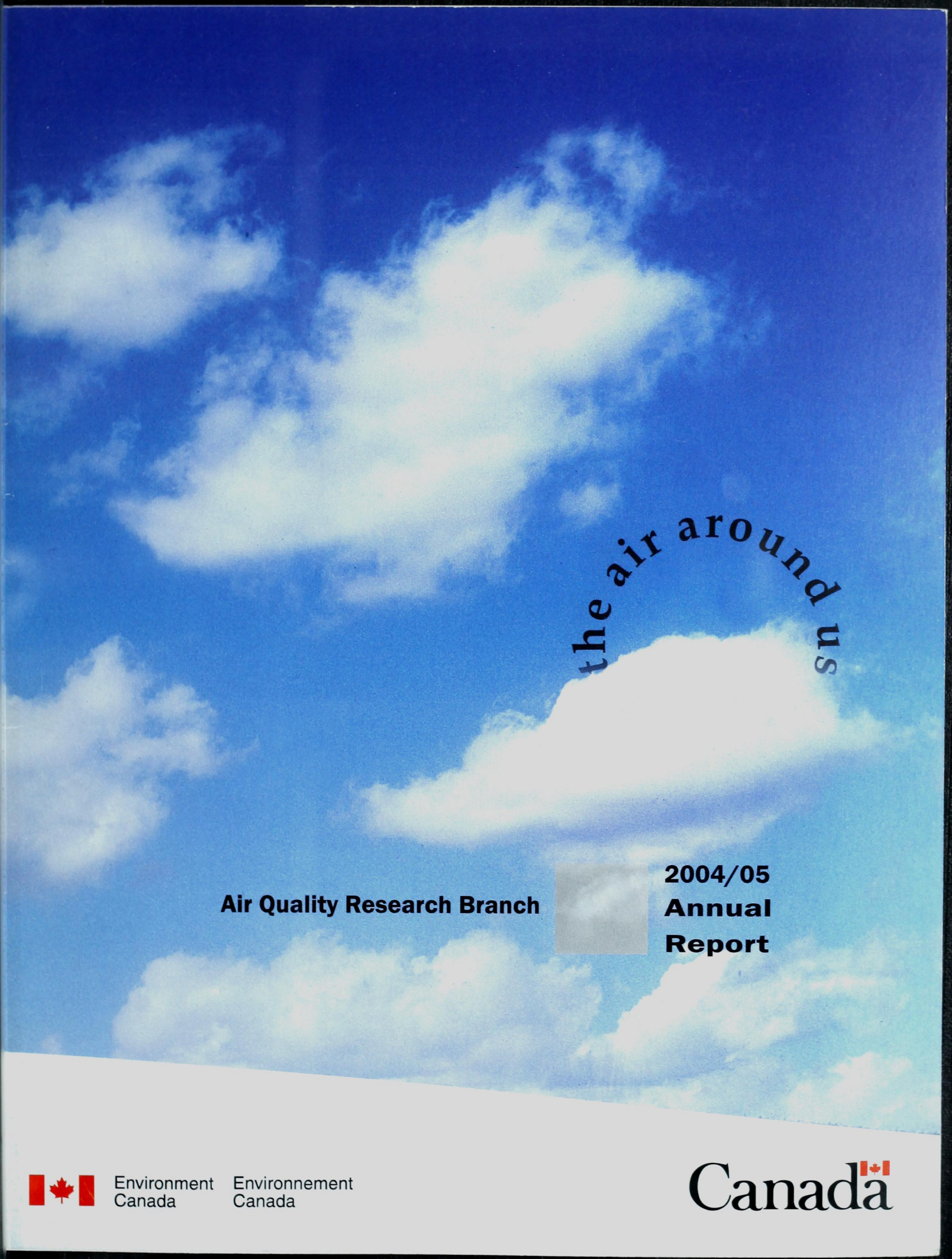

Air Quality Research Branch

2004/05
Annual
Report

Environment Canada
Environnement Canada

Canada

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The 2004/05 fiscal year was marked by noteworthy milestones. Our accomplishments are illustrated by our progress in air quality measurement and modelling activities along with field studies, collaborations, publications and scientific contributions to public policy and services to Canadians.

Of significance is the expansion of the national Air Quality Research and Development Program in support of the Federal Clean Air Agenda. For example, the Branch increased its research and development (R&D) activities by carrying out field studies to characterize air pollution in cross-border regions as part of the Canada-US Border Air Quality Strategy. Also of significance was the Branch's participation in a major international field study known as ICARTT (International Consortium for Atmospheric Research on Transport and Transformation) which focused on the transport and transformation of air pollutants.

Branch scientists were instrumental in the development and employment of cutting edge technologies to quantify and define air quality in Canada.

The Branch also provided the science contribution to the 2004 Canadian Acid Deposition Science Assessment and provided the R&D input to the 2004 Canada - U.S. Transboundary Particulate Matter Science Assessment in support of the Canada-U.S. Air Quality Agreement.

In addition, a significant contribution was made to the Atmospheric Chemistry Experiment (ACE) which focused on ground-based validation measurements for the Canadian ACE satellite mission. Results from this experiment will help facilitate the development of models to improve air quality forecasts.

This past year, the Branch led the establishment of national and global monitoring networks to provide new information on emerging chemicals and currently-used pesticides to support national screening assessments and obligations under the Stockholm Convention on persistent organic pollutants (POPs).

Our accomplishments continue to strengthen the Air Quality R&D Program by delivering relevant and credible scientific information to support policy and services such as air quality and UV forecasts.

The Program facilitates a cohesive integrated air quality science portfolio by involving staff from Environment Canada's Departmental Services and Regions, other government departments, universities, provincial and territorial governments and other local, national and international organizations.

These collaborations are important as we work toward enhancing Canada's competitiveness while ensuring environmental sustainability. Our research and development program will continue to help protect the health of Canadians and their environment.

Dr. Keith J. Puckett

About the Branch

The Air Quality Research Branch consists of approximately 140 staff based at Downsview (Ontario), Dorval (Quebec), Egbert (Ontario) and Bratt's Lake (Saskatchewan) and has strong linkages to the Department's regional air quality science community. The Branch aims to develop and provide unbiased, relevant and scientifically sound knowledge, advice and data on air quality.

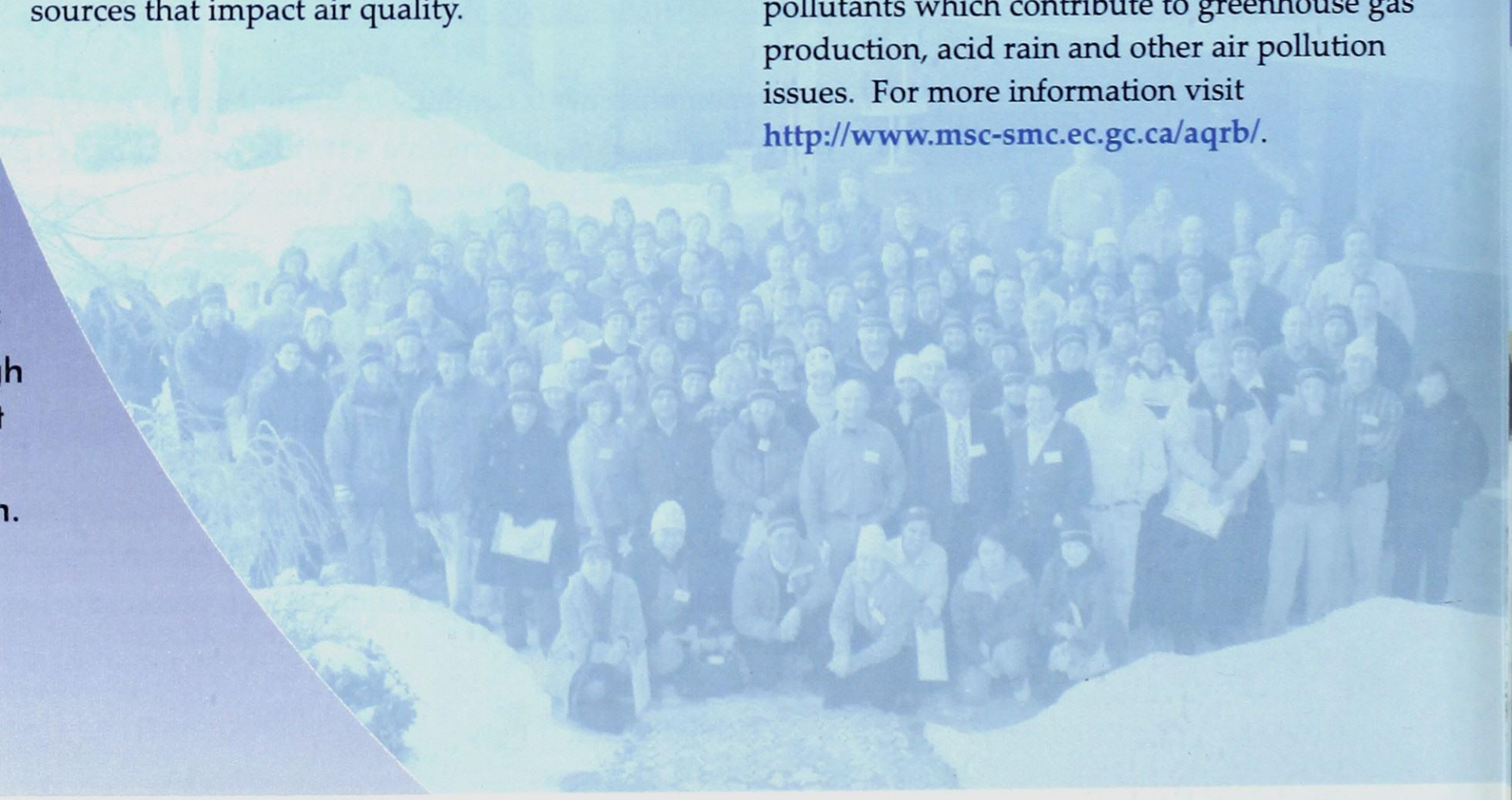
The Branch's Air Quality Research and Development Program provides the national leadership and the scientific foundation needed to understand the changing chemistry of the atmosphere and is a significant element of Canada's overall air quality research agenda.

The Program provides the scientific basis for policy development on air pollution and provides the technology to support timely air quality and UV forecasts.

In efforts to identify threats to humans and the natural ecosystem, the Branch investigates the transport, dispersion, chemical transformation and deposition of anthropogenic and natural sources that impact air quality.

Specific Branch activities include 1) field and laboratory studies conducted to understand air pollutants and how they affect the behaviour of the atmosphere; 2) long-term monitoring of the atmosphere to assess trends in air quality, provide reliable information on ambient pollution levels, and measure progress against air quality control targets; and 3) development of air quality models to understand the chemistry of the atmosphere, forecast air quality and to evaluate control measures aimed at reducing air pollution.

Ongoing research is needed to understand the changing chemistry of the atmosphere and its impacts on human and ecosystem health. The Branch recognizes the benefits of applying a "one-atmosphere" approach to air quality research for understanding these changes. Air pollutants and greenhouse gases have common sources and understanding how emissions from these sources interact is important for policy-makers and air quality forecasters. For instance, reducing emissions of smog-producing pollutants can have significant co-benefits by also reducing some of the same pollutants which contribute to greenhouse gas production, acid rain and other air pollution issues. For more information visit **http://www.msc-smc.ec.gc.ca/aqrb/**.



Advancing our understanding of air quality through credible, relevant and reliable scientific research.

Figure 1 - Air Quality Management Committee

Front row: A. Meditati, K. Patel, C. Banic, C. Tonna;
Back row: B. McArthur, M. Lusis, K. Puckett, F. Froude, D. McDonald
Absent: S. Venkatesh

The Branch management committee meets on a monthly basis to address Branch issues and issues related to the Air Quality R&D Program.

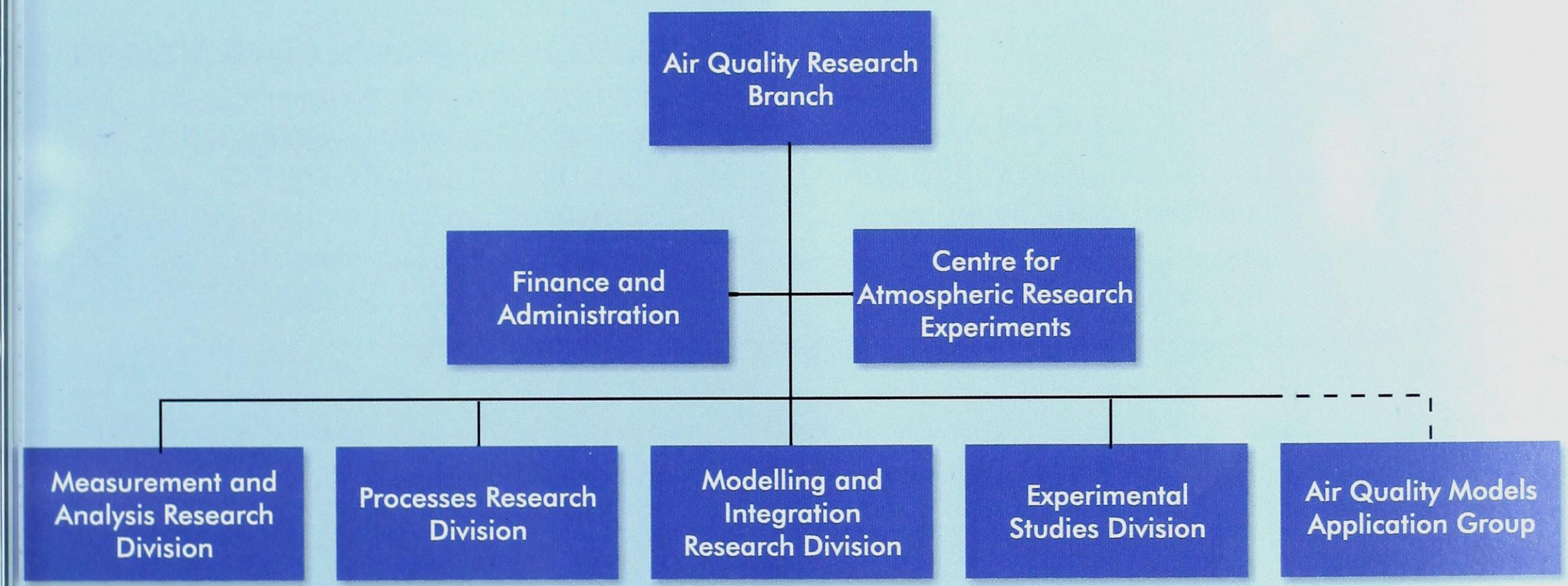


Figure 2 - Air Quality Research Branch Organizational Chart

Summary of Performance Highlights

The summary of performance highlights includes key activities in support of the Air Quality R&D Program. Descriptions of progress on R&D carried out by the Branch include: air quality measurements by surface and upper air monitoring networks, field and lab studies, air quality model development and technology transfer and work supporting air quality management policies and the development of air quality forecasts.

Systematic measurements are taken to:

- provide long-term, high quality observations of atmospheric composition and radiation at locations representative of major atmospheric regimes (and geopolitical regions) across Canada;
- monitor and assess the impact of atmospheric pollution on human and ecosystem health;
- produce datasets and trend analyses for air and precipitation chemistry to assess the impact of human activities on the atmosphere; and
- help provide real-time information on air quality processes for assimilation into air quality prediction models and other predictive methodologies.

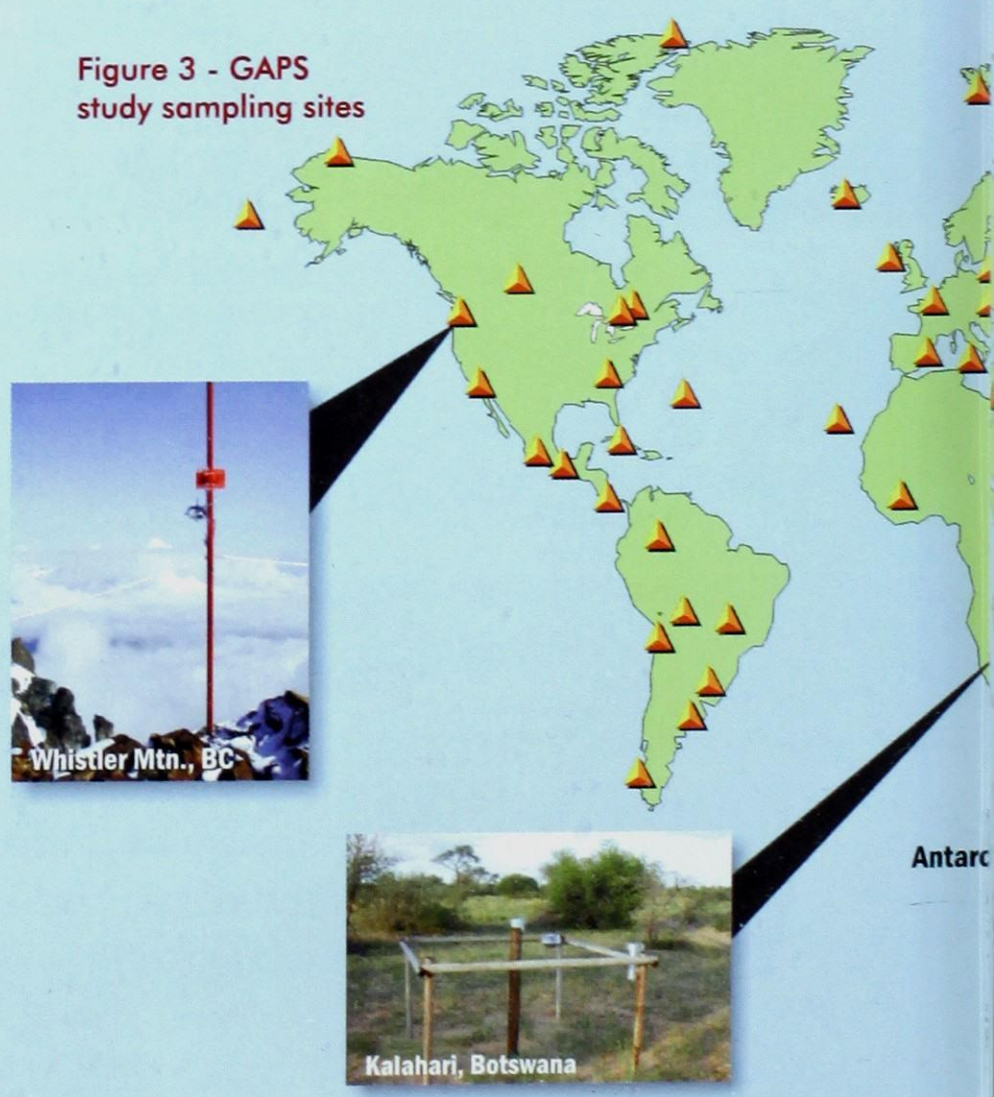
Surface Measurements
INTERNATIONAL

Global Passive Air Sampling — Monitoring of Toxics

The Global Atmospheric Passive Sampling (GAPS) Study is a global network for monitoring chemicals in the environment using simple sampling devices that do not require electricity. This one year pilot study was initiated in December 2004 at more than 50 sites around the world on all continents and is managed by scientists in the Branch. The network focuses on describing levels in legacy and current use pesticides and industrial chemicals (e.g. Persistent Organic Pollutants - POPs). The goal is to provide comparable monitoring data through harmonized methodologies on the presence of these chemicals as well as their regional and global environmental transport. GAPS is a collaborative effort that includes a team of international researchers.

Results from GAPS will be available in 2005 and contribute to Canada's obligations under international agreements on POPs, such as the Stockholm Protocol under UNEP (United Nations Environment Program) and the UN-ECE (United Nations Economic Commission for Europe) POPs protocol.

Figure 3 - GAPS study sampling sites



NATIONAL

The Canadian Baseline Network: Air Quality Measurements in Support of Climate Change

The Canadian Baseline program's focus is the measurement of greenhouse gases and aerosols which provide scientific information on the air quality-climate change interface. Measurements continued at Alert in the high Arctic which is Canada's contribution to the World Meteorological Organization's (WMO) Global Atmosphere Watch Program's Global Observatory network. Work also continued at two coastal (Estevan Point on the west coast and Sable Island on the east coast) and two inland (Fraserdale, Ontario and Prince Albert, Saskatchewan) measurement sites. This year saw an enhancement of the aerosol measurement activities at Alert and Fraserdale. Also, a regular aircraft sampling program over the Estevan Point site was initiated in coordination with the National Oceanic and Atmospheric Administration's (NOAA) Climate Monitoring and Diagnostic Laboratory, as part of the North American Carbon Program. Data on greenhouse gases from the sites continued to be deposited in international databases.


Cape Grim, Australia

In connection with the Branch's greenhouse gases measurement activities, a report was edited and coordinated by Branch scientists stemming from the World Meteorological Organization International Atomic Energy Agency Expert Meeting of Carbon Dioxide (CO_2) and Related Tracer Measurement Techniques, held in September 2003. The report consists of recommendations made by world experts in CO_2/tracer measurement techniques. Branch scientists also contributed to the recommendations which are part of an important measurement guideline for the atmospheric global carbon cycle measurement committee. These efforts support the goal of standardizing measurement techniques globally.

Canadian Air and Precipitation Monitoring Network and National Atmospheric Chemistry Database and Analysis Facility

In 2004/05, the Canadian Air and Precipitation Monitoring Network (CAPMoN) continued to support ozone measurements across Canada by providing the background information required for Environment Canada's environmental prediction and air quality forecasts and by exchanging data under the Canada - U.S. Air Quality Agreement Ozone Annex. As well, data were provided to the U.S. Environmental Protection Agency (EPA) Aerometric Information Retrieval System (AIRS) database for near-real time reporting of ozone levels in Canada and the U.S. Data have also been collected at selected sites on a wide range of other pollutants, including substances deemed toxic under the Canadian Environmental Protection Act (CEPA) such as particulate sulphate, ammonium, nitrate, gaseous sulphur dioxide and nitric acid. In excess of 25 000 samples of all types were analyzed in 2004/05 in support of Canadian environmental research initiatives. For more information visit **http://www.msc-smc.ec.gc.ca/capmon/**.

CAPMoN measurements contributed to two major projects undertaken as part of the Acid Deposition Research Program. The first was the completion of Chapter 3 of the 2004 Canadian Acid Deposition Science

Assessment titled "Atmospheric Response to Past Emission Changes" and the second was completion of a set of field studies carried out under the Acid Rain Business Case known as the "Nitrogen Scoping Study".

Chapter 3 of the 2004 Canadian Acid Deposition Science Assessment focused on: (1) establishing the levels of wet, dry and total deposition in eastern Canada, (2) determining whether wet deposition changed during the 1990s in response to North American sulphur dioxide (SO_2) emission reductions (3) estimating the percentage contribution of various North American SO_2 and nitrogen oxides (NO_x) emission areas to wet and dry deposition at receptor sites in eastern Canada and; (4) estimating critical load exceedences in Canada.

Estimation methods for determining atmospheric deposition of acidifying substances have been improved. These were employed to determine to what extent critical loads are being exceeded in terrestrial and aquatic ecosystems, and hence, what further acid gas emission controls will be needed in Canada and the U.S.

Included in the acid deposition science assessment, wet deposition data compiled and analyzed by the National Atmospheric Chemistry (NAtChem) Database and Analysis Facility showed that SO_2 emission reductions in eastern Canada and the eastern U.S. produced marked reductions in wet deposition levels across most of eastern North America during the 1990s. This can be seen by contrasting figures 4a and 4b which show non-sea-salt (nss) sulphate wet deposition levels in eastern North America in the lower emission period 1996-2000 with lower emissions compared to the higher emission period 1990-1994.
For more information visit
http://www.msc-smc.ec.gc.ca/natchem/.

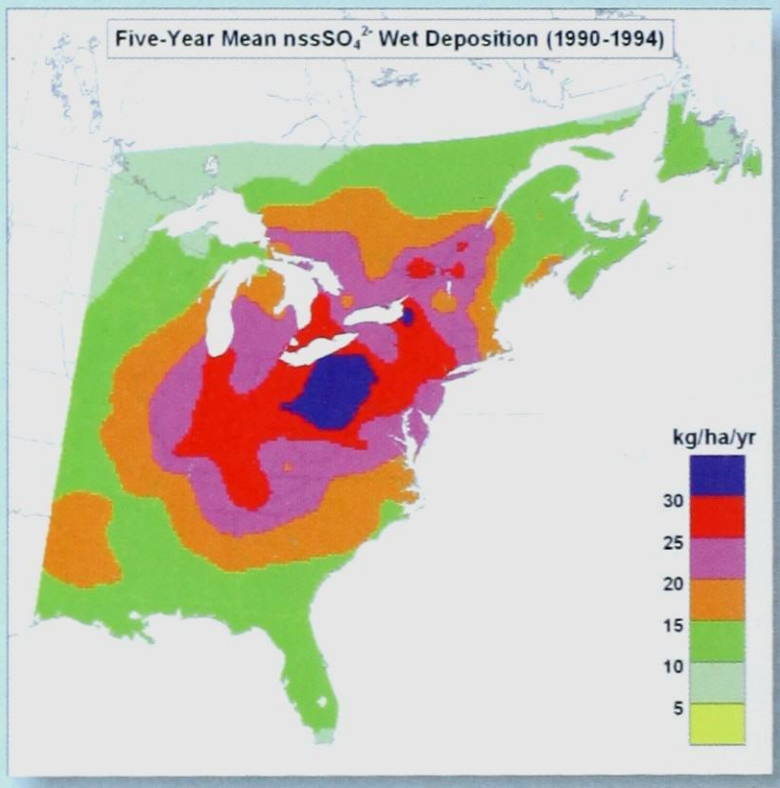


Figure 4 - Changes to the spatial patterns of non-sea salt sulphate wet deposition (in kg/ha/yr) in eastern North America from the early to late 1990s. The map (a) shows the 5-year-mean wet deposition pattern for the period 1990-1994 and the map (b) shows the 5-year-mean pattern for the period.

A combined analysis of air mass back trajectories with wet and dry deposition data made it possible to estimate the contribution of different emission areas to total (i.e., wet + dry) sulphur deposition at different CAPMoN sites across Canada. The results (Figure 5) indicate that more than 50% of sulphur deposition in eastern Canada is attributable to SO_2 emissions in the eastern U.S. Improvements were also made in our estimation capabilities for nitrogen compounds by carrying out special studies focussed on these species. The Nitrogen Scoping Study consisted of 15 short-term field studies carried out at eight different CAPMoN sites from November 2001 to February 2005. The objective of the field studies was to measure the ambient concentrations of all major atmospheric nitrogen species with a view to estimating each species' contribution to total nitrogen dry deposition during those periods. The results suggest that nitrogen total deposition values produced using existing measurements are underestimated by approximately 40% in southwestern Ontario and approximately 10% in the rest of eastern Canada because NO_2 and PAN (peroxyacetylnitrate) are not measured routinely and therefore not included in the estimates of nitrogen deposition. These are the first ever estimates of the nitrogen dry deposition uncertainties in Canada. Data from these field studies are currently being quality controlled and analyzed.

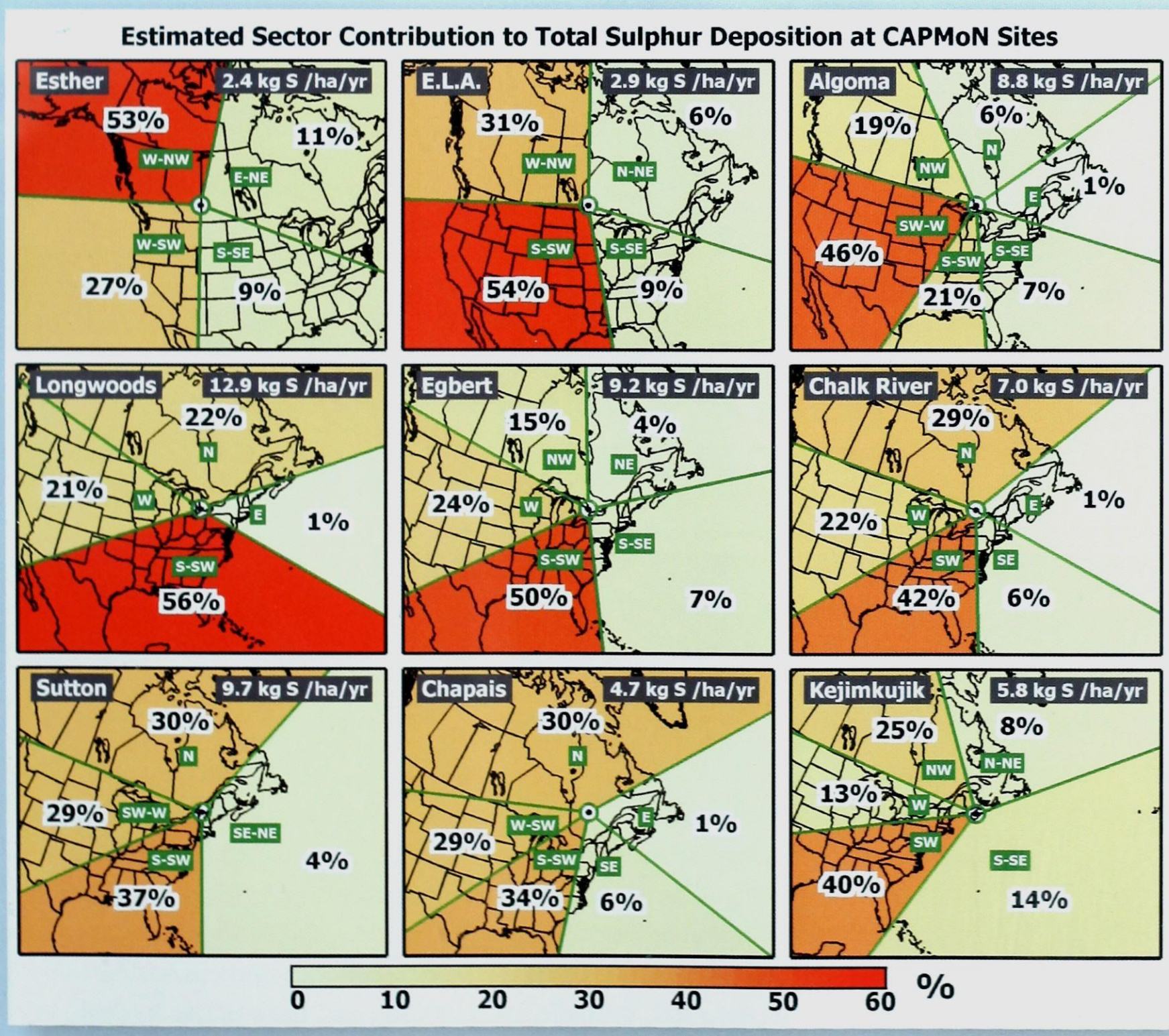


Figure 5 - Percentage Contribution of each sector to total (wet + dry) sulphur deposition at each CAPMoN site. The inset values in the top right corner of the diagrams indicate the total sulphur deposition at each site.

Canadian Atmospheric Network for Current-Use Pesticides

The Canadian Atmospheric Network for Current-Use Pesticides (CANCUP) was initiated through funding from the Environment Canada Pesticide Science Fund (PSF) and integrates efforts of collaborators in several agricultural regions in Canada to assess atmospheric levels of currently used pesticides (CUPs). The first data on CUPs in air and precipitation were reported in 2004/05. For many of the pesticides investigated, this is the first time these measurements have been made. This information will address issues concerning pesticide transport and fate and potential risks associated with exposure. This will assist the Pesticide Management Regulatory Agency (PMRA) and other government bodies to make informed decisions regarding pesticides.

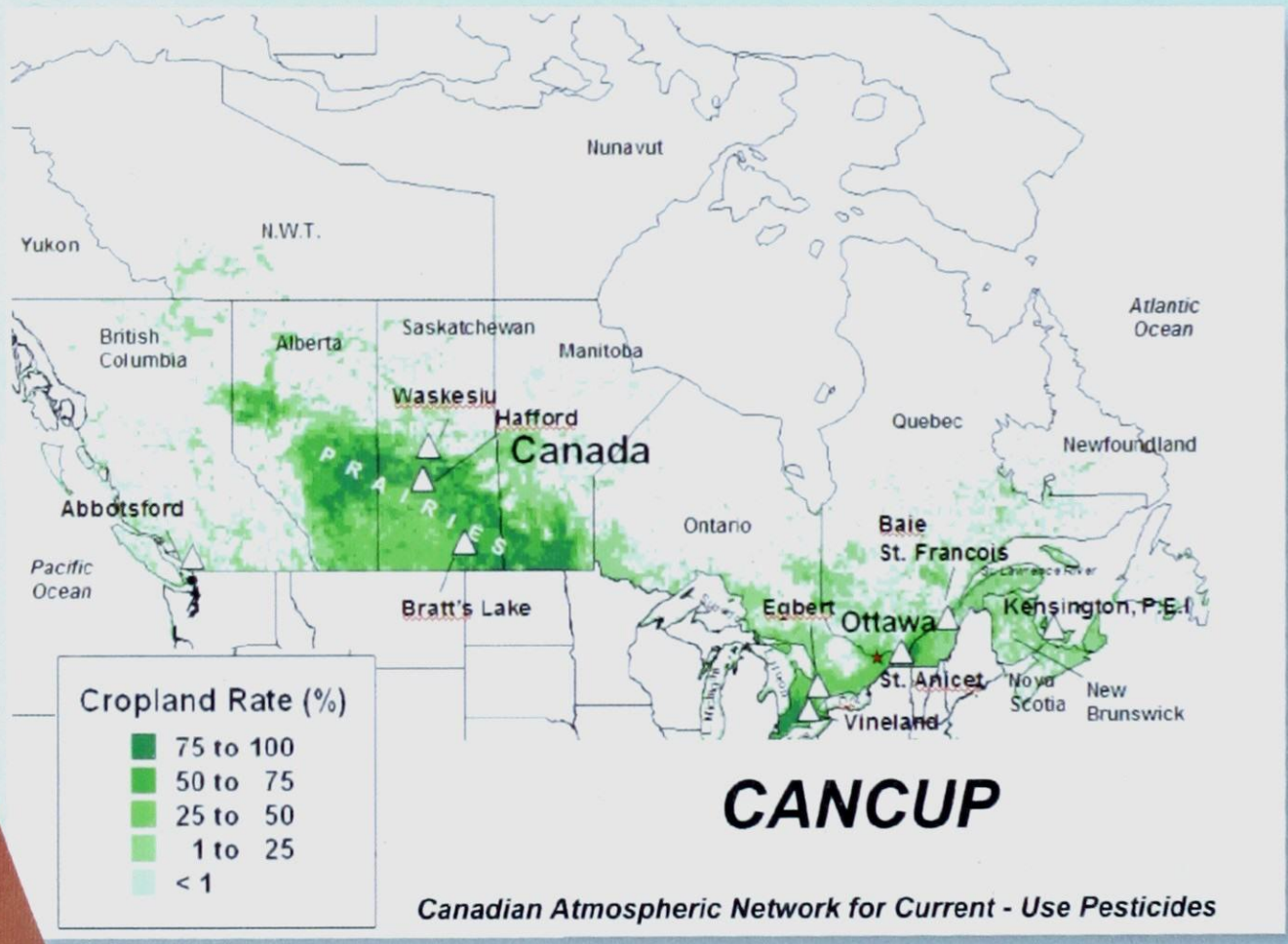


Figure 6 - Map of Canada showing major agricultural regions and locations of sampling sites operated under CANCUP.

REGIONAL

Integrated Atmospheric Deposition Network: Atmospheric Deposition to the Great Lakes

The Integrated Atmospheric Deposition Network (IADN) is a Canada - U.S. network that monitors concentrations of persistent, bioaccumulative and toxic pollutants in the air and precipitation around the Great Lakes. In 2004/05, the network measured the concentrations of polychlorinated biphenyls, organochlorine pesticides, polycyclic aromatic hydrocarbons and trace metals in the

atmosphere at several stations located on the shores of the Great Lakes. The results show that the lakes are receptors of atmospheric deposition of toxic chemicals and that banned compounds are generally decreasing following in-basin emission control of these substances. In addition, data indicate that future reductions of toxic chemical levels in the water will be directly related to decreasing concentrations of these compounds in the atmosphere. A loadings report covering the period 1999-2000 was published in 2004 and reported on some of these findings. Loadings estimates continue to show no trend for currently-used pesticides. Loadings of combustion and industrial by-products such as polycyclic aromatic hydrocarbons and trace metals have remained constant over time. Urban areas are important atmospheric sources of toxic pollutants and the inclusion of urban data to the loading estimates is critical. The loadings model was improved to include lake-wide averaged values for precipitation rates and wind speeds as well as updated physico-chemical properties for polychlorinated biphenyls and selected pesticides. For more information visit **http://www.msc.ec.gc.ca/iadn/**.

Northern Contaminants Program Baseline Air Monitoring Project

The Branch conducts research under the Northern Contaminants Program (NCP) which is managed by the Department of Indian and Northern Affairs Canada with the aim of reducing and, where possible, eliminating contaminants in the Arctic ecosystem. Since 1992, under the NCP baseline air monitoring project, persistent, toxic and bioaccumulative chemicals continue to be measured at various Canadian and Russian Arctic locations to determine whether atmospheric concentrations and deposition of priority pollutants in the Arctic are changing in response to various national and international initiatives, such as the Stockholm Convention on POPs. Long-term monitoring data obtained from Alert, Canada, shows that banned chemicals are generally declining in Arctic air. However, pesticides that are currently in use, such as endosulfan, appear to decline extremely slowly.

The role of the atmospheric circulation pattern, which controls the movement of contaminants into, through and out of the Arctic, was investigated and shown to be a controlling factor for the observed seasonality in the POP concentrations. For more information visit **http://www.ainc-inac.gc.ca/ncp/**.

Measurements of Greenhouse Gases and CO_2 Stable Isotopes on a 107m Tall Tower in Western Canada

Over the last year, a partnership between MSC and the Fluxnet Canada Research Network (FCRN), a network created to study the influence of climate and disturbance on carbon cycling, was formed in an effort to install two tall towers in Western and Eastern Canada for up-scaling from local to regional scales. Plans are underway to instrument/equip a 107m SaskTel tower located near the Boreal Ecosystem Research and Monitoring Sites (BERMS) in Saskatchewan to measure continuous greenhouse gases and perform weekly sampling for CO_2 isotopes. This high tower will provide continuous data in the planetary boundary layer, and therefore provide representative data for large areas upwind of the tower. These data will be extremely useful for upscaling FCRN tower measurements to the surrounding region and therefore will be a useful extension of FCRN to achieve their goals of obtaining improved carbon budgets for Canada's forests. This work also has direct relevance to government policies related to climate change. The integration of different datasets (concentrations, fluxes, multi-species tracers) from different spatial scales (local to continental) and different time scales (diurnal to seasonal) will help scientists retrieve reliable information about the regional carbon budgets of Canada.

Figure 7 - Ozonesonde launch

Upper Air Measurements

INTERNATIONAL

Stratospheric Ozone and UV Radiation

The statistical relationship between springtime and summertime stratospheric ozone over middle and polar latitudes was analyzed using zonally averaged total stratospheric ozone data. It was demonstrated that about 39% of summertime stratospheric ozone decline over southern midlatitutes and about 15% of summertime stratospheric ozone decline over northern midlatitudes can be attributed to polar ozone depletion in the stratosphere in spring. Long-term monthly mean UV Index values for Canada and the U.S. were calculated using information from satellites and UV Index values obtained from observations of global solar radiation, total ozone, dew points, and snow cover. Both climatologies were validated against spectral UV irradiance measurements made by the Brewer spectrophotometers.

NATIONAL

Changes in Vertical Distribution of Ozone over Canada from Ozonesondes

Previous analyses of ozone trends over Canada were made using data from ozonesondes (balloon-borne sampling devices). These analyses have shown strong downward trends in tropospheric and stratospheric ozone concentration. A new analysis of trends in the vertical distribution of ozone shows that over the longer term (1980-2001) ozone in both the troposphere (where it is generally regarded as a pollutant) and the stratosphere (where it blocks harmful UVB) has declined. It appears that stratospheric ozone has rebounded to some degree at all levels below about 20 km. Analysis shows that this rebound is probably a result of small changes in the atmospheric circulation, rather than a recovery of the ozone layer from depletion caused by chlorofluorocarbons (CFCs).

The long-term trends in average tropospheric ozone concentrations over remote sites in northern Canada are similar to corresponding lower stratospheric trends, and annual average tropospheric ozone

values (including surface values) are correlated with lower stratospheric ozone amounts. This suggests that ozone levels in the troposphere in northern Canada are controlled by stratospheric ozone in ways that are not yet well understood. For more information visit **http://exp-studies.tor.ec.gc.ca**.

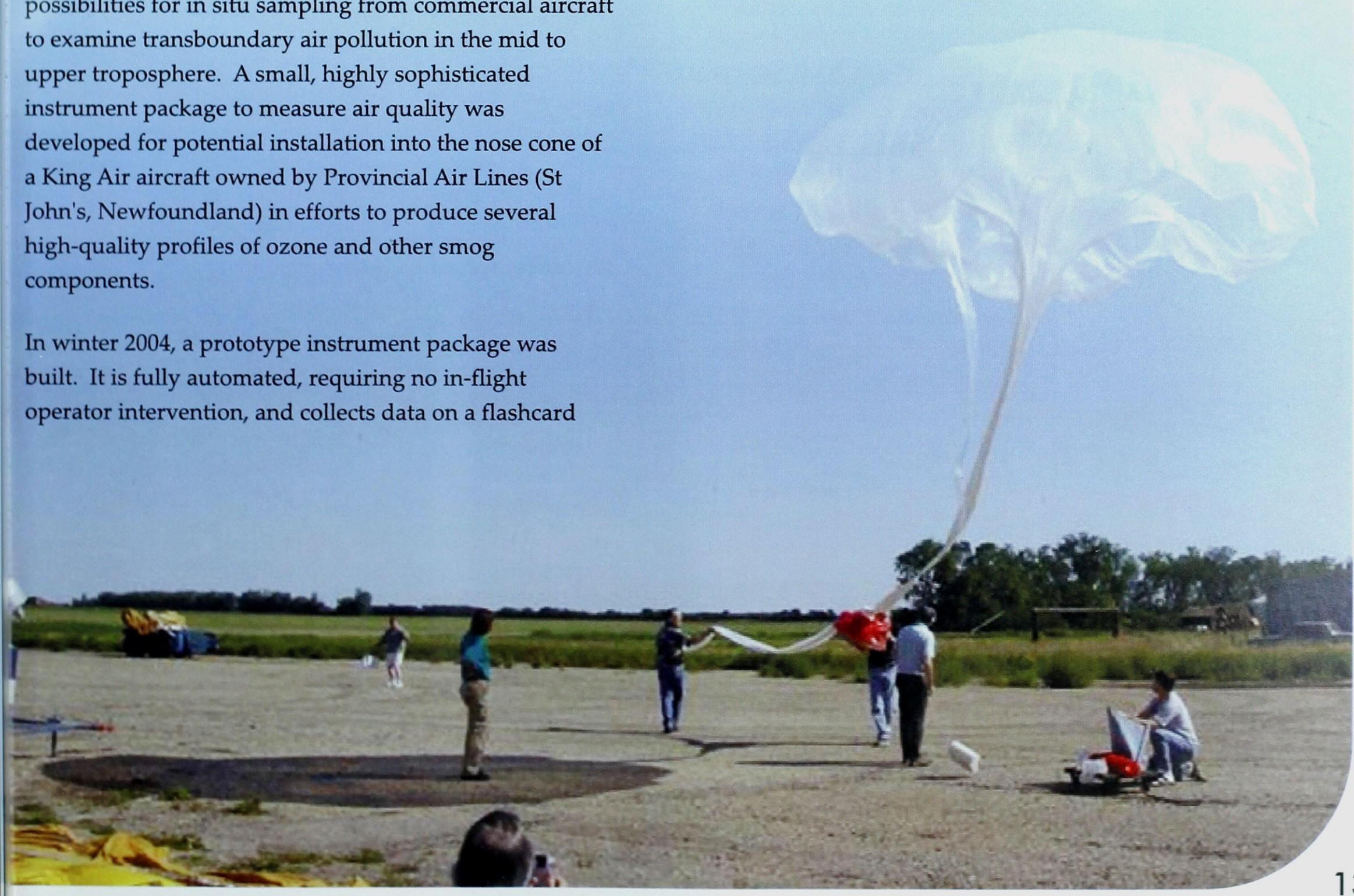
REGIONAL

Routine Inflight Assessment of Lower Tropospheric Oxidants (RIALTO)

The project RIALTO was conceived to explore possibilities for in situ sampling from commercial aircraft to examine transboundary air pollution in the mid to upper troposphere. A small, highly sophisticated instrument package to measure air quality was developed for potential installation into the nose cone of a King Air aircraft owned by Provincial Air Lines (St John's, Newfoundland) in efforts to produce several high-quality profiles of ozone and other smog components.

In winter 2004, a prototype instrument package was built. It is fully automated, requiring no in-flight operator intervention, and collects data on a flashcard that can be easily exchanged so that data can be transmitted immediately upon termination of a flight to Meteorological Service of Canada's headquarters office for processing.

Following the development and installation of the prototype instrument package, data were collected during the summer and early fall of 2004. Several lessons were learned from these initial flights and are currently being studied. A second updated version of the instrument package will be developed during 2005. This work will support the potential of expanding a similar initiative into other regions of the country. Once sufficiently efficient data transmission is established, the ozone profile data will be made available for validation and data assimilation in air quality forecasting efforts.



The Branch conducts field studies to:

- understand the transport, transformation and deposition processes of atmospheric pollutants;
- determine air pollution source-receptor relationships; and
- develop and test new air quality measurement approaches.

INTERNATIONAL

2004 International Consortium for Atmospheric Research on Transport and Transformation (ICARTT) Field Campaign

In summer 2004, Branch scientists took part in the ICARTT field study along with 500 researchers from Canada, the U.S., Britain, France, and Germany. The Canadian team was led by the Branch in collaboration with the National Research Council of Canada's Institute for Aerospace Research and York, McGill, and Dalhousie universities. The study focused on the movement of air pollution from the northeastern U.S. across the North Atlantic to Western Europe. Its goal was to improve the scientific understanding of how pollutants - including aerosols and oxidants such as ozone - and their precursors change during transport.

The study included an examination of the impact of air pollution on the properties of clouds, especially the amount of sunlight they reflect. The study also provided an observational dataset for use in air quality model evaluations and improvements.

Figure 8 - ICARTT 2004 Canadian Team

The Canadian effort of the 2004 intensive measurement campaign of ICARTT comprised of two components:

1) The Chemical transformation and Transport by Clouds (CTC) project to obtain more data pertaining to the interactions among clouds, trace gases and particulate matter (PM).

2) The Transport into the Maritimes (TIMs) project which evolved as a Border Air Quality initiative to make measurements during episodes of significant transport of pollution from the eastern U.S. over the Maritime Provinces.

Measurements of aerosol chemistry and size distributions, trace gases (CO, O_3, H_2O_2, NO, NO_x, HNO_3, SO_2 and NH_3), cloud microphysics and dynamics were made in addition to particle chemistry. For the first time, cloud droplet chemistry was measured in real time.

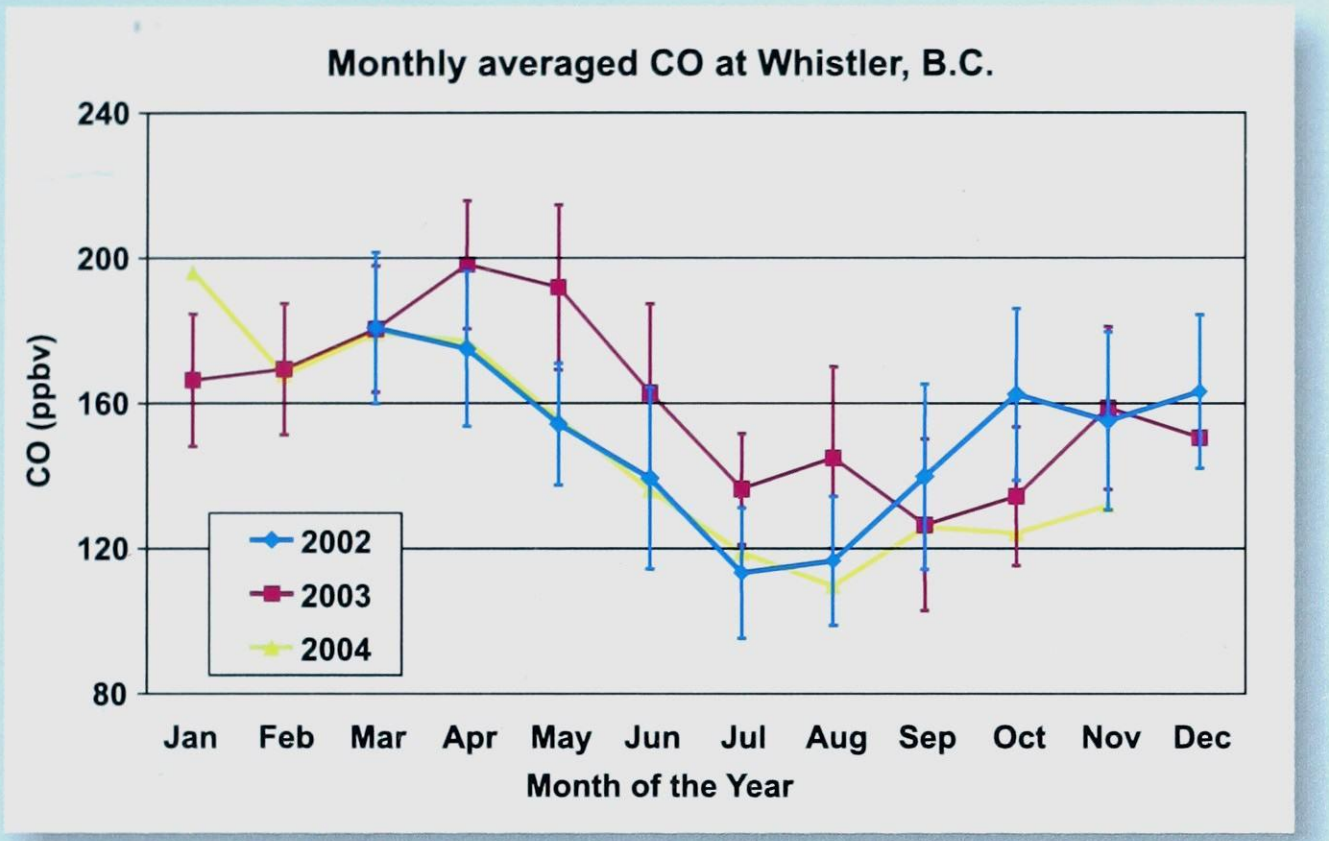


Figure 9 - Monthly averaged carbon monoxide (CO) at Whistler Peak from March 2002 to December 2004.

Air quality forecast products from the Canadian Hemispheric and Regional Ozone and NOx System (CHRONOS) and A Unified Regional Air-quality Modelling System (AURAMS) air quality models provided guidance for determining flight paths, and in particular for deciding on when to conduct a CTC or TIMs mission. The models were also part of a real-time model evaluation/inter-comparison study coordinated by the NOAA-Air resources laboratory and used in an experimental real-time ozone forecast. The data collected during the field campaign are being used in post field campaign model evaluations.

This research will help scientists better understand how air pollutants change during transport and the important role clouds play in the processing and cycling of chemicals in the atmosphere. For more information visit **http://www.msc-smc.ec.gc.ca/research/icartt.**

Investigation of background chemistry at a free tropospheric site and incidences of trans-Pacific transport of pollution

Three years of measurements were completed at the Whistler, British Columbia (B.C.) high elevation site in an effort both to characterize particle and gas-phase species at a background free tropospheric site and to examine influences of trans-Pacific pollution transport to Canada's west coast. Seasonal cycles are observed for carbon monoxide (CO), ozone, and particle sulphate with maximum values observed in springtime. Significant inter-annual variability is observed among the three measurement years, March 2002 to March 2005. During the spring of 2003, there were a large number of fires in Siberia and production of CO and subsequent transport affected air quality across the Pacific. This increase in CO, a long-lived gas-phase species, is clearly observed at Whistler during spring and summer of 2003 with monthly average values approximately 20% greater than those during 2002 or 2004 (Figure 9). Particle inorganic chemistry is measured year round as either one-day or two-day samples. A comparison of this chemical analysis with the total mass of the particles is available for select periods throughout the year. Results suggest that this inorganic fraction does not account for the total particle mass and in fact is a smaller fraction of the total mass estimate at lower mass concentrations. Plans are in place to investigate the composition of this missing particle mass by further chemical speciation of the particles with an aerosol mass spectrometer on site during spring 2005.

NATIONAL

Measurements Taken by Mobile Air-Monitoring Laboratories (CRUISER & RASCAL) in Support of Smog Pollutants and Precursors Studies

In July 2004, the installation of the Canadian Regional and Urban Investigation System for Environmental Research (CRUISER) was completed and further development and testing of the mobile lab was made in preparation for field studies. In the past year CRUISER has taken measurements in tandem with another mobile lab, the Rapid Acquisition SCanning Aerosol Lidar (RASCAL).

Last summer CRUISER was used in health exposure studies with Health Canada and in measurement studies with the Ontario Ministry of the Environment and McMaster University. In fall 2004, CRUISER and RASCAL were part of the Windsor measurement campaign which focused on particle nitrate, exposure spatial patterns, and roadway concentrations in collaboration with the University of Toronto, Sherbrooke University, and University of Windsor. In winter 2004, more research was carried out in Windsor as part of the MicMac Park study with the Universities of Windsor and Maryland. After the Windsor study both CRUISER and RASCAL took measurements in southern B.C. A measurement intensive in Golden, B.C. focused on $PM_{2.5}$ and emissions sources such as the trans-Canada highway, railway traffic, plywood plant and local wood burning. In this study, excellent concurrent LIDAR (LIght Detection And Ranging) and in situ measurements were obtained showing complex three dimensional pollutant structures. Both CRUISER and RASCAL are taking measurements to describe air quality in support of the Canada-US Border Air Quality Strategy.

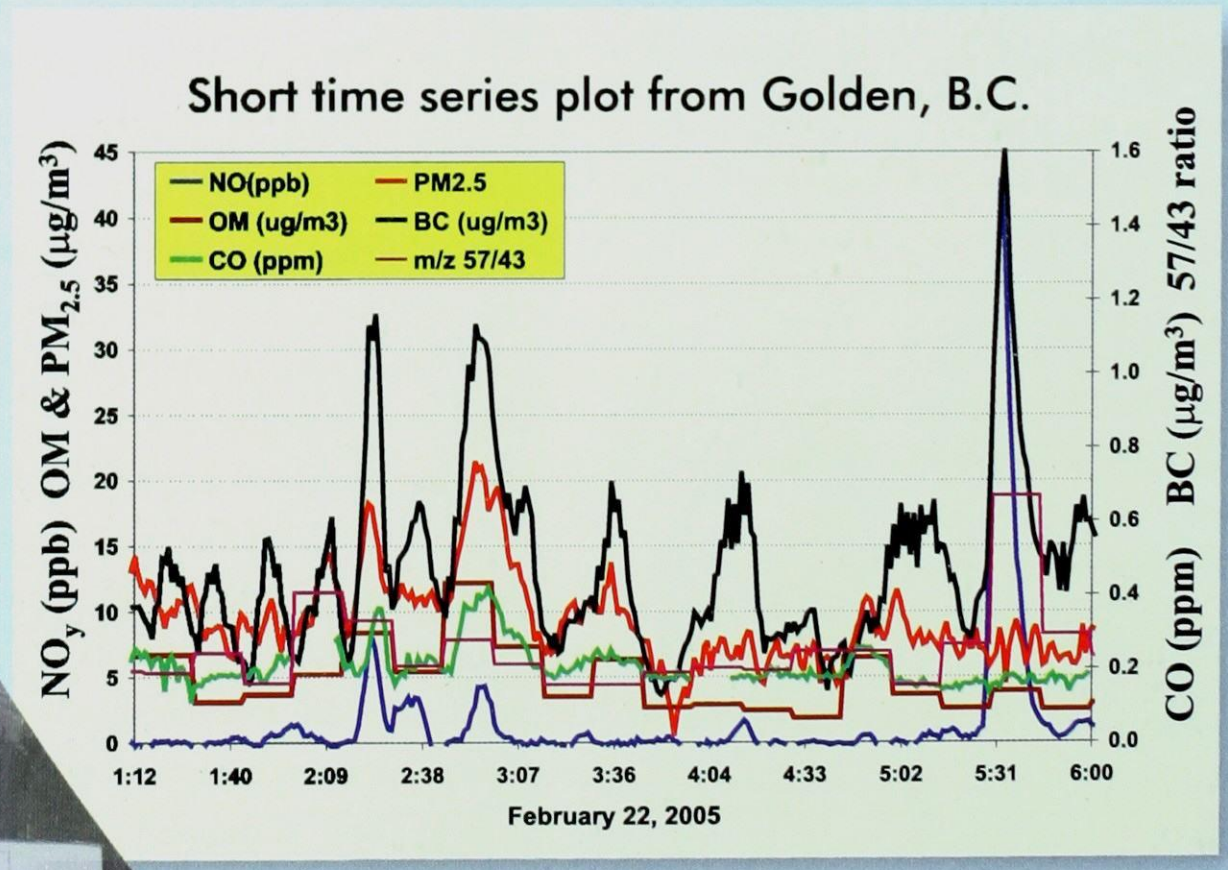


Figure 10- This short time series plot from Golden, BC shows how the pollutant mix changed within a short time from a wood smoke influence (~2:15-3:15 AM) to a diesel locomotive influence (~5:30-5:45 AM). This demonstrates the capability of CRUISER to detect such changes and highlights the complexity of our air quality problems. The thin pink line is a ratio of mass fragments from the Aerosol Mass Spectrometer (AMS) and provides evidence that the AMS may be a very useful tool for adding increased confidence to our source apportionment efforts. A very large amount of information is being collected by CRUISER and RASCAL at multiple locations in Canada.

Figure 11 - RASCAL mobile laboratory in action (a laser is being projected high into the troposphere to spot pollutants in the air).

Figure 12 - CRUISER mobile laboratory

2004 MANTRA Campaign

The fourth MANTRA (Middle Atmosphere Nitrogen TRend Assessment) large balloon mission was held in Vanscoy, Saskatchewan in August 2004 to study the changing chemical balance of the stratosphere. The study was a collaborative effort between scientists at the University of Toronto, the Meteorological Service of Canada, York University, the University of Waterloo, the University of Denver (U.S.), and the Service d'Aeronomie of the Centre National de la Recherche (France).

A series of high-altitude balloon campaigns were conducted to measure stratospheric trace gases, which included ozone profiles obtained from a number of ozonesondes, along with additional ground-based instruments, which provided ozone and nitrogen dioxide total columns and vertical profiles.

The balloon campaigns ended with mixed results. The primary goal of making a comprehensive measurement of nitrogen species, which control the amount of ozone in the stratospheric ozone layer, was not achieved due to different technical faults in the payload support systems. However, several MSC spectrometers and radiometers produced scientifically important data, although in reduced amounts. A number of other scientific results were also achieved during the project, including data collected during a comparison of ground-based spectrometers, an independent balloon flight of a French instrument for measuring bromide (BrO) in the stratosphere and an extended series of soundings of the stratospheric ozone layer using ozonesondes. These data are being used to define future studies and to validate models, instrumentation and retrieval techniques via satellite. On the technical side, this was the most ambitious MANTRA campaign yet with 12 separate instruments comprising the balloon payload.

On the ground, a comparison of four Canadian spectrophotometers with the French SAOZ instrument (Systeme d'Analyse par Observation Zenithale) was conducted. The French instrument is used globally in the Network for Detection of Stratospheric Change and is certified by the network for making accurate ozone and nitrogen dioxide (NO_2) measurements. The Canadian instruments included the MSC Brewer, SunPhotoSpectrometers (SPS), the Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO) and the University of Toronto UV-Visible spectrometer. The results from this comparison appear to be very good, and will help validate the MAESTRO instrument for both ground-based and space-based observations. For more information visit **http://www.atmosp.physics.utoronto.ca/MANTRA/**

Figure 13 - Inspection of an empty barn in the Abbotsford, B.C. area.

REGIONAL

Fraser Valley Avian Influenza and Ammonia Emissions Study: An Opportunity to Assess the Impacts of the Poultry Industry on Air Quality

While the avian bird flu and the subsequent culls in the Lower Fraser Valley, B.C. (Abbotsford area) in early 2004 were devastating, they created a unique opportunity for Branch scientists and other collaborators to be involved in advancing the understanding of agricultural emissions and its influence on regional air quality. A field study in the Abbotsford B.C. area is underway to determine the impact that ammonia (NH_3) originating from poultry barns and manure has on air quality and to expand the understanding of the contribution ammonia makes to the formation of particulate matter.

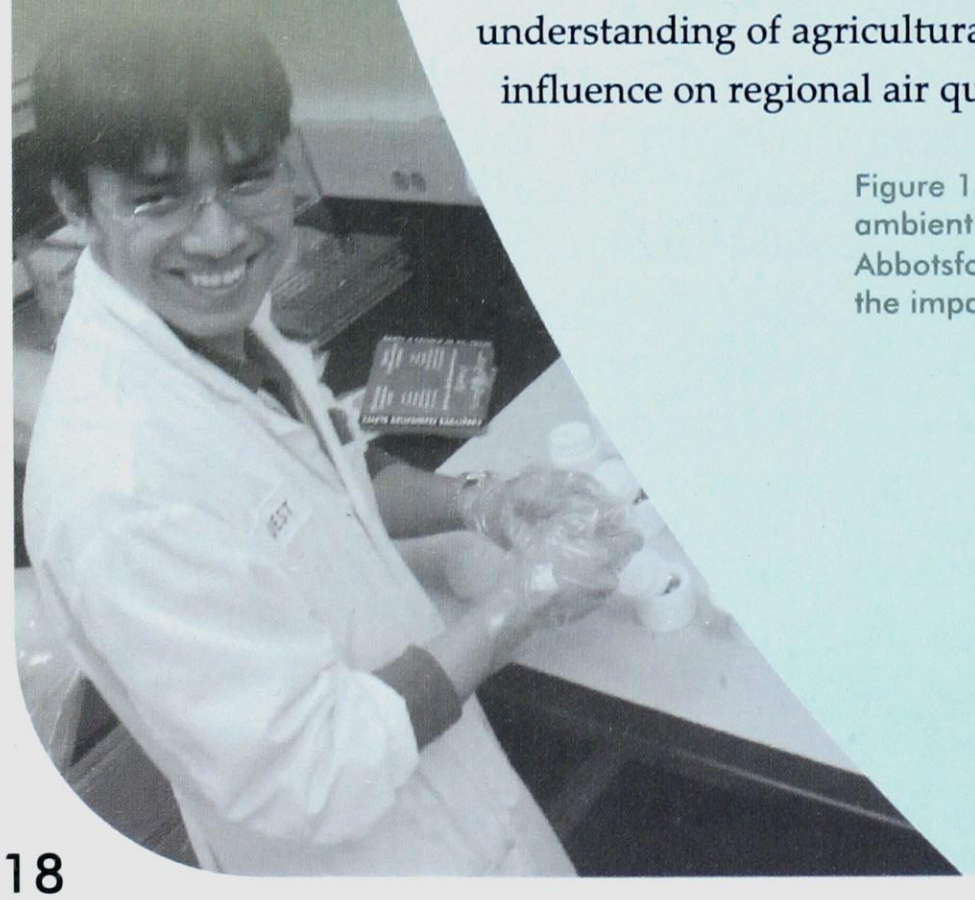
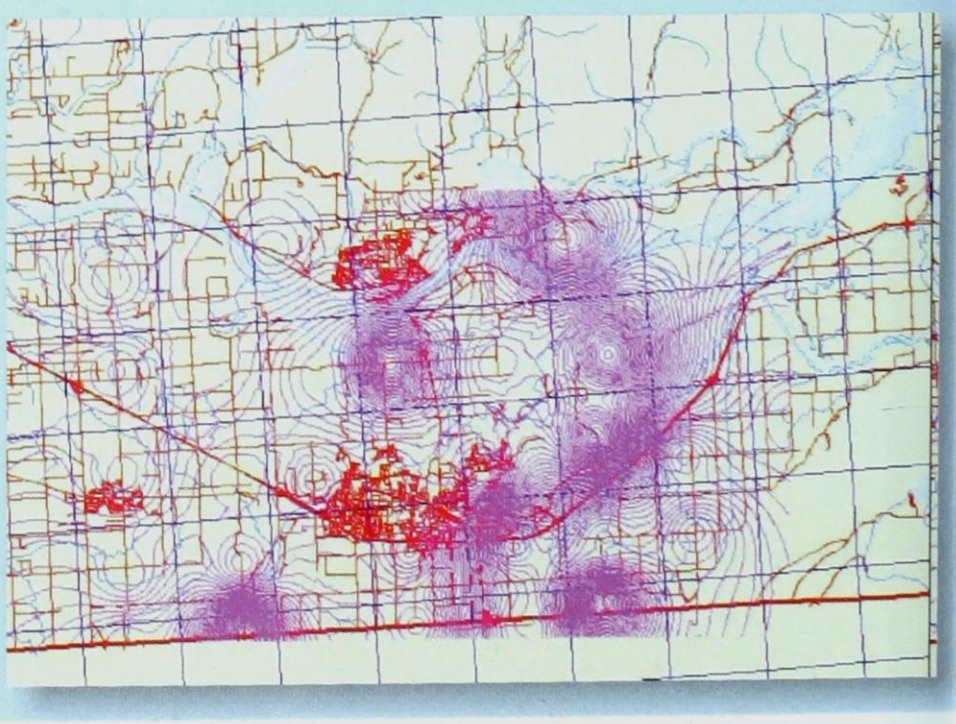


Figure 14 - Passive sampling of ambient ammonia (NH_3) in the Abbotsford, B.C. area showing the impact of discrete sources.

Over the last year, a national R&D program on atmospheric ammonia was implemented. As part of the program, passive sampler measurements were taken around the Abbotsford area to determine ambient ammonia spatial patterns resulting from poultry production in the area. These spatial patterns will be used as a basis for modelling activities to determine the influence of poultry sources on air quality. Monitoring activities carried out in the last fiscal year clearly show a dramatic drop in the ambient levels of ammonia resulting from the chicken culls with levels recovering after repopulation in the Abbotsford area. These barn studies are the first to detail emission factors based on the poultry sector in Canada. This information will be used to improve ammonia emission inventories.

The ammonia field study is part of the National Agri-Environmental Standards Initiative (NAESI) to



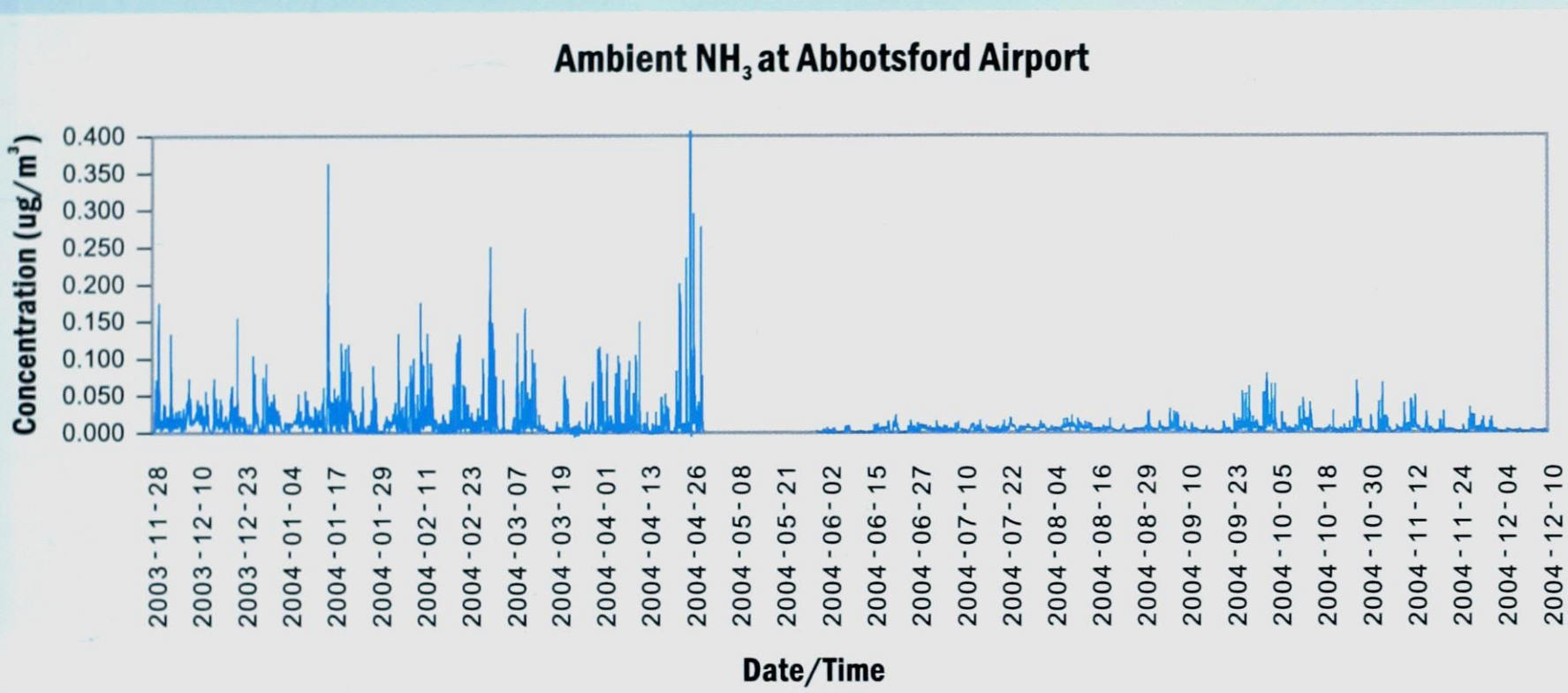


Figure 15 - Ambient ammonia (NH_3) concentration at the Abbotsford Airport in B.C., located at the centre of the major poultry production. The effect of the chicken cull on NH_3 can be clearly seen at the end of April, 2004.

develop agri-environmental standards. Collaborators include Agriculture and Agri-Food Canada, Environment Canada (Canadian Meteorological Centre, Environmental Protection Service, Prairie and Yukon Region Office), provincial and municipal environmental and agricultural agencies as well as, poultry producers in British Columbia. This cooperative research effort supports the Agricultural Policy Framework (APF) with the goal of making Canada a leader in food safety, innovation and environmentally responsible production.

Sources and pathways of POPs to the Great Lakes

A series of studies were conducted to understand the impacts of global sources on the Great Lakes region. A study of chlorinated pesticides in background soils from around the world was carried out to understand the fate of atmospherically deposited pesticides and the influence of re-emissions on chemical signatures in the atmosphere. In Mexico, air samples of persistent organic pollutants (POPs) were collected to determine whether emissions from the Mexico region could impact the Great Lakes basin. DDT concentrations in air in the state of Chiapas (southern Mexico) were found to be about 100 times higher than Great Lakes levels. The chemical composition of the DDT in Mexican air suggests emissions from current usage and "old" sources (soil residues). In addition, the banned pesticide toxaphene was found to be about 10 times higher in Chiapas air than over the Great Lakes, and the chemical composition suggests that the main source is emission of soil residues. Furthermore, chlorinated pesticide fluxes from agricultural soil were measured in Ontario and British Columbia to determine the contribution of this source to atmospheric levels. These soils received applications of chlorinated pesticides from the 1950s to early 1970s and the pesticides are still volatilizing into the atmosphere 30-40 years later. Such emissions compete with air transport pathways from Mexico and across the Pacific in delivering these legacy chemicals to Canada. The results of these studies are being used to improve our understanding of the loading of POPs to the Great Lakes.

Rural and Urban Studies of Particulate Matter

During 2003, intensive measurements of the size and chemistry of particulate matter (PM) were made at the Centre for Atmospheric Research Experiments (CARE) site at

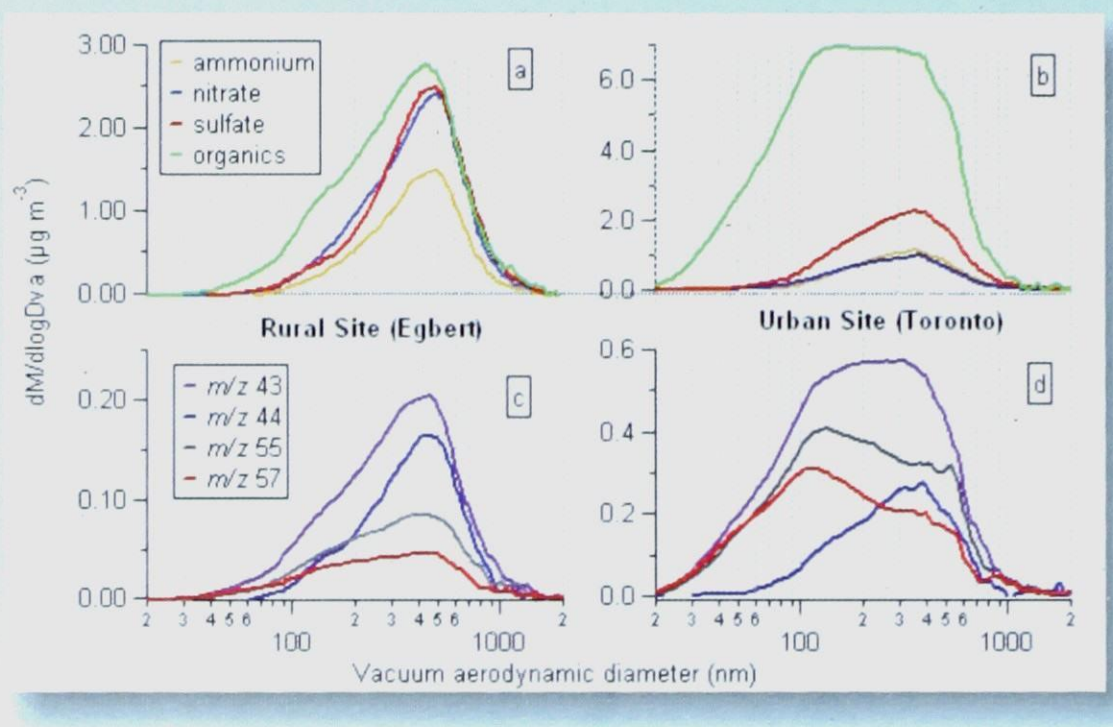


Figure 16 - the figure to the left illustrates average size distributions of major chemical species at Egbert and the University of Toronto (ammonium, nitrate, sulphate and total organics) as well as the average size distributions of the oxygenated organic components (m/z 44), the hydrocarbon-like components (m/z 57) and mixtures of oygenated and hydrocarbon-like components (m/z's 43 and 55). The oxygenated component of the aerosol (m/z 44) is relatively higher at Egbert and the hydrocarbon component (m/z 57) is relatively higher in Toronto. In Toronto compared with Egbert, the total organic fraction of the aerosol is higher relative to the major inorganic components of the fine particle aerosol (ammonium, nitrate and sulphate) and there is more organic mass in smaller particles. At Egbert, higher concentrations of nitrate are more prevalent during the dark periods, while higher concentrations of sulphate and organics tend to be found in the daytime. The concentrations of the inorganic species at Egbert are also influenced by higher levels of ammonia in the air due to surrounding agricultural activities.

Average size distributions of major chemical species at Egbert and the University of Toronto

Egbert, Ontario (April 1 to May 8) and at the University of Toronto (August 20 to September 25). The purpose of the measurements was to obtain more detailed characterizations of the chemical, physical and optical properties of PM to help increase our knowledge of the properties of PM in southern Ontario. Students at the University of Toronto, and Dalhousie and York Universities in collaboration with MSC scientists are undertaking further analysis of these datasets.

A comparison of the two sites shows that the carbonaceous material in the particles sampled at Egbert is relatively more oxygenated and more closely associated with inorganic species (ammonium, sulphate and nitrate). This is consistent with a greater level of chemical processing expected as the aerosol travels away from sources. As the smaller organic particles emitted at sources (such as observed in Toronto) travel away they become more oxidized, and inorganic species from the oxidation of reduced sulphur and nitrogen gases are added to the particles. The results of these processes are illustrated in Figure 16 showing the differences in the chemical size distributions of particles measured at Egbert and at the University of Toronto.

Through changing the composition of the PM and increasing its average size, the various processes operating on the aerosol as it is transported alter how the PM affects health, climate and visibility. Observations of this nature contribute to determining how well our models simulate PM and what further improvements to the models are needed.

Out On the Ice (OOTI) Study

While the basic features of ozone and mercury (Hg) depletion at the earth's surface after polar sunrise are reasonably well understood, the source of the required reactive halogens is speculative. Bromide (BrO) data from satellites suggest that large parts of the Arctic boundary layer ozone may be depleted, but a link between those data and surface based observations has not been conclusively established.

It has long been known that in the Arctic, convective mixing above open leads (long cracks in the sea ice) injects heat, water vapor, and sea salt aerosol as much as several kilometers into the atmosphere. This would imply an important source of the halogens involved in springtime ozone depletion, but it is also known from satellite BrO retrievals that ozone depletion seems to occur over completely frozen surfaces. An intriguing possibility is provided by frost flowers, which not only present a high surface area medium for heterogeneous chemical processes, but may also be an important mechanism for sea salt aerosol generation, from wind-driven dispersion. Frost flowers are high surface area, dendritic and highly saline (~100 PSU) crystalline structures that grow in clumps on the surface of refrozen leads, resulting from vapor deposition and the strong temperature gradients across the first few centimeters of the surface-atmosphere interface. There is considerable speculation in the literature about the importance of these structures to air-surface exchange and hence is one of the arguments for undertaking the OOTI study.
The most straightforward way to investigate this fascinating process is to design a measurement system to perform measurements right at the source. To this end a highly portable, fully automated measuring system for ozone, Hg and BrO was assembled. In addition a small meteorological tower (3m) was outfitted with flux measurement equipment, a web cam and a GPS. Operation, including data acquisition, was designed to be fully battery powered, and the whole system was mounted on a sled for transport from a base camp out on the frozen ocean.

This package was operated successfully in April/May 2004 from the Alert base camp. Interesting data were obtained about the nature of the boundary layer over the ocean but no frost flower fields were found (a paper on this work will appear in April 2005 in the journal Geophysical Research Letters). By invitation the same instrument package will be operated in March 2005 from Barrow, Alaska. The main reason for this second experiment is the fact that open leads and frost flower fields are a common occurrence near Barrow, hence permitting a more promising environment to address the key question of frost flower activity.

Atmospheric Chemistry Experiment Arctic Campaign

The Canadian Arctic Validation component of the Atmospheric Chemistry Experiment (ACE) 2005 campaign was conducted at Eureka, Nunavut, to make ground-based validation measurements for the Canadian ACE satellite mission from mid-February to the end of March. With the collaboration of scientists from the Meteorological Service of Canada, the Universities of Toronto and Waterloo and funding from the Canadian Space Agency, a suite of seven instruments were used to determine total columns, vertical profiles where possible of the 14 ACE atmospheric target species, as well as, atmospheric extinction, temperature and pressure. Although the timing of the campaign was dictated by the period of satellite overpasses occurring close to Eureka it also coincided with the time when the Arctic stratosphere is chemically perturbed leading to chemical ozone destruction. Some of the validation measurements obtained during a similar campaign in the February to March, 2004 time frame were submitted for journal publication.

Air Quality Modelling Activities

Air quality models are developed to:

- understand the changing chemistry of the atmosphere including the current and future state of air quality;
- contribute to air quality and UV forecasts in efforts to provide warnings and information to Canadians; and
- create scenarios that test policies aimed at reducing air pollution.

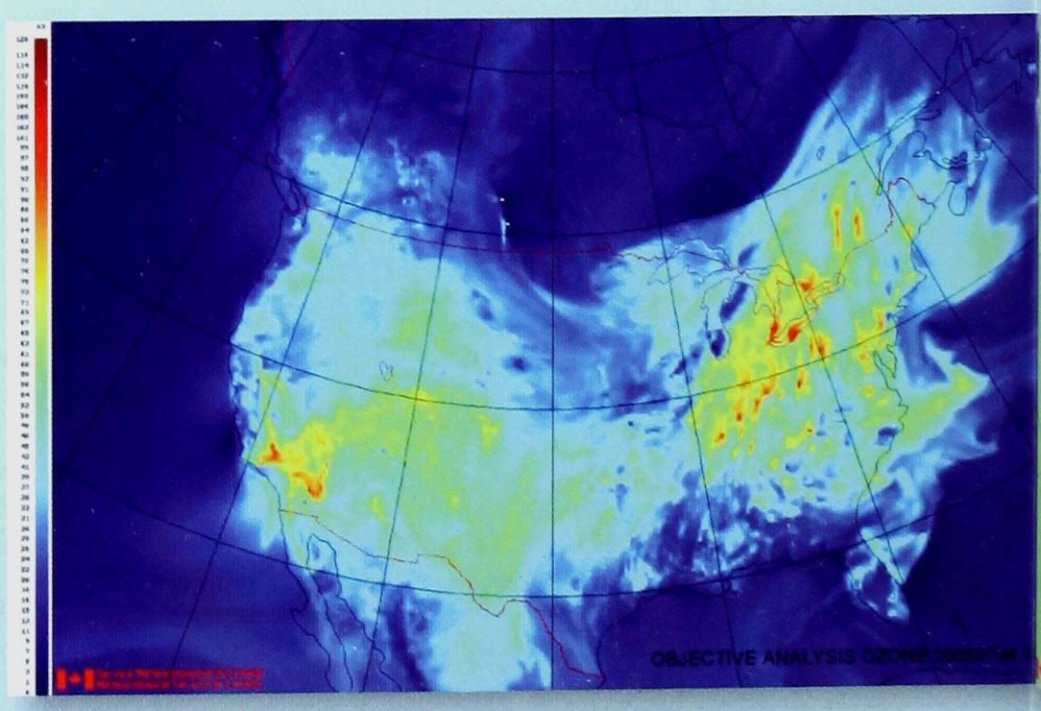
INTERNATIONAL

Air Quality Forecasts

A successful experimental version of the CHRONOS air quality forecasting model which included a methodology to assimilate AIRNow surface ozone data has been run since July 4th 2003. AIRNow is a program led by the U.S. Environmental Protection Agency which consists of a centralized data management centre that receives real-time air quality data from more than 100 U.S. and Canadian agencies as well as air quality forecasts from over 300 U.S. cities.

Following this success, the production of objective analysis maps of surface ozone became operational at the beginning of 2004. This production was the first objective analysis of surface ozone ever to be put into near real time production and on a continental scale.

The experimental analysis, which was carried out over Canada and the U.S., is the first step in creating a full data-assimilation system of atmospheric-chemical observations. Data assimilation is the process of analyzing the atmosphere's current conditions, which is required to drive numerical air-chemistry and weather prediction models. It is a process of optimizing the information given on one hand by the observation system and on the other hand by the modelling system.



The Branch, in co-operation with the Air Quality Models Applications Group of the Canadian Meteorological Centre, spent a year developing the new system, which combines output from the CHRONOS air quality model with ozone observations from AIRNow.

The biggest advantage of the system is that it automatically rejects observations that are unusual or incorrect. This ensures that the data are quality controlled in near real-time — a process that would otherwise take weeks or even months to perform. Using these data, maps of ground level ozone over North America are produced on an hourly basis with a lag time of approximately one hour. In addition to allowing scientists to extract more information on the chemical composition of the atmosphere from existing surface observations, the system will create a framework for assimilating data more rapidly from new or non-conventional observations — such as those received from satellites.

Maps of surface-ozone analysis can be used to construct ozone climatologies, seasonal maps, and other products that link air pollution and environmental impacts.

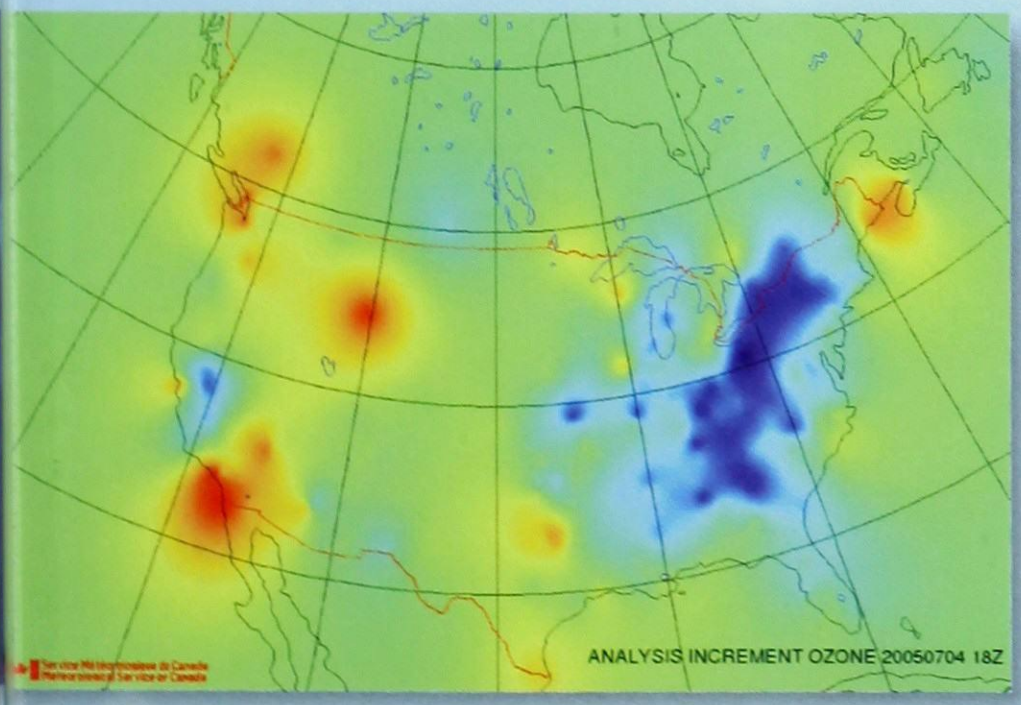


Figure 17 - The panel on the left indicates surface concentrations of ozone in parts per billion, as determined by the objective analysis. The panel on the right shows the significant corrections that had to be made to a model forecast for the same day in order to bring its surface-ozone values in line with the observations of the objective analysis.

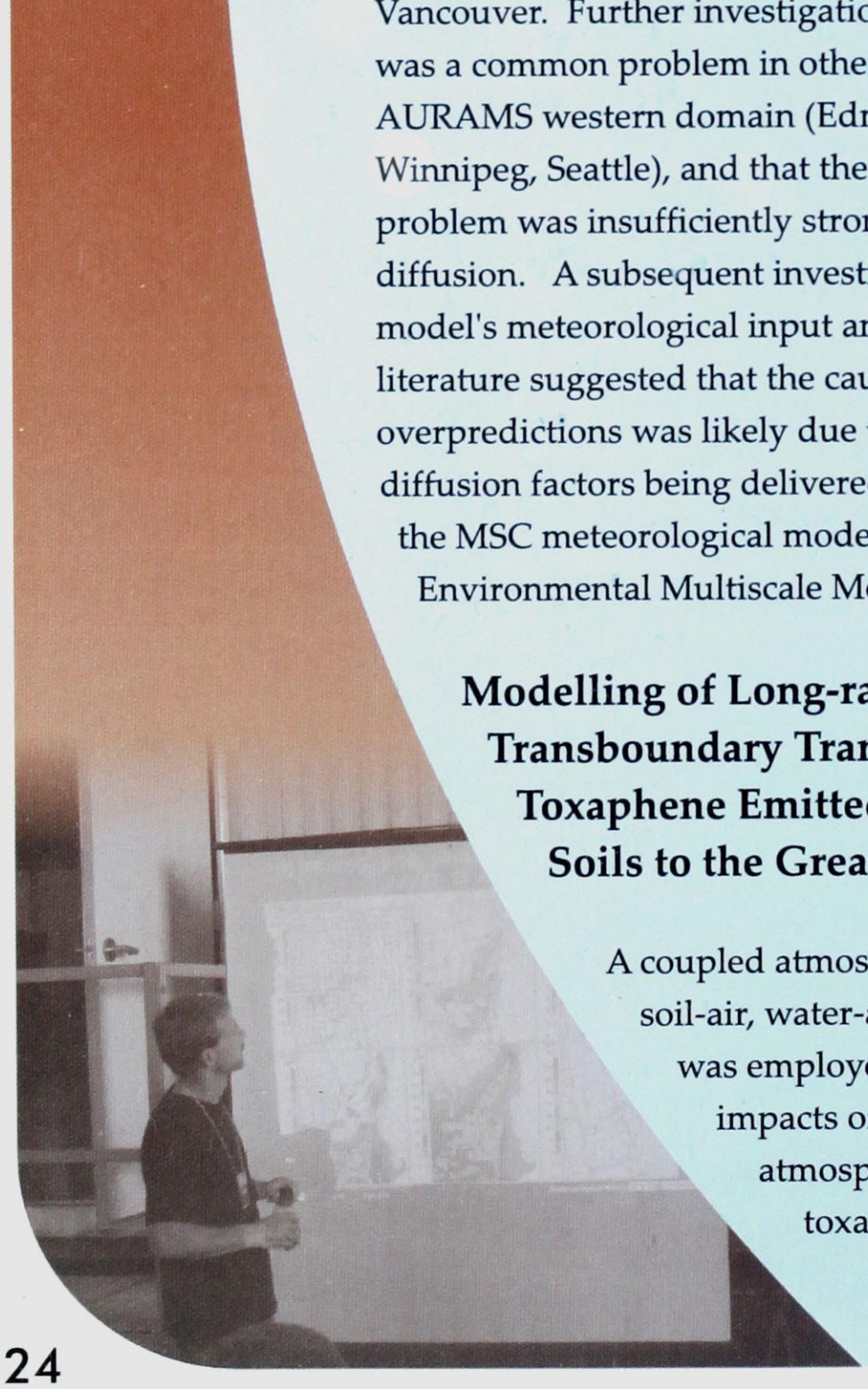
REGIONAL

Air Quality Model Development

A detailed evaluation of the AURAMS air quality model output against data collected during Pacific2001 was performed and the results presented at the North Atlantic Treaty Organization - Committee on the Challenges of Modern Society (NATO/CCMS) air quality meeting in Banff. The evaluation showed that AURAMS was overpredicting the concentration of emitted species in the downtown core of greater Vancouver. Further investigation revealed that this was a common problem in other cities in the AURAMS western domain (Edmonton, Calgary, Winnipeg, Seattle), and that the root cause of the problem was insufficiently strong vertical diffusion. A subsequent investigation of the model's meteorological input and recent and older literature suggested that the cause of the overpredictions was likely due to low vertical diffusion factors being delivered to AURAMS from the MSC meteorological model, Globel Environmental Multiscale Model (GEM).

Modelling of Long-range Transboundary Transport of Toxaphene Emitted from U.S. Soils to the Great Lakes Basin

A coupled atmospheric transport, soil-air, water-air exchange model was employed to investigate the impacts of soil residues and atmospheric transport of toxaphene from the U.S. on the toxaphene budget over the Great Lakes. The model results indicated that toxaphene reemissions in the southeast U.S. made the largest contribution to toxaphene distribution over the Lakes, followed by the northeast U.S., southwest U.S., northwest U.S. and the west coast of the U.S. (Figure 18). A significant proportion of these contributions occur during relatively short episodic events, particularly in the winter/spring and summer/autumn transition periods due primarily to the interseasonal changes in atmospheric circulation patterns. A strong episodic long range transport event of toxaphene air concentration from the southeast U.S. occurring for the days of 9-13 September 2000 was detected by the numerical simulations (Figure 19). This event also comes with warm and humid air mass moving from the Gulf of Mexico and the southern U.S. to the Great Lakes, resulting in strong precipitation and wet deposition to the Lakes (Figure 19). The event suggests that a short but intense episodic event can be a major pathway for atmospheric transport of toxaphene from its major reservoir in the southern U.S. to the Great Lakes. The information has been used to improve estimates of deposition of toxaphene to the Great Lakes.



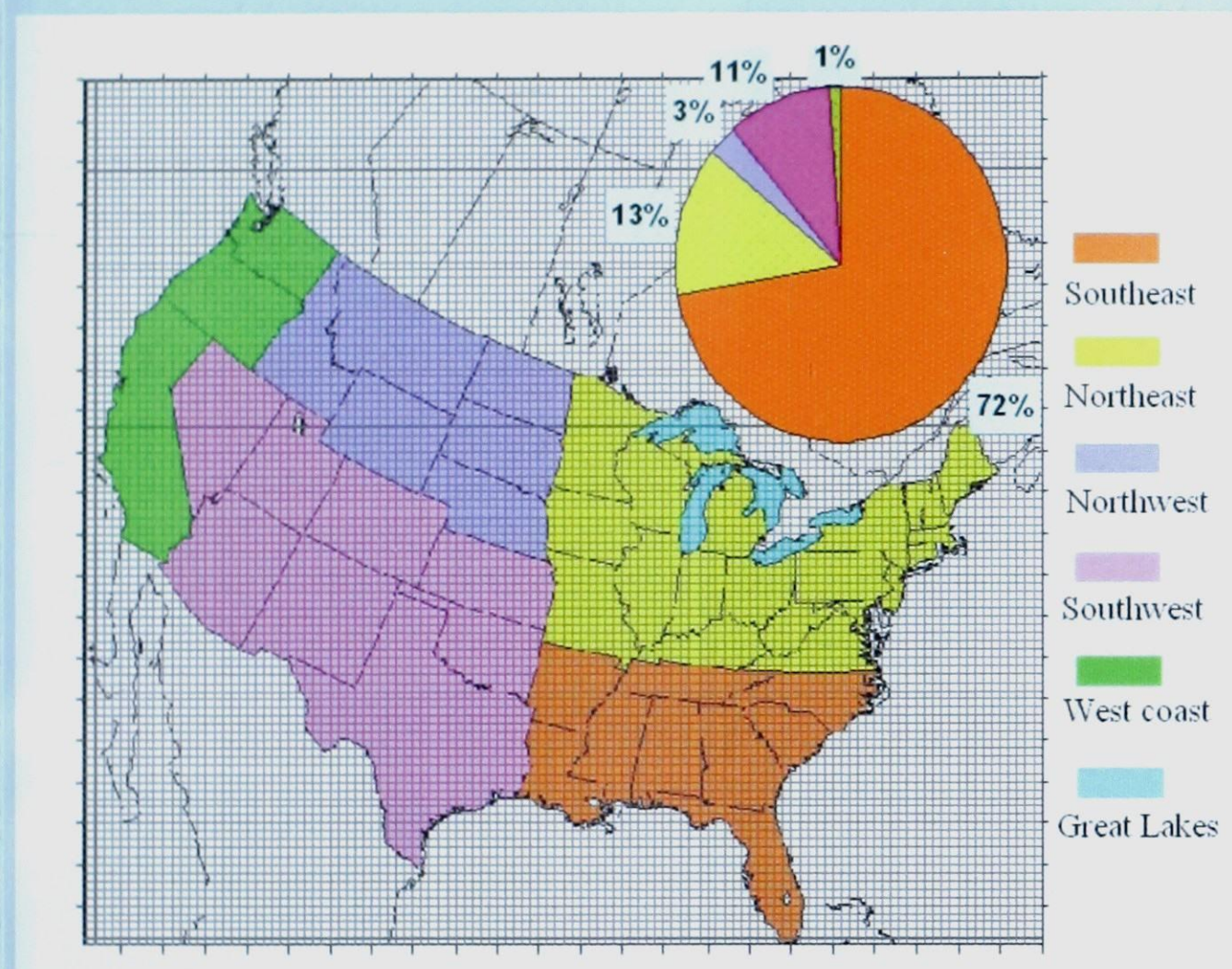


Figure 18 - Model domain, grids and model estimated contribution of each source region in the U.S. to annually averaged toxaphene air concentrations over the Great Lakes (inset).

Figure 19 - Modelled toxaphene air concentration (pg m-3) at 1200 m superimposed on the GOES-8 visible satellite image for September 10th 2000 showing a rain band extending from the Gulf of Mexico and southern U.S. to the Great Lakes.

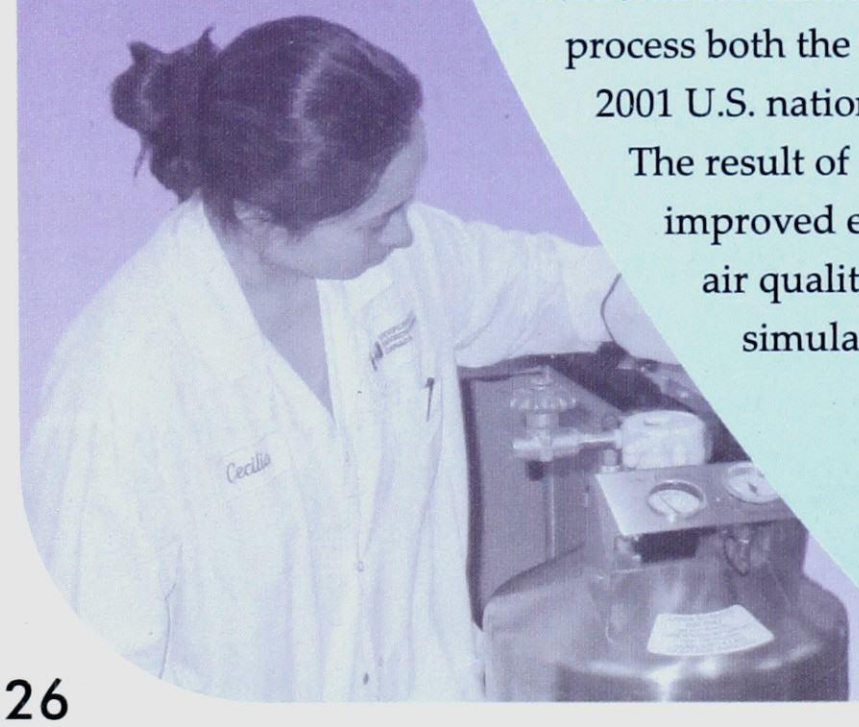
Sound science on air quality is essential to:

- the health of Canadians and their environment;
- policy makers and decisions on air quality management and
- air quality forecasters in providing timely information to the public on atmospheric conditions.

Science to Action

Air Quality Predictions and Applications Support to Policies

The Branch works closely with the Canadian Meteorological Centre's Air Quality Models and Application Group (AQMAG) by transferring technologies and information to support timely air quality forecast services to Canadians and applied scientific support for decision-makers to develop effective air pollution control strategies. The collaboration aims at constantly improving the suite of air quality models for the benefit of both forecasting and air quality management. Over the past fiscal year the AQMAG transferred forecast results on a daily basis to the National Oceanic and Atmospheric Administration (NOAA), contributing to an ensemble forecasting experiment for air quality in real-time. Furthermore, a new emission processing system for air quality models, adapted for the needs of MSC's models in close collaboration with the National Research Council, was used to process both the 2000 Canadian and the 2001 U.S. national emission inventories. The result of the processing is an improved emission input field for air quality forecasts and scenario simulations.



Science Support to the Canada-U.S. Transboundary PM Science Assessment

Several Branch scientists provided input to the Canada-U.S. Transboundary PM Science Assessment's chapters on observations and data analysis results, and modelling. This report was prepared by the Canada-U.S. Subcommittee on Scientific Cooperation in support of the Canada-U.S. Air Quality Agreement. The data analyses included the characterization of PM concentrations and deposition in the Canada-U.S. border region and the application of a number of PM source attribution techniques. Near-border stations were found to be in exceedance of national PM standards in both countries and episodes of PM transboundary transport were identified in both directions across the international border. The AURAMS air quality model was run for one summer and one winter case for five emission scenarios: a base case, two 2010 scenarios, and two 2020 scenarios.

AQMAG provided the modelling support for the generation of scenario runs to evaluate the effect of various emission reduction scenarios for the PM transboundary assessment. The Branch analyzed the simulations and drafted the scientific description of the outcome of the scenarios. The information presented in the assessment report will be used to determine the need for a PM annex pursuant to the Canada-U.S. Air Quality Agreement.

Science Support to the Canadian Acid Deposition Science Assessment

The Branch contributed to the science component of the 2004 Canadian Acid Deposition Science Assessment. Chapter 3 of the Assessment written by Branch scientists focused on wet, dry and total deposition trends and analyses. The Branch also carried out several new acid rain model simulations in response to additional laws passed since 1997 to examine whether these additional control measures would finally solve the acid rain problem in eastern Canada. Unfortunately, the answer obtained was "no". While the new control measures will increase the area of eastern Canada for which acid deposition levels are predicted to be acceptable, some parts of central Ontario, central Quebec, and the Maritime provinces will still experience levels of acid deposition that are damaging to aquatic and terrestrial ecosystems.

Atmospheric Chemistry Research in Support of the European Space Agency Program

In January 2005, the Branch led the work on a two-year contract with the European Space Agency (ESA) to explore ways of creating an integrated data-assimilation system for meteorological and chemical observations of the atmosphere (chemical weather). The Branch is collaborating with York University and the Belgian Institute for Space Aeronomy to create this coupled chemical-dynamical data assimilation system. Except for the assimilation of stratospheric ozone data in operational weather centres, this will be one of very few data assimilation activities to be carried out using a fully coupled dynamical-chemical model.

As part of the research under the ESA contract, the Branch with its collaborators have completed a significant amount of work towards the implementation of model-assimilation systems. This work will contribute to MSC's efforts to develop a chemical weather forecast capability and give the MSC the ability to promote innovative Canadian technologies on an international scale.

Chemical weather forecasting can help scientists better understand the relationships between air quality, meteorology and climate change. Such forecasts would help predict air pollution on a national and global scale — thereby improving public air quality forecasts and day-to-day decision making and adaptation by both individuals and businesses in Canada.

Working with Others

In efforts to strengthen air quality R&D and extend the knowledge needed to support science assessments, management plans, policies and a wide range of services to Canadians, the Branch expands its research capacity by collaborating with various organizations. Scientists frequently work with researchers in universities and other federal and provincial departments, as well as with experts in the private sector. The Branch also collaborates with other branches in Environment Canada's Atmospheric and Climate Science Directorate on issues that affect air quality such as climate and meteorology. Also there are collaborations with the Department's regions on air quality-related issues in more specific geographical areas. With respects to public policy and services, the Branch works closely with the policy and meteorology community.

Some examples of key collaborations include:

- Environment Canada Branches, Regions and Services — conduct air quality studies, inform policies and support air quality-related services
- Universities — R&D on air quality issues of mutual interest
- Health Canada — define health exposure conditions from air quality and UV radiation; shares expertise to determine the impacts of radioactive substances on humans
- National Resources Canada — through the Program of Energy Research and Development develop strategies to reduce pollution from the transportation sector

Figure 20 - Key Partnerships

- Agriculture and Agri-Foods Canada — As part of the National Agri-Environmental Standards Initiative (NAESI), research methods to reduce agricultural emissions
- Indian and Northern Affairs Canada — As part of the Northern Contaminants Program, carry out R&D to address air quality in the Arctic
- U.S. Environmental Protection Agency — joint research under various air and water Canada-U.S. agreements
- National Oceanic and Atmospheric Administration — research atmospheric pollutant transport and transformation and monitoring of environmental change in the Arctic
- National Aeronautics Space Administration — space-based monitoring of the environment
- World Meteorological Organization — monitor global environmental conditions and stratospheric ozone

Human Resources

Workforce

During the 2004/05 fiscal year, the Air Quality Research Branch had 139 full-time employees and 20 university Co-op students. In addition, the Branch had 45 visiting scientists and students working on collaborative research projects and two Scientists Emeritus.

Branch Retreat

A Branch retreat was held in January 2005. Approximately 120 staff were brought together in a team environment to develop and implement an action plan to meet the goals of staff and Environment Canada's People Plan (a strategy to build, retain and enable staff to meet the Department's mission and mandate). The staff found the retreat very useful as demonstrated by the results from an evaluation questionnaire. A number of recommendations stemming from the retreat were implemented in efforts to enhance the working environment and address staff needs.

Career Development

A Branch training and development committee was formed to help meet the training and development needs of staff. The committee led a series of in-house information/training sessions to provide staff with learning and training opportunities on work-related areas of interest. The Branch participated in the Environment Canada Youth Network's Science Symposium to educate and raise awareness of air quality research as a potential career area. The Branch also led a pilot project geared towards communicating complex science to the general public.

Branch scientists participated in regular lunch time seminars to communicate and exchange information on current research projects. Scientists prepared plain language summaries of their research papers to communicate their research results to staff, internal clients and other government departments. Furthermore, Branch staff attended 85 conferences and/or symposiums, as well as 41 international business meetings to increase their knowledge and advance their scientific research.

Recognition & Awards

- 35 staff members received "Long Service Awards". These awards ranged from 5 to 35 years of service.
- The ICARTT research team received the Citation of Excellence Award recognizing Air Quality Research Branch scientists, technicians and modelers (including CMC's Air Quality Models and Application Group) for their efforts in the ICARTT field campaign
- Vitali Fioletov and Jim J. Kerr (Scientist Emeritus) were recipients of the US EPA 2005 Stratospheric Ozone Protection Award as members of the Ozone Science Tiger Team for their research efforts in the protection of the ozone layer
- Balbir Pabla and Alexander Kallaur received the "Instant Award" for their efforts in optimizing the AURAMS and CHRONOS air quality models to run on the new IBM supercomputer. The efforts enabled AURAMS real-time use in the 2004 ICARTT field study and the successful implementation of the 2004 Air Quality Prediction Program; Liisa Jantunen received an instant award for her initiative in locating and obtaining parts for laboratory instrumentation, which resulted in substantial cost-savings to the Branch.
- Andrew Sheppard and Véronique Bouchet were awarded the "All Season's Award"; Véronique for assembling, training, and outfitting a meteorological and air-quality forecasting team to support aircraft operations for the MSC contribution to the ICARTT / New England Air Quality field experiment and Andrew for his work on improving the Lake Ontario BUOY.
- Tom McElroy was appointed to the GAW Ozone Scientific Advisory Group
- Bruce McArthur was elected a member of the International Radiation Committee of IAMAS (International Association of Meteorology and Atmospheric Sciences)

Funding for the 2004/05 Fiscal Year

The Air Quality Research Branch receives funding from three different business lines: Weather and Environmental Prediction (WEP), Clean Environment (CE), and Nature. Each business line is set up to deliver a distinctive long-term strategic outcome, therefore the research performed within the Branch will help achieve the following results:

1. through the WEP business line, help Canadians adapt to their environment in ways that safeguard their health and safety, optimize economic activity and enhance environmental quality

2. through the Clean Environment business line, protect Canadians from domestic and global sources of pollution

3. through the Nature business line, conserve biodiversity in healthy ecosystems.

Each business line contributes funding for salary, operating and maintenance expenses (O&M) and capital investments.

AQRB'S funding for the 2004/05 fiscal year is as follows (in '000s):

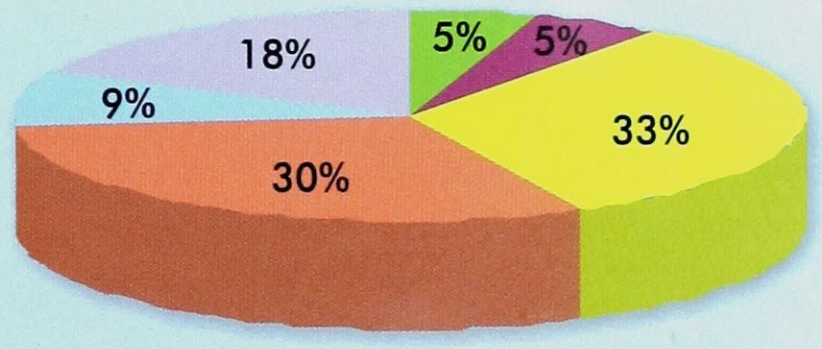
Business Line	Salary	O&M	Capital	Total
WEP	$5,002.2	$1,859.1	$407.2	$7,268.5
CE	$4,137.2	$5,261.3	$1,828.0	$11,226.5
Nature	$375.1	$464.7		$839.8
Total	$9,514.5	$7,585.1	$2,235.2	$19,334.8

Use of Funding

The Branch is organized into the following divisions: Processes Research (ARQP), Measurements and Analysis Research (ARQM), Modelling and Integration Research (ARQI) and Experimental Studies (ARQX). Each of the divisions receives specific funding to carry out the Branch's research activities. The Centre for Atmospheric Research Experiments (CARE) and the Director's Office are also sections of the Branch. Funding for these sections include items that benefit the branch as a whole, such as, the Thomson Lab, computer maintenance, and conference travel.

Resources by Division 04-05			
Director's Office	ARQD	$	1,001.1
Centre for Atmosphere Experiments	CARE	$	1,038.0
Air Quality Processes	ARQP	$	6,273.1
Measurements & Analysis	ARQM	$	5,855.1
Modeling & Integration	ARQI	$	1,717.4
Experimental Studies	ARQX	$	3,451.0
	TOTAL		19,335.7

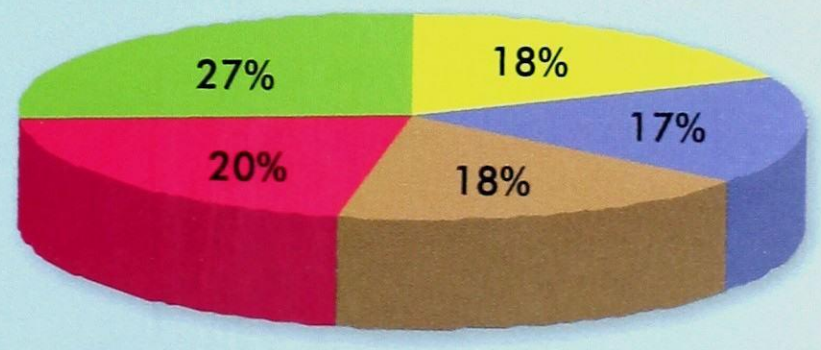
Distribution of Resources by Division



The Branch's research portfolio is organized into five main air quality issues: smog, hazardous air pollutants (HAPs), acid deposition, greenhouse gases and aerosols (GHGs), and stratospheric ozone and radiation. Each issue is dedicated funding as indicated in the pie chart below.

Resources by Program 04-05		
Smog	$	2,594.0
Hazardous Air Pollutants	$	2,013.1
Acid Deposition	$	1,755.1
GHGs / Aerosols	$	1,701.6
Stratospheric Ozone & Radiation	$	1,773.9
TOTAL	$	9,837.7

Distribution of Resources by Program



2004 Peer-reviewed Publications (and other Documents)

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Alfarra, M. R., Coe, H., Allan, J.D., Keith, N.B., Boudries, H., Canagaratna, M.R., Jimenez, J.L., Jayne, J.T., Garforth, A., **Li, S.-M.**, Worsnop, D.R., (2004). Characterization of urban and regional organic aerosols in the Lower Fraser Valley using two Aerodyne aerosol mass spectrometers, Atmos. Environ., 38, 5745-5758.

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