Evaluation of ventilation conditions and bioclimatic comfort conditions in Moscow at the microclimatic level, depending on different types of the buildings structure

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Abstract: Since a large number of people live in Moscow, as well as in the city there are many sources of aerosols harmful to health (for example, transport), there is a need to study the conditions of ventilation and bioclimatic comfort. To study this problem, an experiment was set up to consider 8 periods with different weather conditions in order to obtain a more complete picture of the distribution of areas with unfavorable conditions. To calculate the trajectories of particles, wind flows, temperature distribution, a three-dimensional non-hydrostatic microclimatic model ENVI-met was used. Since Moscow is characterized by a heterogeneous development of buildings, the LCZ approach was used to describe the underlying surface. It has been shown that the most comfortable zone in terms of particle dispersion and thermal stress conditions is LCZ 15 and LCZ 4.

Main issue: to identify the most vulnerable and most comfortable zones in terms of blowing conditions and thermal comfort conditions

Objectives of the research:

❖ to highlight the main local climatic zones for the center of Moscow
❖ to calculate the values of wind speed and thermal comfort indices for a selected area using the ENVI-met model for heat wave and cold wave conditions
❖ to average the values for the identified LCZ zones and to conduct an analysis

Local climate zones distribution in center areas of Moscow, study area

The territorial domain of the center of Moscow (Balchug) was taken as the study area. The center of Moscow is characterized by different underlying surfaces.

Local Climate Zones (LCZ) have been used to describe the different structures of the underlying surface. The LCZ approach implies that urbanized areas can be divided into 17 categories (10 types of buildings and 7 types of natural surfaces). Each category is unique in its combination of surface structure, surface types, and human activities. This classification allows to compare climatic conditions in different cities within the same LCZ.

Especially for the territory studied in this work, a local climate zone (LCZ) distribution map was obtained with a step of 50 meters x 70 meters. For further analysis of ventilation conditions, homogeneous areas of local climate zones were selected: LCZ2, LCZ4, LCZ5, LCZ8, LCZ15.

Weather conditions for experiments

As the initial data, it was decided to use the meteorological values for June 2019 and January 2017 as one of the hottest and coldest periods, respectively, in recent years. For the selected two months, an analysis was carried out in order to identify heat waves and cold waves. In each of the periods, 4 points were taken: 2 nighttime (with and without wind), and 2 daytime (with and without wind).

Experiments' results for PET index

During the summer heat wave the most comfortable area will be the one where the wind speed is higher - LCZ 15. At night, especially in the presence of wind, the population in the center of Moscow finds itself in a zone of slight cold stress (PET ~ 13 °). During the day, with light winds, very high values of the index are observed, which correspond to extreme heat stress.

LCZ	Summer			
	night		day	
	windy	calm	windy	calm
	03h 19.06	03h 08.06	15h 18.06	15h 20.06
2	13,4	18,4	37,4	43,7
4	**13,3**	**18,2**	**37,0**	**42,0**
5	13,8	18,6	37,6	42,1
8	**13,0**	**18,2**	**39,2**	**45,3**
15	**12,6**	**18,1**	**37,6**	**43,4**

Experiments' results for wind speed

The results of wind experiments showed that local decreases in wind speed are mainly concentrated in yards, between buildings. The lowest speeds are observed in square courtyards - buildings closed on all 4 sides. Large values of wind speed (more than 2.5 m/s) are mainly confined to either narrow passages between houses, and the passage is directed perpendicular to the main stream (the effect of an urban canyon), or to the corner of a building bordering an open area (for example, a water body). Wind speed enhancement effects are only observed at high background values. On the basis of the previously selected homogeneous LCZ in the considered area, the wind speed was averaged in the experimental periods.

LCZ	Winter				Summer			
	night		day		night		day	
	windy	calm	windy	calm	windy	calm	windy	calm
Date	03h 07.01	03h 09.01	15h 07.01	15h 08.01	03h 19.06	03h 08.06	15h 18.06	15h 20.06
2	1,4	0,6	1,0	0,5	1,2	0,7	2,2	1,6
4	**1,6**	**0,6**	**1,2**	**0,6**	**1,4**	**0,9**	**2,5**	**1,9**
5	1,4	0,6	1,0	0,6	1,1	0,7	2,0	1,7
8	1,5	0,6	1,0	0,6	2,6	0,8	2,2	1,7
15	**1,7**	**0,7**	**1,3**	**0,7**	**1,5**	**0,9**	**2,6**	**2,0**

Conclusions

- Buildings in the center of Moscow are quite variegated, but the main local climate zones are LCZ2, LCZ4, LCZ5, LCZ8, LCZ15.

- The most blown area - LCZ 15. On the map, it corresponds to the Zaryadye park. The average background of the wind there is high in all the periods under study, which means that the rate of dispersion of particles is higher. It is worth highlighting LCZ 4, in which high wind speeds are also observed. The most vulnerable areas to accumulation of pollution are LCZ 2 (dense buildings) and LCZ 5.

- From a bioclimatic point of view, the most comfort zones are also LCZ 15 and LCZ 4, the most uncomfortable is LCZ 8. **Thus, from both aspects considered (wind speed and bioclimatic comfort), LCZ 15 and LCZ 4 are the most healthy areas of the center of Moscow.**