Comments on "An Atmospheric Dust Fall Experiment"

K. D. HAGE

The Travelers Research Center, Inc., Hartford, Conn.

14 May 1964

In a recent note by Csanady (1964), the statement is made that ". . . the maximum crosswind-integrated deposition rate should occur where the center of the 'cloud' reaches the ground, i.e., at a distance of

$$\chi_m = \frac{Uh}{f}, \tag{1}$$

where U is mean wind speed, f free falling speed and h the height of emission." The author then notes that the observed maximum was found at roughly half this distance.

Even if one is reluctant to accept the predictions of various particle dispersion models (see, for example, Godson, 1958; Hage, 1961b) that the maximum crosswind-integrated deposit should be found closer to the source than the position given by (1) as a consequence of eddy diffusion in the vertical, the possibility of such behavior can be seen from the geometry of the crosswind-integrated plume.

Unauthenticated | Downloaded 09/27/22 08:58 PM UTC

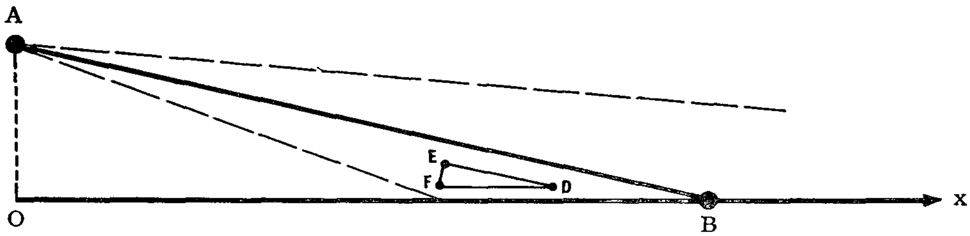

FIG. 1. Schematic diagram of time-averaged, crosswind-integrated falling particle plume.

Fig. 1 shows an idealized time-averaged, crosswind-integrated plume centerline AB for falling particles from a continuous point source at A and two mean trajectories that outline the diverging plume. Variations in crosswind-integrated concentration in the direction of the mean wind along a horizontal segment DF may be viewed as the sum of variations along a segment DE parallel to the plume centerline and variations along a segment EF normal to this line. For distances x near but less than OB, the segment DE will be near the centerline and the increase in crosswind-integrated concentration from D to E, approaching the source, may exceed the decrease from E to F. In this event, if the deposition rate is proportional to concentration, it will increase at first as we proceed from B to 0. For smaller values of x, however, the plume boundary will ultimately be reached and concentration will decrease along both segments DE and EF. The magnitude of the difference between point B and the point of maximum deposition rate will depend not only on the ratio Uh/f in (1) but also on the degree of vertical spreading of the plume. The degree of vertical spreading can be substantial for the time-averaged plume from a continuous source because of contributions due to meander and looping under neutral and unstable conditions.

The observed distance to the position of maximum crosswind-integrated deposit found by Csanady agrees rather well with previous results for 100 μ diameter glass spheres emitted under approximately neutral stability conditions (Hage, 1961a). The earlier work contained a check on wind speed and fall speed values, and it is quite unlikely that the differences between the observed positions of peak deposit and those given by (1) were due to errors in U and f. The check consisted of data from trials conducted under strong inversion conditions when turbulent dispersion was at a minimum. Under these conditions, the observed positions of peak deposit agreed reasonably well with (1).

It should be noted that a distinction must be made between the median and modal deposit values. If mean vertical motions are absent (1) yields a minimum estimate of x_m for the position of *median* crosswind-integrated deposit. The position of modal deposit, however, may be closer to the source than x_m.

The use of elevated collection surfaces in experimental studies of this nature may result in serious errors even in the assessment of relative particle numbers. The gross effects of wind on such samples have been studied in the wind tunnel (Gregory and Stedman, 1953) and in the atmosphere (Hage, Diehl and Dudley, 1960).

The shortcomings of the fluorescent dye technique referred to by the author were found also in the previous experimental work. However, in view of the agreement between observed deposits under strong inversion conditions and those predicted by a fallout model containing only the dispersive effects of fall speed and horizontal wind speed variance, it seems unlikely that the dye particles seriously altered the fall speed of the beads. In view of the high total recovery values (ratio of mass accounted for by sampling to mass emitted at the source) in the experiments, considerable confidence was placed in the absolute deposit densities. In later experiments with 50 μ beads, however, this dye technique was abandoned due to difficulties in counting the imperfectly coated beads. Particles prepared with a relatively complete and uniform coat of dye by the Minnesota Mining and Manufacturing Company were utilized.

REFERENCES

Csanady, G. T., 1964: An atmospheric dust fall experiment. *J. atmos. Sci.*, 21, 222–225.

Godson, W. L., 1958: The diffusion of particulate matter from an elevated source. *Archiv Meteor. Geoph. u Bioklim., Ser. A*, (4) 305–327.

Gregory, P. H., and O. J. Stedman, 1953: Deposition of air-borne lycopodium spores on plane surfaces. *Ann. appl. Biol.*, **40**, 651–674.

Hage, K. D., 1961a: Description and test of a model for the deposit of particulates from an elevated source. Suffield Tech. Paper No. 217, Suffield Experimental Station, Ralston, Alberta, 19 pp.

——, 1961b: On the dispersion of large particles from a 15-m source in the atmosphere. *J. Meteor.*, 18, 534–539.

——, C. H. H. Diehl and M. G. Dudley, 1960: On horizontal flat plate sampling of solid particles in the atmosphere. *A. M. A. Archive. Ind. Health*, **21**, 124–131.

Unauthenticated | Downloaded 09/27/22 08:58 PM UTC