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Shading Areas, Sky-View Factor And UV Radiation In Urban Canopy Of Moscow City

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Abstract. The main goal of this investigation is to develop a kind of "urban reanalysis" – the database of meteorological and radiation fields under Moscow megalopolis with high spatial resolution. Sky View Factor (SVF) is widely used for evaluating the solar irradiance attenuation in urban canopy. In this study we suggested raster-based calculation of SVF. We applied this technique for evaluating specific features in UV irradiance at Moscow megalopolis conditions. We showed that relative frequency of SVF over the territory of Moscow higher than 80% is observed in more than 86% of cases. The maps of UV losses due to sky obscuring over the territory of Moscow have been obtained for different seasons.

INTRODUCTION

The main objective of this research is to develop an "urban reanalysis" – the database of meteorological and radiation fields over the territory of Moscow megalopolis with high spatial resolution. Since UV irradiance has a significant influence on human health (UNEP, 2015) we added this characteristic as one of the parameter in the developed reanalysis. For obtaining losses of solar UV radiation in complex urban conditions, sky obscuring by surrounding topographic features is necessary to know. For this purpose we proposed to apply Sky View Factor to account for the urban canopy features similar to the approach proposed in (Ratti and Richens, 2004; Gal et al., 2008; Chen et al., 2012).

METHOD

The distribution of UV radiation in urban conditions is quite inhomogeneous first of all due to urban opacity determined by structures of urban canyons. To characterize urban opacity, sky view factor (SVF), percentage of visible sky from the point, is usually used (Oke, 1987). In this research, SVF was calculated using the proprietary topographic database provided by Geocenter Consulting Ltd Moscow. The database consists of several layers including building footprints with heights as attributes. Spatial accuracy of the data corresponds to 1:10 000 scale, which means that RMS error of building coordinates is about 1-2 meters. Calculations of SVF in our approach are based on raster model of data. Firstly, polygonal layer of buildings was transformed in the raster. Values of raster correspond to heights of buildings in each cell of the grid. The initial SVF surface was calculated with 5 m spatial resolution and obstacle search radius of 2000 meters. After that the values of SVF were averaged inside the reanalysis grid cells (1 km). The areas of building footprints were excluded from statistics. The obtained raster was combined with digital elevation model to embedded buildings as artificial relief. The detail description of the

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computation methodology of geometric characteristics of urban canyons can be found in (Samsonov et al., 2015). UV transmittance was obtained using the empirical relationship between SVF and UV irradiance measurements in Moscow conditions (Environmental ..., 2011).

RESULTS

Using this approach we obtained the SVF frequency distribution for the whole territory of Moscow. The results are presented in Fig.1. For this purpose, we used SVF data with 1 km spatial resolution. The mean value of SVF is 0.92. However, one can see significant variations over Moscow in SVF from 0.45 to 0.99 (Fig.2). Low values of SVF correspond to areas where high density of buildings and high-storey buildings are existed. As we can see in Fig. 1, relative frequency of SVF over the territory of Moscow higher than 80% is observed in most cases.

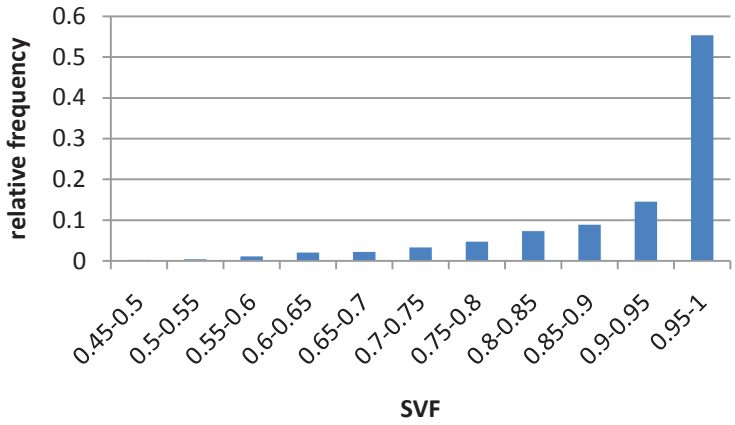

FIGURE 1. Relative frequencies of SVF over the territory of Moscow

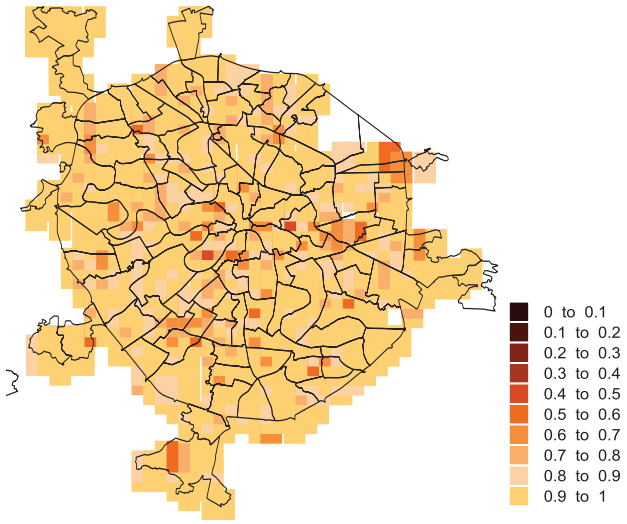

FIGURE 2. SVF distribution over the territory of Moscow

Using the developed approach, we estimated noon UV indices over the territory of Moscow for different months of 2010 taking into account for the urban opacity as well as ozone, aerosol properties of the atmosphere according to COSMO-CLM model parameters. The resulting UV maps are presented in Fig. 3.

In average, UV indices in urban conditions over the territory of Moscow reach 70%, 90%, 90% and 83% from values without accounting for the influence of urban canopy effects in January, April, July and October, respectively. For some points over the considered territory, UV indices in urban conditions can decrease to 21% and 39% from values without accounting for the influence of urban canopy effects in January, April, October and July, respectively.

We should mention that if the spatial distribution of urban opacity is neglected, the changes in UV radiation due to variations in aerosol optical thickness and total ozone content as well as spatial variations in solar elevation angles over the territory of Moscow do not exceed 1%.

In January, UV indices in Moscow are very small (less than 0.5). In April, average UV index over the territory of Moscow is 2.8 varying from 0.7 to 3.2 with standard deviation std=0.4. In July, average UV index over the territory of Moscow is 5.4 which correspond to high level varying from 2.3 to 6 with std=0.72. In October, average UV index over the territory of Moscow is only 1.1 varying from 0.3 to 1.3 with std=0.33.

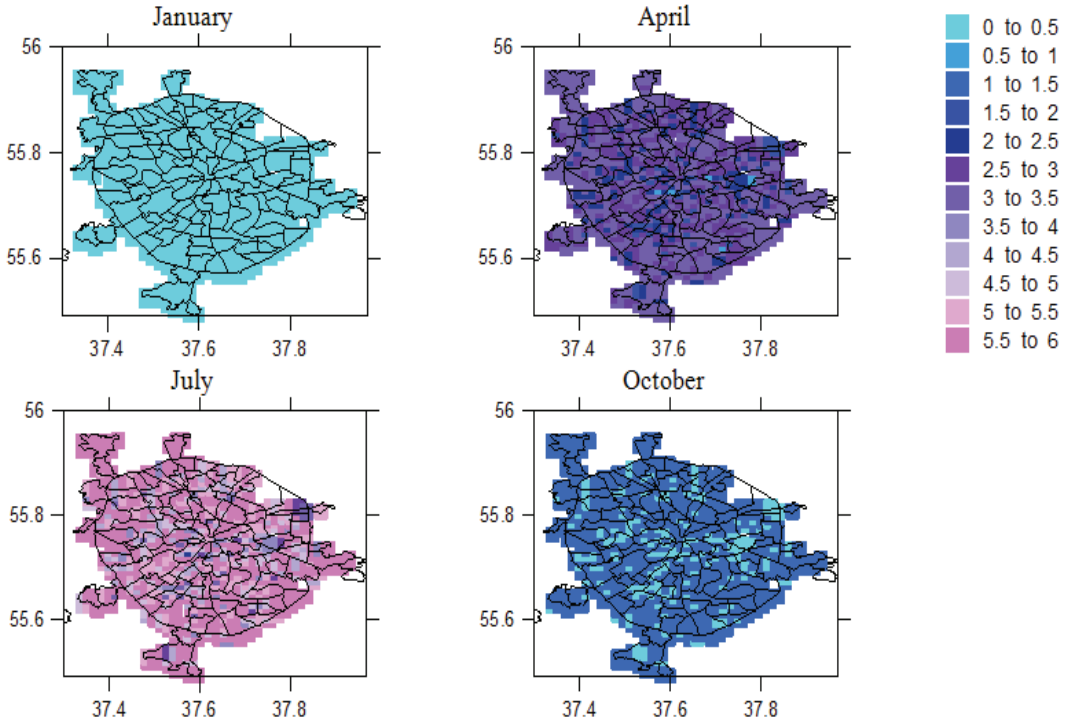

FIGURE 3. Noon UV indices with accounting for urban opacity for central months of the seasons over the territory of Moscow. 2010 year. Clear sky conditions.

CONCLUSIONS

We have obtained spatial distribution of SVF values over Moscow territory using the raster-based approach (Samsonov et al., 2015). The spatial distribution of noon UV indices with 1km resolution was estimated for the central months of the seasons over the territory of Moscow. We showed that the urban canopy can significantly influence on the UV level in the urban area of Moscow megalopolis.

ACKNOWLEDGMENTS

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