Urban Climate 10 (2014) 550–562

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

Urban ‘heat island’ in Moscow

M.A. Lokoshchenko *,[1]

Lomonosov Moscow State University, Faculty of Geography, Department of Meteorology and Climatology, 119991 Lengory, Moscow, Russian Federation

ARTICLE INFO

Article history:
Received 21 August 2013
Revised 18 December 2013
Accepted 28 January 2014

Keywords:
Urban heat island
Air temperature
Climate
Weekly course

ABSTRACT

This paper contains a short review of urban ‘heat islands’. This phenomenon exists in cities almost all over the world with the exception of only some specific areas (e.g., – tropical deserts). It may exist in space field of different meteorological parameters such as air temperature, soil temperature, snow cover depth, dates of frosts, etc. Due to quick growth of big cities, the air temperature inside them increases faster (from 1.5 to 3.0 °C/100 years, in Moscow – by 2.3 °C/100 years in the 20th century) than in rural zones. General information about climate of Moscow is presented.

The mean intensity of the urban ‘heat island’ in Moscow (i.e. averaged in time difference between the air temperature in the city centre and outside the city) was nearly of 1.0–1.2 °C at the end of the 19th century, 1.2–1.4 °C one century ago and 1.6–1.8 °C both in the middle, and at the end of the 20th century. One more parameter – areal, or ‘averaged spatial’ intensity of the ‘heat island’ – is suggested. It represents a value averaged both in time and in space (a difference between mean air temperature in the city area and outside the city). In Moscow the areal intensity was equal to 0.8–0.9 °C both in the middle, and at the end of the 20th century. Thus, during several last decades both parameters remained nearly the same in spite of continued growth of the city. The probable explanation is that the urban growth seems to be extensive now so that urban saturation and density of heat sources in the centre of the city changed only a bit during the last half of the century.

In the diurnal course the ‘heat island’ intensity in Moscow is maximal usually at night. The maximal ‘heat island’ intensity in Moscow may reach up to 14 °C, usually at night or in the early morning.

* Tel.: +7 4991216272/4959394284.
E-mail address: loko@geogr.msu.su

[1] Leading scientific researcher of Lomonosov Moscow State University, associate professor, Ph.D.

http://dx.doi.org/10.1016/j.uclim.2014.01.008

Weekly course of the air temperature in Moscow is closely connected with the urban 'heat island' phenomenon. On the average during the last 50 years there was a gradual increase of T during week-days and sharp decrease (cooling) on weekends. This may be explained by industrial haze which is gradually accumulated from Monday to Friday and reduces effective nocturnal radiation in the city, especially during winter nights.

1. Introduction and short review about the 'heat island' phenomenon

The notion of urban 'heat island' is known since 1820 when Luke Howard for the first time discovered this phenomenon for London by simple comparison of two rows of the air temperature T data inside and outside the city. In fact, any city and even any small village create their own 'heat island' almost everywhere (Adamenko, 1975; Böer, 1964; Kratzer, 1956; Landsberg, 1981; Oke, 1978). The air temperature inside a city is as a rule higher than outside due to not only direct anthropogenic heat sources (winter heating, etc.), but a lot of other climatic factors as well as less hidden heat in a city because of less transpiration due to limited green zones and because of man-made precipitation drainage, bigger heat capacity of building walls and asphalt covering, changes of radiation balance in cities including industrial haze which reduces effective nocturnal radiation, specific albedo, etc.

As a result, usually the bigger a city the higher the air temperature is. At the same time a city creates the urban 'island of dryness' because the relative humidity inside a city is as a rule less than outside. One more additional phenomenon in the urban climatology is local 'cool islands' in green park zones inside cities (e.g., Oke, 1978). A well-known example of a local 'cool-island' inside a 'heat island' is the Imperial palace and surrounding gardens in Tokyo where at night T is 3–4 °C less than in the city centre (Narita et al., 2009). Evidently, similar examples are small-scale in comparison with a total city area. However, it should be noted that sometimes the geographical specifics of a site may change a sign of the urban thermal effect. For instance, in tropical deserts some towns in oases are characterized by higher density of green areas and sources of open water. Thus, in arid tropics sometimes not only a separate park, but the whole town creates a 'cool island' instead of a 'heat island' due to intense transpiration – e.g., Beer Sheva in Israel all the year round before 1985 (Potchter, unpublished) or Cairo in Egypt in late autumn (Robaa, 2003).

It should be also noted that the rate of current climate warming in big cities was higher – e.g., 1.6 °C in New York, 2.3 °C in Moscow (Lokoshchenko and Vasilenko, 2009) and nearly 3.0 °C in Tokyo (Fujibe, 2009) in the 20th century whereas the global increase of the air temperature was on average only 0.6–0.7 °C/100 years. The mean intensity of the urban 'heat islands' ΔT on average for a year (that is a difference of T inside and outside a city) is as a rule from 1 to 2 °C, sometimes up to 2.5 °C (e.g., in Paris and Tokyo). The daily course of ΔT is usually characterized by a maximum in late evening or in the first half of night and a minimum in the afternoon. Sometimes in the middle of a day the value of ΔT even changes its sign and becomes a bit negative (e.g., in Leipzig by Böer, 1964) – probably, due to thermal inertia of building walls and asphalt roads after their cooling at night. The maximal 'heat island' intensity ΔT_{max} may reach up to 10–15 °C, usually – in the evening or at night (Landsberg, 1981; Lokoshchenko and Isaev, 2003; Oke, 1978). However, these maximal differences may be overestimated and must be tested with an account of spatial homogeneity of the T field including influence of relief, possible passing of atmospheric fronts, etc. Studying and detailed mapping of 'heat islands' in cities may be made either by use of more frequent network of ground meteorological measurements including travel measurements by moving meteorological station, or with the help of satellite data. Usually a 'heat island' is mapped by isolines of mean or minimal T; the latter indicates a difference, that is closed to ΔT_{max} in anticyclone conditions. However, sometimes the 'heat island' phenomenon may be seen even in the spatial field of the daily maximal T (e.g., Lokoshchenko, 2012). Moreover, 'heat