NOTES AND CORRESPONDENCE

Comments on "A Quality Control Program for Surface Mesonetwork Data"

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The purpose of this letter is to compliment Charles Wade on his excellent paper (Wade 1987) and to suggest a careful usage of the language of "quality" when the discipline of quality systems is applied to the science of meteorology.

To be specific, the title chosen by Wade suggests a quality control program for "gathering" surface meteorological data. What he gave us was an analytical procedure for "assessing" data validity, which can also be used to define more-likely values. If his procedure had been used early in the field program, with the discrepancies reported and acted upon, it would have been a valuable quality control tool. It is a valuable tool for users who must work with data from mixed and uncontrolled networks.

Careful definition and usage will keep the language of quality from becoming useless through generalization. A recently published standard, ANSI/ASQC Q90-1987, contains a figure (Fig. 1), which provides a context for the use of terms like quality assurance, quality control and quality systems. The standard suggests that a modifier be used with quality control to clarify what is being operationally controlled, e.g., measurement quality control.

Any organization—private, public or ad-hoc—will have some head. The head will set policy about the "quality management aspects" of the organization. More often than not this important first step to quality goals of the organization is neglected. The policy is the authority for the existence of the quality system and its organizational structure. This structure may include functions or suborganizations that deal with the quality control aspects of the "products" of the organization and with the internal quality assurance aspects of the quality system. Quality control (QC) is an active, often real-time, contributor to the achievement of the quality goals set by management. Quality assurance (QA) is an oversight function to make sure the goals are being met or to design methods for meeting the goals. Quality control and QA may have a fuzzy and even overlapping separation in the performance of duties, hence the "S" shape in Fig. 1. Sometimes External Quality Assurance is made a part of an operation. When this happens it is usually because of a contract requirement or government regulation. This function can bring new viewpoints and insights to an organization that becomes too close to the process to see the causes of problems before they occur.

Wade (1987) did a thorough and ingenious job of extracting the signal from the noise of the outputs of 123 weather stations. His techniques demonstrate what can be done to find erroneous data in a network. He shows how he has "corrected" the data or how he has applied corrections to erroneous data based on assumptions about the accuracy of other measurements and the variability of the field in question. These corrections are plausible. They are far superior to some of the methods I have seen applied to bad data. But data adjustment is not quality control.

We do not know if there was a quality system for the Cooperative Convective Precipitation Experiment (CCOPE), probably not. A quality system would define in writing, in advance of a program, the organizational structure and plans describing how and by whom the management policy for quality will be implemented.

We do know that the owners of each network, NCAR and the Bureau of Reclamation, provided for careful calibration procedures in the laboratory, probably before and after deployment (Pike 1984; Holman and McInerney 1983). We do not know much about calibration and maintenance associated with installation and operation.

We do know that the wind-sensor manufacturer (Meteorology Research, Inc.) had production QC and product QA within a formal quality system. It is interesting to note that the accuracy in Table 1 of Wade 1987 for the PROBE wind-speed measurement quotes the MRI data sheet values, which Holman and McInerney say they believe, while the accuracy for the PAM wind-speed measurement (using the same MRI Model 1022 cup anemometer) is 1 m s^{-1}, an order of

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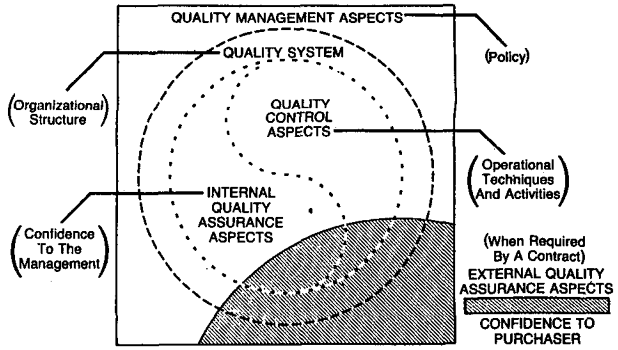

FIG. 1. A context for the use of terms such as quality assurance, quality control, and quality systems (ANSI/ASQC Q90 1987).

magnitude greater (less accurate). PAM is closer to being correct with truth lying between the two.

What Wade (1987) describes is a data error analysis or a data validation test with implementation procedures for test failure. He starts with a raw database, knowledge of the instruments in the network, knowledge of the terrain, knowledge of the behavior of the meteorological fields being sampled, and data from the National Weather Service station in the network space. He applies various difference tests for consistency. He applies the "Barnes technique" to interpolate what the value would be, given the "correct" data everywhere else, compares the interpolated value to the measured value, makes corrections (we used to call that massaging the data), re-runs the program, and produces fields in which the corrected data and the interpolated data from the corrected data are consistent.

That is perhaps a facile summary for a great piece of work. Wade provides new data about different pressure-sensor designs, about different air-temperature sensor exposures, and about the problems with humidity measurement (that's not new!). The wind speed and wind direction analysis is not as clear but is equally interesting. For example, the scatter diagram of the difference between the measured direction and the interpolated wind-field direction as a function of the interpolated direction, Fig. 20(d) of Wade 1987, shows both a fixed bias and a variable bias. This is interpreted as an alignment error (fixed bias) and a topographic effect (variable bias).

If this wind-direction difference analysis were used operationally as a guide for selective calibration or a check of orientation, it would be an instrument quality control activity. A discrepancy report could have been written about the PROBE M25 direction vane. A field check would provide evidence of an orientation failure or a loose installation. After the data collection phase, the wind direction difference analysis becomes a data analysis technique and opens the door to speculation. Perhaps the wind vane was correctly oriented and the terrain influenced the flow to the extent suggested in Fig. 20(d) of Wade 1987; maybe a larger feature caused the apparent 15 degree (4%) bias (Fitzjarrald et al. 1987).

The surface layer variability of heat and water vapor at about 2 m and wind at 4 m or 6 m is considerable in complex terrain. An hourly average will damp out a lot of variability. An interpolative straightjacket will do more smoothing. There are some who will happily model down from an upper air analysis to surface fields, thus eliminating the need for any surface network measurements. But I am old fashioned. I believe that the reason we put out two or more instruments in the surface layer is to find out something about the interactive dynamics between the surface and the air that moves past it. When we do this, however, we had better provide a quality system for our program or we will not know which data are valid and which are biased with erroneous measurement.

A well-designed QA plan will build into the program the QC activities needed in procurement, acceptance testing, installation, operations, and data testing. It will also build in the quality assurance activities to give management confidence that the quality designed into the program is being achieved. The plan may also be subjected to external quality assurance activities to satisfy the customer (funder) that the plan is being effectively implemented. While this sounds like a lot of work and therefore costly, it should not be. There is abundant proof that if it really needs to be done, it will cost less if it is done right the first time.

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