Reports

Precipitation Chemistry Patterns: A Two-Network Data Set

Abstract. *Precipitation chemistry data from two networks, one with nine sites and the other with eight, are shown to provide comparable data, that is, they were drawn from the same population. These data may thus be combined into a 17-site network. This combination of data provides a comprehensive description of the contemporary patterns of acid precipitation in the northeastern United States.*

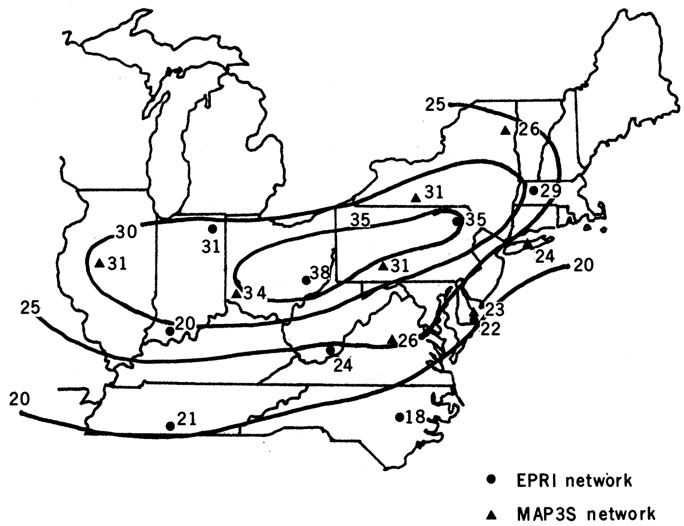
The chemistry of precipitation has received increasing attention over last several years as the evidence mounted that the ion content was resulting in "acid rain" (*1*). However, studies of this problem in the United States have suffered from a lack of accurate and continuous data taken over a sufficient spatial area. A 1-year program was mounted in the mid-1950's (*2*), and a few years of data were collected in the mid-1960's (*3*). In 1970 the National Oceanographic and Atmospheric Administration and the Environmental Protection Agency began a small (ten-site) program for the entire United States as a part of the World Meteorological Organization's global network (*4*). But it was not until 1976 that a network program for the collection and analysis of precipitation "events" for their ionic content was mounted by the Department of Energy as a part of the Multi-State Atmospheric Power Production Pollution Study (MAP3S) (*5*). The initial four-site program has now been expanded to eight locations. In 1977 the Electric Power Research Institute (EPRI) initiated a nine-site precipitation chemistry network (*6*) also based on the collection of precipitation for individual storms ("events").

The question was raised whether the data from these two networks could be combined into a single data set and thus provide a more comprehensive picture of the patterns of the ionic content of precipitation. At the request of the EPRI, I carried out a comparison of the data sets and present the results here.

The sites for the two networks extend from Illinois to Massachusetts and from northern New York to North Carolina (Fig. 1). Since it was known that there were large spatial and temporal variations in ion concentrations, especially for SO_4^{2-} (*7*), a technique had to be devised to reduce the variability associated with individual sites. There are other differences between the networks that might influence their comparability. These include differences in the operators, collectors, and analytical laboratory procedures (Battelle Pacific Northwest for the MAP3S data and Rockwell International for the EPRI data).

There were 11 months of EPRI data (August 1978 through June 1979) available at the time of this analysis. An identical period of MAP3S data was excerpted from the longer period of record. Since there are large differences in the chemistry of individual precipitation events, I calculated a monthly weighted ion concentration (WIC) for each site and for the ions of particular interest (SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, and Na^+) and for *p*H. The *p*H was converted to hydrogen activity, H^+ (in microequivalents per liter) which, for the dilute solutions in precipitation, is equivalent to concentration. This provides a linear equivalent of the ion concentrations for the other components whose concentrations were in micromoles per liter. Each WIC was produced by multiplying the reported ion concentration for each precipitation event by the corresponding collected volume of precipitation, summing this product for an entire month, and then dividing by the total collected precipitation volume for that month. This normalizes the concentrations for the highly variable amounts of precipitation. Although this average is useful, the individual event data are essential for many analyses including source-receptor studies and efforts to determine the dosage statistics for ecological studies and, not least, to minimize potential chemical changes that are possible with longer collection periods (*8*).

If all months of data had been available, there would be 99 WIC's for each ion from the EPRI network and 88 for the MAP3S data set. Actually there were 97 station-months for EPRI and 84 for



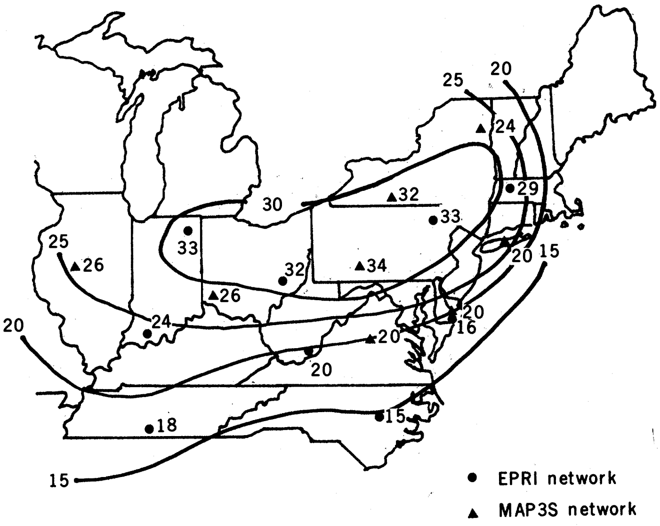


Fig. 1. Average SO_4^{2-} concentrations (in micromoles per liter) for the period August 1978 through June 1979. Average concentrations for individual sites are plotted adjacent to the site locations.

Fig. 2. Average NO_3^- concentrations (in micromoles per liter) for the same period.

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MAP3S. For some MAP3S sites the sample collection did not always encompass the entire month (*9*). I combined the available values into a single value for each ion, the network average, by determining the average ion concentration for the data available at each site in a network and then averaging these values. The standard deviations were calculated from the departures of the eight, or nine, sites about their respective means.

Table 1 shows the results for five ions and for two different H^+ determinations (discussed below). The data were further divided to exclude the coastal locations, one site (Indian River, Delaware) in the EPRI network and two sites (Lewes, Delaware, and Brookhaven, New York) in the MAP3S network. This was done to examine the effect of excluding the majority of any sea-salt contributions.

Table 1 shows that the two data sets can be combined for a much more complete depiction of contemporary precipitation chemistry patterns than would be possible with either network alone. The two networks produce almost identical averages for SO_4^{2-}, NO_3^-, and NH_4^+. The largest difference for NH_4^+, is only 7 percent when the coastal sites are included but only 1 percent for the set of noncoastal locations. In view of the many variables that might have created differences, agreement to within 10 percent supports data comparability.

However, the Cl^- and Na^+ concentrations, especially the Na^+ values at the noncoastal sites, show significant differences. It seems likely that these are due to an as yet unidentified system difference. An intercomparison between the two laboratories, possibly with a third laboratory participating as a reference, can probably resolve the differences and retrieve the correct values. Pending such action, the Cl^- and Na^+ data were not combined for this study.

In addition to the ratio approach, an analysis of variance (*F* test) was made to test the conclusion that both data samples were drawn from the same population. Table 2 shows the observed variance ratios and the 5 and 1 percent significance levels (*10*). An observed ratio less than the 5 percent level supports the hypothesis that the samples are from the same population. Ratios larger than the 1 percent level suggest that the samples are significantly different. For the "all sites" set, only the H^+ (field) variance ratio fails the test. However, when the coastal sites are excluded, the Cl^- and Na^+ comparisons support the setting aside of these ions. Note also that the elimination of possible sea-salt contributions improves the data comparability, especially for SO_4^{2-}.

Table 1. Network average ion concentrations (in micromoles per liter), network standard deviations (S.D.), and EPRI/MAP3S concentration ratios.

Data base	SO_4^{2-}	NO_3^-	NH_4^+	Cl^-	Na^+	H^+ (field)	H^+ (lab)
				EPRI network			
All data							
Concentration	29.26	25.50	17.22	11.22	15.85	97.69	61.79
S.D.	7.93	6.79	2.90	7.69	6.35	42.02	19.35
Noncoastal sites							
Concentration	28.09	25.46	17.27	8.26	14.08		
S.D.	6.84	7.26	3.10	3.64	3.69		
				MAP3S network			
All data							
Concentration	28.13	25.87	16.08	12.10	9.31	72.35	65.68
S.D.	3.92	5.06	4.61	12.68	12.18	12.26	11.09
Noncoastal sites							
Concentration	29.68	27.12	17.47	5.61	3.25		
S.D.	3.18	5.18	4.52	1.11	0.87		
				Ratio of EPRI to MAP3S data			
All data	1.04	0.99	1.07	0.93	1.70	1.35	0.94
Noncoastal sites	0.95	0.94	0.99	1.47	4.33		

Table 2. Analysis of variance (*F* test) to test for the equivalence of two samples as representing the same population; d.f., degrees of freedom.

Data base	d.f.	Significance level (*10*)		Variance ratio						
		5 percent	1 percent	SO_4^{2-}	NO_3^-	NH_4^+	Cl^-	Na^+	H^+ (field)	H^+ (lab)
All sites	8/7	3.73	6.84	4.09	1.80	2.53	2.70	3.68	11.75	3.06
Noncoastal sites	7/5	4.88	10.45	1.80	1.96	2.13	10.60	17.92		

The behavior of the *p*H data (expressed as H^+) is intriguing. As soon as possible after sample collection at the field sites, the *p*H and conductivity are measured by the local observer before the sample is shipped to the appropriate laboratory [values designated as H^+ (field) in Table 1]. When the sample is received at the laboratory, the *p*H and conductivity are measured again [tabulated as H^+ (lab) in Table 1]. There are differences between the field and laboratory *p*H in both networks. For the EPRI data the H^+ decreases by 37 percent even in the average, a *p*H change from 4.01 to 4.21. The change is less for the MAP3S data, with the values increasing by 9 percent from a *p*H of 4.14 to 4.18. This change of 0.04 *p*H unit is probably not significant since it is near the accuracy limit of individual *p*H determinations. The H^+ (field) differs significantly between the networks, as shown by both the ratio of 1.35 (Table 1) and the *F* test of the variance ratios. Lacking information on the cause of these differences, I set these data aside and did not combine them into a single data set. On the other hand, the H^+ (lab) values agree to within 6 percent, and the comparability is confirmed by the variance ratios. These data were meshed to determine the pattern of H^+ deposition over the area.

Since this analysis indicated that the two networks produced comparable data for SO_4^{2-}, NO_3^-, NH_4^+, and H^+ (lab), the individual site 11-month average values were used to determine the patterns of these ions for the area encompassed by both networks. Figure 1 shows the SO_4^{2-} pattern. Isopleths were drawn subjectively by hand to fit the data. The maximum SO_4^{2-} concentration extends west-southwestward from Massachusetts to eastern Ohio and thence westward to the limit of the data. There is a definite north-south gradient with the SO_4^{2-} concentrations at the southern edge of the data lower by 30 to 50 percent than the maximum concentrations. There is also a significant gradient along the Atlantic coastal area, but the data density is insufficient to determine if this is confined close to the coast or occurs more gradually as the distance inland increases. (The isopleths are drawn as though the latter condition prevails.)

Figure 2 is a similar analysis of the NO_3^- data. The pattern is generally similar, although the maximum is somewhat broader north-south and does not appear to extend as far west as the SO_4^{2-} pattern. The north-south gradient, south of the axis of maximum, is even more marked for NO_3^-. There is a 50 percent reduction in concentration at the southern edge of the data. There is also, as in the data for SO_4^{2-} concentrations, a large gradient along the coast.

The NH_4^+ data are not so neatly patterned. The lowest values, near 12 μmole/liter, extend from the Long Island site southwestward across Virginia to the West Virginia location. The highest NH_4^+ concentrations were measured over Ohio, Indiana, and Illinois with the maximum value for either network occurring at Champaign, Illinois (24 μmole/liter).

The *p*H pattern follows the general contours of the SO_4^{2-} and NO_3^- patterns. The north-south and coastal gradients are even sharper than for the individual ions since the H^+ concentrations combine the effects of both ions. The three highest H^+ values were 85, 82, and 82 μeq/liter at Scranton, Pennsylvania; Ithaca, New York; and State College, Pennsylvania, respectively. These values represent *p*H values of 4.07 and 4.09 averaged over this 11-month period. The lowest H^+ concentrations were reported at the southern edge of the network at Raleigh, North Carolina, and Giles County, Tennessee, where both sites had an average H^+ concentration of 35 μeq/liter, which translates to a *p*H of 4.46.

These data show that precipitation chemistry data, carefully collected and rigidly quality-controlled, acquired by different organizations can be intermixed. This combination of data provides a much more comprehensive picture of the patterns than data from either network alone. The pattern analysis stops at the U.S. border since an attempt to incorporate Canadian precipitation chemistry data (*11*) for the same period of record and the same averaging technique indicated that those data did not compare to either the EPRI or MAP3S values.

For the first time in two decades, the United States has begun to produce a body of data that can be used to examine the chemistry of precipitation from individual storms as they pass across the eastern part of the country. These data will illuminate the nature of the variability in the chemistry (*12*). These results can be integrated and averaged to study the patterns and trends of anions and cations that control precipitation acidity. However, these data are only preliminary and this short period of record can tell little or nothing about trends in precipitation acidity or shifts in the proportional ion contributions to this acidity. The sharp north-south gradients and the inability to locate the NH_4^+ maximum argue for the continuation of these existing networks and their extension south and west. The development of a National Plan for Acid Precipitation is under way. This analysis may be useful in establishing the monitoring aspects of the plan.

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12. The probability of various ion concentrations is now being investigated (D. H. Pack, in preparation).
13. Support for this study was provided, in part, by the Environmental Assessment Department, Electric Power Research Institute.

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The Striking Resemblance of High-Resolution G-Banded Chromosomes of Man and Chimpanzee

Abstract. *The fine structure and genetic organization of the chromosomes of man and chimpanzee are so similar that it is difficult to account for their phenotypic differences.*

A comparative analysis of G-banded late prophase, prometaphase, and early metaphase chromosomes of humans and chimpanzees demonstrated that essentially every band and subband observed in man has a direct counterpart in the chimpanzee chromosome complement. The high-resolution technique employed allowed the observation of up to 1200 bands per haploid set, permitting the precise localization of breakpoints in the structural rearrangements that distinguish the two species. This work confirms and extends previous findings obtained with metaphase chromosomes (300 to 500 bands) that made it possible for earlier workers to agree in the 1975 report of the Paris Conference (*1–3*) that (i) human and chimpanzee chromosomes have a large degree of homology, (ii) the most conspicuous structural changes between the two species can be explained by a series of pericentric inversions and differences in amounts of centromeric and telomeric constitutive heterochromatin (*4, 5*), and (iii) the presence of 46 chromosomes in man and 48 in the chimpanzee can be explained by fusion of two acrocentric chromosomes to form the human chromosome 2. Because of the limited resolution of metaphase chromosomes, however, uncertainties persisted as to the nature and extent of the observed structural differences. The fine detail achieved with the high-resolution G-banded chromosome technique developed in our laboratory (*6*) resolved such ambiguities because it was possible to follow, subband by subband, the virtually total homology that exists for nonheterochromatic bands in the two species.

Four female and two male chimpanzees (*Pan troglodytes*), as well as 7 adult women and 17 adult men, were examined. A detailed schematic representation of human G-banded chromosomes in late prophase, prometaphase, and early metaphase has been reported elsewhere (*6*) and was used as a standard for a detailed comparison between man and chimpanzee. To test for equivalence between chromosomes and bands in the two species, ten straight, sharply banded examples of each chromosome from both species were photographed at ×1600 at each stage of chromosome condensation and enlarged approximately four times. The chromosomes of each stage were then matched side by side for a detailed analysis of banding patterns, band thickness, and staining intensity. To determine to what extent the banding patterns observed were related to het-

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