STUDY OF SEASONAL AND INTERANNUAL FEATURES OF URBAN ISLAND VERTICAL STRUCTURE ABOVE MOSCOW CITY

Ekaterina Vorobyeva*, Evgeny Miller*, Evgeny Kadygrov*
*Central Aerological Observatory, Dolgoprudny, Russia

Abstract

During 2005-2008 two microwave temperature profilers (MTP-5) were used simultaneously in Moscow region, Russia, for continuous measurements of ABL temperature profiles. Continuous microwave remote sensing observation of thermal structure (at altitude range 0-600m) in the city center and in suburb gave a good possibility for study of seasonal interannual variations and features of the urban heat island vertical structure above Moscow city. On the base of this data were calculated features of vertical temperature gradient for each 100 meters above the city and above suburb at two seasons (summer, winter). It was also calculated parameters of temperature inversions in city center and in suburb and it's seasonal variations. Last two winters in Moscow were anomaly warm and so more attention we gave to the winter temperature profilers data from two point: Moscow city center and from north border of Moscow city. One of the analysis results was also estimation of some features of urban boundary layer altitude above Moscow megalopolis in different seasons.

Key words: urban heat island, temperature inversions, microwave temperature profiles

1. INTRODUCTION

The numbers of researches dedicated to urban heat island (UHI) increased significantly in last two decades. These works shows that anthropogenic interactions in the form of powerful sources of pollution and water vapor and supplemental heat sources can exert a substantial influence on the intensity and form of the environment response in the large industrial cities and megalopolises. These factors lead to special climate formation in a megalopolis. To investigate this special formation and especially it's vertical structure of it's temperature characteristics it s required to have long rows of temperature data and is very desirable to have it's vertical distribution.

Since 2001 in Moscow region two microwave temperature profilers (MTP) are successfully used for retrieving temperature profiles at the altitude range up to 600 m and with accuracy 0,5 °C . The MTP is an angular scanning scanning single-channel instrument with central frequency of about 60 GHz designed to provide continuous, unattended observations. It can measure thermal emission of the atmosphere with high sensitivity (0.03 K at 1 s integration time). [Troitsky et. al., 1993; Kadygrov and Pick,1998].

The data obtained from two MTP set in Moscow region provide the possibility to make the analysis of interannual and seasonal features of UHI in Moscow. On the base of this data were calculated features of vertical temperature gradient for each 100 meters above the city and above suburb at two seasons (summer, winter). It was also calculated parameters of temperature inversions in city center and in suburb and it's seasonal variations. In the last 50 years mean temperature in Moscow region increased on 1.5 °C. [Kuznetsova et. al, 2003; Khaikine et. al., 2006.]. Especially large changes is in winter period. For this season mean temperature increased on 3 °C, as for summer, autumn and spring its 0.6, 0.8 and 2.2. °C accordingly. The last three winters (06/07, 07/08, 08/09) in Moscow was the warmest for the last 50 years. The only warmer winter in the last 100 was in 1960/61. So more attention was paid on winter temperature profiles.

Last two winters in Moscow were anomaly warm and so more attention we gave to the winter temperature profilers data from two point: Moscow city center and from north border of Moscow city.

2. PROCEDURE OF MEASUREMENTS AND DATA PROCEEDING

One of the MTP was installed in the centre of Moscow city (Krasnaya Presnya region). The other is placed on the territory of Central Aerological Observatory in Dolgoprudny. Dolgoprudny is a small city in the north border of Moscow, approximately 20 km away from the 1st device. Both of them are placed on the roof of 4stored buildings (approximately 20 m above ground). The relative position of 2 microwave profiles is shown on figure 1.

Figure 1. The relative position of two meteorological temperature profiles set in Moscow and Dolgoprudny

The temperature profiles was obtained “round-the-clock” every 5 min. For the further analysis the 1 hour mean temperature was calculated and the data between 2 points was synchronized. Table 1 shows the summary data, used in this study.

Season, year	Number of profiles
Winter 2006 (Jan-Feb)	1416
Winter 2007 (Jan-Feb)	1348
Winter 2009 (Jan-Feb)	1234
Summer 2005 (Jul-Aug)	395
Summer 2006 (Jul-Aug)	744
Summer 2007 (Jul-Aug)	744

3. RESULTS AND CONCLUSIONS

On figure 2 it is shown the diurnal distribution of inversions in winter and summer period
Here it can be seen that the amount of inversions in Moscow and Dolgoprudny is almost the same. The quantitative difference for three years is explained by different weather conditions.
For instance, winter 2006 (Jan-Feb) was very cold. The mean temperature for that year was 2.3 degrees lower than normal. Whereas winters 2007 (Jan-Feb), 2006 (Jan-Feb) was on contrary the warmest in the last 40 years. And it’s mean temperature was more than 4 degrees greater than normal.
For summer figure 2 shows the distinct differences in the frequency of cases and in the time of destruction and formation of inversions. In Dolgoprudny in summer the quantity of inversions is very close to that in winter, but in Moscow in summer the same number is less almost twice. The time of destruction and formation of inversions in Moscow is usually earlier or later than that in the suburb. It is probably connected with the differences in the characteristics of underlying surface.
To get more clear understanding in the characteristics of inversion we calculated the statistical distribution of temperature gradients for Moscow and Dolgoprudny. On figure 3 it is shown an example of such distribution for two years (with a warm and cold winters). The character of the figures for each season looks similar. Between the seasons it is obvious that there is a difference.
The results of this work shows the features of seasonal and interannual differences of thermal regime of atmospheric boundary layer. The most distinct these differences for the conditions of intense radiative cooling and heating in summer seasons 2006-2007. The analysis of diurnal distribution of inversions from view point of seasonal differences puts a question about the nature of stability of ABL for the centre of megalopolis and its suburb.
During this study we were interested in investigation the question of typical heights, on which the influence of Moscow city is effected. In the first place it is the seasonal variation of such height and having the long rows of data we evaluated theinter annual differences of temperature stratification. Using the results if this study it can be said about the reduction of the differences between cities and it’s near suburb at the 300 m height.

References

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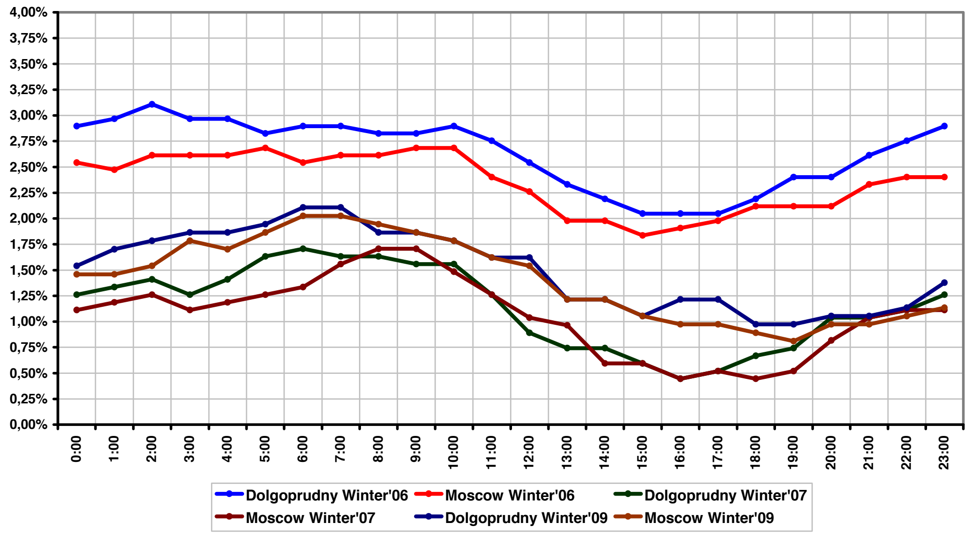
Diurnal distribution of inversions for winter period



Diurnal distribution of inversions for summer period

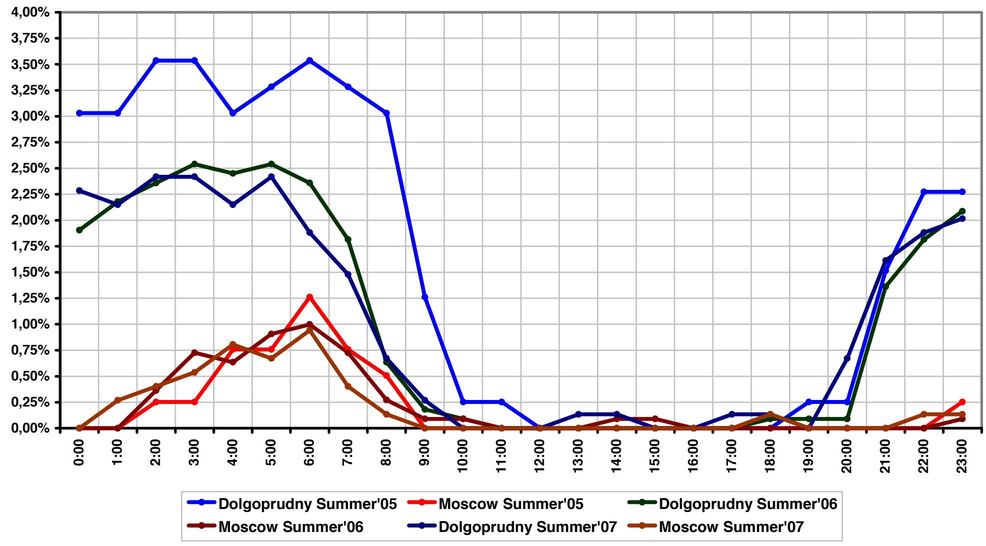


Figure 2. Diurnal distribution for winter and summer period.

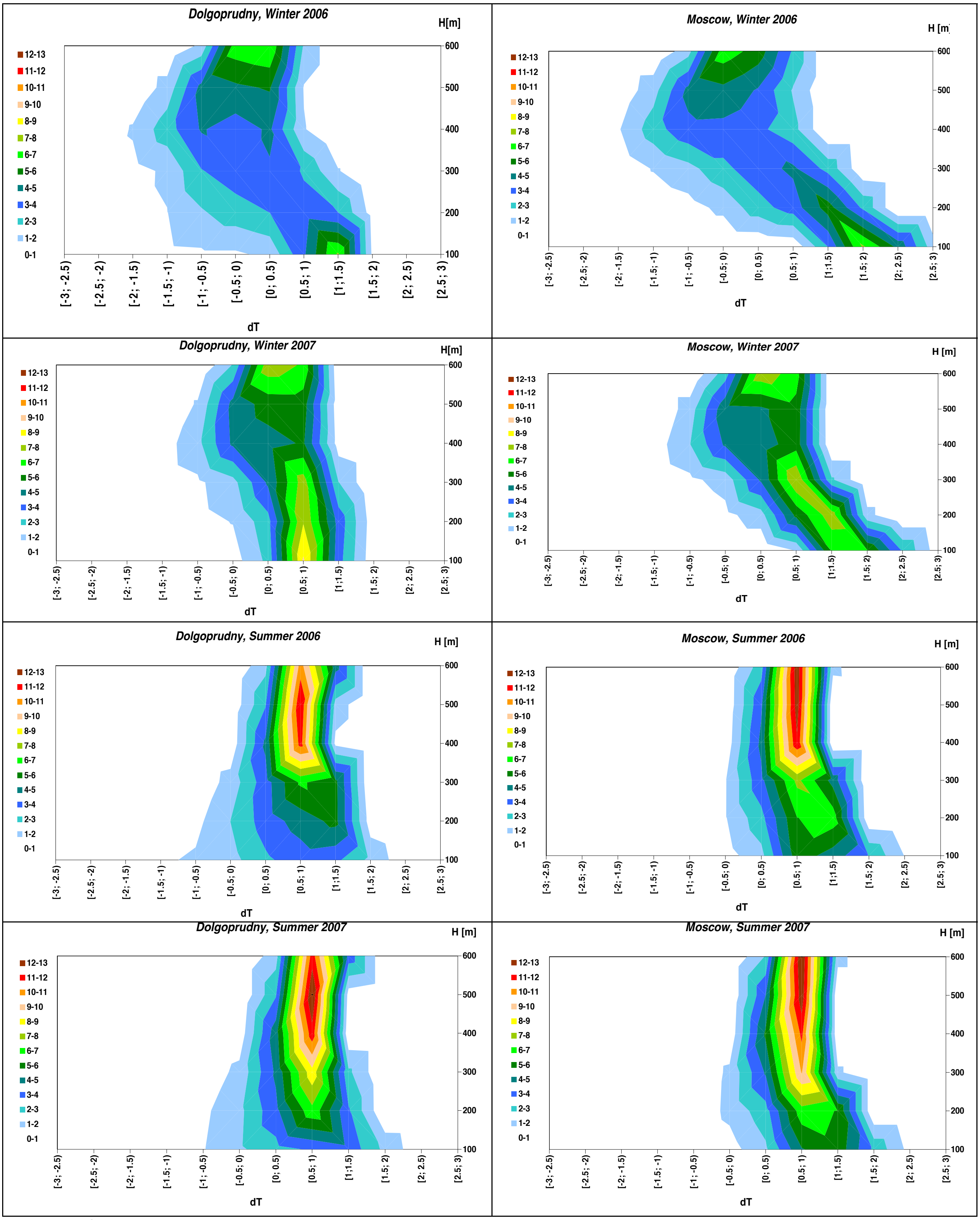


Figure 3. Statistical distribution of temperature gradients for Moscow (right) and Dolgoprudny (left) for 2 summers and 2 winters.