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GEOGRAPHY

Altitude Profiles of Bioaerosol Concentrations in the Troposphere of Southern West Siberia

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Workers of the RIA SRC VB "Vektor" and the Institute of Atmospheric Optics are carrying out systematic monitoring of tropospheric bioareosols in southern West Siberia. Since 1999, atmospheric air has been sampled in one of the days of the last decade of every month at a site with coordinates 54°23′ N and 82°09′ E at eight altitude *h* levels (0.5, 1.0, 1.5, 2.0, 3.0, 4, 5.5, and 7 km) using the flying laboratory *Optik-E*. The samples are then used to determine the total contents of protein and viable microorganisms. Methodological aspects and summarized results can be found in [1].

The data obtained revealed seasonal changes of bioaerosol concentrations (BC) in the troposphere. It was shown that the annual BC change is inconsistent with the cycle of maximal activity of flora and fauna in the study region. This allows us to assume the substantial influence of remote sources of atmospheric aerosols.

To substantiate quantitatively this assumption, we carried out special estimates of the possible location of sources using the method of inverse modeling combined with methods from the theory of sensitivity and functionals. We calculated the Lagrangean backward transport trajectories of air masses sampled at the measurement point [1]. The analysis of calculation results demonstrated that air masses at the sampling site differ in their prehistory. They are located in the course of transportation at different altitudes over different areas (frequently, over different continents and oceans) and their trajectories converge at one point only when they approach the sampling point. An example of the calculations is presented in Fig. 1. In the course of their transport, air masses shift from one altitude to another and approach the Earth's surface, where they obviously become enriched in bioaerosols. They are intensely mixed with each other in some places, which are different for every backward trajectory, and then reach the sampling site.

This communication presents altitude profiles of the concentrations of total protein and viable microorganisms, which were obtained by averaging data on the tropospheric BCs in 1999–2003, and discusses their properties.

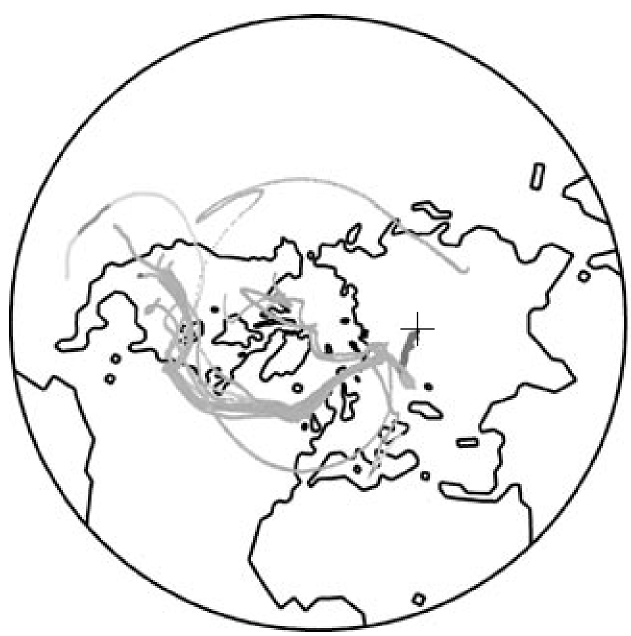

Fig. 1. An example of the backward transport trajectories of air masses calculated for an altitude of 1.5 km (July 29, 1999). The sampling site is shown by the cross.

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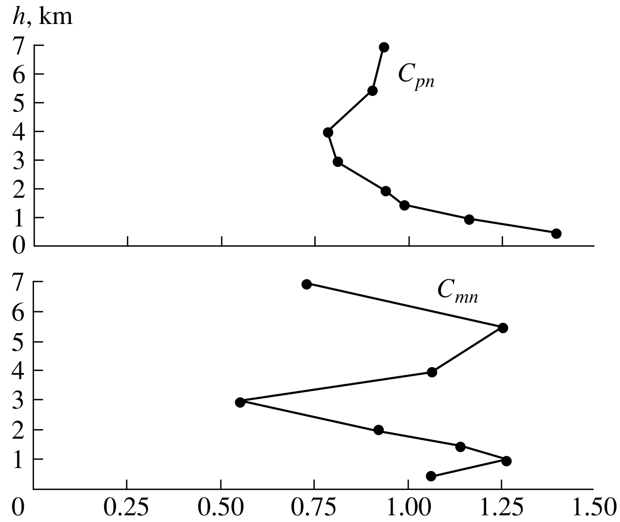

Fig. 2. Normalized altitude profiles of the concentrations of total protein (C_{pn}) and viable microorganisms (C_{mn}) aerosols.

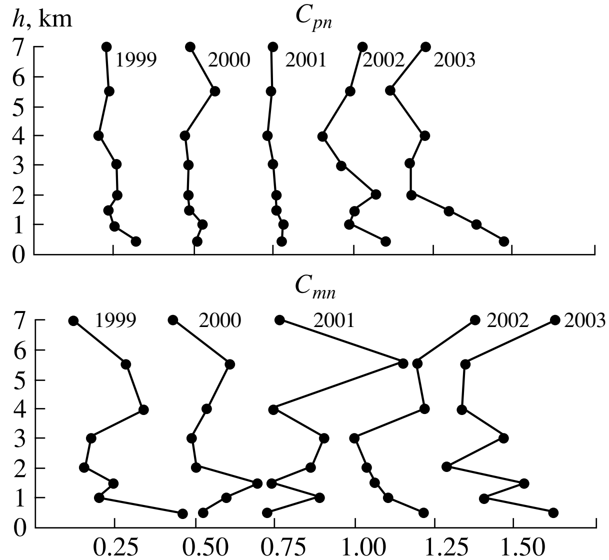

Fig. 3. Normalized altitude profiles of the concentrations of total protein (C_{pn}) and viable microorganisms (C_{mn}) aerosols in different years.

The sources of bioaerosols are located in a sufficiently thin near-surface layer of the atmosphere. They are mainly governed by the activity of the flora and fauna. Without the influence of atmospheric circulation, the BC profiles would have represented functions that uniformly decrease with the altitude.

Figure 2 demonstrates normalized altitude profiles of the concentrations of total protein (C_{pn}) and viable microorganisms (C_{mn}) aerosols. These values were calculated by averaging the annual measurements with the subsequent normalization of monthly data for average altitude values. This allows us to exclude the influence of seasonal BC changes from the calculations. Figure 3 presents normalized altitude profiles of the total protein (C_{pn}) and viable microorganisms (C_{mn}) concentrations compiled separately for every observation year. Figure 2 shows that the total protein content in the BC profile for 5 years reaches the maximal values at an altitude of 0.5 km and then gradually decreases with altitude. This indicates that the main sources of total protein aerosols are located near the Earth's surface. However, these aerosols are derived from both local and remote sources. This is evident from the significant quantity of total protein in samples taken in winter, when the West Siberian region is covered in snow. This feature is also evident to a variable extent in the annual concentration profiles (Fig. 3). It is seen that both the 5-yr (1999–2003) total and annual profiles are superimposed by separate local concentration maximums, which are related to the intricate transport trajectories of air masses in the atmosphere.

The altitude profiles concentrations of viable microorganism aerosols (Figs. 2, 3) indicate that their prehistory was probably more intricate than that that of total protein aerosols. The trend of decrease in the concentrations of viable microorganism aerosols is virtually absent in the C_{mn} altitude profiles. At the same time, they show many peaks related to numerous "elevated effective" sources.

Since 2001, we have also been monitoring atmospheric aerosols in the SRC VB "Vektor" territory (Koltsovo Settlement, Novosibirsk district). In contrast to the air-born sounding, monthly measurements in this area are carried out at mid-month. The two observation areas differ in terms of topography and are located at a distance of approximately 100 km from each other. Nevertheless, the comparison of annual mean BC values for these two areas is of interest, because it provides additional information on the altitude BC profiles. The table presents the average values and standard deviations of the concentrations of total protein and viable microorganism aerosols obtained for the near-surface

Concentrations of protein (C_{pn}) and viable microorganisms (C_{mn}) aerosols

Years	C_{pn}, μg/m^3		$\log C_{mn}$, specimens/m^3	
	near-surface layer	altitude 0.5 km	near-surface layer	altitude 0.5 km
2001	2.07 ± 2.84	3.41 ± 3.34	3.32 ± 3.14	3.38 ± 1.10
2002	0.38 ± 0.36	2.23 ± 2.18	3.52 ± 0.69	3.47 ± 0.94
2003	0.32 ± 0.33	3.39 ± 2.50	3.27 ± 0.63	3.15 ± 0.62
2001–2003	1.36 ± 2.18	3.01 ± 2.72	3.37 ± 0.61	3.34 ± 0.89

layer in the SRC VB "Vektor" territory and at the airborn sounding site at an altitude of 0.5 km averaged for 2001, 2002, 2003, and 2001–2003. The comparison of data on the concentrations of total protein and viable microorganisms in the near-surface layer and at the lower tropospheric boundary also indicates the substantial influence of the intricate dynamics of atmosphere mixing and the crucial influence of remote sources on the formation of bioaerosol background in the study region.

Thus, all the obtained altitude BC profiles, including the annual version, represent unique records of the atmospheric state in the Northern Hemisphere, incorporating generalized information on the numerous possible sources of bioaerosols and the processes responsible for their transformation in the atmosphere.

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