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Applications of automatic algorithms for improvement of outdoor thermal comfort in cities

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Abstract

There is a strong need for user-friendly software among urban planners and climatologists in order to develop climatologically conscious urban designs. In this paper we present possibilities (i.e. software packages) for the improvement of outdoor thermal comfort in built urban environments using Universal Thermal Climate Index (UTCI) calculations. For this purpose, automatic algorithms for changing body locations, buildings heights and trees locations in street parking lot areas were developed and applied in the Grasshopper software. The applicability of the algorithms was tested in real-world street parking lot in a Central European city as an example. Temporal analyses were performed during heat wave period in 2015. Outdoor thermal comfort was improved at approximately 66% of body locations during heat wave period. Usage of automatic algorithms in appropriate software showed to be a valuable contribution for urban planning strategies aimed at counterattacking the adverse effects of urban climate and expected climate change (i.e. temperature rise) in cities.

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Keywords: outdoor thermal comfort; tree and building; parking; UTCI; Ladybug software

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1. Introduction

The global urban population exceeded the global rural population in 2007 and the world population has remained predominantly urban since [1]. Consequently, it is important to improve outdoor thermal comfort of urban dwellers. Climate and weather data have to be taken into account by planners and architects in the process of designing climate conscious urban areas.

Outdoor thermal comfort conditions of humans can be assessed via thermal comfort indices calculations in different software such as ENVI-Met [2], RayMan [3] and Ladybug (Grasshopper plug-in) [4]. In general, models ENVI-met and RayMan are used by climatologists and meteorologists and are not user-friendly for urban planners and architects. Grasshopper software is familiar to urban planners and architects and can be used in the decision-making process during the initial stage of urban design [4-5]. Integrating the calculation of UTCI into Ladybug enables cooperation among urban planners, architects, urban bio-meteorologists and climatologists on outdoor thermal comfort issues in urban planning [6].

In this paper we applied a procedure for the outdoor thermal comfort improvement in street parking lot area in the city. For this purpose, the algorithms for changing body locations, buildings heights and trees locations were applied. Temporal analysis is performed during heat wave period when the improvement of outdoor thermal comfort is needed.

2. Materials and methods

2.1. Study area and urban climate monitoring network

Novi Sad is located in Central Europe (45°15' N and 19°50' E), in the northern part of the Republic of Serbia (Fig. 1) on a gentle relief (80 and 86 m a.s.l). It is the second largest metropolitan region in the country with population of 340,000 and urban area of 112 km^2 [7]. Novi Sad has a Cfb climate (temperate climate, fully humid, and warm summers, with at least four $T_{mon} \geq +10$ °C) based on the Köppen-Geiger climate classification [8]. The mean annual air temperature in Novi Sad is 11.2 °C with annual range of 22.1 °C. The coldest month is January (-0.4 °C), and the warmest is July (21.7 °C) [6].

Fig. 1. Novi Sad location in Europe and in the Republic of Serbia.