The United Nations World Water Assessment Programme

Scientific Paper

Water and Climate Change in Québec

Luc Vescovi, Pierre Baril, Claude Desjarlais, André Musy and René Roy

Ouranos Consortium

OURANOS

World Water Assessment Programme | Side publications series | SCIENTIFIC PAPER

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World Water Assessment Programme

The United Nations World Water Development Report 3
Water in a Changing World

Coordinated by the World Water Assessment Programme, the *United Nations World Water Development Report 3: Water in a Changing World* is a joint effort of the 26 United Nations agencies and entities that make up UN-Water, working in partnership with governments, international organizations, non-governmental organizations and other stakeholders.

The United Nations' flagship report on water, the WWDR offers a comprehensive review of the state of the world's freshwater resources and provides decision-makers with the tools to implement sustainable use of our water. The WWDR3 represents a mechanism for monitoring changes in the resource and its management and tracking progress towards achieving international development targets. Published every three years since 2003, it offers best practices as well as in-depth theoretical analyses to help stimulate ideas and actions for better stewardship in the water sector.

Water in a Changing World has benefitted from the involvement of a Technical Advisory Committee composed of members from academia, research institutions, non-governmental organizations, and public and professional organizations. To strengthen the scientific basis and potential for implementation of its recommendations, interdisciplinary expert groups were also created for a number of topics, including 'Indicators, Monitoring and Databases', 'Business, Trade, Finance and Involvement of the Private Sector', 'Policy Relevance', 'Scenarios', 'Climate Change and Water', 'Legal Issues' and 'Storage'. An accompanying case studies volume, Facing the Challenges, examines the state of water resources and national mechanisms for coping with change in 23 countries and numerous small island developing states.

This series of side publications also accompany the WWDR3, providing more focused, in-depth information and scientific background knowledge, and a closer look at some less conventional water sectors. These publications include:

Scientific Side Papers

This series provides scientific information on subjects covered in the WWDR and serves as bridge between the WWDR3's contents and scientific, peer-reviewed publications.

Sector and Topic-Specific 'Insight' Reports

The reports and documents in this series will provide more in-depth information on water-related sectors, issues and topics in a stand-alone manner. Examples of the subjects of this series include Integrated Water Resources Management, transboundary issues and technology, among others.

Dialogue Series

Sectors and topics to which water is cross-cutting or important will be covered in this series of side publications. Some examples of subjects discussed in this collection of reports include climate change, security, biodiversity, poverty alleviation and land use.

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Introduction

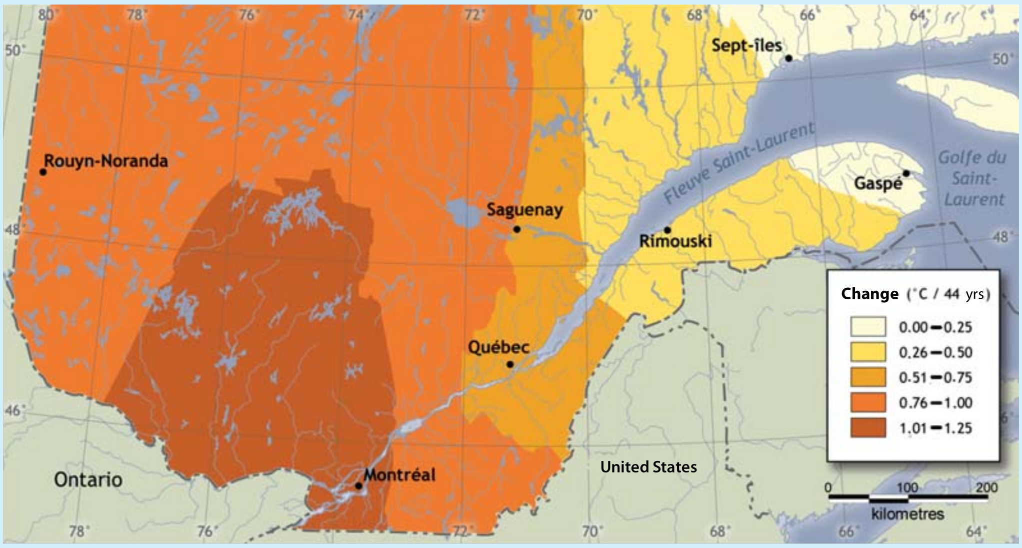
According to the Intergovernmental Panel on Climate Change (IPCC), the average global temperature has increased by 0.6 °C since the beginning of the twentieth century. Yet, various scenarios under study show that global warming, brought on by increases in greenhouse gas concentrations, will accelerate over the next half century. Impact studies indicate dramatic consequences in several regions of the world, in particular in terms of water supply, food production, health and the environment. Hundreds of millions of people may suffer from hunger, water shortages and coastal flooding as the planet warms (IPCC, 2007*a*). In Québec, a study undertaken by the Québec Ministry of Sustainable Development, Environment and Parks and the Ouranos Consortium (Yagouti et al., 2008) shows that air temperature increased over the period 1960–2005, and that this warming was more pronounced in the western, southern and central parts of the province (where mean annual temperature increased by 0.5 to 1.2 °C, compared to an increase of less than 0.5 °C in southeastern Quebec). This trend is illustrated by Figure 1. Particularly in the summer, significant increasing temperature trends and decreasing precipitation trends in many stations were observed.

Faced with such a global and regional scenario, it is clear that society must rapidly reduce the growth of greenhouse gas emissions and concentrations. Yet, even if, through highly interventionist policies, we succeed in doing so, it will not be possible to avoid substantial increases in greenhouse gas concentrations in the coming decades. The world will therefore need to cope with significant climate change (IPCC, 2007*b,c*).

Québec will be affected in a number of ways, in particular in the north, where temperature increases will be greater, but also in coastal areas, in the boreal forests and in the agricultural and urban areas in the south (Lemman et al., 2008). In addition to temperature increases, other closely related parameters will also be affected, including: evaporation, precipitation, freezing rain and snow, the hydrology of lakes and rivers, extreme events, and wind and storm regimes. These changes will impact the environment (both natural and built) as well as people (their health, safety and well-being) and the activities that connect them (economy, transport, energy, etc).

Québec, as everywhere else, will therefore have to confront these climate changes in order to minimize their adverse effects, as well as to optimize any possible beneficial effects. It is thus necessary to develop a balanced and integrated strategy

Figure 1 **Trends in Mean Temperature, 1960–2003**



Source: Cartography Laboratory, Department of Geography, Université Laval

Based on data from Québec Ministry of Sustainable Development, Environment and Parks (MSDEP)

to both reduce greenhouse gas emissions and adapt to the inevitable climate change. It was to accomplish these goals that the Ouranos Consortium (www.ouranos.ca) was created, with the particular aim of providing support to decision-makers in carrying out the latter part of this strategy.

The Ouranos Consortium

Created in the wake of major meteorological events that struck Québec in 1996 (with the Saguenay flood, causing $CAN 1.2 billion of damage), 1998 (the St-Lawrence Valley ice storm, $CAN 4.2 billion) and 2001 (extreme summer heatwave), Ouranos today plays a leading role in the development of knowledge in climate projections and scenarios, the impacts of climate change, and the development of adaptation strategies. Ouranos was created thanks to the initiative and participation of the Government of Québec, the Crown Corporation Hydro-Québec and the Meteorological Service of Environment Canada. Also part of the consortium are eight Government of Québec ministries and four Québec universities: the Université du Québec at Montréal, McGill University, Université Laval and the Institut National de la Recherche Scientifique (INRS). More recently, the École de Technologie Supérieure (ETS), the Université du Québec at Rimouski and the Crown Corporation Manitoba Hydro have joined as affiliate members.

Ouranos comprises a team of some 100 scientists and specialists, while partnerships with several universities and other institutions directly or indirectly contribute an additional 150 researchers. Scientists and researchers work in integrated teams, on some 40 modelling and climate change adaptation projects. The consortium's annual budget averages nearly $CAN 10 million, of which approximately half comes from contributions by Ouranos members.

Ouranos's role has five components:

- to produce climate change projections and scenarios on various regional scales with the help of several models, including the Canadian Regional Climate Model (CRCM - Plummer et al. 2006; Music and Caya, 2007; Caya and Laprise, 1999);
- to provide support to specialists at research centres and universities, including data and scaling up of data, according to their needs;
- to act as a catalyst of, and participant in, impact and adaptation studies, identifying and bringing together researchers, users and decision-makers in defining research projects;
- to raise awareness among both decision-makers and the public about climate change and what actions can be undertaken to respond to it;
- to provide support for Québécois and Canadian research.

As illustrated in Figure 2, Ouranos's scientific programme is structured around several major programmes: (1) arctic populations and ecosystems, (2) northern resources, (3) public safety and secure infrastructures, (4) energy supply, (5) water resources, (6) health, (7) coastal erosion, (8) forestry, agricultural, mining, tourism and transportation operations, (8) protecting the natural environment. These programmes address local issues and answer to the needs expressed by Ouranos members and government departments and institutions in Quebec, as well as in other parts of Canada.

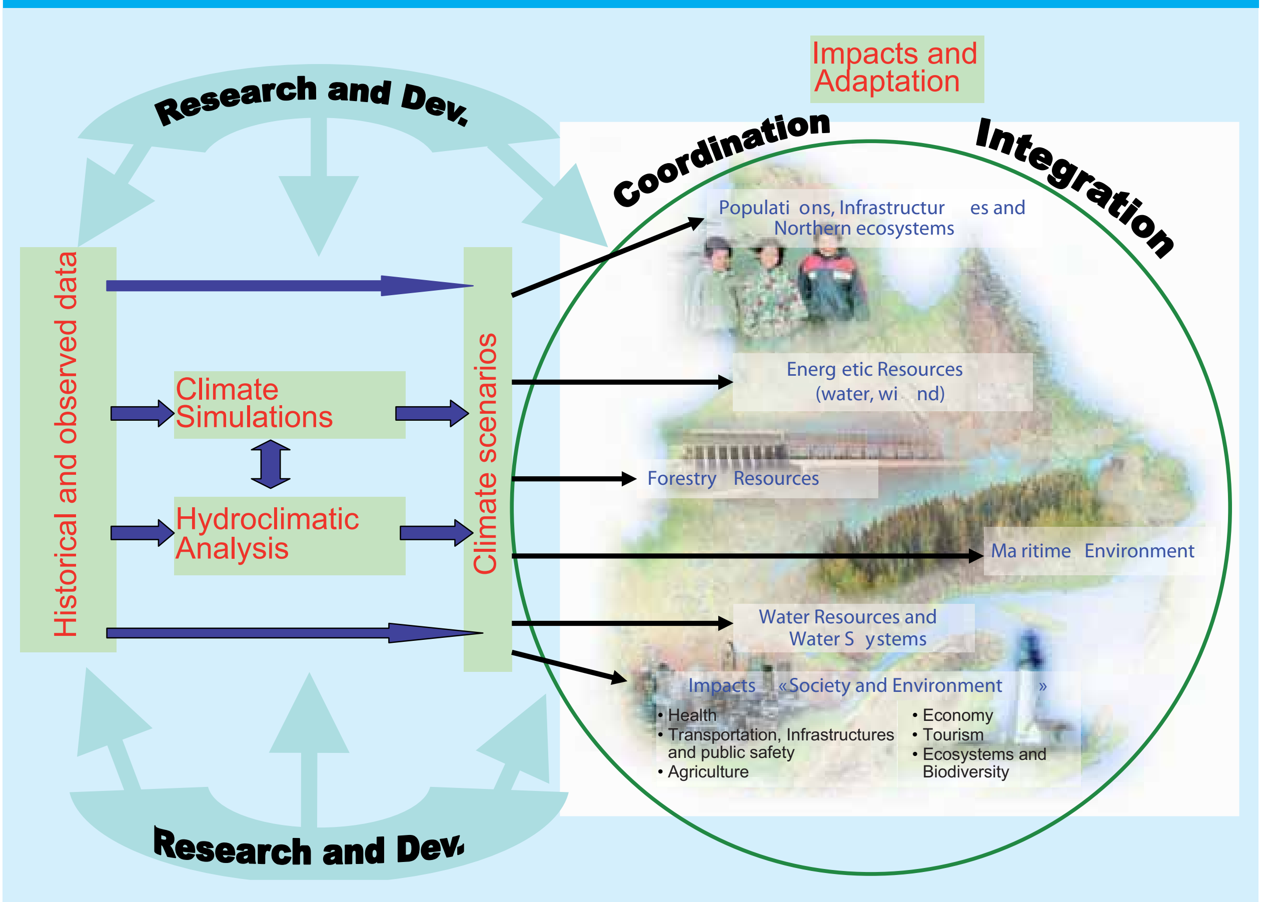
Since its creation, Ouranos has completed numerous studies in collaboration with over a dozen institutions. These studies, in accordance with Ouranos's scientific programme, have ranged from developing climate scenarios using the CRCM to assessing the impact of climate change on the ski and golf industries and on energy demand for heating and air conditioning. They include studies of the consequences of melting permafrost in Québec's arctic region and on airport runways and Inuit villages. Other research has focussed on the impact of climate change on broadleaf forests, agriculture and demand for water, and on health issues such as the effects of cold and heat waves and pollen dispersion. Important work has also been done on rainfall on Québec watersheds and the consequences in terms of flow.

The extent, diversity and complexity of these issues require a coordinated approach, drawing on all available resources. While several organizations in Canada and Québec have addressed, each in their own field, issues of climate change impacts and adaptation, none has so well brought together climate experts and scientists with experts on the physical, human and social impacts of climate change. Ouranos's strength is that it fills this gap, ensuring the complementarity of work done in full inter-disciplinarity. Indeed, the information required to address the impacts of climate change is very varied and requires an integrated and multidisciplinary approach. Regional, even local, climate scenarios are needed, as well as climate, hydrological, geospatial, biophysical, economic, social and health data at the regional level. It is important that climatologists provide scientific impact experts with pertinent climate indicator values, ranging from annual or multi-year averages over large areas, to the intensity and frequency of precipitation per 10 minutes over relatively small areas.

Interdisciplinarity also entails an inter-institutional approach. Indeed, it would be difficult to imagine uniting within one institution all the skills needed to study these complex issues. Thus, in addition to its approximately 30 staff members, plus another 30 specialists on loan from its members, Ouranos calls upon a network of some 250 researchers, from various higher-educational institutions in Québec, to carry out its projects. As one can see, Ouranos is indeed a consortium.

This multidisciplinary and multi-institutional team structure is not only innovative, it is a source of great strength for Ouranos, providing it with undeniable added-value (Figure 3). By creating a working

Figure 2 **Ouranos's Scientific Programme**



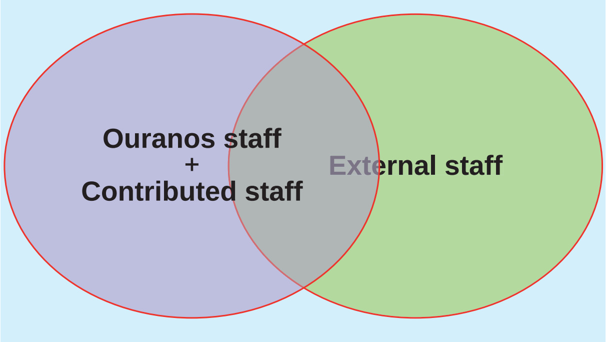
environment that is both stimulating and productive, it allows the consortium to better attain its objectives and meet the expectations of its members. In addition to this synergy of researchers who come from many different fields and backgrounds, another major advantage of Ouranos is its ability to bring together researchers and decision-makers. Because of its partnerships with governmental agencies, Ouranos is well positioned to create the dialogue necessary to help researchers and decision-makers work together, from the conception and orientation of research projects to their successful completion. In this way, the consortium is able to assure decision-makers of the relevance of projects, as well as to facilitate their progress through the provision of on-site experts, the formulation of hypotheses and gathering of data. Finally, Ouranos assists with the transfer of knowledge of research results, both directly and in participation with potential beneficiaries of the various adaptation measures that may be proposed or adopted.

Québec and water management in the context of climate change

At the start of the third millennium, southern Canada and Québec are home to the majority of the country's population and to major economic activities whose impacts on water resources are considerable (Vescovi, 2003). With 65% of its population living in highly urban watersheds and 32% in moderately urban watersheds (Statistics Canada, 2005), the pressure on watersheds in southern Québec is enormous, and despite the relative abundance of water resources in the province, it is important, particularly given the sensitive nature of the issue, to examine the impacts which climate change will have on this resource (Rousseau et al., 2003; Nantel et al., 2005). In southern Québec, water management involves a multitude of uses and users, in both rural and urban areas, including removals for various consumptive uses (e.g. bottled water, industrial and municipal supply, aquaculture, agriculture and mining), and on-site uses (e.g. river transportation, recreation and wastewater evacuation). Consequently, the impacts of future hydro-climatic changes could exacerbate existing use conflicts. Indeed, these conflicts have already generated political interest, leading, in 2002, to the adoption of a new Québec Water Policy (Government of Québec, 2002). Furthermore, the Crown Corporation Hydro-Québec, which produces nearly 80% of the province's hydroelectricity from very large complexes north of the 49th parallel, is justifiably very concerned about any potential changes in hydraulicity (Hydro Québec, 2008, Roy et al., 2008).

Thus, based on the most recent studies completed by Ouranos, we propose here to outline the potential impacts of climate change on the main uses of water resources and on the means in place to counter

Figure 3 **Organization of Ouranos's Human Resources**



these problems as well as to optimize any possible benefits. We will examine the issues of floods and flood control, dam management in the southern basins, drinking water supply and the problem of low flows, groundwater recharge, urban drainage, inland navigation and hydroelectricity.

The question of floods and flood control

Regarding the magnitude of floods in southern Québec, the potential effect of climate change has not yet been clearly determined, and conclusions vary depending on the climate simulation tools used. However, according to a study by a research team at the Université du Québec's École de Technologie Supérieure (ETS), we can anticipate that spring floods will occur earlier but that flood volumes will probably be reduced (Caron, 2005; Mareuil, 2005). This study, conducted on the Châteauguay River watershed (Figure 4), used a modelling exercise based on the development of a stochastic climate generator factoring in monthly anomalies of temperature and precipitation taken from three general circulation models (GCM). Thus, the potential climate change in southern Québec, in particular on the Châteauguay River, is expected to impact more directly on spring floods and less directly, via levels of the Saint-Lawrence River, on summer open-water floods.

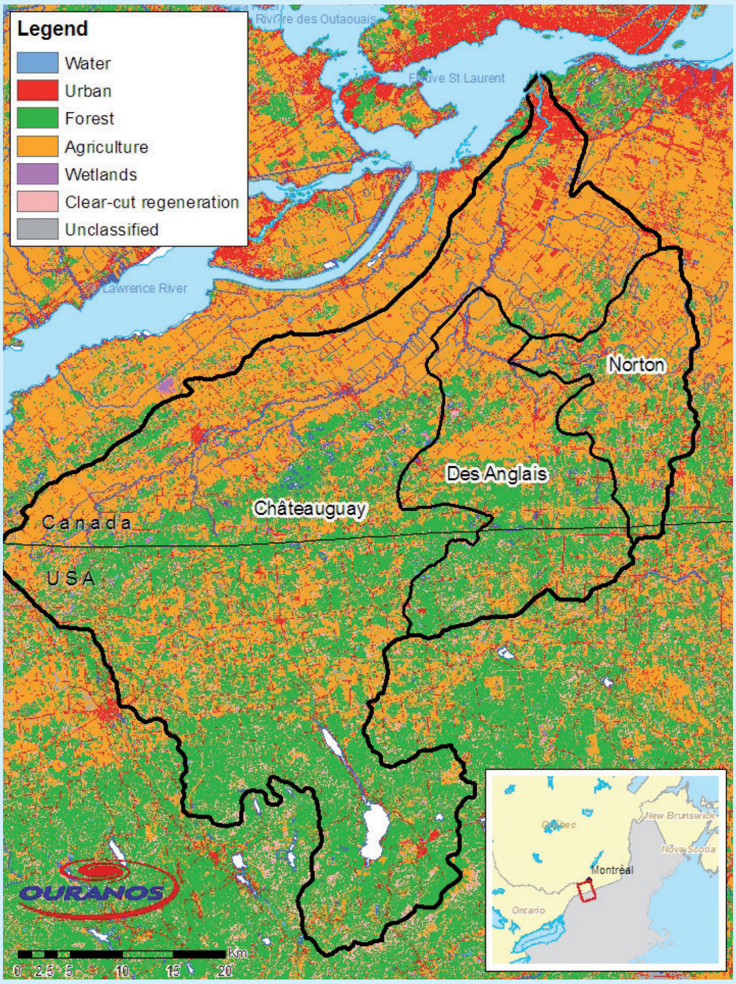
Dam management in the southern basins

The Government of Québec has numerous dams, which are designed to achieve multiple objectives including flood control, water supply, and support for recreation, as well as production of hydroelectric power.

In a context of climate change and, particularly, changes in precipitation regimes, the question arises as to the capability of current management plans to address potential impacts. For this reason, the Centre d'Expertise Hydrique du Québec, which manages the water regime of dams for the government, is evaluating possible adjustments of management plans to adapt to new climate realities.

In order to develop a methodology to evaluate options for adapting management plans, a pilot project was carried out, with the support of Ouranos, on the Saint-François and Aylmer

Figure 4 **Châteauguay River Watershed**



reservoirs, located in the Upper Saint-François River sub-watershed in south-central Québec (Fortin et al., 2007). As illustrated in Figure 5, the results of one of these studies show that the annual inflows to these southern Québec reservoirs will increase and that spring floods will occur earlier, by from few days to a few weeks. As for the impacts on the intensity of peak spring and summer/autumn floods, and the impacts on winter flows, the severity of low water levels, and increases in annual volumes – all vary according to the climate model and greenhouse gas emission scenario used.

Furthermore, the simulation of the current management plan shows that climate change will affect the current compromise between the different uses of reservoir water. Adaptation strategies of realistic management plans can be set up for each of the climate scenarios, taken individually. It is not possible, however, to decide now on a single solution applicable to all possible scenarios.

The results illustrate the importance of reflecting on the question of climate change as a factor that will alter the current balance between water uses and of considering together the adaptation of management plans and discussions with stakeholders to plan the future balance of uses.

More generally, as regards the management of multiple-use watersheds in southern Québec, Ouranos is developing, in close collaboration with its partners, a novel programme to propose recommendations of appropriate and targeted adaptations to current problems. The Châteauguay River watershed, represented in Figure 4, is one of the sites being studied for this purpose, where the problems connected with agricultural irrigation are studied, in particular, in collaboration with the Centre d'Expertise Hydrique du Québec (CEHQ) and the Québec Ministry of Agriculture, Fisheries and Food.

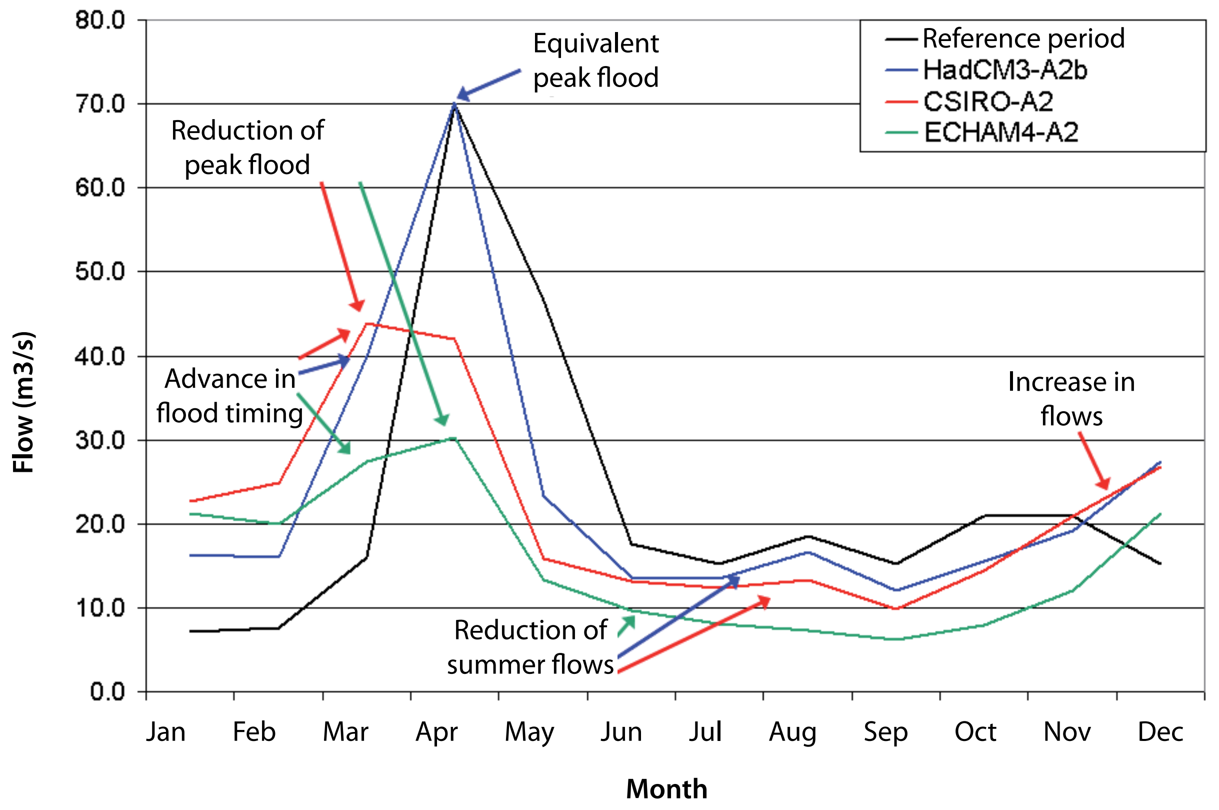
Drinking water supply and the problem of low flows

Climate change will have an impact on the availability of water resources through an increased frequency and magnitude of low flows and droughts. The study cited above illustrates this fact. Surface water alone represents 80% of all water used in Québec (Rousseau et al., 2004; Mailhot et al., 2004; Nantel et al., 2005). Thus, the future vulnerability of drinking water supply systems in Québec involves, on the one hand, the amplitude of the changes likely to affect the resource, and on the other, the capacity of supply systems and infrastructures, as well as organizations, to deal with such changes. The adaptation measures that should be considered are numerous and involve both infrastructures (e.g. rehabilitation, or even relocation, of certain water intakes, improving effectiveness of treatment, reducing the volume of water lost in the network, and increasing reserve capacities) and management methods (e.g. water saving measures).

Groundwater recharge

Concerning groundwater, according to a study done by Natural Resources Canada (Rivard et al., 2003), the annual recharge appears to have remained stable or declined slightly in recent decades, while both precipitation and temperatures have been rising since the beginning of the century. Significant decreases in water availability could have major impacts, especially in rural areas where a large proportion of the population (90% in Québec) obtains its water from (sometimes private) wells. Their vulnerability is even greater as our knowledge of groundwater resources in Canada remains incomplete. The mapping of the Châteauguay River Basin, in Québec, is a step in the

Figure 5 **Monthly inflow into Lake Saint-François**



right direction (Côté et al., 2005). Furthermore, as discussed above, several research projects, supported by Ouranos and the Natural Sciences and Engineering Research Council of Canada (NSERC), begun in 2006, are aiming to improve our knowledge of, for example, systems integrating surface and groundwater, using coupled models (Broda et al., 2008). This knowledge will contribute to our ability to study the vulnerability of these aquifers at the local level.

Urban drainage

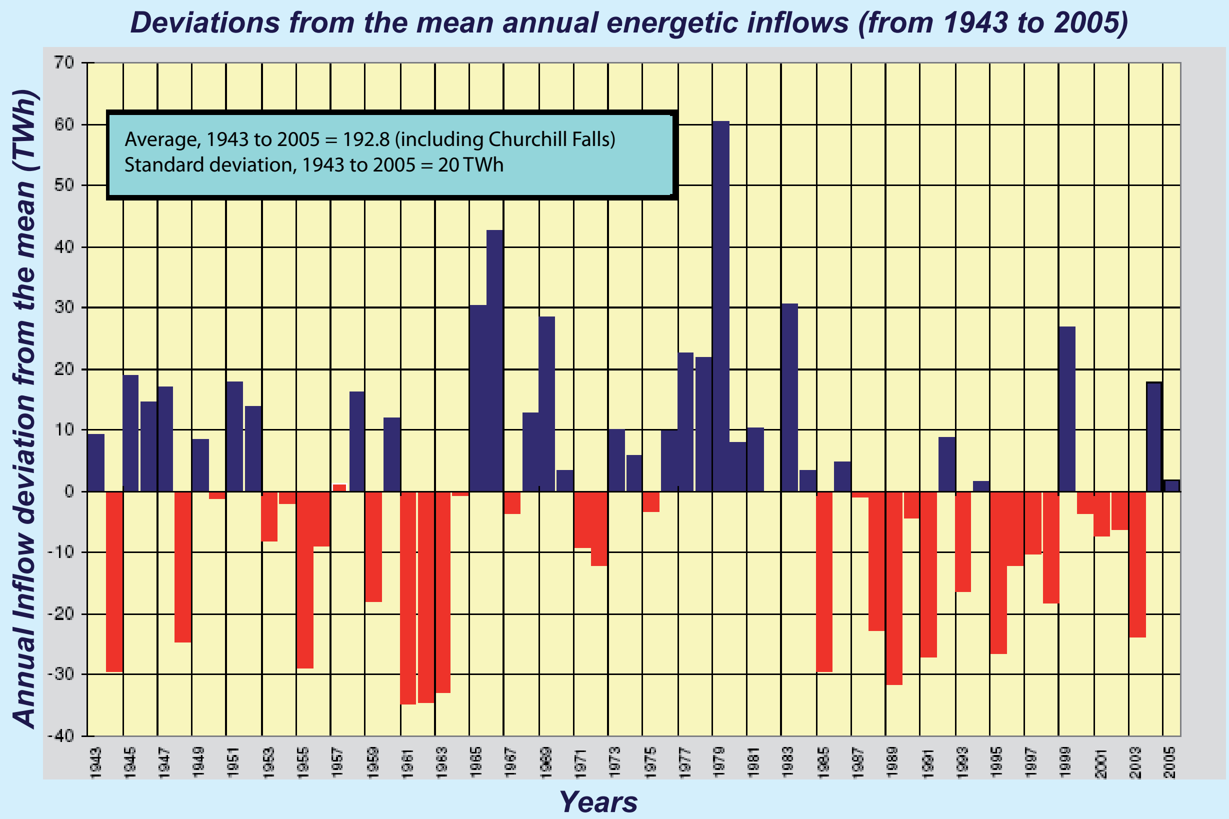
Traditionally, the design of urban drainage systems is carried out based on recurrence interval statistics generated from analysis of historical rainfall data at a given site (Mailhot and Duchesne, 2005). If, as climate change scenarios suggest, there should be a significant increase in the frequency of intense rainfalls, there is a danger of increased sewer overflows, backflows and even flooding. Several adaptation measures are possible, depending on the level of a given municipality's vulnerability to climate change. But it is necessary to review the design criteria of urban drainage systems with a view to potential changes in the frequency of intense rainfall events that may occur during the life of the infrastructure. These new criteria should also be kept in mind and factored into the design of any upcoming repair work to improve the condition of aging, soon to be replaced, drainage systems (Mailhot et. al, 2007).

Inland navigation

Certain climate scenarios predict reduced inflows into the Great Lakes St. Lawrence Seaway system, causing significant impacts on commercial shipping. In the context of sustainable navigation, the Navigation Committee of the St. Lawrence Action Plan has studied adaptation options which would allow port and maritime activities to be maintained at their current levels (D'Arcy et al., 2005). Should hydrological conditions around 2050 be those of an average water year, the drop in the river level will not adversely affect commercial activities. If, on the other hand, they are typical of a low water year, the lower water levels in Montréal could reach as much as 1.0 m below Chart Datum for several months in a row (in a hot and dry scenario), with the lowest levels occurring at Bécancour.

Using outputs from four GCMss, Croley (2003) estimated that outflows from Lake Ontario into the St. Lawrence River would be reduced. Depending on the various projections, this reduction would vary from 4% to 24% annually. In their study of the Ottawa River, the St. Lawrence's main tributary, Fagherazzi et al. (2005), using the same climate models, estimated there would be a slight reduction

Figure 6 **Variation in annual hydroelectric production, 1945–2006**



Source: Hydro-Québec, 2008

in flows of the Ottawa River, varying from 1% to 8%. This reduction of flows into the St. Lawrence River will have direct impacts on water uses. In a recent analysis of various plans to regulate the flow system, initiated by the International Joint Commission (IJC), several management plans were tested including an analysis of flows under climate change conditions (IJC, 2006).

Hydroelectricity

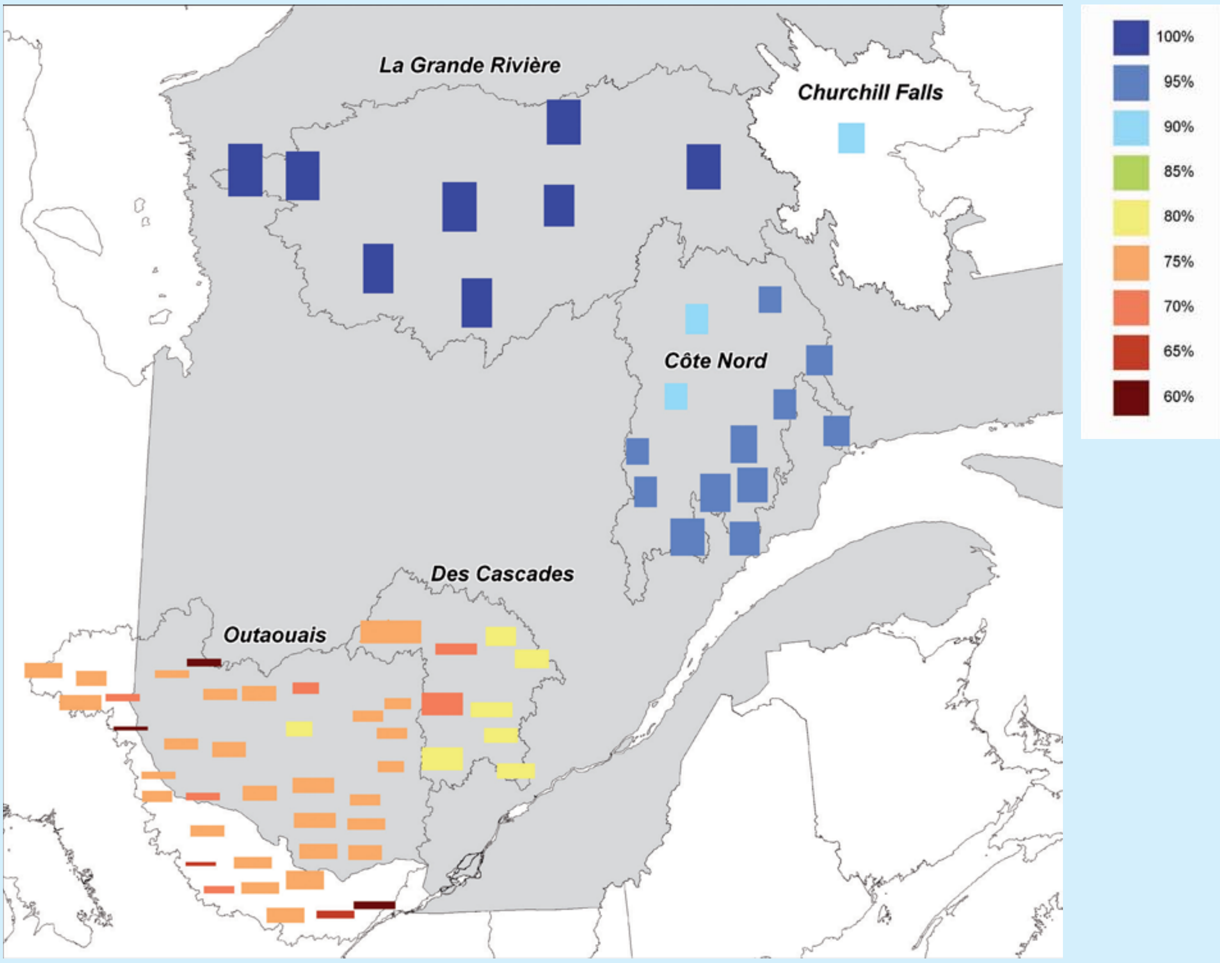
In Québec, the electricity produced by the Crown Corporation Hydro-Québec comes primarily (more than 96%) from hydroelectric generating stations. The total installed capacity available to Hydro-Québec (including the production of Churchill Falls) is 42,747 MW (Hydro-Québec, 2008), of which 80% is produced north of the 49th parallel, including the three large hydroelectric complexes Bersimis–Manic-Outardes, La Grande and Churchill Falls.

Hydroelectricity represents nearly 40% of Québec's energy supply, or around 70% of residential heating and sales in Québec alone, more than $CAN 10 billion in 2007.

It is easy to see, therefore, the need to determine the impacts, both economically and in terms of the energy security of Quebeckers, of climate change on existing production. Figure 6 illustrates the extent of variations in the annual hydroelectric production of Hydro-Québec over the period 1943–2006 (Hydro-Québec, 2008). In particular, the long period of deficit (with respect to the long-term average) from 1985 to 1999 should be noted.

In a recent Hydro-Québec study (Roy et al., 2008), using outputs from 9 global and regional models (or 36 hydro-climate projections), climate projections for the time horizon 2050 show higher trends for average annual hydroelectric production. However, as Figure 6 shows, for every river system managed by Hydro-Québec, increases will vary considerably depending on the region, with relatively minor increases in the south (Ottawa River) and much larger increases in the north (La Grand River and Côte-Nord), where the James Bay hydroelectric complex is located. In Figure 7, the amount of the increase is indicated by the height of the bars (increases are seen in all regions, but especially in the north of the province), while the variation between the 36 hydro-climate projections is indicated by the width of the bars; the colour represents the degree of convergence of the various scenarios (blue, strong convergence; brown/red, weak convergence). For the hydroelectric industry, the best scenario would be represented by a long, narrow, dark blue bar.

Figure 7 **Difference between future (c. 2050) and current natural inflows of river systems managed by Hydro-Québec.**



The height of the bars represents the amount of increase of inputs; the width represents the deviation between projections; the colour represents the degree of convergence of projections
(blue = strong convergence, brown-red = weak convergence)
Source: Roy et al., 2008

Figure 8 shows 36 mean annual hydrographs simulated by a hydrological model fed by climate projections over a 30-year period for the time horizon 2050 (2041–2070) (coloured lines), compared with the hydrograph simulated from reference climate data observed for the period 1960–2002 (black line). Comparing the mean annual hydrograph with the simulated hygrographs for the time horizon 2050 helps one to visualize the following overall conclusions concerning seasonal variations in hydrological conditions expected for northern Québec:

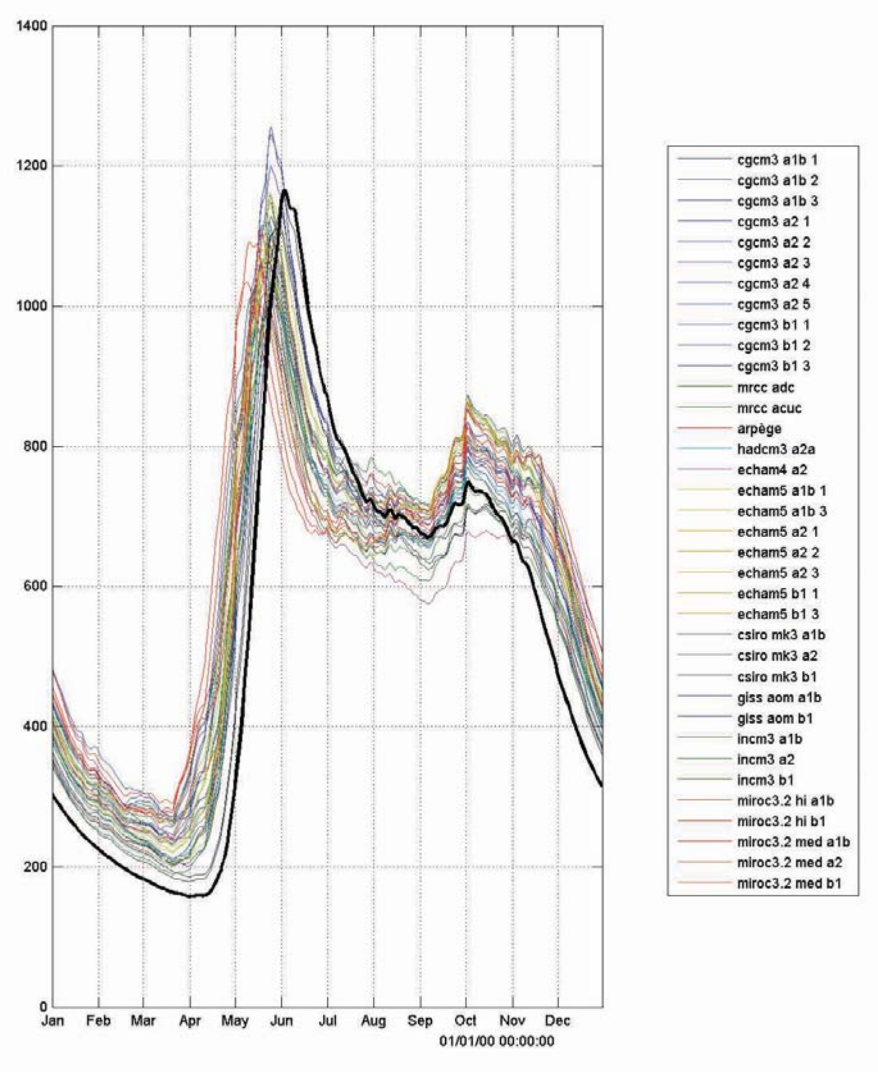
- winter inflows will be more sustained (from November to April);
- spring floods will occur two to four weeks earlier; and
- summer inflows may be significantly reduced, due to higher evapotranspiration rates (caused by higher temperatures).

For planning purposes, and to optimize the operation of future hydroelectric installations, we should underline the importance of high spatial and temporal resolution hydro-climatic scenarios, which allow a consideration of the future conditions of hydrological regimes. It is also important to quantify the uncertainty associated with different climate scenarios and to analyse impacts in detail. Ouranos is developing and continuing its programmatic activities in this direction particularly.

Conclusion

In Québec, the management of water resources, with their multiple uses and users, will be strongly

Figure 8 **Average hydrograph over 30 years**



Simulated using climate observations (black lines) and the results of hydro-climatic studies via 9 models using different greenhouse gas emission scenarios (coloured lines: 2041–2070) for a northern watershed.

Source: Roy et al., 2008

influenced by the coming climate change, both in terms of higher temperatures and changes in precipitation behaviour. As described above, the preliminary studies developed by Ouranos indicate that the effects of climate change may have the following consequences:

- to advance spring floods in southern and northern watersheds;
- to increase the frequency of ice jams, and thus the risk of flooding of downstream municipalities;
- to affect the level of the St. Lawrence River;
- to alter the behaviour of the river's tributaries;
- to affect the optimization of reservoir management regulating southern basins;
- to cause an increase in irrigation needs for farmland;
- to increase winter inflows to Hydro-Québec reservoirs (from November to April);
- to possibly reduce summer inflows to Hydro-Québec reservoirs, due to a higher rate of evapotranspiration (higher temperatures); and
- to increase the vulnerability of urban drainage and drinking water supply infrastructures in many Québec municipalities.

Admittedly, the inherent uncertainty of these hypotheses based on modelling results and scenarios is still considerable. Recent years have seen scientific advances in climate modelling, and research efforts, particularly using regional atmospheric climate models, should be intensified.

Nevertheless, adaptation options can be discussed in light of currently available climate projections.

Taking into account environmental and socio-economic uncertainties and constraints, Ouranos's preliminary studies indicate that flood management, the satisfaction of future irrigation and drinking water needs, and the protection of ecosystems require an integrated and comprehensive water resources management plan at the watershed level.

Furthermore, major urban centres, because of their heavy dependence on surface water, are likely to be particularly vulnerable to any changes in river levels and consequent alterations in water intake. In contrast, rural areas, being able to rely on groundwater, should be less vulnerable, in quantitative terms; however, the question of water contamination remains to be monitored. Here too, adaptation options require integrated, comprehensive management, adapted to the water cycle of the southern basins as well as to the Great Lakes St. Lawrence Seaway system. Finally, the question of repairing water pumping and treatment infrastructures (for raw, potable and waste waters) must also be addressed in this integrated context and be an important component of any adaptation options to be developed.

Faced with future climate change, the adaptation of water management in Québec requires the search for multidisciplinary and multi-institutional adaptive solutions. Ouranos is clearly well positioned to play a key role in this process.

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World Water Assessment Programme side publications, March 2009

During the consultation process for the third edition of the World Water Development Report, a general consensus emerged as to the need to make the forthcoming report more concise, while highlighting major future challenges associated with water availability in terms of quantity and quality.

This series of side publications has been developed to ensure that all issues and debates that might not benefit from sufficient coverage within the report would find space for publication.

The 17 side publications released on the occasion of the World Water Forum in Istanbul in March, 2009, in conjunction with *World Water Development Report 3: Water in a Changing World*, represent the first of what will become an ongoing series of scientific papers, insight reports and dialogue papers that will continue to provide more in-depth or focused information on water–related topics and issues.

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by Keith Kennedy, Slobodan Simonovic, Alberto Tejada-Guibert, Miguel de França Doria and José Luis Martin for UNESCO-IHP

Institutional Capacity Development in Transboundary Water Management
by Ruth Vollmer, Reza Ardakanian, Matt Hare, Jan Leentvaar, Charlotte van der Schaaf and Lars Wirkus for UNW-DPC

Global Trends in Water-Related Disasters: An Insight for Policymakers
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Inland Waterborne Transport: Connecting Countries
by Sobhanlal Bonnerjee, Anne Cann,Harald Koethe, David Lammie, Geerinck Lieven, Jasna Muskatirovic, Benjamin Ndala, Gernot Pauli and Ian White for PIANC/ICIWaRM

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OURANOS

Ouranos is a research and development consortium that brings together 250 scientists and professionals from different disciplines. It was created in 2001 as a joint initiative by the Quebec government, Hydro-Québec and Environment Canada, with the financial support of Valorisation-Recherche-Québec.

Ouranos' mission is to acquire and develop knowledge on climate change, its impact and related socioeconomic and environmental vulnerabilities, in order to inform decision makers about probable climate trends and advise them on identifying, assessing, promoting and implementing local and regional adaptation strategies

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