ANALYSIS OF QUANTITATIVE DATA ON THE AEROSOL ATTENUATION COEFFICIENT OF THE TROPOSPHERE AND STRATOSPHERE IN A SUBSATELLITE EXPERIMENT

V.S. Maximyuk and S.V. Tat'yanin

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The results of airborne spectronephelometric measurements of the aerosol attenuation coefficient $\mu_a(\lambda)$ in the lower and middle troposphere are studied. These results are compared with separate independent data, which are coincident in time and space and which were obtained from SAGE satellite optical measurements performed abroad by the method of photometry of the horizon at sunrise and sunset. It is concluded that the vertical profiles $\mu_a(\lambda, H)$ and the values of Angstrom's coefficient measured by different methods agree satisfactorily and supplement one another for different altitudes. This indicates that it is technically possible to perform modern complex optical studies of the entire thickness of the atmosphere with the required spatial resolution, reliability, and accuracy.

Instruments placed onboard satellites now permit obtaining diverse and systematic information about the characteristics of the atmosphere and underlying surface. The methods developed for solving the corresponding inverse problems make it possible to reconstruct a number of parameters and to obtain information about atmospheric processes in the stratosphere and upper troposphere on global scales.[1,2] One possible alternative scheme to the use of a satellite for obtaining the missing information about the quantitative characteristics of the underlying layers of the atmosphere is to use in a subsatellite experiment a special method of airborne sounding in preselected reference geographical regions characterizing the background conditions of the measurements.

In this paper we examine the results of direct spectronephelometric measurements of the aerosol attenuation coefficient μ_a in the region of the spectrum $\lambda = 0.38 \ldots 1.02$ μm from an airborne laboratory at altitudes from 0 to 5 km for background conditions corresponding to the central part of the European Territory of the Soviet Union.[3–6] The results are compared with data obtained by synchronous sounding from a satellite as a part of the SAGE program, in which regular studies of the stratospheric and tropospheric aerosol (with the exception of the aerosol of water clouds) are performed using the method of reconstruction of the vertical profile of the attenuation coefficient β_a ($\lambda_1 = 0.45$ μm, $\lambda_2 = 1.00$ μm) based on measurements of the transmission of the atmosphere along "eclipsing" paths.[7] The vertical distribution of solar radiation was measured during the day for 15 sunrises and sunsets. The quantitative averaging of the array of vertical profiles β_a is performed over two- or five-day time intervals and over the geographic zone within a band of 10° in the latitude and 20° in the longitude. It is important to note that we are comparing the above-indicated average values of β_a with the unique results of airborne nephelometric sounding of μ_a, which gives a more accurate but only "instantaneous" picture of the vertical section of the atmosphere neglecting variations over a period of many days. The measurements are compared for two different methods of sounding, differing with respect to the spatial averaging but coincident in time and the geographic zone as well as the altitude $H_0 = 5$ km, which is at the same time the lower limit of the satellite measurements of $\beta_a(\lambda_2)$ and the upper limit of the airborne measurements of μ_a. Of the two arrays of experimental data in the random subsatellite experiment eleven coincident series of observations in which 18 profiles $\mu_a(\lambda_3, H)$ at the wavelength $\lambda_3 = 0.54$ μm were obtained. The results of the satellite sounding of β_a at the wavelength $\lambda_2 = 1.00$ μm were converted to the wavelength λ_3 using Angstrom's formula $\beta_a \sim \lambda^{-n}$. Angstrom's index n was determined from the starting experimental data on $\beta_a(\lambda_1)/(\beta_a(\lambda_2))$ assuming that $\log\beta_a$ is related linearly with $\log\lambda$.

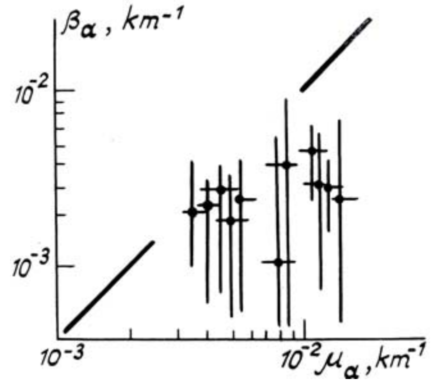

FIG. 1. Comparison of airborne μ_a and satellite β_a measurements of the aerosol attenuation coefficient at $H_0 = 5$ km and $\lambda_3 = 0.54$ μm.

To compare the measurements obtained by the two methods of sounding Fig. 1 shows the relationship between the synchronous pair of values $\mu_a(\lambda_3)$ and $\beta_a(\lambda_3)$, which, taking the instrumental and methodical errors in the measurements into account, agree satisfactorily. The systematic disagreement in the experimental data is equal to on the average +31% for a group of seven series of observations and +72% for a group of four series of observations. The vertical and horizontal segments in Fig. 1 show the measurement errors in the form of the standard deviation from the average value.

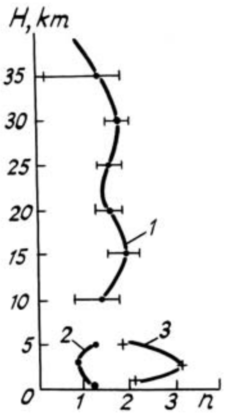

FIG. 2 Example of the vertical distribution of Angstrom's index. 1 — the value of $\bar{n}_1$ and the standard deviation; 2, 3 — the variability of the corresponding values of n_2, obtained with an interval of three days.

To study not only the quantitative characteristics of the aerosol but also the dynamics of the qualitative composition of the aerosol as a function of altitude the results of the corresponding spectral measurements are compared. The vertical profile of Ansgtrom's index presented in Fig. 2 refers to satellite measurements of n_1 for altitudes exceeding 10 km and airborne measurements of n_2 for altitudes below 5 km. Examples of the altitude distribution of $\bar{n}_1$ show that the average value varies insignificantly $\bar{n}_1 = 1.7\pm0.5$; this is typical for SAGE measurements? The average value $\bar{n}_2 = 2\pm1$ and its altitude variabi1ity[5,6] agree qualitatively and quantitatively with the values of $\bar{n}_1$, taking into account the zone of spatial incertainty at altitudes in the range 5 ... 10 km as well as the probable difference in the chemical and dispersion composition of the tropospheric and stratospheric aerosol.

Thus the quantitative characteristics μ_a and β_a as well as the values of $\bar{n}_1$ and $\bar{n}_2$ obtained in the subsatellite experiment agree well, supplementing one another as a function of altitude, and indicate that combined satellite and airborne studies of the entire thickness of the atmosphere can be performed with satisfactory reliability and accuracy for the background conditions of the measurements.

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