# The Synergistic Effect of Urban Heat and Moisture Islands in a Compact High-Rise City: Mechanisms and Mitigation Strategies

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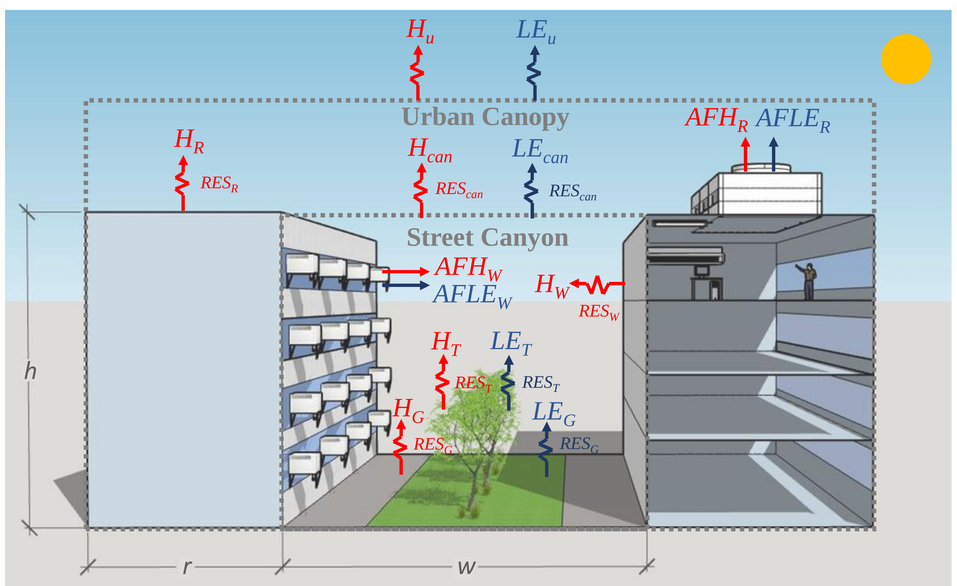
## Research Background

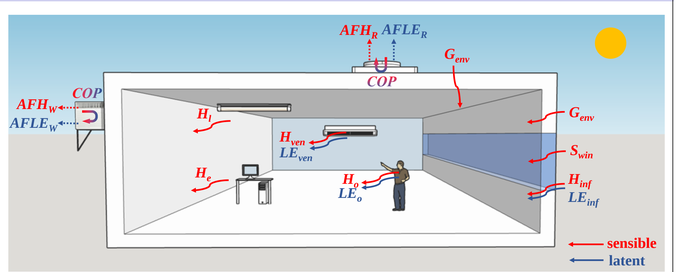
1. The synergistic effect of urban heat island (UHI) and urban moisture island (UMI) **increases building energy consumption** and **aggravates human thermal stress**.
2. A unique **all-day UMI phenomenon** is witnessed in Hong Kong, possibly due to the **complicated building-tree-air interactions** in its **compact high-rise urban landscape**.
3. Urban moisture budgets including **anthropogenic moisture emissions** and **tree evapotranspiration** have not been fully resolved in previous urban canopy models (UCM).

Therefore, we aim to investigate the mechanisms and mitigation strategies for the synergistic effect of UHI and UMI in terms of urban geometries, building emissions, and tree effects.

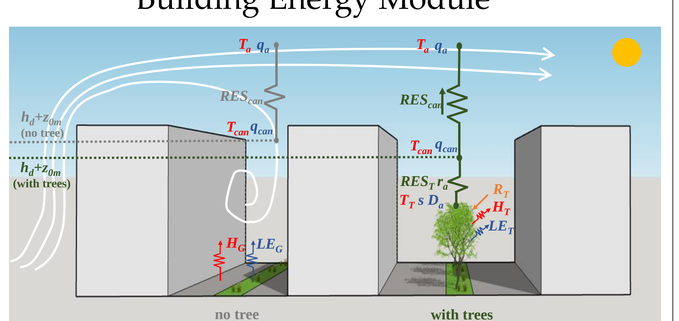
## Advanced Urban Canopy Model




Urban Canopy Model



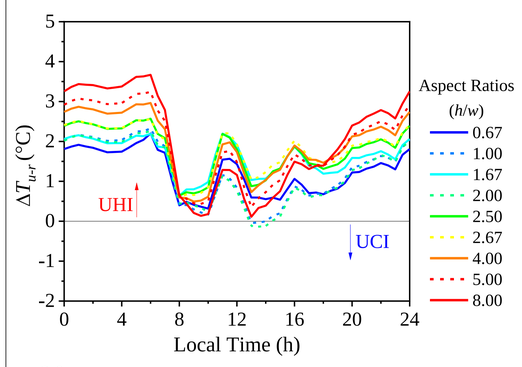

Building Energy Module

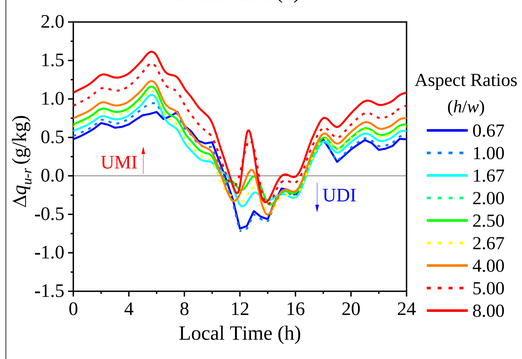



Urban Tree Module

## Mechanisms

### (1) Impacts of street geometry

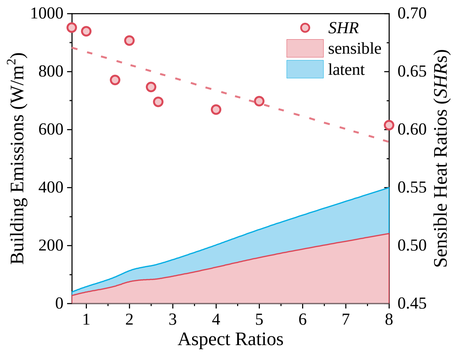


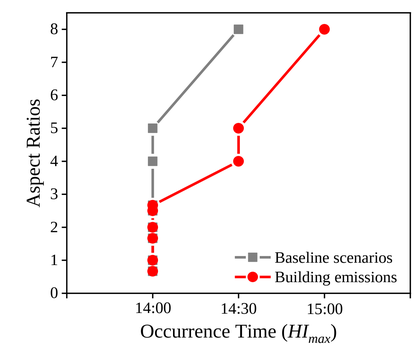




Dominant UHI and UMI phenomena were found at night for all aspect ratios.

Increasing aspect ratios aggravates UHI at night and UMI at both day and night.

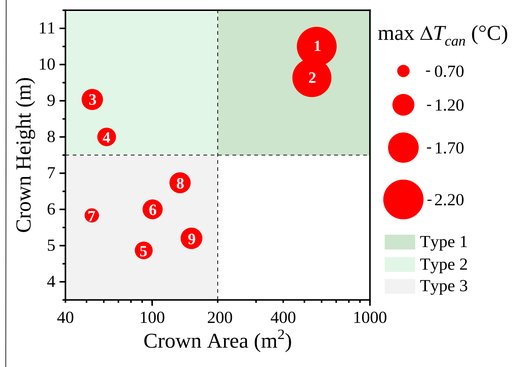
### (2) Impacts of building emissions

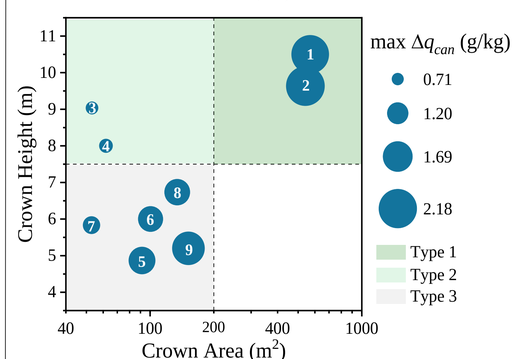



In the most compact high-rise scenario, building emission is nonnegligible (up to 400 W/m2, including ~60% sensible heat flux and ~40% latent heat flux), which can in turn increase intensities of UHI and UMI by 1.64 ° C and 0.89 g/kg, respectively., and postpone occurrence time of maximum heat stress by 0.5 h.

### (3) Impacts of urban trees



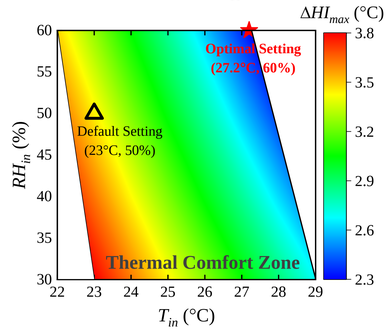




Both the greatest cooling effect (−2.20 ° C) and the greatest humidifying effect (+2.18 g/kg) were found for tall trees with large crown areas (Type 1).

The slightest humidifying effect (+0.71 g/kg) was found for tall trees with small crown areas (Type 2).

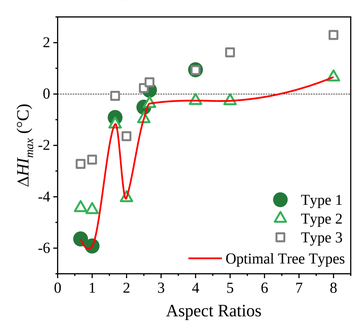
## Mitigation Strategies

### (1) Air-conditioning Control



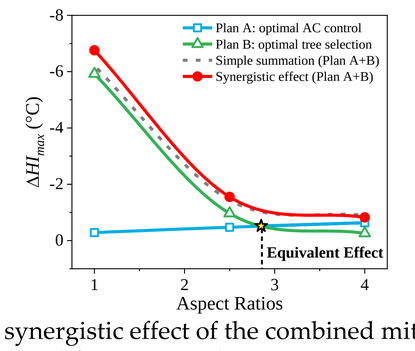

An optimal AC setting (Tin = 27.2 ° C, RHin = 60 %) could reduce Tcan, qcan, and HImax by 0.47 ° C, 0.33 g/kg, and 1.10 ° C, respectively.

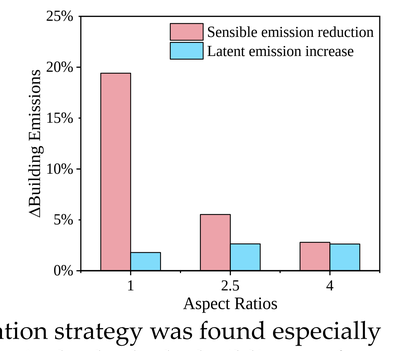
### (2) Tree Species Selection




Tall trees with large and small crown areas are optimal tree types for street canyons with low and high aspect ratios, respectively.

### (3) Combined Mitigation Strategy




A synergistic effect of the combined mitigation strategy was found especially in low-h/w scenarios because trees can effectively shade the building surface and cool the outdoor air, further reducing the sensible building emissions from AC. The two mitigation strategies show an equivalent mitigation effect in mid-h/w scenarios (e.g., h/w=2.8).

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**References:** [1] X. Huang, J. Song, C. Wang, T.F.M. Chui, P.W. Chan, The synergistic effect of urban heat and moisture islands in a compact high-rise city, Build. Environ. (2021) 108274. https://doi.org/10.1016/j.buildenv.2021.108274.
[2] R. Du, J. Song, X. Huang, Q. Wang, C. Zhang, O. Brousse, P.W. Chan, High-resolution regional modeling of urban moisture island: Mechanism and implications on thermal comfort, Build. Environ. (2021) 108542. https://doi.org/10.1016/j.buildenv.2021.108542.