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# Assessment of thermal structure of boundary layer atmosphere of Western Siberia

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The assessment of frequency of temperature inversions makes it possible to investigate the probability of coincidence of unfavorable conditions of atmospheric stratification and the results of the intensive business activity. This paper is devoted to the study of thermal structure of the atmosphere boundary layer of Western Siberian territory in the period from 1990 to 2010 by using reanalysis of NCEP/NCAR data. The data of reanalysis is the only available information for similar research. Basic climatic characteristics of inversion were investigated. The special attention was paid to thick inversion. The analysis of dependence of the periods with long thick inversions upon a synoptic situation was made.

*Keywords:* thermal structure; atmosphere boundary layer; Western Siberia; thick inversion; climatic characteristics of temperature inversion.

## 1. Introduction

Stratification of the atmosphere is the important characteristic of weather conditions. Temperature inversions are part of the stable and indifferent stratification [1]. Existence of steadily stratified layers has essential impact on many atmospheric phenomena. Inversions in a ground layer lead to the increase of the environmental situation above the territory over which they are located [2, 3]. In the surface layer the inversion results in an increase of the environmental situation in the territory over which they are located. In a ground layer inversions lead to the intensification of the environmental situation above the territory over which they are located [2, 3].

The assessment of frequency of temperature inversions makes it possible to investigate the probability of coincidence of unfavorable conditions of atmospheric stratification and the results of the intensive business activity.

The aim of this work is studying the thermal structure of the air basin of Western Siberian territory.

## 2. Materials and methods of investigation

The assessment of thermal structure of the atmosphere boundary layer for four terms (for 00, 06, 12, 18 UTC) was made by using reanalysis data of NCEP / NCAR [4]. The data on air temperature at standard isobaric surfaces 1000, 925, and 850 hPa with a spatial resolution of $2{,}5 \times 2{,}5^{\circ}$ is used. The main advantage of this type of data is a uniform covering of the territory. The data of reanalysis is the only available information for similar research, due to the lack of rather dense regular grid over the territory of Western Siberia.

The territory under study is represented as a network consisting of 63 nodes. The amount of values of air temperature at three levels in each knot of a grid was created by using an available demoversion of the Matlab program.

Climatic characteristics of temperature inversions for the territory of Western Siberia in the period from 1990 to 2010 were estimated in order to detect changes in the structure of the atmospheric boundary layer.

The maps of the calculated characteristics of inversions on the basis of the data obtained were constructed using the Surfer program of version 8.0.

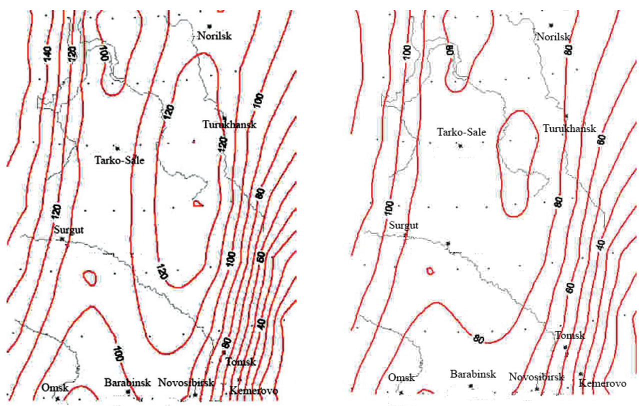


Fig 1. The distribution of average long-term number of cases with inversion in the layer 1000–925 hPa for night terms (00–06 h) during 1990–2010 years

### 3. Results and discussion

The distribution of average long-term number of cases with inversion in the layer 1000–925 hPa for the night terms (00–06 hours) is shown in fig.1, whereas for the day terms (12–18 hours) in fig.2. It is seen from the analysis that the configuration of isolines doesn't change significantly from term to term and varies only quantitatively. The maximum average annual number of cases with the phenomenon is observed in the 6-hour term and makes up 147 cases with the phenomenon in a year.

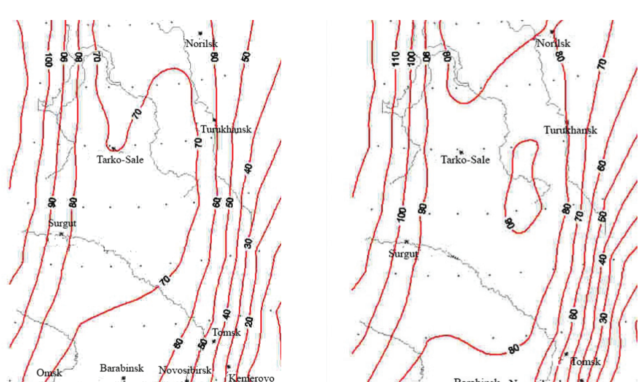


Fig. 2. The distribution of average long-term number of cases with inversion in the layer 1000–925 hPa for day terms (12–18 h) during 1990-2010 years

When analysing the map of average long-term number of cases with inversion in the layer 925–850 гПа for night and day terms it becomes obvious that from term to term the configuration of a field of lines of equal average long-term number of days with the phenomenon is almost identical in all terms, with isolines occupying the identical area and having a little quantitative difference. The mean annual number of days with the phenomenon changes from 9 to 108 days.

Consider the cases with thick inversions. The estimation of the average long-term frequency of thick inversions when the inversion occurs, at least during one of the terms shows that within the study area inversion reaches 24.6% of the days in the year. Local features of distribution of the frequency by the isolines constructed through 1% can be marked out. The lowered values are distributed locally toward the south-east. The minimum values are observed in the 54th point and they make up 1,8% of total number of days in a year.

In the 63rd point the presence of thick inversions, at least in one of four terms, isn't fixed. The distribution of this kind is due to the Kuznetsk Alatau influence. The lowered values of average long-term frequency are characteristic of the north-east.

The maximum values of frequency of thick inversions can be found around the 1, 10, 19 and 28 points of a grid respectively in northwest and western parts of the area under consideration ranging from 24 to 24,6%. Also the increased values of average long-term frequency are noted in the north-east. In the central part of the area frequency changes from 16 to 22%.

In order to assess the maximum possible duration of thick inversion the absolute maximum continuous duration in days of thick inversions was calculated. The analysis of distribution of the maximum continuous duration of thick inversions in the territory made it possible to reveal areas with longer or shorter periods with inversions. Two areas where the continuous duration of thick inversions can exceed 15 days are separated. In the western and northwest parts of the territory under study around the 19, 28, 37 points the maximum 18 days is observed. In the northeast, the maximum values are noted in 18, 27 points and inversion lasts 17 days.

The lowest values of the absolute maximum continuous duration are observed in the south-east where they change within 4–9 days. Also they are locally distributed practically along a meridional axis 82.5° east longitude. At 54 and 63 grid points the cases of a thick continuous inversion are not fixed. In the rest of the area the maximum continuous duration of thick inversion ranges from 9 to 14 days.

The further analysis of cases with the absolute maximum of thick inversion made it possible to elicit the fact that the existence of continuous inversion within several days is noted in certain years and mainly in January. Therefore there is a good reason to give a detailed consideration of the maps of distribution of average long-term number of days with inversion for this month, for all four terms, both in the layer 1000–925 hPa, and in the layer 925–850 hPa.

From the analysis of distribution of average long-term number of days with the phenomenon in January in the bottom layer 1000–925 hPa it is seen that the difference in configuration of lines of equal number of days for different terms is insignificant. The area where the number of days with inversion exceeds number 20 is precisely expressed. This area is observed only at 6 and 18 o'clock.

The distribution of average long-term number of days with the phenomenon in January at the top layer looks more smoothed and it is identical for all four terms, which might be caused by the absence of direct effect of the underlying surface. On average, in January this layer is characterized by a frequent recurrence of days with temperature inversions as compared to other months. On average high frequency of days with temperature inversions in comparison with other months is characteristic for this layer in January.

Frequency in the layer 925–850 hPa is generally higher than in the layer 1000–925 hPa. On the main part of the territory the number of days with the phenomenon varies from 15 to 20 cases. The decrease is observed in the south-east. More than 20 cases per month with the inversion are observed in the north-east, south and central parts of the area under study. The similar maps of distribution of average long-term number of days with inversion for every month are also obtained for two cases and for all four terms.

The analysis of dependence of the periods with long thick inversions upon a synoptic situation shows that inverted temperature distribution is caused by definite synoptic situations such as anti-cyclonic baric field, anti-cyclone, crest, crossing point of a high pressure and saddle.

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