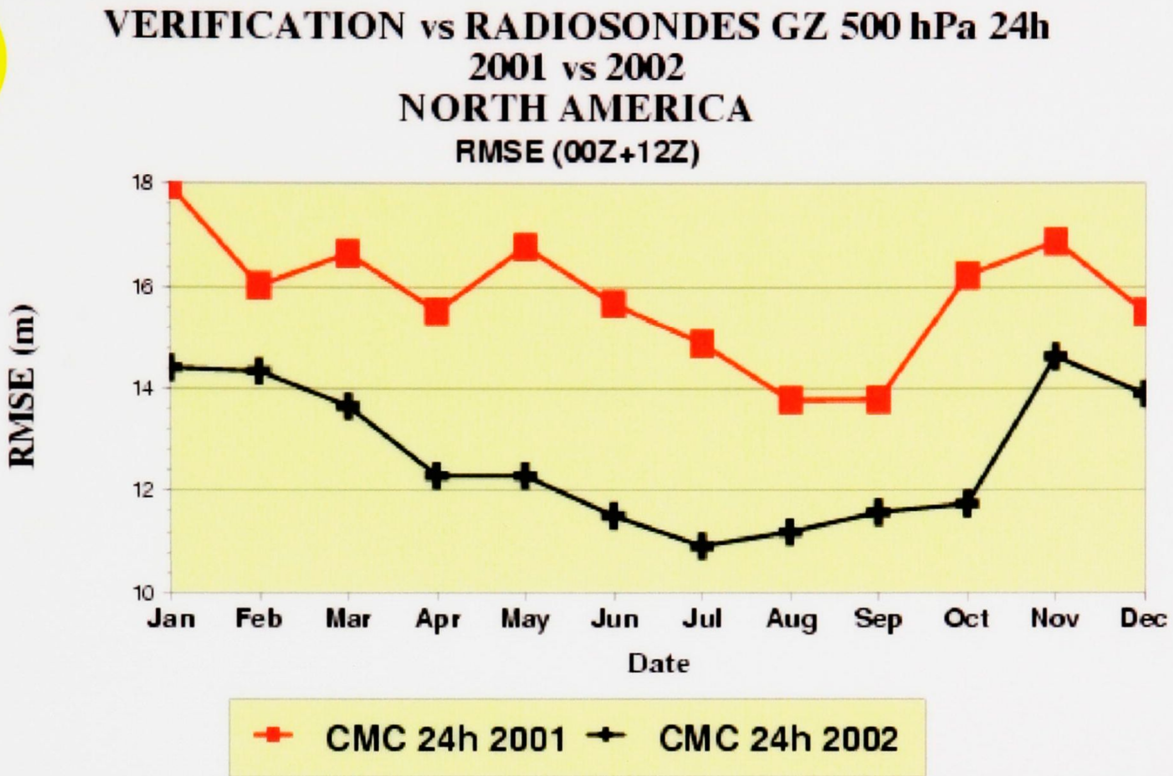
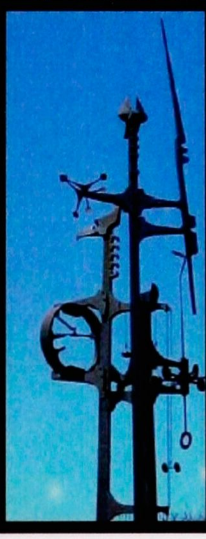
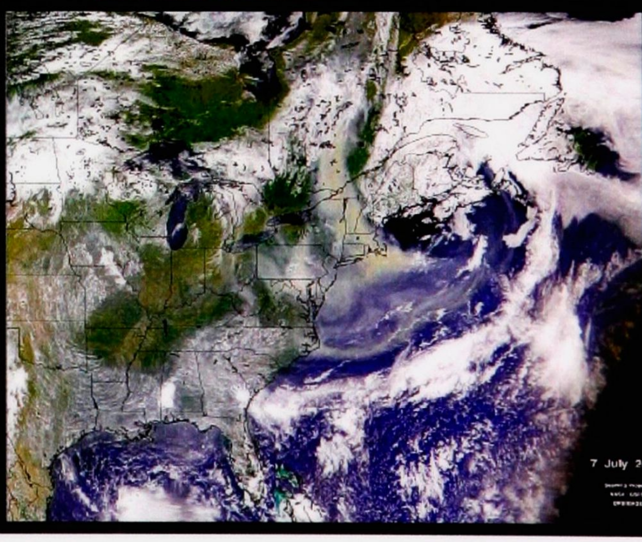
Canadian Meteorological Centre
2002 Annual Review

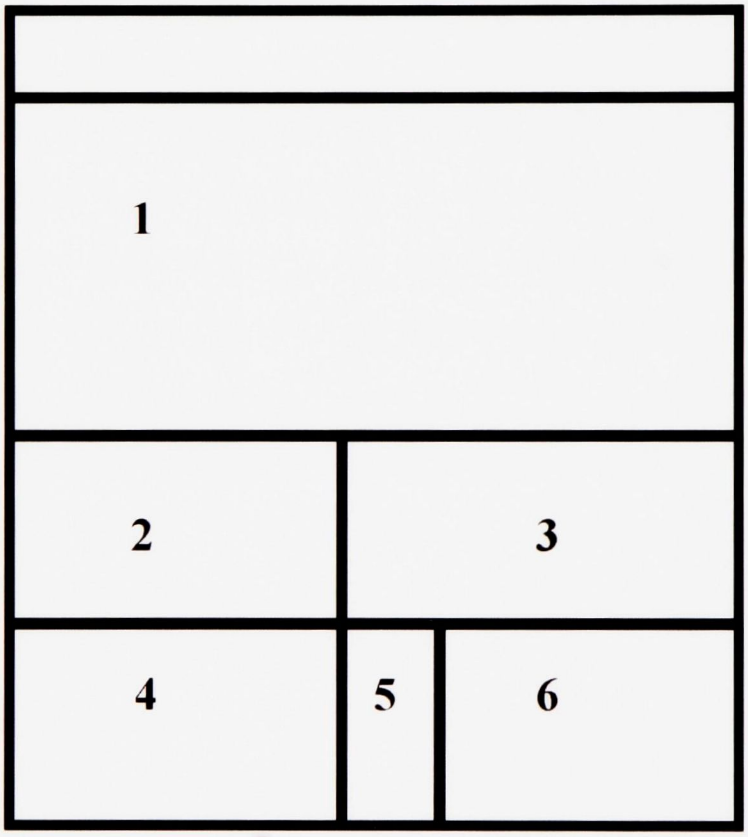






Canada

The **Canadian Meteorological Centre** (CMC) is responsible for the national meteorological and environmental predictions and for the national telecommunications and data management systems. CMC also provides national and international support during environmental emergencies and natural disasters. The Centre gathers, archives, analyses and disseminates data related to climate, stratospheric ozone, ultraviolet radiation, air quality and water quantity and quality. The Canadian Meteorological Centre plays a primary role in technology transfer to the MSC regional offices. Some of the clients for this specialised information include Nav Canada, the Department of National Defence, other government departments and agencies, several airlines, the media and many private companies.



1. Graph showing the improvement of our global model forecasts following the implementation of changes on December 11th 2001.
2. CMC Dorval building.
3. The Kelvin Band comprised of CMC/Dorval employees.
4. Photo of the picnic held at CMC/Dorval June 21st 2002.
5. Sculpture located in front of the Downsview headquarters building.
6. Forest fire plume extending over southern Quebec and New England, July 7th 2002.

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Message from the Director General

2002: a fertile year !

Dear Readers:

I am delighted to introduce the annual review for 2002, because it was a fertile year for us in many areas.

Within the Meteorological Service of Canada, 2002 was the year of a full-scale program review, under the title "Forecast For the Future". The goal was to ensure sustainable program quality over the years to come. A major announcement by the Minister is anticipated for early 2003.

At the CMC, we reaped the harvest of major improvements in the global data assimilation and forecast systems introduced in December 2001. The quality of our numerical weather prediction has improved by leaps and bounds, with a 20% reduction in root mean-square error for 24-hour forecasts! For day one forecasts, we now rank among the top centres in the world. This achievement is the fruit of many years of excellent work by the Research group and CMC staff, and I want to convey to them my wholehearted appreciation.

The CMC was very active this year in projects involving our basic systems. In October 2002, IBM was awarded a contract to deliver the next supercomputer, which will have 2.5 times greater processing capacity. New Origin 3000 front-end processors were put into service for development purposes, boosting performance by a factor of 3. We also substantially upgraded the capacity of our NWS link, with a T1 link 25 times faster than previously, allowing improved exchange of radar, satellite and numerical model data. A major restructuring and improvement of the department's EcoNet is almost complete. A more robust, fully redundant architecture has been installed for the national site: http://www.meteo.ec.gc.ca.

We continued to diversify applications of atmospheric dispersion models to address air quality and safety needs. We staffed a number of positions in the new Air Quality Model Applications Group. This made it possible to improve forecasting models and develop various policy analysis scenarios. In addition, in July 2002, we used a dispersion model to estimate the dispersion of smoke plumes from major forest fires in Quebec.

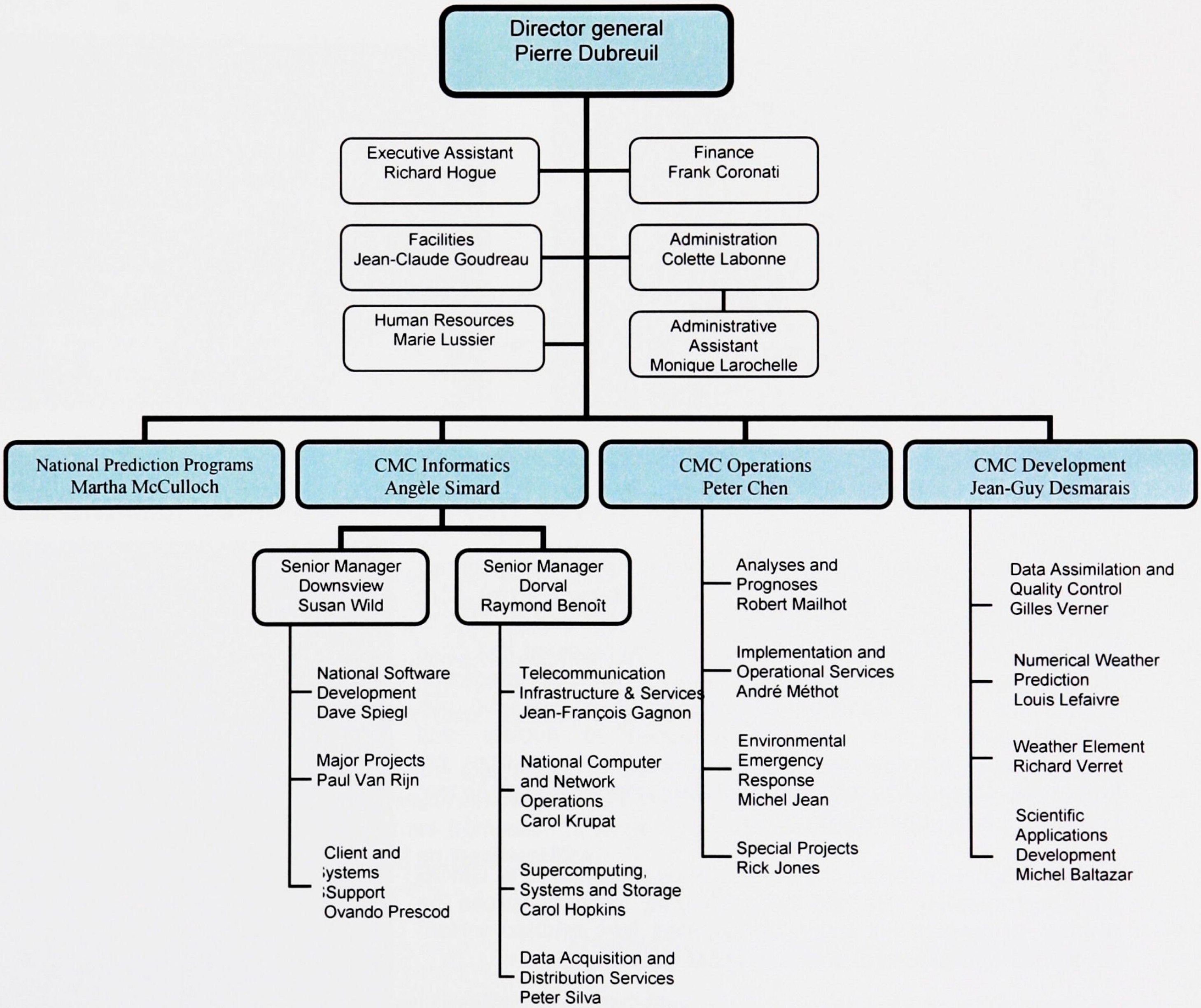
Many CMC employees were very active in the WMO, particularly the Commission for Basic Systems (CBS). We chair several working groups and teams and participate in many more. An example of this contribution is Angèle Simard's work in organising and chairing the WMO Technical Conference on Data Processing and Forecasting Systems held in Cairns, Australia in December. In addition, three CBS expert teams held meetings at the CMC during the year.

In brief, 2002 was a year in which we strengthened CMC programs and services. I encourage you to read this review for more details.

Pierre Dubreuil

Organisation

This organization chart represents the organizational structure of the Atmospheric Environmental Prediction Directorate-General at the end of 2002. Of the 224 employees of the Directorate-General, 189 work in the CMC building in Dorval, while others work under Informatics Branch in Downsview. It is important to note that the CMC building at Dorval also houses several groups under the Meteorological Research Branch (MRB). Exchanges between CMC and groups related to numerical weather prediction research, air quality or data assimilation and satellite meteorology, are numerous, and constitute a very positive contribution to the whole of the program.



Highlights

Departmental award for improved operational forecast systems

The Meteorological Research Branch (MRB), as well as CMC's Development and Operations Branch, received a departmental award in the spring of 2002. It was awarded in recognition of the exceptional work of their employees in the last few years that resulted in innovative systems being implemented in CMC and marked improvements in the quality of the operational forecasts. The comparison of 2001 and 2002 results shows a significant improvement in quality (see the "Performance Reports" section for details).

A BBQ was held behind the CMC's building in Dorval on June 21, 2002 to mark this achievement.

The Andrew Thomson Prize awarded to Michel Jean

Michel Jean, Chief of CMC's Environmental Emergency Response Division, received the Andrew Thomson Prize from CMOS President Dr. Ron Stewart at the 36th annual CMOS Congress, held in Rimouski in May 2002. He received this prize for his role in the development of numerical weather prediction applications to the transport and dispersion of volcanic ash plumes, and to the real-time response to nuclear and environmental emergencies. This prize also recognizes his impressive contribution to the work of the United Nations Nuclear Test Ban Treaty Organization (CTBTO).

As well, Michel Jean had the honour of being named the CMOS 2002 tour speaker. He had the opportunity to travel across the country to present his much appreciated talk, entitled « Non-traditional Applications of Meteorological Modeling ».

CMC signs a contract with IBM for its new supercomputer

The supercomputer replacement process, initiated in 2000, reached a major milestone in 2002 with the signing of a contract with IBM in the fall. Significant effort was involved with respect to this RFP. This was a very complex process, but which resulted in a 5-year contract for a technology that does not currently exist. The installation of the supercomputer requires several changes to the computer room and a major undertaking in order to ensure continuity of MSC operations. The new supercomputer will be composed of over twenty-five (25) of the latest IBM servers (the eServer pSeries 690) interconnected by an ultra fast high speed network. The pSeries 690 server is based on the most advanced processor technology from IBM yet, the Power 4 microprocessor. The new supercomputer will be delivered in March 2003. It will have over two and a half (2.5) times the processing power of the previous supercomputer. Later, the system will be upgraded to over six (6) times the power of the previous supercomputer.

Telecommunications

Significant progress was accomplished on the redesign and upgrade of the ECONET, a project which will be completed in the first quarter of 2003. This project is discussed in further detail in a feature article on Telecommunications further on in this review.

After several years of discussion, the link to the US NWS was upgraded. We now have a T1 link whose capacity is of 1.544 megabits per second. The previous one had a capacity 24 times smaller (64 kbps). This upgrade will fulfil the needs of the US NWS and the MSC for additional data transfers, particularly radar, satellite and model data.

Several new Canadian radar sites were connected to the ECONET. Also much work has been conducted in preparation for Internet connectivity anticipated in the next year, especially as it relates to the support of the Single Window Weather Office web site. Work has been initiated to install a high speed Ca*Net connection that will facilitate exchanges with our partners in the academic community, allowing more rapid access to large model data files.

Single Window Weather Portal

CMC continued to feed - and maintain - the national real-time single window weather web site (http://weatheroffice.ec.gc.ca). This work was done in line with the Government On-Line initiative and TBS common look and feel guidelines. A more robust web infrastructure has been implemented including increased capacity and full redundancy. Applications had to be ported to this improved infrastructure without service interruption. This architecture will allow easy scalability (adding capacity) as demand increases. The expectation is that this activity will grow in importance as more and more Canadians and decision-makers rely on this site for up-to-date, accurate weather information.

In October a new weather warning service was added to the weatheroffice web site. The 'Battle Board' shows a map of Canada, highlighting areas where MSC has weather watches and warnings in effect, and makes links to the warnings and watches from each forecast region. The software, developed in Prairie and Northern Region, was implemented on weatheroffice.

Common Look and Feel Implementation

In June 2000 Treasury Board introduced Common Look and Feel (CLF) requirements for all Government of Canada web sites that can be viewed by the public. The requirements included 33 guidelines and policies, including conformance to the Official languages Act. CMC was tasked with planning and coordinating the conversion of existing MSC web sites to meet the December 31, 2002 deadline. Over 15,000 web pages were assessed and made CLF compliant, including about 5,000 documents that were created to make the content of PDF files accessible. Currently, all new MSC web sites and all changes to existing sites are being reviewed for CLF compliance.

SCRIBE improvements

The development and implementation of SCRIBE continued throughout 2002. All offices are now using SCRIBE for some forecasts. Version 3.8.2 was delivered in June 2002 and version 3.8.3 in December 2002. These versions included improvements in the Concept Generator, the Graphical Interface as well as the Text Generator, mainly for precipitation forecasts. The versions also included corrections to problems reported by users.

In addition, a national workshop was held on November 21-22 with the regional representatives. The goal of the workshop was to identify improvements to the SCRIBE interface necessary to allow operational meteorologists to use this production tool to manage, maintain and improve more effectively the weather elements database used to generate public (and other types of) forecasts. Nearly sixty recommendations were formulated, amongst which eighteen were judged to be of top priority. The workshop was an important step toward making SCRIBE a sustainable operational production tool for all MSC components in the near future.

CBRN (Chemical Biological Radiological/Nuclear) Research and Technology Initiative (CRTI)

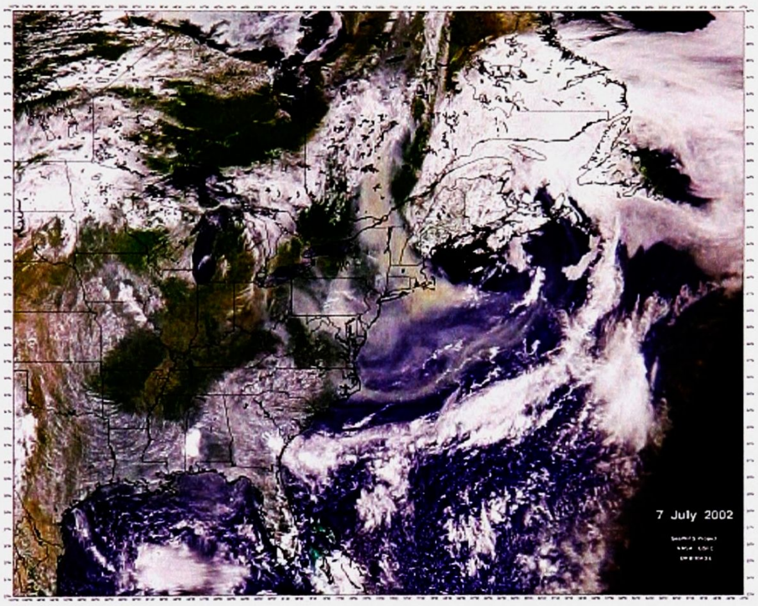
The CMC developed an application, and corresponding visualization tools, permitting the sophisticated numerical simulation of the atmospheric transport of radioactivity and airborne volcanic ash. This application is the basis of its involvement in the organizing and planning of emergency response lab clusters for supporting emergency response in counter-terrorism. In addition, the CRTI initiated a funding program to collaboratively accelerate the implementation of existing technologies, and research and development projects in priority areas identified by the CRTI. The CMC participated, along with other components of Environment Canada, in many workshops and discussions to present the operational services and capabilities of the MSC, as well as the specialized capabilities at the CMC, in relation to emergency response. The CMC has been identified as a laboratory member of each of the Chemical, Biological, and Radiological/Nuclear Clusters.

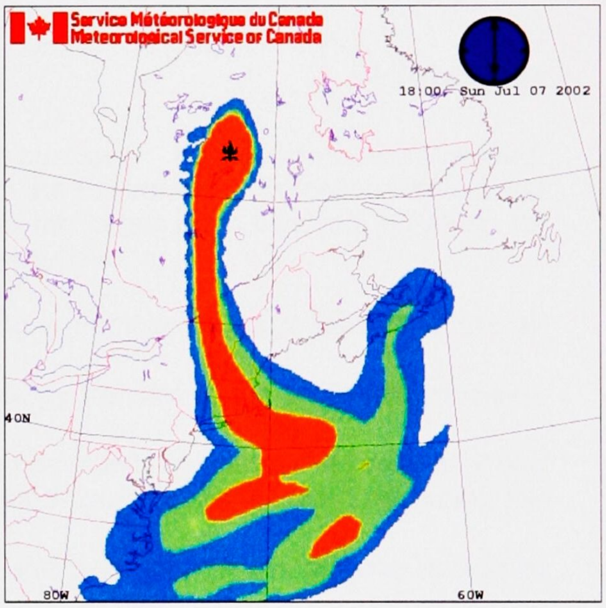
Following the federal budget announcement of new investments in national security activities in late 2001, the CRTI, a five-year government-wide initiative led from DND, was launched in 2002. In its first round of funding allocations, the MSC received an investment in a project to acquire and implement six portable surface and upper air meteorological monitoring systems, to be installed and readied in six major centers across Canada, and operated by Environment Canada's Regional personnel. Data acquired from these units will be used for on-scene command decisions as well as for input to numerical models to track and forecast the movement of dangerous materials in the atmosphere.

The CMC was also identified as a collaborating partner in a two-year project led by Health Canada to produce an operational information management and decision support system for radiological-nuclear hazard preparedness and response. The required data for current and forecast meteorological variables will be provided from the operational numerical weather prediction system at the CMC. The predicted concentrations of airborne radioactive material required by the decision support system will be computed by a number of specialized modeling tools driven by the outputs of the numerical weather prediction models of the Canadian global and regional data assimilation and prediction system.

Modeling Smoke Plumes from Major Forest Fires in Québec

A number of forest fires started to burn in Northern Quebec on July 2, 2002. One of them grew rapidly out of control. After a few days, a 200 to 400 km wide smoke plume moved gradually south-westward and swept into part of Southern Ontario, Southern Quebec, the states of the U.S. eastern seaboard and the Atlantic provinces. In this plume, fine particles were reducing visibilities up to an elevation of 3 km. In the Montreal area, more than 700 km away from the fire, measured concentrations of fine particles were exceeding up to 3 times the defined standards. Numerical modeling of the smoke plume was done in real time with CMC's CANERM dispersion model. The simulations were calibrated from data recorded at the monitoring stations of Environment Canada, Quebec Region, and its regional partners (Quebec Ministry of the Environment and the City of Montreal). A figure of the observed smoke plume as seen from space on Sunday, July 7, 2002 and the predicted smoke plume by CANERM valid at approximately the same time can be seen below (as well on the cover of this document). This experimental, non-validated, and non-operational, application of the CANERM model was used only due to the exceptional circumstances where public health and safety were of immediate concern.
These specialized simulation tools, requiring real-time inputs and expertise from various partners, could possibly allow the development of new collaborative services and environmental information that benefit Canadians in their decision making.





SEAWIFS satellite imagery Sunday July 7th 2002 at 12:35 EDT. The smoke plume is well identified by the beige coloured cloud covering Southern Quebec and Northeastern USA	Vertically integrated (0-5000 meters) smoke plume, as depicted by the CANERM model, for Sunday 07 July 1400 EDT

Estimate of environmental impacts of reduced sulfur content of fuel oils

MSC's Air Quality Modeling Division and Air Quality Model Applications Group used a comprehensive acid-deposition air quality model named ADOM in the context of environmental impact estimate studies. This work was done at the request of the Oil, Gas and Energy Branch (OGEB) of the Environment Protection Service. They wanted to assess the potential costs and benefits of reducing the sulphur content of heavy and light fuel oils used in Canada. Estimates were computed, using the ADOM model, of the level of annual reductions in wet sulphate deposition and sulfur dioxide and particle sulphate air concentrations due to reduced emissions from the combustion of lower-sulfur heavy and light fuel oil in eastern Canada. Since sulfur emissions in Canada contribute both to acid deposition and to atmospheric particulate-matter levels, reducing sulfur emissions will have a positive environmental impact. Most of the emission reductions will occur in eastern Canada, particularly in the Maritimes where oil is widely used for power generation, industrial processing, and residential home heating.

U.S. Delegation visits CMC and meets with Canadian Space Agency & NRCan

On May 22-23, a delegation from the U.S. National Satellite Data and Information Service (NOAA/NESDIS) made a familiarization visit to the Canadian Meteorological Centre (CMC), and later met with Marc Garneau, President of the Canadian Space Agency, and with NRCan/CCRS. The visit was in support of the development of an MOU between the MSC and NESDIS for ongoing access and exchange of satellite data and information products. CMC accesses and assimilates NESDIS data for daily numerical weather prediction, and each MSC forecast centre is equipped to receive NOAA satellite images. Several topics for cooperation under the MOU were discussed - including data exchange, telecommunications and collaborative research in data assimilation techniques for numerical weather models.

Creation of an air quality modeling applications group

Air Quality Modeling Applications Group (AQMAG)

Background

In December 2000, the Federal Government negotiated the Ozone Annex as part of the existing Canada-US Air Quality Agreement (1991). With the new resources that were allocated for the work represented by this Annex, the MSC decided in July 2001 to establish the Air Quality Models Applications Group (AQMAG) located at the CMC. The goal of the AQMAG is to contribute to the assessment of the trans-boundary exchange of ground-level ozone and its precursors, and to provide methodologies and modeling scenarios for the development and evaluation of policy and to support decision making. It is also responsible for the operational modeling in support of Environment Canada's air quality prediction program.

Highlights

Organizing and establishing the Group was the first order of business. Key positions were staffed. Coordination of various modeling and data analysis activities with the Environment Protection Service and the Regions started. Meanwhile, new staff were introduced into the larger team involved including, for example, the Air Quality Research Branch (AQRB) located in Downsview.

Significant progress and early results were accomplished along a number of fronts related to the air quality modeling work:

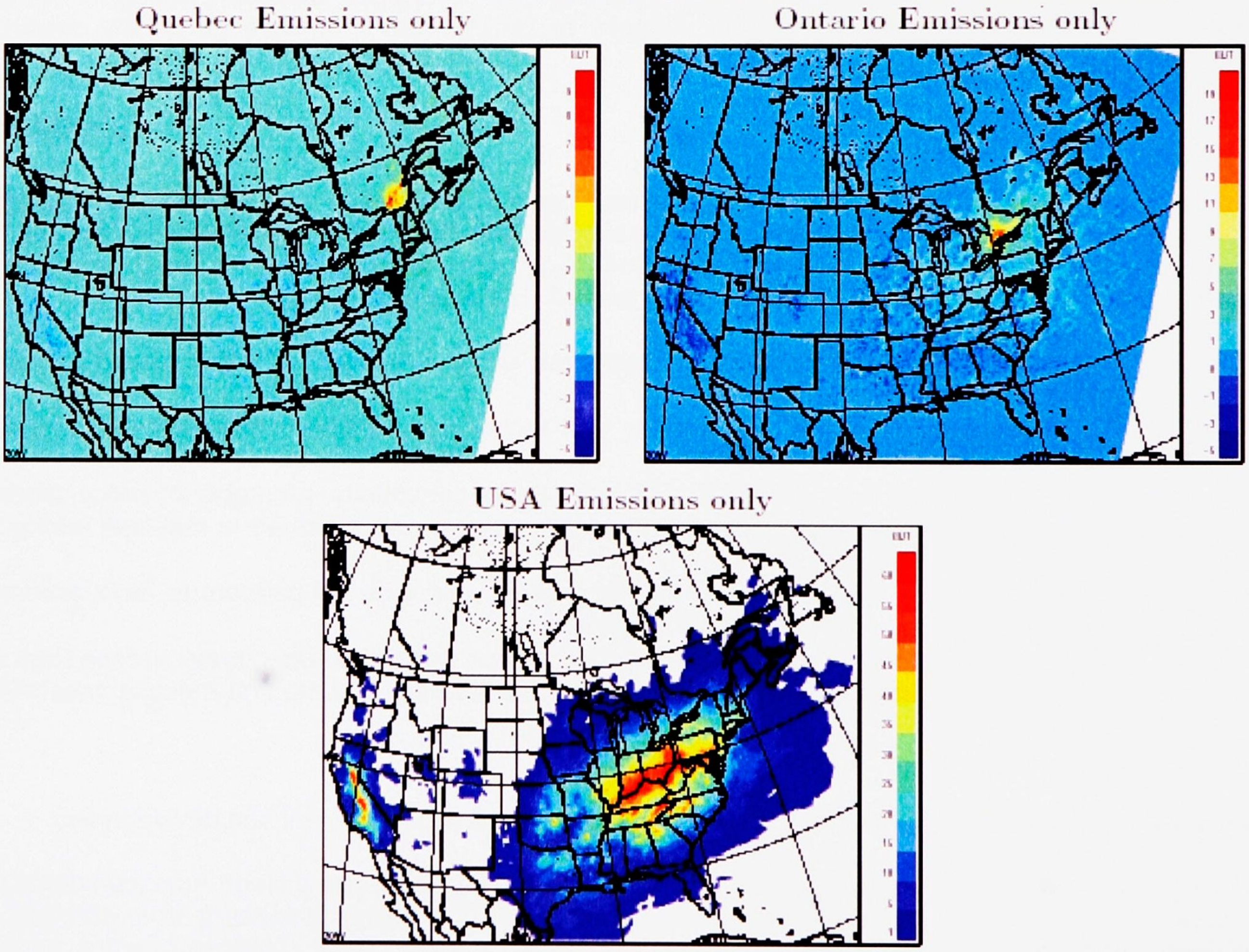
- Collaborative work on the development and technology transfer of the AURAMS modeling system's code to CMC from AQRB.
- In cooperation with the Environment Canada policy community, a number of policy scenario runs using the operational CHRONOS modeling system were carried in real-time during the summer of 2002.
- Development of a web-based interface for internal and external partners to have access to trajectory and back-trajectory modeling products
- In partnership with Environment Canada Air Pollution Prevention Directorate and the Regions, a working group on emission processing was established, and the first meeting was held in November 2002.

A new way forward - the use of modeling tools in real-time for policy assessment and development.

The CHRONOS air quality modeling system is executed on a daily basis over a North American domain to generate hourly forecasts of ground-level ozone and other relevant chemical species up to 48 hours. It has been part of the CMC operational runs since the summer of 1999. The establishment of the AQMAG at CMC takes advantage of the fact that CHRONOS is fully integrated and supported within the CMC production engine. Therefore, it represents a stable environment for examining policy scenarios, and,to launch real-time experiments as degraded air quality episodes occur. These policy runs were implemented and examined as real-time "parallel" runs over the summer of 2002.

Three policy scenarios were initially selected for their simplicity, in order to test the technical aspect of running emission reduction scenarios in real-time. They consisted of setting to zero all anthropogenic emissions only from Quebec (scenario 1), then those only from Ontario (scenario 2), and finally those only from the United States (scenario 3). Each simulation was executed independently of the others. For example, in scenario 1, the CHRONOS configuration was run every day with Quebec emissions set to zero, and used scenario 1 values at the end of the previous day to initialize the current day's run for this scenario. Comparisons were done on the basis of the number of exceedences of the ozone Canada Wide Standard.

The real-time examination of emission reduction scenarios during the summer 2002 was successful in demonstrating the potential of the current air quality forecast program. It was learned that while CHRONOS' daily predictions over North America are important to the routine air quality forecasting program, additional simulations can also be performed to investigate possible impacts of emission reductions options on trans-boundary effects. Although the 2002 scenarios were simplistic, they illustrated the relative roles of three major source-regions to ground level ozone in Canada, and showed very clearly that both local emissions and long-range transport contribute to exceedences of the Canada Wide Standard, especially in Eastern Canada (see figure below). These on/off scenarios were also a good illustration of the non-linear behavior of ozone chemistry, and demonstrated the various pitfalls that could result in the assessment. A peer committee is currently examining a draft report.



An example of absolute difference of the number of days exceeding the ozone Canada Wide Standard (CWS) between the reference case and the scenario runs, resulting in the number of exceedences due to, respectively, Quebec emissions only (top left), Ontario emissions only (top right) and USA emissions only (bottom).

International Activities

The CMC continues to be significantly involved in international activities. Many of our employees continue to make important contributions to many facets of the World Meteorological Organization (WMO), the International Civil Aviation Organization (ICAO) and the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). Our involvement over the years has lead to the designation of the CMC by the WMO as a Regional Specialised Meteorological Centre (RSMC Montréal) with specialisation in Environmental Emergency Response and designation by ICAO as a Volcanic Ash Advisory Centre (Montréal VAAC). CMC plays a leadership role in promoting the important role of meteorology for these activities and others such as the verification regime of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), hence engaging in the evolution of the environmental prediction system of the future.

Through CMC's involvement in the WMO and other international organizations, we share our expertise and our vision, and benefit, in return, a great deal from advances in science and technology and the expertise of others. In addition we have an opportunity to influence future activities and practices such as in international exchanges of data and information, important to global security and the health of the environment.

WMO

The World Meteorological Organization (WMO) is a specialised agency of the United Nations for meteorology, operational hydrology, and related sciences. Its primary purposes are to co-ordinate international activities in generation and exchange of information on weather, water and climate, and to facilitate the development of services that improve the well-being and safety of communities, nations, and the whole of humankind. The World Weather Watch (WWW) is considered the core of the WMO Programmes. It deals with global observing systems, telecommunication and data management, and data-processing centres that are operated by WMO members to make meteorological and related geophysical information readily available to all of its member countries.

The CMC is primarily involved in the World Weather Watch Programme through the Commission for Basic Systems (CBS). The Commission has grouped the programmes for which it has the technical responsibility into four Programme Areas: Integrated Observing Systems (IOS), Information Systems and Services (ISS), Data Processing and Forecasting Systems (DPFS) and Public Weather Services (PWS). Open Programme Area Groups (OPAGs) have been established to look after the activities under these four areas. OPAG tasks are carried out through two types of teams: Expert Teams (ETs) that are mainly based on expertise for developing proposals and solutions to scientific/technical problems, and Implementation/Co-ordination Teams (ICTs) that focus on co-ordinating operational implementation aspects. Rapporteurs are also named, when needed, to report to the OPAGs on specific items within the programme. In addition to CMC employees serving as ET and ICT members, the CMC provides leadership by filling the chair of the OPAG on Data Processing and Forecasting Systems who, therefore, is a member of the CBS Management Board.

As well as the CBS programme structure and organization, regional working groups are organised to work on the planning and implementation of the WWW in their respective WMO regions.

OPAG on Data Processing and Forecasting Systems

This OPAG is chaired by Angèle Simard who, as such, is a member of the CBS Management Board and is consequently able to influence future activities. Several CMC staff are active in the work of this OPAG through membership in its ET's. Ms. Simard also chairs the OPAG's ICT on data processing and forecasting systems (DPFS).

Mr. Peter Chen chairs the Co-ordination Group on Emergency Response Activities and, as such, is also a member of the ICT. This group of experts includes representation from all centres that have been designated as WMO Regional Specialized Meteorological Centres with activity specialization in atmospheric transport modelling capability, principally applied to nuclear and radiological emergencies. As well, the group includes membership from the GTS (Global Telecommunications System) hub at Offenbach, the IAEA, the ICAO, CTBTO, and the WMO Secretariat. This group has been in place since 1993. Michel Jean and René Servranckx of the CMC have contributed extensively to the activities of the Co-ordination Group.

Jean-Guy Desmarais is a member of the Expert Team on the Infrastructure for Long-range Forecasting created at the November 2000 meeting of CBS. This ET is charged with looking into the establishment of an appropriate operational infrastructure for the production and exchange of long-range forecasts, developing procedures for exchange of forecasts, beginning an experimental exchange of long-range forecasts between WMO Centres and other interested agencies and providing recommendations for future consideration and adoption. The ET held a meeting in Geneva in November and provided recommendations to CAS, CCl and CBS.

Richard Verret is a member of the Expert Team to develop a verification system for long-range forecasts. The role of this group is to establish a verification system and to exchange verification results on long-range forecasts. The ET held a meeting at CMC 22-26 April 2002.

Louis Lefaivre became a member of the Expert Team on ensemble prediction systems (EPS) toward the end of the year. This group is working on procedures for the exchange of EPS data between major centres, developing products for distribution to meet WMO programme requirements, reporting on the operational use of EPS to forecast severe weather and extreme events, and to develop standard verification measures for EPS.

OPAG on information systems and services

In 2001, Mr. Jean-François Gagnon, Chief of Telecommunication Infrastructures & Services Division at CMC, was named chair of the Expert Team on Enhanced Use of Data Communication Systems. The WMO CBS Implementation-Coordination Team on Information Systems & Services (ICT-ISS) meeting took place in Geneva from September 9-13. Mr. Gagnon reported on the work of the team at this meeting. Recommendations were made in the area of: file naming conventions for the international exchange of WMO data; Global Telecommunication System (GTS) links using the Internet; use of e-mail to carry GTS messages where no other means exist.

CMC hosts WMO meeting on international data exchange systems

The joint meeting of the World Meteorological Organization (WMO) Expert Team on Enhanced Utilization of Data Communication Systems (ET-EUDCS) and the Expert Team on the Improved MTN and GTS (ET-IMTN) was held at CMC from May 27 to May 31 2002. Participants at this meeting included major national weather centres in Australia, UK, USA, China, Japan, and institutions such as ECMWF and WMO. Mr. Jean-François Gagnon, Chief of Telecommunication Infrastructures & Services Division at CMC, hosted both meetings; he chaired the ET-EUDCS, while Mr. Peilang Shi of the People's Republic of China chaired the ET-IMTN. These Expert Teams developed standards for file transfer protocols, data streaming procedures and file naming conventions, using the new GTS (IMTN) or the Internet. They also examined the establishment of new links between the regions and countries, which would provide the world meteorological community with increased communication efficiency to the benefit of all countries.

Quality Control of surface observations for WMO Regional Association IV

In 1993, the Canadian Meteorological Centre gained a designation as a "Centre responsible for the surveillance of the quality of surface observations for WMO Regional Association IV ". In this role, CMC produces annually two full reports entitled "Reports on the Quality of Land Surface Observations in Region IV". The biannual reports identify "questionable" stations where the general station elevation (or more rarely, the station pressure) may be incorrect. Over the years, we have been able to correct the elevation of a number of stations, thanks to updates to WMO Volume A, or via communications with RAIV members. The reaction of RAIV members has been very positive, and illustrates the importance of this international exchange of information. In 2002, Charles Anderson, who leads the surface observation quality control dossier at CMC, participated in the "WMO Expert Meeting on GDPS solutions for data quality monitoring", from June 24-28, 2002 at Reading, England.

WMO Technical Conference on Data Processing and Forecasting Systems in Cairns, Australia

The WMO held a Technical Conference on Data Processing and Forecasting Systems in Cairns, Australia, December 2-3, 2002. CMC's Director of Informatics Branch, Angèle Simard, as the chair of OPAG, was the conference Director. She organized and chaired the conference. Over 40 countries attended the conference, which focussed on Ensemble Prediction Systems (EPS) and Severe Weather Forecasting. The conference agreed that ensemble forecasting is evolving as a vital tool for weather forecasting on all time scales. It is being applied to severe weather prediction such as tropical cyclone tracks, heavy rainfall, and high winds. It also has potential for applications in the area of environmental emergency response. Richard Verret (Chief of CMC's Weather Elements Division) made three presentations. Two of these dealt with the ensemble forecasting system developed in Canada, while the third concerned automated forecast products, developed by the Analysis and Prognosis Division from the GEM regional model outputs, for both winter and summer severe weather. The wide range of Canadian products generated great interest among the participants.

WMO Implementation Co-ordination Team in Moscow

Angèle Simard, Director of CMC's Informatics Branch chaired the meeting of the WMO Implementation Co-ordination Team on Data Processing and Forecasting Systems, held in Moscow from June 3-7 2002. Peter Chen, Director of Operations (chair of the coordination group on Emergency Response Activities), and Louis Lefaivre, Chief of the NWP Division, (rapporteur for WMO Regional Association IV comprising North America, Central America and the Caribbean) also attended the meeting. The meeting reviewed activities related to severe weather forecasting, atmospheric transport products and,seasonal to interannual forecasting. Recommendations were made for future international work, including the application of atmospheric transport models to air quality, propagation of airborne disease and other hazards related to natural disasters which may have important impacts on health and safety.

WMO Expert Team meets at CMC to develop a verification system for long-range forecast

A meeting of the WMO Expert Team to develop a verification system for long-range forecasts was held at CMC from April 22 to 26 2002. Participants to this meeting represented major national weather centres in Australia, UK, USA, China, Japan, and institutions such as ECMWF and WMO. Richard Verret, Chief of Weather Elements Division at CMC, hosted the meeting as a member of this Expert Team. The mandate given to this Expert Team was to develop detailed procedures and arrangements to operationally measure the performance of long-range forecasts (including seasonal to interannual forecasts) and make this information available to WMO members. These verification procedures will provide users of long-range forecasts with substantial guidance on the extent to which they might rely on products produced by the major centers for their own application and area of responsibility. This will also allow for inter-comparison of different approaches used by major centers such as CMC, and allow for further improvements and collaboration between centers.

WMO's Secretary General visits CMC

The Secretary General of the World Meteorological Organization (WMO), Professor G.O.P. Obasi, visited CMC on September 11. He was accompanied by Mr. Don Nanjira, the WMO Representative to the UN and other UN System Organizations in North America. The Exchanges focussed on CMC's international activities and its many contributions to the WMO Programs. Professor Obasi was particularly interested in CMC's activities which support developing countries.

Real-time meteorological support to a CTBTO on site inspection in Kazakhstan

CTBTO (Comprehensive Nuclear-Test-Ban Treaty) asked CMC to provide weather support for their real-time On-Site Inspection (OSI) Field Experiment. This experiment known as « FE02 » was held from September 23 to October 11. The FE02 saw the actual deployment of a team of inspectors and field monitoring equipment to a hypothetical state, hosted by Kazakhstan. Meteorological products were assembled and updated twice daily in an automated fashion, via a protected web-site. These products were based on the operational GEM-Global model as well as from an experimental high resolution model configuration over the inspection area. Lessons learned and outstanding issues were noted in the CMC's report to the CTBTO.

Role in support of DND international operations

The MSC supports the Department of National Defence (DND) by supplying specialised meteorological services adapted to their requirements. In particular, CMC continued to provide, in 2002, made to order numerical weather prediction products over the Middle-East. Meteorological charts and forecast data centred over this region are prepared from the Canadian Global model (at 100 km resolution), and transmitted to Environment Canada weather offices which support Department of National Defence missions. As well, an experimental high resolution model (10 km) provided numerical weather forecasts over a sub-region centred over Afghanistan. While this experimental system cannot assimilate local high resolution data, and has not been scientifically validated and adjusted, it nevertheless provides superior guidance and greater detail over this very mountainous region, with complex surface forcing. These specialised services are provided to EC forecasters seconded to Canadian Forces offices. This is another example of the capacity of the MSC to respond to the security issues of our times.

Universal access to broadband : from dream to reality

Jean-François Gagnon
Head, Telecommunications Infrastructure and Services

The Minister of Industry has established a national task force to provide all Canadians with broadband access by 2004. Worldwide, the Internet now includes 150 million computers[1] (representing a demand[2] of 60 Terabits/s or 1 billion CD-ROMs a day[3]). Media advertising is filling our heads with the idea of watching videos on our cell phones, while our financial portfolios are suffering from the collapse of the information technology market. Under these circumstances, what can be expected of our Departmental networks?

What is broadband network service?

People have been talking about high-speed transmission ever since the era of computer-based communications technologies began. The state of the art speed has risen gradually from 9.6 Kbps to 19.2 Kbps to 56 Kbps, and we have had to change the way we speak accordingly.

What is meant by the contemporary term 'broadband network service'? According to international standardization organizations, a service must be able to transmit at least 1.5 million bits per second (Mb/s) to be considered broadband[4]. That is equivalent to over 24 simultaneous telephone conversations, or the transmission of a full CD-ROM in about 1 hour.

This level of service meets the minimum requirement for sending video data. It is also the established level at which Internet providers can talk about high-speed connections for individual users.

The definition we use should thus be based on our ability to provide this level of transmission speed to every user on our network.

Importance of broadband

Today, an organization like Environment Canada depends on its telecommunications infrastructure.

In office technology, we can no longer do our work without email, and in the not too distant future we may not be able to work effectively without integrated voice and video tools on our desktops. They will be needed for learning and for team work.

As for our programs, we are now running complex data-exchange systems in real time, and our needs in this regard are growing constantly. Exchanges are automated, and occur between our in-house databases as well as between our databases and those of our clients and partners. The enormous calculating power now available in a personal computer makes it easy for our clients to process large quantities of information. The result is a surprising level of demand for data transfer over our networks. While our organization is still advocating moderation in introducing file exchange and search tools such as Kazaa or Gnutella[5], these are becoming ever more attractive for business purposes.

It's really no longer a question of determining the importance of broadband, but rather a question of deciding when we will be implementing it.

The challenge

It is not easy to estimate the extent of our organization's communication needs.

We could take an arithmetic approach, calculating the potential traffic generated by each individual in a normal day by multiplying the 4700 employees in the Department by the desired bandwidth of 1.5 Mbit/s. We would then need to add something for the automated exchanges among our data-gathering, data production and data distribution systems, and something for access by our clients. The resulting figure would be astronomical.

As it happens, the reality is much more complex than this, because it is necessary to take traffic peaks into consideration even if all applications may not need the network at the same time. Other factors to be considered are the geographical locations of our sites and contacts, priorities, delivery deadlines, budgets and much more.

The situation is comparable to that of the road networks in our big cities: traffic congestion, users with varied needs, and vehicles of various sizes. It is hard to find anyone who understands all the interactions involved and can guarantee that a road will not be congested when you want to go somewhere.

Fortunately, it is usually easier to install telecommunications links than to build new roads (as long as you don't interrupt service during the installation). The real challenge is one of cost. A dedicated 1.5 Mbit/s link between Montreal and Halifax can cost $5000 per month, while such a link between Edmonton and Yellowknife may cost $15000 a month, even though the distance is approximately the same[6]. Geography and the economy have an enormous influence on price, which is different for every link. Based on the above figures, a network connecting every individual to a central point at the prescribed speed would cost $500M a year. Even if we consider only the Department's 150 sites, the figure would be no lower than $16M, which is 4-5 times the current allocated budget.

The challenge is a big one, and the answer must take the form of a number of compromises.

Current situation at Environment Canada

Already in the late 1980s, there was recognition of the importance of telecommunications for the Department and its future. The challenge at that time was mainly related to defining communication standards and implementing a basic network that would provide a uniform, expandable infrastructure for processing information in a distributed environment.

The resulting network architecture still exists. It is based on principles that are well established in the industry such as communication with the TCP/IP protocols. Of course the network has been extended from a dozen sites in 1991 to 150 sites today.

During these years, the MSC satellite distribution network has also been improved and it is now fully compatible with our land-based system.

Currently, however, our telecommunications needs are increasingly leading us to consider the question of broadband service. A study commissioned in connection with the departmental IM/IT strategic review has recommended updating the telecommunications infrastructure in order to better position ourselves for the future.

The issue today is no longer one of communication protocols. All modern computers and networks are compatible. As well, the basic network architecture does not need to be reviewed. However the growth in the number of communication links and in the complexity of interconnections is making change ever more difficult. We need to find a way to make growth possible at moderate cost and to reduce the time required for installation.

The ECONET Improvement Project

In May 2001, when the Department allocated funds to deal with program integrity problems, we were given a mandate to implement some of the changes recommended in a 2000 Departmental study on telecommunications. In addition, some fifty new sites were identified for connection to Econet so that everyone would have a set minimum of network services.

A plan was quickly drawn up for the project, probably the biggest update in the Department's telecommunications facilities since its creation. Fifty new sites will be added at one go, and fifty more will be directly affected by service improvements.

This Canada-wide project requires the purchase of close to $500K in network equipment for the connections, as well as new contractual arrangements with communications providers.

The initial approach was to provide minimum levels of access as described in the table below, based on the principle of broadband access rather than on the specific needs of each site.

Type of site	*Number of employees*	*Minimum band width*
Central hosting site: where there are numerous servers providing applications centrally	> 100	1 Mbit/s
Major hub site: information centre, remote access centre, connection to other organizations, office software servers	> 100	1 Mbit/s
Minor hub site: like major site, but with fewer services	5 - 100	1 Mbit/s
Major branch: deals with client side of applications, does not contain databases, does not connect to other networks	6 - 50	1 Mbit/s
Minor branch: like major branch but with fewer individuals	1 - 5	256 Kbits/s

Design of the new network took into consideration the fact that some connections were already faster than the minimum shown on the table, for a variety of operational reasons. The capacity of these connections was to be maintained.

To simplify the task, it was decided that each site of a given type would have identical infrastructure. With this generalized approach, the project broke down into three parts:
1. Updating the core of the network (about 50 sites),
2. Adding new sites with Virtual Private Network technology,
3. Maintaining viable backup links.

The first of these tasks called for major design work. After numerous discussions with potential providers and lengthy negotiations with Government Telecommunications and Informatics Services (GTIS), AT&T Canada was selected and a network topology was decided upon. Unfortunately, budget limitations made it impossible to achieve the desired technological uniformity at the 50 sites, but from the point of view of functionality, the result will be the same. An agreement was signed with GTIS in August 2002 to provide connections between the sites. The agreements cover the core of the network, which will have 4 types of connection:

- an ATM cloud for the central core,
- a Frame Relay cloud,
- connections through LAN extensions (TLS),
- dedicated private links.

The topology links the first two types of site to two major centres, Dorval and Place Vincent-Massey in Hull. The former has most of the big meteorology servers; the later has protection, conservation and corporate services. The ATM cloud thus has two star topologies, providing a division between meteorology-related traffic and other traffic.

This separation could unfortunately not be maintained in the regions. Additional funding would be required.

The fifty or so new sites to be added to the network will almost all be served by VPN technology, which makes it possible to use the Internet to carry traffic that would normally be private. Of course it will be necessary to add the necessary infrastructure to guarantee the integrity of the private network. The advantage of this technology is that it allows faster service at a favourable price. On the other hand, use of the Internet means these sites have lower reliability since we have no control over certain types of Internet breakdown. Such a compromise is acceptable for this type of site.

The third part of the project will ensure that as these major changes are made, backup links between critical sites are preserved. This is important because the new approach reduces the number of direct connections at each site, in favour of a single connection to a cloud. Redundancy is thus affected. This part of the project will be important once the other steps are complete. Perfect redundancy will not be possible, but there will be reduced-access backup links. Thus the bandwidth available when the main connection is down will be reduced. This may have an impact in problem situations. It will be necessary to work with those responsible for applications in order to monitor non-critical traffic and ensure it does not negatively impact essential operations.

It should be noted that another portion of the network—some 50 sites—will not be directly affected by all these changes.

The new network topology is shown in the schematic below. It compares favourably to the network as it was in December 2002 (as presented on page 28). The two star topologies are clearly visible in the central cloud, and the speed of access to the clouds can be compared to the real speed of the logical connections within the clouds.

The network schematic is updated regularly. Department employees will find it by following the links from:

http://econet.cmc.ec.gc.ca/indexe.html

One of the big advantages of this design is precisely broadband access. Since such accesses can already support large bandwidths, it is easy to increase the size of a connection. The time required to make the change will be shortened, and the cost of the increase reduced. For example, it is now apparently possible to increase the bandwidth between Montreal (Dorval) and Halifax (Dartmouth) from 2 to 3 Mbits/s for just $200 a month more. This is an enormous difference by comparison to the amounts mentioned earlier.

However the budget allocated for this project did not allow for an immediate significant increase in bandwidth across the network. Minimums were set based on the table presented above. As a result, some places have seen increases while others have had only infrastructure improvements.

Remarkably, in view of the geographical extent of our country, all these changes have been made with an addition of only $750K per year.

Other improvements

In addition to this ambitious project, 2002 saw further changes and improvements in the area of telecommunications, the most important of which are the following.

In support of the National Radar Project, our group had to install or improve communications at 6 radar sites. The main difficulty in this project was the remoteness of the radar sites, and the need to build up a system often starting from nothing. The sites are now integrated with Econet.

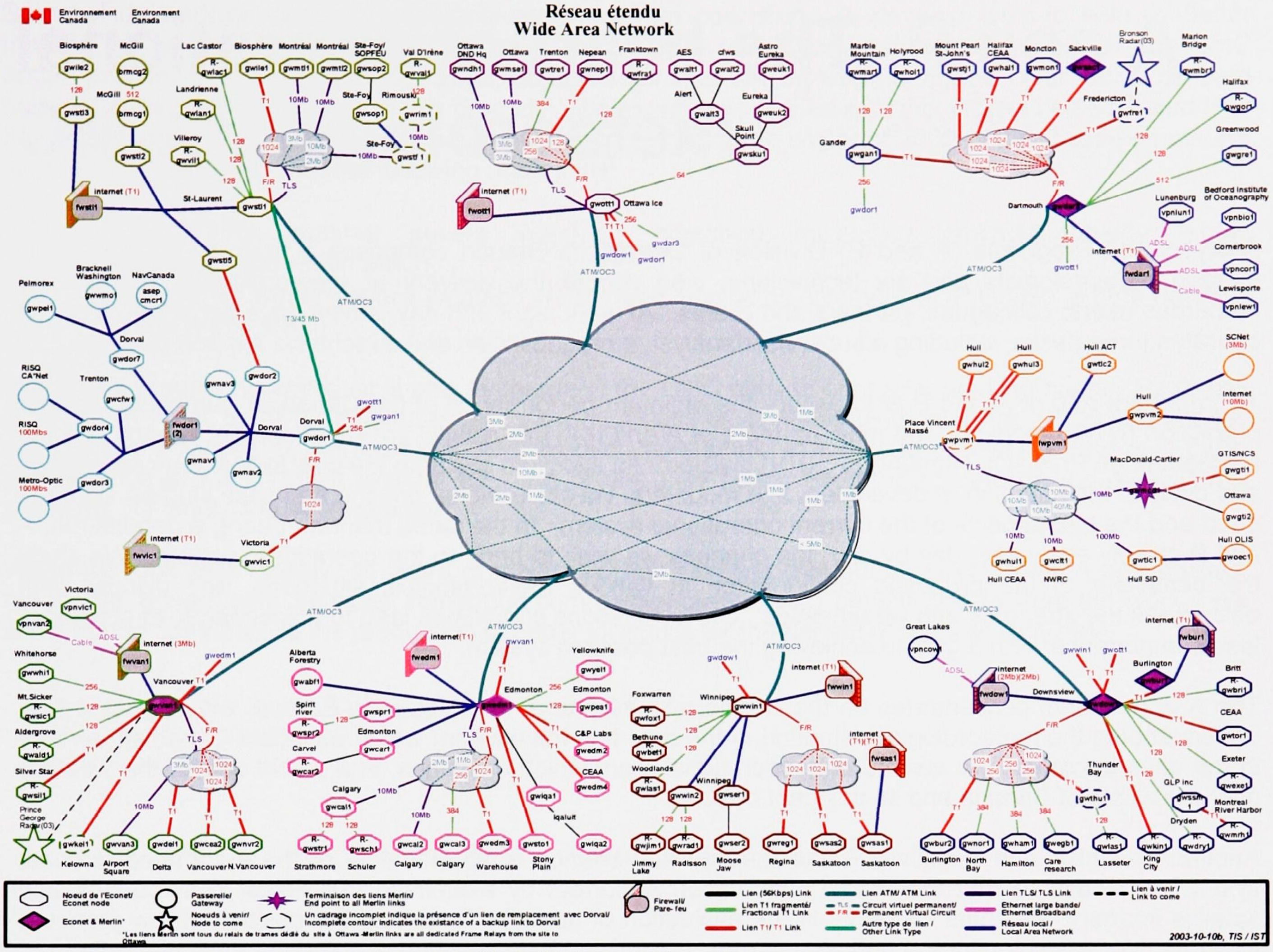
The centralization and incredible growth of the Department's weather web site has called for considerable effort to maintain the Internet links at Dorval, especially as regards redundancy configuration and the configuration of the equipment to ensure satisfactory security. Average traffic increased from about 7 Mbits/s in January 2002 to over 14 Mbits/s in December 2002. As a result of this growth, significant upgrading of the links to the Dorval Internet will be required. This work will be done in 2003, along with the addition of a very broadband (1 Gb/s) link to CA*net4, a network of research and educational institutions[7].

Also worth mentioning are the bigger connection to the National Weather Service in Washington, D.C., numerous upgrades of Internet service across the country, relocation of several installations and regular maintenance work on all these connections.

Between dream and reality

As the improvements to Econet go into effect, we may wonder whether they will meet expectations. Clearly we have passed a major milestone. The investments in infrastructure will bring improved access to many sites and will make it easier to move toward the dream of universal broadband access. However it is also clear that budgetary limitations have prevented us from going all the way. Unrestricted movement of voice and video remains a challenge for us.

We are already at work on the telecommunications architecture of tomorrow. A task force has met several times, and a preliminary overview of the future is coming into focus. Security matters figure prominently in this picture, which is inevitable after the events of September 2001 and the growth of threats over the Internet. The other significant issue is the guarantee of levels of service between the various network-based applications. This presents a technical problem for which the solution is still not obvious.



New Network Topology

The biggest problem will certainly be funding. The recent adjustments in the global telecommunications industry have not yet stabilized.. The trend is to further restructuring and reorganization of services. Reorganization will mean clustering of services, leading to greater difficulty in obtaining pure bandwidth. This will definitely not help clients who want speed without high costs.

The structure of available telecommunications services can be seen as a staircase on which the steps are far apart and unevenly spaced. It may thus be necessary to invest even more money in our network if we want to move up to the next step and achieve our dream of universal broadband access to every desktop.

Meanwhile, we continue to work on the general architecture and on case-by-case improvements and optimization.

Notes:

(1) Source: Internet Software Consortium http://www.isc.org
(2) Source: Columbia University School of Computer Science
http://www.cs.columbia.edu/~hgs/internet/traffic.html
(3) Estimated in 2003 based on source in note 2
(4) International Telecommunications Union http://www.itu.int/broadband
(5) An explanation of peer to peer file exchange software can be found at
http://www.kazaa.com/us/help/glossary/p2p.htm
(6) Costs based on real average list prices including volume discounts applicable to our Department.
(7) For more details on CA*net4 and Canarie, see http://www.canarie.ca/canet4/index.html

A and P: The heart of operational meteorology at CMC

Analysis and Prognosis (A and P) Division of Operations Branch comprises a team of approximately thirteen meteorologists and six technicians, who assure the delivery of meteorological services for numerous users, colleagues, partners and clients. At work night and day, seven days per week, A and P operates three desks, including a supervisor/analyst, a prognostician and a technical support position.

An important role of A and P is to assure the optimum performance of the Canadian numerical weather prediction (NWP) models. The main partners of A and P in this activity are Development Branch and the Recherche en Prévision Numérique (RPN) division. As such, we evaluate the operational forecast system and bring to the attention of developers and modelers, via discussions, briefing and case studies, both the good and the bad aspects of the current operational system. In the same manner, during a parallel run, A and P closely evaluates, day by day, the changes we wish to bring to the operational system. We study the behaviour of the proposed configuration in various meteorological situations, and discuss with developers the strengths and weaknesses. Our evaluations sometimes lead to adjustments, of greater or lesser importance, with a goal to achieving the best possible system.

The A and P team concentrates on the Northern Hemisphere, from Japan to Europe, with a goal to fully understanding the meteorological situation of the day, and the weather which will affect Canadian territory in the days to come. We are the only operational team which examines, in a global sense, the weather over the whole of Canada and its adjacent oceans.

Another crucial A and P activity is the detailed surveillance of all elements of the automated forecast system. We assure that the model initialisation is correct by examining trial fields, observations and satellite imagery: essential elements in the evaluation of humidity fields and the position of low pressure systems. We then monitor the operational runs, comprising the execution of computer jobs, at the heart of the production of analyses, model integration and the production of various outputs (charts, bulletins, web-images and BUFR, ASCII or GRIB files, etc.). In the event of problems, the supervisor/analyst attempts to identify the source, and take action to resolve it as soon as possible. If necessary he or she will call in expert help. Finally, A and P performs quality control on the model outputs. During this time, the technicians also keep busy. They perform an important initial work on many of our aviation forecast products, and produce specialized bulletins for the media from various forecast products issued by our regional colleagues. They also monitor the many messages produced by the Scribe quality control executed in each of the forecast offices. They also respond to the hundreds of e-mails received each month from visitors to the MSC Internet site.

We also provide a service to the MSC regional weather offices by producing discussion bulletins (FXCN01) regarding the meteorological systems of interest over Canadian territory, and the relative performance of Canadian and foreign NWP models. Regional meteorologists may also contact at any time the prognostician or the supervisor/analyst to discuss the situation of the day.

A and P also offers a range of products and services to aviation: subjective surface and 850 hPa analyses, forecast significant weather charts for the North Atlantic and over Canada and adjacent waters, as well as forecast high-level turbulence charts over the North Atlantic. Note also that A and P is the first response in the event of volcanic eruptions or in chemical or nuclear incidents. The supervisor is constantly prepared to run the CMC trajectory or CANERM models to determine the ultimate position of volcanic ash plumes, and to issue, as needed, FVCN bulletins. The outputs of these models are essential to the meteorologists in Kelowna and Gander in the event that they need to issue SIGMET messages related to volcanic ash plumes. These outputs are also available on the web.

Some of us work on project, temporarily removed from operations, to develop tools to help us better monitor the weather. In particular, thanks to the work of our specialists in severe weather, the CMC began producing, in the summer of 2002, objective summer severe weather charts. Our technical team helps with the daily verification of this product. The experience gained with this project helped A and P to develop a series of objective winter severe weather charts for the winter of 2002-2003. These charts are displayed on our Intranet at the following addresses:

- guide for summer severe weather : http://iweb.cmc.ec.gc.ca/cmc/CMOP/tve/tve_e.html (internal site within MSC)
- guide for winter severe weather : http://iweb.cmc.ec.gc.ca/cmc/CMOP/tsh/tsh_e.html (internal site within MSC)

The A and P supervisor/analyst is also in charge of the CMC outside of regular working hours. He or she is ready to react to all ... or almost all ... eventualities, be it responding to a fire, an environmental emergency, a request to retransmit a CMC product, take action in the case of missing data or a faulty performance of the forecast system, etc. He or she also keeps users up to date on the evolution of problems via timely AACN messages.

When we look at is closely, all users of meteorological services (the public, NAVCANADA, universities, the media, government Services, numerous commercial clients, etc.) benefit directly from our work. We are proud to contribute to the production of better forecasts for the benefit of our fellow citizens.

Computing and telecommunications systems

Highlights

The most notable items in 2002 in the area of computing and telecommunications are described in the "Highlights" section of this Review. These include the replacement of the Center's supercomputer, the achievements related to the weather office web site and the redesign and upgrade of the national ECONET network. Here are a few more specific highlights:

DSAT/GOES Replacement Project

It was a very active year for the DSAT/GOES Replacement project. Two years of work culminated with a contract award for COTS (commercial-off-the-shelf) systems, with a plan to implement in CMC and regional centres in early 2003. The RFP was closed and evaluated, and a contract was awarded to Info-Electronics of Montreal. The readout and processing system are HP- UX based and the software is a commercial product produced by Global Imaging. The original plan called for the delivery of 2 systems in FY 2002/2003. With the NESDIS decision to accelerate the deployment of the next generation GOES-12 satellite, the plan was fast-tracked to accept and deploy seven systems into operation by the end of FY 2002/2003.

NCS Replacement Project

The National Communication System (NCS) Replacement project was initiated in April 2002 to evaluate the market for a COTS system for replacing the National Computer Communication System, a legacy custom software system residing on the Tandem in Dorval.

A number of COTS systems were identified as potential candidates, and information was requested from the vendors. After preliminary evaluations, the project team selected certain applications for further testing. Based on the test results, a recommendation was made to proceed with the request for proposal process (RFP) in order to procure a COTS system for replacing NCCS. The RFP and procurement will be done in the coming year.

In addition, the objective of this phase of this project was to gather and document MSC's data communication requirements for operational weather data. Project stakeholders were identified and after the elicitation process, a business requirements document was produced providing the high-level features and functionalities of the NCS. The business requirements document is intended to provide the basis for further detail requirements specifications.

Software Management Board

The Software Management Board has had a busy year. In addition to the 33 change requests that were dealt with at the monthly meetings, 3 new applications have been approved and distributed via the SMB site in the early part of 2003. MetManager, WBS and MultiAlert have been incorporated into the national suite as well as all the Water Survey applications.

In collaboration with the Regions, improvements were made to the maintenance and support of national applications by putting in place a process for the management of a repository of source codes.

First MSC Developer's Workshop

The first MSC Developers Workshop was held at the Nav Canada Training Institute (NCTI) in Cornwall on June 17-19, 2002. Forty-two participants represented MSC software development groups within the Regional and Headquarters organisations. The workshop focused on improving understanding and interactions with the MSC Software Management Board (SMB), improving collaboration and cooperation within the development community, and in developing common goals and strategies for software development within the MSC. The working group produced recommendations on how to improve interactions between developers and the SMB. The positive atmosphere and knowledge sharing contributed to a successful and constructive workshop. It was recommended that this workshop be established as an annual event. More detailed information can be found on the SMB web site: http://smb.tor.ec.gc.ca/Workshop/Jun_2002/index.htm

URP Implementation

In June 2002, URP 2.0 (Unified Radar Processing) was implemented in five regional offices across the country. The upgrade included several significant improvements, including automated convective cell analyses, important tracking and assessment tools that help forecasters determine which convective cells present the greatest threat. The system also included an upgraded interactive viewer and a new Linux cluster based hardware platform developed by CMC IB in Downsview and Dorval. The old HP-UX based URP 1.2 systems were left in production as a backup, and are slated for decommissioning in 2003.

In November 2002 URP 2.1 was released and implemented. This release included a configuration for the best, lowest operating angle for each radar, providing an improved ability to see more low level precipitation.

Status of computer and telecommunication systems at the end of December 2002

The CMC provides 24/7 computer service in support of the forecasting activities. This service provides for round the clock support via the Service Desk. The Service Desk is the single point of contact for all national and international clients, within or outside of Environment Canada, to report problems or request information on products and services. The Service Desk is the critical command and control point for the co-ordination and resolution of operational problems.

A large computing infrastructure of over 100 operational computer systems, including the supercomputer as well as the departmental wide area network (ECONET) are monitored by the Service Desk. This includes over 50 computers and general purpose servers and over 1000 workstations/PCs used as workhorses for software development, data acquisition and distribution, pre-processing, databasing, quality control, production and display of forecasts & graphics, satellite and radar imagery processing, monitoring & managing NWP model runs, small model development and testing office technology. Several teams from the Informatics Branch, located both in Dorval (Montréal) and Downsview (Toronto), provide support to the computing & telecommunication infrastructure.

Statistics on calls and service requests received by the Service Desk and Help Desk for 2002:

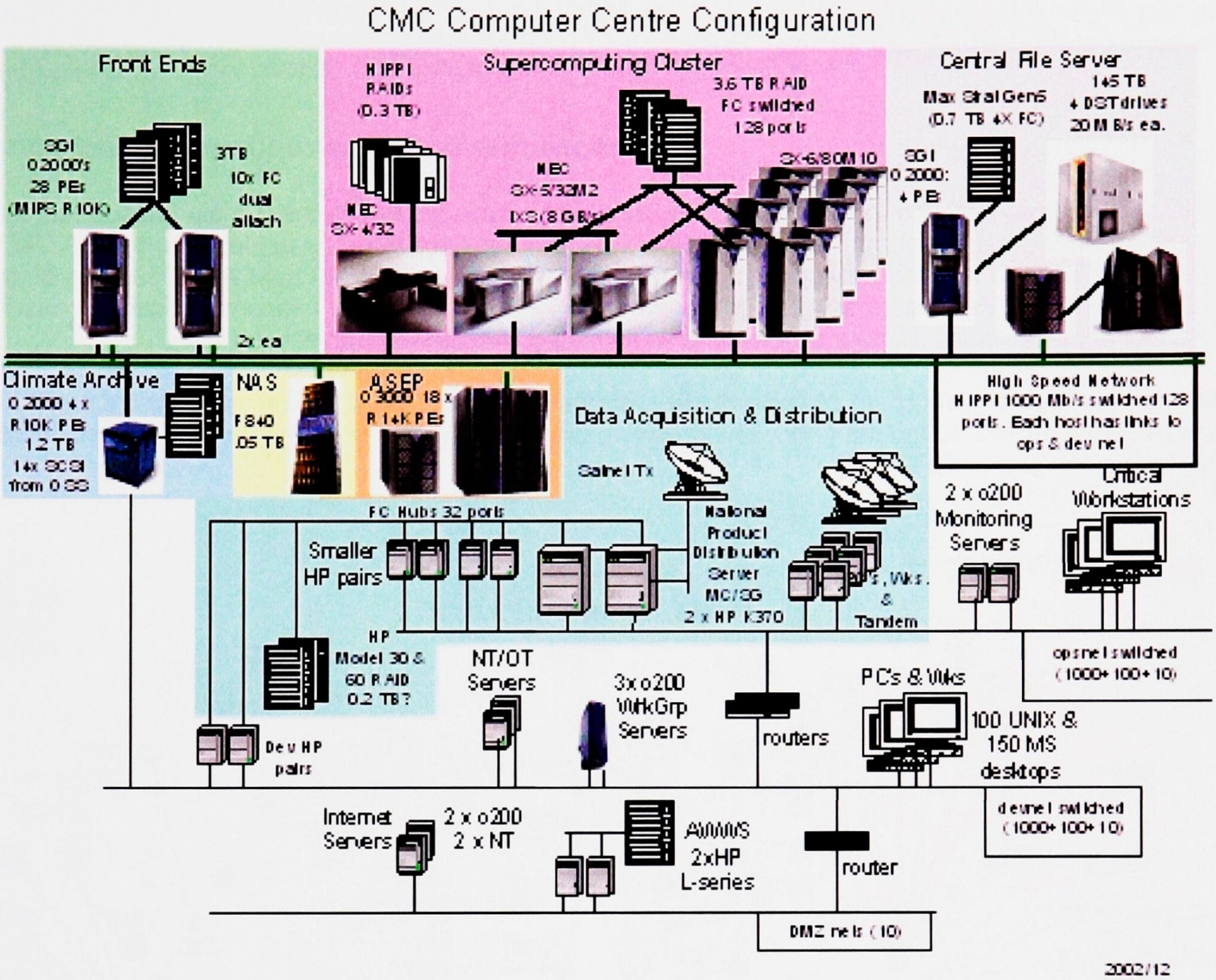
Computer System Problem Tickets	1211
Network Operations Tickets	399
Network Operations Telephone Calls	19200
User Help Desk Tickets	1366
Help Desk Telephone Calls	1350
Secure ID Ace Card interventions	4939

The following table provides a configuration summary of the major systems as of 31 December 2002:

Summary of Operational Systems (December 2002)

	Computer	Processors	Memory (GB)	Disk Capacity (GB)
Supercomputer	NEC SX-4/32 NEC SX-5/16M2 NEC SX-6/80M10	32 32 80	8 (16 XMU) 256 640	7300
Front-Ends	SGI Origin 2000	12 16	3.4	3000
CFS	SGI Origin 2000	4	2	800
Canadian Climate Archive	SGI Origin 2000	4	1	1200
Data Switching	TANDEM Himalaya	4	0.128	24
Data Acquisition	2 HP K370 2 HP K260	2 each 2 each	0.512 each 0.448 and 0.512	60 24

The following diagram provides a simplified view of the computer infrastructure and local area network.



Computing Infrastructure

On the computing infrastructure side, the SX-6/80M10 became the production machine, with the gradual transfer of operational models from the SX-5/16M2. This provides a 2.5 fold performance increase over the SX-5 configuration. With the SX-6 installation, the centre took the opportunity to transition users' jobs from NQS to Sun GridEngine control. This allowed us to have a uniform queuing system for all of our systems (NEC, SGI, linux cluster).

Toward the end of 2002, the development front-end computer was upgraded to Origin 3000, providing a 3 fold increase in performance to the user community. An upgrade to the operational front-end is planned to for early 2003. Aside from increased CPU performance, significant improvements were made to the I/O sub-system. All new disks and disk subsystems have 2Gb/s FC controllers and infrastructure. The equipment was received and made available to users during the last quarter of 2002 to test their applications and ensure adequate performance. In addition, a new Central File Server (CFS) was tested and implemented to meet the new and emerging needs of the users.

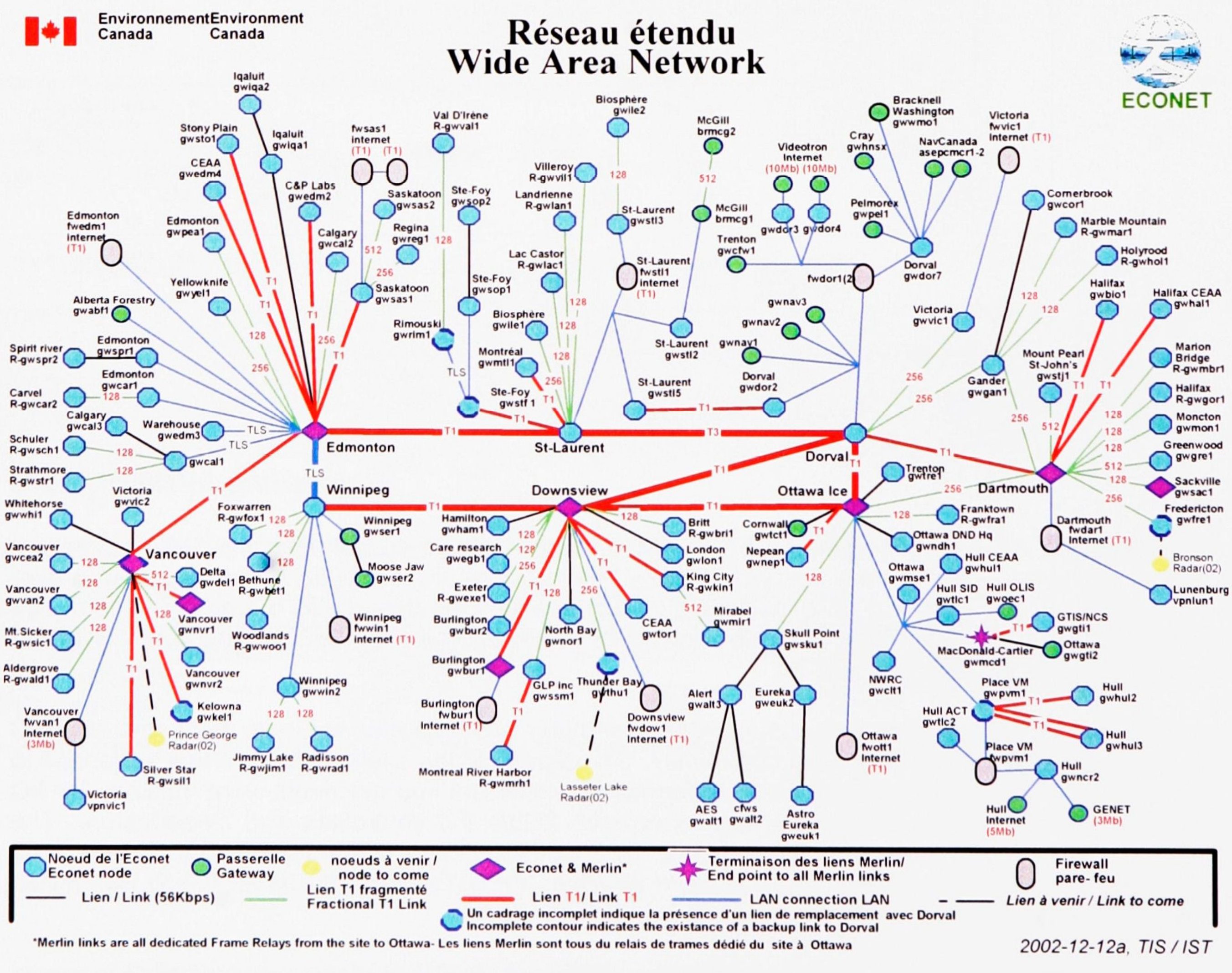
As part of modernisation efforts, a Network Appliance F820 with 0.5TB of storage was installed to merge Windows based homes and unix based homes. This not only simplifies the infrastructure, and backup procedures, but served to simplify the user environment. As part of this project, a new tape robot was acquired & installed to allow for the expanding storage requirements.

The Canadian Aircraft Meteorological Data Relay Program (AMDAR) was launched on August 6, 2002. As part of this data exchange initiative between MSC, AC Jazz and NAV CANADA, CMC maintains and monitors the AMDAR servers and also monitors the reception of data.

Telecommunication Infrastructure and services

CMC's Telecommunication Infrastructure and Services Division maintains the 3 main telecommunications systems of the department, namely the ECONET general purpose Wide Area Network, the SATNET 512 kilobits per second satellite broadcast system and the low capacity (4800 bps) AMIS satellite broadcast system. Further to these activities, the group was also involved in general telecommunication consultation (such as security issues, remote access, inter-networking with other organisations etc.).

Besides the regular work of maintaining these systems up to date, the significant upgrade of the ECONET was the main project during the year. The following diagram describes the status of the national ECONET Network at the end of 2002.



After several years of discussion, a new link to the US NWS was made operational with a capacity of 1.544 megabits per second. (« T1 »). The previous link had a capacity 24 times smaller (64 kbps). This upgrade fulfills the needs of the US NWS and the MSC for additional data transfers, in particular radar, satellite and model data. Several radar sites were connected to the ECONET. Much work was done to improve internet connectivity, especially as it relates to the support of the Single Window Weather Office web site.

SATNET still serves 17 MSC sites with bulk weather data from Dorval. AMIS still serves over 100 clients within and outside the organization. Nav Canada remains the main user of the AMIS system.

Operational runs

Changes in operational runs

Introduction

The operational runs underwent major change in December 2001. As mentioned in the performance reports section of this review, the change had a significant impact on the quality of CMC's numerical forecasts. The changes were described in detail in the 2001 review.

Changes in operational runs in 2002

a) On February 19, a correction was made, in the regional and global assimilation system, to the thinning of SATWINDS data in order to ensure a better treatment of the data near the edges of the selection boxes. As well, a correction to the HUMSAT system was implemented. This corrected a bug which in certain cases was causing an erroneous evaluation of the cloud fraction during daytime.

b) On March 27, the process of thinning aircraft data was improved in the regional and global data assimilation systems. Also, the rejection criteria applied to dropsonde data within the background check process was modified to reduce the number of wind data rejections over the Pacific Ocean. As well, a correction was made to the interpolation process near the computing poles of the grid in the GEM model in order to eliminate problems when processing data at these points.

c) On April 24, a change was made, in the GEM regional model, to the calculation of the geopotential in pressure coordinates. Since January 11, 2001 the geopotential had been computed using a cubic interpolation of the model fields in eta coordinates. It was demonstrated that this method caused a degradation of the geopotential near and above the 250 hPa level. Consequently, the previous more precise method was re-introduced, namely a linear interpolation after re-computing of the geopotential. The meteorological impact of this problem is fairly limited. However, the problem had a negative effect on the monthly verification scores of the geopotential near and above the 250 hPa level.

d) On December 12, NOAA-17 satellite data were introduced in the data assimilation system. This occurred at the time of an unforeseen instrument failure on the NOAA-16 satellite, resulting in ingestion of poor quality data at forecasting centres around the world. The problem was later corrected. This showed the importance of monitoring and quality controlling satellite observations.

Description of operational runs as of December 31, 2002

Global atmospheric and environmental forecast system

This medium range system (to 10 days) covers the entire globe. The full forecasting cycle takes place twice a day based on the observations at 00 and 12 UTC (Universal Time Coordinated). The model is run to 3 days based on 12 UTC data and to 10 days based on 00 UTC data; on Saturdays it is run to 15 days based on 00 UTC data. Analyses are produced at 00, 06, 12 and 18 UTC. This system serves as the basis for preparing 3-day, 4-day and 5-day forecasts.

System	Products	Component	Resolution
Data assimilation	Quality control of data and numerical analysis of temperature, wind, humidity and surface pressure	3D-VAR (three-dimensional variational analysis))	100 km horizontally; 28 *eta* levels vertically
Numerical weather prediction	Wide variety of charts, images, numerical data feeding other components, etc	GEM 'global' configuration (GEM=Global Environmental Multiscale)	100 km horizontally; 28 *eta* levels vertically
Environmental emergency response	Forecast or diagnostic trajectories	CANERM (CANadian Emergency Response Model)	50 km horizontally; 25 levels vertically
Numerical prediction of wave heights	Pacific wave heights	WAM (Wave Model)	100 km
Forecasts of weather elements	Wide variety of guidance for public and aviation forecasting	Perfect Prog Specialized algorithms SCRIBE matrices	264 stations in Canada GEM model grid 1145 points

Regional atmospheric and environmental forecast system

This short range system (to 2 days) covers North America and adjacent oceans north of 30 degrees latitude. The full forecasting cycle takes place twice a day based on the observations at 00 and 12 UTC. Analyses are produced at 00, 06, 12 and 18 UTC.

System	Products	Component	Resolution
Regional assimilation of upper-air data	Quality control of data and analysis of temperature, wind, humidity and surface pressure	3D-VAR (three-dimensional variational analysis)	24 km horizontally; 28 *eta* levels vertically
Regional assimilation of surface data	Quality control of data and analysis of surface humidity and temperature	OI (Analysis based on Optimal Interpolation method)	24 km horizontally;
Numerical weather prediction	Wide variety of charts, images, numerical data feeding other components, etc	GEM regional configuration (Global Environmental Multiscale)	24 km horizontally; 28 *eta* levels vertically
Numerical prediction of air quality	Forecast concentrations of various atmospheric pollutants (O_3, SO_4, SOA)	CHRONOS (Canadian Hemispheric & Regional Ozone & NOx System)	21 km horizontally; 20 *Gal-Chen* levels vertically
Numerical prediction of wave heights	Atlantic wave heights	WAM (Wave Model)	100km
Environmental emergency response	Forecast or diagnostic trajectories	CANERM (CANadian Emergency Response Model)	25 km horizontally ; 25 *eta* levels vertically
Forecasts of weather elements	Wide variety of guidance for severe weather forecasting, public forecasting and aviation forecasting	Perfect Prog UMOS (Updatable Model Output Statistics) Specialized algorithms SCRBIE matrices	264 stations in Canada 674 stations in Canada GEM model grid 1145 points

Local atmospheric and environmental forecast system

This very short term forecast system (24-36 hours) covers parts of North America. The initial conditions are provided by short-term forecasts from the regional system issued at 00 and 12 UTC.

System	Products	Component	Resolution
Experimental numerical weather prediction	charts on the Web and numerical data	GEM high resolution regional configuration (GEM=Global Environmental Multiscale)	10 km horizontally; 35 *eta* levels vertically
Experimental numerical weather prediction	charts on the Web and numerical data	GEM local configuration. Project carried out in cooperation with the Pacific and Yukon Region (PYR) (GEM=Global Environmental Multiscale)	2.5 km horizontally; 42 *hybrid* levels vertically

Analyses of surface fields:

These analyses of surface parameters are vital to the operation of all components of the forecasting system because they make it possible to correctly prescribe boundary conditions.

Products	Assimilation	Resolution
Air temperature near surface (00, 06, 12, 18 UTC)	Optimal Interpolation	0.9 x 0.9 degrees lat-lon Global grid GEM regional model grid
Dew-point depression near surface (00, 06, 12, 18 UTC)	Optimal Interpolation	0.9 x 0.9 degrees lat-lon Global grid GEM regional model grid (18 UTC only)
Sea-level pressure every 6 hours (00, 06, 12, 18 UTC)	Optimal Interpolation	0.9 x 0.9 degrees lat-lon Global grid
Snow depth (00, 06, 12, 18 UTC)	Optimal Interpolation	0.33 x 0.33 degrees lat-lon Global grid
% sea ice coverage (00 UTC)	Averaging of data with return to climatology in areas where data are not available	0.33 x 0.33 degrees lat-lon Global grid

Probabilistic atmospheric and environmental forecast systems

The ensemble forecasting system and the long-term (monthly and seasonal) forecasting system both use several models, reflecting the uncertainty of a multi-scenario approach. These systems cover the entire globe.

Ensemble forecasting system

The ensemble system (which forecasts to 10 days) runs once a day based on the 00 UTC analyses. Perturbed analyses (8) are produced every 6 hours (00, 06, 12 and 18 UTC).

System	Products	Component	Resolution
Data assimilation	Quality control of data and analysis of temperature, wind, humidity and surface pressure	Analysis based on the Optimal Interpolation method with perturbed observations	150 km horizontally; 21 *sigma* levels vertically
Numerical weather prediction	Wide variety of charts, images, numerical data based on the 16 member forecasts of the ensemble and the forecast from the global system	8 different configurations of the GEM model (GEM=Global Environmental Multiscale) 8 configurations of the SEF model (finite element spectral model in the vertical)	135 km horizontally; 28 *eta* levels vertically 135 km horizontally; configurations with 23 and 41 *sigma* levels vertically

Monthly and seasonal forecasting system

The monthly and seasonal forecasting system is also an ensemble system but it uses a sequence of consecutive analyses from the global system (all valid at 00 UTC) as perturbed analyses. The monthly forecast is produced twice a month, and the seasonal forecast once per season (quarterly).

System	Products	Components	Resolution
Monthly forecast	Outlook for temperature anomaly	SEF model (finite element spectral model in the vertical)	166 km horizontally (T63); 23 *sigma* levels vertically
Seasonal forecast	Outlook for temperature and precipitation anomalies Confidence level	GCM II (General Circulation Model) SEF model (finite element spectral	330 km horizontally (T32); 10 *pressure* levels vertically 166 km horizontally (T63);

		model in the vertical)	23 *sigma* levels vertically

You will find more information on CMC's operational runs at the following address: http://www.msc-smc.ec.gc.ca/cmc/op_systems/index_e.html .

Performance reports

CMC Annual 2002 Performance Measurement Report

1. NWP Performance

a) Global model objective scores

The year 2002 saw a significant improvement in the Canadian Global model. As illustrated in figure 1a, a major reduction in 500 hPa geopotential height root mean square (RMS) errors was noted over North America for the 24 hour forecasts. Figures 1a and b, as well as Tables 1 and 2 compare our performance against that of other leading NWP centres, for the same field and for various forecast time periods. The greatest gains occurred at 24 hours, but improvements are noted right out to 120 hours. These improvements are a direct result of changes to the Global model assimilation and forecast system implemented December 11, 2001.

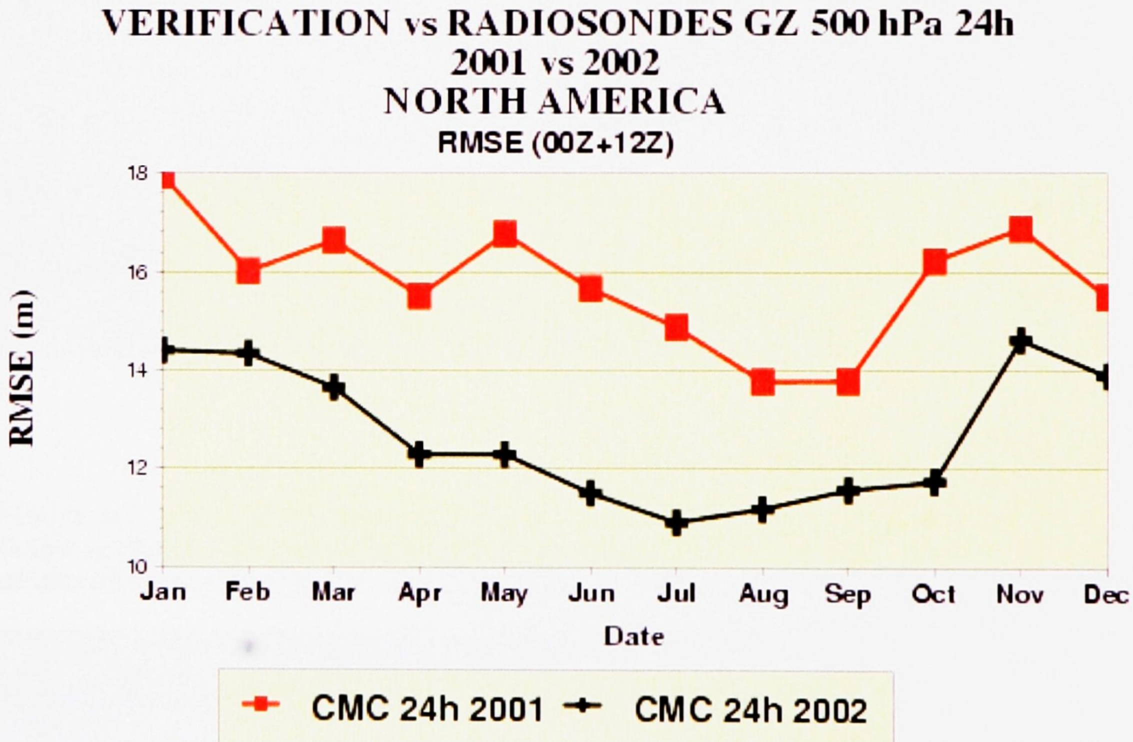
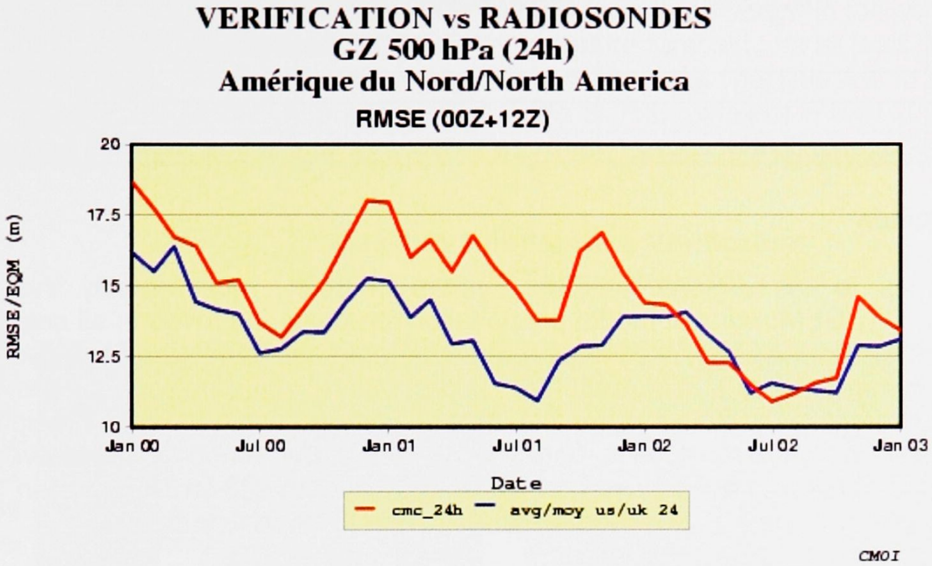


Figure 1a: Root Mean Square errors of the Canadian Global model 24 hour forecasts over North America for the years 2001 and 2002.



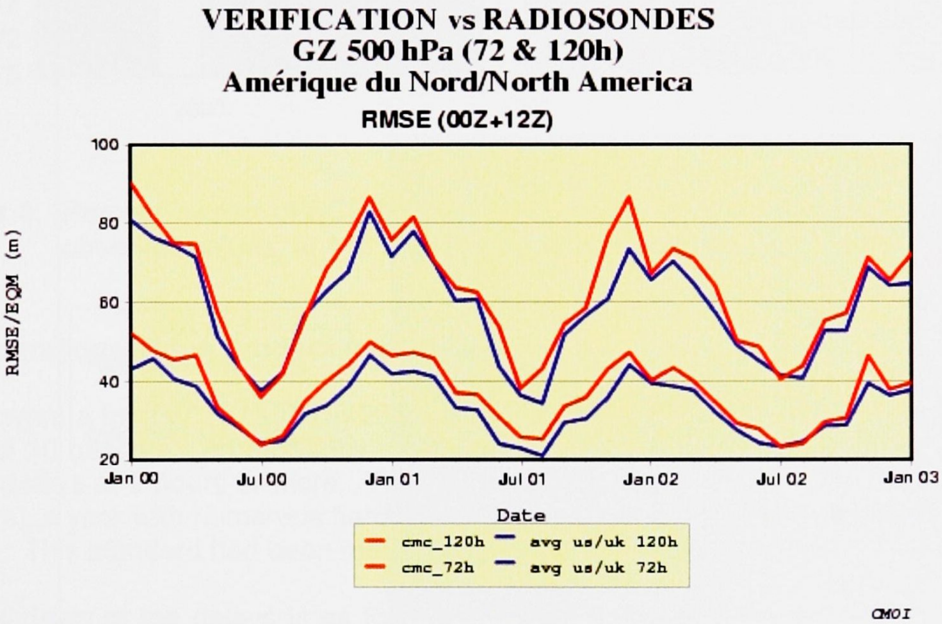


Figure 1b: Comparison of 500 hPa geopotential height RMS errors between CMC global model and the average of the UKMO and U.S. NCEP global models for the period Jan. 2000 to Jan. 2003.

Table 1: 24-h Forecasts

North America	RMSE: CMC	RMSE: Leading Centres	Difference (CMC- Leading Centres)
2001	15.80	12.97	2.83
2002	12.70	12.54	0.16
Improvement (%)	19.62%	3.32%	**94%**

Table/Tableau 2: 120-h Forecasts

North America	RMSE: CMC	RMSE: Leading Centres	Difference (CMC- Leading Centres)
2001	63.73	58.13	5.60
2002	58,94	56.02	2.92
Improvement (%)	7.52%	3.63%	**48%**

b) Regional model precipitation

After three significant changes to the regional forecast system in 2001, most notably the ISBA implementation of September 11th, GEM regional model precipitation forecasts improved in all categories from 2001 to 2002 (Fig. 2). The model also showed improvement in most categories in comparison with its U.S. counterpart, the ETA model. The scores for both 2001 and 2002 are consistent with the prevailing view of CMC operational meteorologists that GEM regional handles significant events (higher precipitation amounts) better, while the U.S. ETA model does a better job in the lower amounts. However, the threshold at which the two lines cross improved from 1.5 inches to 0.5 inches (38 to 12.5 mm) in 2002, meaning that GEM provided better guidance over a broader range of precipitation events.

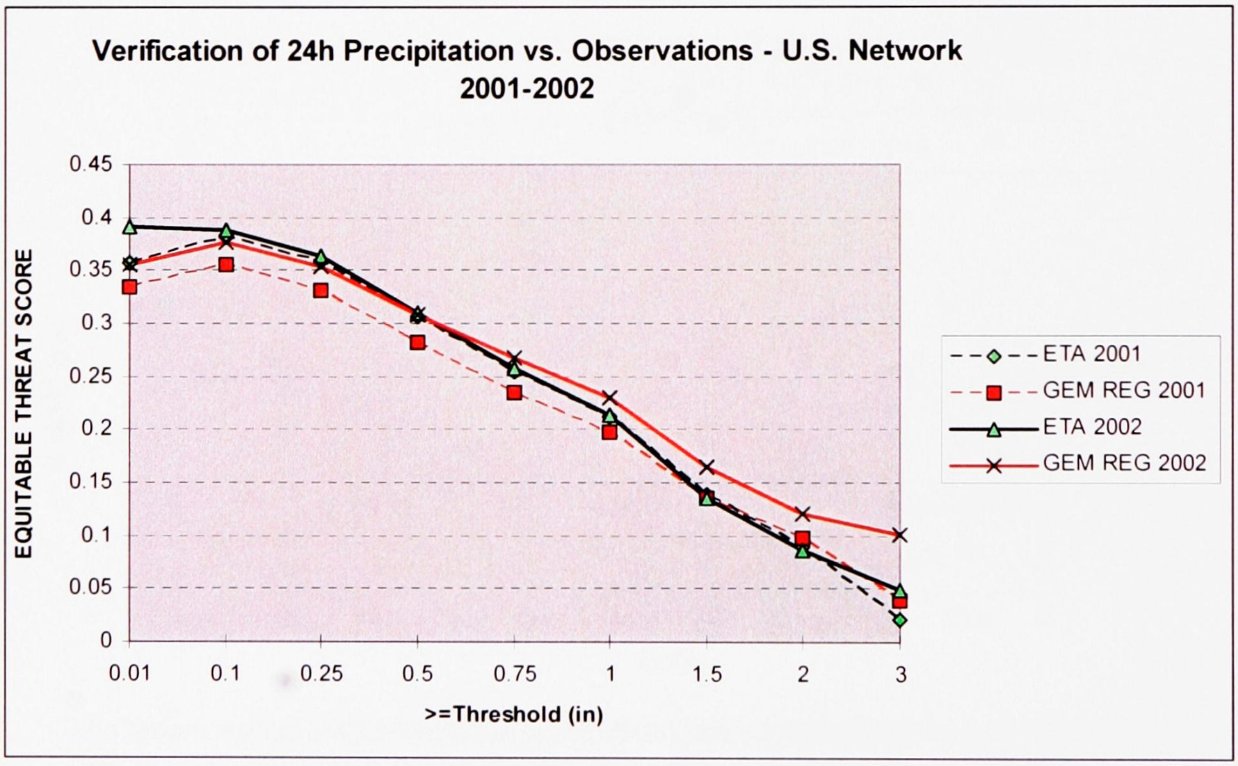


Figure 2: Comparison of GEM Regional model vs. U.S. ETA model Equitable Threat Score for 2001 and 2002. Data for this graph are obtained from the U.S. NCEP. Performance is measured against a dense network of surface observing sites (the SHEF network) over the lower 48 states of the U.S.

A Threat Score is a measure of relative precision in a category, and is defined as:

 # correct forecasts for a category /
 # events (forecast or observed) in that category

The Equitable Threat Score presented here further takes into consideration the number of correct forecasts that would be expected purely due to chance. The score varies between -1/3 and 1 (the latter representing a perfect forecast).

2. Surface Temperatures

Fig. 3 shows the steady improvement, over the previous three years, in the accuracy of both the official public and objectively generated (SCRIBE) temperature forecasts, at all lead times (day 1 and 2 maxima and day 2 minima). The improvements are due both to model changes and to the implementation of UMOS (Updateable Model Output Statistics) in the SCRIBE system in May 2001. Little difference is noted between the SCRIBE and official forecasts (less than 1 percent in all categories).

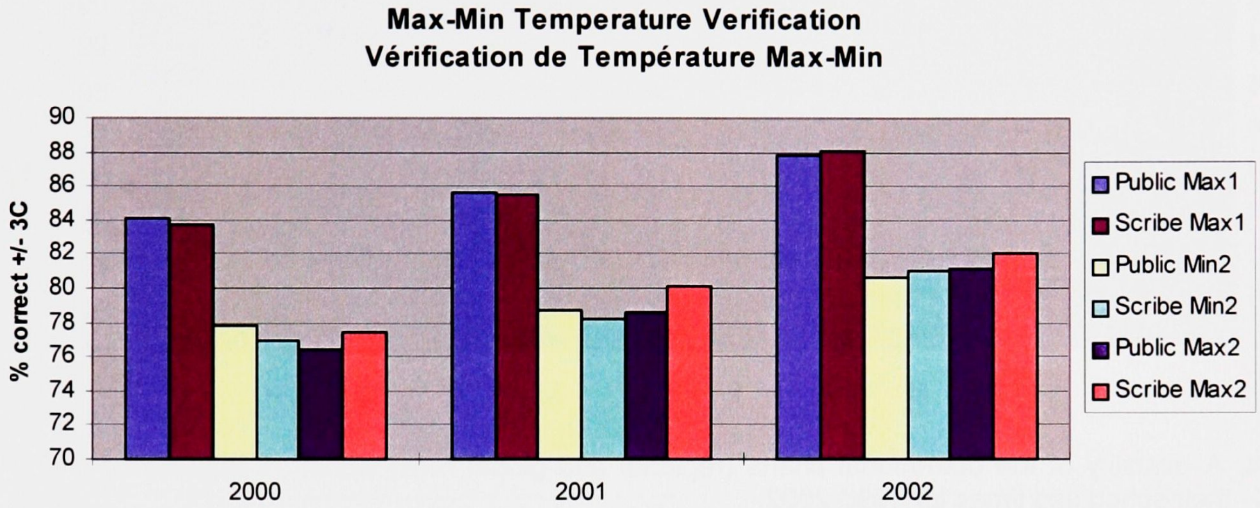


Figure 3: Percent correct of SCRIBE and official public forecast temperatures to within +/- 3°C of observed values, at 118 stations across Canada, for years 2000-2002.

3. Operational Runs Product Availability

There were a total of 20 cases in 2002 where at least 10 regional or global model charts were delayed by at least 10 minutes - an efficiency of 97.3% (20 runs out of 365 days x 2 runs/day). Two of these were major delays of 2 hours or more. This represents an improvement over 2001 (41 delays, eight exceeding 2 hours), a year with numerous hardware problems, but is nonetheless below the 98% standard set for the period. This standard had been met in each of the three years prior to 2001 (Fig. 4).

A breakdown of the delays is as follows: 11 were software related, 7 resulted from hardware problems, while 2 were due to network troubles. Four of the hardware failures occurred on the front-end while three occurred on the supercomputers. The two major delays were due to a disk problem on the front-end machine and a hardware failure on one of the supercomputers.

There were no systematic problems preventing achievement of the 98% goal. On the hardware side, there were two situations where a disk problem resulted in more than one incident, but solutions were quickly implemented, and problems did not recur. The software related problems were of widely varying nature. Two recurring problems which usually have a minor impact resulted in a few cases of longer delays. One caused the runs to abort in the absence of certain data types, but this has been solved. The other concerns situations where a job fails to execute fully, but does not abort either, thus delaying subsequent jobs. There is a known deficiency in the run monitoring system to alert the operational supervisor of these situations. The solution is not simple however, and so fits into longer term plans.

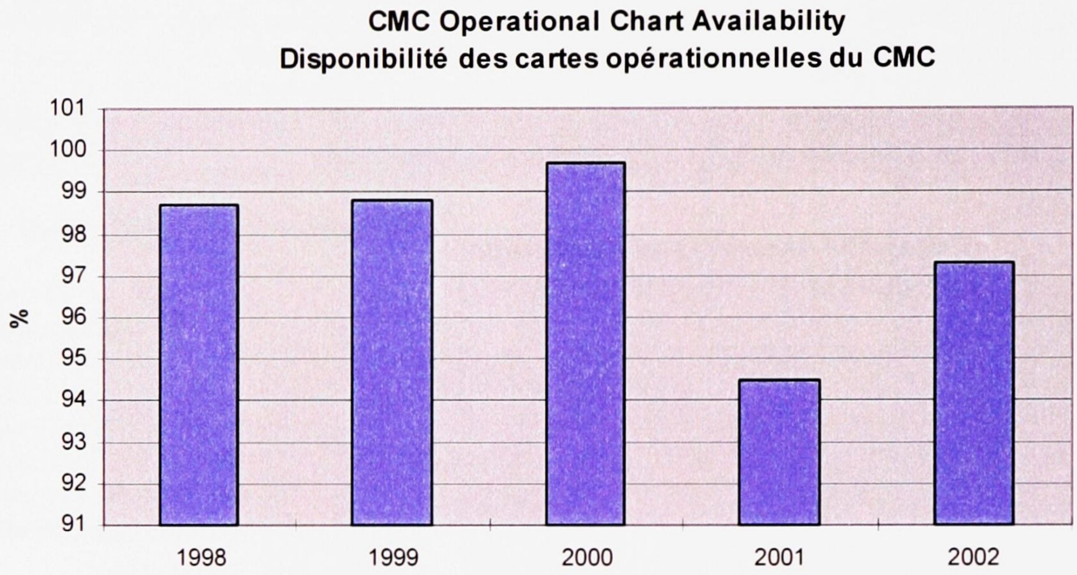


Figure 4: Availability of the operational charts (regional and global runs) within 10 minutes of their scheduled times for 1998-2002.

4. Computer Availability

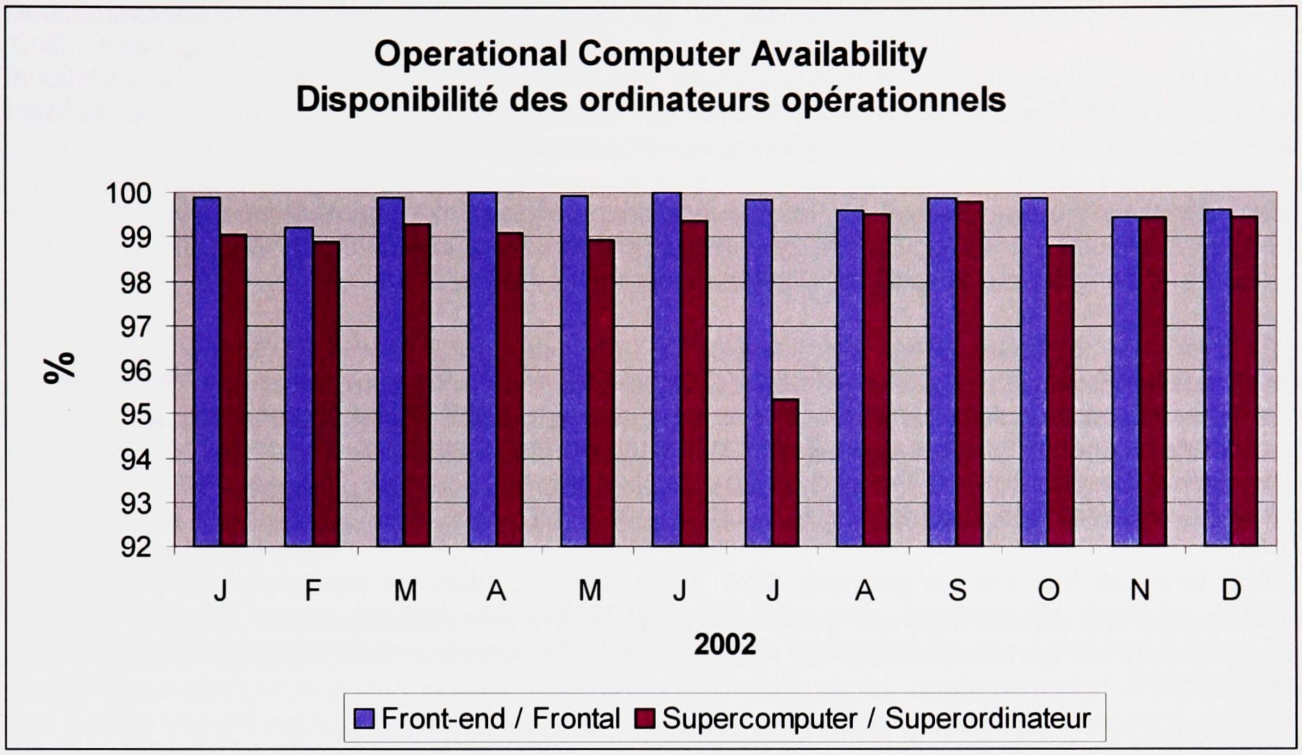


Figure 5: Operational computer availability. This includes down-time resulting from routine maintenance, user software problems etc., with a performance benchmark of 97%.

Reliability of both the operational front-end and supercomputer machines (Fig. 5) were well above performance benchmarks for all months of 2002, with the exception of July, when serious network problems resulted in 29 hours of supercomputer unavailability to users over the course of the month. Overall annual availability was way above the 97% target rate.

Plans 2003-2004

The CMC has a very full agenda for the next two years, one designed to reposition it in both computational and scientific terms. The main item on the agenda for 2003 concerns our computer systems: the front-end computers as well as the supercomputer will be replaced by more powerful systems.

This means there will be a heavy load on the shoulders of the Informatics Branch. In addition to supporting the computer / communications operational infrastructure, the Branch will at the same time have to install and bring on line several new systems over the coming year.

These IT changes will necessitate a restructuring of the operational runs as well as appropriate changes to the codes of all software running on the front-end computers and on the supercomputer. With regard to the supercomputer in particular, there will have to be a massive effort of code conversion, optimization and adjustments to enable the data assimilation systems and the operational environmental forecasting models to run on the new IBM by the end of the specified transition period. The system for controlling production runs will also need to be modified.

In the short term, all this will considerably slow down scientific work on assimilation and modeling. Nevertheless research will continue, and after the new IBM supercomputer comes on line, which is expected in the fall of 2003, we will be able to attend to the technological transfer of research results in an operational context.

As automation comes to play a greater role in developing and distributing weather forecasts, we will continue to improve the quality and robustness of our NWP and post-processing systems, including the tools used by operational meteorologists.

The CMC's business plan for 2003 and 2004 is to a great extent coloured by the above considerations.

Information Technologies (IT) et Telecommunications

The MSC 24/7 operations will continue to rely heavily on advanced systems requiring expert level computer scientists to install, operate and provide continuous operational maintenance, support and problem resolution. The centre will continue to benefit from advances in telecommunications and computer technology.

In 2003, the NEC supercomputer will be replaced by an IBM supercomputer. This supercomputer will initially provide an increase in power of 2.5 times on the SX-6 machines. The transition to the new IBM supercomputer is a major endeavour as the technology is significantly different. The conversion to the new supercomputer involves staff from many components of MSC. Acceptance testing and final acceptance of the new IBM supercomputer will take place once conversion of all operational software is completed.

On the telecommunication side, we will continue to manage the ECONET and make sure it meets the needs of MSC and Environment Canada. We will ensure that proper security, with firewalls, is put in place to avoid putting our operational system at risk. As such, we will begin to implement the policy for Virtual Private Network (VPN) as resources permit. We will continue to manage other MSC networks such as SATNET, our component of the Global Telecommunication System (GTS) and others as needed.

An RFP will be issued to replace the current contract for our internet provider. This RFP will provide for increased bandwidth and more redundancy, thus increasing the reliability and capacity to access our Weatheroffice web site. A special effort is being made to ensure full redundancy of the two internet pipes (including two different ISP providers). A high speed Ca*Net connection to CMC will be available in June 2003 that will provide faster access to large model data files for our academic partners.

Telecommunication and data services support will be provided to the Department of National Defence (DND), Nav Canada and others as per contractual agreements or MOU.

CMC will continue to improve and maintain the national real-time single window weather web site. It will continue to evolve in line with the Government On-Line initiative, and follow the common look and feel guidelines. Before completing the Weatheroffice infrastructure, some components will be redesigned for efficiency. Other improvements to Weatheroffice include access to the national archive and to GRIB data, elimination of the parser by integrating weather element forecasts from SCRIBE. A change management process, including procedures for development and testing, will be put in place.

The work on the NCS replacement project will continue. An RFP will be issued in the fall of 2003. The replacement of the Data Switch (Tandem) is a large project. The Tandem computer is used to switch all observations and all warning and forecasts bulletins and is key to all exchange of data within MSC and to national clients as it feeds other distribution systems. This project started in 2001 with a feasibility study to evaluate the impact of changing from the reliable Tandem technology to lower-cost non-proprietary solutions and the impacts of rewriting all of the applications. The development environment will be completed by March 2004.

Work will continue, in collaboration with the Regions, to improve the maintenance and support of national applications by managing the repository of source codes. We will be ensuring the implementation of a standardized configuration and software for production such as the implementation of Metmanager and also porting current applications to Linux. We will lead the development of the Production database as a prototype fully tested this year. CMC will also continue to participate in the development of the "workstation of the future" project (NINJO) and pursue the on-going maintenance and support of critical operations and national software.

Finally, we will implement the new Office suite "Office XP 2002" and coordinate training for users. Options to improve services to Downsview users, such as remote access, will be examined.

Numerical Weather Prediction (NWP) Systems

As a result of the major changes in the MSC's forecast production program, even more emphasis will be placed on the NWP systems and on post-processing. There will need to be an increase in the accuracy and reliability of these systems if the atmospheric and environmental forecasting program is to be reliable and of high quality.

Over the course of 2003, few scientific improvements are expected since most resources will be devoted to code conversion for applications currently running on the NEC SX-6s, so that they can run on the new IBMs. The changes involved in migrating applications from a vector processing computer to a massively parallel computer are major ones that will take several months and require considerable resources. As a result we have had to put on hold our plan to implement better data assimilation systems and modeling. Nevertheless scientific research will continue, and once the transition to the new IBM computers is complete, a number of proposals (parallel runs, model improvements, data assimilation improvements) will be up for implementation.

Changes to the front-end computers will require conversion to Fortran90 as well as a new version of the official library of programs (RMNLIB) used at the CMC. While this conversion work is of lesser scope than the conversion to the supercomputer, it will nonetheless call for significant resources, in particular as regards the numerous post-processing applications which draw on numerical model outputs.

a) Global system

Major changes are planned in the global forecast system in 2004, affecting both data assimilation and the model itself.

- There will be an emphasis on ingesting new data sources: certain channels of the AMSU-B will lead to a notable improvement of the initial humidity conditions, and GOES infrared radiances will also be assimilated. This will make it possible to eliminate the HUMSAT data currently used by our operational system. We will also work on ingesting data from wind profilers, as well as winds from Quickscat, and we plan to ingest integrated water vapour data and wind data from the SSMI and SSMIS. R&D work is already under way so that we can use data from the AIRS in our operational assimilation systems. Finally, we hope to be able to make operational use of the Canadian AMDAR data. These changes will be coordinated with modifications to the Global forecast model used in the assimilation system; important among these changes is a plan to raise the top of the model from 10 hPa to 0.1 hPa so that additional channels from the stratosphere can be assimilated.

- R&D work on the 4D-VAR assimilation system is progressing as planned. We are now at the final stage of testing and adjustments. The system is expected to go on line during 2004.

- The next significant implementation of the global model will be a version with a horizontal resolution of about 0.4°, and nearly sixty vertical levels. Numerous improvements will be made to the parameterization of physical processes: ISBA (Interactions Soil Biosphere Atmosphere) surface scheme; Kain-Fritsch convection scheme; cloud-radiation interface; reformulation of the shallow convection and boundary layer schemes. This parameterization is similar to the anticipated next implementation of the regional model with horizontal resolution of 15 km, so that the R&D effort required in the development and maintenance of the new version of the global model will be much reduced.

- Finally, modifications to the surface fields will be incorporated, reflecting the new parameterization and the increased resolution. These changes will, for example, affect the analyses of water body temperatures (use of higher resolution satellite data, e.g. ATSR), of ice cover and thickness, and of parameters related to snow on the ground. Similar changes appropriate to the regional forecasting system will also be implemented.

b) Regional system

- The new data to be assimilated in the global system will also be assimilated in the regional system.

- A new version of the regional model is planned for spring 2004. Horizontal resolution at the centre of the grid will be increased from 24 to 15 km, and the number of vertical levels will rise from 28 to 58. A new set of physical parameters should correct the well known defects of the existing system and improve the system's overall performance, especially with regard to precipitation. This is a major implementation because it will include an in-depth reworking of all the physical parameters in the model.

- Use of a very wide range of additional data (from aircraft and remote sensing), already assimilated for 06 and 18 UTC, could allow an increase in the number of runs to four a day. This would require a study of the current regional assimilation cycle (every 12 hours) and of the benefits of moving to a 6 hour interval. Such a study will commence following implementation of the new 15 km resolution model.

c) HIMAP and very high resolution GEM model

- The HIMAP model (a version of the GEM model with a resolution of 10 km) will continue to be operational for some time yet. Development of a version with higher resolution in reduced windows continues, in cooperation with Research Branch and Pacific & Yukon Region. A version of HIMAP with a horizontal resolution of 2.5 km, centred over British Columbia, will be implemented in 2003. This will allow for an improved representation of surface fields in this topographically complex region, yielding more realistic forecast fields for temperature and precipitation than those provided by the regional model. We will also be working on using the forecasts from this high-resolution model as inputs to SCRIBE in order to improve its forecasts for the mountainous and coastal areas of Western Canada.

- After this initial implementation, versions of the model with windows centred over southern Quebec and the Atlantic provinces will also be developed and implemented. With regard to the version centred over southern Quebec and Ontario, the goal is to improve forecasts of the quantity and type of precipitation during the winter season.

d) Monthly and seasonal forecasts

- In addition to deterministic forecasts for the various categories of temperature and precipitation anomaly, the 12 members of the ensemble used in the seasonal forecasting system will be used to provide probabilistic forecasts of temperature and precipitation anomalies for each category.

- MSC research groups will be working more closely with the universities to improve the quality of seasonal forecasts and estimate their reliability, and to make use of the GCMIII (General Circulation Model version 3; Canadian Climatic Model) and GEM models in the seasonal forecasting system.

e) Ensemble forecasting system

- The assimilation scheme for ensemble forecasts (Optimal Interpolation) will be replaced by the ensemble Kalman filter (EnKF) technique. A prototype is already being evaluated. The aim is to replace the OI system by the EnKF technique after conversion to the new supercomputer in 2004. At that time, the SEF model will no longer be required for the assimilation cycle, but it will continue to be used in forecast mode until completion of the work to replace it by GEM-DM (distributed memory version of the GEM model). GEM-DM will then be the sole numerical model used in the CMC's atmospheric forecasting program, with the exception of the GCM model, which will continue to be used in preparing seasonal forecasts.

- The ensemble system forecasts will be extended from 10 to 15 days. Also, the resolution of the models used in the ensemble system will be increased, and the system will be run at 12 UTC in addition to the present 00 UTC run. The criteria for optimizing the benefits from increasing the resolution and increasing the number of members in the ensemble have yet to be identified.

- A number of new products based on the ensemble system will be developed. Once the forecasts are extended to 15 days, products dealing with days 7 to 14 will be developed and implemented.

- Probabilistic forecasts of various parameters will also be part of the operational production system. Development will commence on extending the valid period for public forecasts to day 7 or perhaps even day 10.

- We will do more work with the NWS regarding exchange of ensembles and product development.

f) Air quality

- Air quality activities will continue to be driven by the need of Canadians to know and to be assured of the quality of the air they breathe. Both the daily operational prediction program and the policy assessment work will depend on and benefit from planned improvements in the numerical tools, such as the CHRONOS and AURAMS modelling systems, and the forward and backward trajectory calculators at the CMC.
- The CHRONOS operational system will be converted to run on the IBM supercomputer, then a scheme to predict particulate matter, $PM_{2,5}$ and PM_{10}, will be implemented. To support policy assessment, CHRONOS sensitivity runs on various anthropogenic emissions reduction scenarios will be executed during the summer of 2003, in real-time.
- The AURAMS will be run in real-time starting mid-2003 in preparation for our participation in the New England Field Experiment that will take place in summer of the following year. Emissions reduction scenarios will be finalized based on AURAMS.
- Progress will be made toward establishing a transparent emissions processing system through joint work with the National Research Council of Canada. The currently used emissions data, based on the 1990 inventories, will be revised using the final version of the 1995 Canadian and the 1996 U.S. inventories.
- A simple objective analysis scheme for surface ozone will be implemented into the operational production during the summer of 2003.

g) Environnemental emergency response

- Operational robustness of the specialized atmospheric transport modeling and visualization tools will be routinely tested and assured. Our commitments to the Technical Advisory Group under the Federal Nuclear Emergency Plan will be met. Joint monthly tests with the US Center in Washington and the Australian Centre in Melbourne will continue, with the possible expansion to include the participation of the IAEA's Emergency Preparedness and Response Unit. New web-based technologies will be explored and developed for efficient exchange of specialized products among centres and possibly users from the National Meteorological Services. The coupling of the trajectory model with the current operational global and regional NWP models will be extended to include the experimental high-resolution regional GEM model. Improvements to the Lagrangian particle dispersion model will be validated using the data from the ETEX experiment and the data from the Ottawa River experiment. The Short Range Lagrangian Particle model will be implemented and tested in real-time during the TOPOFF experiment to be held in May 2003. The model will then be implemented for real-time emergency response.

- Emergency response activities will continue to receive high priority attention in the context of enhancing security of Canadians in relation to counter-terrorism. Various projects will be undertaken to increase CMC's capabilities to provide modeling support to lead response and security agencies, in particular to the Department of National Defence and the Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP). Many aspects of meteorology play an important role in operational assessment and decision making with respect to counter-terrorism. Specialized modeling of the atmosphere (e.g. high resolution) could feed agent specific applications (dispersion, transformation, impacts) for many chemical, biological, radiological and nuclear threats. Progress on the use of high resolution POES satellite imagery and radar data during emergency situations will be achieved.

  Note : Tracking and Predicting the Atmospheric Dispersion of Hazardous Material Releases: Implications for Homeland Security. Committee on the Atmospheric Dispersion of Hazardous Material Releases, National Research Council, 2003, 114pp.

h) Statistics and post-processing

- We will finish work on all our statistical guidance for 0-48 hours based on the Updatable Model Output Statistics (UMOS), with the addition of 12-hour probability of precipitation and cloud cover forecasts. At that point, all the statistical forecasts drawing on the regional model will be UMOS-based.

- We will modernize all the statistical guidance currently based on the Perfect Prog (PP) approach by developing statistical models based on NCEP reanalyses. The guidance based on the PP approach will continue to be used for medium-range forecasts, for post-processing of ensemble forecast outputs, and perhaps even as predictors in the UMOS system.

- Statistical integration of observation data with SCRIBE data will improve the quality of short-term public forecasts produced by SCRIBE. The project to incorporate surface observations, radar observations and lightning data into SCRIBE continues. In this regard, we intend to use surface data, radar data and lightning data to improve the representativeness of the initial conditions used by SCRIBE, given that point data may not be representative of the initial conditions over a forecast region. In a further phase of development, satellite data will be added. Over the next two years, an operational version of SCRIBE that ingests these types of data will be implemented and used in the MSC's forecast production system.

- Recent research has shown that lightning data may be useful for producing thunderstorm probability forecasts. The technology will be improved and transferred to an operational environment at the CMC, where these forecasts will be incorporated into SCRIBE.

- Significant improvements will be made in the SCRIBE system. It will benefit from all the improvements made in the assimilation system and the models, and it will draw on outputs from very high resolution numerical models. The incorporation of UMOS statistical guidance will help improve the quality of SCRIBE products. Further benefit will arise from the improvement of short-term inputs resulting from the integration of statistical and numerical guidance with observed data. A workshop to improve the interface that lets users change concepts was held in 2002 and resulted in a set of recommendations, many of which will be implemented. The text generator used to produce public forecasts will be greatly improved to standardize terminology across the country and assist machine translation of forecasts. These changes will be incorporated in the new version of SCRIBE in mid-2003.

- The version of SCRIBE used to produce marine forecasts will be improved. The text generator will be changed to reflect the new production standards for marine forecasts to be adopted during 2003, and a local effects module will be included. An initial version of marine SCRIBE will be delivered in mid-2003.

- Finally, given the growing importance of the Web as a means of dissemination, CMC products (graphics products in particular) will be overhauled when the 15 km regional model is implemented. Changes will be made to the graphics products over the next two years to improve their usefulness and to reflect changes in the post-processing systems following improvements to the driving models.

Staff

The Canadian Meteorological Centre is a centre of excellence in meteorology. It relies on its highly qualified and dedicated employees. At the end of 2002, the staff of the CMC consisted of 224 employees, of whom 189 work in Dorval and 35 in Downsview. Fifty percent of CMC staff work in information technology, 34% in meteorology and physical sciences, and 16% in management, administration, and technical support.

New Employees in 2002
Marc Besner, Véronique Bouchet, Diane Caouette, Chantal Côté, Sophie Cousineau, Antoine Duval, Juan Sebastian Fontecilla, François Fortin, Aubin Guillemette, Alain Guillotte, Aida Koumaré, Ervig Lapalme, François Lemay, Alain Malo, Martha McCulloch, Robert Ménard, Pierre Michaud, Lewis Poulin, Isabelle Provost, Moufid Samri, Charles Schwartz, Nadine Vibert and Vincent Vu

Promotions
Louis-Philippe Crevier, Richard Hogue, Cortina Jone, Alain Lavoie, Hélène Leblanc, Sylvain Ménard, André Méthot, Lam Binh Ngo, Patrice Parent, Paul Pestieau, Maryse Sohier, Serge Trudel and Lorraine Veillette.

Departure
Anita Chan, Ekaterina Radeva

Retirements
Micheline Boies, Normand Brunet, Gene Drapeau, Gabriel Lemay, Diane Lespérance

Queen's Jubilee Commemorative Medal
The Queen's Jubilee Commemorative Medal was awarded to Denis Filiatrault and Jean-François Gagnon in recognition of their contribution to the workplace, and to Charles Anderson, Howard Salomon and Gilles Richard in recognition of their long service.

Departmental Group Award
In spring 2002, the CMC's Meteorological Research Branch, Development Branch and Operations Branch received a departmental citation of excellence in recognition of the exceptional work done by their employees over the last few years that resulted in innovative systems being implemented in CMC operations.

Departmental Award for Contribution to MSC Internet Technology
In spring 2002, a departmental citation of excellence was awarded to Andrew Hunt of the Informatics Division of CMC at Downsview. This prize was awarded to Andrew in recognition of his contribution over the last few years to developing internet technologies for delivering meteorological information to our users and partners, including the public MSC website.

Environment Canada Diversity Leadership Award
The Environment Canada Diversity Leadership Award was awarded to the national meteorologist recruitment team for their work between 1999 and 2002. This award recognizes the team's contribution to increasing the representation of employees belonging to employment equity groups. Several CMC employees played key roles in the recruitment team: Pierre Dubreuil, Martha McCulloch, Marie Lussier, Tom Nichols and André Giguère.

Long Service Awards

35 years of service: Gilles Richard

30 years of service: Michel Baltazar, Réal D'Amours, Pierre Dubreuil, Jacques Hallé, Claude Handfield, Richard Jones, Edward Kirkwood and Richard Verret

25 years of service: Raymond Benoît, Jean-Claude Goudreau

Employee Activities

CMC employees are recognized for their involvement in various social and athletic activities throughout the year. Many activities took place in 2002.

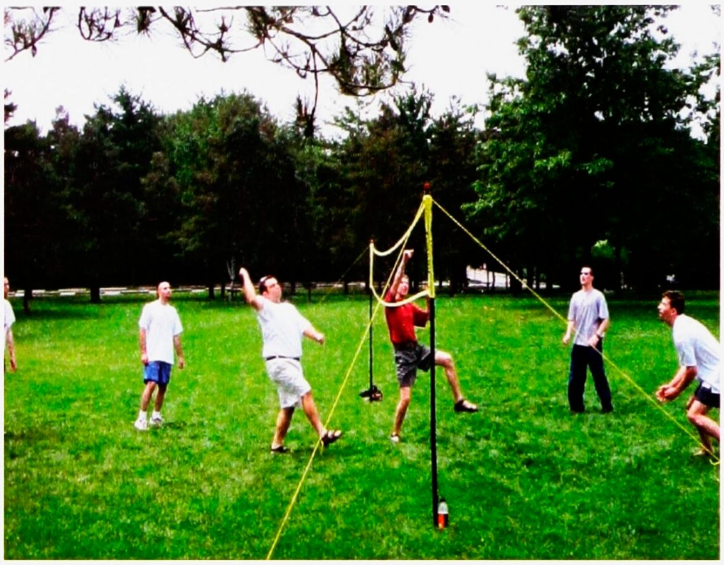
Kelvin Band, once again put on several shows in 2002. The band, formed 10 years ago for the CMC Christmas party, consists of employees from various disciplines working at the Dorval facility.

Kelvin Band

Another popular activity was the weekly social dance class. Other activities included tai chi and Pilates classes, which were enjoyed by many people.
Athletic activities included the evening hockey, tennis and soccer games. Many people also participated in the annual end of summer hiking, biking, and golf day, which allowed staff to take some fresh air together.

The CMC was also very involved in the 2002 United Way Campaign to raise money for people in need in the Montreal area.

Our colleagues at CMC Downsview also participated in many activities throughout the year. Here they are at their annual summer picnic:



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Acronyms

3D-VAR	3-Dimensional Variational Analysis
ACARS	Aircraft Communication Addressing and Recording System
ADS	Aviation Defence Service
AEP	Atmospheric Environment Prediction
AES	Atmospheric Environment Service
AMDAR	Aircraft Meteorological Data Reporting
AMIS	AES Meteorological Information Service
AQRB	Air Quality Research Branch
AWeD	Aviation Weather Database
AWG	CBS Advisory Working Group
BUFR	Binary Universal Form for the representation of meteorological data
BURP	Binary Universal Report Protocol
CANATEX	CANadian NATional nuclear EXercise test
CANERM	Canadian Emergency Response Model
CANFIS	Classification And regression tree Neural-Fuzzy Inference System
CBC	Canadian Broadcasting Corporation
CBS	Commission for Basic Systems (WMO)
CEO	Chief Executive Officer
CFS	Central File Server
CHRONOS	Canadian Hemispheric Regional Ozone and NOx (Nitrous oxide) System
CMC	Canadian Meteorological Centre
CREX	Character form for the Representation and Exchange of data
CS	Computer Science
CTBT	Comprehensive (Nuclear) Test Ban Treaty
CTBTO	CTBT Organization
DMO	Direct Model Output
DPFS	Data-Processing and Forecasting Systems
ECMWF	European Centre for Medium-Range Weather Forecasts
ECS	Environment Conservation Service
EPS	Ensemble prediction system
ET	Expert Team
ETEX	European Tracer Experiment
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FIR	Flight Information Region
FNEP	Canada's Federal Nuclear Emergency Plan
FTP	File Transfer Protocol
GCMIII	General Circulation Model
GB	Gigabyte (10^9)
GDPS	Global Data Processing System
GEM	Global Environmental Multi-scale (Model)
GENet	Government wide intranet
GEWEX	Global Energy and Water Cycle Experiment
GMS	Geostationary Meteorological Satellite
GOS	Global Observing System
GRIB	Gridded Binary (data format)
GTIS	Government Telecommunications and Informatic Services
GTS	Global Telecommunications System

GWMC	Government Wide Mission Critical
HIMAP	High resolution Mesoscale Application Project
HIPPI	High Performance Parallel Interface
HRPT	High Resolution Picture Transmission

IAEA	International Atomic Energy Agency
IAVW	International Airways Volcano Watch
IB	Informatic Branch
ICAO	International Civil Aviation Organization
ICT	OPAG Implementation and Coordination Team
IEEE	Institute of Electrical and Electronics Engineers
IM/IT	Information Management/Information Technology
IMS	Global International Monitoring System (CBTB)
INEX	International Nuclear Emergency Exercises
IPI	Intelligent Peripheral Interface
IXS	Internode crossbar (X) Switch
ISBA	Soil-Biosphere-Atmosphere Interactions
ISDN	Integrated Services Digital Network
LAN	Local Area Network
MDA	Multiple Discrimant Analysis
MLR	Multiple Linear Regression
METRo	Heat exchange model
MRB	Meteorological Research Branch
MSC	Meteorological Service of Canada
MOS	Model Output Statistic
NAOS	North American Atmospheric Observing System
NCEP	U.S. National Weather Service's National Centers for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration (USA)
NO_x	Nitrous oxide
NWP	Numerical Weather Prediction
NWS	NOAA National Weather Service
OPAG	Open Programme Area Group (WMO)
PDS	Product Dissimination Server
ppb	parts per billion
POP	Probability Of Precipitation
PP	Perfect Prog
RA	Regional Association
RAID	Redundant Array of Independent Disks
RAOBs	Radiosonde observation
RMSE	Root Mean Square Error
RPN	Meteorological Research Branch
RSMC	Regional Specialised Meteorological Centre
SAN	Storage Area Network
SATNET	Satellite Network
SCRIBE	System to assist the meteorologist in bulletin preparation
SCSI	Small Computer System Interface
SGI	Silicon Graphic Inc
SSCP	Sum of Square and Cross Product
TB	Terabyte (10^{12})
TCO	Testing and Certification Office
TCRB	Testing, Certification Review Board
TOVS	TIROS Operational Vertical Sounder

UKMO	United Kingdom Meteorological Office
UMOS	Updateable Model Output Statistics
UN	United Nations
UPS	Uninteruptable Power Supply
URP	Unified Radar Processing
UTC	Coordinated Universal Time (Greenwich Mean Time)
VAAC	Volcanic Ash Advisory Centre
VPN	Virtual Private Network
WAM	Ocean wind-wave generation and propagation model
WGB	Working Group "B" (CTBT)
WMO	World Meteorological Organization
WWW	World Weather Watch
XMU	Extended Memory Unit
Y2K	Year 2000