Observation data sources

Climate database for Moscow and Saint-Petersburg
Situations in 2014, 41.UF, for 2000-2010, 41.UF 15.07.2015

Investigation of the climate change within Moscow metropolitan area
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Climate change in Moscow metropolitan area

<table>
<thead>
<tr>
<th>Climate parameter</th>
<th>Average temperature 1977-1997</th>
<th>Average temperature 2001-2010</th>
<th>Linear trend, °C/10 years 1977-2010</th>
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Abstract

As the urbanization continues worldwide more than half of the Earth's population live in the cities (U.N., 2010). Therefore the vulnerability of the urban environment – the living space for millions of people - to the climate change has to be investigated. It is well known that urban features strongly influence the atmospheric boundary layer and determine the microclimatic features of the local environment, such as urban heat island (UHI). Available temperature observations in cities are, however, influenced by the natural climate variations, human-induced climate warming (IPCC, 2007) and in the same time by the growth and structural modification of the urban areas. The relationship between these three factors and their roles in climate changes in the cities are very important for the climatic forecast and requires better understanding.

In this study, we made analysis of the air temperature change and urban heat island evolution within Moscow urban area during decades 1977-2010, while this urban area had undergone intensive growth and building modification allowing the population of Moscow to increase from 7 to 12 million people. Analysis was based on the data from several meteorological stations in Moscow city and surrounding territory. It shown that climate in Moscow region is rapidly warming, and warming rates, especially for night temperatures (00 UTC), are higher for urban stations – Balchug in city center and University in the south-west. Average warming rates for rural site are about 0.6 °C/10 years and for urban – about 0.7 °C/10 years. This allows to separate ‘urban warming’ trend at 0.19°C/10 years. It should be noted that rates of urban warming are maximum for night temperature (up to 0.2°C) and especially for night summer temperatures (up to 0.97 °C/10 years). The most significant effect of such warming is increasing of the number of days with extreme heat during the summer. e.g., during the Moscow heat wave 2010 the effect of the heat on mortality in Moscow was much stronger than in nearby regions, probably because of heat island, which keeps temperature above the comfortable level not only during the day, but also at night. Our analysis shown that during considered time period the probability of day-averaged temperature higher than 27°C in the city center has reached from 0.2 to 1.5%.

Because of the need for better understanding processed of observed climate change and prediction of probable climate changes and its consequences, we investigated the ability of climatic model COSMO-CLM to simulate extreme heat waves. Numerical experiments shown high sensitivity of the model to initial volumetric soil water content and to surface parameters database: different combinations of these models leads to different signs of average errors for daily-mean, day and night temperatures. Also it was shown that even for the best combinations of these parameters square error is higher than for reanalysis, which is used for boundary and initial conditions.

Several numerical experiments was launched version of model with urban parameterization, based on the urban canopy scheme (Masson, 2000, Trusilova, 2013). They shown that this parameterization is possible to reproduce average Urban intensity, but could correctly simulate its diurnal variation with daily minimum and nightly maximum, which could be caused by the fact, that this parameterization resistances for heat and momentum don't depend on stratification conditions.

References:


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Numerical experiment with COSMO-CLM model

Integration periods: May – August of 2002 and 2010 (years with the warmest summer seasons in Moscow)

System of nested domains:

Initial & boundary conditions

Variation of UHI

Sensitivity to the initial soil volumetric moisture content:

Sensitivity to the choice of surface database (GLC vs ECMAP):

The search for the optimal model parameters

Simple tests with urban module

• TEB scheme (Masson, 2000), implemented into the model code (Trusilova, 2013).
• Urban fraction from ECMAP/GLC
• Building fraction; 0.5
• Building height; 21 m
• H/W ratio; 1:1.5
• Typical for Moscow thermophysical parameters

Fluxes in urban canopy in TEB parameterization (Masson, 2000)