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LIDAR STUDIES OF LIGHT SCATTERING ANISOTROPY IN THE ATMOSPHERE

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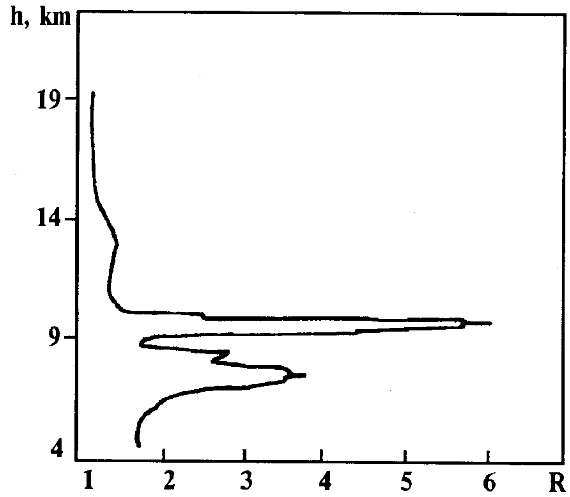
During a long time we carry out, on a routine basis, measurements of Backscattering phase matrices (BPM) of aerosol formations of the atmoshpere using a lidar with a changeable polarization of sounding radiation and a receiving optical system that enables us to measure all Stokes parameters of scattered radiation[1]. The measurement technique we use in our studies has been described in detail in Refs. 2 and 3.

The experimental data we have compiled till now show that in 30 to 40 per cent of observations of the upper level clouds their BPMs are of nondiagonal form what is definitely indicative of preferred orientation of crystal particles in clouds and probably of optical anisotropy of the particulate matter. To interpret lidar sounding data we use models of axially symmetric elongated particles (ASEP)[4] and axially symmetric plates[5]. In the case of ASEP we manage to determine the direction of preferred orientation and the value of the parameter defined in Ref. 6 that enables one to estimate the degree of particles ordering. This parameter varies from 0 to 1 what corresponds to the case of absence of any preferred orientation of particles and to the case when particles axes are oriented exactly along one and the same direction, respectively.

To illustrate the capabilities of the technique used to measure BPMs let us analyze the situation observed on one of the nights in the fall of 1991.

In the figure one can see two distinct and well pronounced peaks at 7.6 and 9.3 km height on the profile of the ratio of total backscatter to the molecular one R(h). Besides, a weak maximum (R=1.5) of the scattering ratio can be identified at altitudes from 10 to 16 km. This latter peak is characterized by a nondiagonal BPM. The values of BPM elements for this layer normalized by the backscattering coefficient for the case of nonpolarized sounding radiation are as follows $m_{11} = 1$; $m_{22} = 0.97$; $m_{33} = m_{44} = -0.97$.



The error in absolute value of these matrix elements is estimated to be of ±0.04. We identify this aerosol layer to be of volcanic origin and we have observed it since July 11, 91 till October, 1991. Normalized BPMs for the layers at 7.6 and 9.3 km are as follows.

$$\begin{pmatrix} 1 & 0.39 & 0 & 0 \\ 0.39 & 0.81 & 0 & 0 \\ 0 & 0 & -0.60 & -0.31 \\ 0 & 0 & 0.31 & -0.38 \end{pmatrix} \quad \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0.62 & 0 & 0.12 \\ 0 & 0 & -0.55 & -0.32 \\ 0 & 0.12 & 0.32 & -0.15 \end{pmatrix}$$

h=7.6 km   h=9.3 km

The BMP for the layer at 7.6 km can satisfactorily be interpreted within the frameworks of ASEP model. Such an interpretation allowed us to determine the direction of preferred orientation. In this case it happened to be along East-West direction. The parameter of ordering degree was estimated to be 0.33.

Analysis of the BMP for layer at 9.3 km has shown that it can not be interpreted neither within the frameworks of the ASEP model nor the model of axially symmetric plates. In this connection and taking into account possible interrelation of this layer with the upper one, which presumably is of volcanic origin, we make an assumption that light scattering anisotropy observed in this layer is caused not by the peculiarities in particles shapes but by the optical anisotropy of the particulate matter itself. Most probable candidate for such a substance is the ammonium sultate.

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