Some Statistical Regularities of Variations of Optical and Microphysical Characteristics for the Surface Aerosol

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Introduction

Daily spectropolarimeter measurements were carried out from February to March 1999, February to November 2000, and February to December 2001 at the Zvenigorod Scientific Station of the A.M. Obukhov Institute of Atmospheric Physics.

The spectropolarimeter measures the spectral dependencies of the two polarized components of directed scattering coefficient. The light source is based on the grating monochromator with spectral region $\lambda = 0.4 - 0.75$ μm. Three photometers with photomultipliers as photodetectors are mounted on the aerosol chamber at scattering angles $\varphi = 45°, 90°, 135°$. The total number of realizations obtained was about 300 for the first period, about 1400 for the second period, and about 2000 for the third period. The long periods of measurements allowed us to analyze the statistical characteristics of data obtained and to consider some statistical relations between optical and microphysical characteristics of the aerosol. It was found that inverse power law can be used for approximation of the spectral dependencies of the directed scattering coefficient $D(45°,\lambda)$ (or scattering coefficient): $D \sim \lambda^{-\alpha}$. The values of α (so-called Angstrom's exponent) were found to be related statistically to the $D(45°,\lambda = 0.54\text{mcm})$ values (correlation coefficient $R \approx 0.65\text{-}0.7$) by a simple formula $\alpha = \beta_1 \ln D + \beta_2$. This is illustrated in Figure 1 (2000) and Figure 2 (2001). Parameters β_1 and β_2 have seasonal variations. The average values of α in three winter seasons ($\langle\alpha\rangle \approx 2.1$) are greater, than in summer ($\langle\alpha\rangle \approx 1.8$); parameters β_i are also greater in winter ($\beta_1 \approx 0.5$, $\beta_2 \approx -0.4$) then in summer $\beta_1 \approx 0.35$, $\beta_2 \approx 0$).

For all data, the inverse problem was solved. The results are presented in the form of the aerosol particle volume distributions on sizes $dV(r)/dr$. It was found that 1) the distribution of the basical accumulative fraction of aerosol has a single-top form but in size region $r = 0.1\text{-}0.6$ μm it can be approximated as the first approach by inverse power law: $dV/dr \sim r^{-\nu}$ (so-called Yunge distribution), and 2) by increasing the D value of the distribution maximum, r_{max}, and parameter, ν, change: r_{max} increases and the value of ν decreases. Therefore, the distribution of natural aerosol combines the properties of Yunge and Whittby models.

Earlier, the statistical relation, which relates the total volume of aerosol submicron particles V_Σ to the scattering coefficient (or D) value, was proposed in Institute of Atmospheric Physics. This relation was obtained on the basis of limited data. We have analyzed this relation and established that these values correlate to each other for whole periods of measurements (about 600 days) as well as for subperiods

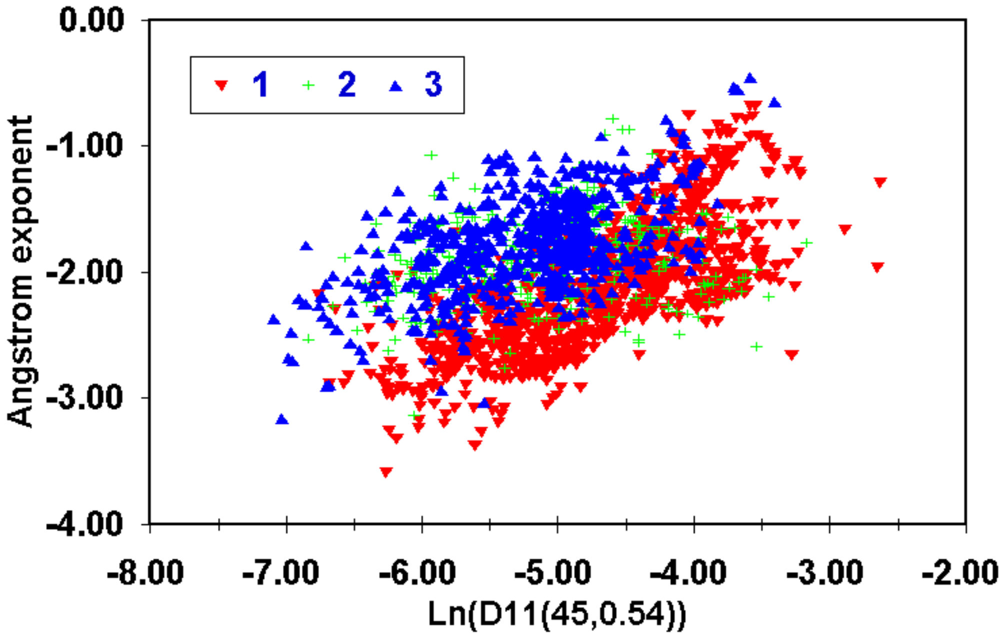

Figure 1. The relation between the Angstrom exponent and directed scattering coefficient D for 2000. Periods: (1) February to April, (2) May to July, and (3) August to October.

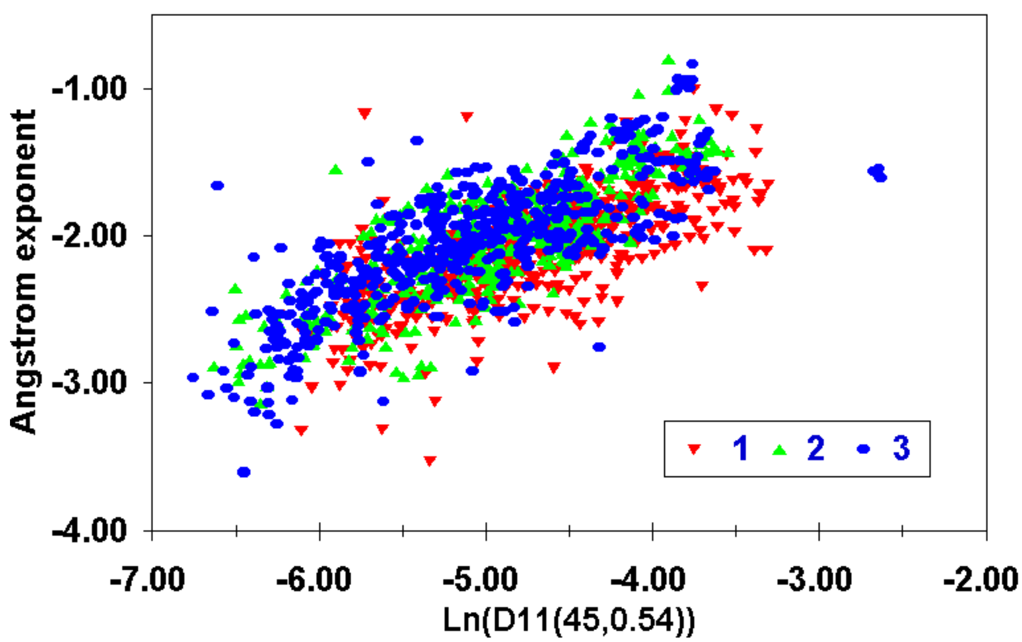

Figure 2. The relation between the Angstrom exponent and directed scattering coefficient D for 2001. Periods: (1) February to April, (2) June to July, and (3) August to October.

with correlation coefficient R = 0.96-0.97. This is illustrated in Figure 3. Here, 1 is the total particle volume for radii region r = 0.07 - 1.5 µm, and 2 is the summary volume of particles with radii r = 0.07-0.5 µm. This allows us to estimate the V_{Σ} value using D measurements, with an error of about 15%.

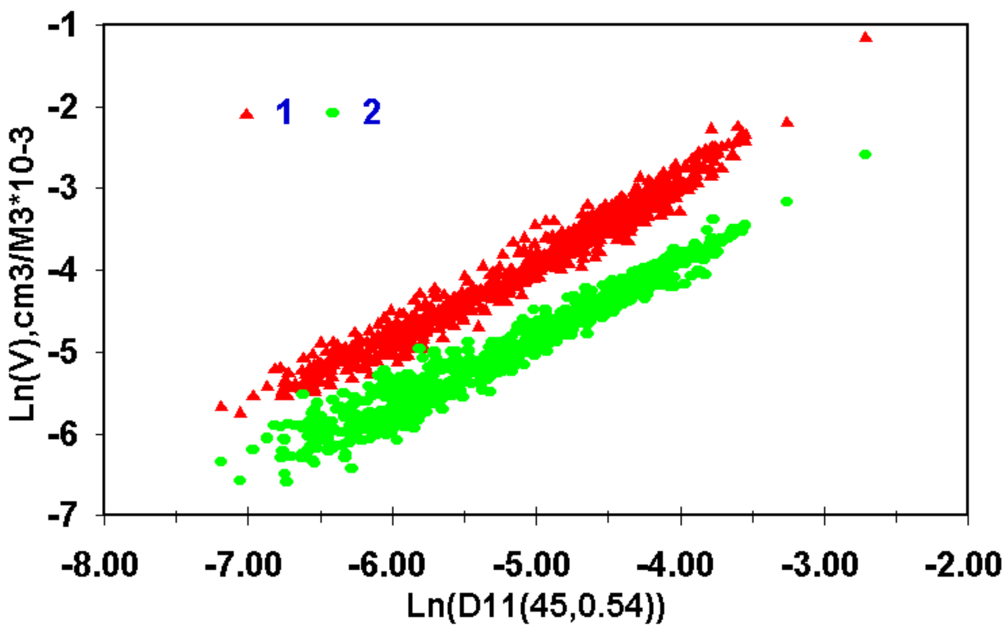

Figure 3. The relation between directed scattering coefficient D and total particle volume for particles radii r-0.05-1.5 µm (1) and summary.

Acknowledgment

This work is partially supported by Russian Foundation for Basic Research, Project N01-05-64405 and Atmospheric Radiation Measurement (ARM) Program (Contract 354760-A-Q1).

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