MEASUREMENTS OF SLANT VISIBILITY BY DIFFERENT METHODS

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ABSTRACT

Measurements of slant visibility are becoming allways of greater interest especially for landing facilities at airports. Lidar techniques seem to be particularely interesting in this field and allready many authors have worked on this subject (1,2,3).

Up till now the results have not been completely satisfactory since the application of different methods in the determination of visibility has given rise to different results, with great discrepances between them as we shall show in this paper. Especially difficult seems the measurement of visibility under bad weather conditions, such as during rainfall, snow, and more generally when the aerosol cannot be considered homogeneous.

Measurements have been carried out during February and March 1974 under different weather conditions. The lidar data obtained with the DFVLR lidar system IV have been elaborated considering the different models existing. The investigated methods were:

1) The so called "slope method" whereby the backscattering coefficient $\beta(R)$ is considered as constant, and for which the visibility V_m yields:

$$V_m = -\frac{7.824 \times \Delta R}{\Delta \ln \left(UR^2\right)}$$

where U denotes the received signal, ΔR the interval in which visibility is beeing measured, and R the range.

2) An iterative method where an initial value of the visibility at a distance R_o must be given. From this $\sigma(R_o)$ is obtained and therefore the backscattering coefficient $\beta(R_o)$,holding a relation $\sigma = k\beta$. Placing such value in the lidar equation and solving this for $\sigma(R)$,the new visibility can be computed.

3) We calculated the expressions

$$\sigma(R) = \exp 0.15 \left\{S(R) - S(R_o)\right\} \cdot \left[\frac{1}{\sigma(R_o)} - 1.3 \int_{R_o}^{R} \exp 0.15 \left\{S(R) - S(R_o)\right\} dR\right]^{-1}$$

where

$$S(R) = 10 \log \frac{U(R) \cdot R^2}{U(R_o) \cdot R_o^2}$$

Also in this case a known value of $\sigma(R_o)$ must be given at range R_o.

We have also measured at night slant visibility processing Raman N_2 echos. The Raman method consists in comparing the signals received by the two telescopes of DFVLR lidar System IV. One of the telescopes detects the aerosol echo, the other the Raman echo. The ratio of the two echos gives:

$$\frac{U_1(6943)}{U_2(8280)} = \frac{K\beta_A}{\beta_R} \exp\left\{-\int_0^R \sigma_A(6943)\,dR + \int_0^R \sigma_A(8280)\,dR\right.$$

where β_A and β_R are respectively the aerosol and the Raman backscattering coefficients. For a visibility lower then 5 km we can consider $\sigma_A(6943) = \sigma_A(8283)$ .Therefore

$$\frac{\beta_R\ U_1(6943)}{K\ \ U_2(8280)} = \beta_A = K'\sigma = \frac{K''}{V_m}$$

and the visibility can be computed. The results have been compared, it appares evident that various models give rise to different results. The discrepances between the different methods are very high, up to two orders of magnitude. In many cases especially when the visibility conditions are more severe, many of these models do not even allow to calculate a visibility.
The cause of the great discrepances between the results may be due to the fact that the basic equation from which all the methods take the move is the lidar equation which does not account for multiple scattering.

[1] Viezee,Oblanas,Collis:Lidar evaluation of fog dissipation techniques, Feb.1973,AFCRL-TR-73-0052.

[2] Hagard:Slant visibility measurement with lidar, May 1972, FOA 2 rapport A-554-E1

[3] Lifsitz,Ingrao:Two candidate system for unmanned fog bank detection, Report No. DOT-TSC-CG-71-3