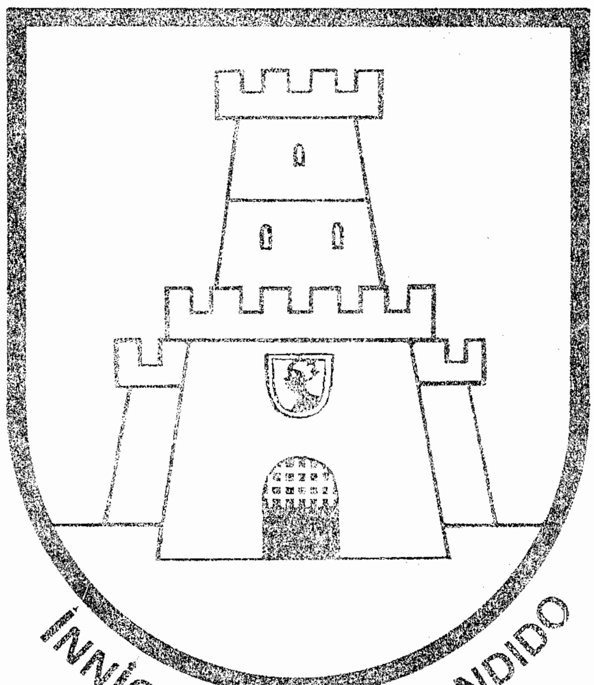
INTERNATIONAL LASER RADAR CONFERENCE

CONFERENZA INTERNAZIONALE LASER RADAR



INNICHEN–SAN CANDIDO

ITALY

# PROGRAM

# RAMAN AUGMENTATION FOR RAYLEIGH LIDAR

W.P. Moskowitz, and G. Davidson, Photometrics, Inc.*

D. Sipler, C.R. Philbrick, and P. Dao, Air Force Geophysics Lab

Raman detection has recently been added to the Air Force Geophysics Laboratory's ground-based lidar system (GLEAM) to augment that system's Rayleigh lidar measurements. In this paper we examine the possibilities of using the Raman measurements to self-normalize, and downwardly extend, our measurements of stratosphere and lower mesosphere molecular density.

Rayleigh lidar is a proven tool for measuring relative molecular densities in the stratosphere and lower mesosphere. When absolute density measurements are needed, however, the utility of lidar as a self contained remote sounder has been frustrated by the need to normalize data to balloon rawinsondes. The normalization compensates for the variable, and unknown attenuation in the lower atmosphere (up to ~20 km).

By combining inelastic (Raman) and elastic (Rayleigh plus Mie) scatter measurements, one can isolate the Mie component of the scattering using the techniques of Cooney, et.al.[1] and correct the data to eliminate the effects of atmospheric attenuation. At the wavelengths of our measurements (doubled and tripled Nd:YAG) Mie scattering is the dominant cause of attenuation. Extinction is derived from the Mie backscatter signal via the Klett inversion technique. This technique assumes a relationship between Mie backscatter and extinction which is constant with range. For cloudless conditions, under which the GLEAM system is usually run, small particles are responsible for Mie scattering and the Klett assumption is justified. (Particles with dimensions comparable to or less than the wavelength of the laser light are small for this application).

Molecular density profiles result from compensating the lidar backscatter returns for the derived extinction. The compensated elastic and inelastic profiles complement each other in range of usefulness: At high altitudes where Rayleigh scattering dominates, the elastic scattered return is a good measure of density. For these data, the extinction compensation is merely a multiplicative factor to account for the total attenuation of the lower atmosphere.

A unique characteristic of the GLEAM lidar is the simultaneous measurement of the green and ultraviolet elastic backscatter. The ultraviolet return, which has a larger ratio of Rayleigh to Mie backscatter, serves as an indicator of significant Mie scattering in the green return at lower altitudes. Using extinction compensation, the ultraviolet measurement can extend the molecular density profile downward.

At still lower altitudes where even the elastic ultraviolet return is obscured by Mie

[1] J. A. Cooney, J. Orr, and C. Tomasetti, "Measurements Separating the Gaseous and Aerosol Components of Laser Atmospheric Backscatter", Nature, 224 (1969)

*This work was sponsored by Air Force Geophysics Lab.

backscattering, the inelastic Raman data provides a more accurate measurement of molecular density. The Raman data are corrected for a degree of attenuation which increases with altitude. The entire density profile would preferably be derived only from the Raman data, but the Raman cross section is three orders of magnitude smaller than the Rayleigh cross section resulting in negligible Raman return from high altitude.

Examples of preliminary data are shown in the following figures:

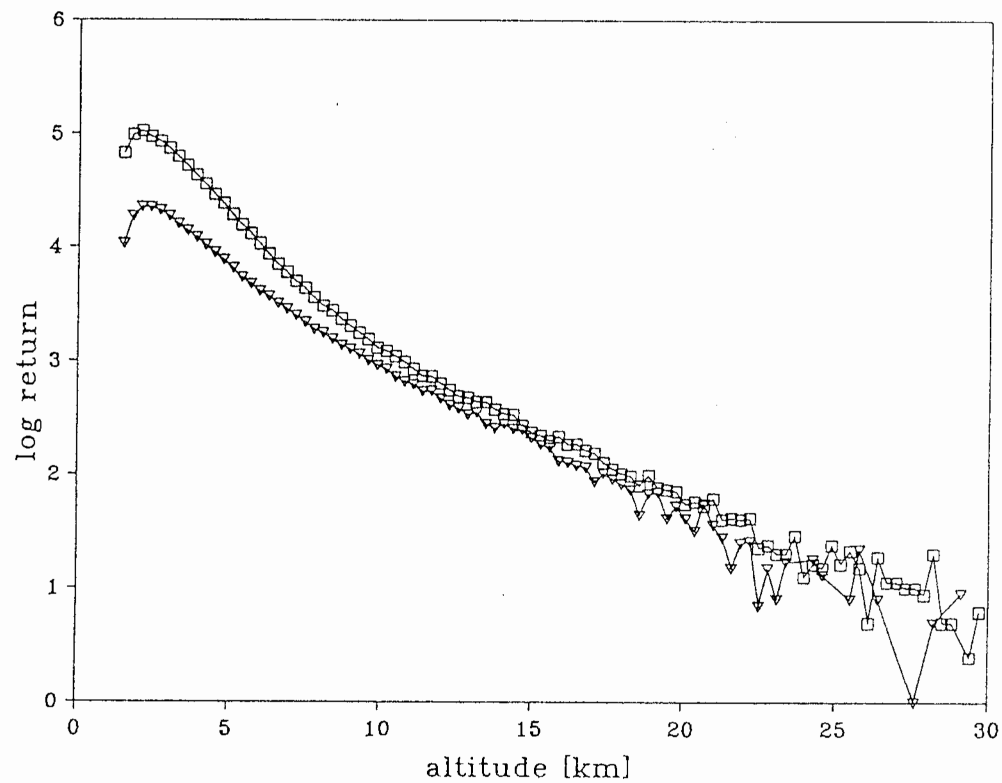



Figure 1: Lidar returns: elastic(Rayleigh and Mie) signal at 355 nm □; Raman $N_2$ signal at 386 nm ▽.

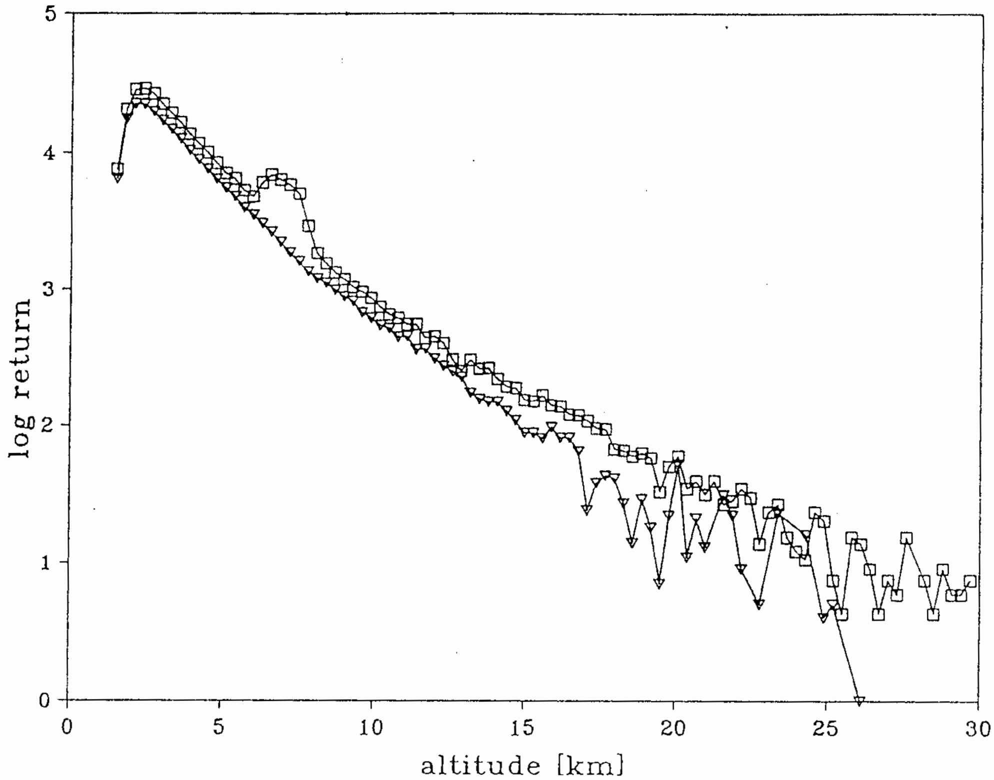



Figure 2: Lidar returns with thin cloud: elastic(Rayleigh and Mie) signal at 355 nm □; Raman $N_2$ signal at 386 nm ▽.