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THE METEOROLOGICAL SERVICE OF CANADA

CLIMATE CHANGE: SUPPORTING ACTION THROUGH SCIENCE





Climate change threatens our ecosystems, our society and our economy. It's an environmental challenge that has governments and citizens looking for answers and guidance. Scientists were the first to focus public attention on climate change and they continue to play a defining role in how we deal with it.

Canada has good reason to make climate change a priority. Ours is a vast country, encompassing a huge portion of the global climate system. The better we understand climate change, the better prepared we will be to make decisions about our future.

The Meteorological Service of Canada (MSC) is at the forefront of climate change science, having brought together experts to focus on climate data and analysis, processes and modelling, and impacts and adaptation research. Some 100 MSC experts, along with their partners across the country, provide Canadians and their governments with up-to-date scientific information and advice on climate change.

Working with other government departments and agencies, universities and the private sector, MSC scientists are investigating the remaining questions surrounding climate change, with a focus on issues of particular interest to Canada. This research sparks new ideas – encouraging scientists and researchers across Canada and around the world to work together and share their knowledge.

Addressing climate change is a long-term challenge. As the climate continues to evolve, MSC will continue to seek answers to the key questions and provide the solid scientific basis needed for implementing the Kyoto Protocol and beyond.

Why do we track the climate?

Long-term observations of air, water and ice conditions read like a history book and help us understand the atmosphere and climate. Information from climate monitoring is used to help us understand the natural variability of the climate, develop building codes, construct climate models, analyze energy needs and select the best-performing crops. The most reliable information comes from climate monitoring networks and programs that gather data continuously and systematically over decades.

CLIMATE MONITORING ACTIVITIES

MSC maintains a national network of climate observing stations extending from coast to coast and into Canada's North that gather data on the atmosphere, water, ice cover and greenhouse gases (GHGs). Some of the data is gathered by hundreds of Canadians who are part of a national network of volunteer observers. Data is also collected through cooperative agreements with Agriculture and Agri-Food Canada, and Parks Canada. MSC shares this information with partners and the public through a climate data management system.

MSC has established itself as a leader in climate monitoring by providing high quality data and promoting standards for atmospheric and hydrometric measurement in Canada. The monitoring program is based on the standards set by the World Meteorological Organization. MSC also directs research and development to improve monitoring methods and technologies. Day in, day out, Canadians turn to MSC for authoritative climate information.

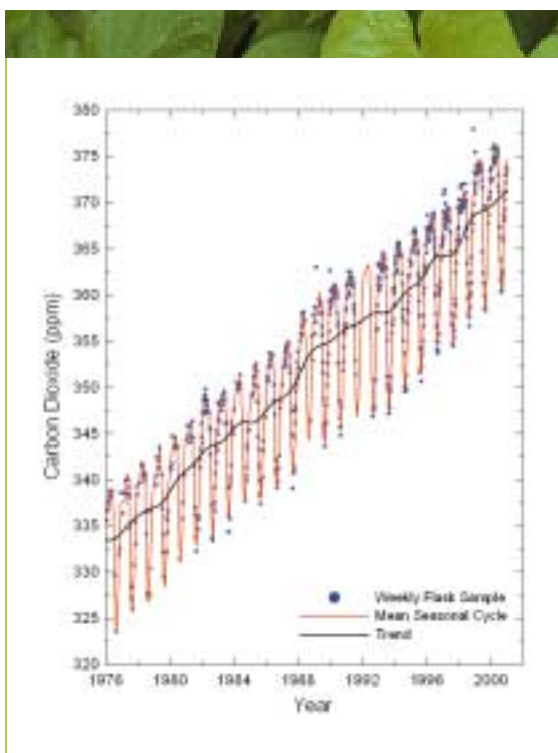
AND IS THE CLIMATE CHANGING?

By analyzing long-term data collected across the country, MSC scientists have detected changes in our climate. For example:

- temperatures in southern Canada have increased significantly over the past 100 years, with the greatest warming in the daily minimum temperatures;

- in the past 50 years, western Canada has warmed significantly, while the northeast has cooled;
- between 1950 and 1998, yearly precipitation totals increased in most parts of Canada by 5% to 35%. The largest increases occurred in the central Arctic; and
- the ratio of snowfall to total precipitation has decreased over southwestern Canada.

The patterns and the timing of changes show us which regions may be vulnerable to climate change. This information helps Canadians and government make decisions on the extent of GHG emission reductions and on adapting to the unavoidable impacts of climate change. Ongoing monitoring lets us track the results of our actions.



CO₂ trend as measured at Alert, Nunavut





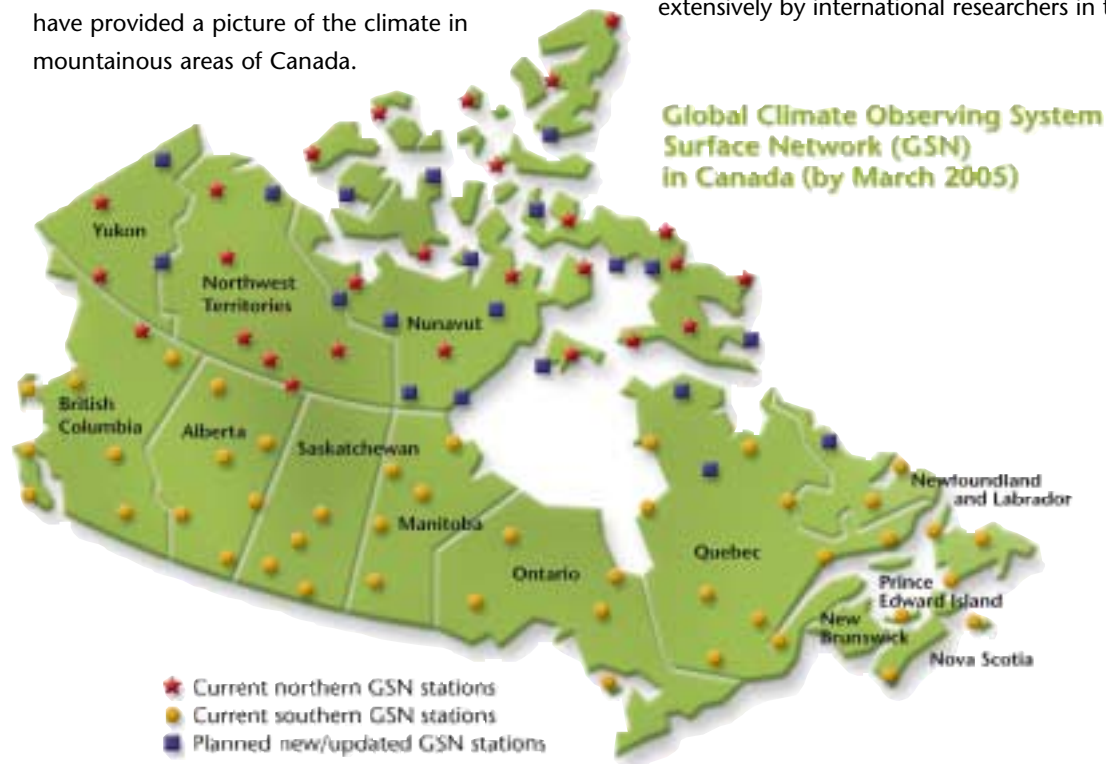
At the MSC observatory in Alert, Nunavut, technicians monitor concentrations of greenhouse gases, ozone-depleting substances and aerosols each day.

MSC also draws on climate information and analyses to create products used by researchers, industry and the public. They include:

- the Internet-based *Climate Trends and Variations Bulletin*, which summarizes climate conditions across the country and highlights trends (pda.msc-smc.ec.gc.ca/ccrm/bulletin). The Bulletin recently showed that 20 of the past 21 seasons have had above-normal temperatures; and
- high-resolution climate maps of monthly temperature and precipitation, which have provided a picture of the climate in mountainous areas of Canada.

Canada's monitoring programs have proven their value. However, there are still many aspects of the climate system that scientists need to understand more fully, particularly in the North. That knowledge is especially important since climate change is expected to pack a bigger punch in the Arctic. MSC is adding six new Arctic stations to the monitoring network and upgrading equipment at other sites. MSC and its partners are also gathering critical information on how snow, ice and ocean waters affect our climate. This work is part of the Government of Canada's *Action Plan 2000 on Climate Change*, a strategy to tackle greenhouse gas emissions and meet Canada's commitments under the Kyoto Protocol, as well as enhance our knowledge of the climate system.

MSC has been systematically measuring carbon dioxide and other greenhouse gases since 1975 – the only such program in Canada. These measurements, when combined with other data from around the globe, have shown increases of 31% in carbon dioxide concentrations, 151% in methane and 17% in nitrous oxide since the beginning of the Industrial Revolution. Canada's measurements of carbon dioxide are among the most precise in the world and have been used extensively by international researchers in their studies.



What do we learn from climate research?



BERMS Instrument Tower

HOW THE CLIMATE SYSTEM WORKS

The better we understand how the climate system works, the more accurate our climate predictions will be. MSC scientists and their partners are investigating how different elements of the climate system — the atmosphere, clouds, oceans, sea ice and the land surface — relate to each other and are studying the role that forests, agriculture, wetlands and oceans play in the global carbon cycle.

□ THE WATER CYCLE:

THE MACKENZIE GEWEX STUDY

Canadian scientists make an important contribution to the international Global Energy and Water Cycle Experiment (GEWEX) by investigating the flows of water and energy in the Mackenzie Basin (known as the Mackenzie GEWEX Study, or MAGS). MSC scientists and their colleagues have determined how much water originates outside the basin and how much is recycled within the basin in warm and cold seasons (about 50/50 in the warm season). Such information is invaluable for managing water resources, and the techniques used are being transferred to other major river basins worldwide that are being studied in GEWEX.

□ CRYOSPHERE RESEARCH

Studying the cryosphere (snow, ice and glaciers) fills a distinctly Canadian niche. The Cryosphere System in Canada (CRYSYS) project, led by MSC and involving the Geological Survey of Canada and others, has improved our knowledge of the cryosphere in Canada. MSC scientists have documented a trend toward increasing winter snow accumulation over North America. Another important finding, the abnormally long melting season during the very warm summer of 1998, is an indication of conditions that may become more common in the future.

□ BOREAL ECOSYSTEM RESEARCH AND MONITORING SITES (BERMS)

Under the Kyoto Protocol, countries can partially fulfill their GHG emission reduction commitments by accounting for the carbon dioxide taken up by forests. Through a collaborative project in Saskatchewan's Prince Albert National Park, scientists from MSC and the Canadian Forest Service are examining how carbon uptake and release by the boreal forest varies by time of day, by season and from year-to-year. Such information will

help establish the potential for so-called "carbon sinks" in Canada. This work contributes to a major cross-Canada program called FLUXNET, funded by the Natural Sciences and Engineering Research Council of Canada and the Canadian Foundation for Climate and Atmospheric Sciences.

□ BIOCAP

The BIOCAP Canada Foundation coordinates a series of national, university-based research networks investigating biosphere GHG management. Working with private and public sector partners, researchers explore how our forests and farmlands can be harnessed to meet Canada's climate change objectives and contribute to a dynamic and sustainable bio-based economy. MSC and its federal partners are working with BIOCAP through an initial \$6-million federal contribution.



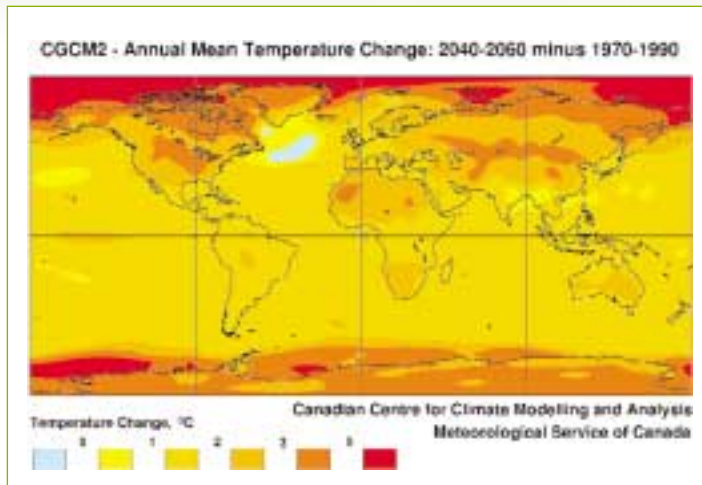
Mackenzie GEWEX Study Area

What will our climate be like in the future?

Climate models are the best available tools to answer this question. Models are sophisticated computer programs that simulate the climate system and let researchers peer hundreds of years into the past or the future.

CCCMA: A LEADER IN CLIMATE MODELLING

MSC, university partners and scientists at Fisheries and Oceans have developed highly respected global and regional climate models that enable scientists to make credible predictions about the magnitude, rate and timing of climate change and its possible impacts. These models are run on the MSC supercomputer in Montreal, one of the most powerful systems in the world.



Canada's climate modelling activities are based at the MSC's Canadian Centre for Climate Modelling and Analysis (CCCma) in Victoria, B.C. The Centre has developed three generations of global climate models (GCMs). These are sophisticated mathematical representations of all parts of the climate system – the atmosphere, oceans, sea ice, clouds, vegetation and more. The GCMs have been used in a series of simulations, including several estimating conditions 100, 250 and 1,000 years into the future.

International experts consider the Centre and its models to be among the best in the world. The Intergovernmental Panel on Climate Change (IPCC) used Canadian models in its Third Assessment Report – *Climate Change 2001*. These models were also used in the U.S. National Assessment of the Impacts of Climate Variability and Change, and are being used in the ongoing Arctic Climate Impact Assessment.

The MSC has been a major force in attracting researchers to work on climate modelling and analysis activities. These activities were supported initially by the Climate Research Network and now by the Canadian Foundation for Climate and Atmospheric Sciences. Researchers at universities across the country are improving the climate models through projects focusing on:

- climate variability (McGill);
- a regional climate model for Canada (UQAM);
- the meteorology and chemistry of the upper atmosphere (Toronto; York);
- aerosols (Dalhousie); and
- sea ice (Victoria).

Future modelling work will focus on how models deal with ocean circulation, the land surface, and biological and chemical processes. New climate modelling experts will be engaged in these critical areas.

Talking to Canadians

MSC staff across Canada are actively engaged in helping Canadians understand the science of climate change. In addition to giving media interviews, MSC researchers make presentations to schools, community groups, industry, government and other researchers. MSC data is also used in posters, booklets, Web sites and educational materials that explain the climate and climate change to Canadians.



How will climate change affect us and how can we adapt?

CLIMATE IMPACT SCENARIOS

Climate impact scenarios piece together the raw results of climate models and observations, such as temperature and precipitation estimates, to create an image of possible climate conditions. The scenarios are tailored to the unique needs of impacts and adaptation researchers in fields such as agriculture, forestry, fisheries and health.

MSC has created the Canadian Climate Impacts Scenarios Facility, based in Regina, to provide researchers with national climate impact scenarios. Its Web site, offering about 30 scenarios developed by MSC, has some 300 registered users and receives over 1,000 visits per month. MSC scientists have in turn prepared regional scenarios for such areas as the Okanagan Basin, Québec and Atlantic Canada.

IMPACTS AND ADAPTATION STUDIES

How will climate change affect our lives and the health of the planet? This is the kind of question MSC researchers and their partners are tackling.

□ CANADA COUNTRY STUDY

Completed in 1998, this was the first-ever national assessment of how climate change will affect Canadians and their social, economic and biological environments. The Study noted that while climate change could have some positive impacts, such as a longer growing season, it poses many threats, including health problems due to more frequent and severe heat waves.

□ WATER BASIN IMPACTS AND ADAPTATION IN B.C.

MSC and its research partners are examining how climate change could affect water supply and demand in the Okanagan Basin. Changes in streamflow could mean a decrease in water quality and increased pressure on water resources. Through focus groups, residents are considering ways to adapt, such as changing irrigation methods.

□ CLIMATE CHANGE AND CANADA'S PROTECTED AREAS

Research led by MSC showed that climate change could dramatically affect the ecosystems that Canada's national parks were created to protect. For example, polar bears could disappear from Manitoba's Wapusk National Park. The study is being used to factor climate change issues into park management.

□ CLIMATE CHANGE AND PEI

In a study of climate change impacts for Prince Edward Island, MSC regional scientists and their partners found that almost \$60 million worth of Charlottetown's municipal and heritage properties would be threatened by a rise in sea level. The study also recommended adaptation strategies.

□ IMPACTS ON THE GREAT LAKES

Climate change is expected to affect water levels and water quality. Lower levels will increase the cost of shipping and hydroelectric power. Scientists from MSC, the University of Waterloo and the U.S. Environmental Protection Agency are investigating these issues in the Great Lakes Basin and reporting on the results.

Science Assessment: Staying on top of climate change research

Canada plays a key role in international efforts to assess climate change information and further research needs. Over 80 scientists from MSC, other government organizations, universities and the private sector helped to prepare the IPCC's Third Assessment and associated special reports.

The Okanagan study team at the Okanagan Lake Dam speaking with Brian Symonds, Senior Floodplain Officer with the BC Ministry of Water, Land and Air Protection, responsible for regulating the level of Okanagan Lake.





Canada's climate change partnerships

PARTNERSHIPS ARE AN ESSENTIAL INGREDIENT

MSC works with a variety of organizations, for example:

- key federal departments and agencies (Agriculture and Agri-Food, Fisheries and Oceans, Natural Resources, Health, Industry, and the Canadian Space Agency);
- Canadian Foundation for Climate and Atmospheric Sciences;
- provincial/territorial governments;
- universities;
- the private sector;
- Intergovernmental Panel on Climate Change;
- World Climate Research Program;
- U.S. agencies.

OURANOS Program

A consortium of government, university and private sector partners, OURANOS is helping vulnerable sectors in Québec make wise decisions to adapt to and mitigate the regional impacts of climate change. MSC is making scientific tools and data available to scientists, decision makers and stakeholders.

Some key areas of interest to OURANOS are the impacts of winter warming on the Québec road system, water level variations in the St. Lawrence, and human health.



Looking ahead

MSC scientists have strengthened Canada's voice internationally and made great progress in understanding climate change. But there is still much to learn. We need to better understand the climate system, particularly in the Arctic. We need more accurate information about how the climate will change in specific regions of the country. The threat of extreme weather and climate events, which are often dangerous and costly, make these important issues for research. The farther we can move from uncertainty to understanding, the better we can predict the future and prepare for it. We can safeguard our natural world, our communities and our health. It all starts with sound science.

For more information, please visit these Web sites:

- The Government of Canada Climate Change site
www.climatechange.gc.ca
- Environment Canada
www.ec.gc.ca
- Meteorological Service of Canada
www.msc-smc.ec.gc.ca
- Canadian Centre for Climate Modelling and Analysis
www.cccma.bc.ec.gc.ca
- Canadian Climate Impacts Scenarios
www.cics.uvic.ca/scenarios