MEASUREMENTS OF THE LASER RADIATION EXTINCTION IN CLOUDS OF DIFFERENT TYPES

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This paper presents some data of direct airborne measurements of the extinction coefficients of laser radiation at 0.632 *and* 10.6 μ*m wavelengths in clouds.*

Even though a large amount of information about the losses of optical radiation in different types of clouds has been obtained, the need to obtain new results exists.[1,2] This is due to the fact that the majority of these data were obtained either based on theoretical representations[3,4,5] or indirect measurements.[6,7] Until the present time the direct measurements of radiation extinction coefficients in clouds have poor frequency resolution and low accuracy, especially in high clouds.[1,8] The large scatter of results was observed caused by the spread of the parameters of the same type of cloud, since the cloud was identified based on meteorological rather than radio physical parameters. There is a lack of direct measurements particularly in high clouds.

Though we made our measurement rather long ago (in 1975–1983), the results were not published. Analogous data by the other authors are practically lacking (particularly in high clouds at the wavelength λ = 10.6 μm).

In this paper, we describe the results of direct measurements of laser radiation extinction coefficient at two wavelengths: λ = 0.632 and 10.6 μm. This is accounted for by widespread use of He-Ne and CO_2 lasers. The measurements were made directly in clouds using the instrumentation which was placed onboard the IL-18 aircraft–laboratory. Over a long period not only the extinction coefficients were determined, but also the statistical results were accumulated. To this end, the extinction coefficients were measured for different regions of the former USSR in different seasons and at different time.

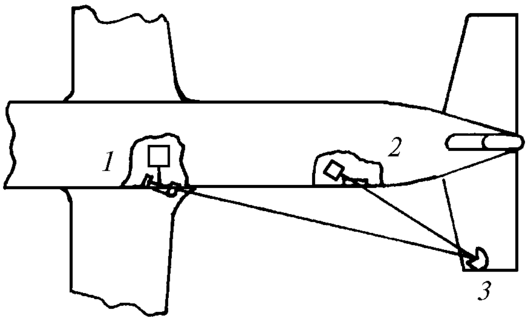

Fig. 1. Layout of instrumentation placed on board the aircraft.

The experimental setup is depicted in Fig. 1, where *1* is the meter of the extinction coefficient at λ = 0.6328 μm (measurement path length is 18 m), *2* is the meter of the extinction coefficient at λ = 10.6 μm (measurement path length is 32 m), and *3* is the corner–cube reflector. The paths were located above the projections of the aircraft propellers into a vertical plane perpendicular to the longitudinal axis of the aircraft.

The basic circuits of the setups were identical and appropriate for the transmission method. Depicted in Figs. 2 and 3 are the block diagrams of measuring setups for visible and infrared radiations, respectively. Here *1* is the optical quantum generator, *2* is the modulator, *3* are the mirrors, 3′ are the semitransparent mirrors, *4* is the lens, *5* is the illuminator, 5′ is the zinc-selenide window, *6* is the corner–cube reflector, *7* is the receiving antenna, *7′* is the counter-reflector, *8* is the receiver, *9* is the reference receiver, *10* is the selective amplifier, *11* is the recorder, *12* is the power supply unit, and *13* is the optical quantum generator (LG–56) that was added to the setup operating at λ = 10.6 μm for adjustment.

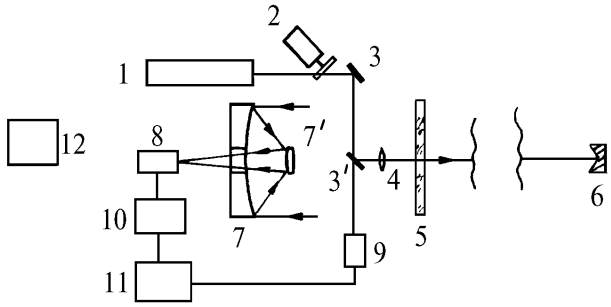

Fig. 2. Block diagram of the measuring setup at λ *= 0.632 μm.*

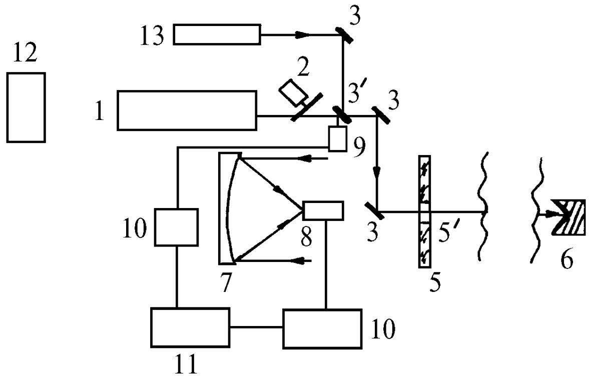

Fig 3. Block diagram of the measuring setup at λ *= 10.6 μm.*

In measurements particular attention was given to the determination of radiation extinction coefficients in middle and high clouds. The reason is that in these clouds the coefficients were measured most seldom and with the worst accuracy.

The measurement results are listed in Table I.

TABLE I.

N	Type of clouds	Characteristic of cloud	<σ>, km^{-1}		<Δσ>/<σ>, %	
			λ_1=0.63	λ_2=10.6	λ_1	λ_2
1	St	Center		120		8
		Top	88	75	9	8
2	Cu *hum*		38	30		
	Cu *fr*	Bottom	42	39	8	1
	Cu *fr*	Center	190	92	45	5
	Cu *fr*	Top	79	55	10	3
3	Ci		21	7	62	8
4	Cs		6	9	66	5
5	Ac		130	111	82	
6	Sc		87	56	39	

The estimated instrumental accuracy was 35% for the visible range and 15% for the IR. The comparison with the results obtained elsewhere[1,2,3] indicates an increase of the extinction coefficients for most types of clouds in the visible range. This can be accounted for by worse accuracy of the results obtained in the aforementioned papers due to much shorter pathand wider spread of cloud characteristics whose values may differ by a few hundreds of per cent. Moreover, in Ref. 1 the radiation extinction was measured not at a specific wavelength but within a wide spectral range ($0.4 < \lambda < 0.7$). The results obtained testify to some advantages of the IR range over the visible one in clouds of practically all types. These results enable micro structural models of clouds to be refined.

REFERENCES

1. I.P. Masin, ed. *Optical Density of Clouds* (Gidrometeoizdat, Moscow, 1976).
2. V.P. Bisyarin, Radiotekhnika, No. 5, 21 (1983).
3. V.E. Zuev, B.A. Savel'ev, O.A. Volkovitskii, et al., in: *Abstracts of Reports at the Tenth All-Union Conference on Radio Wave Propagation* (Nauka, Moscow, 1972), pp. 303–307.
4. V.E. Zuev and M.V. Kabanov, *Optics of Atmospheric Aerosol* (Gidrometeoizdat, Leningrad, 1987), 253 pp.
5. K.Ya.Kondrat'ev, N. I. Moskalenko, and D.V. Pozdnyakov, *Atmospheric Aerosol* (Gidrometeoizdat, Leningrad, 1983), 224 pp.
6. K. Sassen, Appl. Opt. **17**, No. 5, 804–806 (1978).
7. K. Sassen, Appl. Opt. **20**, No. 2, 185–193 (1981).
8. I.P. Mazin and A.Kh. Khrgian, eds., *Clouds and Cloudy Atmosphere* (Gidrometeoizdat, Leningrad, 1989), 647 pp.