URBAN CLIMATE: THE MOST IMPORTANT MODIFIED

N. V. Kobysheva
Main Geophysical Observatory, St. Petersburg, Russia

Keywords: convection, greenhouse effect, heat island, local circulation, roughness, urbanization.

Contents

Summary

The changes of solar radiation and heat balance in the urban areas are the consequences of atmospheric pollution, water vapor release, weakening of wind and evaporation reduction. As a result, heat islands are formed in the cities. Thus the shower and fog frequency decreases and the temperature and wind vertical distribution changes considerably in the air layer up to 100 m.

More than half of the population of the world lives in cities. In the advanced countries more than 70% of population lives in the urban areas. There is a constant population shift to cities in many areas. Modern cities and their suburbs have grown up to the huge sizes. Various kinds of human activity in cities cause local effects in the atmosphere. These effects are enhanced in the process of cities growth.

A modern city represents mesoclimatic heterogeneity sharply distinguished from the surrounding area. It creates the local climate differed from rural area climate in many respects.

1. Introduction

There are some basic reasons resulting in features of urban climate. First of all the city is a powerful source of dust and pollution of air by aerosol and gaseous pollutants. So, for example, in London each square meter of territory for one day receives 12 g of dust or 4.5 kg per year. In industrial centers it is twice as much. In the Russian cities in 1994, 4.3 million tons of particulate matter was emitted into the atmosphere. In the cities of Byelorussia per 100 thousand of the urban population about 12 tons of carbon oxide, 2 tons of nitrogen oxides and hydrocarbons, about 1 ton of particulate matter are emitted

annually. The role of this pollution in urban climate conditions is large and with many plans.

First of all, pollution has an effect on the radiation regime. It reduces the income of solar radiation by 10% and even sometimes 20%. Ultraviolet radiation can be decreased by 40% and more. The gas component of pollutants (carbonic gas, methane etc.) produces "greenhouse effect" - reduces effective radiation. The air of large cities contains from 15 to 20 times more aerosol particles, than that of rural area. They become the centers of water vapor condensation. Thus the condensation can occur when humidity is less than 100%. The aerosol reduces the transparency of urban atmosphere, makes the urban sky more whitish because of the neutral diffusion of solar radiation. The smoke dome creates temperature inversion, which complicates vertical ventilation.

The second important reason of urban climate peculiarities is the urban building. The increased roughness arises due to different height of houses and their various arrangements. As a result the air flows are transformed. The local areas of air stagnation can be created. Solar radiation is reflected and absorbed repeatedly from the buildings walls and asphalt covering. So the albedo decreases from 5 to 10%. The exceptions are the parks which reflect from 20 to 25% of incoming radiation. The buildings form additional obstacles which close the horizon, reduce the sunshine duration by 20% and change the illumination. So convective flows and turbulence can be intensified appreciably due to the non-uniform heating of variously oriented houses, strong heating of asphalt and the buildings roofs.

2. Cities of High and Middle Latitudes

One of the most important city effects is its heat release. The city uses a plenty of fuel for heating, industrial and transport purposes. Thus almost the whole produced energy turns to heat. The city heat release for one year makes up to 50% of radiation heat on the average. For example, according to the data of McGoldrick (1980) the average daily heat emission in the center of London reaches $234\ W\ m^{-2}$. The global radiation income amounts $106\ W\ m^{-2}$. In winter time in the northern cities the heat income is higher than radiation balance everywhere. M. I. Budyko considers that if the city were isolated from the surrounding area, the air temperature inside it would rise by 10°.

The influence of big cities on the water balance is of no less importance. The city changes the water balance components and hydrological cycle. A significant amount of water vapor is released into the air when burning of natural gas, petrol, petroleum, coal, evaporating in cooling systems, from ponds - coolers, pools - conditioners. On the other hand, organized snow and ice runoff results in the fact that the streets surface dries up more quickly and evaporation decreases. A great amount of water is spent by the systems which supply water for industrial and household needs. The time of precipitation runoff decreases due to the water-proof roofs and sewerage systems. The artificial and natural lakes are exposed to urbanization effect. The red and brown algae expand because of biological wastes dumping. Besides, the lakes are silted up.

The urban climate is also affected by the municipal services (clearing of snow, measures

taken for its thawing, gardening etc).

Often the various reasons of urban climate formation lead to the opposite results. For example, the atmospheric aerosol strengthens the water vapor condensation. It should be accompanied by the increase of the fogs number. At the same time the higher air temperature causes reduction of the fogs frequency. "Roughness" of city reduces a wind speed, but when air flow moves along narrow streets, the wind speed increases because of the effect of "aerodynamic tunnel". Global radiation decreases in the narrow streets due to the shading by high building. On the other hand, reflection by walls and pavements increases diffuse radiation.

So, urban climate formation depends on the reasons prevailing in the given city

-
-
-

Bibliography

Budyko M.I., (1971). Climate and Life. L., Gidrometeoizdat [The urban impact in air temperature regime is investigated].

Davenport A.G. (1980). The relationship between wind structure and wind loading.-Proc. Conf. Wind Effects on structures. V.1 Natl. Phys. Lab. H.M. Stationary office, London, p.53-102 [The vertical profiles of wind speed are studied for various types of surface roughness in city].

Jauregue, E.,(1984). The Urban Climate of Mexico City. In W.M.O. 1986. pp.63-86 [The features of heat and wind regime in Mexico City are described]

McGoldrick B.,(1980). Heat release from Great London, Physics Division Energy Workshop Rept. 20. Dept. Of Physical Sciences. Sunderland Polytechnic, Sunderland, 32 p. [The statistical distributions of daily and fixed-time values of temperature-humidity complex are considered].

Oke T.R.,(1982). Climates of Boundary Layer. Gidrometeoizdat, (Translation from English by Dubov. AMPERE-SECOND.), 359 p. (The basic regularities of the climate of boundary layer in particular city are described).

Padmanabhamurty, B. and Mandal, H.D., (1982). Urban-Rural Radiation Differences, *Mausam 33*, 509 p.

W.M.O.,(1992). Guidance material on the calculation of climatic parameters used for building purposes [The methods for climatic characteristics calculating for building are presented]

Biographical Sketch

Kobysheva Nina Vladimirovna, Dr. of geogr. Sci., Professor, Honoured Scientist, Head of the technical climatology laboratory of MGO, Professor of St-Petersburg University. Fields of scientific interests are statistical methods in climatology, applied climatology. Author of 7 monographs, 3 text-books, Building Standards and Rules "Building Climatology", more then 200 papers. Supervisor and editor of Scientific-Applied reference book. About 25 Candidate's dissertation were defended under her guidance. A member of working group of WMO, working group № 13 CIB, working group № 75 of International

Electrotechnical Commission. Was conferred a medal of National Exhibition of economy achievements, medal "Honoured expert of gidro-meteo service", Voeikov's prize, International WMO and CCL certificate.

Was born in 1925 in Omsk city. Was graduated from the Odessa Hydrometeorological Institute in 1948. In 1955 has defended the candidate dissertation after finishing the post-graduate course of Main Geophysical Observatory.