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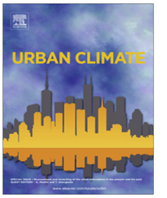

A new software tool for SVF calculations using building and tree-crown databases

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ABSTRACT

This paper presents some results related to the development of an automatic evaluation method locating tree-crowns and building roofs, as well as a new method for Sky View Factor (SVF) calculation using tree-crown and building database.

For the software based calculation of the SVF a detailed building and vegetation database is needed. In most of the urban areas some kind of urban building database is available, however there is a lack of detailed information related to the tree-crown data in general. The vegetation, and especially the tree-crowns are crucial parts of the urban 3D geometrical configuration, and they play a notable role in the regulation of long-wave radiation heat loss. Therefore in urban climate investigations a new method could be very useful in the evaluation of this kind of information.

The automatic tree-crown and building database generation uses digital photogrammetric methods for tree height measurement and spectral information from aerial photographs. Using the generated tree-crown and building databases we can calculate the SVF pattern of any given urban area. Additionally, this calculation is fast and it is as precise as any vector based calculation method.

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1. Introduction

It is known, that the urban areas have climate modification effects from meso (or local) to micro scales depending on the size of the built-up area. The two most important modifications are related

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to the thermal environment and the airflow conditions, and both of them are primarily connected with the changed geometrical and physical characteristics of the urban surface compared to the rural one (Landsberg, 1981; Oke, 1987).

The thermal modification often appears in urban temperatures higher than in the surrounding rural areas (urban heat island – UHI). The largest UHI, which is the strongest urban–rural temperature contrast, generally appears at night, while during the daytime the difference is moderate or absent. The main reason of the UHI is the urban–rural difference in the nocturnal cooling processes, which are primarily forced by outgoing long wave radiation. In urban areas the 3D geometrical configuration of the surface plays an important role in the restriction of long-wave radiative heat loss, and contributes to intra-urban temperature variations below roof level [e.g. (Oke, 1981; Eliasson, 1996)]. The Sky View Factor (SVF) is the most appropriate parameter describing the urban geometry (Oke, 1981; Upmanis and Chen, 1995; Svensson, 2004). SVF is defined as the ratio of the radiation received (or emitted) by a planar surface and the radiation emitted (or received) by the entire hemispheric environment (Watson and Johnson, 1987). It is a dimensionless measure between zero and one, representing totally obstructed and free spaces, respectively (Oke, 1988).

There are several options to calculate SVF values in urban environment (see Unger, 2009 and Chen et al., 2012 for brief reviews). One is a computer algorithm that requires a 3D surface database about the examined area [e.g. (Souza et al., 2003; Lindberg, 2007; Ratti and Richens, 1999)]. These methods can be separated by the input data used (raster or vector). Most of them utilize high resolution raster DSMs (digital surface models containing the terrain and the buildings) for computing patterns of continuous sky view factors. Their advantage is that the roof of buildings can be managed more easily; however the accuracy of the results is significantly affected by the selection of the resolution of the input data (Lindberg, 2007). Most of the building databases for cities are in vector format, thus for these raster-based methods a vector-raster conversion is needed as a preprocessing. Data loss can occur during this conversion, so the rasterization of the buildings can alter the results of the SVF calculation (Gál et al., 2009).

There are some examples for vector-based methods as well. Souza et al. (2003) developed an algorithm using an Avenue script language of the ESRI ArcView GIS. This script calculates the SVF values more accurately because the buildings are in vector format, thus the locations of the building walls are unequivocal and do not depend on the resolution.

Most of the software based methods do not deal with vegetation because of the lack of detailed data on it, especially on trees which have 3D extension. However, tree-crowns are an important part of the urban 3D geometrical configuration and likely play a major role in regulating long-wave radiation heat loss. Recently there are some developments to fill this gap. One example is the SOLWEIG method (Lindberg et al., 2008) whose current version (Lindberg and Grimmond, 2010) applies raster based digital surface model to represent the terrain and the buildings, and two raster based digital surface models for the tree canopy and trunk zones. The other example is the SkyHelios software (Matzarakis and Matuschek, 2010; Hämmerle et al., 2011), however it needs very detailed vegetation database which can be obtained via time consuming field measurements.

In our earlier work (Unger, 2009; Gál et al., 2009) a new vector based algorithm was developed for SVF calculation. It is an Avenue script using the database of buildings of Szeged (Hungary) in shapefile format (Gál et al., 2009), but it can be applied in any other settlement if a similar database is available. The precision of this algorithm was tested and it was compared to other calculation methods with adequate results (Gál et al., 2009; Hämmerle et al., 2011; Gál et al., 2007).

The main objectives of this study are to develop such methods that operate without the use of any GIS software and the interaction of the user: (i) the first one is an automatic evaluation method calculating the shape and elevation of the tree-crowns and building roofs. (ii) The second one is a method for SVF calculation using the databases obtained in the previous procedure. This new method is designed only for the calculation of SVF therefore it has to be more time effective than other existing methods. It is developed in a study area in Szeged (Hungary), however it can be applied in any other study areas if similar datasets are available. A further objective is to imply the possible applications of the developed methods.

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