REMOTE SOUNDING OF HYDROMETEORS WITH A POLARIZING LIDAR

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ABSTRACT

Hydrometeors are the main factor making the atmosphere turbid subjected to considerable changes and variations. Depending on the thermodynamic atmospheric conditions the hydrometeors produce various types of specific formation, i.e., clouds, mists, hazes and rainfall determining weather conditions. The shape of the particles forming them may be spherical and inhomogeneously unsymmetric, irregular for liquid and crystal water phases in the atmosphere, respectively. For the remote investigation of such media it is profitably to use the polarization method.

A polarizing lidar, completing usual lidars by the analysis of the state of polarization of the reflected field, enables to select the phase composition of water formations and to determine the zones of the multiple scattering influence for liquid media and, therefore, to take into account its contribution in the reflected pulse. The aim of the present paper is the conducting of the comparative analysis of the results of the field physical measurements followed by the microstructure analysis of the aerosol particles and the calculations obtained by numerical solution of the rigorous equation of radiative transfer in a vector form for the initial and boundary conditions corresponding to the experiment carried out. The investigation procedure consisted of transmitting a completely polarized light

pulse in the atmosphere and simultaneous reception of the signals reflected with orthogonal polarizations in the laser light polarization basis. Thus the values investigated were F_e and F_z, i.e., power of the base and orthogonal signal components, respectively. The ratio $d = \frac{F_z}{F_e}$ gives the value of the depolarization degree of the reflected beam.

For crystal objects in the atmosphere the value d can be changed within 0.3 ÷ 1 depending on the crystal shape and their sizes and it does not depend practically on the sounding depth. For fine crystals the depolarization is small. For liquid objects the coincidence of exact calculation with real measurements was obtained that confirm the correctness of the experiment procedure and that of the calculation algorithm. The difference in the behavior of the components F_e and F_z against the depth of penetration was discovered due to the influence of multiple scattering. As a rule, the radiation reflected from the front limit of a drop object is fully polarized, while propagating deeper the depolarization increases. The component F_z and the degree of depolarization are absolute and relative criteria of the multiple scattering level in a total signal of backscattering. The position of maximum F_z coincides approximately with the maximum value of contribution of multiple scattering. The observed time delay of F_z^{max} relative to F_e^{max} depends on the value of volume attenuation factor of a scattering medium. A satisfactory coincidence with the calculated values allows to see in this effect one more base for the diagnostics of optical density of clouds and mists.

At sounding of optically thick clouds on the base of the polarization processing of the signal the background level of multiple scattering can be taken into account or lowered, and thereby the applicability limits of the laser radar equation can be widened up to the optical thicknesses more than two.