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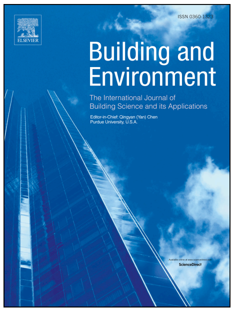

Simulation and validation of solar heat gain in real urban environments

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Simulation and validation of solar heat gain in real urban environments

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Abstract

The development of modelling techniques to study the urban heat island effect by accurately evaluating solar heat gain in urban environments is presented. The modelling techniques consist of: a realistic geometrical modelling tool that reproduces real urban morphologies; a parallelized gridding algorithm that generates evenly distributed grids on urban facades, and efficient solar heat gain calculation algorithms for accelerated capturing of the solar irradiance impinging on urban surfaces. The developed techniques are validated against in-situ measurements in urban areas in Singapore with different scenarios covering a wide range of urban morphologies found across the city and various weather conditions, and applied to study solar heat gain distribution for existing and new towns. The simulation results reveal that the developed techniques are able to evaluate the effects of urban geometries, materials and tree shading on solar heat gain on urban surfaces, which provides insight into the fundamental physics applied to mitigate the urban heat island effect.

Keywords: microclimate scale; ray tracing; solar heat gain; urban climate; urban heat island

1. Introduction

Urban Heat Island (UHI) is an urban climate phenomenon where the temperature in urban areas is higher than that in rural surroundings and was first addressed in 1837 by Howard, in London [1]. Solar heat gain on urban surfaces is a major contributing factor to changes in urban climate, and increasing urbanization, making characteristics of the urban landscape more complex, has led to modifications of surface partitioning of solar energy essential to the practical mitigation of UHI [2].

Urban landscapes can be characterized by the physical properties of surface materials and urban geometries, and studies have shown that they are the major causes of UHIs [3-5]. Green roofs and materials with high albedo, such as cool pavements and cool roofs, have been developed to reduce the impact of UHI on energy use [6-9]. Urban geometries are mainly represented by several types of numerical models in urban climate simulations, based on various study purposes. A surface scheme model for atmospheric mesoscale models was presented by Masson [10], where a generalization of local canyon geometry is defined instead of the usual bare soil formulation to represent cities, and assumes the following: 1) buildings have the same height and width; 2) buildings are located along identical roads, the length of which is considered far greater than their width; and 3) the space contained between two facing buildings is defined as a canyon. This kind of two-dimensional (2D)

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