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Modeling of thermal comfort conditions inside the urban boundary layer during Moscow's 2010 summer heat wave (case-study)

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ABSTRACT

Heat waves in megacities at the beginning of XXI century become more dangerous. For example, Great Russian Heat Wave 2010 cause about 11 000 death additionally to mean value for late summer months (Revich, 2011). The main objective of this case-study is to evaluate the thermal comfort conditions of the warmest day in Moscow during the summer heat wave of 2010 – 29th July. For that purpose several biometeorological indices, particularly PET (physiological equivalent temperature), WBGT and ET were analyzed and calculated for this date in Moscow. The calculations were provided for several street canyon on the territory of the Moscow State University as well as for the places with natural vegetation. Meteorological conditions of 29 July 2010 were reproduced in south-west of Moscow-city at micrometeorological scale. Biometeorological indices were calculated for every hour of 29 July using output data of elaborated microscale model for Moscow megalopolis Urb_Mos 1.0 (Varentsov et al., 2012).

The results were compared with each other and, thus, the complex thermal comfort assessment was done. Also, the results of the calculations for the 29th of July 2010 were compared with the mean meteorological data for this period. The results showed, that PET index is the most relevant index for thermal comfort assessment during the summer, because it perfectly shows

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micrometeorological differences between the points. Duration of extreme heat pressure (according to PET values) measured up 4 h at open city landscapes.

1. Introduction

Biometeorological indices are used to assess thermal comfort conditions and evaluate the influence of the weather on the human organisms and their health. Despite of the fact, that some biometeorological indices are already used in weather forecast, the assessment of these indices is especially important during the extreme weather conditions like continuous heat or cold waves. One of the very urgent issues in the applied climatology is the assessment of thermal comfort conditions in the urban areas, because nowadays more than half of the word population lives there. Especially important is to study thermal comfort conditions in the biggest and, thus, densely populated cities, because the effect of heat waves becomes stronger by the urban heat island effect. To identify the heat wave in Moscow the definition from (Revich and Shaposhnikov, 2006) was used: during the heat waves mean daily temperature has to be more than +22.7 °C five consequent days long, and at least at three of them mean daily temperature has to be more than +25 °C. In July and August 2010 the longest and the strongest heat wave as well as the warmest day (29th of July 2010) were recorded since the beginning of meteorological observations in Moscow, Russian Federation (1879).

Moscow is a very big megalopolis, where according to data of the year 2010 over 11 million people live. Climate in that city is strongly affected by the densely placed buildings, which strongly affect human wellbeing by changes in thermal feeling. Good thermal feeling (thermal comfort) is the kind of physiological agreement with the thermal environment. This effect on human health is mostly dangerous in summer, during long heat waves connected with anti-cyclonic blocking, when there is an increased risk of deaths because of cardio vascular or respiratory diseases. But the mean air temperature is not the best indicator for the heat stress conditions, because human feelings also depend on the humidity, wind, radiation balance and many other factors. To assess thermal comfort conditions (conditions, by which the mind expresses satisfaction with the thermal environment (ASHRAE, 1992) and thermal feelings of a human biometeorological indices are used.

Biometeorology and thermal climate assessment particularly is an urgent issue, because it could be widely used for example, in tourism (Grigorieva and Matzarakis, 2011; Lin and Matzarakis, 2008), for urban planning (Matzarakis et al., 2010) or for understanding some health problems, for example, sleep disturbances (Nastos and Matzarakis, 2008). We decided to use biometeorological indices to assess thermal comfort conditions during strong heat event.

2. Materials and methods

2.1. Data

In July and August 2010 there was a blocking anticyclone over Moscow as well as central part of European Russia, therefore weather conditions were anomalously hot for long time. This heat wave lasted from the 4th July till 18th August. During this period the warmest day for Moscow in 143-year period of direct meteorological measurements was recorded on 29th of July (+39.0 C in city center), so it was decided to calculate thermal climate indices for this date and compare the results with thermal comfort indices calculated using mean meteorological data for July.

2.2. Study area

The study area is situated in the south–west part of Moscow in the campus territory of Lomonosov Moscow State University. This area includes the group of buildings forming the street canyon, the