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SPECTROPHOTOMETRIC STUDIES OF ATMOSPHERIC AEROSOL CHARACTERISTI--ETC(U)
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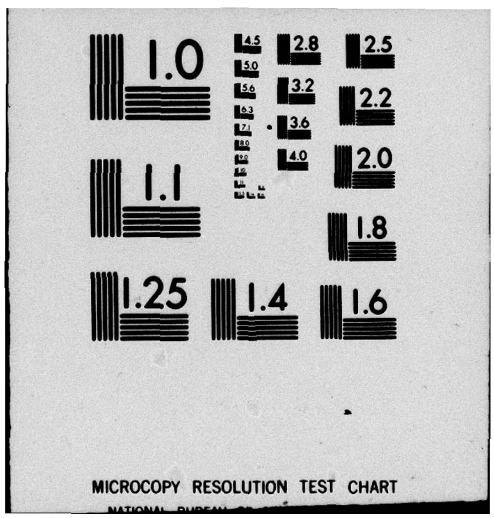
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SPECTROPHOTOMETRIC STUDIES OF ATMOSPHERIC AEROSOL CHARACTERISTICS IN VARIOUS GEOGRAPHIC REGIONS OF THE USSR

By

G. P. Gushchin

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EDITED TRANSLATION

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SPECTROPHOTOMETRIC STUDIES OF ATMOSPHERIC AEROSOL CHARACTERISTICS IN VARIOUS GEOGRAPHIC REGIONS OF THE USSR

By: G. P. Gushchin

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А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
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К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
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Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

SPECTROPHOTOMETRIC STUDIES OF ATMOSPHERIC AEROSOL CHARACTERISTICS IN VARIOUS GEOGRAPHIC REGIONS OF THE USSR

G. P. Gushchin

§1. Study procedure and equipment

This article is the first part of work on the systematic study of atmospheric aerosol in various geographic regions of the USSR on the basis of the spectrophotometric method. This method permits us to conduct a study without the direct influence on the aerosol layer. This presents a certain advantage over other methods in the use of which the influence on the easily changing aerosol substance is permitted. A distinguishing feature of this method is also the fact that the creation and use of a network of aerosol stations which are operating in accordance with a single program and which cover the territory of the USSR comparatively uniformly is envisioned. The network of aerosol stations coincides with the presently operating ozonometric network [1, 3] which consists of 38 stations. Some of these stations began regular aerosol observations in 1967 while at other stations the start of these observations is planned for 1968.

Considering the circumstance that attenuation of radiation by aerosol is manifested most strongly in the ultraviolet and visible regions of the spectrum, we selected for the studies a section of the spectrum from 350 to 650 nm which is free from the absorption bands of other atmospheric components (except for the long wave portion of this section where the absorption of ozone in the Chappuis band which was considered in our measurements has an influence to a small degree).

An M-83 ozonometer [2] is used to measure the optical characteristics of atmospheric aerosol in various regions of the spectrum in this work. It has eight combined glass light filters which are arranged inside the instrument housing in a rotating disk. The characteristics of the light filters are shown in Table 1.

The F-4 photoelectric cell is virtually insensitive in the region of the spectrum which lies to the right of the 700-nm wavelength.

The M-83 instrument measures the flux of direct solar radiation in eight sections of the spectrum, the attenuation of this radiation in the atmosphere following the Bouguer-Beer law

$$S_\lambda = S_{\lambda,0} 10^{-m(\beta_\lambda + \delta_\lambda)}, \quad (1)$$

where $S_{\lambda,0}$ and S_λ - are radiation fluxes of the wavelength λ (corresponds to the maximum transmission of the light filter) prior to entry and after passage through the atmosphere, m - the air mass, β_λ - the optical thickness of the Rayleigh atmosphere, δ_λ - the optical thickness of the aerosol. Formula (1) is employed for seven light filters of the M-83 ozonometer beginning with the second. The first light filter separates the section of the spectrum where, in addition to the Rayleigh and aerosol attenuation, absorption of the ozone is noted (to a small degree, absorption of the ozone also has an effect on the 8th light filter). For light filters 2-8 (Table 1), in measurements on direct sunlight the Bouguer-Beer law is satisfied with an accuracy which is sufficient for this work. This was proven in [1] for light filter 3 with the altitude of the sun from 1 to 90°. Since the Forbes effect is manifested more strongly the shorter the wavelength, it is virtually absent for the remaining light filters except the first. The direct satisfaction of the Bouguer-Beer law was checked for light filters 2-8 by the construction of Bouguer lines ($\log S_{\lambda}$. depending on m).

Table 1. Characteristics of glass light filters of the M-83 ozonometer No. 3R.

(1) № светофильтра	(2) Марка стекла и толщина, мм (в скобках)	(3) Длина волны в максимуме пропускания λ_{max} нм	(4) Ширина полосы пропускания на половине высоты кривой (в максимуме пропускания) $\Delta\lambda$, нм
1	ЖС-3 (2) + УФС-2 (5)	314	21
2	СЗС-9 (2) + УФС-2 (3,5)	369	22
3	ЖС-19 (3) + УФС-2 (3)	360	24
4	ЖС-11 (3) + ФС-7 (2)	444	23
5	СС-5 (6) + ЖС-16 (3)	458	26
6	ЗС-2 (5)	530	55
7	ЗС-2 (3) + ОС-14 (2)	570	30
8	СЗС-21 (1) + КС-13 (1)	634	50

KEY: (1) No. of light filter; (2) Mark of glass and thickness, mm (in parenthesis); (3) wavelength in transmission maximum λ_{max}, nm; (4) Width of transmission band on half the height of the curve (at the transmission maximum) $\Delta\lambda$, nm.

The following formula for the optical thickness of the aerosol follows from expression (1)

$$\delta_{\lambda} = \frac{l_{0,\lambda} - l_{\lambda}}{m} - \beta_{\lambda}, \qquad (2)$$

where

$$l_{0,\lambda} = \lg S_{0,\lambda} \text{ and } l_{\lambda} = \lg S_{\lambda}.$$

The well known procedure for determining $l_{0,\lambda}$ which is based on the construction of the Bouguer lines was employed [1]. Table 2 presents a number of values of $l_{0,\lambda}$ for two wavelengths of 369 and 530 nm which were obtained in Voyeykovo in 1967. Measurements were conducted on cloudless days as well as days with variable cloud cover. Those graphs in which the value of δ_λ changed noticeably in one direction were discarded. As is evident from Table 2, the scatter of the values for $l_{0,\lambda}$ is small and the addition of new values does not lead to a noticeable change in the mean value of $l_{0,\lambda}$.

Table 2. Values of $l_{0.1}$ and $l_{0.2}$; M-83 instrument No. 24R, Voyeykovo, 1967. λ_1 = 369 nm, λ_2 = 530 nm.

Дата (1)	$l_{0,1}$	$l_{0,2}$	Дата (1)	$l_{0,1}$	$l_{0,2}$
3 VII	2,65	1,78	25 VIII	2,72	1,82
8	2,60	1,71	12 IX	2,69	1,78
11	2,64	1,73	14	2,61	1,82
15	2,61	1,75	17	2,74	1,82
17	2,56	1,71	20	2,75	1,77
18	2,76	1,80	21	2,64	1,69
21	2,58	1,74	28	2,62	1,78
27	2,68	1,72	1 X	2,72	1,76
28	2,62	1,76	Среднее значение (2)	2,65	1,76
30	2,52	1,68	Средняя квадратичная ошибка отдельного значения (3) . . .	0,053	0,045
2 VIII	2,64	1,70			
12	2,73	1,81			
13	2,61	1,78			

KEY: (1) Date; (2) Mean value; (3) Mean-square deviation of individual value.

An estimate of the error in the value of δ_λ is given in [1]. For average measurement conditions the relative error varies within limits of 1-8%; however, the upper limit of this interval can be increased with small values of δ_λ [1].

Because the transmission of the light filters depends on temperature, measurements of the temperature coefficients of the ozonometer q_T were conducted in a specially constructed calibrated thermostat with an optical output. A 12-V incandescent lamp was used as the light source. It was placed outside the thermostat while a check lamp was placed inside the ozonometer. The power supply of the lamps was accomplished from storage batteries and was checked by an ammeter. The results from the measurements of the coefficient q_T for the first three light filters are presented in Table 3.

The reading for the light filter at J_i was calculated from the formula

$$J_i = \frac{p_i r q_T \cdot 100}{p_k}, \qquad (3)$$

where p_i - the reading without correction, r - the coefficient for the transition to the basic sensitivity, and p_k - the reading for the internal check lamp on the basic sensitivity. Because of the linearity of the ozonometer, the reading J_i is directly proportional to the light flux S_λ and, since the difference $l_{0,\lambda} - l_\lambda$ stands in formula (2), the coefficients of proportionality cancel each other in this difference and do not have an effect on the measured value of δ_λ.

In addition to the collection of regular information on the optical thickness of the aerosol in seven sections of the spectrum, the work also provided for obtaining systematic information on the parameters of aerosol particle distribution by dimensions. Here, it is assumed that in a vertical column which penetrates the entire atmosphere, the distribution of aerosol particles follows the Junge formula [6]

$$\frac{dN}{dr} = cr^{-n}, \qquad (4)$$

where N - the total number of particles in a vertical column of the atmosphere with a single cross section whose radius is less than r; n - the Junge index; c - constant. According to Junge [6], formula (4) is applicable in the case where $0.08 < r < 10$ μm; the mean value of the index $n = 4$.

Table 3. Temperature coefficient of light filters of M-83 ozonometer for reduction of readings to 20° C: λ_I = 314 nm, λ_{II} = 369 nm, λ_{III} = 530 nm.

Температура прибора, град.	Светофильтр			Температура прибора, град.	Светофильтр		
	1-й	2-й	3-й		1-й	2-й	3-й
—10	0,85	0,76	0,82	20	1,00	1,00	1,00
—9	0,85	0,77	0,82	21	1,00	1,01	1,01
—8	0,85	0,77	0,83	22	1,01	1,02	1,02
—7	0,86	0,78	0,83	23	1,02	1,03	1,03
—6	0,86	0,78	0,83	24	1,02	1,04	1,04
—5	0,86	0,79	0,84	25	1,03	1,05	1,05
—4	0,87	0,79	0,84	26	1,04	1,07	1,07
—3	0,87	0,80	0,85	27	1,04	1,08	1,08
—2	0,87	0,81	0,85	28	1,05	1,10	1,09
—1	0,88	0,82	0,85	29	1,06	1,11	1,10
0	0,88	0,82	0,86	30	1,06	1,12	1,11
1	0,88	0,83	0,86	31	1,07	1,13	1,12
2	0,89	0,84	0,87	32	1,08	1,14	1,13
3	0,89	0,84	0,87	33	1,09	1,15	1,15
4	0,90	0,85	0,88	34	1,10	1,17	1,16
5	0,91	0,86	0,88	35	1,10	1,18	1,17
6	0,91	0,86	0,89	36	1,11	1,20	1,18
7	0,92	0,87	0,89	37	1,12	1,21	1,20
8	0,92	0,88	0,90	38	1,13	1,23	1,21
9	0,93	0,89	0,90	39	1,14	1,24	1,23
10	0,94	0,90	0,91	40	1,15	1,25	1,24
11	0,94	0,91	0,92	41	1,16	1,27	1,25
12	0,95	0,92	0,93	42	1,17	1,28	1,27
13	0,95	0,93	0,93	43	1,18	1,30	1,29
14	0,96	0,94	0,94	44	1,19	1,31	1,30
15	0,97	0,95	0,95	45	1,20	1,32	1,32
16	0,98	0,95	0,96	46	1,21	1,34	1,33
17	0,98	0,96	0,97	47	1,22	1,35	1,35
18	0,99	0,97	0,98	48	1,23	1,37	1,37
19	0,99	0,99	0,99	49	1,24	1,39	1,39
				50	1,25	1,40	1,41

KEY: (1) Temperature of instrument, degrees; (2) Light filter.

At the present time, a comparatively small number of direct measurements of aerosol particle dimensions in a broad band of 0.08-10.0 μm is known because of experimental difficulties [6]. Depending on the dimensions of the particles, these measurements were conducted by various methods with different errors [6]. The results of the indicated measurements are basically confirmed by the Junge formula (4). However, it is possible that in the surface layer the instantaneous distribution of the particles does not follow formula (4) since the underlying surface and local sources of the particles have a strong influence on this distribution. On the other hand, it is possible that above the surface layer and in a sufficently large volume the distribution of the particles follows formula (4) in many cases.

The further accumulation of good-quality experimental material is required for the solution of this problem.

This work posed as one of its tasks the collection of statistical experimental material which characterizes the distribution of particles by dimensions in various geographical regions of the USSR under different physical conditions in the atmosphere.

The parameters n and c in formula (4) were selected as the characteristics for the distribution of aerosol particles by dimensions which were subjected to measurement. If, as we assumed, the values of parameters n and c which were obtained as the result of the measurements prove to be close to the parameters obtained by other authors and by other methods, if these parameters prove to be comparatively stable under similar conditions, and if they prove to be close with the use of various spectral sections for measurements, we will be able to draw the preliminary conclusion that (4) reflects the actual distribution of aerosol particles by dimensions in a vertical column of the atmosphere.

A special procedure which is presented below was developed to determine parameters n and c. On the basis of Mie theory [4, 7], the attenuation of the light which is caused by scattering on aerosols is described by the formula

$$\delta_{\lambda} = 0{,}434 \int_{r_1}^{r_2} \pi r^2 K(y) \frac{dN}{dr} dr, \qquad (5)$$

where r_1 and r_2 - the least and greatest radii of particles in a given distribution, K(y) - the total Mie scattering coefficient [7] which depends on the refractive index of the substance, the shape of the aerosol particles, and on the parameter

$$y = \frac{2\pi r}{\lambda}. \qquad (6)$$

If the volume being examined coincides with a vertical column of the atmosphere of a single cross section, the value of δ_λ in formula (5) coincides with the optical thickness of the aerosol in formula (1). Substituting dN/dr from (4) into (5) and changing from the variable r to the variable y with the aid of (6), we obtain

$$\delta_\lambda = 0{,}434\pi c\left(\frac{\lambda}{2\pi}\right)^{3-n}\int_{y_1}^{y_2} y^{2-n}K(y)\,dy. \quad (7)$$

Since, as Junge points out [6], parameter n lies in the interval of $3.0 < n < 5.0$ and the values of r_1 and r_2 equal respectfully 0.08 and 10.0 μm, then without noticeable error we can accept that in expression (7) $y_1 = 0$, and $y_2 = \infty$. Here, the following is considered.

a. The improper integral in equation (7) converges on the basis of the Cauchy convergence test [5] since $K(y) < 5$ [7] and $n - 2 > 1$.

This is equivalent to where, with $y_1 = 0$, $y_2 = \infty$, and $n > 3$ δ_λ is always a finite value.

b. Since $r_1 = 0.08$ μm, $r_2 = 10.0$ μm, the corresponding values of y for $\lambda = 369$ nm equal:

$$y_1 = \frac{6{,}28\cdot 0{,}08}{0{,}369} = 1{,}36;\quad y_2 = \frac{6{,}28\cdot 10{,}0}{0{,}369} = 170,$$

and for $\lambda = 0.530$ nm

$$y_1 = \frac{6{,}28\cdot 0{,}08}{0{,}530} = 0{,}95;\quad y_2 = \frac{6{,}28\cdot 10.0}{0{,}530} = 118.$$

The integrand in expression (7) with refraction index $m = 1.33$ (water) and parameter n equal to 3, 4, and 5 has the form shown in Fig. 1. From Fig. 1 it follows that for $n > 3$ the replacement of the numerical limits to integration indicated above by the limits 0 and

∞ do not cause a noticeable change in the value of the integral in expression (7). An even smaller change in the integral in expression (7) occurs if, in our case, the integration limits change *only* as the result of a change in wavelength λ. Thus, for example, if the limited integration in expression (7) $y_2 = 118$ is replaced by $y_2 = \infty$, the relative error in the value of the integral with n = 4 will equal

$$\frac{\int_{118}^{\infty} 2y^{-2}dy}{\int_{0}^{\infty} y^{-2}K(y)\,dy} \cdot 100 = 1{,}4\%,$$

and with the replacement of the limit $y_2 = 118$ by the limit $y_2 = 170$ the relative error in the value of the integral will equal

$$\frac{\int_{118}^{170} 2y^{-2}dy}{\int_{0}^{\infty} y^{-2}K(y)\,dy} \cdot 100 = 0{,}43\%.$$

In the calculation of the error, it was assumed for simplicity that K(y) = 2 with $y \geq 118$.

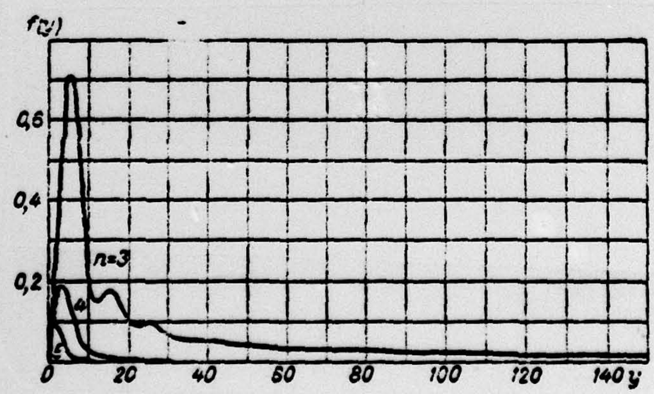

Fig. 1. Function $f(y) = y^{2-n}K(y)$.

c. The error in expression (7) increases with the replacement of the integration limits by 0 and ∞ with a decrease in the index n. With $n < 3$, this replacement leads to where $\delta_\lambda = \infty$. However, for the purposes of this work we can limit ourselves to the replacement of the limits by the extreme and, consequently, constant values y_{min} and y_{max} which are determined by the longest and shortest wavelengths in the region of the spectrum being examined (for example, the replacement of the limit $y_2 = 118$ by the limit $y_2 = 170$).

With consideration of remarks "a," "b," and "c," expression (7) acquires the form

$$\delta_\lambda = 0{,}434\pi c \left(\frac{\lambda}{2\pi}\right)^{3-n} R, \tag{8}$$

where the value

$$R = \int_{y_{min}}^{y_{max}} y^{2-n} K(y)\, dy \tag{9}$$

depends on the parameter n, the refractive index of the particles m, and does not depend on λ.

Formula (8) is similar to the well-known Angstrom formula $\delta_\lambda = c_1 \lambda^{-b}$ if we assume that $b = n - 3$.

For th[e t]wo selective wavelengths, the ratio of the optical thicknesses of the aerosol measured at the very same time, in accordance with (8), will equal

$$\frac{\delta_{\lambda_1}}{\delta_{\lambda_2}} = \left(\frac{\lambda_1}{\lambda_2}\right)^{3-n}, \tag{10}$$

where, in the case of employment of light filters, λ_1 and λ_2 will correspond to the maximums of spectral sensitivity of the instrument in the region of the first and second light filters.

From expression (10) formula

$$n = 3 + \frac{1}{\lg \lambda_2 - \lg \lambda_1} \lg \frac{\delta_{\lambda_1}}{\delta_{\lambda_2}}, \qquad (11)$$

follows with the aid of which the dimensionless parameter n is calculated depending on the ratio $\frac{\delta_{\lambda_1}}{\delta_{\lambda_2}}$. A graph of the dependence of n on the ratio $\frac{\delta_{\lambda_1}}{\delta_{\lambda_2}}$ is shown on Fig. 2 for the pair of wavelengths λ_1 = 369 nm and λ_2 = 530 nm. We note that the parameter n in formula (11) does not depend on the refractive index and the shape of the aerosol particles.

Using formula (11), the error in the parameter n depending on the error in the ratio $\frac{\delta_{\lambda_1}}{\delta_{\lambda_2}}$ with the presence of a Junge distribution of aerosol particles by dimensions in the atmosphere is easily estimated. From expression (11), after differentiation we obtain the following formula:

$$\Delta(n) = \frac{0,434}{\lg \lambda_2 - \lg \lambda_1} \left[\frac{\Delta(\delta_{\lambda_1})}{\delta_{\lambda_1}} + \frac{\Delta(\delta_{\lambda_2})}{\delta_{\lambda_2}} \right], \qquad (12)$$

where $\Delta(n)$, $\Delta(\delta_{\lambda_1})$ and $\Delta(\delta_{\lambda_2})$ - the limiting absolute errors of n, δ_{λ_1}, and δ_{λ_2}. Assuming for average conditions that $\frac{\Delta(\delta_{\lambda_1})}{\delta_{\lambda_1}} = \frac{\Delta(\delta_{\lambda_2})}{\delta_{\lambda_2}} =$ = 0.04 and n = 4, we obtain that the limiting absolute error in n equals

$$\Delta(n) = \frac{0,434}{0,158} (0,04 + 0,04) = 0,22,$$

and the relative error in n equals

$$\frac{\Delta(n)}{n} = \frac{0,22 \cdot 100}{4} = 5,5\%.$$

For convience in the practical use of this work, Table 4 is presented which provides the values of n depending on $\frac{\delta_{\lambda_1}}{\delta_{\lambda_2}}$.

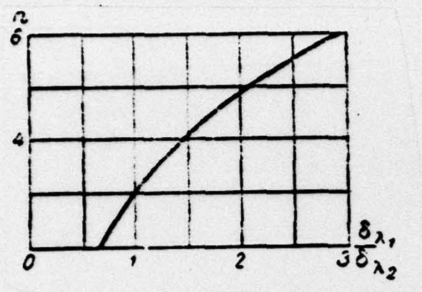

Fig. 2. Parameter n depending on ratio $\frac{\delta_{\lambda_1}}{\delta_{\lambda_2}}$; λ_1 = 369 nm, λ_2 = = 530 nm.

Table 4. Values of n depending on $\delta_{\lambda_1}/\delta_{\lambda_2}$.

$\delta_{\lambda_1}/\delta_{\lambda_2}$	n	$\delta_{\lambda_1}/\delta_{\lambda_2}$	n	$\delta_{\lambda_1}/\delta_{\lambda_2}$	n	$\delta_{\lambda_1}/\delta_{\lambda_2}$	n
0,50	1,0	1,1[illegible]	3,4	1,80	4,6	2,45	5,5
0,55	1,3	1,2[illegible]	3,5	1,85	4,7	2,50	5,5
0,60	1,6	1,25	3,6	1,90	4,8	2,55	5,6
0,65	1,8	1,20	3,7	1,95	4,8	2,60	5,6
0,70	2,0	1,35	3,8	2,00	4,9	2,65	5,7
0,75	2,2	1,40	3,9	2,05	5,0	2,70	5,7
0,80	2,4	1,45	4,0	2,10	5,0	2,75	5,8
0,85	2,5	1,50	4,1	2,15	5,1	2,80	5,8
0,90	2,7	1,55	4,2	2,20	5,2	2,85	5,9
0,95	2,9	1,60	4,3	2,25	5,2	2,90	5,9
1,00	3,0	1,65	4,4	2,30	5,3	2,95	6,0
1,05	3,2	1,70	4,5	2,35	5,4	3,00	6,0
1,10	3,3	1,75	4,6	2,40	5,4		

The second parameter of the distribution (4) c is found from formula (8)

$$c = \frac{\delta_\lambda}{B}, \qquad (13)$$

where

$$B = 0.434\pi \left(\frac{\lambda}{2\pi}\right)^{3-n} R. \qquad (14)$$

the dimensionality B being cm^{3-n} and the dimensionality c - cm^{n-3}.

As is evident from formulas (14) and (9), the value of B is the function n, λ and the refractive index m. Table 5 provides values of B for λ_1 = 369 nm, λ_2 = 530 nm, and m = 1.33 depending on n. As is evident from Table 5, the values B_1 and B_2 increase rapidly with an increase in n. In order to estimate the error in the value of B depending on error n, we use Table 5. Assuming $n = 4$ and $\Delta(n) = 0.2$, we will have

$$\delta(B_1) = \frac{(8.1 \cdot 10^5 - 1.0 \cdot 10^5) \cdot 100}{8,1 \cdot 10^5} = 99\%,$$

where $\delta(B_1)$ is the relative error in the value B_1.

Table 5. Values of B_1 and B_2 depending on n, λ_1 = 369 nm, λ_2 = 530 nm, m = 1.33.

n	B_1 см$^{3-n}$	B_2 см$^{3-n}$	n	B_1 см$^{3-n}$	B_2 см$^{3-n}$
3,1	$3,5 \cdot 10^1$	$3,4 \cdot 10^1$	4,6	$1,8 \cdot 10^8$	$1,0 \cdot 10^8$
3,2	$9,2 \cdot 10^1$	$8,4 \cdot 10^1$	4,7	$5,4 \cdot 10^8$	$2,8 \cdot 10^8$
3,3	$2,5 \cdot 10^2$	$2,1 \cdot 10^2$	4,8	$1,6 \cdot 10^9$	$8,1 \cdot 10^8$
3,4	$6,5 \cdot 10^2$	$5,4 \cdot 10^2$	4,9	$5,0 \cdot 10^9$	$2,6 \cdot 10^9$
3,5	$1,7 \cdot 10^3$	$1,4 \cdot 10^3$	5,0	$1,5 \cdot 10^{10}$	$7,2 \cdot 10^9$
3,6	$4,7 \cdot 10^3$	$3,8 \cdot 10^3$	5,1	$4,5 \cdot 10^{10}$	$2,1 \cdot 10^{10}$
3,7	$1,3 \cdot 10^4$	$1,0 \cdot 10^4$	5,2	$1,4 \cdot 10^{11}$	$6,5 \cdot 10^{10}$
3,8	$3,6 \cdot 10^4$	$2,6 \cdot 10^4$	5,3	$4,4 \cdot 10^{11}$	$1,9 \cdot 10^{11}$
3,9	$1,0 \cdot 10^5$	$7,0 \cdot 10^4$	5,4	$1,4 \cdot 10^{12}$	$5,6 \cdot 10^{11}$
4,0	$2,8 \cdot 10^5$	$2,0 \cdot 10^5$	5,5	$4,4 \cdot 10^{12}$	$1,8 \cdot 10^{12}$
4,1	$8,1 \cdot 10^5$	$5,6 \cdot 10^5$	5,6	$1,4 \cdot 10^{13}$	$5,6 \cdot 10^{12}$
4,2	$2,3 \cdot 10^6$	$1,6 \cdot 10^6$	5,7	$4,7 \cdot 10^{13}$	$1,8 \cdot 10^{13}$
4,3	$6,8 \cdot 10^6$	$4,5 \cdot 10^6$	5,8	$1,6 \cdot 10^{14}$	$5,6 \cdot 10^{13}$
4,4	$2,0 \cdot 10^7$	$1,2 \cdot 10^7$	5,9	$5,2 \cdot 10^{14}$	$1,8 \cdot 10^{14}$
4,5	$6,0 \cdot 10^7$	$3,5 \cdot 10^7$	6,0	$1,7 \cdot 10^{15}$	$5,8 \cdot 10^{14}$

In accordance with (13), the relative error in the value of c will equal

$$\delta(c) = \delta(\delta_\lambda) + \delta(B). \tag{15}$$

Assuming that $\delta(\delta_\lambda) = 4\%$, we obtain $\delta(c) = 4\% + 99\% = 103\%$. The estimates which are presented show that the parameter c is measured with a considerably larger error than the parameter n.

In accordance with the existing classification [6], natural aerosols are divided into three groups: Aitken particles (r < 0.1 μm), large particles (0.1 ≤ r ≤ 1.0 μm), and giant particles (r > 1.0 μm). The phenomenon of haze in the atmosphere is caused primarily by large particles; therefore, transparency and visibility outside of clouds and fog are closely linked with the presence of large aerosol particles.

Knowing the parameters n and c, using equation (4) one can make a rough estimate of the total amount of large or giant particles in a vertical column of the atmosphere with a single cross section. Dividing the varibles in (4) and integrating, we obtain

$$\int_{N_1}^{N_2} dN = c \int_{r_1}^{r_2} r^{-n} dr, \tag{16}$$

whence

$$N_{1,2} = N_2 - N_1 = \frac{c}{n-1} (r_1^{1-n} - r_2^{1-n}), \tag{17}$$

where $0 < r_1 < r_2$, and $N_{1.2}$ - the total number of particles whose radius r lies in the interval $r_1 \leq r \leq r_2$.

Assuming $r_1 = 0.1\ \mu m = 10^{-5}$ cm, $r_2 = 1\ \mu m = 10^{-4}$ cm, from equation (17) we will obtain the total number of large particles $N_Б$ in a vertical column of the atmosphere with a cross section of 1 cm^2.

$$N_Б = \frac{c}{n-1} \cdot 10^{5(n-1)}. \tag{18}$$

In deriving (18), we disregarded 0.001 by comparison with 1.

Similarly, assuming $r_1 = 10^{-4}$ cm, $r_2 = 10^{-3}$ cm, from equation (17) we obtain that the number of giant particles

$$N_Г = \frac{c}{n-1} \cdot 10^{4(n-1)}. \tag{19}$$

The ratio of the number of large particles to the number of giant particles, in accordance with expressions (18) and (19), equals

$$\frac{N_Б}{N_Г} = 10^{n-1}. \tag{20}$$

The dimensionality of values $N_{1.2}$, $N_Б$, and $N_Г$ with consideration of the dimensionality of the values of c and r equals cm^{-2}.

The relative error in $N_Б$ from (18) is expressed by the formula

$$\delta(N_Б) = \delta(c) + \frac{\Delta(n)}{n-1} + \frac{5n-6}{10}\Delta(n). \qquad (21)$$

The formulation of the mean values of the quantities $\delta(c)$, n and $\Delta(n)$ in (21) provides

$$\delta(N_Б) = 103\% + 7\% + 28\% = 138\%.$$

To check the assumption that a Junge distribution of aerosol particles by dimensions exists in a vertical column of the atmosphere (4), two methods were used. The first method consists of the simultaneous measurement of parameter n by different pairs of wavelengths and a comparison of the results which have been obtained. Because n is measured with a comparably large error and does not depend on the aerosol substance, the agreement of various values of n within the limits of error points to the fact that a Junge distribution exist in the atmosphere at the moment of measurements (4) at least in the region of large particles. The second method consists of the fact that first the parameters n and B are determined using one pair of wavelengths and then, using formula (8), the value of δ_λ is calculated in the region of $350 < \lambda < 650$ nm. The agreement of the calculated values for δ_λ with the measured values of the same quantity in five sections of the spectrum within the limits of error will testify to the presence of a distribution of particles of type (4) in the atmosphere. Here, use should be made of various values of the refractive index m when calculating the quantity B using formulas (14) and (9) (for example m = 1.33 and m = 1.50). Because of the large error in the value of B, the second method can provide only a rough impression of the presence or absence of a Junge distribution in the atmosphere and some judgement of the aerosol substance is also possible (liquid or solid particle depending upon the index m at which the values of δ_λ are calculated agree in the best manner with the measured values).

§2. Some results from the measurements of optical characteristics of atmospheric aerosol

Observations of atmospheric aerosol were organized in 1967 at bases of the GGO [Main Geophysical Observatory] in Voyeykovo and Karadag as well as in Dushanbe, Bol'shaya Yelan' (Yuzhno-Sakhalinsk), Kuybyshev, and Murmansk. Aerosol observations were conducted in Voyeykovo using M-83 ozonometers No. 24R and No. 3R. Eight light filters were inserted in the No. 3R ozonometer whose characteristics are indicated in Table 1. Ozonometer No. 24R and ozonometers at other stations had light filters with wavelengths in the transmission maximum λ_1 = 369 nm and λ_2 = 530 nm for aerosol observations.

Table 6 is presented as an example of the calculation of the values δ_{λ_1}, δ_{λ_2}, n, c, $N_Б$, and $N_Б/N_Г$ which was conducted using formulas (2), (11), (13), (18), and (20). Measurements were conducted in Voyeykovo, there being no cloud cover in the region of the sun at that time.

Table 7 is presented for comparison of aerosol data measured at the very same place and at the very same time by two M-83 instruments. It contains the results of parallel measurements of the values δ_{λ_1}, δ_{λ_2}, n, and $N_Б$ by instruments No. 28R and No. 13R in Karadag for 25, 26, 27, and 28 August 1967.

As is evident from Table 6, the deviations of individual values of δ_{λ_1}, δ_{λ_2}, n, and $N_Б$ and those which are averaged for a day and which were obtained by different instruments at the very same time lie primarily within the limits of errors in the values indicated above.

Table 8 contains the values of the quantities δ_{λ_1}, δ_{λ_2}, n, and $N_Б$ which are mean for the day and obtained as the result of observations in Karadag, Bol'shaya Yelan', Murmansk, Kuybyshev and Dushanbe. It follows from Table 8 that the mean value of the parameter n is close to four. The value of n fluctuates primarily from three to five. In contrast to all other stations, in Dushanbe the parameter n is close to three. In this case (n = 3), it follows from formula (8) that the optical thickness of the aerosol does not depend on wavelength. Perhaps, this means that in the relatively dry atmosphere of Central Asia, which is the central portion of the very large Eurasian continent, the optical activity of the aerosol is formed by comparatively large and dry dust particles.

Table 6. Example of the calculation of values δ_{λ_1}, δ_{λ_2}, n, c, $N_Б$, and $N_Б/N_Г$. Voyeykovo, 4 July 1967. M-83 ozonometer No. 24R.

λ_1 = 369 nm, λ_2 = 530 nm

(1) Московское время, час., мин.	(2) Высота солнца, град.	δ_{λ_1}	δ_{λ_2}	n	c см$^{n-3}$	$N_Б$ см$^{-2}$	$\frac{N_Б}{N_Г}$
10 30	44,9	0,105	0,070	4,1	$1,3\cdot10^{-7}$	$1,3\cdot10^{8}$	$1,3\cdot10^{3}$
10 35	45,3	0,092	0,063	4,0	$3,2\cdot10^{-7}$	$1,1\cdot10^{8}$	$1,0\cdot10^{3}$
10 55	46,9	0,085	0,059	4,0	$3,0\cdot10^{-7}$	$1,0\cdot10^{8}$	$1,0\cdot10^{3}$
11 00	47,4	0,081	0,053	4,2	$3,2\cdot10^{-8}$	$1,0\cdot10^{8}$	$1,6\cdot10^{3}$
11 05	47,9	0,091	0,061	4,1	$1,1\cdot10^{-7}$	$1,1\cdot10^{8}$	$1,3\cdot10^{3}$
11 25	49,3	0,083	0,056	4,1	$1,0\cdot10^{-7}$	$1,0\cdot10^{8}$	$1,3\cdot10^{3}$
11 35	49,9	0,078	0,057	3,8	$2,0\cdot10^{-6}$	$0,7\cdot10^{8}$	$0,6\cdot10^{3}$
11 50	51,2	0,116	0,075	4,2	$4,6\cdot10^{-8}$	$1,5\cdot10^{8}$	$1,6\cdot10^{3}$
12 00	51,3	0,101	0,067	4,1	$1,2\cdot10^{-7}$	$1,2\cdot10^{8}$	$1,3\cdot10^{3}$
Среднее (3)		0,092	0,062	4,1	$3,5\cdot10^{-7}$	$1,1\cdot10^{8}$	$1,2\cdot10^{3}$

KEY: (1) Moscow time, hours, minutes; (2) Altitude of the sun, degrees; (3) Mean.

From observations in Karadag (Table 8), it follows that from July through November a three-fold decrease occurs, on the average, in the optical thickness of the aerosol δ_λ in both sections of the spectrum (λ_1 = 369 nm and λ_2 = 530 nm). The number of large particles $N_Б$ in the vertical column of the atmosphere of a single cross section decreases approximately the same amount during this period.

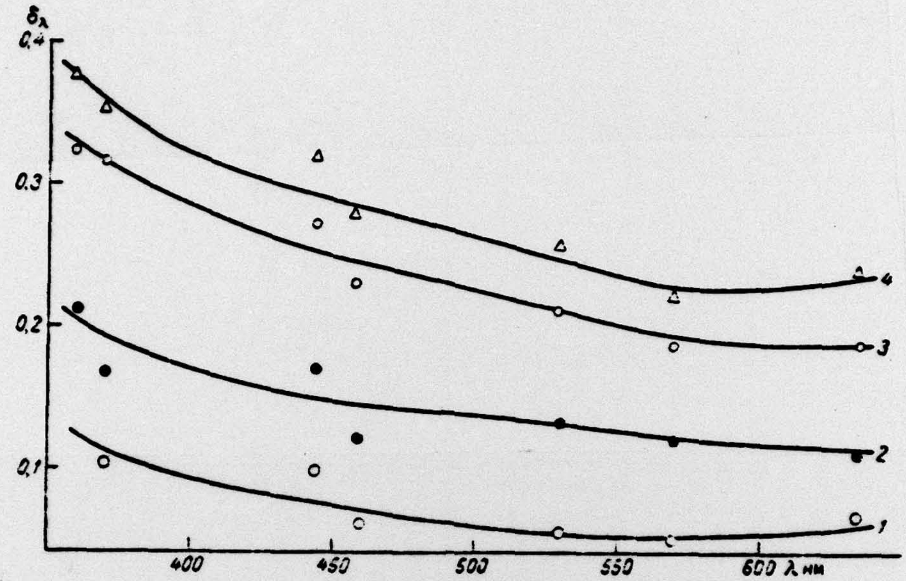

Fig. 3. Optical thickness of aerosol δ_λ depending on wavelength λ. M-83 ozonometer No. 3R, Voyeykovo, 1967. 1) 1-14 September. 1205 hrs; 2) 2-14 September 1005 hrs; 3) 3-6 September 1105 hrs; 4) 4-6 September, 1205 hrs.

Earlier [1] we noted that Voyeykovo the optical thickness of the aerosol in the ultraviolet and visable regions of the spectrum increases noticeably from winter to summer.

The dependence of the optical thickness of the aerosol on wavelength was obtained as one of the results of the study.

As a rule, a decrease in the optical thickness of the aerosol δ_λ with an increase in wavelength (Table 8) is observed at all stations (except for Dushanbe). This can signify that at these stations the aerosol particles have comparatively small dimensions and are primarily either nuclei of condensation with an aqueous shell or droplets of water.

Figure 3 shows the course of the optical thickness of aerosol δ_λ with a change in λ which was obtained at Voyeykovo in September 1967. As is evident from Fig. 3, the optical thickness of the

Table 7. Values of δ_{λ_1}, δ_{λ_2}, n, and $N_Б$ from the M-83 instruments No. 28R and No. 13R. Karadag, 1967.

$\lambda_1 = 369$ nm, $\lambda_2 = 530$ nm

Moscow time, h, min.	M-83 Instrument No.28R				M-83 Instrument No. 13R			
	δ_{λ_1}		n	$N_Б$	δ_{λ_1}	δ_{λ_2}	n	$N_Б$
				25 August				
7 55	0,182	0,108	4,5	$2,7\cdot 10^8$	0,147	0,069	5,1	$2,4\cdot 10^8$
8 00	0,164	0,099	4,4	$2,3\cdot 10^8$	0,146	0,069	5,0	$2,4\cdot 10^8$
8 05	0,172	0,101	4,5	$2,6\cdot 10^8$	0,148	0,074	4,9	$2,4\cdot 10^8$
8 55	0,168	0,105	4,3	$2,2\cdot 10^8$	0,127	0,064	4,9	$2,0\cdot 10^8$
9 00	0,183	0,120	4,2	$2,3\cdot 10^8$	0,152	0,083	4,7	$2,3\cdot 10^8$
9 05	0,173	0,103	4,5	$2,6\cdot 10^8$	0,146	0,076	4,8	$2,3\cdot 10^8$
9 55	0,215	0,141	4,1	$2,7\cdot 10^8$	0,215	0,134	4,3	$2,9\cdot 10^8$
10 00	0,238	0,190	3,6	$1,9\cdot 10^8$	0,246	0,184	3,8	$2,3\cdot 10^8$
10 05	0,267	0,205	3,7	$2,2\cdot 10^8$	0,253	0,180	3,9	$2,5\cdot 10^8$
10 55	0,257	0,169	4,1	$3,2\cdot 10^8$	0,325	0,230	3,9	$3,3\cdot 10^8$
11 00	0,257	0,194	3,7	$2,1\cdot 10^8$	0,291	0,194	4,1	$3,6\cdot 10^8$
11 55	0,240	0,157	4,2	$3,0\cdot 10^8$	0,296	0,180	4,4	$4,1\cdot 10^8$
12 00	0,265	0,155	4,5	$4,0\cdot 10^8$	0,330	0,196	4,5	$5,0\cdot 10^8$
12 05	0,222	0,130	4,5	$3,3\cdot 10^8$	0,280	0,171	4,4	$3,8\cdot 10^8$
14 05	0,276	0,155	4,6	$3,9\cdot 10^8$	0,331	0,186	4,6	$4,7\cdot 10^8$
14 58	0,232	0,128	4,6	$3,3\cdot 10^8$	0,283	0,177	4,3	$5,4\cdot 10^8$
15 55	0,217	0,118	4,7	$3,3\cdot 10^8$	0,235	0,136	4,6	$3,3\cdot 10^8$
16 00	0,211	0,125	4,5	$3,2\cdot 10^8$	0,236	0,143	4,4	$3,2\cdot 10^8$
16 05	0,200	0,111	4,6	$3,1\cdot 10^8$	0,240	0,140	4,5	$3,6\cdot 10^8$
16 55	0,215	0,134	4,3	$2,8\cdot 10^8$	0,220	0,125	4,6	$3,3\cdot 10^8$
17 00	0,215	0,119	4,6	$3,1\cdot 10^8$	0,215	0,120	4,6	$3,1\cdot 10^8$
17 05	0,207	0,119	4,6	$3,1\cdot 10^8$	0,223	0,131	4,5	$3,3\cdot 10^8$
17 25	0,197	0,113	4,6	$2,8\cdot 10^8$	0,198	0,103	4,8	$3,2\cdot 10^8$
17 30	0,202	0,118	4,5	$3,1\cdot 10^8$	0,203	0,111	4,7	$3,1\cdot 10^8$
17 37	0,204	0,120	4,5	$3,1\cdot 10^8$	0,221	0,127	4,7	$3,3\cdot 10^8$
Mean	0,215	0,133	4,4	$2,9\cdot 10^8$	0,229	0,136	4,5	$3,2\cdot 10^8$
				26 August				
7 55	0,103	0,057	4,6	$1,5\cdot 10^8$	0,083	0,036	5,3	$1,3\cdot 10^8$
8 00	0,103	0,058	4,6	$1,5\cdot 10^8$	0,088	0,039	5,2	$1,4\cdot 10^8$
8 05	0,100	0,058	4,5	$1,5\cdot 10^8$	0,078	0,039	4,9	$1,3\cdot 10^8$
9 00	0,067	0,035	4,8	$1,0\cdot 10^8$	0,057	0,024	5,4	$0,9\cdot 10^8$
9 05	0,074	0,037	4,9	$1,2\cdot 10^8$	0,063	0,021	6,0	$0,7\cdot 10^8$
10 05	0,057	0,031	4,7	$0,9\cdot 10^8$	0,057	0,031	4,7	$0,9\cdot 10^8$
10 55	0,083	0,041	4,9	$1,4\cdot 10^8$	0,128	0,079	4,3	$1,7\cdot 10^8$
11 00	0,085	0,042	4,9	$1,4\cdot 10^8$	0,124	0,072	4,5	$1,9\cdot 10^8$
11 05	0,095	0,058	4,4	$1,3\cdot 10^8$	0,126	0,073	4,6	$1,8\cdot 10^8$
11 55	0,089	0,056	4,3	$1,1\cdot 10^8$	0,097	0,072	3,8	$0,9\cdot 10^8$
12 00	0,091	0,057	4,3	$1,1\cdot 10^8$	0,124	0,081	4,2	$1,6\cdot 10^8$
12 05	0,091	0,048	4,8	$1,4\cdot 10^8$	0,116	0,081	4,0	$1,4\cdot 10^8$
13 00	0,069	0,041	4,5	$1,1\cdot 10^8$	0,110	0,082	3,8	$1,0\cdot 10^8$
13 05	0,078	0,041	4,8	$1,2\cdot 10^8$	0,135	0,099	3,8	$1,3\cdot 10^8$
13 55	0,097	0,045	5,1	$1,6\cdot 10^8$	0,177	0,109	4,3	$1,8\cdot 10^8$
14 00	0,094	0,045	5,0	$1,3\cdot 10^8$	0,158	0,123	3,7	$1,3\cdot 10^8$
14 05	0,069	0,044	4,2	$0,9\cdot 10^8$	0,147	0,122	3,5	$1,1\cdot 10^8$
15 55	0,143	0,081	4,6	$2,1\cdot 10^8$	0,153	0,092	4,4	$2,2\cdot 10^8$
16 00	0,123	0,066	4,7	$1,9\cdot 10^8$	0,140	0,084	4,4	$2,0\cdot 10^8$
16 05	0,123	0,064	4,8	$1,9\cdot 10^8$	0,145	0,082	4,6	$2,1\cdot 10^8$
Mean	0,092	0,050	4,7	$1,4\cdot 10^8$	0,115	0,072	4,5	$1,4\cdot 10^8$

Moscow time, h, min.	M-83 Instrument No. 28R				M-83 Instrument No. 13R			
	b_{λ_1}	b_{λ_2}	n	$N_Б$	b_{λ_1}	b_{λ_2}	n	$N_Б$
				27 August				
7 55	0,146	0,090	4,3	$1,9\cdot10^8$	0,128	0,078	4,4	$1,8.10^8$
8 00	0,148	0,097	4,2	$1,8\cdot10^8$	0,137	0,090	4,1	$1,6.10^8$
8 05	0,138	0,098	3,9	$1,4\cdot10^8$	0,130	0,079	4,4	$1,8.10^8$
8 55	0,130	0,089	4,0	$1,5\cdot10^8$	0,115	0,069	4,4	$1,6.10^8$
9 00	0,132	0,092	4,0	$1,6\cdot10^8$	0,122	0,076	4,3	$1,6.10^8$
9 05	0,137	0,096	4,0	$1,6\cdot10^8$	0,129	0,080	4,1	$1,4.10^8$
9 55	0,133	0,094	3,9	$1,3.10^8$	0,114	0,074	4,2	$1,4.10^8$
10 00	0,118	0,082	4,0	$1,4.10^8$	0,131	0,096	3,8	$1,2.10^8$
10 05	0,129	0,091	3,9	$1,3.10^8$	0,122	0,098	3,6	$1,0.10^8$
11 55	0,105	0,072	4,0	$1,3.10^8$	0,130	0,096	3,8	$1,2.10^8$
12 00	0,097	0,072	3,8	$0,9.10^8$	0,130	0,104	3,6	$1,0.10^8$
12 05	0,097	0,064	4,1	$1,2.10^8$	0,130	0,096	3,8	$1,2.10^8$
12 55	0,078	0,049	4,3	$1,0.10^8$	0,121	0,099	3,5	$0,9.10^8$
13 00	0,076	0,057	3,8	$0,7\cdot10^8$	0,140	0,114	3,5	$1,0\cdot10^8$
13 05	0,083	0,057	4,0	$1,0\cdot10^8$	0,149	0,122	3,5	$1,1\cdot10^8$
14 00	0,095	0,076	3,6	$0,8\cdot10^8$	0,150	0,123	3,5	$1,1\cdot10^8$
14 55	0,183	0,147	3,6	$1,5\cdot10^8$	0,241	0,184	3,7	$2,0\cdot10^8$
15 00	0,190	0,144	3,7	$1,6\cdot10^8$	0,245	0,193	3,6	$2,0\cdot10^8$
Mean	0,123	0,087	4,0	$1,3\cdot10^8$	0,142	0,104	3,9	$1,4\cdot10^8$
				28 August				
7 55	0,150	0,114	3,7	$1,3.10^8$	0,125	0,093	3,8	$1,2.10^8$
8 00	0,147	0,114	3.7	$1,2.10^8$	0,137	0,099	3,9	$1,3.10^8$
8 05	0,146	0,108	3,8	$1,4.10^8$	0,124	0,094	3,7	$1,0.10^8$
8 55	0,108	0,078	3,9	$1,1.10^8$	0,103	0,073	3,9	$1,0.10^8$
9 00	0,106	0,083	3,7	$0.9.10^5$	0,107	0,071	4,1	$1,3.10^8$
9 05	0,113	0,079	4,0	$1,3.10^8$	0,108	0,084	3,7	$0,9.10^8$
9 55	0,111	0,080	3,9	$1,1.10^8$	0,098	0,067	4,0	$1,2.10^8$
10 00	0,108	0,081	3,8	$1,0.10^8$	0,109	0,082	3,8	$1,0.10^8$
10 05	0,113	0,083	3,8	$1,1.10^8$	0,114	0,083	3,8	$1,1.10^8$
10 55	0,096	0,055	4,6	$1,4.10^8$	0,096	0,070	3,8	$0,9.10^8$
11 00	0,084	0,056	4,1	$1,0.10^8$	0,114	0,094	3,5	$0,8.10^8$
12 00	0,074	0,055	3,8	$0,7.10^8$	0,130	0,104	3,6	$1,0.10^8$
12 05	0,074	0,055	3,8	$0,7.10^8$	0,097	0,080	3,5	$0,7.10^8$
12 55	0,058	0,040	4,0	$0,7.10^8$	0,059	0,032	4,7	$0,9.10^8$
13 00	0,058	0,040	4,0	$0,7.10^8$	0,067	0,048	3,9	$0,9.10^8$
13 55	0,040	0,021	4,8	$0,6.10^8$	0,024	0,013	4,7	$0,4.10^8$
14 00	0,037	0,020	4,7	$0,6.10^8$	0,038	0,028	3,8	$0,3.10^8$
14 05	0,035	0,020	4,6	$0,5\cdot10^8$	0,051	0,035	4,0	$0,6.10^8$
15 55	0,070	0,043	4,4	$1,0\cdot10^8$	0,071	0,043	4,4	$1,0\cdot10^8$
16 00	0,077	0,048	4,3	$1,0\cdot10^8$	0,089	0,058	4,2	$1,1\cdot10^8$
16 05	0,083	0,057	4,0	$1,0\cdot10^8$	0,089	0,057	4,2	$1,1\cdot10^8$
16 57	0,123	0,079	4,2	$1,5\cdot10^8$	0,128	0,079	4,3	$1,7\cdot10^8$
17 00	0,120	0,080	4,1	$1,4\cdot10^8$	0,118	0,077	4,2	$1,5\cdot10^8$
17 05	0,136	0,095	4,0	$1,6\cdot10^8$	0,128	0,084	4,1	$1,5\cdot10^8$
17 27	0,138	0,089	4,2	$1,7\cdot10^8$	0,124	0,072	4,5	$1,9\cdot10^8$
17 30	0,133	0,088	4,1	$1,6\cdot10^8$	0,116	0,071	4,4	$1,6\cdot10^8$
17 35	0,121	0,081	4,1	$1,5\cdot10^8$	0,116	0,069	4,5	$1,8\cdot10^8$
Mean	0,098	0,068	4,1	$1,1\cdot10^8$	0,099	0,069	4,0	$1,1\cdot10^8$

Table 8. Daily means for optical thickness of aerosol δ_{λ_1}, δ_{λ_2}, parameter n, and number of large particles $N_Б$ in a vertical column of the atmosphere with a cross section of 1 cm^3, [sic], 1967.

λ_1 = 369 nm, λ_2 = 530 nm

Date	δ_{λ_1}	δ_{λ_2}	n	$N_Б$ cm^{-2}
Karadag				
July				
11	0,329	0,208	4,3	$4,8 \cdot 10^8$
12	0,351	0,223	4,3	$4,8 \cdot 10^8$
13	0,440	0,302	3,9	—
15	0,328	0,187	4,2	$4,2 \cdot 10^8$
16	0,189	0,131	4,0	$2,1 \cdot 10^8$
17	0,433	0,311	3,9	$4,1 \cdot 10^8$
18	0,211	0,148	3,9	$2,3 \cdot 10^8$
20	0,111	0,078	3,9	$3,3 \cdot 10^8$
21	0,108	0,091	3,4	$3,2 \cdot 10^8$
22	0,070	0,062	3,3	$0,8 \cdot 10^8$
23	0,148	0,103	4,0	$2,0 \cdot 10^8$
24	0,145	0,100	4,0	$2,3 \cdot 10^8$
25	0,259	0,161	4,3	$3,4 \cdot 10^8$
27	0,182	0,110	4,4	$2,7 \cdot 10^8$
30	0,295	0,176	4,4	$4,0 \cdot 10^8$
Mean	0,240	0,159	4,0	$3,1 \cdot 10^8$
August				
1	0,256	0,171	4,1	$3,0 \cdot 10^8$
2	0,305	0,204	4,1	$3,6 \cdot 10^8$
3	0,214	0,158	3,9	$2,3 \cdot 10^8$
4	0,368	0,247	4,1	$4,3 \cdot 10^8$
5	0,285	0,190	4,1	$3,4 \cdot 10^8$
6	0,323	0,296	4,0	$3,7 \cdot 10^8$
7	0,283	0,206	4,0	$2,8 \cdot 10^8$
8	0,303	0,196	4,2	$3,9 \cdot 10^8$
9	0,304	0,194	4,2	$3,9 \cdot 10^8$
10	0,374	0,234	4,2	$4,3 \cdot 10^8$
11	0,134	0,090	4,0	$1,6 \cdot 10^8$
12	0,197	0,130	4,1	$2,4 \cdot 10^8$
13	0,112	0,081	3,9	$1,1 \cdot 10^8$
15	0,109	0,075	4,0	$1,2 \cdot 10^8$
16	0,185	0,152	3,7	$1,6 \cdot 10^8$
17	0,174	0,117	4,2	$2,1 \cdot 10^8$
19	0,177	0,126	3,9	$2,7 \cdot 10^8$
21	0,264	0,174	4,2	$3,2 \cdot 10^8$
23	0,146	0,104	3,9	$1,6 \cdot 10^8$
24	0,023	0,015	4,3	$0,3 \cdot 10^8$
25	0,212	0,131	4,3	$2,8 \cdot 10^8$
26	0,097	0,053	4,7	$1,7 \cdot 10^8$
27	0,126	0,088	4,0	$1,4 \cdot 10^8$
28	0,090	0,061	4,1	$1,1 \cdot 10^8$
29	0,339	0,245	3,9	$3,5 \cdot 10^8$
30	0,060	0,034	4,6	$0,9 \cdot 10^8$
31	0,055	0,021	5,5	$0,9 \cdot 10^8$
Mean	0,204	0,140	4,2	$2,4 \cdot 10^8$
September				
1	0,110	0,074	4,2	$1,3 \cdot 10^8$
2	0,304	0,219	3,9	$3,1 \cdot 10^8$
3	0,177	0,116	4,2	$2,2 \cdot 10^8$
4	0,095	0,060	4,4	$1,3 \cdot 10^8$
5	0,128	0,089	4,2	$1,5 \cdot 10^8$
6	0,189	0,133	4,2	$2,6 \cdot 10^8$
7	0,055	0,052	3,1	$0,7 \cdot 10^8$
8	0,105	0,060	4,7	$1,4 \cdot 10^8$
9	0,058	0,036	4,6	$0,8 \cdot 10^8$
10	0,077	0,054	4,1	$0,9 \cdot 10^8$
11	0,061	0,026	4,4	$1,0 \cdot 10^8$
12	0,039	0,034	3,6	—
13	0,032	0,017	4,5	$0,9 \cdot 10^8$
15	0,101	0,059	4,7	$1,4 \cdot 10^8$
16	0,057	0,028	4,7	$1,2 \cdot 10^8$
17	0,237	0,178	3,8	$2,2 \cdot 10^8$
20	0,021	0,011	4,3	$0,5 \cdot 10^8$
21	0,169	0,114	4,3	$2,0 \cdot 10^8$
22	0,034	0,019	5,1	$0,7 \cdot 10^8$
23	0,030	0,018	4,9	$0,8 \cdot 10^8$
24	0,010	0,013	5,3	$0,6 \cdot 10^8$
26	0,224	0,144	4,3	$2,9 \cdot 10^8$
27	0,272	0,184	4,1	$3,2 \cdot 10^8$
28	0,095	0,044	5,0	$1,6 \cdot 10^8$
30	0,063	0,030	4,7	$1,1 \cdot 10^8$
Mean	0,110	0,073	4,4	$1,5 \cdot 10^8$
October				
1	0,131	0,081	4,4	$1,7 \cdot 10^8$
2	0,113	0,065	4,6	$1,6 \cdot 10^8$
3	0,039	0,026	5,0	$1,1 \cdot 10^8$
4	0,105	0,064	4,1	$1,4 \cdot 10^8$
5	0,108	0,067	4,4	$1,4 \cdot 10^8$
6	0,034	0,025	4,5	$0,6 \cdot 10^8$
7	0,089	0,062	4,3	$0,9 \cdot 10^8$
8	0,050	0,026	4,6	$0,8 \cdot 10^8$
10	0,178	0,115	4,3	$2,3 \cdot 10^8$
11	0,054	0,026	4,9	$0,9 \cdot 10^8$
13	0,001	0,000	—	—
14	0,000	0,000	—	—
15	0,012	0,002	5,1	$0,4 \cdot 10^8$
16	0,084	0,038	5,1	$1,4 \cdot 10^8$
17	0,039	0,012	5,0	$0,8 \cdot 10^8$
18	0,060	0,031	4,6	$1,1 \cdot 10^8$
19	0,033	0,012	5,1	$0,7 \cdot 10^8$
21	0,077	0,033	5,2	$1,2 \cdot 10^8$
22	0,000	0,000	—	—
23	0,001	0,000	—	—
24	0,010	0,005	4,5	$0,7 \cdot 10^8$
25	0,054	0,028	4,8	$0,8 \cdot 10^8$
26	0,078	0,045	4,4	$1,1 \cdot 10^8$

Date	δ_{λ_1}	δ_{λ_2}	n	$N_Б$ см$^{-2}$
27	0,145	0,106	3,8	1,4·10^8
29	0,051	0,035	4,1	1,6·10^8
30	0,056	0,038	4,3	0,7·10^8
Mean	0,062	0,036	4,6	1,1·10^8
November				
1	0,039	0,035	3,1	0,4·10^8
2	0,008	0,003	4,7	0,4·10^8
3	0,075	0,067	3,4	0,4·10^8
5	0,015	0,013	3,7	0,4·10^8
14	0,053	0,020	5,6	0,7·10^8
15	0,076	0,045	4,4	1,2·10^8
17	0,079	0,047	4,6	1,1·10^8
20	0,182	0,163	3,4	1,4·10^8
22	0,014	0,008	2,8	0,1·10^8
29	0,168	0,122	4,0	1,8·10^8
Mean	0,071	0,052	4,0	0,8·10^8

Bol'shaya Yelan'

Date	δ_{λ_1}	δ_{λ_2}	n	$N_Б$ см$^{-2}$
October				
4	0,067	0,030	5,0	10,6·10^7
5	0,046	0,020	5,2	7,9·10^7
6	0,038	0,029	4,1	5,8·10^7
7	0,008	0,010	3,6	1,6·10^7
8	0,040	0,030	4,0	6,6·10^7
9	0,109	0,056	4,8	17,0·10^7
10	0,243	0,126	4,9	37,0·10^7
11	0,171	0,093	4,8	25,2·10^7
12	0,245	0,211	3,4	17,7·10^7
25	0,021	0,007	5,6	3,0·10^7
30	0,038	0,029	4,4	5,1·10^7
Mean	0,075	0,055	4,5	12,5·10^7
November				
1	0,041	0,045	3,3	3,7·10^7
3	0,033	0,034	3,3	2,8·10^7
4	0,037	0,033	3,7	4,1·10^7
5	0,125	0,132	3,7	5,3·10^7
6	0,064	0,048	3,8	6,3·10^7
7	0,066	0,048	4,4	7,2·10^7
8	0,057	0,056	3,1	4,3·10^7
9	0,035	0,044	3,0	2,5·10^7
11	0,056	0,091	2,6	—
14	0,019	0,016	3,5	1,8·10^7
26	0,042	0,039	3,4	3,7·10^7
27	0,085	0,076	3,7	9,6·10^7
28	0,032	0,031	3,4	5,0·10^7
Mean	0,053	0,053	3,5	4,7·10^7

Murmansk

Date	δ_{λ_1}	δ_{λ_2}	n	$N_Б$ см$^{-2}$
September				
4	0,155	0,127	3,4	1,5·10^8
6	0,046	0,020	4,8	2,1·10^8
7	0,050	0,026	4,6	1,4·10^8
10	0,032	0,026	4,2	0,5·10^8
12	0,029	0,012	4,7	2,7·10^8
24	0,132	0,075	4,6	1,8·10^8
Mean	0,074	0,048	4,4	1,7·10^8

Kuybyshev

Date	δ_{λ_1}	δ_{λ_2}	n	$N_Б$ см$^{-2}$
August				
2	0,232	0,134	4,6	2,6·10^8
3	0,284	0,183	4,3	3,4·10^8
4	0,377	0,275	3,7	3,1·10^8
Mean	0,298	0,197	4,2	3,0·10^8

Dushanbe

Date	δ_{λ_1}	δ_{λ_2}	n	$N_Б$ см$^{-2}$
August				
20	0,495	0,524	2,9	
21	0,538	0,554	3,0	
22	0,548	0,562	3,0	
24	0,438	0,433	3,1	
25	0,595	0,612	3,0	
26	0,670	0,680	3,0	
27	0,598	0,608	3,0	
28	0,535	0,526	3,0	
30	0,466	0,491	2,9	
31	0,438	0,445	2,9	
Mean	0,532	0,544	3,0	
September				
1	0,448	0,468	2,9	
2	0,463	0,470	3,0	
3	0,433	0,451	2,9	
4	0,454	0,461	2,9	
19	0,381	0,392	3,0	
20	0,433	0,457	2,9	
21	0,369	0,389	2,9	
22	0,519	0,558	2,8	
23	0,339	0,359	2,9	
24	0,277	0,296	2,8	
25	0,411	0,427	2,9	
27	0,255	0,271	2,9	
28	0,287	0,305	2,9	
29	0,279	0,294	2,9	
30	0,238	0,243	3,0	
Mean	0,372	0,389	2,9	

aerosol in the region of 350-550 nm decreases with an increase in wavelength. In a number of cases, a small increase in the optical thickness of the aerosol is observed in the region of 550-650 nm with an increase in wavelength. However, this increase exceeds the limits of errors in measurements only insignificantly.

BIBLIOGRAPHY

1. Гущин Г. П. *Исследование атмосферного озона.* Гидрометеоиздат, Л., 1963.
2. Гущин Г. П. Озонометр. Авторское свидетельство № 160877 от 14 июня 1962 г. Бюллетень изобретений и товарных знаков, № 5, 1964.
3. Данные об общем содержании атмосферного озона по станциям СССР (материалы МГСС за 1964—1965 гг.). Под ред. Г. П. Гущина. Гидрометеоиздат, Л., 1967.
4. Кондратьев К. Я. Актинометрия. Гидрометеоиздат, Л., 1965.
5. Фихтенгольн Г. М. Курс диффереициального и интегрального исчисления, т. II. «Наука», М., 1966.
6. Юнге Х. Химический состав и радиоактивность атмосферы. Перевод с английского. «Мир», М., 1965.
7. Penndorf R. B. New tables of total Mie scattering coefficients. Journ. Opt. Soc. Amer. Vol. 17, No 11, 1957.

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