LABORATORY MEASUREMENTS OF FORWARD AND BACKWARD SCATTERING OF LASER BEAMS IN WATER DROPLET CLOUDS

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Many aspects of the forward and backward scattering in dense water droplet clouds have been studied using a laboratory scattering facility. A summary of the results will be presented in this paper. This system is configured in a lidar geometry to facilitate comparison of the laboratory results to current lidar oriented theory and measurements. The backscatter measurements are supported with simultaneous measurements of the optical density, mass concentration and droplet size distribution of the clouds.

Measurements of the extinction and backscatter coefficients at several important laser wavelengths have provided data on the relationship between these quantities for our laboratory clouds at .633, 1.06, and 10.6μm. The results of the measurements have been used to test the approximations of Pinnick et al.[1] In addition, the effect of multiple scattering on the measured coefficients has been studied.

The polarization characteristics of the backscatter of 1.06μm have been studied using several different types of clouds. These measurements extend the results of Ryan et al.[2] The linear depolarization ratio has been shown to be very important in two respects:

1/ as a qualitative measure of the amount of multiple scattering in the measured backscatter

2/ as a sensitive indicator of the particle shape (ie. spherical versus irregular). This is an important result in the application of lidar measurements of the atmosphere where clouds may consist of either spherical droplets or irregular ice crystals

The use of spatial filtering in combination with the polarization measurements has greatly extended our understanding of the distribution of multiple backscattering radially about the incident beam. This has also helped define the polarization characteristics of the multiple backscatter. We have observed a radial distribution of the multiple backscatter which is Gaussian in form. This result agrees with previous observations by Ryan et al.[2] and Donchenko et al.[3] The addition of the polarization characterization to these measurements has helped define the radial dependence of the polarization in the backscatter.

Transmitted beam profile measurements have illustrated the broadening of the propagating laser beam profile due to scattering. This broadening has been observed to be very strong at 0.633 and 1.06μm but virtually non-existent at 10.6μm.

More recently, the laboratory facility has been modified to allow range-resolved backscatter measurements at 1.06μm. These measurements extend those described by Smith and Carswell.[4] In this case we can construct clouds made up of 3 layers, each with its own density. This allows the study of the effect of cloud inhomogeneity on the forward and backscatter.

References:

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