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Modelling the effect of urban ventilation on urban heat mitigation in precinct context

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Many cities are undergoing severe temperature problems during summertime, while cooler breeze that are derived from seaside and rural area, has been recognised as a good control of urban temperature. However, the existing urban planning approach is unreasonable, making buildings become the wall blocking cities from fresh and cooler wind.

In order to enhance urban ventilation, various studies on urban morphology have been conducted, while most of them relate to pedestrian wind comfort around buildings, pollutant dispersion, outdoor thermal environment, convective heat transfer, while few are about how urban ventilation can impact urban heat at the precinct scale. Moreover, urban ventilation performance is affected by the myriads of morphological factors, while there is a lack of a protocol governing the analysis of precinct ventilation, inadequate to support the use of ventilation for UHI mitigation.

This paper aims to develop an approach to characterising precinct ventilation and examine the effect of precinct ventilation on urban heat mitigation. In specific, this paper developed the protocol for the classification of different ventilation zones, characterised precinct ventilation zones in the context of Greater Sydney, Australia, and experimentally investigated the cooling effect of sea breeze on the thermal environment.

Based on the pluridisciplinary method, it is found that precinct ventilation is affected by both external meteorological conditions and morphological characteristics. External meteorological conditions including macro contextual background and local wind environment, form the boundary conditions of precincts. Morphological characteristic is another significant intervention, which is characterized by the three-component protocol of 'compactness +building height +street structure'. Based on this protocol, 20 distinctive types of precinct ventilation zones in the Greater Sydney, Australia were presented.

Empirical analysis indicates that temperature showed a trend of decrease, strictly consistent with the increase of wind speed. Positions that were close to buildings witnessed a reduction in ventilation performance, but they underwent a lower temperature. The corridor formed by lift-up structure had the capability of enhancing ventilation performance and the temperature was the lowest. Although a point was on grassland, its temperature was still higher than baseline point because of stronger solar radiation. Under similar wind conditions, building shading might have better cooling effects than tree shading. Statistically, wind speed had apparent cooling effects on air temperature, which also exhibited obvious spatial variations.