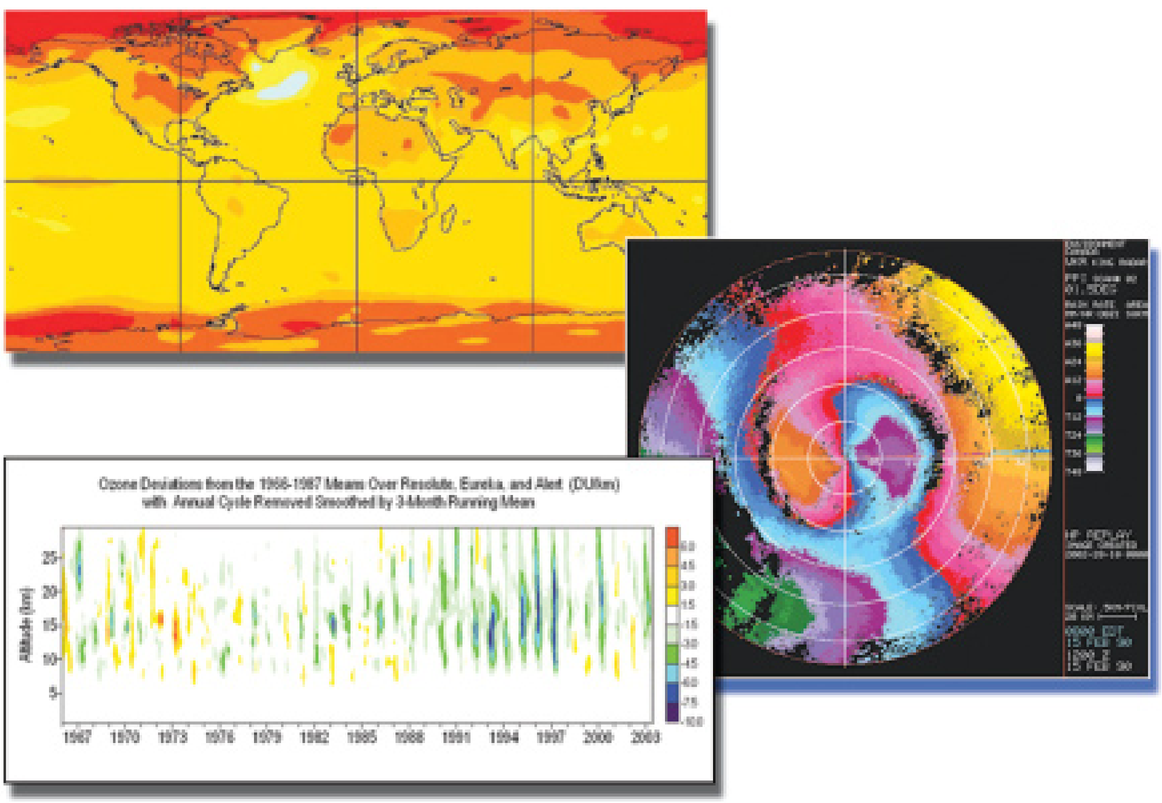
Environment Canada / Environnement Canada
Meteorological Service of Canada / Service Météorologique du Canada

Strategic Plan 2003-2012

Research and Development Program



MSC

Canada

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MESSAGE FROM THE DIRECTOR GENERAL

In 2001, an international Peer Review Panel found that the MSC R&D program was meeting the needs of clients with a high level of excellence – we led the world in some areas and in other areas, our R&D was world class or the best available in Canada. One of the recommendations of the Panel was that the MSC R&D program would benefit from developing a strategic plan.

This document is in response to the Panel's recommendation. It will challenge us scientifically and guide our scientific and program-related decisions in the short and long term. It will help staff to see where we are going and enable them to participate in our exciting future. This plan allows the rest of the MSC and the Department to see how a strong internal R&D program can help them to realize their long-term goals, and at the same time will help them to identify what we in turn need to achieve our goals. It will also provide stakeholders with a clear vision of our future directions, enabling them to participate in initiatives that will help us to achieve our strategic objectives.

In the next few decades, the atmosphere, and its underlying surface will go through unprecedented changes, partly because of humankind's activities, and partly due to its natural variability and evolution. The loading of the atmosphere with greenhouse gases, ozone depleting substances, particulate matter, toxics, etc., combined with the increasing human footprint on the earth's surface (deforestation, tilling, irrigation, urbanization), will have a profound impact on our environment.

Some of those impacts are so severe that not only are they threatening to the survival of major ecosystems, but in some catastrophic scenarios, to humankind itself. For example, climate change, ozone depletion, and air pollution all affect our health and well-being, and could eventually threaten our survival as a species. Determining how the atmosphere and water systems will respond to these changes, and whether or not we can eventually restore them to a state that poses no threats, or, at the very least, developing adaptation and mitigation strategies, will require solving some of the most challenging scientific problems of the 21st century.

Dr Michel Béland,
Director General, Atmospheric & Climate Science Directorate

As our appreciation of the complexity of the underlying science issues grows, the investigations will become more and more multidisciplinary in nature, necessitating a more holistic and team approach. An example of this is the broadening range of skills and capacity needed to support and improve climate models of the atmosphere. Over the next ten years, the amount of earth observation data that will be available to atmospheric scientists will increase by about five orders of magnitude. Computing and telecommunication capacity will also significantly increase, allowing for more accurate simulations of the atmosphere and the environment. Many exciting multidisciplinary field experiments, some global in nature, such as the International Polar Year, GEO or THORPEX, will result in the creation of databases that are vital for the validation of theories and model scenarios.

MESSAGE FROM THE DIRECTOR GENERAL.... CON'T

Increasingly, climate, air quality and weather modelling systems will be tightly coupled, move to increasingly finer scales, and rely on complex multivariate data assimilation systems. There will be a tremendous increase in the resolution of data (spectral, temporal, and spatial), and in the generation of simulation products, as well as a shift in prediction paradigms (deterministic to probabilistic). These changes will greatly enhance our capacity to solve some of the challenges, and develop policies and services more relevant to the needs of policy and decision makers.

The internal environment, in which we conduct our activities, will also evolve significantly. The changes are already apparent. There is a strong push to increase the support to university-based research, sometimes at the expense of government conducted R&D activities. An optimal balance will ultimately be achieved, but the stresses during this transition will create interesting management challenges. Management also has the challenge of closely tying our R&D programs to the needs of our stakeholders, while at the same time nurturing and preserving a challenging and motivating research environment for scientists that is based on curiosity, passion and dedication to excellence, which is their fundamental motivation.

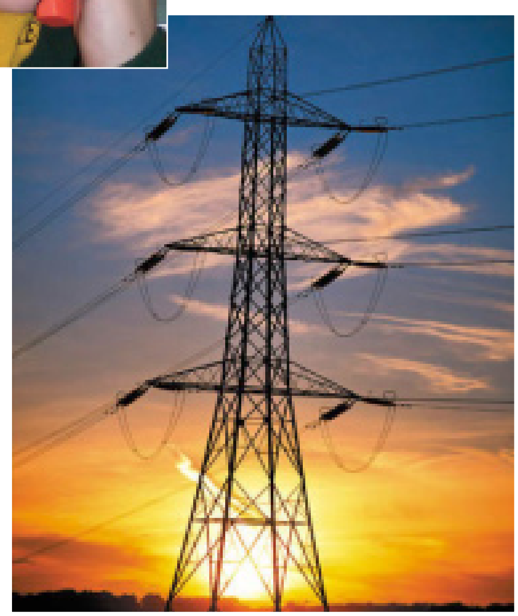
Atmospheric science issues are becoming increasingly globalized and more complex. They require so much data that they cannot be tackled by any individual country without stressing their research capacity to the limits. Canada will have to increase its contribution to the resolution of these issues, particularly in regards to data. This will enable Canada to keep its largely free access to unlimited sources of data and knowledge that are essential to solving its own national environmental challenges. An indirect consequence of this trend will be the increasingly stiff competition for the best scientific talents worldwide. The 'graying' of our scientific population will make this a greater challenge. The organizations that succeed will be those who manage to maintain an exciting and rewarding work place for their employees, and who are able to provide them with state-of-the-art infrastructure and competitive compensation.

This plan has carefully considered the above stressors and factors of change. It assumes that knowledge of the atmosphere, hydrosphere and cryosphere and how they are changing is, and will remain, of strategic importance to decision-makers – Canadians, their governments, academia and industry. Through this plan, we will provide the sound science, data, information and advice needed to understand and reduce the vulnerabilities to our social, economic and environmental systems due to our changing environment.

The challenges in this plan are exciting and I anticipate meeting these challenges enroute to achieving our strategic objectives. I also look forward to watching the long-term evolution of the MSC based on its strong scientific foundation, and the evolution of the science and the R&D program in response to the needs of its clients and research partners.

I would like to express thanks to all of the managers, scientists, staff and those external to the MSC who contributed to the development of this plan. In particular, I would like to thank Dave McCulloch who developed and drove the process, ran most of the consultation sessions and drafted many versions of this document. I would also like to thank Victoria Hudec who carefully selected most of the graphics, edited the document and worked with the publisher to create the final product.

EXECUTIVE SUMMARY



EXECUTIVE SUMMARY

Within the context of the Meteorological Service of Canada's (MSC's) Vision for 2011, this plan has been designed as an evolving tool to meet the strategic and near-term planning needs of its R&D managers. MSC R&D has roles and responsibilities towards realizing each of the MSC attributes shown below.

MSC ATTRIBUTES FOR 2011 (Vision)

A. An essential national institution contributing to the health and safety of Canadians and their communities.

B. A catalyst and partner in developing innovative services in support of economic efficiency, productivity and competitiveness.

C. Accountable to Canadians for quality and program effectiveness.

D. The recognized authority and source of science information on weather, climate, water, air quality and related environmental issues.

E. A recognized contributor to Canada's international role in helping solve complex and multidisciplinary environmental issues facing the global society.

F. A valued, strategic and innovative partner with other government agencies, academia and industry to achieve shared goals.

OUR CHANGING ENVIRONMENT – VULNERABILITY, OPPORTUNITY AND ADVOCACY

Our changing environment is a double-edged sword – making Canadians more vulnerable to weather and environmental conditions and creating new economic opportunities (e.g., green energy). The Institute for Catastrophic Loss Reduction (ICLR; http://www.iclr.org) warns, "Catastrophic losses threaten to occur more frequently in the future... This growing threat could seriously undermine our social and economic viability."

The importance of atmospheric and related environmental R&D increases as Canadians become more vulnerable to weather and environmental conditions. The change in vulnerability comes about as the population concentrates in urban areas, Canadians grow more dependent on electricity, Canada's essential infrastructure ages and new technology creates complex but vulnerable production and delivery systems in the private sector.

There is also a positive side to our changing atmosphere – opportunities (e.g., green energy, intensive crops, recreation) for improving economic productivity and competitiveness which are possible due to our changing atmosphere. Atmospheric and related environmental science is of prime importance to addressing these threats, managing the risks and identifying the opportunities.

Every day, our changing environment affects personal health and safety, domestic security, economic efficiency and competitiveness, and environmental health. Knowledge of the atmosphere, hydrosphere and cryosphere and how they are changing is of strategic importance to Canadians, their governments, academia and industry. Our mission-driven multidisciplinary R&D program provides:

- The scientific credibility for domestic and international policy development.
- The integrity behind essential government products and services.
- Data and knowledge for academia.
- The integrated tools which help decision-makers reduce social, economic and environmental vulnerabilities and optimize related opportunities.

MSC R&D will also need to engage its clients and partners in advocacy. Many clients already know the importance of atmospheric and related environmental science to health, safety, security, Canadian businesses and the environment. Some have not made the link. Either way, clients and partners need to advocate support for atmospheric and related environmental research and applications. Over the next five years, the most likely candidates for advocates will be those who must deal with the uncertainties of extreme events and climate change (e.g., provinces and municipalities, the re-insurance industry, transportation industry, agriculture, energy and federal agencies such as NRCan, DND, and PSEPC (formerly OCIPEP).

POLICY AND SERVICE BASED ON SCIENTIFIC EXCELLENCE

Driven by science excellence, MSC R&D's role is to ensure that Canada has the scientific capacity needed to: provide essential government services (e.g., weather data, forecasts and warnings; climate and air quality data, information and advice); and effectively respond to key environmental, health and safety policy issues such as climate change, ozone depletion, air quality and water quantity.

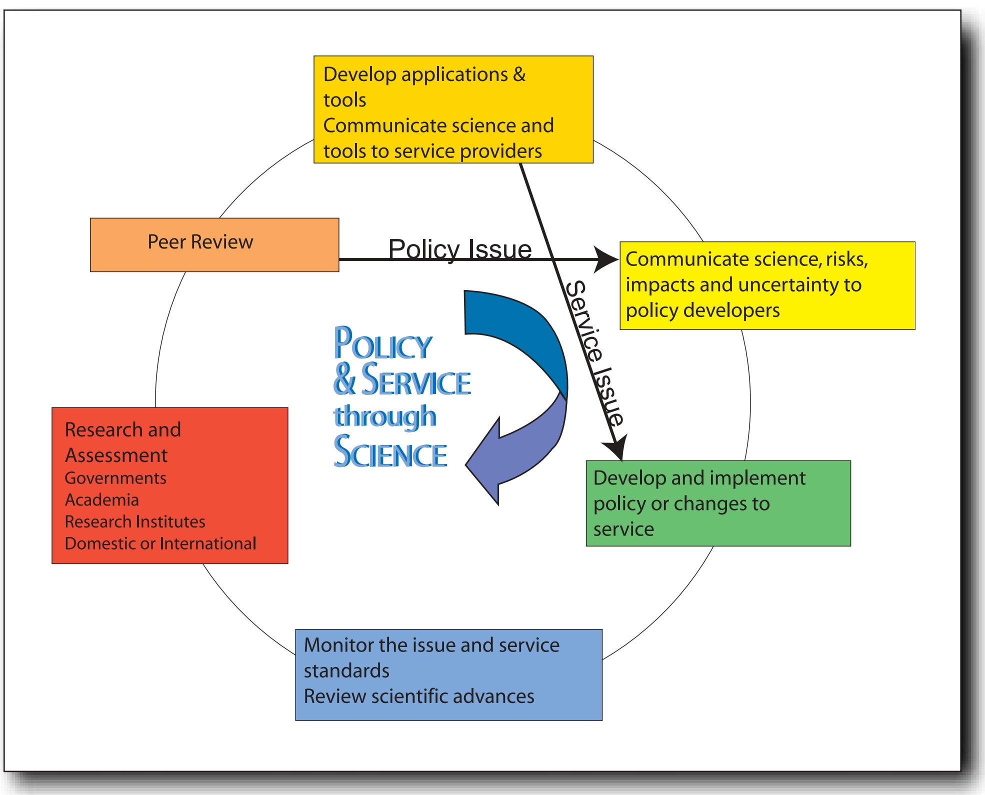
MSC R&D provides Canadians and their governments with the sound science, data, information and advice needed to ***understand*** and ***manage the risks*** to human health and safety, domestic security, economic competitiveness and efficiency and environmental health ***resulting from our changing environment***. In doing this, we must:

- Provide scientific leadership (within Canada and internationally).
- Engage others through research networks, ventures, partnerships and advocacy.
- Transfer internal and external science and technology to clients.
- Shape and support government principles and directions for managing government science.

The process of integrating science into services and policies is an iterative process (see figure below) which can begin almost anywhere on the circle. It can begin with a service issue.

For example, a poorly forecast weather event could define a service need which would trigger a research project. A science assessment that identifies research gaps or contradictory research results from an external source can trigger new research. Monitoring of a "mature issue" could also trigger a research project (e.g., the discovery of pesticides in Lake Ontario that had been banned 25 years ago). Finally, research can also begin the process as it did with the discovery of the stratospheric ozone hole, leading to the development and implementation of new policy and the UV Index™ Service.

Regardless of how research becomes involved in a service or policy-based problem, scientific excellence drives us to find the solution. By promoting innovation and linking it to increased productivity and decreased vulnerability, we will also help Canada become one of the top five-rated R&D countries in the world by 2010.



CURRENT STATUS AND FUTURE NEEDS

According to the 2001 Peer Review[1] , MSC R&D is currently meeting the needs of Canadians with a high level of excellence. Our science is relevant and appropriate and in many areas, we are world leaders. One of MSC R&D's many strengths is that it is multidisciplinary, bringing together meteorologists, climatologists, hydrologists, atmospheric physicists, chemists and biologists to tackle the complex problems posed by the interactions between people, the atmosphere and the related environment.

The challenge now is to maintain this ***level of R&D capacity and excellence*** and ***demonstrate the value of science as an integrator of policy issues*** across Environment Canada in the face of ***an aging scientific community and diminishing internal resources***.

Because of the complexity of atmospheric and related environmental science issues, the MSC will:

- Continue to work collaboratively with Canadian and international research communities through special project teams and networks (e.g., the Climate Research Network, the WMO Global Atmospheric Watch Program, and the Northern Contaminants Program) and the WMO Global Atmospheric Watch Program).
- Continue helping universities through the science subvention program and support for the Industrial Research Chairs.
- Participate in the management and direction of the Canadian Foundation for Climate and Atmospheric Science (CFCAS), facilitating international partnerships and participating in undergraduate and graduate scholarship supplement programs.
- Meet the ongoing needs of Canadians and their governments of the 21st century, by ***continuing to promote basic research in the universities, building new research network and engage partners***.
- Continue to address the trans-boundary scope and global nature of the scientific issues.
- ***Continue to create domestic and international joint ventures to ensure multidisciplinary and multilateral solutions***. Because clients often require answers before complete scientific understanding is available, MSC R&D must ***provide the best possible science advice at any given time, while continuing to work on reducing the scientific uncertainties***. An excellent example of this is climate change. While the international scientific community agrees that climate change is a certainty, and many countries have signed the Kyoto Protocol, there is still uncertainty in how much change there will be, and when and where it will occur. Climate change remains a real threat in the short and long term. It is imperative that climate change R&D continue to reduce these uncertainties to better understand the impact on health, safety, security, economy and the environment, and to develop options for addressing the impacts at the federal, provincial and municipal scales.

HIGHLIGHTS OF THE STRATEGIC PLAN

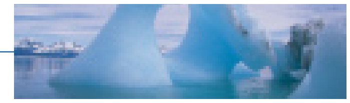
Over the next 10 years, MSC R&D will focus on ***atmospheric and related environmental research*** leading to informed decisions which will increase opportunities and decrease social, economic and environmental vulnerabilities caused by changes in the atmosphere and related environment.

MSC R&D has identified three strategic objectives for the year 2012:

1. Support risk-based decision making affecting Canadians' safety and security, their economy and the environment due to high impact atmospheric and related environmental events (e.g., severe weather, poor air quality, floods and storm surge) on the scale of minutes, days and weeks.
2. Support risk-based decision making affecting Canadians' security and health, economy and the environment due to changes and variability in the atmosphere and related environment on the scale of weeks, years and centuries.
3. Provide a coherent and consistent picture of the present and past states of the atmosphere and related environment.

To achieve these strategic objectives, we have identified several high level strategies that cross all aspects of R&D (mission oriented, applications, science assessment, impacts and adaptation and knowledge transfer). Chapter 5 shows the links between the client needs and the strategies needed to reach the strategic objectives. In implementing these strategies, we believe that the **MSC R&D program will continue to be a valued, strategic and innovative partner, a catalyst for innovative solutions, a recognized authority, and a contributor to Canada's international role in R&D and policy.**

[1]2001 PEER REVIEW Research and Development Program, Meteorological Service of Canada, Environment Canada (http://www.msc-smc.ec.gc.ca/acsd/index_e.html



Link Between the Strategic Objectives, R&D Program Elements and Key Issues

Each of the strategic objectives requires coordination across the various R&D program elements and each addresses several key issues.

Strategic Objective	R&D Program Elements	Key Issues to be Addressed
1. Risk-based decision making – minutes, days and weeks	weather, water, air quality, science assessment, knowledge and technology transfer, outreach and education	High impact weather (health, safety, security), extreme hydrological events, water quality, smog, stratospheric ozone, biometeorology, science capacity, national lab implementation, Arctic
2. Risk-based decision making – weeks, years and centuries	weather, climate, air quality, water, science assessment, impacts and adaptation, knowledge and technology transfer, outreach and education	High impact weather, climate variability and change, smog, acid rain, toxics, water availability, cryosphere, health, biometeorology, security, Canada's infrastructure, energy, agriculture, environmental assessment, ecosystem health, science capacity, Arctic
3. Past and present states of the environment	all	Data density, quality and diversity in support of strategic objectives 1 and 2, new observing technologies and strategies, data assimilation and analytical tools, new analytical capabilities

NOTE: weather, climate, air quality and water research include data methods, data assimilation, process research, modelling and applications

ONE PAGE OVERVIEW

The following table provides a one-page overview of the strategic plan.

MSC VISION
Essential national institution; Catalyst and partner for innovative services; Recognized authority and source of science; Accountable to Canadians; Contributor to Canada's international role; Valued and innovative partner

MSC R&D STRATEGIC INTENT – Supporting risk management decisions by ministers, Canadians, industry, policy makers and other decision makers. We will initially focus on research which leads to more informed risk management decisions, increasing the opportunities and reducing short and long term vulnerabilities caused by changes in the atmosphere, climate, hydrosphere and cryosphere with impacts in the areas of health, energy, agriculture and Canada's essential infrastructure.

Strategic Objective	Strategic Objective	Strategic Objective
1 Support risk-based decision making involving high impact atmospheric and related environmental events on the scale of minutes, hours, days and weeks.	**2** Support risk-based decision making involving atmospheric and related environmental change and variability on the scale of weeks, months, years and centuries.	**3** Consistent, coherent and integrated picture of the past and present state of the atmosphere and related environment.
R&D Outputs (examples) Air quality predictions down to urban scale (2012) Mesoscale windows at 1 km resolution (2008) Implement science assessment recommendations on high impact weather capabilities (2008) National/regional communication tools in place (2006) Workstation program operational (2006) Assess vulnerabilities to high impact events(2005) National labs in place (2005) Global mesoscale weather model (2004) 4-D Var operational (2004)	**R&D Outputs (examples)** Regional climate model at 25 km resolution (2012) Chemical weather predictions on regional scale (2008) Fourth IPCC Assessment (2007) Assess impacts of regional climate change on air quality and environmental cycling of toxics (2007) Assess economic vulnerability, impacts and adaptation options for forestry (2005), agriculture (2007) and energy (2007)	**R&D Outputs (examples)** CloudSat (2006); HYDROS (2010); GPM (2010); EOS (2012) Troposheric and stratospheric profiles as contribution to GEO (2008) Track and assimilate antecedent conditions (2007) Interactive carbon cycle in GCM (2007) Tools for post-event analysis (2006) Comprehensive proxy data sets extending back 500 years (2006)

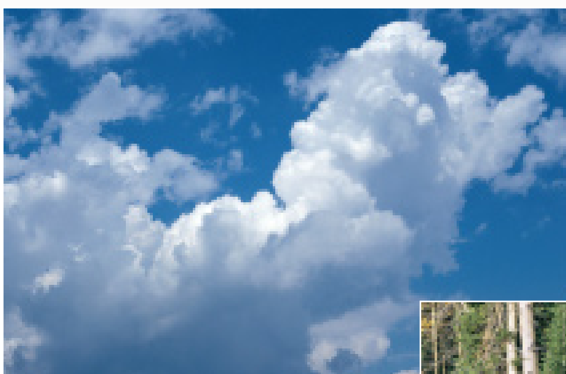
Key Assumptions –Computing power, availability of supercomputer and mass storage; Data density, frequency, quality and metadata; Human health and effectiveness of Canada's health system a growing issue for federal and provincial governments; Funding for climate research inside/outside of government; Environmental prediction tools effective on key departmental issues; Telecom capacity available for mesoscale data, etc.; Able to get high impact event information into emergency plans

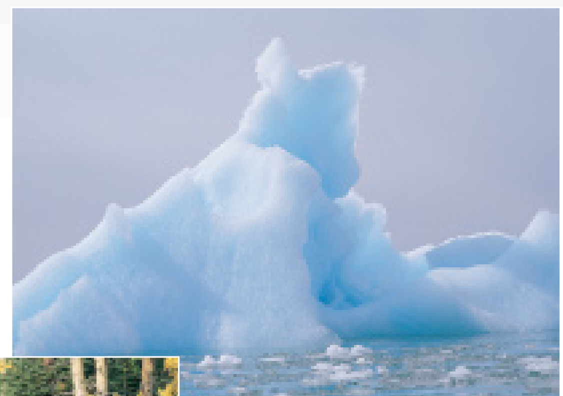
MSC R&D VALUES – Scientific excellence; Straight talk; Responsiveness; Trust and integrity; "Walk the talk", Science; Leadership

MSC R&D PRINCIPLES – (based on the SAGE Principles) Early identification; Inclusiveness; Sound science and science advice; Uncertainty and risk; Openness; Review

MSC R&D MISSION – To develop, apply and provide unbiased, relevant and scientifically sound knowledge, advice, data and information and build Canada's science infrastructure on the atmosphere and related environment.

INTRODUCTION





INTRODUCTION 1

1.1 PURPOSE OF THIS DOCUMENT

This plan outlines the strategic direction of MSC's R&D program over the next 10 years. It is designed as an evolving tool to meet the strategic and near-term planning needs of the MSC R&D staff and management and to help stakeholders understand and participate in our future directions. In some ways, research is a "journey without maps", yet it is still prudent to plan towards long-term objectives which challenge us and ensure that we remain relevant to the MSC and the Department and raise the visibility of the MSC R&D program.

This document also provides the framework needed for consistent one-pass planning. It will be used as the basis for developing a three-year business plan (coincident with the Department's business planning cycle), provide input to the Department's Report on Plans and Priorities, and allow managers to develop performance management agreements. Finally, this plan provides the context for responding to the recommendations of the 2001 international peer review.

Beginning with a brief discussion of the breadth and achievements of the current program (chapter 2), the document provides an understanding of the clients' needs over the next decade and presents a mission statement (chapter 3). It then builds a case for, and defines how we will achieve our three strategic objectives (chapter 4) for the year 2012 and measure success in terms of intermediate goals and outcomes (chapter 5), values and principles (chapter 6).

This plan outlines a tremendous amount of valuable work as defined by our clients. Due to the volume, scope and scale of the work, we will need to engage others through research networks, ventures, partnerships and advocacy.

1.2 PERSPECTIVES ON THE NEED FOR A STRATEGIC PLAN

The need for innovative, multidisciplinary and multilateral solutions based on scientific excellence is increasing due to the globalization of environmental and economic issues, the complexity and linkages between these issues, and the redistribution of federal R&D resources to external research institutions.

MSC R&D, through a strong foundation of scientific excellence, lends integrity and quality to MSC's products and services and the Department's policy development. Since science operates on much longer time lines than operations or policy, there is a corresponding need for a framework which helps MSC make decisions about the longer term and ensures that we will continue to have the capacity to deliver the R&D and innovative solutions that are critical to federal policy and services. Some of the decisions we need to make are:

- How do we decide what investments (skill sets, equipment, partners, etc.) are needed to help the MSC realize its vision and support the needs of MSC, its partners, domestic and international policy and decision-makers, and Canadians? (Currently we invest about $45 million[2] per year – or about 1/2 billion dollars over the next 10 years)
- How do we provide continuity during changes in leadership?
- How do we provide leadership in times of uncertainty?
- How can we best integrate MSC R&D with other R&D in the Department and across government?
- How do we decide which opportunities to pursue?
- How do we respond to the recommendations of the recent Peer Review of MSC's R&D?
- How do we respond to the constant change and sometimes confusing signals about the future of government-based R&D, the needs of the Department and our own programs?
- How do we build advocates for our R&D program?

Strategic planning also complements and responds to many government initiatives and directions. For example, the strategic planning process:

- Clearly complements the **STEPS (Science and Technology Excellence in the Public Service –** http://www.csta-cest.ca/index.php?ID=74&Lang=En) Framework by allowing R&D to demonstrate leadership within a science-based organization, ensure the relevance of what we deliver, understand risks and opportunities, create scientific values and principles, ensure excellence and facilitate the peer-review process.

[2]Includes about $36.5 million in tax appropriations and another $8 million from other sources (e.G., PERD, CCAF, NSERC)

- Provides a framework within which to respond to the recommendations on managing government S&T discussed in the **EDGE (Employees Driving Government Excellence** –http://dsp-psd.communication.gc.ca/Collection/IU4-20-2002E.pdf) Report (Response to the Council of Science and Technology Advisors (Draft report June 2003).
- Responds to the Auditor General's report on ***Attributes of Well-Managed Research Organizations*** (November 1999 – http://www.oag-bvg.gc.ca) by, amongst other things, helping to co-ordinate cross-sector research activities, anticipating future challenges while staying focussed on long-term goals, and creating clear targets on time scales that are meaningful to the S&T community and the research process.
- Provides a coherent framework to ensure results for Canadians by driving the 3-year business planning cycle, the performance management agreement exercise and allows us to plan ahead for the skill sets, partnerships and other resources we will be needing.
- Responds to staff's need to know where we are going (a point which has been clearly made in the last two ***Public Service Employee Surveys***).

1.3 TERMINOLOGY

The following terms used throughout this document should be interpreted as indicated below. (Annex 5 contains a complete glossary.)

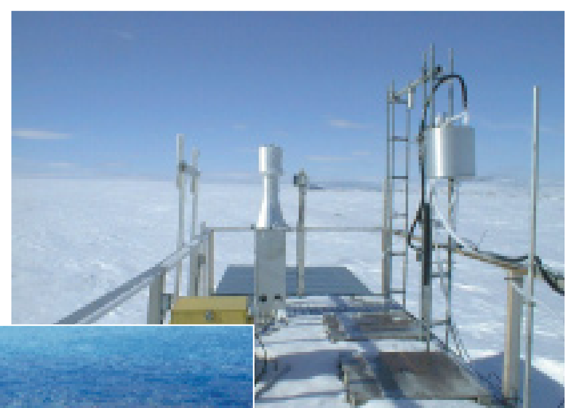
MSC R&D is delivered through a partnership between the MSC Headquarters science components and the atmospheric and related environmental science units in the EC Regions who together carry out scientific activities (e.g., mission-oriented R&D, applied science, knowledge and technology transfer, communications, science assessment, etc.). This means that MSC R&D includes:

- The complete Science Function of the Weather and Environmental Prediction (WEP) Business Line of Environment Canada.
- MSC's air quality science program which falls under the Clean Environment Business Line (e.g., acid deposition, HAPS, air quality prediction and support to policy).
- Other science activities such as: ice R&D, marine weather R&D (including hurricane science), environmental emergency response development and production automation R&D which have not been captured properly in the financial coding system as R&D activities.

Atmosphere and related environment refers to ***atmosphere*** (weather, climate, air quality, and stratosphere), ***hydrosphere*** (rivers, lakes and oceans), ***cryosphere*** (snow and ice), and the ***linkages with the surface*** (e.g., biosphere) and includes applications such as environmental prediction.

Multidisciplinary environment indicates that: i) MSC R&D often includes disciplines (e.g., hydrology, oceanography, chemistry, biology, geography and social sciences) in addition to the traditional mathematics and physics; and/or, ii) the outcome of MSC R&D is used directly in fields other than meteorology (e.g., engineering, agronomy, forestry).

BREADTH AND SOME MAJOR ACHIEVEMENTS OF THE MSC R&D PROGRAM



BREADTH AND SOME MAJOR ACHIEVEMENTS OF THE MSC R&D PROGRAM 2

2.1 BREADTH

The MSC R&D Program includes the following components: meteorological research (including ice and water quantity), climate research, air quality research (including the stratosphere), adaptation and impacts research and science assessment. The research activities include the development of ground, space-and aircraft-based measurement technologies, systematic observations, remote sensing, field and laboratory process studies and the development of numerical models (meteorological, hydrological, climate, ice and air quality). It also includes impacts and adaptation research on atmospheric change and science assessments on the state of the science of key policy related issues.

Scientists use models to further test hypotheses by comparing model outputs with past and present observed data. The goal is to integrate knowledge from research elements into environmental predictions and simulations. These then become the scientific foundation for weather forecasts, air quality advisories, climate change projections and flood and ice advisories. MSC R&D also provides the scientific underpinning for a wide range of government policy initiatives such as national air quality standards for air pollutants, the Canada-US Air Quality Accord, the Montréal protocol on depletion of the ozone layer, the Stockholm Convention on Persistent Organic Pollutants and the Kyoto protocol on climate change.

Science assessment and integration of environmental issues across disciplines is critical to ensuring that our environmental policy is based on sound science. A science assessment provides a critical review and synthesis of the state of knowledge on a particular issue. A formal science assessment integrates knowledge from different environmental disciplines, details the current uncertainties of the science and their implications for public policy and provides a means to monitor the effectiveness of policies that have been implemented. The scope of activity may range from local through regional and national to international. For the public, it describes the science behind the issue, and for the research community it provides feedback with respect to future research needs.

2.2 MAJOR ACHIEVEMENTS

The strength and excellence of MSC science make it a significant contributor in many international arenas. Canadian Global Climate Models (GCMs) are among the best in the world and were used extensively in the Third Assessment Report of the Intergovernmental Panel on Climate Change – an international panel of climate experts.

Many of MSC’s air quality monitoring stations are part of the World Meteorological Organization’s networks helping the scientific community to maintain a watch over global environmental issues such as greenhouse gases, stratospheric ozone, acid rain, and the bioaccumulation of toxic pollutants.

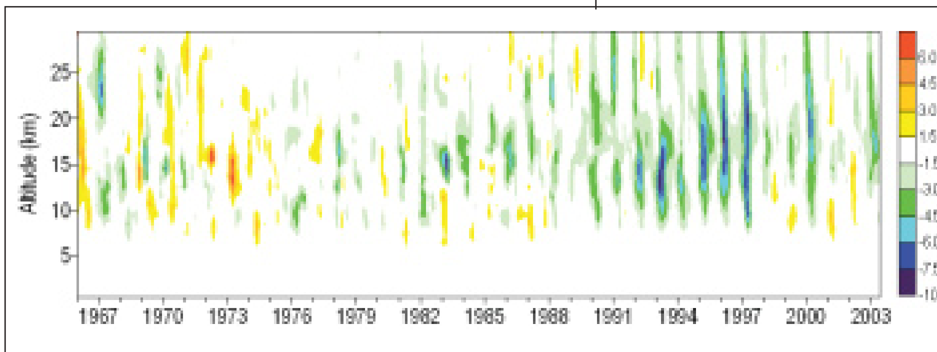
In some cases, MSC R&D components are the ***world leaders***. For example:

- The MSC leads the world in cloud physics instrumentation and data analysis.
- The numerical dynamic core of the Global Environmental Model (GEM) for numerical weather prediction represents the leading edge of the science.
- The Research Data Management and Quality Control System (RDMQ™) has received worldwide attention and been adopted by other agencies including the World Meteorological Organization's (WMO) World Data Centre for Precipitation Chemistry and the United States Environmental Protection Agency (EPA).
- The Brewer spectrophotometer, developed by MSC scientists, is now used worldwide for monitoring stratospheric ozone and UVB.

In several areas, the MSC R&D program components are ***world class*** – representative of the best that the global science community has to offer.

- Notable among these is the Canadian climate modelling capability. The Canadian climate model and the United Kingdom's Hadley Centre climate model were recently used by the United States for input into the national climate impacts assessment.
- Researchers worldwide have used Canada’s world-class measurements of greenhouse gases to investigate the global carbon cycle and climate change.
- Canadian science has been fundamental in formulating international protocols for the long-range transport of persistent organic pollutants and heavy metals.

Long term vertical ozone distributions over the Canadian Arctic from 1966-2003 with the annual average for 1966-1997 subtracted from the data to show concentration deviations from normal. The green and blue areas indicate lower than normal ozone concentrations, and are evident in the recent years (1993, 1995, 1996, 1997, 2000, 2003). These major losses occur in late winter - early spring. (The data are in Dobsin Units (DU) per km which is equivalent to 0.01 mm thickness at standard temperature and pressure.)



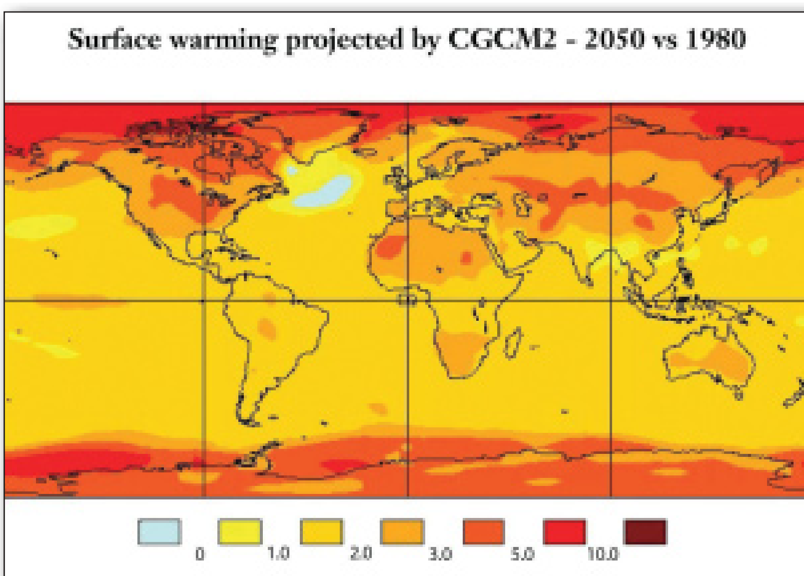
In several cases the MSC R&D components represent the ***best available science within Canada***. One example is the capability within MSC for sophisticated data assimilation methods vital to state-of-the-art numerical weather, air quality, and climate prediction. Many of the laboratory capabilities within air quality research are the best in Canada:

Other notable MSC R&D achievements include:

- Doubling the range and halving the cost of Doppler radar measurements.
- Developing and implementing the Unified Radar Processor (URP) which is the world leading radar applications operational software.
- Developing fog collectors to provide remote arid communities with safe drinking water.
- Characterizing aircraft icing conditions for safe flights in northern climates.
- Developing the first operational storm surge prediction system for coastal communities.
- Determining the chemistry and pathway of toxic chemicals in the Arctic.

For further information on the breadth of the program and accomplishments to date, please see http://www.msc-smc.ec.gc.ca/acsd for the following documents:

- *"Atmospheric and Climate Science Directorate Research and Development Activities Report to 2002."*
- *"Atmospheric and Climate Science in the Meteorological Service of Canada; Research Making a Difference"*



THE RAISON D'ÊTRE OF MSC R&D

3 THE RAISON D'ÊTRE OF MSC R&D

3.1 CHARACTERISTICS

In defining the raison d'être of MSC R&D, we have made the following assumptions:

i. Strongly based on a foundation of scientific innovation and excellence, MSC R&D lends integrity and quality to MSC's products and services. The health of MSC R&D provides an indicator of the health of the MSC.

ii. MSC R&D is primarily mission-oriented. Driven by scientific excellence, it is results-based and produces outputs (e.g., peer-reviewed journal papers, new measurement technologies, data, models, assessments, advice, operational tools, information, knowledge, etc.) which are used by its clients.

iii. Because of the scale and scope of atmospheric and related environmental R&D, collaboration is essential. With the Canadian government increasingly investing in research outside of government labs, more collaboration with academia, science-based organizations and others are required to deliver the MSC R&D program.

iv. MSC must have a strong internal R&D capacity to manage the external science programs (assumption iii) and ensure that the science and technology needed by policy developers, decision-makers and providers of essential government services is developed and effectively transferred (assumptions i and ii).

v. Government allocations for MSC R&D allocations will remain flat-lined and it will be necessary to reallocate resources within the R&D budget in response to changing priorities.

vi. The Atmospheric and Climate Science Directorate (ACSD) has a leadership role in defining and implementing the MSC's research and development agenda, its ethos and raison d'être, and ensuring the scientific excellence of the MSC R&D program.

vii. The MSC Regions are primarily involved in applied R&D (responding to Regional science issues, applying research outputs, developing scientific tools to meet client needs), building capacity in environmental prediction and in technology transfer.

MSC R&D has many strengths some of which make it distinctive and/or unique within the Department, government and academia. This distinctiveness means that we have the capacity to meet and provide added value where few others could at this time. In the cases where we have a strength that is unique, our clients should recognize the importance of our work and may become advocates of our program.

The following is a short list of the areas in which MSC R&D has strengths that make it distinct and possibly unique. (Annex 2 provides another list of strengths which MSC R&D shares with other well-managed R&D programs.)

- Since the atmosphere knows ***no political boundaries***, the MSC R&D has a multi-decade history of ***global collaborations and cooperation*** at the scientific and technical levels. As one of the founding members of the World Meteorological Organization of the United Nations, Canada is now one of 186 member nations.
- MSC R&D is the ***only Canadian government source*** of meteorological science in support of its ***essential real-time prediction services*** on all time and space scales (weather, ice, EER, water quantity) and Canadian public policy (climate change, stratospheric ozone, ***Canada Wide Standards***, acid rain, environmental assessment, etc.).
- MSC R&D encompasses laboratory and field measurements, systematic observations, remote sensing, data assimilation and analysis, field and process studies and environmental modelling.
- MSC R&D incorporates the science assessment function that integrates MSC science with that from other sources and disciplines and communicates the state of the knowledge on specific issues to policy and decision-makers.
- MSC R&D includes research on the impacts of atmospheric and related environmental change, and on adaptation strategies that can be used to reduce social, economic and environmental vulnerabilities.
- MSC R&D ***affects the lives and businesses*** of virtually every Canadian every day.

3.2 COMMUNITIES OF INTEREST AND THEIR NEEDS

MSC R&D serves a diversity of communities of interest and Annex 3 provides examples of clients in each of the following communities.

- Providers of essential government services
- Private sector
- General public
- Domestic and international scientific bodies
- Domestic and international policy and decision-making bodies

To meet the needs of clients requires resources and capacity internal and external to the MSC. We have identified the following internal requirements:

a) A capacity to improve the accuracy and utility of MSC's existing atmospheric and related environmental products.

b) A capacity for the MSC to develop and test new products and services in response to its clients' demands.

c) Scientific data, knowledge, information and advice for domestic and international policy and decision-makers to understand and reduce new and existing vulnerabilities of ecosystems due to a changing environment (climate change, atmospheric chemistry, UV, water issues) and economic development (e.g., energy, industry, roads, pesticides, emerging toxic chemicals, environmental assessments).

d) Scientific tools (applications, advice, impact studies and assessments) which help federal, provincial and municipal decision-makers understand and reduce new and existing social and economic vulnerabilities (e.g., extreme weather, climate change, building codes, waterborne disease, EER, etc.) of their citizens.

e) A capacity to build the Canadian public's knowledge, awareness and understanding of atmospheric and related environmental issues that affect their health, safety and wealth.

f) A capacity to set measurement technology standards and improve the accuracy of atmospheric and related environmental measurements in support of improved services, policy development and evaluating the impact of implemented policies.

g) A capacity to build Canada's science infrastructure (e.g., databases, models, observation networks, science networks, experts, scientific facilities) in atmospheric and related environmental R&D and/or be a leader to coordinate such R&D to meet federal government needs.

h) A capacity to identify potential new atmospheric and related environmental threats affecting the safety and security of Canadians.

3.3 MISSION FOR MSC R&D

The following mission statement was approved at the January 17, 2003 WEPSAC and January 27, 2003 ACSD Management Committee.

The mission of MSC R&D is to develop, apply and provide unbiased, relevant and scientifically sound knowledge, advice, data and information, and build Canada's science infrastructure on the atmosphere and the related environment so that:

- The MSC and its collaborators provide accurate and useful products and services to the satisfaction of their clients.
- Domestic and international policy and decision-makers have the knowledge required to reduce emerging and existing social, economic and environmental vulnerabilities caused by a changing environment and economic development.
- Canada participates, influences and benefits from the unbiased and credible science needed to address domestic and global environmental issues.
- Canadians have the knowledge, awareness and understanding of atmospheric and related environmental issues which affect their health, safety and economic opportunities.

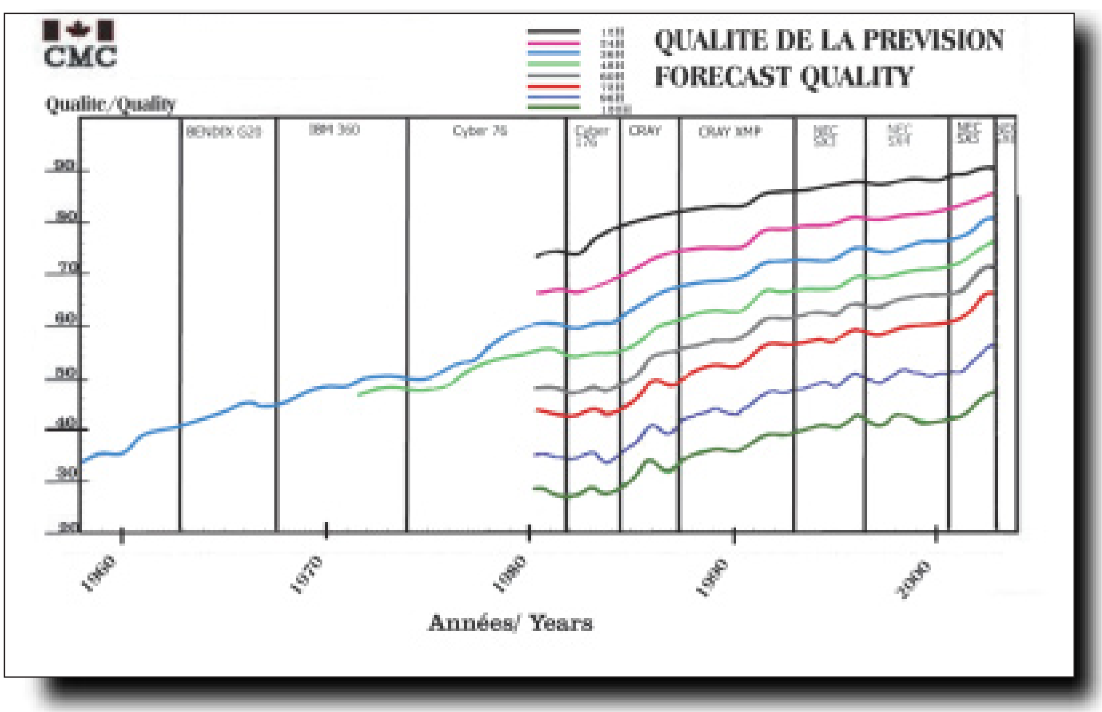
3.4 IMPLICATIONS OF THE MISSION STATEMENT

There are many implications of the mission statement – obviously we must have the capacity to deliver on the client needs specified above and work within the laws of Parliament and the principles/guidelines/directives of public sector management. But what else is ***implied*** by the mission statement about how we run the science program?

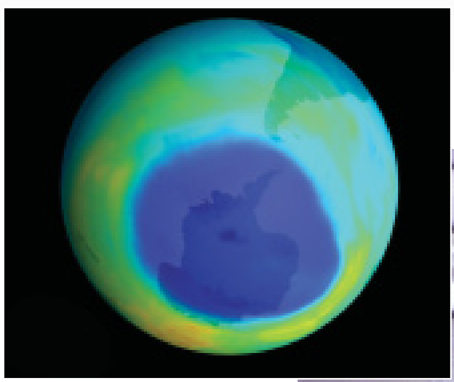
Based on the mission statement, here are four obligations on how we run the science program. These obligations agree well with the "characteristics" of MSC R&D as well as its values and principles.

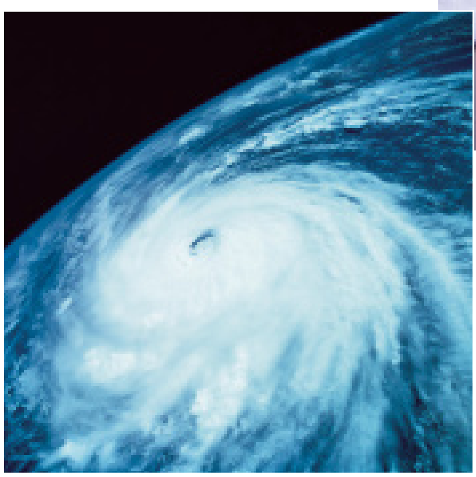
- *Achieving science excellence* – to produce high quality, leading edge, credible and unbiased science which is relevant to our clients' needs and makes us leaders in Canada.
  - Quality – to measure the quality and impacts of our outputs and report on these to the client and to Parliament.
  - Credible and unbiased – to deliver science which is politically independent and stands the test of "time".
  - Relevance – to understand the needs of our clients which may require knowledge of their decision making processes, products and/or services. We can then translate those needs into planning objectives. In cases where a policy client needs an "immediate response", we need to provide as much relevant science as possible while proceeding to address the client's uncertainties.
- ***Managing intellectual capital*** – to stimulate R&D in Canada, to engage the needed collaborations, develop the right skill sets, protect intellectual properties and balance creativity, curiosity and innovation with the need for mission-driven research.
- ***Delivering a national program*** – to ensure a nationally coherent program that can meet the changing and Regional specific needs of Canadians and our other clients.
- ***Encourage advocacy for atmospheric science*** in the context of managing risks to human health and safety, domestic security, economic efficiency and ecosystem health.

The scale and scope of atmospheric and related environmental R&D makes collaboration essential. Today's issues require multidisciplinary and multi-scale solutions which can be applied multilaterally.



STRATEGIC OBJECTIVES AND LONG-TERM DIRECTIONS OF MSC R&D





STRATEGIC OBJECTIVES AND LONG-TERM DIRECTIONS OF MSC R&D 4

4.1 STRATEGIC INTENT

The strategic intent of MSC R&D over the next 10 years is to provide the science capacity that will lead to more informed risk-management decisions in support of risk-based decision making by ministers, Canadians, industry, policy-makers and other decision-makers. We will focus on atmospheric and related environmental research that leads to improved risk management decisions – increasing the opportunities and reducing the social, economic and environmental vulnerabilities (especially in the areas of human health, energy, Canada's built infrastructure and key economic sectors), including the long-term vulnerabilities caused by changes in the atmosphere and related environment.

4.2 STRATEGIC OBJECTIVES AND CHANGING ROLES

Based on the MSC vision (attributes for 2011), and the mission and strategic intent for MSC R&D, we are committing to the following strategic objectives for 2012.

1. Support risk-based decision making affecting Canadians' safety and security, their economy and the environment due to high impact atmospheric and related environmental events (weather, air quality, hydrologic and oceanographic) on the scale of minutes, days and weeks.
2. Support risk-based decision making affecting Canadians' security and health, economy and the environment due to changes and variability in the atmosphere and related environment on the scale of weeks, years and centuries.
3. Provide a coherent and consistent picture of the present and past states of the atmosphere and related environment.

Annex 1 shows the links between these R&D strategic objectives and the MSC Attributes for the year 2011.

In moving towards these strategic objectives, MSC R&D will see its role increase in the following areas:

- *Technology transfer (Outgoing)* – MSC R&D, through a strong foundation of scientific excellence, lends integrity and quality to MSC products and services and the Department's policy development. However, R&D has more relevance and provides the most value to the organization and others when we transfer the knowledge to others, including academia. Technology transfer includes presenting papers at various (domestic and international) fora, helping to implement new process research, participating in model intercomparisons, and assisting in developing new forecast and model applications. Technology transfer will become more important as we move to new measurement technologies, finer and more comprehensive models, respond to the diverse and growing need for more environmental predictions and applications, and contribute to the success of the MSC Transition.
- *Technology transfer (Incoming)* – The MSC R&D program benefits from many domestic and international R&D networks. Through these networks we frequently exchange knowledge, data and expertise. Technology transfer will become more important as academia becomes more involved in public policy issues and MSC develops more research networks to meet the needs of the new national labs.
- *Scientific Applications* – MSC R&D will improve its capacity in environmental prediction especially in areas that affect health, safety, security, economy and environment. For example, MSC R&D will develop biometeorological models to help various decision-makers protect vulnerable populations from excessive heat and poor air quality; MSC R&D will also apply climate predictions to help decision-makers in several economic sectors such as agriculture, forestry, transportation and energy.
- *Communicating Science* – MSC R&D will engage clients (including the public and policy-makers) to help them understand their sensitivity to uncertainty, and develop a mutual understanding of risks, needs and the degree to which science can address their issues. While continuing to transfer knowledge (building awareness, creating understanding, promoting the need to act and providing the decision-making tools for taking action), MSC R&D will also encourage advocacy for atmospheric science. This is especially true in the area of managing risks to human health and safety, domestic security, economic efficiency and ecosystem health.
- *Science of Data* – Data is a core need of all MSC programs, including R&D. As computer models go to finer time and space scales and become more comprehensive, MSC R&D will require more types of data measured at increasingly finer space and time scales and the ability to assimilate those data in the predictions and analyses. Resolving the data density,

quality and diversity issues will require increased collaboration, new technologies and approaches to measurement, a capacity to exploit the explosion of remotely sensed data, and a means to define the social and economic value of data.

- ***Multidisciplinary solutions and synergies*** – As scientific issues grow more complex and interrelated, the need for multidisciplinary solutions increases. The MSC is fortunate to have meteorology, climate, ice, and atmospheric chemistry R&D, along with capacities in science assessment and impacts and adaptation under one roof. However, there is a need for more coordination between the main ***research areas*** (e.g., process research, data, modelling, etc.) and between the ***disciplines*** especially for issues such as high impact weather, toxics, climate change, oceans, ice and the Arctic. In addition, MSC R&D needs to create more synergies with our monitoring colleagues to advance observing systems within the MSC.
- ***Partnerships and Collaborations*** – With the growing scope and scale of atmospheric and related environmental R&D, international and domestic collaborations are essential. While partnerships are a valid means to share expertise, data and other resources, MSC R&D needs to recognize that there are costs and risks to all partnerships. We need to examine all existing and potential partnerships with our eyes wide open to the benefits and costs of such arrangements. One area where we expect partnerships to grow is with Canadian universities. This is because the Canadian government is increasingly using mechanisms such as CFCAS and CFI to fund public policy research in universities.
- ***Ice research*** – As we move towards higher resolution models and do more research on climate change in the Arctic, there will be an increasing need to integrate more ice research into the MSC R&D program. This research will feed into policy development, services and provide knowledge and data for other research programs.

4.3 STRATEGIC OBJECTIVES, R&D PROGRAM ELEMENTS AND KEY ISSUES

Each of the strategic objectives requires coordination across the various R&D program elements and each addresses several key issues.

Strategic Objective	R&D Program Elements	Key Issues to be Addressed
1. **Risk-based decision making – minutes, days and weeks**	weather, water, air quality, science assessment, knowledge and technology transfer, outreach and education	High impact weather (health, safety, security), extreme hydrological events, water quality, smog, stratospheric ozone, biometeorology, science capacity, national lab implementation, Arctic
2. **Risk-based decision making – weeks, years and centuries**	weather, climate, air quality, water, science assessment, impacts and adaptation, knowledge and technology transfer, outreach and education	High impact weather, climate variability and change, smog, acid rain, toxics, water availability, cryosphere, health, biometeorology, security, Canada's infrastructure, energy, agriculture, environmental assessment, ecosystem health, science capacity, Arctic
3. **Past and present states of the environment**	all	Data density, quality and diversity in support of strategic objectives 1 and 2, new observing technologies and strategies, data assimilation and analytical tools, new analytical capabilities

NOTE: weather, climate, air quality and water research include data methods, data assimilation, process research, modelling and applications

4.4 OVERVIEW OF STRATEGIC OBJECTIVE

"Support risk-based decision making affecting Canadians' safety and security, their economy and the environment due to high impact atmospheric and related environmental events (weather, air quality, hydrologic and oceanographic) on the scale of minutes, days and weeks."

4.4.1 The Need for Change

High impact events directly affect the health, wealth and security of all Canadians.

High impact events (e.g., heat waves, tornadoes, hail, ice storms, floods, poor air quality and drought) directly affect the health, wealth and security of all Canadians, our economic efficiency and competitiveness and environmental quality. The following table, based on information from the Munich Re-insurance company and the ICLR, demonstrates the economic impact of high impact events in Canada.

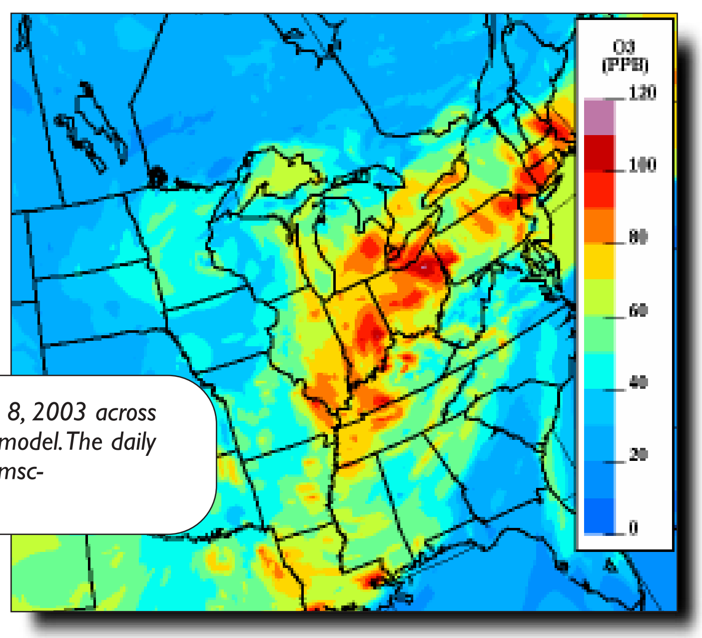
High Impact Event	Year	Economic Loss ($ millions)
Eastern Canada ice storm	1998	5,500
Forest fires	1989	5,000
Prairie drought	1980	3,000
Ontario winter storms	1993	2,500
Saguenay flood	1996	1,200
Calgary hailstorm	1991	600
Red River floods	1997	400
Southwest BC blizzard	1996	200
Barrie tornado	1985	200

Sound science provides the foundation for effective policies and the integrity of essential government services.

These events affected much more than the economy; they also caused deaths, affected Canadians' health, disrupted their lives and damaged ecosystems. Whether a high impact event becomes a catastrophe or not depends on the integrity of the essential infrastructure (electricity, telecommunications, roads, etc.), capacity of first responders and the resiliency of communities.

Sound science provides the foundation for the critical policies and essential services needed to manage the risks of high impact events. The importance of atmospheric and related environmental R&D increases as Canadians become more vulnerable to changing weather and environmental conditions. Canada's change in vulnerability arises as the population concentrates in urban areas, the infrastructure ages and new technology creates complex but vulnerable production and delivery systems. The Institute for Catastrophic Loss Reduction (ICLR; http://www.iclr.org) states, "Catastrophic losses threaten to occur more frequently in the future... This growing threat could seriously undermine our social and economic viability."

Since the atmosphere and hydrosphere can transport various chemicals and other hazardous materials vast distances, risks can come to Canadians from afar. Economic development, increasing energy use and production, locally and around the world, also contribute to the risks and vulnerabilities of Canadians.



The distribution of ground-level ozone for June 8, 2003 across North America as forecast by the CHRONOS model. The daily forecasts can be viewed on-line at http://www.msc-smc.ec.gc.ca/aq_smog

Risks can be from several cumulative events and originate outside of Canada.

The highest risks are not usually from a single high impact event, but from several cumulative events over time. These events can have trickle-down effects on the social and economic systems for years to come. Examples of cumulative events include:

1. The prolonged heat wave (likely combined with poor air quality) that caused some 11,000 premature deaths in France in 2003
2. The Walkerton water-borne disease outbreak (caused by cumulative rainfall events coupled with infrastructure problems and farming practices) that killed over 20 and sickened some 2200 people,
3. The 2000+ premature deaths in Ontario every year due to poor air quality (some of which is transborder and is exacerbated by high heat).

Canada must have the science capacity to deal with multidisciplinary issues on various time and spatial scales.

To manage the risks to its social, economic and environmental systems, Canada needs the science capacity to provide the foundation for, and integrity to, essential government services and effective policy advice. That science capacity must deal with multidisciplinary issues on many time and space scales and consider the complex chemical and physical interactions at various space scales.

Through this strategic plan, MSC R&D, in collaboration with others, will provide sound scientific solutions (knowledge, data, advice, etc.) supporting client needs in the form of:

- Increased lead time and accuracy for high impact events such as severe weather, poor air quality and drought; real-time prediction of precipitation at the watershed level; real-time monitoring of antecedent precipitation conditions (e.g., state of water balance).
- Improved predictions of air quality conditions at a smaller scale (regional or city scale); inclusion of more chemical species in the predictions.
- Short and long-range dispersion predictions for hazardous substances and radiological releases.
- Extreme weather climatologies and statistical tools (extreme precipitation frequency, intensity/duration curves, etc).
- Vulnerability assessments, adaptation strategies (emergency readiness, building codes) and advice to promote resilient communities now, and under a climate changed scenario.
- Predictions of situations which could produce increased mortality based on weather and air quality factors.
- Hydrodynamic and dispersion modelling of petroleum and other pollutants in inland waterways.

4.4.2 Scientific Focus and Strategies for Change

In collaboration with others, MSC R&D will move down certain "roads" and invest in specific areas defined by the following high level strategies.

High Level for Strategic Objective I

- Move to finer time and spatial scales for predictions and analyses.
- Shift to probabilistic outputs.
- Increase capacity in environmental prediction (e.g., applications to agriculture, water quality, forestry).
- Promote the need for expanded lists of environmental parameters to be measured on finer space and time scales. Exploit all available data including antecedent rainfall, soil moisture and snow and ice conditions.
- Move towards more integration of models and observations (data fusion).
- Engage clients and stakeholders to develop a mutual understanding of risks, needs and the degree to which science can address their issues.
- Knowledge and technology transfer for mesoscale prediction and analysis to the Regions.
- Define and communicate social and economic vulnerabilities and potential adaptation strategies.
- Develop the capability to demonstrate the social and economic value of improvements in high impact prediction.
- Develop the capacity to transfer knowledge, technology, data and information for all atmospheric issues over a wide range of depths and complexities.

4.5 OVERVIEW OF STRATEGIC OBJECTIVE

2 "Support risk-based decision making affecting Canadians' security and health, economy and the environment due to changes and variability in the atmosphere and related environment on the scale of weeks, years and centuries."

4.5.1 The Need for Change

Physical & chemical processes and socio-economic impacts link the six key environmental issues.

Currently MSC R&D is addressing six key environmental issues: climate change and variability, smog, acidification, stratospheric ozone depletion, hazardous air pollutants (e.g., mercury) and long-range transport of atmospheric pollutants. These are not mutually exclusive issues. For example, science has linked emissions from energy production and use to acid rain, smog, climate change and mercury in the environment. Stratospheric ozone depletion influences climate change and vice versa. We can build on the physical and chemical linkages and the socio-economic impacts of climate variability and change to help address other air issues.

An intricate web of issues requires multi-scale, multidisciplinary and multilateral approaches.

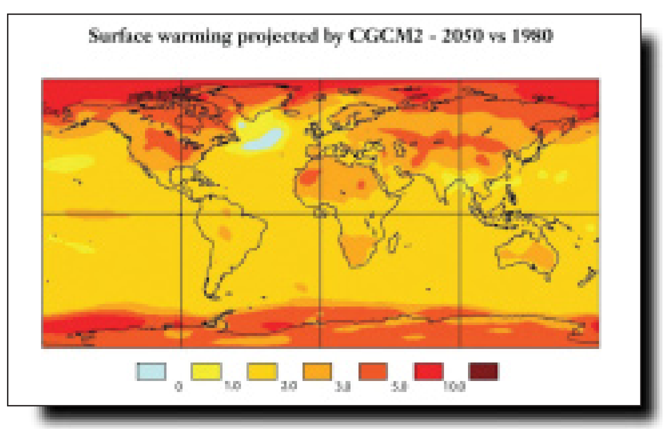
Climate change and variability impact on land use, ecosystem health and water supply. Changes in land use affects community planning, migration routes, habitat availability and water quality. Our changing environment affects the spread of animal diseases, some of which affect humans. The six original environmental issues have created an intricate web of interrelated issues. In addition, there are local, regional and global aspects to these environmental issues. Therefore, we need a collaborative, integrative approach to ensure that the R&D solutions are multi-scale and multidisciplinary and can be applied multilaterally.

Canada's changing environment affects our health, wealth and environment.

Weekly, seasonal and longer term fluctuations in the climate, ozone layer, atmospheric chemistry and hydrology create short and long term threats to our health, economic efficiency and competitiveness and environmental quality. In fact about 1/7 of Canada's GDP is weather and climate sensitive, including key economic sectors such as agriculture, forestry and construction. These and other sectors require more complex and sophisticated decision-making systems to manage their risks. To better manage risks and become more competitive, these sectors require tailored environmental information based on sound science. The quality of Canada's critical infrastructure (telecommunications, roads, bridges, buildings, etc.), and our electrical demands are also directly influenced by our changing atmosphere and the related environment.

Sound science provides the foundation for effective policies and the integrity of essential government services.

Through process research, model development, vulnerability assessments, technology transfer and engaging others through collaboration and advocacy, MSC R&D can help develop adaptation strategies to mitigate the impacts, minimize the risks and identify opportunities. R&D supports decisions affecting economic efficiency, infrastructure and community planning, community resilience, business and environmental management and decisions made by Canadians to safeguard their short and long-term health. In this way, sound science provides the foundation for essential policies and services needed to minimize Canada's social, economic and environmental vulnerability to our variable and changing environment.



Through this strategic plan, MSC R&D, in collaboration with others, will provide sound scientific solutions supporting client needs in the following areas:

- Ability to detect, attribute and understand various climate change processes (e.g., boreal and wetland systems, tundra, farms, etc.).
- Regional scale climate change scenarios and advice; land use change management; impacts in the Arctic (sea ice, permafrost (with impacts on contaminated sites), drilling platforms, etc.), impacts on the hydrological cycle (with applications to water supply, extremes, water apportionment, water export, transportation, irrigation, habitat, etc); frequency and intensity of extreme events (includes vulnerability changes and adaptation strategies); coastal infrastructure; land use change management.
- Seasonal predictions in support of managing risks in key economic sectors (e.g., agriculture, energy and forestry).
- Co-benefits of climate change (building on the physical and chemical linkages and socio-economic impacts of climate change to help address other air issues).
- Support the technology development and mitigation strategies needed to achieve Kyoto targets.
- Understand climate variability and change, and its impact on land use change, habitat loss and biodiversity.
- Coupled atmosphere-ice-ocean-land surface models.
- Photochemical models for regional airsheds.
- Contaminant cycling and accumulation in the atmosphere and terrestrial systems (e.g., mercury in the atmosphere, biosphere, hydrosphere and cryosphere; the role of the atmosphere in making POPs available to bioaccumulate in the food chain).
- More accurate air quality predictions on a regional or city scale; include more chemicals in predictions and analyses (supports development of Canada Wide Standards, analysis of precursors, transboundary agreements, evaluation of emission reduction scenarios, domestic regulations); acid rain and air quality impacts on ecosystems.
- Hydrological analysis for streamflow and transboundary water management.
- Drought monitoring and prediction.
- Options to minimize cross-pollination of genetically modified crops where wind is a factor.

4.5.2 Scientific Focus and Strategies for Change

In achieving the strategic objective #2 and developing the scientific solutions needed by clients, MSC R&D, in collaboration with others, will employ the following high level strategies.

High Level for Strategic Objective 2

- Move to finer time and spatial scales for predictions and analyses.
- Shift to probabilistic outputs.
- Increase capacity in environmental prediction
- Shorten developmental paths for new operational products.
- Engage clients and stakeholders to develop a mutual understanding of risks, needs and the degree to which science can address their issues.
- Move to a science model based on increased collaboration, science networks and advocacy.
- Define and communicate social and economic vulnerabilities and potential adaptation strategies
- Develop capability to demonstrate the social and economic value of improvements in high impact prediction.
- Develop the capacity to transfer knowledge, technology, data and information for all atmospheric and related environmental research issues on a wide range of depths and complexities.

4.6 OVERVIEW OF STRATEGIC OBJECTIVE 3

"Provide a coherent and consistent picture of the present and past states of the atmosphere and related environment."

4.6.1 The Need for Change

Observations are critical to sound science, essential services and policy development.

Data is a core need of the MSC, including the R&D program. Observations are essential to:

- Understanding the past and current behaviour of the atmosphere and related environment.
- Identifying new processes and new chemicals in an environmental system.
- Validating models.
- Predicting future behaviour of the atmosphere and related environment.

➤ Maintaining an archive or climatology to support applications and R&D.

Clearly, responding to the needs of policy developers and essential service providers, and addressing the first two strategic objectives, requires high quality data and data archives.

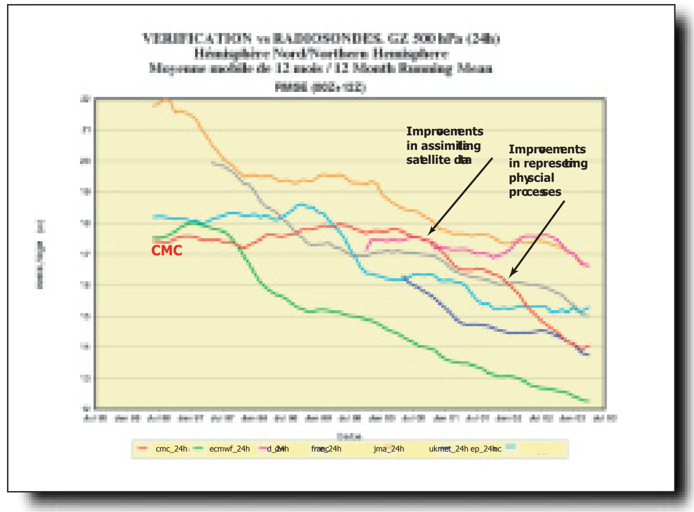
Canada, as part of an integrated global monitoring system, is reducing its investments in data.

Canada, as part of an integrated global monitoring system, is reducing its investments in data.

Canada is already part of an integrated global monitoring system comprising some 190 national meteorological and hydrological services and has data agreements with many agencies. While others (e.g., US, European Union) are investing in their systematic measurement networks, the MSC is reducing its networks in response to budget restrictions.

Need to invest in new collaborations, new technologies and capacity sensed data.

As computer models go to finer time and spacial scales and become more comprehensive (including more complex interactions within the environment), researchers (in Canada and abroad) will need access to more types of environmental data which are measured on finer spacial and time scales. Resolving the data density, quality and diversity issues will require increased collaboration (e.g., provinces and municipalities), new technologies and approaches to measurement, a capacity to exploit the explosion of remotely sensed data from various satellites, and a means to define the social and economic value of data.



Through this strategic plan, MSC R&D, in collaboration with others, will provide sound scientific solutions supporting client needs in the following areas:

➤ Effective MSC systematic monitoring networks, including a better integration of space and ground-based measurements, defining accuracy needs and managing the shift from in-situ to remotely based sensing.

➤ Accurate measurements of water, snow and ice resources.

➤ Post-event analysis tools and tools to calculate the frequency, extremes and trends of high impact events.

4.6.2 Scientific Focus and Strategies for Change

In achieving the strategic objective #3 and developing the scientific solutions needed by clients, MSC R&D, in collaboration with others, will employ the following high level strategies.

High Level Strategies for Strategic Objective 3

- Lead and participate in collaborative programs (domestic and internationally) to improve observing strategies, evaluate measurement systems and better understand the behaviour of the atmosphere and related environmental elements.
- Promote the need for expanded lists of environmental parameters to be measured on finer spatial and time scales.
- Engage clients and stakeholders to develop a mutual understanding of risks, needs and the degree to which science can address their issues.
- Develop high quality data sets to facilitate understanding the behaviour of the atmosphere in time frames ranging from last season to several centuries ago.
- Shorten the development path for assimilating new types of data.

4.7 ASSUMPTIONS, RISKS AND OPPORTUNITIES

The following is a list of major assumptions, risks, and opportunities associated with the strategic objectives. Some of the assumptions are external, the most important of which are those related to health and the economy. There are also assumptions about what we need other parts of MSC to deliver.

The first box lists assumptions, risks and opportunities that are common to all three strategic objectives while subsequent boxes are specific to each strategic direction.

Major Assumptions (common to all strategic objectives)	Risks and Opportunities (common to all strategic objectives)
• Human health, the effectiveness of Canada's health system, the efficiency of the Canadian economy and ecosystem health will continue to be of significant interest to Canadians and their governments. • Computing power will continue doubling every 18 months. • We will have sufficient access to the supercomputer facility. • We will have sufficient access to sufficient mass storage capacity for data and model outputs. • We will continue to have free access to space-based observing systems. • Federal government will provide adequate investment in federal science. • A high degree of collaboration between Canadian and international colleagues will continue. • MSC will continue to influence the direction of R&D in Canadian universities and funding agencies. • We can capture and influence the direction of R&D in universities and external agencies. • An emphasis on communicating science and knowledge to Canadians will continue. • MSC Monitoring Function will provide high quality, reliable data and metadata with spatial and temporal resolution commensurate with client and model needs (new data sources, data QA/QC, validation programs, etc.). Improvements in the measurement of precipitation is especially critical. • MSC National Systems Function can provide sufficient telecom capacity in the Regions for mesoscale data, gridded outputs, etc.	• Opportunity – to engage clients more effectively to build a stronger and more supportive constituency for our work. • Opportunity – Participation in international satellite validation and application studies (CloudSat, EOS, GPM, THORPEX, next generation GOES, etc.) to help optimize systematic networks and position us for rapid application of products to the Canadian environment. • Risk – The shifting balance of technical transfer capability within government to ensure application of Canadian and international research communities to operations. • Risk of harnessing the university and external agency research in the timelines required by policy-makers.

The following assumptions, risks and opportunities are specific to strategic objective #1.

1 Major Assumptions (strategic objective)	Risks and Opportunities (strategic objective)
• MSC will have a Polarized Doppler radar network in place in 2010. • Real-time capacity for mesoscale prediction will exist within CMC with near real-time capacity in the Regions. • MSC Service Delivery Function can work with PSEPC and provinces and municipalities to get high impact event response and mitigation into emergency plans.	• Opportunity – Implementation of National Labs can facilitate technology transfer (Region to Region and HQ to Region) and the development of science networks – it can also balkanize the core science capacity. • Opportunity – Development of military applications for the local area weather warning system.

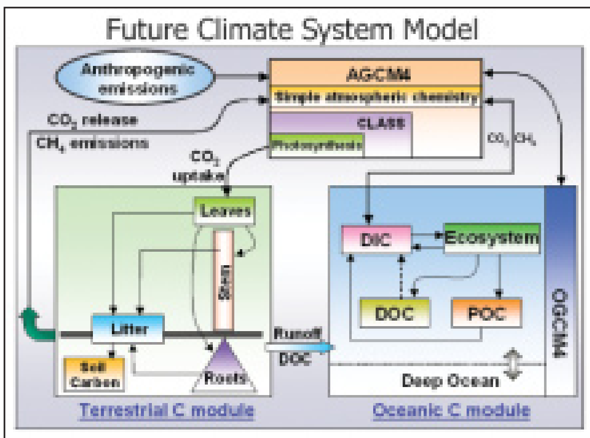
For strategic objective #2...

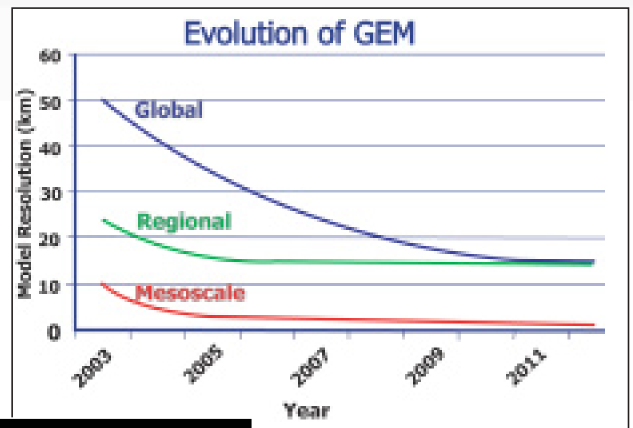
2 Risks and Opportunities (strategic objective)
• Opportunity – To provide direction and coherence to climate science in Canada by leading the development of a national federal plan. • Opportunity – To provide the scientific base for sound adaptation and mitigation policies and measures. • Risk – Federal government reduces/stops funding of climate change R&D now that Kyoto is signed. • Risk – Other groups (e.g., Ouranos) will overtake federal efforts in climate science.

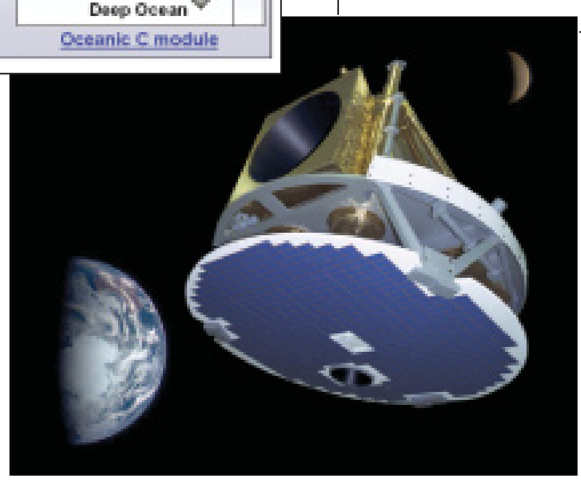
For strategic objective #3...

3 Major Assumptions (strategic objective)	Risks and Opportunities (strategic objective)
• MSC life-cycle manages its mission-critical systematic measurement networks (including CORE), allowing long-term records of high quality data.	• Risk –Need to resolve with AMWSD and Regions, accountability for data analysis and data provision.

OUTPUTS AND EXPECTED OUTCOMES



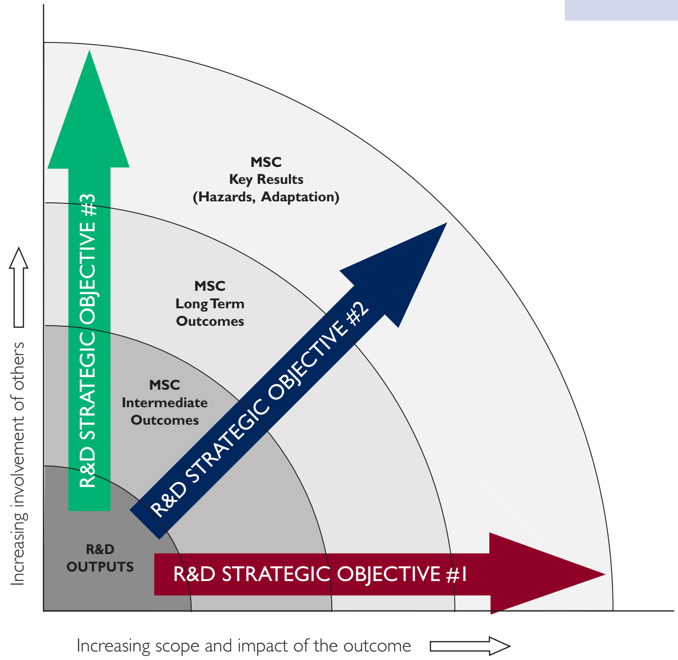




5 OUTPUTS AND EXPECTED OUTCOMES

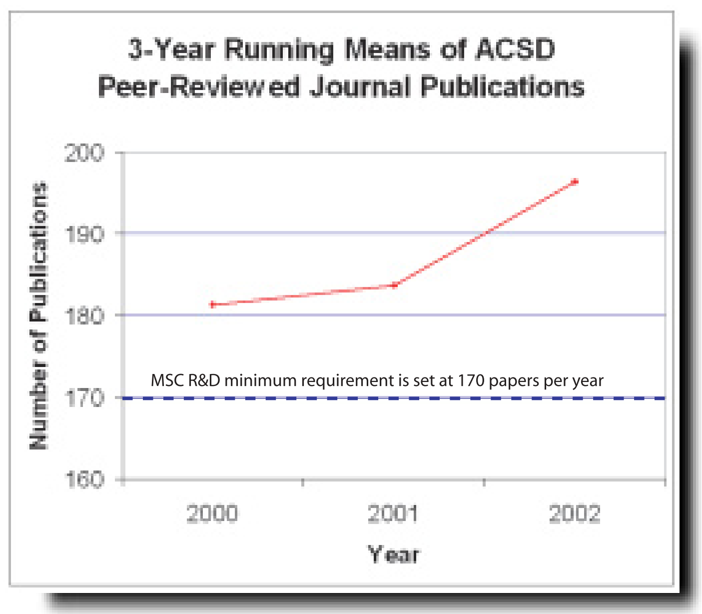
The following tables highlight the MSC R&D contributions to outcomes desired by the whole MSC. As shown in the schematic (right), MSC R&D outputs contribute to various MSC outcomes (or "results"). While the R&D outputs are necessary, they are insufficient to create the desired outcomes on their own – contributions are needed from others across the MSC and from MSC's partners. Hence, ***the outcomes shown in this document represent an accountability shared with others.***

Much work remains to be done with setting targets for the long term and intermediate outcomes. We will complete this exercise in parallel with the EC results-based management and accountability framework (RMAF) and the MSC strategic plan.



5.1 MEASURING SUCCESS IN AN R&D PROGRAM

For an R&D program, it is not sufficient to meet the measures of success for each of the strategic objectives. An R&D program must also demonstrate its credibility and excellence and its adherence to the principles defined in chapter 6. Therefore, in addition to the measures of success shown in the subsequent sections, the R&D program will also track and report on the following:



- The three-year running average of MSC R&D peer-reviewed publications will not go below 170 per year.
- Salary dollars will not exceed 60 percent of the total budget.
- The global weather model will remain one of the top 5 such models in the world.
- Gaps identified in the MSC R&D values and principles will be systematically reduced.
- Succession plans for science managers and key scientists will be maintained to manage the risk to mission-critical programs due to an aging workforce and attrition.
- Rejuvenation of the research scientist population will occur by hiring 5-8 new research scientists per year for at least the next five years.
- The number of scientists attracted to take a sabbatical with MSC R&D.
- The number of MSC scientists leading international committees, sub-committees and technical working groups.
- Complete a peer-review of the management, relevance and excellence of the MSC R&D program (every 5-7 years).
- Beginning in 2006, plans and processes to life cycle manage all mission critical capital assets will be in place.

5.2 FOR STRATEGIC OBJECTIVE

Strategic objective #1 is about reducing vulnerability due to high impact events occurring over a period of the next few minutes, hours or weeks. The following table shows the links between strategic objective #1 and the MSC outcomes.

MSC Key Result	• Reduced impact of hazards
MSC Long-term outcome	• Improve society's capacity to anticipate, mitigate, withstand and recover from high impact weather and related hazards (sub-result #3)
MSC Intermediate Outcomes	1. Canadians recognize MSC as an authority and source of science 2. MSC meets public and client expectations 3. Canadians and their governments are aware of their vulnerabilities 4. OGD's and other levels of government see MSC as a partner in achieving shared goals 5. MSC remains a credible and influential member of the meteorological community

In examining the expected outcomes above, the involvement of others and the impact/scope of the expected outcomes increase as you move from the Intermediate to the Long-term and finally to the Key Result. To be successful in reaching the key results, the MSC must achieve outcomes that lead to behavioural changes in Canadians.

However, all of the outcomes depend on MSC remaining a credible and influential scientific organization. With that credibility and influence, MSC can attract scientific and other partners to achieve shared goals (e.g., addressing the UV or climate change issues). With these partners, the MSC can build awareness and understanding of scientific issues and develop the science needed to meet public and client expectations for tools, policies and services. Our credibility will give clients the confidence to use the tools to respond to the issues (develop policies, wear sunscreen etc.). Through this process, MSC will become recognized as the authority and source of science by the Canadian public, media, policy developers and others.

LONG-TERM OUTCOME:

Improve society's capacity to anticipate, mitigate, withstand and recover from high impact weather and related hazards. As measured by:

- Percent of Canadian municipalities which include high impact weather in their emergency plans (increases to 90 percent by 2012)
- The change in society's vulnerability to high impact events.

I. INTERMEDIATE OUTCOME

Canadians recognize MSC as an authority and source of science information and policy-makers are increasingly satisfied with the quality, integrity and relevance of MSC's science. As measured by:

- Demand for science advice (media queries, web hits, requests for publications, etc.)
- Number of times MSC R&D work is cited in peer-reviewed journals
- Level of satisfaction of policy-makers

STRATEGY

Demonstrate the social and economic value of improvements to predictions of high impact events.

MSC R&D OUTPUTS

- Assess and communicate on the excellence and relevance of MSC's R&D on a regular basis beginning in 2004.
- Report on the socio-economic evaluation of frequency, extremes and trends of atmospheric, hydrological change on the integrity of the built environment; Complete and distribute climate change and Green Roofs Guidelines (2005); Publish the National Hazards Assessment (2005).
- Report on the socio-economic value of MSC products and services on mortality, effectiveness of emergency services (emergency response including hospitals), emergency preparedness, etc. – synergy between weather and air quality on mortality to support asthma and heat alert programs, emergency preparedness (Bill 148 in Ontario and Civil securities Act in Quebec (2010).
- Report on the socio-economic value of MSC products and services on reduced vulnerability to extreme weather and climates, including climate change, on ecosystems; Evaluation of the threats to the conservation of biodiversity and atmospheric science contribution to the plan to reduce the rate of loss of biodiversity (2010).

2. INTERMEDIATE OUTCOME

MSC meets public and client expectations for accuracy, lead time, quality and utility. As measured by:

- Level of public satisfaction
- Probability of detection for high impact weather (excluding tornadoes) in the 0-48 hour period increases to 80 percent by 2012
- False alarm ratio for high impact weather (excluding tornadoes) in the 0-48 hour period decreases to 20 percent by 2012
- Probability of detection and false alarm for tornadoes of 50 percent and 50 percent respectively in the 0-30 minute forecast period
- Quality of forecasts of wind and precipitation in coastal areas and over complex terrain

STRATEGY

Knowledge and technology transfer for mesoscale prediction and analysis to Regions

MSC R&D OUTPUTS

- Implement new National Labs (2005); Mesoscale capacity in each Region (2005).
- Complete the R&D to automate routine production in the Regions (2005); 80 percent of operational forecasters involved 20 percent of their time in technology transfer and scientific applications (2005).
- Implement operationally the URP version for Qualitative Precipitation Estimates (QPE) (2006); Research application of AI technology for detecting and predicting high impact events (2006); Develop and apply data integration technologies that include remote and in-situ observations, to the detection and prediction of high impact events (2007); Transfer polarization research to the operational Doppler polarized radar network (2012).
- Deploy the forecaster workstation operationally (2006); Next generation graphical aviation forecast (FA) operational (2006); Next generation severe weather detection products operational (2006); include fog detection and prediction (2007).
- Implement the operational version of the local area weather warning system (2008); Ensure it is deployable to any location (e.g., Vancouver Olympics) (2009).

STRATEGY

Shift to probabilistic outputs including AI applications for high impact events

MSC R&D OUTPUTS

- Implement an operational ensemble prediction system to define risk and uncertainty of high impact weather. Time and space scales 100 km (2005); 50 km (2008); hours (1 km grid) to two weeks (25 km grid) (2012).

3. INTERMEDIATE OUTCOME

Canadians and their governments are aware of their vulnerability to high impact weather and related hazards. As measured by:

- Level of awareness and understanding of their vulnerability

STRATEGY

Define and communicate social and economic vulnerabilities and potential adaptation strategies within MSC and to policy-makers and Canadians

MSC R&D OUTPUTS

- Tools in place to calculate the frequency, extremes and trends of high impact weather. (2005)
- Assess human health, economic, environmental, infrastructure risks and vulnerabilities (2005); National, regional and municipal communication tools in place (2006).
- Collaborate with the provinces, municipalities, ICLR, PSEPC, media etc. to improve emergency readiness and planning according to provincial legislation (Ontario and Québec 2004); other provinces (2005-2008).
- Complete a pilot project with CFIA, ACSD and CMC on animal disease long-range transport across borders. (2007).
- Under the Border initiative to reduce cross-border air pollution and improve health in the US and Canada: Define human exposure to PM and ozone (2007); Refine source receptor relationships (2007).
- Complete a science assessment on high impact weather prediction and post-event analysis capacity (2006); implement recommendations (2008).

4. INTERMEDIATE OUTCOME

Other government departments and other levels of government see MSC as a partner in responding to their own mandates and achieving shared goals. As measured by:

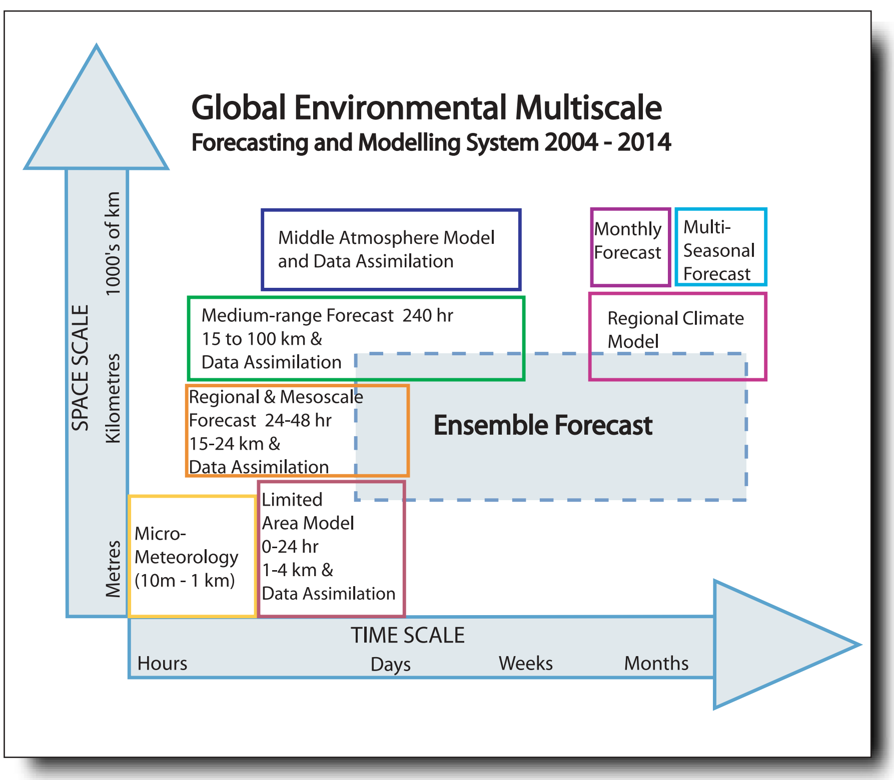
- Level of satisfaction of partners

STRATEGY

Increase capacity in environmental prediction and engage clients in understanding their decision-making needs and the degree to which science can address their issues

MSC R&D OUTPUTS

- Develop a predictive biometeorological model to guide municipal and other agencies responsible for protecting vulnerable populations from heat, air quality and high impact weather. (2006)
- Develop models to predict the meteorological and hydrological conditions at sufficient temporal and spatial scales to provide guidance for provincial, municipal and other agencies responsible for flood warnings, protection of ground-water resources and management of water resources. (2007)
- Develop ensemble applications for water resource managers (2006) and air quality forecasting (2008).
- Develop the capacity for modelling global transport of both particulate and gaseous substances (2007); Develop the capacity for modelling global transport of toxic substances (2008); Implement an operational hemispheric air quality model (PM, O_3, precursors, etc.) which can use real-time data and whose accuracy is 50 percent better than in 2002 (2012).



5. INTERMEDIATE OUTCOME

MSC remains a credible and influential member of the domestic and international meteorological community and has the expertise and tools it needs to provide improved essential services and policy advice in the area of high impact weather and related hazards. As measured by:

- MSC's global weather models remain in the top 5 in the world
- Number of key domestic and international scientific working groups lead by MSC scientists

STRATEGY

Exploit to the extent possible, all available and relevant ground-based and remotely sensed data

MSC R&D OUTPUTS

- Define data density, frequency and quality needs for model development over the next 5-10 years. (2004)
- Complete international satellite validations and application research programs – CloudSat (2006) HYDROS (2010), GPM (2010), EOS (2012), THORPEX (2012) next generation GOES (2006) and subsequently transfer results to operations.

STRATEGY

Move to finer time and spatial scales for predictions and analyses of high impact events

MSC R&D OUTPUTS

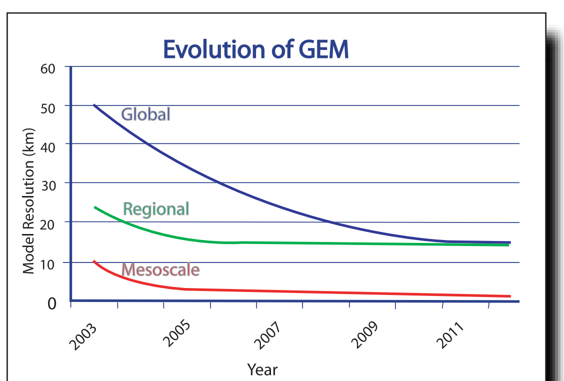
- 4D-VAR data assimilations and Ensemble Kalman Filter operational. (2004)
- Transfer to CMC, mesoscale weather models covering Canada with 4D data assimilation capacity of 15 km (2004); mesoscale windows of 3 km (2006); and 1 km (2008).
- Transfer to CMC, global mesoscale weather model with regional physics at 35 km (2004), 20 km (2008), and 10 km (2012).
- Develop the capacity for modelling global transport of both particulate and gaseous substances (2007); Capacity for modelling global transport of toxic substances (2008).
- Air Quality modelling and forecasting system (2006); Predictions of future states of air quality and UV on various time and space scales down to urban scale (2012).

STRATEGY

Move to more integration of observations (data fusion) and models

MSC R&D OUTPUTS

- Complete advanced satellite, radar, lightning and other remote sensing and in-situ measurement analysis and data integration strategies at one hour and 50 km (2005); 1-5 km and 1-5 minute resolution (2012).
- Operational application of data integration technologies (including AI) that include satellite, radar, lightning and other surface observations to the detection and prediction of high impact weather (2007); application of these techniques to the operational program through incorporation into the workstation project (2008).



- Complete an improved wave-ocean-atmosphere system for GEM (2008).

5.3 FOR STRATEGIC OBJECTIVE #2

2 Strategic objective #2 is about reducing vulnerability and increasing opportunity related to our changing atmosphere, hydrosphere and cryosphere over a period of time ranging from weeks to years to centuries. The following table shows the links between strategic objective #2 and the MSC outcomes.

MSC Key Result	Adaptation to day-to-day and longer term changes in the environment	
MSC Long-term outcome	Increase economic efficiency, productivity and competitiveness	Demonstrate scientific leadership
MSC Intermediate Outcomes	1. Canadians recognize MSC as an authority and source of science 2. Canadians and their governments are aware of their vulnerabilities 3. OGD's and other levels of government see MSC as a partner in achieving shared goals	4. Canadians recognize MSC as an authority and source of science 5. MSC meets public and client expectations 6. Canadians and their governments are aware of their vulnerabilities 7. OGD's and other levels of government see MSC as a partner in achieving shared goals 8. MSC remains a credible and influential member of the meteorological community

In examining the expected outcomes above, the involvement of others and the impact/scope of the expected outcomes increase as you move from the Intermediate to the Long-term and finally to the Key Result. To be successful in reaching the key results, the MSC must achieve outcomes that lead to behavioural changes in Canadians.

However, all of the outcomes depend on MSC remaining a credible and influential scientific organization. With that credibility and influence, MSC can attract scientific and other partners to achieve shared goals (e.g., addressing the UV or climate change issues). With these partners, the MSC can build awareness and understanding of scientific issues and develop the science needed to meet public and client expectations for tools, policies and services. Our credibility will give clients the confidence to use the tools to respond to the issues (develop policies, wear sunscreen etc.). Through this process, MSC will become recognized as the authority and source of science by the Canadian public, media, policy developers and others.

LONG-TERM OUTCOME:

Increase economic efficiency, productivity and competitiveness through atmospheric and related science and services. As measured by:

- The change in the economic vulnerability in specific economic sectors
- The change in economic efficiency and competitiveness in specific economic sectors

1. INTERMEDIATE OUTCOME

Canadians recognize MSC as an authority and source of scientific information in the areas of weather, climate, water and related environmental issues. As measured by:

- Number of times MSC R&D work is cited in peer-reviewed journals
- Demand for scientific information (e.g., media requests, web hits)

STRATEGY

Develop capability to demonstrate economic value of improvements in atmospheric and related environmental prediction

MSC R&D OUTPUTS

- Assess and communicate the value of our outputs on a regular basis beginning in 2004.
- Produce studies on the economic value of managing risks in various economic sectors using atmospheric (2006) and hydrological science (2008).

2. INTERMEDIATE OUTCOME

Canadians and their governments are aware of their vulnerability to longer term changes in the environment and have the tools to manage the risks. As measured by:

- Level of awareness and understanding of vulnerability by economic sector
- Level of awareness and understanding of vulnerability by OGD's and other levels of government

STRATEGY

Define and communicate economic vulnerabilities and potential adaptation strategies

MSC R&D OUTPUTS

- Assess economic vulnerabilities, impacts and adaptation options at the national, regional and municipal levels due to atmospheric and hydrologic change beginning with forestry (2005), marine transportation (2006), agriculture (2007), energy (2007), construction (2007), biodiversity (2007) and offshore resource extraction (2012).

3. INTERMEDIATE OUTCOME

Other government departments and other levels of government see MSC as a partner in responding to their own mandates and achieving shared goals. As measured by:

- Level of satisfaction of partners

STRATEGY

Increase capacity in environmental prediction in specific economic areas

MSC R&D OUTPUTS

- Develop collaborative applications of climate models with various sector clients (e.g., DFO for marine prediction and AAFC for crop yield (2006), energy (2007), construction and forestry (2008).)
- Develop and document objective procedures to produce 3-12 month predictions of sea ice conditions. (2006)

LONG-TERM OUTCOME:

- Demonstrate scientific leadership in supporting domestic and international policies and protocols on global environmental issues.

4. INTERMEDIATE OUTCOME

Canadians recognize MSC as an authority and source of science information and policy-makers are increasingly satisfied with the quality, integrity and relevance of MSC's science. As measured by:

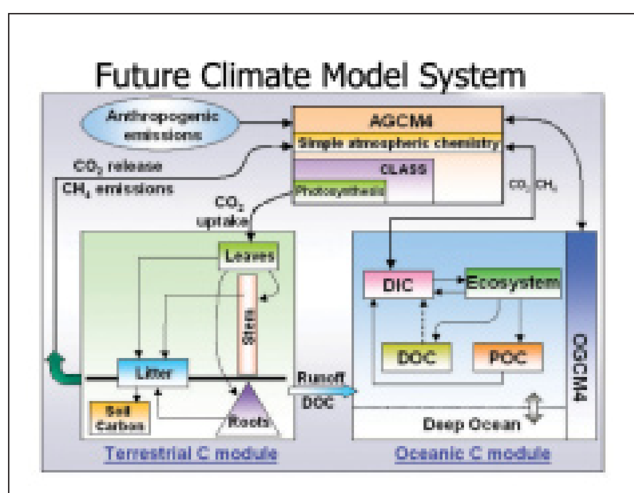
- Demand for science advice (web hits, requests for publications, etc.)
- Number of times MSC R&D work is cited in peer-reviewed journals
- Level of satisfaction of policy-makers

STRATEGY

Demonstrate the social and economic value of MSC R&D

MSC R&D OUTPUTS

- Assess and communicate the quality of our outputs on a regular basis beginning in 2004.
- Make a substantial contribution to the Fourth IPCC Assessment Report in terms of scientific leadership and publication of new research results on climate change. (2007)
- Identify and demonstrate how MSC products, services and science affect the security of Canadians and environmental quality. (2008)



5. INTERMEDIATE OUTCOME

MSC meets public and client expectations for awareness and understanding of key issues linked to the changing environment. As measured by:

- Level of client satisfaction

STRATEGY

Increase capacity to transfer knowledge, technology, data and information for all atmospheric issues over a wide range of depth and complexity

MSC R&D OUTPUTS

- Develop an MSC climate science plan (2004), a federal climate science plan (2005), and a Canadian Arctic climate science plan as part of a Canadian CliC contribution (2006).
- Put in place the capacity to communicate assessments of scientific findings against past advice, existing services, or identify and define new/emerging issues at the international, national and smaller scales. (2005)
- Contribute to national, regional and municipal communication tools (at various levels of complexity for a variety of audiences and fully bilingual). (2005)
- Implement timely communication (including web-based) of information, data and knowledge on future states of the atmosphere and related environment at the requested resolution. (2006)
- Implement new national laboratories (2005) with ACSD expertise in each Region. (2006)

STRATEGY

Engage clients in understanding their decision-making needs and the degree to which science can address their issues

MSC R&D OUTPUTS

- Establish more effective ways to engage key clients and stakeholders (policy- and decision-makers, scientific users such as OURANOS, and impacts and adaptation communities). (2005)
- Improve our communication of uncertainty in climate change projections, based on ensemble projections (2005) and better understanding of key feedback processes (2007).

6. INTERMEDIATE OUTCOME

Canadians and their governments are aware of their vulnerability to high impact weather and related hazards. As measured by:

- Level of awareness and understanding of their vulnerability

STRATEGY

Define and communicate social vulnerabilities and potential adaptation strategies within MSC and to policy-makers and Canadians.

MSC R&D OUTPUTS

- Enhance the China-Canada impacts and adaptation research on vulnerability to agriculture in China –CIDA. (2006)
- Assess vulnerabilities, impacts and adaptation options at the national, regional and municipal levels due to atmospheric variability and change beginning with extreme events (2005); and social and environmental risks and vulnerabilities (2007).
- Communicate vulnerabilities, impacts and adaptation options at the national, regional and municipal levels due to atmospheric variability and change beginning with extreme events (2006); and social and environmental risks and vulnerabilities (2008).

7. INTERMEDIATE OUTCOME

Other government departments and other levels of government see MSC as a partner in responding to their own mandates and achieving shared goals. As measured by:

- Level of satisfaction of partners

STRATEGY

Increase capacity in environmental prediction

MSC R&D OUTPUTS

- Develop collaborative applications of climate models and observational products with various sector clients (e.g., land use change and biodiversity). (2006)
- Develop capacity to produce emission reduction scenarios with specific chemicals and precursors. (2004)
- Develop applications linking acid rain and air quality impacts to ecosystem health. (2004)
- Complete report on Okanogan Climate Change and Water Management Collaborative Study. (2005)
- Develop applications for mercury cycling (in the atmosphere, cryosphere, hydrosphere and biosphere) with links to human and ecosystem health (2006); Assess the impact of regional climate change on air quality and the environmental cycling of toxics (2007).
- Advance understanding of the atmospheric chemistry phenomena specific to the Arctic. (2010)

8. INTERMEDIATE OUTCOME

MSC remains a credible and influential member of the domestic and international meteorological community and has the expertise and tools it needs to provide improved services and policy advice. As measured by:

- Number of key domestic and international scientific working groups lead by MSC scientists
- IPCC and others continue to use MSC R&D models in their assessments

STRATEGY

Move to finer time and spacial scales and more comprehensive models as appropriate to client needs (anticipated or stated)

MSC R&D OUTPUTS

- Make reliable, long-term climate and hydrological data sets at finer spatial and temporal resolution available for model evaluation. (2007)
- Complete numerical experiments and diagnostics to validate GEM-LAM as the next Canadian RCM. (2008)
- Incorporate the terrestrial and marine global carbon cycle into the Canadian GCM (2006); Improved representation of important biogeochemical cycles (e.g., sulfur and aerosols in climate models (2008); Understand biosphere feedbacks on the climate system (e.g., boreal and wetland systems, tundra, farms) (2009).
- Provide decade to century climate change projections with the global atmospheric model at 200 km resolution (2007) and at 100 km resolution (2011); and with the global coupled model at 300/100 km atmosphere/ocean resolution (2006) and at 200/100 km resolution (2011).
- Provide Canada-wide, downscaled decade to century climate change projections with the Canadian RCM2 at 45 km resolution (2004) and with RCM4 at 25 km resolution (2010).
- Complete the development of GEM-chem (2005); Include more chemicals in air quality predictions (2005) and emission reduction scenarios (2005); Chemical weather predictive capability on a regional scale (2008).

STRATEGY

Move to a new science model based on increased collaboration, science networks and advocacy

MSC R&D OUTPUTS

- Establish a scientific group to provide a strong focus on regional climate modelling and data analysis (2004); Establish the role of MSC's climate modelling group as a full partner in the University of Victoria Climate Science Institute (2006).
- Enhance joint R&D and technology transfer between MSC climate and NWP modelling groups (adaptation of radiation code for GEM (2004); Adaptation of GEM-LAM for RCM (2008).
- Evaluate federal/provincial implementation plans for attaining CWS for PM and ozone (2005); Complete an environmental science assessment of the PM/ozone annex (2007).
- Develop strategies to influence the following national and international committees: CCRP, IPY, Canadian Polar Commission and ICARPII.
- Participate with CFCAS. Interact with NSERC and CFI.
- Develop a Canadian Climate Change Scenarios Facility with 5NR and others to meet the needs of Canadians. (2008)

5.4 FOR STRATEGIC OBJECTIVE

3 Strategic objective #3 is about providing a coherent and consistent picture of the present and past states of the atmosphere and related environment. The following table shows the links between strategic objective #3 and the MSC outcomes.

MSC Key Result	Reduce impact of hazards
MSC Long-term outcome	Provide Canada with a quality and citizen-centred weather and related environmental prediction service.
MSC Intermediate Outcomes	Improve public and industry satisfaction with information, date and knowledge.

LONG-TERM OUTCOME:

Provide Canada with a quality and citizen-centred weather and related environmental prediction service

INTERMEDIATE OUTCOME

Improved public and industry satisfaction with information, data and knowledge. As measured by:

- The extent to which MSC data sets are used by various clients for policy development, improving services or decision making (subjective assessment)
- Level of satisfaction of our key clients with the data, information and knowledge we provide (target to be developed)
- Quality and density of various measured parameters (targets to be developed)
- Ease of integration of MSC data sets with other MSC data sets and data sets of clients (target to be developed)
- Accuracy and reliability of analyzed fields (target to be developed)
- Quality of automated streamflow measurements (target to be developed)

STRATEGY

Lead and participate in collaborative programs to improve observing strategies, evaluate measurement systems and increase understanding of atmospheric behaviour.

MSC R&D OUTPUTS

- Develop joint projects with AMWSD on instrument evaluation, algorithm development and network design. (2005)
- Complete AIRS II program for validating remote sensing platforms for detecting severe winter weather (2005); Evaluate the potential for retrieving lake ice thickness in large Canadian lakes using 6.9 GHz data (2006); Upgrade research aircraft (2006); Capability to provide a validation capability for new remote sensing instruments and NWP models, and to assess new instrumentation (2012).
- Lead the Canadian Societal Impacts and Applications component of THORPEX (2006); Report on the social and economic value of data (2007).
- Maintain and apply ground based remote sensing and observational measurement tools (radar, lidar, radiometer, POSS, radiosonde, CORE, mesonets, etc.) capable of supporting ACSD research objectives and operational nowcasting development programs. (2006)
- Secure access to multiple polarisation and polarimetric SAR satellites and improve information extraction capabilities (2006); Precipitation data assimilated into the operational regional model (2006); Implement ability to track and assimilate antecedent atmospheric and hydrological conditions (2007); Doppler and profiler winds into the mesoscale model (2010).
- Establish the BERMS co-operative Canadian super-site as a national surface reference site for Fluxnet, WCRP/CEOP, and related satellite missions (2004); Participate in international satellite validation and application research programs – e.g., Cloud Sat (2006), HYDROS (2010), GPM (2010), EOS (2012), THORPEX (2012), and others; Contribute Canadian measurements to GEO including profiles through the troposphere and stratosphere (2008).

STRATEGY

Develop data tools and products as appropriate to meet client needs.

MSC R&D OUTPUTS

- Tools in place to calculate the frequency, extremes and trends of high impact events (2005); Transfer tools for post-event analysis to the Regions (2006).
- Develop a plan for polarizing the Canadian radar network. (2007)
- Deploy operationally the URP version for QPE using Doppler radar network (2006); provide QPE over all of Canada at a time and space resolution to support meteorological and hydrological client needs down to the basin scale (2012).
- Develop Regional and national integrated observational products for snow and ice resources at a scale and frequency suitable for RCM evaluation. (2008)
- Automate the production of quality assured streamflow data while eliminating the safety risks of streamflow measurements (2008); Provide capacity for partners to generate reliable streamflow estimates on a national scale at a sub-kilometer resolution (2010).

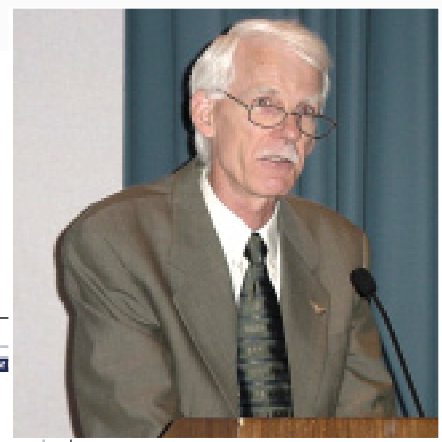
STRATEGY

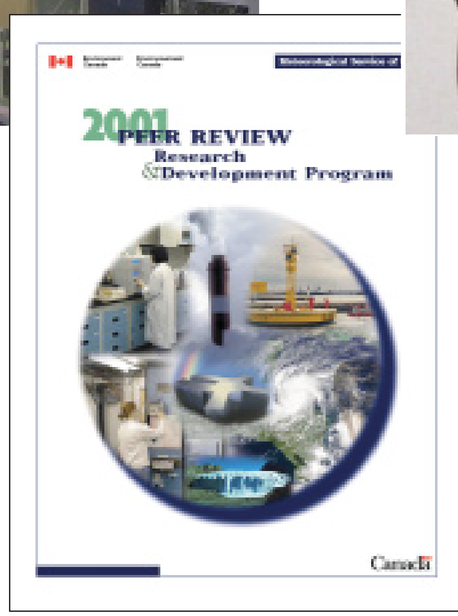
Develop high quality data sets to facilitate understanding the behaviour of the atmosphere at times ranging from last season to at least 5 centuries ago

MSC R&D OUTPUTS

- Provide gridded climate data sets for Canada on a sub-diurnal time scale for a wide range of climate elements for the past season and year. (2006)
- Provide 50 to 100-year homogenized historical climate station data sets for Canada on a sub-diurnal time scale for a wide range of climate elements. (2006)
- Provide blended products from remotely sensed and conventional sources for snow, precipitation and soil moisture in near real-time for the past season and year. (2010)
- Produce historical climate data sets: 50-year wind and wave (with KNMI/ECMWF/US Army Engineers); 100-200 year marine data (with NOAA, NCAR, Hadley, SOC); 1000 year proxy climate data (with UWO, Regina, NRCan) (2006).
- Understand the air quality/UV system in order to explain its past and current states and behaviour. (2012)

VALUES AND PRINCIPLES





VALUES AND PRINCIPLES 6

6.1 VALUES

Values define things that are important to us in the day to day running of the R&D program, and principles are deeply held beliefs by which MSC R&D will manage the program. Both guide managerial and staff behaviour when making decisions. Gaps between these and our existing practices increase risk to our staff, clients and collaborators.

VALUES

- We value ***scientific excellence***. This means we promote creativity, encourage and recognize innovation, expect competence and are willing to take reasonable risks in pursuing excellence.
- We value ***straight talk***. This means we promote openness, operate transparently and encourage innovative thinking and intellectual freedom even if it disagrees with existing views.
- We value ***responsiveness***. We value staff and collaborators when they see a need and respond to it to the best of their ability, do their share, and honour their commitments.
- We value ***trust and integrity***. This means that our relationships with staff and others will be based on confidence, fairness, respect and moral principles.
- We value people who ***"walk the talk"***. This means we value people when they follow through with their commitments and do what they say they will do.
- We value ***science***. This means we encourage staff and collaborators to rigorously use the scientific method in creating knowledge that is relevant, credible, and politically independent.
- We value ***leadership***. This means we encourage taking reasonable risks, taking a stand and demonstrating initiative.

6.2 PRINCIPLES

We have agreed to adopt the SAGE (Science Advice for Government Effectiveness) principles with modifications to also reflect the service foci of MSC R&D. The desired outcome of these principles is to ensure that:

- Scientific knowledge used by government service providers and the science/expert advisory process is the best available at the time.
- The uncertainties can be properly identified, assessed and reported.
- New knowledge will be continuously evaluated for relevance and impacts on previous advice.
- Science linkages and shared agendas will be fostered with others within and external to government.
- The process of converting science advice into policy and services will be effective.
- Research within government remains open, independent and peer-reviewed.

In this way, scientific knowledge allows decision-makers (governments, policy-makers, Canadians) to make more effective decisions, minimize crises and unnecessary controversies, and capitalize on opportunities (e.g., economic productivity and competitiveness).

6.3 GAPS

Currently, no gaps have been identified in MSC R&D between current practices and the above values and principles. We will continue to monitor the situation through various committees, client feedback and the next peer-review. When gaps are identified, corrective targets will be set and included in the 3-year plan and performance management agreements.

PRINCIPLES (ADAPTED FROM THE SAGE PRINCIPLES)

- ***Early identification*** – This principle means that we will anticipate, to the best of our ability, those issues for which government services and/or science advice will be required. We will identify, frame and address issues in a timely manner through interdisciplinary, interdepartmental and international cooperation. Key parts of the early identification process include modelling, data analysis, process research, vulnerability, impacts and adaptation research and science assessment tools.

- ***Inclusiveness*** – This principle means that we will draw advice from a variety of scientific sources and from experts in many disciplines to capture the full diversity of scientific opinion in addressing policy and service issues. It is important to use this principle when there is a high degree of scientific uncertainty, a large range of scientific opinion and when there are potentially significant implications for sensitive areas of public opinion. Through the science assessment process, we will then evaluate the scientific evidence provided to us and provide an expert judgement to policy-makers and government service providers.

- ***Sound science and science advice*** – Through this principle we will build into the science advisory and service development processes the due diligence procedures needed to ensure quality, independence, reliability, integrity, objectivity and peer-review of our science. We also commit to having sufficient in-house capacity to develop, assess, integrate and communicate science to decision-makers and service providers. This means making provisions for scientists to actively participate and collaborate in the global search for scientific knowledge.

- **Uncertainty and risk** – Through this principle we commit to using a risk management approach to assess, manage and communicate the degree of uncertainty in the science on which policies and services are based. The goal of risk management is to produce scientifically sound, cost-effective and integrated actions that reduce risks while taking into account social, cultural, ethical, political and legal considerations. This is consistent with the "precautionary approach".

- **Openness** – This principle addresses the need to communicate scientific findings inside and outside of government. It requires that we provide service developers and policy-makers with access to the underlying science as quickly as possible, even if means crossing departmental boundaries. Science advisors need to convince policy-makers and service providers that their science is current and sound and should have confidence that their science is being seriously considered in decision making.

- **Review** – This principle obliges us to determine whether recent scientific advances could impact on past scientific advice and/or existing government services, and to monitor and report on (likely annually) the application of the above principles.

OVERVIEW OF THE PLANNING PROCESS

Once managers agreed on the need for a strategic plan, we began defining the future of MSC R&D in terms of roles, responsibilities, capacities and goals. We did this from many perspectives such as a survey of service and policy needs across Environment Canada (see annex 4), understanding key issues affecting our future (such as those raised during the Peer Review), assessing our own strengths and weaknesses, delineating our future roles and responsibilities and examining the directions of other relevant R&D organizations around the world. Other steps included:

- Developing a clear mission statement based on clients and their needs.
- Analyzing the MSC Vision, long-term results and strategic framework to determine the need, roles and responsibilities for R&D.
- Determining where the major changes needed to take place.
- Iterating on the above with MSC R&D managers (HQ and Regions) to create a consultation draft of a strategic plan.
- Consulting widely across the Department and the university community on the draft plan.

Through the strategic planning process, we expected to:

- Shape the evolution of the MSC's R&D program and position ourselves to influence the evolution of various scientific programs and the environment around us (including the development of new technology).
- Communicate a clear and common understanding of our future directions and the key strategies for getting us there.
- Ensure that the future is taken into account so we can prepare for the inevitable, pre-empt the undesirable and control the controllable.
- Raise the visibility and importance of R&D in order to encourage advocacy for atmospheric science.
- Demonstrate how R&D can horizontally integrate issues across the EC business lines and other government departments.

With the completion of this plan, we commit to:

- Monitoring and reporting on progress annually.
- Reviewing and updating the plan every couple of years with a major review coinciding with the next peer-review.

LINKS BETWEEN R&D STRATEGIC OBJECTIVES AND MSC ATTRIBUTES

MSC has expressed its vision in terms of the following attributes for 2011.

MSC ATTRIBUTES FOR 2011

A. An essential national institution contributing to the health and safety of Canadians and their communities.

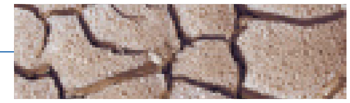
B. A catalyst and partner in developing innovative services in support of economic efficiency, productivity and competitiveness.

C. Accountable to Canadians for quality and program effectiveness.

D. The recognized authority and source of science and information on weather, climate, water, air quality and related environmental issues.

E. A recognized contributor to Canada's international role in helping solve complex and multidisciplinary environmental issues facing the global society.

F. A valued, strategic and innovative partner with other government agencies, academic and industry to achieve shared goals.



The following table shows how MSC R&D's strategic objectives will respond to the MSC vision. Cumulatively, the MSC R&D strategic objectives should "add up" to the R&D needed to translate the MSC vision (attributes) into reality.

MSC R&D Strategic Objectives	Links to MSC Attributes					
	Essential A	Catalyst B	Accountable C	Authority D	International E	Partner F
1 Support risk-based decision making on the scale of minutes, days and weeks	✓	✓	✓	✓	✓	✓
2 Support risk-based decision making on the scale of weeks, years and centuries.	✓	✓	✓	✓	✓	✓
3 Provide a coherent and consistent picture of the present and past states of the atmosphere and related environment.	✓		✓	✓	✓	✓

ANNEX 2

CHARACTERISTICS OF MSC R&D

The main document listed some characteristic strengths of MSC R&D which made it distinctive and/or unique within the Department and government. The following is a list of characteristics which MSC R&D shares with many other well-managed R&D programs.

- MSC R&D ***values science excellence*** and has the ***capacity to deliver and practice*** excellence nationally (science units exist in HQ units and all of the EC Regions) and ***internationall***y.
- MSC R&D can ***attract and engage others*** to create the many collaborative relationships (locally, nationally and internationally) on which we depend.
- MSC R&D is becoming increasingly ***responsive*** to the monitoring, production and service delivery elements of the MSC.
- MSC R&D ***communicates*** leading edge science in a form which is useful to ministers, Canadians, decision-makers and policy-makers.
- MSC R&D ***promotes innovation*** and ***encourages creative and rigorous R&D*** solutions to government and departmental needs.
- MSC R&D is ***multidisciplinary*** (see definition section on "Terminology") and ***positioned to be engaged*** by various departmental issues:
  - All atmospheric issues are under one roof (weather, climate, air quality, stratospheric ozone).
  - We combine meteorological science with other fields of atmospheric, hydrologic, and cryospheric science (e.g., air quality, UV, water quantity, ice).
  - Through the concept of environmental prediction, we/others can link atmospheric and hydrological sciences with other departmental issues (e.g., pollution reduction, habitat protection, biodiversity, water quality, etc) and with other disciplines (e.g., engineering, biology, agronomy, forestry, oceanography, etc.).
- MSC R&D is in the process of developing ***near-term planning*** and ***performance management*** processes which translate government priorities, department mandates and the needs of Canadians into clearly defined research objectives and programs and tracks and reports on their success.
- MSC R&D is in the process of engaging staff, clients and stakeholders in a ***strategic planning process*** to understand emerging and potential issues, respond to recommendations of an international Peer Review and ensure that we will continue to have the capacity to deliver the R&D critical to federal policies and services.

MAJOR CLIENTS

The following table shows examples of major clients for each community of interest.

COMMUNITY OF INTEREST	EXAMPLES OF MAJOR CLIENTS
Providers of essential government services	• MSC (HQ and Regions*) • Environment Canada Business Lines • Other government departments and agencies (e.g., DND, DFO, TC, HC, CIDA, PSEPC, NRCAN (CFS), AAFC, CSA, etc.) • Other levels of government (provincial and municipal agencies)
Domestic and international policy and decision making bodies	• Environment Canada (Minister, all Business Lines) • Other government departments and agencies (e.g., NRCAN, DND, DFO, NRC, TC, HC, CIDA, PSEPC, AAFC, CSA, etc.) • Other levels of government (provincial and municipal agencies), Canadian Council of Ministers of the Environment (CCME) • ENGO's • International science-based organizations (e.g., WMO, IPCC, IAI, ICAO, UNECE, NARSTO, UNESCO, WWF, CEC, Arctic Council, etc.) • Regulatory agencies and decision-making bodies (e.g., IJC, Prairie Provinces Water Board, NAVCANADA, etc.)
Domestic and international scientific bodies	• Environment Canada (all Business Lines) • Universities • Research institutes • International scientific programs (e.g., WCRP, GAW, WWRP, R&D components of other national meteorological and hydrological services)
Private sector	• Various economic sectors (e.g., agriculture, forestry), financial services sector (insurance, re-insurance, futures market), industries (e.g., aviation) including the value-added meteorological sector • Various industrial advisory boards
Various public	• Canadian public • Media

* also a key partner in delivering the MSC R&D program.

ANNEX 4

OCTOBER 2002 SURVEY OF ENVIRONMENT CANADA BUSINESS LINES

INTRODUCTION

MSC R&D has recently begun a strategic and near-term planning process. As the prime users of MSC R&D, we would like your input to help guide the plans for our evolution over the next 10 to 15 years. In order for us to make the best use of your answers, we request your response by October 25, 2002.

Two definitions:

- "MSC R&D" includes MSC HQ science components and the atmospheric and related environmental science units in the Regions. Science activities include developing and transferring new knowledge and technology, providing scientific advice and information, modelling, developing applications, etc.)
- "Atmosphere and the related environment" refers to the atmosphere (weather, climate, air quality, and stratosphere), hydrosphere (rivers, lakes and oceans), cryosphere (snow and ice) and the interrelationships defined through environmental prediction (climate change/land use change/habitat/biodiversity, GMO pollen dispersion, pollution prevention (e.g., road weather, pesticide management), climate change co-benefits, etc.)

DEFINING THE NEEDS AND ROLES FOR MSC R&D

The Changing World of MSC R&D

Moving from the realm of weather and climate, to the atmosphere and related environment, MSC R&D is now evolving to environmental prediction in support of integrated decision making (e.g., road weather supporting a reduction in road salt, fewer road deaths and more efficient roads) and knowledge management.

What are the key areas in which MSC R&D should be responding – is it climate change which impacts on land use change, habitats, migration routes and biodiversity? Is it ocean modelling which impacts fish movements, storm surges, regional climate, hurricane development, day-to-day weather? Is it heavy rainfall events which relate to storm runoff issues, waterborne disease outbreaks and floods? In which capacities should MSC R&D invest and in what areas should it let others take the lead?

MSC R&D needs your assistance in building its strategic plan, guiding its long-term evolution as well as its response to the International Peer Review, Living within Our Means and other near-term issues.

Question 1 – Future Challenges

a) What are the top 3-5 service (e.g., extreme weather and air quality prediction) and policy challenges (e.g., land use change/habitats, air quality source-receptor issues, GMO pollen dispersion) that you need to address over the following timeframes:

- next year? (please indicate relative priorities)
- next two to five years? (please indicate relative priorities)
- next five to 15 years? (please indicate relative priorities)

b) What do you expect MSC R&D to deliver to help you resolve these issues?

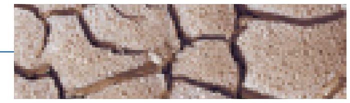
c) How will you judge the success or value of what MSC R&D delivers to you?

Question 2 – An Essential National Institution

One of the MSC attributes for 2011 states that MSC will be an essential national institution contributing to the health and safety of Canadians and their communities through innovative science, service and technology.

a. From your perspective, what makes MSC R&D distinctive and unique within government? What does MSC R&D provide to you that you could not easily receive from elsewhere in government, academia or the private sector? Of the items in your list, what are essential to the health and safety of Canadians and their communities?

b. From your perspective, how will you know that MSC R&D helps the MSC be an essential and national institution? What measures should MSC R&D use to demonstrate that it is essential and national?



Question 3 – Recognized Authority and International Leadership

Another of the MSC attributes for 2011 is that it will be the "recognized authority and source of science and information in the areas of weather, climate, water, and related environmental issues." In addition, the MSC will be a "recognized contributor to Canada's international role in helping to solve complex and multidisciplinary environmental issues facing the global society in the coming decade."

Thinking about the future challenges that you identified in question 1, from your perspective:

a. In what niches should MSC R&D be world class and the recognized Canadian authority?

b. What level of performance must MSC R&D reach in 10 years for you to see them as world class in these areas and the recognized Canadian authority?

c. Within the realm of MSC R&D, in what issue areas must the Department/government have access to politically independent scientific advice and information?

d. In what areas should MSC R&D let others become the recognized Canadian authority? In what areas is there existing capacity elsewhere, or the science is mature enough that MSC R&D could reduce its profile? In this situation, how should MSC R&D ensure the political independence of the science produced by others?

e. In what areas should MSC R&D help others build the capacity to help you address your identified future challenges? Who are the "others"? What high level strategy should MSC R&D use to build their capacity or transfer knowledge, etc?

f. How do you see the roles of MSC R&D changing over the next 10 to 15 years with respect to other government science programs, universities (domestic and foreign), private research institutes (domestic and foreign)? How should MSC R&D position itself to make that happen?

Question 4 – Reviewing the "Why" of MSC Science

MSC R&D is reviewing its raison d'être. The following identify some off the primary needs which are met by MSC R&D.

a) What is missing?

b) Which of the following are the most important to you?

- Capacity to improve the accuracy and utility of MSC's existing atmospheric and related environmental products and services?
- A capacity for the MSC to develop and test new products and services in atmospheric and related environmental fields?
- Scientifically credible advice and information for domestic and international policy-makers on atmospheric and related environmental issues?
- R&D and applications which help provincial and municipal decision-makers understand and reduce the social and economic vulnerabilities (e.g., extreme weather, climate change, building codes, waterborne disease) of their citizens
- A capacity to build Canadians' awareness and understanding of atmospheric and related environmental issues?
- A stimulus and/or capacity to improve the accuracy of atmospheric and related environmental measurements?
- A stimulus to grow Canada's capacity in atmospheric and related environmental R&D and/or a leader to coordinate such R&D to meet federal government needs?

Question 5 – Managing R&D in the MSC

a) What mechanism(s) should MSC R&D use to: a) understand the Department's changing needs for MSC R&D on an ongoing basis; and, b) prioritize and implement new initiatives?

b) What are the roles of the HQ and Regional science units in meeting Departmental and Regional needs?

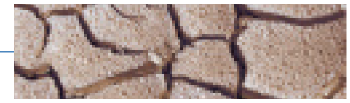
c) How can the Regional and HQ units improve communication (Region to Region and Region to HQ) and cohesiveness of the MSC R&D program?

Question 6 – Other Comments on the Future of MSC R&D

Please provide other comments you may have.

GLOSSARY

AAFC	Agriculture and Agri-food Canada
ACSD	Atmospheric and Climate Science Directorate of MSC
AI	Artificial intelligence
AIRS	Alliance Icing Research Study
AQ	Air quality
AMWSD	Atmospheric Monitoring and Water Survey Directorate of MSC
BERMS	Boreal Ecosystem Research and Monitoring Sites
CCME	Canadian Council of Ministers of the Environment
CCRP	Canadian Climate Research Program
CEC	Commission for Environmental Cooperation
CFCAS	Canadian Foundation for Climate and Atmospheric Science
CFI	Canadian Foundation for Innovation
CFIA	Canadian Food Inspection Agency
CIDA	Canadian International Development Agency
CliC	Climate and Cryosphere project
CMC	Canadian Meteorological Centre of MSC
CSA	Canadian Space Agency
CWS	Canada Wide Standards
DFO	Department of Fisheries and Oceans
DND	Department of National Defence
ECMWF	European Centre for Medium-range Weather Forecasts
EDGE	Employees Driving Government Excellence
EER	Environmental Emergency Response
ENGO	Environment non-government organization
EOS	Earth Observation Summit
GCM	Global Climate Model
GEM	Global Environmental Multi-scale
GHG	Green house gases
GMO	Genetically modified organism
GOES	Geostationary Operational Environmental Satellite
GPM	Global Precipitation Mission
HAPS	Hazardous air pollutants
HC	Health Canada
High impact event	Any meteorologically related event, or combination of events, which occurs within a time period less than seasonal that can result in significant impacts (real or perceived) on safety, health, environment or economy.
HQ	Headquarters
HYDROS	Hydrosphere States Mission
IAI	Inter-American Institute
IBC	Insurance Bureau of Canada
ICAO	International Civil Aviation Organization
ICLR	Institute for Catastrophic Loss Reduction
IPCC	Inter-governmental Panel on Climate Change
KNMI	Royal Netherlands Meteorological Institute
LWOM/FFF	Living within our means / focusing for the future
MSC	Meteorological Service of Canada
NARSTO	North American Research Strategy on Tropospheric Ozone and Particulate Matter
NCAR	National Centre for Atmospheric Research



NRCan	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council of Canada
NWP	Numerical Weather Prediction
O_3	Ozone
PSEPC	Public Safety and Emergency Preparedness Canada
PM	Particulate matter
QPE	Qualitative precipitation estimation
RCM	Regional climate model
RES	Research Scientist Classification
RMAF	Results-based management and accountability framework
SAGE	Science Advice for Government Effectiveness
SCRIBE	An interface for a computer-generated forecast tool
SOC	Southampton Oceanography Centre
STEPS	Science and Technology Excellence in the Public Service
TC	Transport Canada
THORPEX	The Hemispheric Observing System Research and Predictability Experiment
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
URP	Unified Radar Processor
UV	Ultraviolet radiation
WCRP	World Climate Research Program
WEP	Weather and Environmental Predictions business line
WEPSAC	WEP Science Advisory Committee
WMO	World Meteorological Organization
WWF	World Wildlife Federation