Adaptive shading: How microclimates and surface types amplify tree cooling effects?

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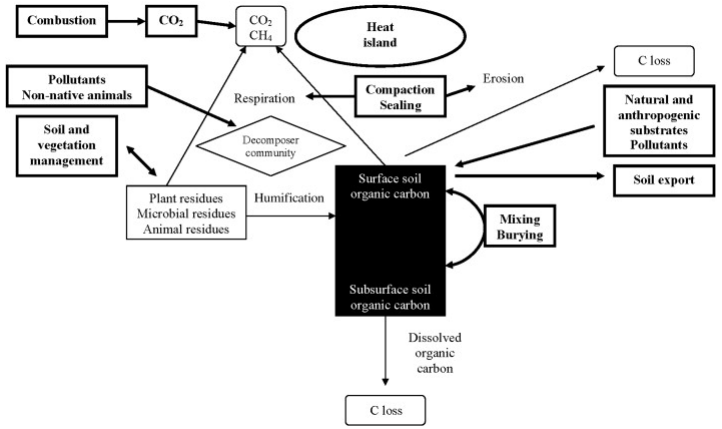
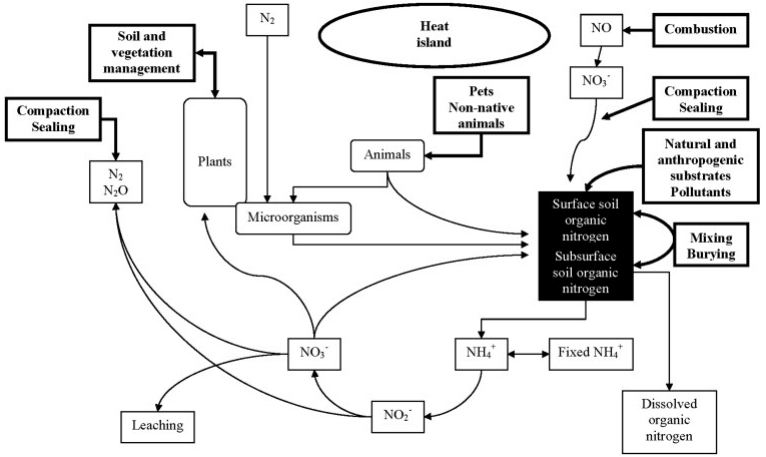
1 Background

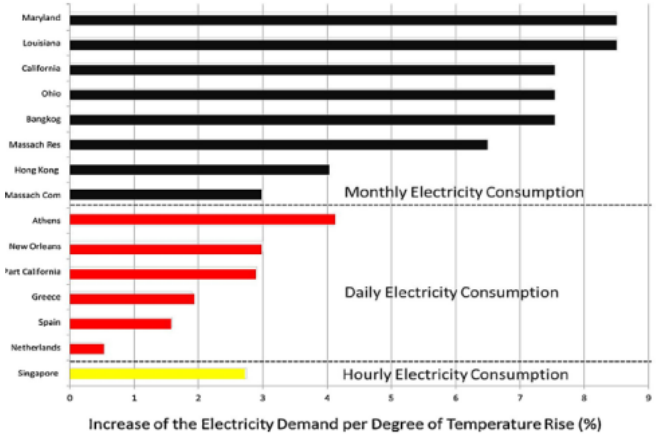
- Sustained deterioration of the thermal environment places significant stress on urban ecosystems

Global cities are warming at twice the rate of the global average

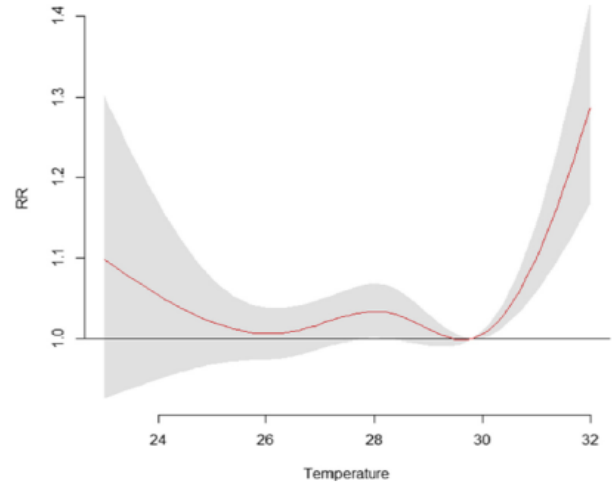




(Lorenz & Lal 2009)



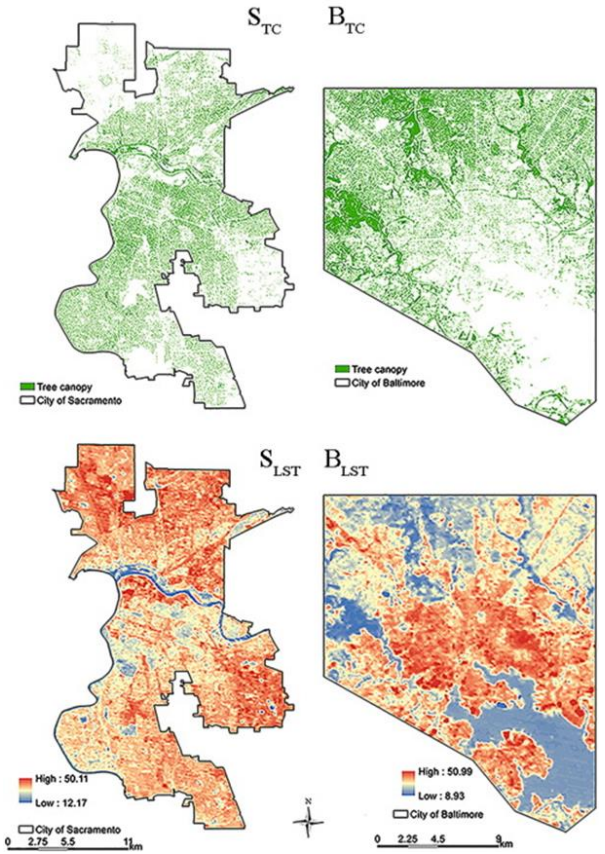
(Santamouris et al. 2015)



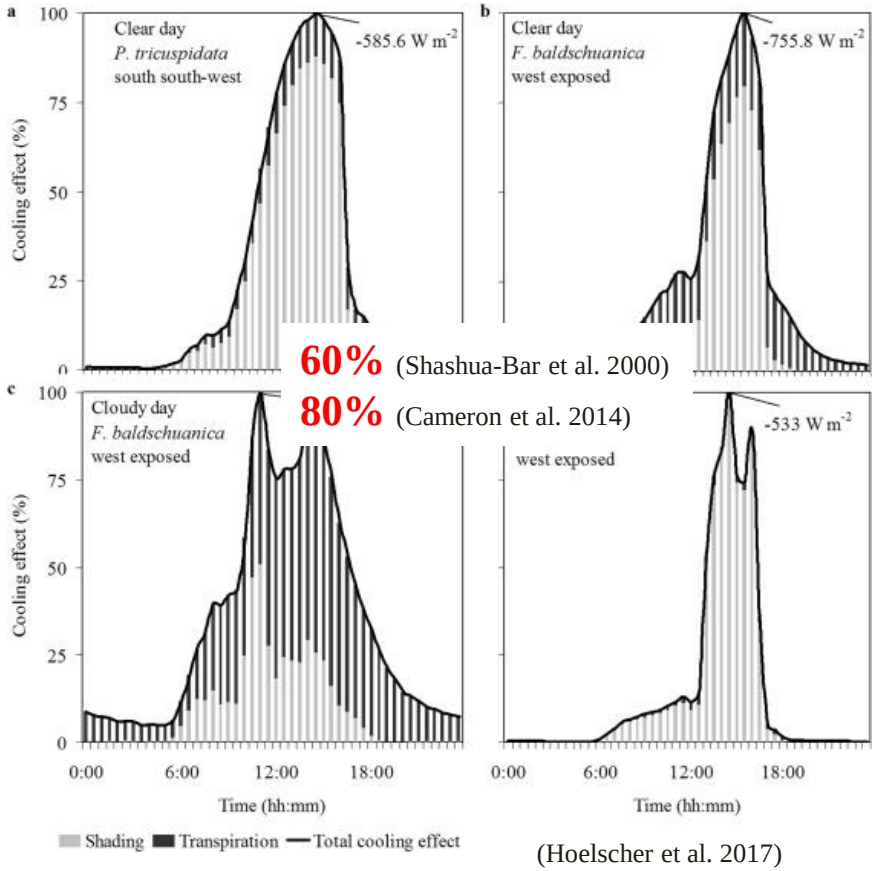
(Dung et al. 2016)

1 Background

- Strategically placing greenspaces to enhance shading may be a key approach to efficiently improving urban thermal environments.



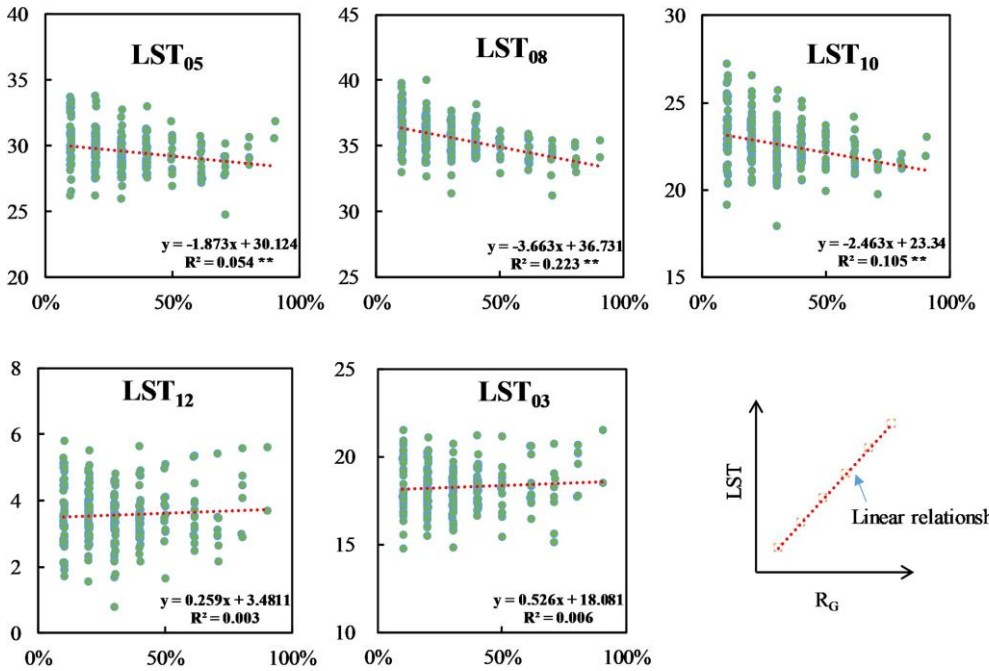
(Zhou et al. 2017)



60% (Shashua-Bar et al. 2000)

80% (Cameron et al. 2014)

(Hoelscher et al. 2017)



(Yao et al. 2020)

✓ Green spaces mitigate heat islands

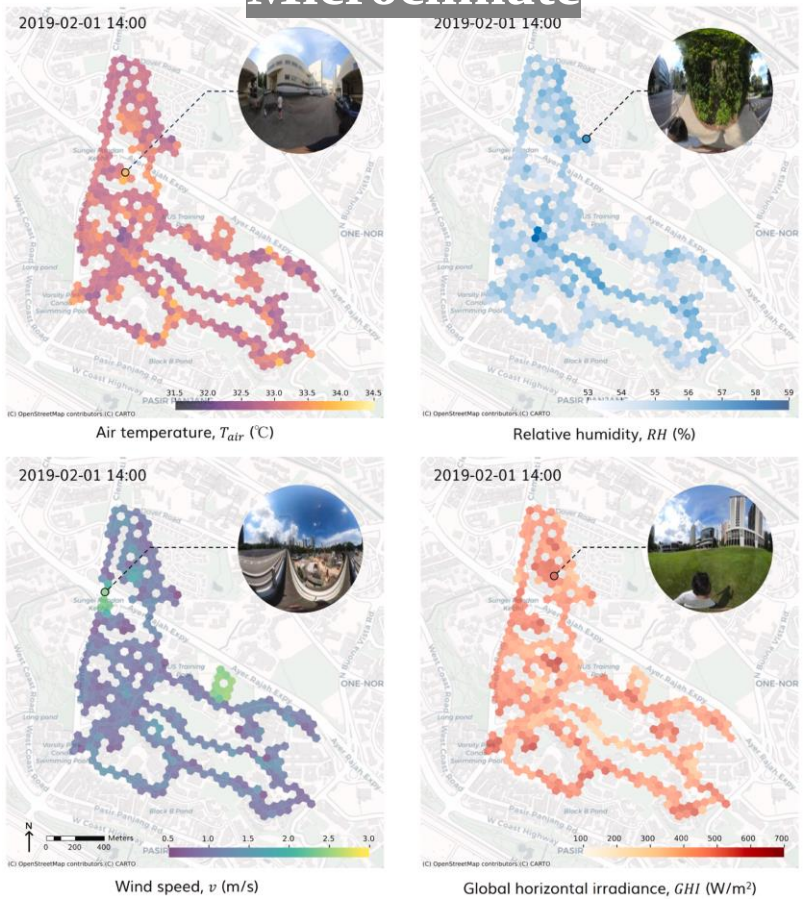
✓ Shading dominates cooling effects

✓ Green space cooling is context-dependent

1 Background

- How tree shading varies with urban space heterogeneity and identifies optimal environments for maximizing cooling efficiency

Microclimate



(Fujiwara et al. 2024)

Land cover

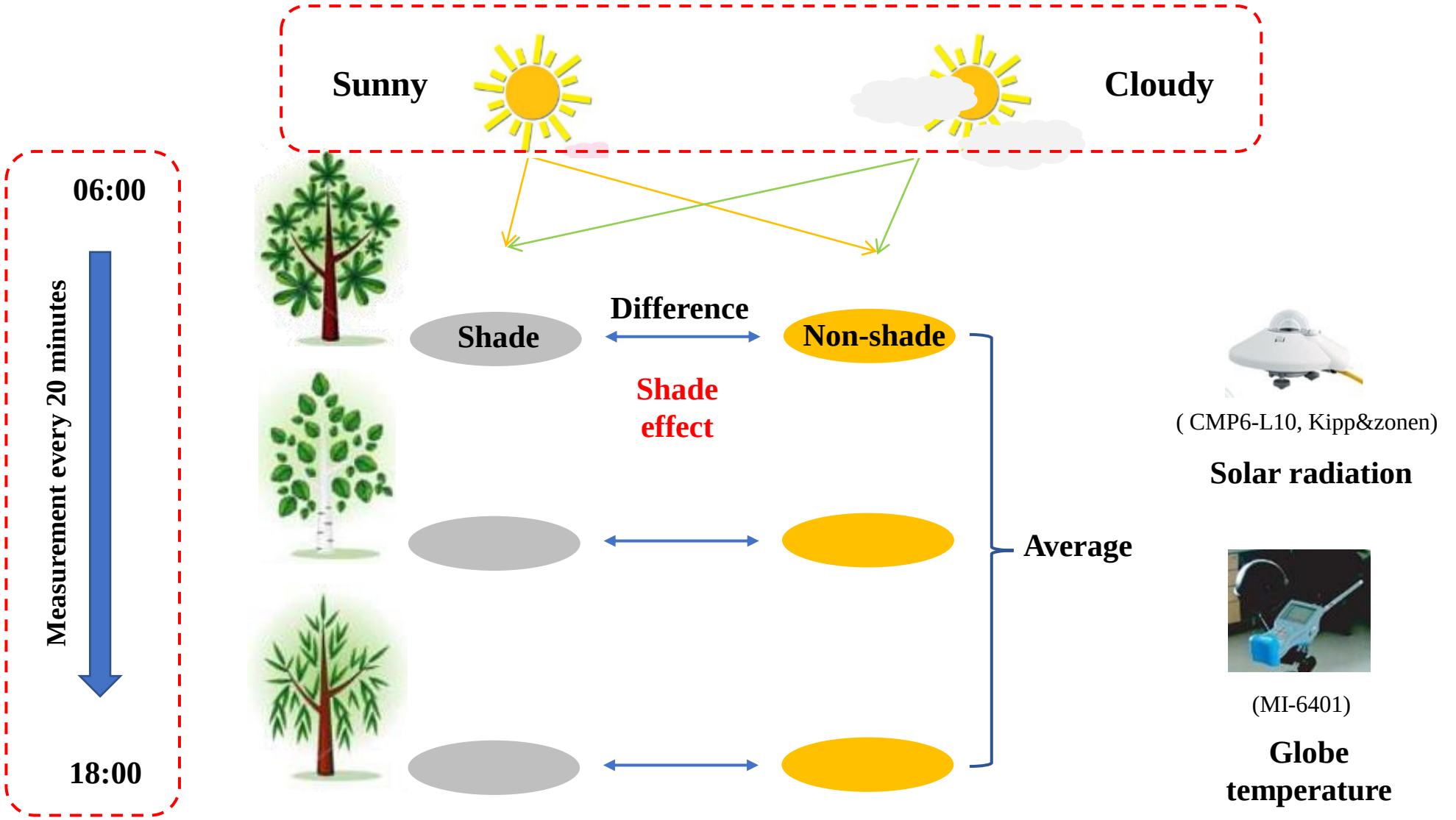

Concrete


Asphalt


Permeable brick

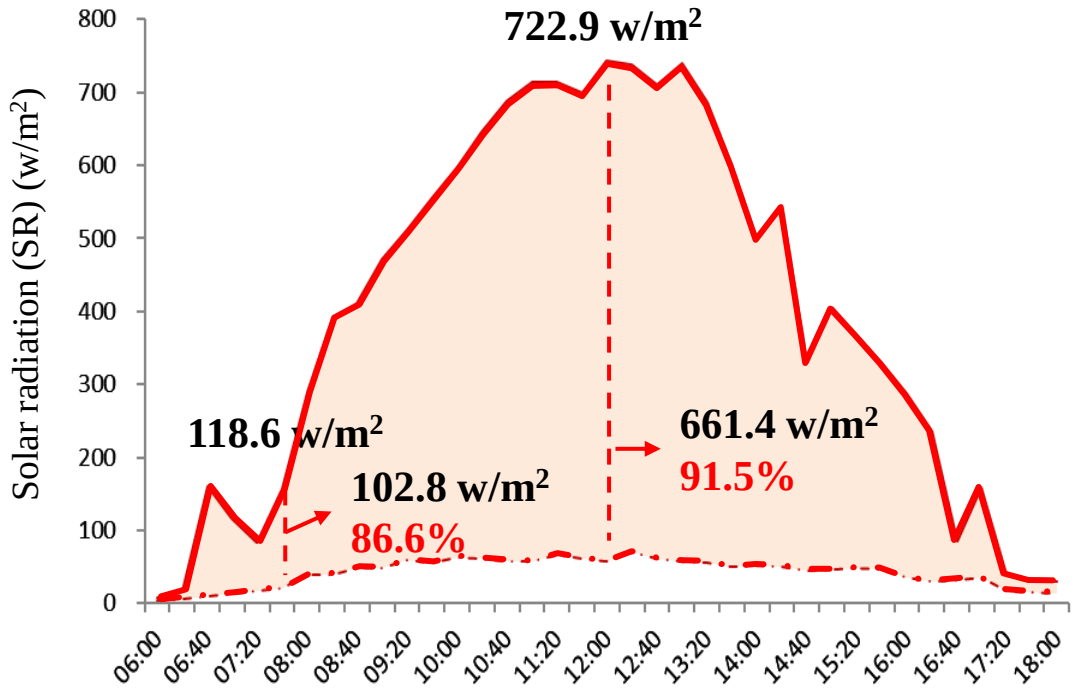

Grassland

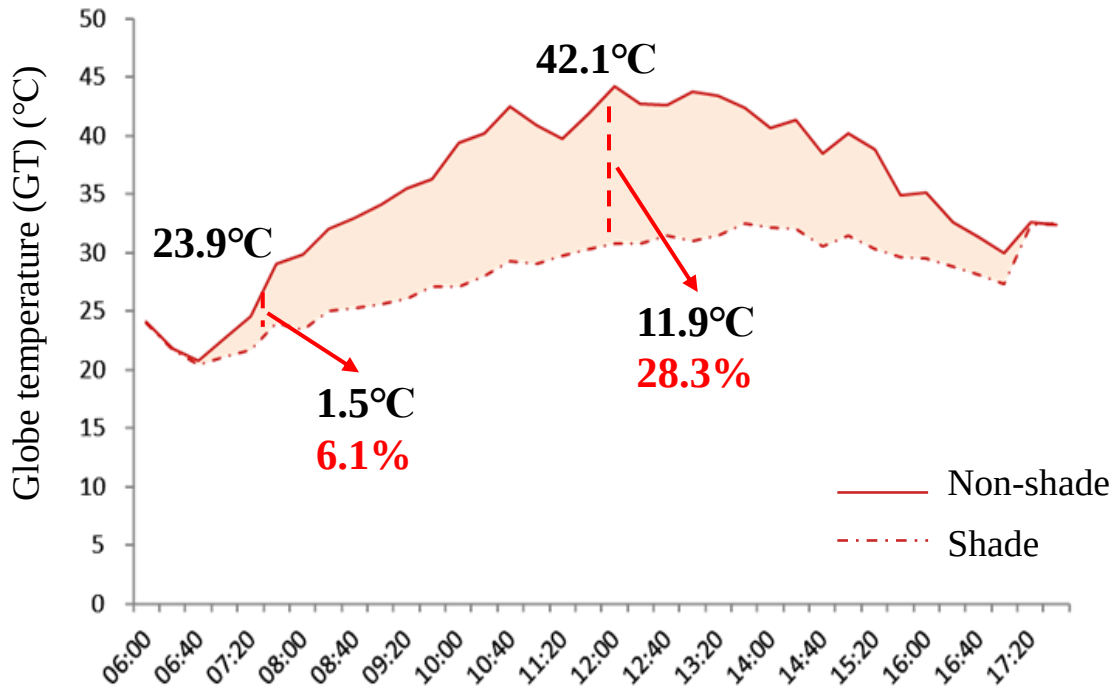
2 **Microclimate-**Dependent Variations in Tree Shade Cooling



2 **Microclimate-**Dependent Variations in Tree Shade Cooling

- Tree shade can effectively improve local thermal environments
- The cooling effect of tree shade is not fixed, it increases with higher external heat stress

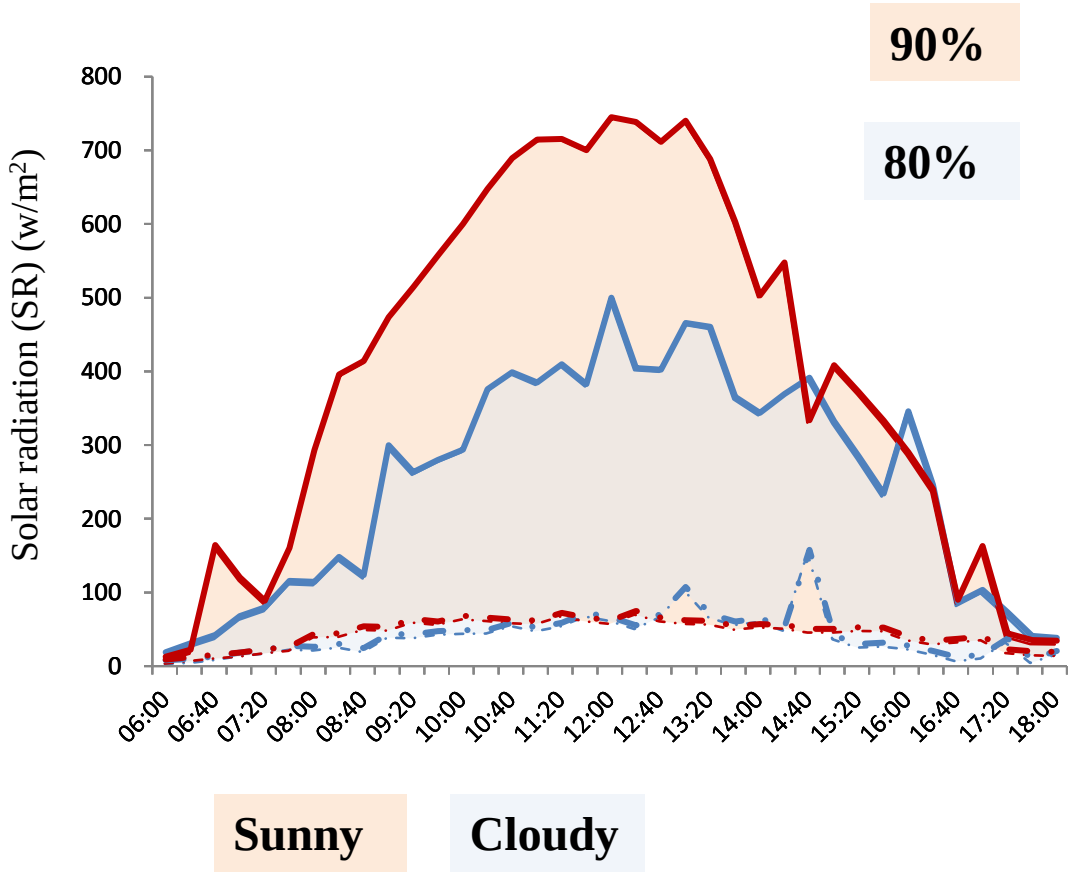


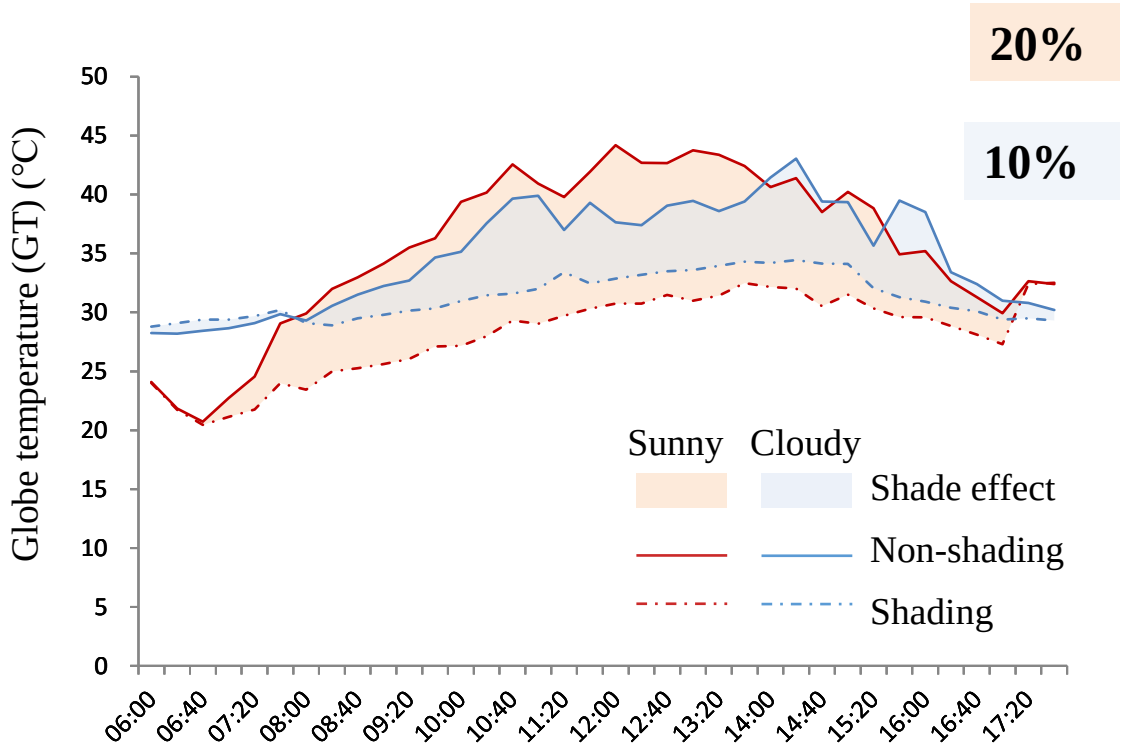


Sunny

2 **Microclimate-**Dependent Variations in Tree Shade Cooling

- Tree-shaded areas remain stable despite extreme external climate fluctuations
- Prioritizing tree shade in areas with higher heat stress can enhance cooling efficiency

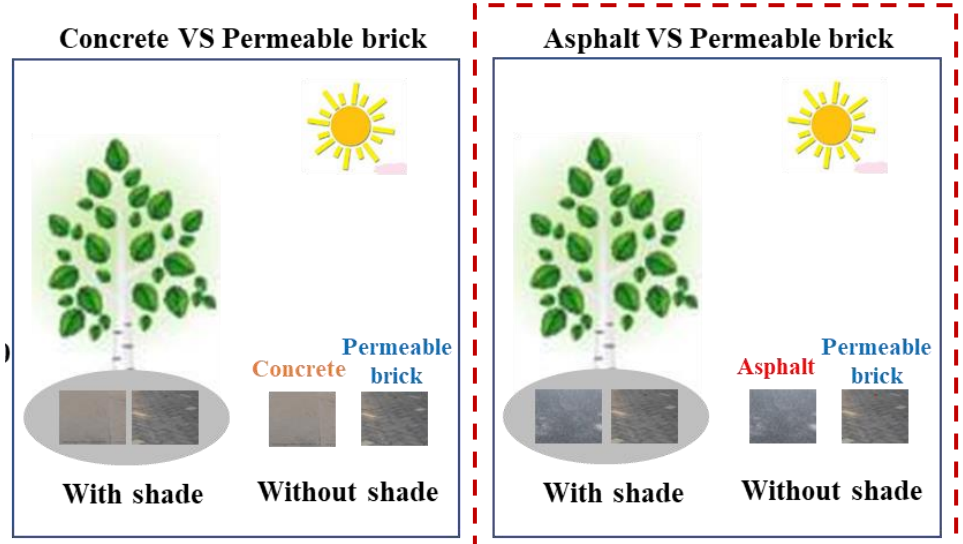


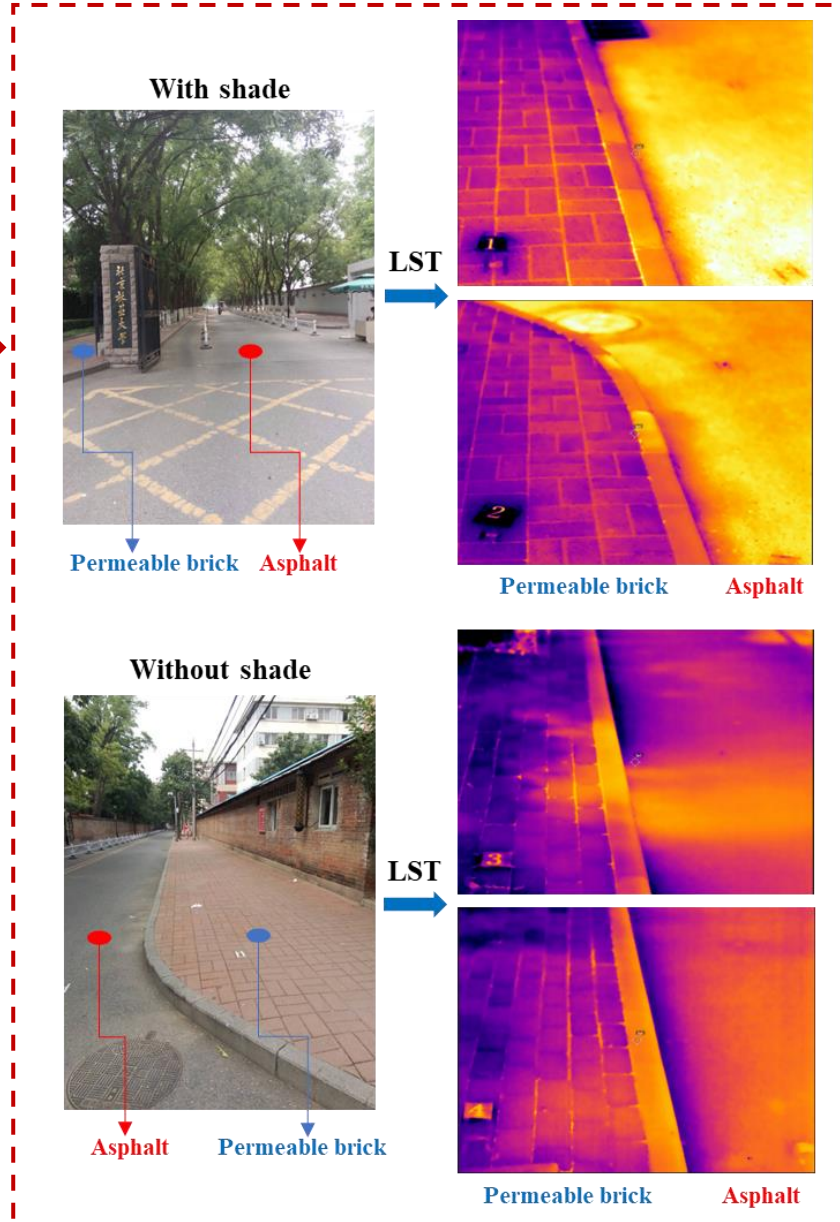


3 Land Cover-Dependent Variations in Tree Shade Cooling

Unattainable Scenarios

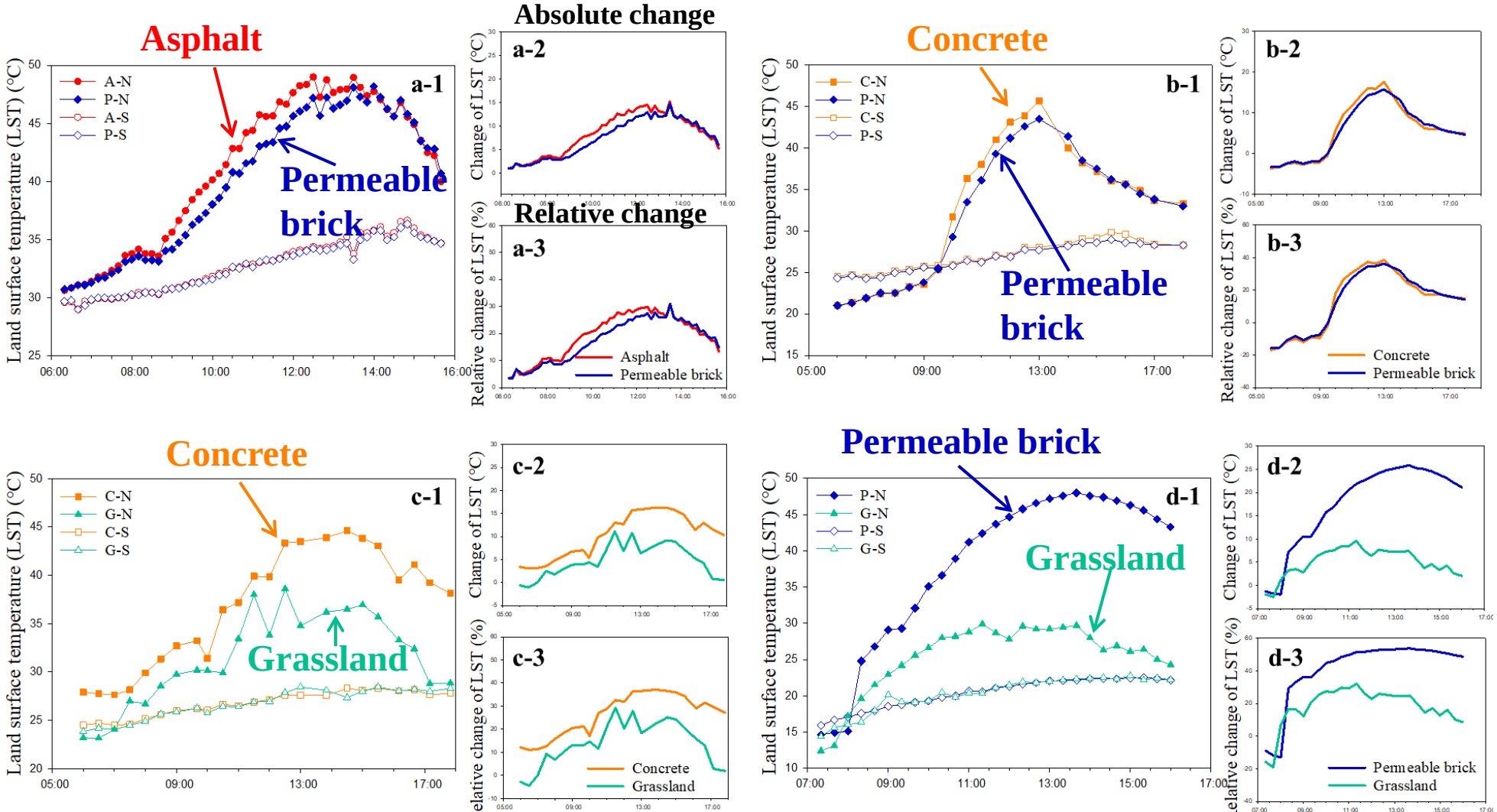
Pairwise Comparison





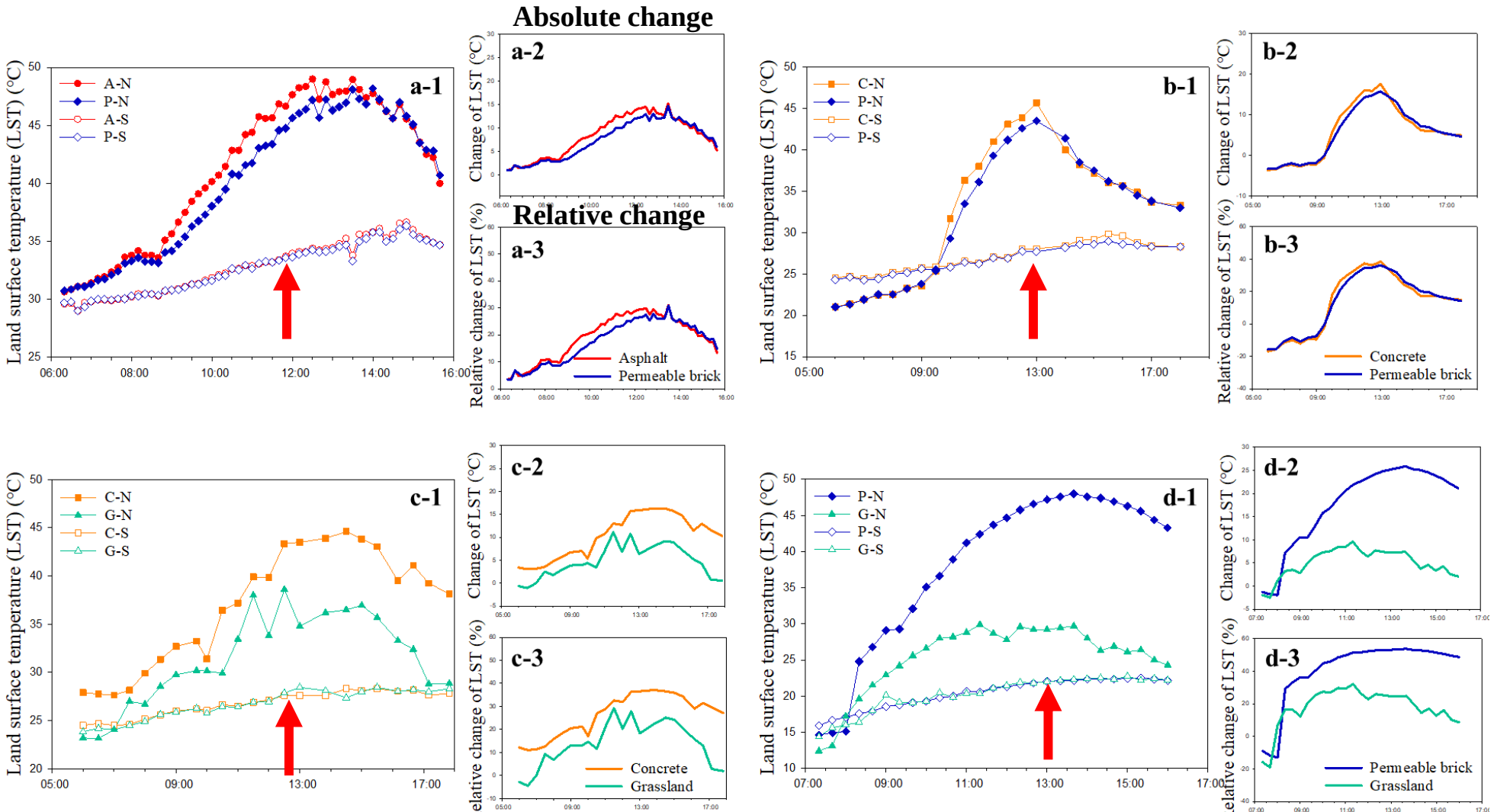
3 Land Cover-Dependent Variations in Tree Shade Cooling

- Asphalt, Concrete > Permeable brick > Grassland
- Tree shade shows higher cooling efficiency on hotter surfaces



3 **Land Cover-**Dependent Variations in Tree Shade Cooling

- In shaded areas, surface temperatures of various land covers, including grassland, were similar



4 Conclusions

- Tree shade significantly improves thermal environment, but with varying efficiency
- The efficiency of tree shade increases with external thermal stress
- Tree shade is more efficient on surfaces with higher temperatures
- Under various conditions, the thermal environment beneath tree shade tends to be stable

Thank you & any questions

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