Selecting the AERONET data. Part II: Method of correction for halos

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We discuss the necessity of selecting and correcting the observation data on sky brightness along the Sun almucantar at azimuth angles of 2 to 6° presented at the highest confidence level (Level-2) in AERONET tables. To completely exclude the cloud situations and situations with optical inhomogeneities in the atmosphere, the conditions of systematic decrease in angular gradient of brightness with increasing azimuth are to be fulfilled at the first stage. The second stage includes the use of empirical regularities in the brightness angular distribution inferred from the highly accurate observations aimed at elimination of the systematic errors in the experimental data obtained with CIMEL sun photometers. Formulas and tables, necessary for the practical use, are presented.

Introduction

The ground-based monitoring of aerosol optical thickness of the atmosphere and sky brightness conducted by NASA at many points over the globe by means of the CIMEL photometers yields an extensive material for solution of a wide scope of radiation problems. However, preliminary analysis of observation data on sky brightness $B(\Psi)$ available at the AERONET site[1] for different azimuth angles Ψ from the Sun leads to the following conclusions. The NASA specialists carried out the selection of observation data in order to exclude the cloud situations. Nevertheless, the angular distributions of $B(\Psi)$ brought up to the highest confidence level (Level-2) in supposedly cloudless atmosphere still include the brightness of single clouds along some directions.[2] Overall, certain shortcomings in brightness determination are caused not only by incomplete elimination of cloudy situations, but partially by certain imperfections in the equipment used.

In this paper we propose to make use of some techniques that would enable one to perform the next stage, after Level-2 stage, quite simply selection of the experimental data collected at small azimuth angles and then to carry out their correction to exclude the systematic instrumental errors. Finally, this will improve the quality of the observation material and make its use more efficient.

Peculiarities of measurement procedures and possible sources of errors

To make grounds for using techniques proposed, let us briefly consider the measurements of $B(\Psi)$ with CIMEL photometers. Observations of $B(\Psi)$ along the sun almucantar are carried out at different azimuth angles Ψ, counted from the Sun ($\Psi = 0°$), at four wavelengths: 0.44, 0.68, 0.87, and 1.02 μm. First, the device is set at $\Psi = 354°$ (or $\Psi = -6°$) and the measurements of $B(\Psi)$ are being carried out over the angular range $354° \le \Psi \le 358°$. After that, the photometer automatically passes across the disk of the Sun ($\Psi = 0°$) and then $B(\Psi)$ is measured at $2° \le \Psi \le 6°$. Let us term these angles on both sides from the Sun – the circumsolar halo. After the halo has been scanned, the photometer measures $B(\Psi)$ at mean and large azimuths $6° \le \Psi \le 354°$, and then halo measurements are repeated: from 354 to 358° and after the second passage of the sun disk – from 2 to 6°. Thus, each distribution of $B(\Psi)$ in the azimuth interval from 358 to 2° contains four groups of data on the circumsolar halo: $B_1(\Psi)$ over the range of $354° \le \Psi \le 358°$ and $2° \le \Psi \le 6°$ at the beginning and $B_2(\Psi)$ in the same azimuth intervals at the end of the series (first and second photometer passages, respectively). Since further both azimuths Ψ and the scattering angles φ will be used, it is necessary to make a remark. Transition from Ψ to φ at the Sun almucantar is carried out by formula

$$\cos\varphi = \cos^2 Z_0 + \sin^2 Z_0 \cos\Psi, \qquad (1)$$

where Z_0 is the zenith angle of the Sun. If $Z_0 > 60°$, therefore, Ψ and φ for the halo differ a little (φ is always less than Ψ). For instance, at $Z_0 = 60°$ and $\Psi = 6°$ or $\Psi = 354$, respectively, on the opposite side from the Sun, so φ in both cases equals 5.2°. It is natural that at $\Psi \le 4°$ and $Z > 60°$, the difference between φ and Ψ will be appreciably lower.

Since aiming of the CIMEL photometer at the points of solar almucantar at the above-stated Ψ is carried out not by an optical method using an optical viewer,[3] but mechanically with a stepper motor, the absolute errors $\Delta\Psi$ of the device setting along the assigned direction can be significant.

Thus, it is known that just produced photometer that is being put into operation provides the error $\Delta\Psi$ equal to about 0.05°. However, the running gear of the device wear out, and the error of its aiming at the assigned points of halo increases in a year or two up to 0.25° and even more.[4,5] Each device is characterized by its own value of $\Delta\Psi$. These errors, certainly, affect the measured results on brightness distributions near the Sun that is caused by a significant brightness angular gradient within the halo.

When $\Delta\Psi > 0.25°$, one more effect can arise, whose influence on $B(\Psi)$ practically cannot be taken into account. If $\Delta\Psi$ is equal for all points of the halo, the angles closest to the Sun will be equal $(358° + \Delta\Psi)$ or $(2° - \Delta\Psi)$. In this case, there is a real danger that direct flares penetrate the input channel of the photometer and reach the photodetector. This light reflected from the diaphragms and inner walls of the photometer will distort (increase) $B(\Psi)$ significantly and unpredictably as compared with a true value connected only with atmospheric scattering. Owing to the systematic error in the photometer aiming, the values of $B(\Psi)$ in the halo and at other azimuths will be distorted (though not that strong): on the one side from the sun disk they will be too high, on the other one lower than the actual ones.

Preliminary analysis of AERONET data

We have scrutinized vast material of AERONET observations on $B(\Psi)$ at the Level-2 confidence level from the points located in arid localities: Solar Village (Arabian Peninsula), Tinga Tingana (Australia), and Dalanzadgad (Mongolia); on islands: Tahiti (Pacific Ocean, center), Nauru (Pacific Ocean, west), and Ascension Island (Atlantic Ocean, north); at the continental points covered with forests: Belterra (South America), Santa-Cruz (North America), and Zambezi (Africa); and also in three Russian towns: Moscow, Tomsk, and Barnaul. Overall, 246715 circumsolar halos were analyzed in four spectral regions at different zenith distances from the Sun Z_0. As a result, the following conclusions have been drawn.

The situations with clouds present along some directions, as well as obviously wrong values of $B(\Psi)$ discovered by NASA specialists, are marked in AERONET tables by the symbol "–100". If one excludes from analysis the brightness distributions containing at least one negative brightness in the intervals $2° \le \Psi \le 6°$ and $354° \le \Psi \le 358°$, the number of the halos that can be investigated will decrease almost tenfold making it equal to 27015. It should be noted that at some observation sites, for instance, in Mongolia, such data selection rejected practically all observation results.

The natural behavior of the brightness distribution in the circumsolar halo caused by polydisperse aerosol hazes in the atmosphere with broad size-distributions of particles is a systematic fall off of $B(\varphi)$ (or $B(\Psi)$, respectively) with the increase of φ (or Ψ). Moreover, our observations with small-angle photometers with optical aiming at assigned φ directions showed that in the steppe and at foothills of the southeast Kazakhstan, as well as in Black Sea coast,[3,6,7] the condition of systematic decrease of the angular brightness gradient $\Delta B(\varphi)/\Delta\varphi$ with the increase of φ is always satisfied.[2] Violation of this rule including the decrease of $B(\varphi)$ with the increasing φ occasionally occur being caused by the dense local dust or water clouds captured by the photometer field of view. Usually, they can be well observed with the naked eye. Let us use the condition of $\Delta B(\varphi)/\Delta\varphi$ decrease with the increasing φ as a criterion for the selection among the 27015 remaining angular brightness distributions in the halos and test all the remaining monitoring curves on its basis. Finally, the number of distributions $B(\varphi)$ (or $B(\Psi)$, respectively), which can be used in the future analysis, appears to be equal to 10866.

Let us compare $B(\Psi)$ measured at points being symmetrically located on the right and on the left from the Sun, for instance, $B(2°)$ and $B(358°)$, by dividing the larger value of $B_{\max}$ by the smaller one $B_{\min}$ in each of the photometer passages. A similar comparative approach to analysis of observation results is widely used by the majority of specialists in AERONET data selection. It is based on an obvious assumption: $B(\Psi)$ at equal angular distances of φ from the Sun under conditions of uniform aerosol distribution along horizontal direction should be identical at both sides from the solar vertical plane.

Therefore, according to Refs. 4 and 5, if the observed values of $B_{\max}$ and $B_{\min}$ differ by more than 10%, such distributions should be excluded from the subsequent reconstruction procedure of the large particle spectrum in the atmosphere. It should be noted that similar approach to sampling high-qualitative observation data is rather a tough criterion and only few data remains after its application. If one uses it directly for the selection of 27015 halos remaining after the initial elimination of $B(\Psi)$ with the values marked with "–100", the number of angular dependences $B(\Psi)$, which can be used in the future analysis will reduce down to 796 that will make only 0.3% of their original number (246715) in AERONET tables available for analysis.

Van de Hulst formulas

Figure 1 presents the averaged results on ratio $B_{\max}/B_{\min}$ obtained from observation data on 10866 halos, for which the regular decrease condition $\Delta B(\varphi)/\Delta\varphi$ with the increase of φ is satisfied.

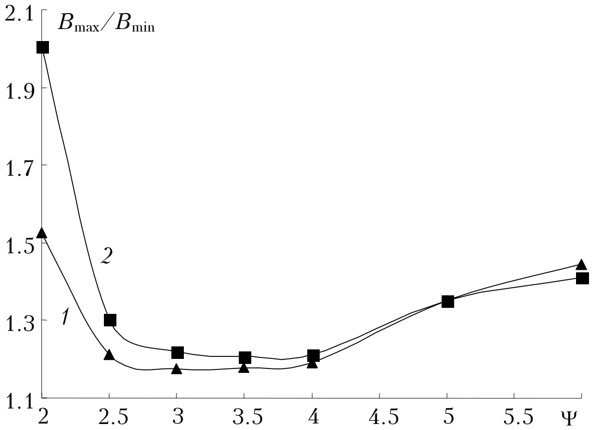

Fig. 1. Mean ratios B_{max}/B_{min} at first (*1*) and second (*2*) scanning by the CIMEL photometers of the circumsolar halos.

The differences of B_{max}/B_{min} from unity point either to the predominantly nonuniform distribution of the atmospheric turbidity along the directions close to the Sun, or to the essential role of the error ΔΨ of photometer aiming at the assigned points of the firmament at measurements of $B(\Psi)$ on the left and on the right from the sun disk. In the first case, the data should be excluded from the future analysis, and in the second case, one can try to correct the measured results of $B(\Psi)$, thus decreasing the influence of the photometer aiming on the result.

In order to develop the methods of selection and correction, it is necessary to involve the halo observation data collected under absolutely cloud free conditions obtained with the instruments equipped with high-precision aiming. Such measurements of $B(\varphi)$ were carried out at Astrophysical Institute of Kazakhstan Academy of Sciences from the beginning of 60s until the end of the past century.

The photometer aiming operated in ultraviolet, visible, and infrared spectral regions at the assigned small φ with an error Δφ less than 1′ and was performed by the observers by means of the optical selectors mounted on each device.[3,6,7] According to data obtained, discrepancies between $B(\varphi)$ values on the right and on the left from the Sun at fixed $\varphi \geq 2°$ very seldom exceeded 2–3%, moreover, those were irregular at transition from one observation series to another. As follows from these observations, $B(\varphi)$ in the visible and near infrared spectral regions with high accuracy (usually no worse than 2–3%) is described by the Van de Hulst formula[3,6,8]:

$$B(\varphi) = A\varphi^{-q}, \qquad (2)$$

where A does not depend on φ, and the parameter q is determined mainly by optical properties of large particles in the atmosphere. The relation (2) is valid over the range $2° \leq \varphi \leq 6–7°$; and there is no systematic dependence of q on λ.

To make sure that the Hulst formula is versatile, additional investigations of angular brightness distributions were carried out at $2° \leq \varphi \leq 6°$ at a site in southeast Kazakhstan in steppe and in the foothills of Zailian Ala Tau. The data obtained in the Black Sea coast[6,7] were also used for this purpose. Analysis of 180 halos in the cloud free atmosphere has shown that relation (2) is surely valid practically everywhere. The histogram of recurrence interval of q values is presented in Fig. 2.

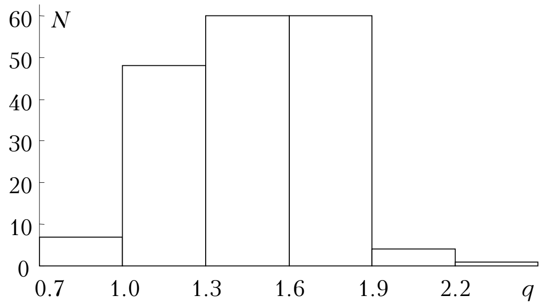

Fig. 2. The recurrence interval of q in Southeast Kazakhstan. N is the number of events.

Actually, its value does not regularly depend on λ; q varies over the range from 0.72 up to 2.2 and on the average it equals 1.46. Since the angular dependence of sky brightness in the halo is described by the power law function, naturally, the best choice in the subsequent data correction of halo observations through averaging of $B(\varphi)$, measured on the left and on the right from the Sun, is the use of geometrical mean, instead of arithmetical mean brightness values.

5. Methods of halo selection and correction

In developing the methods for selection and correction of monitoring observations of the circumsolar halos, it is necessary to take into account that angular brightness distribution in the cloud free atmosphere measured by means of CIMEL photometers is determined mainly by three factors, namely by the scattering phase function at small φ, systematic errors in the device setting, ΔΨ, to the initial position, and possible direct sunlight flares reaching the photodetector. Since such techniques can be based only on analysis of the experimental $B(\Psi)$, the formed selection filter should transmit the most forward-peaked $B(\Psi)$, formed just due to light scattering in the atmosphere. Otherwise, the information about the largest particles in the air will be lost. Therefore we suppose that at the points of the CIMEL photometers operation, brightness of the cloud free sky with maximum angular gradient at small φ is formed by aerosol having the scattering phase function with the parameter $q = 2.2$.

In using formula (2), let us calculate the model ratios $B(\Psi - \Delta\Psi)/B(\Psi + \Delta\Psi)$ for Ψ = 2, 4, and 6°. The corresponding results for the Sun zenith angle $Z_0 = 60°$ and nine values of ΔΨ are presented in the Table. If $Z_0 = 75°$, practically the same ratio values are obtained.

Table. Effect of the error $\Delta\Psi$ in device aiming at the assigned halo points Ψ on the ratio B_{max}/B_{min} at maximum forward peaked small-angle scattering phase function (q = 2.2)

$\Delta\Psi$	$\frac{B(2° - \Delta\Psi)}{B(2° + \Delta\Psi)}$	$\frac{B(4° - \Delta\Psi)}{B(4° + \Delta\Psi)}$	$\frac{B(6° - \Delta\Psi)}{B(6° + \Delta\Psi)}$
0.00	1.00	1.00	1.00
0.05	1.12	1.06	1.04
0.10	1.25	1.12	1.08
0.15	1.39	1.18	1.12
0.20	1.55	1.25	1.16
0.25	1.74	1.32	1.20
0.30	1.95	1.39	1.25
0.35	2.18	1.47	1.29
0.50	3.08	1.74	1.44

Let these values of $\Delta\Psi$ be equivalent to the absolute errors in the CIMEL photometer aiming at assigned directions Ψ. Then, the above-stated tabular ratios $B(\Psi - \Delta\Psi)/B(\Psi + \Delta\Psi)$, or B_{max}/B_{min}, allow one to isolate such $B(\Psi)$ out of the entire observation files, for which the difference of brightness values at symmetrical points on the left and on the right from the Sun will be caused mainly by inaccuracy of the device aiming, and not by any other factors (clouds, flares of direct sunlight in the photometer, etc.).

If in the newly produced photometers[4,5] the absolute error $\Delta\Psi$ at small Ψ makes about 0.05°, the ratios B_{max}/B_{min} for Ψ equal 2, 4, and 6° should not exceed the values in the second line of the Table: 1.12, 1.06, and 1.04, respectively. For the photometers operated for several years and being characterized on the mean by $\Delta\Psi = 0.25$, the ratios $B(\Psi - \Delta\Psi)/B(\Psi + \Delta\Psi)$ for the same azimuths should be less than 1.74, 1.32, and 1.20. If such excess of the observed ratios over the calculated ones takes place, they cannot be explained by the influence of scattering phase function on brightness owing to the inaccurate aiming of the device at the assigned Ψ.

There must be other additional reasons leading to a more significant discrepancy between B_{max} and B_{min}. Such brightness distributions cannot be corrected they simply should be excluded from the data array prepared for analysis.

Figure 1 shows that the mean observed values of B_{max}/B_{min} at Ψ = 2° correspond to the absolute errors $\Delta\Psi = 0.2°$ in the first and $\Delta\Psi = 0.3°$ in second scans with the photometer. Thus, even mean values of ratios B_{max}/B_{min} at the second halo scan exceed the indicated boundary limits. According to Table, for Ψ = 6°, the ratio B_{max}/B_{min} should not exceed 1.44 even at $\Delta\Psi$ = 0.5°. As follows from Fig. 1, this condition is not satisfied.

The growth of B_{max}/B_{min} with azimuth increase at $\Psi > 4°$, cannot be caused by inaccuracy of the photometer setting at the assigned points of the halo. One can only assume that preliminary cleaning of brightness data acquired near the Sun from the effect of almost translucent cloud formations with subsequent output to the confidence level (Level-2) along directions at Ψ = 5–6° in AERONET tabular data was carried out less thoroughly than for Ψ = 2–4°. Apparently, the sampling criterion of cloud free conditions based on the principle of angular brightness gradient decrease[2] $\Delta B(\varphi)/\Delta\varphi$, does not fully satisfy adequate solution of the problem in the region of small φ.

Discussion of the results

If one assumes that a photometer is just put into operation, i.e., $\Delta\Psi$ = 0.05° is the absolute error of its aiming at the assigned points near the Sun,[4,5] only 259 observations have been selected for the analysis from the remaining 10866 brightness values according to the selection proposed. The rest 10607 values should be excluded, since the restrictions by B_{max}/B_{min} dictated by the second line of the table, are not satisfied for them at least for one of the angles. At the aiming error of the device $\Delta\Psi$ = 0.25°, after its long-term operation, the number of observations should be limited by the value of 5007. It should be noted that the majority of AERONET data obtained at the above-mentioned observation points correspond just to the second case.

The criterion confirming the above-stated considerations can be the agreement between the mean experimental brightness at the same halo points at first and the second photometer scans. As it was mentioned above, in the case of power law brightness dependence on φ, the correct result of data averaging is obtained if using the geometrical mean values:

$$L_1(\Psi) = \sqrt{B_1(\Psi)B_1(360 - \Psi)}, \quad (3)$$

$$L_2(\Psi) = \sqrt{B_2(\Psi)B_2(360 - \Psi)}, \quad (4)$$

where the subscript denotes the number of the scan. Let us use the values of $B(\Psi)$ observed on the left and on the right from the Sun at $\Delta\Psi$ = 0.05° in 259 observations to calculate $L_1(\Psi)$ and $L_2(\Psi)$, and compare them.

Figure 3*a* presents the deviation histogram $d = (L_1 - L_2)/L_1$ for $\Psi = 2°$ at $\Delta\Psi = 0.05°$. The mean deviation of L_1 from L_2 makes 5.4%.

Since it is impossible to identify the cause of that regular deviation between L_1 and L_2, it simply worth calculating the mean values:

$$L(\Psi) = [(L_1(\Psi) + L_2(\Psi)]/2. \quad (5)$$

At Ψ = 2°, the systematic mean error in determination of the brightness value $L(\Psi)$ will be approximately equal to 2.7%. This is quite a tolerated error for future investigations, since the absolute sky brightness is measured with the CIMEL photometers accurate to 5%.[4,5] With the growth of Ψ, this systematic error will rapidly reduce. The disappearance of wings in the corresponding histogram (Fig. 3*b*) at $\Psi = 6°$ confirms this fact. The error in calculation of $L(\Psi)$ due to the device aiming inaccuracy will not exceed a fraction of percent.

Therefore, selection of AERONET data for the circumsolar halos can be reduced to the following procedures.

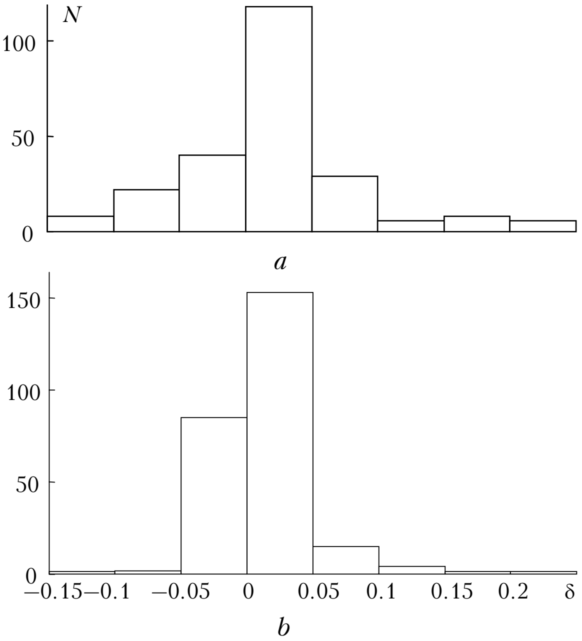

Fig. 3. Deviation histograms of geometrical mean brightness values L_1 and L_2 for $\Psi = 2°$ (*a*) and 6° (*b*).

The preliminary analysis of the observation data at the confidence level (Level-2) for excluding the obvious clouds is carried out on the basis of criterion of systematic decrease of $\Delta B(\varphi)/\Delta\varphi$ with the increase of φ at both sides from the sun disk.

The following stage of selection is in using of tabular data for elimination of those observations of $B(\Psi)$, which exceed the limits of differences between brightness at the left and right from the Sun due to the photometer setting inaccuracy in each observation. Moreover, the following soft tolerance is made: scattering phase function at small angles is considered the maximum forward-peaked. If $q < 2.2$, the elimination could be more significant.

Finally, the third stage is in correction of the rest brightness values: mean values of $L(\Psi)$ are determined by the relations (3)–(5) for each of the observations.

The validity control of the obtained results on the corrected brightness values of $L(\Psi)$ can be carried out in the following way. It is natural that for $\Psi > 3°$, at $\Delta\Psi = 0.05°$, the cases of direct sunlight flares reaching the photodetector are less probable. Let us convert Ψ into φ, and then, using the Hulst formula (2), determine the value of q for each angular brightness distribution $L(\varphi)$ in the interval $3° \le \varphi \le 6°$. Then, assuming that the obtained value of q should be conserved and for smaller angles, i.e., for $\varphi = 2$ and $\varphi = 2.5°$, as well calculate the values of L_q at $\Psi = 2$ and 2.5°, and compare them with the values of $L(2°)$ and $L(2.5°)$, calculated from observations by formula (5). If all our previous considerations are valid, the correspondence of values L and L_q should take place.

Figure 4 presents the generalized distribution histograms of q over N in all the above-mentioned AERONET observation sites and at all λ. Total number of analyzed halos at $\Delta\Psi = 0.05°$ is equal 259, and at 0.25° is 5007. The histograms are quite similar. In comparing their shapes with the shapes of the histogram presented in Fig. 2, one can arrive at the following conclusions. The values of q in new histograms are essentially shifted toward smaller values: mean values of q for all areas are equal to 1.02 and 1.21, respectively; the minimum value equals 0.104. Most likely, these differences are connected with the excess of large dust particles in the atmosphere of Southeast Kazakhstan, that has already been mentioned.[6]

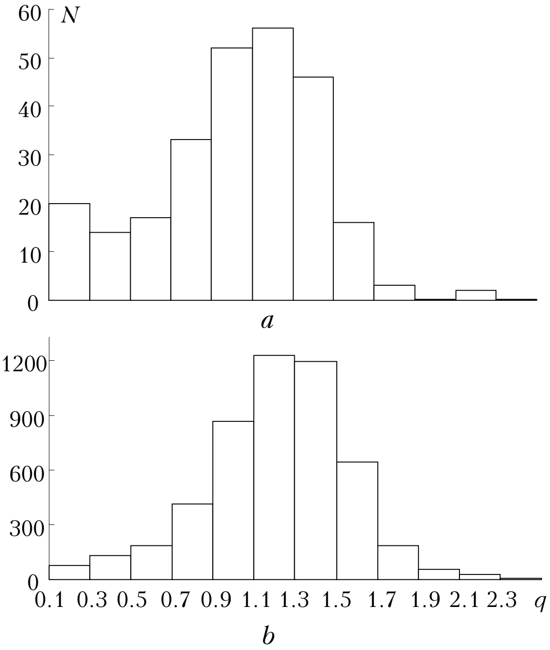

Fig. 4. Distribution histograms of q obtained from AERONET data at $\Delta\Psi = 0.05°$ (*a*) and 0.25° (*b*). Calculations at $\varphi \ge 3°$.

As follows from analysis, there is no systematic dependence of q on λ. The value of $q > 2$ is found 57 times in data file from 5007 distributions with $\Delta\Psi = 0.25°$, moreover, in the single case, q reached the value of 2.4. It follows that the proposed tabular data on ratios $B_{\max}/B_{\min}$ for halo correction are quite versatile.

Let us return to the problem on comparison of $L(2°)$ and $L_q(2°)$, also $L(2.5°)$ and $L_q(2.5°)$. Figure 5 presents the distribution histograms of the ratios $\delta = (L - L_q)/L$ over the number of cases N for $\Psi = 2°$ at $\Delta\Psi = 0.05$ and 0.25°.

In the first case, about 80% of observations fall in the interval $-0.2 \le \delta \le 0.2$. One can see the first manifestations of the deviation from symmetrical distribution of δ due to the increase of the wing at large differences between $L(2°)$ and $L_q(2°)$. This leads to the deviation of mean value of $(L - L_q)/L$ from zero: $\delta_m = 0.05$. With the increase of $\Delta\Psi$ to 0.25°, the large δ values wing dominates and the mean deviation of δ_{av} becomes equal to 0.25.

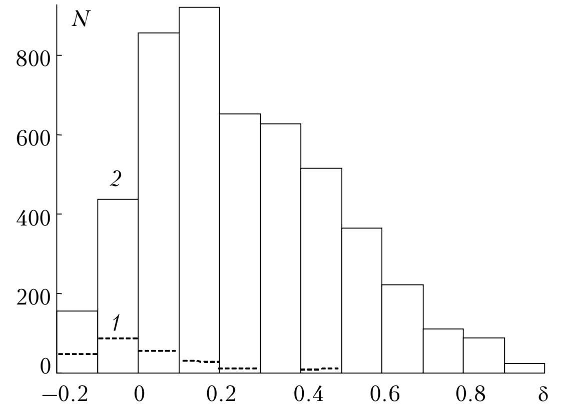

Fig. 5. Histograms of deviations of L from L_q for $\Psi = 2°$ at $\Delta\Psi = 0.05°$ (*1*) and $\Delta\Psi = 0.25°$ (*2*).

That large differences between L and L_q typical for the right histogram wing, especially in the second case, are hardly caused by deviation of the angular brightness distribution from that by the Hulst formula. Most likely, they occur due to bleeding through the filters of such observations, where q is small, into the selected data file. However, the error $\Delta\Psi$ of the device aiming does not exceed 0.25°. In this case, the tabular condition $B_{\max}/B_{\min} \leq 1.74$ does not guarantee the exclusion of direct solar flares in the photometer affecting the measured brightness of $B(2°)$ or $B(358°)$, and then – after averaging – the brightness of $L(2°)$.

Probability of catching such flares by the photodetector should essentially diminish, if to analyze the measurements at $\Psi \geq 2.5°$. Figure 6 presents the calculated results of the corresponding deviations of L from L_q for $\Psi = 2.5°$ at $\Delta\Psi = 0.05$ and 0.25°.

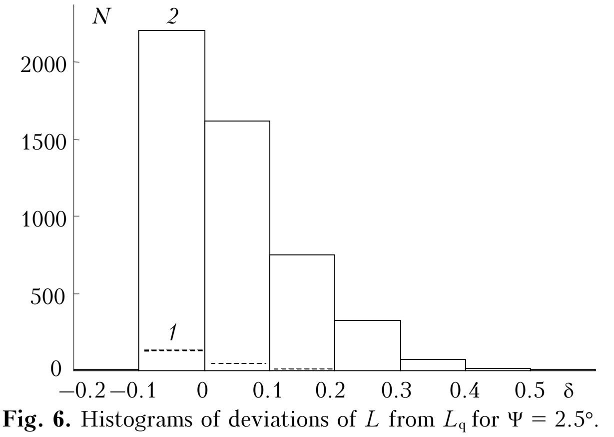

Fig. 6. Histograms of deviations of L from L_q for $\Psi = 2.5°$.

One can see that in the first case, absolute majority of observations (88%) falls in the interval $-0.1 \leq \delta \leq 0.1$; mean deviation of L from L_q makes −0.0008, i.e., practically zero. In the second case, at $\Delta\Psi = 0.25°$, according to the above-mentioned reasons, $\delta_{av} = 0.044$. Remind that the number of distributions for this case, passed through selection, equal 5007. Thus, if one starts not with $\Psi \geq 2°$, but with $\Psi \geq 2.5°$ in solving the radiation problems using AERONET data, the quality of the used data would appreciably increased.

Let us take the absolute error $\Delta\Psi$ of photometer aiming along the assigned direction equal 0.25° that corresponds to the realities for the majority of AERONET data. Then, according to Figs. 5 and 6, the most appreciable deviations of δ from zero on the left from the histogram maxima equal −0.2. Consider that they are caused by deviations from the Hulst formula. If one considers that these deviations have the same limit also on the left from the histogram maxima, the simplest way of brightness filtration distorted by solar flares or by any other effects apart from those caused by the scattering phase function, is shown in restriction of observation materials according to the condition $|\delta| \leq 0.2$. After implementation of all the above-stated procedures, the observed brightness with $|\delta| > 0.2$ should be excluded from the subsequent consideration. If the experimental $B(\Psi)$ with the differences between L and L_q exceeding $|\delta|$ due to deviations from the Hulst formula will incidentally be filtered out at such a selection, their number will be certainly small. In this case, the corrected values of brightness $L_q(2°)$ and $L_q(2.5°)$ can be introduced into the scheme of the inverse problem solution on restoration of the aerosol particle size distributions,[4,5] where they are not used at present.

Conclusion

On the basis of independent experimental data, obtained by means of the sky photometers equipped with high-precision aiming at the assigned scattering angles, the following methods have been proposed:

– objective methods of screening cloud situations out of brightness data arrays in the region of halos presented at the AERONET website at the (Level-2) confidence level;

– method of subsequent correction of the rest $B(\Psi)$ to exclude the effect of systematic instrumental errors on the results obtained.

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