Peculiarities of Seasonal and Diurnal Behavior of the Content of Aerosol and an Absorbing Substance in the Near-Ground Air Layer

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Introduction

Soot is the main light-absorbing component of atmospheric aerosol. It is the important climatic factor because of its significant effect on the atmospheric transparency and albedo of clouds and snow. In this paper we consider some results of the experimental study of the scattering coefficient of fine aerosol and the content of soot in the near-ground atmospheric layer, which were carried out in 1997 and 1998 near the city of Tomsk.

Methods and Instrumentation

In 1996 we created a stationary aerosol station. It is located at the east outlying district of the city of Tomsk. Round-the-clock measurements are carried out every hour. Each cycle includes measurement of the directed light scattering coefficient at the angle of 45° of the dry matter of aerosol particles $\mu_0(45)$ ($km^{-1}ster^{-1}$) and the mass concentration of soot M_V ($\mu g/m^3$) (Kozlov et al. 1997). Let us note that under the atmospheric haze conditions the total aerosol scattering coefficient σ_0 (km^{-1}) determined using the value μ_0 is well correlated with the mass concentration of fine aerosol (Gorchakov and Sviridenkov 1981). The mass concentration of soot was measured by an aethalometer analogous to Hansen et al. (1984). Duration of one sampling is 10 minutes. The scattering coefficient values are averaged over 600 readings.

Results and Discussion

The principal attention was paid to the study of long-term (year, season) and short-term (less than one month) temporal variations of fine aerosol and soot. Figure 1 shows an example of the temporal behavior of the content of aerosol and soot measured in May 1998. In general, the variations of the considered parameters are more than one order of magnitude. The scattering coefficient values vary within the range 0.001-0.1 $km^{-1}ster^{-1}$. The range of the soot concentration variations is 0.1 $\mu m/m^3$ to 15 $\mu g/m^3$. The comparison with the available data (Cass et al. 1984; Kopeikin et al. 1993) shows that the air pollution with soot near Tomsk is not big, it is 2 to 3 times less than is characteristic of big industrial centers.

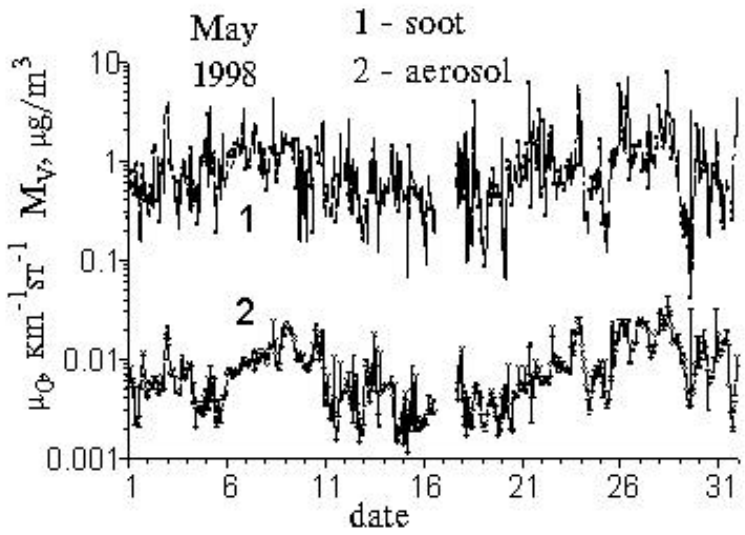

Figure 1. Temporal behavior of scattering coefficient $\mu_0(45)$ and soot concentration M_V in May 1998.

The analysis of the total data array shows that in spite of the great variations, quite stable rhythms are displayed on the seasonal and diurnal scales.

The monthly average values of aerosol scattering coefficient and soot concentration shown in Figure 2a and 2b, respectively, are in good agreement between each other. They are characterized by maximum in winter and minimum in summer. Variations of the monthly average values reaches 3 to 5 times.

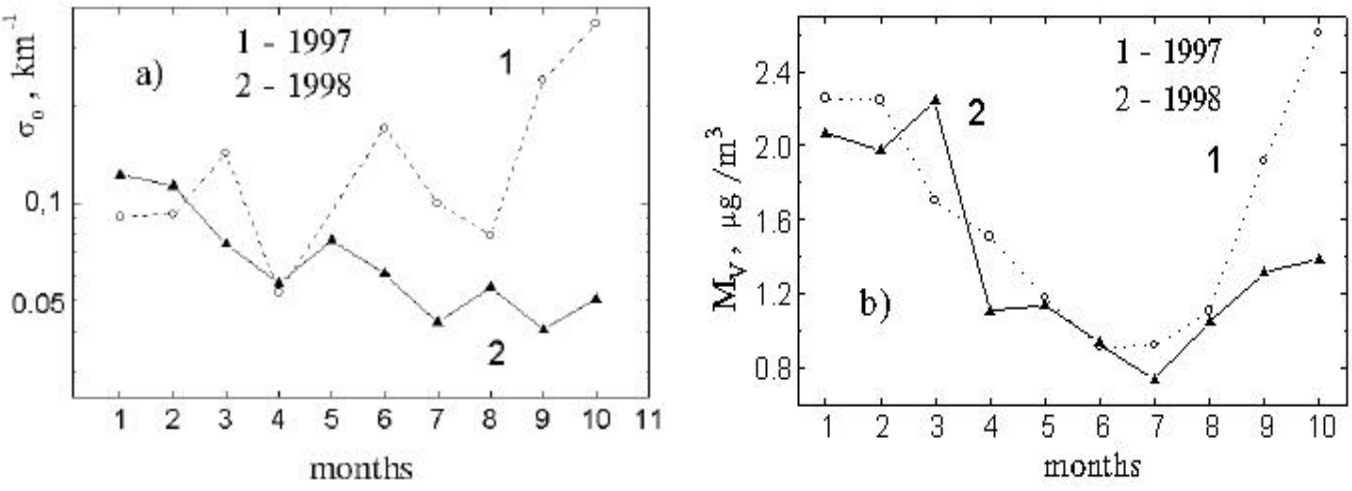

Figure 2. Annual behavior of the content of aerosol (a) and soot (b) in 1997 (1) and 1998 (2).

Winter maximum can be explained by the aerosol accumulation under the temperature inversions, which are often in this season. Summer minimum appears due to the increase in the intensity of aerosol transport to the upper altitudes. These tendencies are the most well pronounced for the soot content. It is caused by the significant increase of the soot emission during the cold season and, hence, by the decrease of the effect of these sources in spring and summer. Let us note that, in spite of the qualitative coincidence of the principal peculiarities of the annual behavior in 1997 and 1998, the quantitative differences are observed. There was a great increase of the aerosol and soot content in the near ground air layer in fall 1997 due to the appearance of a dust haze caused by forest and peat fires on the area of Western Siberia and Altai.

The analysis of the experimental data made it possible to study the peculiarities of the diurnal behaviors of the content of aerosol and soot and to reveal their seasonal differences. The diurnal behaviors of aerosol scattering coefficient and soot content normalized to the daily average values are shown in Figures 3 and 4, respectively.

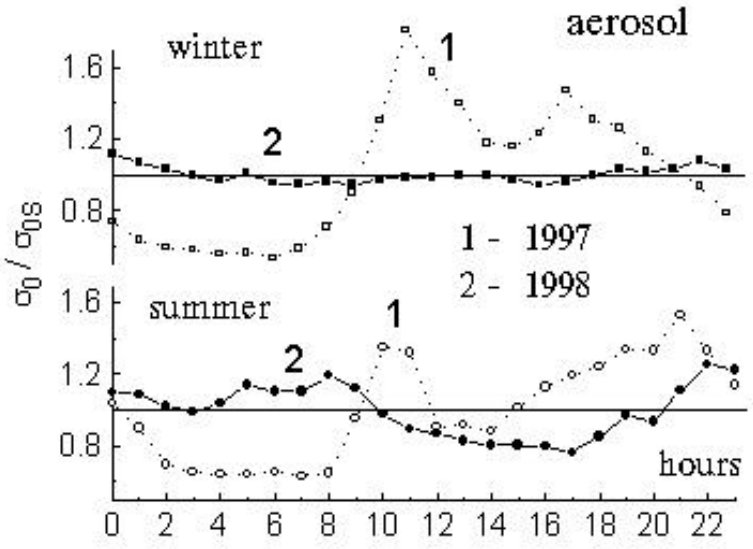

Figure 3. Mean diurnal behavior of the aerosol content in winter (a) and summer (b).

As a rule, the diurnal behaviors of the aerosol and soot content in spring and summer contain two maxima, in the morning and in the evening, and two minima, in the nighttime and in the daytime. One should relate them with the processes of generation of aerosol and soot during a day, convective emission of aerosol while heating the atmosphere, under-inversion accumulation of particles and sedimentation.

The diurnal behavior of soot in fall and winter is more smooth. Accumulation of soot during a day is often observed in winter.

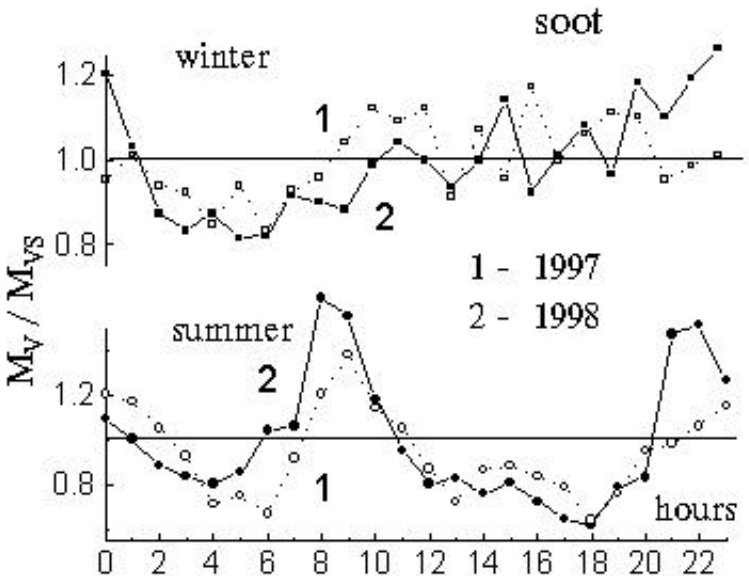

Figure 4. Mean diurnal behavior of the soot content in winter (a) and summer (b).

In general, diurnal behaviors of the soot content in different seasons are similar. As for the aerosol scattering coefficient, its diurnal behavior changes from season to season and from year to year. Significant quantitative differences for different years are observed for all seasons, except fall. Besides, there are also qualitative differences in diurnal behaviors of aerosol scattering coefficient in different years. The diurnal behavior in winter 1997 is similar to the summer one, while in 1998 it is more smooth (see Fig. 3a).

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Conclusion

- The annual behaviors of aerosol scattering coefficient and the soot concentration are similar to each other. They are characterized by maximum in winter and minimum in summer with the amplitude of variations of 2.5 to 3 times.

- The diurnal behavior of soot is similar for different years, while that for aerosol has some variations.

References

Cass, G. R., M. H. Conclin, et al., 1984: Elemental carbon concentration: estimation of an historical data base. *Atmos. Environ.*, **18**, 153-162.

Gorchakov, G. I., and M. A. Sviridenkov, 1981: One-parametric model of near-ground aerosol. *Atmos. Oceanic Physics*, **17**, 39-49.

Hansen, A. D. A., H. Rosen, and T. Novakov, 1984: The aethalometer —an instrument for the real-time measurement of optical absorption by aerosol particles. *Sci. Total Environ.*, **36**, 191-196.

Kopeikin, V. M., V. N. Kapustin, and M. S. Pekur, 1993: Monitoring of soot aerosol in the atmosphere of the city of Moscow. *Atmos. Oceanic Physics*, **29**, 213-217.

Kozlov, V. S., M. V. Panchenko, A. G. Tumakov, V. P. Shmargunov, and E. P. Yausheva, 1997: Some peculiarities of the mutual variability of the content of soot and submicron aerosol in the near-ground air layer. *J. Aeros. Sci.*, **28**, Suppl, 231-232.