Relationship between the number density of aerosol particles and the parameters of temperature distribution in the atmospheric boundary layer

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The spatiotemporal variability of the basic parameters of surface temperature inversions is analyzed from the data of aerological sensing at stationary Russian stations (collected in 1984–1986). The data obtained during daily aerological rises of radiosondes at altitudes up to 3 km at five Far-East subarctic stations have been used as input data for an analysis of spatiotemporal variability of the surface temperature inversions. The lower boundary height H_i, the thickness ΔH, and the temperature jump ΔT are the basic parameters that characterize inversion layers in the troposphere. Vertical temperature profiles have been investigated in the visual medium Delphi 3.0. Average monthly values of the basic parameters, derived from a series of three-year observations, are presented for all seasons.

Investigations carried out in different regions have revealed a dependence of the degree of atmospheric surface layer pollution on the temperature stratification in the lower troposphere. The Earth's atmospheric stratification for many physical parameters is the result and simultaneously the governing factor of atmospheric processes and phenomena. There are relatively stable stratification types, among which is the vertical temperature profile. However, in the Earth's atmosphere the unstable atmospheric layers in the form of temperature inversions persist, disappear, and appear again.

Temperature profiles and inversion layers in the troposphere are determined by many climate-formation processes connected with the radiative transfer and tropospheric circulation.[1] The number density of natural and anthropogenic aerosols is partially determined by the presence and thickness of temperature inversions in the troposphere at higher latitudes, because the inversion layer parameters in many respects determine the intensity of exchange processes in the lower troposphere. Thus, inversion layers are barriers for penetration of aerosol pollutants in the upper atmospheric layers, which frequently leads to their accumulation in the lower layers up to dangerous number densities.

The development of scenarios for atmospheric aerosol content variations is a very complicated problem, especially for the atmosphere at higher latitudes, where the aerosol parameters, especially in lower layers, undergo significant spatiotemporal variations caused by changes in the conditions of aerosol transport from the middle latitudes. Up to now, the development of the scenarios for long-period aerosol content variations at higher latitudes has not yet been completed. The established relationship between the number density of aerosol particles near the surface with the surface temperature inversions has allowed one, given that charts of spatial distribution of the temperature inversions are available, to identify the regions with the highest degree of pollution of the atmospheric surface layer.[2]

The data on the relative humidity and vertical distributions of the temperature and pressure[3,4] were used as initial fields in calculations of atmospheric stratification dynamics at higher latitudes in 1984–1986. Errors of radiosonde observations[5,6] were used as criteria for the temporal variability of meteorological parameters: in estimating the air temperature variability in the layer up to 3 km over a period of one month or 10 years, the maximum error did not exceed 1.0 and 0.5°q , respectively. Radiosonde is an inertial device; it affects the measurable parameters of inhomogeneities as follows: it overestimates the lower boundary height and underestimates the thickness of the temperature inversion layers.[7]

Seasonal variations of the lower boundary height measured at the stations Anadyr' (64° 47′N, 177° 34′E) and Magadan (59° 35′N, 150° 47′E) had two maxima (in the spring and fall) and two minima (in winter and summer). The principal maximum in winter, the second maximum in summer, and the minima in the spring and fall were typical of the seasonal behavior of H_i at the station Markovo (64° 41′N, 170° 25′E). At the stations Gizhiga (62° N, 160° 30′E) and Korf (60° 21′N, 166°E) one minimum was observed in the seasonal behavior of H_i in summer and one maximum in winter (Fig. 1). During the warm period, anomalies in the vertical profile of the temperature T were recorded at lower altitudes.

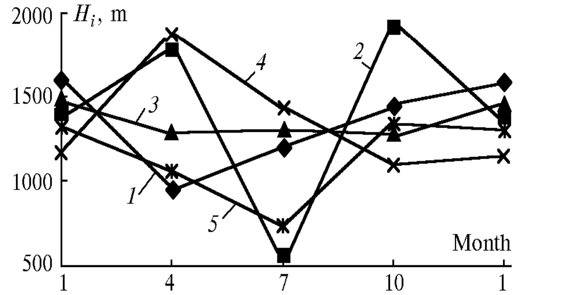

Fig. 1. Seasonal behavior of the lower boundary height of the temperature inversion layer at the stations Markovo (*1*), Anadyr' (*2*), Gizhiga (*3*), Magadan (*4*), and Korf (*5*).

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At the continental subarctic station Markovo the layer thickness was maximum in winter and minimum in summer. At the coastal stations the seasonal behavior of the inversion layer thickness had two maxima in the spring and fall (Fig. 2).

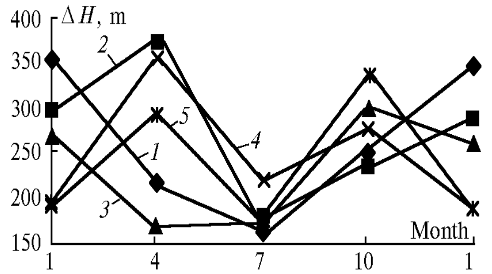

Fig. 2. Seasonal behavior of the inversion layer thickness at the stations Markovo (*1*), Anadyr' (*2*), Gizhiga (*3*), Magadan (*4*), and Korf (*5*).

Figure 3 illustrates the temporal behavior of average monthly height of the lower boundary (*a*) and thickness (*b*) of the surface temperature inversion layer in the troposphere of Far East. Over a period of three years the lower boundary height varied from 600 to 2000 m. In spring the lower boundary height increased at the coastal stations, whereas at the continental station it decreased. In summer the layer thickness at the continental station decreased. In coastal regions the layer thickness decreased in the spring and fall and was between 150–350 m. Analyzing the temporal behavior of the lower boundary height at the station Magadan at night, we established its increase by spring, whereas at the station Markovo its decrease in summer. The layer thickness increased in the fall and reached 480 m.

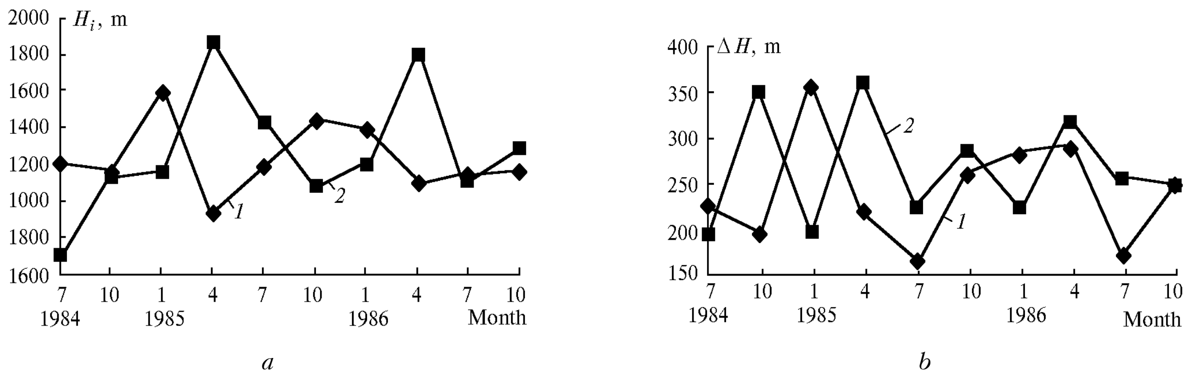

Fig. 3. Temporal behavior of the average monthly lower boundary height (*a*) and thickness (*b*) of the surface temperature inversion layer at the stations Markovo (*1*) and Magadan (*2*).

In the daytime the inversions in the troposphere were observed at altitudes from 400 to 1800 m. The values of H_i decreased in spring. The layer thickness at the continental station decreased in winter, whereas at the coastal stations it increased in spring and oscillated within the limits from 100 to 450 m.

Conclusions

1. The following basic regularities have been revealed in the seasonal behavior of the inversion parameters in the troposphere of Far East:

(a) The lower boundary height of surface inversion layers in the examined region was maximum mainly during the cold period and minimum during the warm period.

(b) At the continental subarctic stations the layer thickness was maximum in winter and minimum in the fall, whereas at the coastal stations the principal maximum was observed in seasonal behavior of ΔH in the fall and the deep minimum – in summer.

2. In the subarctic zone the inhomogeneities were most often encountered during the cold period, whereas in the moderate coastal zone – during the warm period. In the continental subarctic zone the recurrence of inversions in the vertical profiles of the temperature T was maximum in winter and summer at night, whereas in the spring and fall – in the daytime. At the coastal stations the recurrence was maximum in January at night, whereas in July – in the daytime.

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