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AEROSOL CORRECTION OF THE ATMOSPHERIC OZONE SOUNDING DATA

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The problem of interpretation of ozone laser sounding data is very complicated since aerosol is an irregular atmospheric component. This is convincingly illustrated in Fig. 1 (curve 2). The negative value on the curve 2 corresponds to the layer with increased (see Fig. 2) aerosol content. In this paper we consider the method of aerosol correction based on the use of a multifrequency lidar, that is, a there- or four- frequency lidar without an ozone channel.

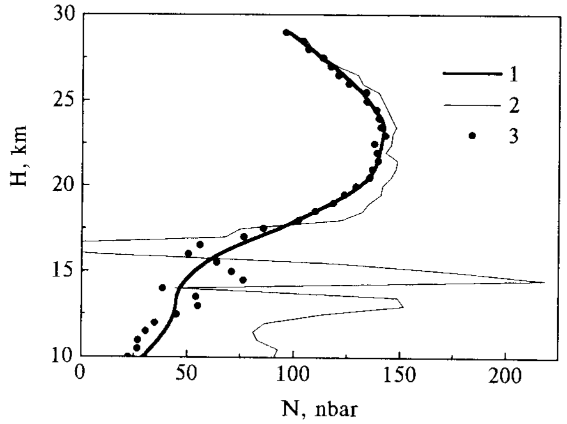

Fig. 1. The profiles of ozone concentration. 1 denote precise distribution. 2 and 3 are obtained based on the difference diagram. 2 - without correction. 3 - with aerosol correction.

The mathematical problem reduces to the solution of the set of lidar equations:

$$N(\lambda_i,h_e) = h_e^{-2}\, b(\lambda_i)\,[\beta_\pi^m(\lambda_i,h_e) + \beta_\pi^a(\lambda_i,h_e)]\; T_a^2(\lambda_i,h_0)\,T_a^2(\lambda_i,h_e - h_0)\; T_m^2(\lambda_i,h_0)\,T_m^2(\lambda_i,h_0-h_e)\Delta h_e ,\quad i=1, 2, \dots , n \qquad (1)$$

where $N(\lambda_i,h_e)$ is the number of photons recorded from the altitude h at the wavelength λ_i , $b(\lambda_i)$ is the calibration constant; $\beta_\pi^a(\lambda_i,h_e)$ and $\beta_\pi^m(\lambda_i,h_e)$ are the aerosol and molecular backscattering coefficients, respectively; and $T_a^2(\lambda_i,h_0)\, T_a^2(\lambda_i,h_e-h_0) = T_a^2(\lambda_i,h_e)$ and $T_m^2(\lambda_i,h_0)\, T_m^2(\lambda_i,h_e-h_0) = T_m^2(\lambda_i,h_e)$ are the squares of aerosol and molecular transmittance, h_0 is the altitude of lidar calibration;Δh_e is the value of sounding layer (strobe).

In order to make the problem definite, the lidar is assumed to be calibrated, i.e., the values of $b(\lambda_i)$, $T_a^2(\lambda_i,h_0)$ and $T_m^2(\lambda_i,h_0)$, are known. It should be noted that molecular optical characteristics are related by the following ratio:

$$\beta_\pi^m(\lambda_i,h_e) = P_i\beta_\pi^m(\lambda_1,h_e);$$

$$\beta_{sc}^m(\lambda_i,h_e) = 2\beta_\pi^m(\lambda_i,h_e)/3, \qquad (2)$$

where $$P_i = \left(\frac{m_i - 1}{\lambda_i^2}\,\frac{\lambda_1^2}{m_1 - 1}\right)^2 . \qquad (3)$$

The value of the air refractive index is determined by the Edlen formula:

$$(m_i - 1)10^6 = 64.328 + \frac{29498.1}{146 - \frac{1}{\lambda_i^2}} + \frac{255.4}{41 - \frac{1}{\lambda_i^2}} \qquad (4)$$

Expressions (2)-(4) denote that the set of molecular optical characteristics is defined by one value. As to aerosol characteristics, the definite physical basis should be taken into account. It lies in the fact that aerosol optical characteristics form a system of interrelated quantities. By this is meant that in practical use of the method for determining the aerosol component, the two or three frequencies are prominent. We are coming now to the results of the numerical experiment. The basis of this experiment is the profile of the scattering ratio for the wavelength of 532 nm given in Fig. 2 .

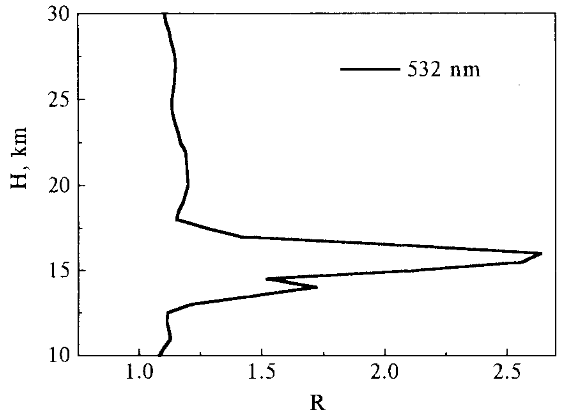

Fig. 2. The profile of the scattering ratio for λ = 532 nm.

The Deirmendjian model H is selected as a model of aerosol microstructure. At the altitudes ranging from 12 to 18 km the "perturbation" is introduced. Its microstructure is described by the lognormal distribution. The results of the experiments are appropriate for those of the lidar operating at four wavelengths (λ =339, 353, 532, and 683 nm; λ=339 nm is given for determining the molecular component). Fig. 3 presents the behavior of the aerosol coefficient of aerosol backscattering.

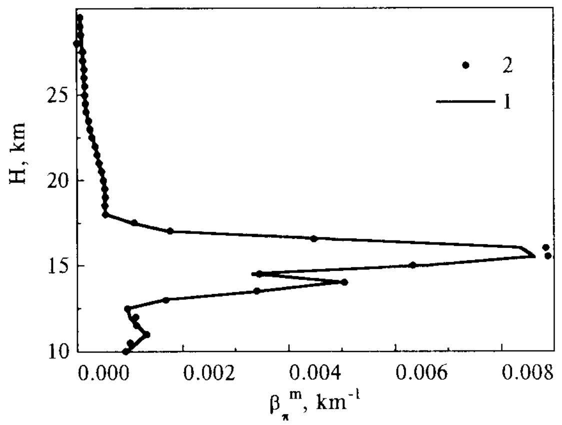

Fig. 3. The profile of the backscattering aerosol coefficient for λ=339 nm; 1- given profile; 2- reconstructed profile.

From the figure it is clear that the deviation of the exact solution (curve 1) from the restored one (curve 2) increases and peaks in the aerosol perturbation layer. The analogous result is presented in Fig. 4.,where the behavior of the molecular scattering coefficient is shown. At the same character of behavior the error here is essentially less.

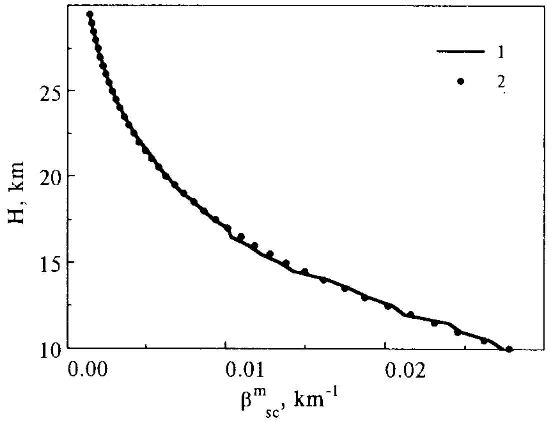

Fig. 4. Profiles of the molecular scattering coefficient for λ=339 nm. 1- given profile; 2- reconstructed profile.

Having divided the scattering components, in calculations we can introduce the corrections to the algorithm of ozone determination. The same result is presented in Fig. 1 (curve 3).