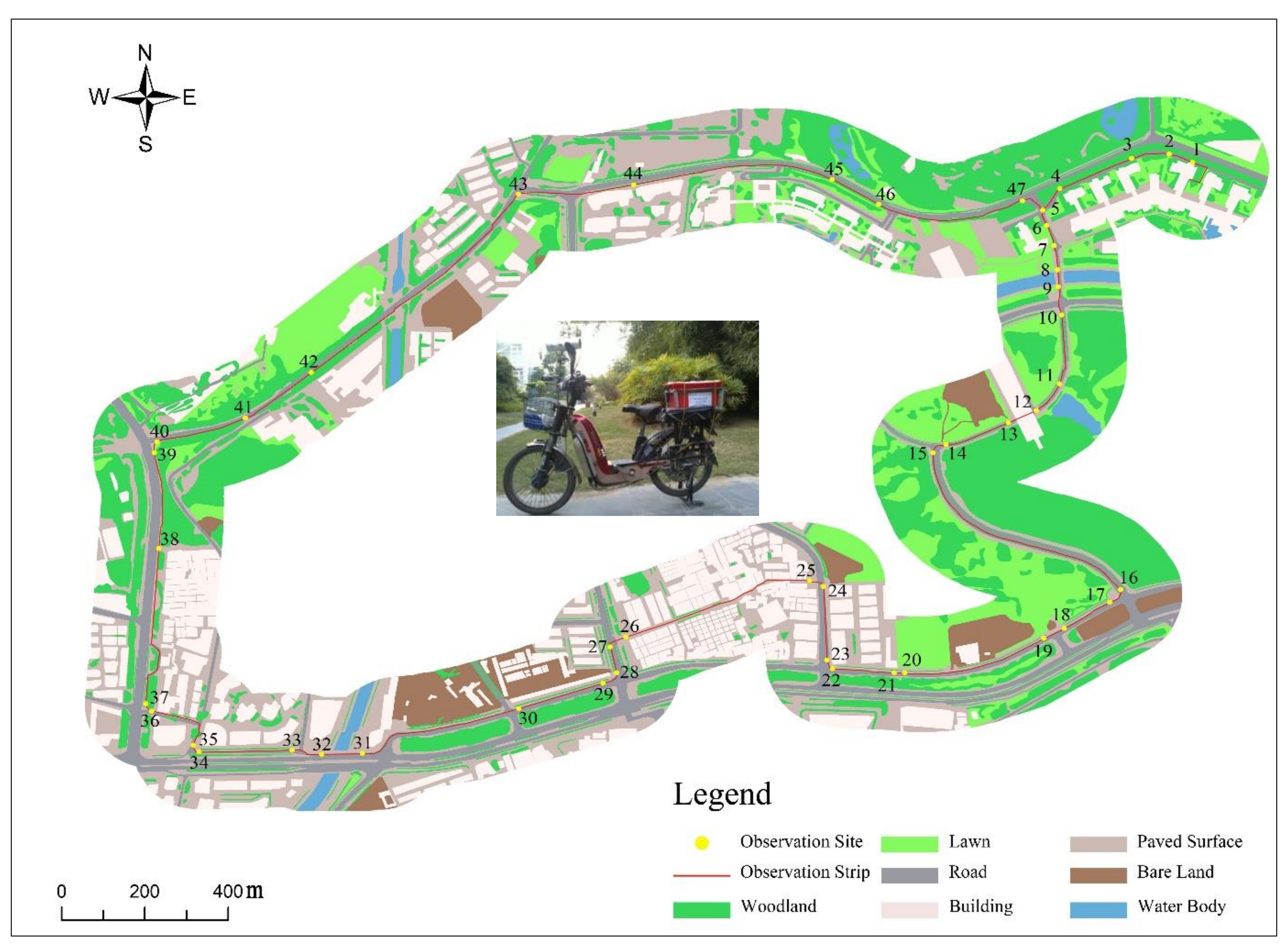

Fig.1. Study area, observation transect and observation sites. The length and width of the transect were 8 km and 300 m, respectively. A total of 47 sites were included, determined according to the similarity of vegetation coverage and land use type.

RESULTS

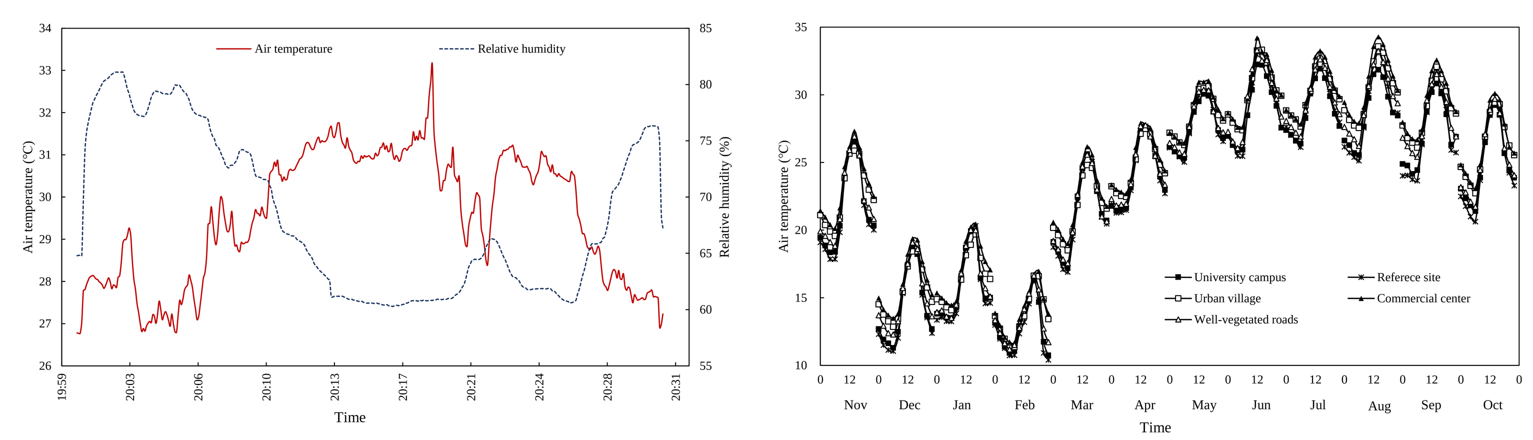

Fig. 2 Characteristics of air temperature and relative humidity along the observation transect during a typical fine day (20:00–20:30, August 24, 2012) (left), and average diurnal variation of air temperatures for five typical land cover types (November 2011 to October 2012) (right).

1. There were similar temperature and relative humidity at the beginning and ending site for each observation (For air temperature, p = 0.995 and for relative humidity, p = 0.17, by the independent samples-T test).
2. The UHII of these five sections vary in the order: commercial center > urban village > well-vegetated road > university campus > reference forest.

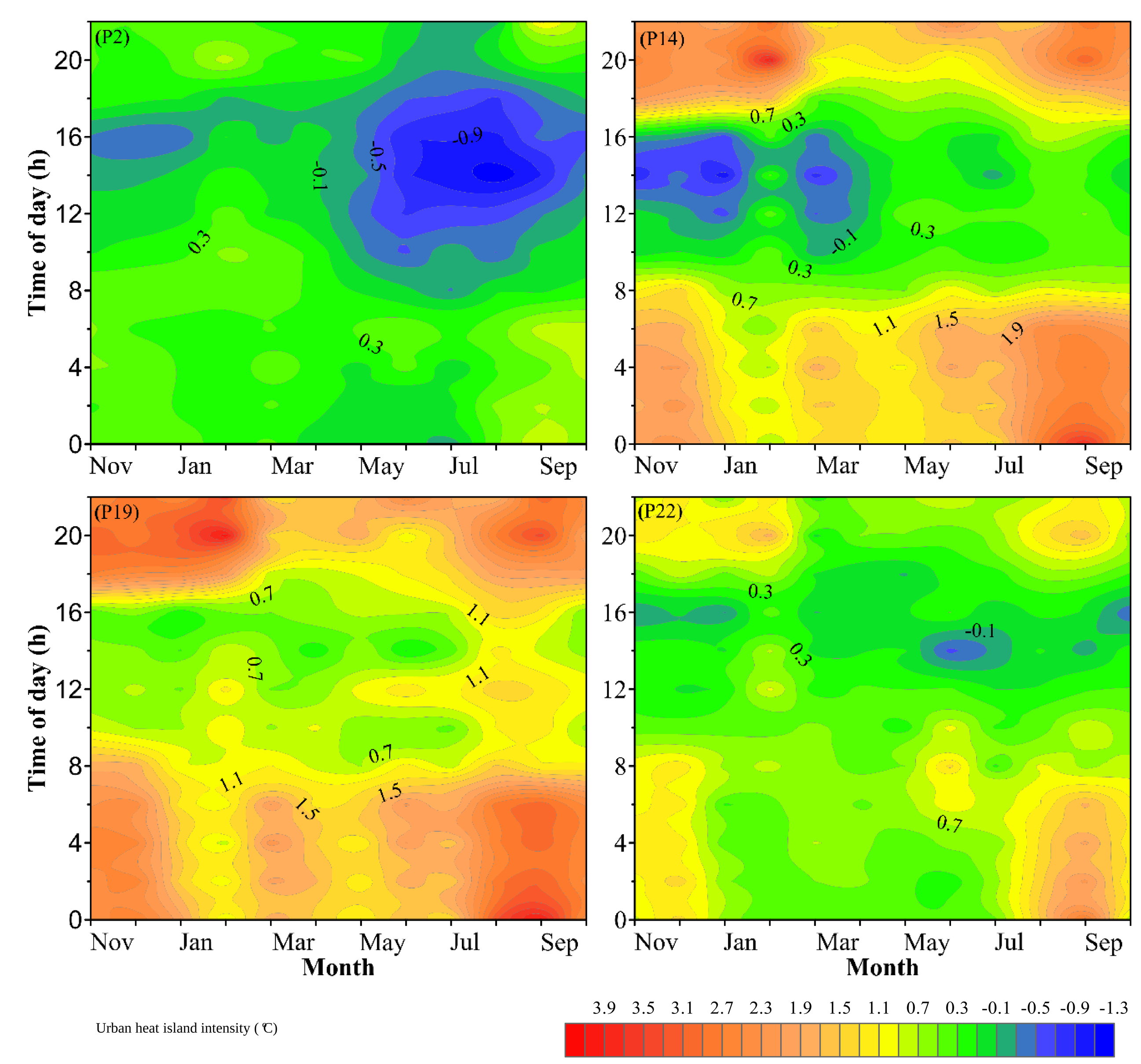

Fig. 3 Diurnal and monthly variation of UHII for different land use types: (a) university campus (P2), (b) urban village (P14), (c) commercial center (P19), and (d) well-vegetated road (P22). The observation period lasted from November 2011 to October 2012.

3. The UHII are generally greater during nighttime than during daytime.

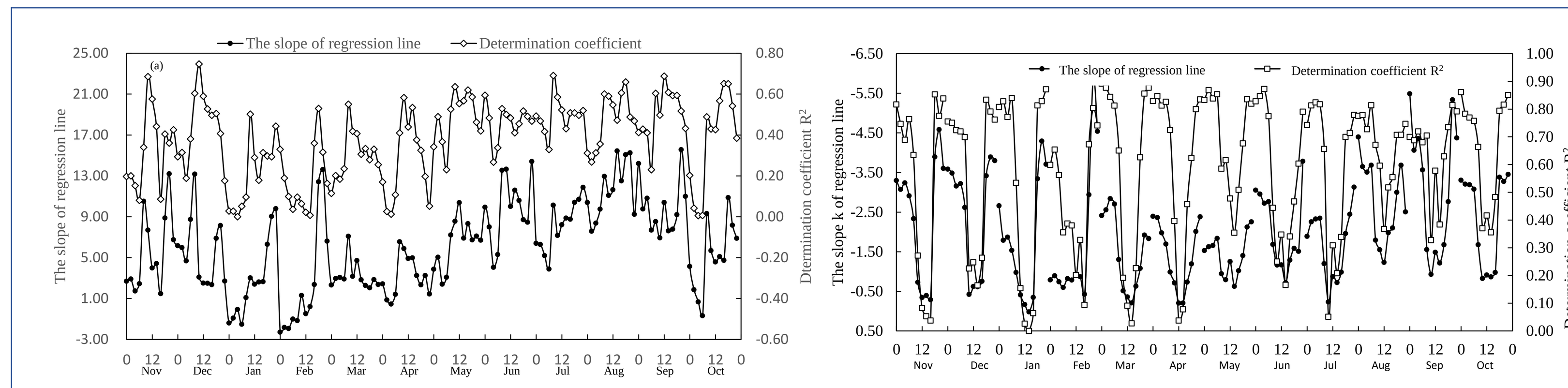

Fig. 4 Diurnal and monthly variations in slope and determination coefficient of the regression line between vegetated area ratio and UHII (left), relative humidity (right).

4. The correlation between the UHII and vegetated area ratio was a good linear fit for the nighttime throughout the year, with the slope ranging from -5.49 to -1.63 and the R^2 consistently higher than 0.70. The slope during daytime ranged from -1.51 to -0.5 and the R^2 were lower than 0.50.
5. During wet season from April to October, there was a higher slope than in the dry season and the positive slope peaked around noontime, which can be possible explained by the higher evapotranspiration from urban lawn and transpiration from urban individual tress

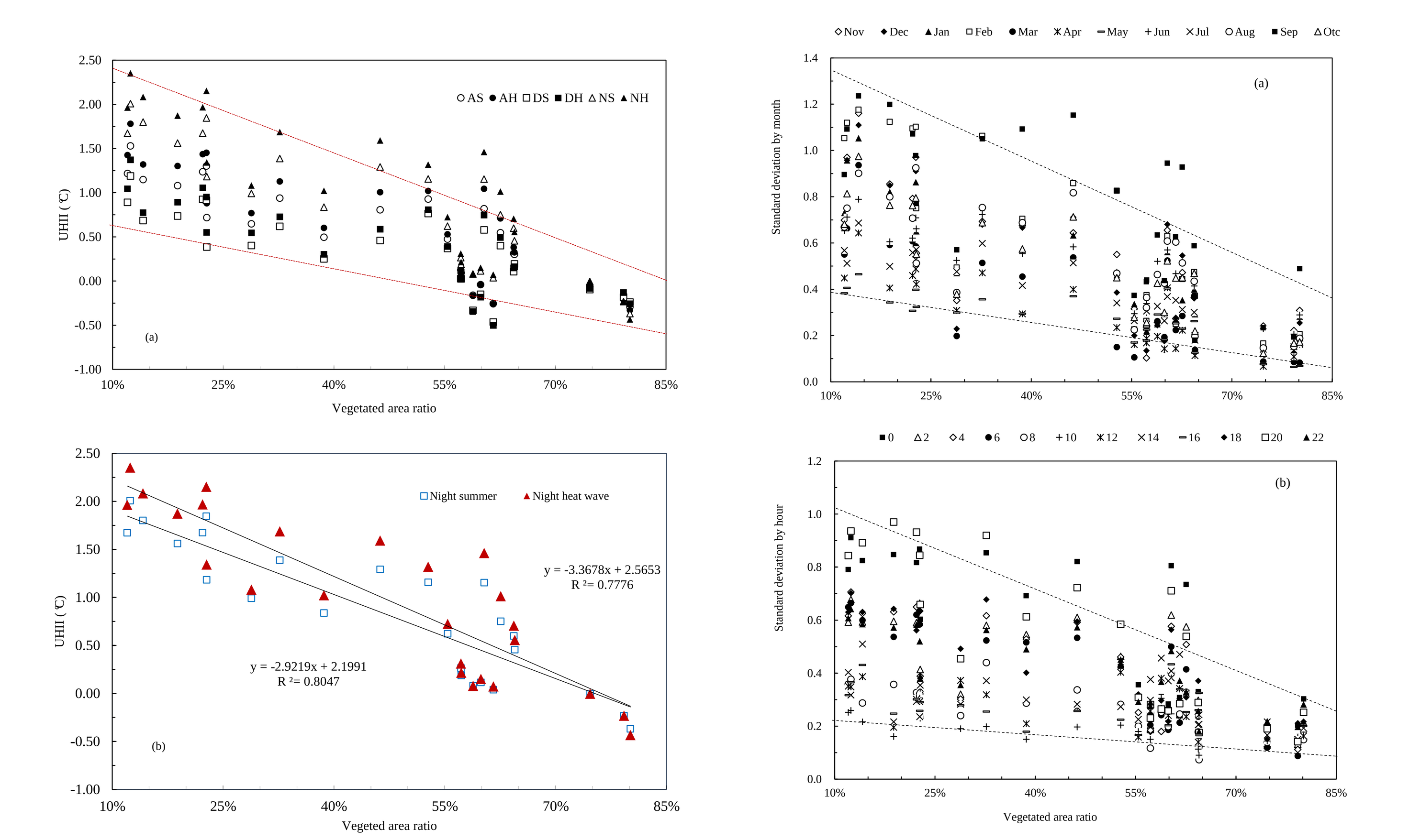

Fig. 5 Relationship between urban heat island intensity (UHII) and vegetation coverage during the hot season (left) and relationships between vegetated area ratio and standard deviation (SD) of UHII (right)

6. An increase in vegetation could significantly reduce air temperature fluctuation, and areas with vegetation coverage greater than 55% could maintain a relative stable thermal environment as the natural land for the dwellers.

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