THE MAP OF SKY VIEW FACTOR IN THE CENTER OF LODZ

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Abstract

The study presents a virtual map of sky view factor and H/W ratio in the center of Lodz. Lodz is the town located in central Poland with 800 000 inhabitants. Town morphology is typical for all European cities. The map is based on many (a few thousands) digital fish – eye photos, which were taken in the middle of street canyons situated in the study area. The distance between adjacent fish-eye photo points was about 50 – 100 meters. On the base of measurements a virtual map was constructed.
This map presents an information about sky view factor and H/W ratio distribution e.g. including/excluding crossroads and distribution of analyzed parameters across the street canyons. Such information can be useful for urban climate analysis and modeling.

Key words: urban climate, sky view factor, fish-eye photographs

1. INTRODUCTION

Geometry of the urban structures, especially street canyons (Nunez, Oke 1976), which is usually represented by sky view factor (SVF) or H/W ratio (Steyn 1980; Johnson, Watson 1983), exerts a great influence on specific net solar radiation in urban areas, both on absorption of incoming short wave radiation and on effective emission of outgoing long wave radiation (Oke 1987). It gives rise to differences between urban and non-urban air temperature – urban heat island phenomenon (Oke 1981; Bärring at al. 1985; Unger 2004). Because the magnitude of UHI depends on geometry of urban structures, the knowledge of variability of the sky view factor is very important in climatological studies. This paper presents the distribution of sky view factor in the center of Lodz, variability of H/W ratio for chosen street canyons and influence of green areas for values of sky view factor.

2. STUDY AREA AND METHODOLOGY

The base of this study were digital fish – eye photos, which were taken along all streets (in the middle) inside study area with frequency about 50 – 100 meters. On the canyon of the main street, called Piotrkowska, in two places the photos were taken also across the street with exactly 1 meter frequency. Moreover, in four measurement points, inside study area (subarea A1) fish – eye photos were taken with frequency about 2 – 3 weeks in the period 2007 – 2008 (excluding about all winter time). The study area (about 4 km^2) was situated in the central part of Lodz, Poland – figure 1.

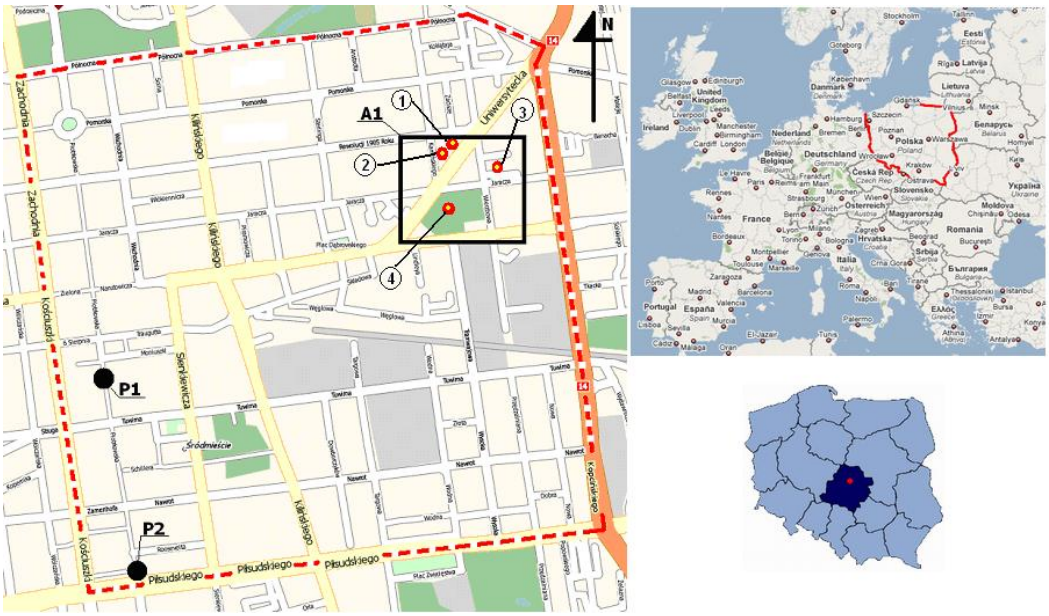

Figure. 1 Localization (on the right) and boundary (on the left, discontinuous red line) of the study area. A1 – sub area inside which a year long experiment of variability of sky view factor was carried on. P1, P2 – the points where distribution of sky view factor across the street was created (following www.zumi.pl, http://maps.google.pl)

The calculations of sky view factor values, based on the set of fish-eye photos were obtained using the BMSky-view program (Rzepa et al. 2006; Rzepa, Gromek 2006; Rzepa et al. 2008). BMSky – view is a software application, with graphical interface. The main algorithm of the software bases on Steyn method (Steyn 1980). It was implemented using C++ programming language and works in Windows environment. The software can compute the sky view factor values directly from digital camera with fish eye lens.

3. VIRTUAL MAP OF SKY VIEW FACTOR

The values of sky view factor which were calculated for all measurements points are included in a virtual map of sky view factor. The map is a project constructed under Macromedia Flash MX 6.0 software. It consists on many active boxes, which represent all measurement points (the places where fish - eye photos were taken). The active box shows a miniature of fish – eye photos, the sky view factor values, the distribution of sky view factor for the whole street and value of H/W ratio if the was example of symmetric street canyon – figure 2.

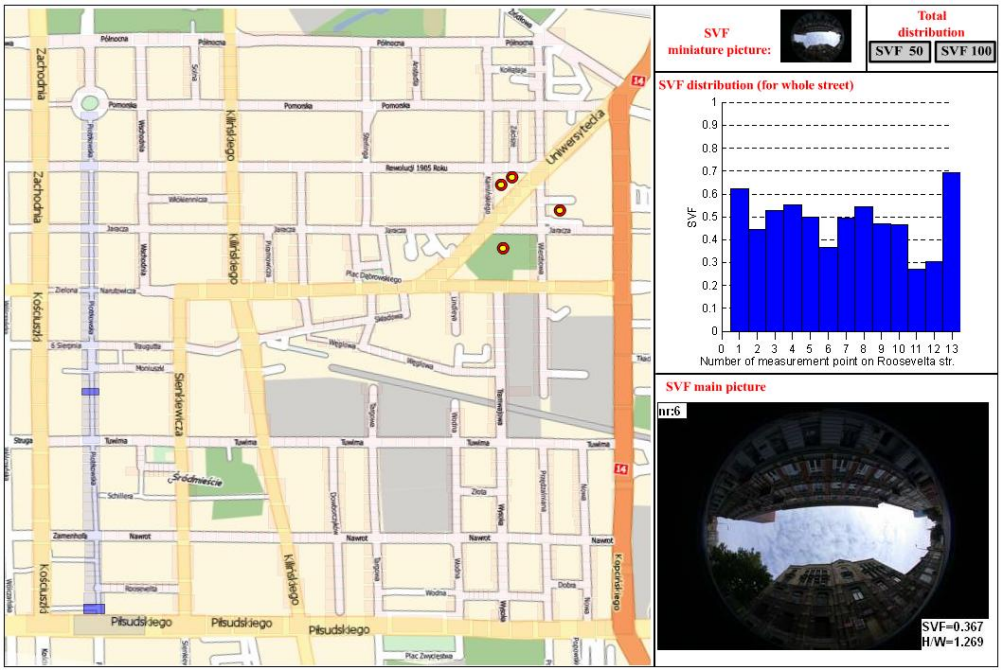

Figure 2. The map of sky view factor. Exemplary distribution of sky view factor for whole Roosevelt street; sky view factor and H/W ratio values for one of the measurement points on Roosevelt str. Red/yellow points represent places where a year long experiment of variability of sky view factor was carried on.

In addition, for many sections of the main street, Piotrkowska street, the minimum, maximum and average values were calculated upon sky view factor values for all measurement points. The key for the division of Piotrkowska street was a number of crossroads. For two places, which were characterized by different height of surrounding buildings, the distribution of sky view factor across the street were also computed – figure 1 (points P1, P2). The results of this part of study are included into virtual map.
Inside study area four places were also selected, which were characterized by different influence of green areas, e.g. trees and shrubs – figure 1 (sub area A1), figure 2 (red points). In all those four points a year long experiment of variability of sky view factor was carried on. This experiment shows a yearly variability of sky view factor in the period 2007 – 2008. The results of this part of study are also included into virtual map.
The virtual map of sky view factor was published on the server of Department Meteorology and Climatology University of Lodz, Poland : http://nargeo.geo.uni.lodz.pl/~meteo/stronki/klimat_lodzi.html

4. RESULTS

The distribution of sky view factor calculated along all streets inside study area shows a specific features of geometry of the city center. The buildings in the city center characterize quite similar height, and there is only some high – tower buildings, but the variability of sky view factor is very high. The reasons for this situation are: high variability of width of the streets, high number of crossroads, small parking places, yards and influence of green areas e. g. trees and shrubs. The same results was obtained even for very small sections, between two nearest crossroads, on Piotrkowska street – in this case differences between maximum and minimum values for all sections were about 0.2 or more. The distribution of sky view factor across the streets shows another one feature of geometry of the urban structures – in city center there is a lots of asymmetrical street canyons.

A year long observations of variability of green areas in four selected points (sub area A1 on figure1) give important information about influence of trees and shrubs on sky view factor values. For all measurement points inside subarea A1 seasonal variability of sky view factor was observed. Maximum values were observed in winter, contrary minimum values were observed in summer – figure 3. The differences between maximum and minimum values of sky view factor ranged from 0.272 to 0.484. When all trees and shrubs were excluded over roof boundary, which was possible using BMSky-view, the differences between maximum and minimum values of sky view factor increased.

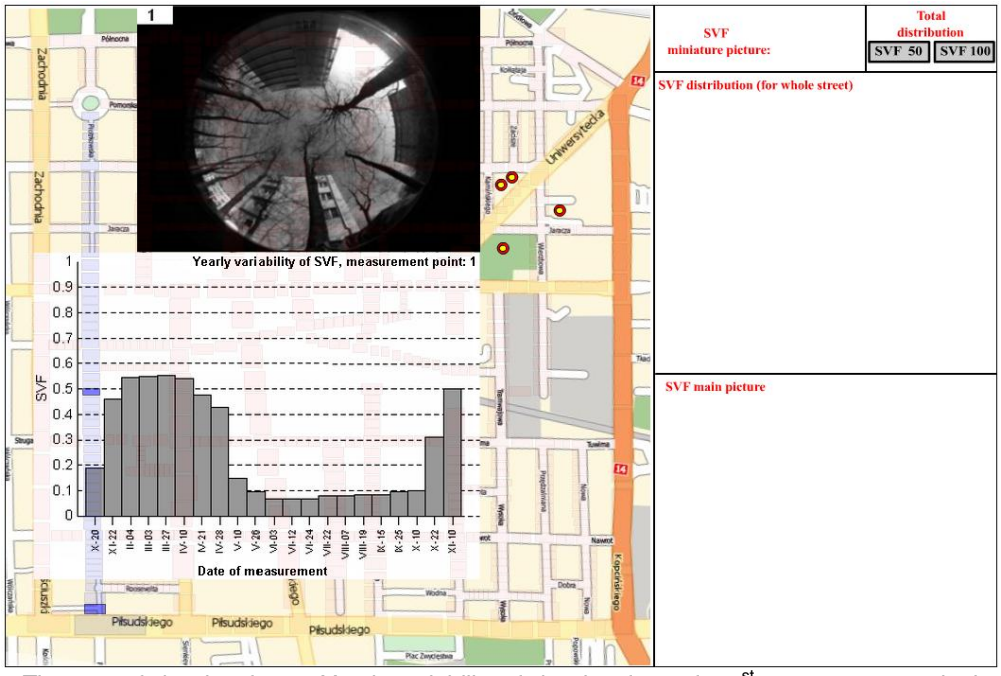

Figure 3. The map of sky view factor. Yearly variability of sky view factor for 1st measurement point inside sub area A1 (following figure 1).

All calculated values of sky view factor were used to create the total distribution of sky view factor for city center – figure 4. All of the crossroads inside study area were excluded from the map.

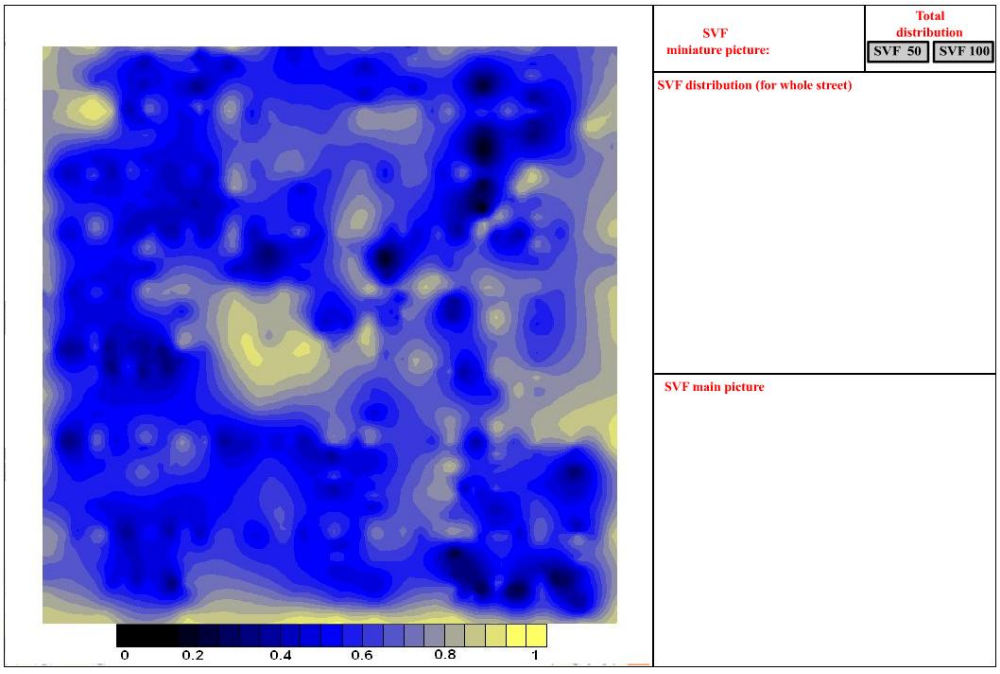

Figure 4. The map of sky view factor. Total distribution of sky view factor for study area. The crossroads are excluded.

The sky view factor values inside study area ranged form about 0.1 (especially in the north/east and south/east part of study area) up to 0.96 (especially in the center and on the borders of study area). In the case of low values of sky view factor the reason of that situation is generally high influence of green areas, especially high deciduous trees, and narrow width of the streets. Contrary, the high values of sky view factor were characteristic for open areas and wide two – direction roads.
Especially low values of sky view seems to be important for residents of the city. The places which characterize the low values of sky view factor decreasing incoming direct short wave solar radiation. On the one hand decrease of direct short wave solar radiation, especially in long term conditions may cause discomfort, because it contributes to apathy or depresion. On the other hand decrease of above mentioned solar radiadion, during hot summers, makes our thermal comfort better, because human organism do not overheat so easly. Thats why knowledge about sky view factor should be used in urban planing e. g. to creation of rest places or settlements.

5. CONCLUSIONS

All experiments in this study show a high variability of sky view factor in the center of Lodz. The high variability of this parameter depents on specyfic geometry of urban structures in Lodz (e. g. high variability of width of the streets, high number of crossroads, small parking places and yards) and influence of green areas represents by tries and shrubs. The total distribution of sky view factor for study area shows many places which characterizes a high (SVF>0.9) and low (SVF<0.2) values of this paramiter. The knowledge about sky view factor distribution seems to be very usefull in urban planing, modeling of urban climate and bioclimatic influence for residents of the cities.

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