N87-10353

CLOUD DETECTION BY LIDAR EXTINCTION CALCULATIONS

W. J. Lentz
Naval Postgraduate School, Physics Dept Code 61
Monterey, California, U.S.A.

A new lidar method of measuring cloud ceiling height using the Klett solution to the lidar equation has been developed. This simple technique will find cloud ceiling heights for clouds that rangefinder-like lidars cannot theoretically detect. In addition, the noise signals that do not correspond to clouds are removed by using the convergence of the Klett solution to discriminate between transient signal changes and broader signal changes due to clouds. Clouds above rain or light fog can be detected without error, and it is possible to discriminate against haze layers by the magnitude of their maximum extinction.

Not all lidar returns from clouds produce an abrupt increase in the scattered signal like that associated with the return from a hard target. In many cases, there is not clear air between the cloud and the ground, and the extinction increases slowly with altitude rather than abruptly. In many cases a light haze or fog may be associated at low altitudes with the cloud layer. An example of the type of lidar return that may occur from such a cloud is shown in figure 1.

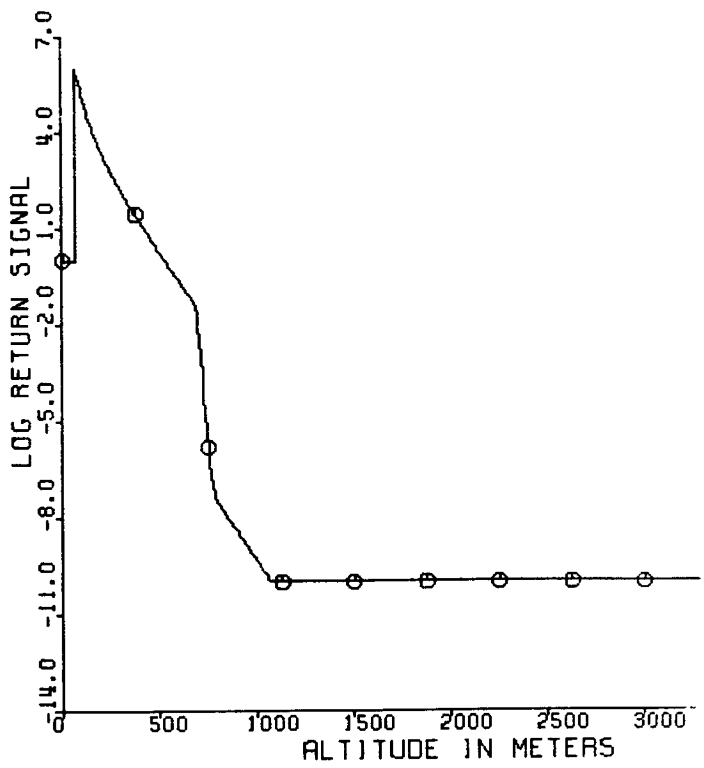

Figure 1. Theoretical Lidar Return from Opaque Cloud Layer

The lidar return was calculated by assuming a vertically pointing lidar that is firing into a totally opaque cloud of extinction similar to that obtained by independent measurements. It should be emphasized that the lidar return does not exhibit an abrupt increase such as that associated with a target anywhere along the path. Instead, the lidar return shows a rather marked decrease in backscattered signal when it strikes the cloud, and the scattered signal drops till it reaches an assumed minimum noise floor. The extinction from which this lidar return was calculated is shown in figure 2. The peak value of extinction is 30 kilometer, and the cloud is totally opaque to the eye.

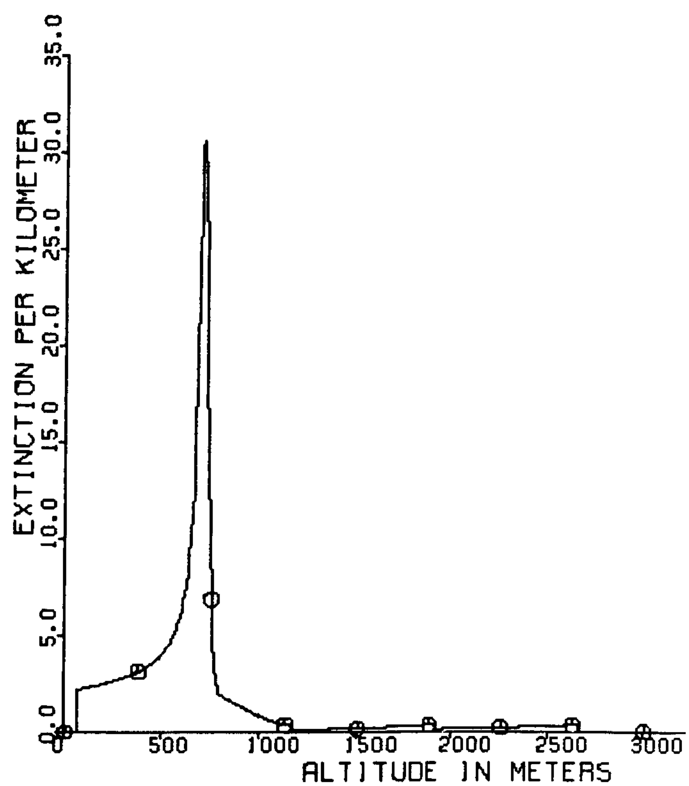

Figure 2. Theoretical Extinction Producing No Increased Lidar Return

Figure 3 shows experimental data obtained by a hand held lidar in Cardington, England in 1982. The solid line was calculated from aerosol size distributions measured by a balloon borne particle counter that slowly ascended while the lidar made several vertical shots. Each triangle corresponds to the extinction extracted from the lidar return at the altitude that the balloon was measuring aerosols. The extinction from each aerosol size distribution at a given altitude was calculated from Mie scattering theory.

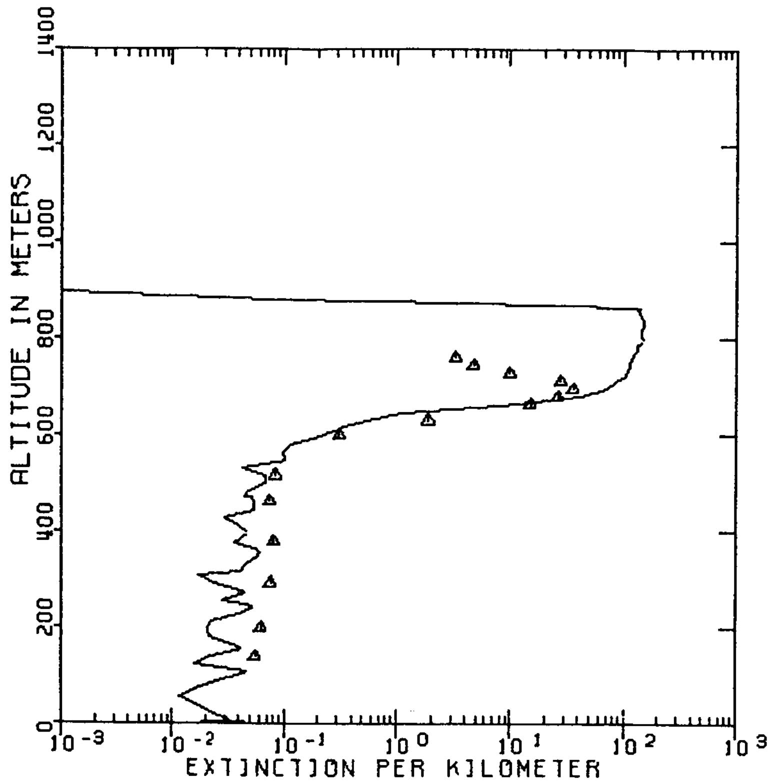

Figure 3. Comparison of Lidar and Particulate Measured Cloud Height

The agreement between the balloon extinctions and the lidar extinctions is very good, and the difference in altitude at which the cloud begins is very small. The fall of the lidar extinction in the cloud is due to the convergence of the extinction in the Klett method when a smaller boundary value than the actual value is put in the solution. This same convergence is used to eliminate false convergence to 'spikes' in the return that might be caused by rain or noise as the signal decreases.

J.D. Klett, "Stable Analytical Inversion Solution for Processing Lidar Returns," Appl. Opt. 20,211 (1981).

J.D. Lindberg et al, "Lidar Determinations of Extinction in Stratus Clouds," Appl. Opt. 23(13) 2172-2177, 1 July 1984.