Inuit Circumpolar Council - Canada

INUIT

The Sea Ice is Our Highway

An Inuit Perspective on Transportation in the Arctic

A Contribution to the Arctic Marine Shipping Assessment

March 2008

INUIT

Inuit Circumpolar Council - Canada

Acknowledgements:

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Photo Credit, p.1: H. Finkler.

5. Conclusion

In the Arctic, the sea ice is our highway in wintertime and the open sea is our highway in summertime. The sea is integral to our way of life as Inuit. Because we still rely on traditional Inuit food for a large portion of our diet, and because hunting and being out on the land are central to our culture, we continue to use the land and sea the same way our ancestors have done for thousands of years. This gives us a great sense of pride and well-being.

In the Arctic, the sea ice is our highway in wintertime and the open sea is our highway in summertime. The sea is integral to our way of life as Inuit.

In the face of climate change and the potential for greater use of the Arctic by newcomers, we urge anyone making any plans regarding our land and sea to remember who has been living in the Arctic for thousands of years, and who will continue to live here for thousands more.

Any activity in the Arctic, whether it is resource extraction, tourism, or military-related, must be undertaken according to the Inuit definition of sustainability – it must support the continuation of the Inuit way of life for thousands of years to come.

The point we wish to emphasize through these accounts from various Inuit communities is that the environment is vital to our entire way of life as Inuit. If something were to happen to our fragile Arctic ecosystem, our way of life would be lost and we as a people would be lost. Therefore, any activity in the Arctic, whether it is resource extraction, tourism, or military-related, must be undertaken according to the Inuit definition of sustainability – it must support the continuation of the Inuit way of life for thousands of years to come.

Executive Summary

Context:

This report from the Inuit Circumpolar Council (ICC) Canada contributes to the Arctic Marine Shipping Assessment (AMSA) being conducted by the Arctic Council. It provides the AMSA project with an Inuit perspective on the human dimension of shipping. As a Permanent Participant at the Arctic Council, ICC speaks on behalf of all 155,000 Inuit living in Greenland, Canada, Alaska and Russia.

Sources:

The report investigates Inuit use of sea ice. It draws upon three sources:

- Thirty-year old land use and occupancy studies upon which the modern Inuit land claims agreements in Canada were based;
- Recent interviews with Inuit hunters in Canada; and
- Additional studies from Alaska and Greenland.

Parts of this report are written in the first person with Inuit telling their story.

Main Point:

This report demonstrates unequivocally that life in the Arctic is dependent on movement, and that sea ice is integral to this movement. The Inuit have been a nomadic people living in the Arctic since ancient times: their entire culture and identity is based on free movement on the land. Inuit rely on free movement in order to eat, to obtain supplies for traditional clothing and art, and generally to keep their rich cultural heritage alive. Inuit temporarily move out from settlements to harvest resources that are sometimes bartered or traded. This movement takes place on the sea ice that surrounds and connects Inuit communities.

Key Findings:

1. Tradition and Adaptation
   The key findings contained in this report begin with the recognition that Inuit are deeply connected to the past, both distant and more recent, but have also adapted. The report also finds that Inuit continue to eat traditional foods for a large portion of their diet. This diet requires continued hunting and harvesting of the available resources in the Arctic. Because the wildlife, birds and sea mammals that make up most of the Inuit diet are highly transient, it is often necessary for Inuit to travel over great distances in order to obtain a harvest sufficient to feed their communities.

Although climate change and thinning sea ice are posing great challenges, Inuit are a highly adaptive people who are seeking ways to cope with these changes while maintaining their culture. But in order for them to adapt, they must have free movement over sea ice and open sea in order to follow the migratory wildlife they rely on. It is also important to note that, as many of the hunters interviewed said, if one species in the food chain suffers, the others down the line suffer as well. Inuit will, therefore, be directly affected by any damage inflicted upon the Arctic environment -- one that they have sustained and been sustained by for thousands of years.

2. Standard of Sustainable Use
   The Arctic is home to Inuit. They have lived there for thousands of years. It is the Inuit position that any action or intervention that affects their land must protect the environment, wildlife, and therefore the Inuit people in such a way that they can continue to live off this land for thousands more years. This is the standard of sustainable use that they insist upon.

3. The Sea Ice is Our Highway
   The sea, for Inuit, is their highway. In wintertime, their highway is sea ice. In summertime, it is the open sea. The sea is integral to the Inuit way of life. Because they still rely on traditional Inuit food for a large portion of their diet, and because hunting and being out on the land are central to their culture, they continue to use the land and sea in the same way as did their ancestors for thousands of years. This connection to land and ice gives Inuit a great sense of pride, well-being, and connection to the past.

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saw any narwhals around. Usually we catch our quota, but not in these past years." Tommy Qaqqasiq, Pangnirtung, Nunavut.[53]

"A few years ago there were 28 whale hunters who went out to go hunting. I love to take pictures, so I was filming our trip the whole way with my video camera. We ended up getting three whales, but because of the ice conditions that the ships left, there was almost like a disaster. We lost skidoos and equipment [when they fell through the ice]. Because I was taping the whole thing, I was a witness and we got compensated for the skidoos and hunting equipment we lost. The people who came in the helicopters asked for my tape, which they used to give us skidoos. They were smart enough to realize that they had wrecked the area with their ships and it was their fault, so they ended up compensating us for what we had lost." Tommy Tatateapik, Arctic Bay, Nunavut.[54]

"In one way [ships are] good for us. We need material, we need housing, we need goods, of course. But in another way, when it comes to hunting and fishing, there are less animals that come around our shores if there's a big boat off-loading, with its big lights and so on. That scares off some of the marine mammals that do come here. Therefore it affects the hunting when there's a big boat anchored in the middle of the bay." Paulusie Novalinga, Puvirnituq, Nunavik.[55]

Another example of the difficulties related to shipping comes from the community of Tuktoyaktuk on the Beaufort Sea coast. Tuktoyaktuk has long been a key hub for supply ships servicing many of the Inuit communities in Canada. Because the harbour is also teeming with various species of fish, Tuktoyaktuk is an instructive example of colliding interests between economic activities and Inuit use of the sea. Inuit hunter, trapper, and fisherman Chucky Gruben describes the issues:

"We have a hunters and trappers committee here, we take care of the wildlife. We deal with the people, we deal with the shipping companies. We have done some things where after freeze-up, the ships are not allowed to come into the harbour. But this past year, because of late shipping to other communities, we had to keep our harbour open longer than usual because the supplies hadn't gone out to the other communities.

The community of Tuktoyaktuk is right in a harbour where a lot of fishing takes place. There's two entrances to the Tuk harbour. What we call the west entrance is where the smaller boats come in, and over by the east entrance is where the larger ships come in. The east entrance is a place where a lot of people here that do their fishing set their nets right in the channel. Because the ships had made a ship track through the east entrance, they kept it open up right until November sometime, and the people couldn't set their nets there because of the ships going back and forth. That is one of the impacts of shipping on our harvest.

Usually with that kind of thing, we do have a say on whether the ships can use the area, but times are changing and every year we get applications to come into the harbour later and later. They wanted to do that the year before last, too, but we had to say no. Last fall we didn't really have a choice because there was still fuel and a lot of supplies that needed to go out to the other communities, so we had no choice."[56]

53 Interview on March 14, 2008
54 Interview on March 14, 2008
55 Interview on March 14, 2008
56 Interview on March 31, 2008

bad options: Stop hunting the animals which supply us with our meat, which would be a terrible tragedy for our culture and leave our communities without an affordable source of protein. Or, continue to hunt and eat our traditional foods, with negative consequences for our health.

We travel all over our land and so do the animals we eat

The following quotes illustrate some of the problems associated with economic activities that do not meet the Inuit standard of sustainability:

> *"I am going to tell you a story about a trip I made once to the Alert area, near Eureka, in 1961. That area, more to our side of the community, had neither caribou nor polar bear tracks. Even behind Eureka, as well as overland, there were not even Arctic hares, not a single sign of foxes. It had no evidence of animal life at all. Obviously Qallunaat had been living there. I am telling you of this event because I have some remembrance of it. But some time ago, that area, even on the sea ice between Grise Fiord and Eureka, used to have caribou and polar bear tracks. Naturally, because the animals had not been forced to go somewhere else. I have thought a lot about this." Akeeagok, Grise Fiord, Nunavut.*[50]

> *"In our area even the meat itself has changed. For the past ten years or so, I get stomach problems, horrible cramps, when I eat seals and seafood. There is lots of sewage, garbage, and mining waste draining into the sea near Rankin Inlet, so eating the animals is giving us problems now. I know this is specific to our area, because when I went to Igloolik, I could still enjoy the traditional delicacies. I can't enjoy them here anymore because of the terrible side-effects." Lizzie Ittinuar, Rankin Inlet, Nunavut.*[51]

> *"I think what done it [caused the seals to disappear] in this bay up here, [an oil company] used to have a lot of oil up there, you know. Up in Makkovik Bay, here. They used to have it up on the beach every summer, for the last nine or ten years – I suppose more than that. Some of the drums be leaky, and there be like oil over the water in the spring. You wouldn't see a seal up in the bay now. You wouldn't get one up there to save your soul." Bert Winters, Makkovik, Nunatsiavut.*[52]

Ships coming through our seas are also a cause for concern. On the one hand, they can be used to supply our communities with building materials and goods for our stores, which might bring a welcome reduction in the high cost of living in the Arctic. However, ships have also caused a lot of damage, as these hunters explain:

> *"In recent years, all kinds of cruise ships are coming in to our area. Last year alone, there were maybe five or six cruise ships that came into town. More are coming every year. There's a national park here in Pangnirtung, further inside the fiord, that's what they are coming to see. The tourists come into town and buy all kinds of art, like carvings, craft work, soapstone, whatever they can afford to buy. They help the artists. But hunters have been complaining about those ships because they go all over Cumberland Sound, even to the campsites. People are saying they are scaring away the animals, the mammals and whales. We are really noticing this because in the past couple of summers we hardly*

50 Quoted in Brody, "Land Occupancy: Inuit Perceptions", In Freeman, Vol. 1, p. 233.

51 Interview on March 15, 2008.

52 Quoted in Carol Brice-Bennett, ed. Our Footprints are Everywhere. p. 258

Caution and Concern:

In the face of climate change and the potential for greater use of the Arctic by newcomers, there is a feeling of concern among Inuit. While they have resolved to adapt to the changed climate and thinning ice as best they can – and show considerable confidence they will succeed – they are less sure about what increased shipping may mean for their future. While the pages that follow do not overtly discuss constitutional and legal issues, Inuit – through ICC and other bodies – strongly caution those making plans regarding the Arctic to remember the land claims agreements, self-government arrangements, and international legal instruments that call for consultation and informed consent. And to pay close attention to the direct quotations of Inuit hunters found in this report. Newcomers are reminded that Inuit have lived in the Arctic for thousands of years and intend to live there for thousands more.

Shipping route through Kugluktuk region illustrates colliding interests between Inuit land use and shipping.
Map source: Inuit Land Use and Occupancy Project, 1976.

"Before game laws were laid down by the government, people used to hunt in places until the animals were no longer plentiful. Instead of hunting all the animals until there were none, they would move elsewhere, to where the animals were more abundant, so that the animals they left would multiply. I used to hunt musk-oxen on the Prince of Wales Island until there were not many animals left. The musk-oxen there were no longer plentiful. Instead of staying to hunt all of the musk-oxen, we moved to another area around Pelly Bay, where we then hunted musk-oxen again." Constant Sallarina, Spence Bay, Nunavut.[48]

"I think of the time we used to go out camping in spring. I still know where the seals are. Even though I'm sitting right here, I'm thinking of how we used to go out after seals in spring. We used to go where the seals would mostly be found. We used to take many seals. We never wasted any. We used the skin for making boots or for making a bag in which we could put seal blubber for the next winter. We used to eat the meat and give a part of it for our dogs. We would never waste any. When we got many seals, we would save some for the next winter, for dog food and for ourselves. We would use seal skins for making a tent and storing food when we travelled. Seal skins were looked after well by our wives because the skins were so useful. We used them in summer, winter, fall and spring. In summer, we used seal skins for boots and kayaks because they are waterproof. We even used them to make harnesses for our dogs." Dominique Tungilik, Pelly Bay, Nunavut.[49]

We live in the Arctic. This is our home. This is where our people have lived for thousands of years and we intend to live here for thousands more.

When thinking about sustainability, it is important to understand that we Inuit live in the Arctic. This is our home. This is where our people have lived for thousands of years and we intend to live here for thousands more. When we talk about the future, we are not talking about a five-year plan or even a ten-year plan. We are talking about our children and our children's children. We are talking about living in the same communities where we can see the evidence of our ancestors. We are talking about preserving our way of life and the natural environment it depends upon for hundreds and thousands of years. This is what Inuit call sustainability.

4.1 Sustainability, the Local Economy, and Shipping

Inuit are practical people. We know that it is not possible to turn back the clock on changes, so we do our best to adapt. For example, many of our people work in wage employment at the same time as they live off the land. This means we need jobs, and we need them in our communities so that our young people do not need to move down south and our men and women are able to live with their families.

At the same time, we Inuit are very concerned about the effect that various activities associated with "economic development" are having on our land. As this report has described, we travel all over our land and so do the animals we eat. When any kind of disruption in the natural order of things occurs – for example, an oil spill, dumping of waste, or noise from machinery or ships – the animals are affected. This automatically affects our health and well-being as well, because we are left with a choice between two

48 Quoted in Brody, "Land Occupancy: Inuit Perceptions", in Freeman, Vol. 1, p. 200

49 Ibid., p. 210

4. Inuit Sustainability

In recent times, many people in business and government and universities have begun to speak about **"sustainability."** They speak about sustainable development, for example, which seems to mean different things to different people. There is also talk of economic sustainability and ecological sustainability. This is not a criticism of the people who promote these ideas, because it is certainly important to think about the long-term consequences of our actions. The point is simply this – as a people who have lived in harmony with our ecosystem for thousands of years, we Inuit have a very different concept of sustainability. For us, an action that can continue for ten or twenty, or even fifty years before its damaging effects are seen does not qualify as sustainable. A way of doing things, a way of living and behaving, must be done in such a way that it could continue for hundreds and thousands of years without harming the natural way of things in order for it to meet the Inuit standard of sustainability.

> ***As a people who have lived in harmony with our ecosystem for thousands of years, we Inuit have a very different concept of sustainability***

The primary resource for Inuit is the animals. Our people have always known how to care for this resource. We live in harmony with the land. When we hunt, we only take what we need and make sure to leave enough of the herd so that it can replenish itself.

"Caribou in the 1990s declined to a very low level, so on our own we put on a restriction of one caribou per household per year, just to preserve the caribou. We started changing over to musk-ox and now musk-ox is a very staple diet for our community." John Keogak, Sachs Harbour, Inuvialuit Settlement Region.[47]

47 Interview on March 13, 2008.

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In recent years, hunters have begun using modern communication devices to stay in touch with other hunters or their families while out on longer hunting trips. In the interviews conducted in March 2008, most respondents said they used some kind of communication device. Some used two-way radios or mobile phones to stay in touch with home or other hunters. One mentioned looking up ice condition reports on the Internet. Several said they used a GPS device, with one describing a sophisticated system for reporting the location of all big game he took. Opinions on the usefulness of GPS varied, however:

> *"I don't use the new gadgets much. Only when I'm going to an area known to be dangerous. But actually they can be dangerous too sometimes, because then you go by your compass or GPS when you should be going by your human senses. They are better in the summer on the water than out on the ice." James Kukkik, Hall Beach, Nunavut.*[44]

> *"I can either travel by the stars or use GPS, nowadays. They keep advancing. Now they have maps and charts that show how deep the water is. Navigation now is a lot easier than before." Paulusie Novalinga, Puvirnituq, Nunavik.*[45]

> *"I don't use GPS on the ice, knowing there might be open water anytime out there. I've noticed that people using GPS on the ice seem to get more into problems. The ice breaks up anytime here, so the trail you might have used breaks off sometimes. So I try and use what I've been taught out there and not rely on GPS." Loule Padluq, Kimmirut, Nunavut.*[46]

While it is true that we live differently than we did one hundred, or even fifty years ago, at the core we are still the same

With all of these changes, some people think we have lost part of our culture. While it is true that we live differently than we did one hundred, or even fifty years ago, at the core we are still the same. We may use fibreglass boats instead of skin boats and, in some areas, snowmobiles more often than dog teams. We may use rifles for much of our hunting instead of spears or wooden harpoons. We may even live in stationary settlements and spend less time in temporary camps. But we Inuit are still hunters and we still rely on the hunt for a large part of our diet, which means we are still out on the land and sea, still travelling great distances to seek out the animals whose behaviour we know so well.

44 Interview on March 14, 2008.
45 Interview on March 14, 2008.
46 Interview on March 14, 2008.

3.3 Recent Adaptations

Throughout our over 4000 year history, we Inuit have proven to be a highly adaptive people. We have learned new ways of travelling, adapted the construction of our snow houses to variations in climate, and adjusted our diet according to the availability of fish and wildlife. However, it is only in the past one hundred years or so that we have had ongoing contact with non-Inuit people, who we call *Qallunaat*. This contact has led to many changes for us, but we have worked hard to maintain our rich cultural heritage even as we adapt to the changes thrust at us.

> *We have worked hard to maintain our rich cultural heritage even as we adapt to the changes thrust at us*

In our Alaskan and Canadian settlements, regular contact with the *Qallunaat* began in the early 20th century with the establishment of fur trading centres in many of our communities. Many Inuit changed their hunting patterns during this time in order to capitalize on this opportunity to sell furs. Trapping became a more important activity, while sealing declined somewhat. Trappers also hunted more wolves and other predators in order to protect the foxes along the traplines.[41] In this way, we began to engage with the economic system of the *Qallunaat* while maintaining our connection to the land and the animals.

Around the same time, Inuit began using rifles for hunting. This was a major change that affected every type of hunting.

Also in the early 20th century, many Inuit whalers switched from using the traditional skin boats to using schooners. In Alaska and the Inuvialuit Settlement Region this meant they no longer went as far inland to follow the caribou, choosing rather to stay near the coast in order to concentrate on whaling and fishing.[42]

In the late 1950s and 1960s, many Inuit began using snowmobiles instead of, or in addition to, dog teams. This had a great effect on hunting. For example, caribou hunting became easier:

"Wherever they are found, caribou are afraid of men and dogs. Hunters approached them by pretending to be another caribou, but a hunter had to make judicious use of terrain and wind to enter a herd and then to pick his kills. The snowmobile has changed that. Caribou are not so afraid of the noise of an engine, and they sometimes will approach a hunter on his snowmobile in apparent curiosity. With good rifles and snowmobiles, the caribou has become relatively easy quarry."[43]

41 Freeman makes frequent mention of these kinds of changes when the fur trade expanded in the Arctic.

42 Peter Usher, "Inuit Land Use in the Western Canadian Arctic," in Freeman, Vol. 1, p. 22.

43 Quoted in Brody, "Land Occupancy: Inuit Perceptions", in Freeman, Vol. 1, p. 208.

1. Introduction

1.1 Context

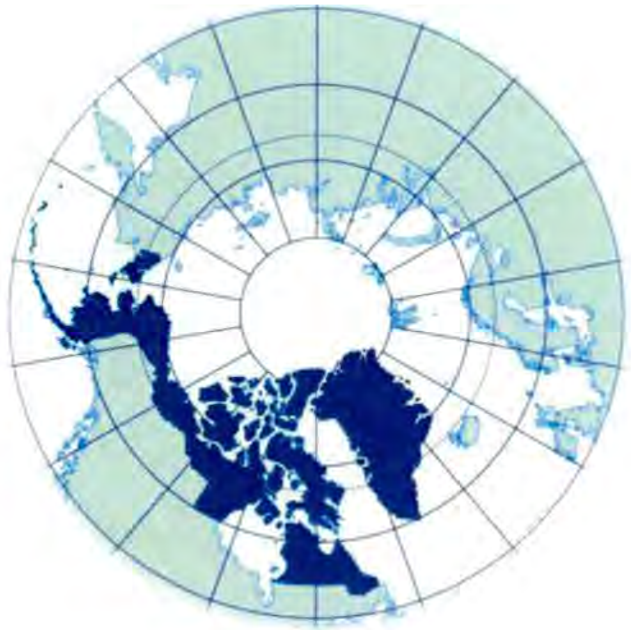
This report from the Inuit Circumpolar Council (ICC) Canada is a contribution to the Arctic Marine Shipping Assessment (AMSA) being conducted by the Arctic Council. This scoping report is intended to provide the authors of the AMSA with an Inuit perspective on the human dimension of shipping. As a Permanent Participant at the Arctic Council, the Inuit Circumpolar Council speaks on behalf of all 155,000 Inuit living in Greenland, Canada, Alaska and Russia. ICC Canada represents Canadian Inuit on matters on international importance, and also acts as a representative for Inuit from Greenland, Alaska, and Russia within Canada.

This report is important because it gives voice to Inuit, the people who have lived in the Arctic for thousands of years, sustaining and being sustained by the unique animals, fish, and fowl found here. Governments and industry have for decades used this same Arctic for their own benefit. Sometimes they consult with us. In contrast to such consultations, this report comes on the initiative of ICC Canada and is intended to frame the dialogue from an Inuit perspective, to discuss the issues related to land and sea ice use as we see them. From this discussion, the reader will come to learn how ice is central to how we have moved in the past and continue to move in the present.

1.2 Inuit Definitions

1.2.1 The Arctic

The first distinction of an Inuit view of the Arctic is our definition of the term Arctic itself. Within Canada, Inuit view the Arctic as the places where Inuit have traditionally lived. These areas are the four land claims regions: Nunatsiavut along the coast of Labrador, Nunavik in Northern Quebec, the entire territory of Nunavut, and the Inuvialuit Settlement Region along the northern coast and around the northern islands of the Northwest Territories. Other indigenous peoples also live in the Canadian North, but because they are impacted less by shipping than are Inuit, their views are not covered in this report. The Arctic also includes all of Greenland, much of Alaska, from the North Slope Borough down the Bering coast, and much of Russia, certainly including the region of Chukotka across the Bering Strait from Alaska. These regions where Inuit live are all part of the Arctic according to our view.



Circumpolar Map with Inuit lands highlighted

The Arctic also includes the northern portions of Finland, Sweden and Norway where the Saami live, as well as the northern parts of Russia where nearly forty different indigenous peoples live. Our Arctic is increasingly the focus of attention from many outside interests, the latest of which is the shipping industry.

1.2.2 The Land

The Inuit concept of land will be expanded upon in this report. When defining our "land", Inuit do not distinguish between the ground upon which our communities are built and the sea ice upon which we travel, hunt, and build igloos as temporary camps. Land is anywhere our feet, dog teams, or snowmobiles can take us.

> ***Land is anywhere our feet, dog teams, or snowmobiles can take us***

1.3 Scope of the Report

This report is a scoping level investigation focusing on Inuit use of sea ice. It looks at existing sources of information regarding land use and occupancy to extract the highlights regarding sea ice, augmenting this with responses from interviews with Inuit hunters, and using additional studies from Alaska and Greenland to provide a pan-Inuit perspective. The report will not provide comprehensive data on current Inuit use of sea ice, as such information is not yet available. It will also not use the AMSA's target dates of 2020 and 2050 to make specific projections on how increased Arctic marine use by non-Inuit may affect the Inuit. Note that the report does include general predictions about the future in light of climate change

Inuit Communities in Greenland
Source: Greenland Home Rule Government

3.2.3 Necessity of Movement Over Land and Sea

These regional maps and descriptions of land and sea use show the vast territory covered by Inuit harvesters of sea mammals, fish, and game. As subsistence hunters, we Inuit follow the animals as far as needed in each season, according to the overall conditions of that particular year. While Inuit do use the sea ice for general transportation in addition to hunting, we are practical people who harvest as close to our communities as possible. The fact that we often travel long distances as part of the hunt means our people from Chukotka to Greenland need free movement over the land and sea in order to continue our subsistence-based way of life.

As climate change and reductions in sea ice affect the migration routes of the land and sea animals we rely upon, it may be necessary for us to travel even further than before in order to reach them. Inuit hunters are reporting many changes in the locations and times that our traditional animals can be found. In some communities this is reducing the territory that hunters need to cover, while in others they have to travel much further than before in order to harvest enough food for the communities. This is why we are very concerned that sea ice routes remain passable for hunters as well as the migratory game they follow, and that the entire Arctic environment be kept free from contamination – both in the areas we are now using regularly and in those areas where we may need to hunt in the future.

> ***As climate change and reductions in sea ice affect the migration routes of the land and sea animals we rely upon, it may be necessary for us to travel even further than before***

The Baffin Region in the east consists of Baffin Island as well as the islands to the north and the smaller islands in Hudson Bay. This region includes the communities of Iqaluit, Kimmirut, Pangnirtung, Qikiqtarjuaq, Clyde River, Pond Inlet, Nanisivik, Arctic Bay, Igloolik, Hall Beach, and Cape Dorset, all the way up to Resolute and Grise Fiord, and down to Sanikiluaq. Ever since the time of the Thule ancestors, the region around the Hudson Strait and Foxe Basin has been an area with many Inuit communities because of the plentiful food resources found here. Many of the fiords, inlets and bays on the coast of Baffin Island are ideal for harvesting seals, polar bears, and narwhals. Caribou are also hunted extensively for food and to make clothing. In fact, the ideal time to hunt caribou for clothing on North Baffin Island is the summer, so the local term for the summer hunt means "the search for material for clothes."[36]

Nunavik

The Nunavik settlement region in northern Quebec has fourteen villages. The principal village and administrative centre is Kuujjuaq, on the southern shore of Ungava Bay; the other villages are Inukjuak, Salluit, Puvirnituq, Ivujivik, Kangiqsujuaq, Kangiqsualujjuaq, Kangirsuk, Tasiujaq, Aupaluk, Akulivik, Quaqtaq, and Umiujaq.

While comprehensive land use studies are not available for this region, an interview with the president of the Nunavik Hunters and Trappers Organization revealed that white fox, wolves, otters, muskrat, and mink are trapped in the region, while seals, walrus, beluga whales, polar bears, sea ducks, and caribou are among the animals currently being hunted. He highlighted the fact that Inuit hunters have always been long distance travellers, and noted that hunters from his community of Puvirnituq travel hundreds of kilometres north by snowmobile or speed boat to hunt on the Hudson Strait near Baffin Island.[37] Another Inuit hunter added that they collect mussels and shrimp from under the sea ice.[38]

Nunatsiavut

The Labrador Inuit are the most recent to obtain a settlement agreement. The newly created Nunatsiavut settlement region includes the communities of Saglek, Hebron, Nutak, Nain, Hopedale, Postvale, Makkovik, and Rigolet. Like Inuit in other regions, these communities also harvest caribou, mostly in the winter; various species of seal; some walrus and polar bears; migratory birds in the fall; and large quantities of fish, including char and salmon.[39] Land hunting occurs throughout the settlement region, while extensive use is made of the sea ice and open water along the coast.

Greenland

The 18 municipalities in Greenland are, as in the other regions, located mainly on the coast in order to easily access the sea, but also due to the nearby Greenland ice cap. The municipalities, in turn, are made up of unincorporated towns, villages, and hunting settlements. Hunters travel by boat or over the ice by dog team to harvest several species of seal, hunt beluga whales and narwhal, and fish for capelin and other species of fish.[40] On land, Greenland Inuit hunt caribou (reindeer), musk-oxen, birds, and polar bears. Inuit in northern Greenland often travel as far as various islands near the Canadian border in search of sea mammals. Because of the warmer west Greenland current, much of South Greenland has ice free port access, whereas west and North Greenland have winter sea ice conditions.

36 Hugh Brody, "Inuit Land Use in North Baffin Island and Northern Foxe Basin," Freeman, Vol. 1, p. 160.

37 Paulusie Novalinga, Interview on March 14, 2008.

38 Pitseolaq Pinguartuq, Interview on March 15, 2008.

39 Carol Brice-Bennett, ed. Our Footprints are Everywhere.

40 Sila Inuk. Interviews conducted in Disko Bay region, Greenland. July 9-10, 2007.

and reduced sea ice based on the experience and traditional knowledge of the Inuit hunters interviewed, but these predictions are not directed specifically to those target dates.

The central idea of this report is that life in the Arctic is dependent on movement, and that sea ice is integral to this movement. The Inuit have been a nomadic people living in the Arctic since ancient times. As such, our entire culture and identity is based on free movement on the land. Indeed, we rely on free movement in order to eat, first of all, and also to obtain supplies for traditional clothing and art as well as to maintain pride in our rich cultural heritage. We also temporarily move out from our settlements to harvest resources that we sometimes barter or trade. As this report will show, much of this movement takes place on the sea ice that surrounds and connects our communities.

Life in the Arctic is dependent on movement, and sea ice is integral to this movement

Because the goal of this report is to give voice to Inuit perspectives and concerns regarding the impact of changes in the Arctic, the text will include many direct quotations from interviews with Inuit. Many of the Inuit interviewed for this report emphasized the importance of the sea in their everyday lives, and were very concerned that their voices be heard by the people whose decisions will affect their culture and livelihoods. The use of direct quotes is our means of presenting their concerns to a wider public.

2. Our Nomadic Tradition

2.1 The Four Stages of Inuit History

According to the studies compiled in the Inuit Land Use and Occupancy Report of 1976, Arctic historians and archeologists have found that Inuit populations have inhabited the Arctic for about 4000 years,[1] in nearly the same regions as they do today. This history began with the Pre-Dorset, Paleo-Eskimo people who lived in the Arctic starting around 2000 BC, then continued with the Dorset people who lived in Greenland starting in 1000 BC and in the Canadian Arctic from 500 BC, then on to the Thule people whose variation of Eskimo culture originated in what is now Alaska and spread across the Canadian Arctic to Greenland, all the way to the present-day Inuit. Historians and archeologists tell us that the cultural similarities seen in the prehistoric artifacts and the physical similarities discovered through the unearthing of ancient graves indicate a clear progression from the pre-Dorset, Paleo-Eskimo people through to today's Inuit.

Virtually the whole Arctic region from Chukotka to Greenland was inhabited by people with a common culture

Archeological findings from the Paleo-Eskimo era show that virtually the whole Arctic region from Chukotka to Greenland was inhabited by people with a common culture. They have found common tools adapted to the Arctic tundra in the region from the southeast coast of Siberia "across northern Alaska, the central Canadian Arctic and the eastern Arctic islands to Greenland" and "as far as northeastern and southwestern Greenland, Ungava peninsula in northern Quebec, and down through the Barren Lands and the west coast of Hudson Bay to Churchill, Manitoba."[2] Though the groups who lived in this vast region had slight regional variations, they are similar enough that archeologists call them all the Arctic Small Tool tradition.[3] The nature and location of the remains of their camps indicate that they lived in "small, widely scattered, nomadic bands, moving seasonally to exploit various game resources. They used toggling harpoons, spears, lances, and bows and arrows in hunting caribou and seals."[4] It appears they also fished extensively and hunted bears, wolves, musk-oxen and walruses.[5]

1 M.M.R. Freeman, ed. 1976. Inuit land use and occupancy project. 3 vols. Department of Indian Affairs and Northern Development. Ottawa: Supply and Services Canada Vol. 2, p. 103-104.

2 William E. Taylor, Jr., "The Fragments of Eskimo Prehistory." In Freeman, Vol. 2, p. 105.

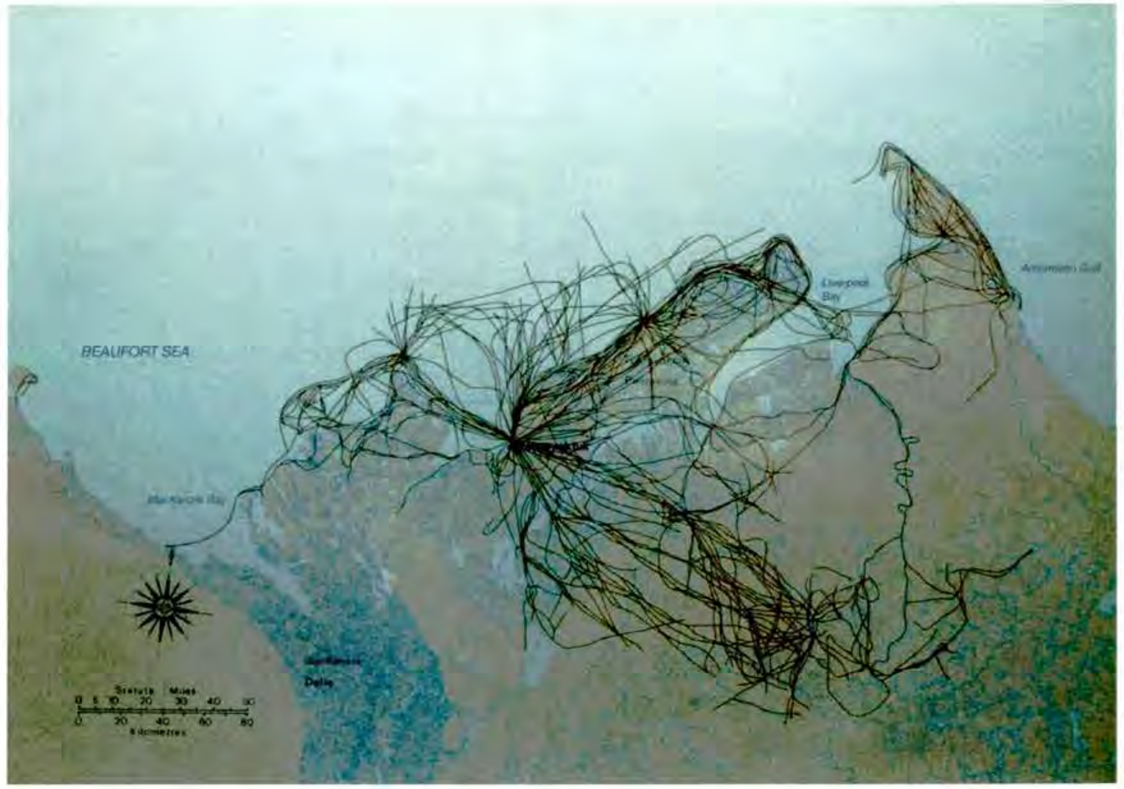
3 Ibid. p. 105.

4 Ibid. p. 105.

5 Ibid. p. 106.

Hunting Area of Kugluktuk (Coppermine), Nunavut, 1955-1974.
Source: Inuit Land Use and Occupancy Project, 1976.

Kivvaliq is the central region of Nunavut and includes the communities of Arviat, Whale Cove, Rankin Inlet, Baker Lake, Chesterfield Inlet, Coral Harbour, and Repulse Bay. Caribou are an important staple here in the fall and winter, while spring and early summer are the prime times to hunt for seals, walruses and white whales along the coast of Hudson Bay. As in other regions, fishing, hunting of ptarmigan and geese, and gathering of wildfowl eggs contribute to the traditional diet, as does harvesting of seafood.



Trapping Lines of Tuktoyaktuk, Inuvialuit Settlement Region, 1955-1974.
Source: Inuit Land Use and Occupancy Project, 1976.

The Inuvialuit Settlement Region communities engage in a full range of subsistence hunting, fishing, and whaling activities. On land they hunt caribou, musk-oxen, geese, and in some places moose. On the sea the western communities focus on whaling, while the eastern communities harvest more seals and polar bears. Fish are particularly abundant in Tuktoyaktuk, though all of the Inuvialuit communities engage in fishing.

Nunavut

Nunavut is a large territory, which is why it is commonly divided into three regions. Kitikmeot is the eastern-most region and includes the settlements of Kugluktuk (Coppermine), Bathurst Inlet, Cambridge Bay, Gjoa Haven, Kugaaruk, Umingmaktok (Bay Chimo), and Taloyoak (Spence Bay). This area enjoys healthy populations of caribou, seals that are hunted year-round on the sea ice or in the open water, and rich nesting areas for ducks and geese. Many of the rivers and lakes contain char and trout, and cod can be found in some of the bays. Inuit in this region use the straits and gulfs between the mainland and the islands extensively for all kinds of hunting.

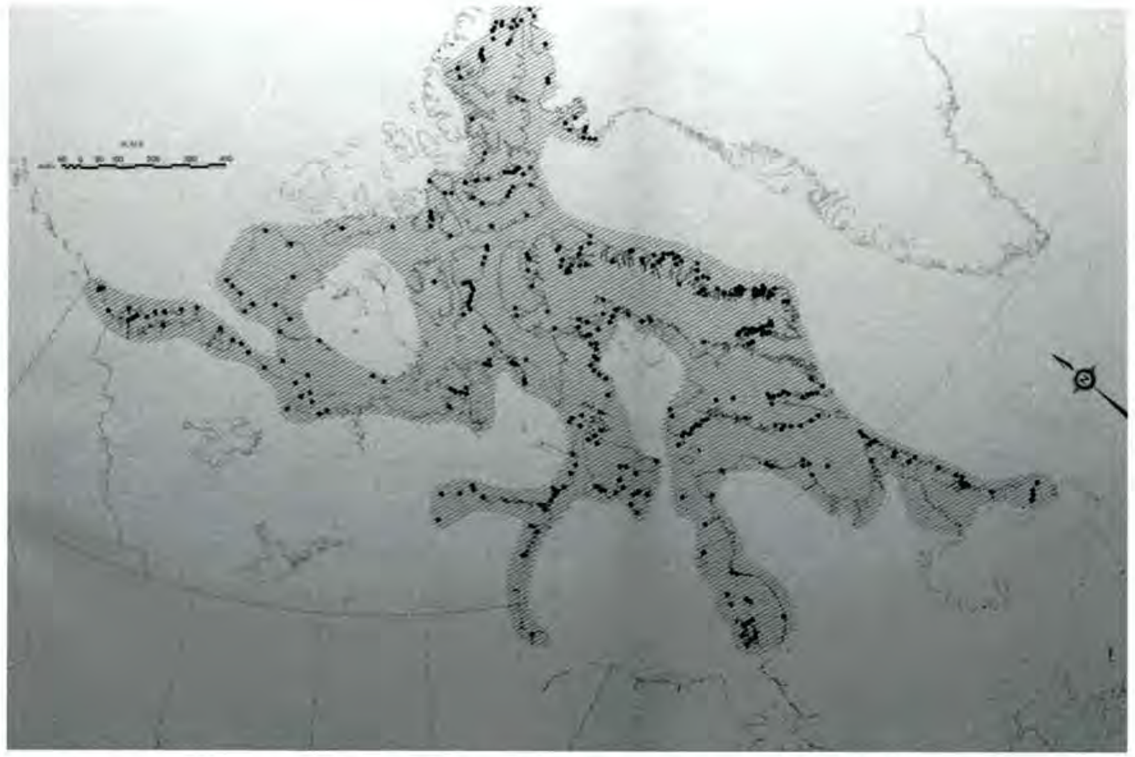
Canadian site locations and presumptive land use: Early Paleo-Eskimo.
Source: Inuit Land Use and Occupancy Project, 1976.

The Dorset culture moved quite clearly out of this pre-Dorset, Arctic Small Tool tradition. The Dorset culture, which existed from 800 BC to 1300 AD, stretched from Bernard Harbour and Melville Island in the west to eastern Greenland and the northwest part of Labrador in the east. Like the Paleo-Eskimo people, the Dorset people "lived in small seasonally-nomadic bands with little camps of skin tents in summer, sheltering in winter in small clusters of partly-underground pit houses."[6] The Dorset people apparently also used snow-houses and may in fact have invented them. The tools and weapons found in Dorset archeological sites indicate they hunted a variety of sea mammals, birds, and caribou, and also fished extensively. Following the tradition of the pre-Dorset culture, they used soapstone blubber-burning lamps for heat, light, cooking, and drying clothing,[7] a tradition which was later carried on by the Thule and Inuit people.

The Dorset people were gradually displaced by the Thule people between 900 and 1300 AD as the Thule people slowly drifted over from Alaska across the Canadian Arctic all the way to Greenland.[8] These two cultures were similar in many ways and learned from each other during the time they co-existed.[9]

6 Taylor, Jr., In Freeman, Vol. 2, p. 106.
7 Ibid. p. 106.
8 Ibid. p. 107.
9 Ibid. p. 108.

However, the Thule culture was more effectively adapted to the Arctic because the people possessed dog-teams that allowed them to travel over greater distances more easily and they had developed a full range of gear for hunting the great baleen whales, which afforded them a major food supply not available to the Dorset people.[10] The prominence of the whale hunt is the primary distinguishing feature of the Thule era.



Canadian site locations and presumptive land use in the Thule period.
Source: Inuit Land Use and Occupancy Project, 1976.

The most recent stage in Inuit history began in the 18th century with the people known as the Central Eskimo. This culture followed directly from the Thule culture, using virtually the same hunting equipment, modes of transportation, clothing, and even toys as the Thule people did. The primary differences between the Thule period and the Central Eskimo period came about because of the collapse of the baleen whale hunt. Without this major source of food, the Central Eskimo people abandoned the villages of sturdy winter houses from the Thule era for a more nomadic life dependent on the scattered herds of seals and walruses. During this time "there was a gradual shift to the snow-house on the sea ice as the customary winter residence."[11]

10 Taylor, Jr., in Freeman, Vol. 2, p. 107.
11 Ibid. p. 108.

summary of the variations in land use and occupancy in the Inuit settlement regions according to the available sources.

Alaska

Residents of Alaska's North Slope Borough coastal communities travel throughout the Borough area in pursuit of subsistence activities. These include a fall whale hunt, in some cases a spring whale hunt, caribou and bird hunting throughout most of the year, as well as fishing. The use areas for coastal settlements extend 40 km or further from the coast, as the Inupiat-Inuit use a combination of traditional skin boats and motorized boats to harvest sea mammals. Snowmobiles are also used on the ice in the hunt for sea mammals.[35]

Northwest Territories, Full Extent of Inuit Land Use.
Source: Inuit Land Use and Occupancy Project, 1976.

Inuvialuit Settlement Region

The Inuvialuit Settlement Region includes the communities of Aklavik, Inuvik, Tuktoyaktuk, Paulatuk, Sachs Harbour, and Ulukhaktok (Holman Island). According to experienced hunters from Paulatuk, Sachs Harbour, and Ulukhaktok, the area they cover in search of game is approximately the same now as it was at the time of the Inuit Land Use and Occupancy Project (ILUOP) – with two exceptions. First, difficult ice conditions prevent the hunters from going as far out onto the sea ice in the Amundsen Gulf, and second, trapping has declined somewhat due to changes in the local economy.

35 North Slope Borough Comprehensive Plan – Background Report, Chapter 3, p. 69-70.

enjoyed excellent access to caribou herds that crossed the Dolphin and Union Strait to reach Victoria Island for the summer. Shortly after the rifle was introduced in the region, the caribou stopped crossing the strait. The caribou migration pattern changed and the community went from regular, easy access to caribou to having none at all in their vicinity. The Read Islanders adjusted by switching to a smaller caribou variety that could still be found reasonably nearby, by making longer journeys to the mainland to harvest caribou there, and by trading with neighbouring communities in order to obtain skins used to make clothing, boats, and so on.[31]

Another very difficult time was the year when an unseasonably late rain fell on Banks Island in the Inuvialuit Settlement Region. Rain fell late in October, forming a thick layer of ice that covered all the ground vegetation normally eaten by the musk-ox herd. More than 20,000 musk-oxen were wiped out, eliminating the main source of winter food for the community of Sachs Harbour. John Keogak described the event this way:

> ***"In 2004 we had a big die-off of musk-ox because of a late rainfall in October. After it had snowed, it rained for a whole day. That created a big thick layer of ice. We had musk-ox trying to leave the island and falling through the ice, some were dying of starvation. All of their food was under ice. That was a bad year."***[32]

In a tough year it may be possible to mitigate the lack of large game or whales by taking more geese or ducks, ptarmigans, fish, or other small game available in the region. In general, however, unexpected difficulties in the hunt for big game mean hunters must search further and further away until they manage to find enough big game or sea mammals to sustain the community until the next hunting season. This was the case in Kangiqsujuaq, Nunavik recently:

> ***"This past year we had a really hard time finding caribou. We travelled all over and didn't find any. We ended up going over to the island, which we never do, but finally there we managed to catch a caribou. It was really affecting our community already." Pitseolak Panguartuq.***[33]

In this example, the community of Kangiqsujuaq was spared the hardship of being completely without caribou for the winter because the hunters were able to cross the Hudson Strait from Nunavik to Nunavut.

3.2.2 Regional Variations in Land Use and Occupancy

Inuit from Chukotka all the way to Greenland share a common culture based on similar hunting, fishing and whaling patterns. There are certain variations by region because the communities have easier access to various species.

Detailed land use studies are available for Alaska, the Northwest Territories, Nunavut, and Labrador. For Nunavik and Greenland there are studies that provide similar information but are less comprehensive. Unfortunately there is little information at all about land use in Chukotka.[34] What follows is a brief

31 Don R. Farquharson, "Inuit Land Use in the West-Central Arctic," In Freeman, Vol. 1, p. 33-36.

32 Interview on March 13, 2008.

33 Interview on March 15, 2008.

34 Note that the Sea Ice Knowledge and Use Project under the International Polar Year 2007/2008 is currently underway. Though SIKU is not a comprehensive land / ice use and occupancy study, it will combine Inuit-centred research from Chukotka, Alaska, Nunavut, Nunavik, and Greenland to present a wealth of information on the Inuit use and extensive traditional knowledge of sea ice.

For thousands of years our forefathers have gone before us and passed on the traditions that still help us today

Today's Inuit continue to benefit from this rich ancestry, knowing that for thousands of years our forefathers have gone before us and passed on the traditions that still help us today. Said one Inuk[12] from Igloolik, Nunavut:

> ***"We live here because our ancestors did before us. If they had not lived here, I don't know what we'd do, we wouldn't have anything. They tried hard to hunt animals in order to live – that's why we are living. Those old places are easy to spot. I've been to many places by dog-team in the direction of Pond Inlet and others, where you would have thought no people have ever been before. I've seen rocks piled one on top of the other. They were fixed like that by Inuit. They are everywhere."***[13]

Another Inuk from Chesterfield Inlet, Nunavut put it this way:

> ***"Even when you go to a place you thought was empty, there is always something that tells you that people were there."***[14]

2.2 Travellers and Nomads

As indicated in this brief overview of Inuit history, Inuit have always relied on hunting for subsistence, a way of life that requires a great deal of movement in order to follow the migratory patterns of the wildlife and sea mammals in the region. Because the game and sea mammals in the Arctic ecosystem are highly transient – take the mysterious annual migration of the caribou, for example – we Inuit have adopted a nomadic lifestyle for much of our history. Evalak from Hall Beach said it well:

> ***"The game never moved around in only one area. In some years the people occupy some parts of the land, and at other times they occupy another part of the land."***[15]

Although most Inuit in Chukotka, Alaska, Canada, and Greenland now live in settlements, the traditional knowledge still passed down from our elders to our children continues to reflect this nomadic tradition.

> ***"My father taught me how to make my gear by letting me make toys for myself that would eventually become real things as I grew older. The next step in my training as a hunter was when my father started to take me on actual trips by dog team. ... My father lectured me on how some day my livelihood would depend on hunting, as well as on other people. And he also told me that this was the one and only way to earn my living, and he told me to watch carefully and do as he did. I went to distant places by dog-team and boat. As I became older, I started making trips on my own, in the area where my father had taught me." Koveyook Natsiapik, Broughton Island, Nunavut.***[16]

Much of the traditional knowledge passed down from generation to generation is meant to hone the skills necessary for hunting and fishing. In order to hunt and fish safely and effectively in the Arctic, we train our

12 Inuk is the singular of Inuit.

13 Quoted in Hugh Brody, "Land Occupancy: Inuit Perceptions", In Freeman, Vol. 1, p. 191.

14 Ipiak, Quoted in Brody, "Land Occupancy: Inuit Perceptions", Freeman, Vol. 1, p. 202.

15 Quoted in Brody, "Land Occupancy: Inuit Perceptions", Freeman, Vol. 1, p. 200.

16 Ibid. p. 225.

young people to recognize different types of ice and to know the dangers associated with different seasons – for example, where the ice is likely to be thin at different times of year, or the signs that the edge of the ice might break off and leave a person stranded on an ice fracture that is rapidly drifting away. One traditional method for testing thin ice involves stabbing the ice two or three feet ahead with a stick with a piece of iron attached to the bottom of it. If the stick goes through the ice, this is a warning to backtrack and find another route, but if the ice feels solid, it is safe to gradually move forward. Inuit hunters spend much of their time out on the ice, mostly in small groups or even alone; therefore, reliable knowledge of the ice can be a matter of life and death.

> ***Reliable knowledge of the ice can be a matter of life and death***

Part of travelling on the ice, sometimes over long distances, is the ability to navigate based on landmarks that the untrained eye might not perceive and the untrained memory might not be capable of archiving over long time periods. The Inuit language for describing and naming places has made such travel possible for thousands of years. This quote from a Pelly Bay hunter is illustrative:

> *"All the lakes where you can find fish or caribou have names. That is the only way we can travel. The one way we can recognize lakes is by their names. ... The names of places, of camps and of lakes are all important to us, for that is the way we travel – with names. ... Most of the names you come across when travelling are very old. Our ancestors named them because that is where they traveled." Dominique Tunglik, Pelly Bay, Nunavut.*[17]

Out on the sea where there are fewer landmarks, and the features of the ice may change from year to year, traditional knowledge teaches hunters how to navigate using the sun, wind, and stars. A skilled navigator can use the ridges in the snow like a compass based on which direction the prevailing winds come from at that time of year. Additionally, he can use the location of the sun, or in the long Arctic nights, the stars, to deduce what direction he is travelling in. Another more widely-known navigation aid is the inukshuk, which acts as a marker for passers-by. In these ways and others, traditional knowledge enables us to travel over great distances without losing our way.

When a trip requires an overnight stay, or when a sudden storm or other setback leaves a traveller stranded on the ice, the traditional means of finding shelter is to build an igloo. Igloos are no longer used as seasonal shelter as they were in the recent past – several hunters interviewed for this report described growing up in igloos – but a seasoned hunter still knows how to build them and will do so if the situation requires it. Because igloos can be built quite quickly as shelter, they are an invaluable technology for the travelling Inuit, even today.

Also necessary for a long trip in the harsh Arctic climate is warm clothing. Inuit traditional knowledge passed down through the generations includes instruction on how to dry and stretch the skins of the animals harvested for food in order to make warm boots, pants, parkas, and mittens out of them. For example, caribou skins are often used for parkas, while sealskin is used for boots because it is waterproof when prepared correctly.

17 Quoted in Brody, "Land Occupancy: Inuit Perceptions", Freeman, Vol. 1, p. 198.

3.2.1 General Inuit Land Use and Occupancy Patterns

With few exceptions, Inuit settlements are located on sea coasts or on major waterways with easy access to the sea. This clearly reflects the importance of the sea to our Inuit way of life. Whether thickly frozen or open for the summer, the sea is our primary means of transportation. The usually ice-covered sea is our highway, the only physical connection between many of our communities and the only way we can access many of the animals we depend on for food.

> ***The usually ice-covered sea is our highway, the only physical connection between many of our communities and the only way we can access many of the animals we depend on for food***

The ability to move freely over long distances is foundational to hunting in the Arctic because the animals we hunt are constantly on the move.

> *"Game always moves around. It is the way animals live... It has long been known that game have a way of searching for food, so they are always moving. Birds search for other birds. Sea animals search for food. So the seals are kept moving by other sea animals, searching for food. If sea animals did not search for food, maybe we would not have any seals!" Qayadjuak, Hall Beach, Nunavut.*[28]

> *"[Jar seals] are moving around all the time. They don't stay in one area all of the time. You probably could see about 100 seals outside of Hopedale this week. Maybe there's no seal in Makkovik. Maybe about a couple of weeks after, someone gets a nice bunch of seals up in Makkovik. They would be some of the same flock of seals moving forth and back.*[29] *George Lane, Hopedale, Nunatsiavut.*

> *Like the hunters who know their way, polar bears depend on ice for their seasonal movements. Each year, beginning in midwinter and continuing into spring, bears move northward, following the shore ice and the floe edge. Because they also depend on killing seals on the sea ice, the location of bears is as variable as the ice conditions.*[30]

At the appropriate times each season, Inuit hunters set out to find these animals as their migrations bring them through their area. Some communities are lucky to have a favourable cove for whales, a feeding ground for caribou, or a nesting area for wild birds nearby. Others must travel further away to find these sources of food. Some communities live in places where the floe edge – the point at which the sea ice stops and the open water begins, and generally the best place to find sea mammals – is an hour away from shore. Others must travel three or four hours to reach it. As one might expect, these harvest conditions fluctuate from year to year, largely dependent on the weather. This is why we Inuit must be ready to travel long distances if necessary.

From time to time, disaster strikes and a community must completely alter its subsistence pattern in order to survive. For example, the community of Read Island near Kugluktuk in western Nunavut had

28 Quoted in Brody, "Land Occupancy: Inuit Perceptions", in Freeman, Vol. 1, p. 209.

29 Carol Brice-Bennett, ed., 1977. Our Footprints are Everywhere: Inuit Land Use and Occupancy in Labrador. Labrador Inuit Association. p. 149.

30 Brody, "Land Occupancy: Inuit Perceptions", in Freeman, Vol. 1, p. 214.

meat and seal meat, geese. You just change with the changes, I guess. I'll still be here. As long as I'm alive I'll keep doing what I'm doing."[24]

After describing in detail how climate change is forcing his community to deal with new challenges, John Keogak of Sachs Harbour shared this idea on how he can continue his harvesting practices:

> *"A buddy of mine is into making little sleds out of aluminum, which you can use as a little kayak or boat. If you're out on the ice and you have to cross an open lead or something you can use that. It's one of the things that can help. I'm going to get one of those. It's combined as a little sleigh and, if you have to, you can use it as a boat. That's one way I can adapt."*[25]

We will do whatever it takes to keep eating our traditional food

These responses illustrate that no matter how hard things get, we Inuit are not giving up on hunting. Even though climate change may prove to be the most difficult adaptation challenge we Inuit have ever faced, we will do whatever it takes to keep eating our traditional food.

3.2 Harvesting What the Land Provides

Because we are determined to maintain our traditional diet – and in fact we need to eat harvested meat due to the high cost of store-bought meat, in addition to the cultural reasons for doing so – it follows that there will be continued reliance on hunting, or harvesting as it is commonly known. Since traditional Inuit foods are rarely sold in stores, they must be obtained by hunters who criss-cross the land and sea around their communities, regularly travelling hours and sometimes days to track down the wildlife and harvest what is needed for their families and communities.

This does not mean that all Inuit hunt – though most able-bodied men and some women do. And those who hunt often have other employment. For example, many hunters in the Canadian Inuit settlement regions have at least part-time or seasonal wage employment in addition to hunting.[26] Indeed, interview respondents lamented that high fuel costs to run snowmobiles have in some cases made it necessary to engage in wage employment in order to finance hunting expeditions. Along these lines, Inuit in northern Greenland have moved toward a division of labour in order to supply their communities with traditional country food. A substantial portion of the harvest is done by Inuit who are licenced professional hunters and sell their products to Inuit households in open-air markets.[27]

Nevertheless, the hunt continues. We Inuit keep on adapting to the new economic environment in ways that sustain our connection to the land and the harvest it provides.

24 Interview on March 28, 2008.

25 Interview on March 13, 2008.

26 Poppel, Birger, Jack Kruse, Gerard Duhaime, Larissa Abryutina. 2007. SLiCA Results. Anchorage: Institute of Social and Economic Research, University of Alaska Anchorage. p. 6.

27 Poppel et al., p. 4.

Movement will always be a necessary part of life in the Arctic. We do our best to prepare our young people for that reality

All of this traditional knowledge, much of it at the very core of the Inuit way of life, has been developed and passed down in order to impart the knowledge of a nomadic people to its future generations. We Inuit recognize that movement will always be a necessary part of life in the Arctic and therefore do our best to prepare our young people for that reality.

3. Moving to Follow the Game

3.1 Continued Importance of Traditional Diet

One thing that has remained most constant in Inuit life since the mid 1970s when Milton Freeman's team of researchers combed the area then called the Northwest Territories, and Carol Brice-Bennett's team studied the Labrador region, is the centrality of "country food" to the Inuit diet. As in the former days when meat, fish, and blubber were the dietary staples, augmented seasonally by berries and wildfowl eggs, Inuit today still rely heavily on foods obtained through hunting and gathering.

Interviews done by the land use and occupancy researchers in the mid 1970s evoked numerous responses stressing the importance of hunting and the traditional Inuit diet. A selection of statements is reproduced here:

> *"I can't stand it (store-bought food). We were brought up living off the country, and we don't like to eat the food that you buy from the stores steady, you know. It's alright for two, three days; a week maybe." Charlie Gruben, Tuktoyaktuk, Inuvialuit Settlement Region.*[18]

> *"We like our land, we like our natural foods. They give us the freedom to do what we want, the kind of life we like to live. Our culture we'll never forget. To keep our culture, we got to keep our land and have it free from being developed, so we'd kind of like to protect the land where we trap and hunt all our lives." Sam Raddi, Inuvik, Inuvialuit Settlement Region.*[19]

> *"There are all kinds of animals... Inuit have been living here for a long time, and some people live only on game, and some have done so for many years. That is why we want to protect the land." Lucassie Inuktaluk, Sanikiluaq, Nunavut.*[20]

"Our culture we'll never forget. To keep our culture, we got to keep our land and have it free from being developed"

> *Interviewer: Is it possible that people will gradually do less and less hunting? Young family man from Arctic Bay, Nunavut: No, I do not think so. Right now many people in Arctic Bay work in the white way, either here or in other places. But they still hunt. Look at me. I have a job here, but I go out hunting. I was out yesterday. People here will always want real food, and for that reason alone we are all hunters. We'll always be hunters. ... For the young as well as for adults, to be an Inuk is inseparable from being in touch with the land and from the possession of the technical skills and moral qualities that make such contact both possible and valuable. All Inuit agree that the land is the mainstay of their life. Even in the most wage-oriented families, local foods are valued and sought above all others. And it is, of course, the young who must be relied upon to maintain the supply of local foods so that the people may continue to be Inuit.*[21]

18 Quoted in Brody, "Land Occupancy: Inuit Perceptions", Freeman, Vol. 1, p. 218.

19 Ibid. p. 236.

20 Ibid. p. 236.

"We'll always be hunters. ... For the young as well as for adults, to be an Inuk is inseparable from being in touch with the land"

> *"I think and sometimes speak the thought that my children should eat well from the land. This is what I want to pass on to my descendants: good food from the land, caribou and fish. The land makes you live well and be healthy." Rosia Paulla, Gjoa Haven, Nunavut.*[22]

Interviews conducted by ICC Canada in March 2008 indicate that despite the increased difficulty in finding and harvesting big game and sea mammals due to thinning and less predictable sea ice, Inuit communities are persistent in maintaining their traditional diets. When asked whether changes in ice conditions were affecting their traditional diets, respondents spoke of having to travel further or in a different month than usual; they spoke of dietary substitutions such as hunting more musk-oxen when the caribou migration shifted away from their area, or they explained how melting permafrost has made the natural ice cellars used to age and store meat less effective. Not one of them said anything to suggest they were giving up on hunting despite the considerable challenges some were facing in getting out on the ice and land.

Not one of them said anything to suggest they were giving up on hunting despite the considerable challenges

When asked how his life might change because of poorer ice conditions in the future, Tommy Qaqqasiq from Pangnirtung, Nunavut said:

> *"Then we'll use other equipment. People will still hunt. It's part of our life. When things change, you just have to go with it."*[23]

This sentiment was echoed by Frank Pokiak from Tuktoyaktuk in the Inuvialuit Settlement Region, who said:

> *"I'm still going to depend on harvesting, different species if it has to be. The majority of my food I still get from the land, I still depend on all the fish that we get and different ways to prepare it. Whale*

21 Quoted in Brody, "Land Occupancy: Inuit Perceptions", Freeman, Vol. 1, p. 229.

22 Ibid. p. 241

23 Interview on March 14, 2008

Classement CCEK

Titre Glaces

Type Dossiers Environementaux

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Document: Koksoak River ice monitoring using RADARSAT-1- Freeze-up period 2007-2008

Indian and Northern Affairs Canada
Impacts and Adaptation 2008-2009 Funding

Project Submission

1. Project Title:

Acquisition de connaissances locales sur le comportement des glaces de mer et d'eau douce du Nunavik au voisinage des infrastructures maritimes.

Proponent/Community/Organization

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Note :

Cette étude s'intègre dans le projet : « Nunavik - Infrastructures maritimes - Susceptibilité aux changements climatiques et adaptation », mené par le ministère des Transports du Québec. Elle est également complémentaire au volet : « Étude par télédétection, du comportement des glaces de mer et d'eau douce du Nunavik au voisinage des infrastructures maritimes », soumis en parallèle à AINC.

2. Background/Rationale for this project:

What issue(s) does this project address? Why is this important? Describe why the team assembled is the right group to deliver the project. (max 500 words).

D'après de récentes études, la durée de la saison de glace devrait diminuer de manière significative dans la baie d'Hudson, le Détroit d'Hudson et la baie d'Ungava au Nunavik. Une diminution de l'ordre de 5 à 6 semaines de la durée de la saison des glaces est attendue d'ici 2050. Les glaces devraient devenir plus instables, plus mobiles et former davantage de crêtes et de radeaux sur les côtes. La glace des estuaires et des rivières subira également des changements de cette nature. Les conséquences potentielles de ces changements sont les suivantes (certains de ces impacts sont déjà notés par la population du Nunavik) :

- Les conditions de sécurité plus risquées et difficiles lors des déplacements des Inuits sur le couvert de glace, notamment en raison des changements climatiques (CC) qui modifie les conditions de glace et qui rendent de moins en moins fiables les prédictions de celles-ci basées sur le savoir traditionnel;
- Le potentiel plus élevé de poussées glacielles dans certaines zones propices ou exposées à des conditions extrêmes, pouvant menacer l'intégrité et la sécurité des infrastructures côtières;
- Une modification du bilan sédimentaire et de la stabilité des berges dans certaines zones puisque les glaces fixes protègent la rive en général contre l'action des tempêtes alors que les glaces mobiles peuvent au contraire fragiliser la berge et perturber le bilan sédimentaire des plages et des marais côtiers;
- L'impact sur le régime des niveaux d'eau. Dans la baie d'Hudson, par exemple, les marées sont fortement atténuées lorsque la baie est couverte de glace. Ces glaces ont aussi pour effet d'atténuer l'impact des tempêtes hivernales sur les surcotes, contexte qui risque d'être différent dans les années à venir étant donné la diminution du couvert de glace.
- Les glaces ont enfin pour effet d'inhiber les vagues de tempête. Leur disparition progressive devrait donc se traduire par une plus grande exposition des infrastructures côtières et des rives aux surcotes et aux vagues de tempêtes dont la simultanéité peut engendrer des risques d'incidents majeurs pour ces infrastructures et les usagers.

- Lorsqu'elles sont plus mobiles, les glaces peuvent être transportées par les courants et agitées par les vagues sur les infrastructures pouvant causer des dommages importants à ces dernières.

C'est pourquoi ce projet est d'une importance vitale pour les communautés étant donné qu'il permettra de mieux comprendre et évaluer les risques reliés à l'impact des changements climatiques sur les conditions de glace côtières. Les connaissances acquises sur le régime des glaces permettront de contribuer à mettre en place des mesures d'adaptation afin d'assurer la pérennité ainsi que la sécurité des infrastructures maritimes et des usagers.

La justification de l'équipe de recherche proposée pour adresser cette problématique sera argumentée dans la section « Méthodologie du projet ».

3. Project Description:

(*max 250 words*)

Le projet s'intègre dans une évaluation de l'impact des CC sur les glaces de mer et sur leur interaction avec les glaces côtières et d'estuaires, de même que sur les risques que ces changements poseront pour les infrastructures et la sécurité des usagers afin d'identifier les mesures d'adaptation à mettre en place dans sept communautés Inuits au Nunavik. Plus particulièrement, pour comprendre ces phénomènes et afin de mieux s'y préparer, on manque d'études sur le comportement des glaces côtières (banquises, glaces de rivage et glaces d'estuaires et de rivières) dans le Nunavik. L'approche proposée comporte deux volets : 1) Une caractérisation historique des glaces et des phénomènes extrêmes (débâcle inattendue, prise hâtive, haut niveau d'eau, tempête, dommages aux infrastructures, érosion des côtes, etc.), qui mise sur les connaissances traditionnelles et des observations locales des communautés et 2) Une caractérisation actuelle et future des glaces, qui mise sur une technologie de surveillance locale en temps réel, à l'aide de caméras.

4. Objective(s):

Define project objective(s) (max 250 words)

L'objectif est de récolter l'information la plus détaillée possible sur les conditions d'englacement et les événements extrêmes au voisinage des villages à l'étude et plus particulièrement, des infrastructures maritimes. Les objectifs spécifiques sont : **1)** Utiliser les connaissances traditionnelles et actuelles des communautés pour caractériser l'historique et les changements relatifs aux conditions d'englacement et aux événements climatiques extrêmes dans ces communautés et plus particulièrement, aux alentours des infrastructures maritimes ; **2)** Utiliser une technologie de caméras de surveillance en temps réel pour caractériser les conditions d'englacement actuelles et les événements climatiques extrêmes à venir, sur les sites des infrastructures maritimes.

Cette information sera par la suite essentielle à deux volets du projet sur la vulnérabilité des infrastructures. Dans un premier temps, elle permettra de valider les observations faites à partir d'images satellites au niveau régional (historique) et local (situation actuelle). Dans un deuxième temps, elle permettra de valider des modèles élaborés par Ouranos. (à élaborer par OURANOS et MTQ).

5. Methodology:

Provide the sources of existing information (if relevant); describe how this and new information will be gathered (method, material infrastructure, space, travel, etc.) and how it will be will used.

Connaissances traditionnelles (objectif 1):

La transmission des connaissances traditionnelles sur les conditions de glace et les événements extrêmes sera faite à partir d'ateliers de consultation des communautés locales. Il s'agit donc d'obtenir une information historique et un aperçu des changements perçus par la population. Un questionnaire est élaboré afin de recueillir des informations sur les conditions de glace, les zones d'érosion et de sédimentation, le régime des niveaux d'eau, le régime des tempêtes et des évènements extrêmes (débâcle, inondation, érosion, etc.).

Sous la responsabilité de l'ARK et en collaboration avec l'INRS une rencontre sera organisée dans 3 villages ciblés : Kuujjuaq (rivière Koksoak), Umiujaq (Baie d'Hudson) et Quaqtaq (Baie d'Ungava).

Pour appuyer les questions en atelier, on utilisera des cartes et photos satellites des sites d'intérêt. Les gens seront également appelés à se déplacer sur les sites des infrastructures maritimes pour mieux documenter la localisation des informations recueillies. On recherchera aussi l'existence de photos d'événements extrêmes pouvant exister dans la communauté.

Une autre facette de la consultation se fera auprès des étudiants des communautés. En partenariat avec les écoles, on instaurera un système d'observation, où les étudiants noteront au cours de l'année, les dates d'arrivée et de départ de la glace, ainsi que toute autre information sur des événements particuliers. On pourrait alors créer une habitude qui serait très utile à long terme.

Les informations recueillies seront ensuite colligées pour établir un portrait historique et actuel des conditions d'englacement et des événements extrêmes.

La présente demande permettra de financer la tenue de ces consultations et l'analyse des données recueillies pour la période 2009-2011. OURANOS et le MTQ financeront la cueillette supplémentaire d'informations (2011-2012) et l'intégration de ces informations au projet sur la vulnérabilité des infrastructures. L'utilisation des données pour la validation de l'étude par télédétection sera couverte par la demande présentée à AINC en parallèle.

Surveillance en temps réel (objectif 2):

Pour mieux documenter les conditions actuelles et futures d'englacement au voisinage des infrastructures de ces mêmes villages, on prévoit l'installation de caméras fixes, qui fourniront des images en temps réel ou différé. Sous la responsabilité de l'ARK et en collaboration avec Ouranos et l'INRS ces caméras seront installées sur des mâts, près des infrastructures maritimes des 3 villages mentionnés plus haut. Il sera alors possible de connaître les dates exactes d'arrivée et de départ de la glace, ainsi que le comportement de ces glaces autour des infrastructures maritimes. Ces caméras pourraient également capter des événements extrêmes à venir. Les photos seront archivées et si techniquement possible, disponibles sur Internet en temps réel pour le bénéfice des utilisateurs des infrastructures maritimes.

Le financement demandé permettra d'abord de déterminer le type d'équipement le mieux adapté aux besoins et aux conditions extrêmes des villages à l'étude. Il permettra ensuite l'achat, l'installation et l'entretien à court terme (2009-2011) de ces équipements, ainsi que l'archivage des nombreuses photos. Il permettra finalement de développer une méthodologie permettant le traitement des photos pour passer d'une vision oblique à une vision verticale. OURANOS et le MTQ financeront l'entretien à moyen terme (2011-2013) des caméras et l'intégration des informations au projet sur la vulnérabilité des infrastructures. L'utilisation de ces photos pour calculer des statistiques et des indicateurs climatiques, ainsi que pour valider les observations satellites, sera assumée par la demande du volet Télédétection, présentée à MAIN en parallèle.

En combinant les deux types d'information, il est même possible d'établir le niveau d'incertitude relié aux observations locales. En effet, en 2012, on retournera voir les populations pour leur demander de spécifier les dates d'arrivée et de départ des glaces autour des infrastructures maritimes depuis 2009. Comme on aura les dates exactes grâce aux caméras et aux observations des étudiants, il sera alors possible d'estimer le degré d'incertitude des observations locales. Cette opération sera financée par Ouranos (est-ce possible?).

La présente demande de financement couvre donc un aspect primordial de la collecte d'information sur les conditions d'englacement et les événements extrêmes, soit celle détenue par les populations locales. Elle permet également d'implanter un outil de surveillance supplémentaire pour le futur.

Les deux objectifs poursuivis par ce projet seront menés par ... qui a une expertise en ... Il bénéficiera du soutien essentiel de l'Administration

Régionale Kativik (ARK), responsable du territoire et des citoyens au niveau municipal et qui possède aussi une grande expertise dans les consultations publiques au Nunavik. Ils seront également le pivot local pour la logistique entourant le choix, l'installation et l'entretien des caméras. Le parrainage et le soutien financier du ministère des transports du Québec, responsable gouvernemental des infrastructures maritimes du Nunavik, et d'Ouranos, groupe de recherche sur les changements climatiques, permettra d'étendre l'étude sur une plus longue période et d'intégrer les résultats dans une étude plus globale sur la vulnérabilité des infrastructures. Le partenariat du laboratoire de télédétection de l'INRS - Centre Eau Terre Environnement permettra quant à lui, d'assurer le traitement des photos et le lien avec le volet télédétection.

6. Community Engagement:

Provide a short description of which communities will be approached and how they will be involved with the project.

Le projet global sur la vulnérabilité des infrastructures s'intéresse particulièrement à sept villages : Kuujjuaq, Quaqtaq, Umiujaq, Inukjuak, Puvirnituq, Ivujivik et Kangiqsujuaq, au Nunavik. Par contre, la présente demande de financement vise spécifiquement 3 villages : Kuujjuaq, Quaqtaq, et Umiujaq, afin d'établir une méthodologie et une preuve de faisabilité. La cueillette des informations de source traditionnelle et locale demande évidemment la participation des autorités locales, pour la logistique, et des populations, pour le partage de leurs connaissances. L'implication des étudiants est également un aspect porteur. Enfin, l'installation et l'entretien des caméras nécessitent aussi l'implication des autorités locales et cet équipement représente un legs pour les communautés.

7. Work plan (*timelines and funding*):

Activity	Description	Estimates ($)	Timeline
Objectif 1 Connaissances traditionnelles	Planification des consultations	7500$	Été 2009
	Tenue des consultations	25 000$	Automne 2009
	Traitements des informations	7500$	Hiver 2010
	Analyse des informations	12 000$	Hiver 2010
	Validation des consultations	7000$	Automne 2010
	Rapport final	15 000$	Hiver 2011
Objectif 2 Surveillance	Choix des équipements	2000$	Été 2009
	Installation des équipements	39 000$	Automne 2009

	Méthodologie pour l'archivage et la diffusion	15 000$	Aut. 2009 et hiver 2010 Hiver 2010-2011

8. Deliverables:

Describe clearly the deliverables for this project.

<u>Livrables à la fin de la 1ère année</u>

- Installation des caméras;
- Consultation (atelier) des communautés.

<u>Livrables à la fin de la 2ème année</u>

- Validation des informations provenant de la consultation des communautés;
- Production du rapport sur le savoir traditionnel et les observations locales;
- Archivage et diffusion des photographie (analyse réaliser par l'INRS).

<u>Livrables à la fin de la 3ème année (financé par MTQ)</u>

- Entretien des cameras dans les villages (à déterminer avec MTQ)
- Dernière consultation l'incertitude des incertitudes relatives à la précision des dates des évènements (formation de la glace, évènements climatiques, etc.) des observations locales ;
- Présentation des résultats dans les communautés.

9. Funding Break Down:

Indicate <u>cash</u> and <u>in kind</u> broken down in the categories included in the table below.

Expenses categories	INAC	Other: *source, in kind*	Total
Salaries & wages (and benefits where they apply)	90 000$		
Travel (including meals), Accommodation, Transportation	38 250 $		

Engineering, project management and accounting			
Data collection, analysis and reporting			
Research			
Communications			
Training / Workshop	14 000$		
Community information initiatives			
Professional services (please detail in proposal)			
Audit and evaluation			
Office supplies and equipment dedicated to the project	26 000$		
Printing services (e.g. reports, surveys, etc)			
Administrative costs (including telephone, fax, internet, postage, photocopying etc.) Maximum of 15% of total project budget.			
TOTAL	198 250 $		

Le projet proposé ici s'intègre dans un projet global financé par MTQ (2 000 000$) et OURANOS (200 000$). La contribution directe du MTQ pour le volet … est de … (2009-2012), dont … 2009-2011. Celle d'OURANOS est de…

Funding Partner(s)

If applicable, list all funding partners and their contribution, including other INAC and federal programs.

Funding partners	Cash	In-Kind
INAC funding requested	198 250 $	

MTQ INRS CCG	??? ??? ???	??? ??? ???
TOTAL		

Total INAC funding requested: _______$___________

Other funding source: ______ $___________

In-kind: ________$________

Total cost of the project: _______$________

CDIM# 1334286

Koksoak River ice monitoring using RADARSAT-1

Experimental ice cover map from satellite data. To be validated.

Freeze-up period 2007-2008

http://climatechange.krg.ca/kuujjuaq.html

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

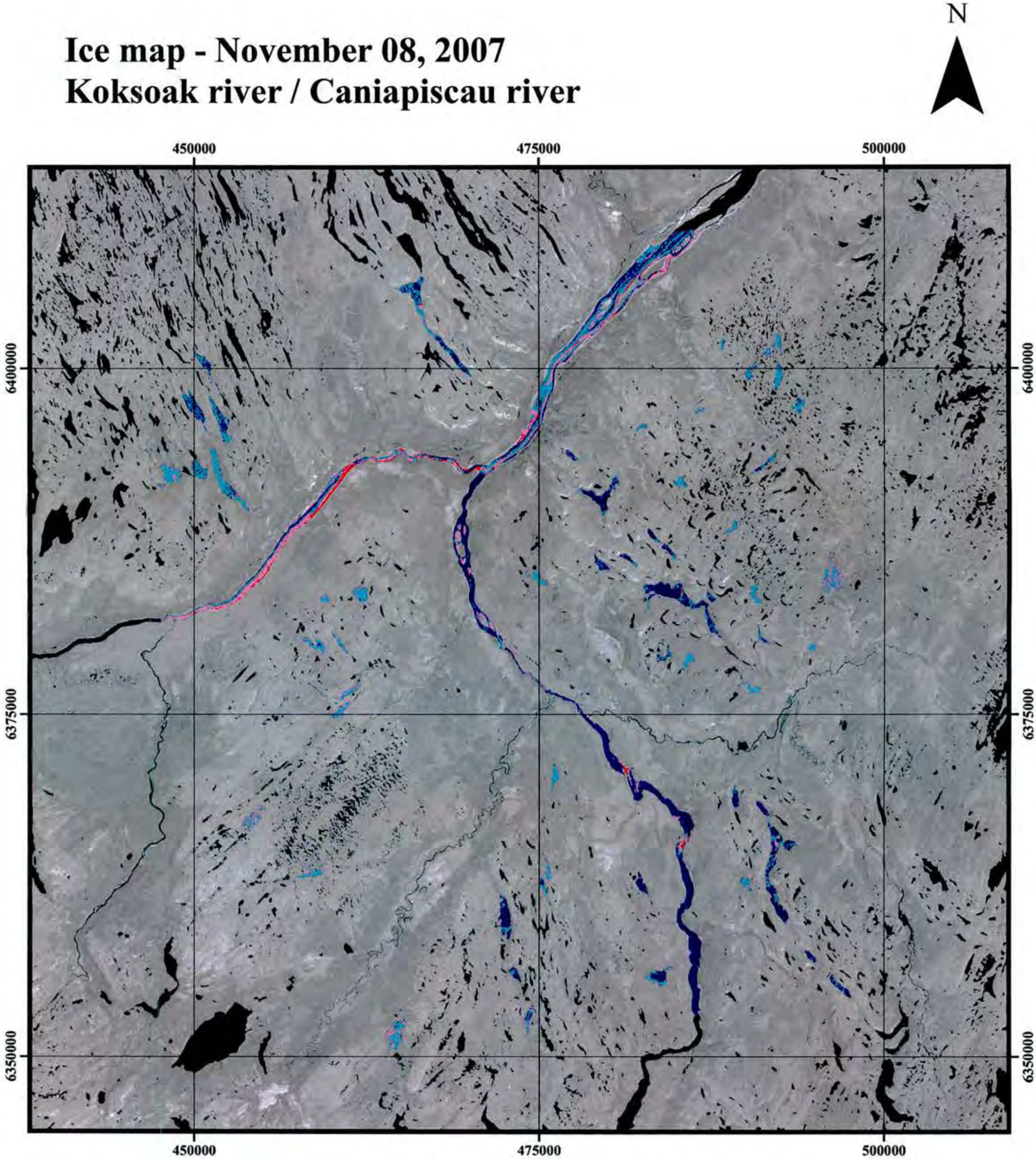
Université du Québec
Institut national de la recherche scientifique

KATIVIK

Trent University

Coordinator:
Martin Tremblay
Renewable resources department
mtremblay@krg.ca
Phone: (819) 964-2961 ext 2322
Fax: (819) 964-0694

Ice map - November 08, 2007
Koksoak river / Caniapiscau river



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

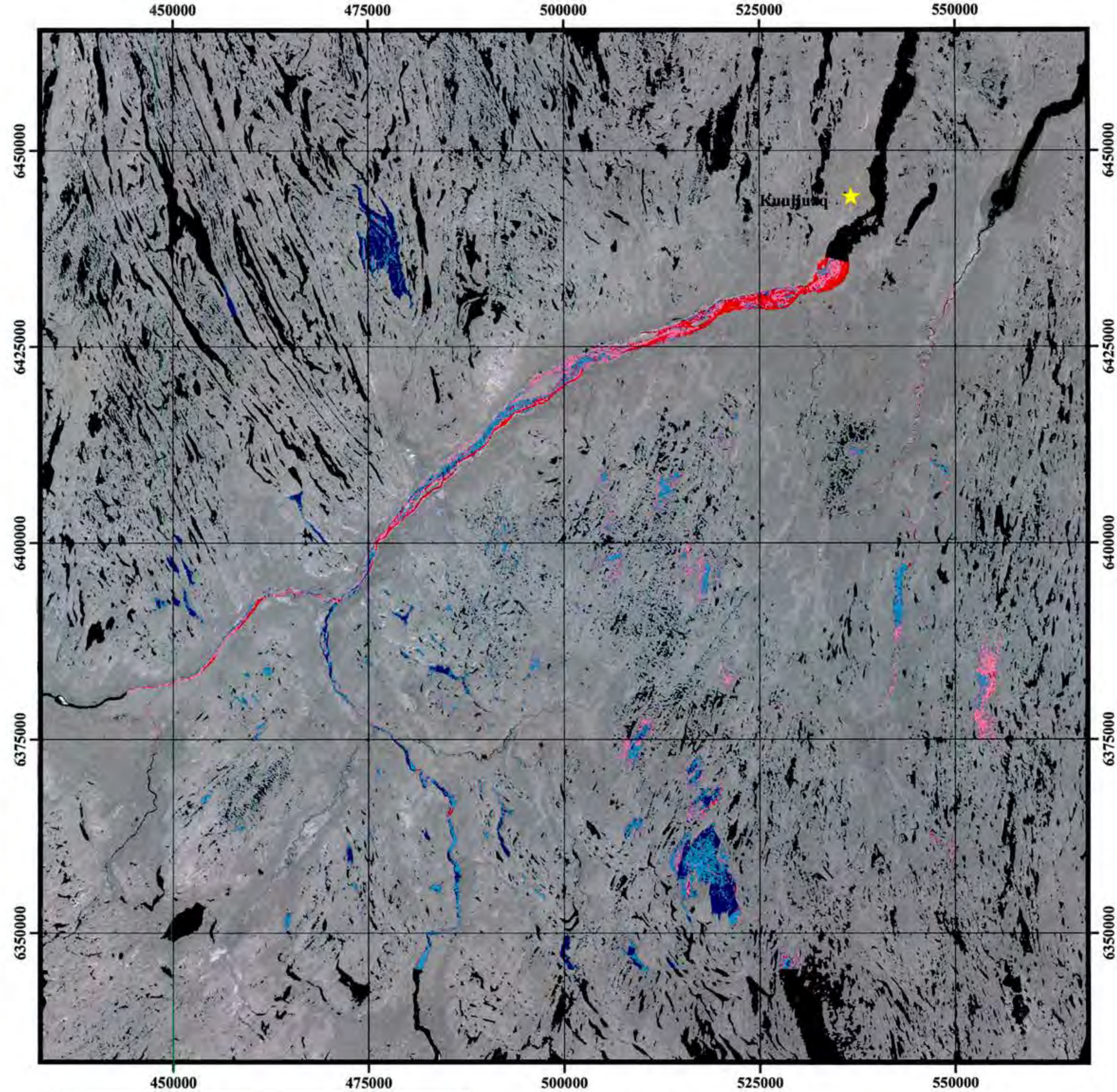
Kilometers (km)
0 5 10 15 20

Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - November 18, 2007
Koksoak river / Caniapiscau river

N



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

Kilometers (km)

0 10 20 30 40

Data projection :
UTM Zone 19

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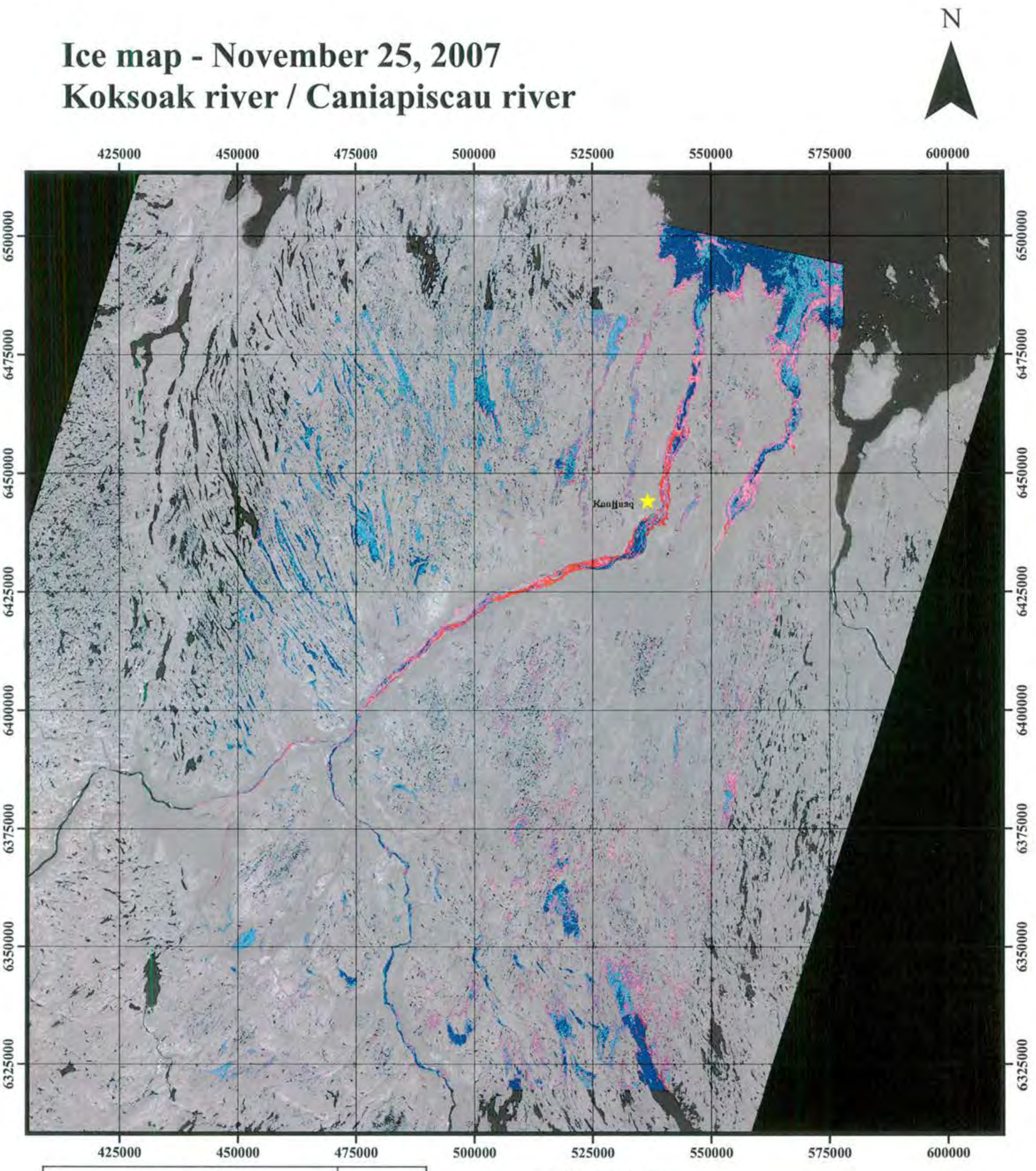
Ice map - November 25, 2007
Koksoak river / Caniapiscau river



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

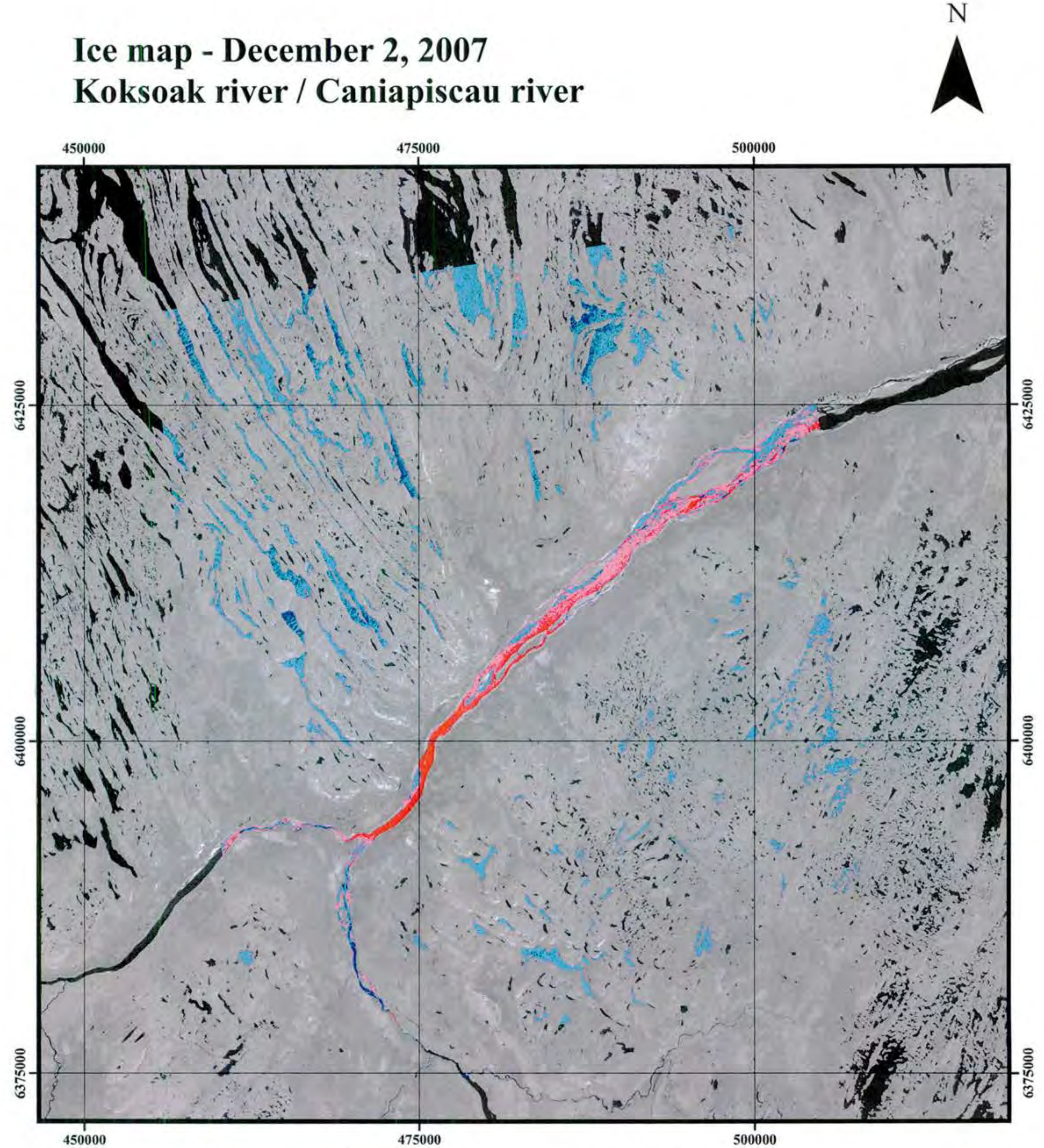
Kilometers (km)

0 10 20 30 40 50 60

Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - December 2, 2007
Koksoak river / Caniapiscau river



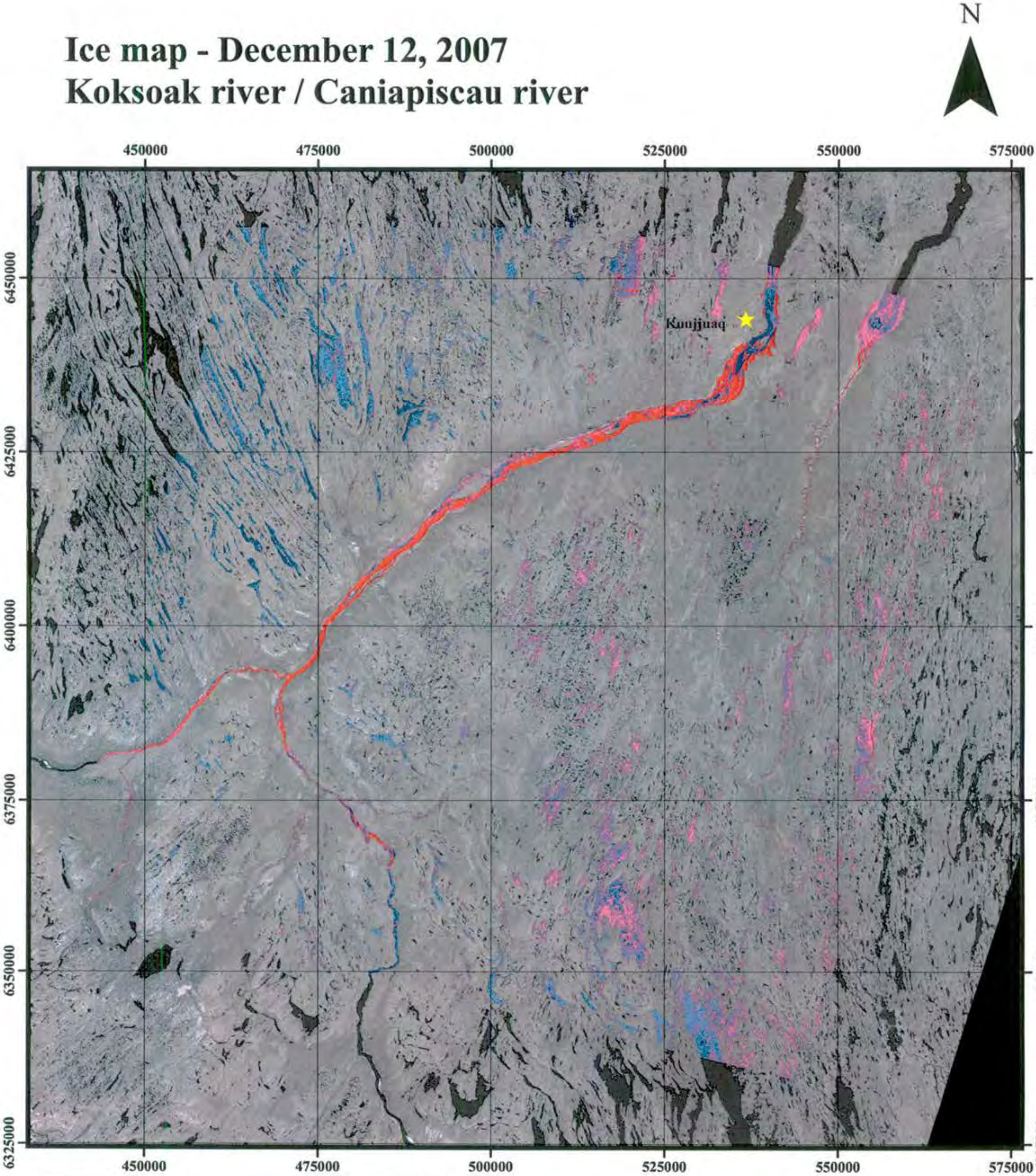
Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

Kilometers (km)
0 5 10 15 20

Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - December 12, 2007
Koksoak river / Caniapiscau river



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

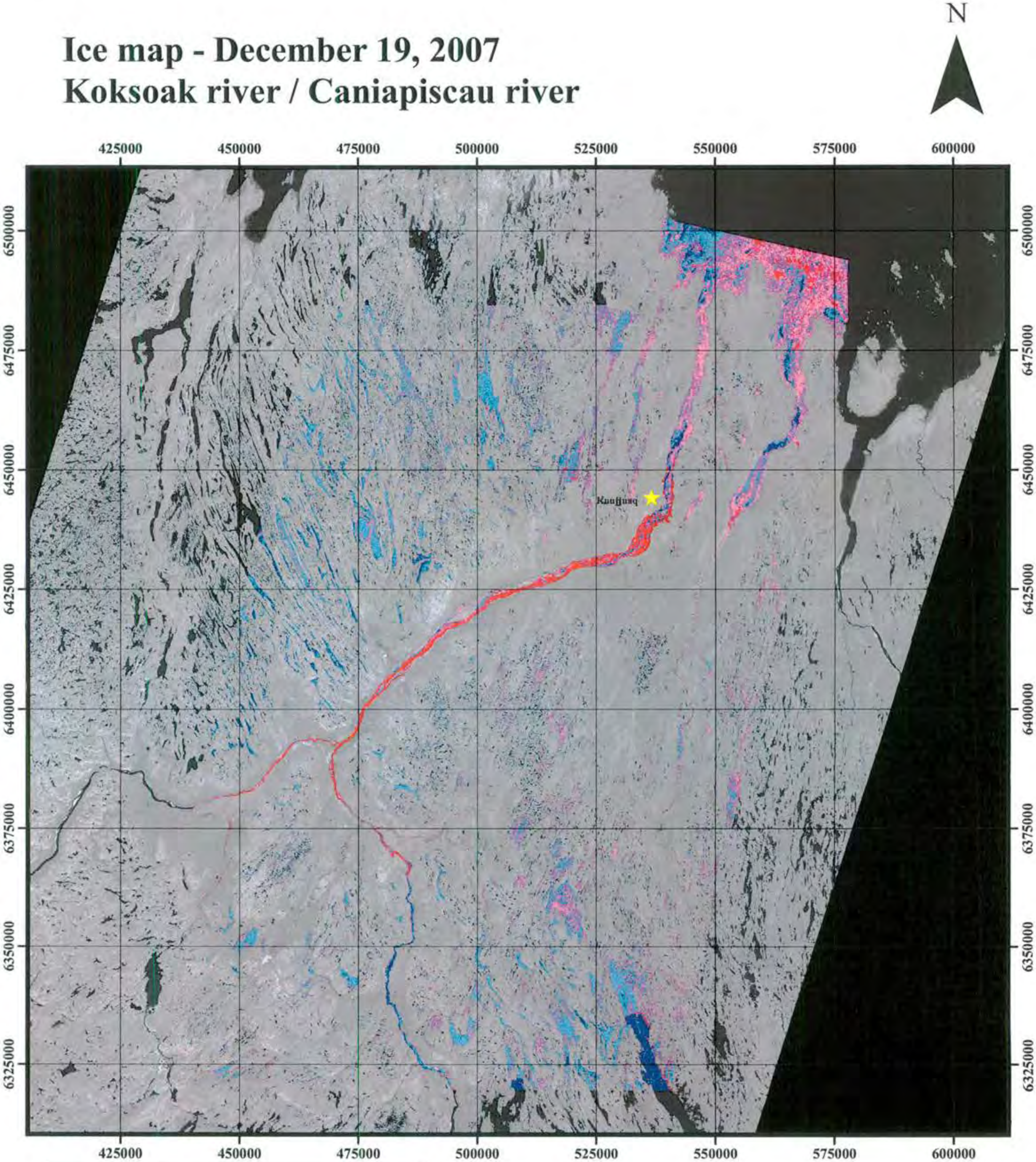
Kilometers (km)

0 10 20 30 40

Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - December 19, 2007
Koksoak river / Caniapiscau river



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

Kilometers (km)

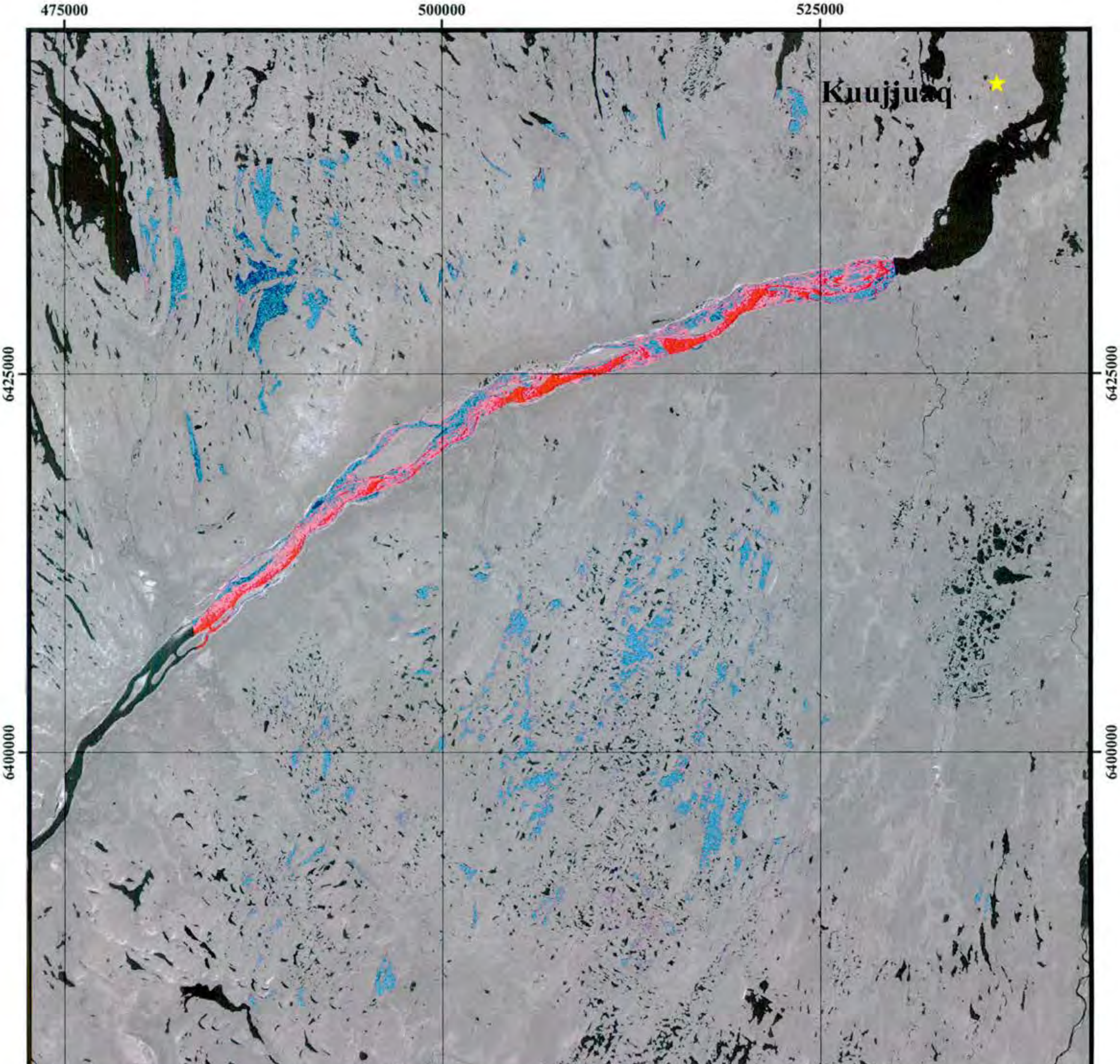
0 10 20 30 40 50 60

Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - December 26, 2007
Koksoak river / Caniapiscau river

N



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

Kilometers (km)

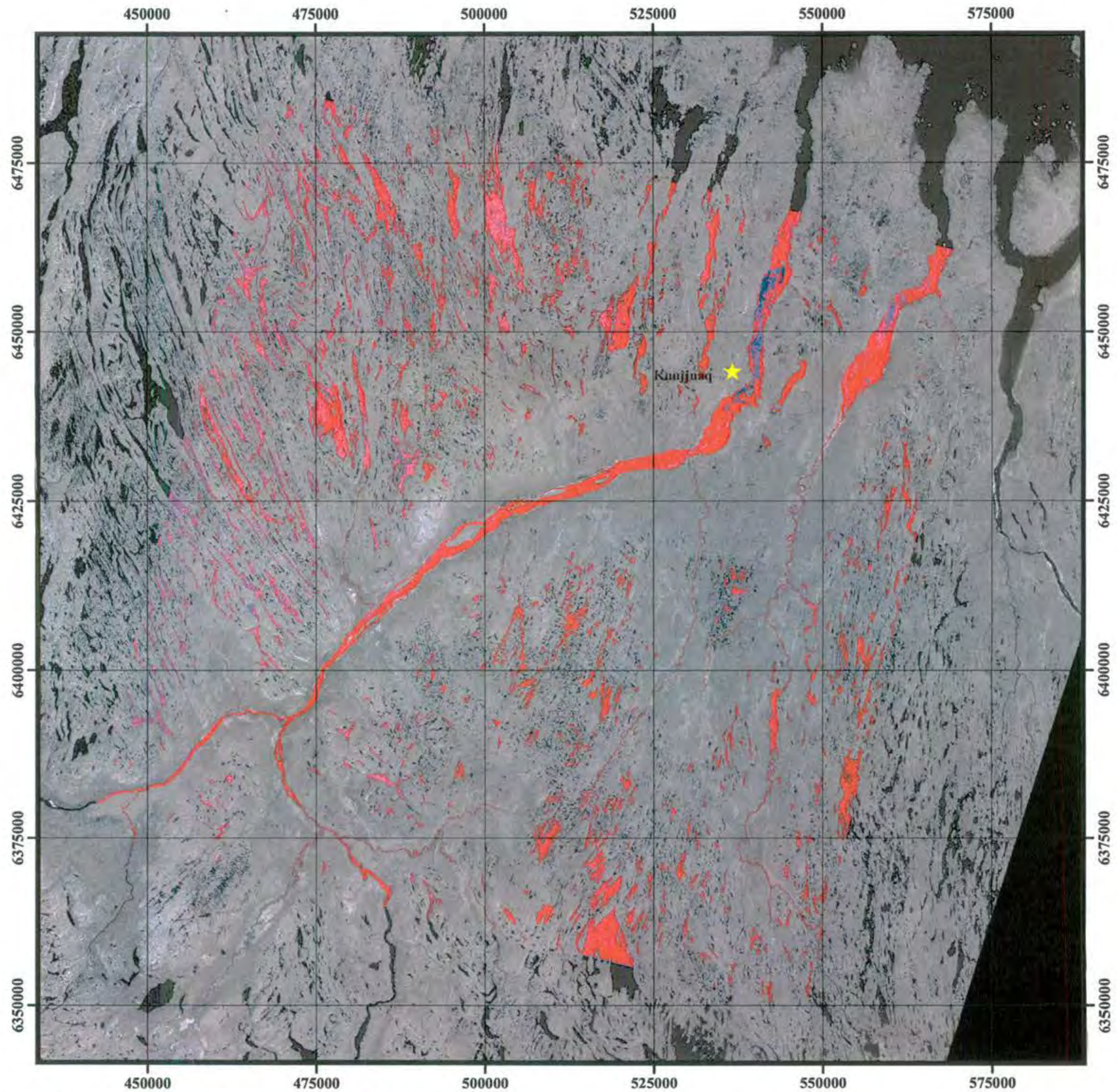
0 5 10 15 20

Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - January 5, 2008
Koksoak river / Caniapiscau river

N



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

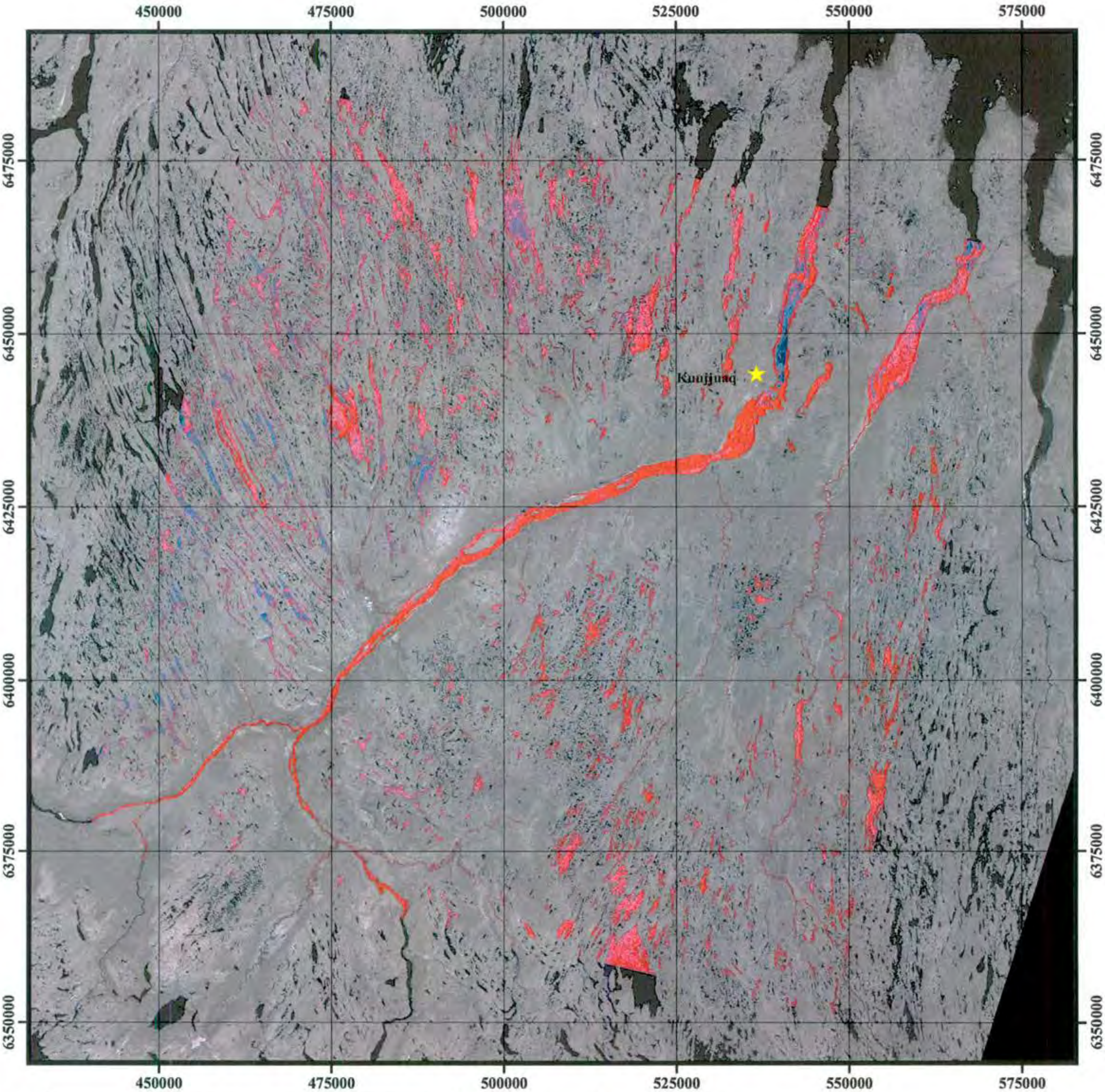
Kilometers (km)

0 10 20 30 40 50

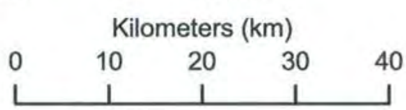
Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - January 12, 2008
Koksoak river / Caniapiscau river



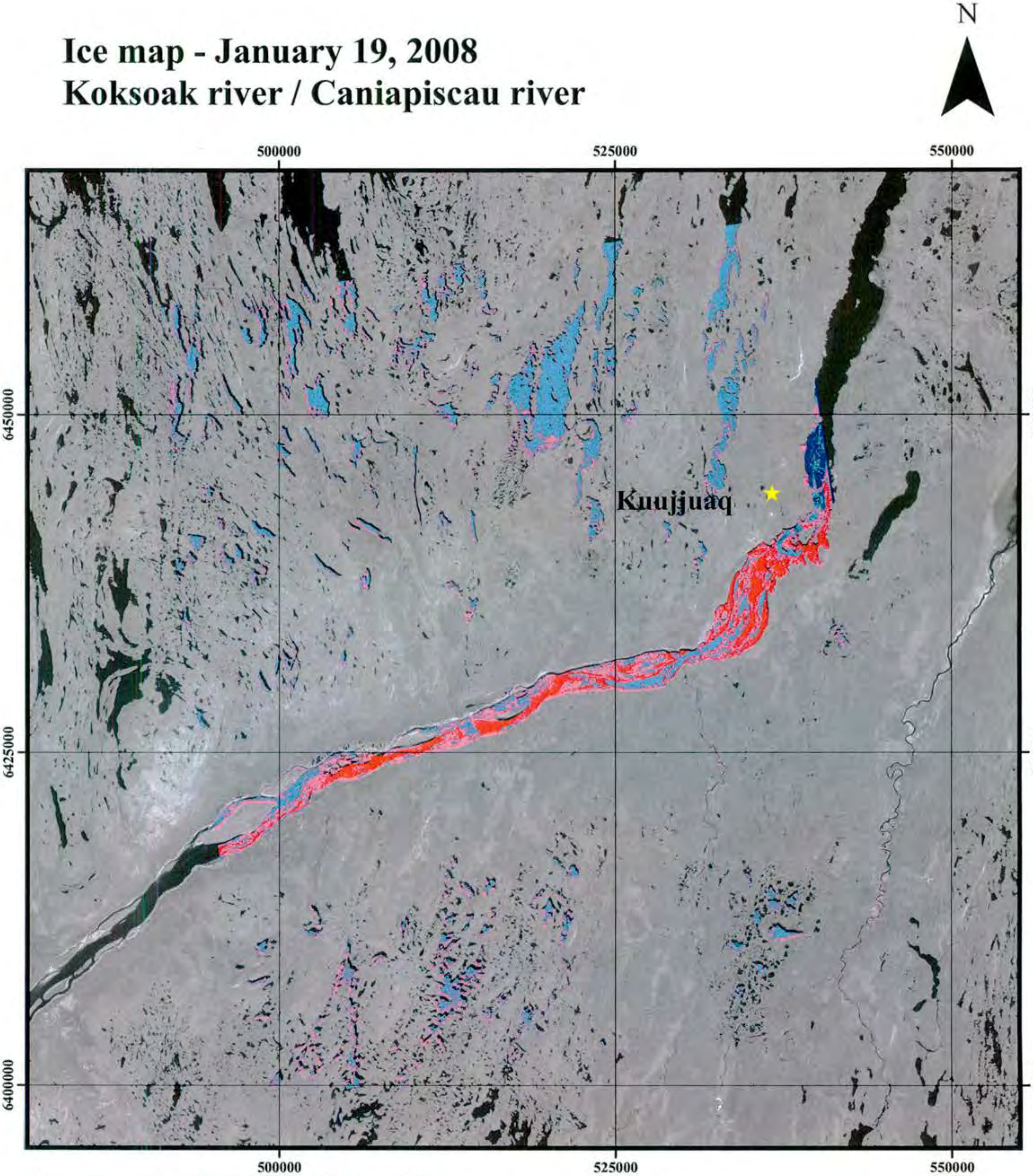
Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	



Data projection :
UTM Zone 19

Notes: The information provided by the Kativik Regional Government on this map is provided for information purposes only. Actual conditions may differ due to the update frequency. The KRG shall not be held responsible for any incident or damages that may occur with regards to the provided information.

Ice map - January 19, 2008
Koksoak river / Caniapiscau river



Ice type	Legend
Water or Clear ice	
Smooth ice	
Slightly rough ice	
Rough ice	

Kilometers (km)

0 5 10 15 20

Data projection : UTM Zone 19

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Title:

Climate change in Northern Québec: Adaptation strategies from community-based research

Martin Tremblay[1], Christopher Furgal[2], Caroline Larrivée[3], Tuumasi Annanack[4], Peter Tookalook[5], Markusi Qiisik[6], Eli Angiyou[7], Noah Swappie[8], Jean-Pierre Savard[3], and Michael Barrett[9]

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ABSTRACT: Arctic communities are recently reporting warmer and shorter winters which have implications for the ice season and, consequently, on their access to local territories and resources by members of these communities. These climatic shifts are resulting in increased risks for travel during the winter season associated with less stable and thinner ice. An Integrated Community-Based Monitoring (ICBM) program was developed in Nunavik to generate adaptation tools to support safe access to land and resources and to enhance local adaptive capacity via participation in community-based monitoring activities. The Nunavik ICBM approach brings together partners (northern communities, organizations and Canadian universities) having various perspectives on the issues of land and resources in Nunavik. The ICBM project also brings together traditional knowledge and scientific knowledge linking data collected through semi-structured interviews, local ethno-cartographic interviews, ice monitoring and from weather stations. The partnership-based Nunavik ICBM program dealing with territory and resource access is an example of how communities and scientists can work together to further understand the issues of climate change impacts in the North, their importance for Aboriginal people and how local adaptive capacity can be developed through an integrated, cooperative research process.

Key words: adaptation, climate change, ice monitoring, integrated community-based monitoring, semi-structured interviews, Northern Québec, scientific knowledge, traditional knowledge.

RESUME : Les communautés arctiques rapportent depuis quelques années des hivers plus chauds et plus courts qui ont des implications sur la saison de glace et par conséquent sur l'accès aux territoires et aux ressources locales par les membres de ces communautés. Ces conditions climatiques ont comme conséquence d'augmenter les risques lors des voyages hivernaux en raison de glaces instables et plus minces. Un programme intégré de surveillance des glaces (PISG) a été développé dans le Nunavik pour produire des outils d'adaptation pour soutenir l'accès sécuritaire au territoire et aux ressources et pour augmenter la capacité d'adaptation locale par l'intermédiaire de la participation communautaire aux activités de surveillance. L'approche du PISG rassemble plusieurs partenaires (les communautés nordiques, organismes et universités canadiennes) qui s'intéressent particulièrement aux questions d'accès au territoire et aux ressources au Nunavik. Le projet du PISG rassemble le savoir traditionnel et le savoir scientifique utilisant plusieurs sources de données (rassemblées par des entrevues semi-structurées, des entrevues ethno-cartographiques locales, de la surveillance de glace et des données météorologiques). Le PISG est un exemple de partenariat entre les communautés nordiques et les scientifiques qui permet de mieux comprendre les impacts des changements climatiques en cours dans le nord, leur importance sur les peuples autochtones et la façon dont la capacité d'adaptation locale peut être développée par une recherche intégrée et coopérative.

Mots clés : adaptation, changement climatique, surveillance de glace, suivi communautaire intégré, entrevues semi-structurées, Québec nordique, savoir scientifique, savoir traditionnel.

INTRODUCTION

Trail networks in Nunavik and Northern Québec are very important for local populations. These networks provide links between the communities because no road network exists in the region and communities are only accessible by plane or by boat. Thus, trails are used to conduct traditional activities such as hunting, fishing and trapping. Harvesting activities remain an important activity for economic, cultural and nutritional reasons (Myers et al., 2005; Van Oostdam et al., 2005). Climate change has begun to impact the timing and security of access to local environments and modify individuals' access to key resources (Furgal et al., 2002; Lafortune et al., 2004). The changes observed in this region also constitute critical social and economic issues for Northern Quebec residents. In response to these changes, an integrated community-based monitoring (ICBM) program is being developed in the region, and is contributing to local population abilities to cope with climatic change and maintain traditional harvesting activities.

The Third Assessment of the Intergovernmental Panel on Climate Change (IPCC, 2001) reported that climate change has already started to occur in the polar regions. Change is resulting in warmer temperatures, mainly in winter, the impacts of which can be seen in a decrease in the extent and thickness of sea ice, by the melting of permafrost, increased coastal erosion and by changes in the distribution and abundance of key northern species. Moreover, the IPCC (2001) projects that this region will be affected by some of the largest and most rapid changes of any region in the world, which will have important consequences for both northern environmental and human systems. Most climate models for the 21st century forecast that the Arctic will be affected by increases in precipitation and temperature, especially during autumn and winter seasons (ACIA, 2005).

In Nunavik, the 20th century was the warmest to date (Lavoie and Payette, 1992; Overpeck et al., 1997); however, until recently, this region was not affected by the warming trend observed elsewhere.

Some studies even observed a cooling trend in the region over recent decades (e.g. Allard et al., 1995). However, since the mid-1990s, Nunavik has been affected by warmer temperatures, which have already had consequences for the environment (Allard et al., 2004). Local populations also report warmer and shorter winters (Lafortune et al., 2004; The Communities of Kangiqsujuaq et al., 2005) which affect the ice season (i.e. delayed freeze-up, thinner ice and earlier break up) and consequently on human access to local territories and resources (Lafortune et al., 2004; Tremblay et al., 2006). These new climatic conditions result in increased risks for travel during the winter season associated with changes in ice and weather characteristics.

> *"Before, the snow and the land were solid enough to travel safely. Because of global warming the situation has changed. They* [harvesters] *have to be more careful and the routes that are taken during the winter are sometime not frozen, especially the river".* Quitsak Tarriasuk, Ivujivik

> *"Before, we could go along the shore in front of Umiujaq all the time. Now you have to be careful. It is only during real winter that you can use that area (...). In May, the whole area is no longer passable. Back then we could have used dog teams. But now it is melting faster, the ice is going out faster."* Davidee Niviaxie, Umiujaq.

These new climatic conditions also have significant consequences on individuals' access to local territories and resources. In many cases, harvesters have to wait for better conditions or use alternate trails in response to the new circumstances.

"It is mainly on the coast that we have problems [by snowmobile] *because the ice is not frozen as much today as it used to be. In the past we could travel confidently but today the sea ice is melting near the current."* Mattiusi Iyaituk, Ivujivik

"The difference between my regular routes and today is because I would normally be going fishing because there is usually snow at this time of year. But now, today [3 November 2005], *there still no snow."* Henry Quissa, Akulivik

Climatic changes have been well documented since the beginning of the Holocene (Alley, 2000; Korhola et al., 2002) and over the last few centuries (Overpeck et al., 1997). Several generations of Arctic peoples have used various strategies to cope with changes in the past (Nelson, 1969). Their adaptative capacity is well known (Robards and Alessa, 2004). Traditional knowledge (TK) systems are critical in supporting local adaptation to climate change (e.g. Krupnik and Jolly, 2002). TK refers here to the cumulative body of knowledge, practice and belief, evolving by adaptive processes handed down through generations (Berkes, 1999). However, contemporary climatic changes seem to differ in their intensity from earlier shifts. New climate conditions, in some cases, are responsible for unprecedented environmental changes in northern regions. In the case of ice dynamics, some local ice experts have difficulties describing these new environmental conditions. Consequently, TK, at the individual scale, may not always be effective in adapting to recent contemporary climatic change.

"*I can not answer you on this question* [Can you tell me how you know when the ice is safe to travel on?] *because now the ice behaviour is different than what it is used to be.*" Paulasi Qaunaaluk, Ivujivik

The project "Access to Territory and Resources" was initiated by the Kativik Regional Government (KRG), in response to concerns expressed by the communities, to improve adaptive capacity of Northern communities in Nunavik with respect to climate change. This community-based monitoring project has developed an integrated approach that brings together people from Northern communities, regional administrative agencies and universities in a multidisciplinary approach involving both TK and scientific knowledge. The program is studying aspects of climatology, ice dynamics and human safety, and food security to respond to community concerns and need for adaptation. The principle objective of the project is to enhance local adaptive capacity via participation in community-based monitoring activities. The purpose of this paper is to describe the Integrated Community-Based Monitoring (ICBM) model used to develop adaptation tools for safe access to land and resources in Nunavik communities.

REGIONAL CONTEXT

The region of Nunavik is composed of 14 communities located along the coasts of Hudson Bay, Hudson Strait and Ungava Bay (Fig. 1). The communities are accessible only by plane or by boat (in summer). Five Inuit communities (Akulivik, Ivujivik, Kangiqsualujjuaq, Kangiqsujuaq and Umiujaq) and one Naskapi community (Kawawachikamach) were selected to participate in the current project because they are representative of the different bioclimatic zones that make up the region and because each community expressed interest in participating in the study. Kawawachikamach is the only community outside of the Nunavik region involved and is located inland just south of the Nunavik border (55°N). This village is linked by road to the community of Schefferville, Quebec, which is accessible by train from the Lower North Shore of the St.-Lawrence River. None of the communities in the study are linked to each other or to the rest of the province via a road network, as is the case in some other northern regions of the country (e.g. the Baffin region of Nunavut, Nunatsiavut, some regions within the Northwest Territories). Winter trail networks throughout the region, comprised of land and sea ice trails that have been used for generations, are therefore particularly significant because they connect the communities to each other and provide access to traditional harvesting grounds throughout the year.

PRELIMINARY STUDIES AND IDENTIFICATION OF PROJECT PRIORITIES

The first phase of the project began with community workshops in 2002-2003 that were conducted in three Nunavik communities (Community of Kangiqsujuaq et al., 2005; Community of Ivujivik et al., 2005; Community of Puvirnituq et al., 2005). These workshops brought together representatives from the communities to discuss the changes that residents had observed in their local environment and the impacts of these changes on the community and individuals' activities. The workshops revealed that, among other things, the weather was now more unpredictable and winter temperatures were warmer than ever before. Moreover, these new winter conditions influenced ice dynamics, creating later freeze-up and earlier break-up times and thinner ice throughout the winter. Changes to the sea and lake ice conditions were beginning to have impacts on residents' access to important local hunting and fishing areas and, thus, resources throughout the year.

The ICBM project was developed based on the requests made by communities to address some of the critical concerns identified during the workshops (Communities of Kangiqsujuaq et al. 2005; Community of Ivujivik et al. 2005; Community of Puvirnituq et al. 2005) and has focused specifically on the issue of access to territory and resources to respond to the communities' adaptation needs. The project now involves several sources of data and brings together traditional knowledge (TK) and scientific knowledge (SK) based on quantitative and qualitative analysis of ice conditions.

COLLABORATION BETWEEN PARTNERS

The Nunavik ICBM approach brings together partners with various perspectives on the issues related to access to territory and resources in Nunavik. Community participation is the cornerstone of the project and is organized and sustained by a local researcher responsible for the development of the research directions in each community and the liaison between community members and scientists involved in the project. Ideally, the goal is for the community to take responsibility for, as much as possible, the research project in order to direct it in ways to best find solutions for the issues that concern local residents the most.

Northern Authority and Scientific Researchers

The Nunavik ICBM program was developed based on the relationships between the KRG Renewable Resources Department and Parks Section and university-based scientists. The development of these partnerships constituted the first step in developing the network that supports the project today. The KRG has been responsible for project planning since its inception, and support has been provided by the scientific partners in proposal writing, fundraising, and training of individuals and analysis of locally collected data. The ICBM was implemented in Nunavik communities under the direction and authority of the KRG. The local researchers in the project, based in many of the participating communities, have a strong interest in the issue of climate change and related impacts in their region and were already employed by the KRG Renewable Resources Department at the outset of the project. Their participation in the research and monitoring project was seen as a supplement to their originally scheduled work and now comprises an official component of their job description. A strong partnership was developed with scientists from the Nasivvik Center at Laval University in Quebec City who are dedicated to supporting community-based research initiatives through training and cooperative project development. This relationship has facilitated the conduct and analysis of local ethno-cartographic interviews with hunters and elders related to community trail networks, local ice dynamics, and changes in local and regional climate patterns. Through training and cooperative research experience, local researchers have taken more and more control of collecting these local data on their own. Collaboration with the consortium of climate change researchers in Montreal (Ouranos Consortium), and researchers at Laval University's Centre d'études nordiques has supported the quantitative analysis of climate indicators that complement the investigation into local changes and their impacts on human activities.

Northern Communities

The ICBM was implemented in Northern Quebec communities in the spring of 2004. The development of partnerships with communities began with meetings and presentations to the municipal councils and the local Hunters, Fishers and Trappers Associations. The project was a requested response from the community workshops, so support already existed for the initiative within communities and the initial meetings constituted a project planning and adaptation phase. This initial step ensured that the project covered issues deemed significant at the individual community scale and that it would have relevant benefits for the local population.

Local involvement in the ICBM is composed of, among other things, the sharing of local observation-based data and TK. This information is gathered directly by the local researchers with the help of scientists through semi-structured interviews using an ethno-cartographic process. During these interviews, elders and hunters share their observations and knowledge about changes in local climate conditions, changes in ice dynamics, and the impacts of these changes on the use of traditional trails and human safety while on the land (Table 1). One of the key contributions to the communities in this process has been the identification and documentation of increasingly 'risky areas' in local ice or land trails because of recognized changes in climate. Participants are aware of the importance of communicating these local observations and TK for the benefit of current and future generations to promote and maintain the safe practice of traditional activities and travel on the land and sea.

"It would be best if this information is handed down to the next generation and was used by people growing up." Paulasi Qaunaaluk, Ivujivik

Other interview participants saw an opportunity to update or learn from the TK shared in the project.

"I would like the knowledge to be used because I have data [experience] *that was gathered 30 years ago and it will be good to update them to see if they are still true. It will be nice to see, for instance, if risky areas* [that I have seen] *are really still like that. It would be nice to get new data* [observations] *for the past 10 past years*." Henry Alayco, Akulivik

Local participation and knowledge are critical in the development of community adaptation strategies because adaptation tools already exist in TK systems. Indeed, this type of knowledge is community-specific, place-based, related to environment-dependant practices and developed through past and current experience (Berkes et al., 2000). It represents a local database of adaptive measures to succeed in the local environment. As a result, the TK information collected from semi-structured interviews in this study is being used to develop a 'safe practices guide' for land and ice travel. As well, an interactive CD-ROM regarding access to local land and resources is being produced that will contain results from the study on ice dynamics as well as maps illustrating principal and alternate trails and 'risky areas' around each participating community. Also, local participants have provided weekly information on winter trail conditions. This information is being used to identify and validate, from a local Inuit perspective, climatic indicators characterizing safe ice conditions, and it is used in the generation of new indicators for ice modeling. These climate indicators are developed through the collection of both quantitative and qualitative information through ice monitoring activities (IMA) in sea and lake environments in collaboration with researchers at Ouranos (Tremblay et al., 2006).

Local Researcher in Northern Communities

The Nunavik ICBM is based on an 'investigation in the North, for the North and by the North' approach which is essential to developing adaptive capacity at the local scale. To this end, one active and trained local researcher is present in all but two communities, where one researcher is responsible for both locations. In all cases, the local researchers play a critical role in the investigation, and in maintaining a link between scientists supporting the project and the communities (Fig. 2). Local researchers are in charge of data collection and are fully involved, as partners with the scientists, in the development of adaptation strategies based on analysis and interpretation of results. For example, local researchers are responsible for conducting the semi-structured interviews and collecting the quantitative data in the IMA. They are also responsible for the communication of project information to the local population. In some cases, some of the local researchers have also presented study results at scientific meetings and conferences outside of their region on behalf of the project.

The training of local researchers has been a significant stage in the development of the ICBM. Prior to each winter, local researchers participate in a team meeting where winter fieldwork is planned and organized. This seasonal meeting is an opportunity for the local researchers to review methods used during the previous year and to identify training needs related to these activities or those associated with any new methods to be used in the upcoming season. At this time, training workshops or modules are identified by the research team and the local researchers receive training. Training on data entry, organization and analysis is provided on an ongoing basis. The main goal of this ongoing training is to ensure that the local researchers have the ability to become progressively more in charge of the project in their own community. Local researchers have received training in such things as the conduct and transcription of ethno-cartographic interviews (semi-structured) with experienced hunters and elders (Table 2, Fig. 3). Local researcher have also been trained in the standardized collection of ice and snow data for the IMA at critical nodes in local trail networks (Fig. 4) around their community and the conduct of short key-informant interviews with harvesters regarding winter trail conditions (Table 2). Currently, IMA weekly measurements are taken at two different sites and both snow level and ice thickness are recorded during December to May (freeze-up to break-up). The data are entered by the local researcher into a spreadsheet and sent electronically to a central researcher coordinating activities among all communities. This central researcher then posts the weekly data on the project's web site (http://climatechange.krg.ca) for public viewing. Thus, the community has access, via the internet or the local researcher, to weekly updates consisting of both quantitative measurements and qualitative observations by local experts, of ice conditions in key locations around their community.

BENEFITS FOR NORTHERN PEOPLE AND THE SCIENTIFIC COMMUNITY

The Nunavik ICBM program has developed through strong community participation and it strives to benefit local people by supporting their adaptations to changes in the local environment. In particular, the project contributes to increasing the community's capacity to collect, understand, deliver and use local information related to climate and environmental change. The TK, local observations and IMA information gathered in this project are made available to the local populations as soon as possible after their collection and organization. The project uses the internet (http://climatechange.krg.ca) to maintain and provide updated information to interested individuals. This mode of dissemination has become significantly more effective and acceptable in the region since the implementation of region-wide broadband access. One of the objectives of disseminating this information is to try to inform both active and future harvesters. This medium makes it possible to disseminate IMA information and details regarding trail conditions in real time. Throughout the ice season, it is possible to consult the weekly ice data for strategic locations along the winter trail networks and obtain information reported by local ice experts about the general conditions of the trail (e.g. "the ice is formed but you have to be careful because of the presence of open water near …", "the ice is safe to go anywhere along the trail", "the fast ice is still solid, but be careful near …"). Through the internet it is also possible to disseminate material such as updated regional trail/route maps showing trails used for snowmobile, dog team, ATV, kayak, peterhead (boat), speedboat and canoe travel for each community. The maps are available in PDF format, easy to download and print thus making them more 'user friendly' for local residents. Also, it is possible to adjust the documents and communication tools on a periodic basis to better respond to the needs of the population by the provision of this material to the local population and feedback heard through the local researcher on its applicability and use. For example, users can comment on the scale, symbols and time to download maps available on the project website, and then this information is used by the research team to improve these products. The web site also provides access to information on weather conditions, weekly tide charts and marine weather forecasts through links with agencies such as Environment Canada and others.

The Nunavik ICBM has also used standard and accepted methods of data collection to ensure scientific quality in the collection and analysis of its data. For example, interviews with elders and hunters on ice dynamics and climate change, IMA and weather analysis all follow accepted scientific methods. Qualitative thematic content analysis (Creswell, 2003) of the interviews (TK on regional trails and ice dynamics) has used the standard method of Tesch (1990). The IMA respects a strict protocol and the methods used are identical for all participating communities (Tremblay et al., 2007). The IMA protocol includes weekly measurements of snow depth and ice thickness taken in both sea and lake ice environments (Fig 4). Recently secured funding (ArcticNet) and collaboration with networks of scientists (University of Manitoba and Laval University) have allowed the acquisition of automated ice monitoring stations to further improve the quality of the local weather monitoring data. These stations could aid, for example, in the identification of variables other than temperature (e.g. wind, humidity, solar radiation, etc.) that have an impact on local sea ice dynamics but about which we currently have little understanding at the local scale.

CONCLUSION

The Nunavik ICBM project promotes the development of adaptive capacity based on the participation of local populations in all aspects of the research process. This project takes a multidisciplinary approach, integrates several sources of data and brings together TK and SK based on quantitative and qualitative analyses in the natural and social sciences. Knowledge on climate and environmental change, ice dynamics and local land and ice trail use facilitates the identification of current and potential future problems and the development of adaptation tools to support 'safe' access to territory and resources in Nunavik. The inclusion of both TK and SK has been essential in helping understand climatic and environmental changes in a way that respects both the Aboriginal perspective and the scientific view. As a result, the project is producing credible and relevant information to support adaptations to climate change by northern communities.

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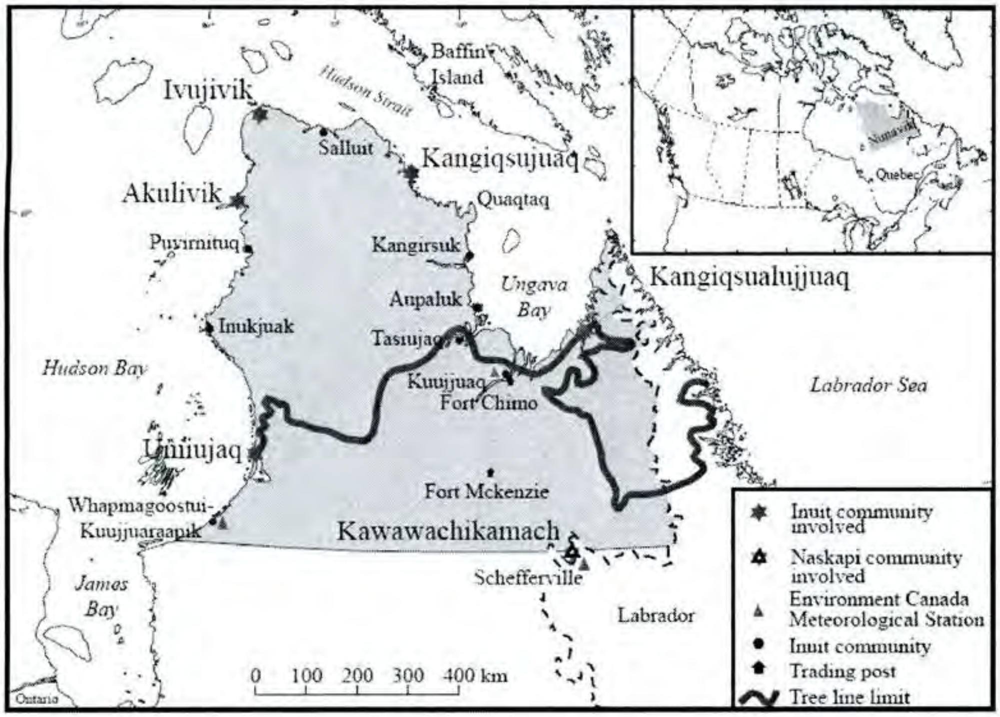
Figures



Baffin Island
Hudson Strait
Ivujivik
Salluit
Kangiqsujuaq
Akulivik
Quaqtaq
Puvirnituq
Kangirsuk
Ungava Bay
Kangiqsualujjuaq
Aupaluk
Inukjuak
Tasiujaq
Hudson Bay
Kuujjuaq
Fort Chimo
Labrador Sea
Umiujaq
Fort Mckenzie
Whapmagoostui-Kuujjuaraapik
Kawawachikamach
James Bay
Schefferville
Labrador
Ontario
0 100 200 300 400 km
Nunavik
Quebec
Inuit community involved
Naskapi community involved
Environment Canada Meteorological Station
Inuit community
Trading post
Tree line limit

Figure 2: Nunavik showing participating communities.

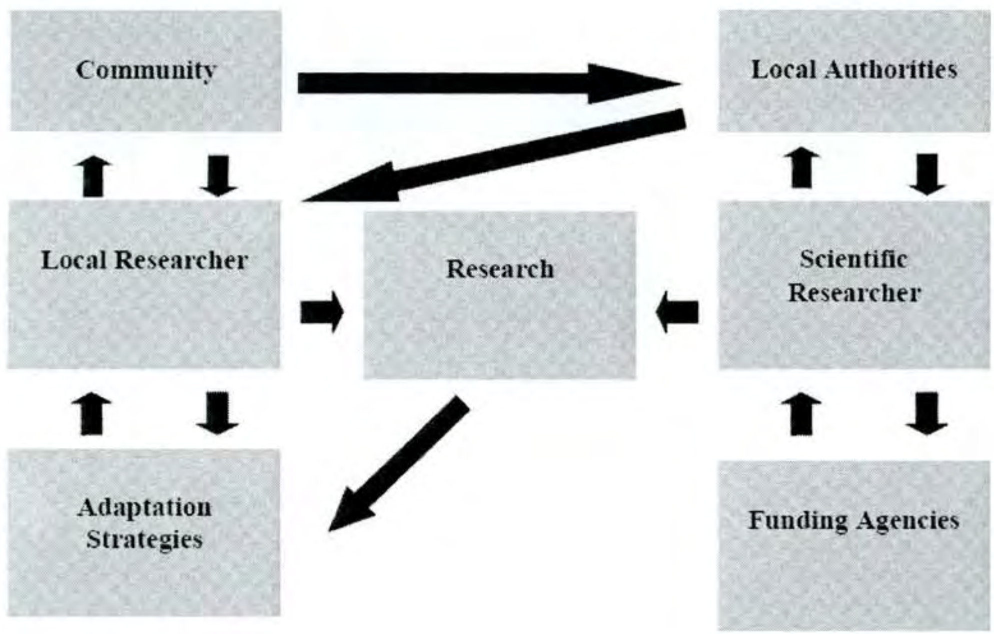

Community
Local Authorities
Local Researcher
Research
Scientific Researcher
Adaptation Strategies
Funding Agencies

Figure 2: Integrated Community-Based Model (ICBM). The community-based network looks to respond to local issues with and for northern residents. Several partners are needed. When issues have been identified, local authorities and scientific researchers request resources from funding agencies in cooperation with community or regional agencies. When funds have been allocated, communities are consulted and project goals and timelines are adapted. Community-based monitoring work is directed by the local researcher in cooperation with scientific researchers playing an advisory role. The adaptation strategies are developed together with the local researcher, community members and the scientific researchers. Finally, adaptation tools are disseminated within the community by the local researcher.

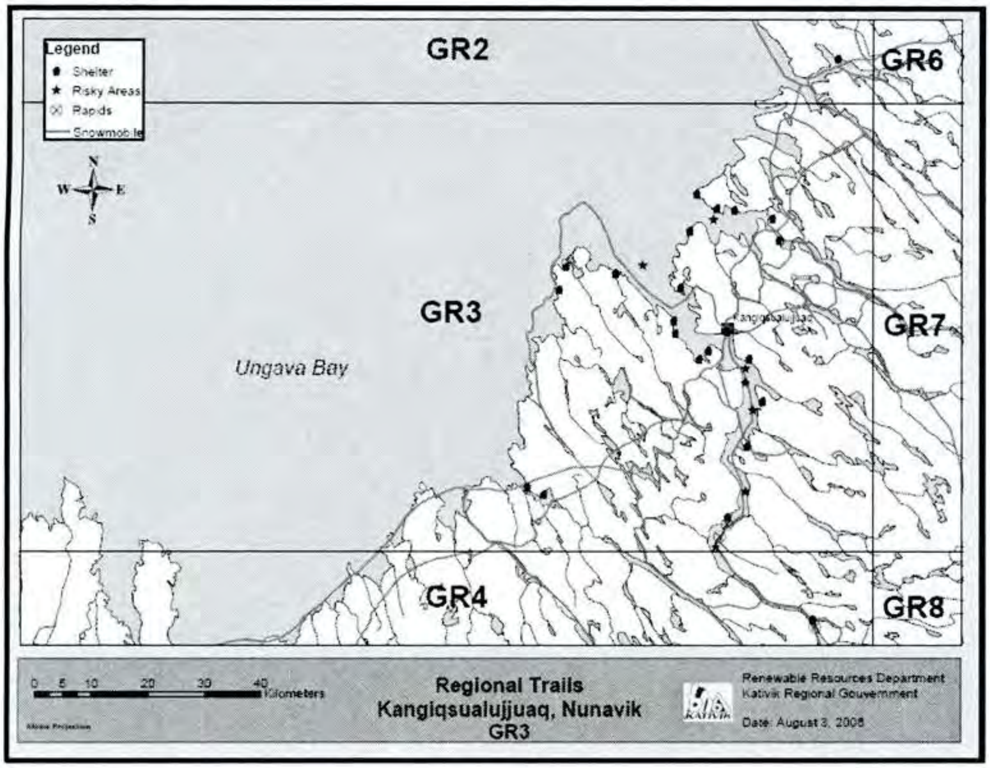

Legend
Shelter
Risky Areas
Rapids
Snowmobile
N
W
E
S
GR2
GR6
GR3
Ungava Bay
GR7
GR4
GR8
0 5 10 20 30 40 Kilometers
Regional Trails
Kangiqsualujjuaq, Nunavik
GR3
Renewable Resources Department
Kativik Regional Gouvernment
Date: August 3, 2006

Figure 3: Snowmobile trails in the Kangiqsualujjuaq Area. Shelters and 'Risky Area' have been identified by local harvesters. Maps of trails and routes are also available for ATV, dog team, kayak, canoe, Peterhead (boat) and speedboat. Maps are available in PDF format. Trail users can download maps from the project web site (http://climatechange.krg.ca) and print them in black and white or colour. Interactive maps allow trail users to have easy map access without needing advanced computer skills.

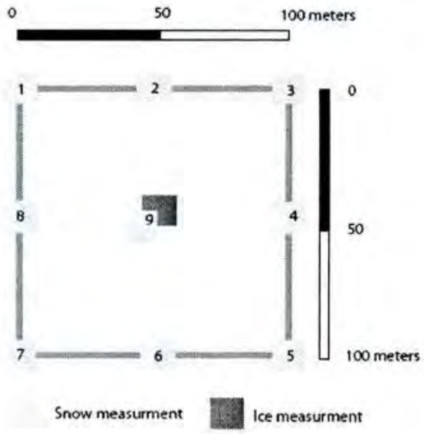

0
50
100 meters
1
2
3
8
9
4
7
6
5
0
50
100 meters
Snow measurment
Ice measurment

Figure 4: Ice monitoring activities (IMA). Local researchers measure ice (one measurement) and snow thickness (nine measurements to get a site specific average) in both sea and lake environments.

TABLE 1. Community contributions to the Integrated Community-Based Monitoring (ICBM) program.

Description	Contribution
Several experts on ice dynamics and traditional trails from six communities (Akulivik, Ivujivik, Kangiqsualujjuaq, Kangiqsujuaq, Kawawachikamach and Umiujaq) in six bio-climatic zones.	Identification of concerns of the population
	Community project support
	Traditional knowledge (TK) on ice dynamics
	Key (environmental and climate) indicators of ice safety
	Tools to evaluate ice safety
	TK on traditional trails
	TK on climate change
	Local information on trail conditions to validate the climate indicators of safe ice

TABLE 2. Contributions of local researchers to the ICBM program.

Abilities Developed among Local Researchers	Responsibilities of Local Researcher
Can carry out interviews independently with elders and experienced hunters and	Interviews with elders and hunters
translate/transcribe interviews into English	Interview translations and transcripts
Responsible for collecting standardized field ice and snow data at weekly intervals	Mapping workshop activities
	Ice monitoring
Can enter data entry in electronic spreadsheet and create basic graphs illustrating changes in ice and snow characteristics over the winter	Fieldwork data computing
	Disseminating study results in communities
Can present project results during scientific conferences	Scientific conference presentations

NOUVEAU | PROJET

EFFETS DES CHANGEMENTS CLIMATIQUES SUR LA BIODIVERSITÉ AU QUÉBEC

DÉMARRAGE ET DURÉE DU PROJET

Octobre 2007 • 3 ans

Information : projet@ouranos.ca
514 282-6464 • www.ouranos.ca

CONTEXTE

Les changements climatiques appréhendés soulèvent un questionnement quant aux impacts qu'ils auront sur l'évolution des processus biologiques et des stratégies comportementales et adaptatives des espèces vivantes. Au Québec, les répercussions de ces changements sur la biodiversité sont très peu connues mais des migrations importantes vers le nord sont anticipées.

OBJECTIFS

- Évaluer l'impact des changements climatiques sur la distribution et l'abondance de la biodiversité des écosystèmes terrestres du Québec et étudier les actions humaines nécessaires pour en faciliter l'adaptation.
- Répondre aux besoins spécifiques des gestionnaires de la biodiversité au Québec et au Canada, partenaires du projet.

RÉSULTATS ATTENDUS

- Développement, au Québec, d'une expertise reconnue sur la biodiversité et la climatologie régionale.
- Mise en valeur des données historiques et des données sur les oiseaux et les plantes.
- Base de données à référence spatiale sur la distribution de grands groupes d'espèces au Québec.
- Identification des changements phénologiques récents en réponse au réchauffement.
- Développement et application de techniques statistiques innovantes intégrant des données quantitatives (présence, absence d'espèces) et qualitatives (avis d'experts) pour modéliser la répartition actuelle et future des espèces en fonction du climat au Québec.
- Production d'atlas sur la réponse des espèces aux changements climatiques comme outils d'aide à la gestion.

DÉMARCHE

- Effectuer une analyse statistique des liens entre les espèces et certaines variables environnementales (climatiques, géomorphologiques), afin de développer des modèles de niches écologiques.
- Introduire les variables issues des projections climatiques dans ces modèles pour en prévoir l'évolution.

PARTENAIRES

- Canards illimités
- Conservation de la nature Canada
- Ouranos
- Ministère des Ressources naturelles et de la Faune (MRNF)
- Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP)
- Parcs Canada
- Service Canadien de la faune
- Université de Grenoble
- Université de Montréal
- Université du Québec à Rimouski
- Université McGill

FINANCEMENT

- CRSNG
- Ouranos
- Parcs Canada
- Canards illimités

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OURANOS

IMPACTS DES CHANGEMENTS CLIMATIQUES SUR LES BASSINS VERSANTS CANADIENS ET STRATÉGIES D'ADAPTATION POUR L'INDUSTRIE HYDROÉLECTRIQUE.

Eastmain

DÉMARRAGE ET DURÉE DU PROJET

Septembre 2007 • 3 ans

Information :
projet@ouranos.ca
514 282-6464
www.ouranos.ca

CONTEXTE

Les compagnies hydroélectriques prennent graduellement conscience que les changements climatiques auront des impacts sur leurs activités. Une meilleure connaissance de la nature des changements climatiques anticipés pour les ressources en eau permettra aux administrateurs de prendre des décisions stratégiques et opérationnelles éclairées.

OBJECTIF

Évaluer les impacts à long terme des changements climatiques sur la variabilité et la quantité des apports en eau des bassins versants d'intérêt pour Hydro-Québec et Manitoba Hydro, deux producteurs hydroélectriques majeurs au Canada.

RÉSULTATS ATTENDUS

- Consolidation et développement de l'expertise d'Hydro-Québec et de Manitoba Hydro pour l'analyse des impacts des changements climatiques sur les ressources en eau à l'échelle des bassins versants.
- Transfert des connaissances et des techniques développées dans le cadre du projet à d'autres compagnies concernées par les changements climatiques : industrie hydroélectrique canadienne, agences de ressources en eau et firmes d'ingénierie.

DÉMARCHE

- Développer des scénarios de changements climatiques à l'échelle du bassin versant;
- Utiliser ces scénarios pour simuler le débit futur des rivières, en utilisant des modèles hydrologiques rephasés avec des résultats de modèles climatiques globaux et régionaux.
- Quantifier l'incertitude associée aux estimations des débits futurs;
- Évaluer l'impact des changements climatiques sur la production hydroélectrique.

PARTENAIRES

- Hydro-Québec
- Manitoba Hydro
- Ouranos
- École de technologie supérieure (ÉTS)
- Université du Manitoba

FINANCEMENT

- Programme de recherche et développement coopératif (RDC) du Conseil de recherches en sciences naturelles et en génie du Canada (CRSNG)
- École de technologie supérieure (ÉTS)
- Ouranos

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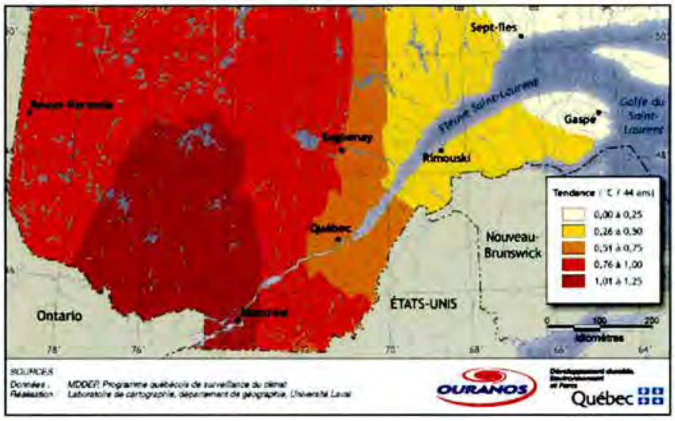
Stéphane Krau
ÉTS

Luc Roy
Hydro-Québec

OURANOS

UN PORTRAIT RÉGIONAL, POUR LE QUÉBEC MÉRIDIONAL, DE L'ÉVOLUTION DES TEMPÉRATURES ENTRE 1960 ET 2005.



DURÉE DU PROJET

2 ½ ans

Information :
projet@ouranos.ca
514 282-6464
www.ouranos.ca

CONTEXTE

Un frein important à l'analyse de l'évolution du climat est l'introduction de biais dans les données historiques mesurées, attribuables à des facteurs humains, tels que des déplacements de stations climatologiques, des changements d'instruments de mesure ou encore des changements de procédures d'observation. Ceux-ci doivent être décelés et corrigés avant de procéder à l'analyse des tendances climatiques observées par le passé pour éventuellement, effectuer des prévisions du climat.

OBJECTIF

Obtenir un portrait régional, pour le Québec méridional, de l'évolution des températures et de plusieurs indicateurs climatiques qui en découlent, pour la période de 1960 à 2005.

RÉSULTATS

Les résultats du processus d'homogénéisation ont fait ressortir les faits suivants :

- 64 % des séries de températures traitées ont été corrigées.
- Un réchauffement au Québec méridional est noté de 1960 à 2005, plus particulièrement dans l'ouest de la province. Au centre, le réchauffement est moins marqué alors que dans l'est, il n'est pas significatif.
- L'hiver et l'été ont connu le réchauffement général le plus marqué. Cependant, l'analyse des températures extrêmes indique une nette augmentation du nombre de nuits aux températures beaucoup plus élevées, en toutes saisons.
- Les indicateurs calculés suggèrent une augmentation de la fréquence des périodes de gel/dégel au cours de l'hiver, mais une diminution de la longueur de la saison de gel.
- On note également une augmentation des degrés-jours de croissance et de climatisation, et une diminution des degrés-jours de chauffage.

PORTÉE

Afin de compléter les analyses des données climatiques historiques, une évaluation des précipitations a été effectuée. Les résultats ont montré une augmentation des précipitations annuelles totales même si plusieurs stations indiquent des tendances à la baisse durant l'été. De plus, le nombre de jours avec neige ainsi que l'accumulation totale de neige ont diminué au cours des 46 années analysées.

Cette étude, qui a le mérite d'améliorer notre connaissance climatologique du Québec méridional, offre une base d'analyse solide pour tout intervenant qui désire des informations climatiques rétrospectives.

PARTENAIRES

- Ouranos
- Ministère du Développement durable, de l'Environnement et des Parcs du Québec (MDDEP)

FINANCEMENT

- Ouranos

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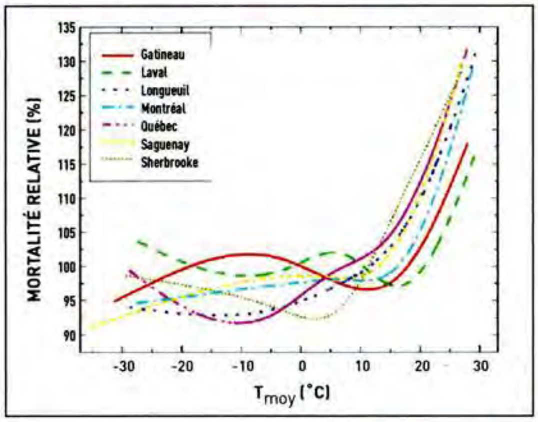
Ouranos

DÉMARCHE

Les données annuelles, mensuelles et journalières des températures maximales et minimales de 52 stations météorologiques, retenues de façon à couvrir l'ensemble des régions du Québec méridional, ont fait l'objet d'une analyse statistique selon une procédure appelée homogénéisation.

EFFETS DU CLIMAT SUR LA MORTALITÉ AU QUÉBEC MÉRIDIONAL DE 1981 À 1999 ET SIMULATIONS POUR DES SCÉNARIOS CLIMATIQUES FUTURS



RELATION MORTALITÉ-TEMPÉRATURE POUR QUELQUES VILLES DU QUÉBEC

DÉMARRAGE ET DURÉE DU PROJET

Janvier 2005 • 1 an

Information :
projet@ouranos.ca
514 282-6464
www.ouranos.ca

CONTEXTE

Des vagues de chaleur d'une ampleur inégalée ont frappé Chicago en 1995 et l'Europe en 2003. Ces événements semblent aussi indiquer une augmentation récente de la fréquence des canicules. En considérant le réchauffement climatique, le Québec pourrait faire face à des phénomènes similaires. Une hausse de mortalité est appréhendée, en particulier pour les populations vulnérables.

OBJECTIFS

- Déterminer le lien entre le climat et la mortalité pour le Québec, avec les données météo et sanitaires actuelles.
- Estimer l'augmentation des mortalités futures dans un contexte de changement climatique.

RÉSULTATS

La température moyenne est la principale variable météo qui explique la relation entre le changement climatique et la mortalité. L'analyse des simulations a fait ressortir les faits suivants, pour la plupart des régions étudiées :

- Une augmentation de la mortalité de 2 à 3 % durant l'été dès l'horizon 2020.
- Une augmentation de la mortalité estivale d'environ 10% vers 2080, en absence de mesures d'adaptation.
- Une diminution des décès l'hiver.
- Un accroissement annuel de 3% de la mortalité vers la fin du 21e siècle, toutes saisons confondues.
- Une vulnérabilité accrue des personnes âgées et des personnes souffrant de maladies respiratoires.
- Les résultats précédents sont probablement sous-estimés en raison du vieillissement anticipé de la population et du fait de la quasi absence historique de canicules.
- D'un autre côté, des adaptations pourront éventuellement diminuer cet impact.

DÉMARCHE

- Étudier les séquences de mortalité entre 1981 et 1999, de même que les séries météorologiques de plusieurs paramètres, afin d'en dégager des modèles statistiques.
- Utiliser un modèle climatique et la méthode de mise à l'échelle SDSM pour générer des séries météo futures, sur les principales agglomérations du Québec.
- Incorporer ces séries dans les modèles statistiques afin d'établir le changement de mortalité autour de 2020, 2050 et 2080, par rapport au climat de la période de référence.
- Analyser les résultats par groupe d'âge, cause de décès et par région.

PARTENAIRES

- Institut national de santé publique du Québec (INSPQ)
- Ministère de la santé et des services sociaux (MSSS)
- Ouranos
- Santé Canada

FINANCEMENT

- Ouranos
- MSSS
- Santé Canada

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INSPQ
Philippe Gachon
et ***Marie-France Sottile***
Ouranos

PORTÉE

- L'étude a permis d'orienter l'approche statistique à adopter dans un projet subséquent reliant la morbidité et le climat.
- Le projet a mis en évidence certaines faiblesses de la mise à l'échelle SDSM.
- Les résultats obtenus encouragent les intervenants en santé publique à mettre en place des mesures pour lutter contre les vagues de chaleur.
- Les modèles statistiques développés pourraient servir à établir des seuils d'alerte à la population.

NOUVEAU | PROJET

OURANOS

UNE MEILLEURE CONNAISSANCE DES MÉCANISMES DE POLLUTION AGRICOLE DANS L'OPTIQUE D'AMÉLIORER LA CAPACITÉ D'ADAPTATION DES ÉCOSYSTÈMES.

DÉMARRAGE ET DURÉE DU PROJET

Mai 2008 • 2 ans

Information :
projet@ouranos.ca
514 282-6464
www.ouranos.ca

CONTEXTE

La baie Missisquoi du Lac Champlain est l'un des plans d'eau les plus en danger dans le sud du Québec et le nord du Vermont. Depuis 1998, le niveau de contamination des eaux de la baie a considérablement augmenté à cause de la prolifération des cyanobactéries résultant de l'augmentation des apports en phosphore. Conséquemment, la région a dû fermer des plages et l'activité touristique et économique de la baie Missisquoi a périclité.

OBJECTIF

Développer, dans un contexte de changements climatiques, un modèle associant transport du phosphore et croissance des cyanobactéries en utilisant les données du bassin de la rivière aux Brochets. Cette rivière, qui se jette dans la baie Missisquoi, est un important contributeur canadien en sédiments et en pollution par le phosphore.

RÉSULTATS ATTENDUS

- L'équipe du projet travaillera en étroite collaboration avec les agences gouvernementales, les comités de conseils des bassins versants et les agriculteurs afin de développer des stratégies d'adaptation aux changements climatiques, dans l'optique d'améliorer la qualité des plans d'eau et la capacité de récupération des écosystèmes.
- Les résultats de ce projet seront complémentaires et comparés à ceux obtenus de l'autre côté de la frontière, aux États-Unis.

DÉMARCHE

Les données colligées dans la rivière aux Brochets seront utilisées dans un modèle de transport du phosphore et de processus cyanobactériens afin d'évaluer les différents modes de gestion de la baie Missisquoi et ainsi sélectionner les meilleures pratiques, dans une optique de développement durable.

PARTENAIRES

- Ouranos
- Institut de Recherche et de Développement en Agroenvironnement (IRDA)
- Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP)
- Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ)
- Université McGill

FINANCEMENT

- Programme stratégique du Conseil de recherches en sciences naturelles et en génie du Canada (CRSNG)
- Ouranos

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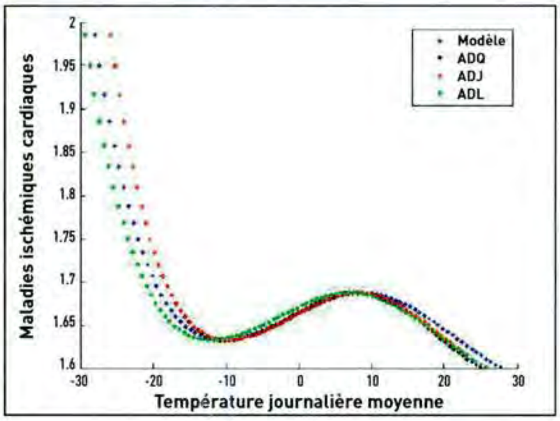
Diane Chaumont et ***Marie-France Sottile***
Ouranos

OURANOS

ÉTUDE DE LA RELATION MORBIDITÉ-CLIMAT ET SIMULATION POUR DES SCÉNARIOS CLIMATIQUES FUTURS



NOMBRE D'HOSPITALISATIONS POUR MALADIES CARDIAQUES EN MONTÉRÉGIE EN FONCTION DE LA TEMPÉRATURE : SIMULATIONS ET OBSERVATIONS SUR LA PÉRIODE 1989-2002.

DÉMARRAGE ET DURÉE DU PROJET

Janvier 2007 • 2 ans

Information :
projet@ouranos.ca
514 282-6464
www.ouranos.ca

CONTEXTE

Avec les variations climatiques prévues, une augmentation des événements météorologiques extrêmes est anticipée. Très peu d'études au Québec ont traité de l'impact de la variabilité météorologique sur la morbidité (urgences et hospitalisations).

OBJECTIF

Explorer la relation entre les variables météorologiques et la morbidité pour certaines maladies dans la province du Québec sur les 20 dernières années et sur les 50 prochaines, sous certaines hypothèses d'évolution démographique, sanitaire et climatologique.

DÉMARCHE

Trouver le meilleur modèle statistique reliant l'effet du climat à la morbidité pour 15 régions socio-sanitaires du Québec, avec les données de 1983 à 2006. Les résultats seront analysés par catégorie d'âge, maladie, région et jour de la semaine. Les variables météo (5) seront utilisées en fonction de leur poids explicatif. Une fois le modèle établi, les morbidités seront évaluées jusqu'en 2070 à l'aide de plusieurs séries du MRCC.

RÉSULTATS À CE JOUR

- La méthode Bayesienne P-spline avec les modèles additifs généralisés (GAM) a été adoptée comme approche statistique pour relier le climat à la morbidité.
- Parmi l'ensemble des consultations médicales, les maladies cardiaques, cérébro-vasculaires, la pneumonie et l'influenza ont été étudiées de plus près.
- Les variables météo les plus influentes sont la température et l'humidité relative du jour et des jours précédents (jusqu'à 3 semaines).
- Les consultations médicales diminuent depuis 1994, dans la majorité des régions socio-sanitaires, lorsque les températures sont inférieures à 20°C.
- Une fois introduites dans le modèle de morbidité, les journées météo simulées sur la période de référence montrent un biais faible, par rapport aux données observées.

PARTENAIRES / FINANCEMENT

- Institut national de la recherche scientifique (INRS-ETE)
- Institut national de santé publique du Québec (INSPQ)
- Ouranos

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Ouranos
Audrey Smargiassi,
Bernard Doyon
INSPQ

PORTÉE

Cette étude permettra de répondre aux questions suivantes :

- Comment tenir compte du vieillissement de la population, de l'augmentation de l'obésité, du diabète, des maladies à transmission vectorielle (ex : parasites) ?
- Comment considérer l'incertitude, les biais et la variabilité des simulations climatiques ?
- Quelles sont les variables météo ayant des effets directs sur certains types de morbidité ?
- Quelles mesures d'adaptation permettraient de contrer les impacts anticipés sur la morbidité au Québec ?
- La pollution a-t-elle un effet sur la morbidité dans la région de Montréal ?
- L'évolution des traitements médicaux a-t-elle un effet sur la morbidité ?

NOUVEAU | PROJET

OURANOS

ÉVALUATION DES IMPACTS DES CHANGEMENTS ENVIRONNEMENTAUX SUR LES TRIBUTAIRES DU ST-LAURENT : ÉTUDE INTÉGRÉE ET DÉVELOPPEMENT D'OUTILS DE MODÉLISATION.

DÉMARRAGE ET DURÉE DU PROJET

Novembre 2007 • 3 ans

Information :
projet@ouranos.ca
514 282-6464
www.ouranos.ca

CONTEXTE

Une première étude a démontré que les changements hydrologiques et la baisse conséquente du niveau du fleuve, anticipés dans le contexte des changements climatiques, auront des effets importants et variables sur le profil longitudinal des tributaires du St-Laurent et sur les apports sédimentaires au fleuve. Cette étude a été effectuée sur 5 tributaires du St-Laurent, soit les rivières Richelieu, St-François, St-Maurice, Batiscan et Yamachiche.

OBJECTIFS

Cette seconde phase vise à élargir l'approche de modélisation hydro-sédimentaire 1D utilisée dans la première étude afin d'inclure une vue plus globale des impacts potentiels des changements environnementaux sur la dynamique des tributaires. Le projet sera développé autour de trois grands thèmes :

1) la simulation des ajustements morphologiques des tributaires et la prévision des volumes de sédiments qui seront apportés au fleuve
2) une meilleure compréhension des effets des changements de températures et de débits sur la formation du couvert de glace et les processus de débâcle
3) une évaluation des impacts hydrologiques, morphologiques et sédimentologiques sur les habitats riverains.

RÉSULTATS ATTENDUS

Le projet fournira de nouvelles données et contribuera au développement et à l'amélioration des outils de modélisation existants afin de les rendre compatibles avec le modèle hydrodynamique présentement utilisé pour le fleuve St-Laurent. Le projet est arrimé aux besoins des partenaires en termes de compréhension des processus de transport des sédiments, d'érosion des berges, de formation du couvert de glace et d'impacts sur la végétation riveraine.

DÉMARCHE

Cette recherche combinera une approche de modélisation et des relevés sur le terrain sur deux tributaires du St-Laurent, les rivières Batiscan et St-François. À l'aide des données de terrain, un ensemble d'améliorations sera apporté aux modèles 1D et 2D afin de raffiner les processus de modélisation d'ajustement des cours d'eau. Les nouveaux modèles seront testés pour les deux tributaires d'intérêt et les résultats permettront d'évaluer l'impact des changements climatiques sur les régimes hydrique et sédimentaire de ces rivières de même que sur les habitats fauniques qu'elles offrent.

PARTENAIRES

- Hydro-Québec
- Ouranos
- Environnement Canada
- Institut national de recherche scientifique (INRS)
- Clarkson University
- Université Concordia
- Université de Montréal
- University of Durham
- University of Southampton

FINANCEMENT

- Programme de recherche et développement coopératif (RDC) du Conseil de recherches en sciences naturelles et en génie du Canada (CRSNG)
- Ouranos

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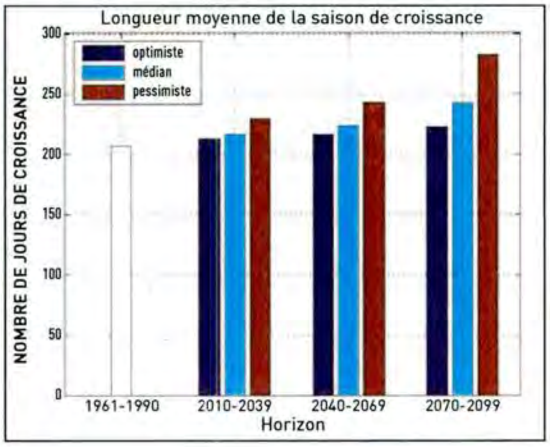
HAUSSE DES CONCENTRATIONS DE POLLENS CAUSÉE PAR LE CHANGEMENT CLIMATIQUE ET SES CONSÉQUENCES SUR LES MALADIES RESPIRATOIRES DES POPULATIONS EN MILIEU URBAIN



Longueur de la saison de croissance des végétaux par rapport à la période de référence, pour 3 horizons futurs, dans la région de Montréal. Les prospectives optimistes, médianes et pessimistes réfèrent à la fourchette de résultats issus de 5 modèles climatiques et 2 scénarios d'émissions de gaz à effet de serre.

CONTEXTE

Les analyses effectuées à partir de sédiments holocènes ont permis d'identifier une hausse de productivité pollinique associée à des conditions climatiques plus chaudes au cours des derniers millénaires. Le 21e siècle aurait les conditions favorables à une hausse des concentrations de pollens, et par conséquent, aux problèmes de santé associés. Déjà, les allergies et maladies respiratoires causées par le pollen sont en hausse dans les pays industrialisés. Les coûts annuels associés au problème dépassent 50 millions de dollars au Québec seulement.

OBJECTIFS

- Reconstituer, entre 1994 et 2002, les variations polliniques en relation avec la température et les impacts sanitaires des populations à risque, à Montréal et à Québec.
- Projeter cette dynamique dans un contexte de réchauffement climatique.

DÉMARCHE

- Caractériser le contexte biophysique et socio-économique de Montréal et Québec.
- Intégrer ces données dans un système d'information géographique afin d'identifier les populations vulnérables.
- Établir les corrélations entre les séries chronologiques d'herbe à poux, de températures et de consultations médicales pour rhinite allergique.
- Estimer l'exposition future en considérant les changements climatiques anticipés à l'aide de plusieurs modèles de simulation.

RÉSULTATS

- Au cours de la période 1994-2002, un allongement de 33% de la saison de croissance des végétaux, un accroissement des concentrations polliniques et une augmentation de la fréquence des consultations médicales sont notés.
- Un lien entre les concentrations polliniques et la température maximale à Montréal et à Québec a pu être établi.
- La saison de croissance des végétaux serait rallongée d'environ 1 mois d'ici la fin du siècle, avec le scénario médian.
- La prolifération des pollens serait aussi favorisée par l'augmentation de la concentration de CO2 et l'étalement urbain.
- Au cours des prochaines décennies, une hausse des rhinites allergiques est anticipée, en particulier chez les jeunes de moins de 24 ans et les populations socio-économiquement défavorisées.

DÉMARRAGE ET DURÉE DU PROJET

Janvier 2005 • 1 an

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PORTÉE

- Cette étude a permis le développement de nouveaux projets de recherche : dynamique de dispersion de l'herbe à poux, effets des spores sur la santé, incidence de l'asthme relié aux pollens et aux spores, etc.
- L'étude met en évidence la nécessité de diffuser les concentrations de pollens dans les médias et d'établir des seuils d'alerte.
- Des campagnes de sensibilisation identifiant les sources de pollens et incitant à l'automédication permettraient de diminuer l'exposition et le taux d'absentéisme au travail.
- L'étude contribue à appuyer les groupes de citoyens qui demandent des lois ou règlements régissant l'arrachage de l'herbe à poux, principal agent allergène.

LE PERGÉLISOL ET LES CHANGEMENTS CLIMATIQUES DANS LES RÉGIONS CÔTIÈRES DU CANADA NORDIQUE

IMPACTS ET ADAPTATION POUR LES COMMUNAUTÉS

CONTEXTE

Dans les régions nordiques, le pergélisol, cette partie du sol qui est gelée en permanence, assure un rôle essentiel tant au niveau des écosystèmes que du mode de vie des communautés locales et des infrastructures qui y ont été érigées. Il est donc primordial d'évaluer l'évolution du pergélisol dans un contexte de changements climatiques futurs.

OBJECTIFS

- Évaluer comment le pergélisol réagira aux changements climatiques au cours des prochaines décennies.
- Analyser les facteurs qui jouent un rôle sur l'ampleur des impacts du réchauffement du pergélisol, comme le type de sol, le couvert végétal, le couvert de neige, la topographie et surtout, le contenu en glace dans le sol.

RÉSULTATS ATTENDUS

- Produire des cartes illustrant les températures futures du pergélisol et les modifications de l'environnement qui en résulteront.
- Supporter les décideurs dans la gestion du territoire en leur fournissant les outils nécessaires pour évaluer les impacts liés à un environnement changeant.

DÉMARCHE

- Déterminer les températures de surface du sol en fonction du climat actuel et futur à l'aide de modèles climatiques régionaux.
- Surveiller et analyser les modifications à l'environnement attribuables à des changements de température du pergélisol. Plusieurs types d'environnements seront étudiés afin de distinguer les changements qui arrivent naturellement de ceux qui sont induits par des facteurs humains.
- Compiler et utiliser les données de mesures thermiques produites par un réseau de sites de mesures sur le terrain pour valider les modèles climatiques régionaux.
- Produire des plans d'aménagement du territoire dans les communautés inuites pour optimiser les conditions d'adaptation.
- Établir par des relevés et des travaux de cartographie les liens entre les changements du couvert végétal et la dégradation du pergélisol dans les milieux naturels.

DÉMARRAGE ET DURÉE DU PROJET

Avril 2008 • 3 ans

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OURANOS

ANALYSE DES DONNÉES CLIMATIQUES POUR UN MEILLEUR SUIVI DU CLIMAT DANS LE NORD DU QUÉBEC.

DURÉE DU PROJET

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CONTEXTE

L'analyse de l'évolution temporelle du climat est effectuée à partir de données historiques et actuelles acquises sur le terrain. Le nord du Québec, bien qu'étant une des régions qui sera particulièrement affectée par les changements climatiques, dispose de données d'observation fragmentaires et incompatibles, tant d'un point de vue temporel que spatial. Ceci s'explique par le peu de stations couvrant le territoire et appartenant à différentes institutions.

OBJECTIF

Définir un réseau d'observation optimal du climat pour la région nord du Québec à partir des données provenant de fournisseurs différents et développer une méthode pour estimer les valeurs manquantes.

RÉALISATIONS

Un portrait du climat pour la période 1986 à 2005 a pu être établi, en partie grâce à une méthode d'estimation des valeurs manquantes développée par Ouranos. Cette dernière a permis de récupérer certaines données, la faible densité du réseau et la discontinuité temporelle des données ayant limité leur nombre récupérable.

Des patrons de température ont été identifiés par interpolation et confirmés par la climatologie connue de la région.

Sur cette base, il appert que 4 à 8 stations additionnelles suffiraient pour compléter le réseau et interpoler plus fidèlement les données de l'ensemble de la région.

La robustesse de ce « réseau optimal » et sa capacité à bien mesurer une climatologie future ont été testées en utilisant des résultats du MRCC pour les périodes 2010-2039, 2040-2069 et 2070-2100. Ainsi, pour chacune des trois périodes retenues, la représentativité spatiale des stations du réseau proposé est adéquate pour faire le suivi du climat nordique.

PERSPECTIVES

Les bases du réseau optimal établi sur l'analyse des données de température devront être fixées en les appuyant sur les données de différents paramètres climatiques. La méthodologie proposée constitue un premier pas vers une analyse plus étendue. D'autres configurations du réseau pourraient aussi être évaluées en variant le nombre et l'emplacement des stations.

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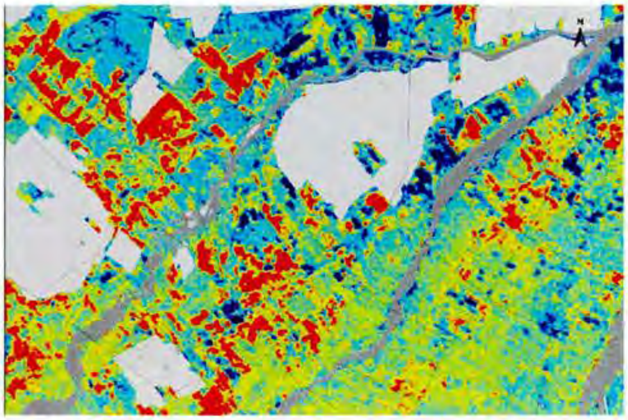
DÉMARCHE

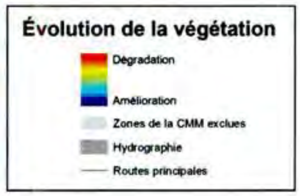
Les données de température provenant de diverses sources ont été utilisées et analysées afin de vérifier la représentativité des stations climatiques présentes sur le terrain. Cette analyse a ensuite servi à définir un réseau d'observation optimal du climat de la région. La représentativité de ce futur réseau a été testée en utilisant des sorties du Modèle régional canadien du climat (MRCC).

OURANOS

IDENTIFICATION DES SECTEURS VULNÉRABLES À LA CHALEUR INTENSE À MONTRÉAL, EN VUE D'INTERVENTIONS ET D'ÉTUDES CIBLÉES EN SANTÉ PUBLIQUE



ÉVOLUTION DES TEMPÉRATURES SUR LE TERRITOIRE DE LA COMMUNAUTÉ MÉTROPOLITAINE DE MONTRÉAL (CMM) ENTRE 1985 ET 2005



CONTEXTE

Le développement urbain des dernières années a contribué à exposer davantage la population aux températures extrêmes. Les changements climatiques exacerberont ce problème. Les températures à l'intérieur des logements sont parfois encore plus élevées qu'à l'extérieur. Certains secteurs défavorisés semblent plus vulnérables.

OBJECTIF

Identifier, à très haute résolution, l'évolution des îlots de chaleur et les populations à risque.

DÉMARCHE

- Mesurer et comparer les températures dans les bâtiments, aux stations météo et sur les photos thermiques satellites.
- Évaluer les vulnérabilités médicales, sociales et économiques dans les différents secteurs.
- Sonder les comportements contribuant à atténuer ou accroître l'effet de la chaleur.
- Estimer l'évolution des îlots de chaleur dans le futur à l'aide de simulations climatiques.
- Calculer et cartographier les îlots de chaleur sur le territoire au cours des 20 dernières années et pour le 21e siècle.
- Calculer l'évolution de quelques indicateurs météo reliés à la santé.

RÉSULTATS

- Les cartes thermiques montrent un accroissement des îlots de chaleur en intensité, en nombre et en superficie, entre 1984 et 2005. Les politiques d'aménagement sont en cause.
- Le problème s'aggravera vers la fin du 21e siècle, si l'occupation actuelle du sol est maintenue.
- Les extrêmes chauds et les canicules augmenteront en fréquence, en durée et en intensité à Montréal.
- Les principales vulnérabilités sont : la pauvreté, la maladie, le vieillissement et la perte d'autonomie.
- Les climatiseurs ne sont pas utilisés par les populations à risque.

PORTÉE

- Un outil a été développé pour cartographier l'ensemble des températures intérieures sur l'Île de Montréal et estimer l'exposition des habitants dans différentes conditions météo.
- L'étude encourage l'adoption d'un urbanisme qui limite la minéralisation et augmente la végétalisation.
- L'approche cartographique développée (SIG) est appliquée à d'autres villes canadiennes (Vancouver et Toronto).

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Les aires protégées au Québec

Les aires de mise bas du caribou au nord du 52e parallèle

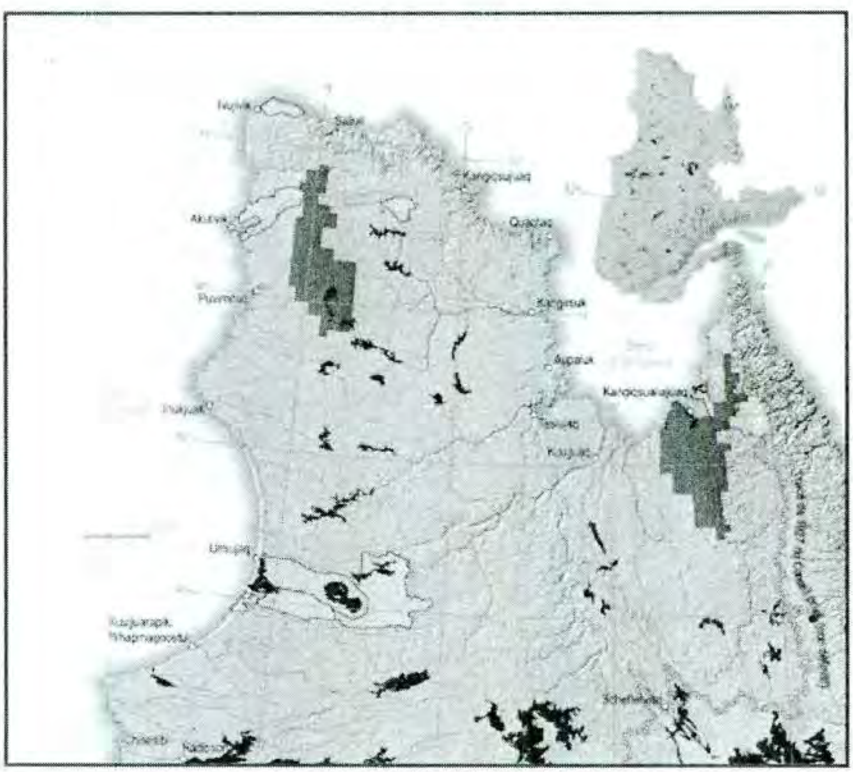
Des aires de mise bas du caribou protégées

Une « aire de mise bas du caribou au nord du 52e parallèle », c'est « un territoire caractérisé par le fait qu'il est fréquenté par au moins cinq caribous femelles par kilomètre carré au cours de la période du 15 mai au 1er juillet ». Ces territoires sont protégés par le Règlement sur les habitats fauniques et le chapitre IV.1 de la Loi sur la conservation et la mise en valeur de la faune.

Dans l'esprit de ces mesures, l'aire de mise bas est un lieu habité par une population de caribou à l'état naturel. Cependant, le champ d'application de ces mesures a été limité à un habitat jouant, de façon temporaire, un rôle déterminant dans le maintien ou le développement d'une population de caribou. De façon encore plus précise, l'habitat protégé est limité aux sites d'emplacement de caribou femelle pendant la période de mise bas.

Les plans de ce type d'habitat faunique ont été dressés en 1993, modifiés en 1998 et ils seront de nouveau modifiés au printemps 2007. En fait, l'aire réelle de mise bas de cette espèce change pratiquement chaque année. Les données d'inventaire de 1999 à 2003 montrent que sur le territoire de la Rivière aux Feuilles, l'aire de mise bas du caribou, s'est déplacée de 100 % par rapport à l'aire actuellement désignée légalement. Pour ce qui est de l'habitat associé à la rivière Georges, l'aire de mise bas s'est déplacée de 76 % à l'extérieur de la délimitation légale actuelle.

De façon générale, les habitats fauniques au Québec sont reconnus comme des aires protégées. Les deux aires de mise bas font cependant exception, puisque les limites de ces habitats fauniques sont modifiées environ à chaque



Aires protégées

Aires de mise bas du caribou au nord du 52e parallèle

Québec

période de cinq ans, en fonction de l'emplacement des sites de mise bas des années antérieures. Ainsi, il n'est pas possible de statuer sur un espace « géographiquement délimité » commun au fil des années et bénéficiant d'un engagement permanent de protection.

La protection de la diversité biologique et des ressources naturelles associées au territoire couvert par les habitats de 1993 a été abandonnée au bénéfice du nouveau territoire désigné en 1998 et il en sera de même pour le nouvel emplacement de 2007.

Dans ces circonstances, la contribution à la protection et au maintien de la biodiversité par et dans ce type d'habitat est partielle et non durable au regard des principes de base des définitions reconnues d'aire protégée.

Un territoire est admissible au statut d'aire protégée, notamment en fonction de l'engagement à protéger ce milieu. Ce critère d'engagement à long terme ou de permanence de l'engagement envers la protection de la biodiversité des territoires est en accord avec les normes internationales définies par l'UICN concernant les catégories de gestion des aires protégées.

De plus, de l'exploration minière a cours sur ces territoires. Cela ne respecte pas les restrictions adoptées par l'UICN. En effet, en octobre 2002, à Amman en Jordanie, le Congrès mondial de la conservation a adopté la Recommandation 2.82, qui a trait à la « protection et conservation de la diversité biologique dans les aires protégées contre les effets dommageables des activités de prospection et d'exploitation minière ». Cette recommandation « invite tous les gouvernements et toutes les corporations à promouvoir et à mettre en œuvre les meilleures pratiques dans tous les aspects de l'exploitation minière, depuis la prospection jusqu'au démantèlement de la mine et à la nouvelle affectation des terres ». Elle demande à tous les États membres de l'UICN d'interdire l'exploration et l'exploitation minière dans les aires protégées de Catégories I à IV de l'UICN et recommande notamment « que toute autorisation de prospection et d'exploitation localisées soit soumise à une étude d'impact sur l'environnement [...] » et « que les projets de prospection et d'exploitation minière autorisés soient soumis à des conditions strictes de planification, de fonctionnement, de surveillance et de restauration après usage ».

Soulignons que près de 660 km² de l'aire de mise bas du caribou de la rivière Georges seront protégés contre toute activité industrielle en raison du fait que l'habitat se trouve en partie dans la Réserve de parc national de la Kuururjuaq.

Ces constats ne réduisent toutefois aucunement la reconnaissance de ces territoires à titre d'habitats fauniques, ni la protection dont ils bénéficient par la Loi sur la conservation et la mise en valeur de la faune.

James Bay Advisory Committee on the Environment
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PORTRAIT AND KNOWN ENVIRONMENTAL IMPACTS OF CLIMATE CHANGE ON THE JAMES BAY TERRITORY

June 2007

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COVER PAGE GRAPHICS: **CAROLINE C. DE LÉRY**

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1. Introduction

Concern about global warming has become widespread since 1992, the year the Kyoto Protocol (Japan) was signed. The relationship between the planet's average temperature and carbon dioxide was first stated in 1894 by Svante Arrhenius (Nobel Prize in Chemistry in 1903). The hypothesis regarding the impact of human activity on the climate was advanced during the world's first climate conference in 1979. The scientific consensus on the issue is recent, however. Controversy over the reality and causes of global warming comes more from the media than the scientific community. Most opponents of the hypothesis that human activity affects the climate are connected to the major oil companies.

The role of the James Bay Advisory Committee on the Environment (JBACE) includes counselling governments (federal, provincial, regional and local) on the environmental and social protection regime (Section 22 of the James Bay and Northern Quebec Agreement). In this respect, the JBACE comments on proposed laws, regulations and policies affecting the regime. In addition, the Committee oversees application of the environmental and social impact assessment and review procedure; under this procedure, development projects are the subject of an evaluation and, occasionally, of an impact assessment, to "minimize the negative impact of development (…) upon the Native people and the wildlife resources…" (JBNQA; para. 22.2.2a).

To the extent that climate change has an impact on the Cree environment and social milieu, the JBACE would like to gain a better understanding of this phenomenon and, if need be, recommend a course of action to governments. This summary document, which describes the current understanding of climate change in general and of the James Bay Territory in particular, should help the JBACE fulfill its role.

This document comprises three sections. The first aims to describe the key scientific elements relating to global warming. These elements concern the global climate as well as the climate in Canada and in Quebec. This first section on the climate ends with some data pertaining to the James Bay Territory. The second section of the document deals with the consequences of global warming on water, forest and wildlife resources. An understanding of the impacts on these various resources involves a context that goes beyond the James Bay Territory. Finally, the last section of the document presents various avenues that can be explored to further define the impact of global warming on the populations in the James Bay Territory.

2. The science of climate change

The benchmark for an understanding of climate change is undoubtedly the Intergovernmental Panel on Climate Change (IPCC). This organization was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). The IPCC's mission is to "assess the scientific, technical and socio-economic information" in order to gain a better understanding of the risks related to human-induced climate change. The IPCC does not conduct research but its publications are based on scientific and technical publications whose scientific value is widely recognized (IPCC 2007). The IPCC is comprised of hundreds of experts from universities, research centers, companies and environmental protection associations. Each IPCC member is accredited by his or her own government.

At regular intervals (every five to six years), the IPCC does an assessment of the state of knowledge relative to climate warming. The most recent reports were published in 2007. These reports contribute, among other things, to the "implementation of the UN Framework Convention on Climate Change (UNFCCC)".

In Quebec, the Ouranos Consortium, an organization that is international in scope, was established in 2002 to pool and develop expertise on global warming. This organization aims to "advance the understanding of the issues and the associated requirements for adaptation resulting from climate change on the scale of the North American continent". The Government of Quebec, the Meteorological Service of Canada, Hydro-Québec, research groups and centres as well as universities work in partnership with the Ouranos Consortium. The ArcticNet Group is also spearheading research into the Arctic climate.

Although temperature and precipitation are now being recorded precisely in many locations, that was not always the case. Data series from thermometers and pluviometers are relatively recent (the oldest series go back 300 years). Climate studies often require knowledge of the climate hundreds or even thousands of years ago. The data used are based on temperature estimates established from tree growth rings, air bubbles trapped in ice cores or marine fossil sediments.

2.1 Temperature

The Earth's surface temperature has increased by an average of 0.6°C from the end of the 19th century to the present day (Folland et al. 2001) (Figure 2-1a). Global warming has been the most rapid over the past 1,000 years (Figure 2-1b). The warming of the climate has not been constant over time. Since 1861 (the earliest date from which reliable trends can be established), two periods have been marked by global warming. These two periods are from 1910 to 1945 and from 1976 to the present. The 1990s is the warmest decade on record since 1861. The greatest surface temperature increase was observed north of the 60th parallel with a rise of 1.3°C since 1880. The degree of warming also varies according to the season. Winter warming exceeds summer warming (2.2°C and 0.6°C, respectively).

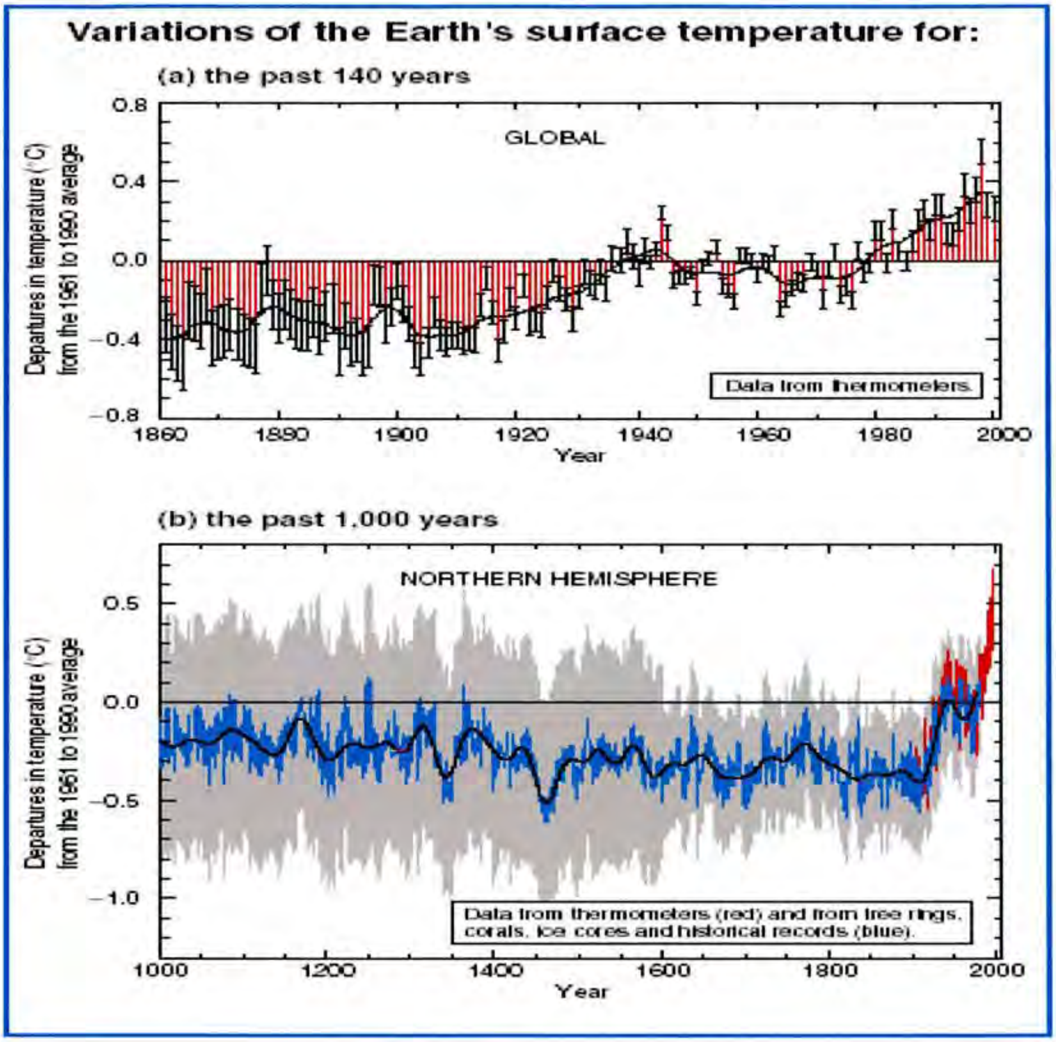


Figure 2-1: Variations in the Earth's surface temperature over the past 140 years and the past 1,000 years (from IPCC 2001): **a)** annual temperature data (grey bars), uncertainty of annual data (uncertainty bars in black), moving average with a window of 10 years (blue line); **b)** annual temperature variations (dark grey and black), data uncertainty (light grey), averages over 50 years (in blue).

For Canada, the average annual temperature increase has been 0.9°C in the past century (Bonsal et al. 2001), with most of this warming occurring during the winter and spring. In Southern Quebec, the studies conducted in connection with the Ouranos Consortium established climate trends relying on 60 weather stations. Between 1960 and 2003, the increases in temperature have been the greatest in winter and more variable during the summer. The warming is greater for minimum temperatures than for maximum temperatures. In Southern Quebec, winters are not as cold with an increase in frost/thaw episodes. The warm season is of the same duration but is becoming hotter. Finally, the results of the interpolation of these data lead one to believe that warming trends are even more pronounced in the north (Yagouti et al. 2006).

2.2 Precipitation

The main global trends point to an increase in nebulosity, rainfall intensity and total concentration of water vapour (IPCC 2001). A 5% to 10% increase in precipitation has been observed since 1900 in the middle and high latitudes of the Northern Hemisphere. A decrease in the snow cover and shortening of the frost period correspond to a warming of the Earth's surface in the Northern Hemisphere.

In Canada, an increase in total annual precipitation is observed for the period from 1960 to 2000 (Zhang et al. 2000). In Eastern Canada, precipitation has increased during the spring and in the north. Abundant snowfalls are more prevalent in the fall and winter. The increase in precipitation is estimated at 1.7% of the average per decade for Canada as a whole between 1948 and 1995. North of the 55^{th} parallel, the increase in precipitation is noticeably greater with an increase of 2.3% over the average per decade (Mekis and Hogg 1999).

In Quebec, rainfall was abundant during the period 1869-1912, but less abundant than that observed in the more recent periods (Gosselin and Perrier 2001). It is not possible to conclude, however, that there has been an increase in extreme events, because the distribution of pluviometers has changed too much since that time.

2.3 Expected climate change

The scenarios derived from climate projections forecast an increase in sea levels of 21 cm to 70 cm by 2100 according to the models (IPCC 2001). The climate change expected for North America and Quebec can be seen on the website of the Canadian Climate Impacts Scenarios Project (CCIS 2006). The many scenarios available give the anomalies in temperature and precipitation between the 2050 horizon and the reference period from 1961 to 1990 (Figure 2-2 and Figure 2-3). With the ECHAM4 gg1 model, the climate change in Quebec consists of a 4°C increase compared with the period from 1961 to 1990 (Figure 2-2). The forecast changes in precipitation are less pronounced. In the southern part of the province, a slight increase in precipitation is forecast (1 mm to 3 mm), and a larger increase, of up to 15 mm a day, is expected in the northern part of the province by 2050. The increase in precipitation is expected to be greater between 2050 and 2080 (Figure 2-3).

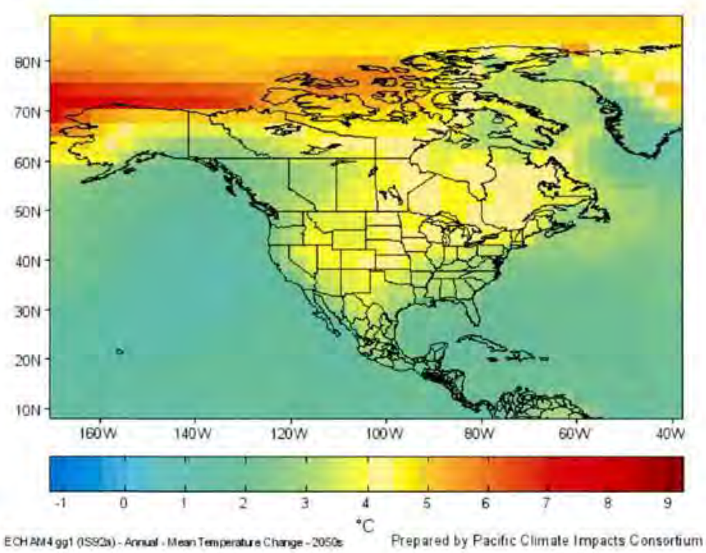


Figure 2-2: Temperature anomalies for 2050 in comparison with the period from 1961 to 1990 according to a ECHAM4 gg1 scenario (CCIS 2006)

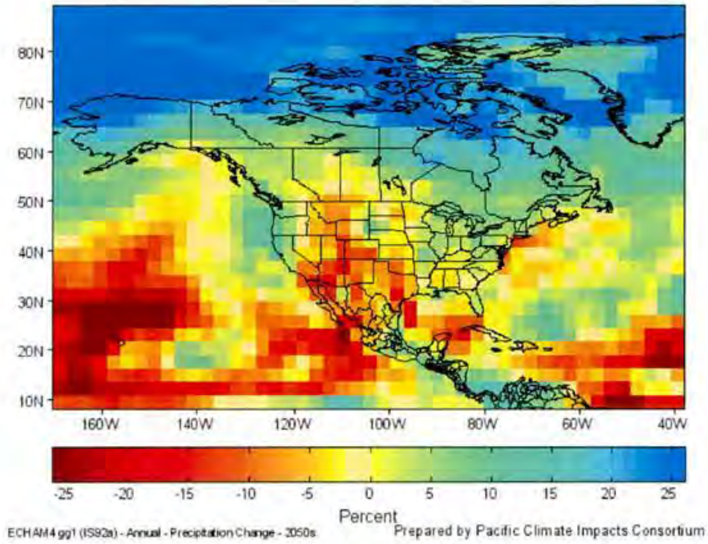


Figure 2-3: Precipitation anomalies for 2050 in comparison with the period from 1961 to 1990 according to a ECHAM4 gg1 scenario (CCIS 2006)

Global warming:

- The global climate has warmed by about 0.6°C since the end of the 19th century.
- The 1990s was the warmest decade of the past century.
- The models predict warming of 1.8°C to 4°C for the central values by the end of the 21st century. The extreme values range from 1.1°C to 6.4°C.

- Mountain glaciers are shrinking as are those of Greenland and the Antarctic, and sea levels are rising faster than before, by more than 3 mm a year.

In Canada and Quebec:

- The climate has warmed by about 1°C over the past century.
- Warming will continue to be more pronounced in the northern regions.
- The models predict a warmer and wetter climate for Northern Quebec.

(Ouranos 2007)

Table 2-1: Summary of forecast climate change compared with 1961-1990

		Northern Quebec		
		2020	**2050**	**2080**
Winter	**Temperature**	2.5 to 3.5°C	4 to 7°C	6 to 12.5°C
	Precipitation	1 to 18%	2 to 32%	5 to 53%
Summer	**Temperature**	1 to 2.5°C	1.5 to 4°C	2 to 6°C
	Precipitation	1 to 12%	3 to 19%	5 to 30%
		Southern Quebec		
		2020	**2050**	**2080**
Winter	**Temperature**	1 to 2.5°C	2 to 5°C	3.5 to 8°C
	Precipitation	-5 to 19%	0 to 32%	1 to 43%
Summer	**Temperature**	1 to 2°C	2.5 to 4°C	2.5 to 6°C
	Precipitation	-5 to 10%	-7 to 14%	-11 to 150%

Source: http://www.ouranos.ca/intro/IPCC2007_f.html

2.4 Acceleration and slowdown factors (carbon sources and carbon sinks)

The increase in greenhouse gases as a result of human activity is the main factor accelerating climate warming (IPCC 2007). Greenhouse gases trap heat on the Earth's surface. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrous oxide (N_2O) and water vapour (gaseous H_2O). These gases are naturally present in the atmosphere and allow for an average Earth surface temperature of 15°C. Without these gases, it is estimated that the temperature would be -18°C (IPCC 2001). Industrialization, the use of fossil fuels and deforestation have, however, contributed to an increase in the concentration of greenhouse gases from 280 parts per million (ppm) in the mid-19th century to 380 ppm today (IPCC 2001). The increase in greenhouse gases has been exponential since industrialization began (IPCC 2001).

The main carbon dioxide sources and sinks are factors that, respectively, accelerate and slow climate change (Table 2-2).

Table 2-2: Average annual estimate of carbon dioxide sources, sinks and reservoirs derived from anthropogenic carbon dioxide emissions 1980–1989 (Environment Canada 2006a)

A. Sources	
	Estimate (range) (gigatonnes/year)
Emissions from the combustion of fossil fuels and cement production	5.5 (5.0 – 6.0)
Net emissions from changes in the use of tropical lands	1.6 (0.6 – 2.6)
Total	7.1 (6.0 – 8.2)
B. Sinks	
	Estimate (range) (gigatonnes/year)
Storage in the atmosphere	3.2 (3.0 – 3.4)
Absorption by oceans	2.0 (1.2 – 2.8)
Absorption by second-growth forests in the Northern Hemisphere	0.5 (0.0 – 1.0)
Additional terrestrial sinks (fertilization with carbon dioxide, fertilization with nitrogen, climate effects)	1.4 (0.0 – 2.9)
Total	**7.1**

*The upper and lower limits correspond to an estimated confidence interval of 90%.
** Fertilization with carbon dioxide and nitrogen constitutes additional sinks where increases in atmospheric concentrations of carbon dioxide and nitrogen oxides from anthropogenic emissions provide additional nutrients necessary for plants in the ecosystems concerned. Climate feedback occurs when changes in temperature, precipitation or other climate variables enhance the growth conditions of plants and, consequently, favour the accumulation of biomass.

Source: IPCC, 1995

In addition to greenhouse gases, aerosols (suspended particles in the atmosphere) have an impact on solar radiation. Aerosols include soot and sulphates. These particles reduce surface temperatures by absorbing the incident solar radiation (soot) in the lower atmosphere or by dispersing and reflecting the incident light (sulphate aerosols) and favouring the formation of clouds. The presence of aerosols reduces the effect of greenhouse gases but cannot offset them.

In Canada, greenhouse gas emissions totalled 740 megatonnes (Mt) of CO_2 equivalent in 2003. Quebec accounts for 12.3% of these emissions, or the equivalent of 91.0 MT of CO_2 (in 2003), which corresponds to an average of 12.1 tonnes per person. The transportation sector alone accounts for 34 Mt CO_2 eq., or 37.4% of emissions (Figure 2-4).

To calculate the emissions for a given territory, there are formulas that take into account the vehicle types and the number of kilometres travelled in the city or over longer distances. The average emissions for light vehicles are 2,400 kg of CO_2 for 10,000 km (Energuide 2006). Heavier vehicles consume more. In the James Bay Territory, more than 20,000 vehicles of all types are in use. A rough approximation (based on these numbers) yields 0.5 Mt of CO_2 emissions due to road transportation in the Territory. A more precise calculation of CO_2 emissions in the James Bay Territory would, however, take into account the types of vehicle and the distance travelled by these vehicles.

Comparison of average CO_2 emissions by type of transport:

- **Air transport**: 0.85 kg of CO_2 per kilometre and per passenger (if the plane is full);

- **Road transport**: 0.20 kg of CO_2 per kilometre and per passenger (for one occupant per vehicle); and

- **Bus transport**: 0.07 kg per kilometre and per passenger (if the bus is full).

(Environment Canada 2005)

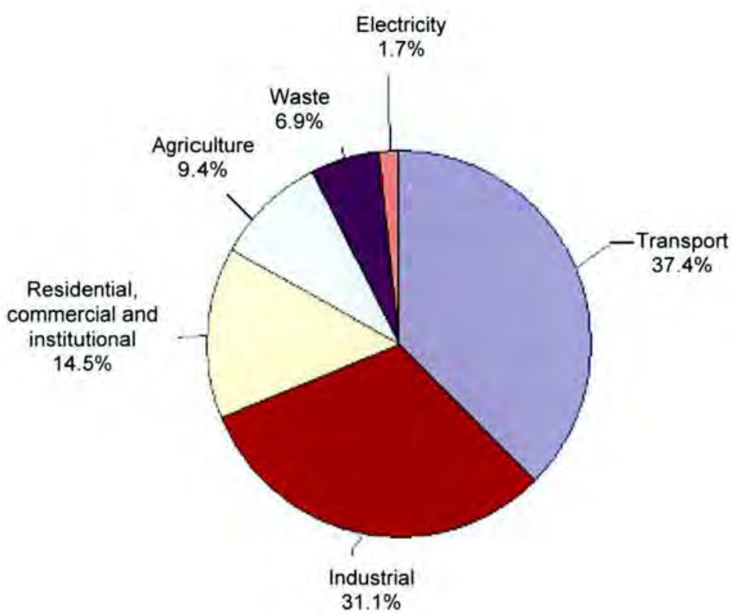


Figure 2-4: Breakdown of greenhouse gases in Quebec by sector of activity in 2003 (MDDEP 2003)

The main cause: greenhouse gases (GHG)

- "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations" with a probability greater than 90%

- Carbon dioxide concentrations in the atmosphere "exceed by far" what has been observed for the past 650,000 years. The same is true of methane.

(IPCC 2007)

2.5 Impacts specific to northern environments

Climate scenarios suggest that global warming may be even more pronounced in northern regions. In the Canadian north, this phenomenon has already caused melting of the permafrost, a shorter snow cover and a shorter icy period. The impacts on infrastructures, such as residential buildings and airports, are being studied by teams from Environment Canada, Transport Canada, Transport Quebec, Ouranos and the Centre d'études nordiques at Université Laval. This warming also tends to reduce the duration and thickness of the ice cover on lakes and rivers. This phenomenon makes river crossing a high-risk activity during strategic periods of the year when wildlife is available for hunting and trapping. A study is being made in Nunavik under the stewardship of the Kativik Regional Government with the support of Environment Canada through the Northern Ecosystem Initiative, Ouranos and ArcticNet.

2.6 The James Bay Territory and its climate

The James Bay Territory is a vast area covering more than 350,000 km², or one-fifth of the Province of Quebec. This territory lies approximately between the 49th and 55th parallels. It is bounded on the west by James Bay and Hudson Bay and on the east by the watershed of the Otish Mountains toward the basins of the St. Lawrence and of James Bay. The James Bay Territory is in the boreal ecoclimate zone (MRN 2005). The territory has a population of about 30,000. It is home to nine Cree villages: Whapmagoostui, Chisasibi, Wemindji, Eastmain, Waskaganish, Nemaska, Waswanipi, Ouje-Bougoumou and Mistissini. The other villages are mainly in the southern portion of the territory

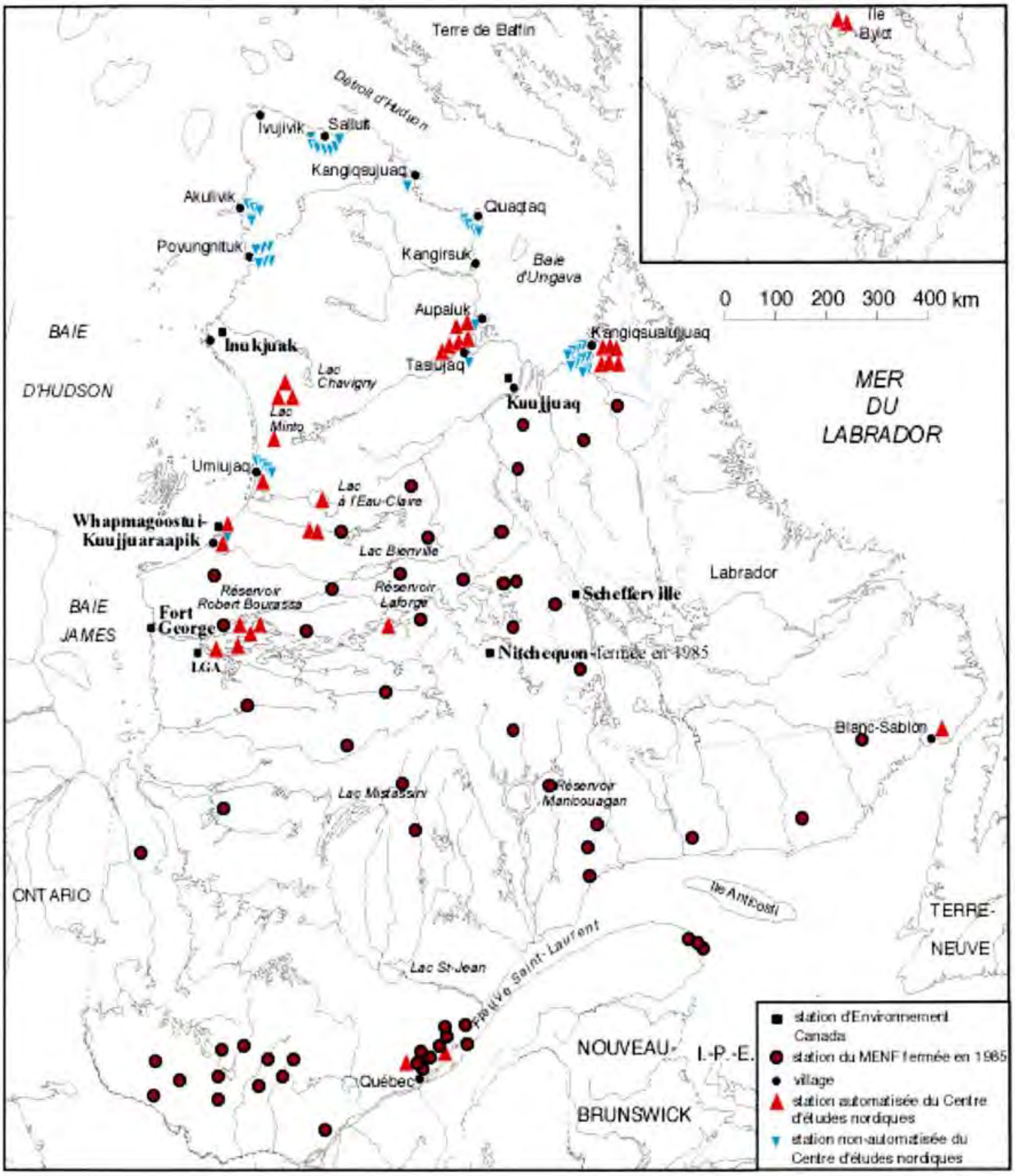
(Chibougamau, Chapais, Lebel-sur-Quévillon, Matagami, Radisson, Val Canton and Villebois). In the Nord-du-Québec administrative region, more than 50% of the population is less than 30 years old (2004 data).

2.6.1 Available climate data

Many weather stations are located in the James Bay Territory. The Centre d'études nordiques has had its own weather stations since 1995, Hydro-Québec since the 1980s, Quebec's Department of Sustainable Development, Environment and Parks (MDDEP) during various periods from 1970 to 1995 and Environment Canada since the 1920s. These stations have been mapped (Figure 2-5) with the exception of Hydro-Québec's stations.[1] Hydro-Québec had a network of weather stations in the James Bay Territory. These stations were active from 1995 to 2004 (Marie-Josée Doray, Hydro-Québec, personal communication). The quality of the historical weather observations of this network ranges from fair to unusable (Enviromet International Inc. 2003). Hydro-Québec therefore installed a new network in 2005 to meet the international standards of the World Meteorological Organization. The co-ordinates of the network active from 1990 to 2004 and the measured meteorological parameters are presented in the appendix in Tables 7-1 and 7-2. The co-ordinates of the new network's stations and the parameters measured are shown in Tables 7-3 to 7-6.

A list of data available by station in the James Bay Territory will be compiled by the Centre d'études nordiques. The map below does not show all the Environment Canada stations in the James Bay Territory but most are indicated elsewhere in this report (Table 2-3).

[1] See the appendix for a list of Hydro-Québec weather stations.



Legend:			
■	Environment Canada station	●	MENF station closed in 1985
•	Village	▲	Automated station of the Centre d'études nordiques
▽	Non-automated station of the Centre d'études nordiques		

Figure 2-5: Map of the weather stations of the Centre d'études nordiques (triangles) and the MDDEP (then known as the Ministère de l'Environnement et de la Faune (MENF)) from 1970 to 1995 (circles)

Table 2-3: Environment Canada weather stations in the James Bay Territory

Name of station	Latitude	Longitude	Altitude
* BONNARD	50°44' N	71°03' O	506 m
* CHAPAIS 2	49°47' N	74°51' O	396 m
HEMON	49°04' N	72°36' O	183 m
JOUTEL	49°28' N	78°18' O	290 m
* KUUJJUARAPIK A	55°17' N	77°45' O	10 m
LA GRANDE RIVIERE A	53°38' N	77°42' O	195 m
MATAGAMI A	49°46' N	77°49' O	281 m

Note: An * indicates stations that meet World Meteorological Organization standards.

2.6.2 Spatial climate variations in the James Bay Territory

The main spatial climate differences in the James Bay Territory can be summarized as follows (Figure 2-6):

- The southern part of the Territory is warmer and wetter than the north;

- The southern and eastern regions of the Territory get more solid and liquid precipitation than do the west and north.

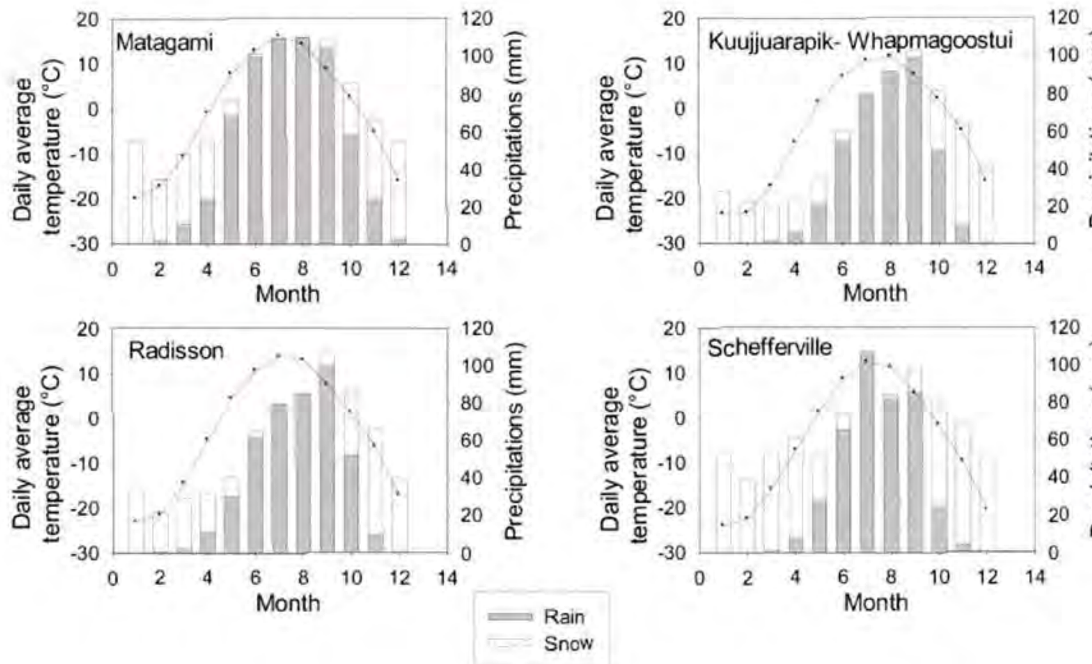


Figure 2-6: Climatograms for Matagami (southern portion of the Territory), Kuujjuarapik-Whapmagoostui (northern portion), Radisson (western portion) and Schefferville (to the east and outside the Territory). Source of data: Environment Canada stations

2.6.3 Main climate trends

The climate trends observed during the period from 1970 to 2002 show that the average annual temperature increased by 1 to 1.5°C. The thermal sum (degrees-days above 5°C) increased from 100 to 140 degrees-days during this period in the boreal forest zone (Meunier 2006). The warming has been especially pronounced since the mid-1990s.

The climate models suggest an increase in temperature of about 4°C for the James Bay Territory and an increase in precipitation of 5 to 15 mm a day by 2050 (CCIS 2006)

3. Consequences of climate change

3.1 Water resources

The expected climate change should affect the frequency of El Niño and La Niña events. El Niño events, which are responsible for dryer winter conditions in Canada, should be longer and more frequent. El Niño years should be punctuated by years of heavy rainfalls because of the effects of La Niña. Indeed, the frequency of El Niño and La Niña events increased during the 20th century, and it appears that their intensity rose in the 1980s and 1990s compared with the 1950s (Table 7-7 and Table 7-8) (Environment Canada 2007).

For instance, studies conducted in the Canada-U.S. Great Lakes region show the effects of global warming on river flow, groundwater, the water supply in the Great Plains region and the level of the Great Lakes. Many of the lake and river systems whose levels and rates of flow are expected to decrease, on average, are among the most heavily used in Canada and are also shared with the United States. It has already been observed that the minimum flow rates and low-water levels have decreased in the summer and early fall in south-central British Columbia since 1995 (Leith and Whitfield 1998) and on the southern Prairies since 1993 (Yulianti and Burn 1998). Consequently, it appears that water-conservation measures will be important, especially in cases of high consumption, such as for irrigation. There is also the risk of a reduction, over the long term, in the groundwater replenishment rate in southern Canada.

As for Quebec's northern rivers, which are generally covered with ice in the winter, ice breakup and the flooding it causes could occur in the wintertime rather than in the spring (Clair et al. 1997).

Climate change could increase river flows and groundwater levels in the James Bay Territory. The risk of ice jams could be greater in the winter.

3.2 Coastal areas

Sea-level rise caused by partial melting of glaciers and polar ice caps increases the sensitivity of coastlines. Coastal areas will be more prone to flooding, erosion, beach migration and coastal-dune destabilization (Natural Resources Canada 2006c). Two areas of Canada are particularly at risk: Atlantic Canada and parts of the Beaufort Sea coast. The James Bay and Hudson Bay coastlines present a low to average sensitivity (Environment Canada – Canada Atlas). They are gradually being spared these effects because of an even more rapid isostatic rebound in the region.

The James Bay **coastal areas** present a **low sensitivity to climate change,** in part because the isostatic rebound is still rapid in this region.

3.3 Forests

Forests absorb and release large quantities of CO_2. A growing forest is a carbon sink, whereas a mature forest is in equilibrium with the atmosphere in terms of carbon exchanges. Photosynthesis allows the absorption of CO_2. The climate factors that affect the rate of photosynthesis are light intensity, air temperature, water availability, atmospheric concentration of CO_2, atmospheric pollutants and soil conditions (Kozlowski and Pallardy 1997). In the next few paragraphs, we will examine the main elements modified by the expected climate warming.

3.3.1 Impacts of climate change on forest physiology

The increase in greenhouse gases, especially CO_2, over the past 150 years, warming and increased precipitation should affect the physiological processes of plants. The combined action of these various factors is difficult to predict, however (Forget et al. 2003).

3.3.1.1 CO_2 concentrations

Certain physiological processes appear to be favoured by an increased concentration of CO_2 (Table 3-1). Plants are expected to make more efficient use of light, water and nutrients. Photorespiration should be less efficient, however. Given that the growth of tree species is often limited by the availability of CO_2, an increase in greenhouse gas concentrations should have a positive effect (Kirshchbaum 2000). Still, the positive impact of CO_2 on growth is highly dependent on the availability of soil nutrients (Drake et al. 1997, Kirshchbaum 2000). The positive impact of CO_2 on growth will also depend on the species considered and the development stages. The species benefiting the most from an increase in CO_2 are annual and perennial herbaceous species. Those benefiting the least are conifers and late-succession tree species (maple, yellow birch, white spruce and white pine). Younger trees will benefit more from CO_2 fertilization than will older trees (Papadocol 2000).

It is important to note that the positive effects of CO_2 on tree growth could be cancelled out by the negative effects of certain gases, such as ozone (O_3) and sulphur dioxide (SO_2) (Isebrands et al. 2001). Studies of the quaking aspen show that the tree's productivity has already decreased because of the current levels of ozone in the air (Percy et al. 2002).

For the black spruce, the dominant species in Quebec's boreal forest, the consequences of a doubling of CO_2 are:

- A quicker budbreak in the spring;
- Greater tolerance to frost by young buds in early fall;
- Regulation of photosynthetic activity.

(Bertrand and Bigras 2006)

3.3.1.2 Temperature

Physiological processes are affected by an increase in temperature (Table 3-1). In general, temperature increases benefit both photosynthetic activity and respiration. The net carbon balance will, however, plateau and then diminish with a continued increase in temperature (Kirshchbaum 2000).

The effects of temperature on growth vary according to the species. Growth of the sugar maple (Courchesne et al. 2001) and the grey pine (Brooks et al. 1998) is favoured, but an increase in temperature can reduce the length of the terminal shoot of the Douglas fir (Olszyk et al. 1998).

- In general and for Quebec, an increase in temperature should favour tree growth.

- For black spruce and grey pine, the dominant species in the James Bay Territory, radial growth is positively correlated with an early start to the season (Hofgaard et al. 1999).

3.3.1.3 Precipitation

The impact of water stress depends on the physiological process considered. For instance, where photosynthetic activity is concerned, efficient use of light diminishes with drought, whereas photorespiration, respiration, efficient use of water and tree sensitivity to insects and disease increase under the same conditions of water stress.

- For the black spruce, a study of Western Quebec showed that an increase in precipitation in June appeared to have a beneficial effect on radial growth (Hofgaard et al. 1999).

- **In Northern Quebec (north of 50°N), an increase in precipitation could compensate for a potential increase in evaporation caused by higher temperatures** (Forget et al. 2003).

Table 3-1: Effect of an increase in the concentration of CO_2 and of the temperature on the various physiological processes (from Colombo 1998)

Physiological process	Increase in CO_2 concentration	Increase in temperature
Photosynthesis	Increase subject to feedback related to available resources	Increase subject to feedback related to available resources
Photorespiration	Decrease (in general)	Increase
Night respiration	Slight decrease	Increase
Stoma conductivity	Decrease	Increase up to temperatures of 30-35°C
Light-use efficiency	Increase	No change
Water-use efficiency	Increase	Decrease
Nutrition-use efficiency	Increase	No effect
Phenology	Shorter growing season because of later budbreak and/or earlier bud formation	• Earlier budbreak in the spring • Hardening of buds later in the season
Allocation of carbon / structure of tree	• Increase in growth rates • Reduction in stoma density • Increase in root growth	• Increase in growth rates • Earlier budbreak and flowering
Sensitivity to stress	Increase in tolerance to drought with closing of stomata	Increase in potential damage from winter and spring frosts

The effects of increases in CO_2 concentrations and temperatures on the physiological processes of plants can be positive or negative depending on the process considered. Generally speaking, the most recent IPCC reports consider that the boreal forest would be favoured by an increase of 2 to 3°C, but the boreal ecosystem would be greatly harmed by increases greater than 3°C.

3.3.2 Migration of species and relocation of ecosystems

Paleoecological studies have shown that the distribution of ecosystems was linked to the climate (Delcourt and Delcourt 1988). In line with the studies of climate and vegetation changes that occurred thousands of years ago, one can consider the impact of the present climate warming on the composition and distribution of the current ecosystems. In this sense, the studies of Rizzo and Wilken (1992) and Luckman and Kavanagh (2000) lead us to believe that the habitats of species move northward and to higher altitudes. Paleoecological studies have shown that it is not ecosystems that migrate but rather individual species. Still, the speed of the current climate warming is unprecedented, so it is difficult to establish projections respecting the migration of species. Statistical models describing landscapes seem to perform best in predicting changes. An example that is frequently quoted in government documents is presented below:

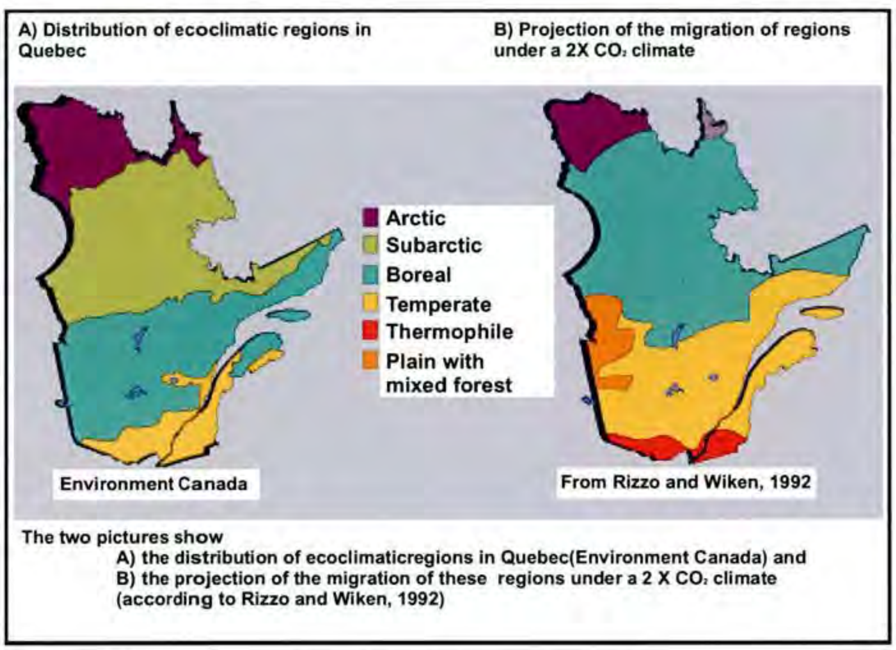


Figure 3-1: Breakdown of Quebec's ecoclimatic regions a) now and b) under a climate where CO_2 concentrations would be twice the level measured in the pre-industrial era (2 x 280 ppm)

Still, we can question the merits of a map that is based solely on climate projections. The dynamics of forest ecosystems are more complex and do not react only to temperature but also to precipitation and frequency of disturbances. One must also consider the various phases of the forest dynamics, namely seed production, the installation of seedlings and individual growth.

Consequences for forest ecosystems:

- Significant changes in habitat potential for tree species are expected and could lead to a new composition of vegetation communities in Quebec (Rizzo and Wilken 1992)

- The speed of climate change is unprecedented and could lead to local loss or extinction of species with a weak dispersion capacity or a limited dispersion area (Thompson et al. 1998)

- The ability of species to migrate in response to climate change will be strongly influenced by auto-ecological species constraints, such as seed dispersion, and by factors such as forest fragmentation, regeneration practices and disturbance regime (Flannigan et al. 2001)

From Forget et al. 2003

3.3.3 Natural disturbances

Natural disturbances, such as epidemics and forest fires, have considerable influence on the forest dynamics of boreal forests. An impact assessment of climate change on Quebec's boreal forest requires an understanding of how climate change can affect the frequency and intensity of natural disturbances.

3.3.3.1 Forest fires

The impact of higher temperatures on forest fires is difficult to forecast. In the early 1990s, it was recognized that an increase in temperatures could increase the occurrence of forest fires (Overpeck et al. 1990, Flannigan and Van Wagner 1991, Clark 1998). Still, opinions voiced by an expert in that area (Dr. Mike Flannigan), and reproduced on the website of Natural Resources Canada, show that it is difficult to draw such a conclusion: "My best guess is a 50 percent increase in Canadian forest fires by the year 2050, but that figure could be completely incorrect " (Information Forestry 2001).

In Quebec, most of the studies done on the subject have been carried out in the Lake Duparquet area of the Abitibi region by the team of Dr. Yves Bergeron. These studies show that an increase in temperature could be more than offset by an increase in abundance and a better temporal distribution of precipitation (Bergeron 1998).

The work now being done by Dr. Bergeron's team aims to assess the impact of climate change on forest yields to help forest stakeholders adapt more effectively to the possible consequences. The five key objectives are: (i) to quantify the relationship between climate and radial growth for two major commercial species, namely the quaking aspen and the black spruce, and to project their expected growth as a result of forecast climate change; (ii) to determine the relationship between climate and forest-fire frequency, and to make frequency projections, again based on forecast climate change; (iii) to evaluate how climate change will affect the growth and distribution of the two species in relation to a topographical drainage gradient and to use these results to factor climate into the growth equations of yield tables; (iv) to simulate various scenarios for a forest management unit, taking into account the effects of climate change on growth and forest fires; and (v) to assist stakeholders in order to maximize adaptation of silvicultural practices to climate change.

In a scenario where the CO_2 rate is doubled, studies forecast that Quebec's forest-fire season will be 27 days longer (Wotton and Flannigan 1993) and that it will start earlier (Stocks et al. 1998).

The global models that form the basis for climate simulations used to determine the risks of forest fire show an increased risk for the James Bay Territory. The map produced by Brian Stocks and his colleagues at the Canadian Forest Service (Natural Resources Canada 2006a) shows that the risk of forest fires will increase in the 21st century for the James Bay Territory. Thus the forest-fire risk index, which was 1 to 2 (on a scale of 0 to 6) for the period from 1980 to 1989, is now estimated at 2 to 4 for the period from 2090 to 2099, depending on the location in the James Bay Territory (Environment Canada – Canada Atlas).

It is very difficult to predict **the impact of climate change on the risk of forest fires**. The increase in precipitation could reduce the risk of forest fires but the models established by Natural Resources Canada indicate an increased risk for the James Bay Territory.

3.3.3.2 Epidemics

In the boreal forest, the most damaging epidemics for the forest cover are caused by the spruce budworm (Choristoneura fumiferana (Clem.). The forecast climate warming could have a positive effect on the reproduction of insects and their development (Lysyk 1989). Milder winters could also be beneficial to the survival of certain pest insects (Williams 1995). Given the more rapid migration of insects, one of the risks of climate warming is an invasion of exotic pest insects in the temperate and boreal forest distribution area (Dale et al. 2001). Still, it is difficult to forecast the incidence of epidemics on the forest landscape. Changes in the composition of the vegetation cover vary depending on whether the models consider the effects of pest insects (Niemela et al. 2001). Finally, fibre loss due to the herbivorous nature of pest insects results in a flow of carbon to the atmosphere, which could aggravate global warming (Volney and Fleming 2000).

Climate warming should favour insect epidemics and the invasion of ecosystems by exotic pest insects.

3.3.4 Socio-economic impacts

Phenologic changes in forest ecosystems as a result of climate change could have consequences for the social milieu as regards forest use (Table 3-2).

Table 3-2: A few examples of the socio-economic impacts of climate change (Environment Canada 2006b)

Physical impacts	Socio-economic impacts
Changes in forest productivity	Changes in the production of timber and rental value
Increase in greenhouse gases in the atmosphere	Introduction of mitigation policies and carbon credit-permits creating a carbon sequestration market
Increase in disturbances	Loss of forest products and non-commercial goods
Migration of ecozones northward	Changes in land values and land-use options
Climatic and ecosystemic changes	Economic restructuring leading to social and individual tensions and other social pathologies
Changes in ecosystems and specialized species	Changes in non-commercial values
Changes in ecosystems	Deterioration of parks and natural reserves, and increase in conflicts over land use

3.4 Peat bogs

Peat bogs are an essential feature of the Canadian landscape as they cover 14% of Canada's land mass (Natural Resources Canada 2006b). Peat bogs are areas where decomposing vegetation has accumulated on the surface to depths that may exceed 40 cm. Peat bogs have an important ecological role to play in the regulation of drainage networks. Water is stored in these wet environments and slowly replenishes aquifers. These processes help reduce river flows during flooding and maintain them during drought. Peat bogs are also a habitat for many wildlife species, in particular waterfowl. Finally, wet environments retain contaminants. With respect to climate change, peat bogs are now huge carbon sinks, but in a warmer climate the captured carbon could be freed and thus accentuate global warming (Natural Resources Canada 2006b).

At present, peat bogs constitute sites that reduce atmospheric CO_2 (**carbon sinks**) but they **could become sources** of greenhouse gases with the forecast warming.

Studies are now being made in the James Bay Territory to assess the impact of climate change on these complex ecosystems. Three 150-km^2 areas have been retained in the LG1, LG2 and LG3 regions, all of which include various types of peat bog. The findings will help identify the relationship, over the past four decades, between changes in the surface characteristics of peat bogs and the climate in this boreal region, where climate-prediction models forecast a more pronounced increase in temperatures. These studies are being made under the direction of Michelle Garneau (of the Université du Québec à Montréal) and Serge Payette (of Université Laval in Quebec City).

3.5 Wildlife

Most studies aiming to better understand the impact of climate change on wildlife are concerned with changes in the phenology of organisms (the timing of recurring life-cycle events, such as reproduction, and organisms' response to their environment). The climate can have a direct impact on wildlife phenology or indirect effects through changes in wildlife habitats. Thus the survival of certain vertebrates may depend on a proper fit between the phenology of plant species and reproduction (Einum and Fleming 2000, Thomas et al. 2001).

3.5.1 Indirect effects of the climate

Experimental studies in controlled environments show that increased warming accelerates plant growth and hastens the beginning of the next phenological stage (Saxe et al. 2001, Badeck et al. 2004). One of the consequences of climate change could be desynchronization between the availability of plants and the wildlife that eats them. Herbivores usually raise their offspring during the peak availability of the plants that they consume (Perrins 1970, Nilsson 1994). Consequently, animals may have to reproduce earlier to stay in tune with the phenology of their food.

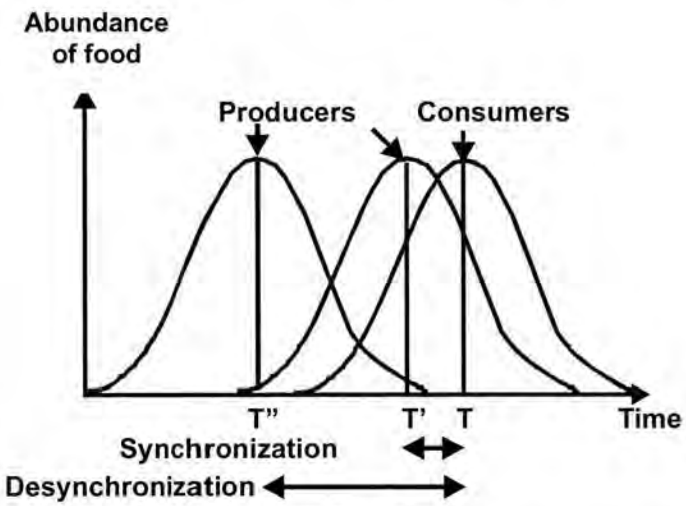


Figure 3-2: Phenological synchronization between the needs of consumers (vertebrates) and the abundance peak of producers (vegetation or related herbivores) during reproduction (adapted from Durant et al. 2005).

A study made in the Yukon shows the indirect effect of climate warming on red squirrels (*Tamasciurus hudsonicus*). Climate warming and an increase in the abundance of spruce cones are correlated with earlier reproduction dates for the red squirrel population studied (Réale et al. 2003, Berteaux et al. 2004).

The indirect effects of global warming on wildlife include thawing and reduction of the ice cover in Arctic regions. This has a major effect on polar bears, which must swim far more and have difficulty obtaining food (Envirozine 2005).

3.5.2 Direct effects

Many studies have shown a correlation between climate warming and the reproduction dates of certain vertebrates (Crick and Sparks 1999, Sanz 2002). In North America, the average egg-laying date occurred 10.1 days earlier in 1998 than in 1971. Meta-analysis of 675 species in many locations has shown an overall advance in spring phenologies (plants and animals) of 2.3 days per decade (Parmesan and Yohe 2003). Not all species react in the same fashion, however. In birds, for instance, 47% of the 168 species studied brought forward their reproduction date, whereas 8% delayed it and 45% did not change it (Parmesan and Yohe 2003, Visser et al. 2004).

3.5.3 Studies of the James Bay Territory

Research is taking place at the Université du Québec à Rimouski under the direction of Dominique Berteaux under the auspices of the Canada Research Chair in Northern Ecosystem Conservation (Berteaux et al. 2006). A research theme developed by Dominique Berteaux in partnership with ArcticNet focuses on the response of boreal forest mammals to climate change.

Moreover, one of ArcticNet's research themes is "food, water and resources in the shifting north-south geothermal gradient of the terrestrial Eastern Canadian Arctic" (ArcticNet 2006). This theme is an integrated regional impact assessment of climate warming and societal conditions along the north-south gradient of the Eastern Canadian Arctic and subarctic. Research will take place in the Northern RiSCC sector, an area that covers more than 30 degrees of latitude, from 53°N (James Bay) to 83°N (Quttinirpaaq National Park, Ellesmere Island, Nunavut) and has various ecoclimatic zones, such as boreal forest, shrubby tundra and High Arctic polar desert.

The Canadian Wildlife Service conducted research on the James Bay goose (Canadian Wildlife Service 2006). The species studied were the brant, the Canada goose and the lesser snow goose. These species have an economic importance because they are hunted by the Cree and Inuit populations of Northern Quebec. The purpose of the study was to obtain information on the ecological needs of geese in those periods when they gather and reproduce in the coastal wetlands of James Bay to assess, forecast and mitigate the impact of the region's activities. The study was made in partnership with Arctic Goose Joint Venture (AGJV), James Bay Energy Corporation (SEBJ), GENIVAR consulting group and Eeyou Corporation. The knowledge acquired during the study could allow for an evaluation of the indirect effects of climate change on the avian populations observed and, consequently, a better understanding of the impacts of climate change on this resource.

Studies to be monitored:

- The studies by Dominique Berteaux of the Université du Québec à Rimouski concerning the response of mammals living in the boreal forest to ongoing climate change.

- The studies conducted by ArcticNet on "food, water and resources in the shifting north-south geothermal gradient of the terrestrial Eastern Canadian Arctic."

- The Canadian Wildlife Service studies on avian wildlife, including waterfowl.

3.6 Energy and the James Bay Territory

The watershed of the La Grande Hydroelectric Complex covers 177,000 km², or 12% of Quebec's total area. The annual electrical output of the La Grande Hydroelectric Complex is about 83 terawatt hours (TWh) and represents more than 40% of the electricity consumed in Quebec (193 TWh in 2003). The construction of three new generating stations between 2003 and 2011 (Eastmain-1, Eastmain-1A and Sarcelle) and the diversion of the headwater of the Rupert River toward the La Grande power stations will raise the total output of the La Grande Hydroelectric Complex to about 94 TWh.

Studies conducted in the James Bay Territory have assessed the changes in runoff in three drainage basins that are important for hydroelectricity production. Singh (1988 in Bruce et al. 1999) foresees an increase in the runoff of the La Grande River (15.6% to 16.5%), the Caniapiscau River (13.0% to 15.7%) and the Opinaca-Eastmain River (6.7% to 20.2%). These increases do not, however, exceed the annual variations in the net capacity of the drainage basins (Bruce et al. 1999).

The expected increase in precipitation in the James Bay Territory should lead to an increase in the generation of electricity.

In relation to climate change, it should be noted that hydroelectricity generates the least amount of greenhouse gases (during the operations phase) and far less than generating stations that use oil, coal or natural gas (Tremblay 2005). The first years after the priming of reservoirs are marked by an increase in greenhouse gas emissions. These emissions are due to the decomposition of the labile fraction of flooded organic materials. The reservoirs' emissions return to rates equivalent to those of lakes and rivers after a 10-year period (SEBJ 2004). Indeed, the maximum flooded area of the Rupert reaches for the Eastmain-1-A project is equivalent to 346 km.[2] The maximum greenhouse gas emissions should be measured every two to four years after priming and reach 128,000 to 685,000 tonnes of CO_2 equivalent per year. Thereafter, emissions should drop to 32,000 to 71,000 tonnes of CO_2 equivalent per year whereas they are now –36,000 to 81,000 tonnes of CO_2 equivalent per year (SEBJ 2004).

4. Research to address knowledge gaps regarding the James Bay Territory

The research directly linked to climate change and carried out, at least in part, in the James Bay Territory is listed in the table below (Table 4-1). These research themes generally involve many projects and are the subject of ongoing work, which explains why they do not have a precise timetable associated with them.

Table 4-1: Themes of research conducted in the James Bay Territory

	Research theme and objectives	Resource persons or institutions
Climate	Regional modelling of the climate to forecast the scope of climate change and its impacts	Ouranos (Montreal) Environment Canada
	SILA network of experimental stations (monitoring of northern climate)	Yves Bégin (Université Laval)
Water resources	Variations in the levels of Quebec's subarctic great lakes	Yves Bégin (Université Laval) Ouranos
	Vulnerability and adaptation to climate change for the water sector	Meteorological Service of Canada
Forest	**Southern James Bay** Study on the dynamics of forest ecosystems and their interactions with the climate and disturbances	Yves Bergeron (UQAT)
	Northern James Bay - Long-term impacts of interactions between disturbances and climate change	Dominique Arseneault
	- Ecology of Upper Boreal fires - Forest dynamics at the boreal-subarctic interface - Reproduction ecology of boreal ecosystems (forecast the reproductive behaviour of boreal ecosystems under the impact of climate change)	Luc Sirois
Peat bogs	James Bay peat bogs: historical monitoring and climate change This study aims to recreate the spatio-temporal dynamics of peat bogs to predict how they will be affected by climate change	Michelle Garneau (UQAM) Serge Payette (Université Laval)
Wildlife	Response to climate change of mammals living in the boreal forest	Dominique Berteaux (UQAR)
	Impact of climate change on avian wildlife	Joel Béty (UQAR) Jean-Luc DesGranges (Canadian Wildlife Service)
Energy	Quebec's energy strategies determine the province's energy needs and policies in line with greenhouse gas reduction objectives	Hydro-Québec Ministère des Ressources naturelles et de la Faune du Québec

5. Conclusion

Representatives of the scientific community present in Paris on February 1, 2007, published a summary of the work of several hundred researchers throughout the world. Their conclusions were clear. Climate change is indisputable. In the Northern Hemisphere, the past century was the warmest in 1,300 years (IPCC 2007). Eleven of the past 12 years have been the warmest since 1850. The average increase in terrestrial temperatures is expected to be 3°C by 2100. These scientists also assure us with a probability of 90% that human activities causing greenhouse gas emissions are responsible for this warming (IPCC 2007).

The impacts of climate change are sometimes difficult to forecast. The concentration of greenhouse gases, temperature and precipitation all act on ecosystems. The interactions between these factors are complex and hard to forecast.

Some key conclusions can be drawn, however, with respect to the James Bay Territory (Table 5-1). Average warming of 4°C is forecast by 2050. This warming should be more pronounced in the winter than in the summer. The models indicate that precipitation will increase by about 15 mm a day by 2050. This climate change will have consequences for ecosystems. In the James Bay Territory, we can expect the same changes as those already observed globally, including migration of plant and animal species farther north. As in the past, these migrations will vary according to the characteristics of each species. The coastal areas of the James Bay Territory are not threatened by accelerated erosion, as is the case with the North Shore.

Table 5-1: Main impacts for the James Bay Territory

Sector	**Expected impacts**
Climate	Average warming of 4°C by 2050 compared with the 1961-1990 period Increase in precipitation of 15 mm a day by 2050 compared with the 1961-1990 period
Water resources	Increase in water resources Little or no risk for coastal areas
Forest	Positive and negative impacts on plant ecology depending on species and development stage. Generally speaking, more extensive growth of tree species. Trend to northward migration of forest ecosystems No consensus on a possible increase in forest fires More epidemics
Peat bogs	Now a carbon sink but could become a source of greenhouse gases with climate warming
Wildlife	Northward migration of certain species Earlier reproduction Risk of desynchronization with vegetation, which could be detrimental to animal health or lead to wildlife reproduction at earlier dates

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7. Appendices

This last section contains information tables on Hydro-Québec's stations of its old network active from 1995 to 2004 (Table 7-1 and Table 7-2) and of its new network installed since 2005 (Table 7-3, Table 7-4, Table 7-5 and Table 7-6). These data were provided by Hydro-Québec.

The data influenced by El Niño and La Niña events is compiled in Tables 7-7 and 7-8

Table 7-1: Co-ordinates of Hydro-Québec's weather stations active between 1990 and 2004 and the parameters measured (section 1)

Name of station	RMCQ indicative	Territory unit	Status	Latitude	Longitude	Measured meteorological parameters [2]						
						T	RH	P	IP	Vpcpn	Wind	Snow
Brisay - Barrage amont	CQBR	La Grande	Inactive	54°26'39"	70°30'43"	x		x			x	
Caniapiscau Nord-Est	CQCQ	La Grande	Inactive	54°31'06"	69°13'23"			x				
Caniapiscau Nord-Ouest	CQCN	La Grande	Inactive	54°25'38"	70°10'42"	x		x			x	
Caniapiscau Sud	CQCS	La Grande	Inactive	54°06'47"	69°55'32"	x		x	x			
Duncan - Barrage amont	CQDC	La Grande	Inactive	53°35'27"	77°30'16"	x		x			x	
Duplanter - Barrage amont	CQDP	La Grande	Inactive	54°50'47"	69°48'44"	x		x			x	
Eastmain - Météo	CQEA	La Grande	Inactive	52°12'35"	76°35'00"	x		x			x	
LA 2 KD-04	CQDK	La Grande	Inactive	54°40'04"	71°02'10"	x		x	x		x	
La Sarcelle - Météo	CQLS	La Grande	Inactive	52°40'01"	76°38'08"	x		x			x	
Lac Frégate	CQLF	La Grande	Inactive	53°12'14"	74°50'10"	x		x				
LG 2- Barrage amont	CQXP	La Grande	Inactive	53°47'25"	77°26'30"	x		x			x	
LG 2 Nord-Est	CQXN	La Grande	Inactive	54°08'35"	76°15'12"	x		x			x	
LG 3 - Barrage amont météo	CQXM	La Grande	Inactive	53°43'30"	75°59'00"	x		x			x	
LG 3 TA10	CQXI	La Grande	Inactive	53°55'54"	75°23'12"	x		x			x	
LG 3 TA12	CQXJ	La Grande	Inactive	53°55'40"	75°27'55"	x					x	
LG 3 TA32	CQXK	La Grande	Inactive	53°29'01"	76°00'35"	x		x			x	
LG 4 - Barrage amont	CQXA	La Grande	Inactive	53°53'11"	73°27'48"	x					x	
LG 4 Est	CQXE	La Grande	Inactive	53°57'33"	73°00'09"	x		x			x	
LG 4 Sud	CQXS	La Grande	Inactive	53°49'35"	73°06'49"			x				
Petit Opinaca	CQPO	La Grande	Inactive	52°22'21"	76°45'27"	x		x			x	
Vincelotte	CQVI	La Grande	Inactive	54°14'25"	72°27'42"	x		x				
Bourque - Barrage amont	CQBQ	La Grande	Inactive	47°36'49"	77°18'29"			x				
Dozois Est	CQDZ	La Grande	Inactive	47°27'08"	77°04'43"	x		x			x	x

[2] T: air temperature; **RH**: relative humidity; **P**: total precipitation on precipitation gauge; **IP**: rain on swivelling runnel pluviometer; **Vpcpn**: wind direction and speed on precipitation gauge; **Wind**: wind direction and speed at 10 metres; **Snow**: snow thickness.

Table 7-2: Co-ordinates of Hydro-Québec's weather stations active between 1990 and 2004 and the parameters measured (section 2)

Name of station	RMCQ indicative	Territory unit	Status	Latitude	Longitude	Measured meteorological parameters [3]						
						T	RH	P	IP	Vpcpn	Wind	Snow
Bersimis 1 Est	CQBM	Manicouagan	Inactive	49°36'21"	70°06'21"	x		x	x		x	
Bersimis 1 Ouest	CQBO	Manicouagan	Inactive	49°25'58"	70°55'41"	x		x	x			
Lac Ste-Anne	CQAE	Manicouagan	Inactive	50°08'33"	67°53'57"	x		x	x			
Manic 3 Nord	CQYN	Manicouagan	Inactive	50°12'49"	68°36'32"	x		x	x			
Manic 5 - Météo	CQYY	Manicouagan	Inactive	50°37'20"	68°43'20"	x		x	x			x
Manic 5 Est	CQYE	Manicouagan	Inactive	51°19'20"	68°09'53"	x		x	x		x	
Manic 5 Nord-Ouest	CQYO	Manicouagan	Inactive	51°39'13"	69°03'22"	x		x	x			
Manic 5 Sud	CQYS	Manicouagan	Inactive	51°06'14"	68°50'02"	x		x	x			
Mistigougèche - Barrage amont	CQMG	Manicouagan	Inactive	48°10'30"	68°01'30"	x		x				
Mitis - Barrage amont	CQMM	Manicouagan	Inactive	48°19'53"	67°54'54"	x		x				
Outardes 4 Nord	CQON	Manicouagan	Inactive	50°32'19"	69°12'12"	x		x	x			
Outardes 4 Sud	CQOS	Manicouagan	Inactive	50°06'13"	68°59'15"	x		x	x		x	
Pamouscachiou - Barrage aval		Manicouagan	Inactive	49°19'45"	70°58'52"	x						
Ste-Marguerite - Campement	CQSM	Manicouagan	Inactive	50°46'57"	66°54'57"	x	x	x	x		x	
Châteauvert C - Barrage amont	CQCV	Des Cascades	Inactive	47°45'29"	73°53'48"	x		x				
Châteauvert C - Bris barrage		Des Cascades	Inactive	47°45'34"	73°53'12"	x						
Gouin - Barrage aval	CQGV	Des Cascades	Inactive	48°20'59"	74°05'55"			x				
Gouin Sud-Ouest	CQGS	Des Cascades	Inactive	48°27'04"	75°19'48"	x		x			x	
Matawin - Barrage amont	CQMW	Des Cascades	Inactive	46°51'42"	73°39'32"	x		x				
Matawin - Bris barrage	CQMX	Des Cascades	Inactive	46°51'48"	73°39'30"	x					x	
Mékinac - Barrage amont	CQKM	Des Cascades	Inactive	46°58'32"	72°39'20"	x		x				
Barrière - Barrage amont	CQBA	Beauharnois-Gatineau	Inactive	47°29'55"	76°43'50"			x				
Cabonga - Barrage amont	CQCB	Beauharnois-Gatineau	Inactive	47°18'35"	76°28'14"			x				
Mercier - Barrage amont	CQME	Beauharnois-Gatineau	Inactive	46°43'06"	75°59'11"	x		x		x	x	x

[3] **T**: air temperature; **RH**: relative humidity; **P**: total precipitation on precipitation gauge; **IP**: rain on swivelling runnel pluviometer; **Vpcpn**: wind direction and speed on precipitation gauge; **Wind**: wind direction and speed at 10 metres; **Snow**: snow thickness.

Table 7-3: Co-ordinates of Hydro-Québec's weather stations installed since 2005 and the parameters measured (section 1)

Name of station	RMCQ Indicative	Prov/Territ.	Partners	Elevation (metres)	Latitude	Longitude	Measured meteorological parameters																		
							TAi000H (201)	TAm000H (203)	TAx000H (204)	TAn000H (205)	TDi000H (206)	HAi000H (301)	HAm000H (302)	VDm400H (402)	VVm400H (502)	VDm500H (403)	VVm500H (503)	VDxi500H (406)	VVxi500H (506)	VVxih500H (507)	VDm025B (405)	VVm025B (505)	PC030B (604)	PC040H (701)	NSi000H (801)
Barrage Robert-Bourassa	CMBU	Québec	Hydro-Québec	191.0	53°46'37"	77°28'25"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Barrage Vincelotte	CMVN	Québec	Hydro-Québec	446.0	54°20'12"	72°30'43"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Barrière - Barrage amont	CMBA	Québec	Hydro-Québec	363.2	47°29'56"	76°43'50"	x	x	x	x		x	x								x	x	x	x	x
Bersimis 1 Est	CMBM	Québec	Hydro-Québec	406.0	49°36'21"	70°06'40"	x	x	x	x		x	x								x	x	x	x	x
Caniapiscau Sud	CMCS	Québec	Hydro-Québec	540.6	54°06'46"	69°55'33"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
De Pontois	CMRP	Québec	Hydro-Québec	329.0	53°09'58"	74°28'16"	x	x	x	x		x	x								x	x	x	x	x
Fontanges	CMFE	Québec	Hydro-Québec	469.3	54°33'17"	71°10'47"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Gorge Prosper 2	CMGP	Québec	Hydro-Québec	337.0	52°10'07"	74°35'35"	x	x	x	x		x	x								x	x	x	x	x
Gouin Sud-Ouest	CMGS	Québec	Hydro-Québec	404.8	48°27'01"	75°19'31"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hart Jaune	CMHJ	Québec	Hydro-Québec	483.1	51°47'05"	67°54'15"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Kepimits	CAKE	Nfld and Labrador	Hydro-Québec	540.0	52°39'10"	64°50'18"	x	x	x	x		x	x								x	x	x	x	x
La Loutre	CMUT	Québec	Hydro-Québec	390.0	48°19'57"	74°01'51"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
La Sarcelle 2	CMAR	Québec	Hydro-Québec	220.0	52°40'08"	76°35'40"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Aunaukach	CMMP	Québec	Hydro-Québec	313.0	52°41'13"	75°26'18"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Bourinot	CMPN	Québec	Hydro-Québec	570.8	52°42'28"	70°57'22"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Chastrier	CMLC	Québec	Hydro-Québec	546.1	53°59'28"	69°04'39"	x	x	x	x		x	x								x	x	x	x	x
Lac Despinolles	CMSY	Québec	Hydro-Québec	707.0	52°29'34"	69°15'09"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Falaise	CMLD	Québec	Hydro-Québec	550.9	54°15'53"	68°14'35"	x	x	x	x		x	x								x	x	x	x	x
Lac Grandjean	CMKW	Québec	Hydro-Québec	360.0	54°27'22"	74°20'04"	x	x	x	x		x	x								x	x	x	x	x
Lac Madigan	CMMZ	Québec	Hydro-Québec	593.5	53°21'25"	69°49'21"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Pau	CMPX	Québec	Hydro-Québec	580.9	54°49'36"	69°54'22"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Plétipi	CMPI	Québec	Hydro-Québec	537.9	51°49'11"	70°03'59"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Puisseaux 2	CMPU	Québec	Hydro-Québec	488.4	53°36'01"	71°10'57"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 7-4: Co-ordinates of Hydro-Québec's weather stations installed since 2005 and the parameters measured (section 2)

Name of station	RMCQ Indicative	Prov/Territ.	Partners	Elevation (metres)	Latitude	Longitude	Measured meteorological parameters																		
							TAi000H (201)	TAm000H (203)	TAx000H (204)	TAn000H (205)	TDi000H (206)	HAi000H (301)	HAm000H (302)	VDm400H (402)	VVm400H (502)	VDm500H (403)	VVm500H (503)	VDxi500H (406)	VVxi500H (506)	VVxih500H (507)	VDm025B (405)	VVm025B (505)	PC030B (604)	PC040H (701)	NSi000H (801)
Lac Raimbault	CMRA	Québec	Hydro-Québec	625.0	53°11'44"	68°21'24"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Rossignol	CMRX	Québec	Hydro-Québec	405.0	52°41'04"	73°47'19"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lac Ste-Anne 2	CMAF	Québec	Hydro-Québec	300.0	50°06'12"	67°56'43"	x	x	x	x		x	x								x	x	x	x	x
LG 3 TA10	CMXI	Québec	Hydro-Québec	277.0	53°55'52"	75°23'13"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
LG 4 Est	CMXE	Québec	Hydro-Québec	378.0	53°57'35"	73°00'06"	x	x	x	x		x	x								x	x	x	x	x
LG-3 Taïga	CMXT	Québec	Hydro-Québec	254.0	53°33'55"	76°06'55"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Manic 5 Est	CMYE	Québec	Hydro-Québec	365.0	51°19'20"	68°09'53"																			
Matawin - Barrage amont	CMMW	Québec	Hydro-Québec	362.7	46°51'43"	73°39'33"	x	x	x	x		x	x								x	x	x	x	x
Metchin	CAMN	Nfld and Labrador	Hydro-Québec	335.0	53°26'22"	63°15'33"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Michikimats	CAMK	Nfld and Labrador	Hydro-Québec	520.0	54°33'49"	64°07'10"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Outardes 4 Sud	CMOS	Québec	Hydro-Québec	357.8	50°06'11"	68°59'15"	x	x	x	x		x	x								x	x	x	x	x
Petit Opinaca 2	CMOA	Québec	Hydro-Québec	220.0	52°22'10"	76°46'34"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Polaris	CMPW	Québec	Hydro-Québec	410.0	53°43'25"	72°51'39"																		x	
Rapide Sept	CMRS	Québec	Hydro-Québec	338.8	47°47'51"	78°17'46"	x	x	x	x		x	x								x	x	x	x	x
Réservoir Baskatong	CMKG	Québec	Hydro-Québec	220.0	46°43'05"	75°59'12"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Réservoir Dozois	CMDW	Québec	Hydro-Québec	360.3	47°26'51"	77°04'34"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Réservoir Pipmuacan	CMPP	Québec	Hydro-Québec	566.2	49°21'35"	70°54'55"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rivière Ashuanipi	CAAH	Nfld and Labrador	Hydro-Québec	520.0	53°13'25"	66°12'23"																		x	
Rivière aux Eaux Mortes - Météo	CMRE	Québec	Hydro-Québec	301.0	47°05'51"	72°29'45"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rivière Betsiamites	CMBS	Québec	Hydro-Québec	423.0	49°58'36"	69°54'48"																		x	
Rivière Eastmain	CMEN	Québec	Hydro-Québec	372.0	52°01'33"	73°21'22"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rivière Kanaaupscow	CMRK	Québec	Hydro-Québec	189.0	54°14'31"	76°09'23"	x	x	x	x		x	x								x	x	x	x	x

Table 7-5: Co-ordinates of Hydro-Québec's weather stations installed since 2005 and the parameters measured (section 3)

Name of station	RMCQ Indicative	Prov/Territ.	Partners	Elevation (metres)	Latitude	Longitude	Measured meteorological parameters																		
							TAi000H (201)	TAm000H (203)	TAx000H (204)	TAn000H (205)	TDi000H (206)	HAi000H (301)	HAm000H (302)	VDm400H (402)	VVm400H (502)	VDm500H (403)	VVm500H (503)	VDxi500H (406)	VVxi500H (506)	VVxih500H (507)	VDm025B (405)	VVm025B (505)	PC030B (604)	PC040H (701)	NSi000H (801)
Rivière Misask	CMHC	Québec	Hydro-Québec	424.0	52°33'57"	72°22'49"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rivière Mouchalagane	CMRM	Québec	Hydro-Québec	400.0	52°08'11"	69°30'29"																		x	
Rivière Opinaca	CMOP	Québec	Hydro-Québec	248.0	52°47'00"	75°44'35"																		x	
Rivière Rupert	CMRZ	Québec	Hydro-Québec	290.0	51°31'14"	75°26'26"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rivière Sakami	CMAK	Québec	Hydro-Québec	440.0	53°05'05"	72°45'56"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rivière Ste-Marguerite	CMSN	Québec	Hydro-Québec	480.0	51°53'48"	67°03'04"																		x	
Rivière Toulnoustouc	CMTO	Québec	Hydro-Québec	332.1	50°42'31"	67°44'09"	x	x	x	x		x	x								x	x	x	x	x
Rivière Windigo - Météo	CMRW	Québec	Hydro-Québec	310.2	47°54'57"	73°22'11"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Simms	CASI	Terre-Neuve-et-Labrador	Hydro-Québec	490.0	53°46'37"	65°48'59"	x	x	x	x		x	x								x	x	x	x	x
Ste-Marguerite - Campement	CMSM	Québec	Hydro-Québec	511.0	50°46'54"	66°54'51"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Valois	CMVO	Québec	Hydro-Québec	648.0	51°40'51"	68°59'00"	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 7-6: Explanation of parameters measured for the network of weather stations installed in 2005

SCADA	Parameter	Element	Height (metre)	Unit	Aggregation	Period (min)	Frequency	Type	Definition
TAi000H_201	Air temperature	Air temperature		°C	average	1	hourly	acquired	Average value of last minute before the hour
TAm000H_203	Air temperature	Air temperature		°C	average	60	hourly	acquired	Hourly maximum value
TAx000H_204	Air temperature	Air temperature		°C	maximum	60	hourly	acquired	Hourly maximum value
TAn000H_205	Air temperature	Air temperature		°C	minimum	60	hourly	acquired	Hourly maximum value
HAi000H_301	Air humidity	Relative humidity		%	average	1	hourly	acquired	Average value of last minute before the hour
HAm000H_302	Air humidity	Relative humidity		%	average	60	hourly	acquired	Hourly maximum value
VDm400H_402	Wind	Wind direction	10	degrees	average	10	hourly	acquired	Average value of last 10 minutes of hour
VVm400H_502	Wind	Wind speed	10	km/h	average	10	hourly	acquired	Average value of last 10 minutes of hour
VDm500H_403	Wind	Wind direction	10	degrees	average	60	hourly	acquired	Hourly maximum value
VVm500H_503	Wind	Wind speed	10	km/h	average	60	hourly	acquired	Hourly maximum value
VDm025B_405	Wind	Wind direction	2,5	degrees	average	15	15 minutes	acquired	Average value of last 15 minutes
VVm025B_505	Wind	Wind speed	2,5	km/h	average	15	15 minutes	acquired	Average value of last 15 minutes
VDxi500H_406	Wind	Wind direction	10	degrees	maximum	60	hourly	acquired	Instantaneous value of last hour wind peak
VVxi500H_506	Wind	Wind speed	10	km/h	maximum	60	hourly	acquired	Instantaneous value of last hour wind peak
VVxih500H_507	Wind	Time of peak wind	10	hh:mm	instantaneous	60	hourly	acquired	Hour/minute of last hour wind peak
PC030B_604	Total precipitation	Accumulated precipitation		mm	analysed	15	15 minutes	acquired	Instantaneous analysed value 15 minutes
PC040H_701	Liquid precipitation	Accumulated liquid precipitation (A/B)		mm	instantaneous	60	hourly	acquired	Instantaneous hourly value
NSi000H_801	Snow on ground	Height of snow on ground		cm	average	1	hourly	acquired	Average value of last minute before the hour

Table 7-7: El Niño and La Niña years, 1950-2004

Year	Classification	Year	Classification	Year	Classification
1950-51	La Niña moderate	1970-71	La Niña moderate	1990-91	El Niño weak
1951-52	Neutral	1971-72	Neutral	1991-92	El Niño strong
1952-53	El Niño weak	1972-73	El Niño moderate	1992-93	El Niño weak
1953-54	Neutral	1973-74	La Niña strong	1993-94	Neutral
1954-55	La Niña moderate	1974-75	La Niña weak	1994-95	El Niño weak
1955-56	La Niña moderate	1975-76	La Niña moderate	1995-96	La Niña weak
1956-57	Neutral	1976-77	El Niño weak	1996-97	Neutral
1957-58	El Niño strong	1977-78	El Niño weak	1997-98	El Niño strong
1958-59	El Niño weak	1978-79	Neutral	1998-99	La Niña moderate
1959-60	Neutral	1979-80	El Niño weak	1999-2000	La Niña strong
1960-61	Neutral	1980-81	Neutral	2000-01	Neutral
1961-62	Neutral	1981-82	Neutral	2001-02	Neutral
1962-63	Neutral	1982-83	El Niño strong	2002-03	El Niño moderate
1963-64	El Niño weak	1983-84	La Niña weak	2003-04	Neutral
1964-65	La Niña weak	1984-85	La Niña weak		
1965-66	El Niño moderate	1985-86	Neutral		
1966-67	Neutral	1986-87	El Niño moderate		
1967-68	Neutral	1987-88	El Niño weak		
1968-69	El Niño moderate	1988-89	La Niña strong		
1969-70	El Niño weak	1989-90	Neutral		

(Source: Environment Canada 2007)
http://www.msc.ec.gc.ca/education/elnino/comparing/index_f.cfm.

Table 7-8: El Niño and La Niña years, 1900-1950

Year	Classification	Year	Classification	Year	Classification
1900-01	Neutral	1920-21	La Niña	1940-41	El Niño
1901-02	Neutral	1921-22	Neutral	1941-42	El Niño
1902-03	Neutral	1922-23	Neutral	1942-43	La Niña
1903-04	La Niña	1923-24	Neutral	1943-44	Neutral
1904-05	El Niño	1924-25	La Niña	1944-45	Neutral
1905-06	El Niño	1925-26	El Niño	1945-46	Neutral
1906-07	Neutral	1926-27	Neutral	1946-47	Neutral
1907-08	Neutral	1927-28	Neutral	1947-48	Neutral
1908-09	Neutral	1928-29	La Niña	1948-49	Neutral
1909-10	La Niña	1929-30	La Niña	1949-50	La Niña
1910-11	Neutral	1930-31	Neutral		
1911-12	El Niño	1931-32	Neutral		
1912-13	Neutral	1932-33	Neutral		
1913-14	Neutral	1933-34	Neutral		
1914-15	El Niño	1934-35	Neutral		
1915-16	Neutral	1935-36	Neutral		
1916-17	La Niña	1936-37	Neutral		
1917-18	La Niña	1937-38	Neutral		
1918-19	El Niño	1938-39	La Niña		
1919-20	Neutral	1939-40	Neutral		

(Source: Environment Canada 2007)
http://www.msc.ec.gc.ca/education/elnino/comparing/index_f.cfm.