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Modelling urban heat islands: The role of high-resolution urban morphology

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Abstract: Frequent heatwaves and rapid urbanization amplify the Urban Heat Island (UHI) effect, raising urban temperatures and associated health risks. The combined impacts disrupt ecological balance and increase heat-related mortality. In Western Australia, this is further intensified by a persistent drying trend. These challenges highlight the urgent need for robust urban climate resilience strategies. Quantifying the multi-scale drivers of UHI and accurately mapping its spatial distribution are critical for informed adaptation and planning. However, regional climate models often operate at resolutions of >1 km, limiting their ability to capture fine-scale urban variability. This study integrates metre-scale (2m) urban datasets into the Single Layer Urban Canopy and Weather Research and Forecasting Model (SLUCM–WRF) framework to improve simulation of UHI dynamics. We designed several model configurations, integrating detailed urban datasets to enhance the accuracy of UHI simulations. Model simulations were conducted to compare the performance of default versus high-resolution urban data in evaluating UHI intensity and spatial distribution. Analysis of the spatial bias distribution shows that incorporating high-resolution urban datasets significantly improves model performance, reducing temperature bias by up to 4 °C during heatwave periods. Including detailed urban parameters enhances model accuracy in capturing intra-urban heat hotspots and thermal patterns across the domain particularly Perth city. This improved resolution allows the model to better identify localized heat extremes, supporting targeted mitigation strategies. This approach offers a scalable pathway for enhancing urban climate resilience under future warming scenarios.

Keywords: *UHI, SLUCM-WRF, Urban Morphology, Heatwaves*

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