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Street Canyon Geometry Effects on Microclimate and Comfort; a case study in Thessaloniki

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Abstract

A case study in Thessaloniki provided microclimate data at street canyons with varying orientation and aspect ratio. Seventeen canyons characterized by diverse geometries including four different canyon axis orientations and a range of aspect ratios from 0.6 to 3.3 as well as variations of vegetation and pavement material, were monitored during summer and winter. Measurements are used to calibrate microclimate simulation models, examine results accuracy and produce further data for larger areas or different climatic periods. This paper presents the simulation studies run with ENVI-met software for models of the study area at different scale used to evaluate results accuracy depending on model resolution, influence of the surrounding built environment and of material and geometric details. The large area - low resolution models take into account the urban environment surrounding the study areas which influences thermal and airflow conditions and provide urban microclimate maps. The small area - high resolution models take into account fine geometric elements, individual building heights, tree species, canopies, and pavement materials and provide detailed microclimate data and pedestrian comfort indices which can inform urban space design.
Keywords: Urban microclimate; Outdoor comfort; Case study; Simulation; Software calibration

1. Introduction

Urban morphology is one of the most influential parameters affecting the microclimate of open spaces in cities. In previous studies the effect of form and materials has been examined in squares, parks, and courtyards through monitoring campaigns and simulation studies (Chatzidimitriou and Yannas 2015; 2004). Other studies have focused on the effects of street canyon orientation and aspect ratios (Ali Toudert and Mayer 2006; Emmanuel et al 2007; Chatzidimitriou and Axarli 2015). However previous research results have not yet been fully interpreted into guidelines to practically inform urban design and planning.

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This paper presents a case study in the urban centre of Thessaloniki in Northern Greece, based on a monitoring campaign at different street canyons in the city centre, followed by a series of simulations of the monitored areas with microclimate simulation software ENVI-met (.ENVI-met website). The study takes into account summer and winter measurements but focuses on hot summer conditions and reports on results for ambient temperature, pavement surface temperature and pedestrian comfort indices of the Physiologically Equivalent Temperature PET (Hoppe 1999). Simulation models with different size and resolution are tested against measured data to explore the influence of the models' details on the results accuracy.

The purpose of the study is to examine the level of agreement between measurements and simulations, as well as the microclimatic variations developed at the surrounding areas beyond the specified points of the monitored street canyons. Simulation results by models calibrated with measured data can become tools for extracting climate related information to aid urban design and planning and to set the basis for new methods, guidelines and new regulations.

Nomenclature

H/W	street canyon aspect ratio calculated by building height H to street width W
Tair, Ta	air temperature (^{o}C)
Ts	surface temperature (^{o}C)
Tg	globe temperature (^{o}C)
Tmrt	mean radiant temperature (^{o}C)
PET	physiologically equivalent temperature (^{o}C)
WV & WDIR	wind velocity (m/s) and wind direction
RH	relative humidity (5)

2. Case study

2.1. Location and climate

The city of Thessaloniki in Northern Greece, at 40.5N latitude, is characterized by temperate - mediterranean climatic conditions, with hot summer periods and cold winter periods, while the vicinity to the coastal zone highly influences humidity and airflow patterns (sea breeze). The climate parameters during the monitoring campaign in July 2015 and February 2016, as recorded by the meteorological station at the airport area, are presented in Table 1 and have been used as input for the simulation studies.

Table 1. Climate data during monitoring period (airport meteorological station https://www.wunderground.com/q/locid:16622000;loctype:3).

monitoring period	mean Tair (^{o}C)	max Tair (^{o}C)	mean RH (%)	mean WV (m/s)	prevailing wind direction
24 – 31 July 2015	26-30	32-38	46-54	1.94-2.78	WNW | S
09-15 February 2016	8-16	12-22	49-92	1.39-3.33	W | NW | SE

2.2. Examined street canyons

Seventeen street canyons characterized by various axis orientation and aspect ratio (building height H to street width W) within the dense city centre (Fig. 1) were included in the monitoring and simulation studies. In particular, canyons with four different orientations were examined: seven NW-SE oriented canyons parallel to the coastline, six NE-SW canyons normal to the coast and four N-S and E-W canyons diagonal to the regular street grid. Mean canyon aspect ratios varied between 0.6 for the widest canyons to 3.3 for very deep and narrow canyons.

2.3. Monitoring campaign

Monitoring took place in July 2015 (24^{th}-31^{st}) and February 2016 (9^{th}-15^{th}), and included air temperature, relative humidity, wind velocity and direction and globe temperature measurements at 1.1m above ground level on one side