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ENAMAP-1 LONG-TERM AIR POLLUTION MODEL
Adaptation and Application to Eastern North America

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ABSTRACT

The long-term EURMAP-1 model, a trajectory-type regional air pollution model extensively evaluated and applied in Europe in conjunction with studies of interregional sulfur transport and deposition, was adapted, tested, and applied to eastern North America. The adapted version, ENAMAP-1, was used to calculate monthly, seasonal, and annual distributions of sulfur dioxide and sulfate (SO_2 and $SO_4^=$) concentrations and wet and dry depositions over the eastern United States, as well as over the southern portions of the Canadian provinces of Quebec and Ontario. This geographical area was partitioned into 13 different regions and interregional sulfur exchanges calculated. Model calculations were based on emission data that included both the specialized data prepared for the Sulfate Regional Experiment (SURE) and the U.S. Environmental Protection Agency's National Emissions Data System (NEDS).

Model results using emissions and meteorological data for the year 1977 are presented. Results include tables showing the calculated interregional exchanges of sulfur deposition between the 13 regions of eastern North America. Comparisons were made between calculated and measured SO_2 and $SO_4^=$ concentrations. Calculated and measured values show reasonable agreement and indicate that improvements in the calculated values may be achieved by refinements in the modeling of mixing height and stability. Results are also shown for an application of the model using projected 1985 emissions in conjunction with meteorological data for 1977.

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SECTION 1
INTRODUCTION

Recent studies have shown that sulfur pollution may present a significant health hazard and may produce a number of adverse ecological effects (United States Department of Agriculture, 1976). With an increase in coal burning anticipated during the next few years in the United States, a marked increase in sulfur loading of the atmosphere can be expected. This has raised serious questions regarding the problem of transboundary—both national and international—air pollution and its effects, which may endanger human health and harm living resources. The need for a quantitative assessment of transboundary air pollution processes and their effects in eastern North American is quite evident.

The distances involved in transboundary pollution processes are significantly larger than those associated with direct local effects of emissions on ambient air concentrations. Transport from a given industrial area could cause higher pollutant concentrations in areas hundreds or even thousands of kilometers away that may themselves have few or no local sources.

SRI International (SRI) has developed innovative trajectory-type regional air-pollution models called EURMAP-1 and EURMAP-2 (*Eu*ropean *R*egional *M*odel of *A*ir *P*ollution).* These models have been designed specifically for studying transboundary air pollution: in particular, for identifying source areas affecting air quality in a given region and for quantifying interregional exchanges of airborne sulfur between various countries or regions (Bhumralkar et al., 1979). The long-term model, EURMAP-1, is used for calculating monthly, seasonal, and annual averages. The short-term model, EURMAP-2, which is still under development, is used to calculate daily averages. The unique features of EURMAP-1 that make it highly suitable for application to assess the transboundary sulfur pollution problem in eastern North America are:

- A realistic treatment of precipitation scavenging and wet deposition.
- The capability to handle all emissions over a very large region such as eastern North America.
- The capability of calculating long-term concentrations and deposition averages as well as interregional sulfur exchanges.

This report describes the results of a study for the U.S. Environmental Protection Agency (EPA) with the objective of adapting and testing a modified version of the EURMAP-1 model [called *E*astern *N*orth merican *M*odel of *A*ir *P*ollution (ENAMAP-1)], applying the model to eastern North America, and evaluating its performance by comparing the calculated results with measured values of sulfur dioxide and sulfates (SO_2 and $SO_4^=$) in this area. Section 2 describes the basic structure of the EURMAP-1 model as originally developed for FRG, and its

*Sponsored by the Environmental Agency (Umweltbundesamt) of the Federal Republic of Germany (FRG)

adaptation for application to eastern North America with respect to model grid boundaries and other variables. Section 3 presents a review of the data base including the air-quality, emissions, and meteorological data used with ENAMAP-1. Section 4 describes monthly, seasonal, and annual results obtained by applying ENAMAP-1 to the data base for 1977, including concentrations of SO_2 and $SO_4^=$ and exchanges of sulfur pollution between various regions included in the model domain. Section 5 describes monthly, seasonal, and annual distributions of sulfur pollution over eastern North America for the year 1985; these were obtained by using projected emissions likely to occur in 1985 as a result of the use of alternative types of fuel. Section 6 presents a summary and the conclusions of the study.

SECTION 2

DESCRIPTION OF THE EURMAP-1 AND ENAMAP-1 MODELS

A. *Basic Structure*

EURMAP-1 was designed as a practical model—one that would have minimum computational requirements for economical use, while at the same time offering acceptable realism in simulating the most important processes involved in the transboundary air-pollution problem. The long-term EURMAP-1 and ENAMAP-1 models can be used to calculate monthly, seasonal, and annual SO_2 and $SO_4^=$ air concentrations; SO_2 and $SO_4^=$ dry and wet deposition patterns; and interregional exchanges resulting from the SO_2 and $SO_4^=$ emissions. They use long sequences of historical meteorological data as input, retaining all the original temporal and spatial detail inherent in these data.

In the developed models, discrete puffs of SO_2 and $SO_4^=$ are assumed to be emitted at equal time increments from cells of an emission grid. Figure 1 illustrates the basic principles behind the operation of the ENAMAP-1 model. Normally the models are run separately for each region of interest. Thus, only the array of emissions cells associated with the particular region of interest is used at any one time. The emission grid that is used is dependent on the form of the available emission data (e.g., in this application, seasonal emission data were conveniently

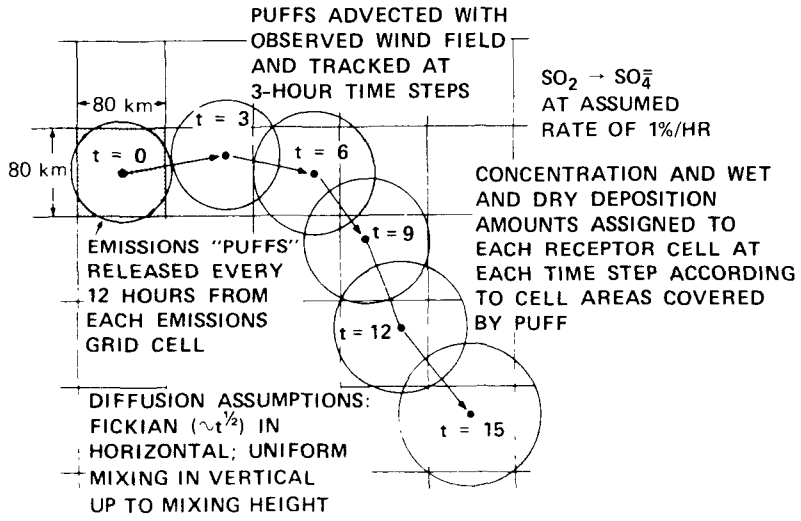


Figure 1. Emissions puff advection and diffusion scheme used in ENAMAP-1.

available on an 80- by 80-km Universal Transverse Mercator (UTM) grid as described in Section 3-C). For each of the emission cells, the average annual or seasonal emissions are divided into discrete 12-hour emission puffs and tracked at 3-hour time steps, until either they move outside the region of analysis or their concentrations drop to an insignificant level. The individual puffs are transported according to a transport wind field that is derived objectively from the available upper-air wind observations.

Since diffusion on the regional scale is not as significant as the transport and removal processes, very simple treatments of vertical and horizontal diffusion have been used in the EURMAP-1 and ENAMAP-1 models. Upon release, each puff is assumed to undergo instantaneous vertical diffusion to give a uniform concentration in the layer between the surface and the top of mixing height. Horizontal diffusion is treated by allowing the lateral extent of the puff to increase on the basis of Fickian diffusion. During the transport of the puff, the model assumes that the pollutant concentration is always uniform throughout each puff at any given time.

Assuming that the rate of loss of SO_2 pollutant mass resulting from transformation and deposition processes is proportional to the total SO_2 mass (m) within the puff, then:

$$dm/dt = -km \tag{1}$$

where

$k = k_t + k_d + k_w \equiv SO_2$ decay rate (hr^{-1})

$k_t \equiv SO_2 \rightarrow SO_4^{=}$ transformation rate (hr^{-1})

$k_d \equiv SO_2$ dry deposition rate (hr^{-1})

$k_w \equiv SO_2$ wet deposition rate $(hr^{-1}) = \lambda \cdot R$

$\lambda \equiv SO_2$ washout coefficient (mm^{-1})

$R \equiv$ Precipitation rate (mm/hr of liquid water).

Similarly, assuming that the rate of loss of $SO_4^{=}$ pollutant mass is proportional to the total $SO_4^{=}$ mass (M) within the puff, then:

$$dM/dt = -KM \tag{2}$$

where

$K = K_d + K_w \equiv SO_4^{=}$ decay rate

$K_d \equiv SO_4^{=}$ dry deposition rate (hr^{-1})

$K_w \equiv SO_4^{=}$ wet deposition rate $(hr^{-1}) = \Gamma \cdot R$

$\Gamma \equiv SO_4^{=}$ washout coefficient (mm^{-1})

Numerical formulations of Eq. (1) and (2) are implemented in the computer program of the long-term EURMAP-1 and ENAMAP-1 models. The amount of pollutant mass that is removed from a puff during each 3-hour time step is dependent on the specified dry and wet deposition

rates used; these amounts are deposited within the appropriate cell of a receptor grid. Also, at each time step, a fraction of the SO_2 is transformed to $SO_4^=$ at the specified transformation rate, k_t.

Figure 2 is a data flow diagram for the ENAMAP-1 computer software showing the relationship between the three types of input data and the principal ENAMAP-1 program, PUFPUF. Weather data and emission data are used by PUFPUF to produce tables of depositions and concentrations, which are compared with air quality data by a subsequent program.

The values for the basic model elements that were used in ENAMAP-1 are listed in Table 1. These values have been based on reviews of recent field, laboratory, and theoretical studies and on an evaluation study that was made using the results obtained from a previous application of the EURMAP-1 model (Mancuso et al., 1978). A more detailed description of the long-term EURMAP-1 model is given by Johnson et al. (1978).

B. *Adaptation to Eastern North America*

Figure 3 shows the sector of the North American continent over which the adapted ENAMAP-1 version of the EURMAP-1 model has been applied. This sector covers the region between 30°N and 50°N latitudes and 105°W and 65°W longitudes. The ENAMAP-1 model used in this study is characterized by the following:

- The receptor cell size is 80 × 80 km instead of 50 × 50 km used in the European applications. The model domain covers the area shown in Figure 3; the pollutant depositions are accumulated and concentrations are averaged in these receptor cells.
- The model calculates the interregional exchanges of sulfur pollution for the EPA regions and subregions shown in Figure 3.
- The Sulfate Regional Experiment (SURE) emissions data, supplemented by data from the National Emissions Data System (NEDS) have been used in this application. The emissions data are given by seasons for an emission cell size of 80 × 80 km which is the same as the receptor cell size. (The emissions data are described in more detail in Section 3-C.)
- The wind profile and precipitation data are based on a relatively greater density of data in the United States than were available in European applications. For example, whereas the precipitation data for the U.S.A. are available on an hourly basis for approximately 2000 stations, the corresponding data for Europe is only four times daily at about 600 stations. Also the wind data between the surface and 850 mb are more complete for the U.S.A. than for Europe. This has enabled calculation of more representative and accurate transport winds for use in the ENAMAP-1 model.
- The mixing height, which is kept constant in European applications, has seasonal dependence and varies from 1.15 km in winter to 1.50 km in summer.

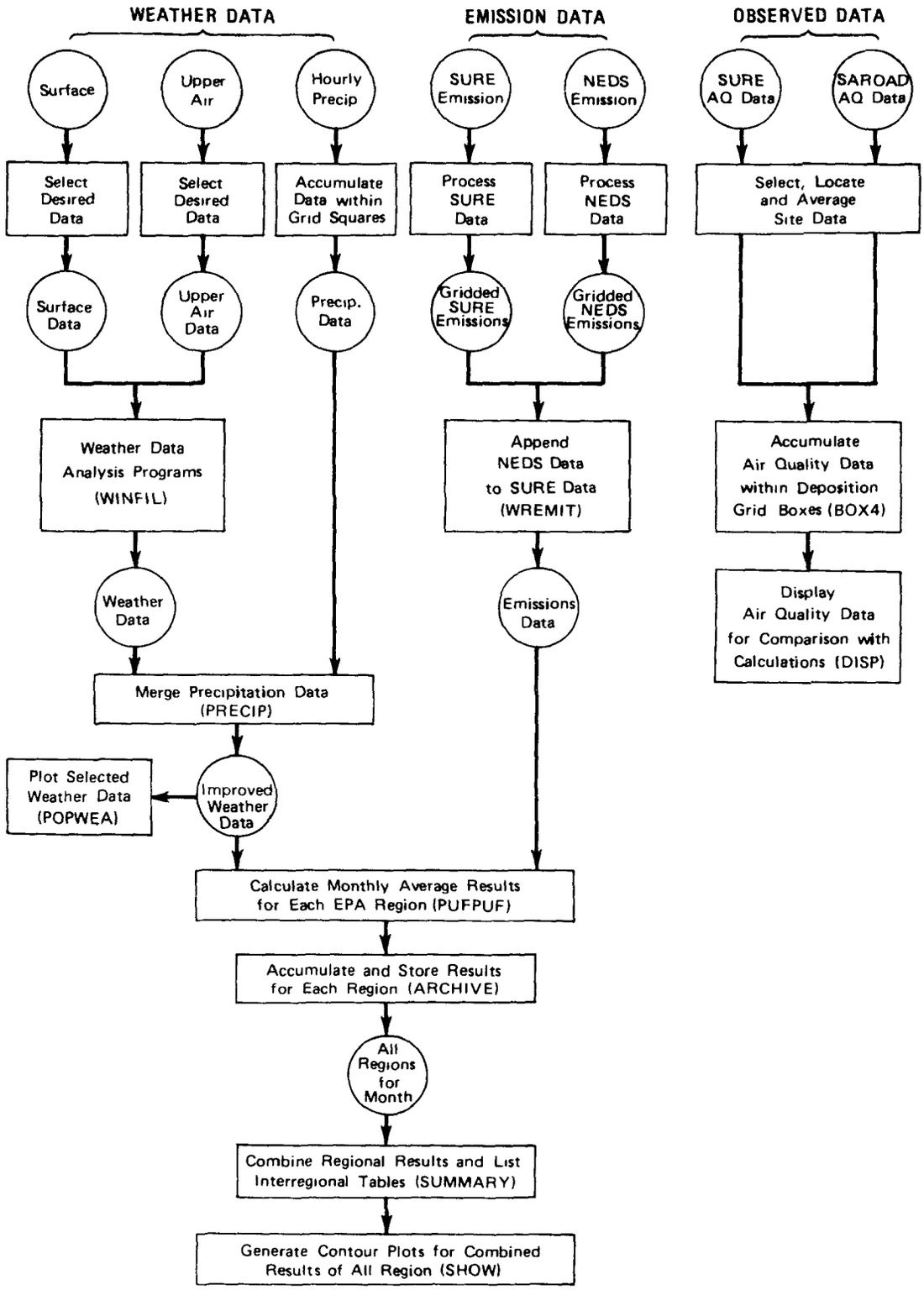


Figure 2. Data-flow diagram for the long-term ENAMAP-1 calculations of monthly values.

Program names are given in parentheses.

TABLE 1. ELEMENT VALUES USED
IN THE ENAMAP-1 APPLICATION TO EASTERN NORTH AMERICA

Element	Values
Emission rate	Data provided by season
Transport windspeed (V) (ms^{-1}) and direction (θ)	Derived by integrating winds over boundary layer
Mixing height (km)	
$h = h_o + \zeta\Lambda^*$	$h_o = 1.3$ $\zeta = -0.15$
SO_2 deposition rates (hr^{-1})	
Dry	0.037
Wet	$0.28R^\dagger$
$SO_4^=$ deposition rates (hr^{-1})	
Dry	0.007
Wet	$0.07R^\dagger$
$SO_2/SO_4^=$ transformation rate (hr^{-1})	0.01

*Λ = +1 in winter, -1 in summer, and 0 in spring and fall.

†R is the precipitation rate in mm/hr^{-1}.

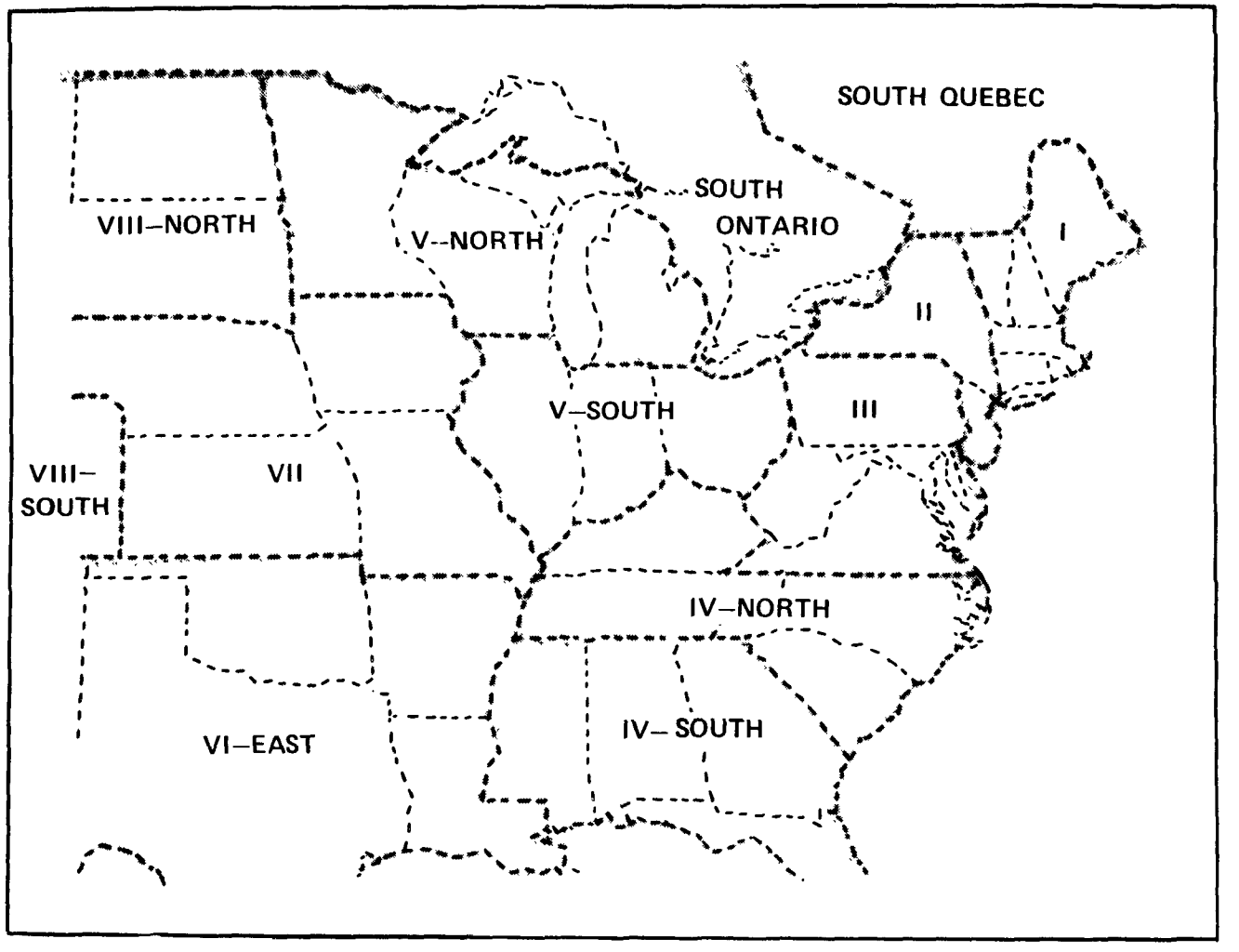


Figure 3. Eastern North American domain and EPA regions used in this study.

SECTION 3
DATA SOURCES

A. *General Considerations*

Any data base used for modeling must have features that correspond to certain special features of the model in question. ENAMAP-1 has the features listed below:

- It can operate on input data updated at arbitrarily specified intervals. This enables the model to calculate averaged concentration patterns on monthly, seasonal, and annual bases.
- It can operate on input data with arbitrary spatial resolution. This enables the model to determine the relative contribution of multiple sources to air quality.

These two features of ENAMAP-1 are valuable assets when the model is used to identify problem source areas and to test alternate approaches to emissions control.

Before applying ENAMAP-1 to any specific period, it was necessary to ascertain that the data bases satisfied some standard modeling requirements. These are:

- Spatial and temporal resolution of the emissions input data should be closely related to spatial and temporal resolutions of the meteorological input data. Spatial and temporal variability should be based, where possible, on measurements or reliable distribution models for the same period of time, preferably one full year or more of data.
- Data chosen for model input and verification should be, if possible, for the same period of time. This ensures a consistent validation of the model results.
- Finally, since long-term transport is to be modeled, the data base should be of sufficient geographical extent.

In order to ensure the greatest compatibility of available data bases, it was decided, in consultation with EPA, to apply the ENAMAP-1 model to the year 1977. The most recent full set of meteorological data and the SURE emission inventory were available for this year, and SURE air-quality data were available for August and October of 1977. The seasonal analyses are based on the results for the months of January (winter), April (transition), August (summer), and October (transition). For the months of January and April, the SAROAD air-quality data were used for the model validation; for the months of August and October, the SAROAD data were supplemented by the SURE data.

B. *Meteorological Data Base*

Historical meteorological data were obtained from the National Climatic Center (NCC) in Asheville, North Carolina. The types of NCC weather data that were used in this study were:

- Upper-air wind data for about 50 United States sites that were available at 12-hourly intervals.
- Precipitation data for the United States and Canada consisting of a limited number of observations (less than 200) every six hours.
- Precipitation data that contain hourly values for a very dense network of stations in the United States, about 2000 within the study region.

The basic analyses were made using the computer program WINFIL (see Figure 2). This program uses the 12-hourly upper-air and the 6-hourly surface data to generate both transport winds and precipitation amounts at 3-hourly intervals for the 80- by 80-km weather grid for input to ENAMAP-1. However, since the number of stations with 6-hourly precipitation was small, available hourly precipitation data was used as well, in order to get more representative precipitation values. Values based on this hourly data were used in place of the values based on the 6-hourly precipitation data over the eastern United States. Over Canada, where hourly data were not available, the values used were those based on the 6-hourly data. Over the Atlantic Ocean, where no precipitation data were available, an average hourly value based on climatic summaries was used. The precipitation data, expressed as rainfall rates in mm/hr, were used directly in the wet deposition calculations described in Section 2.

C. *Emissions Data Bases*

1. *1977 Emissions*

Since 1970, emissions data have been collected and archived in the National Emissions Data System (NEDS) of the EPA. NEDS data cover the entire ENAMAP-1 study area and provide relatively high spatial resolutions. However, the NEDS data base lacks the diurnal resolution of the SURE data base (see below) and does not consistently provide the seasonal variability of emissions. Two other major shortcomings are associated with the NEDS data; one is that the emissions are updated sporadically, and many source emissions contained in the data base are suspected to be outdated. The data cannot, therefore, be considered as adequately representative of the emissions for a single recent year. The second shortcoming is the lack of adequate quality control: Many errors made on coding forms submitted to NEDS by local agencies and contractors were not detected, and large numbers of such errors have been found by persons working with the NEDS data base.

Specialized emissions data have also been prepared for the SURE program (Perhac, 1978). These data are complete for sources existing in July 1977 and effectively represent emissions for the 1977 time period. This SURE emissions data base was essentially a refinement of the NEDS data base; that is, the NEDS data were updated and screened for errors and inconsistencies, especially with respect to electric power plants, which emit 62.4 percent of the total annual SO_2 emissions in the United States (Environmental Protection Agency, 1978). Finally, the refined data were apportioned to a UTM-based geographic grid of 80- by 80-km squares. The SURE emissions data for SO_2 and oxides of nitrogen (NO_x) (among other pollutants) were available for three-hour periods in each of four seasons (spring, summer, fall,

winter) and were provided in six emissions categories (residential-, commercial-, industrial-, and transportation-area sources, and small- and major-point sources depending on whether or not the plant's emissions exceeded 10 ktons/year). Average emissions and emission factors for assigning diurnal and weekend/weekday apportionment were provided for each emissions category. Stack parameters (e.g., height, temperature, flow rate) were provided for each major point source. The SURE emissions data cover most of the area considered in this study except for the western states (Colorado, the Dakotas, Kansas, Nebraska, Oklahoma, and Texas).

After reviewing the relative merits of NEDS and SURE emission data bases, it was decided in consultation with EPA that the SURE emissions inventory would be used as the principal inventory for the ENAMAP-1 modeling. However, since consideration of the emissions not included in the SURE data base was also desired, it was decided to supplement the SURE data with NEDS data.*

The SURE emissions inventory, which was apportioned on an 80- by 80-km UTM grid, covers the eastern United States and southeastern Canada as shown in Figure 4. The six categories of SO_2 and $SO_4^=$ emissions were summed to provide the total SO_2 and $SO_4^=$ emissions for each season for each square. Each emission grid cell in the U.S. was subjectively assigned to an EPA region based on the location of the cell center (e.g., Figure 4). If the center of a grid cell fell within a particular region, it was assigned to that region.

NEDS SO_x point and area emissions data were provided by the EPA for Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas. For area sources, only the annual values were available, and one fourth of the annual emissions were assigned to each of the four seasons. For each point source the seasonal as well as the annual SO_x emissions were provided. The UTM grid used for the SURE emissions was extended to the West, and the NEDS data were used to complete it. The NEDS point-source emissions were assigned to the proper UTM grid cells according to the location of the source. Area sources, which were given by county, were assigned to the grid cells that contained the center of that county. Each grid cell was then assigned to an EPA region as described previously for the SURE data.

While NEDS data provide only total SO_x emissions, SURE data provide separate values for SO_2 and $SO_4^=$ emissions. This information has been used to calculate separate SO_2 and $SO_4^=$ emissions for the NEDS data.

If r is defined as the ratio of SO_2 to total SO_x emissions, and it is assumed that r for NEDS data is the same as that for SURE data, then:

$$SO_2 = r \cdot SO_x \text{ , and}$$

$$SO_4^= = \frac{3}{2}(1-r)\,SO_x \text{ .}$$

*The SURE emissions inventory was compiled by the GCA Corporation of Bedford, Massachusetts, and the NEDS data were supplied by the EPA

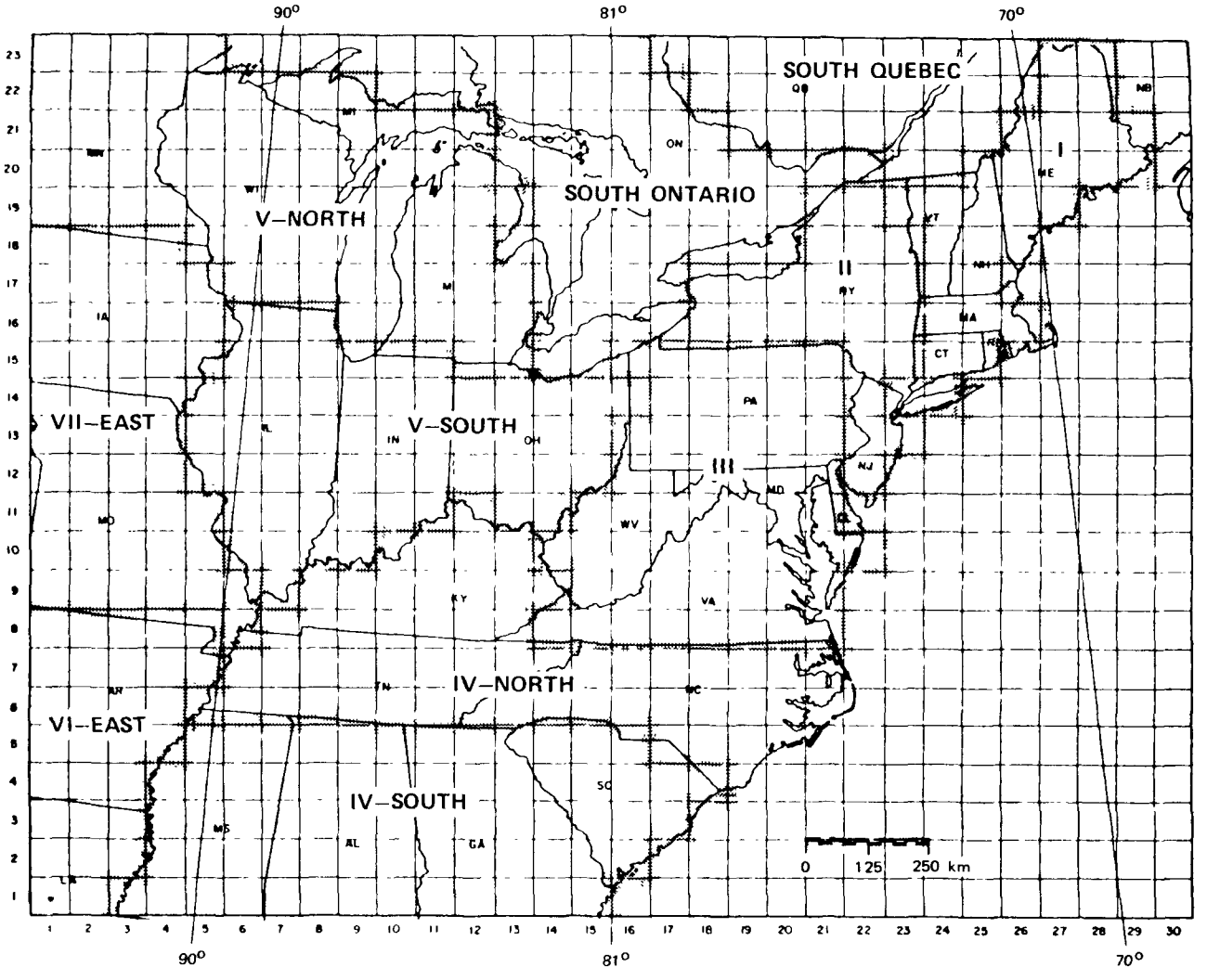


Figure 4. SURE emission grid cells and EPA regions.

where the 3/2 is the ratio of molecular weights of $SO_4^=$ to that of SO_2. The values of r that were derived from SURE data for each season are:

Season	r
Spring	0.9763
Summer	0.9776
Autumn	0.9763
Winter	0.9751

One point source in El Paso, Texas emitted about 20 percent of the total SO_x emissions from Texas. As El Paso is just outside the grid, these emissions were included within the grid as was suggested by the EPA project monitor. Figure 5 shows the average annual values of the SO_2 and $SO_4^=$ emissions data for 1977 that were used in this study.

2. *1985 Emissions*

The emissions used for the 1985 scenario were projected values supplied by the Energy Information Office of the Department of Energy (Pechan, 1978). The emissions were provided as an annual amount of SO_x for each Air Quality Control Region (AQCR), and were based on projections from the year 1975. The data included a state code number, an AQCR indicator, and the annual emissions of SO_x. In addition to the amount of SO_x, the ENAMAP-1 model needed the location and areas of each AQCR. The SO_x amount was separated into SO_2 and $SO_4^=$ emissions by assuming the ratio of $SO_4^=$ emissions to be the same as for the 1977 emissions data. Figure 6 shows the average annual SO_2 and $SO_4^=$ emissions that were used in the 1985 scenario calculations. These annual emission rates were divided by 12 to obtain emission values for each month; that is, no attempt was made to incorporate a seasonal variation in these data. As can be seen by comparing Figures 5 and 6, this projection for 1985 indicated a general decrease in sulfur emissions, particularly at certain locations (such as over the New Orleans area). It should also be noted that there were no projected emissions for Canada available for inclusion in this 1985 scenario.

D. *Air-Quality Data Bases*

1. *General*

The ENAMAP-1 model is structured to calculate average SO_2 and $SO_4^=$ concentrations within 80- by 80-km grid boxes based on emissions data of similar resolution. Thus, it was important to select, for validation purposes, air-quality data representative of such a spatial average. This requirement, in essence, precluded use of air quality data influenced by strong local sources, since such data would generally involve concentrations in excess of any broad spatial averaging. As discussed earlier, two data sources were available from which appropriate air-quality data were selected. These are the SURE data* and the Storage and Retrieval of Aerometric Data (SAROAD). A brief description of each of these data sets is given below.

*The SURE air quality data were compiled by the Environmental Research and Technology, Inc (ERT) for the Electric Power Research Institute (EPRI) ERT has made these data available to SRI for use in this project

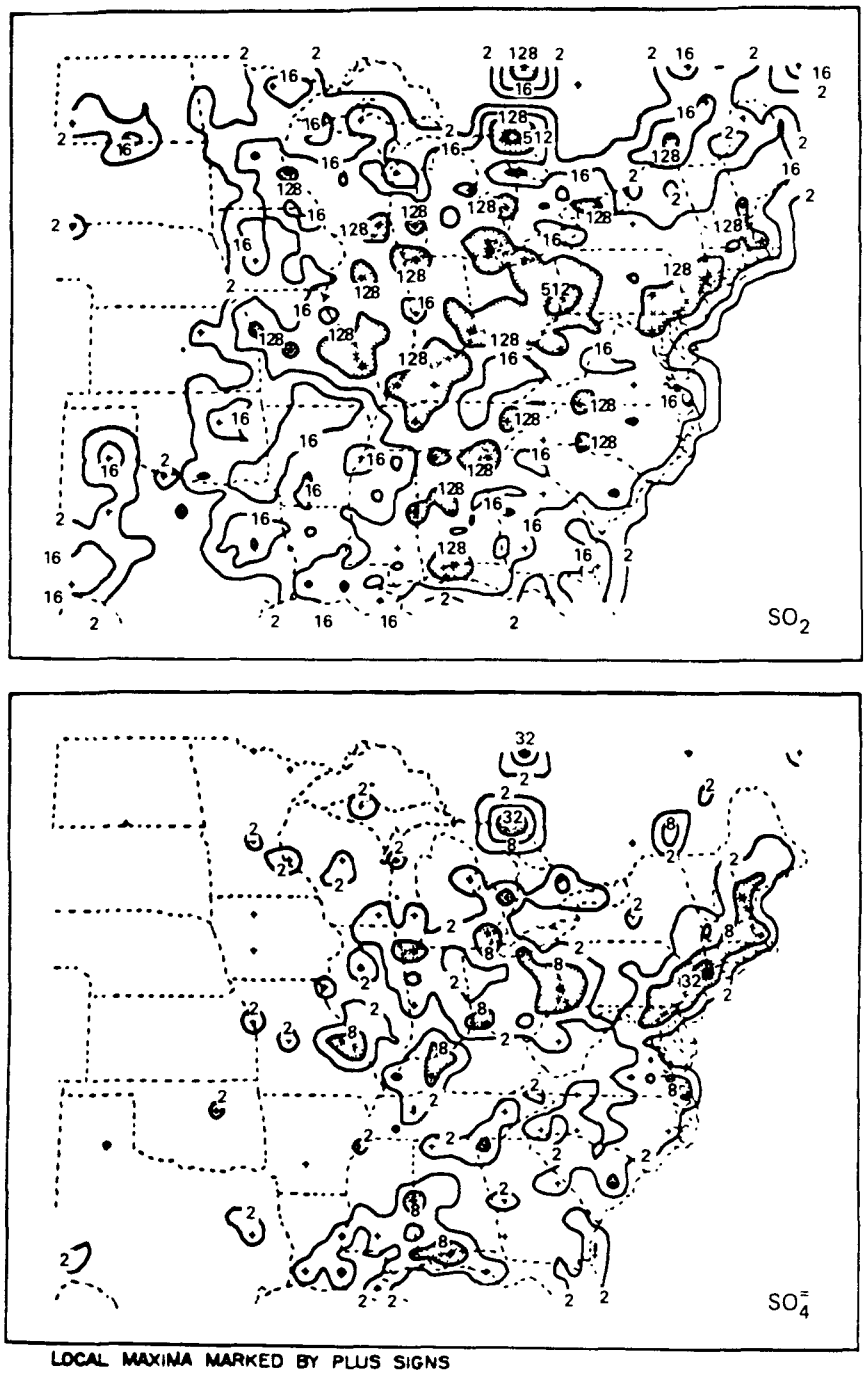
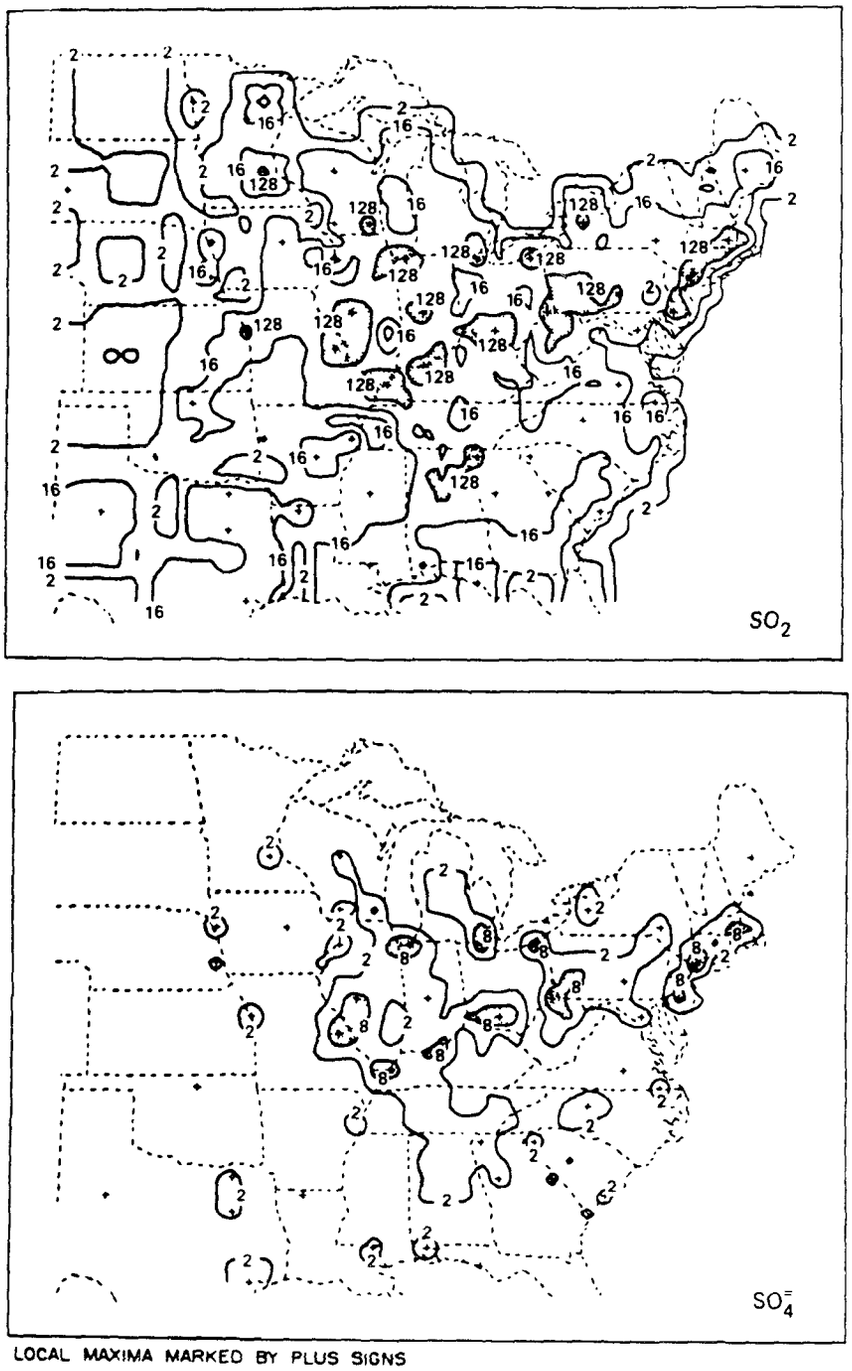


Figure 5. Annual SO_2 and $SO_4^=$ emissions for 1977 (10^{-1} tons/km^2).



LOCAL MAXIMA MARKED BY PLUS SIGNS

Figure 6. Annual SO_2 and $SO_4^=$ emissions used in 1985 scenario calculations (10^{-1} tons/km^2).

No data were available for Canada.

2. *SURE Data*

From the standpoint of representativeness, the SURE air-quality data base is ideal, since SURE air monitoring sites were selected specifically to avoid undue influence of local sources (Perhac, 1978). The SURE air-quality network consisted of a total of 54 sites located throughout the northeastern part of the United States. Nine stations were designated as Class I sites, operated exclusively for use in the SURE program. These stations measured sulfur dioxide (SO_2), oxides of nitrogen (NO_x), nitric oxide (NO), ozone (O_3), sulfates ($SO_4^=$), nitrates (NO_3^-), and total and respirable suspended particulates (TSP, RSP), as well as temperature and dew point. Gases were monitored as hourly averages, while particulates including $SO_4^=$ and NO_3^- were monitored as 3- and 24-hour averages. Forty-five stations were designated as Class II sites, measuring only SO_2 as an hourly average along with 24-hour averages of TSP, $SO_4^=$, and NO_3^-. Of these, 20 were operated routinely by ERT under contract to its clients and 25 stations were operated routinely by agencies and organizations other than ERT.

Air-quality measurements for the SURE program began with 9 August 1977. Class I measurements were available every month thereafter, while Class II measurements were available only for the months of August and October 1977 and January, April, July, and October 1978. Currently available data have been validated through instrumental performance checks, calibration, digitization, and machine reading and were designated as suitable for scientific investigative purposes. While data capture was typically high, data were nonetheless screened for use in ENAMAP-1 on the basis of data capture criteria derived from the data summary criteria of the Monitoring and Data Analysis Division of the National Air Data Branch, EPA, namely:

- Hourly data capture must be 75 percent or more of the total possible for the month in question.
- Data capture for 24-hourly data must consist of three or more observations during the month. (This is based on a typical frequency for 24-hour SAROAD data collection of every sixth day.)

Because of inherent representativeness of the SURE data base, the entire data base was used in the validation of ENAMAP-1 model.

3. *SAROAD Data*

Historical air quality data for SO_2 and $SO_4^=$ are available in the SAROAD data base maintained by EPA. These data are spatially resolved by individual station measurements in the study area and are temporally resolved at intervals of 24 hours or less.

The SAROAD data base contains data from various site types, some influenced by local sources and some not. Since the SURE data were somewhat sparse geographically and were available for only two of the four months involved in the study, they were augmented by SAROAD data screened to reject sites with a likely local-source influence.

For the purpose of screening the SAROAD data, the SAROAD Site Description File was obtained from EPA. This file contains a description of each SAROAD site, including a two-digit *site code* indicating the classifications given in Table 2 and a two-digit *project code* indicating the classifications given in Table 3. This file was interrogated for a clue to a reasonable process of site selection. The *site codes* in Table 2 suggested the most likely representative sites to be those coded 40, indicating remote sites. Suburban residential (22) and rural agricultural (32) sites, however, are also likely representative sites. The *project codes* in Table 3 suggested

TABLE 2. SITE TYPE CODE CLASSIFICATIONS.

First Digit	Description	Second Digit	Description
1	Center city	1	Industrial
		2	Residential
		3	Commercial
		4	Mobile
2	Suburban	1	Industrial
		2	Residential
		3	Commercial
		4	Mobile
3	Rural	1	Near urban
		2	Agricultural
		3	Commercial
		4	Industrial
		5	None of the above
4	Remote	0	

Note: Each classification is composed of a two digit number; for example, the site classification for a rural agricultural area would be 32.

TABLE 3. PROJECT CODE CLASSIFICATIONS.

Code	Description
01	Population-oriented surveillance
02	Source-oriented ambient surveillance
03	Background surveillance
04	Complaint investigation
05	Special studies
06	Episode monitoring
08	Global surveillance
09	Duplicate sampling
10	Continuous Air Monitoring Program station
11-99	For federal networks and future expansion

the most likely sites to be those coded 03, indicating background surveillance. Table 4 indicates that the "background surveillance" designation was properly applied in most cases, since the 03 stations are the types 13, 22, 32, and 40, and are the least likely to be influenced by strong local sources.

TABLE 4. TABULATION
OF BACKGROUND SURVEILLANCE SITES
BY STATION TYPE CODE.

Station Type	Number of Background Sites
11	2
12	7
13	24
14	1
21	4
22	50
23	11
24	2
31	41
32	132
33	9
34	10
35	34
40	109

On the basis of the information above, it was decided to make the first selection of SAROAD sites from among the background surveillance sites by sorting the SAROAD file on the 03 project code. Selections of appropriate 03 sites were made to depend also upon an acceptable rate of data capture. Data capture criteria, discussed earlier, were applied to both the SURE and SAROAD data.

Initial application of these criteria to the 03 sites resulted in a data coverage that was too sparse for a proper validation of the model. In order to augment the data set, it was decided to include additional sites, which, while not remote in the strict sense of the word, would nevertheless be unlikely to suffer the undue influence of strong local sources of SO_2. One promising category of sites was that represented by project code 01, residential. Such sites are usually well removed from industrial areas. Another category was provided by sites with project code 05 for special studies, at least some of which might be remote. While the influence of local sources could not be ruled out in the case of 01 and 05 sites, the tacit assumption was made that such influence, if great, would have been indicated by a coding of 02 for source-oriented monitoring. In any event, printouts of the grid concentrations resulting from their inclusion were checked for an indication of high concentration indicative of undue local source influence. None were found in those checked.

Table 5 shows the number of sites in each region belonging to each of categories, 01, 03, and 05, for October 1977. Although the number of sites can vary from month to month, the differences are not significant, and the n October are quite representative.

TABLE 5. NUMBER OF SURE AND SAROAD SITES BY REGION DURING OCTOBER 1977

Region	SO_2 Air Quality Data				$SO_4^=$ Air Quality Dat		
	SURE Site	SAROAD Site Code			SURE Site	SAROAD	
		01	03	05		01	03
VIII-North	0	6	18	0	0	5	15
V-North	4	171	0	23	4	3	1
S. Ontario	0	82	1	5	0	1	0
VII	0	10	0	2	0	8	1
VIII-South	1	125	4	7	1	23	0
VI-East	3	82	2	15	4	13	0
V-South	7	175	11	29	10	0	0
IV-South	4	101	7	4	7	1	0
IV-North	2	78	11	4	4	2	1
III	8	130	3	14	12	7	1
II	5	86	0	1	5	18	0
I	0	1	0	0	0	0	0
S. Quebec	3	92	0	6	4	4	1

4. *Assignment of Air-Quality Values to Grid Squares*

When the air quality data for a given month had been identified, a single monthly-av SO_2 and a single monthly-average $SO_4^=$ concentration were calculated for 160- by 160-kr squares if they contained one or more acceptable sites. The averaging within these large squares was done for the purpose of averaging out (as much as possible) unrepresentative local values. In determining the grid-square concentrations, hourly or 24-hourly SURE and SAROAD data at individual sites were averaged over the month in question. The grid-squar concentration was then determined as the average of all individual monthly averages within grid square. Assignment to grid squares was made on the basis of UTM coordinates contair in the site description file. The total number of SURE and SAROAD stations reporting SO_2 a $SO_4^=$ concentrations within the 160- by 160-km grid squares is shown in Figure 7 for the mor of October. (Similar distributions occured in the other months.)

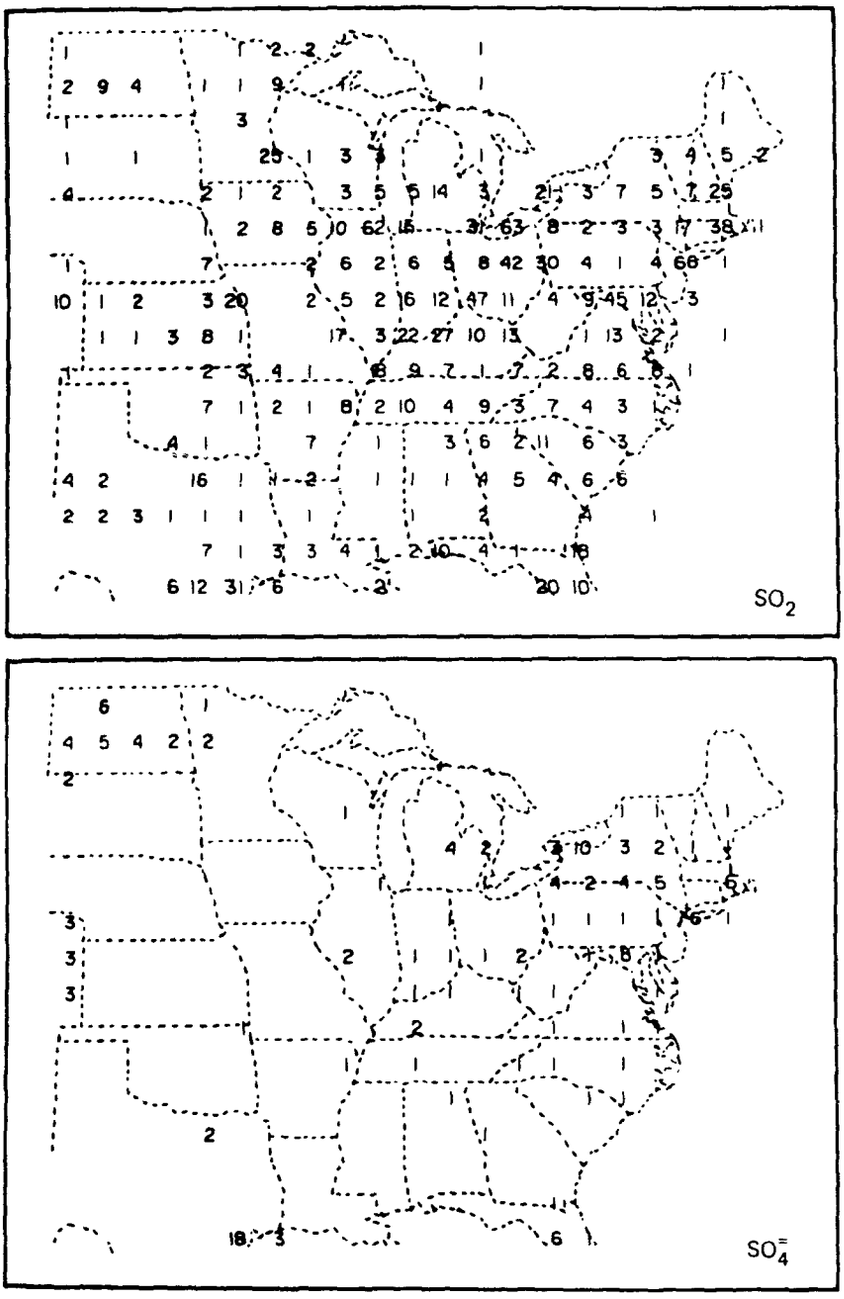


Figure 7. Number of SURE and SAROAD air quality stations within the 160-km grid squares reporting SO_2 and $SO_4^=$ concentrations during October 1977.

SECTION 4

RESULTS OF MODEL APPLICATION USING 1977 DATA

A. *General*

For the purpose of developing a set of model results for evaluation against available observations, the basic model was run for the months of January, April, August, and October, 1977 in the manner described in Section 2 using the detailed emission and meteorological data. These particular months were selected in order to examine the seasonal variations in the results. August, rather than July, was chosen as representative of summer because of the availability of SURE data for August. Separate runs were made for each of the 13 regions for which emissions were available (Figure 3). For each of the four months, fields of SO_2 and $SO_4^=$ concentrations, dry deposition, and wet deposition resulting from the sulfur emissions in each of the 13 individual regions were calculated and stored. The results from the individual runs were than combined into maps for each month showing the total concentration, dry deposition, and wet deposition distributions resulting from SO_2 emissions from all 13 regions taken together. Interregional exchange tables were also generated. These results are shown in this section and also in the Appendices.

Finally, assuming that the results for each of the four months are representative of seasonal values, annualized depositions have been estimated by totalling the four-monthly deposition values and multiplying by three. Similarly, estimates of annual average concentrations have been obtained by averaging values for the four months. These annual results are also presented in this section.

Logarithmic contour intervals (2, 4, 8, 16, 32 ...) are used in the maps shown throughout the text and only the open contours are labelled. The other numbers on the contour maps and the adjacent crosses (+) are the magnitudes and locations of maximum values in the concentration and deposition fields.

B. *SO_2 and $SO_4^=$ Concentrations*

1. *Winter Season (January)*

The calculated SO_2 concentrations for January 1977 are shown in Figure 8 by isolines (local maxima are also indicated). The primary maximum concentrations ($\geqslant 64\ \mu g/m^3$) were near Pittsburgh. Concentration centers greater than 32 $\mu g/m^3$ occur near the cities of New York, Philadelphia, Cincinnati, Cleveland, Detroit, Sudbury (Ontario), and in western Kentucky. Figure 8 also shows the measured values for the SO_2 concentrations averaged over 160- by 160-km squares, in addition to hand-drawn isolines. These measured values are based only on SAROAD data, because SURE data were not available for this month. As mentioned previously, the SAROAD data were averaged for all stations belonging to three project classifications (01,

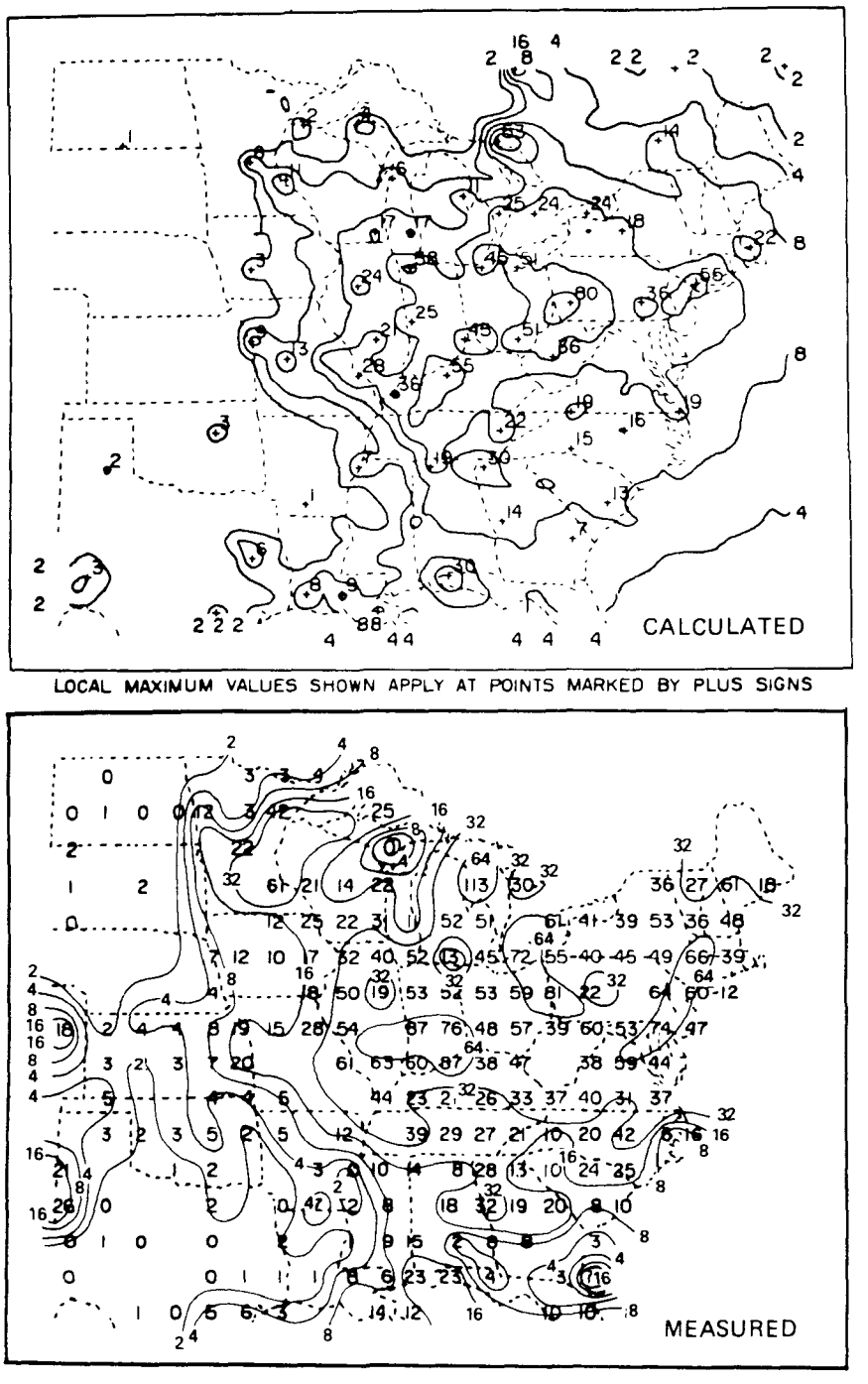


Figure 8. SO_2 concentrations ($\mu g/m^3$) for January 1977.

03, and 05; see Table 3), since there were not enough stations available if only the background classification (03) was considered.

A comparison of the calculated and measured values in Figure 8 shows that the patterns of the model calculations of SO_2 concentrations compare favorably with the measured ones, especially in areas of high concentrations. For example, both the calculated and measured values show maxima in the New York/New Jersey area, as well as in the Pittsburgh area. However, the January calculated values are generally lower than the measured values. This appears to be caused by the choice of mixing-height values that were used in the model (discussed later). Also, there are some significant differences between the calculated and measured concentrations at specific locations. For example, in the northwestern part of the area, measured values of 42 and 61 $\mu g/m^3$ are found along the Minnesota/Wisconsin border, while the maximum calculated value in this region is at most 11 $\mu g/m^3$ (near St. Paul). Another noticeable discrepancy between the calculated and measured concentrations occurs at the western boundary of the model domain, where measured values exceed 16 $\mu g/m^3$ in eastern Colorado and New Mexico. A closer examination of the reasons for the above-mentioned measured values indicates that they all belong to the 01 classification of the SAROAD data, and are thus population (urban) oriented. Therefore, they may not be representative of regional values. (The model did not consider emissions to the west.)

Figure 9 shows both the calculated and measured $SO_4^=$ concentrations for January 1977. In the calculated results, the higher $SO_4^=$ concentrations (>8 $\mu g/m^3$)are centered over the northeastern U.S., while west of the Mississippi the concentrations become quite low (<2 $\mu g/m^3$). The high values off the east coast are a manifestation of the wind being from the northwest to the southeast. The measured concentrations of $SO_4^=$ for January 1977 also show high values in the northeastern U.S. that are consistent with the calculated values. However, some high measured values (up to 10 $\mu g/m^3$) have also been recorded west of the Mississippi. This discrepancy between calculated and measured $SO_4^=$ concentration is perhaps caused by either the unrepresentativeness of the measured data or the neglect of emissions data that are being transported into the domain from outside areas. (For example, long-range transport crossing the western boundary into the grid domain.)

The differences between the calculated and measured values can also be partially attributed to the neglect of natural sulfur emissions in the model calculations. Sulfur compounds exist in the seas, in the soils, and in organic matter; and on a global basis these natural sources can contribute significant amounts of sulfur to the atmosphere. In the lower concentration areas of Figures 8 and 9 (western half of domain), much of the measured SO_2 and $SO_4^=$ may be due to natural sources.

2. *Summer Season (August)*

Patterns of the calculated and measured SO_2 concentrations for August 1977 are shown in Figure 10. For this month, the measured data are based on both SURE and SAROAD data (see Section 3-D). A comparison of the calculated and measured values shows that:

- The calculated results for August generally compare favorably with the measured values both in regard to patterns and magnitudes. For example, the isoline for the measured value of 32 in Ohio and Pennsylvania coincides with the isoline for the calculated value of 32; the measured values of 31 and 37 are located in the proximity of the isoline representing a calculated value of 32.

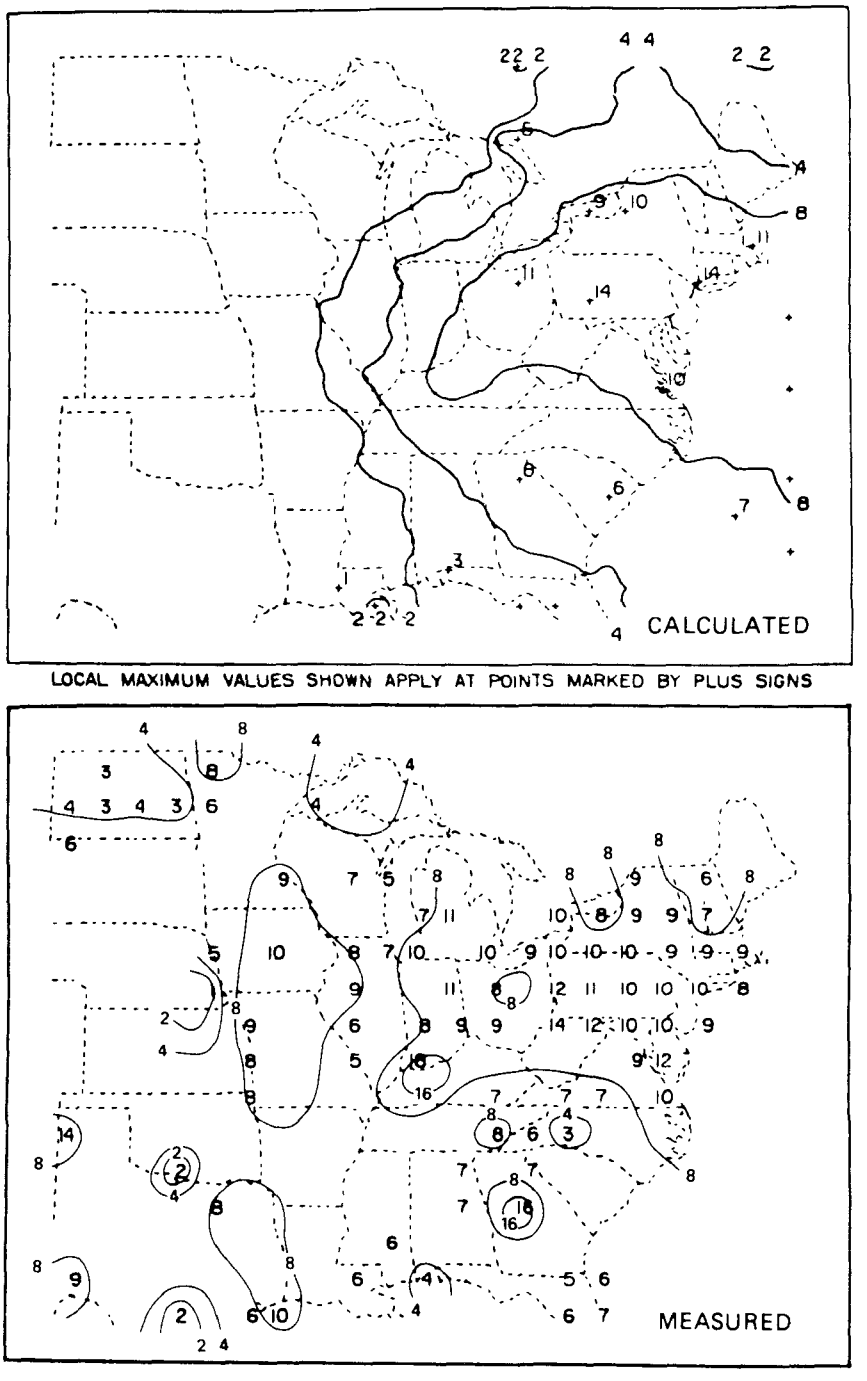
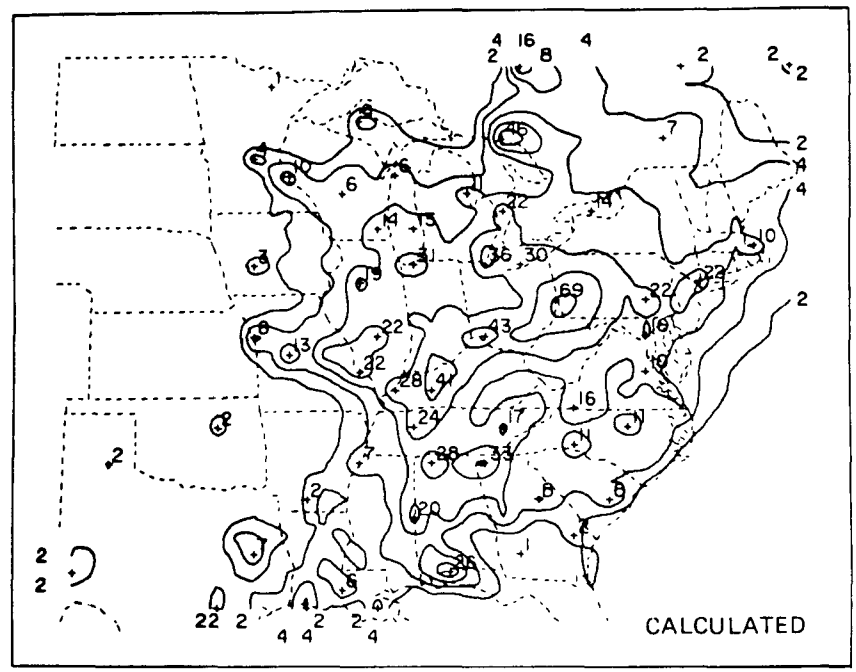


Figure 9. $SO_4^=$ concentrations ($\mu g/m^3$) for January 1977.



LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

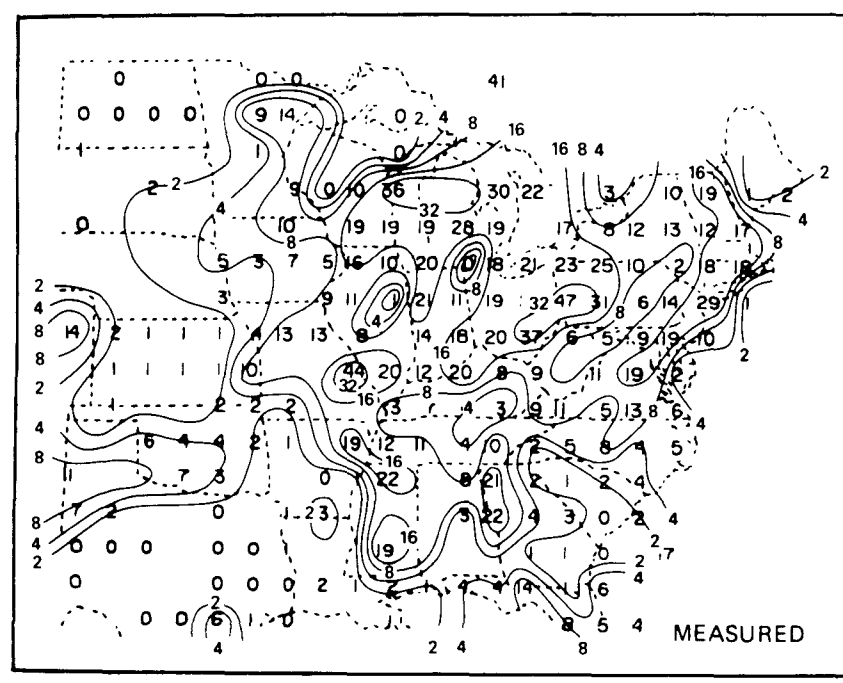


Figure 10. SO_2 concentrations ($\mu g/m^3$) for August 1977

- The highest calculated value in the domain is 69 $\mu g/m^3$, which coincides with a measured value of 47. However, the calculated values apply to a 80- by 80-km grid, while the measured values apply to a 160- by 160-km grid. Thus, the measured value of 47 $\mu g/m^3$ should actually be compared with a calculated value averaged over a similar area (i.e. four 80- by 80-km grid squares), which in this particular case would give a calculated value of 52 $\mu g/m^3$.
- In some regions, the model underestimates concentrations. For example, in the Green Bay area, a measured value of 36 $\mu g/m^3$ is located between the 4 and 8 isolines of the calculated values. In other regions it overestimates concentrations, such as in eastern Kentucky.
- In the north of the domain, the measured value of 41 $\mu g/m^3$ (although located in a region of low calculated values) is very close to the high calculated values (>16) near Rouyn, Quebec.
- The model probably does not accurately simulate the low measured values in the Appalachian region because the model does not incorporate complex terrain.

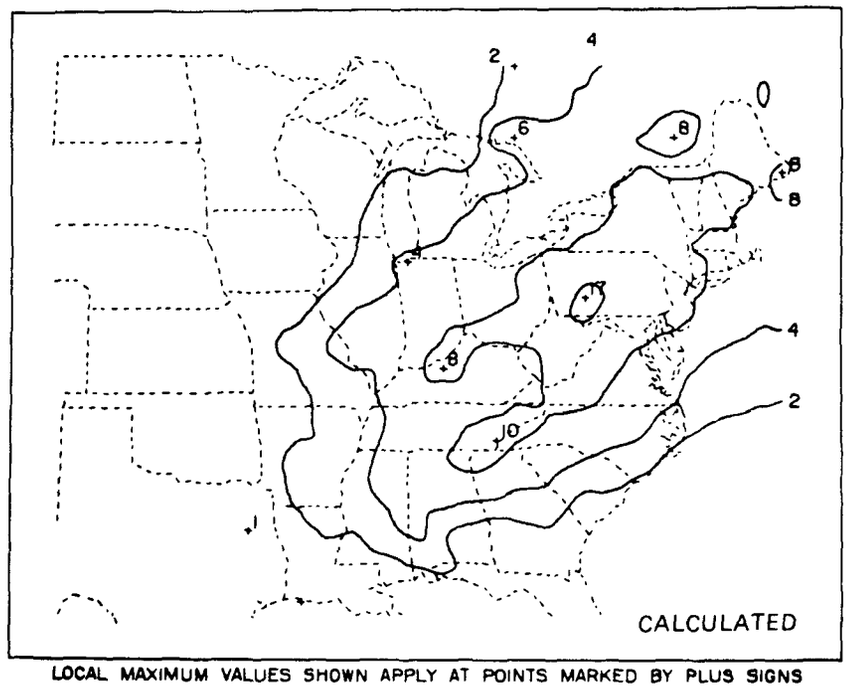
The comparable figures for calculated and measured $SO_4^=$ concentrations are shown in Figure 11. As can be seen, ENAMAP-1 appears to have performed quite well for $SO_4^=$ for this summer period. The higher $SO_4^=$ concentrations (> 8 $\mu g/m^3$) occur over the northeastern U.S. in both the calculated and measured fields, with peak values (17 $\mu g/m^3$) occurring near the Pittsburgh area. A region of low concentrations is indicated in both the calculated and measured fields over eastern Kentucky, although the latter are somewhat lower than the calculated.

3. *Transitional Seasons (April and October) and Annual*

The calculated and measured SO_2 and $SO_4^=$ concentrations for April and October 1977 are shown in Figures 12 through 15. In general both the calculated and measured SO_2 and $SO_4^=$ concentrations lie between the higher values in winter (January), and lower values in summer (August). This seasonal variation, however, is much stronger in the measured data. As mentioned previously, the winter SO_2 and $SO_4^=$ measurements are larger than the calculated values, while the summer measurements and calculations are in close agreement. The results for the transitional months appear to be somewhere in between. The smaller seasonal variability in the calculated results appears to be largely a result of the selected mixing heights, based on results from our European applications, that were used for each season in the model (see Table 1). The use of seasonal mixing-height values closer to those given by Holzworth (1972) would probably produce an improved comparison between the calculated and the measured values.

The seasonal variabilities caused by the prevailing wind flow can be readily seen in the calculated results, particularly the calculated $SO_4^=$ concentration patterns. The patterns of both the measured and calculated $SO_4^=$ concentrations are similar, reflecting the effects of the transport winds. However, the measured data are rather spotty (particularly for $SO_4^=$), and some of the values are likely not to be representative of the 160- by 160-km areas. Thus, the measured patterns are not as clearly related to the wind fields.

Generally, in all seasons, the measured SO_2 and $SO_4^=$ patterns tend to show lower concentrations in the south and higher values in the north compared to those calculated. This could be caused by increased convection and mixing that occur in the southern portions of the domain, resulting in higher mixing heights. Perhaps, this effect could be best parameterized in the ENAMAP-1 model by incorporating certain features of our short-term EURMAP-2 model



LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

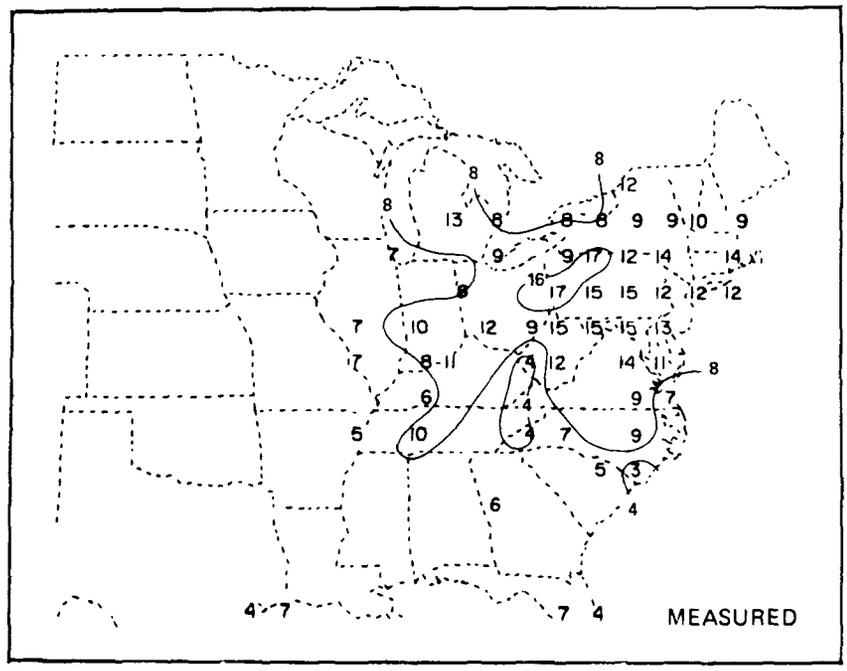


Figure 11. $SO_4^=$ concentrations ($\mu g/m^3$) for August 1977.

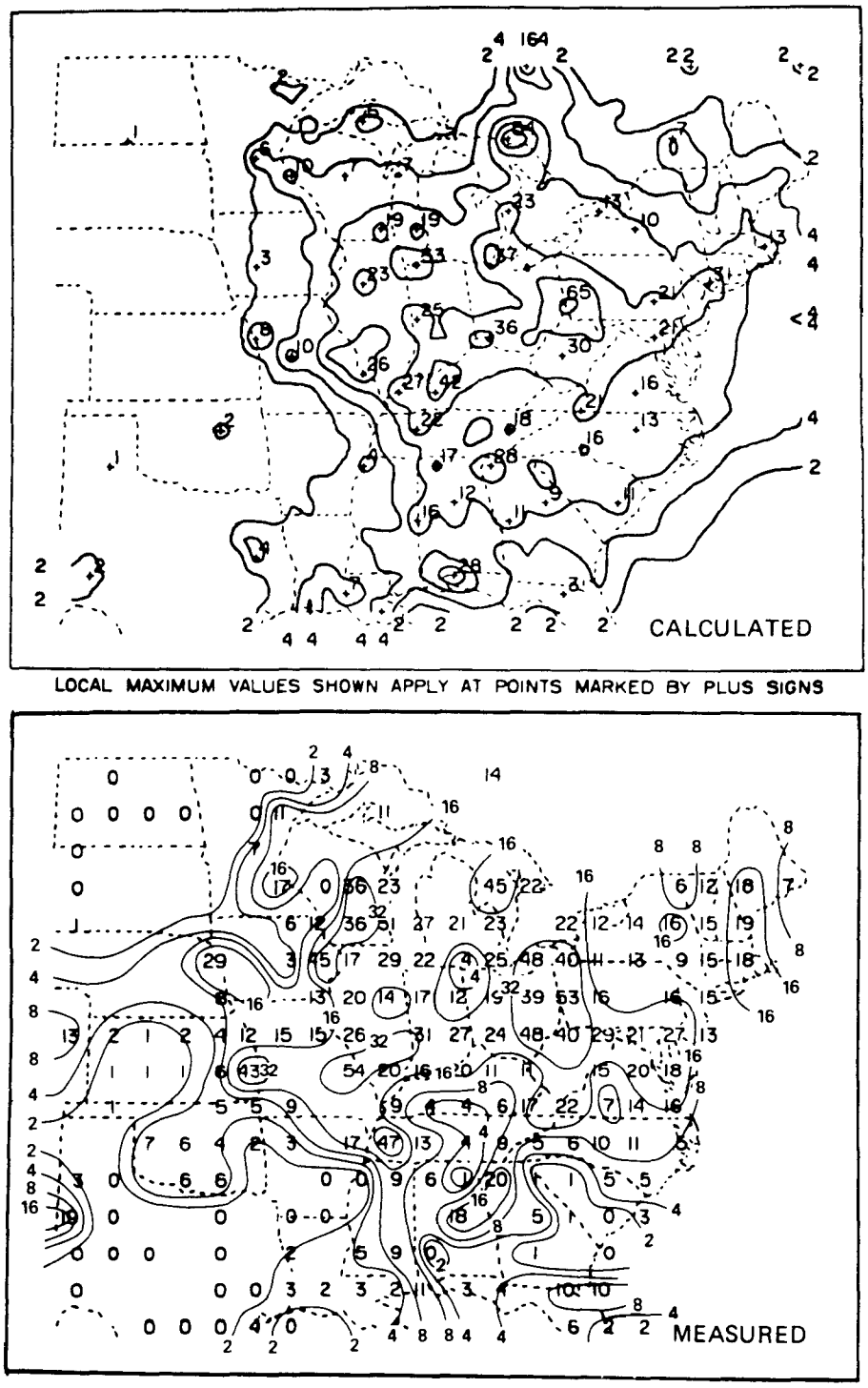
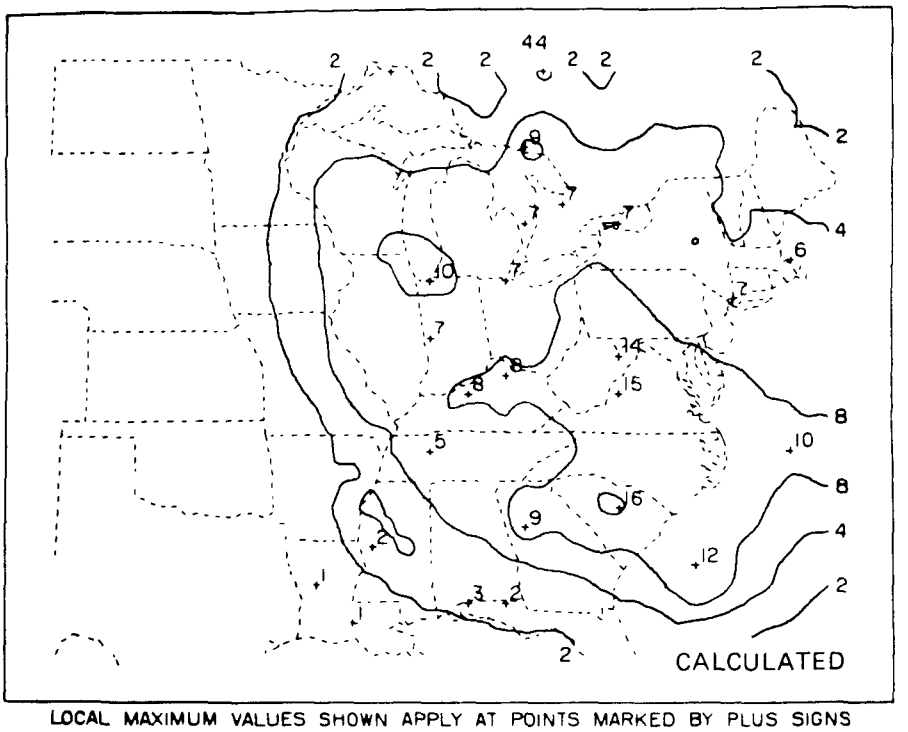


Figure 12. SO_2 concentrations ($\mu g/m^3$) for April 1977.



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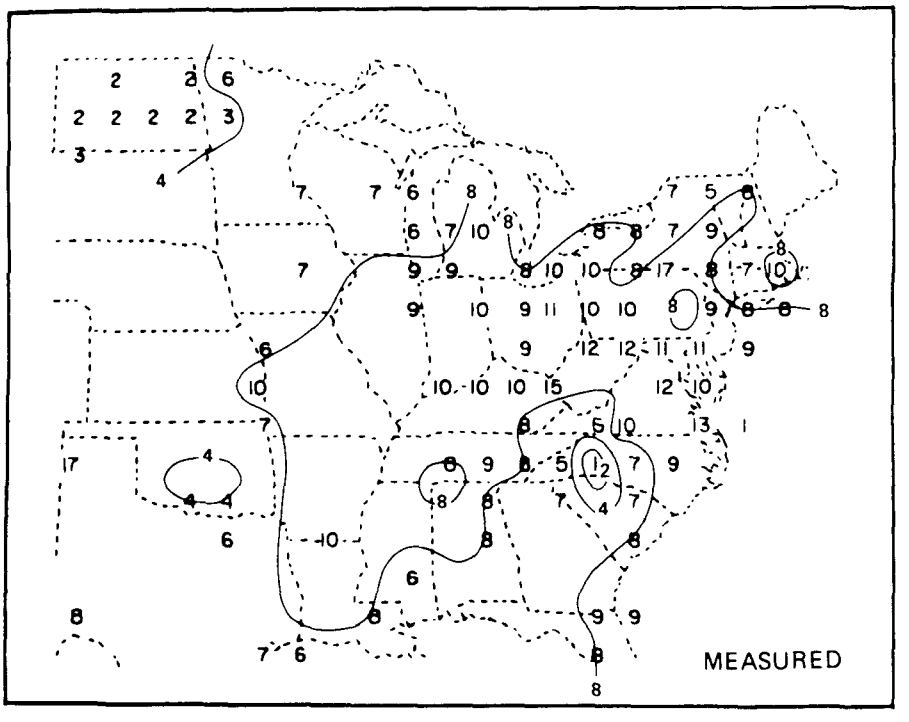
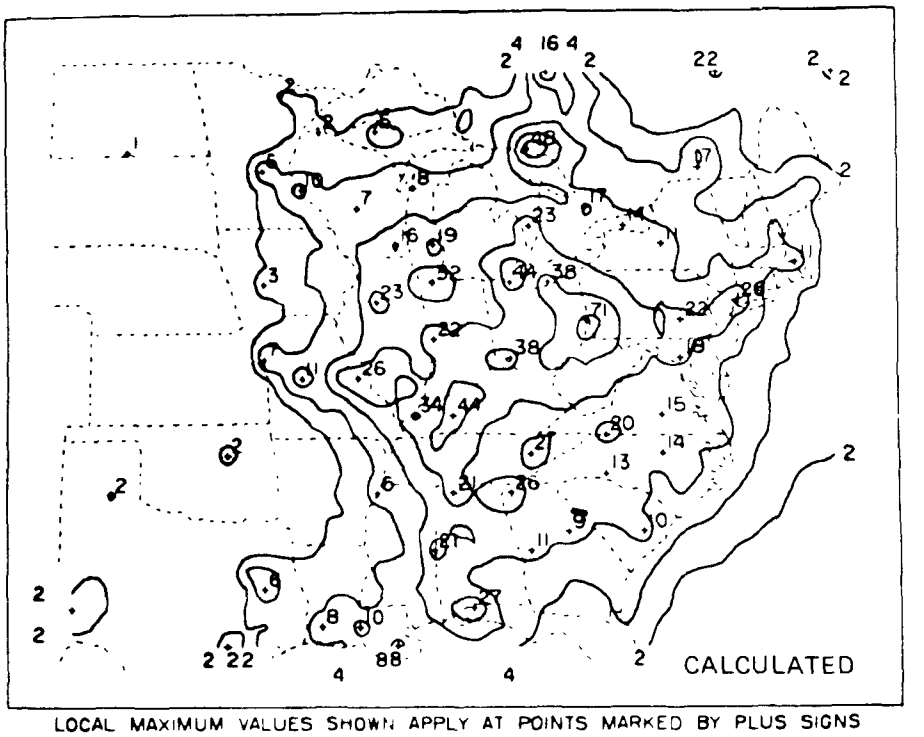


Figure 13. $SO_4^=$ concentrations ($\mu g/m^3$) for April 1977.



LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

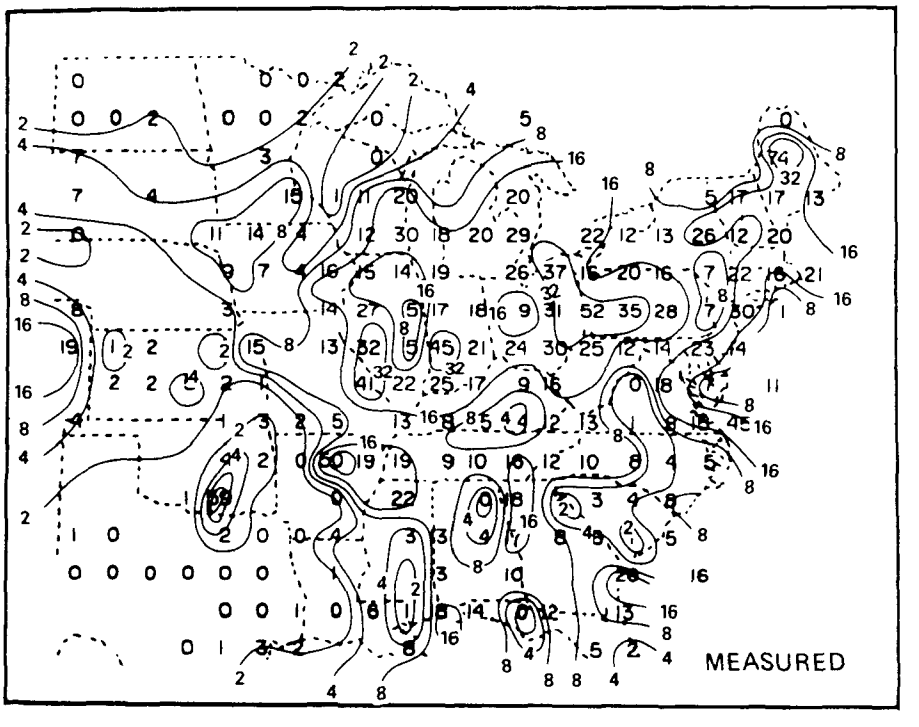
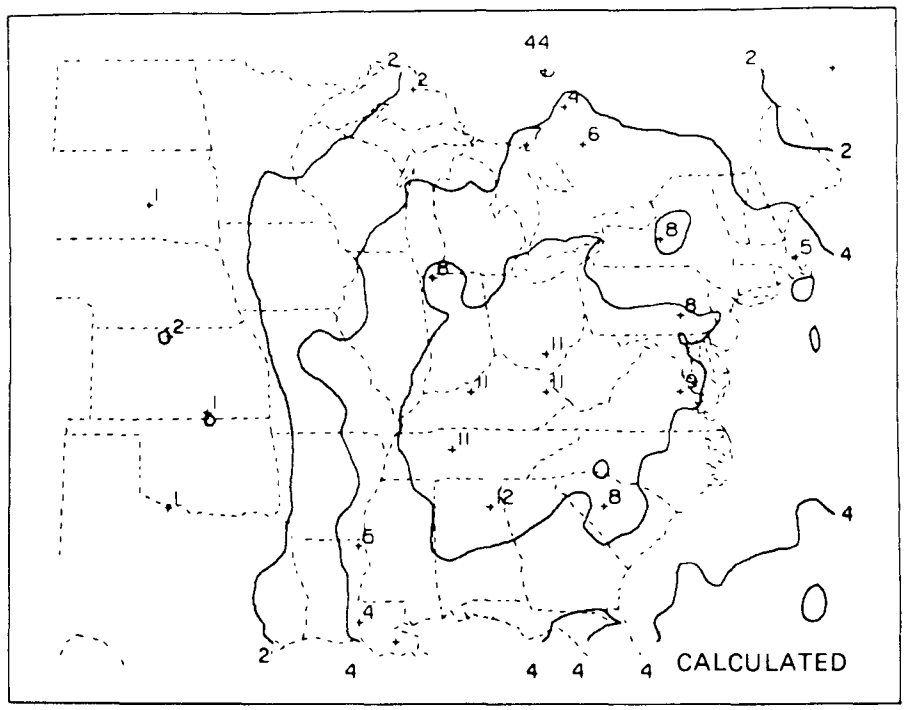


Figure 14. SO_2 concentrations ($\mu g/m^3$) for October 1977.



LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

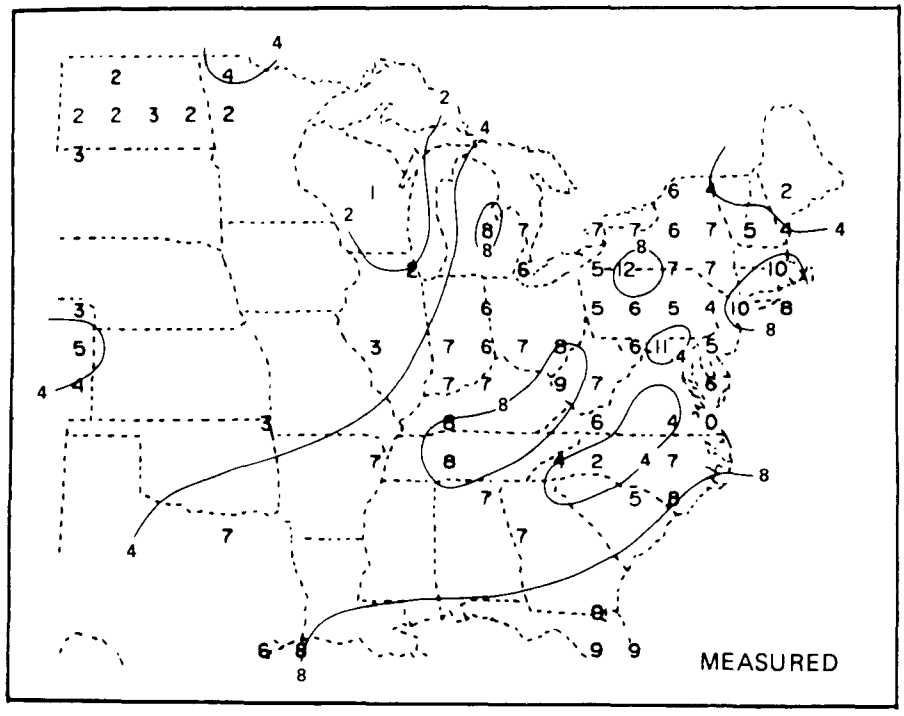


Figure 15. $SO_4^=$ concentrations ($\mu g/m^3$) for October 1977.

(Bhumralkar et al., 1979), in which stabilities and mixing heights are calculated from the meteorological data and used to control the growth of the puff. Also, in all of the seasons, the measured SO_2 and $SO_4^=$ concentrations tend to be higher than the calculated values over the Great Plains. As discussed for the winter season, this would be a result of:

- Unrepresentativeness of measured data
- Neglect of emissions from outside the region
- Neglect of natural emissions (in ENAMAP-1 calculations).

The calculated annual concentrations for SO_2 and $SO_4^=$ are shown in Figure 16. Since these have been obtained by averaging the results for January, April, August, and October, the patterns are relatively smooth.

C. *Dry and Wet Deposition Results*

Figure 17 shows the calculated annual dry and wet depositions of SO_2 and Figure 18 shows the calculated annual dry and wet depositions of $SO_4^=$. These figures show the large horizontal gradient of depositions west of the Mississippi River, which are caused by the sharp decrease in sulfur emissions in this region. The annual dry deposition patterns for SO_2 and $SO_4^=$ are very similar to those for concentration (compare with Figure 16). The annual wet deposition patterns for SO_2 and $SO_4^=$ tend to also reflect the effects of precipitation. For example, the $SO_4^=$ wet deposition amount over Detroit (940 mg/m^2) is less than that over Chicago (1050 mg/m^2), where there was more rainfall. However, the $SO_4^=$ dry deposition amount over Detroit (740 mg/m^2) is slightly greater than that over Chicago (700 mg/m^2). The effects of rainfall are most noticeable in the individual seasonal results for the dry and wet depositions that are provided in Appendix A.

D. *Interregional Exchanges*

Tables 6 and 7 show the annual and seasonal sulfur* exchanges between the different regions of Figure 2. The numerals 1 through 13 at the left of columns and the top of rows in the matrix of Tables 6 and 7 (as well as all other similar tables in the report showing interregional exchanges) should not be confused with EPA regions. These numbers have been assigned here merely to facilitate the interpretation of numbers included in the matrix in terms of emitter and receptor regions. An example of how to interpret these tables follows: Table 6 shows the annual dry and wet sulfur depositions (in kilotons) resulting from emissions from each of the 13 regions for 1977. The values along the diagonal of the matrix represent the amounts emitted by each region and the amount deposited within the region itself due to its own emissions; for example, 10 ktons or 55 percent of the sulfur deposition within the region designated by the numeral 1, that is Region VIII-North, came from its own emissions. Similarly, south Ontario receives from itself 820 ktons or 54 percent of the total sulfur deposition. The table also shows the amount received by each region from other emitter regions. For example, Region VIII-North also received 3 ktons or 19 percent from Region V-North; 2 ktons or 9 percent from Region VII; and the remainder (17 percent) from the other regions. Tables 7(a) through 7(d) provide an indication of the seasonal exchanges. For example, they show that

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*The amount of sulfur (S) is given by $S = \frac{SO_2}{2} + \frac{SO_4^=}{3}$

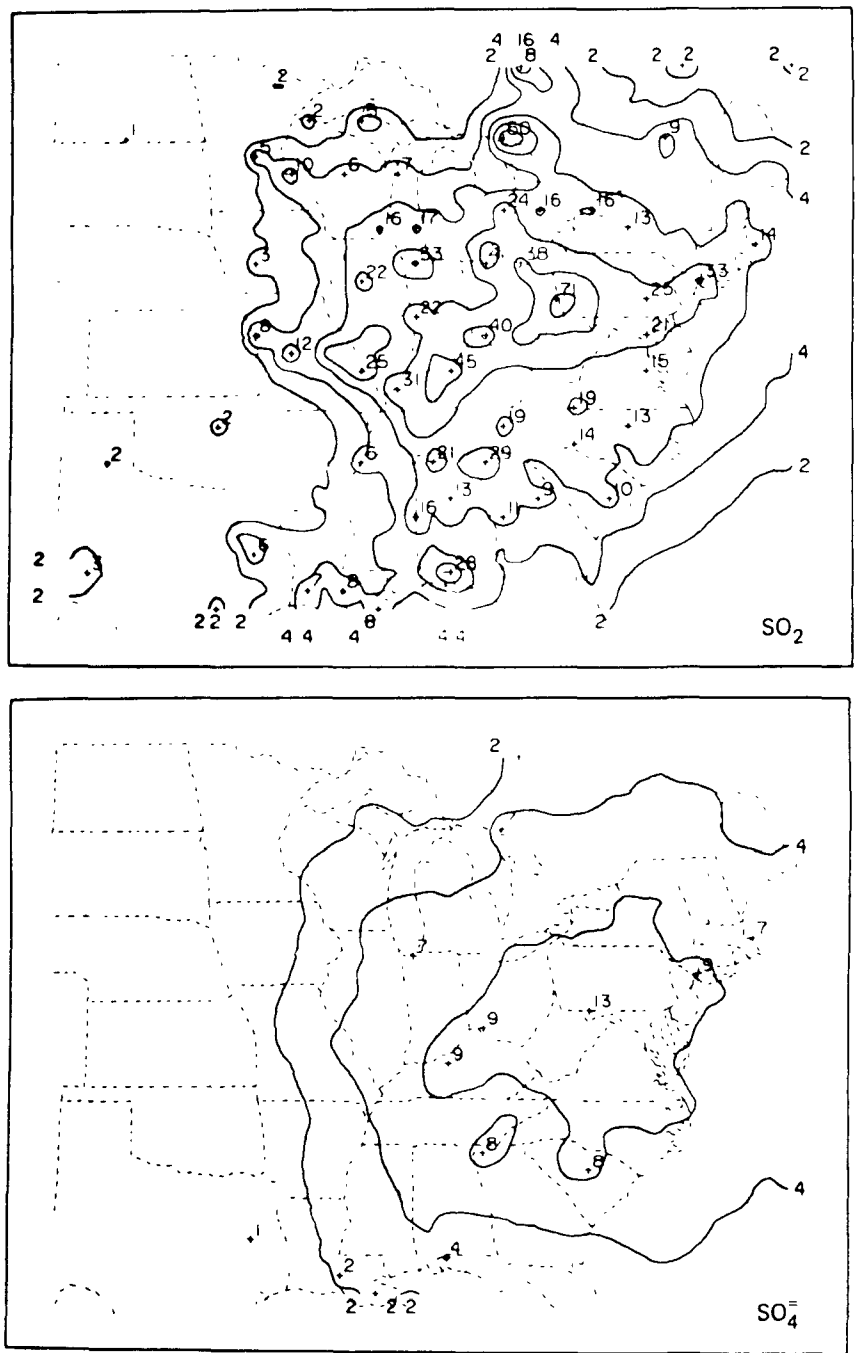


Figure 16. Calculated annual concentrations of SO_2 and $SO_4^=$ ($\mu g/m^3$) for 1977.

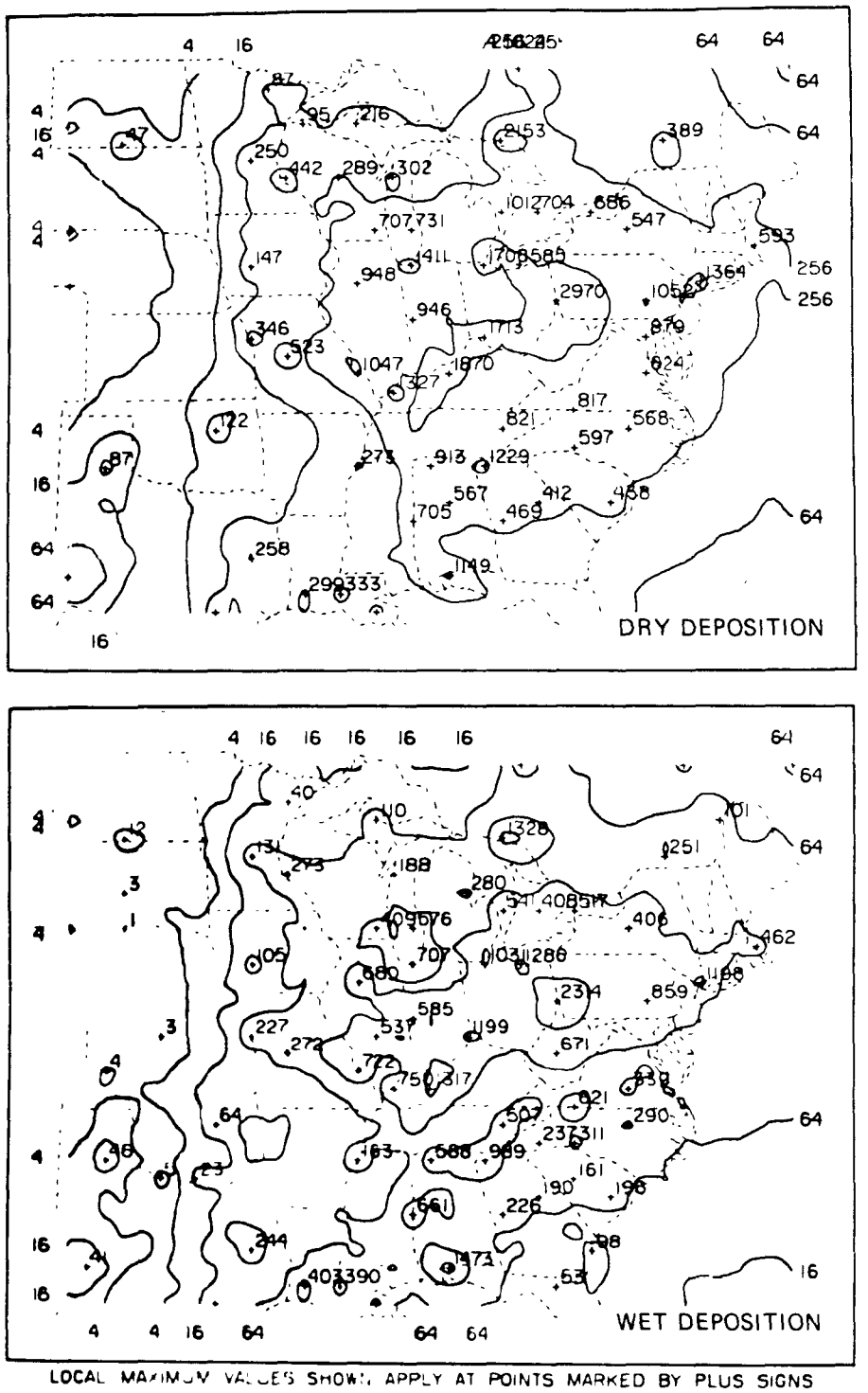


Figure 17. Calculated annual dry and wet depositions of SO_2 (10 mg/m^2) for 1977.

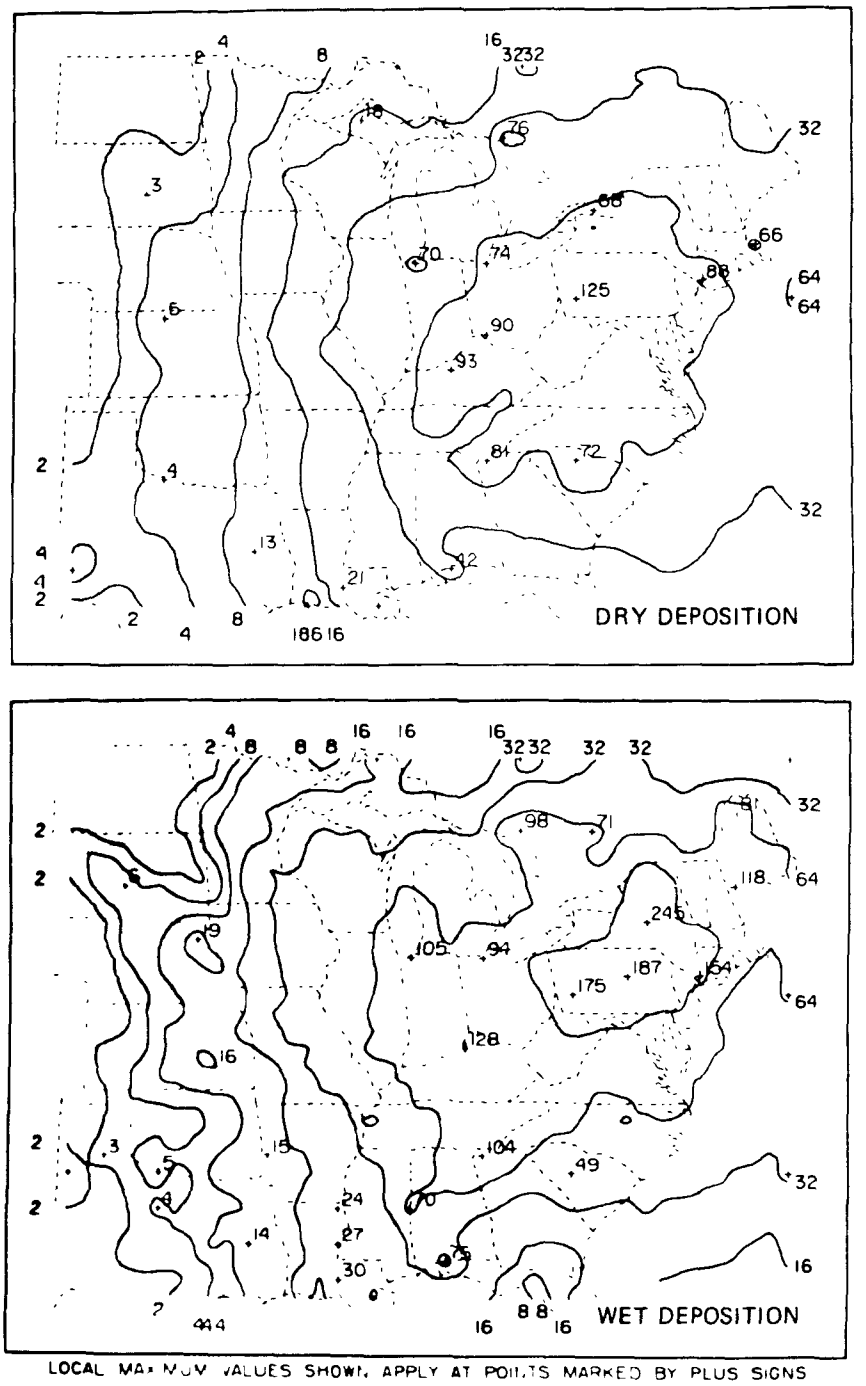


Figure 18. Calculated annual dry and wet depositions of $SO_4^=$ (10 mg/m^2) for 1977.

TABLE 6. ANNUAL INTERREGIONAL EXCHANGES OF SULFUR DEPOSITION FOR 1977

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	10.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2 V-NORTH	3.	655.	290.	46.	0.	3.	229.	6.	24.	78.	50.	18.	23.
3 S. ONTARIO	0.	66.	820.	2.	0.	1.	49.	2.	7.	74.	87.	40.	87.
4 VII	1.	43.	10.	367.	0.	26.	137.	22.	41.	12.	3.	2.	2.
5 VIII-SOUTH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6 VI-EAST	1.	4.	1.	40.	1.	401.	7.	35.	6.	1.	0.	0.	0.
7 V-SOUTH	2.	186.	145.	135.	0.	14.	1566.	59.	425.	520.	92.	30.	26.
8 IV-SOUTH	0.	8.	7.	16.	0.	44.	31.	949.	279.	25.	2.	1.	2.
9 IV-NORTH	0.	19.	24.	11.	0.	13.	221.	108.	929.	159.	15.	7.	6.
10 III	0.	11.	57.	3.	0.	1.	178.	14.	141.	1363.	179.	56.	21.
11 II	0.	1.	53.	0.	0.	0.	1.	1.	4.	37.	204.	65.	14.
12 I	0.	0.	1.	0.	0.	0.	1.	0.	2.	9.	91.	207.	22.
13 S. QUEBEC	0.	2.	105.	0.	0.	0.	1.	0.	0.	2.	8.	41.	204.
TOTAL (KTON S)	18.	997.	1514.	621.	1.	503.	2422.	1197.	1856.	2280.	732.	467.	407.

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	55.	0.	0.	0.	6.	0.	0.	0.	0.	0.	0.	0.	0.
2 V-NORTH	19.	66.	19.	7.	0.	1.	9.	0.	1.	3.	7.	4.	6.
3 S. ONTARIO	3.	7.	54.	0.	0.	0.	2.	0.	0.	3.	12.	9.	21.
4 VII	3.	4.	1.	59.	0.	5.	6.	2.	2.	1.	0.	0.	0.
5 VIII-SOUTH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6 VI-EAST	7.	0.	0.	6.	92.	80.	0.	3.	0.	0.	0.	0.	0.
7 V-SOUTH	9.	19.	10.	22.	1.	3.	65.	5.	23.	23.	13.	6.	6.
8 IV-SOUTH	1.	1.	0.	3.	0.	9.	1.	79.	15.	1.	0.	0.	1.
9 IV-NORTH	0.	2.	2.	2.	0.	3.	9.	9.	50.	7.	2.	1.	1.
10 III	2.	1.	4.	1.	0.	0.	7.	1.	8.	60.	24.	12.	5.
11 II	1.	0.	4.	0.	0.	0.	0.	0.	0.	2.	28.	14.	3.
12 I	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	12.	44.	5.
13 S. QUEBEC	0.	0.	7.	0.	0.	0.	0.	0.	0.	0.	1.	9.	50.

TABLE 7. CALCULATED SEASONAL INTERREGIONAL EXCHANGES OF SULFUR FOR 1977

(a) JANUARY 1977

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.8	.1	.0	.2	.0	.1	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.0	46.9	26.4	3.8	0.0	.1	21.5	.4	1.6	9.8	6.4	2.4	2.0
3 S. ONTARIO	.0	3.3	71.6	0.0	0.0	0.0	3.0	0.0	.1	6.8	12.5	5.7	8.0
4 VII	.0	1.4	.5	29.5	.0	3.5	10.8	4.0	7.6	1.5	.3	.3	.2
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.0	.0	.0	1.1	.0	29.9	.1	3.8	.3	.0	.0	.0	.0
7 V-SOUTH	0.0	5.2	8.1	8.6	0.0	.3	122.0	5.8	42.4	54.7	8.1	3.6	2.3
8 IV-SOUTH	0.0	0.0	0.0	.0	0.0	2.2	.3	72.2	17.3	.8	.0	.0	0.0
9 IV-NORTH	0.0	.0	.4	.2	0.0	.7	12.8	11.9	80.0	14.1	1.1	.7	.3
10 III	0.0	.1	1.8	0.0	0.0	0.0	12.2	.0	8.3	106.1	13.2	5.4	1.0
11 II	0.0	.0	3.8	0.0	0.0	0.0	.0	0.0	0.0	1.8	15.6	5.3	.8
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	.3	8.4	18.6	2.0
13 S. QUEBEC	0.0	.2	7.2	0.0	0.0	0.0	.0	0.0	0.0	.0	.6	6.0	22.9
TOTAL (KTON S)	.8	57.3	120.0	43.4	.0	36.8	182.9	98.2	157.5	196.0	66.1	48.0	39.4

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	95.8	.1	.0	.6	17.8	.1	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	3.1	82.0	22.0	8.8	0.0	.3	11.8	.4	1.0	5.0	9.7	5.0	4.9
3 S. ONTARIO	.0	5.8	59.7	0.0	0.0	0.0	1.6	0.0	.0	3.5	18.9	11.8	20.4
4 VII	1.1	2.5	.4	67.9	.0	9.4	5.9	4.1	4.8	.8	.4	.6	* .6
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.0	.0	.0	2.5	82.2	81.3	.1	3.9	.2	.0	.0	.0	.0
7 V-SOUTH	0.0	9.2	6.8	19.8	0.0	.9	66.7	5.9	26.9	27.9	12.2	7.6	5.8
8 IV-SOUTH	0.0	0.0	0.0	.0	0.0	6.1	.2	73.5	11.0	.4	.0	.0	0.0
9 IV-NORTH	0.0	.0	.3	.4	0.0	1.8	7.0	12.1	50.8	7.2	1.6	1.6	.8
10 III	0.0	.1	1.5	0.0	0.0	0.0	6.7	.0	5.3	54.1	19.9	11.2	2.6
11 II	0.0	.0	3.2	0.0	0.0	0.0	.0	0.0	0.0	.9	23.6	11.0	2.0
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	.1	12.7	38.7	5.0
13 S. QUEBEC	0.0	.3	6.0	0.0	0.0	0.0	.0	0.0	0.0	.0	.9	12.5	58.0

TABLE 7 (CONTINUED)

(b) APRIL 1977

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.8	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.1	56.2	19.1	4.3	.0	.3	18.9	.4	1.9	4.9	2.5	1.2	1.1
3 S. ONTARIO	.0	7.6	66.7	.0	0.0	.0	4.8	.0	.7	6.4	4.0	2.1	4.0
4 VII	.0	5.2	1.2	27.6	.0	1.7	9.8	.9	2.7	1.0	.3	.2	.2
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.2	.9	.3	4.3	.2	30.7	.7	3.1	.6	.1	.1	.1	.0
7 V-SOUTH	0.0	22.7	12.2	11.3	0.0	.6	129.4	3.4	31.8	38.3	3.4	1.5	1.3
8 IV-SOUTH	.1	2.2	1.2	3.0	.0	3.7	3.8	70.2	21.4	3.0	.3	.3	.1
9 IV-NORTH	.0	3.3	2.8	1.0	0.0	.5	19.2	5.1	71.0	9.7	.4	.5	.2
10 III	.0	.4	5.7	.0	0.0	.0	13.3	.2	12.4	108.2	9.9	3.6	1.8
11 II	0.0	.0	4.4	0.0	0.0	0.0	.0	0.0	.0	3.0	15.5	4.4	1.4
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	.0	.3	7.2	14.9	2.4
13 S. QUEBEC	0.0	.3	11.1	0.0	0.0	0.0	.1	0.0	.0	.1	.6	2.8	14.3
TOTAL (KTON S)	1.3	99.0	124.7	51.6	.2	37.6	199.9	83.1	142.6	175.0	44.3	31.5	26.9

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	64.4	.0	.0	.3	10.3	.1	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	9.5	56.8	15.4	8.3	.1	.7	9.5	.4	1.3	2.8	5.7	3.7	4.0
3 S. ONTARIO	.2	7.7	53.5	.0	0.0	.0	2.4	.0	.5	3.7	9.0	6.6	15.0
4 VII	3.0	5.3	.9	53.5	.0	4.6	4.9	1.0	1.9	.6	.6	.5	.6
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	18.0	.9	.2	8.2	89.6	81.7	.3	3.7	.4	.1	.1	.2	.2
7 V-SOUTH	0.0	23.0	9.7	21.9	0.0	1.5	64.7	4.0	22.3	21.9	7.7	4.8	4.9
8 IV-SOUTH	4.2	2.2	.9	5.8	.0	10.0	1.9	84.4	15.0	1.7	.6	1.1	.5
9 IV-NORTH	.1	3.3	2.2	1.9	0.0	1.4	9.6	6.2	49.8	5.5	1.0	1.6	.9
10 III	.7	.4	4.5	.1	0.0	.1	6.6	.3	8.7	61.8	22.4	11.3	6.7
11 II	0.0	.0	3.5	0.0	0.0	0.0	.0	0.0	.0	1.7	35.1	14.1	5.2
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	.0	.2	16.3	47.2	8.8
13 S. QUEBEC	0.0	.3	8.9	0.0	0.0	0.0	.1	0.0	.0	.1	1.5	9.0	53.3

TABLE 7 (CONTINUED)

(c) AUGUST 1977

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.9	.0	.0	.1	.0	.0	.0	0.0	.0	.0	.0	.0	.0
2 V-NORTH	.0	59.9	29.5	1.6	0.0	.1	14.8	.2	.6	4.1	4.5	1.4	3.5
3 S. ONTARIO	.0	2.9	65.5	0.0	0.0	0.0	2.1	.0	.1	3.7	6.4	3.6	12.4
4 VII	.0	4.3	1.3	33.7	.0	1.1	15.6	.2	.7	.3	.3	.2	.2
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.1	.3	.1	4.5	.1	42.3	.9	2.4	.3	.1	.0	.0	.0
7 V-SOUTH	0.0	15.7	15.2	9.7	0.0	1.2	147.4	1.8	26.2	44.4	12.3	3.9	3.2
8 IV-SOUTH	0.0	.2	.9	.8	0.0	3.1	2.6	103.1	36.5	3.6	.3	.1	.5
9 IV-NORTH	0.0	.4	2.9	.4	0.0	1.3	22.9	4.9	85.2	19.7	2.7	.8	1.0
10 III	0.0	0.0	1.8	0.0	0.0	0.0	11.5	.2	5.9	134.9	23.9	7.9	1.1
11 II	0.0	0.0	4.1	0.0	0.0	0.0	0.0	.0	.1	1.7	19.8	7.6	1.4
12 I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	5.2	16.6	1.2
13 S. QUEBEC	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.2	1.9	16.3
TOTAL (KTON S)	1.0	83.8	126.9	50.9	.1	49.1	217.8	112.8	155.5	212.3	75.6	44.1	40.7

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	88.7	.1	.0	.2	.4	.0	.0	0.0	.0	.0	.0	.0	.0
2 V-NORTH	1.2	71.5	23.3	3.1	0.0	.2	6.8	.1	.4	1.9	5.9	3.2	8.6
3 S. ONTARIO	.0	3.5	51.6	0.0	0.0	0.0	1.0	.0	.1	1.7	8.5	8.2	30.3
4 VII	2.0	5.2	1.0	66.3	.0	2.2	7.2	.1	.4	.2	.4	.4	.5
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	8.1	.4	.1	8.8	99.6	86.1	.4	2.1	.2	.0	.0	.0	.1
7 V-SOUTH	0.0	18.7	12.0	19.1	0.0	2.5	67.7	1.6	16.8	20.9	16.3	8.8	7.8
8 IV-SOUTH	0.0	.2	.7	1.6	0.0	6.4	1.2	91.5	23.5	1.7	.4	.3	1.3
9 IV-NORTH	0.0	.5	2.3	.8	0.0	2.6	10.5	4.3	54.8	9.3	3.6	1.9	2.4
10 III	0.0	0.0	1.4	0.0	0.0	0.0	5.3	.1	3.8	63.5	31.7	17.9	2.7
11 II	0.0	0.0	3.2	0.0	0.0	0.0	0.0	.0	.0	.8	26.1	17.3	3.4
12 I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	6.9	37.7	2.9
13 S. QUEBEC	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.2	4.3	40.1

TABLE 7 (CONCLUDED)

(d) OCTOBER 1977

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.8	.1	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	1.0	55.2	21.4	5.5	.0	.6	21.1	1.0	3.8	7.2	3.1	1.0	1.1
3 S. ONTARIO	.1	8.2	69.4	.5	.0	.2	6.5	.5	1.5	7.7	6.0	2.0	4.6
4 VII	.1	3.3	.5	31.5	.0	2.3	9.4	2.2	2.7	1.1	.3	.0	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.1	.1	.0	3.4	.0	30.9	.6	2.5	.8	.0	.0	.0	.0
7 V-SOUTH	.5	18.5	13.0	15.4	.0	2.5	123.2	8.8	41.2	35.9	6.8	.9	1.9
8 IV-SOUTH	0.0	.4	.2	1.4	0.0	5.5	3.7	70.7	17.6	.8	.0	.0	.1
9 IV-NORTH	.0	2.7	1.9	2.2	.0	1.8	18.8	14.2	73.3	9.6	.8	.1	.5
10 III	.1	3.3	9.7	1.0	.0	.4	22.4	4.4	20.3	105.4	12.7	1.8	2.9
11 II	.0	.3	5.3	.1	.0	.0	.5	.2	1.1	5.8	17.1	4.4	1.1
12 I	0.0	.0	.2	.0	0.0	.0	.2	.1	.8	2.5	9.5	19.0	1.9
13 S. QUEBEC	.0	.2	11.2	.1	0.0	.0	.1	.0	.1	.6	1.4	2.9	14.4
TOTAL (KTON S)	2.9	92.2	133.0	61.3	.0	44.2	206.6	104.7	163.2	176.5	57.8	32.1	28.5

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	27.7	.1	.0	.2	1.5	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	34.8	59.8	16.1	9.0	9.0	1.3	10.2	1.0	2.3	4.1	5.4	3.1	3.7
3 S. ONTARIO	5.2	8.9	52.2	.9	4.5	.4	3.1	.5	.9	4.4	10.4	6.2	16.2
4 VII	4.0	3.6	.4	51.5	3.9	5.3	4.6	2.1	1.6	.6	.6	.1	.3
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	3.0	.1	.0	5.5	54.6	69.8	.3	2.4	.5	.0	.0	.0	.0
7 V-SOUTH	18.3	20.0	9.8	25.1	22.3	5.7	59.6	8.4	25.3	20.3	11.7	2.9	6.5
8 IV-SOUTH	0.0	.4	.2	2.3	0.0	12.4	1.8	67.5	10.8	.5	.0	.0	.2
9 IV-NORTH	.9	2.9	1.4	3.6	3.7	4.1	9.1	13.6	44.9	5.4	1.4	.5	1.7
10 III	4.5	3.5	7.3	1.7	.5	.8	10.9	4.2	12.5	59.7	21.9	5.6	10.2
11 II	1.4	.4	4.0	.1	.0	.1	.2	.2	.7	3.3	29.6	13.7	3.8
12 I	0.0	.0	.2	.0	0.0	.0	.1	.1	.5	1.4	16.5	59.1	6.8
13 S. QUEBEC	.2	.2	8.4	.1	0.0	.1	.1	.0	.0	.3	2.4	8.9	50.4

Region VIII-North produced 96 percent of the sulfur deposited within its area in January 1977, but only 28 percent in October 1977. This reflects the importance of the prevailing winds during these months.

The interregional exchange tables (6 and 7) may also be used to determine the exchanges between combined regions, such as between the Canadian regions (regions listed as numbers 3 and 13) and the U.S. regions. For example, Table 6 shows that 1921 ktons of sulfur were deposited over the Canadian regions (1514 ktons over S. Ontario and 407 ktons over S. Quebec). The Canadian provinces themselves contributed 1216 ktons or 63 percent of this sulfur pollution, while the United States contributed 705 ktons or 37 percent.

The results for the interregional exchanges of SO_2 and $SO_4^=$ wet and dry depositions are given in Appendix B.

SECTION 5

RESULTS OF MODEL APPLICATIONS USING THE 1985 EMISSIONS SCENARIO

The ENAMAP-1 model was also applied using the projected emissions for 1985 shown previously in Figure 6. In this application, the weather data for 1977 were assumed to be representative of those in 1985. This assumption permited us to make a more direct evaluation of the impact of the projected 1985 emission data. The 1985 annual results for the SO_2 and $SO_4^=$ concentration calculations are shown in Figure 19 (the seasonal results are included in Appendix C). The differences in the annual results for 1985 (Figure 19) and those for 1977 (Figure 15) primarily reflect the projected changes in sulfur emissions from 1977 to 1985. In general, the 1985 patterns are similar to those for 1977, however the values are smaller, consistent with the emission fields shown in Figures 5 and 6. The maximum SO_2 concentration value over the Pittsburgh area in 1977 was 71 $\mu g/m^3$, whereas in 1985 it is projected to be reduced significantly to 33 $\mu g/m^3$. The maximum value over the Mobile, Alabama, area is projected to be reduced in 1985 to 6 $\mu g/m^3$, from a value of 28 $\mu g/m^3$ in 1977. However, over the St. Louis area, a slight increase has been projected for SO_2 concentrations, from 25 $\mu g/m^3$ in 1977 to 28 $\mu g/m^3$ in 1985. The calculated $SO_4^=$ concentration field for 1977 portrays a large area whose values exceed 8 $\mu g/m^3$ over the central eastern United States; whereas the projections for 1985 do not exceed this value anywhere in the model domain.

The 1985 annual results for the SO_2 and $SO_4^=$ dry and wet depositions are shown in Figures 20 and 21 (the seasonal results are included in Appendix C). These results may be compared with those calculated for 1977, which were given in Figures 17 and 18. The deposition values, like concentrations, are generally projected to be smaller in 1985 than in 1977, consistent with the emission data. For example, the maximum $SO_4^=$ dry deposition near Pittsburgh is projected to be 640 mg/m^2 in 1985 (Figure 21), whereas in 1977 it was 1250 mg/m^2 (Figure 18). However, it can be seen from these deposition figures that the 1985 sulfur pollution over the western part of the domain is projected to be greater than in 1977 due to an increase in the emission rate within these regions.

The projected annual and seasonal sulfur (S) interregional exchanges are given in Tables 8 and 9. The significance of the projected 1985 emissions can perhaps best be seen by comparing the annual percentage contributions listed in Table 8 with those given for 1977 (Table 6). For example, from Table 6 and 8 we find that:

- The small VIII-South region (eastern Colorado) during 1977 received about 92 percent of its sulfur from its southeastern neighbor Region VI-East. In 1985, VIII-South is projected to receive only about 37 percent from Region VI-East, while contributing 54 percent to itself since its own emissions are projected to be significantly higher.
- Region VIII-North (North and South Dakota) during 1977 received 19 percent of its sulfur from Region V-North to its east, and 3 percent from Region VII to its southeast. In 1985, it is projected that it will receive only 7 percent from V-North and as much as 14 percent from VII.

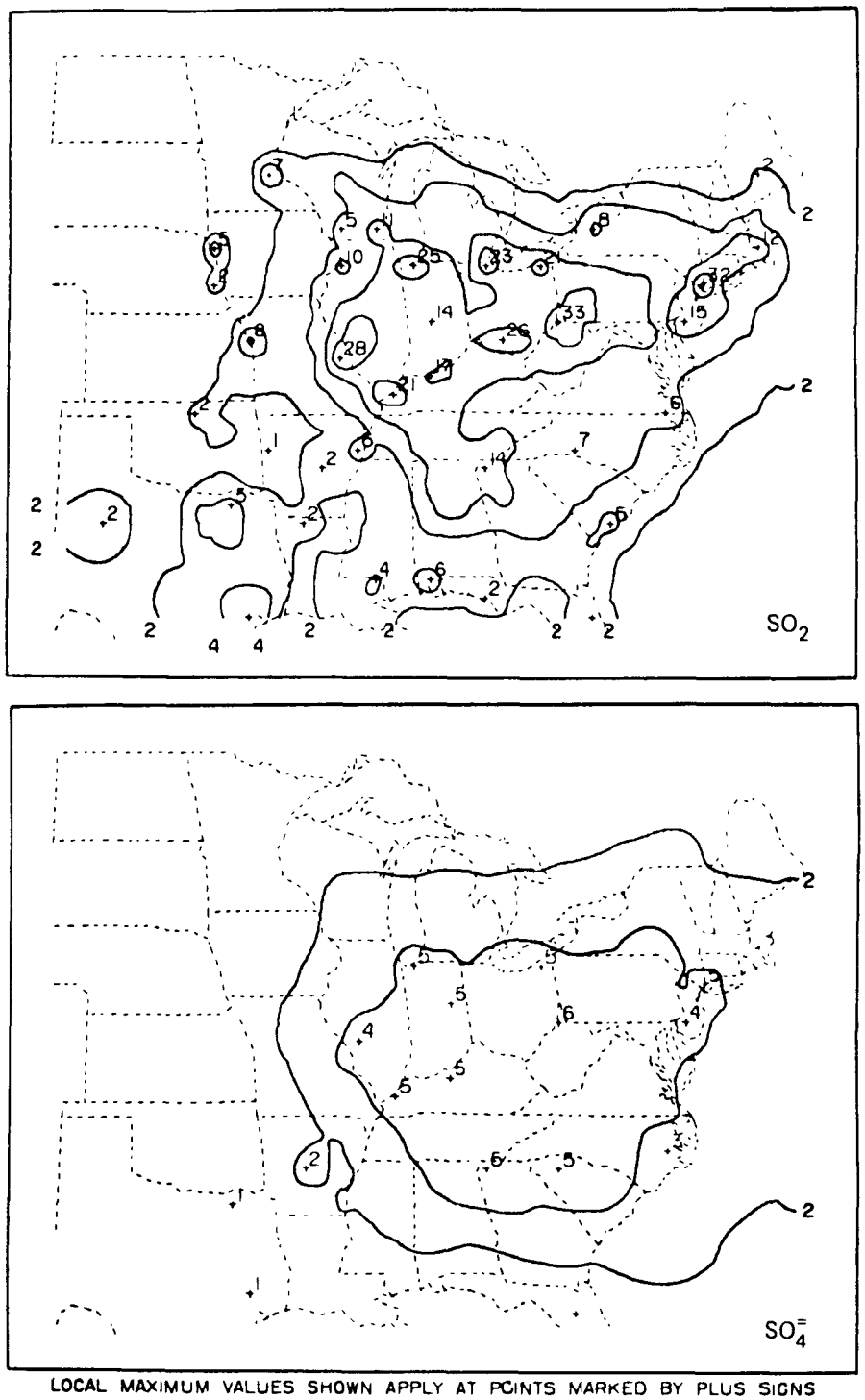
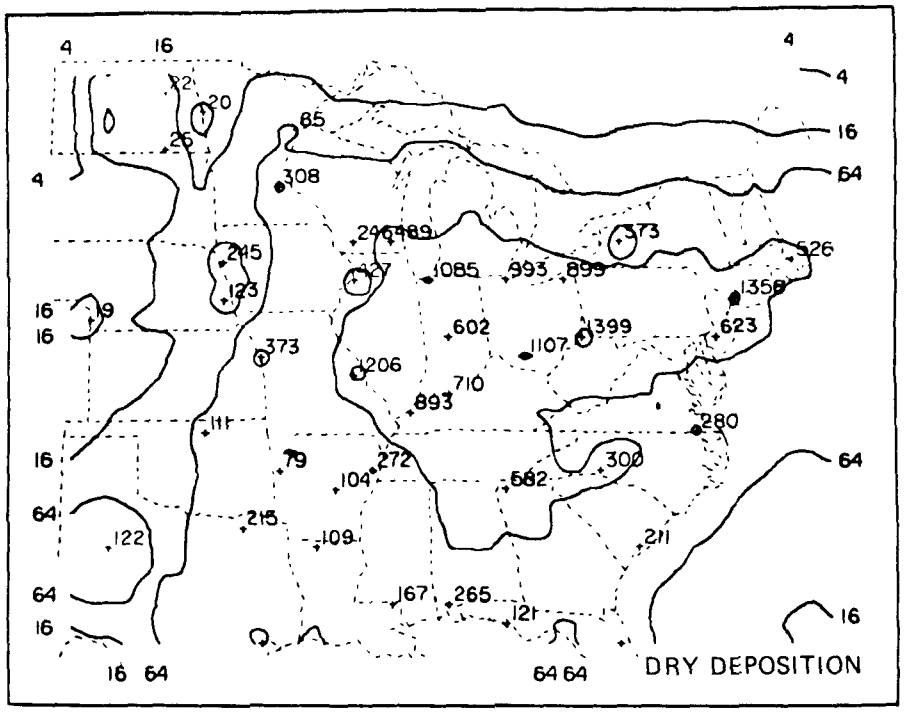
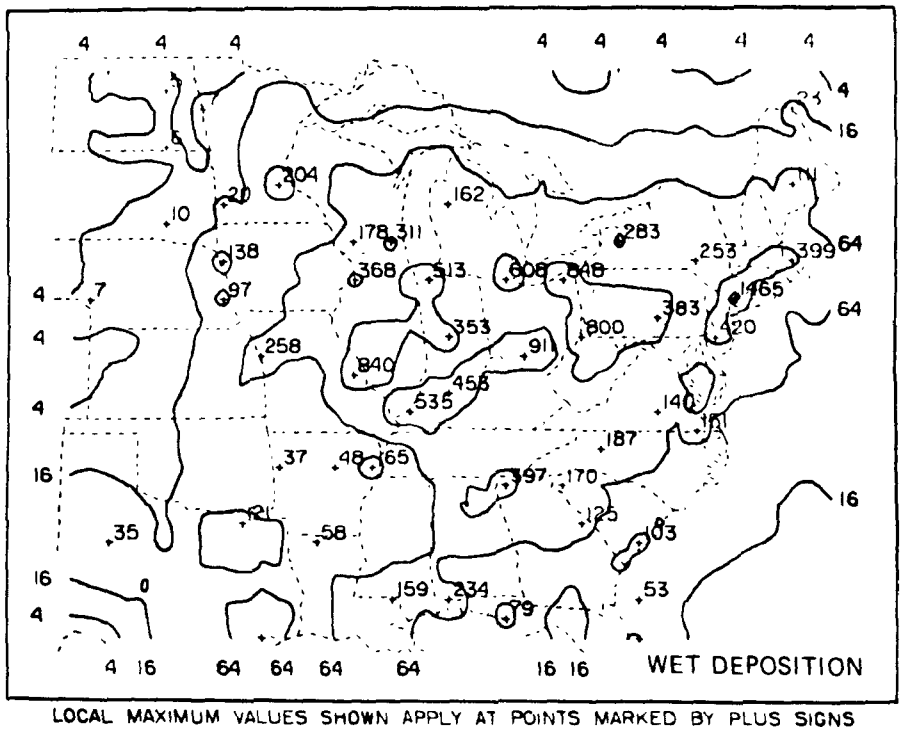


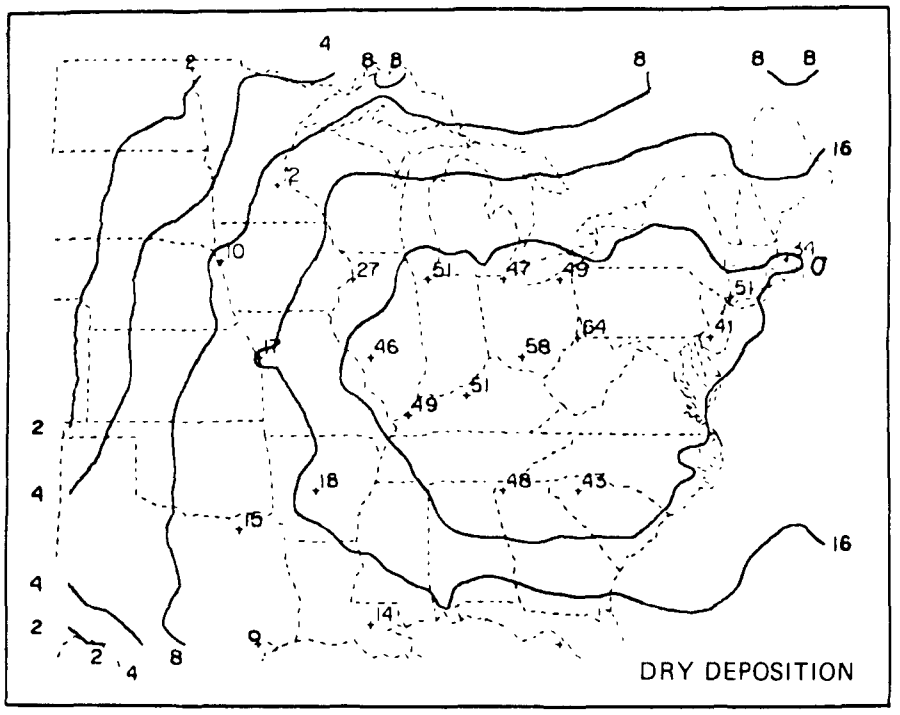
Figure 19. Calculated annual SO_2 and $SO_4^=$ concentrations ($\mu g/m^3$) for 1985.

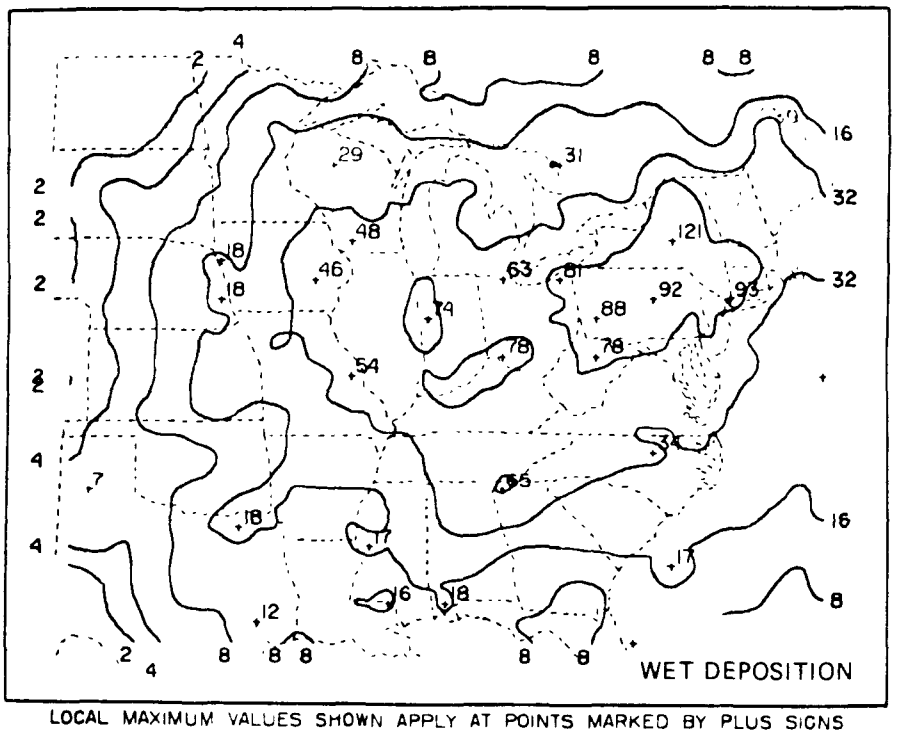




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

Figure 20. Calculated annual dry and wet depositions of SO_2 (10 mg/m^2) for 1985.





LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

Figure 21. Calculated annual dry and wet depositions of $SO_4^=$ (10 mg/m^2) for 1985.

TABLE 8 CALCULATED ANNUAL INTERREGIONAL EXCHANGES OF SULFUR DEPOSITION FOR 1985

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	28.	5.		8.	0.	1.	1.	0.	0.	0.	0.	0.	
2 V-NORTH	3.	399.		27.	0.	2.	114.	3.	13.	38.	26.	10.	
*3 S. ONTARIO													
4 VII	6.	52.		392.	0.	38.	173.	22.	45.	14.	4.	2.	
5 VIII-SOUTH	0.	0.		3.	3.	1.	0.	0.	0.	0.	0.	0.	
6 VI-EAST	3.	0.		84.	2.	639.	13.	39.	9.	1.	0.	0.	
7 V-SOUTH	1.	134.		80.	0.	9.	990.	33.	232.	296.	56.	18.	
8 IV-SOUTH	0.	5.		7.	0.	22.	19.	496.	124.	11.	1.	1.	
9 IV-NORTH	0.	9.		28.	0.	15.	112.	86.	546.	82.	6.	3.	
10 III	0.	4.		1.	0.	0.	36.	5.	44.	551.	120.	32.	
11 II	0.	1.		0.	0.	0.	1.	0.	3.	28.	217.	67.	
12 I	0.	0.	.	0.	0.	0.	0.	0.	1.	3.	8.	144.	
*13 S. QUEBEC													
TOTAL (KTON S)	41.	617.		629.	6.	727.	1459.	684.	1018.	1025.	437.	278.	

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	68.	1.		1.	4.	0.	0.	0.	0.	0.	0.	0.	
2 V-NORTH	7.	65.		4.	0.	0.	8.	0.	1.	4.	6.	4.	
*3 S. ONTARIO													
4 VII	14.	9.		62.	5.	5.	12.	3.	4.	1.	1.	1.	
5 VIII-SOUTH	1.	0.		1.	54.	0.	0.	0.	0.	0.	0.	0.	
6 VI-EAST	7.	1.		13.	37.	88.	1.	6.	1.	0.	0.	0.	
7 V-SOUTH	2.	22.		13.	0.	1.	68.	5.	23.	29.	13.	6.	
8 IV-SOUTH	0.	1.		1.	0.	3.	1.	72.	12.	1.	0.	0.	
9 IV-NORTH	0.	1.		4.	0.	2.	8.	13.	54.	8.	1.	1.	
10 III	1.	1.		0.	0.	0.	2.	1.	4.	54.	27.	12.	
11 II	0.	0.		0.	0.	0.	0.	0.	0.	3.	50.	24.	
12 I	0.	0.		0.	0.	0.	0.	0.	0.	0.	2.	52.	
*13 S. QUEBEC													

*No 1985 projected emissions were available from these regions.

TABLE 9. CALCULATED SEASONAL INTERREGIONAL EXCHANGES OF SULFUR DEPOSITION FOR 1985

(a) JANUARY 1985

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	1.8	.4		.9	.0	.2	.1	.1	.1	.0	.0	.0	
2 V-NORTH	.0	26.1		2.2	0.0	.1	10.3	.2	.9	4.7	3.3	1.1	
*3 S. ONTARIO													
4 VII	.1	1.5		27.8	.0	4.6	12.6	3.5	7.6	1.7	.3	.3	
5 VIII-SOUTH	.0	.0		.3	.2	.2	.0	.0	.0	.0	.0	.0	
6 VI-EAST	.0	.1		2.2	.0	51.6	.2	4.2	.5	.1	.0	.0	
7 V-SOUTH	0.0	3.6		4.8	0.0	.2	72.8	3.0	22.2	30.3	4.6	1.8	
8 IV-SOUTH	0.0	0.0		.0	0.0	1.3	.3	39.2	7.4	.4	.0	.0	
9 IV-NORTH	0.0	.0		1.3	0.0	.9	5.5	8.0	43.4	5.8	.3	.3	
10 III	0.0	.0		0.0	0.0	0.0	2.1	.0	2.2	39.0	7.9	2.5	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	0.0	1.2	14.0	4.7	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.4	10.4	
*13 S. QUEBEC													
TOTAL (KTON S)	2.0	31.6		39.4	.3	59.0	104.0	58.3	84.2	83.2	30.7	21.1	

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	92.2	1.2		2.4	1.4	.3	.1	.1	.1	.1	.0	.1	
2 V-NORTH	2.0	82.7		5.5	0.0	.1	9.9	.4	1.1	5.6	10.7	5.5	
*3 S. ONTARIO													
4 VII	5.1	4.6		70.5	3.8	7.9	12.1	6.0	9.0	2.0	.8	1.7	
5 VIII-SOUTH	.6	.0		.7	85.2	.3	.0	.0	.0	.0	.0	.0	
6 VI-EAST	.1	.2		5.6	9.7	87.4	.2	7.2	.5	.1	.0	.1	
7 V-SOUTH	0.0	11.3		12.1	0.0	.4	70.0	5.2	26.3	36.4	14.9	8.4	
8 IV-SOUTH	0.0	0.0		.1	0.0	2.2	.3	67.4	8.8	.5	.0	.0	
9 IV-NORTH	0.0	.0		3.3	0.0	1.5	5.2	13.7	51.5	7.0	.9	1.2	
10 III	0.0	.1		0.0	0.0	0.0	2.0	.0	2.7	46.9	25.8	11.8	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	0.0	1.4	45.5	22.1	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	1.3	49.3	
*13 S. QUEBEC													

*No 1985 projected emissions were available from these regions.

TABLE 9 (CONTINUED)

(b) AUGUST 1985

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	2.9	.5		.5	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.0	38.7		1.0	0.0	.1	6.9	.1	.4	2.0	2.4	.8	
*3 S. ONTARIO													
4 VII	.5	5.4		37.1	.0	1.7	19.2	.2	1.2	.4	.4	.3	
5 VIII-SOUTH	.0	.0		.3	.3	.0	.0	0.0	0.0	0.0	.0	.0	
6 VI-EAST	.2	.9		10.1	.3	59.8	1.8	2.2	.4	.1	.0	.0	
7 V-SOUTH	0.0	11.8		5.3	0.0	.7	97.0	1.0	13.7	25.2	7.1	2.6	
8 IV-SOUTH	.0	.1		.4	0.0	1.6	1.4	48.2	14.9	1.8	.1	.1	
9 IV-NORTH	0.0	.3		1.9	0.0	1.3	11.4	4.4	52.2	10.2	.8	.3	
10 III	0.0	0.0		0.0	0.0	0.0	1.8	.1	1.9	55.1	15.4	4.8	
11 II	0.0	0.0		0.0	0.0	0.0	.0	.0	.0	1.1	22.1	9.0	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.2	13.2	
*13 S. QUEBEC													
TOTAL (KTON S)	3.7	57.7		56.7	.7	65.0	139.4	56.1	84.8	96.0	48.5	31.1	

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	79.6	.9		.9	1.1	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	1.4	67.1		1.8	0.0	.1	4.9	.2	.5	2.1	4.9	2.6	
*3 S. ONTARIO													
4 VII	12.4	9.3		65.5	3.6	2.6	13.8	.3	1.4	.4	.8	.8	
5 VIII-SOUTH	1.3	.0		.6	47.0	.0	.0	0.0	0.0	0.0	.0	.0	
6 VI-EAST	5.4	1.6		17.8	48.3	91.9	1.3	3.9	.5	.1	.1	.1	
7 V-SOUTH	0.0	20.4		9.4	0.0	1.1	69.6	1.7	16.1	26.2	14.7	8.3	
8 IV-SOUTH	.0	.2		.6	0.0	2.4	1.0	86.0	17.6	1.9	.3	.2	
9 IV-NORTH	0.0	.5		3.3	0.0	1.9	8.2	7.9	61.6	10.7	1.7	1.1	
10 III	0.0	0.0		0.0	0.0	0.0	1.3	.1	2.3	57.4	31.8	15.4	
11 II	0.0	0.0		0.0	0.0	0.0	.0	.0	.0	1.2	45.5	28.9	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.3	42.5	
*13 S. QUEBEC													

*No 1985 projected emissions were available from these regions.

TABLE 9 (CONTINUED)

(c) APRIL 1985

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	2.3	.3		.6	.1	.1	.1	.0	.0	.0	.0	.0	
2 V-NORTH	.2	35.6		2.6	.0	.2	10.3	.2	1.1	2.6	1.4	.7	
*3 S. ONTARIO													
4 VII	.6	6.9		31.1	.0	2.6	12.6	1.1	3.0	1.3	.3	.2	
5 VIII-SOUTH	.0	.0		.2	.4	.0	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	.4	1.5		8.4	.4	48.2	1.1	3.6	1.2	.2	.1	.1	
7 V-SOUTH	0.0	16.5		6.5	0.0	.6	81.1	1.9	17.8	22.0	2.5	1.1	
8 IV-SOUTH	.0	1.2		1.3	0.0	1.8	2.1	38.1	10.6	1.2	.1	.1	
9 IV-NORTH	0.0	1.6		2.9	0.0	1.0	10.7	4.6	43.4	6.4	.4	.5	
10 III	.0	.1		.0	0.0	.0	2.5	.0	3.9	45.2	7.7	2.1	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	.0	2.2	16.6	4.3	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.5	10.8	
*13 S. QUEBEC													
TOTAL (KTON S)	3.7	63.7		53.6	.8	54.6	120.5	49.6	81.0	81.2	29.5	19.8	

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	63.7	.4		1.1	6.6	.2	.0	.1	.0	.0	.0	.0	
2 V-NORTH	4.6	55.8		4.8	.1	.3	8.6	.4	1.3	3.2	4.9	3.7	
*3 S. ONTARIO													
4 VII	17.6	10.8		58.1	4.2	4.8	10.5	2.2	3.7	1.6	.9	.8	
5 VIII-SOUTH	1.1	.0		.4	42.8	.1	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	12.0	2.4		15.6	46.3	88.3	.9	7.3	1.5	.3	.3	.4	
7 V-SOUTH	0.0	25.8		12.1	0.0	1.1	67.3	3.8	22.0	27.1	8.5	5.3	
8 IV-SOUTH	.8	1.9		2.4	0.0	3.3	1.7	76.9	13.0	1.5	.2	.6	
9 IV-NORTH	0.0	2.5		5.3	0.0	1.9	8.9	9.4	53.5	7.8	1.4	2.3	
10 III	.1	.2		.0	0.0	.0	2.0	.1	4.8	55.7	26.1	10.5	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	.0	2.8	56.2	21.8	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	1.6	54.5	
*13 S. QUEBEC													

*No 1985 projected emissions were available from these regions.

TABLE 9 (CONCLUDED)

(d) OCTOBER 1985

TOTAL CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS (kilotons)

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	2.2	.4		.5	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.7	32.6		3.3	.0	.4	10.6	.5	2.0	3.4	1.7	.6	
*3 S. ONTARIO													
4 VII	.7	3.8		34.5	.0	3.7	13.1	2.5	3.3	1.4	.4	.0	
5 VIII-SOUTH	.0	.0		.3	.2	.1	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	.3	.2		7.2	.0	53.4	1.1	3.0	1.0	.1	.0	.0	
7 V-SOUTH	.3	12.9		10.0	.0	1.5	79.2	5.3	23.6	21.3	4.4	.6	
8 IV-SOUTH	0.0	.3		.6	0.0	2.7	2.4	39.6	8.6	.4	.0	.0	
9 IV-NORTH	.0	1.1		3.2	.0	1.7	9.9	11.7	43.1	4.8	.3	.1	
10 III	.1	1.3		.4	.0	.1	5.6	1.5	6.6	44.2	8.9	1.4	
11 II	.0	.2		.1	.0	.0	.4	.1	1.0	4.8	19.7	4.5	
12 I	0.0	.0		.0	0.0	.0	.1	.1	.3	.9	1.6	13.5	
*13 S. QUEBEC													
TOTAL (KTON S)	4.4	52.8		60.1	.3	63.8	122.5	64.2	89.4	81.4	36.9	20.6	

PERCENT CONTRIBUTIONS TO S DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	50.3	.8		.8	3.5	.1	.0	.0	.0	.0	.0	.0	
2 V-NORTH	15.4	61.7		5.4	1.3	.7	8.7	.8	2.2	4.2	4.5	2.7	
*3 S. ONTARIO													
4 VII	16.3	7.1		57.5	12.4	5.9	10.7	3.8	3.7	1.7	1.2	.1	
5 VIII-SOUTH	.8	.0		.5	72.5	.1	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	6.9	.4		12.0	9.3	83.8	.9	4.6	1.1	.1	.0	.0	
7 V-SOUTH	7.4	24.5		16.6	.7	2.4	64.6	8.2	26.4	26.2	11.8	3.0	
8 IV-SOUTH	0.0	.5		1.1	0.0	4.2	2.0	61.7	9.6	.5	.0	.0	
9 IV-NORTH	.3	2.2		5.3	.2	2.7	8.1	18.2	48.2	5.9	.8	.3	
10 III	1.6	2.4		.7	.0	.2	4.6	2.3	7.4	54.3	24.0	6.7	
11 II	1.0	.4		.1	.0	.0	.3	.2	1.1	5.9	53.3	21.8	
12 I	0.0	.0		.0	0.0	.0	.1	.1	.3	1.2	4.2	65.4	
*13 S. QUEBEC													

*No 1985 projected emissions were available from these regions.

- Region VII contributed 137 ktons or 6 percent of the sulfur deposited in Region V-South to its east during 1977. In 1985, its contribution is projected to increase to 173 ktons or 12 percent. (Contributions from most of the other regions are projected to decrease.)

When comparing the tables for 1985 and 1977, particularly the percentage contribution results, it should be noted that both Tables 8 and 9 and the tables of Appendix D do not include any values for the Ontario or Quebec regions. This is because no projected 1985 emissions are available for these regions.

SECTION 6

SUMMARY AND CONCLUDING REMARKS

In this study, the SRI/EURMAP-1 model was adapted for use over eastern North America. The modified version, called ENAMAP-1, was applied to calculate sulfur concentrations, depositions, and exchanges for January, April, August, and October of 1977, as well as average values for the year. The results from this application included:

- Graphical displays of the distribution of SO_2 and $SO_4^=$ concentrations.
- Graphical displays of the distributions SO_2 and $SO_4^=$ wet and dry depositions.
- Tabulated results showing the interregional exchanges of sulfur pollution.

The ENAMAP-1 model calculations were based on SURE emissions data supplemented with NEDS emissions data. The calculations of SO_2 and $SO_4^=$ concentrations were evaluated by comparing them with measured values taken from both the SURE and SAROAD data bases. The calculated values showed reasonably good correspondence with the measured data. General differences between the two, particularly with regard to seasonal and latitudinal variations, appear to be caused by the mixing-height values used in the model and an imperfect simulation of stability and convection. This may be largely resolvable, either by the use of more representative mixing heights (e.g., those provided by Holzworth, 1972) or by the incorporation of various refinements currently being used in our short-term EURMAP-2 model. Further research on this question is required.

The ENAMAP-1 model was also used to calculate projected air pollution results for the year 1985. These results largely show a reduction in the sulfur air pollution, particularly at hot-spot areas. Although these types of results are highly dependent on the validity of the emissions projection used, they do illustrate the usefulness of the model for studying the impacts of various scenarios.

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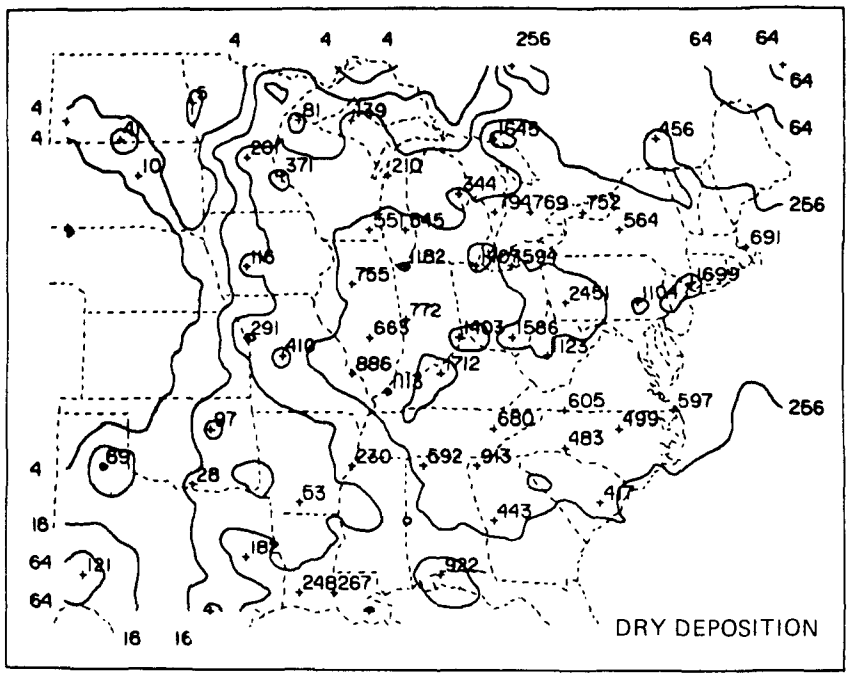
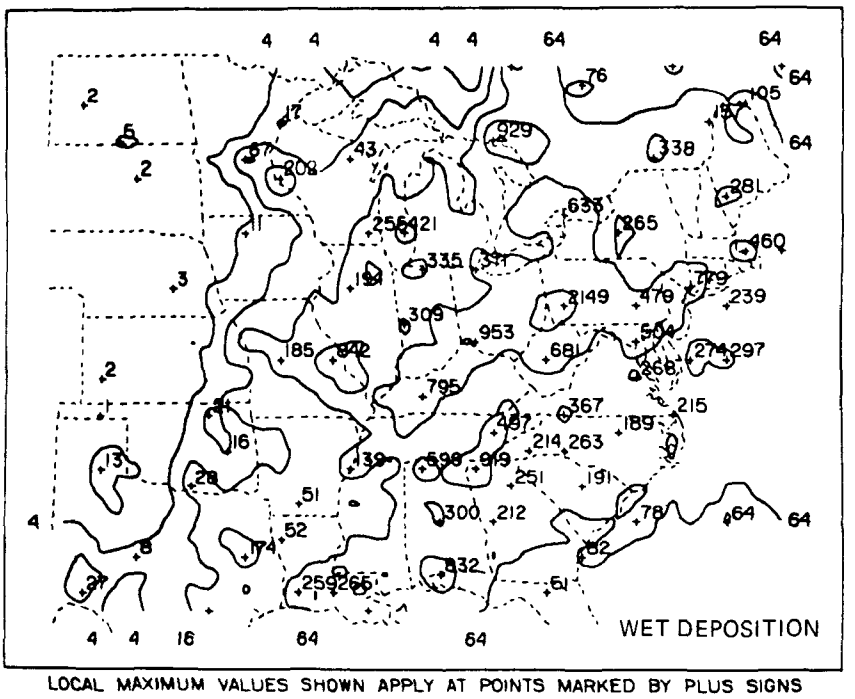
Appendix A

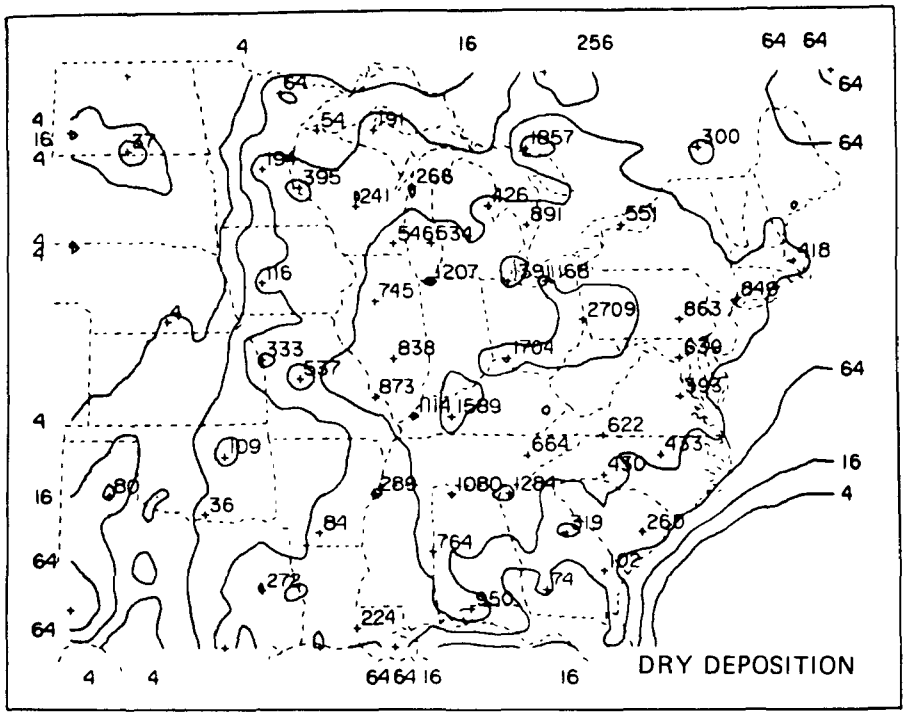
1977 CALCULATED SEASONAL RESULTS FOR SO_2 AND $SO_4^=$ DRY AND WET DEPOSITIONS (mg/m^2)

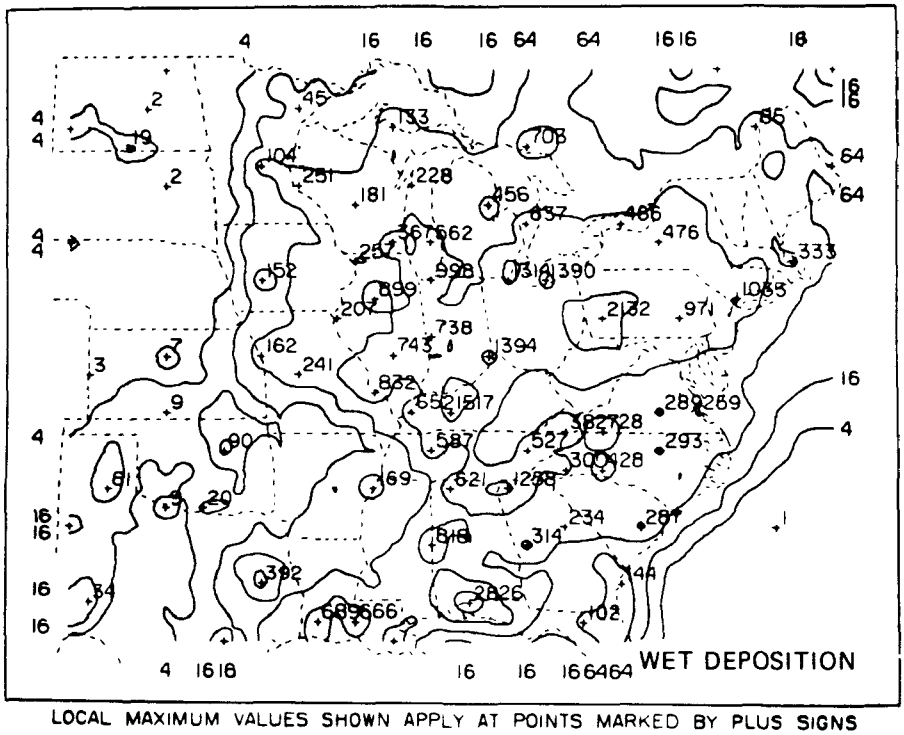




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

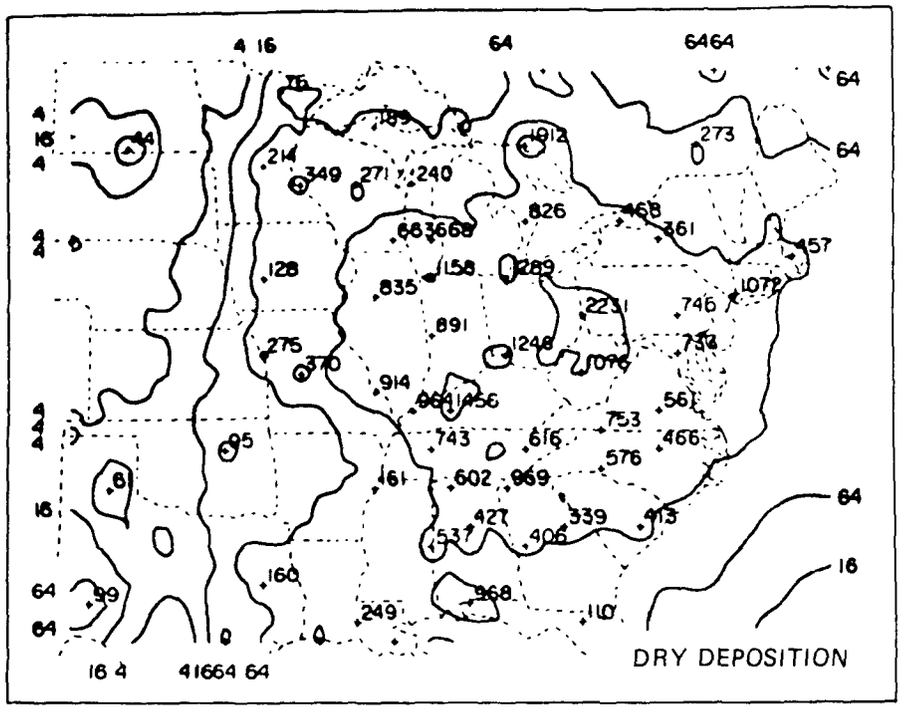
SO_2 (mg/m^2) — JANUARY 1977

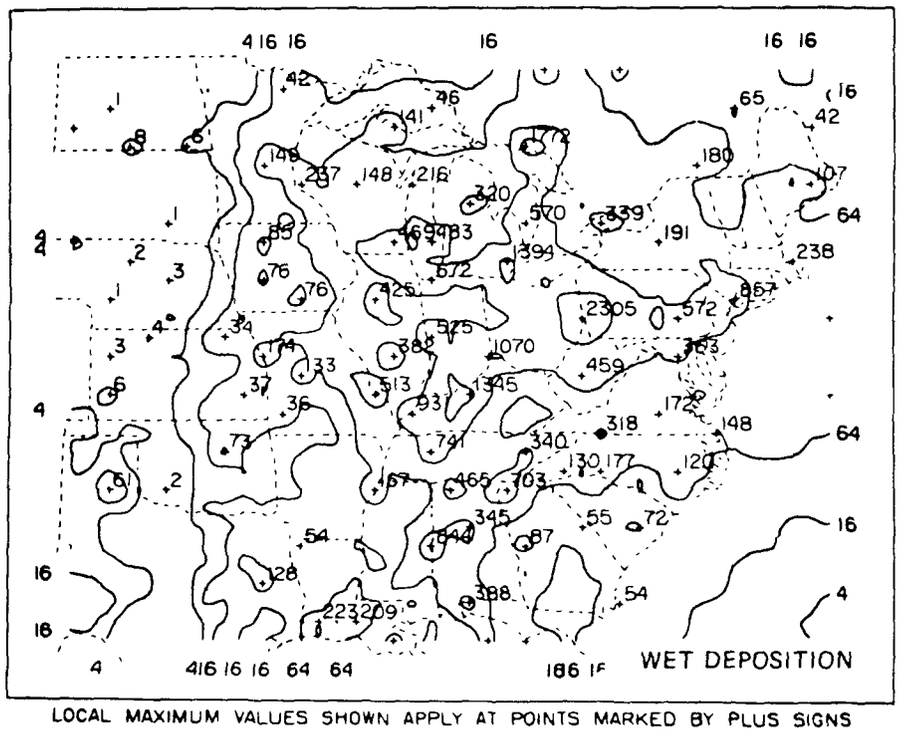




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

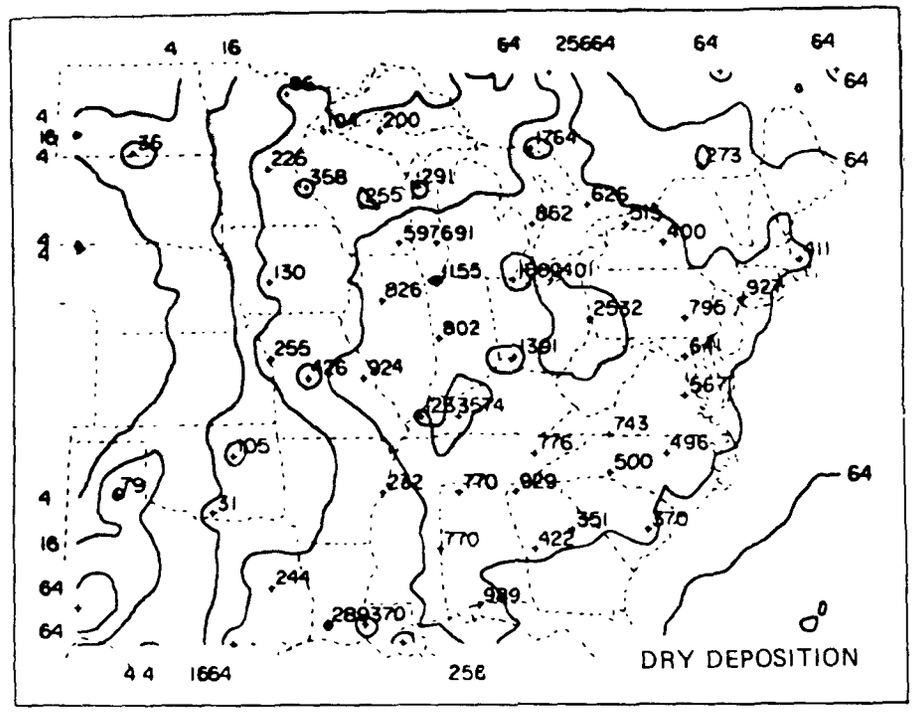
SO_2 (mg/m^2) — AUGUST 1977

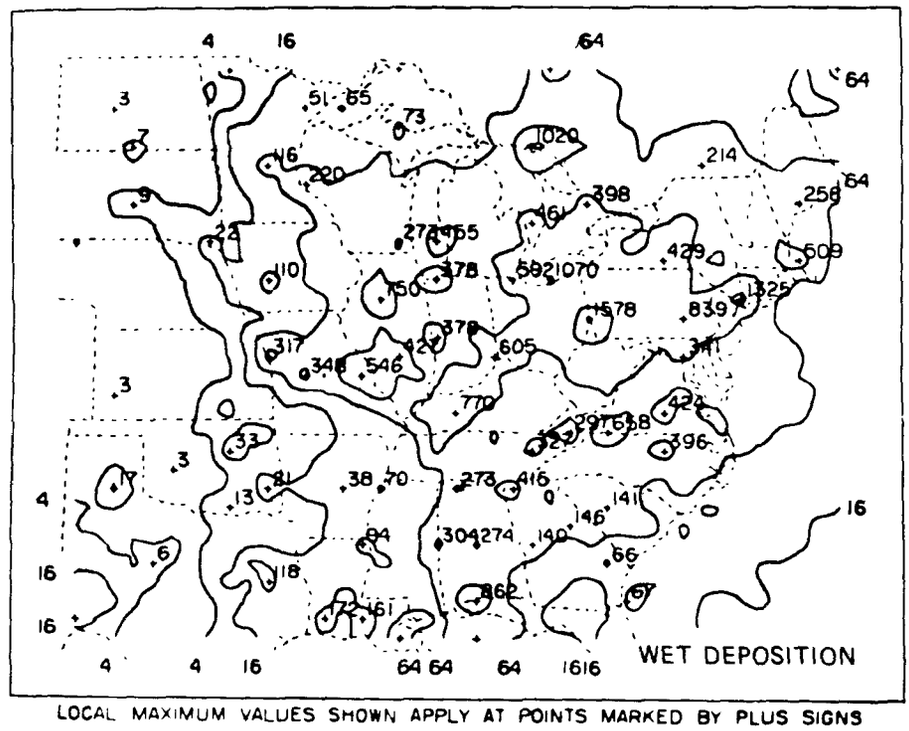




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

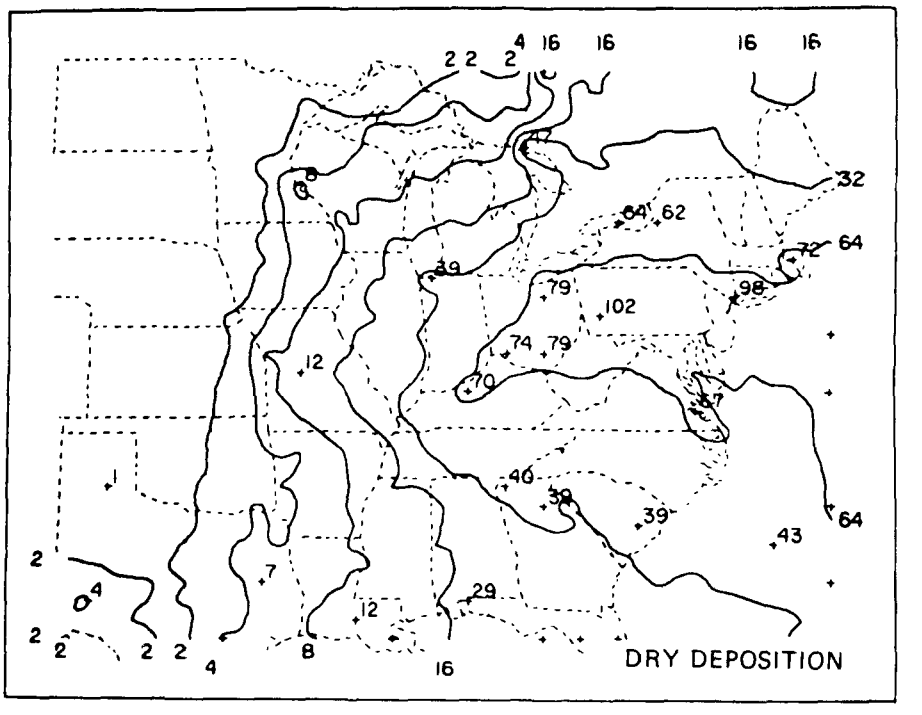
SO_2 (mg/m^2) — APRIL 1977

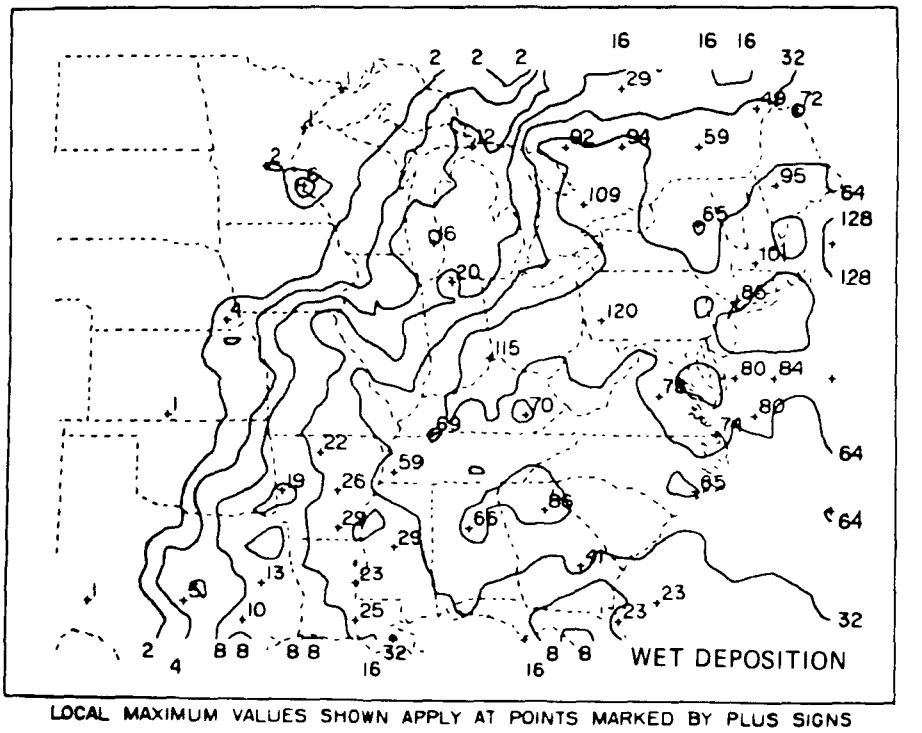




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

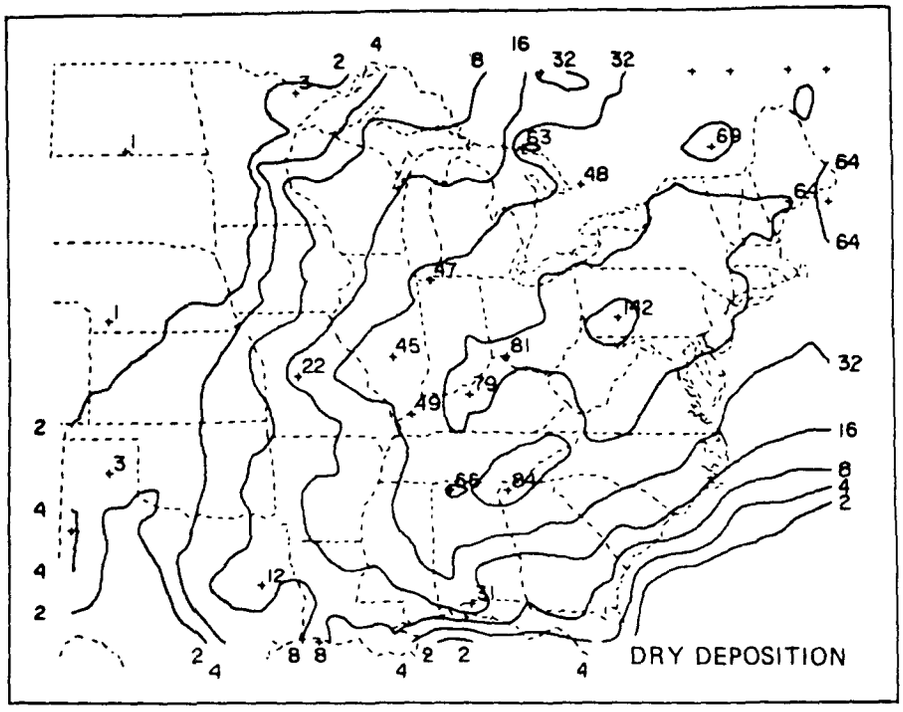
SO_2 (mg/m^2) — OCTOBER 1977

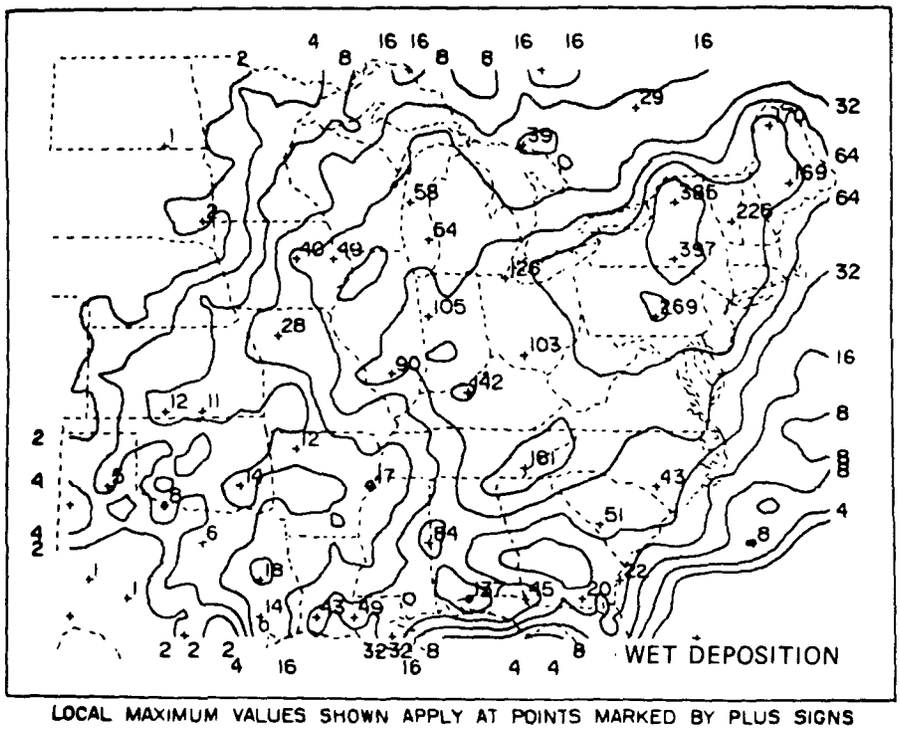




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

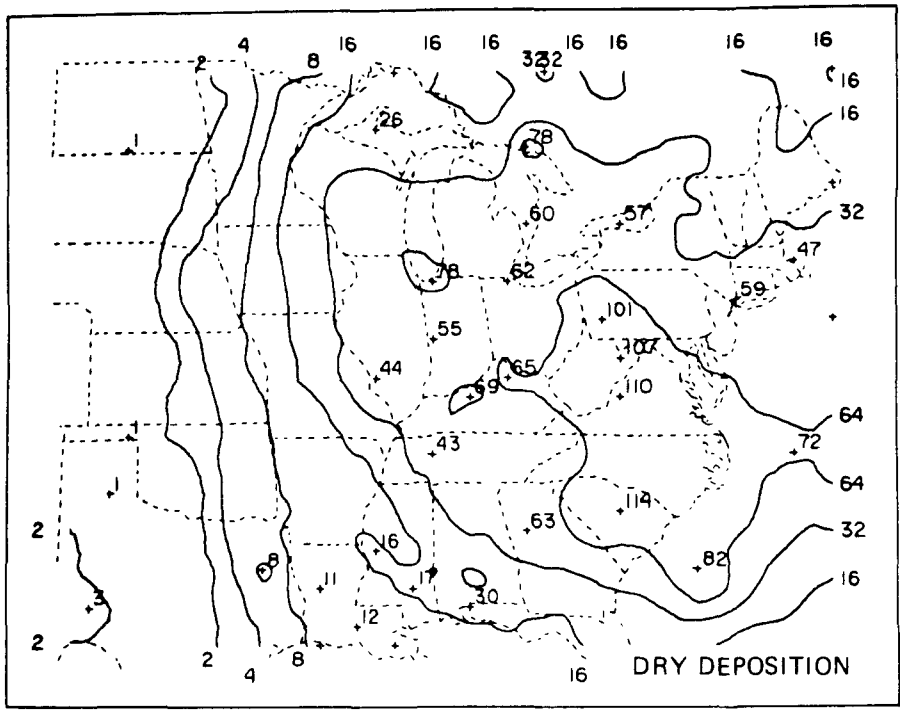
$SO_4^=$ (mg/m^2) — JANUARY 1977

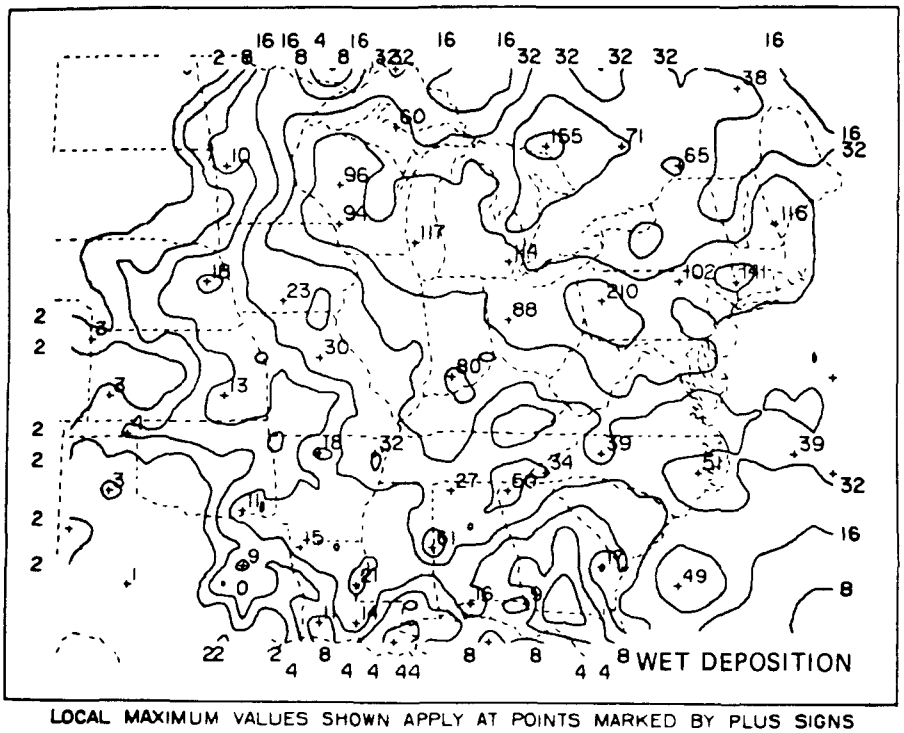




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

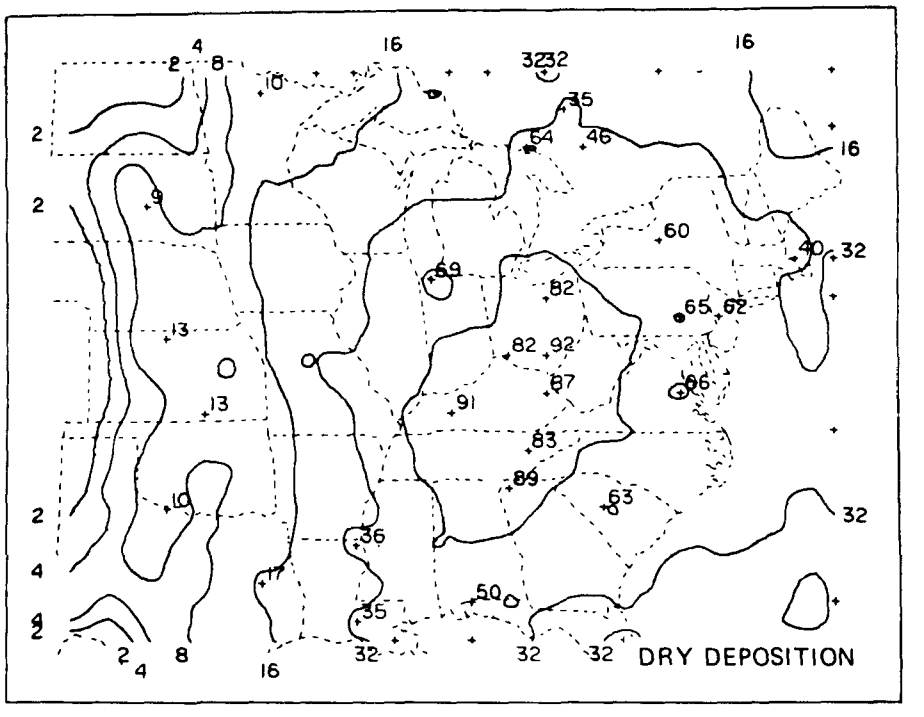
$SO_4^=$ (mg/m^2) — AUGUST 1977

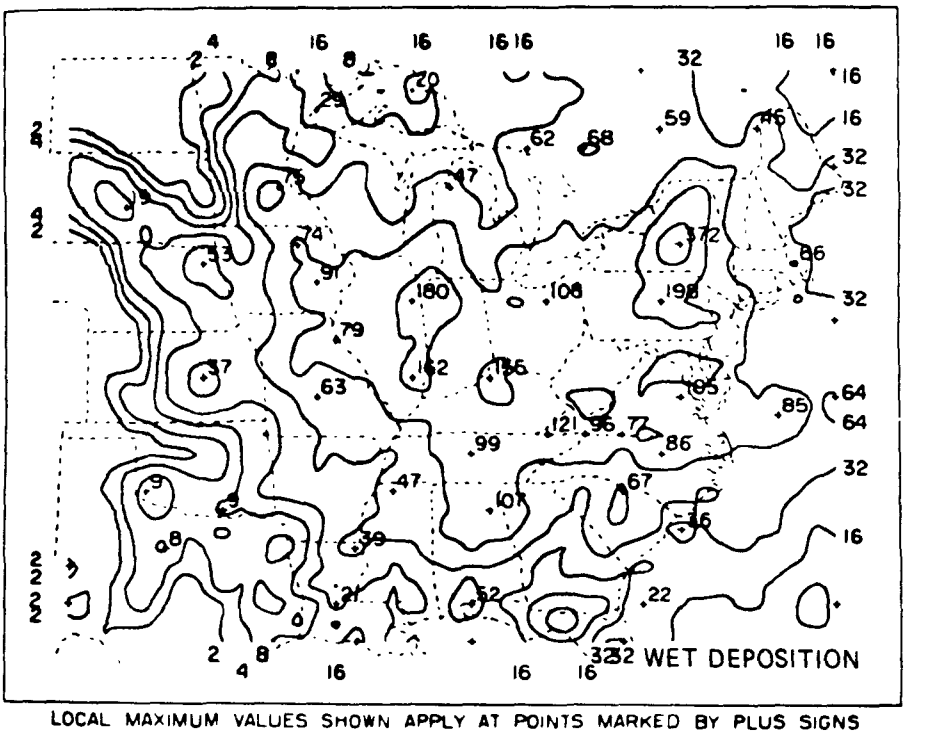




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

$SO_4^=$ (mg/m^2) — APRIL 1977





LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

$SO_4^{=}$ (mg/m^2) — OCTOBER 1977

Appendix B

1977 INTERREGIONAL EXCHANGE RESULTS

JANUARY 1977

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

	EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1	VIII-NORTH	1.3	.1	.0	.4	.0	.1	.0	.0	.0	.0	.0	.0	.0
2	V-NORTH	.0	68.6	30.7	6.3	0.0	.1	31.7	.5	2.1	13.7	8.6	2.9	1.6
3	S. ONTARIO	.0	4.6	86.8	0.0	0.0	0.0	3.9	0.0	.1	10.5	16.3	7.2	8.3
4	VII	.0	1.4	.4	39.5	.0	4.1	14.2	5.9	11.1	1.7	.2	.1	.1
5	VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	VI-EAST	.0	.0	.0	1.1	.0	34.5	.0	3.8	.2	.0	.0	.0	0.0
7	V-SOUTH	0.0	6.8	7.9	8.3	0.0	.1	164.2	8.0	61.5	75.2	8.8	2.7	1.1
8	IV-SOUTH	0.0	0.0	0.0	.0	0.0	1.6	.1	79.4	15.8	.4	.0	.0	0.0
9	IV-NORTH	0.0	.0	.3	.1	0.0	.7	12.8	16.8	103.4	15.8	.9	.4	.1
10	III	0.0	.0	1.3	0.0	0.0	0.0	12.2	.0	12.5	131.5	16.3	4.0	.5
11	II	0.0	.0	3.5	0.0	0.0	0.0	.0	0.0	0.0	2.1	19.8	6.3	.6
12	I	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0	0.0	.1	9.9	19.1	1.1
13	S. QUEBEC	0.0	.1	10.0	0.0	0.0	0.0	.0	0.0	0.0	.0	.8	8.1	26.0
	TOTAL (KTON SO2)	1.3	81.8	140.8	55.8	.0	41.2	239.2	114.4	206.8	251.0	81.5	50.8	39.4

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

	EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1	VIII-NORTH	.2	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	V-NORTH	.0	22.2	15.9	.7	0.0	.0	8.5	.0	.2	3.3	2.3	.7	.8
3	S. ONTARIO	0.0	1.6	48.9	0.0	0.0	0.0	1.7	0.0	.0	2.2	6.5	1.8	4.1
4	VII	.0	1.0	.3	17.1	0.0	1.6	5.3	.6	1.8	.5	.1	.1	.2
5	VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	VI-EAST	.0	.0	.0	.6	.0	20.6	.0	2.5	.1	.0	.0	.0	0.0
7	V-SOUTH	0.0	3.0	5.5	7.5	0.0	.2	69.4	1.1	15.3	23.6	4.4	2.2	1.7
8	IV-SOUTH	0.0	0.0	0.0	.0	0.0	1.7	.3	55.9	14.3	.6	.0	.0	0.0
9	IV-NORTH	0.0	.0	.2	.2	0.0	.5	10.8	3.7	47.4	8.1	.7	.6	.4
10	III	0.0	.1	1.6	0.0	0.0	0.0	11.5	.0	2.7	72.2	7.3	4.5	.7
11	II	0.0	.0	3.8	0.0	0.0	0.0	.0	0.0	0.0	1.4	10.3	3.3	.6
12	I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	.3	6.1	15.7	2.0
13	S. QUEBEC	0.0	.1	3.8	0.0	0.0	0.0	0.0	0.0	0.0	.0	.3	2.5	16.3
	TOTAL (KTON SO2)	.2	28.0	80.1	26.1	.0	24.8	107.6	63.9	81.8	112.2	38.0	31.5	26.7

AUG 1977

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

	EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1	VIII-NORTH	1.1	.0	.0	.1	.0	.0	.0	0.0	.0	.0	.0	.0	.0
2	V-NORTH	.0	67.9	31.6	2.1	0.0	.1	18.5	.1	.6	4.3	2.5	.5	3.3
3	S. ONTARIO	.0	3.3	85.1	0.0	0.0	0.0	2.9	.0	.1	5.2	6.7	3.1	15.3
4	VII	.0	3.0	.7	38.5	.0	1.4	13.3	.2	.6	.1	.0	.0	.0
5	VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	VI-EAST	.0	.2	.0	3.1	.1	40.1	.2	1.4	.1	.0	.0	.0	.0
7	V-SOUTH	0.0	14.6	12.0	10.5	0.0	1.5	161.4	2.0	29.3	43.5	6.9	1.4	2.0
8	IV-SOUTH	0.0	.1	.5	.6	0.0	3.2	2.5	97.7	35.9	1.3	.0	.0	.1
9	IV-NORTH	0.0	.5	2.4	.6	0.0	1.8	29.7	6.2	93.5	13.8	.8	.2	.7
10	III	0.0	0.0	1.7	0.0	0.0	0.0	11.6	.1	7.0	142.8	18.7	5.1	.7
11	II	0.0	0.0	4.2	0.0	0.0	0.0	0.0	.0	.0	1.9	19.6	7.1	1.4
12	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	4.6	17.2	1.2
13	S. QUEBEC	0.0	0.0	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.2	2.4	24.3
	TOTAL (KTON SO2)	1.2	89.6	146.8	55.5	.1	48.1	240.2	107.6	167.2	213.0	60.0	37.0	49.0

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

	EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1	VIII-NORTH	.6	.0	.0	.0	.0	.0	.0	0.0	.0	.0	.0	.0	.0
2	V-NORTH	.0	45.2	21.1	.9	0.0	.0	9.5	.0	.1	1.8	3.3	.4	.9
3	S. ONTARIO	.0	2.5	39.8	0.0	0.0	0.0	1.2	.0	.0	1.1	3.7	1.2	3.5
4	VII	.0	3.6	.7	25.0	.0	.3	13.0	.0	.3	.0	.0	.0	.0
5	VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	VI-EAST	.0	.1	.0	2.6	.1	37.6	.4	2.4	.1	.0	.0	.0	.0
7	V-SOUTH	0.0	12.7	11.7	7.6	0.0	.1	117.5	.4	17.9	31.7	8.8	.9	1.0
8	IV-SOUTH	0.0	.1	.5	.2	0.0	1.6	.9	93.0	23.6	1.7	.1	.0	.1
9	IV-NORTH	0.0	.2	2.0	.1	0.0	.4	12.7	1.9	66.2	14.8	1.5	.1	.2
10	III	0.0	0.0	1.6	0.0	0.0	0.0	11.2	.0	3.3	110.9	18.6	3.8	.5
11	II	0.0	0.0	3.7	0.0	0.0	0.0	0.0	.0	.0	1.3	18.0	5.9	.7
12	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	5.5	13.7	.8
13	S. QUEBEC	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.8	5.9
	TOTAL (KTON SO2)	.6	64.5	83.3	36.6	.1	40.0	166.4	97.8	111.5	163.4	59.4	27.0	13.7

APRIL 1977

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	1.4	.1	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.1	64.5	20.2	4.9	.0	.3	22.8	.4	2.1	6.0	3.0	1.1	.7
3 S. ONTARIO	.0	6.8	71.5	.0	0.0	.0	5.5	.0	.6	8.7	5.7	2.2	3.6
4 VII	.0	5.3	1.1	35.5	.0	2.3	12.8	1.4	3.4	1.1	.3	.2	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.1	.5	.1	4.0	.1	37.6	.5	3.2	.3	.0	.0	.0	.0
7 V-SOUTH	0.0	18.9	8.6	12.4	0.0	.3	152.8	5.1	43.1	52.6	3.5	1.1	.5
8 IV-SOUTH	.0	.4	.2	2.8	0.0	5.1	2.2	93.4	25.7	1.3	.1	.0	.0
9 IV-NORTH	.0	1.2	1.0	1.3	0.0	.6	18.1	7.8	91.9	11.8	.2	.0	.0
10 III	.0	.1	4.4	.0	0.0	.0	12.3	.2	18.7	129.8	10.2	2.1	.6
11 II	0.0	.0	4.5	0.0	0.0	0.0	.0	0.0	.0	4.1	18.6	5.2	1.0
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	.0	.5	7.7	16.8	1.5
13 S. QUEBEC	0.0	.2	13.4	0.0	0.0	0.0	.0	0.0	.0	.1	.9	4.0	16.0
TOTAL (KTON SO2)	1.6	98.0	125.1	61.2	.1	46.2	226.9	111.5	185.7	216.0	50.0	32.6	24.1

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.2	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	0.0	0.0
2 V-NORTH	.1	41.7	12.8	2.3	.0	.1	12.3	.0	.4	1.6	1.4	.4	.4
3 S ONTARIO	.0	6.3	54.2	.0	0.0	.0	2.8	.0	.1	1.5	1.4	.7	2.3
4 VII	.0	2.2	.4	16.5	.0	.7	5.3	.0	1.2	.4	.0	.0	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.0	.2	.1	2.1	.1	19.8	.3	1.9	.4	.0	.0	.0	.0
7 V SOUTH	0.0	16.4	8.6	8.1	0.0	.4	94.2	.1	14.2	16.6	2.1	.6	.4
8 IV-SOUTH	.0	.6	.3	.6	0.0	1.2	2.6	38.7	11.9	2.7	.1	.0	.0
9 IV-NORTH	.0	2.2	1.9	.2	0.0	.3	16.3	1.2	42.4	5.0	.2	.1	.0
10 III	.0	.4	4.9	.0	0.0	.0	13.4	.0	2.5	73.7	6.5	1.9	.9
11 II	0.0	.0	3.8	0.0	0.0	0.0	.0	0.0	.0	1.3	11.1	2.7	1.0
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0 0	.1	6.0	11.1	2 2
13 S. QUEBEC	0.0	.2	7.6	0.0	0.0	0.0	.0	0.0	.0	.0	.2	1.1	10 5
TOTAL (KTON SO2)	.4	70.2	94.9	29.8	.1	22.5	147.3	42.0	73.2	102.7	28.9	18.5	17.9

OCTOBER 1977

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

	EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1	VIII-NORTH	1.2	.1	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	0.0
2	V-NORTH	.9	75.8	25.3	6.9	.0	.5	31.7	.8	4.8	7.8	2.3	.7	.6
3	S. ONTARIO	.1	10.2	82.9	.3	.0	.1	8.6	.2	1.8	9.0	6.0	2.0	4.1
4	VII	.1	2.7	.3	38.2	.0	3.8	11.7	3.3	3.7	.6	.1	.0	.0
5	VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	VI-EAST	.0	.0	.0	2.3	.0	41.7	.1	2.1	.3	.0	.0	.0	.0
7	V-SOUTH	.1	18.7	12.5	16.8	.0	2.7	162.9	12.3	61.8	43.7	4.5	.6	.8
8	IV-SOUTH	0.0	.2	.1	.5	0.0	5.8	1.3	94.6	17.9	.1	.0	.0	.0
9	IV-NORTH	.0	2.3	1.3	1.2	0.0	2.3	19.7	23.0	100.7	9.7	.3	.1	.1
10	III	.0	2.3	8.0	.1	0.0	.0	25.8	4.4	28.0	126.7	11.5	1.8	1.5
11	II	.0	.3	4.9	.0	0.0	.0	.4	.1	.8	6.9	17.4	4.8	.7
12	I	0.0	.0	.0	.0	0.0	.0	.0	.0	.6	2.6	7.5	17.7	.9
13	S. QUEBEC	.0	.2	13.6	.0	0.0	.0	.1	.0	.0	.3	1.6	3.6	15.9
	TOTAL (KTON SO2)	2.5	112.9	149.0	66.5	.0	56.9	262.4	141.0	220.5	207.5	51.2	31.3	24.6

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

	EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1	VIII-NORTH	.3	.0	.0	.0	0.0	.0	.0	.0	.0	.0	.0	.0	0.0
2	V-NORTH	.5	28.5	12.5	1.8	0.0	.0	6.9	.0	.5	3.4	1.6	.3	.5
3	S. ONTARIO	.0	3.9	48.3	.0	0.0	.0	2.7	.0	.1	4.0	3.3	.7	3.1
4	VII	.0	2.4	.2	21.3	.0	.1	5.0	.3	.6	.4	.1	.0	.0
5	VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	VI-EAST	.0	.0	.0	1.8	.0	15.1	.2	2.2	.5	.0	.0	0.0	.0
7	V-SOUTH	.0	12.0	8.6	7.1	0.0	.1	70.3	.7	11.3	19.1	4.1	.3	.8
8	IV-SOUTH	0.0	.1	.0	.7	0.0	2.3	2.4	37.0	11.4	.9	.0	.0	.0
9	IV-NORTH	.0	1.5	1.0	.9	0.0	.1	13.1	1.7	35.6	6.0	.5	.0	.1
10	III	.0	2.2	7.7	.1	0.0	.0	13.2	.2	6.7	74.6	9.5	.7	1.5
11	II	.0	.1	4.9	.0	0.0	.0	.1	.0	.5	3.6	15.1	3.1	.8
12	I	0.0	.0	.2	0.0	0.0	0.0	.0	.0	.4	1.0	10.1	17.7	1.8
13	S. QUEBEC	.0	.0	7.4	.0	0.0	.0	.0	.0	.0	.4	.6	1.4	10.8
	TOTAL (KTON SO2)	.9	50.6	90.9	33.7	.0	17.7	114.1	42.3	67.8	113.4	45.0	24.3	19.4

JANUARY 1977

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.1	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.0	3.1	3.5	.6	0.0	.1	2.8	.3	.8	2.5	1.8	1.1	1.2
3 S. ONTARIO	.0	.3	4.7	0.0	0.0	0.0	.4	0.0	.0	1.0	2.0	1.9	2.5
4 VII	.0	.3	.3	1.7	.0	.7	1.8	1.5	1.8	.6	.2	.2	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.0	.0	.0	.4	.0	2.6	.1	.7	.1	.0	.0	.0	.0
7 V-SOUTH	0.0	.6	1.9	.6	0.0	.1	8.1	1.7	6.4	8.6	2.2	1.2	1.1
8 IV-SOUTH	0.0	0.0	0.0	.0	0.0	.3	.0	4.3	1.3	.2	.0	.0	0.0
9 IV-NORTH	0.0	.0	.1	.0	0.0	.1	1.0	1.9	6.0	2.3	.4	.2	.0
10 III	0.0	.0	.3	0.0	0.0	0.0	.4	.0	1.1	6.0	1.9	.9	.4
11 II	0.0	.0	.1	0.0	0.0	0.0	.0	0.0	0.0	.1	.8	.6	.2
12 I	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.4	1.0	.2
13 S. QUEBEC	0.0	.0	.5	0.0	0.0	0.0	.0	0.0	0.0	.0	.1	1.0	2.2
TOTAL (KTON SO4)	.1	4.4	11.5	3.4	.0	3.8	14.7	10.3	17.6	21.4	9.8	8.1	8.1

TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.0	1.5	5.9	.2	0.0	.1	1.3	.2	.5	1.4	1.2	.8	1.1
3 S. ONTARIO	0.0	.3	6.6	0.0	0.0	0.0	.3	0.0	.0	.4	1.3	1.6	2.9
4 VII	.0	.3	.3	1.9	0.0	1.0	1.5	.8	1.5	.7	.2	.4	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.0	.0	.0	.4	.0	4.5	.2	1.3	.3	.0	.0	.0	0.0
7 V-SOUTH	0.0	.4	2.4	1.4	0.0	.3	7.4	2.1	5.7	7.4	2.2	2.3	1.6
8 IV-SOUTH	0.0	0.0	0.0	.0	0.0	1.4	.3	9.4	5.3	.9	.0	.0	0.0
9 IV-NORTH	0.0	.0	.2	.1	0.0	.2	2.1	2.9	7.8	4.0	.5	.6	.1
10 III	0.0	.0	1.0	0.0	0.0	0.0	.7	.1	1.2	6.7	2.2	2.4	.9
11 II	0.0	.0	.5	0.0	0.0	0.0	.0	0.0	0.0	.2	.9	.8	.4
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	.1	.8	2.5	1.0
13 S. QUEBEC	0.0	.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	.0	.1	1.0	3.0
TOTAL (KTON SO4)	.0	2.6	17.3	4.1	.0	7.5	13.8	16.8	22.2	21.9	9.3	12.5	11.1

AUG 1977

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.1	.0	.0	.1	.0	.0	.0	0.0	.0	.0	.0	.0	.0
2 V-NORTH	.0	3.9	4.3	.2	0.0	.1	1.7	.2	.5	1.7	1.1	.9	2.8
3 S. ONTARIO	.0	.1	5.5	0.0	0.0	0.0	.2	.0	.1	1.0	1.5	1.8	5.7
4 VII	.0	.6	.6	2.3	.0	.5	1.9	.1	.3	.2	.2	.2	.2
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.0	.2	.1	1.3	.1	3.9	.3	.3	.1	.0	.0	.0	.0
7 V-SOUTH	0.0	1.7	3.2	.9	0.0	1.0	9.3	1.2	3.9	6.8	2.6	2.2	2.3
8 IV-SOUTH	0.0	.1	.5	.4	0.0	1.1	1.1	8.5	6.4	1.5	.2	.2	.5
9 IV-NORTH	0.0	.1	.7	.1	0.0	.3	2.4	1.6	6.9	4.6	.8	.6	.8
10 III	0.0	0.0	.2	0.0	0.0	0.0	.2	.2	1.2	10.0	3.4	2.8	.7
11 II	0.0	0.0	.1	0.0	0.0	0.0	0.0	.0	.1	.2	1.0	.9	.5
12 I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	.2	1.0	.2
13 S. QUEBEC	0.0	0.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.1	.5	2.7
TOTAL (KTON SO4)	.1	6.8	15.6	5.2	.1	6.9	17.0	12.2	19.5	26.1	10.9	11.1	16.3

TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.1	.0	.0	.1	.0	.0	.0	0.0	.0	.0	.0	.0	.0
2 V-NORTH	.0	6.2	5.3	.2	0.0	.0	.8	.1	.3	1.4	3.8	1.9	1.5
3 S. ONTARIO	.0	.1	3.7	0.0	0.0	0.0	.0	.0	.1	.5	2.2	2.6	3.2
4 VII	.0	2.4	1.2	3.6	.0	.2	5.4	.1	.5	.7	.6	.3	.3
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.1	.4	.2	3.5	.1	6.5	1.4	1.1	.5	.1	.0	.0	.1
7 V-SOUTH	0.0	4.3	6.8	1.1	0.0	.2	14.6	.8	3.7	13.4	10.9	5.9	2.7
8 IV-SOUTH	0.0	.1	.7	.7	0.0	1.2	1.6	14.8	13.8	4.7	.5	.2	.8
9 IV-NORTH	0.0	.1	1.3	.1	0.0	.1	2.5	1.0	9.1	11.6	4.0	1.5	.8
10 III	0.0	0.0	.4	0.0	0.0	0.0	.2	.1	.9	14.0	12.6	7.6	.7
11 II	0.0	0.0	.3	0.0	0.0	0.0	0.0	.0	.1	.1	1.9	2.4	.5
12 I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	.3	2.4	.3
13 S. QUEBEC	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.4	1.1
TOTAL (KTON SO4)	.2	13.6	20.0	9.3	.1	8.2	26.6	18.0	28.9	46.4	36.8	25.3	11.9

APRIL 1977

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.1	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.0	3.9	3.2	.8	.0	.2	2.3	.4	1.4	1.8	.5	.4	.6
3 S. ONTARIO	.0	.8	5.4	.0	0.0	.0	.8	.0	.9	2.8	.9	.7	1.4
4 VII	.0	1.7	.6	1.9	.0	.5	1.2	.4	.7	.4	.1	.1	.2
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.2	.6	.2	1.3	.0	2.7	.4	.7	.3	.1	.1	.1	.1
7 V-SOUTH	0.0	5.0	3.8	1.2	0.0	.2	8.7	1.9	6.9	6.4	.8	.6	1.1
8 IV-SOUTH	.0	1.7	.7	2.3	.0	1.2	1.4	8.0	4.9	.8	.2	.2	.1
9 IV-NORTH	.0	1.4	1.1	.4	0.0	.1	2.4	1.7	8.4	1.9	.2	.2	.2
10 III	.0	.1	1.2	.1	0.0	.1	.4	.3	4.3	8.8	1.5	1.0	1.1
11 II	0.0	.0	.3	0.0	0.0	0.0	.0	0.0	.0	.5	.9	.5	.5
12 I	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0	.0	.1	.5	1.0	.4
13 S. QUEBEC	0.0	.1	1.1	0.0	0.0	0.0	.1	0.0	.1	.2	.2	.5	1.5
TOTAL (KTON SO4)	.4	15.4	17.7	8.2	.0	5.0	17.9	13.5	28.0	23.9	6.0	5.2	7.2

TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0.0	0.0
2 V-NORTH	.1	5.5	4.8	1.2	.0	.1	1.8	.0	.5	1.5	.6	.8	.8
3 S. ONTARIO	.0	2.5	6.2	.0	0.0	.0	.9	.0	.3	1.2	.5	1.2	1.9
4 VII	.0	2.8	.6	2.8	.0	.3	1.1	.0	.4	.3	.1	.1	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.3	1.0	.4	2.2	.1	3.3	.5	.8	.5	.1	.0	.0	.1
7 V-SOUTH	0.0	10.3	6.8	1.9	0.0	.3	8.9	.2	2.6	4.6	1.1	1.5	1.5
8 IV-SOUTH	.1	3.4	2.0	1.6	0.0	.6	2.9	4.4	3.0	2.3	.4	.8	.2
9 IV-NORTH	.0	3.1	2.8	.1	0.0	.0	3.6	.2	3.1	2.0	.5	1.1	.4
10 III	.0	.4	1.7	.0	0.0	.0	.9	.0	1.0	10.5	3.2	3.7	2.0
11 II	0.0	.0	.4	0.0	0.0	0.0	.0	0.0	.0	.2	1.1	1.0	.7
12 I	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	.1	.8	1.6	1.0
13 S. QUEBEC	0.0	.3	.8	0.0	0.0	0.0	.1	0.0	.0	.0	.1	.4	1.9
TOTAL (KTON SO4)	.5	29.3	26.6	10.0	.1	4.6	20.7	5.6	11.4	22.9	8.5	12.5	10.5

OCTOBER 1977

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

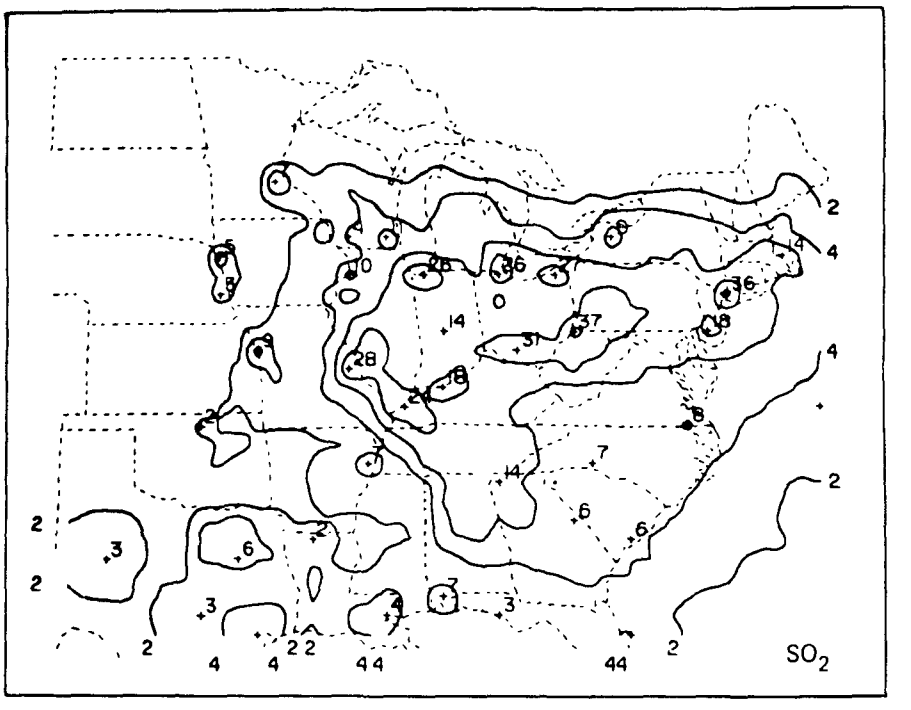
EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.4	4.5	3.7	1.6	.0	.7	3.0	1.0	2.5	2.2	1.0	.6	.6
3 S. ONTARIO	.2	1.4	5.7	.5	.0	.3	1.3	.5	1.1	1.8	1.2	.9	1.4
4 VII	.0	.8	.4	2.3	.0	.9	1.6	1.0	.9	.7	.1	.0	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.1	.1	.0	1.0	.0	3.9	.2	.3	.2	.0	.0	.0	.0
7 V-SOUTH	.5	3.4	3.5	3.8	.0	2.5	9.0	4.9	8.7	5.9	1.7	.6	1.3
8 IV-SOUTH	0.0	.4	.3	.4	0.0	2.0	.8	7.1	2.2	.1	.0	.0	.1
9 IV-NORTH	.0	1.1	1.1	.9	.0	1.4	2.2	4.4	7.3	1.8	.2	.1	.4
10 III	.2	.9	2.0	1.0	.0	.7	2.3	3.3	4.8	6.1	1.7	.7	1.6
11 II	.1	.1	.3	.1	.0	.0	.2	.2	.4	.7	.8	.5	.3
12 I	0.0	.0	.0	.0	0.0	.0	.0	.1	.3	.5	.5	1.0	.3
13 S. QUEBEC	.0	.1	1.1	.1	0.0	.1	.1	.1	.1	.1	.3	.5	1.4
TOTAL (KTON SO4)	1.5	12.9	18.2	11.7	.0	12.6	20.8	22.8	28.4	19.9	7.7	5.1	7.3

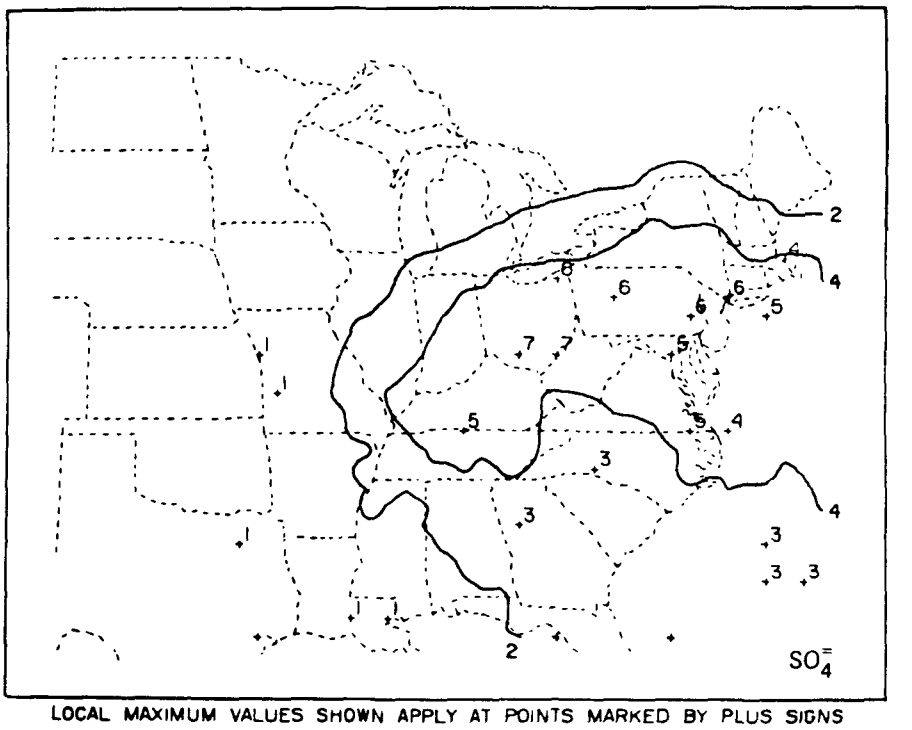
TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3	4	5	6	7	8	9	10	11	12	13
1 VIII-NORTH	.0	.0	.0	.0	0.0	.0	.0	.0	.0	.0	.0	.0	.0
2 V-NORTH	.4	4.7	3.9	1.9	0.0	.2	2.4	.8	1.0	2.7	2.6	.7	.8
3 S. ONTARIO	.2	2.1	5.5	.6	0.0	.2	1.2	.8	.4	1.9	2.8	1.0	1.8
4 VII	.1	1.5	.4	3.1	.0	.2	1.6	.2	.6	1.0	.5	.0	.1
5 VIII-SOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 VI-EAST	.1	.1	.0	3.0	.0	3.4	1.0	.9	.9	.0	.0	.0	.0
7 V-SOUTH	.9	6.1	3.9	6.5	0.0	.9	10.8	1.8	5.2	7.4	5.7	.9	1.9
8 IV-SOUTH	0.0	.2	.2	2.1	0.0	2.3	4.5	7.6	6.8	.9	.0	.0	.1
9 IV-NORTH	.1	1.4	1.0	2.6	.0	.5	5.1	1.3	8.2	3.3	1.0	.2	.8
10 III	.2	2.1	3.6	1.7	0.0	.4	6.5	2.9	4.1	8.0	4.9	.8	2.8
11 II	.0	.3	.9	.1	0.0	.0	.5	.1	.9	1.0	1.8	.8	.8
12 I	0.0	.0	.3	.0	0.0	0.0	.4	.1	.6	1.4	1.7	2.7	1.4
13 S. QUEBEC	.0	.1	1.0	.1	0.0	.0	.1	.0	.1	.6	.5	.6	1.7
TOTAL (KTON SO4)	1.9	18.6	20.9	21.8	.0	8.1	34.3	16.4	28.8	28.3	21.5	7.8	12.2

Appendix C

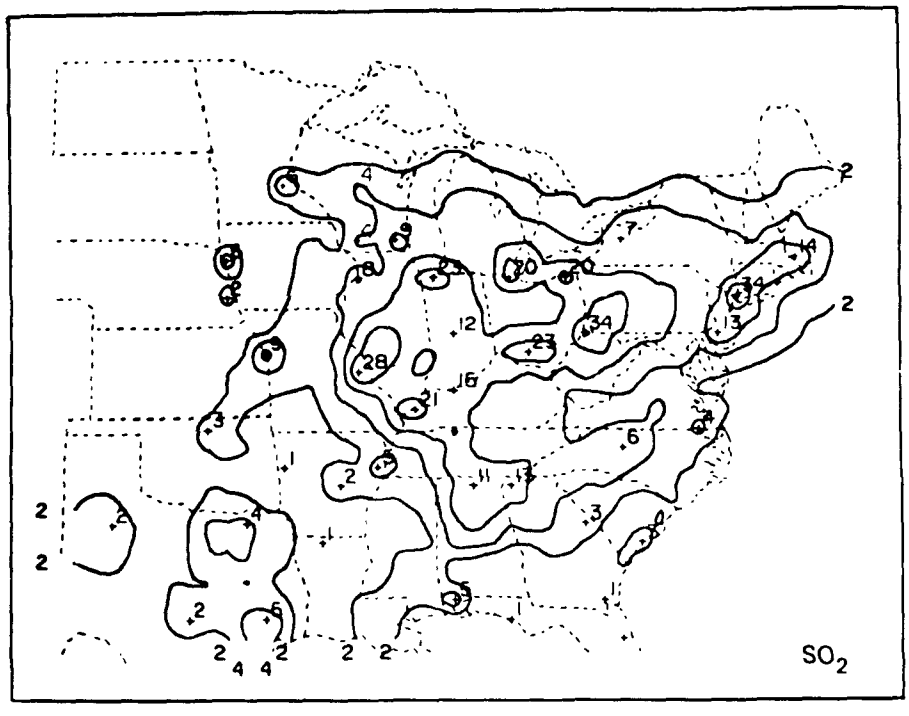
1985 CALCULATED SEASONAL RESULTS FOR SO_2 AND $SO_4^=$ CONCENTRATIONS ($\mu g/m^3$) AND DRY AND WET DEPOSITIONS (mg/m^2)

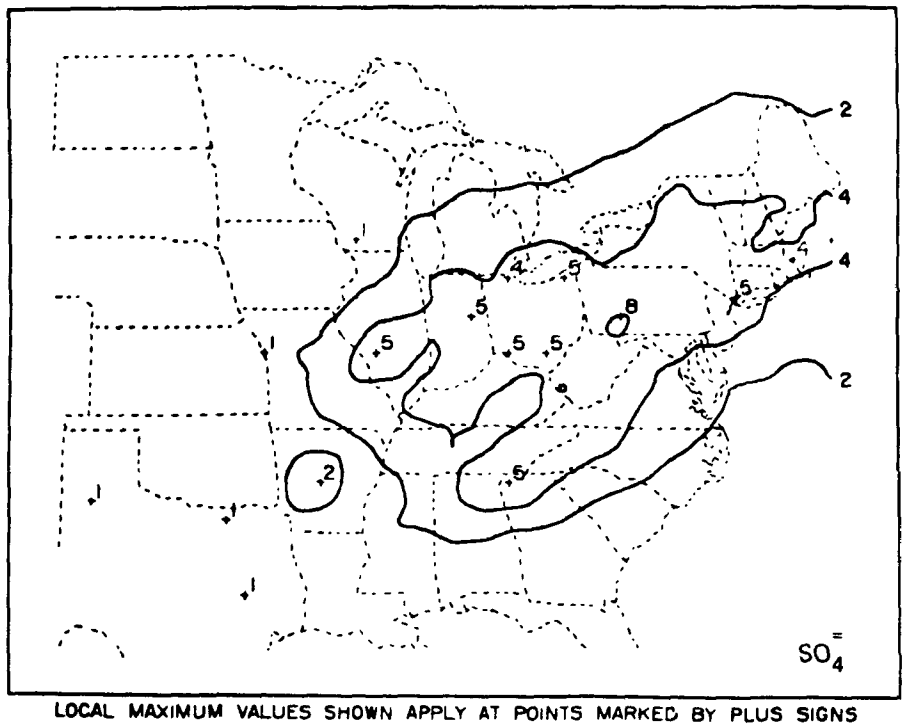




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

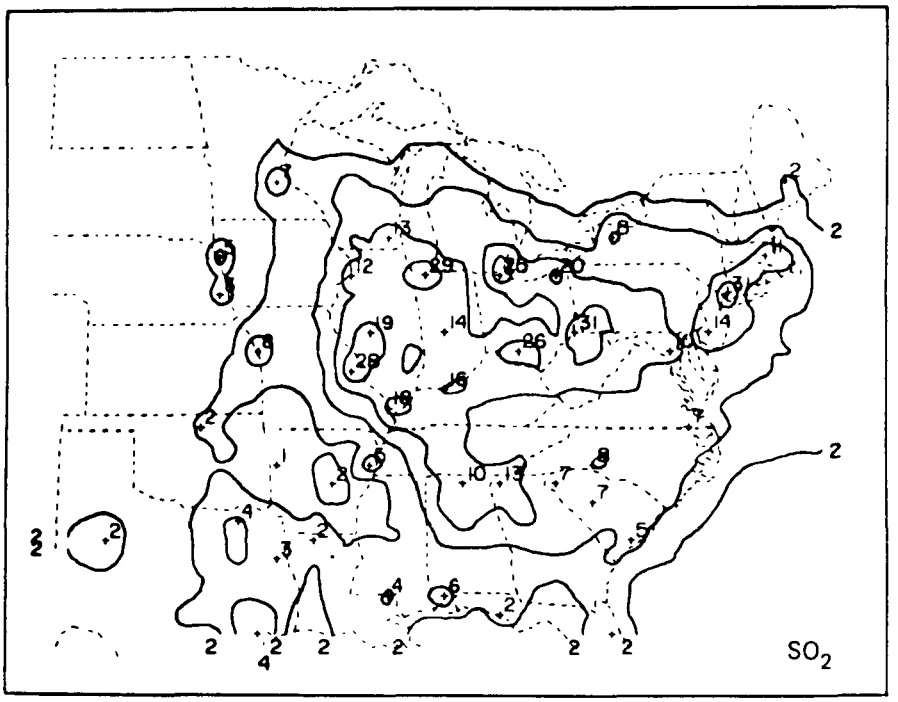
SO_2 and $SO_4^=$ CONCENTRATIONS ($\mu g/m^3$) — JANUARY 1985

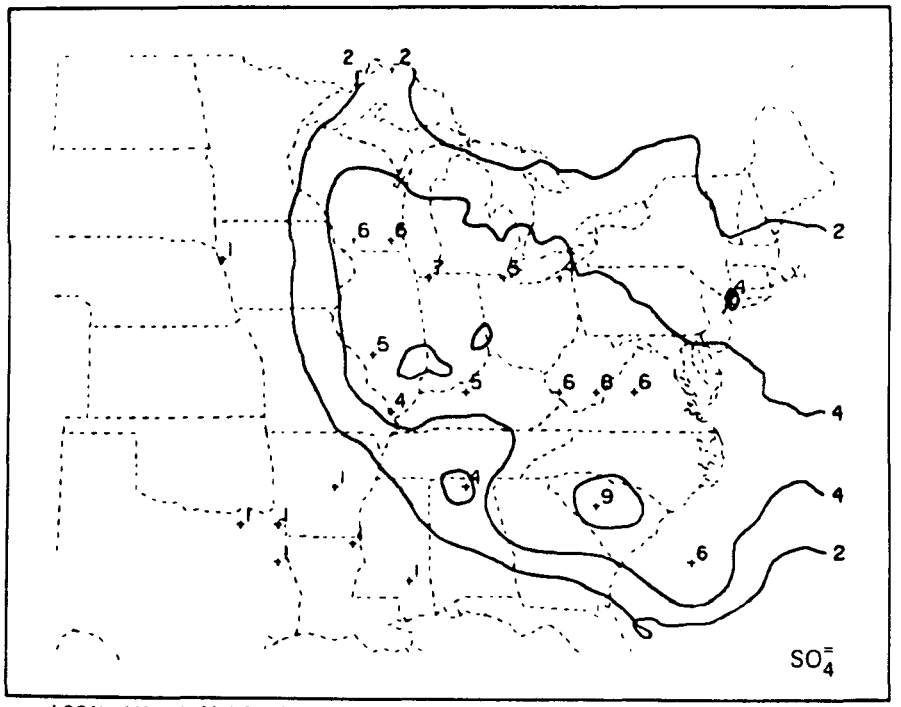




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

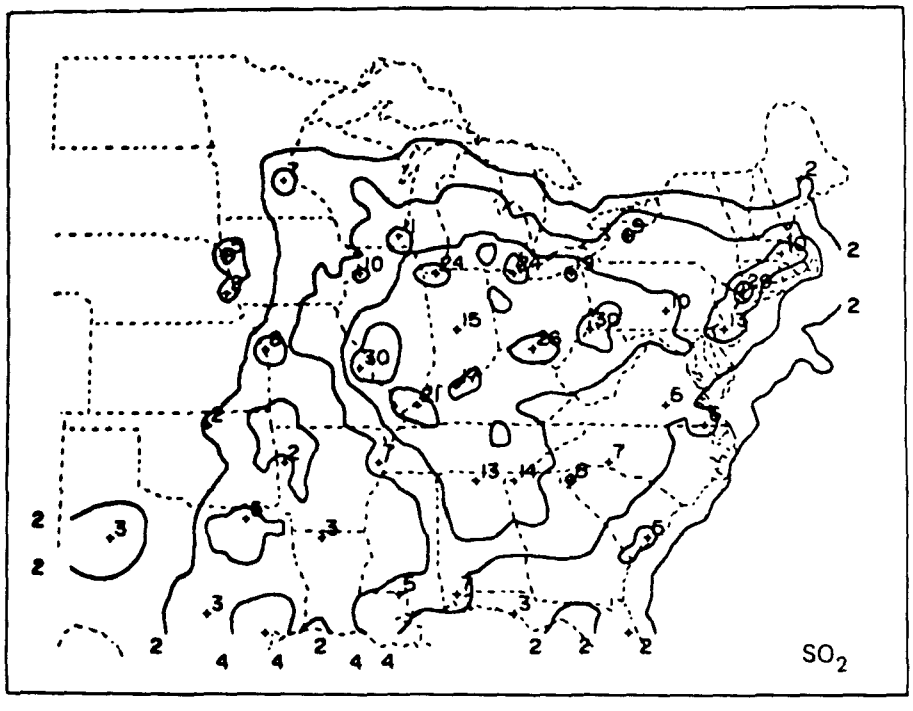
SO_2 and $SO_4^=$ CONCENTRATIONS ($\mu g/m^3$) — AUGUST 1985

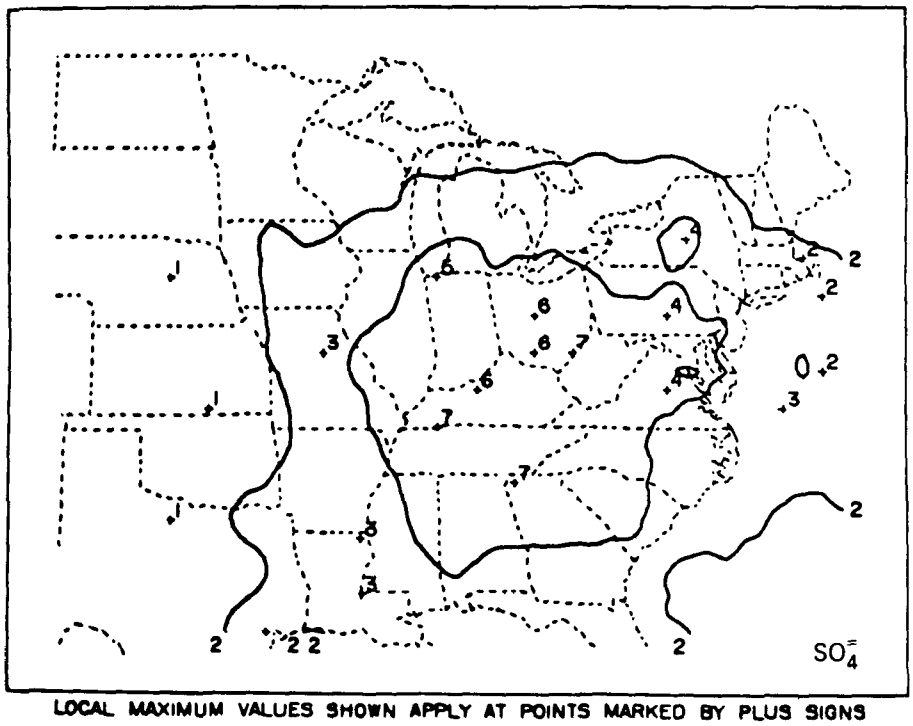




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

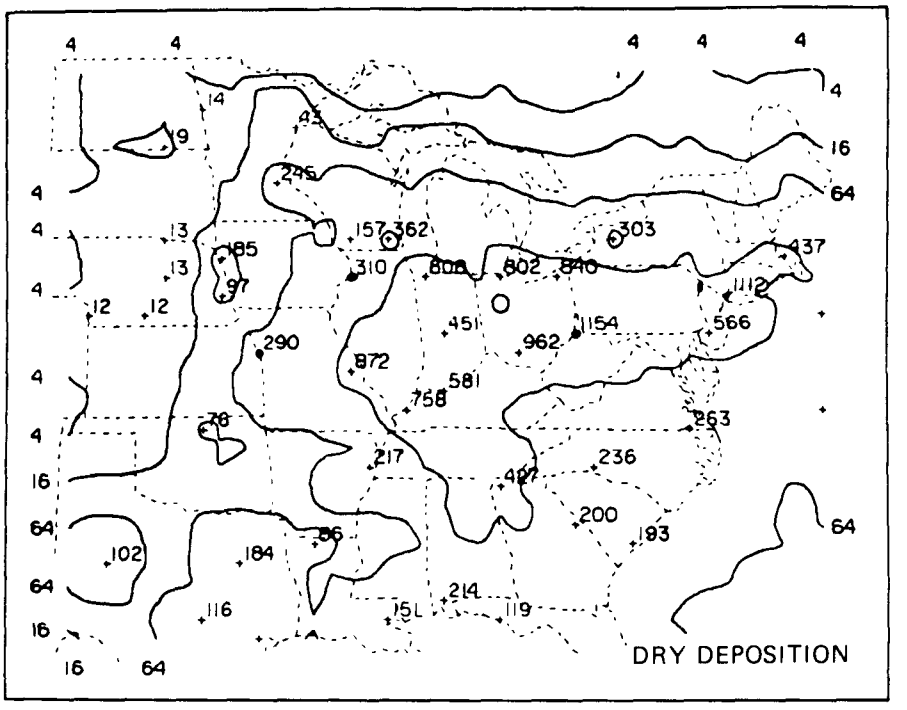
SO_2 and $SO_4^=$ CONCENTRATIONS ($\mu g/m^3$) — APRIL 1985

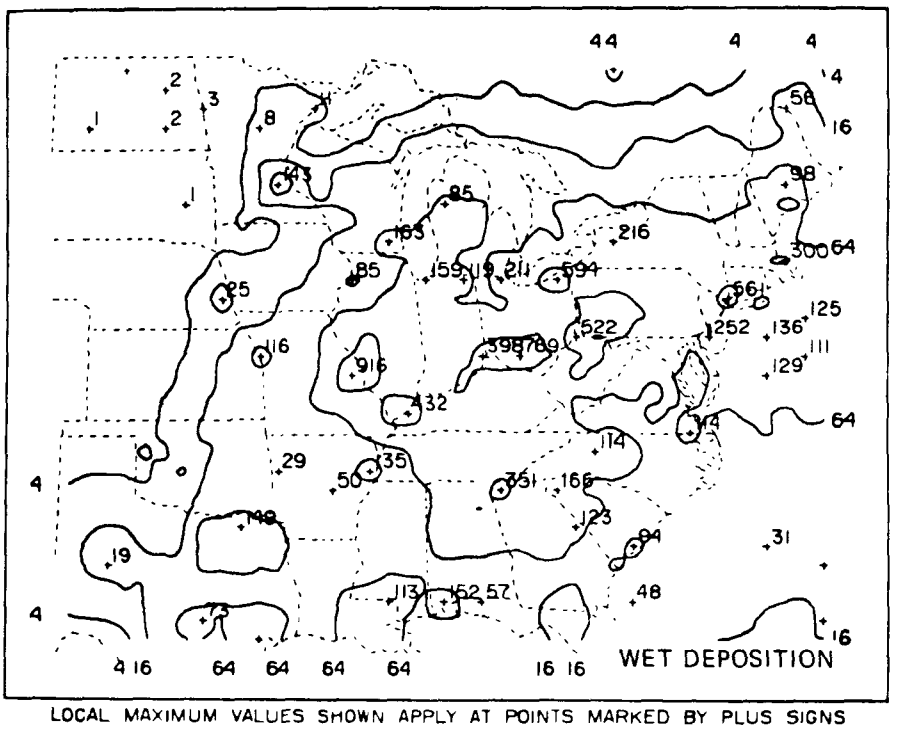




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

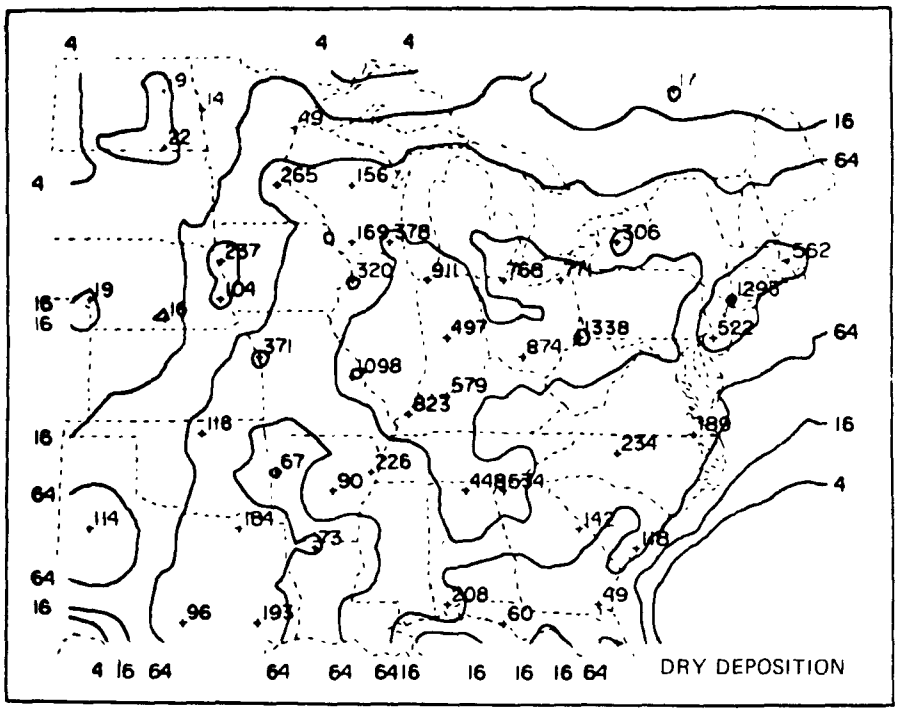
SO_2 and $SO_4^=$ CONCENTRATIONS ($\mu g/m^3$) — OCTOBER 1985

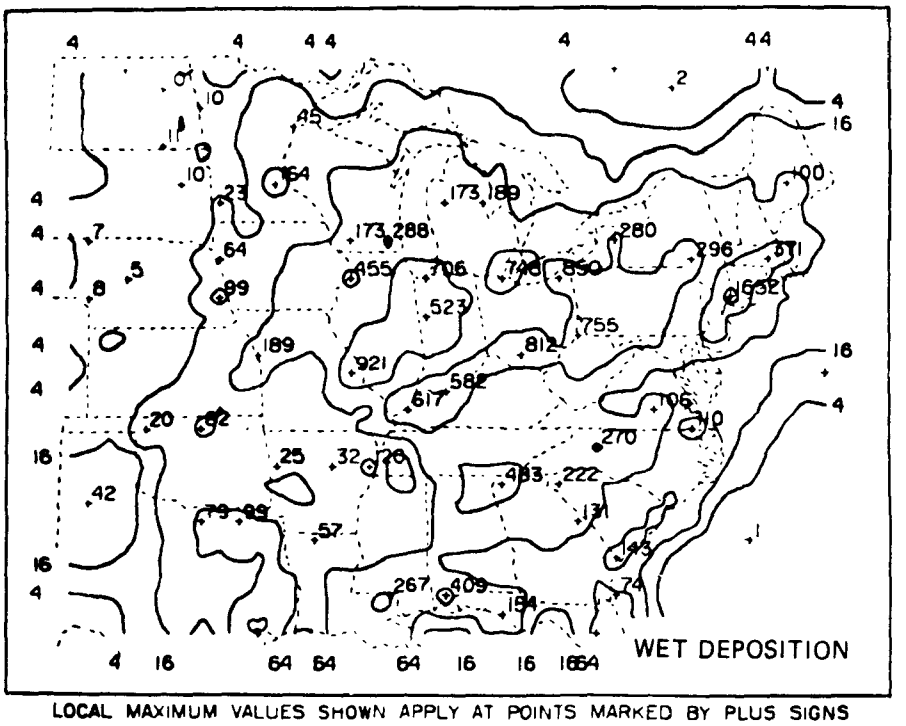




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

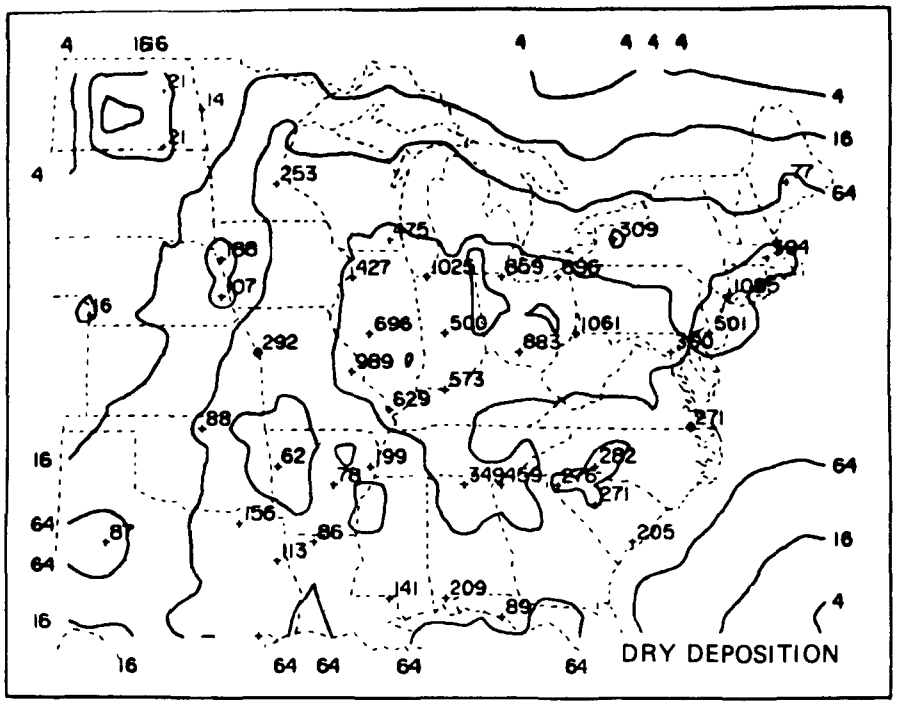
SO_2 DEPOSITIONS (mg/m^2) — JANUARY 1985

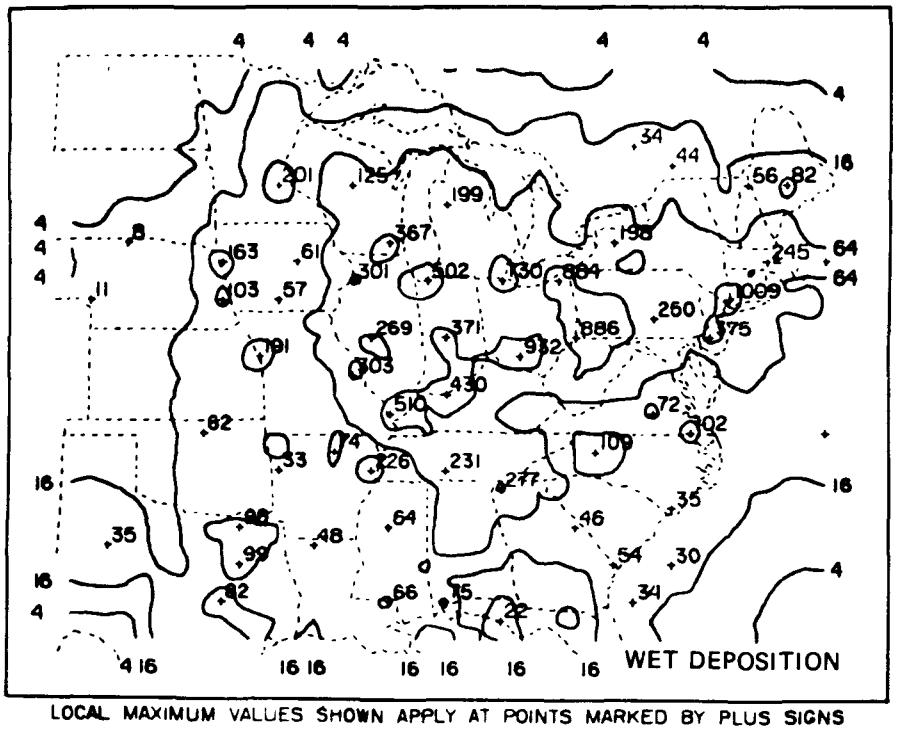




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

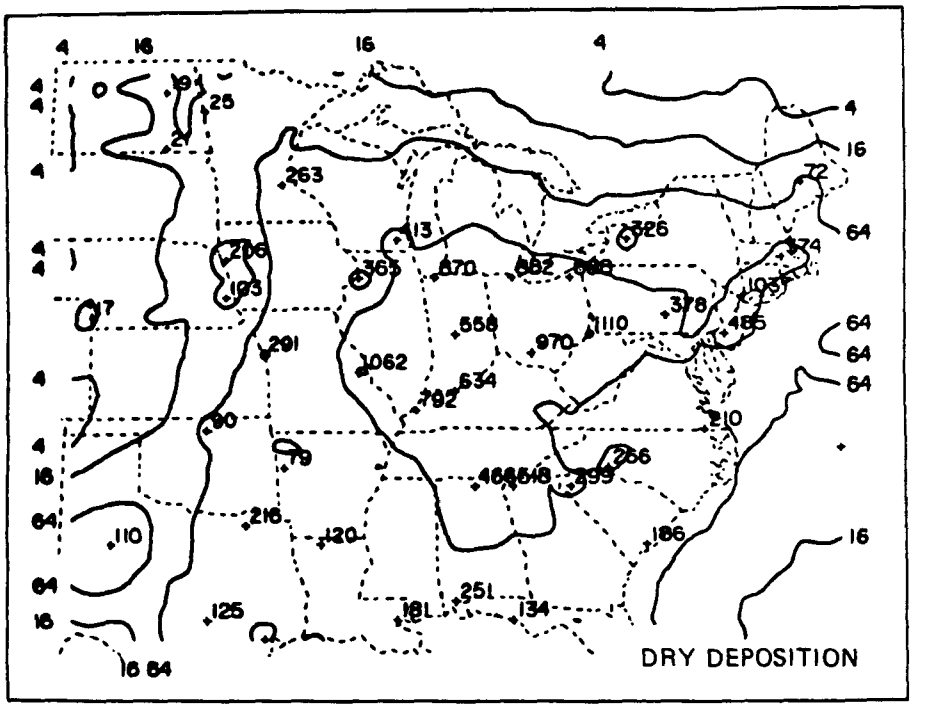
SO_2 DEPOSITIONS (mg/m^2) — AUGUST 1985

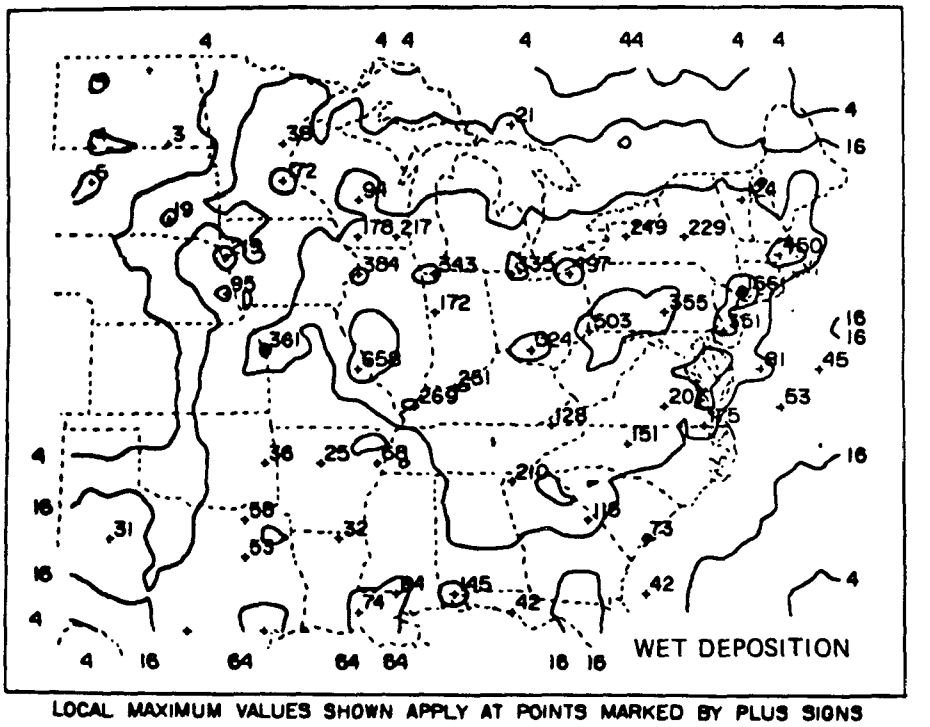




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

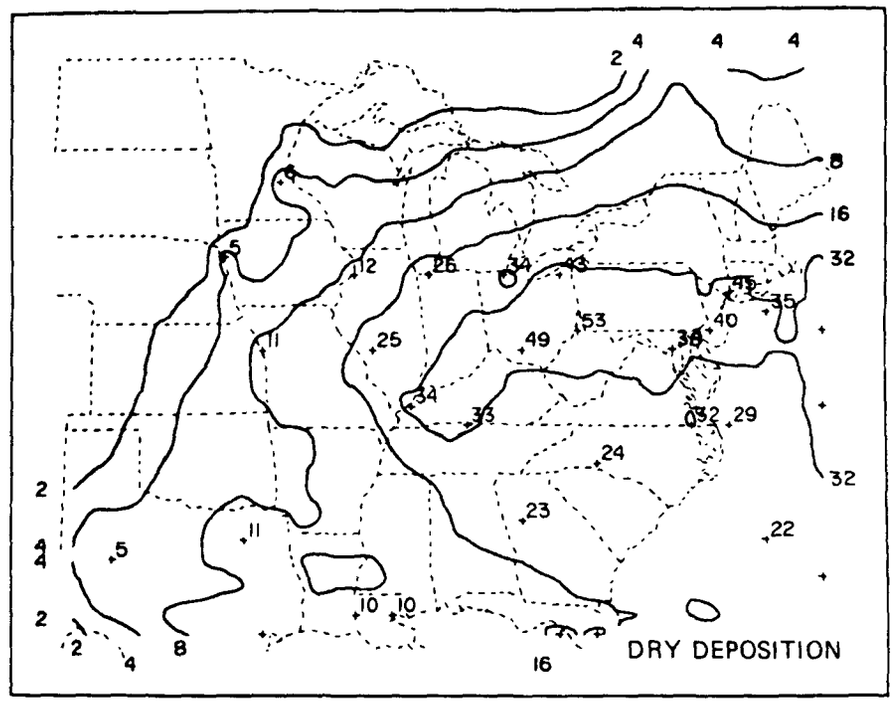
SO_2 DEPOSITIONS (mg/m^2) — APRIL 1985

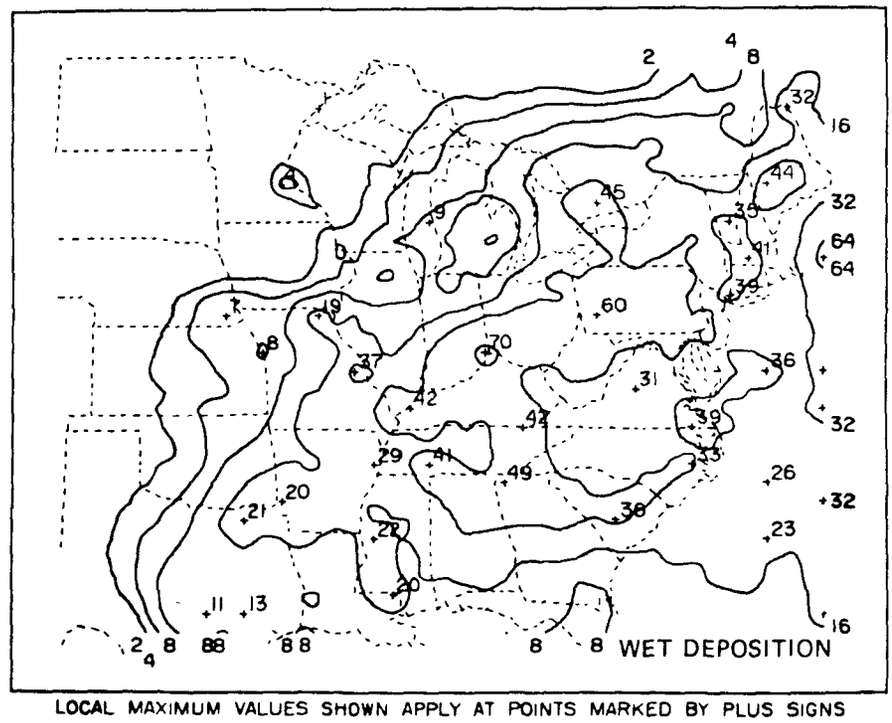




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

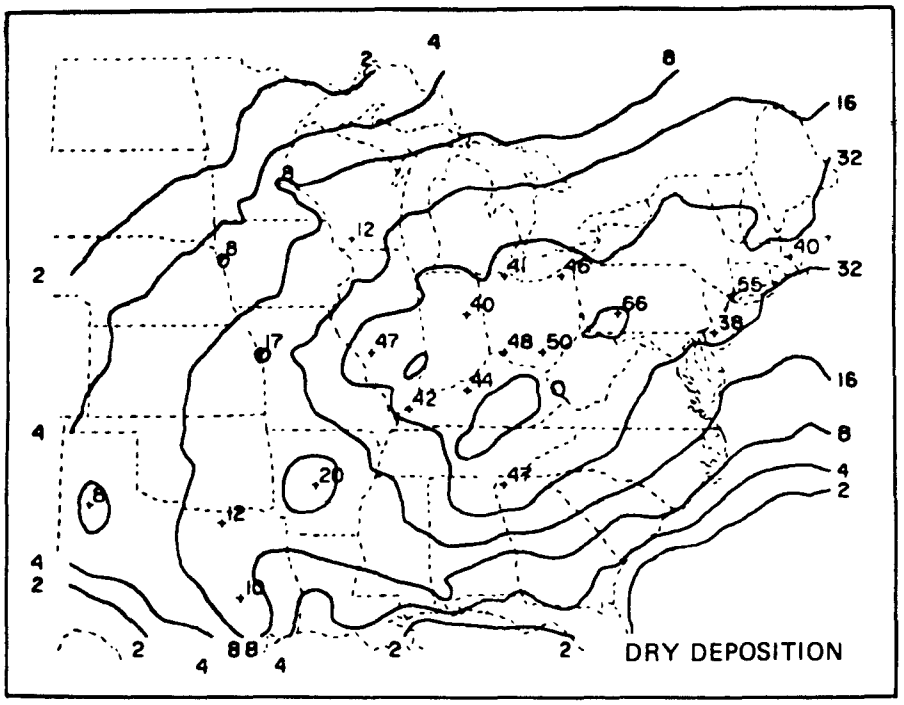
SO_2 DEPOSITIONS (mg/m^2) — OCTOBER 1985

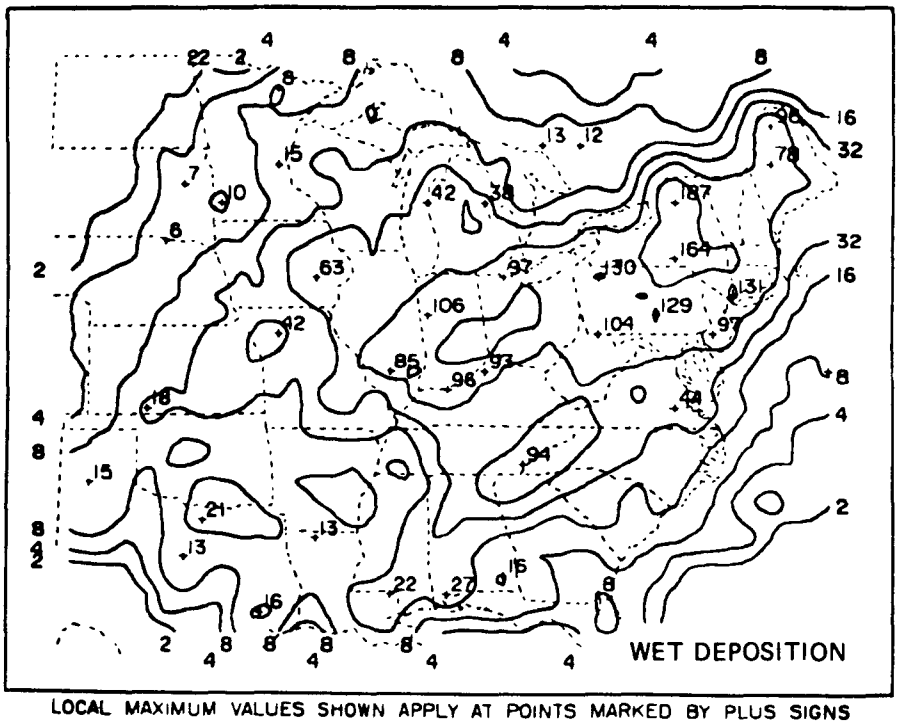




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

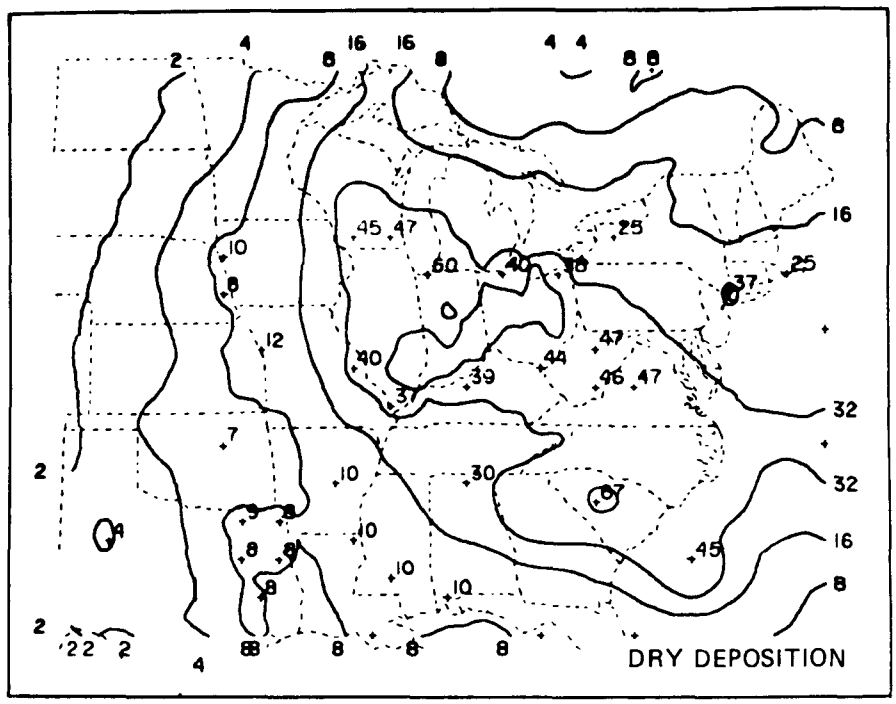
$SO_4^=$ DEPOSITIONS (mg/m^2) — JANUARY 1985

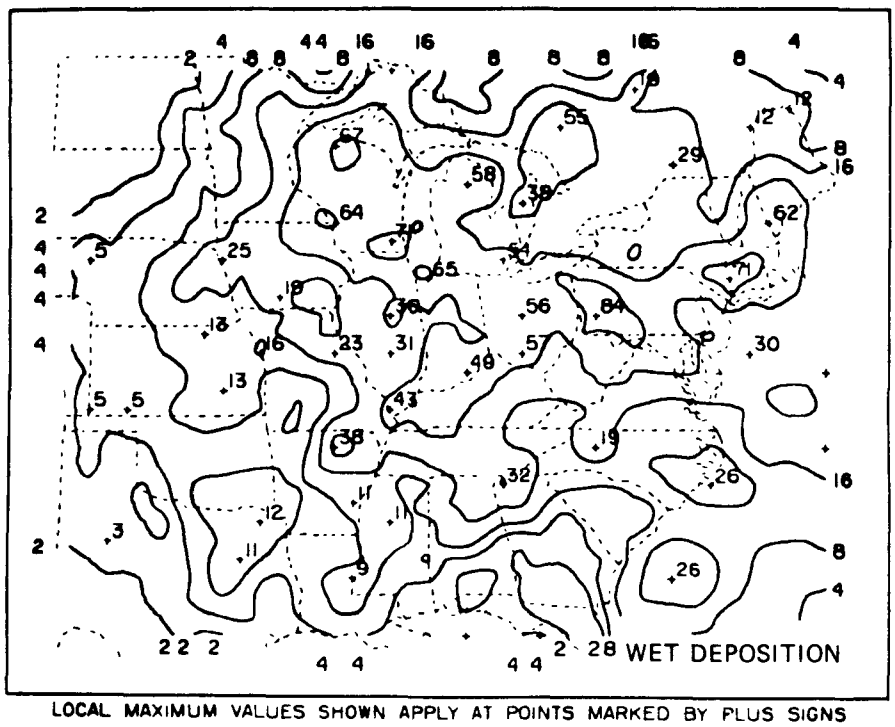




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

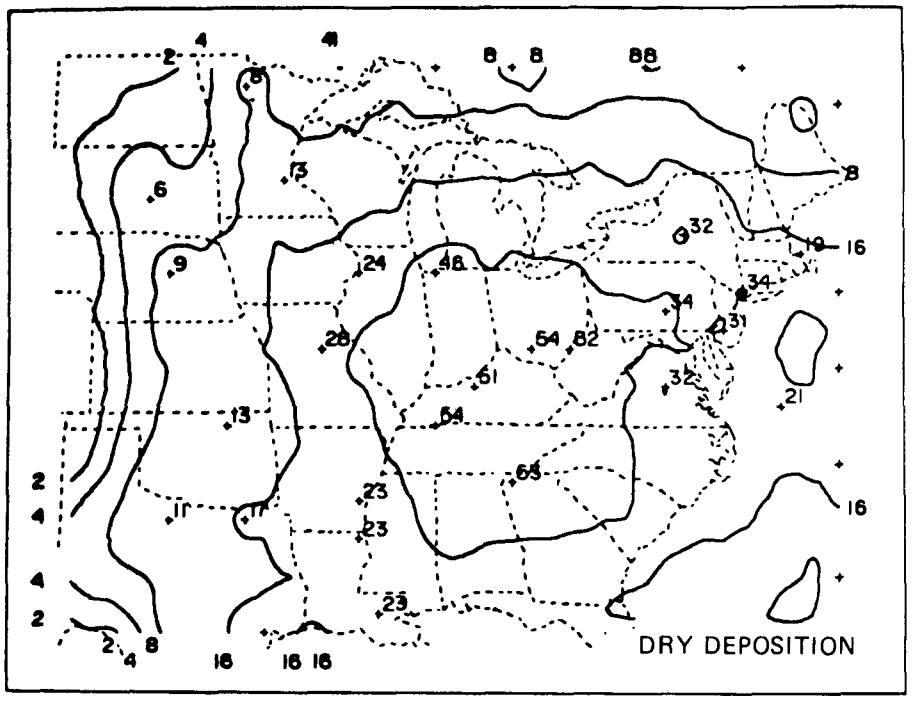
$SO_4^=$ DEPOSITIONS (mg/m^2) — AUGUST 1985

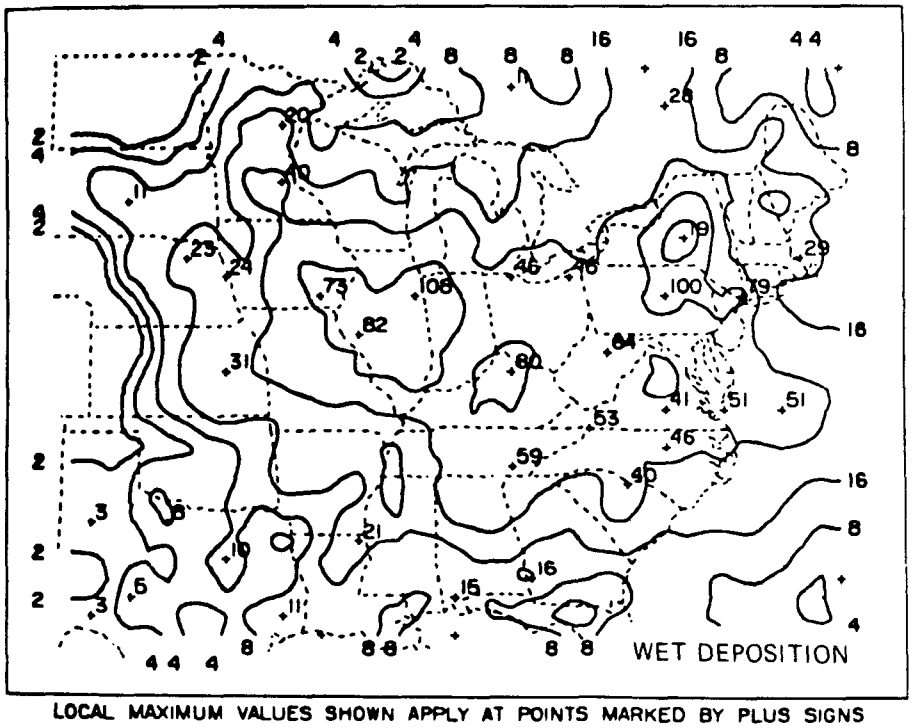




LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

$SO_4^=$ DEPOSITIONS (mg/m^2) — APRIL 1985





LOCAL MAXIMUM VALUES SHOWN APPLY AT POINTS MARKED BY PLUS SIGNS

$SO_4^=$ DEPOSITIONS (mg/m^2) — OCTOBER 1985

Appendix D

1985 INTERREGIONAL EXCHANGE RESULTS

NOTE

No results are shown for South Ontario and South Quebec since there were no emissions from these regions (see text).

JANUARY 1985

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	3.2	.5		1.5	.0	.2	.2	.1	.1	.0	.0	.0	
2 V-NORTH	.1	37.3		3.5	0.0	.1	15.1	.3	1.2	6.4	4.1	1.3	
*3 S. ONTARIO													
4 VII	.2	1.4		35.9	.0	5.9	17.1	5.0	11.0	1.8	.2	.1	
5 VIII-SOUTH	.0	.0		.5	.4	.3	.0	.0	.0	.0	.0	.0	
6 VI-EAST	.0	.0		2.1	.0	63.0	.1	4.5	.4	.0	.0	.0	
7 V-SOUTH	0.0	4.9		4.4	0.0	.1	95.7	3.9	31.9	41.5	5.1	1.5	
8 IV-SOUTH	0.0	0.0		.0	0.0	1.0	.1	45.3	6.3	.2	.0	.0	
9 IV-NORTH	0.0	.0		1.4	0.0	.9	5.4	11.1	54.0	6.1	.2	.1	
10 III	0.0	.0		0.0	0.0	0.0	1.9	.0	3.0	49.2	9.7	2.2	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	0.0	1.4	17.8	5.7	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.3	10.9	
*13 S. QUEBEC													
TOTAL (KTON SO2)	3.4	44.2		49.2	.5	71.5	135.6	70.1	107.8	106.7	37.3	21.8	

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.4	.1		.2	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.0	13.1		.5	0.0	.0	4.0	.0	.2	1.6	1.5	.3	
*3 S. ONTARIO													
4 VII	.0	1.0		16.9	.0	2.0	5.8	.5	1.9	.6	.1	.1	
5 VIII-SOUTH	.0	.0		.0	.0	.0	.0	.0	.0	.0	.0	.0	
6 VI-EAST	.0	.0		1.0	.0	32.2	.1	2.2	.1	.0	.0	.0	
7 V-SOUTH	0.0	1.8		4.2	0.0	.1	43.3	.6	7.8	12.9	2.4	.8	
8 IV-SOUTH	0.0	0.0		.0	0.0	1.0	.3	28.5	6.1	.2	.0	.0	
9 IV-NORTH	0.0	.0		1.1	0.0	.6	4.5	2.8	27.0	3.6	.1	.2	
10 III	0.0	.0		0.0	0.0	0.0	2.0	.0	1.1	25.7	4.9	1.8	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	0.0	.9	9.3	2.9	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.4	9.1	
*13 S. QUEBEC													
TOTAL (KTON SO2)	.4	16.1		24.0	.0	36.1	60.1	34.6	44.3	45.5	18.6	15.2	

*No 1985 projected emissions were available from these regions.

AUGUST 1985

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	3.6	.5		.5	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.1	42.5		1.4	0.0	.0	8.7	.0	.4	2.1	1.2	.3	
*3 S. ONTARIO													
4 VII	.5	3.9		40.9	.0	2.1	18.2	.2	1.0	.1	.1	.0	
5 VIII-SOUTH	.0	.0		.4	.5	.0	.0	0.0	0.0	0.0	.0	.0	
6 VI-EAST	.1	.4		7.6	.3	65.6	.6	1.0	.2	.0	.0	.0	
7 V-SOUTH	0.0	11.5		6.0	0.0	.8	104.9	1.0	15.8	23.7	3.9	.8	
8 IV-SOUTH	0.0	.1		.4	0.0	1.7	1.3	48.7	14.5	.7	.0	.0	
9 IV-NORTH	0.0	.4		2.4	0.0	1.6	12.2	5.3	54.8	8.0	.2	.1	
10 III	0.0	0.0		0.0	0.0	0.0	2.0	.0	2.2	59.0	13.2	3.4	
11 II	0.0	0.0		0.0	0.0	0.0	.0	.0	.0	1.3	21.3	7.9	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.2	14.5	
*13 S. QUEBEC													
TOTAL (KTON SO2)	4.2	59.3		59.5	.8	71.8	147.9	56.2	88.9	94.9	40.3	27.0	

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	1.8	.2		.2	.0	0.0	.0	0.0	.0	.0	.0	.0	
2 V-NORTH	.0	30.4		.4	0.0	.0	4.1	.0	.1	.9	1.6	.2	
*3 S. ONTARIO													
4 VII	.3	4.3		28.3	.0	.7	14.5	.0	.6	.0	.0	.0	
5 VIII-SOUTH	.0	.0		.2	.2	.0	.0	0.0	0.0	0.0	0.0	.0	
6 VI-EAST	.1	.4		5.9	.2	44.3	.9	2.7	.2	.0	.0	.0	
7 V-SOUTH	0.0	9.4		3.4	0.0	.1	77.8	.2	8.5	18.1	4.7	.6	
8 IV-SOUTH	0.0	.1		.1	0.0	1.0	.6	40.2	9.2	.9	.0	.0	
9 IV-NORTH	0.0	.1		1.2	0.0	.6	8.1	2.3	42.0	7.0	.3	.0	
10 III	0.0	0.0		0.0	0.0	0.0	1.5	.0	1.2	44.8	12.7	2.7	
11 II	0.0	0.0		0.0	0.0	0.0	0.0	.0	.0	.8	21.1	7.8	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.1	10.9	
*13 S. QUEBEC													
TOTAL (KTON SO2)	2.2	44.9		39.6	.3	46.6	107.6	45.4	61.8	72.5	40.7	22.4	

*No 1985 projected emissions were available from these regions.

APRIL 1985

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	3.8	.4		.7	.1	.1	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.2	40.6		3.0	.0	.2	12.3	.2	1.2	3.1	1.7	.6	
*3 S. ONTARIO													
4 VII	.6	6.8		38.2	.0	3.1	16.8	1.7	3.9	1.5	.3	.2	
5 VIII-SOUTH	.0	.0		.3	.4	.1	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	.2	1.1		8.5	.3	60.9	.9	4.0	.6	.1	.0	.0	
7 V-SOUTH	0.0	14.3		7.1	0.0	.4	96.2	2.8	24.6	29.8	2.8	.8	
8 IV-SOUTH	.0	.3		1.3	0.0	2.6	1.3	51.4	11.5	.4	.0	.0	
9 IV-NORTH	0.0	.7		3.4	0.0	.9	10.2	7.4	57.6	6.7	.2	.0	
10 III	.0	.0		.0	0.0	.0	2.3	.0	5.7	54.5	8.3	1.5	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	.0	3.3	19.5	5.2	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.1	.6	12.2	
*13 S. QUEBEC													
TOTAL (KTON SO2)	4.9	64.1		62.5	.8	68.3	139.9	57.6	105.2	99.4	33.3	20.6	

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.6	.1		.2	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.1	26.3		1.2	.0	.0	6.7	.0	.3	.9	.8	.3	
*3 S. ONTARIO													
4 VII	.5	3.2		20.0	.0	1.3	6.5	.1	1.2	.5	.1	.0	
5 VIII-SOUTH	.0	.0		.1	.2	.0	.0	0.0	.0	0.0	0.0	0.0	
6 VI-EAST	.1	.3		4.1	.3	29.6	.5	2.1	.8	.0	.0	.0	
7 V-SOUTH	0.0	11.6		4.5	0.0	.4	58.0	.0	7.2	9.8	1.3	.3	
8 IV-SOUTH	.0	.4		.2	0.0	.6	1.3	20.5	6.8	1.2	.0	.0	
9 IV-NORTH	0.0	.7		1.7	0.0	1.0	8.8	.8	23.5	3.9	.2	.1	
10 III	.0	.1		.0	0.0	0.0	2.4	.0	.9	30.7	5.7	1.3	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	.0	.8	12.4	2.6	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.2	8.6	
*13 S. QUEBEC													
TOTAL (KTON SO2)	1.3	42.7		32.1	.5	33.0	84.2	23.6	40.6	47.8	20.7	13.2	

*No 1985 projected emissions were available from these regions.

OCTOBER 1985

TOTAL CONTRIBUTIONS TO SO2 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	3.4	.6		.7	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.7	44.5		4.1	.0	.4	15.5	.5	2.4	3.7	1.2	.4	
*3 S. ONTARIO													
4 VII	.7	3.3		42.0	.1	5.7	16.7	3.5	4.6	.8	.2	.0	
5 VIII-SOUTH	.0	.0		.5	.5	.1	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	.1	.0		4.9	.0	74.0	.4	3.0	.5	.0	.0	.0	
7 V-SOUTH	.1	13.6		11.1	.0	1.5	104.4	7.2	35.5	24.7	3.0	.4	
8 IV-SOUTH	0.0	.1		.3	0.0	3.1	1.0	54.4	8.7	.1	.0	.0	
9 IV-NORTH	.0	.9		3.2	.0	2.2	9.8	18.0	56.7	4.8	.1	.0	
10 III	.0	.9		.1	.0	.0	6.7	1.4	8.3	52.2	8.3	1.4	
11 II	.0	.2		.0	.0	.0	.3	.1	.8	5.9	18.8	4.9	
12 I	0.0	.0		.0	0.0	.0	.0	.0	.3	.9	1.3	12.4	
*13 S. QUEBEC													
TOTAL (KTON SO2)	5.1	64.2	30.2	66.9	.6	87.1	154.8	88.0	117.8	93.0	32.9	19.5	2.5

TOTAL CONTRIBUTIONS TO SO2 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.8	.1		.1	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.3	16.9		.9	0.0	.0	3.6	.0	.2	1.3	.8	.2	
*3 S. ONTARIO													
4 VII	.4	2.4		22.4	.0	.5	6.7	.4	.6	.6	.2	.0	
5 VIII-SOUTH	.0	.0		.0	.0	.0	.0	.0	.0	0.0	0.0	0.0	
6 VI-EAST	.1	.0		3.9	.0	24.7	.4	2.0	.7	.0	.0	.0	
7 V-SOUTH	.0	8.0		4.5	0.0	.0	45.0	.6	5.8	11.9	2.4	.2	
8 IV-SOUTH	0.0	.1		.3	0.0	1.0	1.7	19.6	5.5	.5	.0	.0	
9 IV-NORTH	.0	.6		1.6	0.0	.3	6.9	2.5	22.7	3.1	.2	.0	
10 III	.0	.7		.0	0.0	.0	2.4	.1	2.8	32.4	7.3	.7	
11 II	.0	.1		.0	0.0	.0	.1	.0	.5	2.7	19.0	3.2	
12 I	0.0	.0		0.0	0.0	.0	.0	.0	.0	.5	1.4	13.5	
*13 S. QUEBEC													
TOTAL (KTON SO2)	1.7	29.0		33.8	.0	26.5	66.8	25.3	38.8	53.0	31.1	17.8	

*No 1985 projected emissions were available from these regions.

JANUARY 1985

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.2	.1		.2	.0	.1	.1	.1	.1	.0	.0	.0	
2 V-NORTH	.0	1.8		.4	0.0	.0	1.5	.2	.4	1.3	.9	.6	
*3 S. ONTARIO													
4 VII	.0	.4		1.9	.0	1.0	1.9	1.5	1.9	.7	.2	.2	
5 VIII-SOUTH	.0	.0		.1	.0	.1	.0	.0	.0	.0	.0	.0	
6 VI-EAST	.0	.1		.9	.0	5.2	.2	1.0	.2	.1	.0	.0	
7 V-SOUTH	0.0	.4		.4	0.0	.1	5.2	1.0	3.8	5.1	1.4	.7	
8 IV-SOUTH	0.0	0.0		.0	0.0	.1	.0	2.4	.7	.1	.0	.0	
9 IV-NORTH	0.0	.0		.1	0.0	.1	.5	1.3	3.4	.9	.1	.1	
10 III	0.0	.0		0.0	0.0	0.0	.1	.0	.3	2.3	.9	.4	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	0.0	.1	.6	.5	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	.4	
*13 S. QUEBEC													
TOTAL (KTON SO4)	.2	2.8		4.0	.0	6.8	9.5	7.4	10.9	10.7	4.2	2.8	

TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.0	.1		.1	.0	.1	.1	.0	.0	.0	.0	.0	
2 V-NORTH	.0	.9		.1	0.0	.0	.7	.1	.3	.7	.7	.4	
*3 S. ONTARIO													
4 VII	.0	.4		2.1	.0	1.2	1.5	.9	1.5	.8	.2	.5	
5 VIII-SOUTH	.0	.0		.0	.0	.0	.0	.0	.0	.0	.0	.0	
6 VI-EAST	.0	.1		1.0	.0	6.6	.4	1.5	.4	.1	.0	.0	
7 V-SOUTH	0.0	.3		.9	0.0	.2	4.8	1.3	3.1	4.1	1.2	1.2	
8 IV-SOUTH	0.0	0.0		.0	0.0	.6	.2	4.7	2.7	.4	.0	.0	
9 IV-NORTH	0.0	.0		.1	0.0	.2	.9	1.9	5.2	2.0	.2	.3	
10 III	0.0	.0		0.0	0.0	0.0	.2	.0	.3	2.4	1.1	1.1	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	0.0	.1	.7	.7	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.1	.8	
*13 S. QUEBEC													
TOTAL (KTON SO4)	.0	1.7	6.1	4.4	.0	8.9	8.9	10.3	13.5	10.7	4.1	5.0	

*No 1985 projected emissions were available from these regions.

AUGUST 1985

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.3	.2		.2	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.0	2.6		.2	0.0	.1	1.0	.1	.4	.9	.6	.6	
*3 S. ONTARIO													
4 VII	.1	.9		2.9	.0	.6	2.4	.1	.4	.3	.2	.3	
5 VIII-SOUTH	.0	.0		.1	.0	.0	.0	0.0	0.0	0.0	.0	.0	
6 VI-EAST	.1	.4		2.8	.2	5.9	.5	.2	.1	.1	.0	.0	
7 V-SOUTH	0.0	1.2		.6	0.0	.6	6.5	.7	2.5	4.3	1.6	1.4	
8 IV-SOUTH	.0	.0		.2	0.0	.4	.5	4.0	2.8	.7	.1	.1	
9 IV-NORTH	0.0	.1		.2	0.0	.4	1.3	1.0	4.4	2.4	.3	.3	
10 III	0.0	0.0		0.0	0.0	0.0	.1	.1	.4	4.1	1.7	1.4	
11 II	0.0	0.0		0.0	0.0	0.0	.0	.0	.0	.1	.9	.9	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	.5	
*13 S. QUEBEC													
TOTAL (KTON SO4)	.5	5.4		7.0	.2	7.8	12.2	6.3	11.1	12.9	5.5	5.5	

TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.3	.3		.2	.0	.0	.1	.0	.0	.0	.0	.0	
2 V-NORTH	.0	4.1		.1	0.0	.0	.5	.0	.2	.7	2.2	1.0	
*3 S. ONTARIO													
4 VII	.2	2.9		4.7	.0	.3	6.1	.1	.8	.8	.7	.4	
5 VIII-SOUTH	.0	.0		.1	.0	.0	.0	0.0	0.0	0.0	0.0	.0	
6 VI-EAST	.3	1.1		7.3	.2	8.6	2.5	.7	.5	.2	.1	.1	
7 V-SOUTH	0.0	2.8		1.4	0.0	.2	10.3	.5	2.1	8.5	6.8	4.1	
8 IV-SOUTH	.0	.0		.2	0.0	.4	.9	7.3	6.3	2.4	.2	.1	
9 IV-NORTH	0.0	.1		.2	0.0	.1	2.4	.8	7.1	5.9	1.4	.6	
10 III	0.0	0.0		0.0	0.0	0.0	.0	.0	.3	5.5	5.7	3.9	
11 II	0.0	0.0		0.0	0.0	0.0	0.0	.0	.0	.0	1.6	2.6	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	1.1	
*13 S. QUEBEC													
TOTAL (KTON SO4)	.8	11.4		14.2	.2	9.6	22.7	9.5	17.3	24.1	18.6	13.9	

*No 1985 projected emissions were available from these regions.

APRIL 1985

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.3	.1		.2	.0	.1	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.0	2.6		.6	.0	.2	1.3	.3	.8	1.0	.3	.3	
*3 S. ONTARIO													
4 VII	.1	2.2		2.3	.0	.7	1.6	.5	.8	.5	.1	.1	
5 VIII-SOUTH	.0	.0		.1	.0	.0	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	.3	1.0		2.3	.1	4.1	.6	.9	.5	.2	.1	.1	
7 V-SOUTH	0.0	3.4		.8	0.0	.2	6.0	1.3	4.4	3.9	.7	.5	
8 IV-SOUTH	.0	.9		1.1	0.0	.5	.8	4.3	2.5	.3	.1	.1	
9 IV-NORTH	0.0	1.0		.5	0.0	.1	1.5	1.5	5.9	1.3	.2	.2	
10 III	.0	.0		.0	0.0	.0	.1	.1	1.5	3.7	.8	.5	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	.0	.4	.9	.5	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.1	.5	
*13 S. QUEBEC													
TOTAL (KTON SO4)	.8	11.2		7.8	.1	5.9	11.9	8.8	16.5	11.4	3.2	2.6	

TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.1	.0		.1	.0	.0	.1	.0	.0	.0	.0	.0	
2 V-NORTH	.1	3.8		.8	.0	.1	1.2	.0	.3	.9	.3	.5	
*3 S. ONTARIO													
4 VII	.2	3.5		3.6	.0	.6	1.4	.0	.5	.4	.1	.1	
5 VIII-SOUTH	.0	.0		.0	.0	.0	.0	0.0	.0	0.0	0.0	0.0	
6 VI-EAST	.5	1.6		3.8	.2	4.6	.8	.7	1.0	.3	.1	.1	
7 V-SOUTH	0.0	7.2		1.3	0.0	.3	6.0	.1	1.6	2.7	.7	1.0	
8 IV-SOUTH	.1	1.7		.6	0.0	.2	1.5	2.2	1.7	.9	.1	.3	
9 IV-NORTH	0.0	1.7		.4	0.0	.1	2.2	.1	2.4	1.9	.5	1.0	
10 III	.0	.2		.0	0.0	0.0	.3	.0	.4	4.2	1.4	1.7	
11 II	0.0	.0		0.0	0.0	0.0	.0	0.0	.0	.2	1.0	.8	
12 I	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	.0	.1	.8	
*13 S. QUEBEC													
TOTAL (KTON SO4)	.9	19.6		10.8	.3	5.8	13.4	3.2	7.9	11.4	4.3	6.3	

*No 1985 projected emissions were available from these regions.

OCTOBER 1985

TOTAL CONTRIBUTIONS TO SO4 DRY DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.2	.1		.2	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.2	2.8		1.0	.0	.5	1.7	.6	1.4	1.2	.5	.3	
*3 S. ONTARIO													
4 VII	.2	1.0		3.0	.0	1.4	2.1	1.2	1.1	.8	.2	.0	
5 VIII-SOUTH	.0	.0		.1	.0	.0	.0	.0	.0	.0	0.0	0.0	
6 VI-EAST	.1	.2		2.1	.0	7.2	.5	.6	.2	.0	.0	.0	
7 V-SOUTH	.3	2.3		2.5	.0	1.6	6.3	3.1	5.5	3.9	1.3	.4	
8 IV-SOUTH	0.0	.3		.2	0.0	.9	.6	4.0	1.3	.0	.0	.0	
9 IV-NORTH	.0	.6		.6	.0	.9	1.4	3.2	4.4	.9	.1	.1	
10 III	.1	.4		.4	.0	.2	.8	1.2	1.6	2.6	.8	.4	
11 II	.1	.1		.1	.0	.1	.1	.1	.3	.6	.8	.5	
12 I	0.0	.0		.0	0.0	.0	.0	.0	.1	.2	.1	.5	
*13 S. QUEBEC													
TOTAL (KTON SO4)	1.2	7.8		10.1	.1	12.9	13.6	14.0	16.0	10.3	3.8	2.2	

TOTAL CONTRIBUTIONS TO SO4 WET DEPOSITIONS WITHIN RECEPTOR REGIONS

EMITTER REGION	1	2	3*	4	5	6	7	8	9	10	11	12	13*
1 VIII-NORTH	.1	.1		.1	.0	.0	.0	.0	.0	.0	.0	.0	
2 V-NORTH	.2	2.9		1.2	0.0	.2	1.4	.3	.6	1.4	1.5	.5	
*3 S. ONTARIO													
4 VII	.3	1.6		4.0	.0	.4	2.2	.4	.9	1.3	.6	.0	
5 VIII-SOUTH	.0	.0		.0	.0	.0	.0	.0	.0	0.0	0.0	0.0	
6 VI-EAST	.5	.3		6.3	.0	5.1	1.6	.8	.9	.1	.0	.0	
7 V-SOUTH	.5	4.1		4.1	.0	.6	7.2	1.0	3.4	5.2	3.7	.5	
8 IV-SOUTH	0.0	.2		.8	0.0	.9	2.7	3.8	3.2	.4	.0	.0	
9 IV-NORTH	.0	.7		1.9	0.0	.5	3.3	1.2	5.8	1.8	.4	.1	
10 III	.1	1.0		.6	0.0	.1	2.4	1.1	1.5	3.1	2.3	.5	
11 II	.0	.1		.1	0.0	.0	.5	.1	.7	1.0	1.6	.9	
12 I	0.0	.0		.0	0.0	.0	.1	.0	.2	.6	.6	1.2	
*13 S. QUEBEC													
TOTAL (KTON SO4)	1.9	10.9		19.2	.0	7.9	21.5	8.6	17.2	15.0	10.7	3.6	

*No 1985 projected emissions were available from these regions.