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Illinois State Water Survey
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STUDY OF RAINOUT OF RADIOACTIVITY IN ILLINOIS

Twelfth Progress Report
Contract Number AT(11-1)-1199
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by

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ABSTRACT

The field experiments have been continued to estimate convective storm particulate scavenging efficiency in proximity to the St. Louis, Missouri urban-industrial complex. Complimentary studies of the urban aerosol characterization, source strength, and removal processes were also studied.

The 1973 field effort produced the following types of samples for analysis and interpretation: 1) 1513 total rain samples from 81 sites; 2) 450 sequential rainwater samples from 3 locations; 3) 266 wet/dry samples from 8 sites; 4) 270 air filter samples from 7 locations; 5) 81 Andersen impactor samples from 3 sites; 6) 14 water samples from aircraft in-cloud and precipitation at cloud base; and 7) 9 air filter samples from aircraft. The analysis procedures require that all water samples undergo filtering for separate analyses of soluble and insoluble fractions of the elemental concentrations. This data collection effort provided 4868 samples for chemical analysis.

The status of the analysis of all types of data is described. The preliminary results of an attempt to estimate urban aerosol source coefficients and the source strength of St. Louis are presented.

ACKNOWLEDGMENTS

The successful operation of a field project of this magnitude requires the full cooperation of every individual involved. This has certainly been true of METROMEX from the outset and was more than true in 1973 when many people were asked to go beyond the normal routine of activities and perform added tasks. To all of our METROMEX colleagues, we extend a heartfelt thanks for enduring the hardships placed upon you by us in our pursuit of the scavenging studies and tracer experiments.

We gratefully acknowledge the assistance of Prof. Roscoe Braham, University of Chicago, for obtaining in-flight air samples for our aerosol studies. Likewise, the cooperation of Mr. August H. Auer, University of Wyoming, is gratefully acknowledged for acquiring water samples inside of cumulus clouds and in the precipitation at cloud base.

This research could not be accomplished without the total dedication of Anthony Rattonetti and his associates in the Chemistry Laboratory. This group of men and women have worked beyond expectations in performing seemingly impossible tasks. Without this sort of effort, the analysis would be hopelessly behind.

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INTRODUCTION

The field efforts on this contract have been directed toward the use of tracer chemicals to study the scavenging processes in convective thunderstorms for the past 3 years. The effort was moved in 1971 from the central Illinois area (Project ITREX) to the major field project, METROMEX, in the St. Louis, Missouri area. This project was described in great detail in Eleventh Progress Report. The METROMEX program was envisioned as a 5-year data collection project followed by an additional period of time to catalog and analyze the data relating to the inadvertent modification of precipitation by urban influences. The Survey AEC effort has been a vital part of this project of national importance.

The past 3 years of data collection have been very fruitful, and some preliminary results have been brought together in 2 major publications; the Eleventh Progress Report under this contract, and the report COO-1199-34 in Appendix B of this report. Additional papers have been published and the results of specific research topics have been presented at various scientific meetings (see Appendix A).

Although minor alterations have occurred in the field operations as dictated by the preliminary findings, the results obtained to date have not caused major changes in the emphasis of the research project. An extensive data base of surface and upper-air measurements has been acquired and will necessitate a period of time at the succession of the field effort to interpret the observations. Further efforts of analysis will be required to present the results in a form useful for the prediction and assessment of the impact of our growing urban centers on the frequency, amount, and quality of precipitation.

Since the Eleventh Progress Report contained a comprehensive description of the types of data gathered under the auspices of this contract, and also listed the quantity of observations as well as a status report of the analysis phase at that time, this report will deal with the effort expended during FY-74 in the field and in analysis.

FIELD DATA COLLECTION

A summary of the Water Survey field activities in METROMEX for 1973 is presented in report C00-1199-36 in Appendix B. The following paragraphs will amplify the portions of the data collection effort pertinent to the scavenging research.

AIRCRAFT

The aircraft used for the tracer release flights was flown on 33 occasions during 1973 and logged a total 59.75 hours of flight time. During the 6 week period of flight operations, 7 tracer missions were conducted. The remain 26 flights were composed of second priority sampling missions or aborted attempts to release tracers.

The alternate flights for the aircraft were carried out to provide data on the structure of the atmosphere prior to and during the development of convective activity which is essential to the complete understanding of storm development and structure.

On at least 2 occasions attempts were made to release tracers in the low-level updraft region of a thunderstorm while the aricraft of Battelle

Northwest Laboratories attempted the release of multiple tracers at an upper-level inflow region of the same storm. These flights were not successful during 1973 primarily due to the severity and complexity of the storm systems and the inability to simultaneously communicate with both aircraft. The accompanying proposal for 1974 will address this problem and suggest a solution for the successful dual-aircraft, multi-tracer release experiments.

NETWORK

The instrumentation installed, maintained, and operated under funds from this contract during 1973 within the primary METROMEX research circle (Fig. 1) included: 1) 81 total rainwater samplers; 2) 8 raindrop spectrometers; 3) 7 wet/dry samplers; 4) 3 sequential rain samplers; 5) 7 air filter samplers; 6) 3 Andersen impactors; 7) 1 rawinsonde; and 8) 1 TPS-10 radar. The total rainwater collection network was operated on a nearly continuous basis during the period 9 July through 30 August with changes of samplers occurring each 24 hours. The operation of the network produced rain samples on 14 days and dry samples on 5 days. Included in the samples were tracer experiments on 9, 23, and 30 July, and 9, 10, 12, and 13 August. Since the collected samples, in general, are filtered to separate insoluable and soluable materials, the experiments produced a total of more than 3,000 samples for chemical determinations.

A total of 8 raindrop spectrometer sites were instrumented during the period 15 June through 21 August 1973. Some of these instruments were utilized as a rain-switch for the wet/dry samplers to activate the mechanism exposing a sampler to the rain while closing the side exposed to dry fallout.

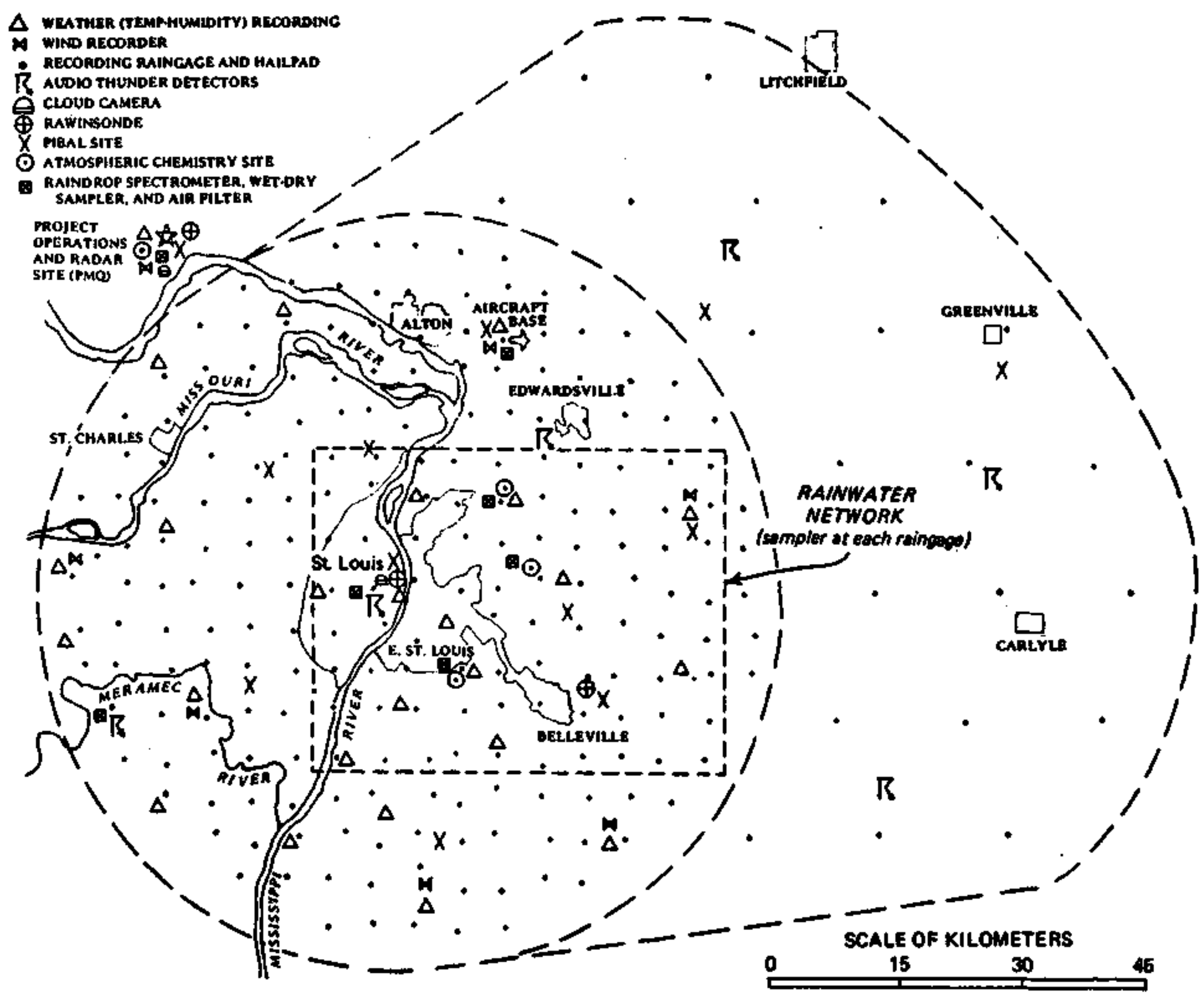

Figure 1. METROMEX networks and facilities of Illinois State Water Survey.

These raindrop spectrometer data are used to assess the scavenging efficiency of individual storm case studies. The distinct difference between the average rural drop-size distribution and the down-city distributions is striking (Semonin and Changnon, 1974) and must be evaluated for its contribution to the total downwind removal efficiency of modified storm events.

A special network of 7 wet/dry samplers, 3 sequential rain samplers, 7 surface air filter samplers, and 3 Andersen impactors was operated to collect data required for the determination of scavenging ratios. These samplers were in operation during the period 12 June through 20 August. A total of 266 wet/dry samples were obtained during the operational period along with 270 air filters, 450 sequential rain samples, and 81 samples from the Andersen impactors. As with the network total rain samples discussed above, the wet/dry and sequential rain samples are filtered resulting in a doubling of the sample size for chemical analysis. The operations of this sub-network yielded a total of more than 1700 samples for routine analysis in the chemistry facility.

AIRFLOW

The airflow studies accomplished in 1971, the first year of the METROMEX field project, were carried out while the principal scientist, Dr. Bernice Ackerman, was employed with the Argonne National Laboratory. Subsequently, Dr. Ackerman was employed at the Survey and the airflow studies in the summer of 1972 were carried out with multi-agency support. In both years the primary field observational effort was accomplished with the support of the Air Weather Service mobile weather teams.

In 1973 due to a severe cutback in the Air Weather Service capability to support this program, personnel and funds were internally redirected, with partial support of new money from the National Science Foundation to continue this vital work. The AEC assisted greatly in this effort by providing a considerable portion of the expendables for the operation and by cooperating with the Survey in acquiring 3 surplus GMD-1 rawinsonde units for operation in the field. One of these rawinsondes was installed at the Pere Marquette Field Headquarters and operated almost daily from 9 July -23 August. This observational capability at the field headquarters was extremely useful in providing the duty meteorologist with a current sounding of the atmosphere and also the ability to acquire special soundings as the daily synoptic weather demanded.

This program in 1973 involved the release of approximately 260 radiosonde flights from 3 sites. The locations of the ground recorders were at Pere Marquette, the Gateway Arch, and Belleville providing a line of observing stations oriented northwest-southeast across the research circle. More than 2200 pilot balloons were released from 10 sites scattered throughout the research circle in a manner to allow the determination of the divergence field in proximity to the major urbanized area of St. Louis.

TPS-10 RADAR

This vertically scanning radar was used extensively, as in previous years, to assist in directing the aircraft operations. During tracer missions, the data were acquired on 16-mm film for subsequent analysis. The radar was operated during the period 15 June through 19 August for the purpose of directing the aircraft and only sporadic data are available. After the cessation of the tracer operations and through 30 August routine operations over the METROMEX research circle provided data on all storm systems.

ANALYSIS EFFORT

The results obtained from the preliminary analysis of the data from the first 2 years of the field effort have been summarized in the report by Huff (1973). A similar report is in preparation concerning the detailed analysis of several storms during the years 1971, 1972, and 1973. This report will be available in late 1974, and will be distributed at that time.

This summary of the analysis effort contains a status report of the various data collected during the 1973 field effort, and summarizes the total data collected during the first 3 years of the project.

AIRCRAFT DATA

The primary function for the aircraft services during the past 3 years has been to release tracer chemicals into the updrafts of convective and other precipitating systems. These operations are entirely dependent upon the occurrence of precipitation approaching or within the sampling area, and it was necessary to have alternate missions for the aircraft for those periods of time when precipitation was not imminent.

The urban area offers the opportunity to use many of the natural and anthropogenic aerosols as tracers for the scavenging research. It is desirable, therefore, to characterize the aerosol concentration as a function of varying synoptic weather conditions. In addition, observations of the structure of convective clouds of all types are valuable to achieve the goal of a convective cloud model for the scavenging prediction.

A very cursory examination of the 1973 aircraft data show that a most comprehensive set of measurements were obtained during 1973 and the analysis program to examine the data in detail is under way. The measurements obtained while in flight are recorded in strip-chart form and require considerable editing, and handling before the data can be used for either case study or modeling research. The charts for the previous years have been partially hand-analyzed for discrete portions of the records. As we anticipate only 2 more years of field experiment, it is appropriate to begin the reduction of all of these data for the final analysis and interpretation of the full 5 year project.

The aircraft data analyzed thus far have shown results which are useful for the guidance of the overall tracer operations as well as having direct application to the overall METROMEX studies of precipitation scavenging. An examination of a few of the variables recorded during aircraft missions has revealed the following: 1) the existence of a measurable temperature anomaly over the urban area of St. Louis at an altitude of 1500 feet; 2) the discernment of the urban plume by condensation nuclei concentrations which are in excellent agreement, when properly interpreted, with cloud condensation nuclei observations; 3) discrete sources of ice nuclei have been identified; and 4) the recognition that many convective storms in the area feed upon multiple updrafts which is extremely important for understanding the scavenging process in Midwest thunderstorms.

NETWORK DATA

The interpretive analysis of the chemistry data obtained from the various network operations has been directed toward their use in a limited number of case studies. To facilitate the interpretation of all of the chemistry data, the laboratory results have been formatted for computer processing to produce statistical information as well as useful data for individual storm studies.

Some examples of the results from tracer experiments have been shown by Semonin (1972, 1973) and Gatz (1974a). The results from the scavenging ratio measurements have been given by Gatz (1973, 1974) and the utility of the data in determining the urban source strength is given below.

The spectrometer data were used to demonstrate the differential average drop-size between rural and urban convective storms (Semonin and Changnon, 1974), but the data have not been mated with the chemistry to identify the role of precipitation particle size distributions and chemical concentration of various elements. All of the available spectrometer data are undergoing editing and processing for incorporation into the data bank of weather variables for the scavenging analysis.

Our air filter samples are collected primarily to measure atmospheric concentrations of elements residing on particles, for comparison with concentrations of the same elements in rain. However, these data on elemental concentrations in air can also be analysed to yield additional information pertinent to the mission of the AEC Division of Biomedical and Environmental Research. More specifically, the data can be used to provide estimates of two important parameters that relate to the source term-in mass budget equations applied to atmospheric constituents.

The first of these parameters is the <u>source coefficient</u>. A source coefficient is the fraction of the total aerosol concentration at a given receptor contributed by a particular kind of source (e.g., wind-raised soil dust or automobile exhaust). Evaluation of source coefficients for all measurable source types, both natural and man-made, at a given receptor, puts into perspective the pollution problem at that particular site, in that i't indicates the relative contributions of all known sources to the total aerosol concentration. Such information makes it possible to evaluate alternate abatement strategies.

The second source parameter that may be estimated from filter measurements is the area-wide emission rate of the various elements measured on the filters. Knowing the emission rate (in tons/yr) of Pb, say, in the St. Louis area allows us to put our measurements of wet and dry deposition of Pb into perspective against the amount of Pb released. This provides the kind of information necessary to make statements about how much of a given element was released into the atmosphere in a given area in a given time, what fraction was deposited within some distance of the source, and what fraction left the area. Such information is important to assessments of elemental pathways through the environment to man.

Source Coefficient Calculations

The calculation method was given by Miller *et al.* (1972). It requires measurements of certain "tracer" elements (ordinarily one tracer element per source evaluated) in the atmosphere, plus estimates of the elemental composition of each source's emissions. Emission compositions used in these calculations are those given by Winchester and Nifong (1971) and were also used by Gatz (1974) to compute source coefficients for Chicago.

The aerosol compositions used in the calculations are given in Table 1. They are median abundances (percents of total aerosol mass) measured at 4 locations (shown on Fig. 2). The number of samples from each site is shown in the table; these samples were collected on days when rain was expected in the St. Louis area.

A fundamental difficulty with this method, as applied to these calculations, lies in the selection of tracers for soil dust and coal

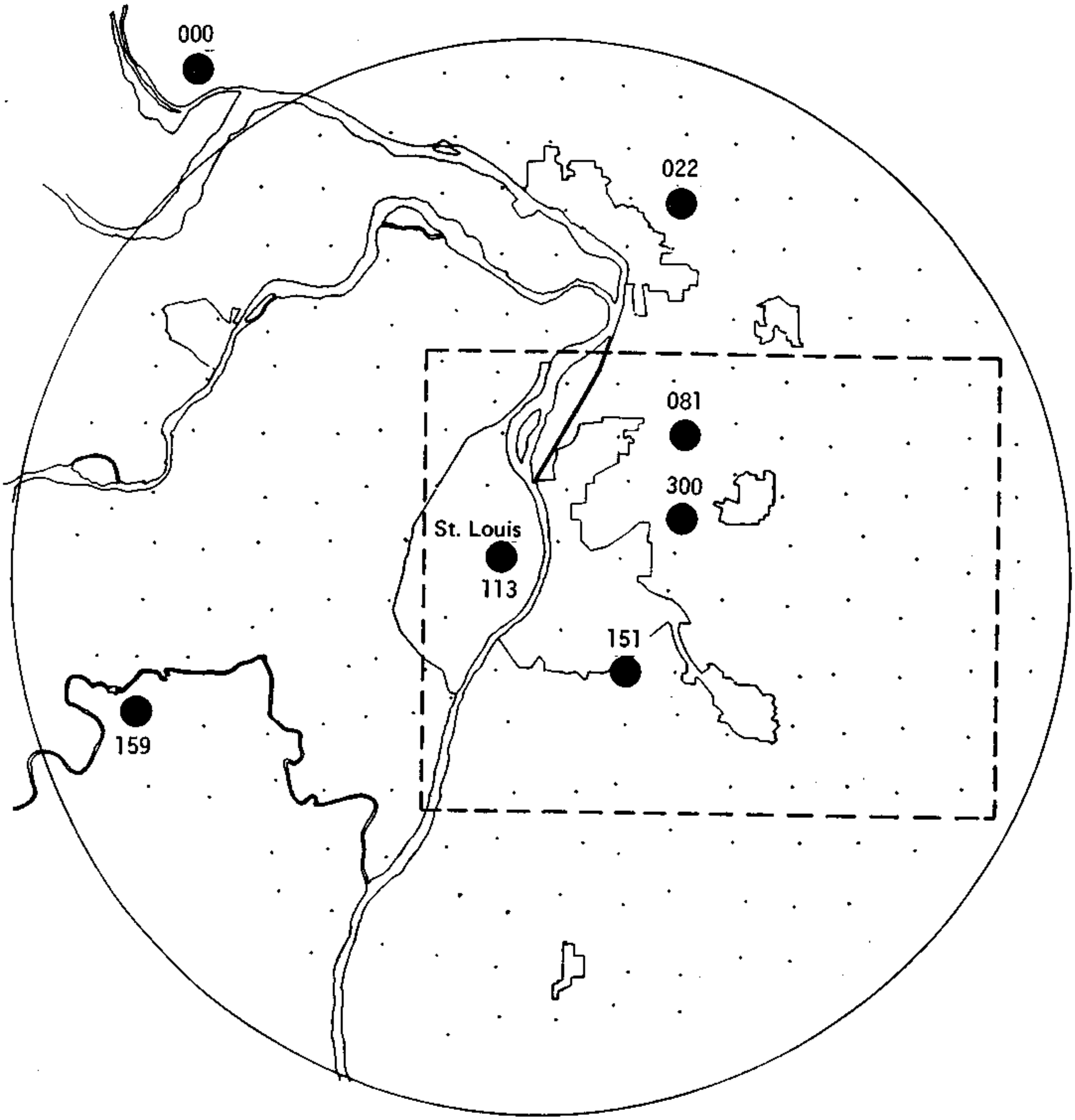

Figure 2. Location of wet/dry samplers and air filter equipment for aerosol emission studies in METROMEX-1973.

Table 1. Median abundances of "tracer" elements in aerosols at 4 locations in the St. Louis area.

Element	Source Type	Median Abundance in Aerosols, %, by gage number			
		n=16[b]	n=16	n=16	n=12
		000	022	113	300
Al	Soil dust, coal combustion[a]	0.56	.0.26	0.85	0.24
S	Secondary sulfate formation	6.6	4.5	4.6	3.2
K	Soil dust[a]	1.1	0.85	0.95	0.85
Ca	Cement manufacturing	3.5	4.2	5.9	5.9
V	Fuel oil combustion	0.050	0.035	0.036	0.103
Fe	Steel manufacturing	2.2	2.4	3.4	2.0
Pb	Auto exhaust	0.34	0.66	1.1	0.36

[a] Al was used to calculate both the lower limit of the soil contribution and the contribution from coal combustion. K was used to calculate the upper limit of the soil contribution.

[b] n=number of samples.

combustion sources. It turns out that Al is the best tracer for both sources, but this has made it impossible to distinguish the separate contributions of these two sources. A method has been presented by Friedlander (1973), utilizing least-squares fitting of 7 equations in 5 unknowns (the source coefficients) that may overcome this difficulty.

For now, however, we report only estimated upper and lower limits to the source coefficients for soil dust and coal combustion. The upper limits are based on assuming that K and Al come exclusively from soil and coal, respectively. Lower limits result from assuming an even split of Al between the two sources after accounting for the Al from the other sources considered.

The uncertainties in the soil and coal coefficients cause a corresponding uncertainty in the estimate of the source coefficient for cement manufacturing. Thus, we report only a possible range of these values at this time.

In addition to primary aerosol sources, where aerosols are released to the atmosphere directly, the data allow the estimation of one secondary source, in which aerosols are formed in the atmosphere by gas-to-particle conversion reactions. The production rate of sulfate was calculated assuming that all measured S was in the form of sulfate.

Computed source coefficients are presented in Table 2 for the 4 sampling sites in the St. Louis area. We emphasize that these results are preliminary; improved estimates should be forthcoming within the next several months.

Any discussion of these preliminary results must necessarily be very tentative. However, it may be worth pointing out a few prominent features. First of all, the relative contributions of the various sources does not vary greatly from site to site, despite the fact that the locations include

Table 2. Preliminary estimates of source coefficients for 4 sampling sites in the St. Louis area.

Source Type	Source Coefficients, by Sampling Site %			
	000	022	113	300
Soil dust	3-54	0.5-1+3	6-47	0-42
Coal combustion	1 - 4	0.2-2	2 - 6	0 - 2
Fuel oil combustion	2	1.4	1.4	4
Steel manufacturing	5	6	8	5
Auto exhaust	1	2	3	1
Cement manufacturing	3 - 7	6 - 9	9-10	10-13
Sulfate (secondary)	20	14	14	10
Total	17 - 93	30 - 76	43 - 89	30 - 77

both urban (113) and rural (000) sites. Secondly, notice that totals, even summing the largest estimated values, are all less than 100%. This has been the case for both Pasadena (Miller et al. 1972) and Chicago (Gatz, 1974). Furthermore, such occurrences should be expected, because water and carbon, much of it formed in the atmosphere from reactions of gaseous hydrocarbons , can account for up to half of the mass of a typical aerosol sample.

Let us turn, now, from this very preliminary look at the relative contributions of various source types to the total aerosol mass, to estimates of area-wide emission rates of some individual elements.

Elemental Emission Rates

Area-wide emission rates of individual elements are of increasing concern, especially in the case of toxic heavy metals like Pb or Cd. Such emission rates have been estimated (Winchester and Nifong, 1971) from such published data as either fuel consumption or industrial production figures, "emission factors", and the chemical composition of emissions from individual sources. Because of the possibility of sizeable uncertainties in estimating these parameters from a few measurements of specific fuels or at specific manufacturing locations, the resulting emission rate estimates are subject to substantial errors.

An alternative method, involving field measurements of elemental concentrations in air, is available. However, it, too, is subject to some uncertainties. This method assumes that emissions take place into an atmosphere in which aerosols both upwind and downwind of the city are uniformly mixed from the surface to some impermeable upper boundary. Then the emission rate, E, is given by

$$E = \frac{H \cdot (Ca - Cu)}{t}$$

where H is the depth of the mixed layer (m), Ca is the measured concentration ($\mu g/m^3$) downwind of the area, Cu is the corresponding concentration upwind, ant t is the time in seconds for an air parcel to traverse the area.

Preliminary emission rate estimates have been computed from available 1973 aerosol samples based on the following assumption:

1) H = 2000m
2) Upwind concentrations may be approximated by mean values at sites 000 and 159
3) Downwind concentrations may be approximated by mean values at sites 022, 081, 113, 151, and 300, and
4) t = 9000 sec. (corresponds to wind speed of 4.1 m sec^{-1} crossing an area 37 km wide).

Results are presented in Table 3, along with estimated production rates for other areas from the literature.

There is little reason to make detailed comparisons of the estimates for the several cities at this time because the reliability of each has not been verified by independent methods. It is worth noting, however, that production estimates for the Chicago - Milwaukee - Gary area generally exceed those for St. Louis, as would be expected from their relative populations and industrial activities. For one group of elements (Fe, Mn, Al) the Chicago estimates are higher by factors of 15 - 30, which seems excessive. On the other hand, the St. Louis estimate for K is higher by a factor of 130, also excessive. No explanation is offered for these differences at this time.

These preliminary results on source coefficients and area-wide production rates have been included to illustrate two kinds of secondary information

Table 3. Preliminary area-wide elemental production rates for St. Louis area, based on environmental measurements, with comparative data from the literature.

Element	St. Louis, this study	Chicago-Milwaukee-Gary, Winchester and Nifong (1971)	Los Angeles, Friedlander (1973)
Al	1,600	50,000	
Si	10,600	65,000	
S	7,400[a]	750,000[b]	
K	2,100	16	
Ca	21,500	41,000	
Ti	900	2,600	
Mn	260	5,100	
Fe	6,300	95,000	
Zn	1,300	1,300	360
Pb	2,600	2,400	7,300 - 11,000

[a] Particulate only

[b] Total (gaseous plus particulate)

available from our aerosol analyses, and to present approximate values of the parameters. Recalculation of these parameters is planned for the next few months as newer methods are applied and/or pertinent meteorological data (e.g. winds, mixing heights) become availabe.

The chemistry data have produced some preliminary results of importance to the understanding of scavenging by convective storms. The salient paints may be summarized as follows:

1) The tracer material released from ground sources is processed by clouds and precipitation in sufficient time to be observed by the total rainwater collector network.

2) The release of tracers from aircraft demonstrate the rapid transport of the material between various convective "elements" and the wide areal dispersion of the tracer.

3) The displacement of the deposition maxima of the lithium (hygroscopic) and the indium (non-hygroscopic) tracers is indicative of the different scavenging processes for these materials.

4) The spatial variability of the deposition of those elements for which chemistry analysis are available and the pH of the rainwater show more variability than the rainfall, indicating a complex problem for the numerical simulation of wet scavenging processes.

AIRFLOW DATA

The numerous rawinsonde and radiosonde data acquired during 1973 have been checked, edited, and computer processed. The computer output consists of a plot of temperature and humidity as a function of altitude for every contact point of the radiosonde baroswitch. These observations are being used for the various case studies which are under investigation and examples of their utility were given by Grosh and Semonin (1973).

The pilot balloon observing network data are vital for the determination of the scavenging efficiency of convective storms as they traverse the research area. These data, in conjunction with the radiosonde data, are used for the calculation of the precipitation efficiency of storms as shown by Grosh and Semonin (1973). The trajectories of the airflow determined from the network measurements are also useful to separate urban-affected storms and those that can be treated as control storms.

Examples of the utility of the data in estimating the effect of the urban region on the airflow have been given by Ackerman (1972, 1974). The convergence of the low-level flow in response to the urban heat island and structural shape is an important concept for consideration in numerical efforts to simulate the urban environment and its effect on the atmosphere.

The analysis of these data, thus far, has been dictated by specific need in case studies of selected storms (Grosh and Semonin, 1972), and airflow situations (Ackerman, 1974). While funds were allocated for partial support of this extremely important observational effort, the-total analysis and interpretation of the data must await the closure of the field project or the acquisition of additional funding.

TPS-10 RADAR DATA

This radar is used to assist in directing the aircraft operations and to provide observations of the 3-dimensional structure of storms of interest. The data were acquired by 16-mm time-lapse photography and consequently the task of reducing all of the data is enormous since it is manually reduced. However, select portions from the operational period are carefully analyzed to assist in the determination of water budgets in the tracer-treated storms. The tediousness of such analysis has precluded the completion of many cases and only two examples are presented in the paper by Grosh and Semonin (1973).

Considerable effort is yet to be expended to incorporate the radar information into the interpretation of all of the tracer cases. Future operations will not require this type of data analysis since the FPS-18 radar will be programmed to automatically record, on magnetic tape, the 3-dimensional storm structure at 5 minute or less intervals. These data are recovered by computer techniques and will accelerate this vital part of the analysis effort.

SUMMARY OF PROGRESS

The assessment of the scavenging efficiency of convective storms is dependent upon the availability of the chemistry analysis of the various samples acquired in the field as well as all of the supporting data from the other various components of the field project. The status of the laboratory analysis of the observed data is shown in Table 4. The progress toward completion of the 1973 data and data acquired in previous years has been significantly delayed recently. The work load in the laboratory had outstripped the facility and the Water Survey is currently investing considerable funds into the renovation of the laboratories which upon completion will allow the analyses to proceed at a greater rate. The laboratory modifications will not be completed until May 15 and all analysis has been halted since March 1. The 2 and one-half month loss in effort.on this aspect of the research has not seriously hampered the overall effort since considerable data were available for interpretive analysis which is currently underway.

Approximately 12 case studies of convective storms are in various stages of analysis at the present time. These analyses will bring together

Table 4. MMX - 73 Atmospheric Chemistry Sample Analysis Status as of 5 March 1974.

	No. of Samples		
Sample Type	Collected	To Be Analyzed	Status
Wet/Dry Samples	266	266	All filtered, no filters ashed. No analyses done.
Network Rain	1531	814	All filtered, no filters ashed. All soluble portions from Expts. 160, 167, 168, 172, 173, 180, 181, and 183 analyzed for Li, Na, K, Ca, Mg, and Zn.
Aircraft Water Samples	14	14	All analyzed (unfiltered) for Li, K, and Zn.
Aircraft Filters	9	9	All analyzed by U. C. - Davis
Ground Filters			
Whatmans	100	74	All ashed, none analyzed
Nuclepores	170	113	94 analyzed by U. C. - Davis
Sequential Rain	450	358	All filtered. No filters ashed. No analyses done.
Andersen Samples	81 Stages	27 Stages	None ashed. No analyses done.

the data from all aspects of the Water Survey effort and will also include measurements from other groups as they pertain to the individual case under investigation.

The research studies of the aerosol characterization in the St. Louis area have shown that useful results can be obtained from a minimum network of sampling stations. The results have also shown that more fruitful work can be accomplished with the realignment of a few of the sampling stations. This type of finding is useful and will allow more representative samples for the remaining 2 years of the field effort and will also allow more intelligent placement of instruments in the future for work of a similar nature.

The surface rainwater network data show that the 700 square mile area is too small to determine the total budgets for various chemical elements, but they also indicate that sufficient material is collected to permit realistic estimates of the areal deposition rate and thus useful data for verification of numerical modeling efforts.

PERSONNEL

The Principal Investigator, Richard G. Semonin, has devoted 60% of the past 12 months to the conduct of this research. This percent is an increase of 10 percent above that stated in the proposal for that period of the contract.

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APPENDIX A

Reprints, Reports, and Presentations

1971 - 1973

APPENDIX A

Reprints, Reports, and Presentations
1971 - 1973

Reprints

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APPENDIX B

Recent preprints, reports, and reports of research wholly or partially supported on Contract AT(11-1)-1199.

COO-1199-31

Final Report METROMEX 1973: A summary of operations conducted by Atmospherics Incorporated during the period 7 July through 19 August 1973

T. J. Henderson, and D. W. Duckering

1973

COO-1199-32

Results from METROMEX

S. A. Changnon, Jr., R. G. Semonin, and W. P. Lowry

1972

COO-1199-33

Moisture budgets and wind fields of thunderstorms passing over an urban area in the Midwest

R. C. Grosh, and R. G. Semonin

1973

COO-1199-34

Summary Report of METROMEX Studies, 1971-1972

F. A. Huff, Editor

1973

COO-1199-35

Washout ratios in urban and non-urban areas

D. F. Gatz

1972

COO-1199-36

1973 Operational Report for METROMEX

W. P. Lowry

1973

COO-1199-37

A collection of papers, 1974

Staff: "METROMEX: An overview of Illinois State Water Survey Projects"

Huff, F. A. and P. T. Schickedanz: "METROMEX: Rainfall analysis:

Gatz, D. F.: "METROMEX: Air and rain chemistry analyses"

Ackerman, B.: "METROMEX: Wind fields over St. Louis in undisturbed weather"

Semonin, R. G. and S. A. Changnon, Jr.: "METROMEX: Summary of 1971-1972 resuts"

APPENDIX C

AEC-1199

Reports, Reprints, and Preprints

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Reports, Reprints, and Preprints

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COO-1199-6 Huff, F. A., 1965: Radioactive rainout relations in convective rainstorms. Res. Report No. 1 to U. S. Atomic Energy Commission. Contract AT(11-1)-1199, 131 p.

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COO-199-36 Lowry, W. P., 1973: 1973 Operational Report for METROMEX. Illinois State Water Survey, Urbana, 63 pp.

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