MEASUREMENTS OF AEROSOL OPTICAL PROPERTIES AT THE KISHINEV SITE, MOLDOVA

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Abstract

Regular measurements of the direct sun radiance, sky radiance in the almucantar and principal plane, and precipitable water vapour content are carried out with the sunphotometer Cimel CE-318 at the Kishinev site, Moldova. Results obtained with the sunphotometer represent a valuable supplement to the datasets with solar radiation measurements made with the multifunctional ground based radiometric complex. Monitoring of the aerosol optical properties is fulfilled in frame of the Aerosol Robotic Network (AERONET) initiated and developed from the NASA/GSFC. Multi-years results of aerosol optical thickness (AOT) measurements made at the Kishinev site, Moldova are presented. Some results obtained during the long distance smoke transport over Kishinev from the forest and peat fires occurred in the west regions of Russia in September 2002 are analyzed.

1. Introduction

Growing rate of the industry development, increasing number of the means of transport, natural and human-made hazards, such as fires, volcano eruptions, etc., exert an essential influence upon the Earth’s atmosphere modifying its structure, properties and components. The main components of such global system as atmosphere are gases and aerosol particles, respectively. Each of these components interacts specifically with the solar radiation by affecting the spectrum of radiation and total value of radiation, which reaches the Earth’s surface. It is remarkable that as early as two decades ago, gaseous components were taken into account as primarily ones in radiation transfer modeling because they are well studied. Atmospheric aerosols remain as an insufficiently known explored and very complex component of atmosphere. Aerosol particles take part in the process of radiation exchange in the atmosphere in two ways: by ‘direct’ effect, when the particles reflect back into the space the solar radiation and partially absorb it, and ‘indirect’ effect, when these particles play the role as centers of condensation in formation of the cloud structures. Mainly the complexity of such phenomenon as aerosols is due both to their diversity of the microphysical and chemical composition, and to spatial and temporal variability. These characteristics ought to be taken into account in complex models development concerning with the solar radiation transfer in real atmosphere, and modeling and analyzing of the climate variability both to a regional and global scales. Another important application consists in pollution monitoring of the atmosphere, where the questions concerning the atmospheric aerosols loading, aerosol transformation and their transport over the specific regions became actual.

To receive comprehensive information about the optical and microphysical properties of the atmospheric aerosols there are used ground-based, air- and satellite platforms. The last two platforms possess the possibility to cover the region of investigation in large scale, operational approach in data acquiring, processing and transmission. Meanwhile these platforms remain cost expensive systems for remote sensing. In this connection special attention is paid to the development of the ground-based stations, joined together into the globally distributed networks and equipped with the state-of-the-art radiometric instrumentation. An excellent example of such kind of stations is a global AErosol RObotic NETwork (AERONET) as ramified, powerful and contemporary network in operation, which consists of more than 150 stations around the world [1,2]. Kishinev site, Moldova, is a part of the globally distributed AERONET.

1. Equipment and background of measurements

All data presented in this study were acquired with the Sun/sky radiometer Cimel CE-318 (France), which is now in operation at the Kishinev site (Fig. 1) in the AERONET global network. Automatic Sun and sky scanning spectral radiometer, or sunphotometer Cimel CE-318, is a backbone radiometric instrumentation for routine site measurements, which has been designed and realized to be a very accurate sunphotometer with all features of field instrument: motorized, portable, autonomous (solar powered) and automatic.

Fig. 1. Sunphotometer Cimel CE-318 in operation at the Kishinev site.

A brief description will be given here, and more detailed instrument specification, measurement sequences, data quality control and accuracy are described in [1-4].

Sunphotometer consists of the sensor head, electronics box with microprocessor and store module, and robot. The sensor head of this instrument has 1.2^{o} full angle field of view, two collimators with length of 33 cm for 10^{-5} stray light rejection and two silicon detectors for measurements of the direct sun and sky radiances. Eight ion assisted deposition interference filters are located in the filter wheel (in front of detectors) which is rotated by drive stepping motor. The sensor head is pointed by stepping azimuth and zenith motors with a precision of 0.05^{o} . These pointing and solar tracking procedures are fulfilled by robot under the control of the microprocessor, which computes the position of the sun based on time, longitude and latitude coordinates of the site of observation. The accuracy of computation and directing of the sensor head is within approximately of 1^{o} of the Sun. To track the Sun position more precisely four-quadrant detector built into the sensor head is used. Electronic box consists of two microprocessors for real time operation for data acquisition and motion control. Data from memory module of the sunphotometer can be transferred to a

PC or via a Data Collection Systems [1], to one of the geostationary satellites: GOES, METEOSAT or GMS, and then retransmitted to the respective ground receiving station. Robot fulfills operations with the sun pointing and tracking.

Sunphotometer Cimel CE-318 provides measurements of the direct solar radiance at 8 wavelengths in visible spectrum, λ=340, 380, 440, 500, 670, 870, 940 and 1020 nm; sky radiance in almucantar and in a solar principal plane at 4 wavelengths, λ=440, 670, 870 and 1020 nm. The channel at 940-nm is used to retrieve the precipitable water vapour content in atmosphere. The bandwidth of these interference filters is varied from 2 (UV channels) to 10 nm for visible and near-IR channels. The total uncertainty of spectral aerosol optical thickness measurements is varied from $\pm$ 0.01 to $\pm$ 0.02, and is spectrally dependent with high errors in the UV spectral range. Total water vapour content in the atmospheric column (in cm of precipitable water) is consistent to within ~ 10% of radiosonde or microwave radiometer measurements [1,3].

The general technique used in sun photometry measurements [1] consists in that the filtered detector of spectral radiometer measures the spectral extinction of direct beam radiation according to the Beer-Lambert-Bouger law:

$$V_\lambda = V_0 \cdot d^2 \cdot e^{-\tau_\lambda \cdot m_o} \cdot T_\lambda \quad , \tag{1}$$

where V_λ is the digital voltage; V_0 is the extraterrestrial voltage, m_o is the optical air mass; τ_λ is the total optical thickness; λ is wavelength, d is the ratio of the average to the actual Earth-Sun distance; T_λ is the transmission of absorbing gases (O_3, O_2, H_2O, etc).

The digital voltage V_λ measured at each wavelength λ is a function of the extraterrestrial voltage V_0 (extrapolated to the optical air mass m_o=0) modified by the relative Earth-Sun distance d which is defined by the day of year, and the total spectral optical thickness τ_λ and optical air mass m_o . The total spectral optical thickness τ_λ is the sum of the Rayleigh $\tau_{R\lambda}$ and aerosol optical thickness $\tau_{a\lambda}$ after correction for gaseous(mainly for O_3 and H_2O) absorption $\tau_{g\lambda}$:

$$\tau_\lambda = \tau_{R\lambda} + \tau_{a\lambda} + \tau_{g\lambda}. \tag{2}$$

Spectral dependence of the aerosol optical thickness, which is of interest for analysis, relays on the Ångström exponent α to quantify this dependence. Ångström's empirical relation [5] is given as follows

$$\tau_{a,\lambda} = \beta \cdot \lambda^{-\alpha}, \tag{3}$$

where λ is the wavelength in μm of corresponding $\tau_{a,\lambda}$, and β is Ångström's turbidity coefficient. By rationing the equation at two different wavelengths and making some manipulation, the Ångström exponent may be computed from spectral values of $\tau_{a,\lambda}$ by

$$\alpha = -\frac{d \ln \tau_{a,\lambda}}{d \ln \lambda} = -\frac{\ln\left(\frac{\tau_{a,\lambda_2}}{\tau_{a,\lambda_1}}\right)}{\ln\left(\frac{\lambda_2}{\lambda_1}\right)}, \tag{4}$$

with a typical values of α range from > 2.0 for fresh smoke particles, which are dominated by accumulation mode aerosols [6] to nearly zero for high optical thickness of Saharan desert dust cases dominated by coarse mode aerosols [7]. Ångström exponent can be computed by Eq. 4 at any pair of wavelengths, λ_1 and λ_2 . Hereafter using of the expression $<\alpha(440\_870)>$ means that the Ångström exponent is computed in the following manner. Aerosol optical thickness is calculated for channels at 440, 500, 670, and 870 nm. These numbers are used to form a least square regression fit to the data. The negative slope of this line to the $\ln\lambda$ -axis (in $\ln \tau_{a,\lambda}$ versus $\ln\lambda$ space) is the Ångström exponent. Brackets designate an averaging of the Ångström exponent for selected datasets.

Since September 1999, in frames of the AERONET program [1,2], dealt with the cooperative investigations of the atmospheric aerosol optical properties at the Kishinev site, every year NASA/GSFC has been placing calibrated sunphotometer Cimel CE-318 to Moldovan research group. Direct sun measurements are made every 15 minute and with steps for optical air masses δm_o= 0.25– 0.5 from m_o=7 A.M. to m_o= 7 P.M. at 8 channels. Almucantar sky measurements are made at optical air masses m_o= 4, 3, 2, and 1.7 (A.M and P.M.), and once per hour in between at 4 channels [1]. These data are used to retrieve the columnar integrated optical and microphysical properties of atmospheric aerosols such as spectral aerosol optical thickness, Ångström exponent (as a parameter of spectral dependence of the aerosol optical thickness), volume size distributions, complex refractive index of particulate matter, and single scattering albedo. Specially developed algorithms for data processing cloud screening and quality assurance [4] and aerosol optical and microphysical property retrieving [8,9] are used.

In September 2003, firstly in Moldova it was developed and established a ground-based multifunctional radiometric complex [10]. This radiometric complex is used for long-term continuous monitoring of solar irradiance at the Earth's surface in a wide wavelength bands from UV to IR. Sunphotometer is incorporated into the complex (Fig. 2) with the aim

Fig. 2. Ground-based multifunctional radiometric complex with operating sunphotometer Cimel CE-318 at the Kishinev site (47.0013^{0}N, λ_o=28.8156^{0}E, h=205 m a.s.l).

to derive aerosol optical properties from direct sun and almucantar sky radiance measurements at the site of observation. Both the multifunctional radiometric complex and sunphotometer are placed at rooftop of the Institute of Applied Physics building, which is situated in an urban environment of the Kishinev city, Moldova (φ=47.0013^{0}N, λ_o=28.8156^{0}E, h=205 m a.s.l).

Acquired and processed data are assumed to be utilized by international scientific community in modeling and analyzing of the solar radiation interaction with aerosols to estimate their role and quantitative influence in radiative forcing, in modeling of the climatic variability both at regional and global scales, for correction of the remote sensing data obtained from the satellite-platforms, for monitoring of the aerosols dynamics of transformation and their transport, for analysis of the aerosol optical propery variation and their trends (aerosol climatology), for evaluation of the aerosol pollution of the atmosphere in specific regions having AERONET sites. Monitoring of the aerosols optical properties in the region of Moldova is fulfilled in frame of the AERONET program under NASA/GSFC supervision. This program is aimed at long-term perspective.

2. Results of measurements

Data presented in this study were acquired with the sunphotometer Cimel CE-318 at the Kishinev site for the period of observation from September 1999 to May 2003. Datasets have quality of Level 2.0 that according to the AERONET adopted protocols means pre- and post-field calibrated, automatically cloud screened, manually inspected and quality approved. Special algorithm [8,9] was used to retrieve total column volume size distributions, refractive indices of aerosol particulate matter, single scattering albedo and asymmetry factor of phase scattering function from the direct sun and almucantar sky radiance measurements.

First results of aerosol optical properties monitoring at the Kishinev site during ~ 3 years are presented below. Multi-annual means of Ångström exponent $<\alpha(440\_870)>$ and AOT $<\tau_a(500)>$ at λ=500 nm for this period of observation are shown in Fig. 3a and 3b, respectively.

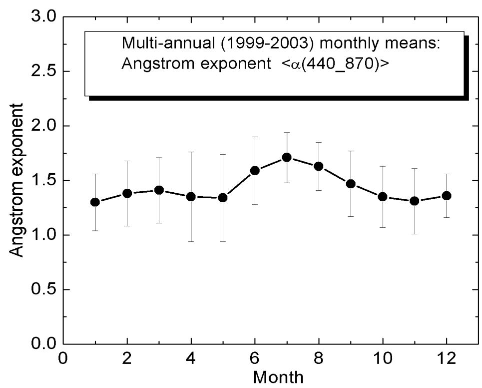


Fig. 3a. Multi-annual means of Ångström exponent $<\alpha(440\_870)>$ for the period of observation from September 1999 to May 2003.

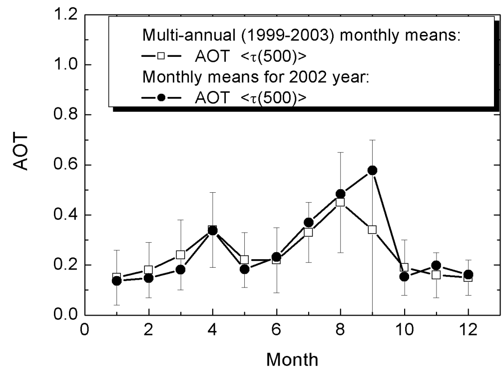
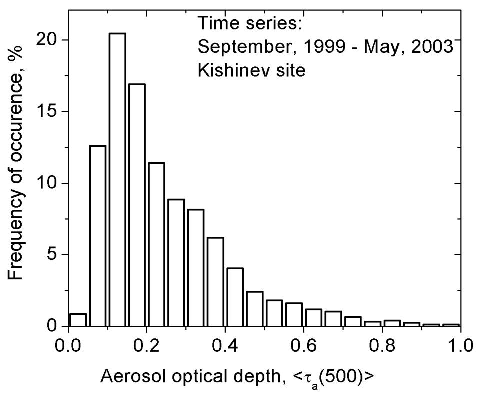


Fig. 3b. Multi-annual means of AOT $<\tau(500)>$ at λ=500 nm for the period of observation from September 1999 to May 2003 and monthly means of AOT $<\tau(500)>$ at λ=500 nm for year of 2002 .

The error bars show uncertainty in retrieved AOT and Ångström exponent from multi-year monitoring. Multi-annual annual means of $<\tau_a(500)>$ and $<\alpha(440\_870)>$ were computed using multi-annual monthly averages and these values are $<\tau_a(500)>= 0.25 \pm 0.10$ and $<\alpha(440\_870)>= 1.43 \pm 0.14$, respectively. The most uncertainty in retrieved AOT was observed during the month of September. It is likely that a reason of this fact was in smoke long distance transport from the Moscow region, west regions of Russia, Belarus and Ukraine, where numerous foci of forests and peat fires have taken place in September 2002 [11]. This conclusion is born out by analyzing of the monthly means of AOT $<\tau_a(500)>$ (for the year of 2002) shown in Fig. 3 from which it is clearly seen that particular AOT value typical for the month of September exceeds two times as high as analogous value representing multi-annual monthly means for this month.

Frequency of occurrence of the multi-annual means of the AOT $<\tau_a(500)>$ at λ=500 nm and Ångström exponent $<\alpha(440\_870)>$ for the period of observation from September 1999 through May 2003 are shown in Fig. 4.



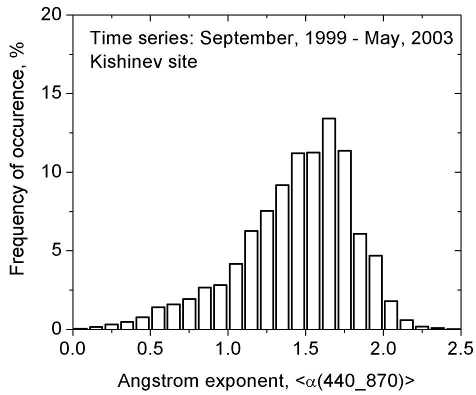


Fig. 4. Frequency of occurrence of the multi-annual means of the AOT $<\tau_a(500)>$ and Ångström exponent $<\alpha(440\_870)>$. Time series: September 1999 - May 2003.

Frequency histogram for $<\tau_a(500)>$ shows a peak at ~0.125 - 0.15. Ångström exponent $<\alpha(440\_870)>$ frequency distribution is relatively wide distribution: almost 75% of α values are located within the range 0.85 – 2.0 . This frequency distribution shows a peak at ~1.65 – 1.70, what means relatively high spectral dependence of aerosol optical thickness, corresponding to small particle sizes (urban/industrial type of aerosol).

Further reason of selection of the specific datasets such as daily means of the AOT $<\tau_a(500)>$ for the period of observation from January 2002 to December 2002, daily average AOT $<\tau_a(500)>$ and Ångström exponent $<\alpha(440\_870)>$ for September 2002, and diurnal variability of aerosol optical thickness spectra $\tau_{a,\lambda}$, was due to the smoke transport events over the region of Moldova. These events were specified to the long distance smoke transport from boreal forests in the Moscow region, west regions of Russia, Belarus and Ukraine, where numerous foci of forests and peat fires have taken place in September 2002 [11]. These data were used for retrieving aerosol optical properties and their analysis.

The real situation with the smoke events over Moldova during September 2002 can be clearly seen from the composite image (see Fig. 5) made from the satellite platforms NOAA-

12, -15, -16 and -17. Fires have been raging east of the Moscow region, Ukraine and Belarus for a prolonged period. This image from September 8, 2002 provides an impressive view of the distribution of the smoke. The coverage extends all the way from the Baltic and the Black Sea to the Caspian Sea and towards the Ural. Meteorological conditions resulted in long distance transport of smoke from the region with numerous loci of both the forest and peat fires.

The 5-days backward trajectory of such long distance transport was computed using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model (http://www.arl.noaa.gov/ready/hysplit4.html). Ending date for this backward trajectory modeling was chosen as September 11, 2002 (00 UTC) and final results are shown in Fig. 6.

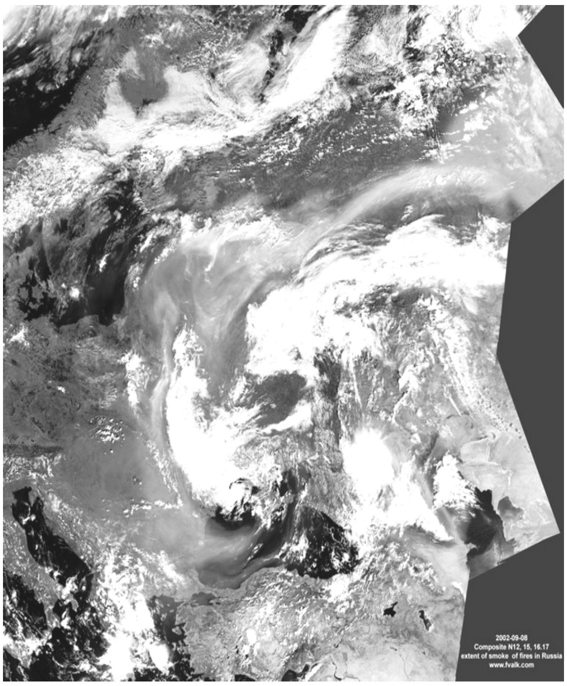


Fig. 5. NOAA -12, -15, -16 and -17 composite image of extent of smoke of fires in Russia, Ukraine and Belarus (date: September 8, 2002).

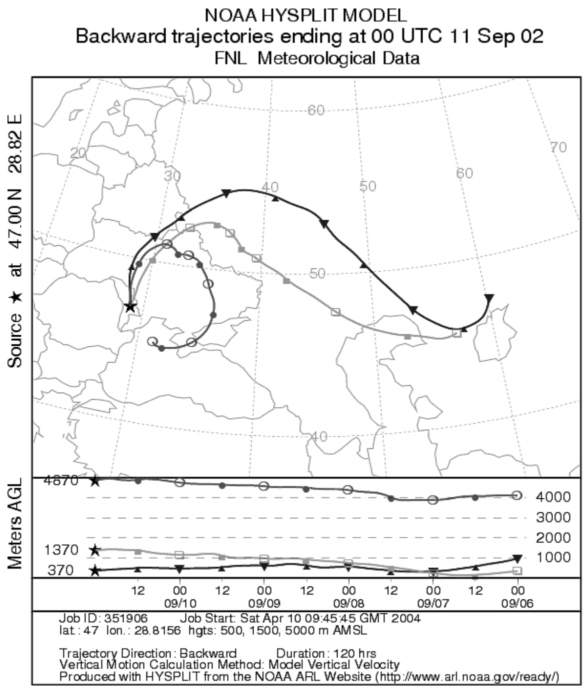


Fig. 6. Five-day Back trajectories chart for the Kishinev site (ending day: September 11, 2002). Heights: 500, 1500, and 5000 m a.m.s.l.

Daily means of the AOT $<\tau_a(500)>$ for the period of observation from January 2002 to December 2002 are shown in Fig. 7. It is clearly seen the existence of the large peak for $<\tau_a(500)>$ (> 2.2) which corresponds to the days 10 and 11 of September with intensive influence of the smoke transferred from the regions with forest fires. The year of 2002 can be characterized as a year with relatively 'stable' AOT values with annually mean that is $<\tau_a(500)>= 0.26 \pm 0.15$, except for the month of September, where monthly mean $<\tau_a(500)>$ reached the value of $<\tau_a(500)>= 0.58 \pm 0.56$. Variation of the daily averaged values of the Ångström exponent $<\alpha(440\_870)>$ and AOT $<\tau_a(500)>$ for the month of September 2002 are shown in Fig. 8. From this figure it is clearly seen the existence of the pronounced peak for $<\tau_a(500)>$ involved on September 11.

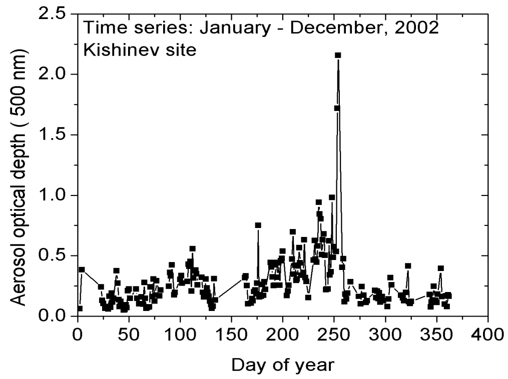


Fig. 7. Daily means of the AOT $<\tau_a(500)>$ for the period of observation: from January 2002 to December 2002.

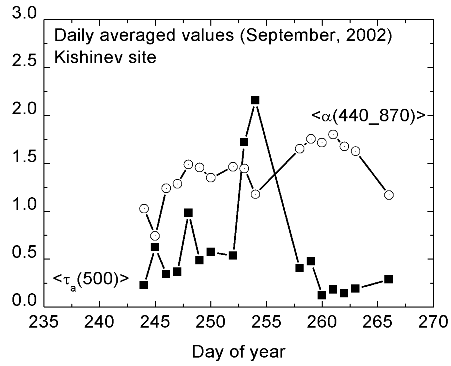


Fig. 8. Daily averaged values of the Ångström exponent $<\alpha(440\_870)>$ and AOT $<\tau_a(500)>$ for the month of September 2002.

Since the smoke was transported to Moldova from the long distance (from back > 1200 km), it is reasonably to invoke aerosol optical thickness data obtained in the region of smoke origin to compare with the analogous data acquired at the Kishinev site. For this purpose it was chosen the Moscow site (55.70^0N, 37.51^0E, 192 m a.s.l.) situated near the region with loci of fires and on the path of smoke transportation. Aerosol optical thickness spectral $\tau_{a,\lambda}$ variation for the Kishinev (06:44 GMT, on September 11, 2002) and Moscow (06:30 GMT, on September 07, 2002) sites is shown in Fig. 9.

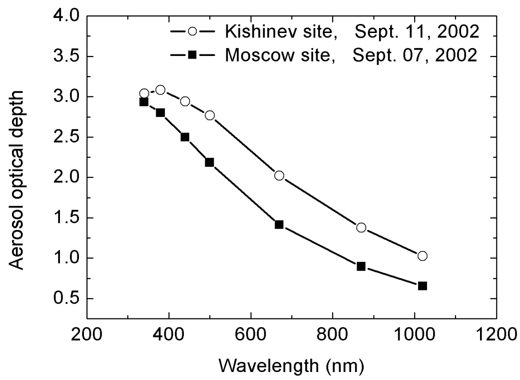


Fig. 9. Aerosol optical thickness spectra $\tau_{a,\lambda}$ variation for Kishinev (06:44 GMT, Sept. 11, 2002) and Moscow (06:30 GMT, Sept. 07, 2002) sites.

The spectral $\tau_{a,\lambda}$ variation shows a non-linear dependence in $\ln\tau_{a,\lambda}$ versus $\ln\lambda$ space (see Eq. 3) due to fine particle size distribution and particulate matter refractive indices. It is recommended to quantify this non-linearity by a second order fit [3,11]. Diurnal variability of aerosol optical thickness spectra $\tau_{a,\lambda}$ (day of observation: September 11, 2002) is shown in Fig 10. Aerosol optical thickness $\tau_{a,\lambda}$ at λ=500 nm on September 11 reached the highest value, $\tau_{a,500}$ = 2.77 (at 06:44 GMT), ever measured at this site for the ~ 3 years period of monitoring. Retrieved daily (on September 11, 2002) averaged value of AOT $<\tau_a(500)>$ is 2.16, monthly (on September 2002) mean $<\tau_a(500)>$ is 0.58 and multi-annual monthly mean of $<\tau_a(500)>$ is 0.25 . At the same time, for the Moscow site (~06:30 GMT, on September 07, 2002) $\tau_{a,500}$ = 2.21, and daily mean of AOT is ~ 2.15, respectively.

Finally, combined direct sun and almucantar sky radiometric measurements, carried out nearly at the same time (GMT), but in different days (on September 7 and 11, 2002), were used to retrieve the column volume size distributions dV/dln R [8,9]. Results of retrieving of the aerosol optical and microphysical properties from the combined measurements made for specific days at the Kishinev and Moscow sites are shown in Fig. 11.

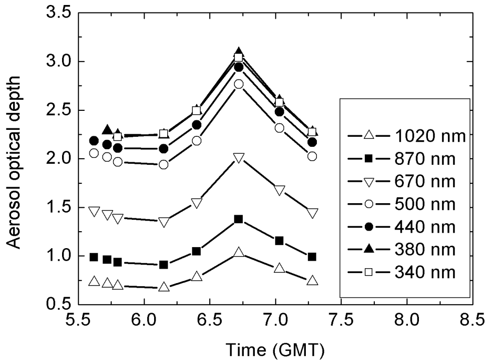


Fig. 10. Diurnal variability of aerosol optical thickness spectra $\tau_{a\lambda}$ (day of observation: September 11, 2002).

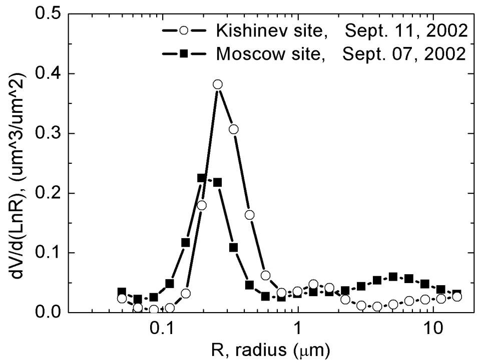


Fig. 11. Column volume size distributions retrieved from the combined direct sun and almucantar sky radiometric measurements at the Kishinev and Moscow sites.

Retrieved column volume size distributions for two different sites of observation show difference in fine mode of size distribution: peak of the volume modal radius for the Kishinev site is 0.26 μm and the same peak for the Moscow site is 0.19 μm. These peaks are ~0.08 μm and ~ 0.02 μm , respectively, greater than the peaks in the model for boreal forest smoke [12]. Although at the Kishinev site the aerosol has mostly the resemblance with the smoke originated in regions with forest and peat fires, meanwhile it should be expected that some mixing of urban/industrial pollution occurred along the path of transportation (during > 2 days) from the Moscow region to Moldova [11]. In addition, the aging and hygroscopic growth should be also taken into account. Ratio of peak values in fine mode of size distributions, for Kishinev and Moscow sites, is ~ 1.67, which can be related with pollution of air masses during their transport. Fine mode in these distributions (see Fig. 11) dominates over coarse mode: for Kishinev site the ratio of $\tau_{a,\lambda}^{fine}$ / $\tau_{a,\lambda}^{total}$ varies from 0.90 to 0.97, and for Moscow site this ratio varies from 0.85 to 0.97 at λ=440, 670, 870 and 1020 nm (the greater value of this ratio corresponds to a shorter wavelength).

Wide range of the Ångström exponent α(440_870) variation for typical time and day of observation depends on differences in fine mode particle size distributions. For Kishinev site (06:44 GMT, on September 11, 2002) values α(440_870) and $\tau_{a,440}$ are 1.12 and 2.94, respectively; for Moscow site (~ 06:30 GMT, on September 07, 2002) values α(440_870) and $\tau_{a,440}$ are 1.52 and 2.50, respectively. High value of α(440_870) for the Moscow site (in the vicinity of forest and peat fire region) can be attributed to the contribution of fresh smoke particles with small sizes. It is likely that lower value of α(440_870) for Kishinev is related with both the aging and condensation growth. The latter is essential because of combustion from peat fires produces a large amount of hygroscopic sulfate aerosol species and mixing with industrial pollution during the transport of air masses with the smoke from the Moscow region to Moldova [11].

Retrieved complex refraction indices for aerosol matter at these sites are presented in Table 1. It is clearly seen from Table 1 that retrieved both real and imaginary parts of refractive indices for aerosols at the Kishinev site have low values in comparison with the analogous ones typical for the Moscow site. Differences in real and imaginary parts of refractive indices are ~ 0.04 - 0.06 and ~ 0.0041 - 0.0047, respectively. The lowest value of the real part of refractive indices of smoke aerosols at the Kishinev and Moscow sites are ~ 1.48 and ~ 1.52, respectively. These differences can be attributed to the hygroscopic growth of smoke aerosols for Kishinev case (RH ~ 83% at the time of measurement) and peculiar optical properties of the fresh smoke aerosols determined by type of combustion for the Moscow case [11]. Mixing with industrial pollutions along the path of the transport of air masses from Moscow region is likely to be another factor, which has an influence upon the composition of smoke aerosols over Moldova. At the same time, it should be noted relatively small spectral variation of the real and imaginary parts of refractive index for both Kishinev and Moscow cases.

Table 1. Complex refractive indices $m=n - ik$ for aerosol particulate matter at two sites.

	440 nm	670 nm	870 nm	1020 nm
Kishinev	1.5098 - i0.0020	1.4804 - i0.0019	1.4822 - i0.0018	1.4811- i0.0018
Moscow	1.5696 - i0.0061	1.5288 - i0.0062	1.5258 - i0.0065	1.5228- i0.0064

Spectral variation of the aerosol single scattering albedo $\omega_{0\lambda}$ retrieved from AERONET measurements at the Kishinev and Moscow sites is shown in Fig. 12. It is clearly seen from Fig. 12 that $\omega_{0\lambda}$ shows a little spectral variation with $\omega_{0\lambda} > 0.986$ for Kishinev case (06:44 GMT, on September 11, 2002). For Moscow case (06:30 GMT, on September 07, 2002) single scattering albedo $\omega_{0\lambda}$ has a well-defined spectral dependence. Retrieved spectral single scattering albedo $\omega_{0\lambda}$ for Kishinev case is greater than for Moscow case and the difference in retrieved values of $\omega_{0\lambda}$ between these cases is ~ 0.02-0.04.

Spectral variation of the asymmetry factor retrieved from AERONET measurements at Kishinev and Moscow sites is shown in Fig. 13. Asymmetry factors at λ=440 nm for Kishinev

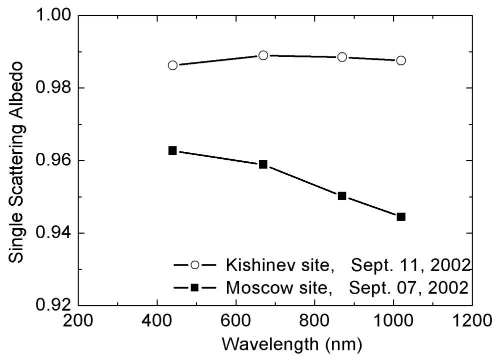


Fig. 12. Aerosol single scattering albedo $\omega_{0\lambda}$ retrieved from AERONET measurements at two sites: Kishinev and Moscow.

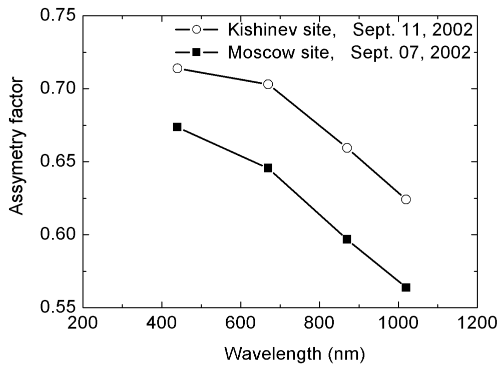


Fig. 13. Asymmetry factor retrieved from AERONET measurements at two sites: Kishinev and Moscow.

case is ~ 0.714 and for Moscow case is ~ 0.674 . These factors reveal distinct spectral dependence both for Kishinev and Moscow cases and the difference between factors for these cases is varied from 0.04 to 0.06. The greater value of the asymmetry factor for the Kishinev case can be attributed to higher value of the peak of fine mode particle radius that is ~0.26 μm, retrieved from direct sun and almucantar sky radiance measurements.

3. Summary and conclusions

First results with aerosol optical thickness and Ångström exponent retrieved from the direct sun and sky almucantar radiances measurements carried out at the Kishinev site during ~ 3 years monitoring are presented. Optical properties of aerosols obtained at the Kishinev site during smoke event associated with the long distance smoke transport from the forest and peat fires, which had occurred in numerous places nearest the Moscow site in September 2002, are analyzed. On September 11, 2002 it was registered the highest AOT $\tau_{a,500}$ ever measured at Kishinev site, by about a factor 11, in comparison with the multi-annual monthly mean for the period of ~ 3 years of observation. Spectral $\tau_{a,\lambda}$ variation (at high smoke aerosol loading, $\tau_{a,500} > 2.0$) showed a non-linear dependence in $\ln\tau_{a,\lambda}$ versus $\ln\lambda$ space and wide variation of the Ångström exponent α(440_870). Ångström exponent for Kishinev case (at > 1200 km from the region with fires) is ~1.12 and for Moscow case (the nearest place to the loci of fires) is ~ 1.52. This was due to fine mode of the particle size distribution and particulate matter refractive indices, which have been retrieved for Kishinev and Moscow cases. Fine mode particle radius for these cases is ~ 0.26 μm and ~0.19 μm, respectively. Single scattering albedo $\omega_{0\lambda}$ is ~ 0.98 and has relatively little spectral variation for Kishinev case, but for Moscow case $\omega_{0\lambda}$ is ~ 0.94-0.96 and reveals the spectral dependence. Asymmetry factors at λ=440 nm for Kishinev case is ~ 0.714 and for Moscow case is ~ 0.674 , and each of them shows spectral variation. It is likely that the difference revealed in retrieved optical properties is related with the aging, condensation growth, type of combustion and mixing with industrial pollution during the transport of air masses with the smoke from Moscow region to Moldova.

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