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Project Summary

Precision and Accuracy Assessments for State and Local Air Monitoring Networks 1983

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Precision and accuracy data obtained from state and local agencies during 1983 are summarized and evaluated. Some comparisons are made with the results previously reported for 1981 and 1982 to determine the indication of any trends. Some trends indicating improvement in the precision and accuracy of monitoring data are given on a national and regional basis. The annual average results from each reporting organization are given so that comparisons may be made from 1981 to 1983 and with other reporting organizations.

A comparison of the precision and accuracy data from the Precision and Accuracy Reporting System and that from the independent performance audit program conducted by the Environmental Monitoring Systems Laboratory is given.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The purpose of the full report is to report the third year of data from the Precision and Accuracy Reporting System (PARS). Federal regulations promulgated on May 10, 1979, require quality assurance precision and accuracy (P and A)* data to be collected. Collection started January 1, 1981, according to requirements set forth in 40 CFR Part 58 Appendix A. These requirements provide for more uniform Quality Assurance programs and specific precision and accuracy reporting requirements across all State and local air monitoring agencies.

The major portion of the full report consists of summarizations and evaluations of the P&A data obtained by the efforts of the States and local agencies. In addition, comparisons have been made of the accuracy data collected for PARS with the results of the National Performance Audit Program (NPAP) which has been an ongoing program conducted by the Environmental Monitoring Systems Laboratory (EMSL) since the early 1970's.

These summarizations and evaluations of precision and accuracy data serve the following purposes:

1. Quantitative estimates of the precision and accuracy of their monitoring data are available to State and local agencies.
2. A comparison of the data from all the agencies can indicate the need to improve quality assurance systems in specific reporting organizations.
3. An evaluation of the results may indicate a need for improvement in monitoring methodology.
4. The assessments provide users of data from the State and Local Air Monitoring Stations (SLAMS) network a quantitative estimate of the precision and accuracy of the ambient air quality data.

Ambient air quality data, collected by States and local agencies since 1957, have been stored in the National Aero-

*When one speaks of precision and accuracy of measurement data, one really means the precision and accuracy of the measurement process from which the measurement data are obtained. *Precision* is a measure of the "repeatability of the measurement process under specified conditions." *Accuracy* is a measure of "closeness to the truth."

metric Data Bank (NADB). These data are used in (1) planning the nation's air pollution control strategy, (2) determining if the National Air Quality Standards are being achieved, and (3) determining long-term trends of air quality. Prior to the EPA air monitoring regulations of May 10, 1979, the procedures used in selecting monitoring sites, operating and controlling the equipment, and calculating, validating and reporting the data varied considerably among agencies. Frequently the procedures being used were not well documented. These conditions made it difficult to intercompare data from different sites and agencies. Furthermore, little information was available on the reliability of the monitoring data.

To help alleviate these problems, EPA's air monitoring regulations imposed uniform criteria on network design, siting, quality assurance, monitoring methods, and data reporting after December 30, 1980. For example, only EPA reference, equivalent, or other EPA-approved air monitoring methods were to be used. Also, calibration standards were to be traceable to the National Bureau of Standards (NBS) or other authoritative standards. Further, the quality assurance systems of the states were required to be documented and approved by the EPA Regional Offices. Finally, the reporting organizations must also follow specific procedures when assessing the P and A of their measurement systems and must report the P&A data to EPA quarterly. Starting January 1, 1981, these regulations became effective for National Air Monitoring Sites (NAMS), and beginning January 1, 1983, for all State and Local Air Monitoring Stations.

The precision assessments were determined by performing repeated measurements on ambient-level "calibration" gases at two-week intervals for continuous methods, or by obtaining duplicate results from collocated samplers for manual methods. The accuracy assessments were generally determined by analyzing blind audit materials traceable to NBS. During each calendar year, each site or instrument must be audited at least once. Details concerning the specific procedures and computations used to assess P and A are contained in the regulations.

National Results

National Data Reporting

The third year of data collected by State and local agencies for P&A has been compiled and summarized. Obvious improvements in the network operation have been made. Table 1 shows the improvement in data reporting for the Nation.

Table 1. *National Percent Data Reporting for Required Precision and Accuracy*

Pollutant measurement	1981	1982	1983
CO	77	89	99
SO_2	82	93	96
NO_2	56	72	88
O_3	83	89	99
TSP	94	97	99
Pb	—	—	93
SO_2 (manual)	—	—	75
NO_2 (manual)	—	—	86

Improvement continues for the continuous NO_2 method; however, the percentage still lags behind that for continuous CO, SO_2 and O_3 methods. Reporting for the manual methods for Pb, SO_2 and NO_2 was required by the regulations beginning January 1, 1983. The fact that 1983 was the first year for reporting the manual SO_2 and NO_2 methods is perhaps one reason for the percentage data capture being somewhat low. Another reason may be the fact that these manual methods are being replaced by the continuous methods, which are much more precise and accurate.

1983 Results From the PARS Program

The measures of precision and accuracy are required to be computed and reported by the States and local agencies as percentage values. For precision, the repeatability for each check is measured as the deviation from expected values as a percentage of the expected value. For accuracy, the deviation of the audit value from the true value is measured as a percentage of the true value. For both precision and accuracy, 95 percent probability limits are computed for the percentage values from the average and standard deviations of the individual percentage values:

$$\bar{D} \pm 1.96\,S$$

where $\bar{D}$ = the average of the individual percent differences;

S = the standard deviation of the individual percent differences;*

1.96 = the multiplication factor corresponding to 95% probability.

*Note: For the precision of manual methods obtained from paired observations, the standard deviation, S, is divided by $\sqrt{2}$, to obtain variability estimates that apply to individual reported values.

These upper and lower 95% probability limits are reported and discussed in the full report.

Moreover, it should be noted that the data and the evaluations presented in the full report include any outlier values which may have been reported by the States and local agencies. It is possible that the presence of outliers might influence such comparisons by having undue impact on average values for individual reporting organizations.

Table 2 shows the national values for each of the manual pollutants. The probability limits in Tables 2 and 3 represent the unweighted arithmetic averages of all the reported probability limits for 1983. Historically, probability limits have been combined in this manner for the full report. Thus, for continuity and comparisons to show trends, the unweighted average method was used here. A more statistically pure procedure for combining probability limits, which is described in Appendix B of the full report is now being used in EPA's PARS system. By examining the numbers of valid collocated data pairs (16,816) and the number of audits (6989) performed for TSP, one can appreciate the amount of effort being expended in this country to obtain these data quality assessments.

The precision limits reflect the repeatability of the methodology used in the field to collect and analyze the samples at ambient levels. The spread of the limits may be somewhat inflated due to measurements at relatively low concentration levels.

The accuracy of the manual methods indicates the limits at predetermined concentration levels for the chemical analysis performed in the samples for lead, sulfur dioxide, and nitrogen dioxide. For the TSP method, the accuracy measurement is for the flow rate only. The probability limits for manual accuracy are very good and reflect the quality of work

done in the chemical laboratories for lead, sulfur dioxide, and nitrogen dioxide analyses, and in the field for flow rate measurement for the TSP method. Because of the continual replacement of the manual SO_2 and NO_2 methods with continuous methods, further discussion of the manual methods is limited. The detailed results, however, are tabulated in an appendix for each reporting organization.

The precision and accuracy limits for automated methods are presented in Table 3. Apparent from the number of precision checks, for example 36,887 for SO_2, the effort expended for the collection of quality assurance precision and accuracy data is appreciable, but necessary to assess data quality. Details of the results are discussed in the analysis section.

National Precision Results Comparison

Figure 1 shows the national values for precision for the various methods. With data from three years, some minor trends are evident. Some slight improvement, as measured by a reduction in the spread of the limits, is noted for TSP and the continuous methods, except for NO_2. The persistent negative bias for the continuous SO_2 method indicates that on the average there is some negative instrument drift from the most recent calibration or instrument adjustment to the time of the biweekly precision check.

Although the manual methods for Pb, SO_2, and NO_2 were not required to be reported until 1983, a number of agencies began reporting in 1981. The results for Pb show a decided improvement. The manual SO_2 and NO_2 methods are much more variable than the continuous methods, and, although the limits were worse in 1982 than 1981, the results for 1983 are appreciably better than in 1981.

National Accuracy Results Comparison

Figures 2a and 2b show the national values for accuracy audits for the manual and continuous methods, respectively. Improvement for the manual methods is not evident except perhaps for Pb and SO_2 level 1. Slight improvement is evident for all the continuous methods. The continuous methods for SO_2 and NO_2 show more inaccuracy than all other methods.

Table 2. *National Precision and Accuracy Probability Limit Values for Manual Methods for 1983*

	Precision			Accuracy						
					Probability Limits (%)					
	Number of valid co-located data pairs	Probability limits (%)		No. of audits	Level 1		Level 2		Level 3	
Pollutant		Lower	Upper		Lower	Upper	Lower	Upper	Lower	Upper
TSP	16,816	-11	+12	6,989	—	—	-6	+6	—	—
Lead	3,885	-14	+15	1,389	-8	+7	-6	+4	—	—
Sulfur dioxide	389	-28	+41	301	-14	+7	-9	+5	-7	+4
Nitrogen dioxide	1,324	-19	+21	348	-6	+10	-5	+6	-5	+6

Table 3. *National Precision and Accuracy Probability Limit Values for Automated Analyzers for 1983*

	Precision			Accuracy						
					Probability Limits (%)					
	No. of precision checks	Probability limits (%)		No. of audits	Level 1		Level 2		Level 3	
Item		Lower	Upper		Lower	Upper	Lower	Upper	Lower	Upper
SO_2	36,887	-13	+8	1,791	-15	+10	-12	+10	-11	+9
O_3	21,342	-10	+9	1,920	-11	+10	-8	+7	-8	+6
CO	15,714	-8	+6	1,515	-12	+9	-6	+6	-5	+4
NO_2	9,299	-13	+12	680	-19	+15	-12	+9	-11	+6

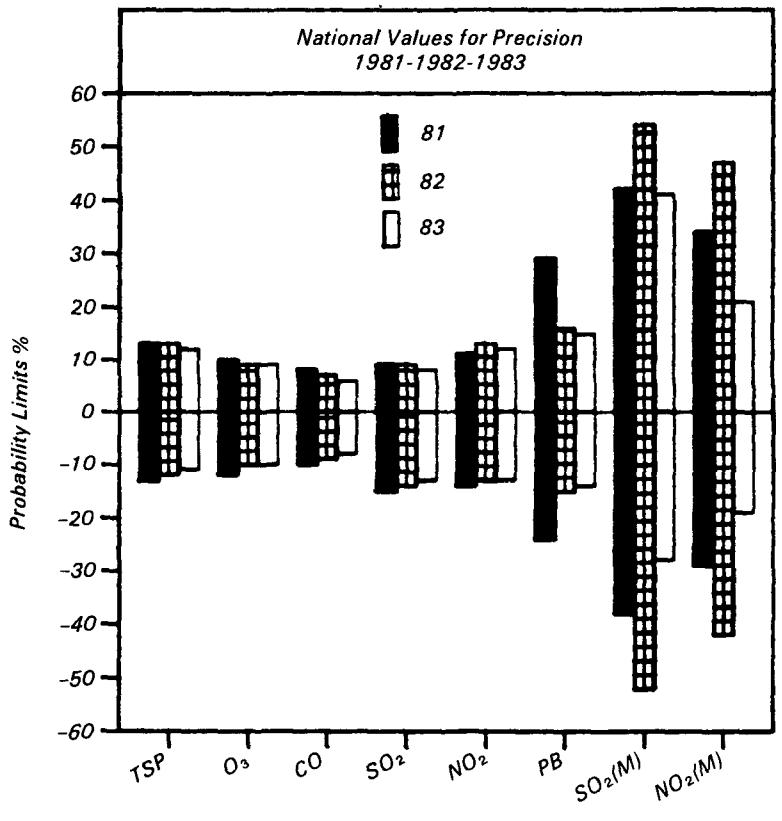

Figure 1. *National precision values for 1981, 1982, and 1983.*

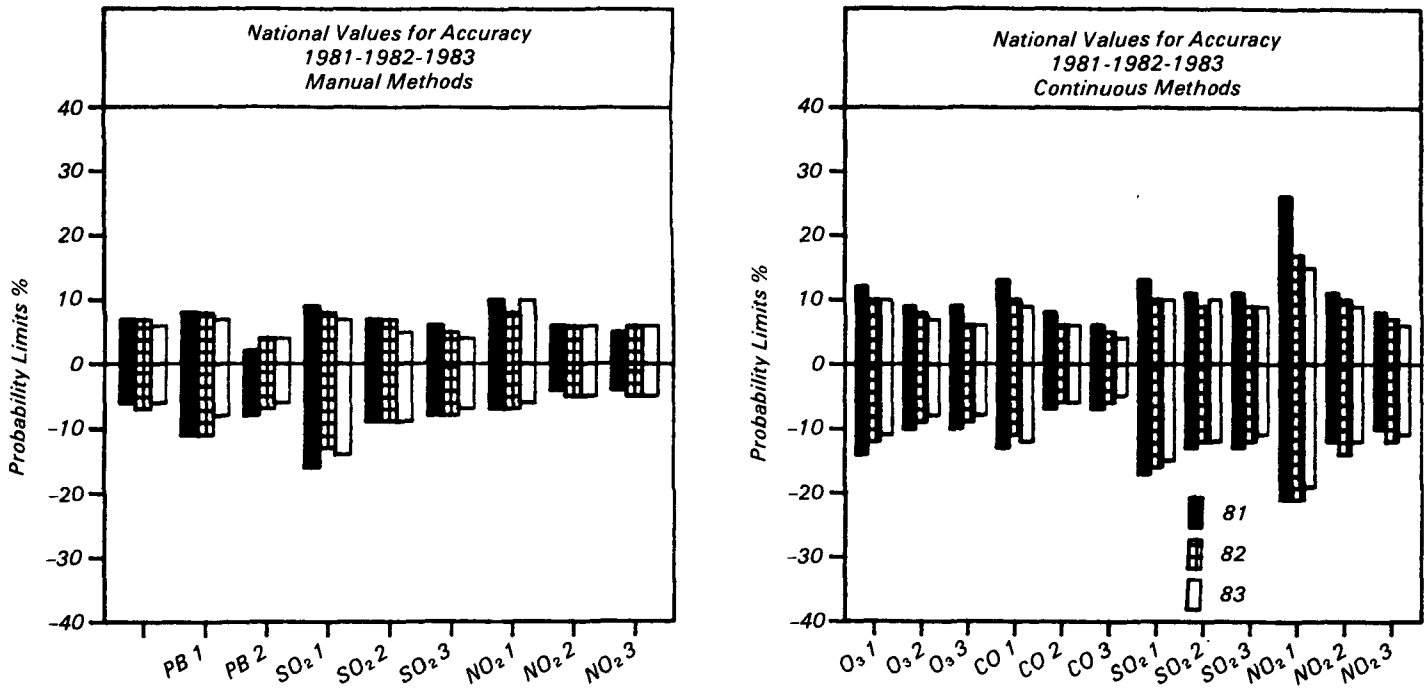

Figure 2. National accuracy values for 1981, 1982, and 1983.

However, it is pointed out that the accuracy audits for the manual methods check only a portion of the measurement method.

The most consistent improvement has occurred with the O_3 method. Although the continuous NO_2 method is more variable than the other methods, it has shown the greatest improvement, particularly for the level 1 concentration.

The general, and expected, pattern of variability across levels is very evident, with the greatest percentage variability at the lowest concentration levels. The slight negative biases for the continuous SO_2 and NO_2 methods are consistent across all three levels. This indicates that, on the average, there appears to be a negative drift with these analyzers from the time of last calibration or instrument adjustment until the time of the accuracy audit.

Comparison of Results from the PARS and the Performance Audit Program

A general comparison between the accuracy data of the PARS program and the Performance Audit (PA) data is included in the full report. The audit data are the results of an independent check, the National Performance Audit Program (NPAP), conducted by the Quality Assurance Division (QAD) of the EMSL.

In the NPAP, specially prepared samples or devices are sent from EMSL to the ambient air monitoring agencies. The samples or devices are carefully and accurately assessed by EMSL utilizing NBS Standard Reference Materials (SRMs) or standards. The monitoring agencies analyze or measure the samples or devices as unknowns or blinds and report their results to EMSL for evaluation. Audit programs are conducted for the following pollutant measurements using the materials indicated:

The audit materials or devices are prepared at three to six different concentrations or flow levels. Separate reports on the evaluation of the PA data are published by EMSL.

As indicated above, the NPAP does not yet include an audit for the ozone or continuous NO_2 methods. Therefore, no comparisons of the NPAP or PA data with the PARS data are possible for these measurements.

Since precision assessments are not made in the PA program, only accuracy can be compared across the PARS and the PA programs. In the full report, the results from PARS and the PA system are compared at approximately the same levels by matching laboratories and reporting organizations. Since the PARS

Measurement	Audit materials	Portion of measurement system audited
SO_2 (manual)	Freeze-dried sodium sulfite	Chemical analytical
NO_2 (manual)	Aqueous sodium nitrite	Chemical analytical
Pb	Filter strip with lead nitrate	Chemical analytical
TSP	Reference flow device	Flow
CO	Cylinders containing CO gas	Continuous instrument
SO_2	Cylinder containing SO_2 gas	Continuous instrument

data are presented with outliers, the same approach was taken with the audit data. Knowledge of the historical audit data reports, however, indicates that the presence of outliers may make a significant difference in the audit results for some agencies.

Comparisons of the national values of the probability limits (Table 4) show good agreement between the results of the two programs. However, there is considerable variation between the results of the two programs when comparisons are made on Regional and reporting organization bases. Lack of better agreement results from several factors. First, the inclusion of outlier values in the PA data appears to have introduced some excessive distortion of general trends. Second, even though the PARS averages in Table 4 are weighted by the number of audits, variations due to many sources of error for both data sets are averaged together to obtain the national values, thereby masking any correlations which may have existed for the results of individual agencies. Third, the concentration levels for the two systems do not coincide exactly at each of the audit levels. Fourth, the PA data are the results of independent *external* audits, while the PARS accuracy data are based on the results of independent *internal* audits. The expected effects of the last-mentioned factor would cause the spread of the limits for the PA to be wider than that for the PARS. The results (see Table 4) confirm these expectations.

Conclusions and Recommendations

The results of PARS data for 1983 indicate some general improvement over the data for 1982. However, considerable differences exist among Regions and individual reporting organizations for most measurement methods. Investigations should be made by the Regions and the states to determine the causes of these significant differences.

Comparison of PARS and PA data show more variability of the PA data than for PARS. These differences are presumably due to the fact that the *external* PA accuracy audits are more completely independent then the *internal* PARS accuracy audits. These differences have been consistent for the years 1981, 1982, and 1983.

Further improvement in the data quality assessments, which are measures of the monitoring data quality, can be achieved only through continuing efforts of State and local agency personnel involved (first-hand) with the operation and quality control of their measurement systems. Regional Quality Assurance (QA) Coordinators can also assist through their review of the operations and quality control practices across the States in their Regions.

Each Regional QA Coordinator should evaluate the PARS data from all the reporting organizations within his Region to identify those organizations having excessively large variations of probability limits. Investigation should be made to determine the causes and correct them to preclude future excessive deviations. Similarly, Regional QA Coordinators should review the operations of the reporting organizations having significantly better precision and accuracy results in order to identify specific procedures which should be uniformly used throughout the Region and the Nation to further improve the reliability of the monitoring data in the National Aerometric Data Base.

Table 4. *Summary Comparison of EMSL Performance Audits (PA) vs. PARS Accuracy Audit Data for Year 1983*

		National values probability limits (%)							
		Level 1		Level 2		Level 3		Level 4	
Pollutant	Audits	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
CO									
PA	1753	-23	+21	-10	+13	-14	+16		
PARS	(1228)	(-15)	(+13)	(- 8)	(+ 8)	(- 7)	(+ 6)	(- 4)	(+ 3)
NO_2 (manual)									
PA	78			-15	+ 7	- 9	+ 7		
PARS	(248)	(- 9)	(+12)	(- 8)	(+10)	(- 7)	(+ 8)		
SO_2 (manual)									
PA	59	-45	+43	-15	+19	-13	+19	- 8	+12
PARS	(184)	(-26)	(+15)	(-18)	(+11)	(-14)	(+ 7)		
LEAD									
PA	644	-24	+23	-25	+22	-20	+19		
PARS	(1097)	(-12)	(+12)	(-10)	(+ 9)				
TSP									
PA	2700			-11	+10				
PARS	(5996)			(- 7)	(+ 7)				
SO_2 (Cont)									
PA	506	-26	+23	-20	+18	-18	+15	- 6	+ 6
PARS	(1281)	(-18)	(+17)	(-12)	(+13)	(-12)	(+12)	(- 8)	(+ 8)

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The complete report, entitled "Precision and Accuracy Assessments for State and Local Air Monitoring Networks 1983," (Order No. PB 86-171 386/AS; Cost: $16.95, subject to change) will be available only from:

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