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# Numerical modelling evaluation for the microclimate of an outdoor urban form in Cairo, Egypt

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**KEYWORDS**

Thermal comfort;
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**Abstract** In order to achieve outdoor thermal comfort it is necessary to understand the interactions between the prevailing climate, the urban form and roughness. The near surface boundary layer is directly influenced by local irradiative and convective exchange processes due to the presence of a variety of different surfaces, sheltering elements and obstacles to air flow leading to distinctive micro-scale climates. The paper presents a micro-scale numerical model for an outdoor urban form for a hot summer's day in Al-Muizz street located at the Islamic quarter of Cairo, where a few studies have attempted to study these conditions in vernacular settings in hot arid areas where the continuously evolving urban patterns and shaded environments were perceived to produce more pedestrian friendly outdoor environments. In situ measurements are used to validate the ENVI-met results which showed an overall agreement with the observed ones, representing adequate mean radiant temperature (Tmrt) which is one of the most important meteorological parameters governing human energy balance and has therefore a strong influence on thermal sensation of the pedestrians using the open public spaces and generating a micro-climatic map as an initial step in addressing the urgent need for a modelling platform accessible to urban designers, architects, and decision makers towards sustainable urban forms.


## Introduction

The 4th IPCC Assessment Report (2011) indicated that Africa is warming faster than the global average, and this is likely to continue. This warming is greatest over the interior of semi-arid margins of the Sahara and central southern Africa [1]. This was compiled with the ACED (2004) [2] studies that reported changes in area averaged temperature and precipitation over Egypt which was assessed based upon a dozen recent GCMs (General Circulation Models) using a new version of

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MAGICC/SCENGEN. All climate models estimated a steady increase in temperatures for Egypt, with little intermodal variance. That mostly attributes to the large fractions of the Earth's surface modified by human changes, particularly in cities through a large number and variety of constructions, leading to a changed energy balance of the surface and to the formation of local, man-modified microclimates.

This caused the urban areas to warm up much faster and cool down much slower than their rural surroundings due to their sealed surfaces. This provokes the creation of warmer zones in urban regions. This is known as urban heat island phenomenon and represents a feedback of the atmospheric variables on the use of the ground and the degree of soil sealing. This phenomenon and the effect it causes on air temperature as a result of urbanisation are now well documented in numerous studies [3–5] stating that the world's average air temperature has risen between 0.3 and 0.6 °C since the late 19th century [6]. As a result, the urban micro climate starts to gain increasing attention during urban design and spatial planning [7], starting with the study and description of microclimate processes, and then focusing on microclimate research in relation to outdoor thermal comfort contributions such as those of Oke et al. [37], Bosselmann et al., Katzschner, Moriwaki and Kanda, Katzschner et al. (2004) and Stathopoulos [8–12] which were interesting for urban design because they addressed factors that can be changed through urban design interventions. As it is well explained in the practice-oriented literature that Urban microclimate depends on the type of city in terms of size, geographical location, population size and density, and land use as well as the street design features such as height of buildings, street widths and orientation, subdivision of the building lots, etc., the urban design of each neighbourhood in a city creates its own particular local climate [13], where with well-defined planning measures the micro climate can be improved or negative effects can be mitigated [14,15]. Givoni et al. [16] highlighted the designers' need for urban climatic predicting tools to evaluate the effect of urban microclimatic changes on outdoor human thermal comfort and these tools need to provide the ability to process detailed environmental information according to time and location variations and to generate analytical results to reveal the relationship amongst the microclimatic environment, outdoor urban design and thermal comfort. In this study the microclimatic effects of an urban site located within the Islamic Quarter of Cairo are numerically assessed using the numerical model ENVI-met 3.1.

## The study context

The Cairo zone lies between latitude 26°50″ N and 30°45″ N. In the middle of that area lies Al-Muizz street as shown in Fig. 1, which divides Islamic Cairo down the middle. The street has the greatest concentration of Islamic architectural treasures in the world and offers a vivid example of how life in Islamic Cairo might have looked like thousands of years ago. In the late 90's the UNESCO recognising that Al-Muizz and its surroundings hold great historical and cultural value declared Islamic Cairo a protected world heritage site. A massive restoration project was commissioned by the Egyptian government to restore Al-Muizz street and its surroundings, transforming the street into an open-air museum. The first part of the street was fully restored and was opened to the public in Early 2010. The second part of the street is yet to undergo restoration work.

The case study – according to Koppen classification – is classified within group B and sub group BWh – arid or desert

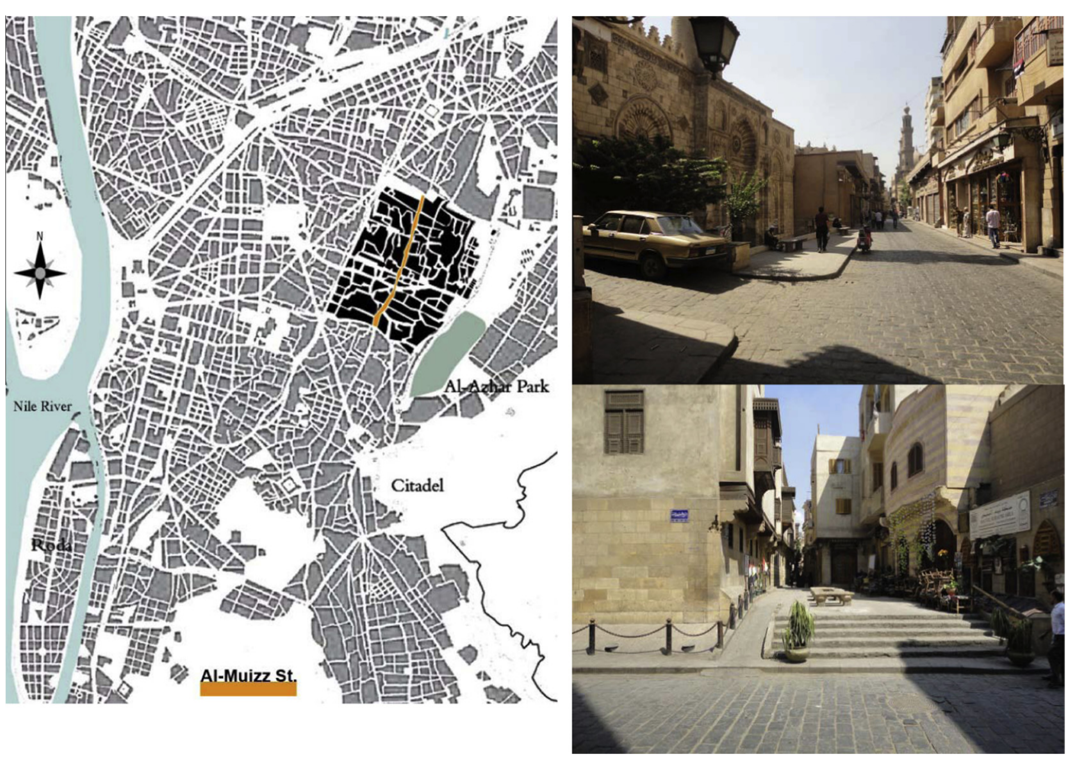


**Fig. 1** Al-Muizz alley location.