# INVESTIGATION OF CLOUDS SPATIAL DISTRIBUTION USING GROUND-BASED LIDAR

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Certain investigations of spatial distribution of clouds by employing ground-based lidar are presented.

The great changeability is one of the main properties of the clouds in the boundary layer. As a result, their optical properties change rapidly which complicates the modelling of cloud evolution/1/. Suitable equipped lidars are widely used for diagnostics of the clouds via a number of scattering and absorption processes. In particular, lidar can provide information on the distribution of meteorological parameters and of the other important cloud characteristics both in vertical and horizontal directions.

The well-known inhomogeneities in vertical direction might be accounted to a certain extent for heavy gradients of the meteorological parameters in the clouds. However in the case of $S_t$ and $S_c$ types those gradients are negligible in the horizontal direction /2/ and nevertheless certain inhomogeneities were found to exist.

In the represented work the time and spatial distribution of the aerosol backscattering coefficient of $S_t$ and $S_c$ clouds was investigated by means of a correlation analysis of the lidar-obtained data provided from several arbitrary directions and heights.

Similar measurements of the other cloud characteristics were conducted basically by means of air-planes /2,3/.

The three-beam lidar employed for the present investigation is a twenty-four-hour running computerized ground-based system /4/ using Q-switched second harmonic YAG:Nd$^{3+}$ laser of about 35 mJ with variable repetition rate from 1 to 10 Hz as the transmitter and a 0.15 m telescope as the receiver. The 64 K byte RAM computer controls the data acquisition system and stores the data on a floppy disc. The scheme of sounding is shown on Fig. 1.

The lidar designed at our institute permits time and spatial distribution of the aerosol backscattering coefficient close to the cloud base to be obtained and in the case of low density to be penetrated for a few hundred meters.

The results of the analysis are presented in the form of autocorrelation function curves computed from return signals which are proportional to the aerosol backscatterring coefficient value /5/. The time scales at half amplitude are determined. Different methods have been used hence to estimate the spatial dimensions: firstly, theodolite measurements of the wind velocity in the area of the cloud base, secondly, determination of the distance between remote located signal volumes in which the autocorrelation functions are still selfsimilar and thirdly, proceeding from the horizontal clouds motion velocity derived by using correlation techniques applied to the lidar returns. All three methods have led to similar results and can be used versus the lidar properties and the synoptic situation. The determined spatial dimensions locate areas in which the mean value of the aerosol backscattering coefficient is constant.

Fig. 2 shows three autocorrelation functions computed from data which have been simultaneously obtained from three space volumes at the same height H=360 m in case of $S_t$ clouds with thickness $\Delta H \backsim 100-150$ m on Nov. 11-th 1983. Proceeding from the determined wind velocity of 4-5 m/s the spatial dimensions have been estimated within 20 to 150 meters.

Fig. 3 shows autocorrelation functions related to $S_c$ clouds. The curve shapes are smoother than those from the $S_t$ clouds which points to more revealed details in stratus cumulus. In this case the mean spatial dimensions have been estimated within 380 to 580 meters.

Fig. 4 shows autocorrelation functions which conform to the data simultaneously obtained from four heights ($H_1$=200 m, $H_2$=225 m, $H_3$=250 m and $H_4$=400 m) in case of $S_t$ clouds. To simplify the drawing only curves bearing on one direction are shown (from other directions the picture is similar to that shown).

Autocorrelation functions derived from different heights in the clouds are in good agreement with the results of studies by air-planes which show that the low part of the clouds is considerably more inhomogeneous than their middle part. This fact might be visually seen when observing the cloud base (from below) which shows great changeability obviously caused by considerable turbulence. Apparently the lower degree of inhomogeneity of the middle part of clouds is conditioned by the so-called "retentive layer" located above the clouds /2/.

The shapes of the autocorrelation function curves (Fig. 2) might be related to the local microstructure of the $S_t$ clouds too. During the air-plane investigations of the local characteristics of stratus it had been found that the particle size changeability coefficient value was about 7-8 percent and the particle concentration changeability coefficient value ranged from 3 to 5 percent in the middle part of the $S_t$ clouds whereas in the low part those coefficients increased to a values of 25 and 60 percent respectively.

In conclusion it should be noted that the obtained lidar data contained information about the temporal and spatial changes of the cloud base and in certain cases (low density) of the cloud top as well. When wave motions have existed in the atmosphere their undulation characteristics like wavelength, amplitude, speed rate and height of display have been determined /4/.

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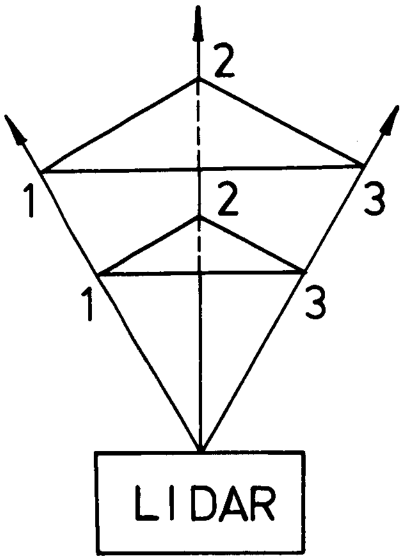


Fig.1

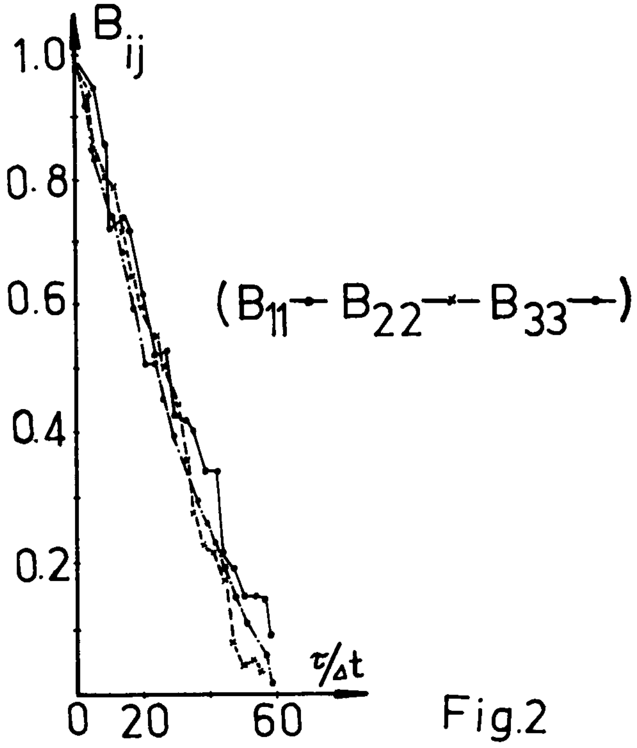
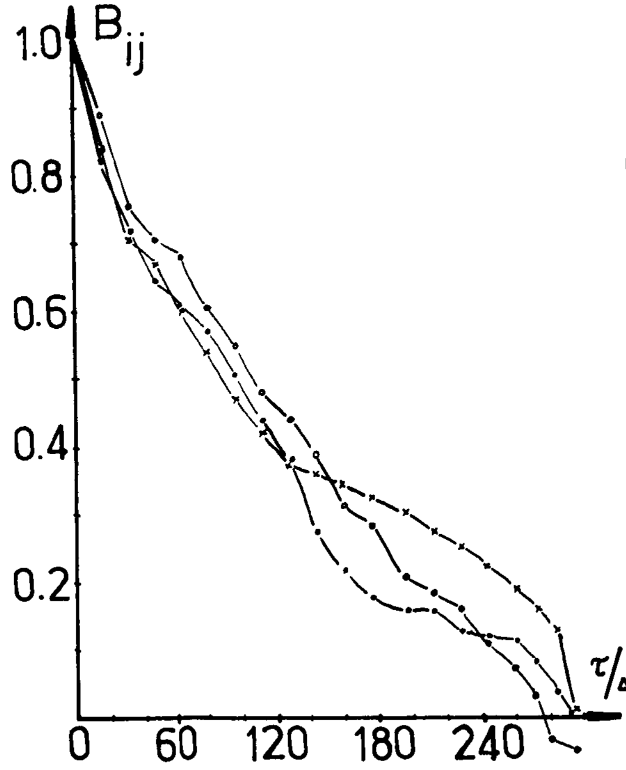


Fig.2



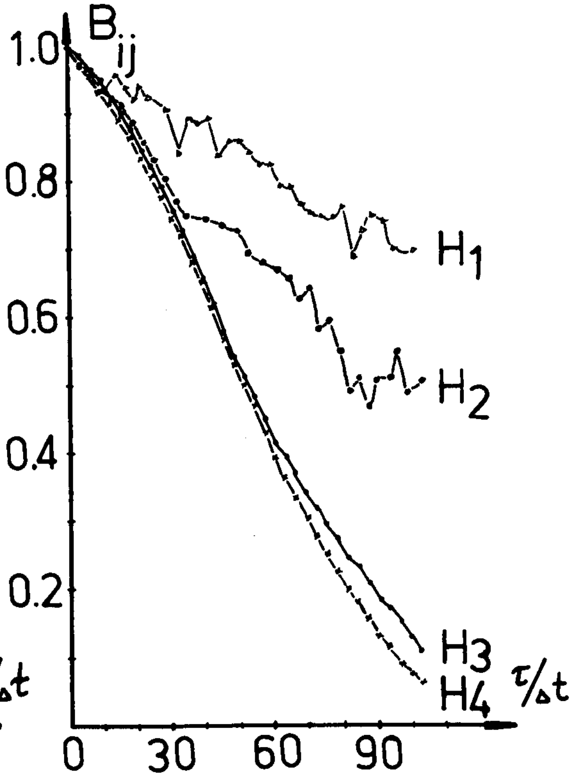


Fig.3 ($B_{11}$—•— $B_{22}$—×— $B_{33}$—∘—) Fig.4