Outdoor Thermal Comfort within the Rotterdam Agglomeration as influenced by City Design

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Societal Importance

Results of the present study support the development of effective adaptation measures to mitigate the impact of climate change on outdoor thermal comfort in urban areas in the Netherlands.

Research Questions

1. How large are temporal and spatial variability in urban climate and outdoor thermal comfort within the Rotterdam agglomeration?
2. To what extent is intra-urban variability in climate and outdoor thermal comfort determined by building and neighbourhood features?

Methods

Meteorological observations (2010-2012) obtained from the monitoring network (**Figure 1**) were analysed and related to urban features

Figure 1. Locations of the meteorological monitoring stations within the Rotterdam agglomeration

Results

Urban Heat Island

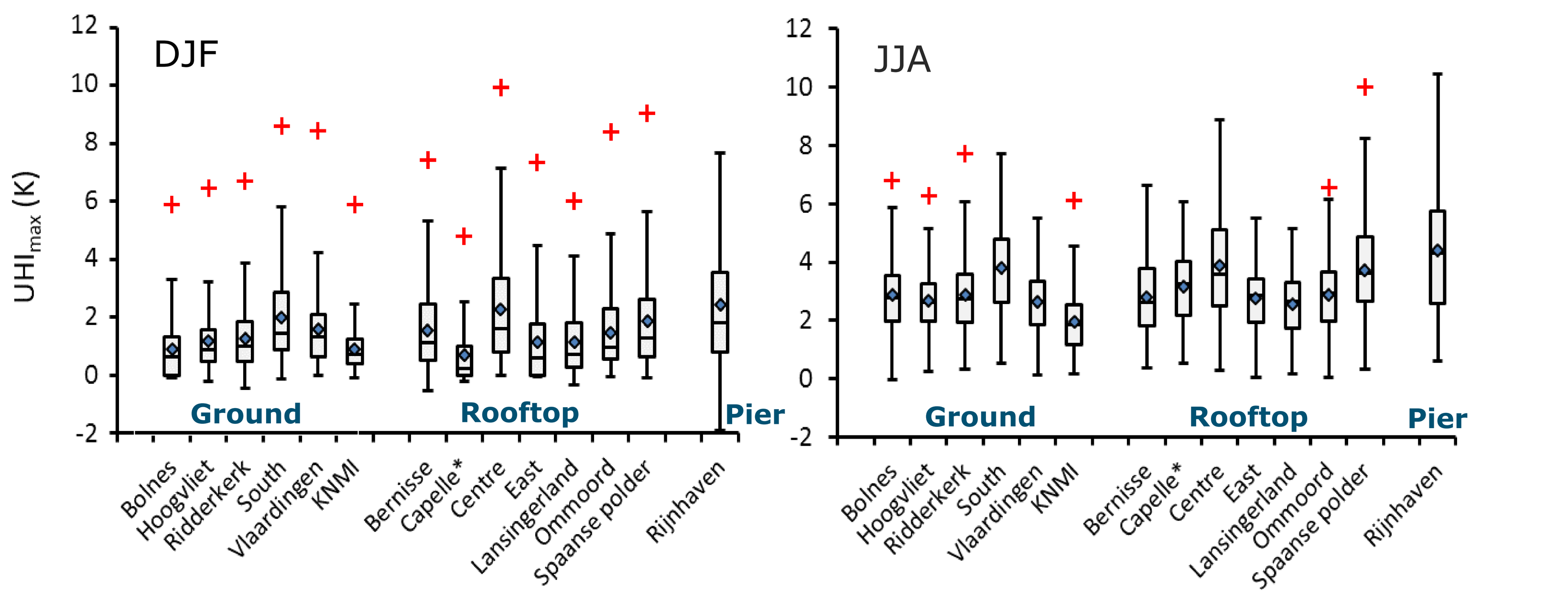

Figure 2. Box whisker plots of UHI_{max} values for December-January-February (DJF) 2010/2011, 2011/2012 and June-July-August (JJA) 2010-2012. * Limited dataset; ♦ Average value,+ Outlier.

Outdoor Thermal Comfort

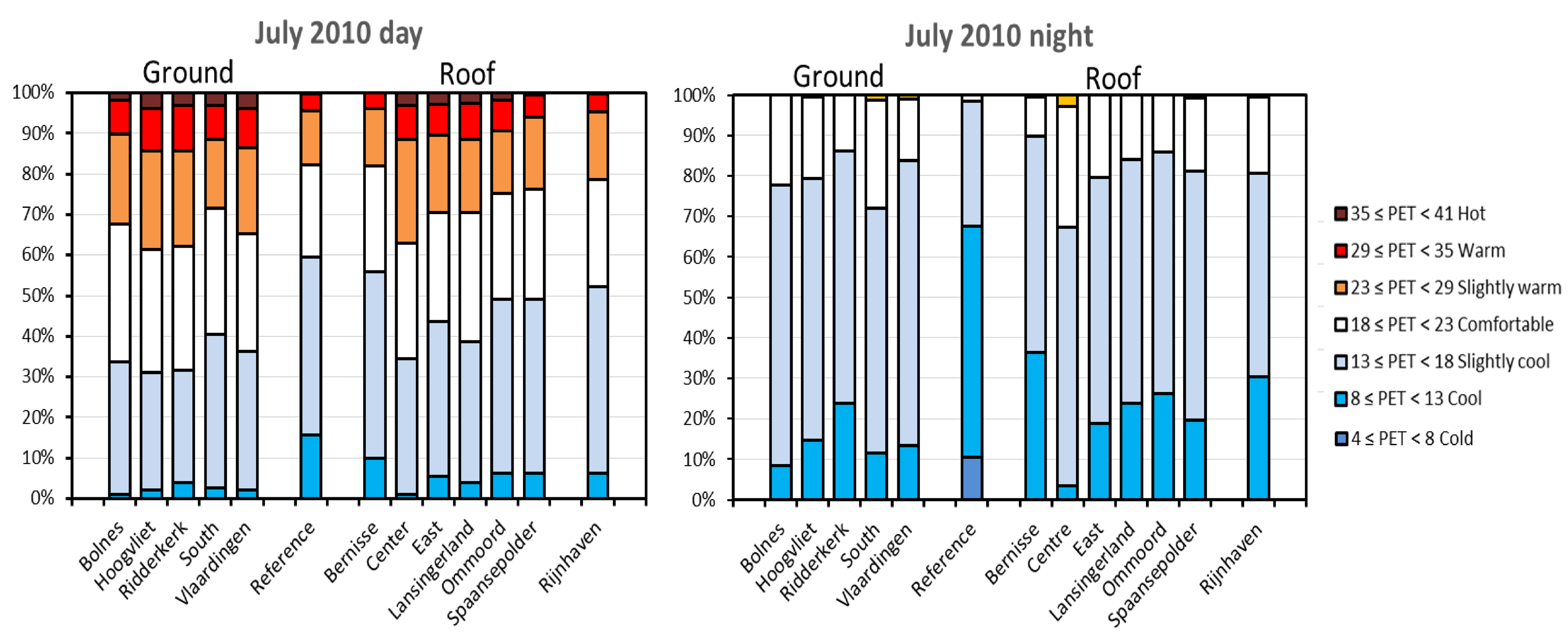

Figure 3. Daytime 6:00 – 22:00 (LT) (Left) and night-time (22:00 – 6:00) (Right) frequency distributions of the different thermal comfort classes for July 2010. PET = Physiologically Effective Temperature.

Urban feature	Effect on UHI_{max} in summer
Building surface fraction	+0,3 °C to +0.6 °C per 10% increase
Impervious surface fraction	+0,3 °C to +0.4 °C per 10% increase
Green surface fraction	-0,3 °C to -0.6 °C per 10% increase
Open water surface fraction	No significant relationship
Sky View Factor	idem
Albedo	idem
Mean building height (meters)	+0.08°C to + 0.17 °C per 1 m increase

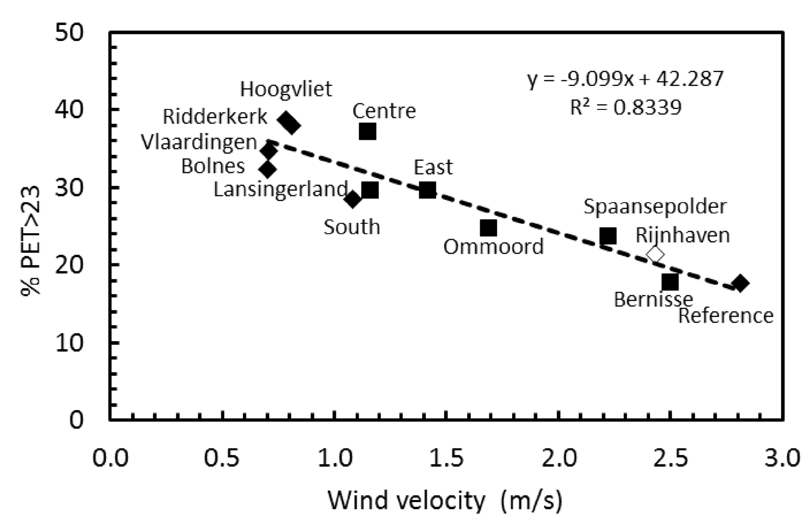

Figure 4. Daytime (6:00 – 22:00 LT) frequencies of PET > 23 °C in July 2010 at the locations plotted against average daytime wind speeds in July 2010. ♦ Ground stations; ■ Rooftop stations; ◊ Harbour station 'Rijnhaven'.

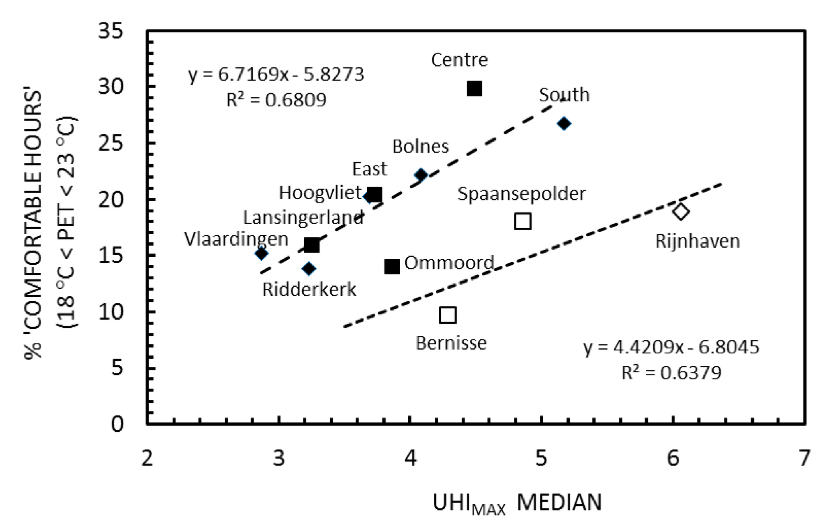

Figure 5. Night-time frequencies of 'comfortable hours' (18 °C < PET < 23 °C) in July 2010 at the locations plotted against median UHI_{max} values in July 2010. ♦Ground stations; ■ Rooftop stations; ☐ roof stations, wind velocity >1 m s⁻¹; ◊ Harbour station 'Rijnhaven'.

Conclusions

- UHI-effect and intra-urban-variability in UHI are considerable throughout the year, with 95 percentile values ranging from 4 K to more than 8K;
- UHI_{max} is significantly related to the building, impervious and green surface fractions, respectively, as well as to mean building height;
- Intra-urban variability in outdoor thermal comfort during daytime is mainly related to differences in wind velocity;
- After sunset, outdoor thermal comfort is stronger related to the UHI effect and urban characteristics affecting this phenomenon;
- High UHI intensity at a location not always coincides with large thermal discomfort.

References

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