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DETERMINATION OF TEMPERATURE VERTICAL PROFILE IN LOWER STRATOSPHERE USING THE MULTIFREQUENCY LIDAR DATA

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At present there are many papers devoted to optical method for determining temperature profiles. In these papers the temperature is determined on the basis of concentration variation of principal gaseous components of the atmosphere when using the law of ideal gas together with the hydrostatic ratio. The main assumption used in these papers is that the value of the signal received depends mainly on molecular scattering. To determine the temperature profiles the method of multifrequency laser sounding should be used in this paper. When using the above method, signal processing is constructed in two steps. In the first step the scattering components are divided and the volume coefficients of molecular scattering are determined. The minimal necessary number of lidar wavelengths equals three in using this method.

In the second step the temperature profile is defined. The molecular scattering coefficients are connected uniquely with the atmospheric density.

$$\beta^{m}_{sc}(\lambda_i,h)=\frac{32\pi^3\, k\, R_a\, T_0^2(m_i-1)^2}{P_0^2\,\lambda_i^4}\,\rho(h) \qquad (1)$$

In Eq. (1) R_a is the specific gas constant of air, k is the Boltzman number; λ_i is the radiation wavelength; $\rho(h)$ is the atmospheric density; P_0=1013.247 mb and T_0=288.15 K are the pressure and temperature, respectively, at which the Edlen formula for the air refractive index is performed:

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

Having determined the atmospheric density $\rho(h)$ and using the hydrostatic ratio, the pressure profile is of the form:

$$P(h)=P(h_0)+g\int_{h}^{h_0}\rho(z)dz \qquad (2)$$

where g is the acceleration of gravity; h is the point of lidar calibration. The temperature profile sought is defined from the equation:

$$T(h)=\frac{P(h_0)+\int_{h}^{h_0}\rho(z)dz}{\rho(h)}\,\frac{1}{R_a} \qquad (3)$$

To verify the method the numerical experiment was performed. When calculating the aerosol component the Deirmendjian model H was selected as a model of microstructure. at altitudes ranging from 12 to 18 km a supplementary aerosol "perturbation" was introduced. Its microstructure is represented by the lognormal distribution. Since we are dealing with the lower stratosphere the refractive index of aerosol particles is chosen to be equal to 1.43. In the calculated signal profiles an error was introduced, which was distributed following the Poison law and being equal to 5% from the profile value. Besides, the aftereffect of photomultiplier was modeled.

Some results of the numerical experiment are represented in Fig. 1-3. In

Fig.1 the profiles of the molecular scattering coefficient are given for the wavelength of 353 nm. From the figure it is clear that the curve 2 (restored value) coincides practically with the curve 1 (precise value). The maximum derivation being about 2.5%, is achieved at the end (h=10.5 km). Except for the measurement errors, a selection of initial value of the pressure $P(h_0)$ (formula 2)) will affect the accuracy of the restored temperature profile. This quantity must be given a priori. Therefore, Fig. 2 describes the temperature profile at exactly given value $P(h_0)$ (curve 2). This profile coincides practically with the precise one (curve 1). Curve 3 represented the temperature profile with $P(h_0)=0$. The deviation, being essentially large in the beginning, decreases fast and coincides at the end. It is evident that the value $P(h_0)$ should be given best when using the model of molecular atmosphere. Fig. 3 shows one more source of errors. It is due to inexact knowledge of the refractive index of aerosol particles matter. The largest deviation of the order of 3°K occurs at too low value of the refractive index (curve 1). These errors are of systematic nature.

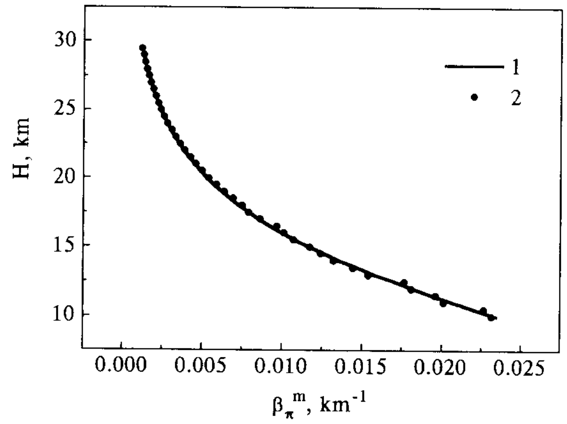

Fig. 1. Vertical profiles of the molecular scattering coefficient for the wavelength of 353 nm. 1 - precise profile ;2 - restored profile;

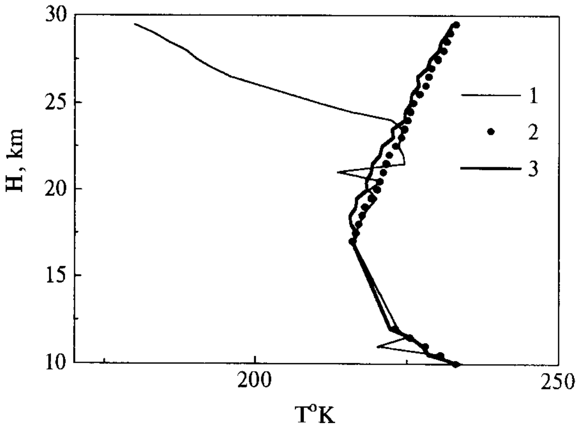

Fig. 2. Vertical temperature profiles at different initial values of pressure. 1 - precise temperature profile ; 2 - restored profile at exact initial value of pressure; 3 - restored profile at zero value of pressure.

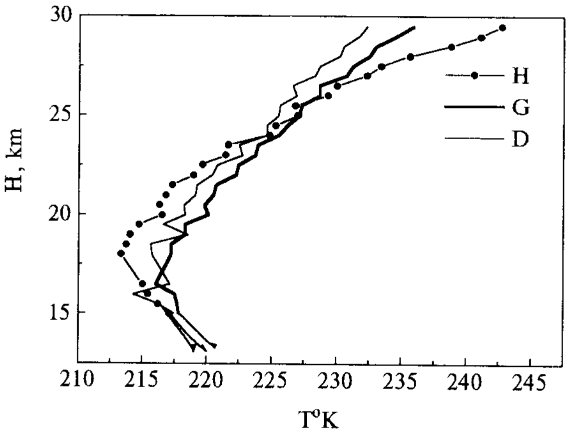

Fig. 3. Vertical temperature profiles at different refractive indices of aerosol particles. 1 - 1.33; 2 - 1.43; 3 - 1.50