STUDY OF THE AEROSOL PROPERTIES IN AIR OVER TELETSKOE LAKE

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We present here some measurement data on the disperse aerosol composition, percentage of ammonium sulfate in aerosols, as well as on the concentration of trace gases in the atmospheric boundary layer. A mobile ecological laboratory was operated on the territory of Altai State national park on the bank of Teletskoe lake (Artybash locality) from May 23 to June 2, 1997. The place of measurements is characterized by its position far from big sources of anthropogenic wastes and motor ways.

The atmospheric aerosols may strongly affect the Earth's radiation budget. The backscattering (reflection back to space) and absorption of solar radiation by aerosol particles decrease the amount of energy reaching the Earth's surface[1] make up the aerosol effect. It is the so-called "white house effect" or direct aerosol effect, giving rise to the Earth cooling. One more effect (indirect aerosol effect) manifests itself in the aerosol particles influence on the radiation balance, because of their active role in the processes of the overcast and precipitation formation.

The region of Altai mountains is the area with very low density of sources of anthropogenic emissions thus being a unique place for studying the background of natural aerosols and minor gaseous constituents of the atmosphere, as well as of natural interconnections among them. At the same time, atmospheric aerosol of Altai mountains has only poorly been studied as compared to other regions.

THE LOCATION AND METEOROLOGICAL CONDITIONS

The investigations have been carried out using a mobile ecological laboratory of "ECOS" group from the Institute for Chemical Kinetics and Combustion, SB RAS. The laboratory provides for continuous, day and night, measurements of a number of characteristics of gaseous and aerosol admixtures of the atmosphere.[2] The aerosol size spectra were measured with the system of a photoelectric particle counter AZ–6 and a diffusion spectrometer of aerosols, DSA, (a mesh diffusion battery). Using that complex it is possible to measure the following characteristics of aerosols:

– number concentration of the coarse aerosol fraction (particle size larger than 0.7 μm) (AZ–6);

– total surface of the particles with the size above 0.7 μm;

– number concentration of the highly-disperse fraction of particles, from 2 to 300 nm (DSA);

– number concentration of the particles within the size range 2 to 4 nm (ultrafine fraction); left boundary of the range is defined by the threshold of the condensation enlarger,[2] while the right one by precipitation of particles on the mesh in the first cascade of the battery.

– mass concentration of the ammonium sulfate aerosol (determined with a thermodenuder system[3] and a fluorescent SO_2-analyzer; the same analyzer was used to detect gaseous sulfur dioxide);

– integral coefficient of light-scattering (measured with an m1550B integrating nephelometer).

The tasks of the field mission were: to investigate the disperse composition of aerosol and concentration of minor atmospheric gases in the near-ground layer of the atmosphere without the account of the sources of anthropogenic emissions. The Artybash locality was chosen for this purpose.

The village Artybash is situated at 150 km distance to the South-East of Gornoaltaisk town. The mobile ecological laboratory was operated on the territory of Altai National park on the bank of Teletskoe lake (from May 23 to June 2, 1997). The place is characterized by a large distance to the nearest populated region and correspondingly by the low density of anthropogenic emission sources (Fig. 1).

The meteorological conditions during this field measurement campaign, (Fig. 2), allowed us to select two wind directions that were typical for the north-eastern extremity of the lake, one from north and the other from south-east with the period of their change, approximately 8 to 30 hours and the wind speed of 3 to 5 m/sec. The whole period of observations is divided into two parts according to temperature. The first one, the conditionally-cold (23–26.05), was

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characterized by low night temperatures 0–2°C and approximately 20°C during day-time and the period of (27.05–2.06) when night temperature raised up to 6–8°C and up to 30°C during day-time.

FIG. 1. Situation of measurement point.

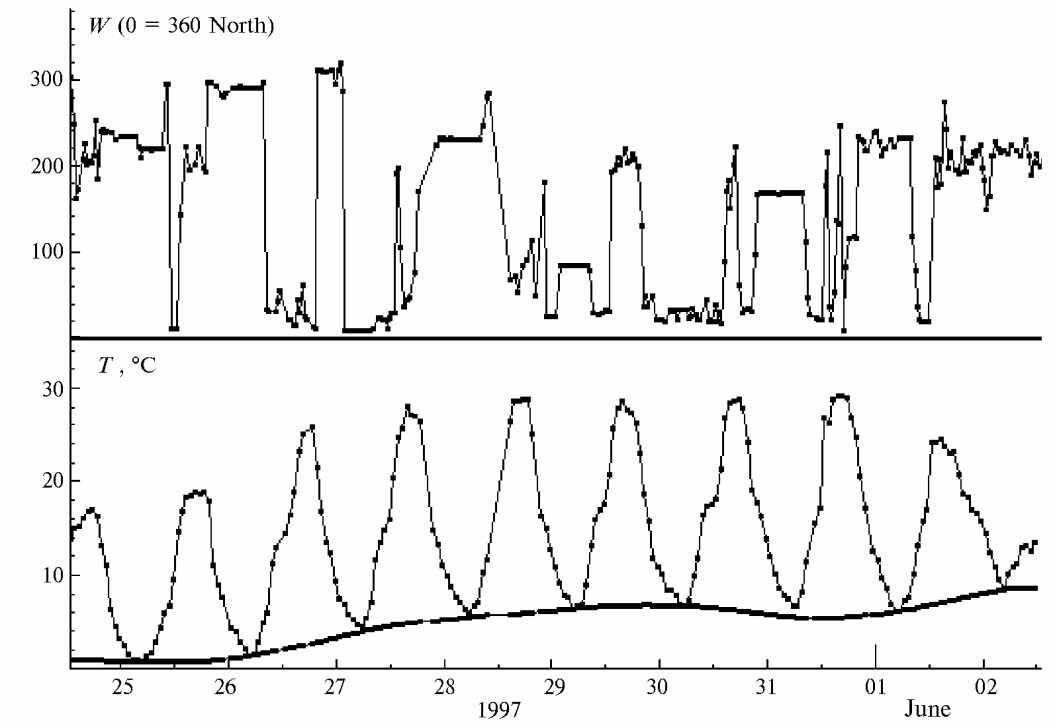

FIG. 2. Wind direction, W, and air temperature, T, with the background component.

AEROSOL MEASUREMENTS

Mostly, the difference that has been revealed in aerosol characteristics during this measurement campaign relates to temperature different periods in time and not to peculiar features of the winds.

Thus, during the cold period the background (minimum) level of number concentration of fine aerosol particles was about 400 cm^{-3} with the increases up to 2500 cm^{-3} (see Fig. 3). In the warm period the inverse (night-time) diurnal variation of concentration from 800 to 5000 cm^{-3} was observed. The beginning of the increase occurred at about 6 p.m. of local time lasting until midnight and then followed by decrease to minimum by 8 o'clock in the morning. The mean diameter of particles observed in the first period was 80 nm and 120 nm in the second one. Typical size spectra are presented in Fig. 4.

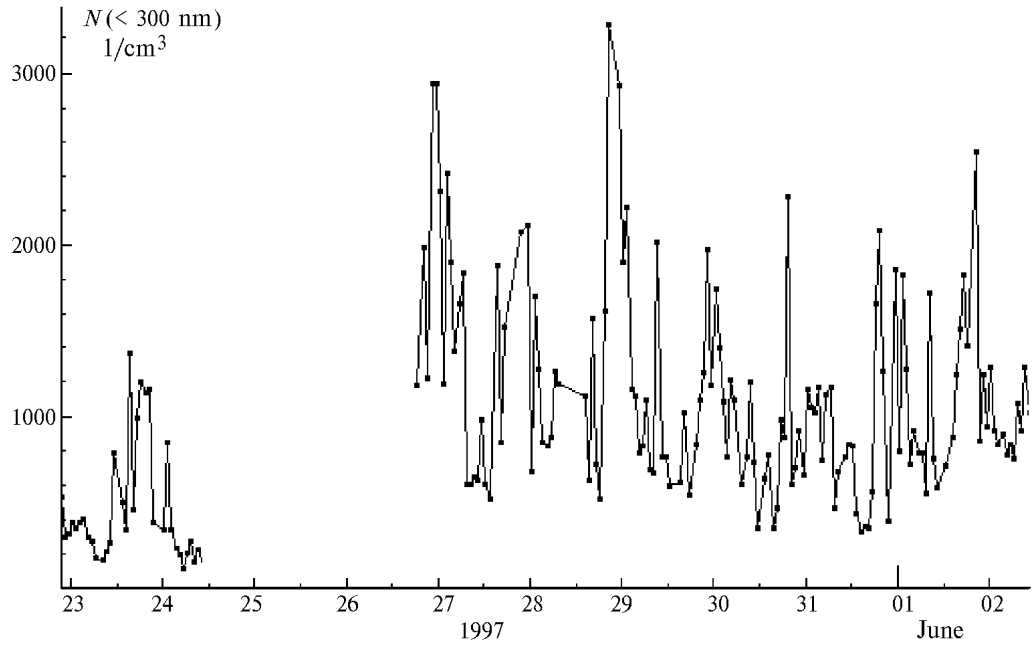

FIG. 3. Time variation of the fine aerosol particles concentration.

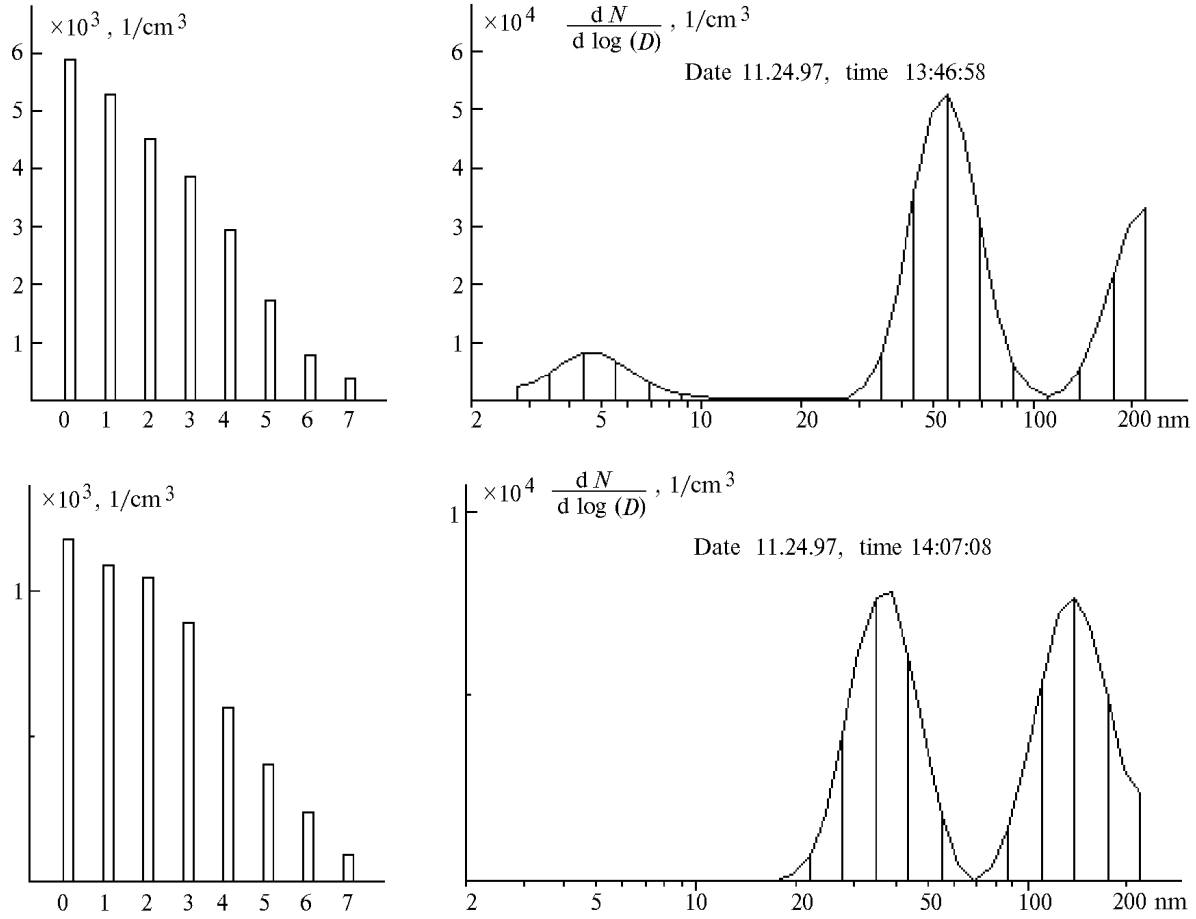

FIG. 4. Typical spectra and size-distributions of the fine aerosol fraction.

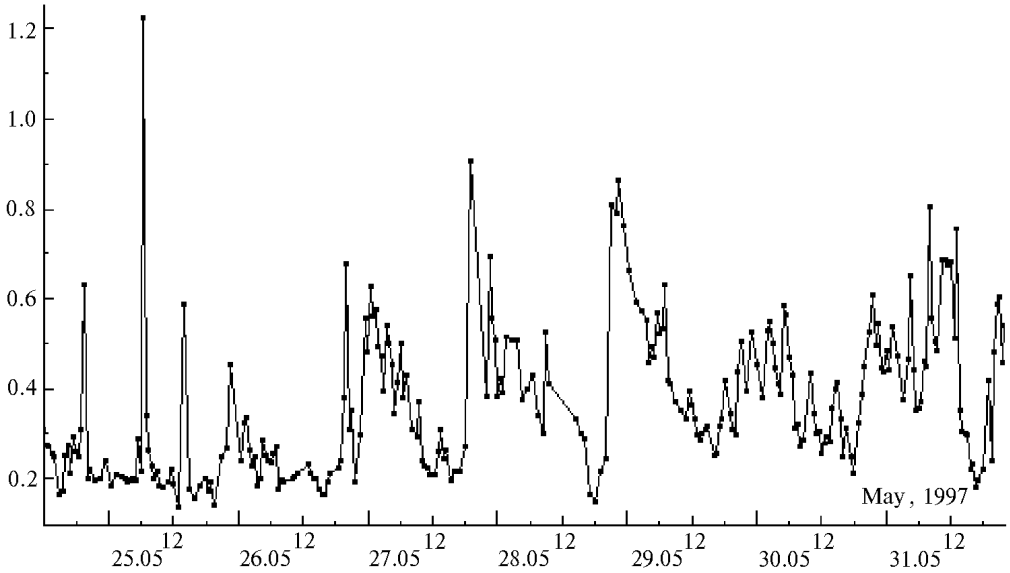

FIG. 5. Integrated backscattering coefficient of aerosol.

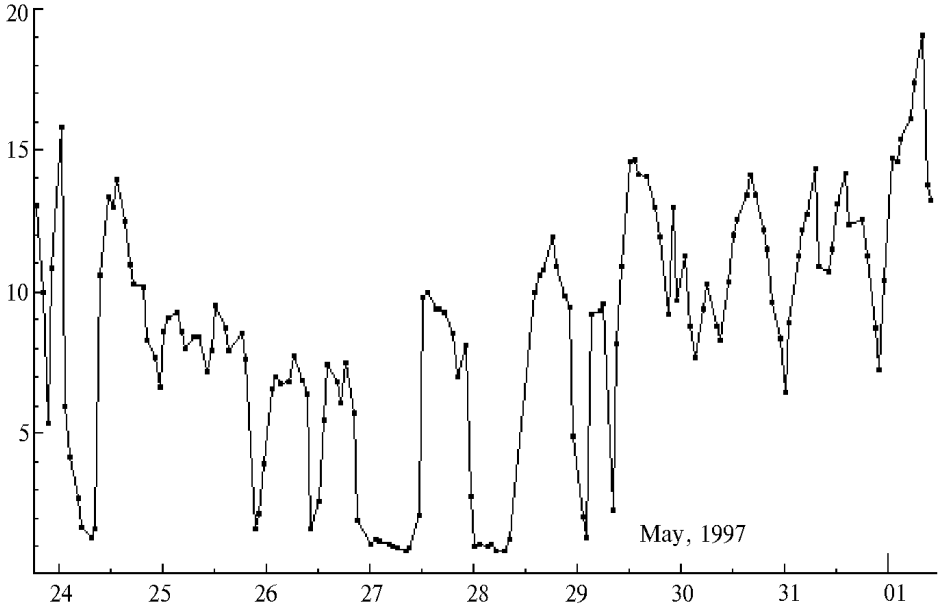

FIG. 6. Mass concentration of ammonium sulfate in aerosols.

The background value of the integrated coefficient of light-scattering was 0.3/10 km with the regularly recorded night-time increase up to 0.6/10 km (Fig. 5). It should be noted, that minimum values of the scattering coefficient for arctic air mass[4] equaled to 0.8/10 km.

MEASUREMENTS OF CHEMICAL COMPOSITION AND CONCENTRATION OF THE GASEOUS ADMIXTURES

Mass concentrations of ammonium sulfate and sulfur dioxide, as its basic producer, have been measured simultaneously with the parameters of aerosol particles (see Fig. 6).

Analysis of data shows, that for the whole period of measurements, one can separate out daily variation of the ammonium sulfate mass concentration. Duration of the day-time peak of ammonium sulfate concentration was 10±20% hours. The beginning of sulfate increase is 4 to 5 hours delayed relative to the illumination one. The maximum in day-time concentration occurs, in time, at the beginning of the illumination decrease (19 o'clock, local time) and coincides with the moment when temperature reaches its daily maximum. It should also be noted that

night-time increases of the sulfate concentration have been observed from time to time, being comparable in power with the day-time ones. Similar time behavior of concentration has been observed in the case with sulfur dioxide.

When processing measurement data the correlation between time behaviors of the ammonium sulfate and sulfur dioxide concentration has been revealed, with the correlation coefficient being about 0.85. Note, that a very close value of 0.89 was calculated for the correlation coefficient in arctic air mass.[4] The duration and the position of day maximum of sulfate concentration are also similar to the arctic air mass.

At the enhanced, by 6 and 10 degrees, night-time temperatures the background (night-time) concentration of sulfate increased by 5 times, and the average height of day-time peak by about 2 times.

The ozone concentration time behavior has a well-pronounced diurnal variation between 7 ppb at night (minimum at 5 a.m.) and up to 20 ppb during day time (maximum 5 p.m.). Small growth of the background concentration of the ozone has been recorded with the increasing temperature.

CONCLUSION

The whole period of field measurements has been divided, according to characteristic temperatures, into two parts, the conditionally warm and cold. It was established, that at a 6-degree night-time and 10-degree day-time increase in temperature the background (night-time) concentration of sulfate increased by 5 times, while the average height of the day-time peak only by two times. When processing measurement data the correlation between time behaviors of the ammonium sulfate and sulfur dioxide concentration has been revealed, with the correlation coefficient being about 0.85. Note, that a very close value of 0.89 was calculated for the correlation coefficient in arctic air mass.

Duration and time of the day-time maximum of sulfate concentration are also similar to that in arctic air mass.

The increases in average concentration by two times and in average size by 40 nm at a temperature increase about 8 degrees have been revealed for the fine aerosol fraction.

The inverse (night-time) diurnal behavior of finely-dispersed aerosol concentration and normal (day-time) one of the ammonium sulfate have been revealed. The background value of the integral scattering coefficient was found to be 0.3/10 km, that is two times lower than the value obtained for the arctic air mass.[4]

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