RECHERCHE ATMOSPHÉRIQUE

Air Quality and Inter-Environmental Research Branch

Annual Report

1986-87

Environment Canada / Environnement Canada

Atmospheric Environment Service / Service de l'environnement atmosphérique

REPORT: AQRB-87-M-002

AIR QUALITY AND INTER-ENVIRONMENTAL RESEARCH BRANCH

ANNUAL REPORT

1986-87

Compiled by

M.E. Still

Illustrated by

F. Fanaki

Cover Photograph by

N.B.A. Trivett

May 1987

This is one of a series of management reports produced by the Research Directorate. It is intended for internal use only.

Air Quality and Inter-Environmental Research Branch
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario, Canada M3H 5T4

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

Foreword

by: James W.S. Young, Director

Air Quality & Inter-Environmental Research Branch (AQRB)

The Air Quality Services Program in AES exists to provide government with adequate information on the chemical and physical state of the atmospheric environment, and an understanding of its trends, for informed policy decisions relating to environmental quality.

Over the next two decades the Program will expand and be more broadly based. Its core of highly skilled scientists and technicians will be strengthened. The Program will be at the cutting edge of advances in science leading to an increased understanding of atmospheric processes. As a result of the shared jurisdictional responsibility and a need to focus Canada's talent and attention on certain issues, the Program will work more closely with allies in industry, universities and other government agencies to maximize the potential of the Program's resources. With the overall change and focus embodied within a new Air Quality Services Strategic Plan, the Program intends to develop its infrastructure and services to provide essential information on air quality issues to both government and the public.

The Program will continue to be primarily research-oriented and will provide government with information in support of policy decisions regarding the maintenance of environmental quality. However, this advice and guidance will be balanced with the need to provide Canadians with adequate information on the state of the national environment. The Program will have:

(1) increased the focus on environmental integration and provided more current information on air quality;

(2) participated actively with industry, the provinces and the universities in environmental research centres tackling specific environmental issues;

(3) provided improved access to its information and supported routine dissemination of air quality to the public; and

(4) a greater fraction of AES resources in line with its expanded role.

In terms of key thrusts, the Air Quality Services Program will:

(1) pursue provincial, federal, industry and university support for the development of integrated environmental research centres as a mechanism for leverage of environmental studies;

(2) reorganize to formally recognize the importance of integration activities and the analysis of routine and non-routine measurements;

(3) enhance the Program's human resource base of management, scientific and technical talent;

(4) develop and employ automation in data measurement wherever cost-effective to do so;

(5) support operational directorates in maintaining the data archive and in the dissemination of information pertaining to air quality;

(6) pursue means of converting external funding to ongoing operational resources and increasing the overall level of funding to the Program;

(7) actively promote the importance of atmospheric research in providing the spin-off benefits to the Canadian economy;

(8) actively support the growth of the private sector in air quality services in Canada;

(9) actively solicit advice and guidance from industry, universities and other governments as to the definition of our basic level of services and other issues of importance to the Program; and

(10) actively cooperate with international agencies on major atmospheric experiments.

By the year 2007 the Air Quality Services Program will provide the essential support for all air quality activities in Canada.

Come and get your annual report illustrated by Fouad

3. AQRB program for 1986-1987

3.1 ACID RAIN

3.1.1 Liaison and Co-ordination

The Branch undertook the liaison and coordination of the atmospheric component of the federal Long Range Transport of Air Pollutants (LRTAP) Scientific Program for AES. Activities included the provision of input of data from the Canadian Air and Precipitation Monitoring Network (CAPMoN) 1979-1984 to the OECD report. A ministerial briefing report was prepared on AES acid rain programs with application to forestry. A summary of AES atmospheric program activities and future directions was submitted to the Interdepartmental LRTAP Committee Science Subcommittee.

Coordination of the AES regional LRTAP program involved requesting and submitting proposals for 1987-88, advising on results of the scientific and management reviews of these proposals, and undertaking discussions with AES regional staff.

Contact: E. Wilson

3.1.2 Eulerian Model Development

The inter-agency project to develop an Acidic Deposition and Oxidants Model (ADOM) using an Eulerian approach has now entered its fifth year. The original three funding agencies (Ontario Ministry of the Environment (OME), AES and the West German Umweltbundesamt) have been joined by the Electrical Power Research Institute (EPRI).

Meteorological and Environmental Planning Limited (MEP) is responsible for developing the North American database. The meteorological driving fields are obtained from the operational meteorological forecast products by using the spectral model to interpolate between 6-hourly sets of objectively analysed fields. The vertical resolution near the ground is then enhanced using a model developed by MEP. The contractor has delivered what are expected to be the final versions of:

(1) the hourly meteorological driving fields for the periods of the projects OSCAR (April 10-29, 1981) and PEPE/NEROS (August 7-13, 1980); and

(2) the hourly National Acid Precipitation Assessment Program (NAPAP) emissions inventory fields for point sources and area sources for weekday/Saturday/Sunday scenarios for each season in 1980, including values for Canada (these will also be used for 1981).

The preliminary model evaluation is being done using the OSCAR and PEPE/NEROS periods as special air quality observations are available.

Environmental Research and Technology Inc. (ERT) has developed the air quality portion of the model. This includes transport and diffusion, gas and aqueous phase chemistry, and wet and dry deposition of a number of chemical species. The first version and several upgrades were delivered this year. Model results to date have been obtained using the preliminary driving fields but, in future, model evaluations will use the driving fields from the OSCAR and PEPE/NEROS periods. One of the most challenging tasks is to develop a realistic cumulus cloud module.

Preliminary evaluation of the US Regional Acid Deposition Model (RADM) is also being carried out for the OSCAR and PEPE/NEROS periods.

Contacts: A.D. Christie, D. Davies

A review of the literature on dry deposition suitable for the Eulerian Model was conducted and documented in a draft report. The existing ADOM computer program was isolated and studied in part. The program will be rewritten to suit AES computers and new computer programs will be prepared for new model developments.

Contact: J. Padro

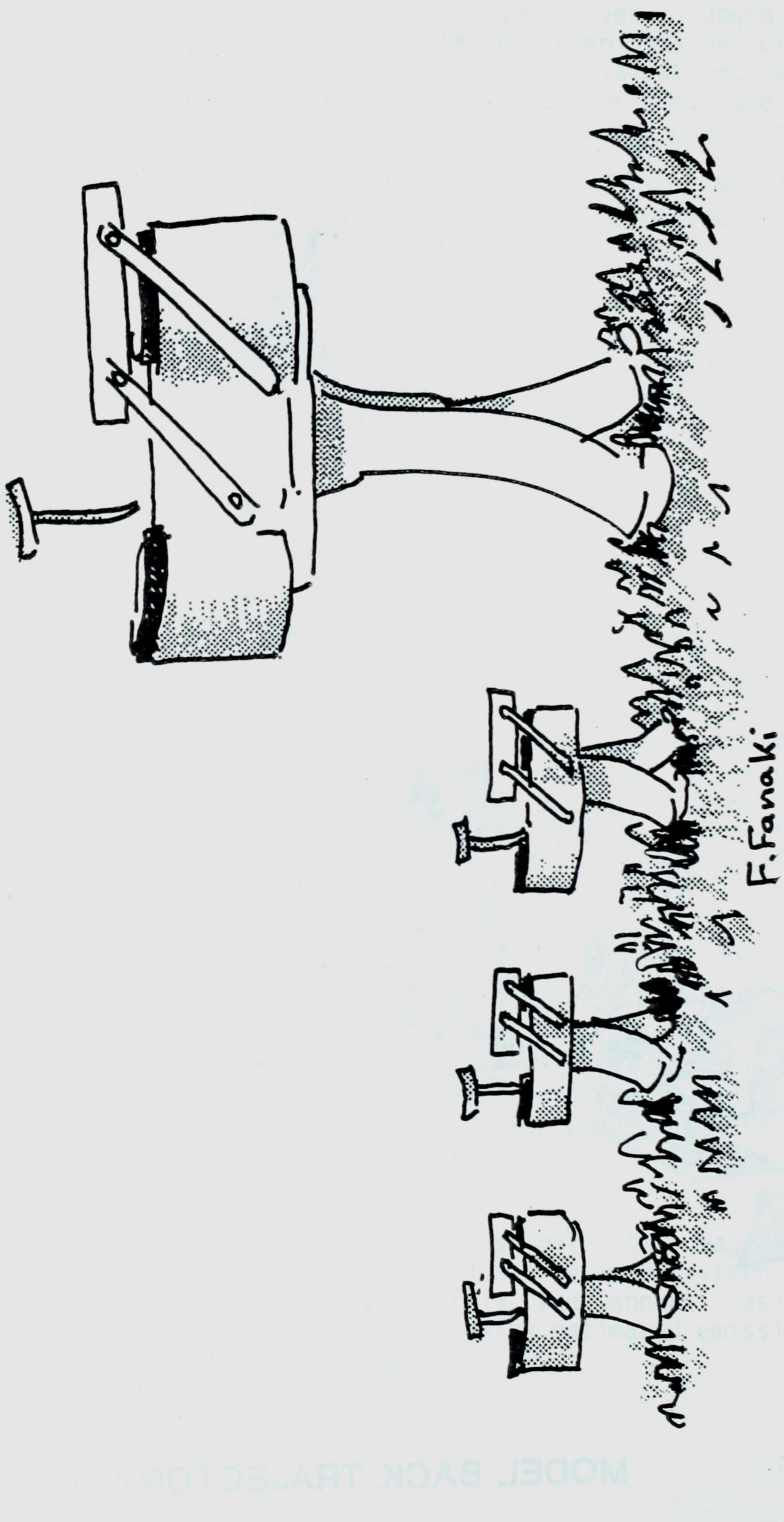
3.1.3 Lagrangian Model

Real-time back trajectories were computed for Alert during the Arctic Gas and Aerosol Sampling Program's (AGASP) 1986 experiment. The forecast trajectory program was activated following the Chernobyl nuclear reactor accident (April 26, 1986). A real-time trajectory computation program was installed to compute trajectories from Alert, Cape St. James and Sable Island for the Branch's carbon dioxide program. Cost recovery trajectory projects, using the Interactive Trajectory Computation and Plotting System (ITCAPS) procedure, were completed for Concord Scientific and Queens University.

The Lagrangian model was used to compute sulphur dioxide and sulphate concentrations for three levels in the atmosphere (925, 850, 700mb) at 36 points around the Arctic circle. A three-level Arctic basin sulphur budget model was developed which simulated the transport of sulphur into and out of the Arctic basin. Currently, the model can be confidently used to estimate the fraction of northern hemispheric sulphur that crosses the Arctic circle as a function of longitude. The model showed a strong late-winter inflow from Eurasia and a Canadian Arctic concentration maximum in March-April.

The Lagrangian model was used to investigate the magnitude and variability of the transboundary sulphur fluxes between eastern USA and eastern Canada for 1980-83 on a monthly and annual basis. For comparison, similar computations were done using estimated emissions for 1970 and 1994 and with 1980 meteorology.

MODEL BACK TRAJECTORY



NEW GENERATION OF SAMPLERS

The final report for the International Sulphur Deposition Model Evaluation project (ISDME) was extensively reviewed and is now being printed. The project evaluated eleven long-range transport models on 1980 wet sulphur deposition data using newly devised spatial analysis techniques. The study revealed different model characteristics and clustered the models into three classes based on their performances.

Contacts: M.P. Olson, E.C. Voldner, K.K. Oikawa

3.1.4 CAPMoN: Canadian Air & Precipitation Monitoring Network

This year the 19th site was added to the precipitation monitoring network. The site is at Esther in Alberta. On the basis of a survey of possible sites by AES Regional staff in British Columbia and central Quebec, two sites have been selected to commence operations next year: Saturna Island (BC) and near Chapais (Quebec).

An intercomparison study has commenced between CAPMoN and the United States National Atmospheric Deposition Program/National Trends Network (NADP/NTN). A CAPMoN station has been installed at the NADP/NTN Penn State site and a NADP/NTN station at our Sutton site (Quebec). Each network is following their respective protocols and using their own laboratory analysis facilities. Our Quebec regional inspectors have the responsibility for the CAPMoN station at Penn State and follow the same inspection protocols as they would for any other CAPMoN station. The study commenced in September, 1986. A preliminary analysis will be undertaken when a year's data have been collected and quality controlled.

The annual inspection of the 8 sites in the air monitoring network was completed. The three new precipitation monitoring sites mentioned earlier were selected so that air monitoring equipment could be installed at a later date.

The design of the new generation air sampling system was completed and all equipment has been purchased. The major design change was to the sampling head where the air filter packs are mounted. The switching of the filter packs is now undertaken in the head at the top of the 10-metre tower thereby eliminating the individual tubing required previously for each filter pack from a ground-based controller. A datalogger controls the switching and also logs the information on airflow, filter pack exposed and time. The next phase will be to test all the systems before deployment in the field.

The CAPMoN Quality Assurance Program was operated throughout the year and included the following: a CAPMoN Regional Inspector's Workshop (May 1986) to update inspectors on new and modified operating protocols; a blind sample submission program to assess laboratory performance; analysis of data from the two co-located collectors at three of the CAPMoN sites to determine the precision of the measurement data; and, finally, on-going data quality control. A contract was awarded for the on-going data quality control.

It was apparent from the quality assurance program that the operation of the CAPMoN wet deposition measurement program has significantly improved over previous years. This was evidenced by higher levels of data completeness compared to other years. A very interesting result of the assessment of the precision of the CAPMoN precipitation chemistry and wet deposition data was the finding that the two sets of instruments at the Sutton and Priceville sites produced 1986 annual sulphate and nitrate wet deposition values within 1% and 3% of each other, respectively. These preliminary data suggest that the measurement of annual wet deposition of sulphate and nitrate is very precise.

Contacts: M.E. Still, R. J. Vet

3.1.5 National Atmospheric Chemistry Database (NAtChem)

The NAtChem database is a federal/provincial facility for archiving, analysing and reporting Canadian atmospheric deposition data. The first phase of this project is nearing completion with the production of functional specifications and an implementation plan. All provincial agencies have agreed to contribute data from their networks. The primary products of NAtChem will be a permanent archive, a standard set of analyses with multi-network summary reports, and a facility for special data analyses on a cost-recovery basis.

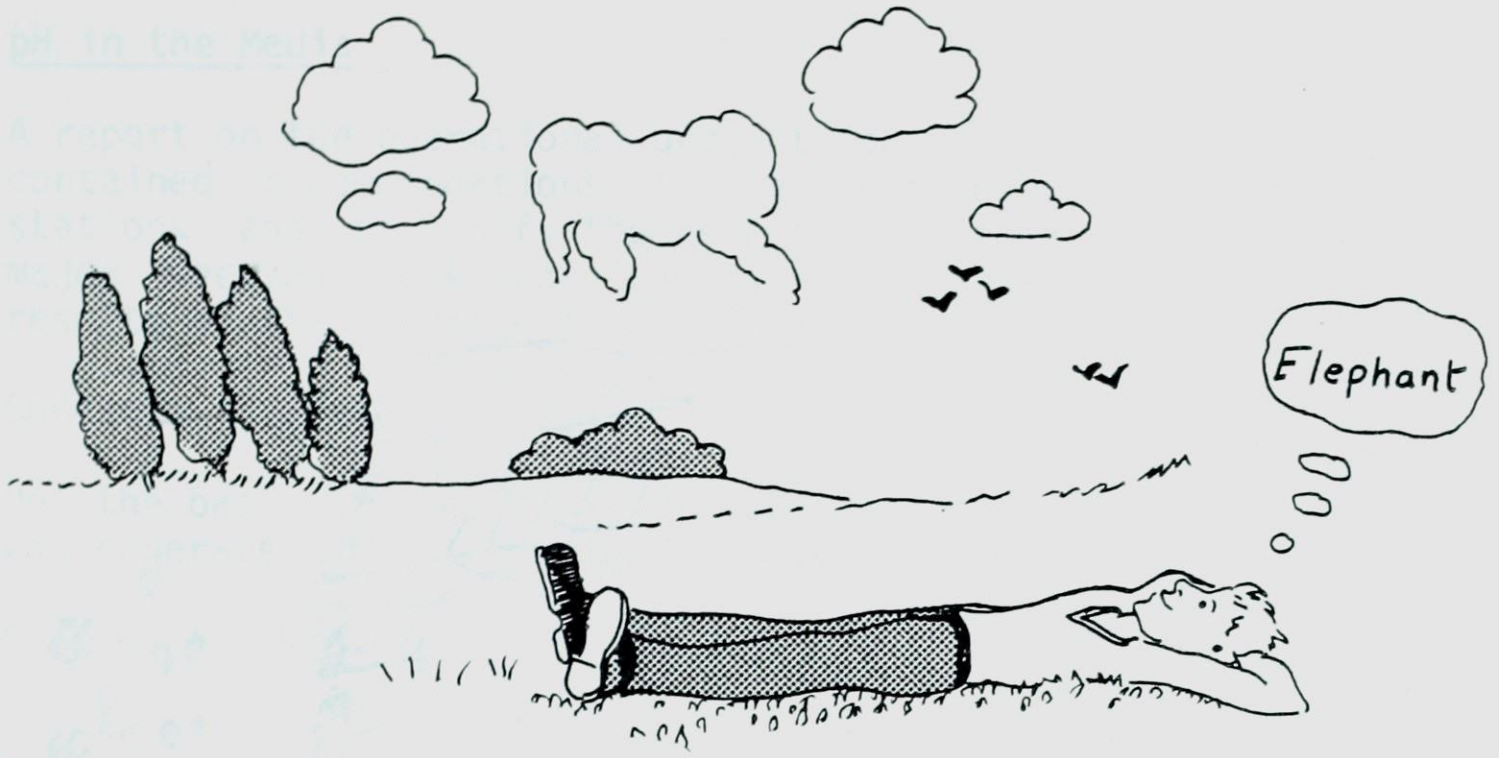
Contact: R.J. Vet

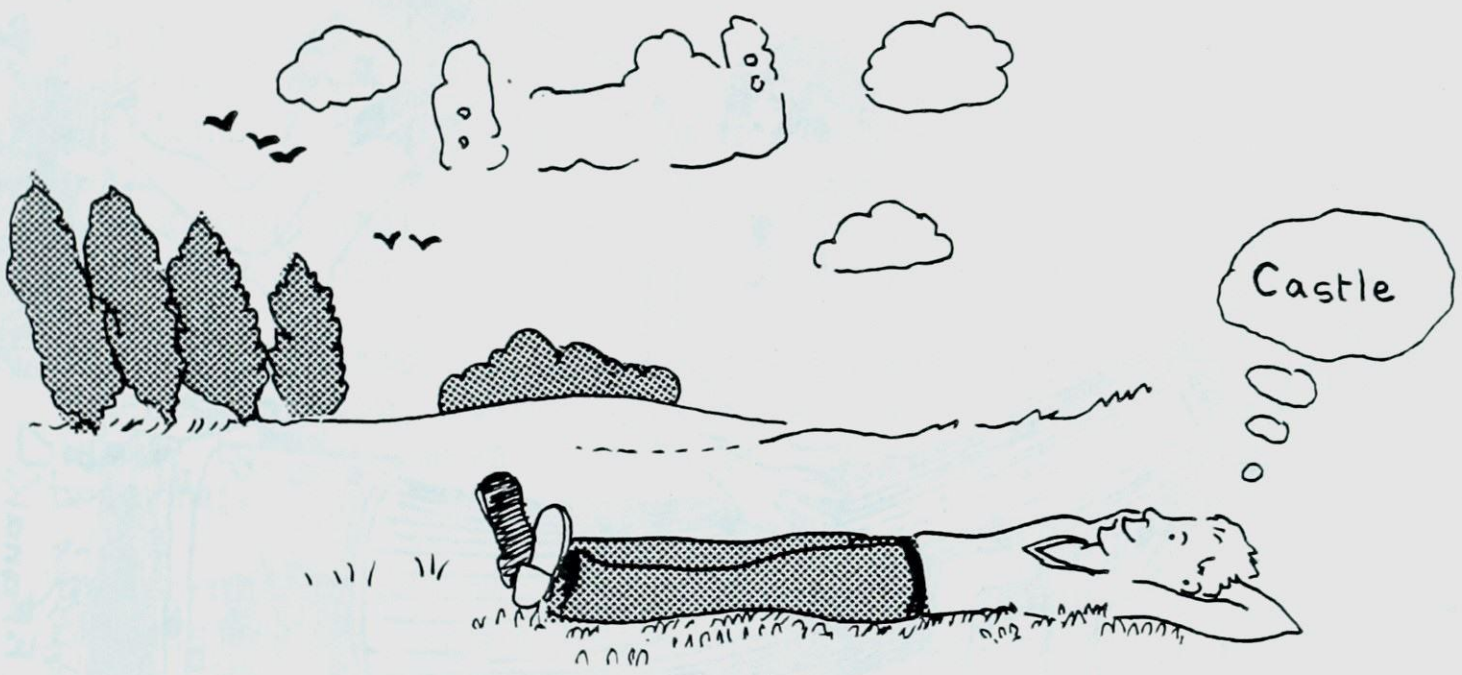
3.1.6 CAPMoN Chemical Analysis

Measurements of atmospheric particles, nitric acid and sulphur dioxide were continued at the 8-site air monitoring network. Analysis of the three filters used in the collection of samples was performed by routine ion chromatography. The quality assurance program for chemical analyses consisted of routine internal controls and three external intercomparison studies. These studies indicated that samples are being analyzed in an unbiased and precise manner.

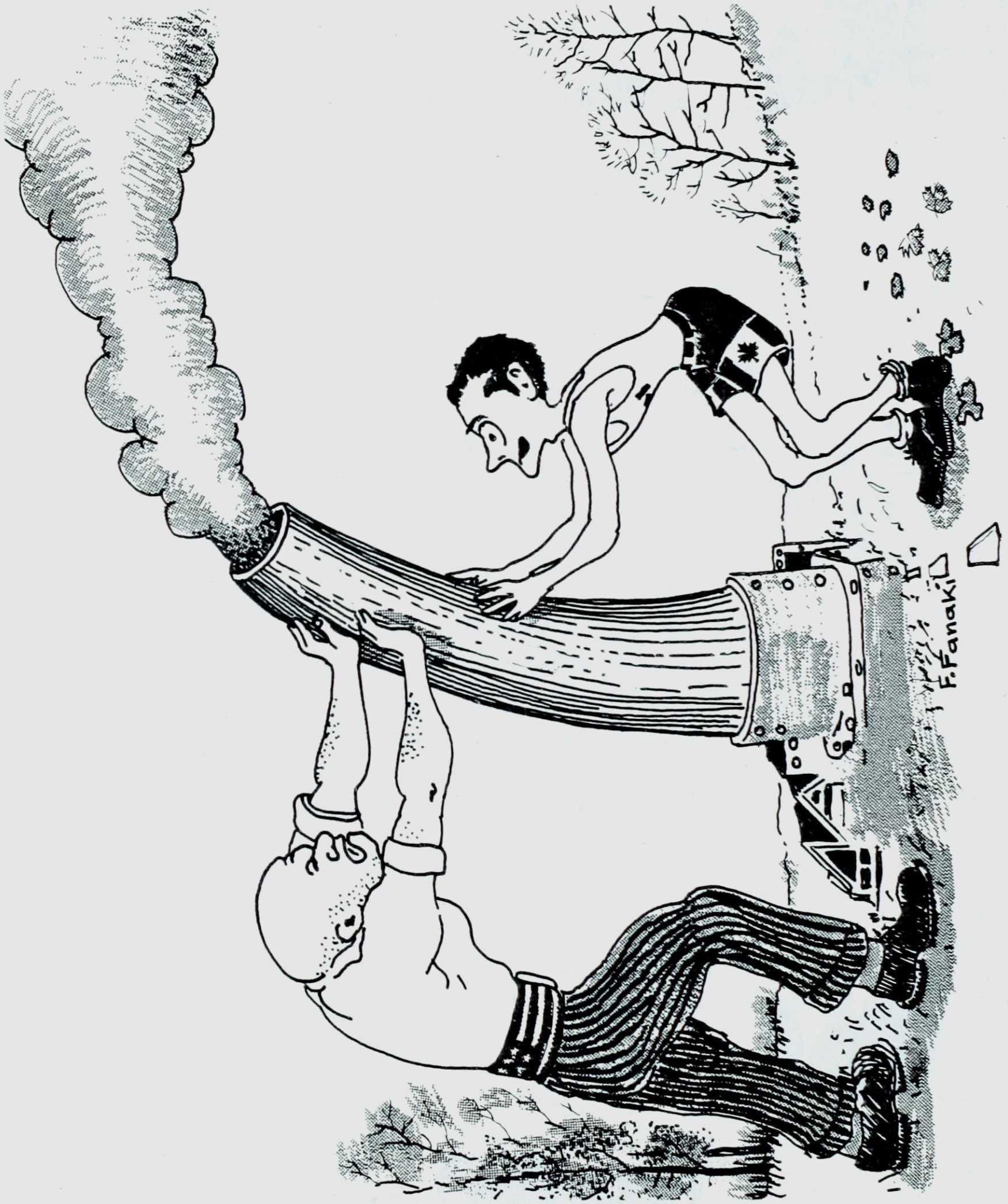
Data from 1983-1985 are being reviewed under contract. The preliminary review has indicated that some changes will be required for the published 1983 data set. These changes are related to previously unrecognized malfunctions of sampling equipment and operator errors at some of the stations. The unverified 1984 and 1985 data sets are currently being quality controlled and should be published within the next year.

Contact: H.A. Wiebe


Elephant


Castle


Acid
Rain
F. Fanaki



SO_2 WAR

3.1.7 pH in the Media

A report on the operational project "pH in the Media" was completed. It contained recommendations to close some of the operational Acid Rain stations and to modify the reporting of acid rain to the Media. Two major meetings were organized with interested AES staff to discuss the results of the report.

Contact: J. Padro

On the basis of this review, a proposal for a more useful public report was generated which is being discussed with interested public groups.

Contact: J.W.S. Young

3.1.8 Data Analysis Integration and Synthesis (DAIS)

The data analysis efforts expanded in 1986/87 and began to integrate atmospheric data with emissions information and surface water quality observations. The major achievements were:

(1) A thorough statistical analysis of the old APN (now CAPMoN) air filter-pack data over the period 1979 to 1984;

(2) An investigation of some discrepancies in the above data and an intercomparison, where possible, with Ontario data provided input to the development of an improved quality assurance program;

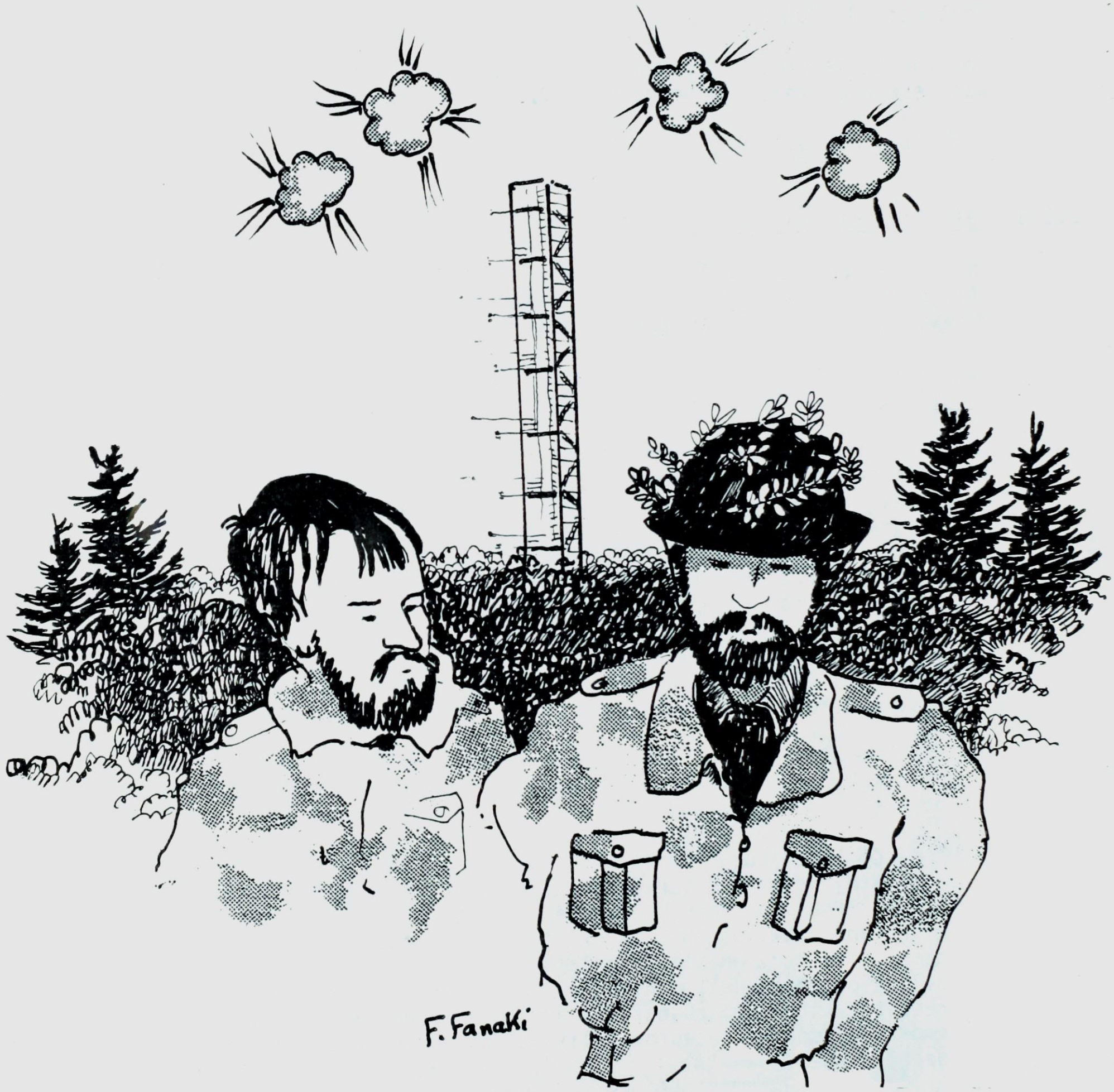
(3) The preparation of data analyses for input to the Economic Commission for Europe (ECE) Working Group on Nitrogen Oxides;

(4) A first estimate of a sulphur budget for the Canadian Prairie Provinces based on a combination of emissions, observational data and modelling results;

(5) The combination of atmospheric deposition with surface water quality data to further develop ideas on the acidifying potential concept; and

(6) The combination of daily observations of air and precipitation chemistry at selected Canadian monitoring sites with air mass trajectories to produce "region of origin" probabilities for the high and low concentration/deposition ranges. The resultant maps give very graphic displays of the source regions for high pollution episodes. Further, by the combination of these results with emissions data and an exponential decay factor, empirical source-receptor relations for sulphur and nitrogen can be generated.

Contact: P.W. Summers



Harold, put your helmet on. They have started target practice again.

3.1.9 Dry Deposition - Forests

The measurement program at our 43m tower in the mixed deciduous forest at CFB Borden (Ontario) continued, completing the first full year at this site. Continuous measurements of wind, temperature, solar radiation, net radiation, sulphur dioxide and ozone have been obtained and are available as half-hour averages. Daily measurements of mean air concentrations were also taken. The fluxes of heat, water vapour, momentum, ozone and sulphur dioxide were measured for about 36 days over the year, encompassing the full seasonal variation in the forest condition. A study on carbon dioxide fluxes using eddy correlation was performed in late summer in collaboration with Professor King (U. of Guelph) and in combination with aircraft flux measurements by the National Aeronautical Establishment (NAE), Ottawa.

An intensive study of the turbulent exchange processes was initiated. Twelve-point wind and temperature profiles extending from ground level through the canopy and up to 45m were obtained. In addition profiles of fast response temperature, wind components, and the relevant cross products were obtained from an array of ten sonic anemometers. This latter data set is yielding detailed information on the canopy-atmosphere transfer process and apparent counter gradient diffusion in the canopy airspace.

Contacts: G. den Hartog, H.H. Neumann

The formulations of the method for determining d, z_o and u_* using canopy data based on mass conservation principal have been modified. This method is now ready to be used to analyze the forest canopy profiles of the Camp Borden dry deposition study.

Contact: A.K. Lo

3.1.10 Dry Deposition - Complex Terrain

Results from the MS3DJH concentration model have been published. New surface boundary conditions (equivalent to surface resistances) were formulated in this model. These boundary conditions will now be formulated for the mixed-spectral, finite-difference (MSFD) model because of its flexible computation method.

Contact: J. Padro

3.1.11 Atmospheric Nitrogen

The 1985 summer field study near Nobleton, Ontario, has shown that night-time formation of aerosol nitrate occurs frequently with simultaneous maxima in nitrogen dioxide (NO_2). Probably, this occurs as a result of conversion of NO_2 to aerosol nitric acid. The day-time measurements of photochemical compounds showed that the regional air mass can be dominated by nitrogen oxide and nitrogen dioxide chemistry.

Two measurement comparison field studies have shown that for nitric acid and 1 hour sampling periods, the Canadian filter pack method compared very well with the sophisticated long-path Fourier Transform Infra-red spectroscopic method. For 24-hour sampling periods, the filter method also compared well with the improved Unisearch tuneable diode laser method. These studies have shown, so far, that the filter method is a simple and reliable method for measuring atmospheric gaseous nitric acid. For NO_2, the tuneable diode laser method compared well with the chemiluminescence method and the newly-developed commercial Unisearch 'Luminox' analyzer. This commercial instrument was further evaluated on its suitability for use in an aircraft environment and for monitoring ozone and peroxyacetyl nitrate (PAN).

Contacts: K. Anlauf, J. Bottenheim. A. Wiebe

3.1.12 Arctic Air Chemistry

The main thrust was continued development of an understanding of Arctic air pollution by:

(1) sustaining routine aerosol chemistry observations at Alert, NWT;

(2) analyzing and reporting the results of a field study at Alert in April 1986;

(3) developing a quantitative estimate of the longitudinal and altitudinal dependence of sulphur flux into the Arctic using a chemical transport model based on trajectories; and

(4) by establishing formal scientific dialogue with the Soviet Union.

The aerosol chemistry time series (July 1980 to May 1985) at Alert shows a persistent seasonal variation in the concentration of light scattering anthropogenic aerosols but a longer time series is necessary to determine if there is a significant trend.

Aerosol and acidic gas measurements at Alert in April 1986 on a daily basis revealed that there were substantial levels of anthropogenic pollution present.

In March 1987, Drs. L. Barrie and J.P.Blanchet visited research institutes in Leningrad as part of a bilateral agreement on Arctic cooperation between Canada and the USSR. The meetings established a program of long-term scientific cooperation on research related to climate and Arctic air pollution. A standing working group of scientists from both countries, that will meet once per year, has been recommended.

Contact: L.A. Barrie

3.1.13 Aerosol Chemistry

The objective of this study was to investigate the chemical compounds that dominate the mass of respirable light scattering aerosols and the usefulness of lead isotope ratios as an indicator of lead origin. Analysis of aerosol samples taken at Dorset, Ontario, and at selected locations throughout eastern North America was done using inductively coupled plasma emission spectroscopy, mass spectrometry, and instrumental neutron activation analysis.

The results of the lead 206/207 isotope ratio study showed that there is a significant difference between the isotope ratios of lead from Canadian automobiles, Canadian smelters and American automobiles. It was concluded that at Dorset in the Fall of 1984 most aerosol lead was from automobile exhaust and it was split equally between Canadian and American sources.

A detailed analysis of the multi-elemental composition of aerosol at Dorset during Fall 1984 revealed that arsenic and indium are excellent tracers of smelter emissions from Sudbury and Noranda/Val D'Or.

Contacts: L.A. Barrie, W. Sturges

3.1.14 Western Atlantic Ocean Experiment (WATOX)

The Western Atlantic Ocean Experiment (WATOX) is a cooperative research project involving several universities and government agencies in Canada, the United States and Bermuda. Its objective is to determine the magnitude of the transport and deposition of North American pollutants over the Atlantic Ocean. During the past year long-term sampling was continued on Bermuda and Ireland for acidic and trace metal species in air and precipitation, but major emphasis was placed on analysis of data from 1985 and 1986 field programs. Preliminary results indicate that episodes of North American pollution can be detected in mid-Atlantic, demonstrating large-scale transport and interference in marine chemical cycling. A number of sampling systems on board aircraft demonstrated excellent comparability in duplicate measurements, and showed significant differences between boundary-layer and free-tropospheric concentrations of several sulphur and nitrogen species off the east coast of the continent. A first determination was made of the amount of anthropogenic sulphur emitted in North America, which travels across the Atlantic Ocean to Europe and Scandinavia -- some four per cent. This amount is small compared to European emissions and is comparable to natural background inputs.

Analysis of previously collected data is continuing, and initial steps are now being taken to amalgamate WATOX and the Atmospheric/Ocean Chemistry Experiment (AEROCE) research efforts in the North Atlantic. These programs are expected to become major components of the Global Atmospheric Chemistry Program.

During the January 1986 flights with the National Oceanic and Atmospheric Administration (NOAA) equipment for measuring peroxyacetyl nitrate (PAN) and nitrogen dioxide (NO_2) was operated, and the data were reduced and analyzed in the past year.

Contacts: D.M. Whelpdale, J.W. Bottenheim.

3.1.15 Snowmelt Acidic Shock

One of the environmental concerns of long range transport and deposition is the accumulation of pollution in the snowpack over the winter season and the sudden concentrated release of these pollutants into the streams and lakes during melt events. The Climate Centre has collected data on the melt rate, snowpack and meltwater chemistry data from field experiments at Dorset, Ontario. Data have been analyzed for four winter seasons. Refinements to an acidic snowmelt shock potential model continued and has been implemented on a microcomputer. A climate study on the frequency and type of melt events based on model simulations in eastern Canada was initiated.

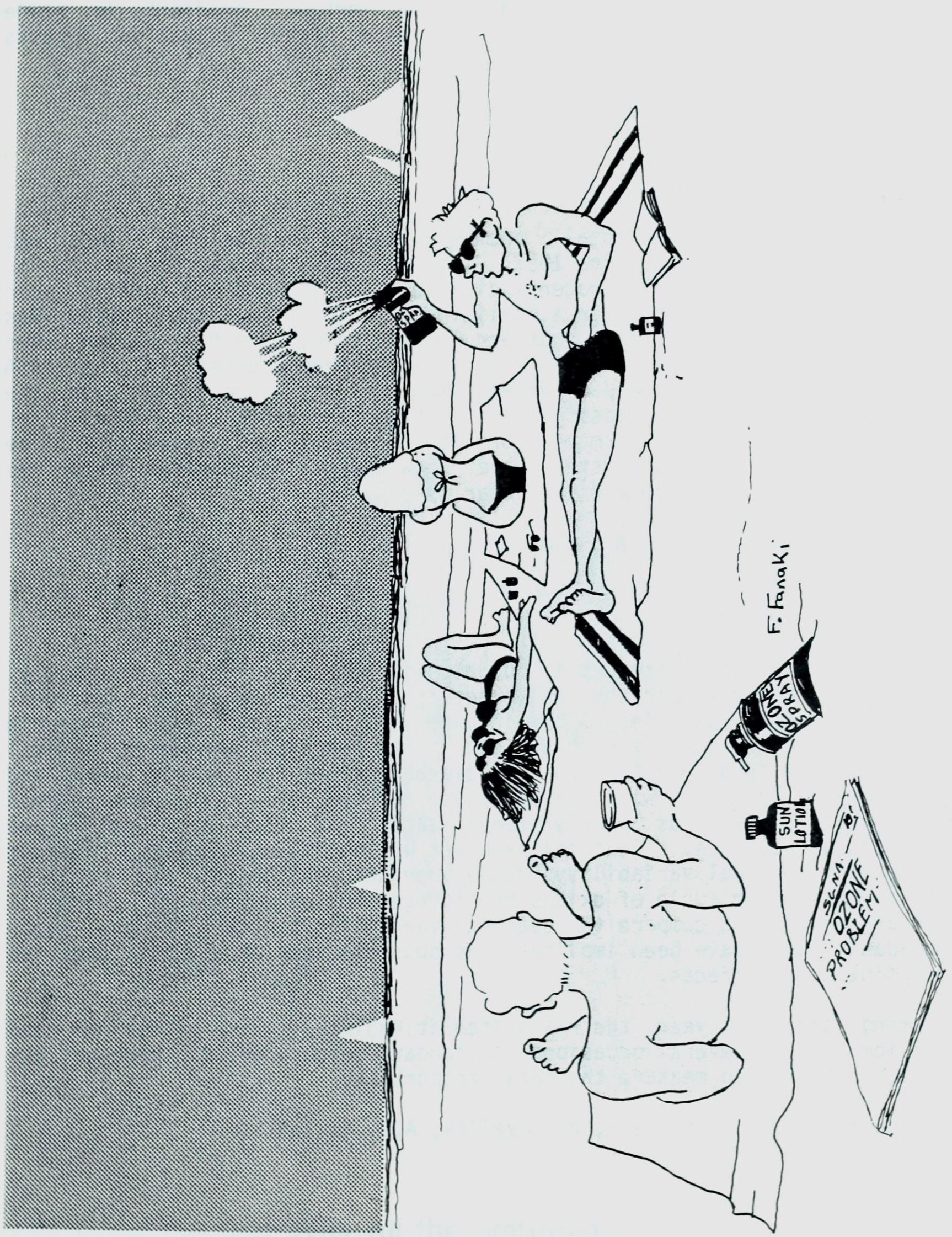
Contacts: P.Y.T. Louie, B.E. Goodison

3.1.16 Chemistry of High Elevation Fog (CHEF)

The objectives are very similar to those of the U.S. Mountain Cloud Chemistry Project (MCCP) and many protocols are identical in both projects.

The first two years of data from the Roundtop Mountain site (970m) in Quebec have shown that an average of 48% of the time the site was in cloud at 8:00 am. Observations at 530m have shown this mean coverage to fall to 24%. In the last half of 1985 the mean values of pH of fog water at sites at greater elevations than 850m ranged from 3.71 to 3.96. The pH values for precipitation are considerably higher than for fog water. Typical mean pH values for precipitation at two sites were: 4.25 compared with 3.82 for fog water at 860m; and 4.32 compared with 3.71 for fog water at 970m.

Ozone measurements have been taken at three sites that are approximately at the same altitude but at different latitudes. During the growing season of May to September, 1986, the mean percentages of hours with concentrations greater than 50 ppb were 20%, 14% and 7%. At these sites, the seasonal means during this time were 40ppb, 34ppb and 30ppb respectively. Ozone was also measured continuously at the CAPMoN Sutton location, a valley site. An analysis of the June-September 1986 data has shown that summer-time ozone maxima were in the range 80-100 ppb but did not occur frequently. However, the maxima generally correlated geographically, showing that synoptic scale meteorology was an important factor. The Roundtop Mountain site frequently showed much higher ozone concentrations than the nearby Sutton valley site due to temperature inversions in the valley and to accumulation of nitric oxide.



OZONE DEPLETION

There is a regional uniformity in the occurrence of ozone episodes in Southern Quebec but the mean duration of the episodes and the mean magnitude of the concentrations decrease from the most southern site to the most northern. There is a strong vertical gradient in ozone concentrations and event durations with higher elevation forests receiving higher ozone dosages.

Contacts: R.S. Schemenauer, K.G. Anlauf

3.1.17 Aircraft-mounted Tuneable Diode Laser

This unsolicited proposal from Unisearch Associates Inc. was successfully completed in 1987. The new laser system proved to be highly sensitive to nitrogen dioxide (NO_2) and to nitric acid (HNO_3). In May 1986 for a preliminary evaluation, the system was flown on an aircraft over southern Ontario to measure NO_2. With some further improvements, the laser system was then mounted in the NASA aircraft and in August/September, 1986, flights were made over the Pacific Ocean to measure the ratio NO_2/HNO_3 in the free troposphere. The performance of the instrument was excellent. The improvements in this system have now been incorporated into the ground-based AES tuneable diode laser system.

Contacts: K.G. Anlauf, A.J. Chisholm

3.1.18 Nitrogen Chemistry

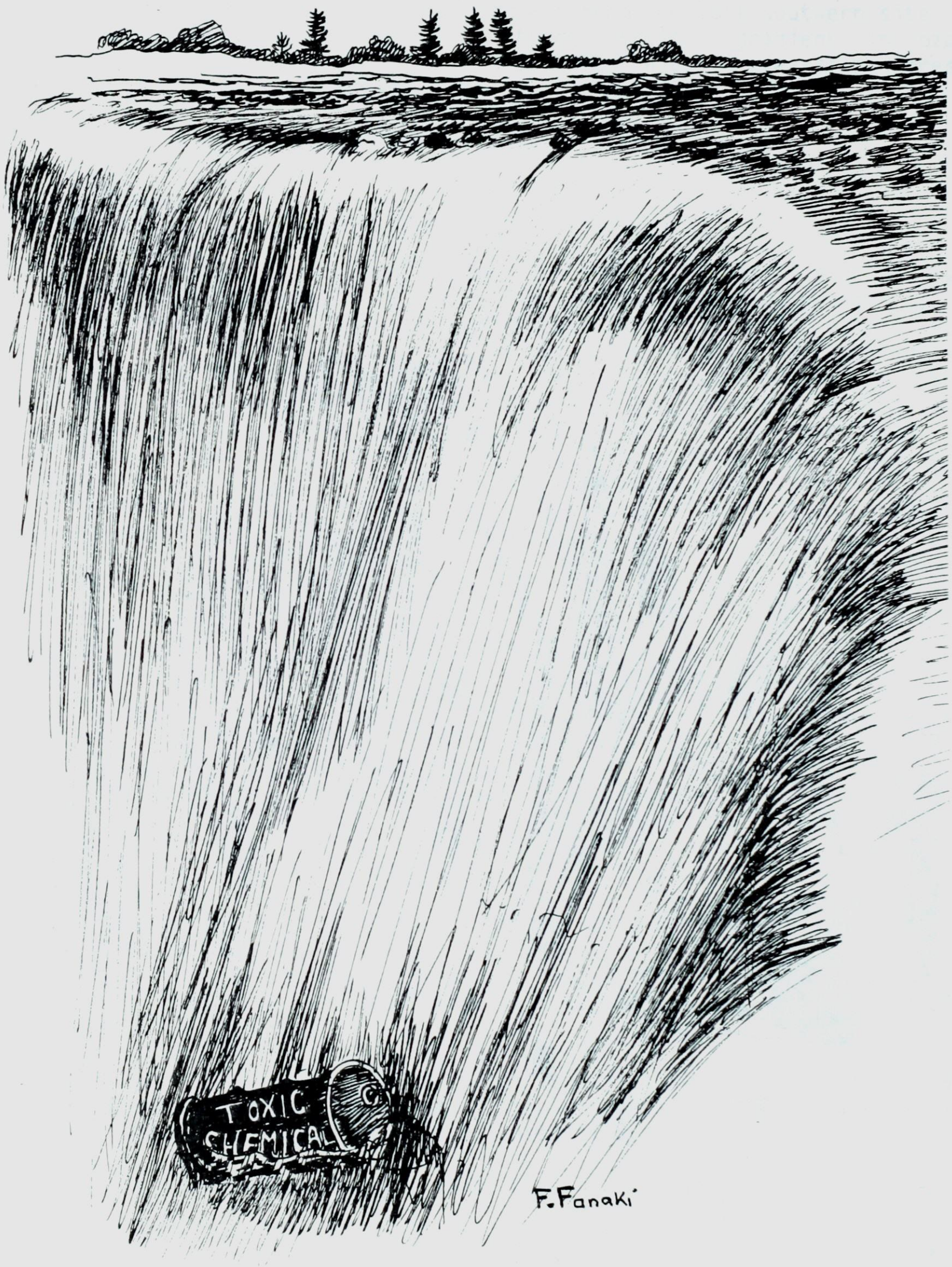
The purpose of this project is to determine the role that peroxyacetyl nitrate (PAN) plays in the long range transport of oxides of nitrogen. A PAN monitor was installed in June 1984 at the CAPMoN site in Kejimkujik National Park, N.S., and it has operated since that time. Besides the PAN monitor 24 hour average data for nitric acid and particulate nitrate will be available for the site from the CAPMoN network, as well as hourly ozone data from the Conservation and Protection Service. The total data set will allow us to obtain insight into the seasonal variability in the inorganic and organic end products of the oxidation cycle of oxides of nitrogen in the atmosphere. We will also be able to compare the seasonal variability in two of the major oxidants that have been implicated as possible species causing negative physiological effects.

During the past year, the PAN system at Kejimkujik was maintained and calibrated on several occasions. A standard meteorological package was also installed to measure the local meteorology.

Contacts: J.W. Bottenheim, J. Kovalick, A.J. Gallant

- Why all the umbrellas?

- I plan to spend my holidays in Canada.



The first toxic chemical to go over the Falls in a barrel

3.2 TOXIC CHEMICALS

3.2.1 Liaison and Co-ordination

The Branch undertook the liaison and coordination of the atmospheric component of the federal Toxic Chemicals Scientific Program for AES. An AES pesticides submission was developed in consultation with branch, private sector and regional offices, and forwarded for consideration by the departmental Pesticide Program Management Committee. A section on pesticides was included in the report to the Minister on AES atmospheric programs with implications to forestry. The objectives, outputs and resources of the AES Air Toxics Program for the next five years were developed and submitted to the department. A presentation entitled 'Atmospheric Toxic Chemicals and AES Programs' was delivered in June as part of the AES Atmospheric Sciences Research Seminars series. Extensive consultation and input was provided for the development of the brochure entitled 'Chemicals in the Atmosphere - A Warning', including the development of tables which summarize the main issues: smog and Arctic haze, acid rain, atmospheric toxics, greenhouse gases, stratospheric ozone depletion and radionuclide releases.

Contact: E. Wilson

3.2.2 Atmospheric Loading

The temporal and spatial resolutions of the Long Range Toxics model (LRTOX) were increased over the Great Lakes region in order to improve deposition estimates. Upgraded emission inventories of lead, oxides of nitrogen and cadmium were installed and implementation of meteorological data for 1980-85 is in progress. Predicted depositions of sulphur, nitrogen, lead and toxaphene were presented at workshops. The predicted cadmium deposition were not presented due to ambiguities in US emissions.

Uncertainties in wet deposition amounts of sulphur and nutrients to the Great Lakes and their basins were estimated from observations. The implications of uncertainties on trend analysis and on network design were assessed.

Emissions inventories for the 14 fast Track Toxic Chemicals, defined by the International Joint Commission (IJC), were summarized and presented at a workshop. Development of a DOE workplan for compilation of emissions inventories of toxic substances has been initiated.

The Atmospheric Monitoring Task Force of the IJC held several meetings and hosted a workshop on "Siting of Monitors".

Contact: E.C. Voldner

3.2.3 Polycyclic Aromatic Compounds

Under the auspices of the International Committee on Polycyclic Aromatic Compounds (ICPAC), contributions were made to the development of the polycyclic aromatic compound (PAC) database.

The ICPAC has grown over the past year and now comprises over 50 of the world's leading scientists in PAC research from over 8 countries. The areas of concern to the committee are the chemical, physical, thermodynamic, biological, spectroscopic, analytical, chromatographic and environmental occurrence data for the PAC. The compilation of data by each of the sub-committees is progressing well and the database should be ready for transfer to the Scientific and Technology Network (STN) International system within two years. The current database is available on request. A sanction document covering the goals and objectives of the ICPAC has been produced.

Contact: D.A. Lane

3.2.4 Organic Gas/Particle Sampler

The Gas and Particle (GAP) sampler, developed by the Ontario Research Foundation on contract to AES, was used during two co-operative field studies in Ontario between AES and National Water Research Institute (NWRI) scientists to determine the gas phase and particle phase distribution coefficient of selected toxic organochlorine compounds.

During the first field program, GAP samplers were deployed both on land and onboard ship. Measurements were made at Niagara-on-the-Lake to investigate gas/particle concentrations of the target compounds as a result of off-shore breeze conditions and at a park on eastern Lake Ontario to investigate the gas/particle concentrations resulting from on-shore breeze conditions. Target compound concentrations were very low in the region of sub nanograms per cubic metre. The second field program involved measurements for the same compounds at the Turkey Lakes region of Ontario. The measurements are anticipated to yield a tentative washout ratio for the compounds.

Contacts: D.A. Lane, W.H. Schroeder

3.2.5 Atmospheric Mercury

Mercury discharges from a pulp and paper mill complex at Dryden, Ontario between 1962 and 1975 resulted in severe contamination of the Wabigoon-English River system in Northwestern Ontario. Previous field observations at several locations on the Wabigoon River pointed to the possibility that mercury was being released (volatilized) from the water surface into the atmosphere. One of the recommendations in a federal-provincial report published in 1984 was that research should be undertaken to investigate and quantify this potential pathway for losses of mercury from the aquatic environment.

In response to this recommendation for additional research, an exploratory field survey was designed and carried out by Branch scientists during the summer of 1986. Atmospheric mercury measurements were performed at two locations on the Wabigoon River and at a control (reference) site. At each location, simultaneous determinations of total vapour-phase mercury were made directly above the water surface as well as over land at a point near the shore. Micrometeorological data were collected at each of the three sites to obtain information on prevailing environmental conditions and to elucidate the mechanism of mercury transfer across the air-water interface. Experimental results from this exploratory set of measurements are currently being interpreted and will be reported later this year. It is intended that, in the future, the techniques utilized in this study be developed for application to the investigation of air-water exchange processes involving volatile toxic chemicals present in the Great Lakes.

Contacts: W.H. Schroeder, F. Fanaki

3.2.6 Pesticide Off-Target Drift

The pesticide research this year has focussed on field experimental work, model evaluation and instrumentation development for spray cloud mapping. The Dunphy field trials were completed this year thus terminating a successful experiment co-ordinated through National Research Council (NRC). The data set includes extensive deposit (ground/canopy) and drift measurements to 900 metres downwind from the spray line. The trials encompassed a variety of wind speed, stability and aircraft height scenarios. In general, the total deposition (and hence drift) was strongly correlated with the "effective" release height of the spray cloud as determined by the aircraft height and the vortex lifetime.

A contract was awarded to Concord Scientific to conduct an objective scientific assessment of the fundamental strengths and weaknesses of existing forest pesticide spray drift and deposition models. The second phase of the contract was to implement and evaluate an enhanced model based on incorporation of state-of-the-art kmowledge. In-house, efforts are being directed towards the use of the WAKE code to assess vortex breakdown in a highly sheared flow above a forest canopy.

During the past year, the Branch Lidar capabilities were enhanced to allow for the rapid mapping of the spray cloud from release to eventual deposit. The technique utilizes a rapid-fire scanning lidar system capable of 10 Hz repetition rates giving a 4 metre vertical by 1 metre horizontal resolution of the spray cloud. It is expected that clouds will be able to be scanned to approximately 1 km downwind from the spray line. An agricultural spray scenario will be mapped in the spring of 1987 and the technique will then be extended to map spraying over forests.

Contacts: R. Mickle, A.K. Lo, R. Hoff, F. Froude.

3.3 CLIMATE CHANGE

3.3.1 Alert Research Station

Canada's first permanent research station for the continuous monitoring of background air pollution was officially opened at Alert, N.W.T., on August 29, 1986, by Mr. Howard Ferguson, Assistant Deputy Minister. The purpose of this laboratory is to measure the concentrations of industrial pollutants and to monitor the changes in their concentrations over time. Increases in the atmospheric concentration of carbon dioxide, a common by-product of fossil fuel burning, has been the focus of concern for several decades now because of the "green-house" effect. This new research facility in the high Arctic signifies Environment Canada's commitment to investigate global environmental problems. The laboratory is part of an international network of stations - in Australia, United States, Japan, France, Germany, Norway and Sweden - coordinated by the World Meteorological Organization under its Background Air Pollution Monitoring Program (BAPMoN) to study the long-term effects of pollution on our atmospheric environment.

The physical facilities consist of a laboratory (4 metre by 9 metre) with twin 10 metre towers at one end of the laboratory. The laboratory is located 50 metres East-North-East of the main meteorological tower. This tower is instrumented for temperature and wind measurements at 2m, 5m, 10m, 20m and 40m, and for humidity at 2m. The laboratory is equipped to measure both gaseous and aerosol pollutants.

Because of its isolated location on the north-eastern tip of Ellesmere Island, Alert is ideally suited to the monitoring of global atmospheric pollutants. If the pollutants are present in the atmosphere here, far removed from the major industrial regions of the northern hemisphere, then they represent a contribution to the background pollution of the northern hemisphere as a whole.

Contact: N.B.A. Trivett

3.3.2 Alert Measurement Program

Continuous monitoring of carbon dioxide commenced in December 1986, and ozone and peroxyacetyl nitrate (PAN) in October, 1986. Earlier Arctic Gas and Aerosol Sampling Program (AGASP) expeditions had shown that PAN is probably the main oxide of nitrogen during the arctic winter. Hence, ignoring its presence will lead to a serious underestimate of the levels of the oxides of nitrogen in the atmosphere and this has major implications for global nitrogen budget estimates. In the Arctic, PAN should also give us a better handle on determining the chemical history of air masses arriving at Alert. Both large particles (nephelometer) and small particles (condensation nucleus counter) have been measured at Alert since 1985, and major ions have been measured, using a high volume filter, since 1980.

Contacts: N.B.A. Trivett, J.W. Bottenheim, L.A. Barrie

3.3.3 Flask Sampling Program

Weekly carbon dioxide (CO_2) flask sampling continued at Alert, Sable Island and Cape St. James. The data show an average annual increase in CO_2 of about 1.3 ppm, an annual seasonal amplitude of approximately 12 ppm may be increasing, and an average concentration in 1985 of about 345 ppm.

The gas chromatograph (GC) developed for in-situ measurement of CO_2 and methane (CH_4) was successfully tested during April 1986. The GC gave higher values than the flasks for CH_4 and lower values for CO_2. These differences are due to differences in calibration standards.

Contact: N.B.A. Trivett

Using these data, a study was continued to test the feasibility of precipitation scavenging of CO_2. The Alert and Sable Island CO_2 data was examined in reference to the hourly weather data of 1981-85. It was found that the frequency of occurrence of relatively low values of CO_2 with precipitation and fog was 64.3% at Alert and 62.0% at Sable Island.

An intercomparison of CO_2 data obtained at Alert, Sable Island, Ship Papa and Mauna Loa was also carried out. Analysis indicated that atmospheric CO_2 has been constantly increasing since the year 1958 at all four stations. By 1985 annual mean values at Alert and Sable Island were approximately 346 ppm.

Contact: Y.S. Chung

3.3.4 Carbon Dioxide Flux Studies

In conjunction with the Camp Borden group (Drs. den Hartog and Neumann), Professor King of the University of Guelph made measurements of carbon dioxide (CO_2) fluxes from the main tower at the Borden site. The National Aeronautical Establishment (NAE) Twin Otter with the Agriculture Canada CO_2 flux measurement equipment on board made several flights over the Borden site to intercompare with the ground based measurements. The gradient-flux equipment was installed on the Borden tower in the autumn and tested out successfully. Preparations were made for an early spring start-up to look at CO_2 exchanges between the forest and the atmosphere throughout the growing season.

Contact: N.B.A. Trivett

3.3.5 Arctic Gas and Aerosol Sampling Program (AGASP)

Arctic haze is caused by a man-made mixture of gases and particles consisting mainly of soot, metals, organic and acidic sulphates. The concentration in the Arctic atmosphere of these by-products of industrial processes has increased by over 75% since 1956, paralleling a doubling of sulphur dioxide emissions in Europe and the Soviet Union. These acidic ions are the major component of what is called acid rain or, in the case of Alert, acid snow. How acidic gases and aerosols make their way into the Arctic environment and how widespread they are has been the focus of two recent international experiments involving Norway, Sweden, West Germany, the United States and Canada. Canadian and American researchers have found evidence of man-made pollutants in layers as high as 20,000 feet in the atmosphere over Alert.

AES and National Aeronautical Establishment (NAE) took part in AGASP at Alert in April 1986. This international program (USA, Norway and Canada) is to study the transport of pollutants into the Arctic. The first measurements of Arctic haze in this year's study showed higher levels of Arctic haze than were measured during last year's study. These measurements continued to rise during the four weeks of the study. Aerosol concentrations did not decrease when trajectories indicated southerly flows as was expected and may be an indication of the extent of Arctic haze this year.

Contact: N.B.A. Trivett

During April 1986, the Branch participated with National Oceanic and Atmospheric Administration (NOAA) in their measurement program. The AES program included measurements of peroxyacetyl nitrate (PAN) and nitrogen dioxide (NO_2) as well as filter samples using the AES filter pack. Three flights were centred on the Beaufort sea area, while three other flights specifically focussed on Alert and environs. The data were reduced during the latter part of the past year and a preliminary analysis was presented at the fall meeting of the American Geophysical Union in December 1986.

Contacts: N.B.A. Trivett, J.W. Bottenheim, A.J. Gallant

Meteorological data including synoptic weather maps and satellite information were analysed for the Canadian Arctic Haze Study in April, 1986. Sporadic eruptions of the Augustine volcano in Alaska were occurring during the study period. From examinations of satellite data and trajectory analyses, to determine whether the volcanic plume was contributing to the concentrations of atmospheric constituents measured at the surface, it appears that this plume was not likely influencing the measurements at Alert.

Contact: Y.S. Chung

ARCTIC HAZE

3.3.6 Biogeochemical Cycle Research

An attempt was made to establish a climatological relationship between anomalous carbon dioxide (CO_2) values observed at Alert and Mould Bay and back trajectories of air parcels arriving at these stations. It was concluded that there are two basic "air masses" over the Arctic Ocean with different CO_2 concentration levels which influence CO_2 values at Alert and Mould Bay.

Contact: K. Higuchi

3.4 CORE RESEARCH

3.4.1 Differential Absorption Lidar (DIAL) Development

In order to obtain vertical profiles of ozone and sulphur dioxide, a differential absorption lidar (DIAL) has been constructed. This system is the only one of its type in Canada and provides AES with the opportunity to examine the dynamics of pollutant transport on a continuous basis. The DIAL consists of a high power ultraviolet laser source which provides two closely spaced wavelengths near 300 nanometres. These wavelengths can be adjusted to correspond with minima and maxima of the sulphur dioxide absorption features in the ultraviolet so that the difference in the return signal of each of the lines is related to the gas concentration above the DIAL. For ozone, the difference in the two wavelengths is maximized subject to the constraints of the available dye laser range and the increase of differential aerosol extinction. During 1986/87, the system has been extensively tested in order to optimize the sensitivity and currently 10 ppb for sulphur dioxide and ozone in 200 meter range cells to 2.4 kilometres distance is achievable. It is believed that the sensitivity will improve with additional modifications to be made in 1987. The system will be used as part of the Eulerian Model Evaluation Project during the next two years where it will alternately provide sulphur dioxide and ozone profiles on a daily basis from the Centre for Atmospheric Research Experiments in southern Ontario.

Contact: R.M. Hoff

3.4.2 Spectroscopy

One of the more elusive species to measure in the study of nitrogen chemistry is nitrous acid (HONO). A technique was initiated during 1986/7 using long path spectroscopy (Platt et al., **Nature**, 285, 312-4, 1980) to attempt to measure parts per billion levels of this gas. A one-half metre spectrometer had its exit slit replaced by a rotating disk and 15 nanometers of the spectrum from a light source 750 metres from the instrument was sampled. The spectrum is sampled in less than a millisecond with 0.02 nm resolution. The system is able to detect Beer's Law optical depths of 3×10^{-3} which, with a 750 metre pathlength and a differential absorption coefficient of 400 $atmo^{-1} m^{-1}$, gives a sensitivity for HONO of about 10 ppb. Since ambient levels of HONO are expected to be about 10-100 times less than this, further work is indicated.

Contact: R.M. Hoff

3.4.3 Laser Radar Conference

This year the 13th International Laser Radar Conference sponsored by the International Committee on Laser Atmospheric Studies of IAMAP and the Committee on Laser Atmospheric Studies of the American Meteorological Society, was hosted in Toronto by AES and York University. A total of 160 persons from 19 countries attended the meeting, at which 120 papers were presented. The conference papers have been prepared in a conference publication: 13th International Laser Radar Conference, NASA Conference publication 2431, NASA Code NIT-4, Washington, D.C., 20546-0001.

Contact: R.M. Hoff

3.4.4 Flow Over Complex Terrain

Our work this year has concentrated on model development and application and on further analysis and interpretation of field data from the Askervein and Kettles Hill experiments.

The major model developments have been in the completion of a first revision of a mixed spectral, finite-difference (MSFD) model of flow above topography and roughness variation and subsquent improvements to the numerical technique used within the model. The main advantages of MSFD over its predecessor (MS3DJH) are in improved representation of the advection velocity profile and in the flexibility to introduce alternative turbulence closure schemes. The recent changes in numerical methods will make it much easier to extend the model to include the thermodynamic equation. We have continued to apply the MS3DJH/3 model in a number of applications and in particular have started work on a demonstration of the model's capabilities for high resolution (down to 0.1 km) diagnostic wind forecasting.

Some work has been undertaken on boundary-layer parameterisation for large scale models. Particular attention has been paid to the relationship between effective roughness length for heterogeneous areas and the sub-grid micrometeorological roughness lengths.

Contacts: P.A. Taylor, J.L. Walmsley, R.E. Mickle.

3.4.5 Canada Olympic Park Study

This continuing project is to establish the wind climatology of the Ski Jump site at Canada Olympic Park, to provide data and to provide advice to Public Works Canada (PWC) and the Olympic Committee on jumper safety. Five wind and temperature towers were operated from January to May 1986 at the site but only two were allowed to remain over the 1986/87 winter season because of engineering work at the site. Reports on the data collected have been prepared and submitted to PWC.

Contact: P.A. Taylor.

Research... Research.. Research..

3.4.6 Canadian Atlantic Storms Program (CASP)

Surface mesonet and Airsonde data from the Jan-March 1986 have been processed and some quality control procedures applied. The data have been supplied to several users and to the CASP data bank. A data report is nearing completion. A particular concern has been to identify possible instrumental causes of anomalous high wind speeds which very occasionally occurred in the CASP data set. A six month field trial of three Windmonitors and a cup anemometer at the Woodbridge test site has failed to produce any anomalies and all systems appear to have operated perfectly. Microbursts are a possible explanation of the high winds but we are still suspicious. Further tests are planned.

Five of the CASP mesonet stations have been deployed in collaboration with Ontario Region to monitor shoreline winds and other parameters during the high-water level emergency on the Great Lakes.

Contacts: P.A. Taylor, R.E. Mickle.

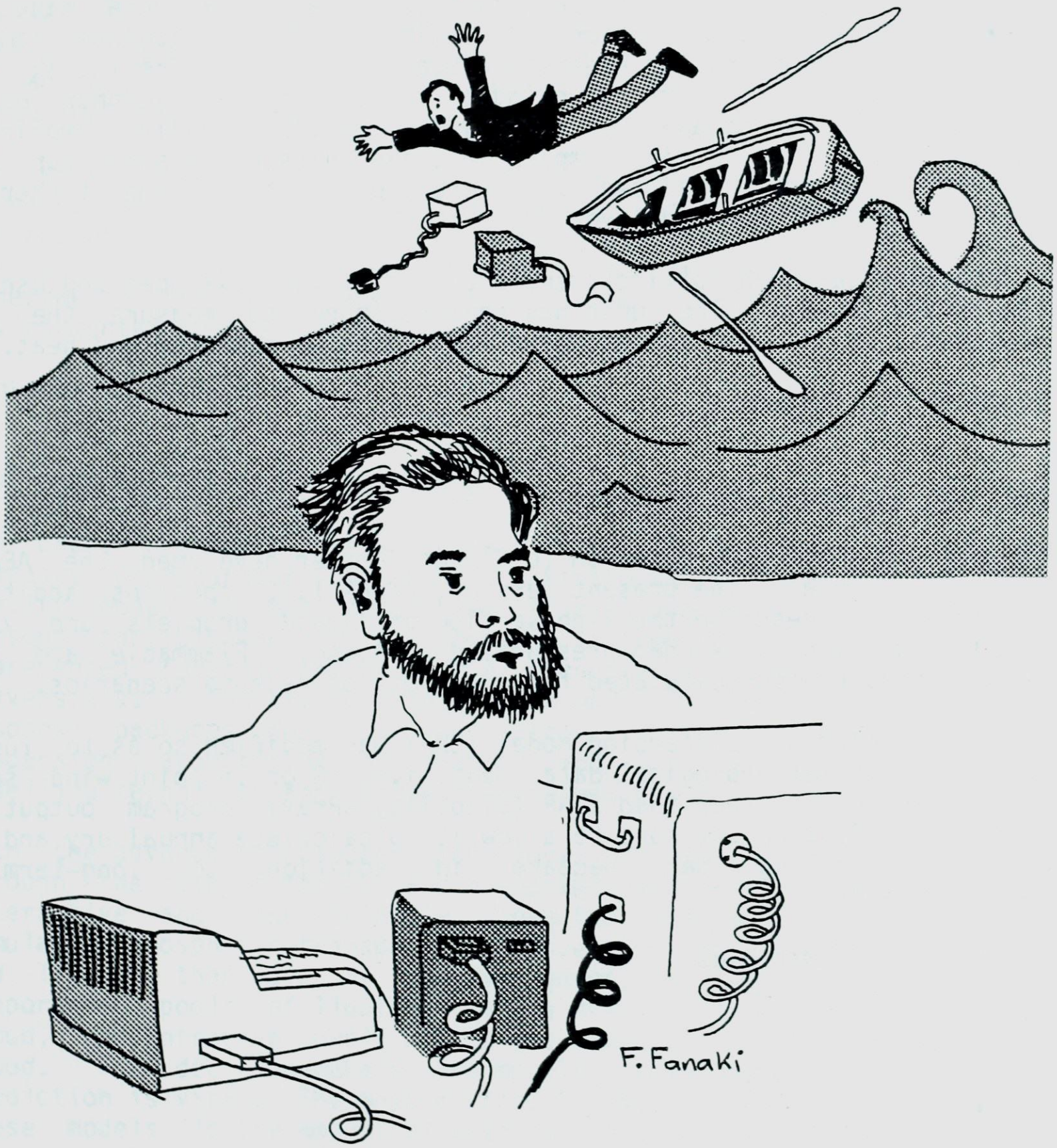
3.4.7 Wind-Driven Entrainment and Enrichment at the Air-Sea Interface

A project concerned with estimating the volume of air being carried across an air-water interface by breaking waves saw progress in several areas. In the theoretical and modelling area two publications entitled 'Distribution of Bubbles near the Ocean Surface' and 'On Aerosol Production and Enrichment by Breaking Wind Waves' advanced the formulation problems. In the experimental area a unique plastic spar buoy was constructed to estimate the area, speed and acoustic properties of breaking waves as a preliminary step in measuring the entrainment rate. This equipment was deployed in the Mediterranean near Elba in conjunction with a joint Northern Atlantic Treaty Organization (NATO) and AES experiment.

On another front, a basic research study of the geometric properties of whitecaps has led to a unique formulation of the ocean surface as a Brownian - random walk process. This work promises a powerful technique for ocean wave-structures applications.

Another air-sea interaction project, funded by the Panel on Energy Research and Development (PERD) saw the deployment of a hydro phone deep in the ocean off Labrador. This system will study the variability in winds in storms during the winter months. Use of such equipment for such a unique application is a spin-off of earlier studies concerned with mechanisms by which sound is generated by breaking waves. A workshop directed by Dr. Kerman under the sponsorship of NATO, but also funded by AES and the U.S. Office of Naval Research, will examine this and other mechanisms of sound generation at the ocean surface.

Contact: B. Kerman



Nick, please wait until a high wave passes by.

3.4.8 Northern Oil and Gas Action Plan (NOGAP)

During the period of February 16 to March 4, 1987, nine members of the Branch were involved in the second NOGAP winter field study. This study was an intensive data gathering exercise, designed to supplement the Inuvik Tower data as well as increase our knowledge of cold weather influences on dispersion characteristics.

The study had two distinct and separate study areas: Tuktoyaktuk on the Arctic coast and Inuvik on the Mackenzie Delta. Simultaneous soundings of the atmosphere using the Beukers microsonde system were made four times daily from each location. In addition, air particulate sampling was carried out using two Anderson cascade impactors. The Inuvik study program included acoustic sounding of the atmosphere, sulphur dioxide measurements, photography of the power plant plume, daily sampling of ambient air by collecting samples in sealed pressure flasks for later ion chromatography analyses of hydrocarbon content and tethersonde profiling of the boundary layer.

A specially designed hotwire anemometer system was developed and used in the field study. The unit has been designed to measure the three components of the wind to determine the fluxes of momentum and heat.

Contact: F. Fanaki

3.4.9 Gaussian and Heavy Gas Research

Concord Scientific Corporation (CSC) has further developed the AES-CSC heavy gas model. The present version, COBRA III, contains additional equations to describe the 2-phase flow of liquid droplets and vapour associated with a sudden pressurized release. Flammable and toxic hazard zones can be calculated for a variety of release scenarios.

The Climatological Dispersion Model (CDM) was modified so as to run on much simpler meteorological data input, i.e., 8 or 16 point wind speeds and directions rather than STAR (STability ARray) program output. A second modification was done to allow it to calculate annual dry and wet deposition in kg per hectare in addition to long-term air concentrations.

Contact: C.S. Matthias

3.5 AIR QUALITY SERVICES

3.5.1 Environmental Emergencies Program

The development of a coordinated Service-wide Environmental Emergency Response (EER) Program was initiated this year. In May, an ad-hoc Work Group was formed and includes representatives from AES components responsible for the delivery of services during emergencies. The Secretariat for the Work Group and the lead in the development of the operational program was provided by the Branch. The committee reviewed and advised on the AES policy, present activities and requirements. An action plan to improve the AES response capability was developed at a workshop held in December. Major deficiencies and actions recommended to address these were prioritized in five areas: system design, communications, training, policy and Service plans and procedures.

The Work Group, in consultation with the Conservation and Protection Service, has also reviewed departmental policy and the AES role. Subsequently, the Deputy Minister has asked that AES take the lead in reviewing current policies related to emergency preparedness by undertaking the development of a 'DOE Policy on Response to Environmental Emergencies' in 1987-88.

Contact: E. Wilson

3.5.2 Environmental Emergencies Workshop

The Branch organized a workshop on "Air Quality Response to Accidental Releases of Hazardous Substances" to review the state-of-the-art in air quality modelling and meteorological measurement systems. About 80 persons participated, 23 as speakers (6 from the United States) and represented federal and provincial governments, private industry and universities. The sessions dealt with modelling for nuclear accidents, response packages for chemical spills, modelling for heavy gas dispersion, acquisition of weather and air quality data, advanced modelling techniques and emergency preparedness.

With the advance of computer technology, response to accidental spills through the use of manuals and nomograms has been superseded by many interactive and user-friendly computer packages. These packages simulate atmospheric transport and dispersion behaviour of both heavier and lighter than air or passive gases, as well as vapours from evaporating pools of liquids. Models predict the movement of a toxic cloud, concentration levels within the cloud and areas affected by this cloud. For decision-makers the models' rapid response in real-time prediction is vital. The most difficult input parameter to estimate for these models is the amount of material that is accidentally released into the atmosphere. Each modelling package has a facility to estimate the source strength but to differing degrees of complexity.

Dispersion modelling of heavy gas releases is a different and more complex problem than that for neutral gas models. In simulating heavy gas dispersion, the response performance of box models has been found to be adequate and their results reasonably accurate when compared to field experimental data. Advanced dispersion modelling techniques using non-Gaussian and similarity methods have superseded the previous methods using Pasquil-Turner stability and Briggs dispersion coefficients.

To initiate and complete protective action could take up to 3-6 hours, depending on population densities, weather conditions, etc. As objective weather forecasts from national weather services do not supply parameters for short temporal scales (less than 6 hours) and spatial scales (less than 50 km), the dispersion models use subjective weather forecasts as input to predict hazardous zones from 3-6 hours in future. Further, most of the response models do not apply for dispersion in complex terrain, urban areas and lakeshore environments. To alleviate these, there is a requirement for development of a three-dimensional meso-scale forecast boundary layer model with terrain and thermal forcing functions as a driving module for the dispersion models.

Contact: S.M. Daggupaty

3.5.3 Environmental Impact Assessment (EIA)

Using a modified version of the Climatological Dispersion Model (CDM), long term ground-level concentrations of lead, cadmium, and arsenic in the atmosphere were calculated. The sources were 9 stacks issuing from 6 non-ferrous smelters located across Canada.

Concentrations resulting from a potential chlorine gas spill were estimated using experimental data as well as 2 models. The source was assumed to be a ruptured 150 lb tank of liquid chlorine used for water purification.

An AES model which is useful for calculating long term pollutant concentrations in a single wind sector (PLT - Plume Long Term) was used for incinerator modelling. The model was applied to a proposed sea-based PCB incinerator in the Atlantic, and to two proposed land-based incinerators. The pollutants of interest were PCBs, chlorine, arsenic, cadmium, chromium, nickel, and products of incomplete combustion (PIC).

A new coal-burning electrical power station is to be built southeast of Estevan, Saskatchewan, near the U.S. border. The Industrial Source Complex Short Term (ISCST) model was applied to estimate SO_2 hourly-averaged concentrations from the plant. ISCST was also applied to an existing plant at Boundary Dam, 12 km to the west, and to both plants operating together. Several operating scenarios were run. The CDM model was run in order to estimate long term concentrations.

Contact: C.S. Matthias, D. Bagg

3.5.4 Upper Air Sounding (Beukers Upgrade)

Several improvements were made to the VIZ-BEUKERS upper air windfinding capabilities.

The latest software version contains several enhancements which provide the user with the option of having wind data reported every 30 seconds with a minimum of 1 minute averages. Also included is the capability of recording the signals during the sounding allowing for playback of wind information. This feature can be used to compute different averaging times or the selection of alternate ground stations to re-compute winds. The capability of replaying data from the flight is also available.

Contact: F. Froude

ACID RAIN

4. WEATHER SERVICES REGIONAL AIR QUALITY REPORT

4.1 Long Range Transport of Air Pollutants (LRTAP)

4.1.1 The Pacific Region are installing a CAPMoN (Canadian Air & Precipitation Monitoring Network) station on a small farm on Saturna Island in the southern region of the Georgia Strait. Routine precipitation monitoring will commence in Fall 1987.

Rain samples were collected along the B.C. coast by a volunteer network until December 1986.

Following the closure of a smelter, scientists from the University of Washington and Central Western Washington have found a near-field decrease in sulphate concentration in precipitation. Small decreases were observed in Canada.

A final draft of the report on the applicability of the target loadings concept for western Canada was presented to the Western LRTAP Technical Committee in April 1987.

A modelling study of sulphur depositions from a generic pulp mill in the lower mainland of B.C., using the Alberta Environment SULDEP model, was undertaken for Conservation & Protection.

Contact: Don Faulkner

4.1.2 Western Region completed a wind analysis using the statistical LRT (Long Range Transport) Model. The data base for the model was received from contractors and reviewed. A licence agreement has been signed with the Canadian Electrical Association for use of LRT models.

The CAPMoN station at Esther, Alberta, began operations in January, 1987. Since the Canadian Network for Sampling Precipitation (CANSAP) ceased operations in Alberta, Alberta Environment has continued to maintain their own network and will be installing a CAPMoN-like station in 1987.

Discussions have begun with Alberta Environment, the Alberta Research Council and the Saskatchewan Research Council on a project to evaluate the role of dust in precipitation chemistry.

A paper was presented on arctic haze to the NWT Climate Advisory Committee. An acid rain brochure was completed and distributed.

Contact: Bill Hume

4.1.3 Central Region has initiated an in-house study to assess airmass trajectories and resultant impacts on Cree Lake measurements.

Contact: Ron Hopkinson

4.1.4 Ontario Region continued the analysis of extreme deposition episodes using 1982 Canadian Air & Precipitation Network (APN) data for ELA, Algoma and Long Point. This second report on these three stations (first report was for Chalk River) will be completed in early 1987-88.

A talk was given to the annual meeting of the Nursery Sod Growers Association of Toronto on the "Greenhouse Effect and Acid Rain."

Contact: Terry Allsopp and Dr. S. Bhartendu

4.1.5 Quebec Region evaluated the pH media reports and prepared the pH bulletin each week. An annual summary was prepared and distributed.

Contact: Gilles Desautels

4.1.6 Altantic Region met with authors of the State of the Environment Report for Canada to discuss Atlantic Region acid precipitation data.

The Atlantic Region Long Range Transport of Air Pollutants (LRTAP) Monitoring and Effects Working Group workshop took place on October 6, 1986. Over 30 federal, provincial and university researchers participated and 14 presentations were given on a wide range of acid rain related research projects.

Work on the Fundy (Acidic) Fog Project with the Canadian Forestry Service, and on the Deposition Data Analysis project is continuing. A report was delivered on acid rain monitoring to the Prince Edward Island Climate Advisory Committee (CAC).

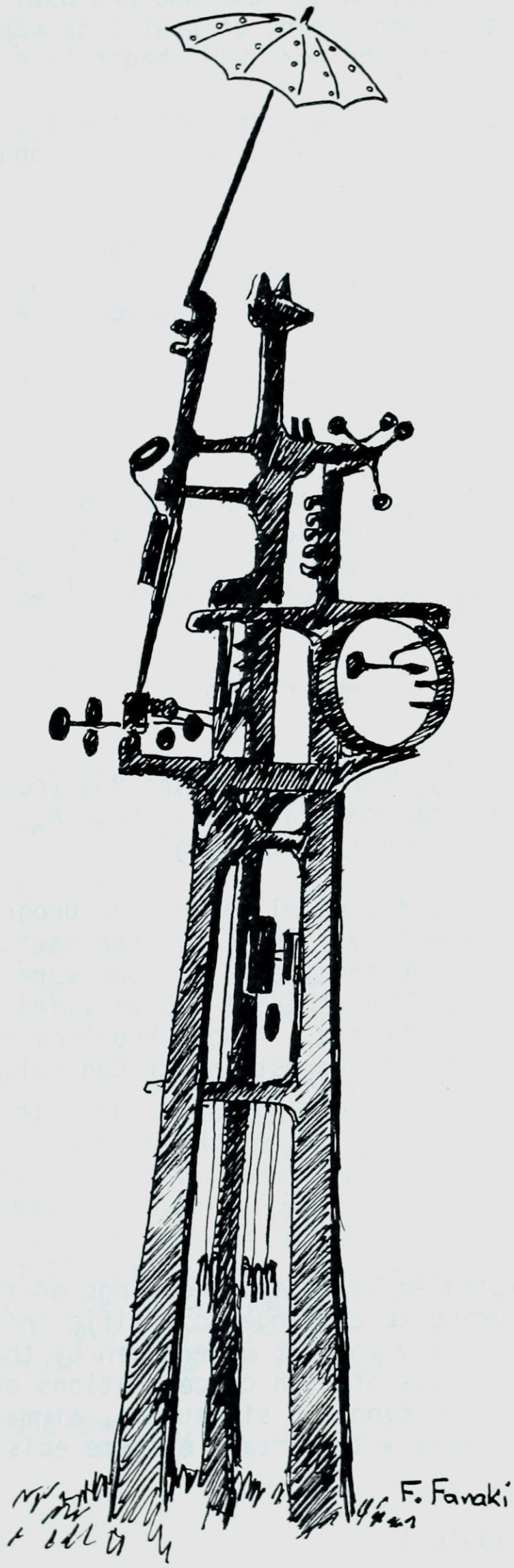
Contact: Billie Beattie

4.2 Toxic Chemicals

4.2.1 Western Region provided consultation services to Conservation & Protection regarding the Riverdale woodsmoke pollution problem in Whitehorse, Yukon.

An article was submitted to Zephyr on the stratospheric ozone observing program at Stony Plain aerological station.

Contact: Bill Hume



ACID RAIN

4.2.2 Central Region assisted the Saskatchewan Research Council in the resubmission of the departmental Pestfund proposal to conduct preliminary atmospheric monitoring of pesticide vapors in the prairies. The proposal was accepted and work will begin this summer.

Back air-flow trajectories were calculated for a study on dispersion of aphids into southern Manitoba. The Canada/Manitoba Contingency Plan for Environmental Monitoring of Emergency Aerial Sprays was reviewed.

An information bulletin on stratospheric ozone monitoring and research was produced that described the Churchill aerological station operation, the ozonesonde and the comparison test between the Brewer and Dobson spectrophotometers.

Contact: Barrie Atkinson

4.2.3 Ontario Region supported the Branch project entitled "Re-suspension of Toxic Substances in a Breaking Wave Regime Over the Great Lakes" by performing wind climatology analysis for several potential field study sites and coordinating data acquisition activities between AES and the Coast Guard.

Contact: Terry Allsopp and Peter Chen

4.2.4 Atlantic Region gave a presentation on the PAN (peroxyacetyl nitrate) project at Kejimkujik National Park, Nova Scotia, at a Regional Toxic Chemicals Coordinating Committee meeting.

An update on the spray drift model validation program was given at an Atlantic Region Pesticides Advisory Committee meeting. A number of simulated aerial pesticide spray applications were run to estimate downwind drift. During June, support was provided to the spruce budworm program in northern Nova Scotia. A workshop took place on "Environmental Monitoring of Forest Insect Control Operations."

Contact: Billie Beattie

4.3 Oxidants

4.3.1 Quebec Region participated at several meetings of the newly-formed inter-governmental group to exchange scientific information on ozone in Quebec. A follow-on study to that undertaken by the Quebec Ministry of Agriculture on the impacts of high concentrations of ozone on vegetation has been initiated. The synoptic situations, airmass trajectories and source regions associated with certain extreme episodes will be evaluated.

Contact: Gilles Desautels

4.3.2 Altantic Region advised Conversation & Protection on possible locations for an ozone monitor in Newfoundland.

Contact: Billie Beattie

4.4 Environmental Emergency Response Program (EERP)

4.4.1 The Chernobyl nuclear accident in April, 1986, led to a significant number of requests for information directed to AES, including TV and radio interviews and consultation on the operation of AES samplers. Requests related to radiation hazards were referred to Health & Welfare Canada. Follow-up recommendations were documented in regional reports.

Each Region took part in two workshops held at AES, Downsview: AES EERP Development, December 3-4, 1986; Modelling and Measurement Technique Workshop, February 4-6, 1987.

4.4.2 Pacific Region updated and distributed the AES Pacific Region contingency plan for environmental emergencies, January 15, 1987. The West Coast Marine Hazards Manual was also reviewed.

Contact: Fred Herfst and Don Faulkner

4.4.3 Western Region revised and distributed the peacetime environmental emergency contingency plans for Alberta, Yukon and NWT. Preliminary discussions have taken place with Alberta Environment on coordinating response programs. A course on environmental emergency response was presented to the Scientific Services and Forecast Operations Staff.

AQPAC models were introduced operationally in November and training of staff on running the models in the Weather Centres took place in March. Whitehorse now has an operational version.

During the year, the Region responded to a range of environmental emergencies, including a minor radioactive spill at the Calgary airport, a small well blowout at Drayton Valley, a sour gas leak at Valleyview and a major sweet gas blowout at Edson. In August, the Yukon Weather Centre provided forecast support to Conservation & Protection during a response to an aviation fuel spill from an overturned tank truck in Whitehorse. In consultation with the Alberta Weather Centre, a briefing note was prepared on the anhydrous ammonia toxic gas release from the fertilizer plant in Calgary, March 29, 1987. The revised draft of a paper on the 1985 Beaufort Storm and oil spill at Minuk was reviewed.

Contact: Bill Hume and Joe Kotylak

4.4.4 Central Region prepared a brief report following the Chernobyl response documenting public dissatisfaction with the lack of locally available authoritative information.

A report entitled "The Answer is Blowin' in the Wind" was published that described the AES environmental emergency response capability in Saskatchewan.

A lecture was delivered to the Regina Hazardous Materials Course. The Federal Peacetime Emergency Procedures (Saskatchewan) were reviewed for Conservation & Protection. Comments were provided on the draft Manifest Regulations for the Transportation of Dangerous Goods for Manitoba.

Contact: Gary Schaefer and Ron Hopkinson

4.4.5 Ontario Region participated in the AES response to the March 11, 1987, spill of storic acid/titanium tetrachloride in Toronto. Technical advice and communications support were provided to Conservation & Protection and the Peel Regional Police. Response was provided to the emergency at Chalk River involving a chlorine release.

An Environmental Emergency Message Tutorial was provided to Ontario Region professional staff. An Ontario Ministry of Environment package of short-range air quality models was obtained.

An updated AES-Ontario Region Contingency Plan was prepared and distributed. An environmental emergency drill exercise was conducted in October simulating a chlorine release.

Contact: Peter Chen

4.4.6 Quebec Region provided direct support to the Canadian Meteorological Centre (CMC) and the scientific lead for AES (R. Gilbert) during the Chernobyl response. Work has been undertaken to improve regional and national response time during such national-scale emergencies. Reviews of responses and reports have been prepared on Chernobyl.

Contact: Pierre Dubreil

4.4.7 Atlantic Region coordinated the installation of an updated version of AQPAC. Instructions for running AQPAC were prepared and provided to staff in the Maritimes and in the Newfoundland Weather Centres.

Portable terminals for emergencies have been located at St. Johns and Gander Weather Centres. The oil drift model SLIK was run by the Maritimes Weather Centre to estimate where and when an oil spill occurred which killed over 1500 sea birds that washed ashore on Sable Island, December 21-23, 1986.

The Region took part in the Point Lepreau, New Brunswick, nuclear station emergency exercise that simulated releases of radioactivity. The AQPAC Puff Model was run and meteorological advice was provided. The mobile minisonde vehicle was dispatched to a simulated chlorine spill during the Fairview Cove drill in Halifax. The Region participated in the international CANUSLANT emergency exercise in Portland, Maine.

Contact: Billie Beattie, John Bursey and Dick Nelis

4.5 Environmental Assessment and Review Process (EARP)

4.5.1 Pacific Region finalized the AES responses to pertinent recommendations made by the West Coast Offshore Exploration Environmental Assessment Panel.

Contact: Bob Beal

4.5.2 Western Region participated in the review of the Gulf Seasonal Production proposal, the DOE evaluation of the Three Rivers Dam project, the Baton Lake Mining project, the Waste Management Strategy for Beaufort Offshore Drilling, the Banff Townsite Developmental proposal and the Oil Spill Contingency Plan for Gulf Extended Flow Test (EFT) at Amauligak.

Contact: Bill Hume

4.5.3 Central Region participated in reviews of the Cluff Lake Uranium Tailing Pond, the Shand Generation Station EIS, the Pasquia Polder III EIS, the proposed Cigar Lake Uranium development, the Polar Gas Mackenzie Valley Pipeline proposal, the uranium site expansion by Eldorado Nuclear at Collins Bay, and the report on Regional Mining South of Latitude 60 Degrees.

Contact: Ron Hopkinson and Barrie Atkinson

4.5.4 Ontario Region prepared a report on the field data from the Port Hope meteorological study. For initial comparisons, the Climatological Dispersion Model (CDM) was run with input data from Port Hope and Trenton, as in the original Environmental Impact Statement.

Contact: Terry Allsopp

4.5.5 Atlantic Region reviewed the following EARP-related documents: adequacy of the terms of reference for a fixed crossing between New Brunswick and PEI, the Conterra Energy Ltd. Contingency Plan for the Scotia Shelf, the Coleson Cove EIS, the Pictou County Coal Project EIA, guidelines for an EIS on military flying activities in Labrador and Quebec, and the Atlantic Region Screening and Coordinating Committee terms of reference.

Contact: John Bursey

The Offshore Drilling Platform Precipitation Data Comparison is nearing completion. Advice was provided on environmental monitoring to the Canadian/Nova Scotia Offshore Environmental Coordinating Committee regarding the Georges Bank oil and gas exploration.

Contact: John Bursey and Rod Shaw

A meeting took place with the Canadian Coast Guard regarding a proposed test of a new oil spill containment boom.

Contact: Stu Porter

4.6 Air Quality Services

4.6.1 Pacific Region initiated work with the Province of B.C. on a pilot project to assess the feasibility of including non-AES data in the national archive, as agreed at the February meeting of the CCREM Deputy Ministers.

A contract was completed to assess the level of public weather services, including air quality aspects, delivered by the media in British Columbia.

4.6.2 Western Region tested and installed various air quality models, including RCDM, SERTAD and MOELRT.

Discussions were held with Alberta Environment on the Fortress Mountain air quality station. AES evaluated and rejected the proposal to assume operation of the air quality monitoring system there.

4.6.3 Central Region (M. Balshaw, CAED) and ADMA (H. Ferguson) officially opened the background air quality research laboratory at Alert on August 29, 1986.

4.6.4 Quebec Region participated in discussions in March with the provincial Ministry of Energy and Resources on the release of smoke during prescribed burns.

4.6.5 Atlantic Region continued contract work to determine the impact of greenhouse gases induced 1 meter rise in MSL on the harbour at Saint John, N.B. and the lower Saint John River.

4.7 Publications

4.7.1 Journal Publications

Faulkner, D. and D.G. Steyn, 1986: "Climate of Sea Breezes in the Lower Fraser, B.C.", Climatological Bulletin, October, 1986.

4.7.2 Internal Reports

Beattie, B. and M. Webber, 1986: "Large Acidic Deposition Episodes at Kejimkujik National Park, N.S. 1979-1983", MAES Internal Report.

Beattie, B., 1986: "Precipitation Chemistry Station Inventory", MAES Internal Report.

Chen, P., 1986: "Field Data From the Port Hope Meteorological Study", OAES Internal Report.

Desautels, G., 1986: "Quarterly Summary of Results Obtained by the Research Measurements of Acidic Precipitation (December 1985 - November 1986)", QAES Internal Report.

Fanaki, F. and B. Beattie, 1986: "Dispersion Characteristics at Tufts Cove Generating Station, N.B.", MAES Internal Report.

Faulkner, D., 1986: "The Effect of a Major Emitter on the Rain Chemistry of Southwestern B.C.: A Preliminary Analysis", PAES Internal Report.

4.7.3 Conference Papers

Beattie, B., 1986: Proceedings of the Atlantic Region LRTAP Monitoring and Effects Working Group.

Hopkinson, R., 1986: "The Answer is Blowin' in the Wind", APCA Technical Proceedings, Canadian Prairie and Northern Section (CPANS).

5. PUBLICATIONS

5.1 Journal Publications

Anlauf, K., H.A. Wiebe and P. Fellin, 1986: "Characterization of Several Integrative Sampling Methods for Nitric Acid, Sulphur Dioxide and Atmospheric Particles." Journal of the Air Pollution Control Association, 36, 715-723.

Anlauf, K., J. Bottenheim, K. Brice and **A. Wiebe,** 1986: "A Comparison of Summer and Winter Measurements of Atmospheric Nitrogen and Sulphur Compounds." Water, Air and Soil Pollution, 30, 153-160.

Barrie, L.A., 1986: "Arctic Air Pollution: An Overview of Current Knowledge." Atmos. Environ., 20, 643-663.

Barrie, L.A., 1986: "Background Pollution in the Arctic Air Mass and its relevance to North American Acid Rain Studies." Water, Air and Soil Pollution, 30, 765-777.

Chung, Y.S., 1986: "Air Pollution Detection by Satellites: The Transport and Deposition of Air Pollutants over Oceans." Atmos. Environ., 20, 617-630.

Fanaki, F., 1986: "Simultaneous Acoustic Sounder Measurement at Two Locations." Boundary-Layer Meteorology, 37, 197-207.

Galloway, J.N., T.M. Church, A.H. Knap, **D.M. Whelpdale** and J.M. Miller, 1986: "The Western Atlantic Ocean Experiment (WATOX): An Overview." In Chemistry of Acid Rain (eds. R.W. Johnson, A.W. Elzeiman, C.E. Gordon and W. Calkens) Amer. Chem. Soc. Special Symposium, No —.

Goodison, B.E., P.Y.T. Louie and J.R. Metcalfe, 1986: "Snowmelt Acidic Shock Study in south central Ontario." Water, Air, and Soil Pollution, 31, 131-138.

Goodison, B.E., P.Y.T. Louie and J.R. Metcalfe, 1986: "Investigations of Snowmelt Acidic Shock Potential in south central Ontario, Canada." Modelling Snowmelt-Induced Processes, Proceedings of the Budapest Symposium, IAHS Publ. 155, 297-309.

Hanafusa, T., C.B. Lee and **A.K. Lo,** 1986: "Dependence of the Exponent in Power Law Wind Profiles on Stability and Height Interval." Atmos. Environ., 20, 2059-2066.

Harvey, H.H. and **D.M. Whelpdale,** 1986: "On the Prediction of Acid Precipitation Events and their Effects on Fishes." Water, Air, and Soil Pollution, 30, 579-586.

Hoff, R.M. and **L.A. Barrie**, 1986: "Air Chemistry Observations in the Canadian Arctic." Water Sci. Tech., 18, 97-107.

Hoff, R.M. and K.W. Chan, 1986: "Atmospheric Concentrations of Chlordane at Mould Bay, N.W.T., Canada." Chemosphere, 15, 449-452.

Leaitch, R., W. Strapp, **H.A. Wiebe, K. Anlauf** and G. Isaac, 1986: Chemical and Microphysical Studies of Non-precipitating Summer Cloud in Ontario, Canada." J. Geophysical Research, 91, 11821-11831.

Lusis, M.A., W.H. Chan, P.K. Misra, **E.C. Voldner, R.J. Vet**, A.R. Olsen, D. Bigelow, T.L. Clark, 1986: "A Unified Wet Deposition Database for Eastern North America Data Screening and Calculation Procedures and Results." Proceedings of the 79th Annual Meeting of the Air Pollution Control Association, Minneapolis, Minn., June 22-27, 1986.

Mackay, D., S. Paterson and **W.H. Schroeder**, 1986: "Model Describing the Rates of Transfer Processes of Organic Chemicals between Atmosphere and Water." Environ. Sci. Technol., 20, 810-816.

Matthias, C.S. and **A.K. Lo**, 1986: "Application and Evaluation of the Fay and Rosenzweig Long-range Transport Model." Atmos. Environ., 20, 1913-1921.

Munn, R.E., **D.M. Whelpdale**, G. Oehlert and **P.W. Summers**, 1986: "The Early Detection of Sulphur Emissions Reductions using Wet Deposition Measurements." Atmos. Environ., 20, 1923-1930.

Padro, J., 1987: "Boundary-Layer Pollutant Concentrations over Complex Terrain." Boundary-Layer Meteorology, 38, 17-28.

Schroeder, W.H. and R.A. Jackson, 1987: "Environmental Measurements with an Atmospheric Mercury Monitor Having Speciation Capabilities." Chemosphere, 16, 183-199.

Schroeder, W.H., 1987: "Book Review of Atmospheric Chemistry: Fundamentals and Experimental Techniques - B.J. Finlayson-Pitts and J.N. Pitts, Jr. (Wiley-Interscience, 1986)." Geochim. et Cosmochim. Acta, 51, 175.

Summers, P.W. and **L.A. Barrie**, 1986: "The Spatial and Temporal Variation of the Sulphate to Nitrate Ratio in Precipitation in Eastern North America." Water, Air and Soil Pollution, 30, 275-283.

Summers, P.W., V.C. Bowersox and G.J. Stensland, 1986: "The Geographical Distribution and Temporal Variations of Acidic Deposition in Eastern North America." Water, Air and Soil Pollution, 31, 523-535.

Voldner, E.C., L.A. Barrie and **A. Sirois**, 1986: "A Literature Review of Dry Deposition of Oxides of Sulphur and Nitrogen with emphasis on Long-range Transport Modelling in North America." Atmos. Environ., 20, 2102-2123.

Walmsley, J.L., P.A. Taylor and T. Keith, 1986: "A Simple Model of Neutrally Stratified Boundary-Layer Flow Over Complex Terrain with Surface Roughness Modulations (MS3DJH/3R)." Boundary-Layer Meteorology, 36, 157-186.

5.2 Conference Papers and Presentations

Alp, E., C.P. Bourque, M. Oliverio, D.H. Napier and **C.S. Matthias:** "Continued development of a heavy gas dispersion modelling system: COBRA III." Technical Seminar for Chemical Spills, Toronto, February 10-12, 1987.

Beljaars, A.C.M., **J.L. Walmsley** and **P.A. Taylor:** "Modelling of Turbulence Characteristics Over Low Hills." 20th Annual Congress, CMOS, Regina. June 3-6, 1986.

Beljaars, A.C.M., **J.L. Walmsley** and **P.A. Taylor:** "Modelling of Turbulence Over Low Hills and varying Surface Roughness." Internat. Conf. on Energy Transformations and Interaction with Small and Mesoscale Atmospheric Processes, Lausanne, Switzerland, March 1987.

Bottenheim, J.W., A.J. Gallant and K.A. Brice: "Development of a method for measurements of low levels of PAN from an aircraft." 5th Symposium on Environmental Analytical Chemistry, Provo, June 1986.

Bottenheim, J.W., and **A.J. Gallant:** "Measurements of PAN and NO_2 during WATOX-86." AGU Annual Fall Meeting, San Francisco, December 1986

Bottenheim, J.W., A.J. Gallant and **J. Kovalick:** "PAN during the 1986 Arctic Haze Season." AGU Annual Fall Meeting, San Francisco, December 1986.

Bottenheim, J.W.: "Atmospheric Chemistry." Seminar presented at University of Toronto, March 1987.

Chakrabarti, C.L., H. Xiuren, W. Shaole, Q. Fu and **W.H. Schroeder:** "A Novel Microsampling Technique for Direct Determination of Solid Samples of Air Particulates by Graphite Probe Furnace Atomic Absorption Spectrometry." 69th Canadian Chemical Conference, Saskatoon, June 1-4, 1986.

Chung, Y.S.: "Variations of Atmospheric CO_2 measured at Alert and Sable Island." Atmos. Science Research Seminars, Toronto, April 15, 1986.

Chung, Y.S.: "Evidence of Large-scale Transport of air pollutants." Invited Seminar given at Graduate Center for Cloud Physics Research, U. of Missouri-Rolla, September 18, 1986.

Daggupaty, S.M.: "Response to Accidental Releases of toxic chemicals into the atmosphere using AQPAC." International Symposium on Natural and Man-Made Hazards, Rimouski, Quebec, August 3-9, 1986 (presented by Dr. Bhartendu, AES).

Daggupaty, S.M.: "Air Quality Package of Programs for Environmental Emergencies." Workshop on Air Quality Response to Accidental Releases of Hazardous Substances, AES, Toronto, February 4-6, 1987.

Daggupaty, S.M.: "AQPAC - Status and its Development." ARD-WSD workshop on Environmental Emergency Response, Downsview, December 3-4, 1986.

den Hartog, G. and **H.H. Neumann:** "A Forest Micrometeorological Research Monitoring Facility." Surface Turbulence Exchange Measurement Workshop, Boulder, Co., August 14, 1986 (invited paper).

den Hartog, G. and **H.H. Neumann:** "Measurements Of Ozone And Carbon Dioxide Fluxes Over A Deciduous Forest." Forest Climate '86 Symposium, Orillia, Ont., November 17-20, 1986 (invited paper).

Fanaki, F.: "NOGAP Arctic Field Study." Presented at the Polar Continental Shelf Project Meeting, EM&R, Ottawa.

Froude, F.A.: "A Portable Weather Monitoring System at Accident Sites." Workshop on Air Quality Response to Accidental Releases of Hazardous Substances, AES, Downsview, Ontario, February 4-6, 1987.

Hoff, R.M.: "Lidar Observations of Arctic Haze." Conference on Lasers and Electro-optics, San Francisco, June 1986.

Hoff, R.M.: "Vertical Structure of Arctic Haze Observed by Lidar." 13th International Laser Radar Conference, NASA Conference Publication 2431, National Aeronautics and Space Administration NIT-4, Washington, D.C. 20546-0001.

Hoff, R.M.: "Coping with Chemicals." Guelph Toxicology Symposium, February 1987.

Johnson, N.D., S.C. Barton, G.H.S. Thomas, **D.A. Lane**, and **W.H. Schroeder:** "Development of a Vapour/Particle Fractionating Sampler for High Molecular Weight Chlorinated Organic Compounds." In Proceedings of the Seventh World Clean Air Congress, Vol. II, H.F. Hartmann, Ed., Clean Air Society of Australia and New Zealand, 1986, 127-134.

Johnson, N.D., S.C. Barton, G.H.S. Thomas, **D.A. Lane** and **W.H. Schroeder:** "Field Evaluation of a Diffusion Denuder Based Gas/Particle Sampler for Chlorinated Organic Compounds." Proceedings of the 79th Annual Meeting of the Air Pollution Control Association, Minneapolis, Minn., June 22-27, 1986.

Lo, A.K.: "On The Aerodynamic Characteristics of a Forest Canopy." Fifth Joint Conference on Applications of Air Pollution Meteorology, Chapel Hill, N.C., November 18-21, 1986,

Martin, A.V.M., P.M. Stokes and **D.M. Whelpdale:** "Organic Contaminants in the Lichen Cladina rangiferina at 9 Rural and Remote Sites in Eastern Canada -- How Does Kejimkujik Measure up?" Presentation to Kejimkujik Workshop, Halifax, November 1986.

Matthias, C.S.: "A comparison of plume hazard zones using a Gaussian model and a heavy gas model on the AQPAC system." Workshop on Air Quality Response to Accidental Releases of Hazardous Substances, AES, Toronto, February 4-6, 1987.

Mickle, R.E.: "A Model for Operational Spraying Events Under Different Weather Scenarios." Forest Climate 186 Symposium, Orillia, November 17-20, 1986. (invited paper).

Neumann, H.H. and **G. den Hartog:** "A Forest Dry Deposition Project." 18th Annual Air Pollution Workshop, Chicago, Il., April 14-17, 1986 (invited paper).

Neumann, H.H. and **G. den Hartog:** "Eddy Fluxes over a Deciduous Forest in Southern Ontario." 20th Annual Congress, CMOS, Regina, June 3-6, 1986.

Padro, J.: "A Model of Pollutant Concentrations, forced by Velocity Perturbations in Complex Terrain." Fifth Joint Conference on Applications of Air Pollution Meteorology, Chapel Hill, N.C., November 18-21, 1986.

Padro, J.: "Boundary-Layer Pollutant Concentrations over Complex Terrain, Extension." Proceedings of International Conference on Energy Transformations and Interactions with Small and Mesoscale Atmospheric Processes-ICEA, Lausanne, Switzerland, March 2-6, 1987.

Padro, J.: "A Mathematical - Physical Simulation of Pollutant Concentrations over a Small Hill." AQRB Seminar Series, January 19, 1987.

Phillips, M.L.: "Atmospheric Deposition of SO_x and NO_x." Forest Decline Workshop, Wakefield, P.Q., October 21, 1986.

Reid, J.D., R.E. Mickle and **E.C. Voldner:** "Evaluation of long-range Drift of Forest Pesticide Spray." SETAL Annual Meeting, Alexandria, VA., November 1986.

Sandberg, D.K., N.R. McQuaker, **R.J. Vet** and **H.A. Wiebe:** "Snowpack: Recommended Methods for Sampling and Site Selection." RMCC Quality Assurance Subgroup Publication, June 1986.

Schemenauer R. and **K. Anlauf:** "Geographic Variations of Ozone Concentrations at High and Low Elevation Rural Sites in Quebec." North America Oxidant Symposium, Quebec City, February 25-27, 1987.

Schroeder, W.H.: "Sampling and Analysis of Toxic Trace Elements in Ambient Air." Fall Meeting, APCA Ontario Section, Minett, Ont., September 14-16, 1986.

Schroeder, W.H. and **D.A. Lane:** "The Role of the Atmosphere in Determining the Ultimate Fate of Toxic Airborne Pollutants." Proceedings of the 79th Annual Meeting of the Air Pollution Control Association, Minneapolis, Minn., June 22-27, 1986.

Shannon, J.D. and **E.C. Voldner:** "Deposition of S and NO_x-N to the Great lakes Basin." Fifth Joint Conference on Applications of Air Pollution Meteorology, Chapel Hill, N.C., November 18-21, 1986.

Sirois, A., W. Fricke and **P.W. Summers**, 1986: "The Temporal Variation in Atmospheric Deposition in Kejimkujik National Park, Nova Scotia." Kejimkujik LRTAP Studies Workshop, October 8-9, 1986.

Summers, P.W., 1986: "The Data Needs for Atmospheric Research." RMCC/ASSG Monitoring Workshop, AES Downsview, June 18-19, 1986.

Summers, P.W., 1986: "The Role of Acidic and Basic Substances in Wet and Dry Deposition in Western Canada." Second Symposium/Workshop on Acid Forming Emissions in Alberta and their Ecological Effects, Calgary, May 12-15 1986.

Summers, P.W., 1986: "Some Results from the 1983 Eastern North American Long-Range Tracer Experiment." Invited lecture at CSIRO, Division of Atmospheric Research, Aspendale, Australia, August 20, 1986. Also invited lecture at the New Zealand Meteorlogical Service, Wellington, New Zealand, September 1, 1986.

Summers, P.W., 1986: "Transport and Dispersion on the 1000 km Scale Determined from Inert Tracer Gas Releases." Poster Paper at the Seventh Clear Air Congress, Sydney, Australia, August 17-22, 1986.

Summers, P.W., 1986: "Source-Receptor Relationships from Observations and Modelling - An Introductory Review of Techniques." Acid Rain Workshop at Seventh Clean Air Congress, Sydney, Australia, August 17-22, 1986.

Taylor, P.A., J.R. Salmon and **R.E. Mickle:** "A Canadian PAM Facility and Its Deployment in CASP." 20th Annual Congress, CMOS, Regina, June 3-6, 1986.

Taylor, P.A. and **J.L. Walmsley:** "High-Resolution Wind Field Modelling in Complex Terrain." Workshop on Air Quality Response to Accidental Releases of Hazardous Substances, AES, Downsview, February 4-6, 1987.

Taylor, P.A.: "Anomalously High Wind Speeds from the Surface Mesonet." CASP Analysis Workshop #2, Halifax, December 1986.

Vet, R.J.: "Results of the Quality Assurance Program of the Canadian Air and Precipitation Monitoring Network." Workshop on Data Handling, Analysis and Quality Assurance for the European Monitoring and Evaluation Program (EMEP), Freiburg, FRG, July 2-5, 1986.

Vet, R.J.: "Deposition in the Turkey Lakes Watershed in the North American Context." Integrated Workshop of the Turkey Lakes Watershed, Sault-Ste. Marie, Ontario, September 16-19, 1986.

Vet, R.J.: "The precision and comparability of CAPMoN and provincial precipitation chemistry data." RMCC Atmospheric Sciences Subgroup Workshop on Monitoring, June 18-19, 1986.

Vet, R.J.: "The Precision and Comparability of Several Canadian Precipitation Chemistry Monitoring Networks." RMCC QA Subgroup LRTAP Analysts Workshop, Burlington, Ontario, October 22, 1986.

Vet, R.J.: "Acid Deposition Monitoring in Snowfall: State-of-the-Science and Proposed Research." EPA Workshop on Acid Deposition Monitoring for Snowfall and Snow Pack. Keystone, Colorado, Nov. 19-21, 1986.

Voldner, E.: "Science Dimensions: Atmospheric Transport and Transformation." Toxic Rain Science and Policy Forum, Burlington, September 3-4, 1986.

Voldner, E. and **W.H. Schroeder**, 1986: "Atmospheric Transport and Deposition of Toxaphene into the Great Lakes Ecosystem." International Association for Great Lakes Research, Annual Meeting, Toronto, June 1986.

Voldner, E.C. and L. Smith: "Emissions Inventories." IJC Workshop on Atmospheric Deposition, Scarborough, Ont., October, 1986.

Voldner, E.C.: "Uncertainties in Wet Deposition Amounts of Sulfur and Nutrients to the Great Lakes and their Basins as estimated from Observations." Workshop on Locations of Monitors, Atmospheric Monitoring Task Force of the IJC, Toronto, March 1987.

Voldner, E.C. and S.J. Eisenreich: "Atmospheric Component of the Great Lakes Surveillance Plan." IJC Surveillance Working Group meeting, March 31, 1986.

Voldner, E.C. and **W.H. Schroeder**: "Atmospheric Transport and Deposition of Toxaphene into the Great Lakes Ecosystem." 29th Annual Conference of the International Association for Great Lakes Research, Toronto, May 26-29, 1986.

Walmsley, J.L. and J.R. Salmon: "A Study of Boundary-Layer Winds on Sable Island, Nova Scotia, Canada: Comparison Between Measured Data and Model Estimates." European Wind Energy Conf., Rome, Italy, October 1986.

Walmsley, J.L., and **P.A. Taylor:** "Preliminary Study of Sub-grid Scale Variations in Anemometer Level Winds using MS-Micro." CASP Analysis Workshop #2, Halifax, December 1986.

Whelpdale, D.M.: "The Large-scale Transport of Pollutants from North America." Invited seminar at Freshwater Institute, Winnipeg, April 1986.

Whelpdale, D.M.: "The Transport of Sulphur and Nitrogen Pollutants in the Atmosphere." Invited seminar at Centre de Recherches en Physiques de l'Atmosphere, Magny-Les-Hameaux, France, May 1986.

Whelpdale, D.M.: "Multi-media Trends in Acid Deposition." Seminar at Institute for Environmental Studies, Toronto, May 1986.

Whelpdale, D.M.: "Acid Rain and Arctic Haze." Invited seminar at U. of Western Ontario, London, January 1987.

Whelpdale, D.M.: "Current Atmospheric Environmental Problems." Invited talk to Univ. of Toronto Engineers, Toronto, January 1987.

Whelpdale, D.M.: "The Use of Lichens as Biomonitors." Invited seminar to Organic Contaminants Working Group, IES, Univ. of Toronto, March 1987.

Whelpdale, D.M.: "The Global Tropospheric Chemistry Program." Discussion paper for WMO EC Panel of Experts on Environmental Pollution, Sixth Session.

Wiebe, H.A. and **K. Anlauf:** "A Comparison of Two Methods for Measurement of Atmospheric Nitrates." 192nd National Meeting of the American Chemical Society, Anaheim, California, September 7-12, 1986.

Young, J.W.S.: "From Drycleaning to Meltdown - A Study of Toxic Chemicals." Invited Paper presented at York University 12th Annual Prospects for Mankind Symposium "Our Fragile Atmosphere: A Chemical Perspective," June 16, 1986.

5.3 Internal Reports

Drake, S. and **D.M. Whelpdale**, 1986: "Acid Precipitation Shock Potential Model Applied to Winter Seasons of 1979 to 1985, Milford Bay, Ontario." Project Report, April 1986.

Hoff, R.M. and **W.H. Schroeder**, 1986: "The Background for a Framework for Toxic Chemicals Research in AQRB." AQRB-87-M-001, Atmospheric Research Directorate Management Report Series.

Matthias, C.S. and **D.L. Bagg**, 1987: "Air Quality Modelling of Boundary Dam and Shand Generating Stations (short term concentrations)."

Matthias, C.S. and **D.L. Bagg**, 1986: "Evaluation of a multiple source regional episode model (REM)."

Salmon J.R. and **P.A. Taylor**, 1986: "Wind and Temperature Observations at Canada Olympic Park." Report No. 2. Report prepared for Public Works Canada and Calgary Olympics Committee.

Still, M.E. (ed.), 1986: Air Quality and inter-Environmental Research Branch Annual Report (1985-86), AQRB-86-M-001, May 1986.

Vet, R.J. and **M.E. Still**, 1986: "The Canadian Air and Precipitation Monitoring Network (CAPMoN): A Description." (Also available in French).

Whelpdale, D.M. (ed.), 1986: "Annual Report 1985-86." University of Toronto, Institute for Environmental Studies.

5.4 Other Reports

Chung, Y.S. (Guest Editor), 1986: Atmos. Environ., 20, 615-812 and 1837-2078.

Padro, J., 1986: "Description of Boundary-Layer Pollutant Concentrations in Complex Terrain." Air Pollution Special Interest Group Update, 6.

6. MAJOR CONTRACTS ($4,000 and over)

Beak Consultants $ 20,200	To load and unload filter packs
Concord Scientific $ 14,544	To evaluate and analyse Data on Peroxyacetyl Nitrate (PAN)
Concord Scientific $ 48,277	To enhance the "COBRA" Hazard Assessment Model
Concord Scientific $ 48,000	To upgrade the COBRA hazard assessment model
Concord Scientific $ 54,000	To conduct a scientific assessment of existing forest pesticide models and implement an enhanced model
MEP Company $ 25,000	To develop procedures for modelling sub-grid scale processes in Eulerian models
MEP Company $ 83,000	To generate meteorological and emission databases
Nortech $ 9,358	To develop and implement the AES continuous CO_2 monitoring system
Ont. Research Foundation $ 74,089	To deploy "GAP" Sampler
Pearce, T. $ 7,461	To assemble, install and program system for Forest Turbulence Study
Promet Environmental Group Ltd. $ 5,700	To service and maintain wind and temperature data acquisition system at Canada Olympic Park
Saini, B. $ 8,000	To upgrade the heavy gas model on the AQPAC emergency response modelling system
Saini, B. $ 28,980	To analyse air quality data and to perform dispersion modelling
Salmon, J.R. $ 32,000	To analyse and interpret CASP '86 Surface Mesonet Data
Salmon, J.R. $ 19,500	To analyse wind and temperature data from Canada Olympic Park, Calgary
Salmon, J.R. $ 5,000	To analyse wind and temperature data from Canada Olympic Park, Calgary

Schroeder, R. $ 29,000	To collect data and to monitor and inspect instrumentation for air pollution monitoring site at Alert
Shannon, J.D. $ 11,974	To consult and modify the LRTOX model for simulation of priority chemicals, structure of meteorological and emissions input on model scenarios
Shaw, R. $ 19,000	To analyse atmospheric turbulence and diffusion processes within and above a forest canopy
Skelton, G.B. $ 6,904	To provide quality assurance and quality control services for CAPMoN Network
Strauss, A. $ 5,064	To develop plotter software on COMPAC 286 computer
Symington, S. $ 6,968	To develop and implement the AES continuous CO_2 monitoring system
Unisearch $ 14,162	To develop aircraft mounted platform for measuring gaseous nitric acid and nitrogen dioxide in air
Univ. of Guelph $ 24,670	To determine the CO_2 exchange between the atmosphere and a large agricultural crop area
Univ. of Toronto $ 13,000	To provide biological monitoring for airborne organic and metal contaminants in the Upper Great Lakes Region of North America
Van Ameron, R. $ 5,200	To provide technical support for the Rapid Fire LIDAR and Differential Absorption LIDAR (DIAL)

7. UNSOLICITED PROPOSALS

CONTRACTOR	UP NO.	PROJECT TITLE
The MEP Company $152,000 ARQD Contribution: $25,000	UP-M-570	Development of procedures for modelling sub-grid processes in Eulerian models.

8. SCIENCE SUBVENTIONS

APPLICANT/ INSTITUTION	SCIENTIFIC AUTHORITY	TITLE
BARIL, M. Laval University $6,000.00	L.A. Barrie	Feasibilty study to obtain the signatures of major industrial sources in Canada.
BUNCE, N. University of Guelph $7,000.00	D.A. Lane	Estimation of the rate of solar assisted decomposition of chlorophenols in the atmosphere.
CAMPBELL, P.G. University of Quebec $7,000.00	W.H. Schroeder	Chemical speciation of certain metals present in atmospheric aerosol.
CARSWELL, A.I. York University $10,000.00	R.M. Hoff	LIDAR Measurements of Cloud Parameters.
CHAKRABARTI, C.L. Carleton University $8,000.00	W.H. Schroeder	Development of a new analytical method for direct determination of heavy metal content in atmospheric particulates.
LEE-RUFF, E. York University $11,000.00	D.A. Lane	Oxidation Mechanisms and Product Characterization of Air-borne Polynuclear Aromatic Hydrocarbons.
MACKAY, D. University of Toronto $10,000.00	D.M. Whelpdale	Mathematical models of toxic chemical pathways between the atmosphere and soil and water.

OKE, T. University of B.C. $5,000.00	G. den Hartog	Direct measurement of the vertical flux of water over suburbanized terrain.
ORMROD, D. University of Guelph $7,000.00	M.L. Phillips	Effects of air pollution mixtures on plants.
PICOT, J.J.C. University of N.B. $6,000.00	R.E. Mickle	Simulation of Aerial Spray Aircraft Wake Vortex Effects for Droplet Dispersion and Deposition in Forestry Aerial Spraying.
SCHIFF, H. York University $10,000.00	K. Anlauf	Improvements in the Luminol Instrument for NO_x Measurements.
SNIECKUS, V. Univ. of Waterloo $8,000.00	D.A. Lane	Simulated Atmospheric Chemistry of Methyl PAHs and Nitro-PAHs.
STUBLEY, G.D. Univ. of Waterloo $6,000.00	P.A. Taylor	Planetary Boundary Layer Modelling with High Order Closure Models
THURTELL, G. University of Guelph $12,000.00	G. den Hartog	The measurement and modelling of dry deposition and pollution fluxes in forests.

9. PERSONNEL

AIR QUALITY AND INTER-ENVIRONMENTAL RESEARCH BRANCH

		PHONE NO. (667-XXXX)	ROOM NO.
ARQD	**OFFICE OF THE DIRECTOR**		
Director:	Dr. J.W.S. Young	4937	4S260
A/Secretary:	Ms. L. Smith	4969	4S250
A/Admin. Officer:	Mrs. E. Veinot	4802	4S240
Exec. Assistant:	Mrs. S.J. Kirkpatrick	4982	4S270
Clerk:	Mrs. M. Stasyshyn	4969	4S250
Senior Res. Scientists:	Dr. P.W. Summers	4796	4S190
	Dr. A.D. Christie	4981	4S160
*Co-ordinator:	Mrs. E.E. Wilson	4796	4S180
PDF:	Dr. W. Fricke	4839	3S650A
ARQA	**ATMOSPHERIC CHEMISTRY, CRITERIA & STANDARDS DIVISION**		
A/Chief:	Dr. K.G. Anlauf	4798	4S140
Secretary:	Mrs. J. Selmes-Brymer	4798	4S015
	Dr. H.H. Neumann	4954	4S830
	Dr. W.H. Schroeder	4794	4S090
	Dr. H.A. Wiebe	4797	4S120
	Dr. D. Lane	4965	4S132
	Mr. D. MacTavish	4965	4S131
	Mr. Y. Tham	4901	4S130
	Dr. S. Ahmed	4965	4S132
CO-OPs:	S. Alibhai	4798	4S140
	B. Fullerton	4794	4S090
	D. Griffith	4797	4S120
ARQL	**BOUNDARY LAYER RESEARCH DIVISION**		
A/Chief:	Dr. R.E. Mickle	4789	4S815
Secretary	Mrs. E. Mathis	4789	4S810
	Dr. G. den Hartog	4780	4S814
	Dr. B.R. Kerman	4791	4S824
	Dr. A.K. Lo	4824	4S821
	Dr. J. Padro	4792	4S813
	Dr. P.A. Taylor	4824	4S823
	Dr. J.L. Walmsley	4780	4S816
	Mr. V.S. Derco	4791	4S822
	Mr. L. Guise-Bagley	4680	4S640A
	Mr. N. Koshyk	4680	4S640A
	Mr. J. Arnold	4791	4S820
PDF:	Dr. S. Karpik	4839	3S690A
**	Dr. R. Shaw	4792	4S811

* Denotes term or assignment
** Visiting Scientist from California
K. Puckett - French Language Training (June 1987)

ARQM AIR QUALITY MONITORING AND ASSESSMENT DIVISION

Chief:	Dr. M.L. Phillips	4610	4S835
Secretary:	Mrs. J. Zarzycki	4610	4S833

Air Quality Assessment and Technology Transfer

	Dr. C.S. Matthias	4954	4S832
	Dr. S.M. Daggupaty	4778	4S843
	Mr. D. Bagg	4988	4S842
	Dr. K. Higuchi	4778	4S841
	Dr. N.B.A. Trivett	4954	4S831
CO-OP:	R. Dugal	4980	4S841

Networks and Surveys Section

Head:	Mr. M.E. Still	4988	4S844
	Mr. W. Kobelka	4970	4S670
	Mr. S. Iqbal	4970	4S670
	Mr. B. Martin	4987	4S640B
	Mr. A. Gaudenzi	4987	4S640B
	Mr. W. Sukloff	4801	4S620
	Mr. R. Vet	4801	4S620
	CO_2 Lab	4787	1S561

ARQT ATMOSPHERIC DISPERSION DIVISION

Chief:	Dr. H.E. Turner	4984	4S310
Secretary:	Mrs. P. Pearson	4984	4S300

Experimental Studies Section

Head:	Dr. F. Fanaki	4786	4S290
	Dr. L.A. Barrie	4785	4S330
	Dr. R.M. Hoff	4786/851-4643	4S280
*	Mr. J. Deary	4680	4S640A
	Mr. F. Froude	4941/851-4643	4S650
	Mr. J. Kovalick	4983	4S660
	Mr. J. Markes	4983	4S660
	Mr. S. Melnichuk	4941	4S650
PDF:	Dr. F. Hopper	4839	3S690A

Modelling and Applications Section

Head:	Mr. M. Olson	4903	4S370
	Dr. J.W. Bottenheim	4797	4S110
	Dr. Y. Chung	4980	4S840
	Dr. D. Davies	683-7952	Dorval
	Dr. E.C. Voldner	4788	4S630
	Mr. A. Gallant	4983	4S660
	Mr. K. Oikawa	4980	4S845
*	Mr. G. West	4941	4S650
CO-OP:	G. Girard	4797	4S110

Special Studies Section

	Dr. D.M. Whelpdale	4903	4S340
	Dr. A. Sirois	4839	3S450B

* Denotes term or assignment

10. ACKNOWLEDGEMENTS

A year of achievements can only be highlighted in this report but readers are welcomed to approach the listed contacts for more information and discussion. To summarize a complete year's work into a few paragraphs is a challenge for both project leader and editor. *** Special thanks must be extended to Fouad Fanaki for his drawings that reflect and comment on the work of the Branch.

This final form of the report was due to all members of the Branch but especially to the following:

- the secretaries (Pat Pearson, Judy Selmes-Brymer, Marg Stasyshyn and Zsa Zsa Zarzycki) who ensured that all divisional input was received by the Director's office in a timely fashion;

- Ev Wilson who coordinated and wrote the Regional review;

- Sheila Kirkpatrick who supplied the updated personnel list and the information on the contracts; and

- Linda Smith who arranged the divisional input into a format for the first draft.

Malcolm E. Still

*** Both must be complimented on a job well done - Jim Young