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Submicron particles in Atmospheric Brown Clouds

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Abstract

The existence of submicron (nanoscale) particles in the Atmospheric Brown Clouds is shown experimentally.

The Atmospheric Brown Clouds

The Atmospheric Brown Clouds (ABC) [1] is an important problem of this century. Investigations of last years and satellite data show that the ABC (or brown gas, smog, fog) cover extensive territories including the whole continents and oceans. For example, the experiment INDOEX in Indian Ocean carried out in February, 1999 has shown that "the phenomenon of the ABC" in Asia (now it is referred to as "South–Asian Brown Cloud") covers the most part of Arabian Sea, Bay of Bengal, and South Asia. As a consequence of distant transfer brown gas, which is connected usually only with the urbanized regions, covers the whole continent and ocean basin now. Last data from NASA satellite have shown that aerosol pollution in the form of brown gas extends over vast regions of the world. These phenomena are called as "South– and North–American Brown Cloud", "Asian Brown Cloud", and "African Brown Cloud". The brown gas consists of a mixture of particles of anthropogenic sulfates, nitrates, organic origin, black carbon, dust, ashes, and also natural aerosols such as sea salt and mineral dust. The brown color is a result of absorption and scattering of solar radiation by the anthropogenic black carbon, ashes, the particles of salt dust, and nitrogen dioxide. The black carbon absorbs strongly the solar radiation. The aerosols result in an increase of reflection of the solar radiation. The latter effect is added to the effect of cooling of an underlying surface ("the indirect forcing"). Simultaneously the aerosols reduce a share of the direct action of the solar radiation on the underlying surface and increase a share of the scattered one ("the direct forcing"). The negative ("indirect") aerosol forcing (the cooling effect) can be compared with positive action of the hothouse gases [2]. The investigation of the ABC is a fundamental problem for prevention of degradation of the environment. At present in the CIS in-situ lidar investigations of the ABC are carried out on Lidar Station Teplokluchenka (Kyrgyz Republic).

Estimates show that if the density of crystal carbon in the atmosphere is only several millionth of the density of carbon containing in the carbon dioxide and the efficiency of the sources of CO_2 is small then the efficiency of the soot particles in the radiation processes is much higher than that of CO_2. This is due to a wide absorption band of the soot particles which corresponds to the wavelengths from 0.3 to 3–4 μm in contrast to a narrow absorption band of CO_2. The short–wave absorption by aerosols is connected mostly with the existence of submicron (nanoscale) sub–fraction consisting of the soot particles. Thus the radiative and climatologic influence of aerosol is connected mainly with the soot component. We note that up to now an analysis of submicron (nanoscale) particles containing in the ABC, which includes the distributions of particles in sizes, study of their properties, chemical and mineralogical compositions, has not been carried out. Here, we present the first results of experimental observation of submicron (nanoscale) particles originating from the ABC.

Measurements

The methodology items of ABC nano- and microscale particle collection and their analysis have been developed. For particle collection plastic containers of the size of 80×50 mm^2 and the height of 40 mm have been prepared. At the bottom of the container Petryanov filters AFA-RSP-10 of the area of about 5 cm^2 each and the

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two-sided scotch tapes have been placed. The software has been developed which allows us to obtain the data on nanoscale particles (including their distributions in sizes), the images of the particles being made with the aid of an electronic microscope. Three containers with samples of dust precipitating from the ABC were obtained. The containers were situated in the following sites:

Table 1

Sample No.	Place	Start of Registration	Finish of Registration
1	Lidar Site	August 07, 2008 at 9:00	August 10, 2008 at 18:00
2	Lidar Site	August 03, 2008 at 17:00	August 04, 2008 at 07:00
7	RAS	August 09 2008 at 17:00	August 10, 2008 at 13:00

Here, Lidar Site corresponds to the area of Lidar Station Teplokluchenka; RAS means scientific station of the Russian Academy of Sciences near Bishkek.

We have used the data on dust collection with the aid of the two-sided scotch tapes. The data for determination of the grain composition were obtained with the aid of the scanned electron microscope JEOL 6460 LV. Mapping was carried out for accelerating voltage of 30 kV and work distance of 8 to 10 mm in the regime of high vacuum. The images of the grains were mapped for magnification marks of 30 to 150 000. This allows us to get (after the image processing) the grain composition within the dust particle size range of 60 nm to 700 μm. In Fig. 1 an example of a shot made with the aid of the electron microscope is shown.

As a result, the following data have been obtained:

Sample No. 1: The grains with the sizes of 520 nm to 140 μm have been registered.

Sample No. 2: The grains with the sizes of 520 nm to 42 μm have been registered.

Sample No. 7: The grains with the sizes of 240 nm to 63 μm have been registered.

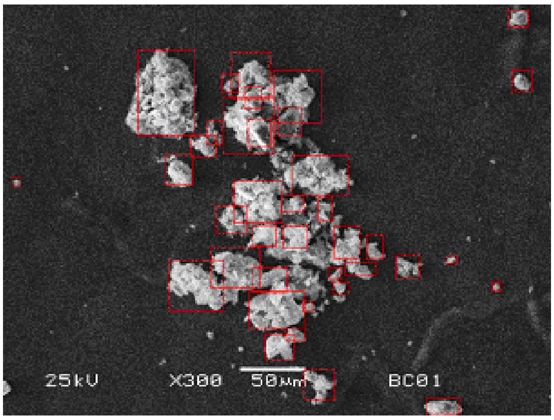

Figure 1: Grains constituting the ABC.

Analysis

Distributions of nano- and microscale particles in sizes have been constructed using Rozin-Rammler coordinates [3]. Analysis of the distributions shows that for samples 1 and 2 submicron (nanoscale) particles play significant role, while for sample 7 there is deficit of such particles. We emphasize that Lidar Station Teplokluchenka is located on a height over 2000 m above sea level, while the altitude of the scientific station of the Russian Academy of Sciences near Bishkek is significantly lower. This allows us to conclude that 1) the ABC contain submicron (nanoscale) particles; 2) at higher altitudes the concentration of the submicron (nanoscale) particles in the ABC is higher than at lower altitudes.

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