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Simulations of Moscow megacity heat island with the COSMO-CLM model using two different urban canopy schemes and realistic building parameters, derived from OpenStreetMap data

Mikhail Varentsov (1,2), Hendrik Wouters (3), Kristina Trusilova (4), Timofey Samsonov (1), and Pavel Konstantinov (1)

(1) Lomonosov Moscow State University, Faculty of Geography, (2) A. M. Obukhov Institute of Atmospheric Physics, (3) KU Leuven, (4) Deutscher Wetterdienst, Department of Climate and Environment Consultancy

In this study we present the application of the regional climate model COSMO-CLM to simulate urban heat island (UHI) phenomenon for Moscow megacity, which is the biggest agglomeration in Europe (with modern population of more than 17 million people). Significant differences of Moscow from the cities of Western Europe are related with much more continental climate with higher diurnal and annual temperature variations, and with specific building features such as its high density and almost total predominance of high-rise and low-rise blocks of flats on the private low-rise houses. Because of these building and climate features, the UHI of Moscow megacity is stronger than UHIs of many other cities of the similar size, with a mean intensity is about 2 °C and maximum intensity reaching up to 13 °C (Lokoschenko, 2014). Such a pronounced UHI together with the existence of an extensive observation network (more than 50 weather and air quality monitoring stations and few microwave temperature profilers) within the city and its surrounding make Moscow an especially interesting place for urban climate researches and good testbed for urban canopy models.
In our numerical experiments, regional climate model firstly was adapted for investigated region with aim to improve quality of its simulations of rural areas. Then, to take into account urban canopy effects on thermal regime of the urbanized areas, we used two different versions of COSMO-CLM model. First is coupled with TEB (Town Energy Balance) single layer urban canopy model (Trusilova, 2013), and second is extended with bulk urban canopy scheme TERRA_URB using the Semi-empircal URban-canopY dependency parametriation SURY (Wouters et. al, 2016). Numerical experiments with these two versions of the model were run with spatial resolution about 1 km for several summer and winter months. To provide specific parameters, required for urban parameterizations, such as urban fraction, building height and street canyon aspect ratio, we used originally technology of GIS-based processing of realistic OpenStreetMap data, which includes size and shape of the most of the in the city (Samsonov et al., 2015).
Our testbed allows to make more detailed comparison between the modelling approaches, and also reveals the importance of correct definition of the of turbulent mixing in the ABL in the atmospheric model, and the realistic specification of the building morphology parameters and anthropogenic heat fluxes. In addition, strong seasonal variation of the importance of different factors, responsible for UHI appearance, was shown. Moreover, the framework allows to identify and solve issues regarding the different model approaches: detailed analysis of spatial and temporal variations of modelled urban temperature anomalies and their vertical extent has shown that version of COSMO-CLM model with TERRA-URB scheme simulate UHI effect in more realistic way.
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