Urban greenness extracted from pedestrian video and its relationship with surrounding air temperatures

Sarah B. Henderson[1,2], Kris Y. Hong[1], Pak Keung Tsin[2], Matilda van den Bosch[2], Michael Brauer[2]

[1]BC Centre for Disease Control; [2]UBC School of Population and Public Health

Introduction

- Extreme heat is linked to elevated morbidity and mortality
- Heat-generating activities, low-albedo infrastructure, and sparse vegetation render urban areas hotter than their surroundings
- Urban greening can cool the urban climate but its effect is challenging to measure and therefore optimize
- Past exposure assessments have been limited to land surface temperature and vegetation index (NDVI) satellite data
- Such data cannot account for vertical vegetation, foliage cover density, and vegetation obstructed by taller landscape features
- Eye-level image and video can overcome satellite limitations

Methods

- Forty runs of twenty 8-10km routes (Figure 1) were walked in Vancouver on sunny afternoons from May-September 2014

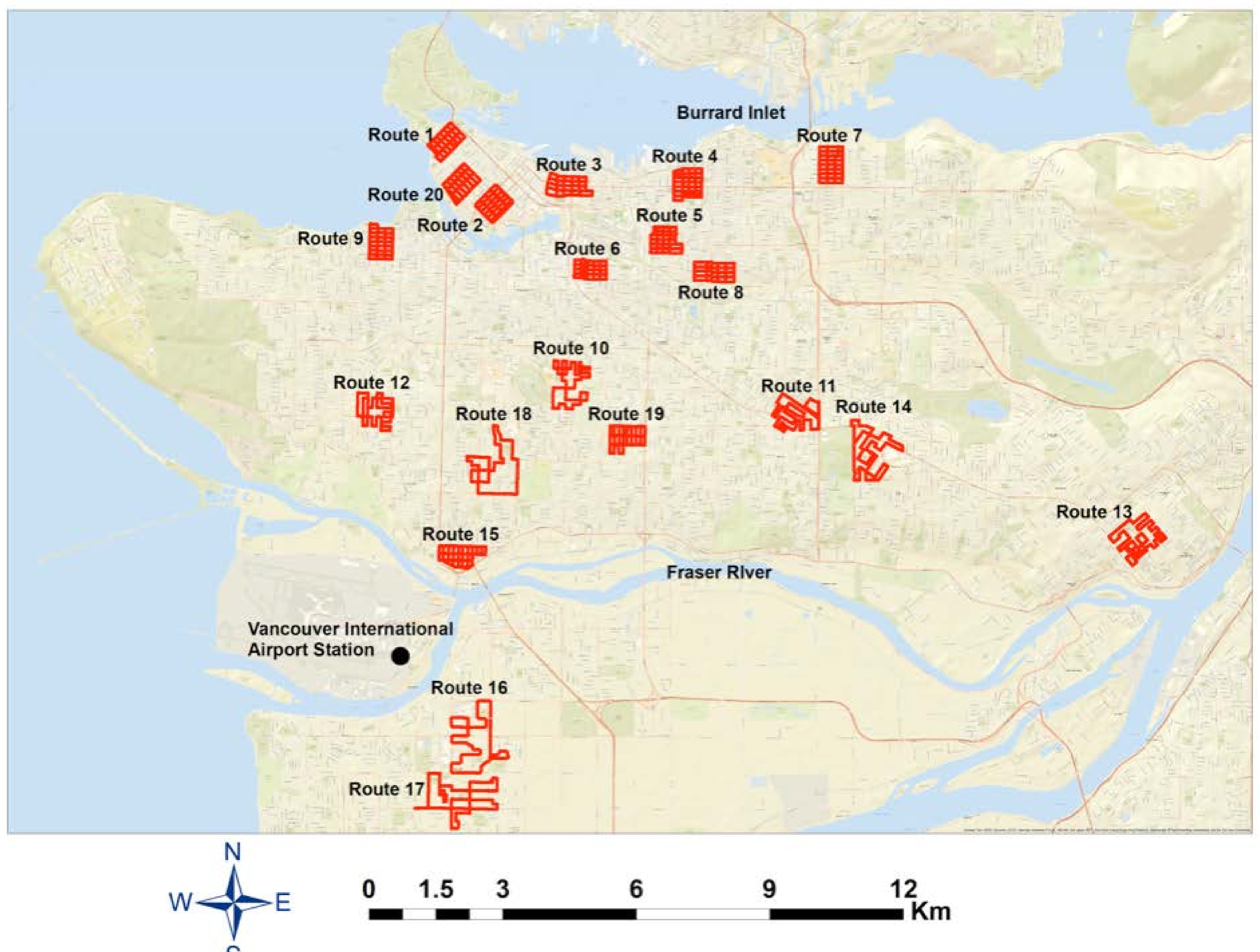

Figure 1: *Map of the 20 mobile monitoring routes*

- Temperature, pedestrian video, and GPS data were collected with a Met One thermometer, GoPro camera, and Garmin GPS
- Greenness, comprising of green, yellow, and shaded pixels, was extracted from the video (Figure 2) by searching for pixels falling within certain hue-saturation-value (HSV) ranges

Figure 2: *Pixel extraction for a single frame showing: (A) the original image; (B) green pixels; (C) yellow pixels; (D) shaded pixels; (E) combined pixels; (F) the inverse*

- Greenness per frame (vegetation pixels divided by total pixels) was averaged into 1-second intervals, lagged by five seconds, and smoothed with a 45-second right-aligned moving average to account for the temperature-greenness misalignment between the camera's field of view and the thermometer
- Correlations, time series, and geospatial maps were used to evaluate the relationship between temporally matched greenness and air temperatures for all forty runs

Results

- Four runs representing strongly negative, negative, flat, and positive correlations, are visualized below (Figure 3).

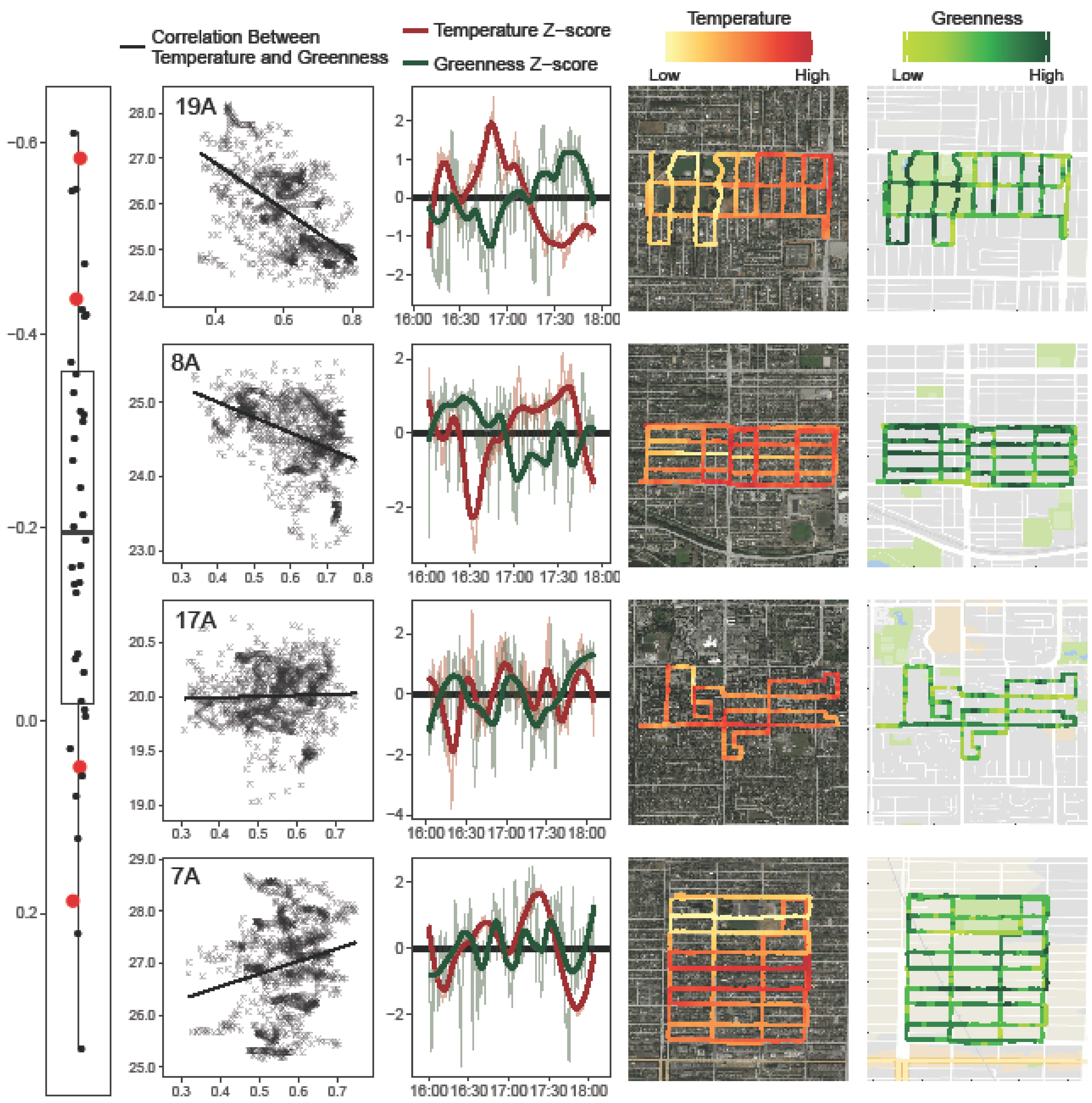

Figure 3: *Left: boxplot showing the distribution of regression coefficients between temperature and greenness. The red points indicate the four routes that are further visualized on the right; Column 1: scatterplots showing the relationship between air temperature (y-axis) and greenness (x-axis). The suffix A/B indicates replicate runs; Column 2: time-series plots showing the temporal relationship between raw and smoothed z-scores for temperature and greenness; Column 3: maps showing the spatial distribution of temperature; Column 4: maps showing spatial distribution of greenness*

- Scatterplots showed variability in the temperature-greenness relationship even where the correlation was strong
- Time series plots showed clear inverse relationships between air temperature and greenness for routes with negative correlations
- Maps generally showed low temperature and high greenness in parks, and vice-versa for major roads and intersections.

Discussion and Implications

- Unlike most temperature-greenness studies, both variables were quantified at the street-level
- Although these methods for measuring greenness are effective, they have room for further improvement
- All pixels were classified by colour alone, meaning that (1) shade could not be separated from dark and low saturation greenery; and (2) vegetation could not be separated from some urban objects such as cars and street signs (although Figure 2F shows successful exclusion of a green utility pole)
- Such limitations could be addressed through advanced computer vision and deep learning
- With further refinement, these methods could provide unprecedented spatial and temporal resolution for greenness exposure in individual-level studies, and could also be useful for evaluating and validating population-scale greenness models