Assessing the thermal behavior of different local climate zones in the Nanjing metropolis, China

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2018/10/12

Outline

- 1. Introduction
- 2. Materials and methods
- 3. Results and Discussion
- 4. Conclusions

1. Introduction

• Background

- **Urban heat island** (UHI) is defined as the air temperature difference between the urban area and the surrounding rural area.The terms ‘urban’ and ‘rural’ are vague and subjective; Inadequate to describe the complexity and variety of a field site.Has little or no climatological relevance;
- Stewart and Oke developed the Local Climate Zone (LCZ) system. This system aims to provide an objective and standardized classification protocol for urban temperature studies for most cities.
- However, the varieties of climates, weather conditions, urban morphologies, and the LCZ types studied are limited in the previous testing of the LCZ scheme.

1. Introduction

- The purpose of the study
  - To assess the thermal behavior of different LCZ classes;
  - To evaluate the applicability of the LCZ scheme to cities in China using empirical data.

2. Materials and methods

- Study area

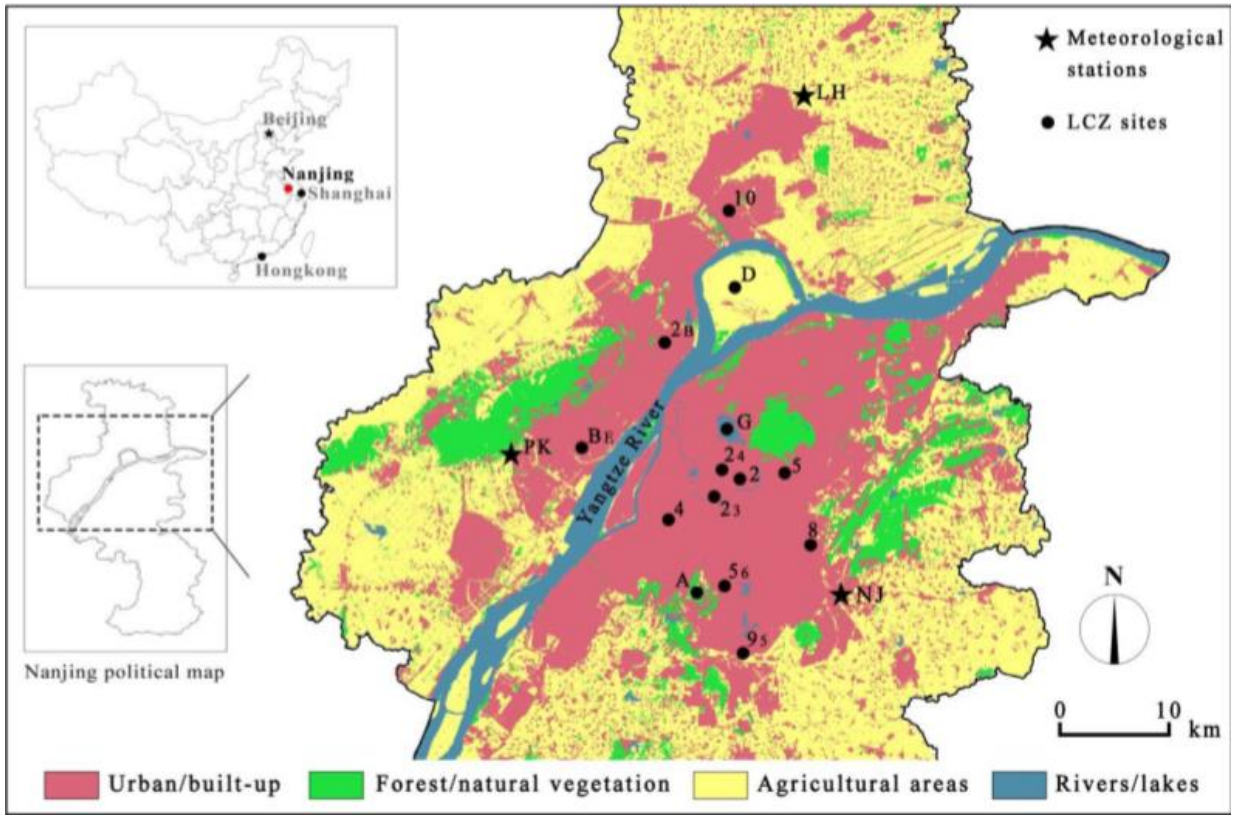


Fig.1. The study area and the locations of the 14 selected local climate zone (LCZ) sites and the three national meteorological stations in Nanjing, China.

2. Materials and methods

- LCZ site selection

  (1)Preliminarily selected by viewing satellite images

  (2) Conducting field visits.

  - The principles :

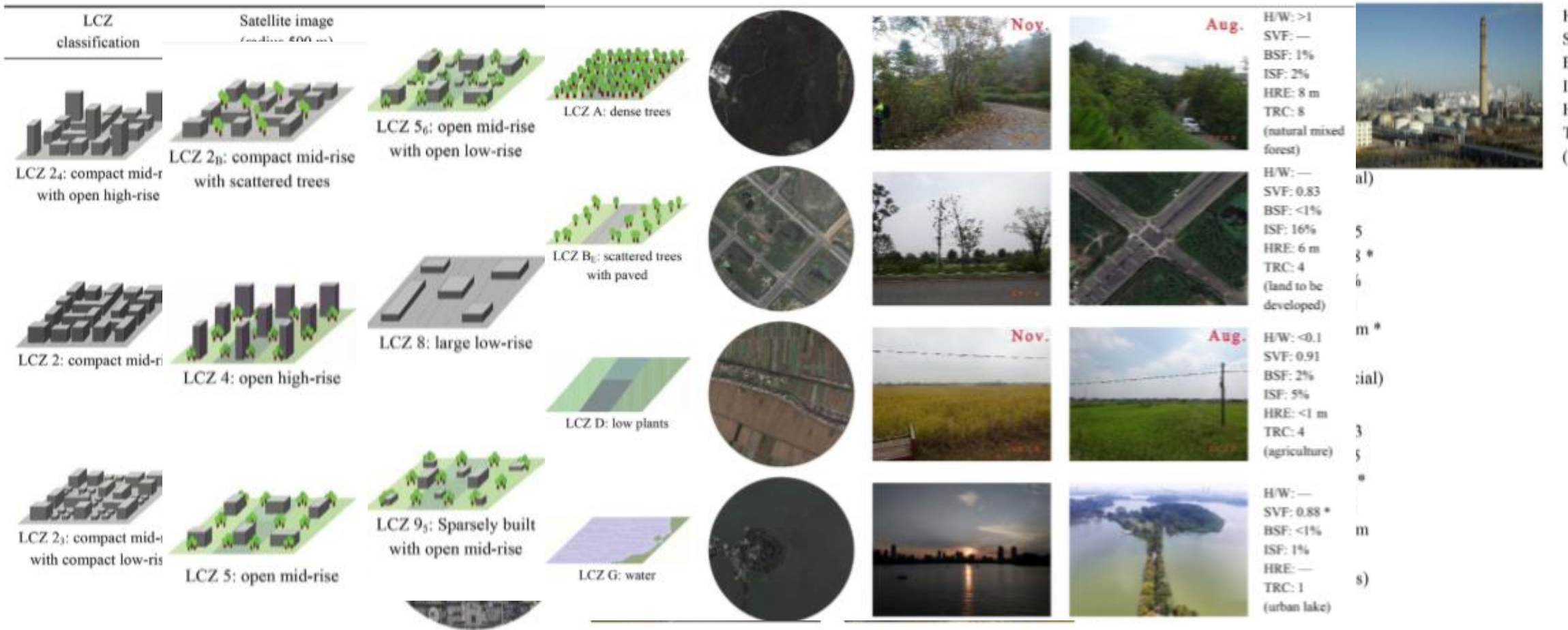
    a) Radius :500m(should be reasonably uniform in surface structure, land cover, construction material, and land function;)

    b) Should be diverse enough to enhance the comprehensiveness of the study.

2. Materials and methods

- LCZ site selection

Table 1
Site metadata for the 14 selected local climate zone (LCZ) sites in Nanjing.



2. Materials and methods

- Air temperature measurement
  - Spatially averaged temperatures (R<100,three points);
  - HOBO U23-001 Pro v2 Temp/RH data logger(keep away artificial heat source and obstacles);
  - Recorded in the internal memory at 1-h intervals;
  - Data collected from July 21, 2016 to August 26, 2017 (401 days in total).
- Identification of ‘ideal’days

$$\Phi_w = u^{-\frac{1}{2}}(1 - kn^2)$$

$\Phi_w \geqslant 0.7$;
with no precipitation in the preceding 24h.

2. Materials and methods

- Temperature-based indices

heat island (HI) and cool island(CI) ($\Delta T_{LCZ\ x-LCZ\ D}$)

$$\mathrm{HIdh} = \sum_{i=1}^{n} (tLCZ\ X, i - tLCZ\ D, i) > 0.5$$ (HI degree-hours))

$$\mathrm{CIdh} = \sum_{i=1}^{n} (tLCZ\ D, i - tLCZ\ X, i) > 0.5$$ (CI degree-hours)

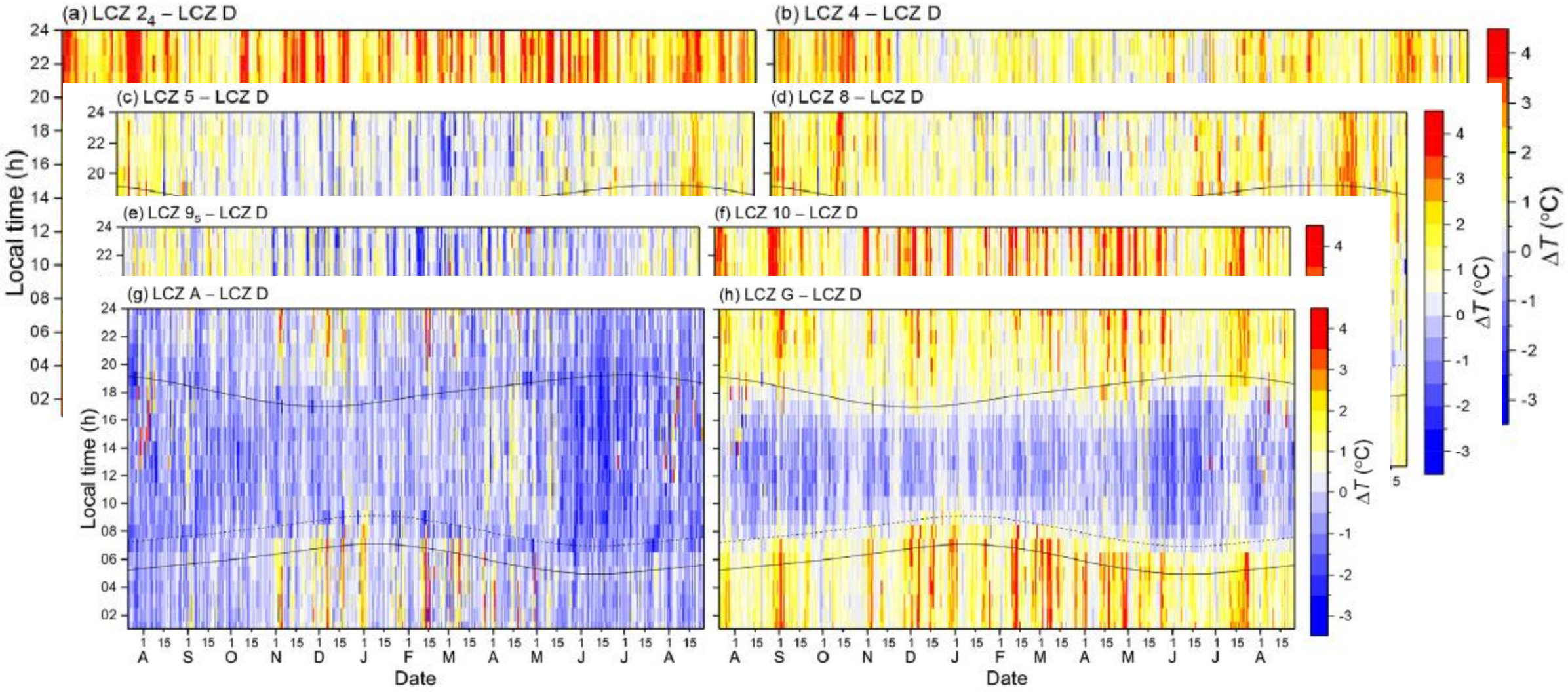
$$HDD18 = \sum_{k=1}^{m} (18 - tLCZ\ X, k) +$$ (heating degree-days)

$$CDD26 = \sum_{k=1}^{m} (tLCZ\ X, k - 26) +$$ (cooling degree-days)

warming / cooling rates (°C /h)

3.Results and Discussion

- Hourly temperature differences



3.Results and Discussion

- Hourly temperature differences

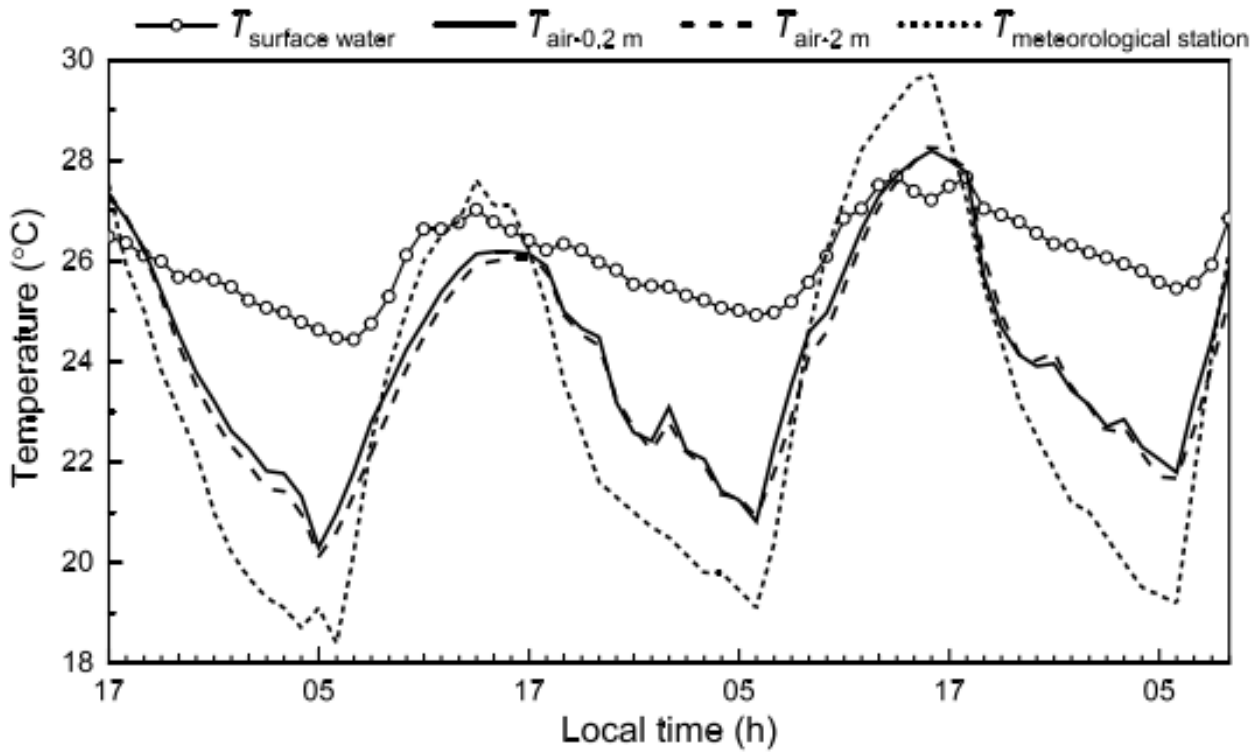


Fig. 3. The temperatures of the surface water ($T_{surface\ water}$), air above water ($T_{air\text{-}0.2\ m}$ and $T_{air\text{-}2m}$) for LCZ G and the air temperature at the suburban national meteorological station ($T_{meteorological\ station}$) from September 15–18, 2017.

3.Results

- Frequencies of heat and cool island events

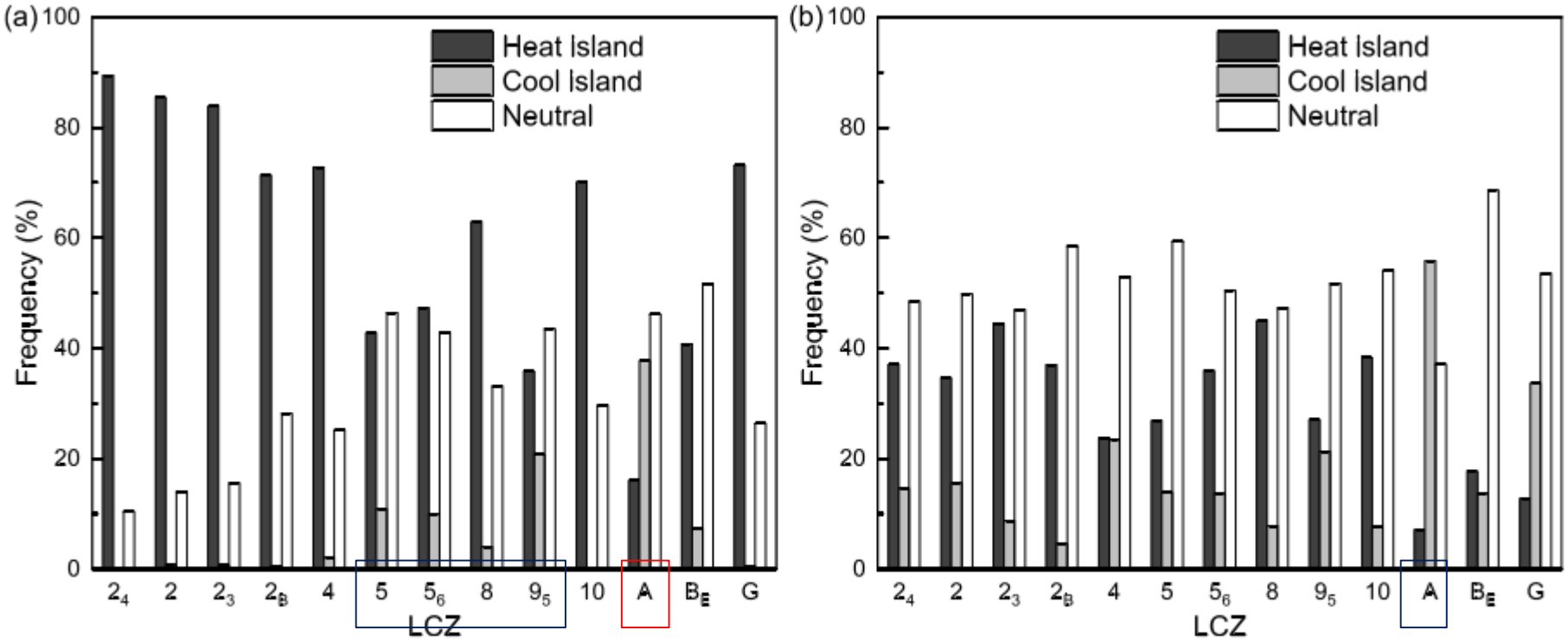


Fig. 6. Frequencies of heat island, cool island, and neutral events for the local climate zone (LCZ) classes in Nanjing for the entire study period (July 21, 2016–August 26, 2017): (a) from sunset to sunrise + 2 h (5471 h in total); (b) from sunrise + 2 h to sunset (4153 h in total). A heat island event is defined as a $\Delta T_{\mathrm{LCZ\ X-LCZ\ D}} > 0.5\ ^{\circ}\mathrm{C}$; a cool island event is defined as a $\Delta T_{\mathrm{LCZ\ X-LCZ\ D}} < -0.5\ ^{\circ}\mathrm{C}$; a neutral event is defined as a $\Delta T_{\mathrm{LCZ\ X-LCZ\ D}}$ within 0.5 °C of zero. See Table 1 for the definitions of the LCZs.

3.Results and Discussion

- Temperature-based indices

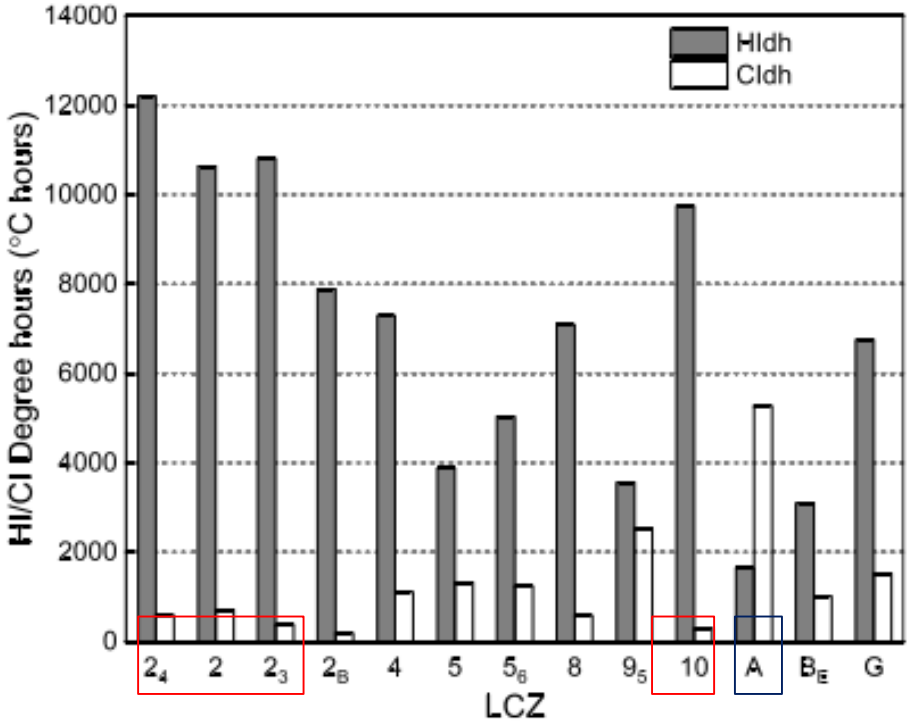


Fig. 7. Accumulated heat/cool island degree-hours (HIdh/CIdh) in the local climate zone (LCZ) classes relative to LCZ D for the period (July 21, 2016–August 26, 2017). See Table 1 for the definitions of the LCZs.

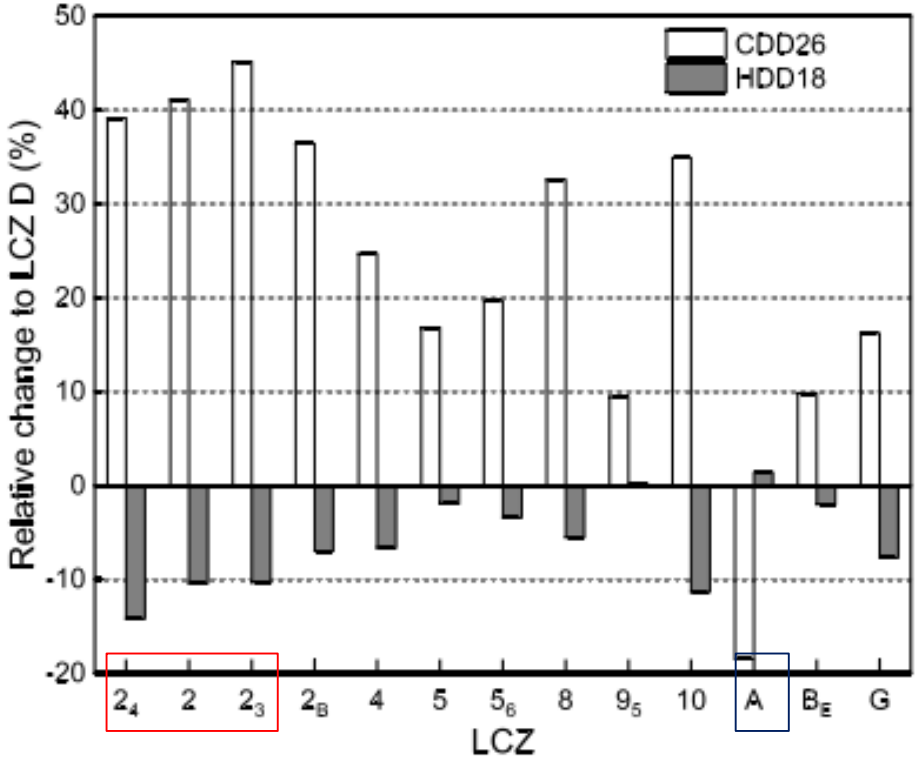


Fig. 8. Changes in values of cooling degree-days (CDD26) and heating degree-days (HDD18) in the local climate zone (LCZ) classes relative to LCZ D for the period (July 21, 2016–August 26, 2017). See Table 1 for the definitions of the LCZs.

3.Results and Discussion

- The hourly temperatures for LCZ D and daily variations of the temperature differences $\Delta T_{LCZ\ X-LCZ\ D}$ for an 'ideal' day of each season in Nanjing.

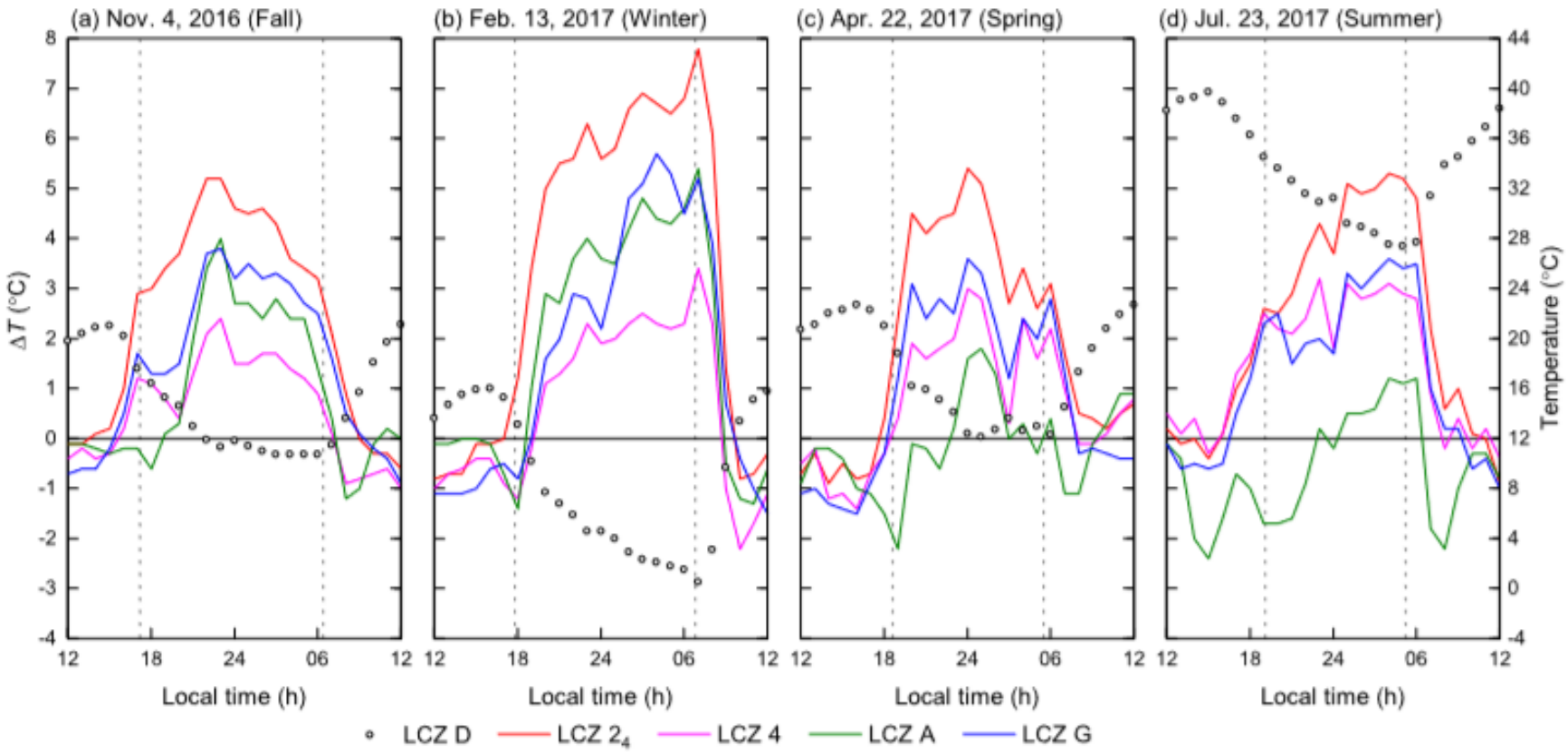


Fig. 11. The hourly temperatures for LCZ D and daily variations of the temperature differences ($\Delta T_{LCZ\ X-LCZ\ D}$) for the four selected local climate zones (LCZs) for an 'ideal' day of each season in Nanjing. The vertical dashed lines represent the time of sunset and sunrise of the day.

3.Results and Discussion

- hourly cooling/warming rates and temperature differences (ΔTLCZ X−LCZ D) averaged for the ideal days.

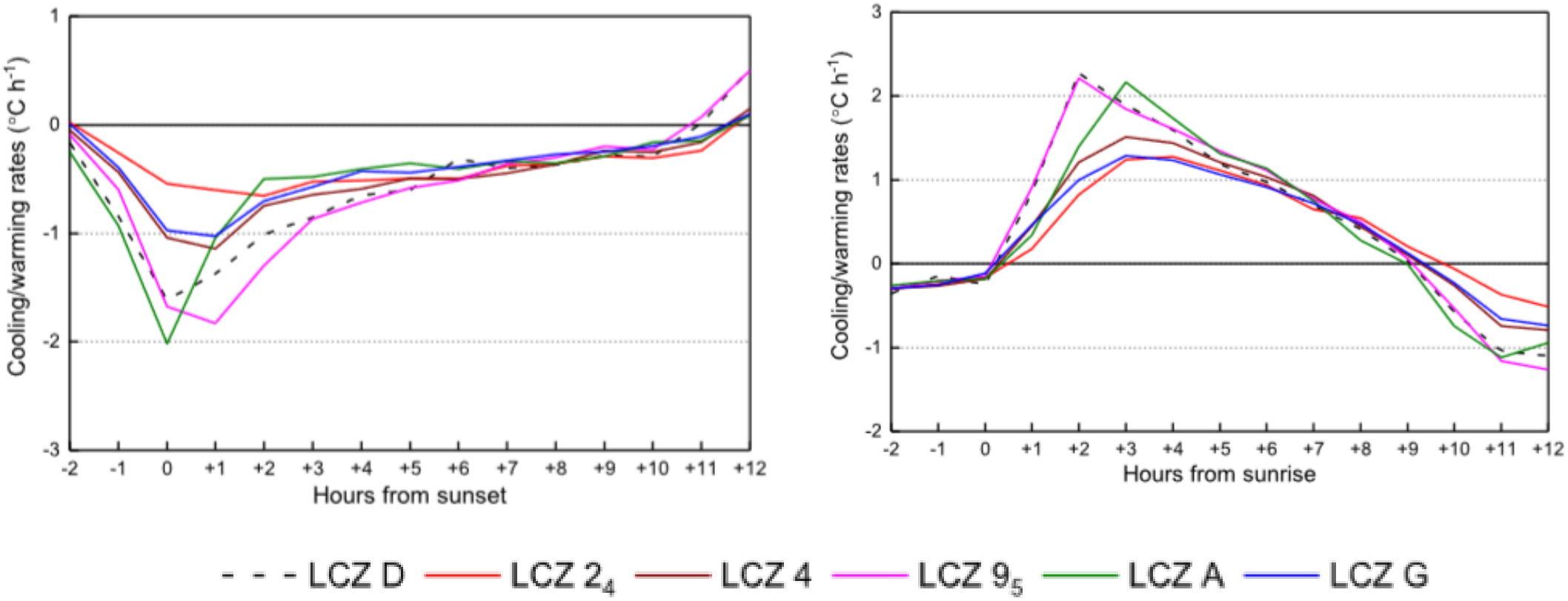


Fig. 12. Nocturnal (from sunset – 2 h to sunset + 12 h) hourly cooling/warming rates(left). Diurnal (from sunrise – 2 h to sunrise + 12 h) hourly cooling/warming rates (right). Times are normalized to sunrise.

4. Conclusions

- Each LCZ class presents a type of distinguishable thermal behavior that is associated with its surface structural and land cover properties;

- Further research should explore the physical mechanisms of temperature differences among LCZ classes;
- The mechanisms of the cool island phenomenon for different categories of LCZs and the timings of maximum heat island intensities are worthy of further investigation.

Thank you!