NONADDITIVE LIGHT ABSORPTION BY ATMOSPHERIC HAZE PARTICLES CONTAINED IN LIQUID-DROPLET CLOUDS

R.F. Rakhimov

Institute of Atmospheric Optics,
Siberian Branch of the Russian Academy of Sciences, Tomsk
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Different ways of atmospheric haze particles contribution into the light absorption by droplet clouds are investigated using the model of a concentric layered water droplet. The presence of a thin moderately absorbing layer, with the volume of 0.1%, *within a water droplet increases almost by an order of magnitude the efficiency of absorption by droplet clouds. The highest effect is achieved when the impurity is concentrated at the droplet center. As the layer moves from the center to the droplet surface its part in light absorption significantly decreases. Strongly oscillating dependence* $K_\alpha(\rho)$ *is found to be characteristic of the droplets with moderately absorbing surface layer. At some* ρ *values it can exceed the absorption by a similar droplet with the centered impurities. Estimations made for a polydisperse ensemble reveal an effect of nonadditive light absorption by atmospheric haze particles when contained in different parts of a cloud. Atmospheric haze particles, if concentrated at the droplet center as impurities, absorb visible light* 1.5–3 *times more efficiently, than the same amount of particles, though having the same geometric sizes and dielectric properties, but contained in the space among droplets.*

1. INTRODUCTION

The fine disperse component of the atmosphere, having well developed surface and mobility, influences the atmospheric heat balance due to its global distribution not only because it absorbs and scatters solar radiation, but also because of being an active participant of phase transformations of the atmospheric moisture, and first of all, by taking part in cloud formation.[1] While significantly changing the microstructure of water clouds and fogs,[2] the atmospheric haze particles finally determine such important, from the climatology viewpoint, properties of the atmosphere as albedo of cloud fields.[3–5]

The problem of anomalous absorption of radiation in clouds[5] still remains a hotly debated topic despite of a long history and many hypothesis being formulated from time to time ranging from underestimation of the contribution coming into the absorption by a cloud from large drops[6] and to the effect of horizontal transfer of scattered radiation within cloud layers caused by their optical inhomogeneity.[7,8] Obviously, it is worth using several hypotheses in a combination to satisfactorily quantify the excess absorption of short-wave radiation in clouds, and relatively low values of their albedo (approximately 78–83%).

In the studies on estimating the radiation regime of the troposphere[7–10] the effect of clouds and cloud fields is forecasted mainly in the framework of the so called pure (i.e. containing only water) Deirmendjian optical models[11] or similar models. Some theoretical estimations of the absorption by atmospheric haze particles contained within the clouds are, as a rule, based on the hypothesis of its additivity. These estimations show that even in an ultimately optimistic case the contribution that may come from the haze particles into the absorption of visible radiation by clouds is several times lower than the empirical one.[12]

Actually, even if the mean value of the single scattering albedo of an atmospheric haze is $\Lambda_0 = 0.9–0.95$[13] at the mean turbidity of the near-ground atmospheric layer being $\beta_\varepsilon \sim 0.15–0.2$ km^{-1}, the haze particles that are being involved in the process of cloud formation at the height of the condensation level, as an additive component of the disperse mixture, would cause an increase in the cloud absorptance by the value $\beta_\alpha \sim 0.012–0.019$ km^{-1}, that is not enough for explanation of the effect of excess absorption in clouds of small optical density.

The process of forming the liquid-drop phase in the atmosphere, at an intense invasion of a warm and moist air mass from the surface layer into the free atmosphere due to convection, occurs in the mixture of gas and disperse components with a high content of atmospheric haze particles.[2] The requirement of only slow temperature decrease in the ascending atmospheric

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moisture flux imposes a restriction on the spontaneous condensation[2,15] and on the involvement of atmospheric haze particles in the formation of droplets because only most hygroscopic of those particles may become the condensation nuclei. Thus, the atmospheric haze particles are present in clouds simultaneously as an independent fraction of low active condensation centers in the space among the droplets, and in the form of insoluble residue of active nuclei within the drops.

The interaction between the global aerosol component of the atmosphere and cloud fields is not only the formation of liquid-drop phase due to the condensation. A number of processes that result in washing-out of atmospheric haze particles in the under cloud layer and inside the cloud make the finely dispersed atmospheric component the material for cloud drops at the stages of cloud development following the condensation as well. Large temperature gradients within clouds of vertical development together with the intense opposite fluxes favor the capture of insoluble strongly absorbing substances by drops (during their motion). One also must not exclude the possibility of forming the so-called cover phase on the drop surface,[14] with the dielectric properties different from water. Multilayer structure of cloud droplets can make the interaction between radiation and a droplet more efficient and even cause the effects of resonance absorption. For these reasons in this paper the question on theoretically expected effect from the presence, in a water-drop cloud, of the atmospheric haze particles is analyzed in a more detail on the basis of the model, assuming the presence of drops having a concentric multilayer inhomogeneous dielectric structure. Special attention is paid to the comparison between theoretical estimations that assume different ways, in which the atmospheric haze particles may contribute to the absorption of radiation by clouds.

2. THE ABSORPTION EFFICIENCY FACTOR OF A MULTILAYER DROPLET

Despite the fact that the number of the papers devoted to investigation of the extinction, scattering, and absorption efficiency factors is well over several hundreds, there are many wrong conclusions drawn about such characteristics of polydisperse systems as single scattering albedo and the absorption coefficient which are primarily the result of a too superficial analysis of the above aspects of the problem, as a whole.

Calculated data are shown in Fig. 1*a* as the absorption efficiency factor of a uniform liquid drop (curve *1*), drops with an impurity concentrated at its center (curve *2*) and on the surface (curve *4*) portion as shown in Fig. 1*e* of a spherical drop, and within the intermediate layer (curve *3*) in different ranges of the diffraction parameter. Here r_1 is the inner radius of intermediate layer, r_2 is the outer radius of the intermediate layer, and r_s is the drop radius. Here the thickness of layers is evaluated on the basis of the fraction in percent of the absorbing component content within the drop. Thus in particular, the ratio η between the total volume of the haze or soot particles, V_h [$\mu m^3 \cdot sm^{-3}$], and the total volume of water component of cloud droplet, V_c [$\mu m^3 \cdot sm^{-3}$], then, for example, for the drop structure shown in Fig. 1*e*, the core radius r_1 was evaluated by the relation $r_1 = r_s \exp(\ln(0.5\eta)/3)$, while $r_2 = r_s \exp(\ln(1 - 0.5\eta)/3)$. In the case, when the absorbing impurity form the intermediate layer, its geometrical parameters are evaluated as $r_1 = \varepsilon_1 r_s$ and $r_2 = \varepsilon_1 r_s \exp(\ln(1 + \eta)/3) = \varepsilon_2 r_s$.

Optical constants (OC) of soot, water layer of a drop, and of the atmospheric haze particles are simulated in accordance with the data from Refs. 16 and 17. Thus, for instance, at the wavelength of a ruby lidar, $\lambda = 0.6943$ μm, those are $m_s = 1.84 - i0.79$, $m_w = 1.33 - i33 \cdot 10^{-9}$, and $m_a = 1.541 - i6.94 \cdot 10^{-3}$, respectively.

As is seen from the above estimations, the absorption efficiency factor K_α significantly depends on the particle morphology, therewith not only from the amount of light absorbing impurity, but on the position of the layer within a drop as well. The estimations, made for the case *2*, in practice do differ only a little bit from those for the case of a double-layer water drop with the absorbing core, and of an intermediate variant *3*, as well. But particles with quite a thin surface layer (the first and the second layer are assumed to be pure water ones), with the same total volume of the absorbing layer as in the cases *2* and *3*, absorb significantly weaker. All dependences are calculated with the ρ step of 0.01. The fragments of the data presented in Fig. 1*a* are shown in a more detail in Figs. 1*b–d*. Well pronounced resonance structure seen in data sets *1* and *4* is explicitly observed by a peak presented by 4 to 7 points (see Fig. 1*b*, curve *3*).

It is obvious from these data that the presence in a droplet of an impurity, though from moderately absorbing materials, sharply (almost by an order of magnitude) changes the absorption properties of particles practically over the entire ranges of the diffraction parameter $\rho = 2\pi r/\lambda$ considered, although their fractional content by volume is only 0.1% of the whole drop. Furthermore, for the polydisperse systems the contribution of the absorbing admixtures is most essential, when these are located at the drop center, and their role slightly decreases as the absorbing layer moves from the drop center to its surface. At the same time one should pay attention to the fact that at the increase of the diffraction parameter up to $\rho \sim 20$ and more the strongly oscillating behavior of the absorption efficiency factor, that may, at some ρ values, exceed the absorption by the drops with an impurity at the drop center, is characteristic of the drops with the surface absorbing layer. But, in the case of averaging over a polydisperse ensemble of particles these high-frequency oscillations does not play an

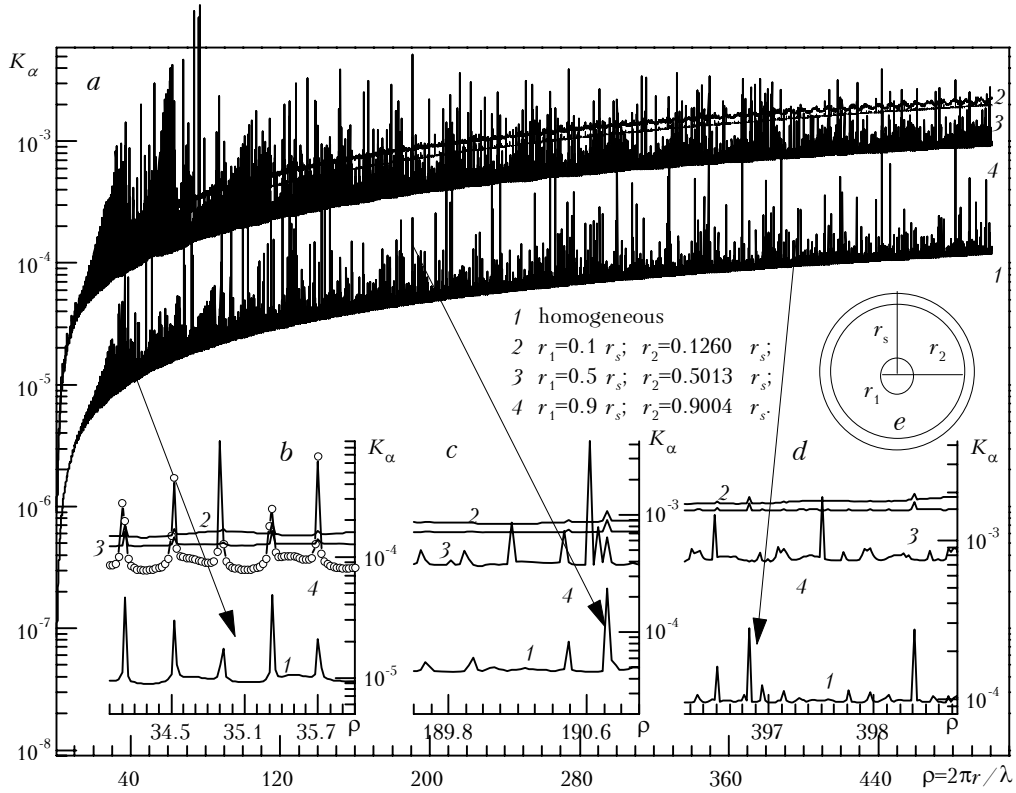

FIG. 1. Dependence of the absorption efficiency factor $K_\alpha(\rho)$: for homogeneous drops (1); for different variants of the absorbing layer location within the drop (2)–(4); in the interval of ρ values from 0.5 to 500 (a); shorter portions of the entire ρ interval (b)–(d).

essential part. So the majority of points on the curves $K_\alpha(\rho)$ well agree with the basic conclusion about the role of the layer location within a three-layer drop plays in the formation of the absorption properties of the drop. At the same time if one performs similar calculations for the homogeneous spheres with the refractive index, calculated with the account for the volume content of water and absorbing component, assuming moderately absorbing materials, by which the continental atmospheric haze particles are meant in this case,[13] the absorptance of such particles will nevertheless be smaller than that of three-layer drops, that is, of those in which the haze particles are located near the drop center or form an intermediate layer.

It should be noted that when the absorbing layer moves from the center to the drop surface the resonance structure in curve $K_\alpha(\rho)$ becomes more pronounced, therefore averaging of the absorption by such drops over a polydisperse ensemble it is necessary to take a very fine ρ step, (~ 0.03–0.01). Therefore the evaluated absorption parameters for the polydispersions depend on the peculiar features in the particle size spectra: range and prevailing particle size, as well as on the ratio between small and large particles. Let us now consider when the above noticed peculiarities in the absorption properties of a single drop can influence the absorptance of a cloud as a polydisperse mixture.

3. HAZE PARTICLE CONTRIBUTION INTO ABSORPTION OF POLYDISPERSE SYSTEM OF CLOUD DROPS

The formation and development of cloud structures are the result of complex interaction between large-scale circulation processes with the mesoscale turbulent fluxes in between the near-ground layer and the free atmosphere and besides it depends on the presence and composition of the condensation nuclei. As a consequence the size spectra of drops that are observed in clouds may strongly vary in shape. The overwhelming majority of experimental data show that the measured size spectra of cloud drops may be quite accurately approximated by the modified gamma-distribution[18]:

$$f(r) = \mathrm{d}N/\mathrm{d}r = Ar^{-\alpha} \exp\{-b\, r^{\gamma}\}. \quad (1)$$

Moreover the size spectra of cloud drops measured show[18] that the range of drop size characteristic of dense cumulus and stratus is well extended towards large sizes thus being significantly wider than in the known Deirmendjian models (Fig. 2).

The parameters of the distribution (1) used in calculations made in this paper are given in the Table I.

Only few theoretical papers may be found in literature on estimations of light scattering by

polydisperse ensembles of concentric inhomogeneous spheres because of laborious computations as well as because of the instability of computer algorithms that are very sensitive to microphysical parameters of particles. The computer calculations in this case face the problem of singularities that occur more frequently because of the finite length of the computer word and very cumbersome mathematical expressions for the coefficients a_n and b_n that determine a solution to the problem of the light scattering by multilayer spherical structures, these coefficients being the amplitude coefficients a_n and b_n from the Mie theory.[16]

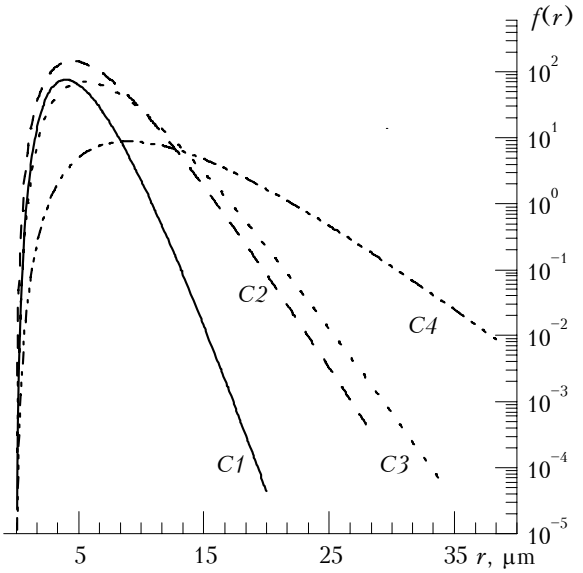

FIG. 2. Size distribution function of drops of clouds (figures at the curves coincide with the designations used in the Table, where the distribution parameters are given).

The algorithm used in this paper for calculating optical characteristics of water clouds assuming concentric inhomogeneity of drops has been described in Ref. 13 in a more detail. For instance, the volume coefficients of optical interactions are calculated by averaging over a polydisperse ensemble using a traditional scheme

$$\beta_{\varepsilon,\sigma,\pi,\alpha}(m,\lambda) = \int_{r_1}^{r_2} K_{\varepsilon,\sigma,\pi,\alpha}(r,m)\ \pi\ r^2\ f(r)\ \mathrm{d}r, \qquad (2)$$

where the subscripts ε, σ, π, and α denote the types of the optical interaction: extinction, total scattering, backscattering, and absorption, $K_{\varepsilon,\sigma,\pi,\alpha}$ being the efficiency factors of the corresponding optical interactions.

The elements of the normalized scattering phase matrix of a polydisperse ensemble are calculated using similar averaging procedures

$$P_j(m,\lambda,f(r),\theta) = \frac{4\pi}{\beta_\sigma}\int_{r_1}^{r_2} \sigma_j(r,m,\theta)\ f(r)\ \mathrm{d}r, \qquad (3)$$

from which the scattering phase function

$$g(\theta) = (P_1(\theta) + P_2(\theta))/8\pi \qquad (4)$$

and polarization degree of the scattered radiation

$$p(\theta) = (P_1(\theta) - P_2(\theta))/(P_1(\theta) + P_2(\theta)). \qquad (5)$$

are calculated.

The probability of a photon survival or the single scattering albedo that is normally used in the analysis of absorption and scattering properties of clouds is defined as follows:

$$\Lambda_\sigma = \beta_\sigma/\beta_\varepsilon, \qquad (6)$$

The backscattering phase function is, in this case, written as

$$g_\pi = \beta_\pi/(4\pi\ \beta_\sigma) = P_1\ (\theta = \pi)/4\pi = \\ = P_2\ (\theta = 180^\circ)/4\pi. \qquad (7)$$

The parameter, that shows the difference from unit of the ratio between the absorption by haze particles when being within the drop and outside it,

$$\xi_{r\alpha} = \beta_{\alpha c}/\beta_{\alpha h} - 1, \qquad (8)$$

is used to compare different versions of the atmospheric haze particle intrusion into a drop.

The calculations of optical characteristics of polydisperse ensembles of cloud drops are performed with the averaging over an ensemble on the size interval from 0.1 to 80 μm, with the step $\Delta r = 0.1$–0.025, in the range of scattering angles 0–180°, with the step $\Delta\theta = 1$–3°.

4. CALCULATED RESULTS

As is seen from Fig. 1, broadening the range for averaging characteristics of polydisperse ensembles of pure water drops to the size of 50 μm and larger produces less significant effect as compared to the case when even a relatively small amount of haze particles penetrates into the cloud drops. The wider size range can provide for an increase in the absorption by the polydisperse mixture only by 2–3%, that is certainly not enough for explaining the effect even if one takes into account multiple scattering of radiation in optically dense clouds.

As model estimations show, the strongest effect from the atmospheric haze particles penetration into the drop may be anticipated in the absorption of light in the spectral regions out of the water absorption bands, for instance in the visible range.

We have considered, in our calculations, four variants of the atmospheric haze particle presence in water clouds:

a) insoluble impurities form the drop core at its center;

b) atmospheric haze particles form a thin layer that covers the drop surface;

c) as an intermediate inner layer within a drop over which the finely dispersed haze particles are distributed;

d) as an independent fraction of a cloud particle ensemble that absorbs the light.

Comparison of different hypotheses on the ways the absorbing particles are involved in the cloud ensembles shows that the impurities, in the form of atmospheric haze particles, buried in cloud drops (see Fig. 3) produce nonadditive contribution into the total absorption by a cloud mixture in the visible wavelength region. The atmospheric haze particles involved during the process of cloud formation into the drop structure, as an impurity, absorb visible radiation by 1.5–3 times stronger than the same amount of haze particles of same geometrical sizes and dielectric properties while being free in between the drops. The dashed line in Fig. 3 shows for a comparison the possible curve for data calculated without the account of the absorption nonadditivity effect.

Several hypotheses on the relative thickness and location of the absorbing layer in a drop, r_1/r_s ~ 0.01 to 0.9, have been considered, therewith in the number of variants the fraction of the absorbing component was assumed to be up to 0.3% by volume. These results are presented in Figs. 4 and 5.

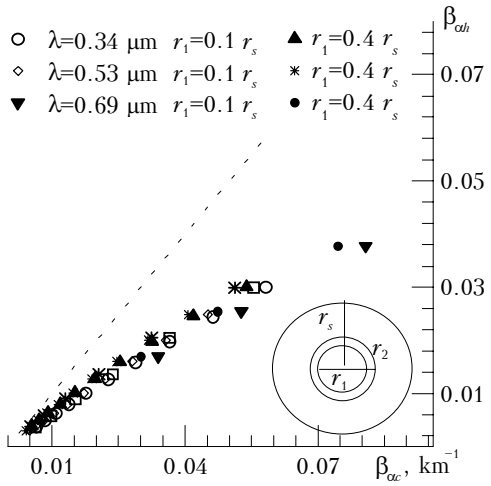

FIG. 3. Comparison between the calculated estimates of the absorption coefficient of haze particles $\beta_{\alpha c}$ within the cloud drop (X-axis) and intermediate space $\beta_{\alpha h}$ (Y-axis) for the various types of visible wavelengths and absorbing layer location within the drop.

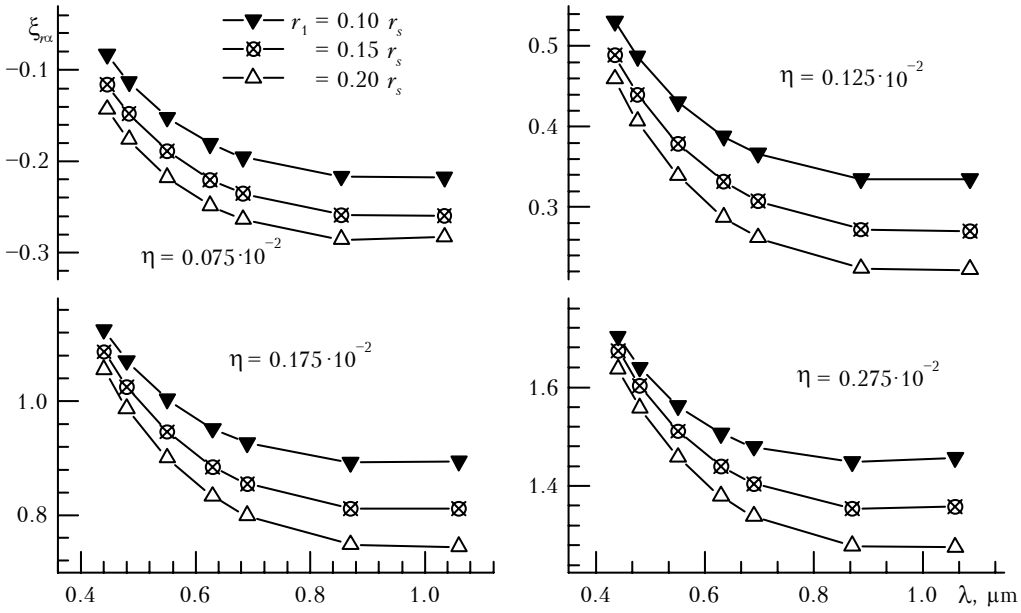

FIG. 4. Spectral variation of the absorption efficiency factor of haze particles, $\xi_{r\alpha}$, as impurities inside a drop concentrated at the drop center for different content η in percent.

The estimates of the Spectral variation of the absorption efficiency factor of haze particles, $\xi_{r\alpha}$, as impurities inside a drop concentrated at the drop center for different content η, in percent, are shown in Fig. 4. The calculations are made for visible and near IR-range of spectrum of optical radiation. As is seen from data presented in Fig. 4, at an increase of the relative fraction of absorbing substances within the drop over 0.1% the contribution coming from haze particles into the absorption by clouds steadily increases because the water cover of a drop makes the absorption by the haze particle impurities more efficient as compared to that by haze particles that are in the air between the drops.

In the case when the impurity inside a drop is concentrated near the drop surface (see Fig. 5), the effect of forcing of the haze particle absorption is essentially weaker, than in the first case. At low concentration the inverse effect can happen that means that the contribution into the total absorption from the haze particles can be smaller than from those in between the drops.

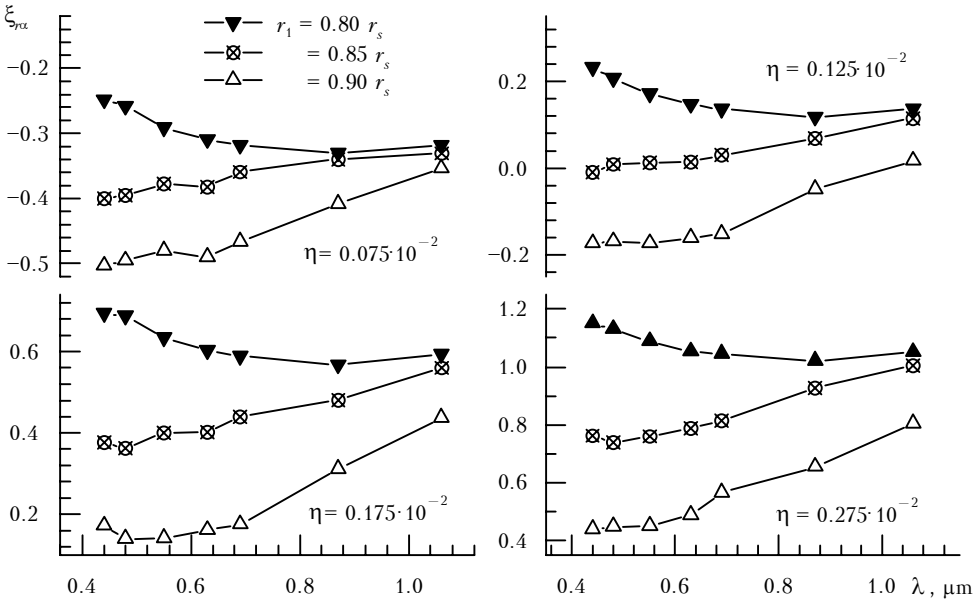

FIG. 5. Spectral variation of the absorption efficiency factor of haze particles, $\xi_{r\alpha}$, as impurities inside a drop concentrated near the drop surface for different content η in *percent.*

The assumption that insoluble impurities may be present within a drop leads to significant changes in the shape of the scattering phase function and angular dependence of the polarization degree (Fig. 6) within the range of scattering angles θ ~ 5–20°, what are qualitatively agrees with the basic difference between two groups of the experimental data.[13] This range is separately shown in the figures both for the scattering phase function (Fig. 6a_1), and for the polarization degree (Fig. 6b_1). As to other scattering angles (Figs. 6a_2 and b_2), the difference between homogeneous and inhomogeneous droplets is not that significant to be a stable regularity. Thus, when modeling the radiation transfer through optically dense clouds, where the effect of multiple scattering dominates, one can neglect the influence of inhomogeneous impurities on the scattering phase function as compared to that due to possible variations in the size spectra (Fig. 6a). It is exactly the size spectrum variations that cause the variation of the polarization degree in the angular range 70–120° (Figs. 6b and b_2).

The basic results of model estimations are given in the Table I. The calculations have been made for the wavelength λ = 0.6943 μm. The optical constants (OCs) of the layers are given in 13th to 15th columns: "aB is the variant when OCs of the layer correspond to the complex absorption index (CAI) of the atmospheric haze particles $m_a = 1.54 - i0.007$; "wB – to that of water with $m_m = 1.331 - i0.6972 \cdot 10^{-7}$; "$s$B – to the soot with $m_s = 1.84 - i0.79$. The values of the inner and outer radii of the intermediate aerosol layer are given in the 16th and 17th columns. The thickness of the layer is evaluated in each particular case regarding the relative volume of the absorbing substances within the drop η, which is depicted in 18th column of the Table.

So far as the question on the soot component of the atmosphere is considered open (considering the increase of the anthropogenic influence on the atmosphere), and the data available are contradictory, three variants have been considered in the model experiment. In accordance with the first two hypotheses the soot content in the atmospheric haze is ~0.1 and 0.3%. The calculated data are given in 13th and 16th rows of the Table. Besides this an anomalous situation is considered when the content of the most strongly absorbing component – soot and haze particles is 0.1% of a cloud drop volume (16th row).

The values of scattering phase function at the angle of backward scattering, $g_\pi = g(\theta = \pi)$, and the photon survival probability Λ for the single-scattering within the clouds are also given in the Table, being useful when estimating the cloud reflectivity.

The model estimations obtained show, first of all, that the haze particles as an impurities in the cloud drops may, at the values of their relative volume within the clouds set in this paper, significantly (up two orders of magnitude, on the average) increase the absorption of radiation by such clouds (for this compare the data given in 3, 7, 11, and 15th columns of the Table, especially from 1st to 13th row). The contribution that comes from the microdisperse aerosol into the absorption is largest when the impurity concentrates at the drop center. The drop structure in the form of an absorbing core and an intermediate layer favor an increase in the backscattering phase function (see 2, 6, 10, and 14th rows of the Table) by 2–4%, while the absorbing surface phase of a cloud drop decreases the fraction of radiation reflected backwards by 1–2% (2nd and 16th rows), that is important when evaluating the up going and down going fluxes of radiation using the radiation models.

TABLE I. Optical parameters of clouds of various types.

Cloud *C1*				Cloud *C2*				Cloud *C3*				Cloud *C4*				Optical constants of layer			Location of obsorbing layer within drop out its valume part		
A = 2.373; α□= 6.0; β□= 1.50; γ = 1.0				A = 0.07621; α = 4.0; β□= 0.684; γ□= 0.9;				*A* = 1.157; α□= 5.0 β□= 1.198; γ□= 0.9				*A* = 7.919; α□= 4.5; β□= 1.291; γ□= 0.9									
β_ε, km^{-1}	g_π	β_α, km^{-1}	Λ_σ	β_ε, km^{-1}	g_π	β_α, km^{-1}	Λ_σ	β_ε, km^{-1}	g_π	β_α, km^{-1}	Λ_σ	β_ε, km^{-1}	g_π	β_α, km^{-1}	Λ_σ	m_1	m_2	m_3	r_1	r_2	η
16.737	0.05070	0.00013	0.99999	34.195	0.05456	0.00061	0.99998	54.223	0.05340	0.00062	0.99999	69.187	0.05258	0.00068	0.99999	w	w	w	0.07937	0.99967	0.001
16.742	0.05155	0.00909	0.99946	34.204	0.05146	0.04063	0.99881	54.242	0.05229	0.04309	0.99921	69.212	0.05248	0.04892	0.99929	w	w	a	0.07937	0.99967	0.001
16.738	0.05094	0.01073	0.99936	34.194	0.05230	0.04436	0.99870	54.227	0.05192	0.04784	0.99912	69.191	0.05286	0.05553	0.99920	w	a	w	0.89979	0.90021	0.001
16.737	0.05250	0.01403	0.99916	34.195	0.05882	0.07500	0.99781	54.223	0.05661	0.07230	0.99867	69.187	0.05551	0.07842	0.99887	w	a	w	0.69966	0.70034	0.001
16.737	0.05114	0.01417	0.99915	34.195	0.06173	0.07656	0.99776	54.223	0.05541	0.07334	0.99865	69.187	0.05384	0.07942	0.99885	w	a	w	0.49933	0.50067	0.001
16.737	0.05158	0.01431	0.99914	34.195	0.06811	0.07800	0.99772	54.223	0.05716	0.07440	0.99863	69.187	0.05478	0.08046	0.99884	w	a	w	0.39896	0.40104	0.001
16.737	0.05130	0.01460	0.99913	34.195	0.06846	0.08003	0.99766	54.223	0.05875	0.07636	0.99859	69.187	0.05629	0.08243	0.99881	w	a	w	0.29814	0.30184	0.001
16.737	0.05220	0.01525	0.99909	34.195	0.05843	0.08149	0.99762	54.223	0.05476	0.07970	0.99853	69.187	0.05353	0.08613	0.99876	w	a	w	0.19574	0.20408	0.001
16.737	0.05362	0.01657	0.99901	34.195	0.05648	0.08346	0.99756	54.223	0.05549	0.08446	0.99844	69.187	0.05476	0.09214	0.99867	w	a	w	0.07937	0.11447	0.001
16.737	0.05147	0.01692	0.99899	34.195	0.05592	0.08195	0.99760	54.223	0.05394	0.08445	0.99844	69.187	0.05303	0.09274	0.99866	a	w	w	0.10000	0.99983	0.001
16.737	0.05347	0.03151	0.99812	34.195	0.05754	0.15746	0.99540	54.223	0.05423	0.16182	0.99702	69.187	0.05398	0.17619	0.99745	w	a	w	0.19129	0.20801	0.002
16.739	0.05131	0.02051	0.99877	34.195	0.05051	0.08566	0.99749	54.232	0.05129	0.09242	0.99830	69.191	0.05196	0.10507	0.99848	w	a	w	0.89959	0.90041	0.002
16.737	0.05082	0.16743	0.99000	34.195	0.05445	0.30303	0.99114	54.223	0.05347	0.51012	0.99059	69.187	0.05267	0.66589	0.99038	s	w	w	0.10000	0.99983	0.0010
16.737	0.05093	0.25421	0.98481	34.195	0.05460	0.46549	0.98639	54.223	0.05364	0.77809	0.98565	69.187	0.05275	1.01383	0.98535	s	w	w	0.12599	0.99967	0.0020
16.737	0.05092	0.32483	0.98059	34.195	0.05476	0.59948	0.98247	54.223	0.05378	0.99775	0.98160	69.187	0.05290	1.29828	0.98124	s	w	w	0.14422	0.99950	0.0030
16.740	0.05185	0.11508	0.99312	34.198	0.05271	0.21766	0.99364	54.230	0.05242	0.35754	0.99341	69.198	0.05255	0.46248	0.99332	s	w	a	0.07937	0.99983	0.0010

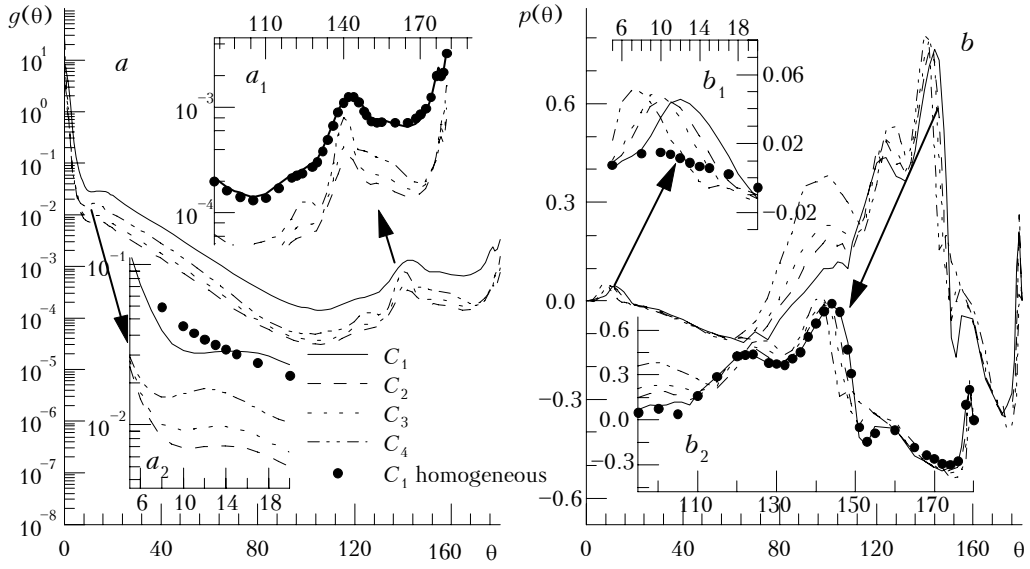

FIG. 6. Influence of the condensation nucleus on the view of angular behavior of the scattering properties of a cloud for the different cloud types: $g(\theta)$ is the normalized scattering phase function; $p(\theta)$ is the polarization degree; circles show the data calculated for homogeneous water drops and the droplet size spectrum characteristic of C_1 cloud type.

But most strong changes in the cloud absorption take place when soot component penetrates into the cloud drops. Estimations show that in this case an increase in the absorption may reach more than three orders of magnitude (see the 13th and 16th rows of the Table).

Summarizing the obtained results, despite of their qualitative diversity (in some variants the haze particles can exhibit a decrease in their optical activity), it is worth recognizing that on the whole the haze particles, as an impurity in the drops, may efficiently cause an increase in the absorption of solar radiation by clouds, especially when being present in a large amount. The latter circumstance, as well as a threatening increase of the anthropogenic impacts on the environment show the necessity of investigating the optical behavior of aerosol component of the atmosphere in the radiation budget of the Earth while accounting not only direct influence of the global aerosol phase component on the transformation of light energy in the general climate system.

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