Reply

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This author appreciates the comments of Brown regarding the discussion of the ratio method appearing in a paper concerning the interpretation problem encountered in lidar transmissometers which utilize backscatter from the particles of an obscuring atmospheric dispersion (Kohl, 1978).

In that paper the reference to Brown's earlier work (Brown, 1973) appearing near Eq. (10)[1] was misleading. This reference should have been made in an enlarged discussion of (11) since Brown (1973) did indeed state that the ratio method should be restricted to homogeneous dispersions where $d\beta/dr$ is zero. (The symbol β stands for the backscatter coefficient and r is the distance along the lidar beam.) However, the experimental results which Brown cites (Brown, 1973) and which were obtained by using the ratio method are inconsistent with $d\beta/dr$ being negligible.

Let us note before proceeding that one should not rely on the ratio method unless there is information to indicate quantitatively that the dispersion being probed is very probably sufficiently homogeneous for the results to be useful. If one has such information and utilizes the ratio method to obtain an experimental value of the attenuation coefficient σ in adjacent incremental distance intervals Δr, self-consistency requires that the first term of (10) involving $d\beta/dr$ be negligible with respect to the second term, which is σ. Eq. (10) is

$$\text{“}\sigma\text{”} = -\tfrac{1}{2}\beta^{-1}\frac{d\beta}{dr}+\sigma, \tag{10}$$

where "σ" is the value of σ obtained by the ratio method. Given the tendency for the ratio β/σ to be somewhat constant within a dispersion of a given type, a reasonable estimate of the first term in (10) should be the first term in (11) as discussed by Kohl (1978). This estimate of the first term is $-\frac{1}{2}\sigma^{-1}\, d\sigma/dr$. With Δ"σ" defined as the difference between the values of "σ" found by the ratio method in two adjacent incremental distance intervals Δr, Δ"σ"$/\Delta r$ should be somewhat typical of $d\sigma/dr$. If, with Δr much smaller than σ^{-1} (as it should be), Δ"σ" is found to be of the order of "σ", as in the results of Brown (1973), the first term in (11), *nee* (10), cannot be small compared to σ and the "σ" found by the ratio method will not be the actual attenuation coefficient.

One should note that for the transmittance (transmission) over a path to be obtained from the ratio technique without error in the principle, β at the endpoints of the path in question must be the same [see Eq. (12)]. However, behavior of β *along* the path can be arbitrary. The backscatter coefficient β may be constant over much of the path, but this is to no effect, as it is only the endpoint values of β which come into play. This is because only the return signal contributions from the two endpoints (a and b) of the path contribute to the transmittance result, "T_{ab}," obtained by the ratio method. Indeed, one could avoid any accumulative experimental error in the integral encountered in using

$$\text{“}T_{ab}\text{”} = \exp\left(-\int_{r_a}^{r_b} \text{“}\sigma\text{”} dr\right)$$

and just use

$$\text{“}T_{ab}\text{”} = \left[\frac{r_a^2 R(t_a) F(r_b)}{r_b^2 R(t_b) F(r_a)}\right]^{\frac{1}{2}}$$

in applying the ratio technique, where the notation is that of Kohl (1978).

Regarding application of the ratio technique to the slant visual-range problem (involving transmittance measurement over a path from the runway level to the decision point on the aircraft glide slope) in fogs which are homogeneous horizontally, it should be mentioned that one would probably like to have a technique which could handle situations where the fog top occurs under the decision point, or the fog bottom occurs between the decision point and the runway level, or one or more fog layers occur between these two heights.

Eq. (12),

$$\text{“}T_{ab}\text{”} = \left[\frac{(\beta_a)}{(\beta_b)}\right]^{\frac{1}{2}} T_{ab}, \tag{12}$$

indicates that a check of the applicability of the ratio

[1] Equation numbers refer to the equations in the paper of Kohl (1978). These equations are given the same numbers here.

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method to transmittance measurement in given circumstances can be done by comparing the backscatter coefficient at the beginning and end of the path over which the transmittance measurement is done. Note that (12) comes directly from (10) without any relation assumed between β and σ, e.g., (5).

This author has no quarrel whatsoever with the idea of applying the ratio technique (or the slope technique) where one is sufficiently sure that adequate homogeneity exists, for whatever task is at hand. Such might occur along a horizontal path in coastal fog formed by lowering coastal stratus, especially in the denser fogs of this type. One must be quantitatively sure that adequate homogeneity exists with adequate probability of occurrence, and one cannot rely solely on the lidar return signal from the atmospheric dispersion to determine this.

REFERENCES

Brown, R. T., Jr., 1973: A new lidar for meteorological applications. *J. Appl. Meteor.*, 12, 698–708.

Kohl, R. H., 1978: Discussion of the interpretation problem encountered in single-wavelength lidar transmissometers. *J. Appl. Meteor.*, 17, 1034–38.