Anfossi (1985) presents an analysis of plume rise data for plants with two or more stacks. His paper extends earlier work (Overcamp 1982) by examining final rise under stable conditions and cases with unequal stack height. His comparisons of the TVA data to the calculations of his enhancement model are a contribution to our understanding of enhanced rise.

This discussion is written to offer a different analysis of the TVA data to determine whether the plume rise enhancement is a function of the number of stacks, N, and the azimuthal angle between the direction of the wind and the line of stacks, \( \phi \). Since Overcamp and Ku (1988) have presented a similar analysis for the “two-thirds” rise law regime, this analysis will be restricted to the data on final rise under stable conditions.

For the discussion, a data point is defined as an \((x, z)\) pair that represents the average plume rise, \(z\), at a given distance downwind, \(x\). An observation is defined as the set of data points for a given period.

This analysis is limited to those TVA data given by Crawford and Coleman (1979a, 1979b, and 1979c) which are classified as final rise values under stable conditions. The criterion to determine the data were in the final or leveling phase was the same as adopted by Anfossi: \(x > 2u(s)\sqrt{g}\), where \(u\) is the mean wind speed and \(s\) the stability parameter. Furthermore, the data are from Anfossi’s class A. This restricts data to those cases with equal stack height and with buoyancy fluxes from the individual stacks within \(\pm 30\%\) of the average buoyancy flux, \(F_b\). For each data point, an enhancement factor was computed using the formula:

\[
E = z/[2.6F_b/(us)^{1.3}],
\]

in which \(F_b\) is the average buoyancy flux for a single stack. For each observation, the enhancement factors were averaged to give a single value of the enhancement factor for the observation period.

In Anfossi’s Table 3, there were 137 data points in this final rise, stable category. In my analysis, there were 148 data points from 40 separate observations. Although I attempted to use the same criteria in data selection as Anfossi, my set is slightly larger and it probably includes two or three more observations than Anfossi’s data. In addition, \(126^\circ\) is used as the azimuthal angle for the line of stacks for the Shawnee plant (Carpenter et al. 1968; Thomas et al. 1969; J. H. Coleman, personal communication) rather than \(118^\circ\) that was listed in Crawford and Coleman (1979a). This small difference would only shift a few of the Shawnee data points among Anfossi’s angular categories, and probably make only small changes in his results.

A common method of plume rise data presentation is to plot individual \((x, z)\) pairs in a dimensionless fashion. This method was used by Anfossi and also by Overcamp (1982). It is useful in determining whether data follow a particular model such as the two-thirds law or whether the plume’s trajectory levels off at far distances downwind. An alternative approach is to compute a parameter for each observation and to plot it versus various independent variables. This approach has been taken by investigators such as Fay et al. (1970), Wright (1977), and Overcamp and Ku (1986) for data from single plumes and by Overcamp and Ku (1988) for plume rise enhancement studies.

The two methods give different weight to observations with unequal numbers of data points. For example, if one observation has one data point and another observation has five data points, plotting individual data points will give the latter observation five times the weight of the former, whereas plotting one value for each observation will give each observation equal weight. To avoid giving relatively too much weight to those observations with few data points, Overcamp and Ku (1986, 1988) arbitrarily chose to consider only those observations having at least three data points. In this analysis, observations with only one or two data points are considered, but they are plotted using open data points. Observations with three or more data points are plotted with closed data points.

Figure 1 shows the average enhancement factor for each observation plotted versus azimuthal angle. The
horizontal dashed lines are enhancement factors of unity. The two stack cases, all from the Gallatin plant, are given in Fig. 1a. These data do not show enhanced rise. The three stack cases, which are from the Allen and Colbert plants, are shown in Fig. 1b. The data from Allen, which have low values of $\phi$, have enhancement factors close to unity. The two observations from Colbert, which have large values of $\phi$, have larger enhancement factors. The cases with four, six, and seven stacks are given in Fig. 1c. Most of the four-stack observations, which are from Colbert, have enhancement factors above unity. The six-stack observations, which are from Shawnee, are scattered about unity. There is only one observation with seven stacks. Figure 1d gives the nine- and ten-stack observations which are from the Shawnee plant. In these cases, there is a larger number of observations. Except for some at large values of $\phi$, most have enhancement factors greater than unity. These data lend support to the hypothesis that rise enhancement is a function of the azimuthal angle.

A simple statistical analysis was performed. The data were pooled into groups with equal numbers of stacks in operation. Assuming that the errors in plume rise measurements are normally distributed, the one-sided Student’s $t$-test was used to determine if the average enhancement factors for the various groups were greater than unity. The result of this test showed that only the enhancement factors for the nine- and ten-stack cases were greater than unity at the 95% confidence level.

In summary, these TVA data do not offer conclusive evidence for rise enhancement in the final, stable regime except for the cases of nine or ten stacks in operation.

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