Comments on "Urban-Rural Differences in Tower-Measured Winds, St. Louis"

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The paper by Shreffler (1979) on comparison of wind data averages in a mesoscale network is interesting for several reasons. Perhaps the most useful reason has to do with something called "representativeness." Regulatory Guides (see OAQPS No. 1.2-096 Section 4.2) require measurements to be representative as well as valid and accurate but there is no standard method to quantify how one measurement represents another, let alone what an acceptable value might be. There is an implicit assumption that some stations represent urban conditions while others represent rural conditions. It would be interesting to see how much variation there is within each classification. The Appendix touches on this and Table A1 shows considerable variability (roughly the same magnitude as shown in Table 3 which reports subsets of averaged classification ratios).

The most interesting reason for commenting on this paper has to do with wind averaging in general. Shreffler is to be commended for clearly describing the way the data were handled to create the data base on which his analysis is based. It is important tc match the averaging technique to the application of the average. For example, if the average wind speed is to be used as $\bar{u}$ in simple Gaussian plume models, the 1 min samples of 1 min average speed u_i should be averaged as follows:

$$\bar{u} = \left[\left(\frac{1}{N}\right)\sum_{i=1}^{N}\frac{1}{u_i}\right]^{-1} \quad \text{or} \quad \frac{\bar{1}}{u} = \left(\frac{1}{N}\right)\sum_{i=1}^{N}\frac{1}{u_i}.$$

This averaging procedure can be shown to be appropriate for the initial dilution of material injected into the air stream. Diffusion meteorologists generally acknowledge initial dilution to be the function of $\bar{u}$ in the Gaussian plume model. In spite of the fact that this procedure is right, it is not used.

If the purpose of an analysis is to characterize the effect of an urban heat island on the flow field and if the averaging time must be as long as an hour, it might be more useful to use a simple scalar average or

$$\bar{u} = \left(\frac{1}{N}\right)\sum_{i=1}^{N} u_i.$$

One could speculate that the variability in 1 min samples (caused perhaps by roughness) when averaged vectorially could account for the ratios reported. MacCready (1966) calls the difference between the scalar average and the vector average a DP error. While the difference is clearly a function of data processing (DP) the characterization of it as an "error" is questionable and can be resolved only in the context of the proposed application of the average. As a simple straw man, assume a 5 m s^{-1} wind oscillating about 180° such that half the direction observations are 180° − $\Delta\theta$ and half are 180° + $\Delta\theta$, and let the angle change $\Delta\theta$ be 5, 30 and 45° as three cases.

	θ_{min} (deg)	θ_{max} (deg)	$\bar{u}$ (m s^{-1})	$\mathbf{u}$ (m s^{-1})	$\bar{\theta}$ (deg)		$\bar{s}$ (%)
Case 1	175	185	5	4.98	180	WS_r	
Case 2	150	210	5	4.33	180	WS	−13.1
Case 3	135	225	5	3.54	180	WS	−28.9

In this example, symmetrical about South, the **u** is obtained by

$$\mathbf{u} = \left(\frac{1}{N}\right)\sum_{i=1}^{N} u_i \cos\theta_i,$$

or simply $u \cos\theta$.

If Case 1 represented rural flow and either Case 2 or Case 3 were urban flow, the $\bar{s}$ calculated from vectorially averaged flow samples **u** would show apparent decreases not unlike the Table 3 values. Of course, this may be an extreme example. The necessarily greater variability of urban station winds may only account for part of the difference due to vector averaging.

It would be both useful and interesting to reexamine these data using scalar averaging for speed. Actually, the ratio $\mathbf{u}/\bar{u}$ is a useful index of variability and therefore one test to compare two stations in terms of representativeness.

REFERENCES

Shreffler, J. H., 1979: Urban-rural differences in tower-measured winds, St. Louis. *J. Appl. Meteor.*, **18**, 829–835.

MacCready, P. B., Jr., 1966: Mean wind speed measurements in turbulence. *J. Appl. Meteor.*, **5**, 219–225.

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