The mean yearly temperature lapse rates in the urban atmospheric boundary layer (ABL) on microwave sounding data.

Kuznetsova I.N.[1], Khaikine M.N.[2], Nakhayev M.I.[1]
(muza@mecom.ru and khaikine@attex.ru)
[1] Hydrometeorological Research Center, Moscow, Russia
[2] Central Aerological Observatory, Dolgoprudny, Russia

The mean yearly temperature lapse rates were calculated using the data of ABL temperature profile measurements made by means of microwave meteorological temperature profiler MTP-5, developed in the Central Aerological Observatory /Kadygrov and Pick, 1998/. The measurements were carried out in three great cities of Russia: Moscow, Krasnoyarsk and Nijni Novgorod during 2004-2005 (table 1). These cities are located on approximately the same latitude but have different relief and landscape.

The lapse rate $G_h(t_i)$ were calculated using hourly averaged temperature $T_h(t_i)$ in the layers H=0-100, 0-200, 0-300, 0-400, 0-500 и 0-600 m. $G_h(t_i) = (T_0(t_i) - T_h(t_i))\ 100/h$, where i=0,1,2... 23 is the number of the hour; t_i = 0:30; 1:30; 2:30... 23:30. $T_h(t_i)$ is mean temperature in i-th hour on height h; h=100, 200, 300, 400, 500 и 600 m.

Mean lapse rates calculated for the whole period of observations are given in Table 1. The minimum and maximum values of lapse rates and the value of mean square root deviations (MSRD) of daily mean lapse rates calculated for the layers is also shown in the table.

The temperature profile measurements were carried out in Moscow by MTP-5 placed in the center of the city. Table 1 shows the mean values of lapse rate vary in range from 0.42°C/100 m up to 1.77°C/100 m. It was noted that the ratio of maximum lapse rate to minimum one equals to almost constant value in all layers (it varies from 2.2 up to 2.5). The greatest variation of lapse rate observed in the lower 100 m layer. The mean lapse rate exceeds dry adiabatic gradient in the lower 100 m layer during 15 hours (from 8 up to 22 LT). The lower 300 m layer remains thermally unstable almost 12 hours (from 10 up to 21) and the whole 600-meter layer was unstable from 14 up to 16 (the instability maximum). Thus, the urban ABL is weakly-steady only third part of day. The conditions of intensive mixing and turbulent exchange are favorable for pollutions scattering observed in the largest part of day.

Profiler MTP-5 is installed in Krasnoyarsk in the center of city at a distance about 800 m from the Yenisey River. The lapse rate range of the intradiurnal changes (Max-Min difference in the day) was 1.8 times greater than that in the center of Moscow and MSRD was 1.6 times greater in Krasnojarsk than in Moscow in the lower 100 m layer. The lapse rates equaled to dry adiabatic gradients and greater were formed in Krasnoyarsk in the lower 300 m layer only in contrast to Moscow. It was observed in the layer 0-300 m for 3 hours (from 13 up to 16) and in the layer 0-100 m for 9 hours (from 10 up to 18), which is less for 7 hours than in Moscow (from 7 up to 22). The strong stability of ABL was observed in the lower 500 m layer from second half of the night (2-3 h) until the morning (7-8 h). Moreover, the layer 200-300 m was steadier than lower layer. It indicates existence of heat source, which decrease the cooling by radiation emission. Such source can be not only UHI, but also the water surface of Yenisey River. The influence of aqueous objects on the thermal regime of ABL is beyond controversy, but we do not have available quantitative estimations of such effects in the scale of a large city. Nevertheless, some conclusions can be done through comparison between consistent data from the three cities.

Nijni Novgorod is located on the banks of two large rivers: Volga River and Oka River. Profiler MTP-5 is installed in Nijni Novgorod on the high bank of Oka River at a distance about 900 m from the river. The maximum value of mean lapse rate in Nijni Novgorod was found to be 0.9°C/100 m, which is less than dry adiabatic gradient. This is the most essential difference from Moscow and Krasnoyarsk. An increase of the mean lapse rate with an increase of the layer thickness indicates the specific temperature conditions of ABL in Nijni Novgorod in the night and morning time (from 21 up to approximately 7) (in Moscow the picture is opposite). It is possible to assume that the moisture evaporating from the water table of two large rivers is the source of latent heat in the lower layers. Local winds formed due to a large difference of altitudes in coastal zone (greater than 100 m) can be the reason for ABL structure deformations, but we do not have the data on the vertical stratification of wind and humidity to carry out the certain conclusions.

Conclusions

- greatest deformations of ABL thermal structure was observed in Moscow. It is caused by the multifactor influence of megalopolis on the thermal regime of the lower layers of the atmosphere;
- Yenisey River do substantial influence on urban ABL in Krasnoyarsk besides the city;
- ABL in Nijni Novgorod does not have expressed features of large city influence. The discovered specific features are probably caused by the influence of large river mirror and by local air circulations above the sharply heterogeneous relief.

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Table 1.

The mean yearly values of lapse rates (°C/100 m).

Hour	Moscow						Krasnojarsk						Nijni Novgorod					
	Layer, m																	
	100	*200*	*300*	*400*	*500*	*600*	*100*	*200*	*300*	*400*	*500*	*600*	*100*	*200*	*300*	*400*	*500*	*600*
0	0,89	0,83	0,76	0,69	0,64	0,62	0,21	0,15	0,16	0,16	0,19	0,24	0,06	0,13	0,20	0,23	0,27	0,32
1	0,85	0,77	0,70	0,63	0,59	0,57	0,11	0,06	0,07	0,09	0,13	0,18	0,01	0,07	0,14	0,18	0,23	0,28
2	0,85	0,73	0,65	0,58	0,55	0,53	0,05	-0,01	0,01	0,03	0,07	0,13	-0,06	0,01	0,09	0,14	0,20	0,25
3	0,83	0,70	0,61	0,54	0,51	0,49	-0,02	-0,09	-0,06	-0,03	0,02	0,08	-0,12	-0,04	0,04	0,10	0,16	0,22
4	0,80	0,64	0,56	0,49	0,46	0,45	-0,06	-0,13	-0,11	-0,07	-0,02	0,04	-0,14	-0,06	0,02	0,08	0,14	0,21
5	0,80	0,62	0,53	0,47	0,43	0,43	-0,09	-0,17	-0,15	-0,11	-0,05	0,01	-0,14	-0,08	0,00	0,07	0,13	0,19
6	0,85	0,64	0,53	0,46	0,43	0,42	-0,06	-0,17	-0,16	-0,12	-0,07	0,00	-0,15	-0,11	-0,03	0,03	0,09	0,16
7	0,99	0,73	0,60	0,51	0,46	0,45	0,09	-0,08	-0,10	-0,08	-0,04	0,02	-0,05	-0,05	0,00	0,05	0,11	0,17
8	1,20	0,90	0,73	0,62	0,56	0,53	0,36	0,12	0,05	0,03	0,05	0,10	0,14	0,06	0,08	0,11	0,15	0,20
9	1,42	1,09	0,92	0,78	0,69	0,65	0,71	0,37	0,25	0,19	0,18	0,21	0,38	0,26	0,23	0,23	0,25	0,29
10	1,57	1,27	1,07	0,91	0,81	0,75	1,01	0,61	0,45	0,36	0,33	0,33	0,58	0,44	0,39	0,36	0,36	0,39
11	1,67	1,38	1,18	1,02	0,91	0,85	1,30	0,87	0,68	0,55	0,49	0,49	0,73	0,58	0,52	0,47	0,46	0,48
12	1,74	1,46	1,27	1,10	0,98	0,92	1,51	1,07	0,86	0,71	0,63	0,61	0,84	0,69	0,62	0,57	0,55	0,55
13	1,76	1,50	1,32	1,14	1,03	0,97	1,62	1,20	0,99	0,82	0,74	0,70	0,89	0,76	0,69	0,63	0,61	0,61
14	1,77	1,52	1,34	1,17	1,05	0,99	1,62	1,23	1,03	0,87	0,78	0,75	0,90	0,79	0,72	0,67	0,64	0,64
15	1,75	1,51	1,34	1,17	1,06	1,00	1,55	1,20	1,03	0,87	0,79	0,76	0,87	0,77	0,72	0,67	0,65	0,65
16	1,71	1,49	1,33	1,16	1,05	0,99	1,42	1,14	0,99	0,85	0,78	0,75	0,80	0,73	0,69	0,65	0,63	0,64
17	1,63	1,44	1,29	1,14	1,03	0,97	1,26	1,04	0,92	0,79	0,73	0,71	0,72	0,67	0,64	0,61	0,60	0,61
18	1,55	1,37	1,23	1,09	0,99	0,94	1,11	0,94	0,84	0,73	0,68	0,67	0,63	0,59	0,59	0,56	0,56	0,58
19	1,40	1,27	1,16	1,03	0,94	0,89	0,95	0,83	0,76	0,67	0,63	0,62	0,55	0,53	0,53	0,52	0,52	0,54
20	1,23	1,15	1,06	0,95	0,88	0,84	0,79	0,70	0,65	0,58	0,55	0,55	0,48	0,47	0,48	0,47	0,48	0,50
21	1,07	1,04	0,97	0,88	0,81	0,78	0,60	0,55	0,52	0,47	0,46	0,48	0,34	0,37	0,40	0,41	0,43	0,46
22	0,99	0,96	0,89	0,80	0,75	0,72	0,44	0,40	0,40	0,37	0,37	0,40	0,25	0,28	0,32	0,35	0,38	0,41
23	0,95	0,89	0,83	0,75	0,70	0,67	0,31	0,27	0,27	0,26	0,28	0,31	0,15	0,20	0,26	0,29	0,33	0,38
Min	0.80	0.62	0.53	0.46	0.43	0.42	-0.09	-0.17	-0.16	-0.12	-0.07	0.00	-0.15	-0.11	-0.03	0.03	0.09	0.16
Max	1.77	1.52	1.34	1.17	1.06	1.00	1.62	1.23	1.03	0.87	0.79	0.76	0.90	0.79	0.72	0.67	0.65	0.65
MSRD	0.38	0.33	0.30	0.26	0.23	0.21	0.61	0.50	0.43	0.36	0.31	0.27	0.38	0.32	0.27	0.22	0.19	0.17

Reference.

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