FUNDAMENTAL LIMITS, ERRORS AND SIGNAL PROCESSING IN DIFFERENTIAL-ABSORPTION LIDARS

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ABSTRACT

Differential-absorption lidar systems have been proposed for remote monitoring of a variety of gaseous materials in the atmosphere. In order to determine the performance level that can be achieved with this type of lidar system, the fundamental limitations on the ultimate system performance must be determined. This is especially true if comparisons are to be made between the differential-absorption lidar and other remote-sensing techniques because the fundamental limitations for these various techniques differ and will result in diverse performance limitations under various operation conditions. These differences will result in an operating regime for each technique in which the benefits of that technique are maximized with respect to the other available techniques.

The purpose of this paper is to present a comprehensive listing of fifteen fundamental limitations, and their effects, pertinent to differential-absorption lidar remote measurements. These limitations may be due to the characteristics of the material to be monitored, the intervening atmosphere including both naturally-occurring and pollutant interfering materials, or to the system hardware itself. The errors caused by six of these limitations have been described previously by Schotland (Ref. 1) in relation to a ruby-lidar, water-vapor monitoring system. Infrared systems, or systems sensing other materials, can be subject to other limitations that have not been discussed in the literature even though these limitations have significant effects on the total system performance.

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1. R. M. Schotland, "An Error Analysis of the Differential-Absorption Technique", Fifth Conference on Laser Radar Studies of the Atmosphere, June 4 - 6, 1973, Williamsburg, Va.

The effect of each of these fundamental limitations will be discussed in terms of its effect on the minimum detectable material concentration, maximum range limitations or concentration measurement error. It should be noted that each of these fundamental limits does not effect all of the system performance characteristics in an equal way. The differences in effect for each fundamental limitation will be emphasized and the specific effects on system performance will be described.

Finally, the signal processing method used in the system will also effect the system performance. Signal processing methods will be presented, which minimize the effect of these error-producing processes and result in the best available performance for differential-absorption lidar systems.