A study on the spatial patterns of the Moscow megacity urban heat island based on the dense official and crowdsourcing observations

Mikhail Varentsov\(^1,2,3\), Timofey Samsonov\(^1\), Pavel Konstantinov\(^1,2\), Pavel Kargashin\(^1\), Daniel Fenner\(^4\), and Fred Meier\(^4\)

\(^1\)Lomonosov Moscow State University, Faculty of Geography & Research Computing Center, Moscow, Russian
\(^2\)RUDN University, Smart Urban Nature Laboratory, Moscow, Russia
\(^3\)A. M. Obukhov Institute of Atmospheric Physics, Moscow, Russia
\(^4\)Technical University of Berlin, Berlin, Germany

The presented study is devoted to the investigation of the spatial patterns of the urban-induced air temperature anomaly, known as the urban heat island (UHI) effect, based on the example of Moscow megacity. The numerous previous studies have already shown that Moscow exhibits urban-induced climatic effects (Varentsov et al., 2018) and could serve as a good test-bed for urban climate studies. In the presented study, we have further analyzed the UHI using high-quality observations from the official meteorological networks in Moscow region as well as the uncertified crowdsourcing observations from Netatmo network. The official meteorological networks include more than 70 observational sites in the city and surroundings, while the Netatmo network additionally provides the data from more than 1500 citizen weather stations (CWSs) in Moscow region. Previous studies have shown that CWS observations could be used for urban climate studies after application of the special quality control and filtering routines (Meier et al., 2017).

The analysis performed for a number of summer and winter seasons has revealed the seasonal variations of the UHI spatial patterns. In order to investigate the driving factors of the observed spatial heterogeneity of the air temperature within the city, we have analyzed its linkages with different qualitative and quantitative parameters of the urban environment, including the Local Climate Zone (LCZ) type, the impervious area fraction, building density, vegetation area fraction, etc. These parameters were obtained using the Landsat and Sentinel satellite images, Copernicus Global Land Cover data and OpenStreetMap data. We have shown that the UHI spatial patterns are shaped both by local and non-local driving factors. The factors such as LCZ type represent the local features of the urban environment, while the non-local drivers represent the influence of remote parts of the megacity, transformed by the atmospheric diffusion and advection. The non-local effects are reflected e.g. in the dependence between the UHI intensity and the distance from the city center; in the differences between similar LCZs, located in the different parts of the city; in the heat advection to the leeward side of the city. The findings of the study clearly illustrate the importance of taking the non-local effects into consideration in urban planning applications, biometeorological assessments and when applying the LCZ approach for big cities.
Acknowledges: The processing and analysis of the official and crowdsourcing observations were supported by Russian Foundation for Basic Research (project no. 19-35-70009). The analysis of the impervious surface area fraction data was supported by Russian Foundation for Basic Research (project no. 18-35-20052). The analysis of the impacts of urban vegetation on the urban heat island was supported by Russian Science Foundation (project no. 19-77-30012).

References:
