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AIRBORNE LIDAR SENSING OF LAKE BAIKAL WATER AREA

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Lake Baikal is situated in Eastern Siberia in the 51-55° N latitude belt and is 40-80 km wide, 600 km long, and extended in the north-eastern direction. Its depth reaches 1.8 km. It has the largest supply of fresh water. Judging from many geophysical parameters, it may be considered as an inland sea. This evokes an interest to a comprehensive study of Lake Baikal.

An OPTIK-È AN-30 aircraft-laboratory[1] of the Institute of Atmospheric Optics was used to perform experimental investigations. A MAKREL'-2 lidar was employed for water sensing in the nadir direction trough a glass hatch of this aircraft. The lidar has the following specifications :

Working laser wavelength	532 nm
Pulse energy	50 mJ
Pulse width	15 ns
Beam devergence at the exit from the collimator	1 mrad
Diameter of the receiving telescope	0.15 m

The above indicated diameter of the reciving telescope ensures a field of view in the range 1.3-13 mrad. A Wollastone prism is used for simultaneous recording of two polarization components of a lidar return signal. A 7-bit ADC with sampling period of 10 ns ensures a depth resolution of 1.1 m. The depth profil of depolarization ratio was defined by the formula $\delta(z)=F_2(z)/F_1(z)$. Here z is the depth in water and F_1 and F_2 are the polarized and crosspolarized components of a lidar return signal. The extinction coefficient was calculated from the formula

$$\varepsilon = \frac{n}{2\,(z_2 - z_1)} \ln \frac{F_1\,(z_1)\,(H+z_1/n)^2}{F_2\,(z_2)\,(H+z_2/n)^2} . \qquad (1)$$

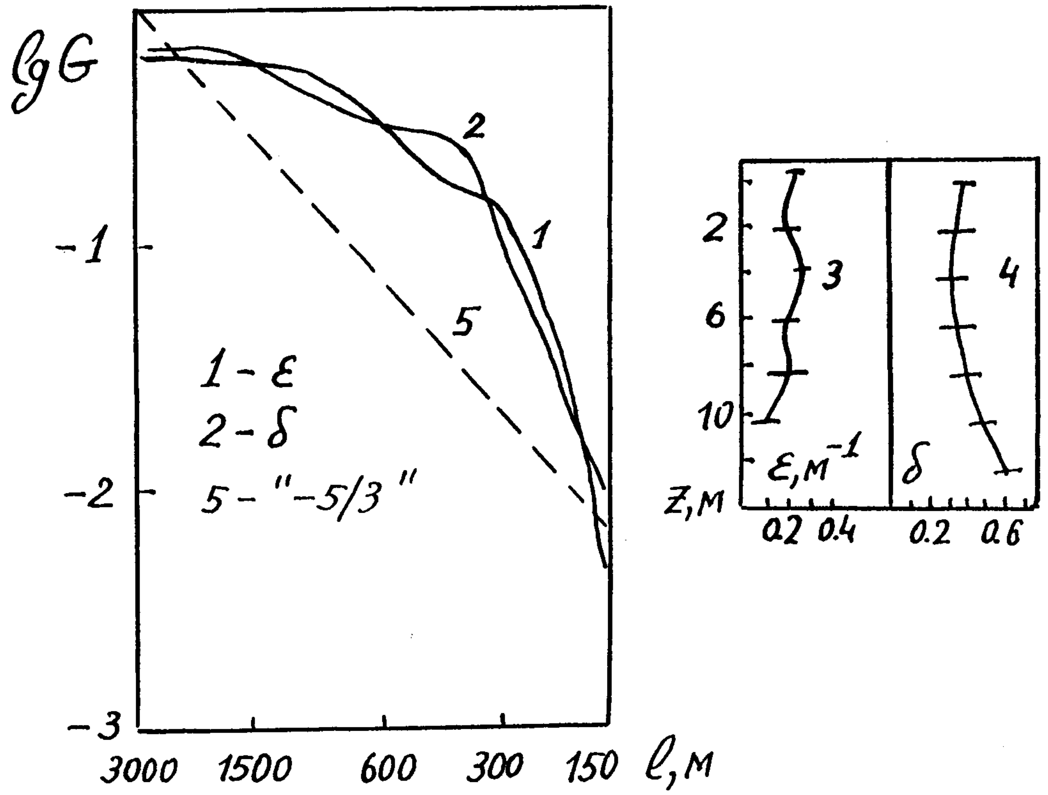
Here H is the altitude above the water surface. In such an optically dense medium as water the effect of multiple scatering is very strong; therefore, the measurable value of e is less then the real extinction coefficient and greater than the real absorption coefficient.

The magnitude of this deviation depends on an experimental configuration[2]. For this reason the flight altitude H was kept at 300 m and the field of view was also kept at 10 mrad. A pulse repetition frequency of 1 Hz ensured a sounding step of 80 m along the flight line.

Flights were performed at distances 1-5 km from the shore. Over the central and southern parts of the lake we flew by the square routes. The square side was 15-20 km long. Depth of visibility of a standard white disk (Secchi disk) z_m calculated from the lidar data was (26 ± 2) m for clearest water. In the southern part of the lake being in the vicinity of the industrial enterprises z_m=(16 ± 1) m.

Near the shore z_m varied within the limits 18-21 m statistical features of the hydro-optical characteristics of Lake Baikal can be illustrated by two examples.

Figure 1 shows the results of sensing near the mouth of the river Selenga. It is a large river rising in Mongolia. When it empties into Lake Baikal , it forms the Delta. Power spectra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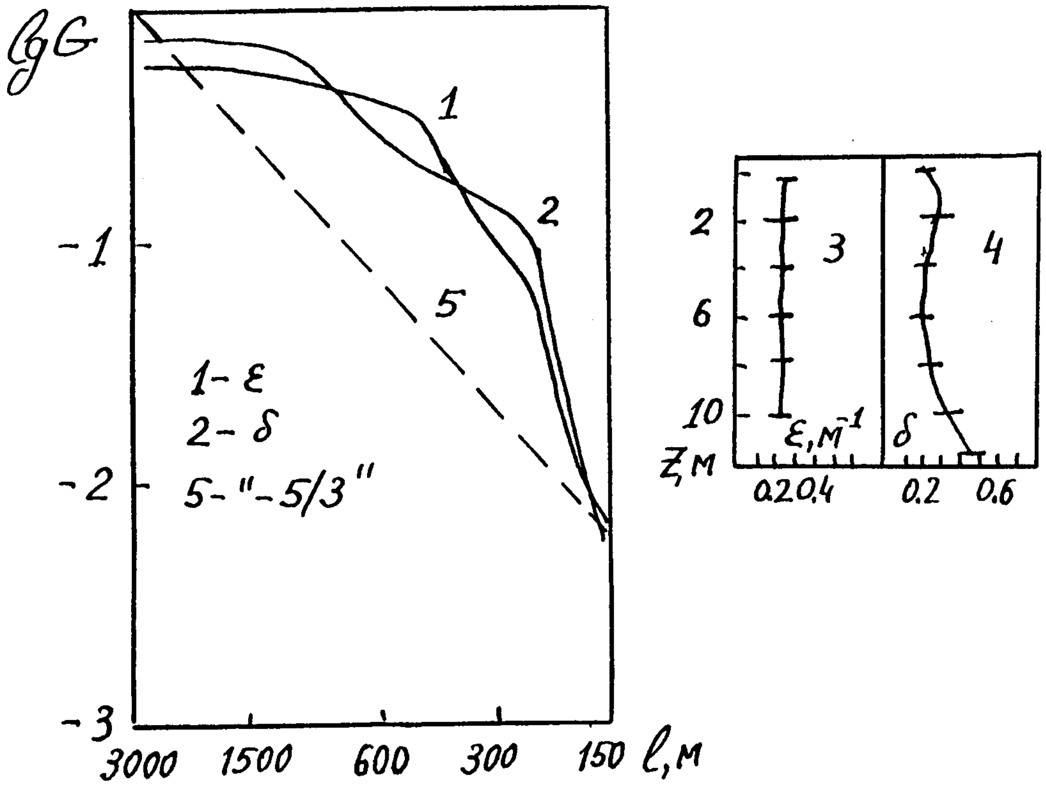
z, м
ε, м^-1
δ
0.2
0.4
0.2
0.6
3
4

Fig. 1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z, м
ε, м^-1
δ
0.2
0.4
0.2
0.6
3
4

Fig. 2

of the extinction coefficient and depolarization ratio fluctuations are shown by curves *1* and *2*. Here l are the spatial wavelength considered as arguments for the spectra G. Curves *3* and *4* show the depth profils of the extinction coefficient and depolarization ratio averaged over the entire flight line 80 km. Standard deviations of these parameters are also indicated here. The spectra G_ε and G_δ have the inflection points at l_0 = 300 and 400 m, correspondingly.Curve *5* shows the power-low decay of the fluctuations with a power of -5/3. Figure 2 was obtained for clear water in the central part of the Lake at distances 10-20 km from the shore. Designations are the same as in Fig.1. These spectra G_ε and G_δ have the inflection points at the spatial wavelenghts of 430 and 270 m, correspondingly. The extinction coefficient ε remains unchanged with depth while the depolarization ratio is less than in the previos case. Monotonic increase of the $\delta(z)$ profiles in both cases agrees with earlier obtained results published in Ref. 2 and testifies the absence of sharply pronounced submerged hydrosol stratifications.

The problem of interpretation of the spectra $G_\varepsilon(l)$ and $G_\delta(l)$ is more difficult; nevetherless, it is of primary interest. The inflection points seen in these spectra testify the presence of definite light scattering structures within the water column. They have characteristic size 300-400 m. However, the rate of decay of the spectral power with decrease of spatial wavelengths deviates from the data currently available and from the well-know -5/3 low. In our measurements the power was equal to 0.6-1.2 before the inflection point and to 4-6.7 after it. Up to now we have not yet compared our results with the data of the other lidar groups. But in Ref.3 the power varied from 2.5 to 3.5, in Ref.4 it varied from 1.3 to 2.0. Gill[5] proposed a power of 1.7 for the basic thermodynamic characteristics, i.e., exactly -5/3 low.

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