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INTERCOMPARISON OF PRECIPITATION CHEMISTRY DATA OBTAINED USING CAPMoN AND NADP/NTN PROTOCOLS

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ABSTRACT. Results of a comparison of precipitation chemistry data, acquired under the CAPMoN and NADP/NTN protocols at two colocated sites, are presented. For this intercomparison study precipitation was collected daily (CAPMoN) and weekly (NADP/NTN) for slightly more than one year. The data were analyzed qualitatively through scattergrams and statistically by testing the difference data against a simple constant-bias model. Although measurable and statistically significant biases exist in some variables (ammonium, nitrate, free acidity, and precipitation depth), the data from each network track each other and can be considered representative of the precipitation at the respective sampling sites, at least on a weekly time scale. It should be possible to combine the data from the NADP/NTN and CAPMoN networks in a meaningful way to analyze the spatial distribution of wet deposition across North America, as long as due concern is given to the comparability of the measurements.

1. INTRODUCTION

Precipitation chemistry data are currently acquired by a variety of techniques employed by numerous agency networks. Each network generally develops a specific protocol for sample collection and analysis, which is then applied uniformly across the network to ensure data quality and within-network comparability. However, adjoining or overlapping networks, employing other sampling intervals, siting criteria, or analytical procedures, may or may not yield data of comparable quality. Beyond the obvious need to avoid disputes between agencies with conflicting economic or societal interests, comparability of data between networks offers opportunities for sharing/combining data to expand the spatial or temporal range of coverage, as needed for instance in certain acidic deposition studies (e.g., Summers and Barrie, 1986; Sweeney and Olsen, 1985). As the needs for high-quality data obtained over extensive geographical areas and long time periods increase, so do the demands for demonstrating data comparability between networks.

The degree of compatibility required among data sets depends in part on the specific applications to be considered. Generally, the purposes for which most precipitation chemistry data are acquired include determination of the influx of chemicals into the surface ecosystem, validation of numerical models, and a general monitoring of the chemical state of the atmosphere. When the magnitudes of species concentrations in rain or snow or the total wet deposition are crucial to a problem, we must be concerned with the measurement attributes of accuracy and precision (Watson et al., 1983). Data comparability, the focus of most between-network intercomparisons designed to study relative trends or increase spatial density, is generally less restrictive.

Past studies have used or intercompared data derived from independent networks. Physical differences in the devices used to collect precipitation were the focus of an early study by de Pena et al. (1980); the sampling interval was an important factor in other studies (e.g., Sisterson et al., 1985; de Pena et al., 1985). Vet et al. (1988) also considered the differences arising from using wet-only or bulk collection techniques. Hansen and Hidy (1982) identified numerous problems that can arise when one tries to assimilate data sets of diverse and inconsistent quality control.

The purpose of this particular study is to compare data obtained using the equipment and protocols of the U.S.-based National Atmospheric Deposition Program/National Trends Network (NADP/NTN) with data from the Canadian Air and Precipitation Monitoring Network (CAPMoN). This intercomparison focuses on the differences in sampling interval employed in each network (weekly in NADP/NTN; daily in CAPMoN), as well as on the comparability of the overall network operations. Given sufficient comparability and the relatively high spatial density of sites in each network, it may be possible to combine these two data sets and so be able to develop isopleth maps that span the U.S.-Canadian border without major discontinuities. Similar use of earlier data from independent U.S. and Canadian networks was made by Summers and Barrie (1986). After a description of the sampling sites and protocols used in this study (Section 2), we consider the analytical methods used to process and intercompare the data (Section 3). Actual results are presented and discussed in Section 4.

2. PROJECT DESCRIPTION

This intercomparison project was initiated in September 1986 at two sites, one in the United States (Penn State University, State College, Pennsylvania) and one in Canada (Sutton, Quebec), for the purpose of comparing the effects of various sampling and analytical procedures on precipitation chemistry data. The locations of these two sites and the other stations in their respective networks are shown in Fig. 1. Complementary equipment was installed at each site specifically for this comparison study so that the protocols of both networks (NADP/NTN and CAPMoN) could be followed at each site. For this report, data are considered that were derived from precipitation sampled over a period of slightly more than one year, from 16 September 1986 through 27 December 1987.

2.1 Site Descriptions

2.1.1 Penn State site (United States)

The Penn State site has been used on a regular basis by the NADP/NTN since mid-1983. Situated in rural central Pennsylvania (at north latitude 40°47'18" and west longitude 77°58'47") and remote from significant pollution sources, this site is considered representative of the air quality on a regional scale. As described by Bowersox (1980), the site is located in the Appalachian Mountains in a geographic regime characterized by alternate ridge chain and valley floor. In general, the valley floors are between 300 and 400 m above sea level and the ridges are about 600 m above sea level. The collection site, which is on Pennsylvania State Game Lands Tract Number 176, is approximately in the middle of a rather broad valley with some rolling hills and is at an elevation of 393 m above sea level.

Fig. 1. Map of North America showing CAPMoN and NADP/NTN sites. (Adapted from Hales et al., 1987.)

Possible sources of anthropogenic atmospheric pollution, which could compromise the representativeness or regionality of precipitation chemistry samples taken at any site, are of two general types: (1) large urban population centers, and (2) large point sources such as fossil-fuel power plants. Table 1 lists the population centers (population > 30,000, according to 1970 census) within 200 km of the Penn State site, along with the range and direction of these sources from the site. A similar tabulation of fossil-fuel power plants outside the metropolitan areas and with an electric generating capacity greater than 500 MW is presented in Table 2. With the single exception of the State College-University Park residential community, which lies generally downwind of the site, all such sources are in excess of 40 km from the precipitation chemistry site, rendering them general contributors to the background air chemistry of the region.

The site itself is a leveled clear-cut square, approximately 180 m on a side in otherwise forested state game lands. There are no large irregular terrain features to disturb the general airflow in the immediate area. The periphery of the clear-cut area is populated by an uneven-aged stand of oak, aspen, and pine, which has a maximum height of about 20 m along the north side and 15 m elsewhere. This barrier of trees affords shelter from the full force of the wind. Grasses and low blackberry bushes offer a splash-suppressing ground cover in the open area. A grid of 15-m high masts, used to support radio antenna cables, is also on the site. Maps and additional information are available in NADP (1986).

The distribution of the collection equipment with respect to the encircling trees and with respect to the masts is intended to minimize any potentially adverse effects these might have on collection. For example, with

Table 1. Population centers within 200 km of the Penn State site with population greater than or equal to 30,000 (NEA, 1979)

Urban or metropolitan area	Population	Range (km)	Direction
Elmira, NY	40,000	165	N
Williamsport, PA	38,000	85	NE
Scranton/Wilkes Barre, PA	162,000	175	NE
State College/University Park, PA	64,000	5	E
Hazleton, PA	30,000	160	E
Harrisburg, PA	68,000	100	SE
York, PA	50,000	130	SE
Lancaster, PA	58,000	155	SE
Reading, PA	88,000	170	SE
Hagerstown, MD	36,000	125	S
Altoona, PA	63,000	50	SW
Johnstown, PA	42,000	90	SW
Pittsburgh, PA	593,000	160	W
New Castle, PA	39,000	195	S
Jamestown, NY	40,000	175	NW

Table 2. Fossil fuel power plants (capacity $\geq$ 500 MW) at a radius of 200 km or less from the Penn State site (NCA, 1978)

Power plant	Capacity (MW)	Range (km)	Direction
Mansfield	1650	130	N
Montour	1641	95	NE
Brunner Island	1558	150	SE
Conemaugh	1872	110	SW
Homer City	2012	100	W
Keystone	1872	100	W
Shawville	625	45	NW

the exception of the antenna masts, the collectors do not approach any tree or other airflow obstruction, including another precipitation collector, to within four times their heights. This is in compliance with World Meteorological Organization standards for siting precipitation-measuring devices of any sort (WMO, 1971). Satisfaction of this requirement for the trees and other obstructions, however, precludes the possibility of simultaneously maintaining a similar separation between the collectors and the radio masts. In order to minimize the possible effects of turbulence about the masts on precipitation quality and collection efficiency, collectors are placed near the middles of the quadrangles defined by the antenna array. This position also puts the collectors away from the drip line of the antenna cable supported by the masts. For this study the CAPMoN collector and precipitation gages were placed in the quadrangle immediately east of that in which the NADP/NTN equipment has traditionally been deployed, at a distance of approximately 50 m.

Travel to and from the site is by way of an infrequently used unpaved road that roughly bisects the state game forest. Possible sample contamination from dust dispersed into the air by vehicles traveling this road is essentially eliminated by the fact that the site is set apart from the road by a 200-m buffer of trees. Access from this unpaved road to the collectors in the clearing is provided by a paved road approximately 600 m long. Only personnel servicing the precipitation chemistry or radio antenna equipment are intended to use this access road.

2.1.2 Sutton site (Canada)

The Sutton site has been used as an official CAPMoN collection site since 1 September 1983. The Sutton site is situated at north latitude 45°04'35" and west longitude 72°40'35" near the U.S. border in the rural Eastern Townships area of Quebec 6 km southwest of the village of Sutton and 85 km southeast of Montreal. The site itself is situated on private property in an open grassed area and surrounded by mixed forest on all sides. To the north the trees are 25 m from the collector, to the east the trees are 160 m away, and to the south the trees are 300 m away. The operator/landowner's house is 60 m west on a hill 30 m high. The general topography is hilly and the Sutton Mountains (elevation 640 m above site) are 10 km east of the monitoring site. Some wheat and corn are grown southeast and southwest of the site, but most of the surroundings is covered by mixed forest. A gravel driveway is 85 m west of the site and an infrequently traveled gravel road is 400 m south of the site. The site is well removed from all industrial and urban activity. Additional details are available in an unpublished site report at the Air Quality and Inter-Environmental Research Branch, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, Canada.

2.2 Sampling Protocols

2.2.1 NADP/NTN protocol

Details of the NADP/NTN protocol are provided elsewhere and need not be elaborated here. A brief history and the general structure of the network are given in NADP (1984b). Although the network as a whole originated in 1978 and later merged with the National Trends Network in 1982, operations under the NADP/NTN protocol at the Penn State site began in mid-1983. At the Sutton site, NADP/NTN equipment was installed and operations first began during the latter half of 1986. In each case, siting and installation criteria have been adhered to, as specified in NADP (1984a) and by Robertson and Wilson (1985). Equipment used at each NADP/NTN site consists of an Aerochem Metrics Wet-Dry Collector and a Belfort Universal rain gage. All data considered here were derived exclusively from wet-only collections of precipitation, both rain and snow. Details of the procedures used during the sampling operations have been provided by Bigelow and Dossett (1988). An essential feature of the NADP/NTN protocol is the requirement that each precipitation sample represent an average of all precipitation events over a 7-day period since the collector is serviced only once per week (on Tuesdays), in contrast to the daily collections of the CAPMoN protocol. After the weight, field pH and electrical conductivity of each NADP/NTN sample have been determined at the site, the remaining sample is sent in the original bucket to the Central Analytical Laboratory at the Illinois State Water Survey in Champaign, IL, for complete chemical analysis (NADP, 1980). Overall quality assurance procedures, as well as data screening and validation methods, are provided in NADP (1984a). Data are processed through the NADP Coordinator's Office (Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO) and ultimately archived in the Acid Deposition System (ADS) data base (Watson and Olsen, 1984).

2.2.2 CAPMoN protocol

Vet et al. (1989) have provided a comprehensive description of the Canadian Air and Precipitation Monitoring Network (CAPMoN). The network in the present form dates back to mid-1983, when it served to replace two earlier sampling networks, the Canadian Network for Sampling Precipitation (CANSAP) and the Canadian Air and Precipitation Network (APN). The Sutton site began operations under the CAPMoN protocol on 1 September 1983, whereas this protocol did not become operational at the Penn State site until 16 September 1986, the beginning of the intercomparison period reported on here. Siting criteria are as specified by Vet et al. (1989). Equipment used at each of the CAPMoN installations consists of a MIC Type A-M Wet Deposition Collector, Canadian Standard rain gage, Nipher-shielded snow gage, and a snow-depth stick. Details of the sampling procedures are given in CAPMoN (1985). The important features distinguishing the CAPMoN procedures from those of the NADP/NTN protocol include daily (versus weekly) sampling and shipment of the precipitation water to the analytical laboratory in Burlington, Ontario, in sealed plastic bags. Although this procedure minimizes possibilities for contamination, neither field pH nor electrical conductivity data are obtained. A rigorous quality assurance program is in place, details of which are available through the Air Quality and Inter-Environmental Research Branch of the Atmospheric Environment Service (AES), Downsview, Ontario. Data are archived at AES using the Climatological Data Management System of the Canadian Climate Centre.

3. DATA ANALYSIS METHODS

3.1 Data Preprocessing

The relevant precipitation chemistry data for both the Penn State and Sutton sites were first obtained from the respective data bases of NADP/NTN and CAPMoN and then processed at the AES. A clear identification of the start and end dates of each NADP/NTN sample was made over the intercomparison period, 16 September 1986 through 27 December 1987, since the NADP/NTN data set is the least time-resolved; 67 weekly sampling periods were identified.

The CAPMoN daily data were then aggregated into equivalent weekly averages to coincide with the same meteorological events as represented by the NADP/NTN weekly precipitation collections. This was accomplished by calculating a precipitation-weighted mean for each ion according to the following relationship.

$$\overline{C} = \frac{\sum_{i=1}^{m} P_i \, C_i}{\sum_{i=1}^{m} P_i} \tag{1}$$

where m is the number of valid daily values in the week interval, and P_i is the daily depth of precipitation that yielded the ion concentration C_i. Trace amounts of precipitation were treated by using a value for P_i equal to 2/3 of the lowest measurable depth, which is 0.2 mm for the CAPMoN standard gage. Values of weekly average pH were calculated from the precipitation-weighted average hydronium-ion concentration.

The weighting factor (P_i) used for this intercomparison was derived from the CAPMoN standard rain gage, which can differ somewhat from the sample depth because of differences in collection efficiency. Even though the NADP/NTN data represent natural (i.e., uncalculated) weekly averages based on weighting by sample depth, standard-gage depths were selected for weighting the CAPMoN data because this method is more accurate for calculating wet deposition, as recommended by the Unified Deposition Data Base Committee (UDDBC, 1985). The effect of this difference on the outcome of the intercomparison, however, is not considered to be great, largely because the bias between the two depths tends to be constant across the range of precipitation depths.

The representativeness of the CAPMoN weekly average concentration data was investigated since it is possible, with data of relatively high temporal resolution, to have a number of daily collections for which the sample volume was too small to permit complete chemical analysis. For this assessment a percentage of each total weekly precipitation depth represented by samples with "valid" daily concentration data was calculated. Thus, consistent with UDDBC specifications, this percentage of total precipitation pertaining to valid data, %TP, was calculated for each ion according to the relationship

$$\%TP = \frac{\sum_{i=1}^{m} P_i}{\sum_{i=1}^{n} P_i} \times 100 \quad , \tag{2}$$

where $m \leq n$ is the number of samples in a week having a completely valid and unqualified concentration value for that ion, and n is the number of the possible samples in the same week. Table 3 summarizes the results of this assessment in terms of the number of weekly values for which the percentage of total precipitation, as calculated by Eq. (2), was less than various specified threshold values (first column in Table 3). Clearly, as the requirement that a given fraction of the total precipitation be represented by valid concentration data increases, so the number of "representative" data values decreases. Requiring that each weekly average concentration be composited from daily data that captured 100% of the weekly precipitation, for instance, effectively removes nearly one-half or more of the data. For most purposes in this report, weekly CAPMoN data are used for which $\%TP \geq 95\%$, since the same statistical methods applied to a subset of the data for which $\%TP = 100\%$

Table 3. Number of weekly values corresponding to various %TP levels

a. Penn State data

	%TP	pH	$SO_4^{=}$	NO_3^-	Cl^-	Ca^{++}	NH_4^+	Mg^{++}	Na^+	K^+	Ion Bal.
Max. Events		67	67	67	67	67	67	67	67	67	67
Missing		4	4	4	4	5	3	5	4	4	5
No Precip.		2	2	2	2	2	2	2	2	2	2
	≥60	61	62	62	62	61	64	60	62	62	59
	≥70	60	62	62	62	60	64	59	62	61	58
	≥80	58	60	60	60	58	62	57	60	59	56
	≥90	57	60	60	60	57	62	56	58	58	53
	≥95	55	58	58	58	56	61	55	55	55	50
Only Trace Missing	≥95	40	49	49	49	42	51	41	43	43	35
	=100	28	37	37	37	31	39	30	32	32	25
Not BDL	=100	28	37	37	37	31	39	30	32	32	25

b. Sutton data

	%TP	pH	$SO_4^{=}$	NO_3^-	Cl^-	Ca^{++}	NH_4^+	Mg^{++}	Na^+	K^+	Ion Bal.
Max. Events		67	67	67	67	67	67	67	67	67	67
Missing		8	7	7	7	8	6	8	8	8	10
No Precip.		0	0	0	0	0	0	0	0	0	0
	≥60	57	57	57	57	56	56	56	58	58	56
	≥70	56	56	56	55	55	54	55	56	56	55
	≥80	54	54	54	54	53	53	54	55	55	53
	≥90	48	50	50	51	49	52	50	54	54	47
	≥95	42	42	42	43	41	47	41	47	49	40
Only Trace Missing	≥95	26	28	28	30	28	35	30	33	33	23
	=100	6	6	6	6	6	7	7	8	8	4
Not BDL	=100	6	6	6	6	6	7	7	8	8	4

yielded almost identical results. Note that trace precipitation amounts are not considered in this calculation of %TP.

After all data from each network had been carefully screened for validity and representativeness (CAPMoN), between-network comparisons were made. For each ion concentration, precipitation depth, sample depth, and ion balance, weekly difference values, ΔX, were computed as

$$\Delta X = X_C - X_N \quad , \tag{3}$$

where X_C is the relevant value for the CAPMoN weekly averaged data set and X_N is the corresponding value from the NADP/NTN data base. In addition, annual deposition values and their differences between networks were calculated from data acquired at the Penn State site for the annual interval 16 September 1986 to 15 September 1987.

3.2 Types of Data Treatment

In order to compare the CAPMoN and NADP/NTN protocols from several points of view, the data are considered in several different ways. An exploratory analysis was accomplished by simply plotting the magnitudes of each variable from the NADP/NTN data set against those from the CAPMoN data set. Such scattergrams used data from weeks in which %TP $\geq$ 95% only in order to gain a qualitative impression of the comparison, for instance to note the sense of any bias and the degree of scatter. Obvious outliers, values found to deviate markedly from the 1:1 line were investigated individually for validity, resulting in the elimination of only two or three data values, for which evidence of problems was clearly noted in the field sheets.

The between-network difference data were investigated to see if the data are normally distributed. The differences in the magnitudes of each variable between the CAPMoN and NADP/NTN data sets were plotted cumulatively against the normal probability distribution function, and a qualitative judgment was made as to the linearity of the data on such graphs. The Kolmogorov-Smirnov test was used to test if the data indicated that the normal hypothesis could be rejected. The difference data were also plotted against sample volume to gain additional information on the likely reasons for any systematic differences that might arise.

3.3 Statistical Methods

For the purpose of quantifying the intercomparison of precipitation chemistry data gathered under the CAPMoN and NADP/NTN protocols, a simple statistical model was selected. If the between-network difference in magnitude of any variable, such as an ionic concentration or a precipitation depth, is calculated according to Eq. (3), then the simplest model can be written (Hollander and Wolfe, 1973, p.39)

$$\Delta X_k = B + \varepsilon_k \quad , \tag{4}$$

where B is the bias assumed to be constant across the range of variable X, and where ε_k is the deviation of the difference data from the bias during week k. This first-order statistical model forms the basis for the present intercomparison and was tested using the data for which %TP $\geq$ 95%. Estimations of the magnitudes of the bias and of the spread of data about the bias depend upon the way in which the data are distributed. If the differences are normally distributed, the set ε_k is considered to represent a random error having a mean of zero and a standard deviation

$$\sigma_X = \left[\frac{1}{N} \sum_{k=1}^{N} \varepsilon_k^2 \right]^{1/2} \quad , \tag{5}$$

where N is the number of weeks (data values) in the intercomparison. The bias is then simply the mean of the between-network differences; that is,

$$B = \frac{1}{N} \sum_{k=1}^{N} \Delta X_k \quad . \tag{6}$$

If the difference data are not normally distributed about the bias or contain a relatively large number of outliers, nonparametric statistics should be used to estimate the magnitudes of the bias and the intercomparison precision. In this case the bias is estimated as the median or 50th percentile of the between-network differences. A nonparametric estimator of precision that has been used previously (Vet and Sirois, 1987) is the Modified Median Absolute Difference,

$$M.MAD \equiv \frac{\text{Median}\left(\frac{|\Delta X|}{\sqrt{2}}\right)}{0.6745} \quad , \tag{7}$$

in which the number 0.6745 is included to ensure that the M.MAD is a consistent estimator of precision that reduces to the standard deviation when the underlying distribution is normal (Randles and Wolfe, 1979).

Statistical tests were made to establish if any of the biases that appear between the CAPMoN and NADP/NTN data sets are significantly different from zero. No formal test was performed to determine if the between-network differences were normally distributed, so both a parametric test and a nonparametric test were carried out. The parametric test was Student's t test (Hogg and Craig, 1978) on the mean of the between-network differences (i.e., on the bias, as calculated by Eq. (6). The between-network differences were deemed to be statistically significant if the 95%-confidence interval of the bias did not span zero. The nonparametric test was the sign test (Hollander and Wolfe, 1973, p. 39) on the median of the between-network difference data. Again, the 95%-confidence intervals of the median were calculated and used as the criterion for significant bias.

4. RESULTS AND DISCUSSION

4.1 Weekly Data

The individual data sets used in this intercomparison are presented in the Appendix. As described in Section 3.1, each value in the CAPMoN data sets represents a precipitation-weighted mean of the daily values during each weekly interval of the NADP/NTN data sets. Differences between the data values from each network are also presented in the Appendix, separately for the Penn State site and the Sutton site. Statistical characteristics of these difference data are provided in Table 4. The data presented in the various tables form the basis for the intercomparisons that follow.

4.2 Data Intercomparisons

As an initial way of comparing the data acquired separately under the CAPMoN and NADP/NTN protocols, scattergrams were developed for all variables. Results pertaining to some of the more important variables are shown in Fig. 2

Precipitation depths at each site are compared in Figs. 2a (precipitation gage) and 2b (sample collector). Although the overall correlation is high in each case, the CAPMoN values are consistently larger than those from NADP/NTN by several millimeters per week, whether measured by gage or sample volume. Since similar results are found at both sites and with such consistency, we suspect a physical cause for the bias. Possibilities include different collection efficiencies between the CAPMoN Standard Gage and the Belfort rain gage used by NADP/NTN and between the respective collectors. Also, since

Table 4. Statistics of the differences in weekly concentration data (mg ℓ^{-1})

a. (CAPMoN - NADP/NTN) at Penn State

	N	Min	5%	10%	90%	95%	Max	Med	MAD
$SO_4^{=}$	55	-0.62	-0.50	-0.41	0.51	0.78	1.96	0.02	0.31
$N\text{-}NO_3^-$	55	-0.09	-0.05	-0.03	0.14	0.18	0.46	0.04	0.05
pH	52	-0.22	-0.18	-0.18	0.02	0.04	0.06	-0.06	0.06
H_3O^+	52	-0.014	-0.007	-0.002	0.027	0.032	0.041	0.008	0.009
Cl^-	55	-0.10	-0.06	-0.04	0.03	0.12	0.22	0.00	0.01
Ca^{++}	54	-0.12	-0.06	-0.03	0.06	0.14	0.46	0.01	0.03
$N\text{-}NH_4^+$	57	-0.02	-0.02	-0.01	0.12	0.15	0.52	0.05	0.03
Na^+	52	-0.13	-0.06	-0.05	0.01	0.03	0.15	-0.02	0.02
Mg^{++}	53	-0.03	-0.02	-0.01	0.01	0.01	0.07	0.00	0.01
K^+	52	-0.03	-0.01	0.00	0.02	0.04	0.05	0.01	0.01
Gage (mm)	57	-1.7	-1.0	-0.6	3.4	4.2	5.4	1.0	1.6
Collector (mm)	59	0.0	0.2	0.3	4.4	5.2	5.3	2.0	1.8

b. (CAPMoN - NADP/NTN) at Sutton

	N	Min	5%	10%	90%	95%	Max	Med	MAD
$SO_4^{=}$	33	-1.22	-0.85	-0.42	0.19	0.30	0.41	-0.04	0.22
$N\text{-}NO_3^-$	33	-0.37	-0.18	-0.04	0.15	0.21	0.26	0.01	0.05
pH	33	-0.53	-0.38	-0.26	0.08	0.14	0.21	-0.08	0.12
H_3O^+	33	-0.034	-0.028	-0.005	0.017	0.035	0.040	0.007	0.007
Cl^-	33	-0.08	-0.08	-0.05	0.02	0.04	0.05	-0.02	0.03
Ca^{++}	31	-0.14	-0.08	-0.03	0.04	0.39	0.89	0.00	0.03
$N\text{-}NH_4^+$	39	-0.04	-0.03	-0.01	0.11	0.17	0.68	0.05	0.04
Na^+	37	-0.29	-0.12	-0.08	0.00	0.01	0.02	-0.02	0.01
Mg^{++}	32	-0.02	-0.01	-0.01	0.00	0.02	0.05	0.00	0.00
K^+	37	-0.01	0.00	0.00	0.01	0.02	0.02	0.00	0.00
Gage (mm)	65	-2.6	-1.0	-0.3	4.1	6.6	10.5	1.7	1.8
Collector (mm)	61	-1.0	0.1	0.6	5.6	8.0	13.2	2.6	1.5

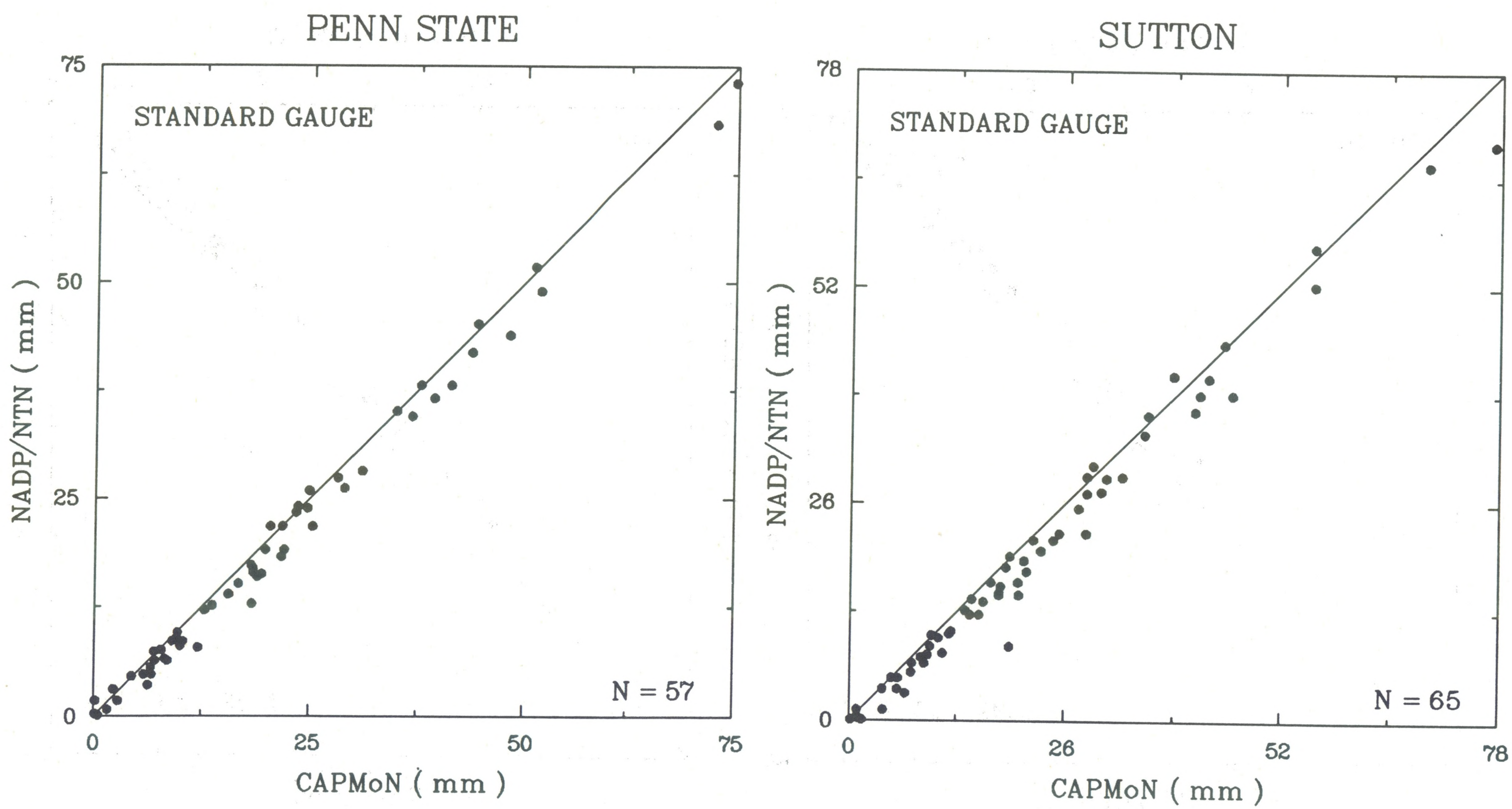


Fig. 2 Scattergrams of selected variables at Penn State and Sutton.

a. Precipitation gage depth

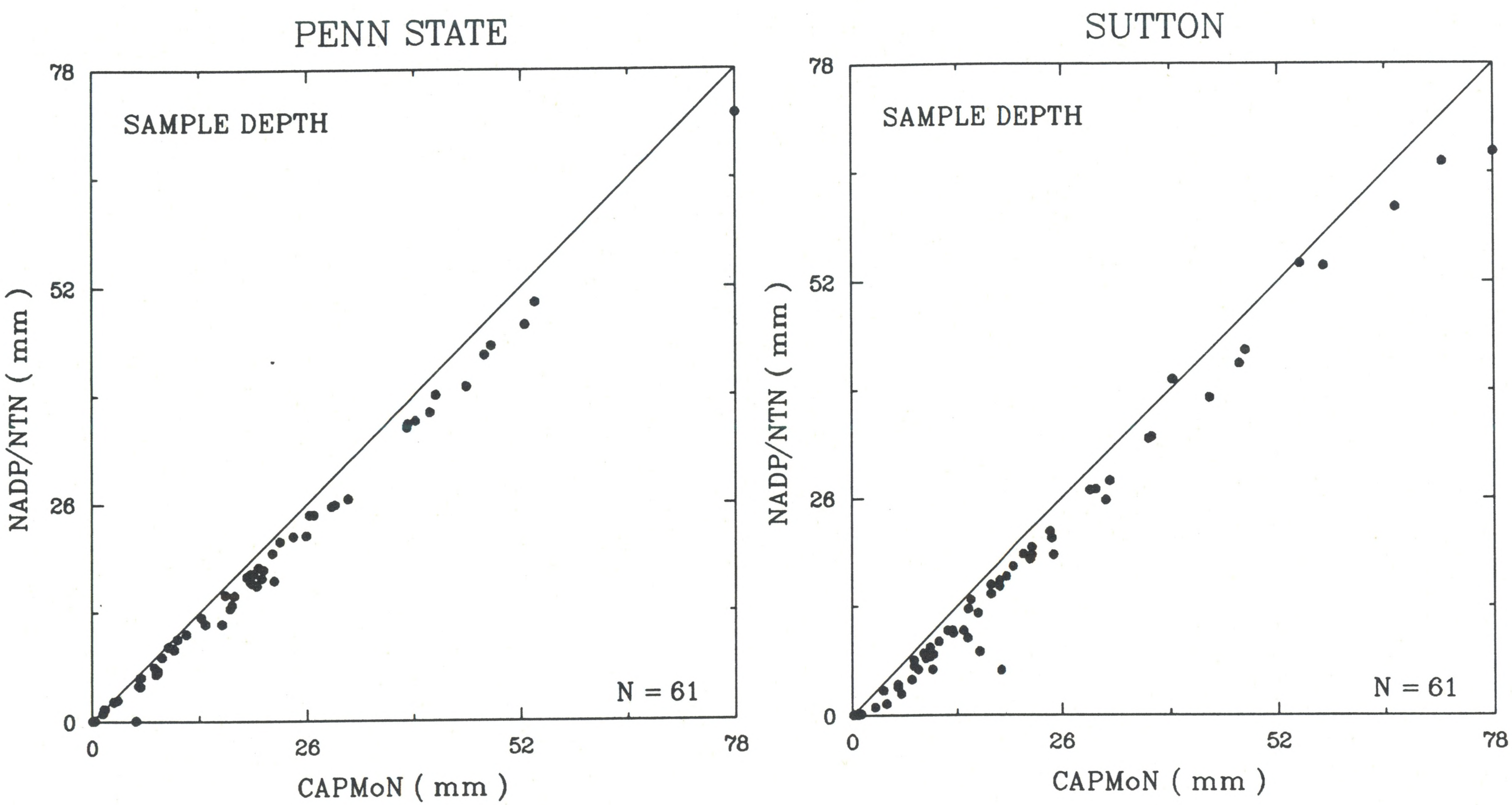


Fig. 2 (cont'd) b. Sample depth

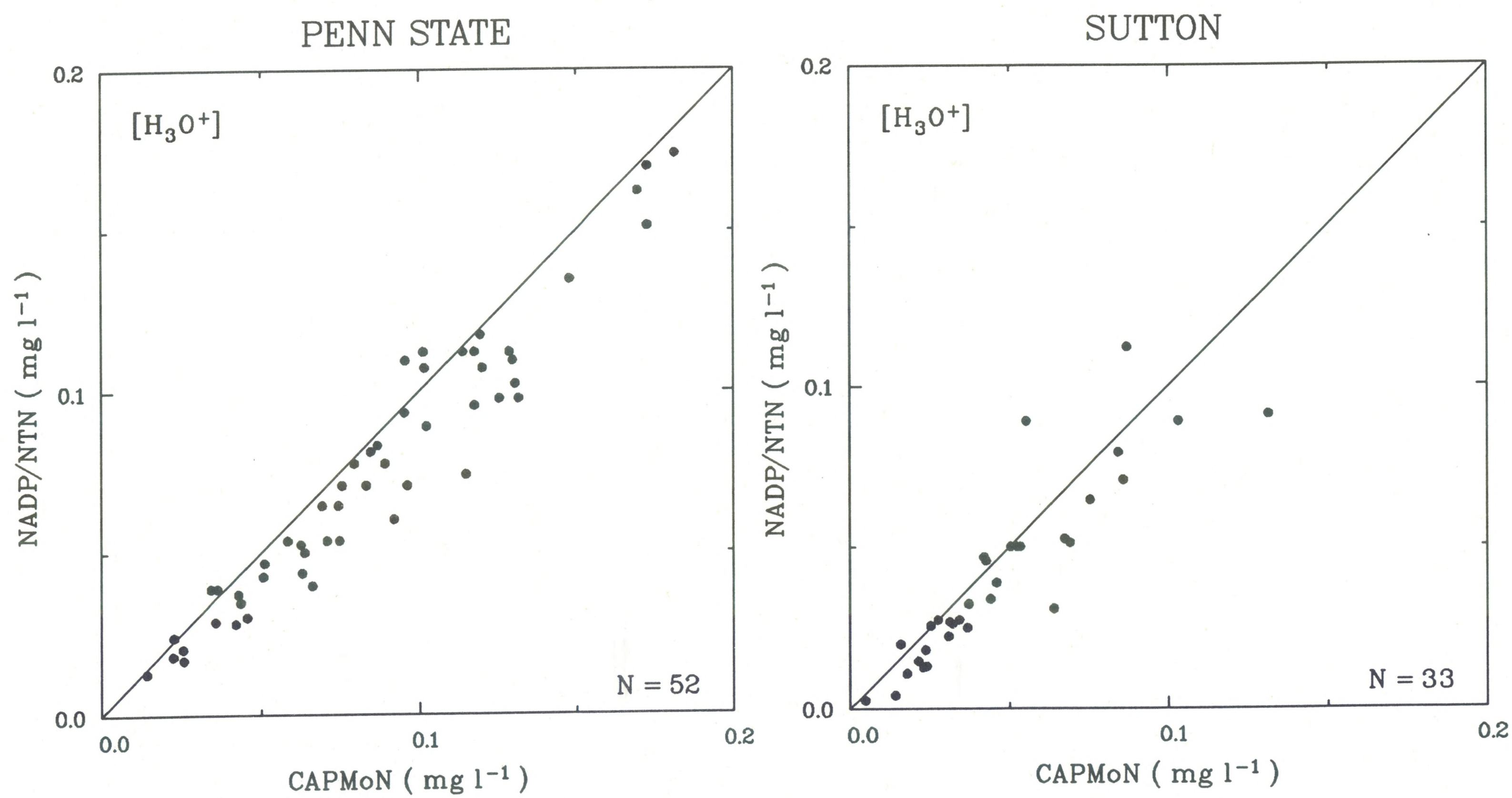


Fig. 2 (cont'd) c. $[H_3O^+]$

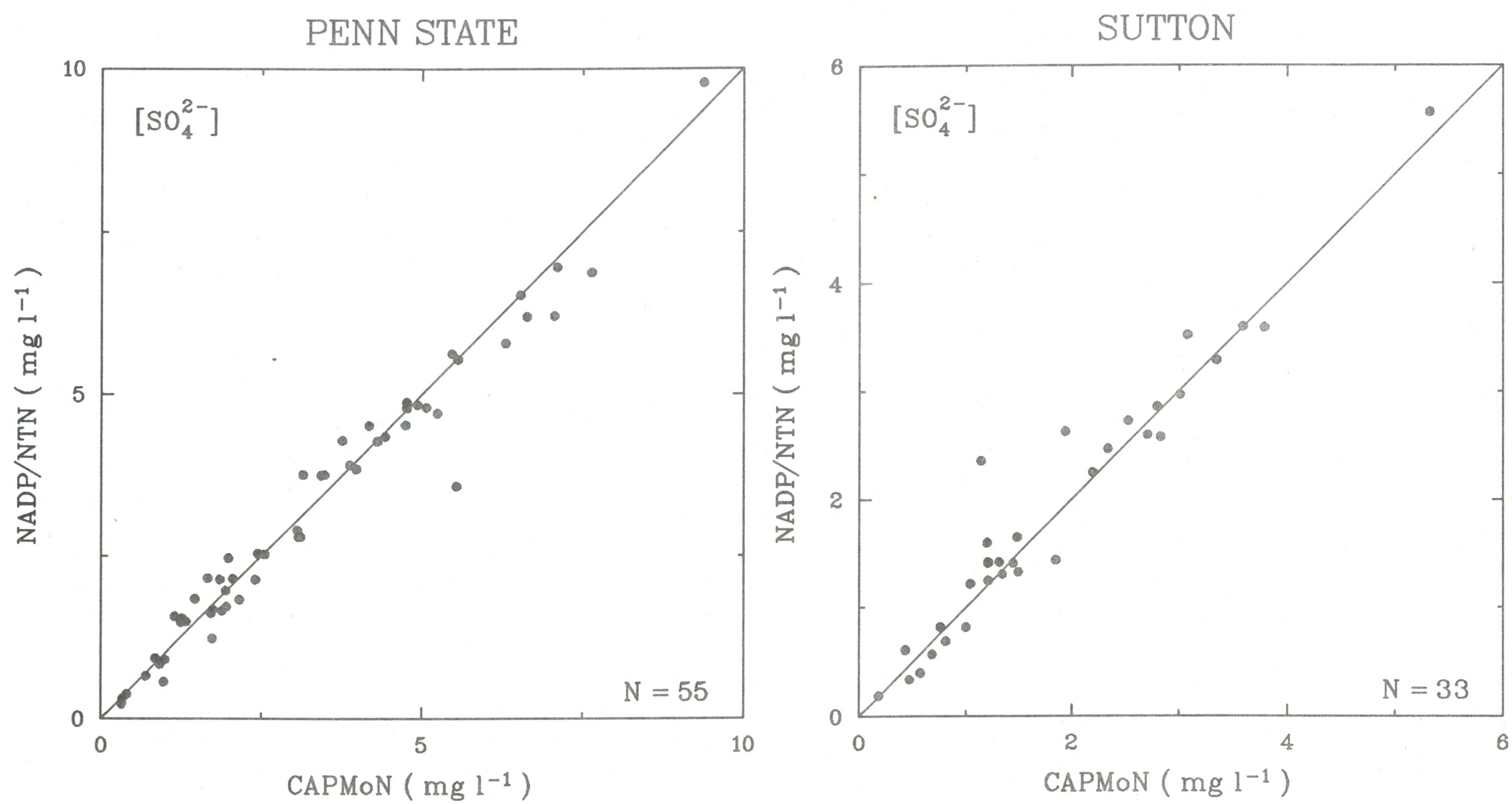


Fig. 2 (cont'd) d. [SO_4^{2-}]

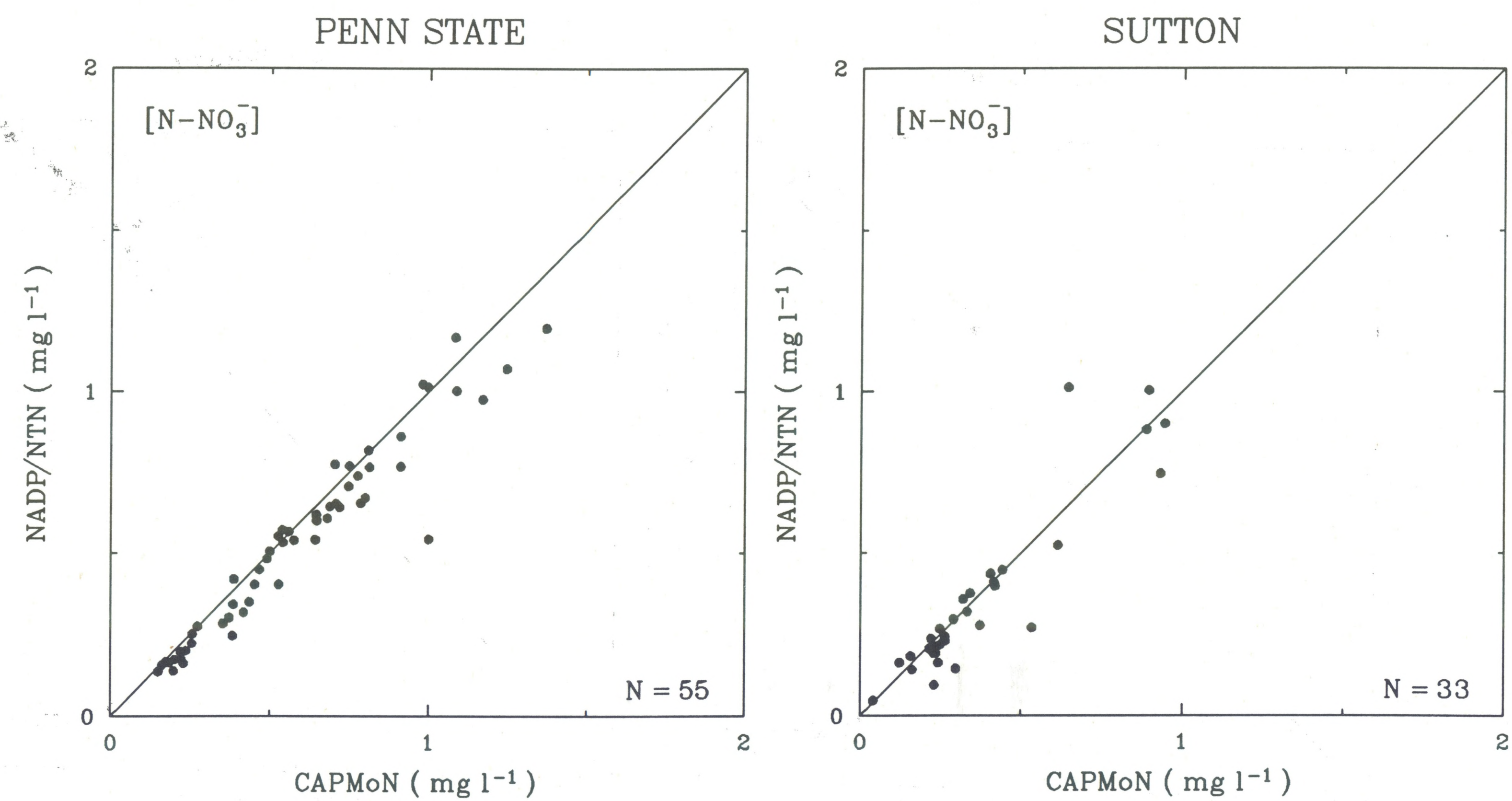


Fig. 2 (cont'd) e. $[NO_3^-]$

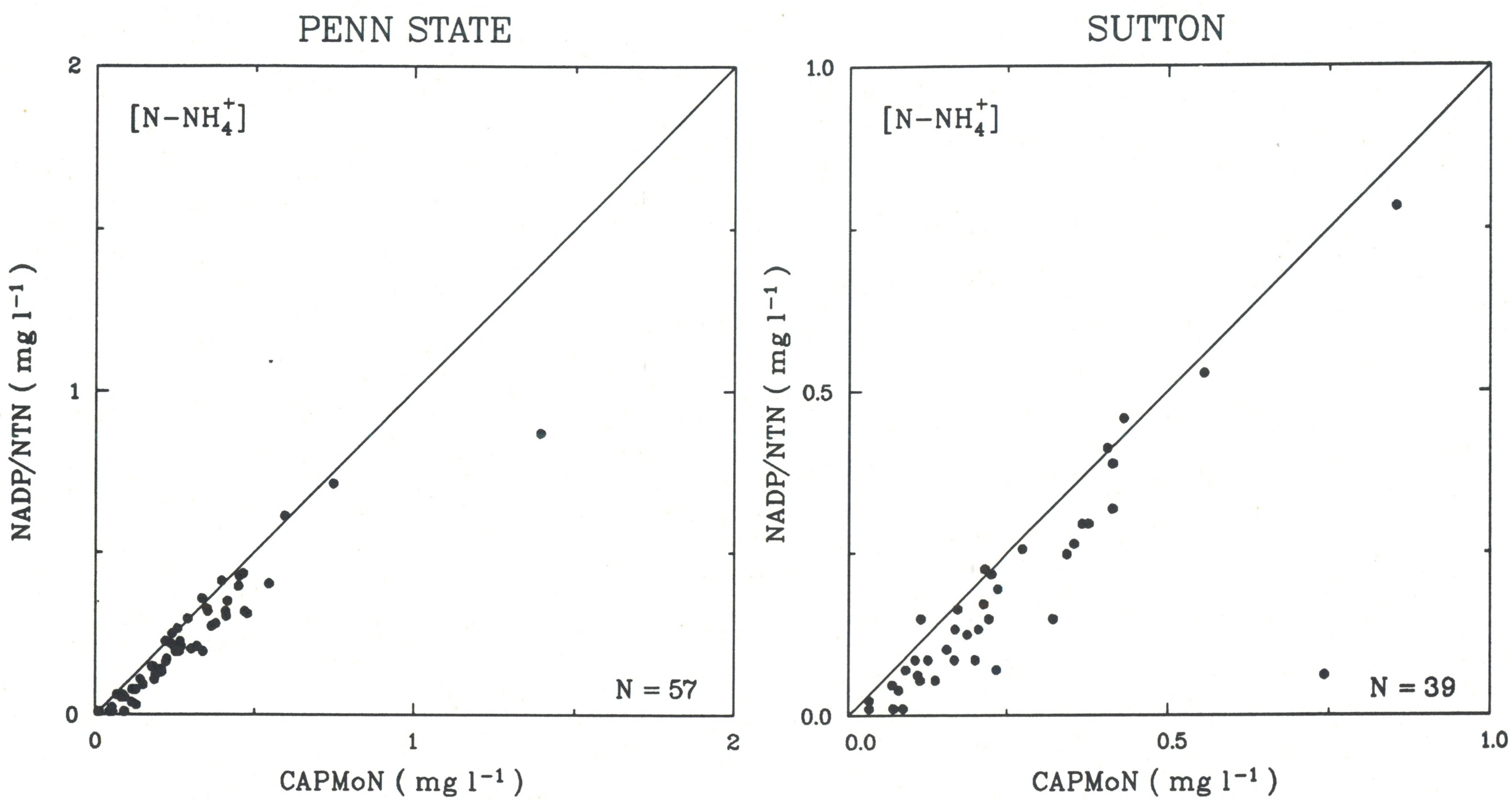


Fig. 2 (cont'd) f. [NH_4^+]

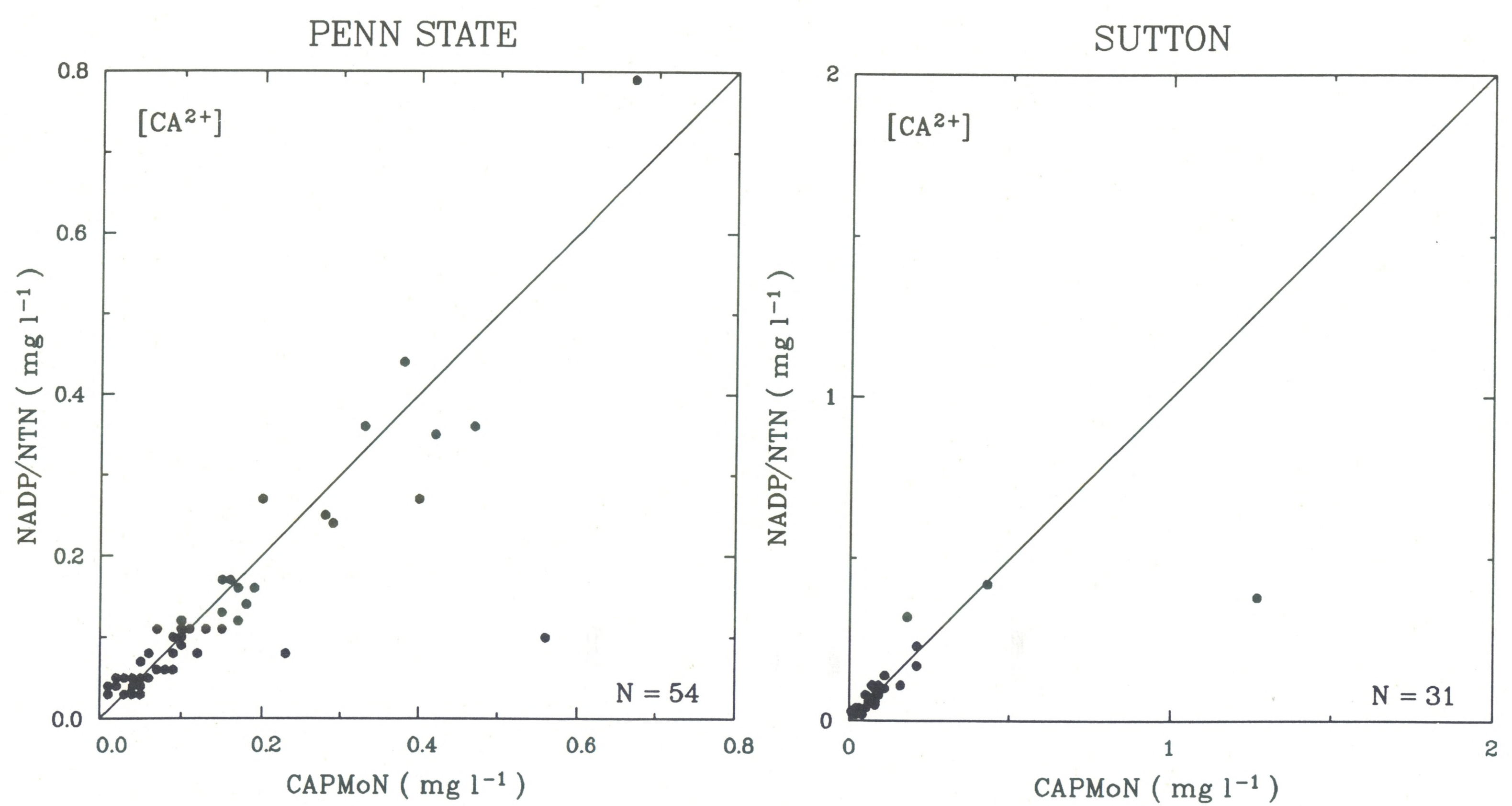


Fig. 2 (cont'd) g. $[Ca^{2+}]$

CAPMoN employs a more sensitive rain sensor on its collector than does NADP/NTN, a bias in the chemical data could result if the more sensitive sensor allowed the sampling of a greater number of low-rain events, which perhaps exhibited higher concentrations. One way of testing the idea that the observed bias in precipitation depth is due to different sensor sensitivities is to link the lid openings on each collector to a common sensor electrically. Such a study has been considered, but it has not yet been implemented.

The concentrations of hydronium ion, $[H_3O^+]$, in precipitation collected by each protocol at the two sites are compared in Fig. 2c. Although the values, calculated from measured pH values, show considerable scatter, they are clearly biased. The lower magnitudes of free acidity obtained under the NADP/NTN protocol (~0.01 mg-H ℓ^{-1} or 10 μeq ℓ^{-1}) correspond to pH values that are higher (by less than 0.1 pH unit) than those obtained under the CAPMoN protocol. Such a bias represents a relative concentration difference of 10% at a pH of 4, increasing even more at higher pH values. Since hydronium is not a conservative ion, but responds rapidly to balance ionic charge in the precipitation samples (Liljestrand, 1985), we must seek an explanation for the bias in terms of the concentrations of other ions.

Figure 2d presents the sulfate data obtained during this intercomparison period. In contrast to the other variables considered thus far, sulfate exhibits no obvious bias on the scale of the presentation. Even though sulfate is the dominant anion contribution to the acidity of the precipitation, it does not appear possible to explain the observed bias in $[H_3O^+]$ in terms of differences in measured sulfate concentration.

The concentrations of nitrate in the intercomparison data set are plotted in Fig. 2e. Although these data, especially those from the Penn State site, are very highly correlated, a small bias is evident; the concentrations of NO_3^- from NADP/NTN fall about 0.1 mg-N ℓ^{-1} short of those from CAPMoN. The direction or sense of this bias is proper to explain the bias in $[H_3O^+]$, but the magnitude can account for only about 4 of the 10 μeq ℓ^{-1} needed.

Ammonium (NH_4^+) is a cation that has the potential of influencing precipitation acidity through its neutralizing ability. The scattergrams of $[NH_4^+]$ from each site in the intercomparison are shown in Fig. 2f. Again, a measurable bias shows up, amounting to less than 0.1 mg-N ℓ^{-1}. Not only is the magnitude of this bias (~6 μeq ℓ^{-1}) too small, but the sense is opposite to that needed to explain the bias in acidity. To first approximation the biases in nitrate and ammonium are self-compensating in their influence on the acidity of the precipitation because of the opposite charges on these two ions. However, both biases lead to a net deficit in ionic nitrogen in precipitation samples analyzed by NADP/NTN compared with those of CAPMoN. It is conceivable, but not yet provable, that the deficit in nitrogen compounds in NADP/NTN samples is real and associated with the length of time (up to seven days) that collected precipitation sits in the NADP/NTN bucket at ambient temperature, during which time microbial activity takes its toll on the nitrogen compounds. (CAPMoN samples are collected daily and refrigerated at 4°C soon after collection.) This is an area in which further investigations are needed.

Another cation that is also known to be an effective acidity neutralizer is calcium (Ca^{2+}), so the concentrations of this ion are presented in Fig. 2g. Despite the different scales and ranges associated with the two panels in this figure, we note that the magnitudes of $[Ca^{2+}]$ are comparable at both sites and not obviously biased in either protocol within the scatter of the data. Thus, this ion is also not a candidate for explaining the observed bias in acidity.

Other ions considered in this regard, but not presented as scattergrams here, include chloride (Cl^-), magnesium (Mg^{2+}), sodium (Na^+), and potassium (K^+). No biases were found with Cl^- or Mg^{2+}. Large relative biases (~50%) were found with both Na^+ (NADP/NTN high) and K^+ (CAPMoN high). However, because of the low concentrations exhibited by these ions, not much more than 1 $\mu eq\ \ell^{-1}$ of acidity could ever be accounted for by such discrepancies.

Ion balances, calculated on an equivalence basis by

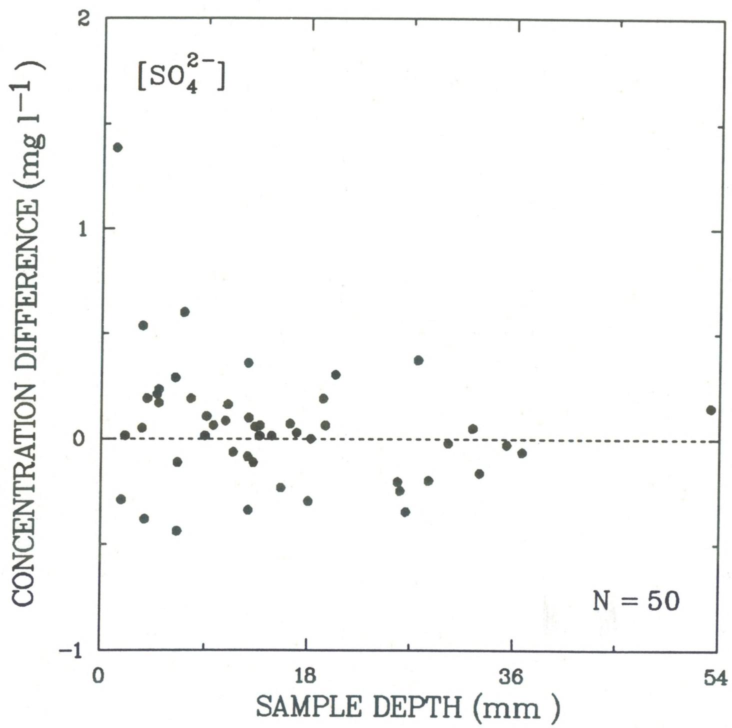
$$IB \equiv \frac{\Sigma anions - \Sigma cations}{\Sigma anions + \Sigma cations} \quad , \qquad (8)$$

tended to be biased by about 10% in the sense of NADP/NTN samples having an excess of anions. This is, again, not rigorously consistent with a lower acidity in the NADP/NTN samples relative to those in CAPMoN samples.

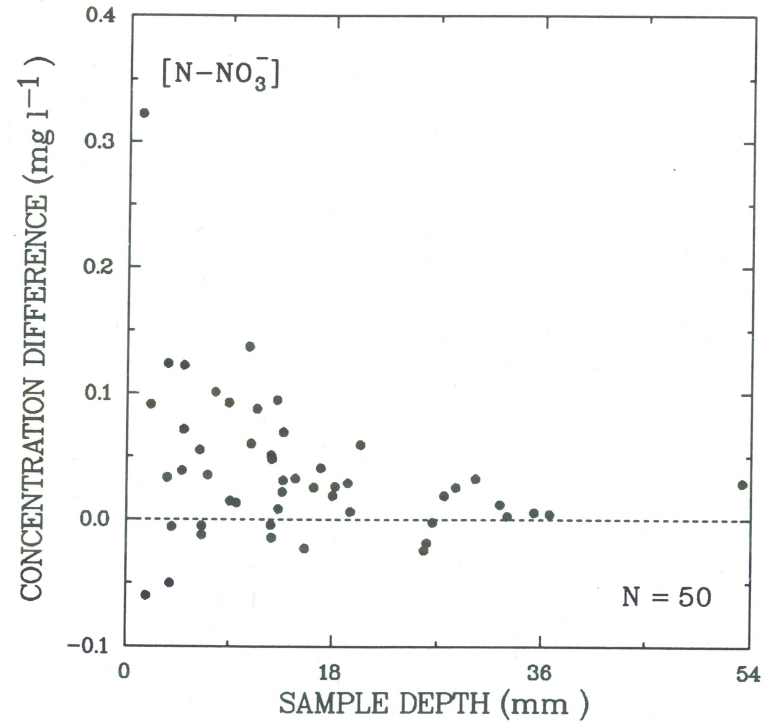
A slightly different way of presenting the data is to plot the difference in concentrations obtained under the two different protocols against the mean collector depth. This is done for sulfate and nitrate at the Penn State site in Fig. 3. Larger scatter or variability in the data tends to occur with low-volume samples. This may be an effect of uncertainties introduced by analytical dilution conducted with low-volume CAPMoN samples, although other factors are probably also important (Vet and Sirois, 1987).

4.3 . Model Testing

The difference data (Appendix) from this CAPMoN-NADP/NTN intercomparison study were analyzed statistically. As discussed in Section 3.3, the statistical model (Eq. 4) is based on the expectation that a simple bias exists in the data; that is, we expect the precipitation chemistry results



a. SO_4^{2-} at Penn State



b. NO_3^- at Penn State

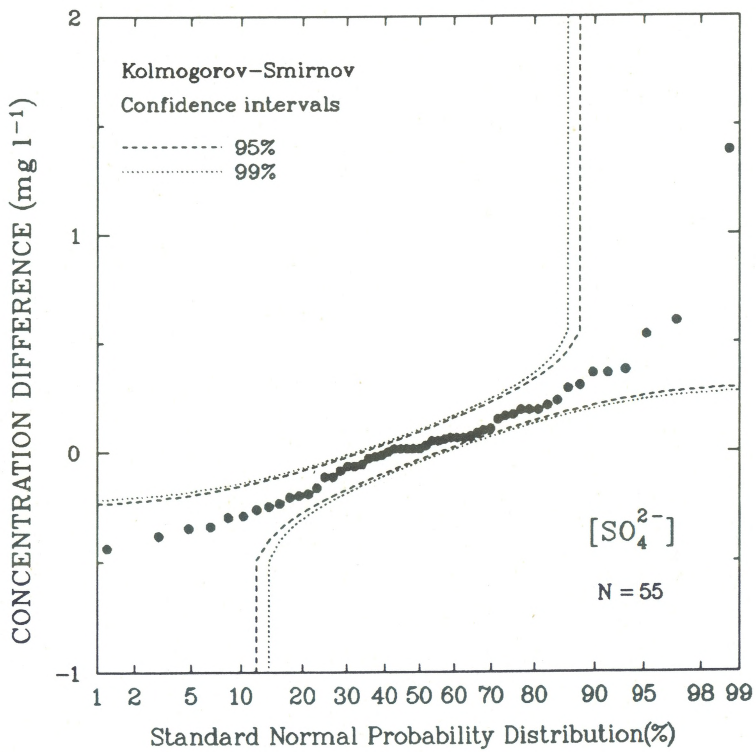
Fig. 3. Dependence of concentration differences on sample volume.

from one network to be reasonably well correlated with those from the other network, but shifted slightly from a strict 1:1 relationship. Such an expectation seems to be borne out by the qualitative results shown in Section 4.2.

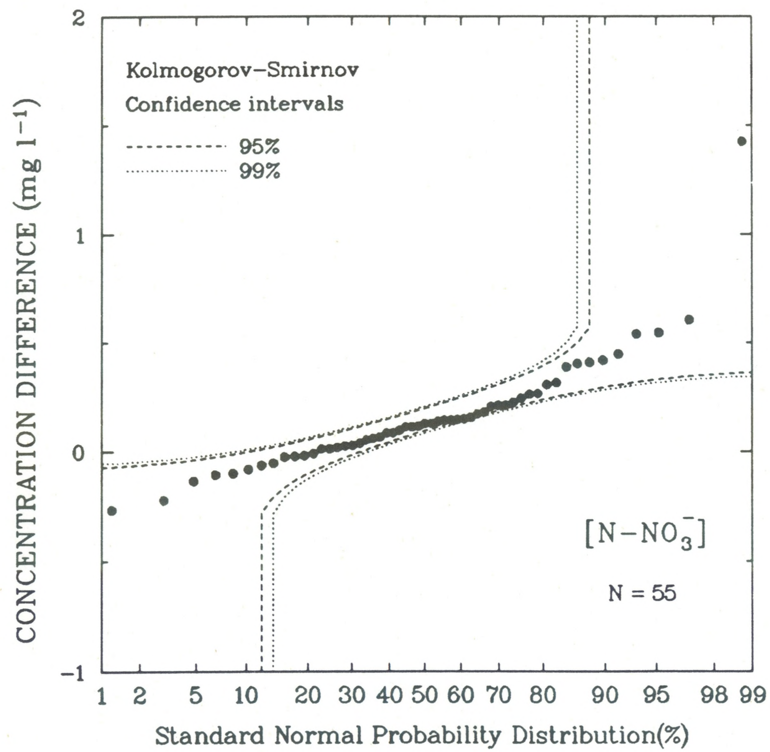
Before testing data against a specific model, one should establish how the data are distributed in order to decide what type of statistical method to apply. The hypothesis of normality was tested using a Kolmogorov-Smirnov test at a 95%-confidence level (Michael, 1983). By way of example, the difference data for sulfate and nitrate were plotted against the normal probability function, as presented in Fig. 4. The hypothesis of non-normality could not be rejected for any of the major ions considered in this study.

Nevertheless, both parametric and nonparametric statistical methods were used to estimate the bias and intercomparison precision. Application of the specific methods outlined in Section 3.3 leads to the results shown in Table 5. For each variable the bias is given as the sample mean (parametric method) and as the median value (nonparametric method). Typically, the median is less than the mean because of the lesser weight given to outliers. Also shown are the intercomparison precision estimates, calculated as the sample standard deviation and Modified Median Absolute Difference (M.MAD, Eq. 7) by the parametric and nonparametric methods, respectively. These precision estimates were used to calculate the 95%-confidence intervals about each bias value. Those cases in which the confidence interval did not span zero were considered to exhibit biases that are statistically significant, as indicated in Table 5.

Note that each of the variables exhibiting significant bias was seen to be qualitatively (i.e., evident by eye) biased, as discussed in Section 4.2. The only exception to this is the case of nitrate at Sutton, earlier



a. $\Delta\ [SO_4^{2-}]$ at Penn State



b. $\Delta\ [NO_3^-]$ at Penn State

Fig. 4. Normal probability plots of selected variables.

Table 5. Bias and precision estimates of difference data (mg ℓ^{-1})

	N	Parametric		Nonparametric	
		Bias (Mean)	Precision (Standard Deviation)	Bias (Median)	Precision (M.MAD[a])
a. Penn State					
$SO_4^{=}$	55	0.06	0.41	0.02	0.31
$N\text{-}NO_3^-$	55	0.05[b]	0.08	0.04[c]	0.05
Cl^-	55	0.00	0.05	0.00	0.01
Ca^{++}	54	0.02	0.08	0.01	0.03
$N\text{-}NH_4^+$	57	0.06[b]	0.08	0.05[c]	0.03
Mg^{++}	53	0.00	0.01	0.00	0.01
Na^+	52	-0.01	0.04	-0.02	0.02
K^+	52	0.01	0.01	0.01	0.01
H_3O^+	52	0.010[b]	0.010	0.008[c]	0.009
pH	52	-0.06[b]	0.07	-0.06[c]	0.06
Gage (mm)	57	1.4[b]	1.5	1.0[c]	1.6
Collector (mm)	59	2.2[b]	1.5	2.0[c]	1.8
b. Sutton					
$SO_4^{=}$	33	-0.08	0.30	-0.04	0.22
$N\text{-}NO_3^-$	33	0.02	0.10	0.01	0.05
Cl^-	33	-0.01	0.03	-0.02	0.03
Ca^{++}	31	0.02	0.16	0.00	0.03
$N\text{-}NH_4^+$	39	0.07[b]	0.11	0.05[c]	0.04
Mg^{++}	32	0.00	0.01	0.00	0.00
Na^+	37	-0.03	0.05	-0.02	0.01
K^+	37	0.00	0.01	0.00	0.00
H_3O^+	33	0.010[b]	0.013	0.007[c]	0.007
pH	33	-0.09[b]	0.14	-0.08[c]	0.12
Gage (mm)	65	1.9[b]	2.2	1.7[c]	1.8
Collector (mm)	61	3.0[b]	2.4	2.6[c]	1.5

a: $M.MAD = \text{Median}(|X_i - \text{Median}|)/.6745$
b: Significant at the 95% confidence level, using Student's t test
c: Significant at the 95% confidence level, using sign test

considered along with nitrate at the Penn State site to be obviously biased. The lack of statistically significant difference at Sutton is probably due to the larger scatter and fewer data points in that data set. Otherwise, the main variables that were found to exhibit statistically significant differences at both sites were [H_3O^+] (and therefore pH), [NH_4^+], sample depth, and precipitation gage depth. The fact that each of these variables showed significant bias by both parametric and nonparametric methods at both sites, where operations are conducted completely independently, suggests that the observed differences are real manifestations of differences in the operational and/or analytical protocols followed by CAPMoN and NADP/NTN.

4.4 Overall Comparability

The magnitudes of the statistically significant biases are sufficiently large to warrant the focusing of further attention on the relevant variables. Although the relative differences (ratio of bias to mean value) for nitrate and precipitation gage depth are less than 10%, the relative differences for the other variables can be considerably greater (~15% for sample depth and [H_3O^-], ~25% for [NH_4^+]). A particular concern arises for deposition calculations, given as the product of the precipitation depth and concentration, since the sense of the biases in the concentrations of each of these ions is the same as that of the precipitation gage depth. Thus, the biases in calculated deposition are magnified. Estimates of annual deposition at Penn State, calculated from the complete daily CAPMoN and weekly NADP/NTN data sets, showed the following between-network relative differences:

Sulfate	9%
Nitrate	16%*
Ammonium	32%*
Hydronium	24%*
Chloride	2%
Calcium	14%
Potassium	69%
Sodium	-22%
Magnesium	0%
Precipitation Depth	6%

Positive values signify that deposition magnitudes derived from CAPMoN data exceed those from NADP/NTN data. The values marked with an asterisk are likely to be both statistically significant (on the basis of earlier week-to-week tests) and of importance to the problem of acidic deposition. However, it should be noted that each of these biases effectively represents only one annual sample since data for only one year have been used. Multiple years of intercomparison would be needed before anything statistically significant could be said about the annual biases.

Despite the measurable differences in the weekly data from NADP/NTN and CAPMoN, the respective variables are well correlated, exhibiting at most modest internetwork bias, but good precision. When the ranges of the variables and the distinctions in sampling methodology are considered, it appears that both the CAPMoN and NADP/NTN protocols are able to capture the essential features of the precipitation chemistry fairly well. That is, data generated by each network are likely to be representative, within the precisions indicated in Table 5, of precipitation at the individual collection sites. However, it must be appreciated that accuracy is a measurement parameter that is not addressable in this type of intercomparison. Similarly, spatial variability of rainfall amount and composition has not been considered in this study, a factor that could well dominate the bias and measurement precision estimates uncovered here, especially in complex terrain, thereby posing a more real limitation to the validation of source-receptor models than would measurement uncertainties.

Finally, the generation of maps showing the spatial distribution of acidic deposition, for instance, is deemed to be a valid application of network data. The reliability and precision of such efforts are generally increased when data sets from adjoining or overlapping networks can be combined, especially since the drawing of isopleths is often limited by sparse data coverage. Given other uncertainties, such as those associated with some assumptions made in the kriging process, and the reasonable degree of comparability between the precipitation data obtained under the CAPMoN and NADP/NTN protocols, these two data sets may be usefully combined for purposes of assessing the regional-scale distributions of wet-deposited ionic species. With due concern over the temporal resolution and the incremental values displayed, isopleth maps of most common ionic concentrations and wet deposition magnitudes may be drawn that span the U.S-Canadian border. The results of this intercomparison suggest that the greatest difficulty will occur with annual depositions of NH_4^+ and H_3O^+. As our collective understanding of the causes of measurement uncertainties improves and we are able to obtain data with greater spatial resolution, the usefulness of displaying data over a geographic region can also be improved.

5. CONCLUSIONS

Precipitation chemistry data have been collected under two distinctly different protocols (CAPMoN, daily sampling; NADP/NTN, weekly sampling) at two widely separated sites (Penn State, Pennsylvania; Sutton, Quebec) for a period of slightly more than one year (16 September 1986 through 27 December 1987). The data were analyzed qualitatively through scattergrams and statistically by testing the difference data against a simple model that assumes a constant bias to exist between the separate data sets. Both parametric and non-parametric methods were used to estimate the magnitudes of the biases and the internetwork precision.

The results of our comparison demonstrate that measurable and statistically significant biases exist in some variables, particularly ammonium, nitrate, hydronium (i.e., free acidity), sample depth, and precipitation gage depth. Furthermore, the directional senses and magnitudes of the biases are comparable at both sites, despite independent operations and equipment, suggesting that the observed differences are real manifestations of the differences in protocols being followed by CAPMoN and NADP/NTN.

Despite consistent differences in some of the data obtained by these protocols, the magnitudes of the statistically significant biases are at worst modest in relation to the ranges of the variables (as is evident in Fig. 2). Thus, while the origins of the observed discrepancies should be of concern and corrective action should be taken, it is concluded that the data sets generated under the CAPMoN and NADP/NTN protocols are generally comparable and representative of precipitation at the individual sampling sites, at least on a weekly time scale. The precipitation chemistry data from the CAPMoN and NADP/NTN networks can probably be combined to analyze the spatial distribution of wet deposition over suitable space and time scales, especially since the natural horizontal variability in precipitation chemistry most likely dominates measurement uncertainties as the limiting factor. Future work should emphasize understanding the relationship of idealized measurements made at a point to the corresponding spatial averages, as well as striving to improve the measurement process itself.

Acknowledgments

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APPENDIX - TABULATED DATA

1. Weekly Concentration and Deposition Data from CAPMoN at Penn State

PENN STATE – CAPMoN

CONCENTRATION (mg l^{-1})

Beginning Date	Standard Gauge Depth mm	Sample Depth mm	pH	Na^{+}	NH_4^{+}	Ca^{++}	Mg^{++}	K^{+}	$SO_4^{=}$	NO_3^{-}	Cl^{-}
16/ 9/86	19.8	20.7	3.89	0.02	0.33	0.09	0.02	0.02	4.30	0.69	0.12
23/ 9/86	44.4	47.6	3.88	0.06	0.22	0.07	0.02	0.02	4.42	0.47	0.19
30/ 9/86	51.9	52.5	3.99	0.07	0.34	0.07	0.02	0.05	3.87	0.49	0.21
7/10/86	23.6	24.3	4.34		0.15	0.05			1.72	0.24	0.09
14/10/86	1.6	1.3									
21/10/86	7.0	7.9	4.13	0.11	0.26	0.12	0.02	0.02	1.96	0.64	0.16
28/10/86	2.3	3.1	3.94	<0.01	0.14	0.09	<0.01	<0.01	2.55	0.80	0.25
4/11/86			4.37	0.01	0.08	0.03	0.01	0.02	1.27	0.26	0.06
11/11/86		5.3									
18/11/86	41.4	41.7	4.20	0.01	0.41	0.05	0.01	0.02	1.86	0.58	0.13
25/11/86	48.2	48.4	4.44		0.08	0.02	0.02	0.01	1.25	0.16	0.29
2/12/86	20.4		4.29	0.04	0.18	0.06	0.01	0.01	1.47	0.35	0.21
9/12/86	7.8	8.4									
16/12/86	9.1	9.9	3.90	0.02	0.45	0.05	<0.01	0.02	3.14	1.00	0.22
23/12/86	24.9	26.3	4.37	0.01	0.12	0.03	0.01	0.01	1.15	0.20	0.06
30/12/86	23.4	21.8	4.59	0.02	0.05	0.05	0.01	0.01	0.40	0.22	0.12
6/ 1/87	6.7	5.9	4.05	0.03	0.36	0.06	<0.01	0.03	2.41	0.81	0.15
13/ 1/87	21.7	20.5	4.64	0.02	0.09	0.03	<0.01	0.02	0.92	0.15	0.10
20/ 1/87	22.0	20.1	4.59		0.04	0.04	0.01		0.33	0.25	0.11
27/ 1/87	12.1	7.9									
3/ 2/87	<0.2	1.5	4.15	0.07	1.39	0.56	0.09	0.04	5.54	1.00	0.60
10/ 2/87	8.2	7.5	3.93	0.08	0.38	0.28	0.03	0.04	2.16	1.37	0.36
17/ 2/87	10.0	9.2	4.18	0.02	0.11	0.17	0.01	0.02	0.98	0.72	0.11
24/ 2/87	15.6	16.9	4.20	0.05	0.25	0.03	<0.01	0.02	1.89	0.44	0.19
10/ 3/87	8.5		4.08	0.01	0.18	0.23	<0.01	0.03	0.85	0.98	0.14
24/ 3/87	51.2	53.7	4.30	0.12	0.18	0.04	0.02	0.04	2.06	0.17	0.23
2/ 4/87	72.5		4.20	0.05	0.19	0.10	0.02	0.03	1.95	0.45	0.15
7/ 4/87	9.7	11.4	4.04	0.02	0.47	0.40	0.06	0.04	3.07	0.91	0.26
14/ 4/87	6.6	7.7			0.30	0.29	0.04				
21/ 4/87	28.2	29.0	3.92	0.05	0.46	0.15	0.02	0.05	5.07	0.75	0.15
28/ 4/87	35.0	38.2	4.07	0.02	0.40	0.20	0.02	0.01	4.17	0.53	0.13
12/ 5/87	21.8	22.7	4.10	0.03	0.24	0.10	0.02	0.02	3.42	0.54	0.13
19/ 5/87	19.4	19.3	3.83	<0.01	0.19	0.02	<0.01	<0.01	6.30	0.68	0.10
26/ 5/87	13.7	13.7	3.94	0.05	0.48	0.10	0.03	0.03	5.56	0.79	0.15
2/ 6/87	24.7	26.8	3.99	0.06	0.75	0.42	0.07	0.04	6.53	0.78	0.23
9/ 6/87	36.8	38.1	4.12	0.01	0.35	0.07	0.02	0.02	3.47	0.39	0.11
16/ 6/87	18.4	18.7	3.77	0.02	0.27	0.09	0.01	0.05	7.10	0.75	0.22
23/ 6/87	16.7	16.1									
30/ 6/87	39.4	41.0	3.89	0.03	0.24	0.13	0.02	0.03	5.24	0.65	0.16
7/ 7/87	10.3	10.3		0.08	0.20			0.03	7.06	0.91	0.34
14/ 7/87	12.8	13.2	4.16	0.03	0.11	0.01	<0.01	0.02	3.05	0.22	0.10
21/ 7/87	2.8	2.6	3.76	0.05	0.60	0.67	0.10	0.07	9.37	1.08	0.34
28/ 7/87	9.5	9.8	3.93	0.02	0.29	0.16	0.02	0.02	5.47	0.56	0.12
4/ 8/87	74.7	78.0	4.06	0.02	0.26	0.15	0.01	0.02	4.74	0.38	0.09
11/ 8/87	0.5	0.1									
18/ 8/87	18.2	19.1	4.02	0.04	0.24	0.15	0.02	<0.01	4.76	0.50	0.13
25/ 8/87	43.8	45.4	3.92	0.03	0.22	0.11	0.02	0.02	4.76	0.65	0.16
1/ 9/87	18.9			0.22	0.13	0.05	0.03	0.07	1.74	0.23	0.35
8/ 9/87	29.0	29.4	3.99	0.08	0.41	0.08	0.01	0.03	4.93	0.54	0.20
15/ 9/87	31.0	31.0	3.74	0.02	0.35	0.17	0.02	0.04	6.63	1.09	0.28
22/ 9/87	5.8	5.7	4.02	0.02	0.41	0.33	0.05	0.04	3.75	0.70	0.49
29/ 9/87	37.8	39.2	4.46	0.03	0.22	0.18	0.02	0.02	1.67	0.27	0.06
6/10/87		16.7	3.88	0.03	0.45	0.47	0.04	0.06	3.97	1.17	0.22
13/10/87	<0.2	0.3									
20/10/87	4.4	5.6	3.76	0.08	0.55	0.38	0.05	0.06	7.64	1.25	0.31
27/10/87	18.4	19.5	4.44	0.02	0.07	0.04	0.01	0.01	1.33	0.38	0.11
3/11/87	7.1	7.7	4.02	0.04	0.32	0.19	0.02	0.04	3.10	0.71	0.16
10/11/87	18.3	15.7	4.85	0.03	0.01	0.09	<0.01	<0.01	0.32	0.18	0.04
17/11/87		19.1		0.49	0.13			0.02			
24/11/87	25.3	25.9	4.64	0.03	0.05	0.01	0.01	0.01	0.70	0.20	0.10
1/12/87	6.3	5.8	4.13	0.01	0.26	0.10	0.01	0.01	1.75	0.81	0.29
8/12/87		17.2		0.06	0.19				2.45	0.53	0.41
15/12/87		19.9	4.23		0.21	0.05	0.01		1.99	0.37	0.11
22/12/87		22.0	4.36	0.01	0.09	0.04	<0.01	<0.01	1.00	0.42	0.13

PENN STATE - CAPMoN

DEPOSITION (mg m^{-2})

Beginning Date	H^+	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	2.566	0.396	6.613	1.782	0.396	0.396	85.140	13.622	2.376
23/ 9/86	5.794	2.664	9.679	3.108	0.888	0.888	196.248	20.735	8.436
30/ 9/86	5.309	3.633	17.490	3.633	1.038	2.595	200.853	25.483	10.899
7/10/86	1.079		3.493	1.180			40.592	5.593	2.124
21/10/86	0.523	0.770	1.792	0.840	0.140	0.140	13.720	4.501	1.120
28/10/86	0.264	0.015	0.320	0.207	0.015	0.015	5.865	1.840	0.575
18/11/86	2.587	0.414	16.891	2.070	0.414	0.828	77.004	23.846	5.382
25/11/86	1.735		3.856	0.964	0.964	0.482	60.250	7.808	13.978
2/12/86	1.042	0.816	3.733	1.224	0.204	0.204	29.988	7.201	4.284
16/12/86	1.141	0.182	4.113	0.455	0.061	0.182	28.574	9.073	2.002
23/12/86	1.051	0.249	2.863	0.747	0.249	0.249	28.635	5.005	1.494
30/12/86	0.606	0.468	1.193	1.170	0.234	0.234	9.360	5.195	2.808
6/ 1/87	0.597	0.201	2.439	0.402	0.045	0.201	16.147	5.427	1.005
13/ 1/87	0.497	0.434	1.953	0.651	0.145	0.434	19.964	3.255	2.170
20/ 1/87	0.565		0.968	0.880	0.220		7.260	5.610	2.420
3/ 2/87	0.009	0.009	0.186	0.075	0.012	0.005	0.739	0.133	0.080
10/ 2/87	0.963	0.656	3.091	2.296	0.246	0.328	17.712	11.234	2.952
17/ 2/87	0.661	0.200	1.140	1.700	0.100	0.200	9.800	7.200	1.100
24/ 2/87	0.981	0.780	3.900	0.468	0.104	0.312	29.484	6.786	2.964
10/ 3/87	0.707	0.085	1.487	1.955	0.057	0.255	7.225	8.330	1.190
24/ 3/87	2.596	6.144	9.216	2.048	1.024	2.048	105.472	8.858	11.776
2/ 4/87	4.618	3.625	13.702	7.250	1.450	2.175	141.375	32.770	10.875
7/ 4/87	0.892	0.194	4.540	3.880	0.582	0.388	29.779	8.837	2.522
14/ 4/87			1.980	1.914	0.264				
21/ 4/87	3.384	1.410	13.085	4.230	0.564	1.410	142.974	21.094	4.230
28/ 4/87	2.961	0.700	13.860	7.000	0.700	0.350	145.950	18.445	4.550
12/ 5/87	1.731	0.654	5.188	2.180	0.436	0.436	74.556	11.772	2.834
19/ 5/87	2.869	0.129	3.628	0.388	0.129	0.129	122.220	13.192	1.940
26/ 5/87	1.559	0.685	6.535	1.370	0.411	0.411	76.172	10.768	2.055
2/ 6/87	2.502	1.482	18.476	10.374	1.729	0.988	161.291	19.167	5.681
9/ 6/87	2.778	0.368	12.843	2.576	0.736	0.736	127.696	14.205	4.048
16/ 6/87	3.124	0.368	4.931	1.656	0.184	0.920	130.640	13.800	4.048
30/ 6/87	5.067	1.182	9.298	5.122	0.788	1.182	206.456	25.452	6.304
7/ 7/87		0.824	2.101			0.309	72.718	9.383	3.502
14/ 7/87	0.886	0.384	1.446	0.128	0.085	0.256	39.040	2.816	1.280
21/ 7/87	0.484	0.140	1.666	1.876	0.280	0.196	26.236	3.032	0.952
28/ 7/87	1.116	0.190	2.736	1.520	0.190	0.190	51.965	5.320	1.140
4/ 8/87	6.476	1.494	19.721	11.205	0.747	1.494	354.078	28.685	6.723
18/ 8/87	1.738	0.728	4.441	2.730	0.364	0.121	86.632	9.100	2.366
25/ 8/87	5.225	1.314	9.724	4.818	0.876	0.876	208.488	28.339	7.008
1/ 9/87		4.158	2.381	0.945	0.567	1.323	32.886	4.328	6.615
8/ 9/87	2.946	2.320	12.006	2.320	0.290	0.870	142.970	15.718	5.800
15/ 9/87	5.627	0.620	10.912	5.270	0.620	1.240	205.530	33.697	8.680
22/ 9/87	0.553	0.116	2.378	1.914	0.290	0.232	21.750	4.083	2.842
29/ 9/87	1.308	1.134	8.278	6.804	0.756	0.756	63.126	10.319	2.268
20/10/87	0.760	0.352	2.402	1.672	0.220	0.264	33.616	5.482	1.364
27/10/87	0.672	0.368	1.214	0.736	0.184	0.184	24.472	7.029	2.024
3/11/87	0.683	0.284	2.258	1.349	0.142	0.284	22.010	5.027	1.136
10/11/87	0.262	0.549	0.183	1.647	0.122	0.122	5.856	3.367	0.732
24/11/87	0.574	0.759	1.341	0.253	0.253	0.253	17.710	5.009	2.530
1/12/87	0.469	0.063	1.644	0.630	0.063	0.063	11.025	5.122	1.827

2. Weekly Concentration and Deposition Data from NADP/NTN at Penn State

PENN STATE - NADP/NTN

CONCENTRATION (mg l^{-1})

Beginning Date	Standard Gauge Depth mm	Sample Depth mm	pH	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	19.1	18.1	3.96	0.04	0.36	0.08	0.02	0.02	4.28	0.64	0.12
23/ 9/86	45.2	43.9	3.99	0.07	0.23	0.06	0.02	0.02	4.35	0.45	0.23
30/ 9/86	49.0	47.5	4.05	0.08	0.19	0.06	0.02	0.02	3.91	0.48	0.21
7/10/86	24.1	22.1	4.52		0.09	0.04			1.62	0.20	0.07
14/10/86	0.8	1.0									
21/10/86	7.4	6.1	4.27	0.14	0.26	0.08	0.02	0.01	1.72	0.54	0.14
28/10/86	3.1	2.6	4.13	0.14	0.11	0.08	0.01	0.00	2.53	0.67	0.24
4/11/86			4.43	0.02	0.06	0.03	0.00	0.00	1.54	0.25	0.07
11/11/86		<0.2									
18/11/86	38.1	39.1	4.28	0.03	0.32	0.07	0.01	0.01	2.14	0.54	0.14
25/11/86	43.9	45.0	4.54		0.05	0.04	0.02	0.00	1.48	0.16	0.29
2/12/86	21.8		4.33	0.06	0.11	0.05	0.01	0.00	1.84	0.29	0.20
9/12/86	7.6	7.7									
16/12/86	8.6	8.6	4.01	0.07	0.43	0.05	0.01	0.01	3.76	1.01	0.24
23/12/86	25.9	24.7	4.55	0.04	0.08	0.05	0.01	0.01	1.57	0.17	0.09
30/12/86	23.4	20.1	4.77	0.02	0.02	0.03	0.00	0.00	0.38	0.18	0.09
6/ 1/87	4.8	5.3	4.11	0.05	0.27	0.08	0.02	0.02	2.14	0.82	0.17
13/ 1/87	18.3	17.1	4.62	0.04	0.05	0.03	0.01	0.00	0.84	0.14	0.11
20/ 1/87	19.1	18.4	4.69		<0.02	0.03	0.01		0.31	0.22	0.11
27/ 1/87	7.9	5.9									
3/ 2/87	1.8	1.5	4.27	0.11	0.87	0.10	0.02	0.02	3.58	0.54	0.38
10/ 2/87	6.6	6.5	4.02	0.07	0.28	0.25	0.04	0.02	1.83	1.20	0.33
17/ 2/87	8.1	8.9	4.40	0.07	0.08	0.12	0.02	0.00	0.57	0.64	0.10
24/ 2/87	14.0	13.9	4.36	0.04	0.19	0.03	0.01	0.01	1.66	0.35	0.17
10/ 3/87	6.4		4.15	0.01	0.15	0.08	0.01	0.01	0.93	1.02	0.13
24/ 3/87	51.8	50.2	4.37	0.11	0.15	0.05	0.02	0.01	2.15	0.17	0.22
2/ 4/87	68.3		4.30	0.05	0.14	0.09	0.02	0.01	1.97	0.40	0.16
7/ 4/87	9.6	10.4	4.22	0.05	0.32	0.27	0.05	0.02	2.80	0.77	0.26
14/ 4/87	5.6	5.7			0.20	0.24	0.05				
21/ 4/87	27.4	25.7	3.97	0.06	0.44	0.13	0.02	0.03	4.80	0.71	0.15
28/ 4/87	35.1	35.6	4.09	0.04	0.41	0.27	0.04	0.03	4.52	0.55	0.17
12/ 5/87	21.8	21.5	4.11	0.03	0.25	0.12	0.03	0.03	3.75	0.57	0.15
19/ 5/87	16.3	16.5	3.87	0.03	0.12	0.05	0.02	0.00	5.79	0.61	0.09
26/ 5/87	12.7	11.6	3.95	0.05	0.31	0.10	0.02	0.02	5.54	0.65	0.15
2/ 6/87	23.9	24.7	3.95	0.07	0.71	0.35	0.06	0.07	6.53	0.74	0.24
9/ 6/87	34.5	35.2	4.15	0.04	0.33	0.11	0.02	0.02	3.76	0.42	0.14
16/ 6/87	16.5	17.3	3.79	0.03	0.21	0.10	0.01	0.01	6.96	0.77	0.21
23/ 6/87	15.2	15.1									
30/ 6/87	36.6	37.0	3.95	0.05	0.22	0.11	0.02	0.02	4.71	0.62	0.17
7/ 7/87	8.6	9.8		0.08	0.14			0.02	6.21	0.86	0.36
14/ 7/87	12.2	12.4	4.19	0.08	0.04	0.04	0.01	0.00	2.90	0.20	0.10
21/ 7/87	1.8	2.4	3.77	0.12	0.61	0.79	0.13	0.05	9.78	1.17	0.43
28/ 7/87	8.9	8.7	3.95	0.08	0.30	0.17	0.03	0.01	5.63	0.57	0.17
4/ 8/87	73.1	72.7	4.08	0.02	0.23	0.11	0.01	0.01	4.53	0.34	0.10
11/ 8/87	<0.2	<0.2									
18/ 8/87	17.3	16.7	3.96	0.08	0.21	0.17	0.02	0.01	4.88	0.51	0.16
25/ 8/87	41.9	40.1	3.93	0.03	0.17	0.11	0.02	0.01	4.79	0.60	0.21
1/ 9/87	16.0			0.15	0.03	0.04	0.02	0.02	1.23	0.16	0.25
8/ 9/87	26.2	25.9	3.97	0.08	0.35	0.06	0.02	0.02	4.84	0.53	0.21
15/ 9/87	28.2	26.6	3.76	0.04	0.32	0.16	0.03	0.03	6.20	1.00	0.27
22/ 9/87	4.8	5.2	4.03	0.08	0.30	0.36	0.08	0.04	4.29	0.77	0.59
29/ 9/87	38.1	36.0	4.41	0.04	0.16	0.14	0.02	0.01	2.16	0.28	0.09
6/10/87		13.5	4.01	0.07	0.40	0.36	0.05	0.04	3.85	0.98	0.23
13/10/87	0.3	<0.2									
20/10/87	4.6	4.3	3.82	0.12	0.40	0.44	0.07	0.04	6.88	1.07	0.36
27/10/87	17.0	17.6	4.41	0.04	0.06	0.05	0.01	0.01	1.49	0.25	0.11
3/11/87	6.4	5.9	4.15	0.08	0.21	0.16	0.02	0.04	2.80	0.65	0.15
10/11/87	12.9	11.6	4.89	0.06	<0.02	0.06	0.01	0.00	0.23	0.17	0.05
17/11/87		17.6		0.34	0.08			0.02			
24/11/87	21.8	22.2	4.74	0.06	<0.02	0.03	0.01	0.00	0.66	0.14	0.12
1/12/87	3.6	4.2	4.19	0.04	0.19	0.11	0.02	0.00	1.68	0.77	0.18
8/12/87		15.0		0.07	0.14				2.54	0.40	0.25
15/12/87		16.2	4.27		0.13	0.05	0.01		2.47	0.30	0.08
22/12/87		16.8	4.46	0.02	<0.02	0.04	0.01	0.00	0.91	0.32	0.11

PENN STATE – NADP/NTN

DEPOSITION (mg m^{-2})

Beginning Date	H^{+}	Na^{+}	NH_4^{+}	Ca^{++}	Mg^{++}	K^{+}	$SO_4^{=}$	NO_3^{-}	Cl^{-}
16/ 9/86	2.093	0.840	6.819	1.528	0.306	0.306	81.748	12.300	2.292
23/ 9/86	4.624	3.074	10.170	2.712	0.678	0.723	196.620	20.340	10.396
30/ 9/86	4.366	3.920	9.506	2.940	0.833	0.833	191.590	23.667	10.290
7/10/86	0.728		2.241	0.964			39.042	4.844	1.687
21/10/86	0.397	1.021	1.954	0.592	0.163	0.081	12.728	4.011	1.036
28/10/86	0.230	0.443	0.338	0.248	0.040	0.015	7.843	2.080	0.744
18/11/86	2.000	1.067	12.116	2.667	0.305	0.343	81.534	20.574	5.334
25/11/86	1.264		2.371	1.756	0.966	0.176	64.972	6.936	12.731
2/12/86	1.020	1.221	2.376	1.090	0.196	0.087	40.112	6.213	4.360
16/12/86	0.840	0.576	3.672	0.430	0.077	0.120	32.336	8.720	2.064
23/12/86	0.730	0.984	2.020	1.295	0.311	0.311	40.663	4.507	2.331
30/12/86	0.398	0.538	0.538	0.702	0.117	0.117	8.892	4.118	2.106
6/ 1/87	0.372	0.221	1.306	0.384	0.086	0.077	10.272	3.926	0.816
13/ 1/87	0.439	0.677	0.988	0.549	0.146	0.073	15.372	2.525	2.013
20/ 1/87	0.390		0.204	0.573	0.115		5.921	4.278	2.101
3/ 2/87	0.097	0.191	1.566	0.180	0.040	0.045	6.444	0.979	0.684
10/ 2/87	0.630	0.469	1.848	1.650	0.238	0.165	12.078	7.900	2.178
17/ 2/87	0.322	0.567	0.632	0.972	0.154	0.024	4.617	5.200	0.810
24/ 2/87	0.612	0.504	2.716	0.420	0.140	0.196	23.240	4.900	2.380
10/ 3/87	0.453	0.064	0.947	0.512	0.070	0.038	5.952	6.547	0.832
24/ 3/87	2.212	5.543	7.666	2.590	1.088	0.570	111.370	8.651	11.396
2/ 4/87	3.422	3.552	9.562	6.147	1.571	0.683	134.551	27.593	10.928
7/ 4/87	0.579	0.480	3.053	2.592	0.470	0.163	26.880	7.373	2.496
14/ 4/87			1.131	1.344	0.263				
21/ 4/87	2.937	1.644	11.919	3.562	0.630	0.795	131.520	19.372	4.110
28/ 4/87	2.854	1.264	14.461	9.477	1.544	1.193	158.652	19.410	5.967
12/ 5/87	1.692	0.698	5.406	2.616	0.567	0.632	81.750	12.470	3.270
19/ 5/87	2.199	0.440	2.021	0.815	0.277	0.081	94.377	9.910	1.467
26/ 5/87	1.425	0.622	3.950	1.270	0.317	0.305	70.358	8.318	1.905
2/ 6/87	2.682	1.745	17.065	8.365	1.506	1.697	156.067	17.662	5.736
9/ 6/87	2.443	1.345	11.247	3.795	0.759	0.621	129.720	14.490	4.830
16/ 6/87	2.676	0.446	3.465	1.650	0.165	0.115	114.840	12.705	3.465
30/ 6/87	4.107	1.684	7.942	4.026	0.622	0.549	172.386	22.655	6.222
7/ 7/87		0.688	1.204			0.129	53.406	7.405	3.096
14/ 7/87	0.788	0.952	0.476	0.488	0.171	0.049	35.380	2.428	1.220
21/ 7/87	0.306	0.220	1.103	1.422	0.236	0.097	17.604	2.102	0.774
28/ 7/87	0.999	0.756	2.625	1.513	0.258	0.098	50.107	5.046	1.513
4/ 8/87	6.082	1.754	16.447	8.041	0.950	0.877	331.143	25.073	7.310
18/ 8/87	1.896	1.367	3.633	2.941	0.363	0.190	84.424	8.754	2.768
25/ 8/87	4.923	1.173	7.165	4.609	0.712	0.503	200.701	25.182	8.799
1/ 9/87		2.400	0.496	0.640	0.368	0.288	19.680	2.608	4.000
8/ 9/87	2.809	2.070	9.144	1.572	0.603	0.550	126.808	13.965	5.502
15/ 9/87	4.901	1.128	8.968	4.512	0.761	0.846	174.840	28.285	7.614
22/ 9/87	0.448	0.374	1.454	1.728	0.394	0.206	20.592	3.720	2.832
29/ 9/87	1.482	1.638	6.210	5.334	0.838	0.343	82.296	10.516	3.429
20/10/87	0.696	0.547	1.858	2.024	0.336	0.198	31.648	4.927	1.656
27/10/87	0.661	0.680	1.054	0.850	0.204	0.119	25.330	4.216	1.870
3/11/87	0.453	0.506	1.344	1.024	0.147	0.243	17.920	4.179	0.960
10/11/87	0.166	0.774	0.138	0.774	0.077	0.026	2.967	2.128	0.645
24/11/87	0.397	1.308	0.233	0.654	0.196	0.065	14.388	3.052	2.616
1/12/87	0.233	0.151	0.698	0.396	0.054	0.014	6.048	2.758	0.648

3. Weekly Concentration and Deposition Data from CAPMoN at Sutton

SUTTON - CAPMoN

CONCENTRATION ($mg\ l^{-1}$)

Beginning Date	Standard Gauge Depth mm	Sample Depth mm	pH	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	23.1	22.4	4.19	0.02	0.20	0.08	0.01	0.01	1.85	0.53	0.05
23/ 9/86	38.8	39.3	4.06	0.04	0.21	0.02	<0.01	<0.01	3.08	0.32	0.07
30/ 9/86	41.4										
7/10/86	10.8	10.7									
14/10/86	18.1	18.3	4.34	<0.01	0.10	<0.01	<0.01	<0.01	1.49	0.29	<0.01
21/10/86	22.2	22.4	4.17	0.01	0.43	0.11	0.02	0.02	2.80	0.44	0.04
28/10/86	35.8	36.5	4.16	0.03	0.41	0.08	0.01	0.01	2.20	0.61	0.07
4/11/86	20.4	18.3	4.36	0.01	0.15			0.01	1.21	0.33	0.03
11/11/86	14.8	10.0	4.12	0.03	0.41	0.21	0.02	0.02	1.94	0.94	0.09
18/11/86	32.8	25.0	4.80	0.02	0.03	0.03	0.01	0.01	0.43	0.12	0.03
25/11/86	29.3	30.1	4.51	0.02	0.17	0.05	0.01	0.01	0.76	0.37	0.04
2/12/86	42.0	31.3	4.64	0.02	0.08	0.03	0.01	0.01	0.57	0.23	0.04
9/12/86	19.4	14.3									
16/12/86	5.1										
23/12/86	5.9	5.6		0.06	0.74			0.02			
30/12/86	15.7										
6/ 1/87	28.6	15.8									
13/ 1/87	16.2	9.9									
20/ 1/87	21.4	12.5	4.62		0.07				0.47	0.30	0.14
27/ 1/87	11.3	8.1			0.32						
3/ 2/87	20.5	13.8									
10/ 2/87	4.1	2.8					<0.01				
17/ 2/87	0.2										
24/ 2/87	18.3	15.6	4.44	0.01	0.03	0.01	<0.01	0.01	0.81	0.23	0.02
3/ 3/87	1.5	0.8									
10/ 3/87	9.8	7.3	4.75	0.04	0.11			0.02			
17/ 3/87	5.8	5.6	4.67	0.07	0.22	0.07	<0.01	0.02	1.00	0.21	0.11
24/ 3/87	9.1	9.1	3.88	0.06	0.38	0.16	0.02	0.02	3.79	0.93	0.19
31/ 3/87	25.3	24.6		0.02	0.09			0.01			
7/ 4/87	7.5	7.6	5.33	0.01	0.07	0.01	<0.01	0.01	0.18	0.04	0.01
14/ 4/87	0.2	0.2									
21/ 4/87	14.6	14.7									
27/ 4/87	19.4	19.2									
5/ 5/87	18.1	17.2									
12/ 5/87	7.6	7.6									
19/ 5/87	21.1	21.4	3.99	0.06	0.85	0.18	0.03	0.03	5.32	0.89	0.15
26/ 5/87	69.3	71.9	4.38	0.02	0.37	0.07	0.01	0.02	2.71	0.26	0.06
2/ 6/87	45.9	47.3									
9/ 6/87	24.6	24.8									
16/ 6/87	12.1	12.4	4.47	0.02	0.17	0.11	0.01	0.03	1.31	0.26	0.06
23/ 6/87	30.3	31.8	4.07	0.01	0.23	0.08	0.01	0.02	3.59	0.41	0.07
30/ 6/87	10.0	11.8	4.50	0.01	0.20	0.06	0.01	0.02	1.45	0.25	0.03
7/ 7/87	44.9	48.0	4.56	0.01	0.56	0.21	0.01	0.02	2.34	0.34	0.05
14/ 7/87	35.4	36.8	4.27	0.01	0.27	0.06	0.01	0.01	2.83	0.26	0.04
21/ 7/87	55.8	57.6	4.30	0.01	0.41	0.09	0.02	0.01	3.35	0.22	0.06
28/ 7/87	28.6	29.4	4.51	<0.01	0.14	0.01	0.01	<0.01	1.34	0.16	<0.01
4/ 8/87	18.9	20.1	4.28	0.01	0.22	0.07	0.01	0.02	2.53	0.25	0.04
11/ 8/87	0.9	1.1									
18/ 8/87	17.1	17.2	4.85	0.01	0.21	0.43	0.05	0.01	1.21	0.16	0.04
25/ 8/87	14.0	14.4									
1/ 9/87	0.9	0.8									
8/ 9/87	77.2	78.0	4.43	0.02	0.11	0.02	0.01	0.01	1.50	0.24	0.04
15/ 9/87	5.8	6.0									
22/ 9/87	9.5	9.6									
29/ 9/87		66.3	4.60	0.06	0.19	0.09	0.01	0.01	1.21	0.23	0.11
6/10/87	4.0	3.8									
13/10/87	<0.2	<0.2									
20/10/87				0.05	0.35			0.03	3.01	0.89	0.09
27/10/87	43.0	43.7	4.63	0.01	0.08	0.04	0.01	0.01	0.68	0.24	0.05
3/11/87	30.9										
10/11/87	1.0	0.8									
17/11/87	28.5	22.2		0.11	0.17	1.27	0.10	0.02	1.20	0.42	0.25
24/11/87	55.8	54.7	4.37	0.03	0.12	0.02	<0.01	0.01	1.04	0.40	0.10
1/12/87	6.8	4.2									
8/12/87	8.7	8.8		0.10	0.23	0.05	0.01	0.01			
15/12/87	27.6	18.5	4.26	0.03	0.11	0.03	0.01	0.01	1.14	0.64	0.04
22/12/87	12.3	9.6	4.06	0.05	0.34			0.01			

SUTTON – CAPMoN

DEPOSITION (mg m^{-2})

Beginning Date	H^+	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	1.481	0.462	4.597	1.848	0.231	0.231	42.735	12.312	1.155
23/ 9/86	3.341	1.552	8.303	0.776	0.259	0.259	119.504	12.416	2.716
14/10/86	0.829	0.121	1.882	0.121	0.121	0.121	26.969	5.249	0.121
21/10/86	1.501	0.222	9.568	2.442	0.444	0.444	62.160	9.790	0.888
28/10/86	2.481	1.074	14.821	2.864	0.358	0.358	78.760	21.981	2.506
4/11/86	0.896	0.204	3.142			0.204	24.684	6.773	0.612
11/11/86	1.120	0.444	6.009	3.108	0.296	0.296	28.712	13.986	1.332
18/11/86	0.515	0.656	1.050	0.984	0.328	0.328	14.104	4.034	0.984
25/11/86	0.902	0.586	4.864	1.465	0.293	0.293	22.268	10.900	1.172
2/12/86	0.958	0.840	3.570	1.260	0.420	0.420	23.940	9.702	1.680
23/12/86		0.354	4.384			0.118			
20/ 1/87	0.509		1.498				10.058	6.356	2.996
27/ 1/87			3.639						
10/ 2/87					0.027				
24/ 2/87	0.672	0.183	0.586	0.183	0.122	0.183	14.823	4.191	0.366
10/ 3/87	0.173	0.392	1.058			0.196			
17/ 3/87	0.124	0.406	1.276	0.406	0.039	0.116	5.800	1.247	0.638
24/ 3/87	1.195	0.546	3.431	1.456	0.182	0.182	34.489	8.481	1.729
31/ 3/87		0.506	2.252			0.253			
7/ 4/87	0.035	0.075	0.510	0.075	0.050	0.075	1.350	0.300	0.075
19/ 5/87	2.178	1.266	17.998	3.798	0.633	0.633	112.252	18.884	3.165
26/ 5/87	2.904	1.386	25.433	4.851	0.693	1.386	187.803	18.295	4.158
16/ 6/87	0.413	0.242	2.021	1.331	0.121	0.363	15.851	3.134	0.726
23/ 6/87	2.560	0.303	7.090	2.424	0.303	0.606	108.777	12.544	2.121
30/ 6/87	0.319	0.100	2.040	0.600	0.100	0.200	14.500	2.470	0.300
7/ 7/87	1.230	0.449	24.964	9.429	0.449	0.898	105.066	15.311	2.245
14/ 7/87	1.890	0.354	9.700	2.124	0.354	0.354	100.182	9.310	1.416
21/ 7/87	2.812	0.558	23.101	5.022	1.116	0.558	186.930	12.332	3.348
28/ 7/87	0.889	0.191	3.890	0.286	0.286	0.191	38.324	4.633	0.191
4/ 8/87	0.992	0.189	4.234	1.323	0.189	0.378	47.817	4.687	0.756
18/ 8/87	0.239	0.171	3.625	7.353	0.855	0.171	20.691	2.685	0.684
8/ 9/87	2.864	1.544	8.646	1.544	0.772	0.772	115.800	18.219	3.088
27/10/87	1.010	0.430	3.354	1.720	0.430	0.430	29.240	10.449	2.150
17/11/87		3.135	4.873	36.195	2.850	0.570	34.200	11.913	7.125
24/11/87	2.372	1.674	6.919	1.116	0.372	0.558	58.032	22.543	5.580
8/12/87		0.870	2.018	0.435	0.087	0.087			
15/12/87	1.526	0.828	3.119	0.828	0.276	0.276	31.464	17.802	1.104
22/12/87	1.073	0.615	4.219			0.123			

4. Weekly Concentration and Deposition Data

from NADP/NTN at Sutton

SUTTON - NADP/NTN

CONCENTRATION (mg l^{-1})

Beginning Date	Standard Gauge Depth mm	Sample Depth mm	pH	Na^{+}	NH_4^{+}	Ca^{++}	Mg^{++}	K^{+}	$SO_4^{=}$	NO_3^{-}	Cl^{-}
16/ 9/86	20.3	19.2	4.51	0.01	0.08	0.05	0.01	0.01	1.44	0.27	<0.03
23/ 9/86	41.4	40.3	4.15	0.04	0.23	0.04	0.01	0.01	3.52	0.36	0.07
30/ 9/86	37.1										
7/10/86	9.9	8.8									
14/10/86	15.0	16.1	4.41	0.03	0.08	0.03	0.00	0.00	1.65	0.30	<0.03
21/10/86	21.6	20.1	4.28	0.02	0.46	0.10	0.02	0.01	2.86	0.45	0.04
28/10/86	36.6	33.2	4.29	0.03	0.32	0.06	0.01	0.01	2.25	0.52	0.06
4/11/86	16.5	15.4	4.47	0.02	0.10			0.01	1.41	0.32	<0.03
11/11/86	14.5	7.3	4.19	0.06	0.41	0.17	0.01	0.02	2.63	0.90	0.08
18/11/86	29.2	19.2	4.70	0.05	0.02	0.04	0.00	0.00	0.61	0.16	0.05
25/11/86	30.5	27.1	4.65	0.02	0.08	0.04	0.01	0.01	0.82	0.28	<0.03
2/12/86	39.1	25.8	4.89	0.02	<0.02	0.03	0.00	0.00	0.40	0.10	<0.03
9/12/86	8.9	9.2									
16/12/86	5.1										
23/12/86	5.1	3.4		0.35	0.06			0.00			
30/12/86	12.7										
6/ 1/87	27.2	7.6									
13/ 1/87	14.2	5.5									
20/ 1/87	17.8	9.8	4.88		<0.02				0.34	0.14	0.09
27/ 1/87	8.1	5.5			0.15						
3/ 2/87	15.0	10.1									
10/ 2/87	1.3	1.0					0.01				
17/ 2/87	<0.2										
24/ 2/87	16.0	12.2	4.60	0.02	<0.02	0.03	0.01	0.00	0.69	0.19	0.05
3/ 3/87	<0.2	<0.2									
10/ 3/87	8.9	4.3	4.96	0.12	0.06			0.02			
17/ 3/87	3.8	3.7	4.83	0.05	0.15	0.06	0.01	0.01	0.82	0.21	0.11
24/ 3/87	6.9	6.8	4.04	0.14	0.30	0.11	0.02	0.02	3.59	0.75	0.19
31/ 3/87	22.4	22.0		0.04	0.07			0.01			
7/ 4/87	5.8	5.9	5.57	0.11	0.05	0.02	0.01	0.00	0.19	0.05	0.06
14/ 4/87	<0.2	<0.2									
21/ 4/87	12.7	13.8									
27/ 4/87	19.6	16.6									
5/ 5/87	15.2	14.5									
12/ 5/87	6.9	6.6									
19/ 5/87	19.1	19.3	4.05	0.13	0.78	0.32	0.04	0.03	5.57	1.00	0.23
26/ 5/87	66.8	66.3	4.33	0.05	0.30	0.07	0.02	0.01	2.60	0.23	0.08
2/ 6/87	39.1	42.2									
9/ 6/87	21.6	21.2									
16/ 6/87	10.4	10.1	4.56	0.04	0.13	0.14	0.02	0.01	1.42	0.23	0.08
23/ 6/87	27.4	28.1	4.10	0.03	0.19	0.10	0.02	0.00	3.60	0.41	0.10
30/ 6/87	10.2	10.1	4.58	0.02	0.13	0.06	0.01	0.00	1.41	0.22	0.05
7/ 7/87	45.2	43.8	4.56	0.05	0.53	0.23	0.03	0.01	2.47	0.38	0.13
14/ 7/87	34.3	33.4	4.30	0.05	0.26	0.06	0.01	0.01	2.58	0.24	0.08
21/ 7/87	56.9	53.9	4.30	0.03	0.39	0.11	0.02	0.01	3.29	0.24	0.07
28/ 7/87	29.2	27.0	4.57	0.02	0.05	0.02	0.01	0.00	1.31	0.14	0.04
4/ 8/87	18.3	17.8	4.30	0.05	0.22	0.11	0.02	0.00	2.73	0.27	0.08
11/ 8/87	0.5	0.2									
18/ 8/87	16.5	15.6	5.38	0.03	0.17	0.42	0.06	0.01	1.42	0.18	0.07
25/ 8/87	13.2	12.7									
1/ 9/87	1.3	0.2									
8/ 9/87	69.3	67.5	4.49	0.03	0.05	0.02	0.01	0.00	1.33	0.19	0.06
15/ 9/87	5.1	2.6									
22/ 9/87	7.9	8.1									
29/ 9/87		60.9	4.59	0.07	0.12	0.08	0.02	0.01	1.25	0.21	0.14
6/10/87	3.8	3.0									
13/10/87	<0.2	<0.2									
20/10/87				0.05	0.26			0.01	2.97	0.88	0.11
27/10/87	41.1	38.1	4.74	0.02	0.04	0.02	0.01	0.00	0.57	0.16	0.06
3/11/87	29.0										
10/11/87	0.3	0.3									
17/11/87	22.4	18.7		0.14	0.16	0.38	0.05	0.02	1.60	0.40	0.27
24/11/87	52.3	54.2	4.34	0.05	0.08	0.02	0.01	0.01	1.22	0.44	0.14
1/12/87	3.3	1.4									
8/12/87	7.6	7.4		0.12	0.07	0.08	0.02	0.01			
15/12/87	25.4	5.4	4.05	0.12	0.15	0.04	0.01	0.01	2.36	1.01	0.08
22/12/87	10.7	7.0	3.95	0.05	0.25			0.02			

SUTTON – NADP/NTN

DEPOSITION (mg m^{-2})

Beginning Date	H^+	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	0.627	0.162	1.725	1.015	0.162	0.122	29.232	5.501	0.406
23/ 9/86	2.931	1.656	9.315	1.656	0.373	0.414	145.728	14.780	2.898
14/10/86	0.583	0.420	1.275	0.450	0.075	0.060	24.750	4.440	0.300
21/10/86	1.134	0.497	9.893	2.160	0.346	0.281	61.776	9.655	0.864
28/10/86	1.878	0.952	11.639	2.196	0.293	0.366	82.350	19.178	2.196
4/11/86	0.559	0.314	1.666			0.115	23.265	5.264	0.330
11/11/86	0.937	0.942	5.974	2.465	0.188	0.261	38.135	13.035	1.160
18/11/86	0.584	1.489	0.672	1.168	0.146	0.088	17.812	4.760	1.460
25/11/86	0.683	0.671	2.592	1.220	0.244	0.244	25.010	8.479	0.610
2/12/86	0.504	0.899	0.417	1.173	0.117	0.117	15.640	3.715	0.782
23/12/86		1.805	0.316			0.025			
20/ 1/87	0.235		0.190				6.052	2.581	1.602
27/ 1/87			1.199						
10/ 2/87					0.018				
24/ 2/87	0.402	0.368	0.171	0.480	0.112	0.048	11.040	3.072	0.800
10/ 3/87	0.098	1.032	0.552			0.142			
17/ 3/87	0.056	0.179	0.562	0.228	0.042	0.023	3.116	0.783	0.418
24/ 3/87	0.629	0.994	2.035	0.759	0.172	0.152	24.771	5.141	1.311
31/ 3/87		0.806	1.568			0.179			
7/ 4/87	0.016	0.621	0.273	0.116	0.058	0.029	1.102	0.273	0.348
19/ 5/87	1.702	2.559	14.974	6.112	0.821	0.611	106.387	19.157	4.393
26/ 5/87	3.126	3.073	19.706	4.676	1.002	0.935	173.680	15.364	5.344
16/ 6/87	0.286	0.426	1.373	1.456	0.187	0.146	14.768	2.371	0.832
23/ 6/87	2.176	0.932	5.316	2.740	0.521	0.082	98.640	11.261	2.740
30/ 6/87	0.268	0.163	1.346	0.612	0.112	0.041	14.382	2.213	0.510
7/ 7/87	1.243	2.215	23.866	10.396	1.175	0.497	111.644	16.950	5.876
14/ 7/87	1.718	1.681	8.781	2.058	0.412	0.240	88.494	8.369	2.744
21/ 7/87	2.851	1.536	22.077	6.259	1.309	0.455	187.201	13.485	3.983
28/ 7/87	0.785	0.496	1.577	0.584	0.204	0.058	38.252	4.146	1.168
4/ 8/87	0.917	0.988	3.971	2.013	0.275	0.091	49.959	4.886	1.464
18/ 8/87	0.069	0.478	2.821	6.930	0.973	0.132	23.430	3.019	1.155
8/ 9/87	2.245	1.802	3.742	1.386	0.554	0.139	92.169	13.306	4.158
27/10/87	0.748	1.027	1.603	0.822	0.329	0.082	23.427	6.699	2.466
17/11/87		3.203	3.651	8.512	1.008	0.403	35.840	8.915	6.048
24/11/87	2.390	2.458	4.445	1.046	0.523	0.366	63.806	22.803	7.322
8/12/87		0.904	0.532	0.608	0.167	0.046			
15/12/87	2.263	3.124	3.759	1.016	0.279	0.305	59.944	25.705	2.032
22/12/87	1.201	0.481	2.654			0.160			

5. Differences in Weekly Concentration and Deposition Data at Penn State (CAPMoN - NADP/NTN)

PENN STATE
CAPMoN - NADP/NTN

CONCENTRATION (mg l^{-1})

Beginning Date	Standard Gauge Depth mm	Sample Depth mm	pH	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	0.7	2.6	-0.07	-0.02	-0.02	0.01	0.00	0.00	0.02	0.04	0.00
23/ 9/86	-0.8	3.7	-0.11	-0.01	-0.01	0.01	0.00	0.00	0.07	0.02	-0.04
30/ 9/86	2.9	5.0	-0.06	-0.01	0.14	0.01	0.00	0.03	-0.04	0.01	0.00
7/10/86	-0.5	2.2	-0.18		0.06	0.01			0.10	0.04	0.02
14/10/86	0.8	0.3									
21/10/86	-0.4	1.8	-0.14	-0.03	-0.01	0.04	0.00	0.01	0.24	0.10	0.02
28/10/86	-0.8	0.5	-0.19	-0.13	0.03	0.01	0.00	0.00	0.02	0.13	0.01
4/11/86			-0.06	-0.01	0.02	0.00	0.01	0.01	-0.27	0.00	-0.01
11/11/86		5.2									
18/11/86	3.3	2.6	-0.08	-0.02	0.09	-0.02	0.00	0.01	-0.28	0.04	-0.01
25/11/86	4.3	3.4	-0.10		0.03	-0.02	0.00	0.00	-0.23	0.00	0.00
2/12/86	-1.4		-0.04	-0.02	0.07	0.01	0.00	0.00	-0.37	0.07	0.01
9/12/86	0.2	0.7									
16/12/86	0.5	1.3	-0.11	-0.05	0.03	0.00	0.00	0.01	-0.62	-0.02	-0.02
23/12/86	-1.0	1.6	-0.18	-0.03	0.04	-0.02	0.00	0.00	-0.42	0.03	-0.03
30/12/86	0.0	1.7	-0.18	0.00	0.03	0.02	0.00	0.00	0.02	0.05	0.03
6/ 1/87	1.9	0.6	-0.06	-0.02	0.09	-0.02	-0.01	0.01	0.27	-0.01	-0.02
13/ 1/87	3.4	3.4	0.02	-0.02	0.04	0.00	0.00	0.01	0.08	0.01	-0.01
20/ 1/87	2.9	1.7	-0.10		0.03	0.01	0.00		0.02	0.03	0.00
27/ 1/87	4.2	2.0									
3/ 2/87	-1.7	0.1	-0.12	-0.04	0.52	0.46	0.07	0.02	1.96	0.46	0.22
10/ 2/87	1.6	1.0	-0.09	0.01	0.10	0.03	-0.01	0.02	0.33	0.17	0.03
17/ 2/87	1.9	0.3	-0.22	-0.05	0.04	0.05	-0.01	0.01	0.41	0.08	0.01
24/ 2/87	1.6	3.1	-0.16	0.01	0.06	0.00	0.00	0.01	0.23	0.09	0.02
10/ 3/87	2.1		-0.07	0.00	0.03	0.15	0.00	0.02	-0.08	-0.04	0.01
24/ 3/87	-0.6	3.5	-0.07	0.01	0.03	-0.01	0.00	0.03	-0.09	0.01	0.01
2/ 4/87	4.2		-0.10	0.00	0.05	0.01	0.00	0.02	-0.02	0.05	-0.01
7/ 4/87	0.1	1.0	-0.18	-0.03	0.15	0.13	0.01	0.02	0.27	0.14	0.00
14/ 4/87	1.0	2.0			0.10	0.05	-0.01				
21/ 4/87	0.8	3.3	-0.05	-0.01	0.03	0.02	0.00	0.02	0.27	0.04	0.00
28/ 4/87	-0.1	2.6	-0.02	-0.02	-0.02	-0.07	-0.02	-0.02	-0.35	-0.03	-0.04
12/ 5/87	0.0	1.2	-0.01	0.00	-0.01	-0.02	-0.01	-0.01	-0.33	-0.03	-0.02
19/ 5/87	3.1	2.8	-0.04	-0.02	0.06	-0.03	-0.01	0.00	0.51	0.07	0.01
26/ 5/87	1.0	2.1	-0.01	0.00	0.17	0.00	0.01	0.01	0.02	0.13	0.00
2/ 6/87	0.8	2.1	0.04	-0.01	0.03	0.07	0.01	-0.03	0.00	0.04	-0.01
9/ 6/87	2.3	2.9	-0.03	-0.03	0.02	-0.04	0.00	0.00	-0.29	-0.03	-0.03
16/ 6/87	1.9	1.4	-0.02	-0.01	0.06	-0.01	0.00	0.04	0.14	-0.02	0.01
23/ 6/87	1.5	1.0									
30/ 6/87	2.8	4.0	-0.06	-0.02	0.02	0.02	0.00	0.01	0.53	0.03	-0.01
7/ 7/87	1.7	0.5		0.00	0.06			0.01	0.85	0.05	-0.02
14/ 7/87	0.6	0.8	-0.03	-0.05	0.07	-0.03	0.00	0.01	0.15	0.02	0.00
21/ 7/87	1.0	0.2	-0.01	-0.07	-0.02	-0.12	-0.03	0.02	-0.41	-0.09	-0.09
28/ 7/87	0.6	1.1	-0.02	-0.06	-0.01	-0.01	-0.01	0.01	-0.16	-0.01	-0.05
4/ 8/87	1.6	5.3	-0.02	0.00	0.04	0.04	0.00	0.01	0.21	0.04	-0.01
11/ 8/87	0.4	0.0									
18/ 8/87	0.9	2.4	0.06	-0.04	0.03	-0.02	0.00	0.00	-0.12	-0.01	-0.03
25/ 8/87	1.9	5.3	-0.01	0.00	0.05	0.00	0.00	0.01	-0.03	0.05	-0.05
1/ 9/87	2.9			0.07	0.10	0.01	0.01	0.05	0.51	0.07	0.10
8/ 9/87	2.8	3.5	0.02	0.00	0.07	0.02	-0.01	0.01	0.09	0.01	-0.01
15/ 9/87	2.8	4.4	-0.02	-0.02	0.03	0.01	-0.01	0.01	0.43	0.09	0.01
22/ 9/87	1.0	0.5	-0.01	-0.06	0.11	-0.03	-0.03	0.00	-0.54	-0.07	-0.10
29/ 9/87	-0.3	3.2	0.05	-0.01	0.06	0.04	0.00	0.01	-0.49	0.00	-0.03
6/10/87		3.2	-0.13	-0.04	0.05	0.11	-0.01	0.02	0.12	0.19	-0.01
13/10/87	-0.2	0.2									
20/10/87	-0.2	1.3	-0.06	-0.04	0.14	-0.06	-0.02	0.02	0.76	0.18	-0.05
27/10/87	1.4	1.9	0.03	-0.02	0.00	-0.01	0.00	0.00	-0.16	0.13	0.00
3/11/87	0.7	1.8	-0.13	-0.04	0.11	0.03	0.00	0.00	0.30	0.06	0.01
10/11/87	5.4	4.1	-0.04	-0.03	0.00	0.03	0.00	0.00	0.09	0.01	-0.01
17/11/87		1.6		0.15	0.05			0.00			
24/11/87	3.5	3.7	-0.10	-0.03	0.04	-0.02	0.00	0.00	0.04	0.06	-0.02
1/12/87	2.7	1.6	-0.06	-0.03	0.07	-0.01	-0.01	0.00	0.07	0.05	0.11
8/12/87		2.3		-0.01	0.05				-0.09	0.13	0.16
15/12/87		3.7	-0.04		0.07	0.00	0.00		-0.48	0.07	0.03
22/12/87		5.2	-0.10	-0.01	0.08	0.00	0.00	0.00	0.09	0.10	0.02

PENN STATE
CAPMoN - NADP/NTN

DEPOSITION (mg m^{-2})

Beginning Date	H^+	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	0.473	-0.444	-0.206	0.254	0.090	0.090	3.392	1.322	0.084
23/ 9/86	1.170	-0.410	-0.491	0.396	0.210	0.165	-0.372	0.395	-1.960
30/ 9/86	0.943	-0.287	7.984	0.693	0.205	1.762	9.263	1.816	0.609
7/10/86	0.351		1.252	0.216			1.550	0.749	0.437
21/10/86	0.126	-0.251	-0.162	0.248	-0.023	0.059	0.992	0.490	0.084
28/10/86	0.034	-0.428	-0.018	-0.041	-0.025	0.000	-1.978	-0.240	-0.169
18/11/86	0.587	-0.653	4.775	-0.597	0.109	0.485	-4.530	3.272	0.048
25/11/86	0.471		1.485	-0.792	-0.002	0.306	-4.722	0.872	1.247
2/12/86	0.022	-0.405	1.357	0.134	0.008	0.117	-10.124	0.988	-0.076
16/12/86	0.301	-0.394	0.441	0.025	-0.016	0.062	-3.762	0.353	-0.062
23/12/86	0.321	-0.735	0.843	-0.548	-0.062	-0.062	-12.028	0.498	-0.837
30/12/86	0.208	-0.070	0.655	0.468	0.117	0.117	0.468	1.077	0.702
6/ 1/87	0.225	-0.020	1.133	0.018	-0.041	0.124	5.875	1.501	0.189
13/ 1/87	0.058	-0.243	0.965	0.102	-0.001	0.361	4.592	0.730	0.157
20/ 1/87	0.175		0.764	0.307	0.105		1.339	1.332	0.319
3/ 2/87	-0.088	-0.182	-1.380	-0.105	-0.028	-0.040	-5.705	-0.846	-0.604
10/ 2/87	0.333	0.187	1.243	0.646	0.008	0.163	5.634	3.334	0.774
17/ 2/87	0.339	-0.367	0.508	0.728	-0.054	0.176	5.183	2.000	0.290
24/ 2/87	0.369	0.276	1.184	0.048	-0.036	0.116	6.244	1.886	0.584
10/ 3/87	0.254	0.021	0.540	1.443	-0.013	0.217	1.273	1.783	0.358
24/ 3/87	0.384	0.601	1.550	-0.542	-0.064	1.478	-5.898	0.207	0.380
2/ 4/87	1.196	0.073	4.140	1.103	-0.121	1.492	6.824	5.177	-0.053
7/ 4/87	0.313	-0.286	1.487	1.288	0.112	0.225	2.899	1.464	0.026
14/ 4/87			0.849	0.570	0.001				
21/ 4/87	0.447	-0.234	1.166	0.668	-0.066	0.615	11.454	1.722	0.120
28/ 4/87	0.107	-0.564	-0.601	-2.477	-0.844	-0.843	-12.702	-0.965	-1.417
12/ 5/87	0.039	-0.044	-0.218	-0.436	-0.131	-0.196	-7.194	-0.698	-0.436
19/ 5/87	0.670	-0.311	1.607	-0.427	-0.148	0.048	27.843	3.282	0.473
26/ 5/87	0.134	0.063	2.585	0.100	0.094	0.106	5.814	2.450	0.150
2/ 6/87	-0.180	-0.263	1.411	2.009	0.223	-0.709	5.224	1.505	-0.055
9/ 6/87	0.335	-0.977	1.596	-1.219	-0.023	0.115	-2.024	-0.285	-0.782
16/ 6/87	0.448	-0.078	1.466	0.006	0.019	0.805	15.800	1.095	0.583
30/ 6/87	0.960	-0.502	1.356	1.096	0.166	0.633	34.070	2.797	0.082
7/ 7/87		0.136	0.897			0.180	19.312	1.978	0.406
14/ 7/87	0.098	-0.568	0.970	-0.360	-0.086	0.207	3.660	0.388	0.060
21/ 7/87	0.178	-0.080	0.563	0.454	0.044	0.099	8.632	0.930	0.178
28/ 7/87	0.117	-0.566	0.111	0.007	-0.068	0.092	1.858	0.274	-0.373
4/ 8/87	0.394	-0.260	3.274	3.164	-0.203	0.617	22.935	3.612	-0.587
18/ 8/87	-0.158	-0.639	0.808	-0.211	0.001	-0.069	2.208	0.346	-0.402
25/ 8/87	0.302	0.141	2.559	0.209	0.164	0.373	7.787	3.157	-1.791
1/ 9/87		1.758	1.885	0.305	0.199	1.035	13.206	1.720	2.615
8/ 9/87	0.137	0.250	2.862	0.748	-0.313	0.320	16.162	1.753	0.298
15/ 9/87	0.726	-0.508	1.944	0.758	-0.141	0.394	30.690	5.412	1.066
22/ 9/87	0.105	-0.258	0.924	0.186	-0.104	0.026	1.158	0.363	0.010
29/ 9/87	-0.174	-0.504	2.068	1.470	-0.082	0.413	-19.170	-0.197	-1.161
20/10/87	0.064	-0.195	0.544	-0.352	-0.116	0.066	1.968	0.555	-0.292
27/10/87	0.011	-0.312	0.160	-0.114	-0.020	0.065	-0.858	2.813	0.154
3/11/87	0.230	-0.222	0.914	0.325	-0.005	0.041	4.090	0.848	0.176
10/11/87	0.096	-0.225	0.045	0.873	0.045	0.096	2.889	1.239	0.087
24/11/87	0.177	-0.549	1.108	-0.401	0.057	0.186	3.322	1.957	-0.086
1/12/87	0.236	-0.088	0.946	0.234	0.009	0.049	4.977	2.364	1.179

6. Differences in Weekly Concentration and Deposition Data at Sutton (CAPMoN - NADP/NTN)

SUTTON
CAPMoN - NADP/NTN

CONCENTRATION (mg l^{-1})

Beginning Date	Standard Gauge Depth mm	Sample Depth mm	pH	Na^{+}	NH_4^{+}	Ca^{++}	Mg^{++}	K^{+}	$SO_4^{=}$	NO_3^{-}	Cl^{-}
16/ 9/86	2.8	3.2	-0.32	0.01	0.11	0.03	0.00	0.00	0.41	0.26	0.03
23/ 9/86	-2.6	-1.0	-0.09	0.00	-0.01	-0.02	0.00	0.00	-0.44	-0.04	0.00
30/ 9/86	4.3										
7/10/86	0.9	1.9									
14/10/86	3.1	2.2	-0.07	-0.02	0.02	-0.02	0.00	0.00	-0.16	-0.01	-0.01
21/10/86	0.6	2.3	-0.11	-0.01	-0.03	0.01	0.00	0.01	-0.06	-0.01	0.00
28/10/86	-0.8	3.4	-0.13	0.00	0.10	0.02	0.00	0.00	-0.05	0.09	0.01
4/11/86	3.9	2.9	-0.11	-0.01	0.05			0.00	-0.20	0.01	0.01
11/11/86	0.3	2.7	-0.07	-0.03	-0.01	0.04	0.01	0.00	-0.69	0.05	0.01
18/11/86	3.6	5.9	0.10	-0.03	0.01	-0.01	0.00	0.00	-0.18	-0.04	-0.02
25/11/86	-1.2	3.0	-0.14	0.00	0.08	0.01	0.00	0.00	-0.06	0.09	0.02
2/12/86	2.9	5.5	-0.25	0.00	0.07	0.00	0.01	0.00	0.17	0.14	0.02
9/12/86	10.5	5.1									
16/12/86	0.0										
23/12/86	0.8	2.4		-0.29	0.68			0.01			
30/12/86	3.0										
6/ 1/87	1.4	8.2									
13/ 1/87	2.0	4.5									
20/ 1/87	3.6	2.7	-0.26		0.06				0.13	0.15	0.05
27/ 1/87	3.2	2.6			0.17						
3/ 2/87	5.5	3.8									
10/ 2/87	2.8	1.8					0.00				
17/ 2/87	0.1										
24/ 2/87	2.3	3.4	-0.16	-0.01	0.02	-0.02	0.00	0.00	0.12	0.04	-0.03
3/ 3/87	1.4	0.6									
10/ 3/87	0.9	3.0	-0.21	-0.08	0.05			0.00			
17/ 3/87	2.0	1.9	-0.16	0.02	0.07	0.01	0.00	0.01	0.18	0.01	0.00
24/ 3/87	2.2	2.3	-0.16	-0.08	0.08	0.05	0.00	0.00	0.20	0.19	0.00
31/ 3/87	2.9	2.6		-0.02	0.02			0.00			
7/ 4/87	1.7	1.7	-0.24	-0.10	0.02	-0.01	0.00	0.00	-0.01	-0.01	-0.05
14/ 4/87	0.1	0.1									
21/ 4/87	1.9	0.9									
27/ 4/87	-0.2	2.6									
5/ 5/87	2.9	2.7									
12/ 5/87	0.7	1.0									
19/ 5/87	2.0	2.1	-0.06	-0.07	0.07	-0.14	-0.01	0.00	-0.25	-0.11	-0.08
26/ 5/87	2.5	5.6	0.05	-0.03	0.07	0.00	-0.01	0.01	0.11	0.03	-0.02
2/ 6/87	6.8	5.1									
9/ 6/87	3.0	3.7									
16/ 6/87	1.7	2.3	-0.09	-0.02	0.04	-0.03	-0.01	0.02	-0.11	0.03	-0.02
23/ 6/87	2.9	3.7	-0.03	-0.02	0.04	-0.02	-0.01	0.01	-0.01	0.00	-0.03
30/ 6/87	-0.2	1.7	-0.08	-0.01	0.07	0.00	0.00	0.01	0.04	0.03	-0.02
7/ 7/87	-0.3	4.2	0.00	-0.04	0.03	-0.02	-0.02	0.01	-0.13	-0.03	-0.08
14/ 7/87	1.1	3.4	-0.03	-0.04	0.02	0.00	0.00	0.00	0.25	0.02	-0.04
21/ 7/87	-1.1	3.7	0.00	-0.02	0.03	-0.02	0.00	0.00	0.06	-0.02	-0.01
28/ 7/87	-0.6	2.4	-0.06	-0.01	0.08	-0.01	0.00	0.01	0.03	0.02	-0.03
4/ 8/87	0.6	2.3	-0.02	-0.04	0.01	-0.04	-0.01	0.02	-0.20	-0.02	-0.04
11/ 8/87	0.4	0.9									
18/ 8/87	0.6	1.6	-0.53	-0.02	0.04	0.01	-0.01	0.00	-0.21	-0.03	-0.03
25/ 8/87	0.8	1.7									
1/ 9/87	-0.4	0.6									
8/ 9/87	7.9	10.5	-0.06	-0.01	0.06	0.00	0.00	0.00	0.17	0.04	-0.02
15/ 9/87	0.7	3.4									
22/ 9/87	1.6	1.5									
29/ 9/87		5.4	0.01	-0.01	0.06	0.01	-0.01	0.00	-0.04	0.02	-0.03
6/10/87	0.2	0.8									
13/10/87	0.0	0.0									
20/10/87				0.00	0.09			0.02	0.04	0.01	-0.02
27/10/87	1.9	5.6	-0.11	-0.01	0.04	0.02	0.00	0.00	0.11	0.08	-0.01
3/11/87	1.9										
10/11/87	0.7	0.5									
17/11/87	6.1	3.6		-0.03	0.01	0.89	0.05	0.00	-0.40	0.02	-0.02
24/11/87	3.5	0.6	0.03	-0.02	0.04	0.00	0.00	0.00	-0.18	-0.03	-0.04
1/12/87	3.5	2.8									
8/12/87	1.1	1.4		-0.02	0.16	-0.03	-0.01	0.00			
15/12/87	2.2	13.2	0.21	-0.09	-0.04	-0.01	0.00	0.00	-1.22	-0.37	-0.04
22/12/87	1.6	2.6	0.11	0.00	0.10			-0.01			

SUTTON

CAPMoN - NADP/NTN

DEPOSITION (mg m^{-2})

Beginning Date	H^+	Na^+	NH_4^+	Ca^{++}	Mg^{++}	K^+	$SO_4^=$	NO_3^-	Cl^-
16/ 9/86	0.854	0.300	2.872	0.833	0.069	0.109	13.503	6.811	0.749
23/ 9/86	0.410	−0.104	−1.012	−0.880	−0.114	−0.155	−26.224	−2.364	−0.182
14/10/86	0.246	−0.299	0.607	−0.329	0.046	0.061	2.219	0.809	−0.179
21/10/86	0.367	−0.275	−0.325	0.282	0.098	0.163	0.384	0.135	0.024
28/10/86	0.603	0.122	3.182	0.668	0.065	−0.008	−3.590	2.803	0.310
4/11/86	0.337	−0.110	1.476			0.089	1.419	1.509	0.282
11/11/86	0.183	−0.498	0.035	0.643	0.108	0.035	−9.423	0.951	0.172
18/11/86	−0.069	−0.833	0.378	−0.184	0.182	0.240	−3.708	−0.726	−0.476
25/11/86	0.219	−0.085	2.272	0.245	0.049	0.049	−2.742	2.421	0.562
2/12/86	0.454	−0.059	3.153	0.087	0.303	0.303	8.300	5.987	0.898
23/12/86		−1.451	4.068			0.093			
20/ 1/87	0.274		1.308				4.006	3.775	1.394
27/ 1/87			2.440						
10/ 2/87					0.009				
24/ 2/87	0.270	−0.185	0.415	−0.297	0.010	0.135	3.783	1.119	−0.434
10/ 3/87	0.075	−0.640	0.506			0.054			
17/ 3/87	0.068	0.227	0.714	0.178	−0.003	0.093	2.684	0.464	0.220
24/ 3/87	0.566	−0.448	1.396	0.697	0.010	0.030	9.718	3.340	0.418
31/ 3/87		−0.300	0.684			0.074			
7/ 4/87	0.019	−0.546	0.237	−0.041	−0.008	0.046	0.248	0.027	−0.273
19/ 5/87	0.476	−1.293	3.024	−2.314	−0.188	0.022	5.865	−0.273	−1.228
26/ 5/87	−0.222	−1.687	5.727	0.175	−0.309	0.451	14.123	2.931	−1.186
16/ 6/87	0.127	−0.184	0.648	−0.125	−0.066	0.217	1.083	0.763	−0.106
23/ 6/87	0.384	−0.629	1.774	−0.316	−0.218	0.524	10.137	1.283	−0.619
30/ 6/87	0.051	−0.063	0.694	−0.012	−0.012	0.159	0.118	0.257	−0.210
7/ 7/87	−0.013	−1.766	1.098	−0.967	−0.726	0.401	−6.578	−1.639	−3.631
14/ 7/87	0.172	−1.327	0.919	0.066	−0.058	0.114	11.688	0.941	−1.328
21/ 7/87	−0.039	−0.978	1.024	−1.237	−0.193	0.103	−0.271	−1.153	−0.635
28/ 7/87	0.104	−0.305	2.313	−0.298	0.082	0.133	0.072	0.487	−0.977
4/ 8/87	0.075	−0.799	0.263	−0.690	−0.086	0.287	−2.142	−0.199	−0.708
18/ 8/87	0.170	−0.307	0.804	0.423	−0.118	0.039	−2.739	−0.334	−0.471
8/ 9/87	0.619	−0.258	4.904	0.158	0.218	0.633	23.631	4.913	−1.070
27/10/87	0.262	−0.597	1.751	0.898	0.101	0.348	5.813	3.750	−0.316
17/11/87		−0.068	1.222	27.683	1.842	0.167	−1.640	2.998	1.077
24/11/87	−0.018	−0.784	2.474	0.070	−0.151	0.192	−5.774	−0.260	−1.742
8/12/87		−0.034	1.486	−0.173	−0.080	0.041			
15/12/87	−0.737	−2.296	−0.640	−0.188	−0.003	−0.029	−28.480	−7.903	−0.928
22/12/87	−0.128	0.134	1.565			−0.037			