International Laser Radar Conference, Sendai, Japan, 1994.

HIGH SPECTRAL RESOLUTION LIDAR MEASUREMENTS OF MULTIPLE SCATTERING.

59-47
71215

E. W. Eloranta and P. Piironen
University of Wisconsin
1225 W. Dayton Street, Madison, Wisconsin 53706, USA
Phone: 608-262-7327 Fax: 608-262-5974
Email: eloranta@lidar.ssec.wisc.edu, paivi@hsrl.ssec.wisc.edu

Calculations show that the multiply scattered lidar signal is strongly dependent on: 1) the angular Field Of View (FOV) of the receiving telescope, 2) the small angle forward peak in the scattering phase function and 3) the scattering cross section profile in the cloud. If the scattering cross section profile can be measured, multiple scattering measurements may allow measurement of the forward diffraction peak width. This would provide particle size information. Traditional aerosol lidar systems do not provide sufficient information to measure the extinction or backscatter cross section without using assumed relationships between the backscatter and extinction cross section. A boundary value specifying the extinction at one point in the cloud is also required.

The University of Wisconsin High Spectral Resolution Lidar (HSRL) provides unambiguous measurements of backscatter cross section, backscatter phase function, depolarization, and optical depth[1,2]. This is accomplished by dividing the lidar return into separate particulate and molecular contributions. The molecular return is then used as a calibration target. We have modified the HSRL to use an I_2 molecular absorption filter to separate aerosol and molecular signals[2]. This allows measurements in dense clouds. Useful profiles extend above the cloud base until the two-way optical depth reaches values between 5 and 6; beyond this, photon counting errors become large. The spectrometer channels have a 0.16 mr FOV; the small FOV suppresses multiple scattering errors in the retrieved optical parameters.

In order to observe multiple scattering, the HSRL includes a channel which records the combined aerosol and molecular lidar return simultaneously with the spectrometer channel measurements of optical properties. The angular field of view of this Wide Field Of View (WFOV) channel is controlled by the system computer and it can be adjusted from 0.22 mr to 4 mr. This channel is rapidly sequenced between several aperture sizes to record the FOV dependence of the lidar return. The system calibration and signals recorded in the spectrometer channels are sufficient to allow removal of the molecular return from the WFOV signal. The depolarization of light received in the WFOV channel is also measured.

HSRL measurements from a water cloud are shown in figure 1. The lidar returns in the WFOV channeldivided by the return in the 0.16 mr spectrometer channel are plotted. The measured backscatter cross section profile is also shown. The increased contribution of multiple scattering with increased field of view is easily seen.

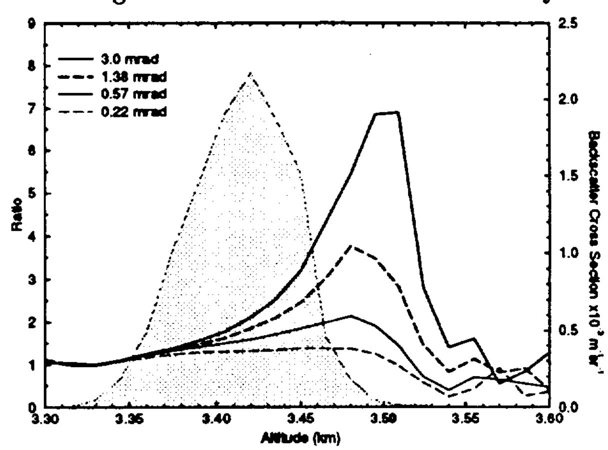

Figure 1. Ratios of the WFOV signals to the signal in the 0.16 mrad spectrometer channel. WFOV acceptance angles of 0.22, 0.57, 1.38 and 3.0 mrad are shown. The backscatter cross section is shaded.

This paper describes HSRL multiple scattering measurements from both water and ice clouds. These include signal strengths and depolarizations as a function of receiver field of view. All observations include profiles of extinction and backscatter cross sections. Measurements are also compared to predictions of a multiple scattering model based on small angle approximations.

Acknowledgements

This work was supported by grants from the Office of Naval Research (N00014-91-J-1558) and the National Aeronautics and Space Administration (NAG-1-882).

References

1. Grund, C.J., and E.W. Eloranta, 1991: University of Wisconsin High Spectral Resolution Lidar, *Optical Engineering*, **30**, 6-12.
2. Piironen, P, and E. W. Eloranta, 1994: Demonstration of an iodine absorption filter based high spectral resolution lidar, *Optics Letters*, **19**, 234.