

# Integrating local and scientific weather knowledge as a strategy for adaptation to climate change in the Arctic

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**Abstract** As the climate warms, stressors are developing that challenge the adaptive capabilities of Arctic peoples. In Nunavut, one of Canada's Arctic territories, increased weather variability and changes in physical and climatic conditions are having profound effects on residents. One problem is that while these changes have magnified risks associated with travel and land-based activities, individuals lack sufficiently reliable and useful information on which to base decisions. In this paper, we argue that weather-related risk assessment can be improved by integrating local and scientific weather knowledge and making this information accessible to residents through the creation of weather hazards impact advisory groups. We present a qualitative case study of Iqaluit, the capital of Nunavut, using data from participant observation and semi-structured interviews conducted with indigenous and non-indigenous long-term residents in summer 2009. We examine how long-term residents of Iqaluit acquire, perceive, and use both local and scientific weather knowledge. We find that various barriers, such as a lack of land-based experience, cultural and linguistic differences, and an absence of social networks, prevent most people from obtaining all the information required to make fully informed decisions about the risks associated with land-based activities at different locations. Experienced hunters are perceived to be a reliable source of weather-related information, while scientific weather knowledge is not as accessible or informative as it could be. Increasing the potential use

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of traditional and scientific hazardous weather knowledge, by making both more universally accessible, can enhance strategies for adapting to climate change in the Arctic.

**Keywords** Arctic · Canada · Community partnership · Local environmental knowledge · Forecasting · Weather service

## 1 Introduction

Based on a qualitative case study of Iqaluit, Nunavut, Canada, we argue that the creation of weather hazards impact advisory groups can help improve strategies for adapting to climate change in the Arctic, by providing a mechanism for integrating local and scientific weather knowledge and making this information more accessible to resident populations. It is predicted that climate change will be earliest and most intense in the high latitudes. As the climate warms, stressors are developing that challenge the adaptive capabilities of Arctic peoples (Anisimov et al. 2007). There is already both empirical and anecdotal evidence of changes in physical, ecological, and climatic conditions across the Arctic, including Canada's northern territories (ACIA 2005; Fox 2002; Krupnik and Jolly 2002; Laidler and Elee 2006; Nunavut Tunngavik Inc. 2005). These changes have magnified risks associated with hunting and travel on the land, activities which are an important part of Arctic residents' lives and culture, and which are constrained by weather conditions. Historically, Arctic populations have been remarkably resilient to natural hazards and the extreme conditions experienced in the North. More recently however, just as changes in climate are provoking hazard events with increasing frequency and intensity, "increased dependence on western-style community services, changes in social structures and reduced experience living on the land have caused a slow erosion of this historical coping capacity" (Newton et al. 2005, p. 546). The increased incidence of sudden and unanticipated changes in the weather is having profound social, cultural, economic, and physiological impacts on residents of the North. Therefore, identifying and improving adaptive strategies for weather and climate-related hazards is increasingly urgent.

The negative impacts of climate change in the Arctic, and on indigenous populations in particular, are well-documented (see especially Crate 2009; Downing and Cuerrier 2011; Huntington and Fox 2005; Pearce et al. 2010). Important contributions to this literature were made during the International Polar Year (IPY 2010) in which the effects of climate change in the Polar Regions was a major focus. Some of the most researched issues include the impacts of climate change on access to traditional food resources, the quality of those foods, and the relationship between food, land and cultural identity (Aporta et al. 2011; Beaumier and Ford 2010; Wesche 2010). In Nunavut, including the area around Iqaluit, the following impacts of climate change have been documented: sea ice becoming thinner, freezing later and thawing earlier; wind becoming more unpredictable, changing usual direction and more frequently reaching storm strength; permafrost thawing; and animals changing migration patterns and declining in numbers (Ford et al. 2010:179). These changes make it more dangerous to travel, hunt and fish, sometimes requiring travelers to take alternate routes, and generally constraining access to hunting areas as well as to other communities.

In this study, we are focusing on changes in climate and weather that affect traveling and activities on the land and water (such as acquiring food) because participants identified these as essential activities which have become more hazardous over the last two decades. This echoes reports from other communities in the region. For example, since the 1990s, Inuit and Cree in the Hudson Bay bioregion have observed earlier snow melt, which restricts their

ability to travel and procure country foods (McDonald et al. 1997). Furgal and Seguin (2006) also mention the increased frequency and severity of accidents while hunting and traveling in Nunavik and Labrador. Limitations on the ability to safely travel, hunt and fish are problematic because eating country foods not only promotes good physical and mental health, while reinforcing cultural values, but also helps offset the extremely high cost of living in the North. Access to reliable information about hazardous conditions and dangerous areas is crucial for enabling people to safely engage in activities on the land. This paper suggests some ways for increasing access to this important information.

In addition to reduced access to and quality of traditional foods, deterioration of the generation and transfer of local/traditional knowledge and decreased contact with other communities is negatively affecting various indigenous Arctic populations (Riewe and Oakes 2006). These impacts subsequently contribute to breakdowns in the cultural and social fabric of communities, which reduces the capacity for adaptation. A key aspect of this paper is social vulnerability, the susceptibility of a given population to be harmed from exposure to weather-related hazards, which directly affects the ability to prepare for, respond to, and recover from such hazards (Cutter et al. 2003). This definition of vulnerability focuses on demographic and socioeconomic factors that reduce the ability to cope with the impacts of hazard events. The United Nations International Strategy for Disaster Reduction (UNISDR 2009) defines ‘coping capacity’ as “the ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters”. The authors of this UN report note that coping capacity requires continuing awareness, resources and good management, both in normal times as well as during adverse conditions. ‘Coping strategies’ refer to short-term responses to situations that threaten livelihood systems and which, over time, can develop into adaptations (Berkes and Jolly 2001). In our research, we examine perceptions of social vulnerability among different groups within the Iqaluit population, in relation to strategies used to cope with weather-related hazards.

This study is part of two multidisciplinary research programs—ArcticNet and Storm Studies in the Arctic—examining the ways communities in the south Baffin Island region of Nunavut, Canada cope with atmospheric hazards and how these strategies can be improved. While weather and climate forecasts can provide information useful in developing strategies for coping with and adapting to these hazards, research that integrates the social and natural sciences has shown that users’ perceptions of forecast value, and hence their use of forecasts, are contingent on a variety of behavioral, cultural, linguistic, and economic constraints (Vogel and O’Brien 2006; Ziervogel and Calder 2003). With the current trend towards interdisciplinary research in the meteorological community, social scientists have begun to inform the process of generating and communicating forecasts (Jankovic and Barboza 2009; Meinke and Stone 2005; Pennesi 2007). Our aim is to build on this work, starting from the idea that a key to making weather forecasts more socially useful is to develop linkages between those making the predictions and those who can benefit from them.

To begin with, forecasters should have a close understanding of the social and geographical contexts of their operations. They need to know the types of weather information used most frequently by the group or sector at which the predictions are aimed, as well as understand how people interpret forecast information and what value it has for them (Lazo et al. 2009; Stern and Easterling 1999). As Pennesi’s (2011) research on climate forecasts in Northeastern Brazil demonstrates, there are multiple understandings and assessments of any given forecast, which are influenced by cultural, linguistic and personal factors. Detailed knowledge of “user” populations is, thus, fundamental to providing effective weather services. Furthermore, local geographical influences on atmospheric conditions create

forecasting challenges that can be reduced by incorporating local knowledge. For example, Morss and Ralph (2007) show that US National Weather Service (NWS) forecasters use their knowledge of local environmental and societal factors, such as the locations of important roads and areas prone to rock or landslides, water drainage characteristics, decision-makers' needs, and residents attitudes towards weather, to help generate more specific forecasts and warnings that are more useful to their communities. Developing forecast products that take into account the people and places they involve can be challenging where resources are limited, but presents benefits worth pursuing.

Our research indicates that taking local *knowledge*, not just local conditions, into account would also be beneficial in the North. This supports previous studies which concluded that people who are active on the land require access to both local and scientific weather knowledge to be properly prepared for hazardous weather while traveling and hunting (Aporta and Higgs 2005; Laidler et al. 2009; Weatherhead et al. 2010). The case study of Iqaluit, Nunavut that we present demonstrates the need for enhancing weather services in the Arctic in ways that will enable all residents to integrate local and scientific weather knowledge. Many residents who depend on the land for their well-being already employ both types of knowledge to cope with hazardous weather and the changes they are experiencing but, we contend, there is a need for universal access to reliable and consistent information.

Before proceeding, it is useful to define some terms used in the paper. We use 'local' weather knowledge to refer to the experiential knowledge of long-term residents (both indigenous and non-indigenous). We recognize that the term 'local' does not capture the sense of continuity and the process of building on what was learned by previous generations, but it was selected in place of 'traditional', 'traditional ecological' or 'indigenous' knowledge because it is more inclusive of the perspectives of long-term Iqaluit residents, not all of whom are indigenous.<sup>1</sup> 'Scientific' weather knowledge refers to forecasts and weather-related information produced and disseminated by meteorological services. Currently, the Meteorological Service of Canada (MSC) provides basic weather forecasts for the general public. When weather events are predicted to exceed specific thresholds, the MSC provides warnings of what is called 'severe weather', 'extreme weather', and more recently, 'high-impact weather' (McCarthy 2007). The definition of hazardous weather used in this paper is broader than that used by the MSC and includes any weather that either poses an inconvenience or a threat to everyday activities in town and out on the land. 'Out on the land' is an expression used by both Inuit and non-Inuit to describe spending time away from town, on land, seas and lakes, engaging in hunting, harvesting, fishing, trapping and survival activities. Going out on the land is considered by Northern residents to be essential to well-being and, therefore, motivates our focus on the use of forecasts in relation to these activities.

Since 2000, climate change research projects have paid particular attention to local knowledge and observations of changing weather patterns, as well as the impacts of these on people's lives. For example, Huntington and Fox (2005) identify changes in weather, seasons, wind and sea ice as one of the five major topic areas pertaining to climate change research. One aim of these projects is to document local and/or indigenous knowledge so that it can be used in conjunction with scientific knowledge to help inform sound policies related to natural hazards (Ford et al. 2010; Leduc 2011; Newton et al. 2005). With the increasing awareness of changing weather patterns in the North, where the effects of climate change are most dramatic, there is greater potential for the incorporation of local weather knowledge in numerical forecast models (Gearheard et al. 2010; Weatherhead et al. 2010).

<sup>1</sup> See Huntington and Fox (2005) and Jack et al. (2010) for a critical discussion of these terms.

The effects of climate change in the Arctic are being documented by both scientific researchers and local residents, and the trend is increasingly that these groups are working together (e.g. Laidler et al. 2009; Riewe and Oakes 2006).

In March 2007, Environment Canada (EC) and Indian and Northern Affairs Canada hosted a workshop in Iqaluit on the topic of community-based Inuit knowledge on weather and sea ice forecasting. Those in participation included elders and community members from several Nunavut communities; however, no community representatives from the capital city of Iqaluit were present. At the workshop, it was recommended that EC continue to search for ways to include local knowledge in its weather forecasts (Furgal 2007). Participants expressed the need to retain community specificity in future work focused on improving weather forecasting capacity in the North. One of the workshop goals was to provide feedback from community members on how to render EC forecasting products more relevant and useful in a community context (Furgal 2007). As stated above, it is now widely recognized that valuable insights are gained by linking local knowledge with scientific research; however, finding formal methods to connect culturally divergent observations can be a complicated task. For example, the report from the 2007 EC workshop in Iqaluit identified the following challenges related to weather forecasting for northern communities: (1) variations in risk perception and behaviors among subgroups, (2) inaccurate and unclear translations of original English forecasts and descriptions of conditions, and (3) differences in the way instrumental versus experiential weather information is interpreted, valued or applied. These issues were also raised in our study and are discussed in the analysis we present below.

Using the Iqaluit case study as an illustration, we argue that weather-related risk assessment can be improved by integrating local and scientific weather knowledge and making this information accessible to residents through the creation of weather hazards impact advisory groups. Toward that end, the rest of the paper is organized into the following parts. First, part 2 describes the environmental and socio-economic characteristics of Iqaluit in relation to changing weather conditions and hazards. In this section, we introduce the issues and challenges Iqaluit residents face in accessing weather services and local weather knowledge. Next, part 3 outlines the methods we used for data collection and analysis. Part 4 describes some local weather indicators, followed by a brief sketch of the process through which scientific weather information is generated and disseminated in Iqaluit, and then, how these two forms of knowledge are acquired and used by Iqaluit residents. Part 5 is a discussion of our findings, in which we examine the feasibility and complexity of recommendations made by study participants. In light of our findings, we propose the creation of weather hazards impact advisory groups to facilitate the inclusion of local weather knowledge in weather services and the dissemination of information to all residents. Finally, the conclusion in part 6 outlines further work that needs to be done.

## 2 Study area

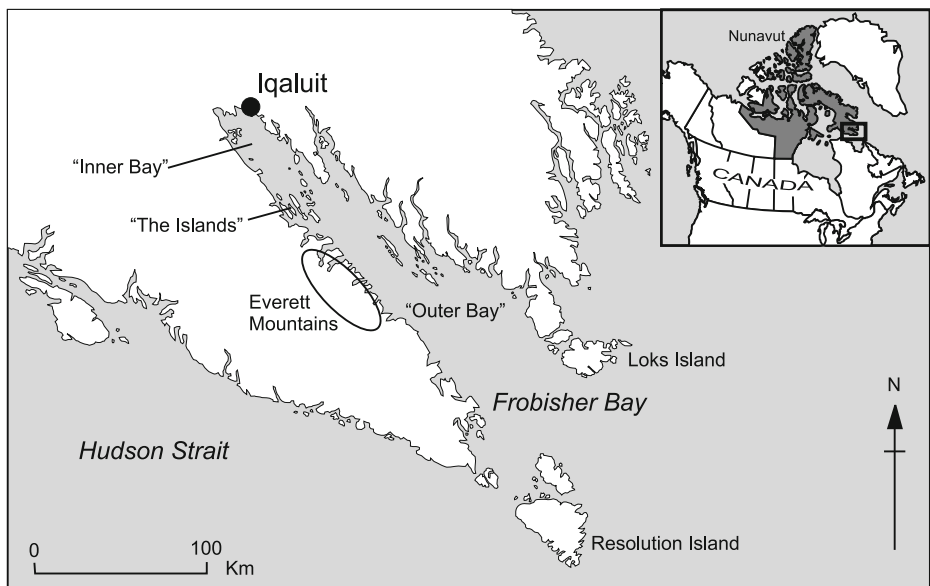
Iqaluit (68.55°W, 63.75°N), the capital of Nunavut, is located on Frobisher Bay on South Baffin Island (Fig. 1). Iqaluit was selected as the research site because of its exposure to hazardous weather, the characteristics of its population, and a lack of existing research in this particular area. Iqaluit is predisposed to hazardous weather in all seasons due to its geographic location in a fjord–river valley at the head of Frobisher Bay (Hudson et al. 2001). The community is flanked by two ridges with a predominant southeast-to-northwest orientation. Highly varied terrain and deep valleys in the Iqaluit area translate into variable

weather conditions that affect everyday activities on the land. Offshore and onshore winds, abrupt shifts in wind direction, blizzards, wind chill, extreme cold, tidal fog and reduced visibility are common in Iqaluit and make it difficult to traverse the landscape (Hudson et al. 2001). In Frobisher Bay, there is a row of islands that separate the upper and lower part of the Bay (see Fig. 1). The water past the islands, referred to as ‘the outer bay’, is deeper than in ‘the inner bay’. The Bay can experience up to 11-m tides that affect the weather and the formation of sea ice (Hudson et al. 2001). The tides affect everyday activities on the land and are of particular concern to boaters and snowmobilers. Figure 2 shows the pier at low tide.

Iqaluit has a unique demographic structure with a large population of newcomers, both from the south and from other northern communities, coming to the city for employment. With only 60% of the population being Inuit (Stats Can 2006), Iqaluit is unique among Nunavut communities and has a high degree of linguistic and cultural diversity. In 2006, Iqaluit had a population of over 6,000 people, with 1,800 new residents in the past 5 years (Stats Can 2006). Thus, there is a broad spectrum of people who use weather services in Iqaluit and careful thought should be given to the needs of various groups within that spectrum.

The past decade has seen a surge of projects and case studies on vulnerabilities and adaptations to climate change in the Arctic, including Alaska (Oozeva et al. 2004; Lynch and Brunner 2007), the western Canadian Arctic (Berkes and Jolly 2001; Nichols et al. 2004; Duerden and Beasley 2006; Pearce et al. 2010) and in other parts of Nunavut, such as Arviat (Blakney 2006), Clyde River (Laidler and Elee 2006) and Igloodik (Ford et al. 2006; Laidler et al. 2009). There has been very little social science research conducted on the vulnerability and adaptive capacity of the community of Iqaluit, however, and none on the value of weather information to residents. Given Iqaluit’s importance as the territorial capital, which attracts a steady flow of people to its hazard-prone location, research in this area is needed.

The Meteorological Service of Canada, within Environment Canada, is the agency responsible for delivering the country’s weather services. The MSC weather observing station, located next to the Iqaluit airport, is one of a small number of sites where weather



**Fig. 1** Location of Iqaluit, Nunavut with local terms for important areas



**Fig. 2** The Iqaluit pier at low tide in July 2009

observations are taken in the eastern Arctic. The forecasts for Iqaluit are issued from the Prairie and Arctic Storm Prediction Centre office in Winnipeg, nearly 2,300 km away. A concern raised by participants is the significant distance of the forecasting office from Iqaluit, as some research shows that the ability of forecasters to interpret and modify the output of numerical models (e.g. by factoring in how such local phenomena as prevailing wind direction or the distribution of snow cover) becomes degraded as one moves away from the local area (Roebber et al. 1996). In addition, the community is located uphill from the airport, the site of the in-situ observations. Weather conditions will often be worse upslope in the town but that information is not directly available to the forecasters.

Currently, residents of Iqaluit face many challenges in gaining access to weather services and local weather knowledge. At the most basic level, there is a problem of accessibility when information is provided in only one language, English or Inuktitut, which excludes non-speakers of that language. Another form of inequality can be found in the distribution of local weather knowledge, in that young people and newcomers lack opportunities and time to have acquired necessary skills and experience. Weather information, both scientific and local, is dispersed among various sources and in multiple formats, sometimes making it difficult for an individual to get a complete picture of what is happening and what is expected. Finally, conditions on the land can change very quickly and can be different from what is experienced in town, making accuracy of information a constant challenge. All of these issues will be discussed in detail below.

### 3 Methodology

To understand local perspectives on hazardous weather and related information in Iqaluit, we collected qualitative data using conventional social science methods such as interviews and participant observation (Bernard 2011). In July and August 2009, one member of the research team recorded 37 semi-structured interviews with Inuit and non-Inuit long-term residents. During her two month stay in Iqaluit, this researcher also observed and participated in community events and land-based activities, such as taking trips on all-terrain vehicles, visiting cabins down the Bay, fishing and hunting seal (*Phoca hispida*). By

accompanying local residents on their outings and engaging in participant observation, the researcher was able to experience, document, and discuss hazards as they were encountered, thus developing an understanding of local practices, attitudes and knowledge that goes beyond what was revealed in interviews.

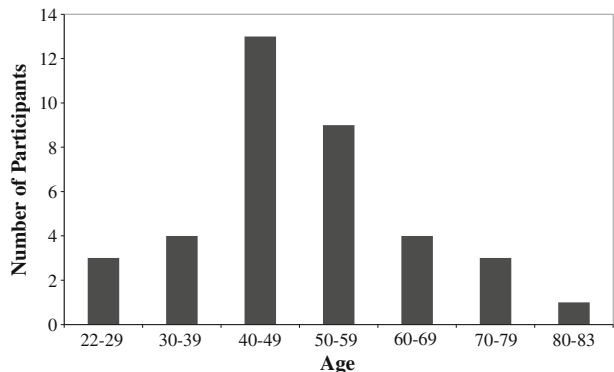
Our research objectives were (1) to describe current weather information services in Iqaluit and identify any deficiencies, and (2) to identify gaps in weather-related knowledge among residents. In order to meet these objectives, we used a purposive sampling strategy in which we sought out participants who were knowledgeable about local weather and related hazards. We were not aiming to obtain a representative sample, but rather to gather a range of perspectives. Community members and representatives of relevant institutions, such as the Amarak Hunters and Trappers Association (HTA), the Department of Environment, Parks Canada, the Nunavut Research Institute (NRI), and Emergency Response Services, recommended key informants among long-term residents. Long-term residents with a variety of occupations and life experiences were interviewed, including: elders, hunters, outfitters, construction and sealift workers, boat owners, emergency response personnel (e.g. Coast Guard, Search and Rescue), and federal and territorial government personnel (Environment Canada, Parks Canada, Corrections, Department of Environment, Department of Health and Social Services, Department of Wildlife, Fisheries and Sealing, Nunavut Tunngavik Incorporated, the Nunavut Research Institute). The participants ranged in age from 22 to 83. The length of time participants have lived in Iqaluit (from eight years to their entire life), the amount of time they spend on the land (from day trips to one week or more at a time) and for what purpose (work or pleasure) were other important attributes that influenced knowledge and practices related to weather. Figures. 3, 4 and 5 show some characteristics of the participants.

Our initial focus on ‘long-term’ residents also reflected the local distinction between ‘newcomers’ and long-term residents. Newcomers are generally people who have only been in the community for one to two years. Although residents often generalize and refer to newcomers as ‘non-Inuit’, newcomers can also be Inuit from other communities. The following quote helps explain the distinction between ‘transient’ and long-term residents in Iqaluit.

Very transient population. Some of that is a result of how jobs are offered here. Terms of employment are usually short-term, 1 year, 2 years, so there’s limited job security which creates that transient type mentality. (Inuit, 35, 10 years in Iqaluit)

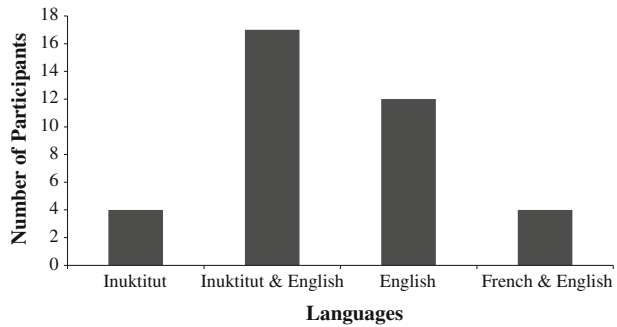
Long-term residents are people who know the community and the landscape. ‘Long-term’ is relative, including those who have lived in Iqaluit all their lives as well as those who have

**Fig. 3** Age of participants





**Fig. 4** Languages spoken by participants



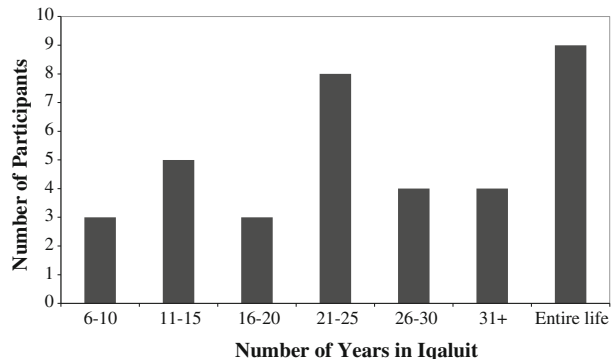
been in the community long enough to know the people and the land. The following quote from the same speaker illustrates how the terms are used by long-term residents themselves.

People who are new to Iqaluit who are outdoor enthusiasts... there’s a lot of them. We’re really concerned for their safety. I think there’s almost some resentment I guess among some of the *longer-term residents* and hunters, sort of lack of respect these people show towards nature. There’s like a community of *newcomers* to the community, non-Inuit who are active out on the land. (Inuit, 35, 10 years in Iqaluit)

With limited time for fieldwork, we decided to concentrate on the group we thought would be able to offer us the most useful data. Long-term residents have developed knowledge of both the land and the community over time and with experience. We assumed that longer-term residents would, therefore, be more knowledgeable about both the weather-related hazards and the type and reliability of weather information available. For this reason, newcomers were not included in the original sample. As we discuss below, our results indicate that newcomers are considered to be one of the groups most in need of weather hazard information. While restrictions on time prevented us from extending field work to add this group to the list of participants in the initial study, a follow-up study should surely include newcomers to complement the perspectives of the longer-term residents presented here and overcome this limitation in our data set.

The interview questions were designed with the input of forecasters from the MSC and then refined through discussions with the Manager of Research Design and Policy Development at the Nunavut Research Institute and the interpreter. Participants were asked open-ended questions about types of hazardous weather in different seasons, how they prepare for and know in advance about hazardous weather, how they receive their weather information,

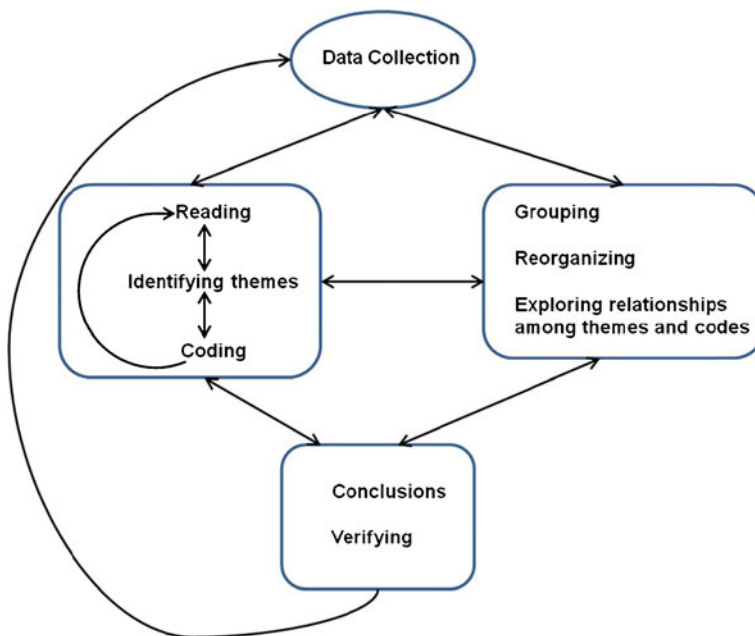
**Fig. 5** Number of years participants have lived in Iqaluit



the impacts of weather on their lives, their perceived safety, the importance of social networks, and recommendations for improving the value of weather information for Iqaluit residents. A sample of interview questions can be found in the [Appendix](#). Interviews were conducted in the language preferred by the participant: either English, French or Inuktitut. Interpreters were hired when necessary and participants were paid for their time.

Field notes from observations and transcripts of recorded interviews comprise the data that we analyzed using a theme coding approach (Miles and Huberman 1994). The documents were organized in a qualitative data analysis software program called TAMS (Text Analysis Markup System) Analyzer<sup>®</sup> (Weinstein 2009). This program facilitated code compilation as we read the textual data looking for content related to hazardous weather and related conditions. We constructed a hierarchy of codes, beginning with two broad themes: ‘scientific weather knowledge’ and ‘local weather knowledge’. Comments in the field notes and interview transcripts that related to either of these kinds of knowledge were highlighted and labeled, using the coding tool of the program, with one of these theme codes. Once the first phase of coding was done, we looked again at the data within these two broad themes and found that further division into subthemes for each kind of knowledge was possible; for example: ‘use’, ‘generation’, ‘access’, ‘reliability’, and ‘shortcomings’. The relevant content was thus recoded using these subthemes. Reading, coding, refining and recoding is an iterative process of interpreting data that is repeated until a meaningful level of detail is achieved that allows us to see patterns of shared understandings among participants and variations in the patterns. Figure 6 illustrates the interpretive analysis process.

Theme coding of qualitative data is especially useful when trying to determine the range of experiences, perceptions, information and attitudes within the study population. Even if something was mentioned by only one participant, it is included as valid data and may



**Fig. 6** Theme coding approach for interpretive analysis of textual data. (Adapted from Miles and Huberman 1994:12)

contain a valuable insight that helps to explain what others say and do. The assumption is that every participant has some shared and some unique experiences, and our aim is to get a sense of how these fit together. While statistical significance is neither sought nor achievable with this approach (e.g. to claim that 37% of Inuit residents consult weather forecasts via the Internet), systematic coding does provide indications of what kinds of knowledge or opinions are shared, and the relationships between various themes. For example, the subtheme ‘generation’ was created for the main themes ‘local weather knowledge’ and ‘scientific weather knowledge’ by grouping together such codes as ‘clouds’, ‘ice’, ‘wind’, ‘storms’, ‘tides’, and ‘precipitation’, which described knowledge of these weather-related elements. In this way, we could identify where local knowledge and scientific knowledge overlapped and which elements were more or less prominent in each knowledge system. Variations between and within segments of the local population were examined by investigating the relationship between such themes as ‘access’ and ‘use’ of local weather knowledge and the number of years a resident has lived in Iqaluit, their age, languages they speak, and the amount of time they spend on the land (examining both recreational and work-related activities). Through this process, we were able to draw such conclusions as: “older residents who have lived in Iqaluit for long periods of time have good access to local weather knowledge.” Figure 7 illustrates the coding structure.

To check how well the results represent processes and perspectives, we obtained feedback from key informants, including MSC personnel with forecasting experience in Iqaluit and other northern communities. All results presented in the following section, related to residents’ perceptions of hazardous weather and the kinds of weather information they use, are derived from the analysis we have just outlined of comments made during interviews and of observations made during participation in land and community-based activities.

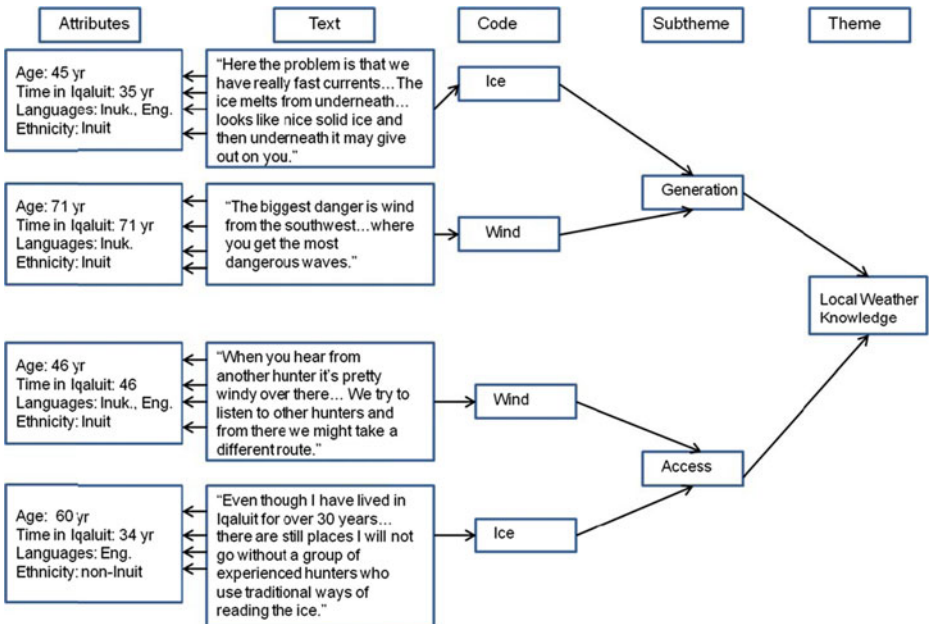


Fig. 7 Illustration of the coding structure for textual data

## 4 Results

In this section, we present the important insights that were gained from examining the interview and observation data. The results are organized into sections that match some of the major themes we found. We first describe local weather knowledge, how it is acquired, and how it is distributed among Iqaluit residents. Next, we describe scientific weather information available in Iqaluit. Then we describe how local knowledge and scientific weather information are used by different groups in Iqaluit. Finally, we discuss issues of inadequacy and inaccessibility of weather information, as reported by study participants.

### 4.1 Local weather knowledge

Iqaluit residents report that they often employ their own local knowledge to read weather conditions and assess likely hazards. Environmental phenomena such as clouds, the sky (e.g. phases of the moon, northern lights), behavior of wildlife, direction of the tide flow, snow drifts, and direction of currents (e.g. suggesting where the ice may be unsafe), were listed as local forecasting indicators used by both Inuit and non-Inuit long-term residents. Henshaw (2006a) discusses traditional weather indicators and the rich Inuktitut vocabulary used to describe a variety of cloud formations in the Cape Dorset area of South Baffin Island. Inuit make similar distinctions among types of clouds when speaking English, reflecting a keen awareness of changing conditions and potentially dangerous situations. One lifetime resident, whose father is an elder and an expert on local weather, talked about how to “read” the cloud formations.

Just reading from the clouds... we have the huge cumulus cloud you know it's not going to get that windy or that cold. We get double clouds... say the high cirrus clouds and the lower ones... we know there's going to be a tunnel there... like the wind. There's one... big long cloud... we know there's going to be a down draft so it's going to be pretty windy that day or that evening. (Inuit, 46, lifetime in Iqaluit)

Weather conditions on the ground in nearby communities, such as Cape Dorset and Kimmirut, are also used as predictors.

We always look towards Cape Dorset... If they get a blizzard that day, we know we're going to get the blizzard the next day or the day after or more. So we tend to look at other communities. (Inuit, 50, weekend hunter, lifetime in Iqaluit)

Residents acquire the skills to interpret weather and predict oncoming hazards by participating in various land-based activities, sharing stories with others, consulting with elders, observing people at work and by listening to the Amarok Hunters and Trappers Association's Inuktitut broadcast of dangerous ice and trail conditions. Land-based training is also offered in the schools. Formal courses, such as the Search and Rescue Management course, teach people how to interpret environmental indicators and how to understand weather reports. Other land-based skills, such as how to build snow shelters and navigate in bad weather, are learned from family members and other experienced residents during hunting and fishing trips (Fig. 8). Both Inuit and non-Inuit participants describe a training period when they first arrived in Iqaluit. For example, two Inuit residents, originally from Pond Inlet, explained that they only attempted to travel short distances on their own after a year of training with local hunters.

Participants report that the necessary skills for survival in various adverse conditions come with fifteen to twenty years of experience. Residents who have not

acquired a working knowledge of local weather and related environmental conditions often rely on other knowledgeable community members for advice. Those who have only been in Iqaluit for a short time and have few contacts in the community, consequently have access to less weather-related information. They are, thus, more vulnerable to hazardous weather and related conditions. A search and rescue worker explains that even residents from other northern communities are at risk because they are not familiar with local hazards.

People from other communities, young families coming here they buy machines and they go out hunting and if they don't know the land, they're pretty lost. The one [rescue] that we did in February, he was from Igloodik. (Inuit, 46, lifetime in Iqaluit)

The most important aspect of developing local weather knowledge is the amount of time spent engaging in a particular activity. For example, residents who are often on boats navigating the open waters know more about the tides and wind-prone locations in the Bay than those who spend the majority of their time on the tundra hunting caribou (*Rangifer tarandus*). One's knowledge depends on one's level of experience pertaining to a particular season or locale, whether tundra, sea ice or open water.

Local knowledge is not only used to predict weather and related hazards, but also in coping with hazardous weather as it is occurring to mitigate or avoid problems. In one example, a teacher recounts her experience of being led home during a blizzard by fellow community member.

We got stuck in a whiteout on the ice and [Johnny] said "we're going to be okay". He totally reassured us and we had tea and everything and it was really blowing snow. The way he got us home was he stood up on his skidoo and he turned his head a certain way and the wind hit him here (points to her face) in the exact same position from across the Bay all the way here. As soon as it moved he would go back to the position. When he got back he had huge frostbite right here (points to her face, cheek). And that's how we got home. If he can get us home in a complete whiteout I'm totally okay. (Inuit, 28, teacher, lifetime in Iqaluit)

This kind of episode demonstrates not only how local knowledge is used, but also how it comes to be trusted.

**Fig. 8** Youth learning land-based skills



## 4.2 Scientific weather information

Iqaluit residents have access to scientific weather information via the radio, television, Internet, and by calling the Environment Canada Public Weather Recording toll-free number. The types of information available include: temperature, wind speeds (available in kilometers per hour, miles per hour, and knots),<sup>2</sup> precipitation (probability and expected accumulation), barometric pressure, relative humidity, visibility, ceiling and clouds, hazardous trail conditions (via the radio broadcast by the Hunters and Trappers Association), humidex/wind chill,<sup>3</sup> ice depth (very coarse scale), tide information (detailed times of low and high tide), and warnings of impending hazardous weather (e.g. blizzards). The Environment Canada Weather Line provides recorded weather forecasts and frequent updates throughout the day. It is a free, automated recording of current conditions, forecasts and warnings for many communities in the local calling area. In Iqaluit, this telephone service provides short-term weather forecasts (3–5 day), current weather conditions, tidal information, forecasts for the Bay, and information on impending hazardous weather. Most information is given in English and Inuktitut; however, the tide information, marine forecast, and 3–5 day forecast are offered in English only. There is only one forecast given for all of Frobisher Bay and it is very brief. For example, “Winds light. Temperature near +2°Celsius,” is a typical forecast for the Bay.

## 4.3 How local knowledge and scientific weather information are used

Long-term residents integrate their own ways of knowing the weather with the scientific weather forecasts. Study participants perceive both local and scientific weather information to be credible sources of information, but in different contexts. Scientific weather forecasts are perceived as relevant when in the community, while local weather knowledge is used to increase safety while traveling on the land, boating or hunting. The following quote from an Inuit hunter illustrates the perception that the scientific forecasts are only useful in town.

The forecast for Iqaluit is for here. Even last week, it was windy right here in Iqaluit but you go out, just over to the next harbor and it's calm. So they're saying it's windy here but calm over there. If you go up on the hill you can see across the Bay it's all flat water. It's very localized. (Inuit, 40, active hunter, lifetime in Iqaluit)

Scientific forecasts are best used to get an idea of general conditions and to know in advance about any impending hazardous weather, according to participants. A forecaster explained that the weather forecasts cannot be more specific because there are limitations on the acceptable terminology and restrictions on the amount of information that can be conveyed through the media and other distribution systems.

Local knowledge provides the framework for interpreting how the conditions reported in scientific forecasts may pose a threat to personal safety. For example, local knowledge of the land and weather is used to determine which locations away from the community may or may not be suitable for travel. The wind forecast given by the MSC is important; however, there are several locations in the Bay where wind is always a concern. Therefore, combining the wind forecast with local knowledge of ‘windy’ areas is the only way to be safe in certain

<sup>2</sup> A knot is a unit of speed defined as 1.852 km per hour.

<sup>3</sup> “Humidex” is an index combining temperature and humidity used to describe how an average person perceives hot air through skin. “Wind chill” is an index which takes into account how wind makes cold air feel colder on skin.

parts of the Bay. The following quote illustrates how residents use the wind forecast in combination with their own knowledge of environmental indicators.

You look at the clouds, you look at the wind, you look at the forecast you know. I always monitor the weather forecasting and then I just look at the clouds. (Inuit, 36, weekend hunter, 11 years in Iqaluit)

Residents draw on past experiences with scientific forecasts to help predict the timing of hazardous weather events. For example, participants explained that predicted conditions tend to occur 12 to 24 h later than the forecasts indicate. Residents then adjust their interpretations according to this observation that the forecast is ‘early’.

One of the real common ones we have here is that the forecasts are early. What they say it’s going to be like tomorrow morning, happens tomorrow night... about 12 h off very consistently... it’s amazing because people have been known to just assume Environment Canada’s forecast is 12 h off. It’s funny there a couple years ago... it was just consistently the same and people just got used to it. So whatever the weatherman said, they made their own adjustments. There must be something to that. It was, or it is, too common for it to be just a random event. I know some communities up here have similar concerns. (non-Inuit, 46, weekend hunter, 14 years in Iqaluit)

All participants who are active on the land report using some sort of technology to increase safety and preparedness. Examples include using sonar to know the depth of areas in the Bay, global positioning systems (GPS) to help navigate, radios to communicate with other boaters or hunters, satellite phones for emergencies, and personal locator beacons to notify authorities if lost or otherwise stranded on the land. Participants also explained that while these are helpful tools, they cannot be used as a replacement for local knowledge. A lifetime Inuit resident and experienced outdoorsman explained that technology, such as GPS, must be used in conjunction with one’s local knowledge (e.g. of trail conditions, safe land and ice-based routes, navigational markers) to be most effective. This is consistent with other research conducted in Arctic communities (Aporta and Higgs 2005; Ford et al. 2010). Some participants report that they access information online to see the weather patterns around the islands and then combine this information with their local knowledge of the land. For example, residents consult the wind forecast and use tide sheets to know the timing of low and high tide. They then make connections between wind and tide direction and their local knowledge of hazardous conditions. Others explained that once they know where the clouds are and how they are moving or changing, they make their own predictions based on what has happened in their past experiences. This data shows that in various ways, local knowledge and scientific knowledge are used in conjunction for optimum results.

#### 4.4 Issues of inadequacy and inaccessibility of weather information

Our proposal to include local knowledge in weather service forecasts addresses the two major concerns Iqaluit residents have in relation to hazardous weather: (1) the information provided in scientific forecasts is limited and (2) access to local weather knowledge is unequally distributed. The nature of these problems is discussed below.

The first problem is that scientific forecast information is limited in several ways. One issue is the difficulty in getting current information. Residents consult forecasts both prior to travel and when away from the community; however, the weather can change very quickly and updates to forecasts cannot always be obtained. Beyond the islands in the Bay, for instance, cellular telephones do not receive signals and the weather broadcasts are

unavailable using very high frequency (VHF) radios. Therefore, unless residents own satellite telephones or expensive radios, they have to rely on reading the weather signs themselves. Another problem is that the sparse data and complex nature of the region's weather complicate forecasting for the south Baffin Island area. While weather and marine forecasts are available through various channels, adequate information about sea ice conditions, wind and tides, which can produce some of the most hazardous conditions for travelers, is not included. The quote below illustrates the importance of getting updated information on tides.

Aside from the dangerous weather, one of the factors that we have to consider here at least in Iqaluit and down in Frobisher Bay is the immense tide system that we have here. As a hunter, you have to be aware of the tide at all times. Even though we know that it's a 12 h cycle, the tide moves and certain times of the month the tide is much higher than the other days, so we have to be mindful of that and watch it all the time. (Inuit, 54, weekend hunter, 30 years in Iqaluit)

While tides can be predicted accurately over a great length of time, storm surges are much harder to forecast because they depend on wind characteristics such as speed and direction. Thus, people need information about how the tide and wind are interacting, and this is not currently available. An MSC forecaster affirms this and points to the expectation that residents will be generators and not just receivers of information:

Normally, Environment Canada does not forecast storm surges for the Arctic although tide tables are available for all areas. Hopefully, Arctic residents will be able to do their own rudimentary surge forecasting based on the predicted wind speed and direction. Wind acting on open water over sufficient distance and time will give you waves. Currents (including tidal currents) can also create rough seas, especially near shore. (Forecaster, Prairie and Arctic Storm Prediction Centre, MSC)

The need for locally specific information is particularly important in many locations down the Bay, where residents can experience completely different weather than what was forecast for the community of Iqaluit. Residents who spend time on the land and water describe the inner bay as behaving much like a big lake, in that the most hazardous weather conditions in all seasons relate to wind. Offshore and onshore winds, abrupt shifts in wind direction, winds that pick up without notice, an increase in south/southeast winds (which make conditions in the Bay treacherous for travel) are all notable wind-related concerns. There is a clear need for more detailed information on wind as well as for supplements to Iqaluit forecasts that describe how conditions may be different further away from town.

There is variation in how reliable different kinds of scientific forecasts are perceived to be and some are used more than others. The most reliable are said to be the marine and short-range forecasts (versus long-range). The marine forecast is available from July 1 to October 31 online or through the weather radio or automated telephone service. It is the only source of information for areas outside the community, at three predetermined locations down the Bay. Ice charts are also perceived as being fairly reliable, especially when used with satellite imagery, both of which can be viewed online. In contrast, participants report frustration with what they perceive as the consistently inaccurate timing of weather events forecast by the weather service. Coupled with the changes they see to the 3–5 day forecast every day, the overall perception is that the weather service is unreliable for information on weather conditions on the land as well as for specific information, such as wind speed and the onset of storms. Hunters describe the difficulties associated with planning weekend trips. They explain that they like to start planning mid-week but that the long-range forecast very seldom



stays the same and there are usually several changes before the weekend arrives. For those who are only able to gather country foods on the weekend, planning and preparedness are essential; however, changing weather makes this difficult. The issue is not lack of information in this case; rather, the variability in the weather, which is reflected in the changing forecasts, results in a perception of unreliability.

Sometimes scientific forecasts conflict with local weather knowledge. Some long-term residents said that if the weather service forecasts hazardous weather for the afternoon, but their local knowledge tells them that it will occur the next day, they may go out on a day trip and just keep monitoring changing conditions. If they were traveling with family, children, or clients, however, the overwhelming response was that they would not take the risk if such a conflict of information occurred. In assessing risks, participants explain that they would feel safer if the forecasting was done closer to home. Interviews and informal discussions show that one reason long-term residents question the reliability of the weather service is because it is a remote operation. They were more satisfied with the accuracy and reliability of the weather forecasts prior to the 1997 closure of the local briefing office, due to budget reductions. Thus, long-term residents displayed more confidence in sources of knowledge, whether local or scientific, when it was produced close to where they live.

The second problem contributing to the vulnerability of Iqaluit residents to hazardous weather is that local knowledge, which could be used in coping and adaptation strategies, is not widely distributed. Many long-term residents rely on real-time weather reports from people on the land for warnings in advance about hazardous weather. Hunters and boaters, for instance, share information on weather and related conditions using citizens' band (CB) radios or cellular telephones. Cellular telephones have a limited range of approximately 20–30 km from the community. CB radios have a similar range but depend on proximity to other boaters. People are at risk if they do not have a CB radio, are out of range with other boaters, or are unable to read the weather using their own local knowledge of environmental indicators. Moreover, the majority of residents who use the radios speak in Inuktitut, so CBs are of little use to most non-Inuit who speak only English and/or French. For this reason, long-term non-Inuit participants explain that they often travel with a friend or family member who can translate. Newcomers generally have fewer contacts in the community and thus, limited access to local information. This is especially problematic given that the scientific weather forecasts are perceived as unreliable for locations away from the community.

There is agreement among participants that inexperienced groups, such as new residents and youth, need to be better informed of dangerous conditions and locations. It is impossible to develop weather-related expertise and other necessary skills for survival in only a few years, they say, leaving newcomers vulnerable to weather hazards. In addition, long-term residents are concerned for youth who are spending increasingly less time learning important land-based skills. One elder described the risks of traveling for inexperienced youth:

Now the reason for today's large number of search and rescues and so on is attributable to the majority of us not having grown up out there. The majority of the population grows up within the city limits. Once they go past the city limits, the younger population anyway, automatically get lost because they don't know the land. They're not well-versed in living under those conditions and so they go among themselves without an elderly person or someone who knows the land there's a good chance they will get lost or they'll have a breakdown of their equipment and so search and rescue has to be activated. But still you need that ability that in the past it took all of our lives to learn about the conditions, the seasons, and the ability to forecast or

recognize signs around us—about the climate, possibly changing weather and basically how to take refuge or take shelter. That is basically absent today among the younger population...For example, today's kids look outside and visibility is good... let's go without thinking about what the weather may turn into. Today's kids depend too heavily on the forecast on the radio, for example, and of course it's not always dependable. In the past we grew up observing things around us and just looking at the cloud formation for example. (Inuit, 83, elder, lifetime in Iqaluit)

As noted in the quote above, the problem is exacerbated when inexperienced people rely solely on scientific weather forecasts. A coordinator of the local Search and Rescue confirms that this contributes to the large number of youth who require search and rescue services because they are unprepared for unforeseen hazards, such as sudden changes in the weather, and become stranded while on a day trip.

It is not only youth who lack experience and local knowledge. For example, newcomers who go boating on the Bay are unfamiliar with the shallow areas and locations of exposed rocks that become hazardous during low tides. An Inuit resident of Iqaluit with three decades of experience on the water explains the risks to newcomers:

Long-time residents are quite aware where shallow areas are but there's always new people and with the type of speed we have now these days, you could wreck your boat or wreck your outboard motor or even kill the occupant of the boat if you should happen to run across at high speed. (Inuit, 54, weekend hunter, 30 years in Iqaluit)

To address these many concerns, participants indicated that local knowledge of hazardous weather and environmental conditions should be more widely shared, documented and disseminated, as illustrated in the following quote.

So everyone from my generation, in their 80s or 70s, the knowledge is there. But our thinking too is that it would help if people are asking for that information... for us to share it wholeheartedly and for that information be dispersed more widely. (Inuit, 83, elder, lifetime in Iqaluit)

Taking into account this view and other insights from the study participants, in the next section, we make some recommendations for how to reduce vulnerability to hazardous weather.

## 5 Discussion: recommendations to reduce vulnerability

This study suggests that individuals in Iqaluit lack important information required to make fully informed decisions about the risk associated with different activities on the land. Iqaluit, and Arctic communities more generally, need weather services that systematically integrate local and scientific weather knowledge because: 1) the scientific weather forecasts alone do not adequately prepare residents for travel away from the community; and 2) many residents do not have sufficient local weather knowledge skills and/or resources. Long-term residents employ a variety of ways of knowing about the weather and other weather-related hazards, including using a local knowledge framework to interpret the conditions reported in scientific forecasts; however, even long-term residents have restricted access to local weather knowledge due to various social factors, such as culture, language, age, and limited social networks. Inexperienced residents, such as newcomers and youth, run a much greater risk of injury or death when they go boating, snowmobiling, hunting, fishing, hiking, and off-roading with all terrain vehicles. By providing improved access to local weather

knowledge, an integrated weather service can help reduce the annual number of search and rescue operations, as well as weather-related injuries and deaths. This is critically important given the limited resources available for search and rescue in the Arctic. For example, despite there being 35 volunteers for search and rescue in Iqaluit, including an Elders Advisory Group that advises on weather conditions in the area and possible locations of the lost party, the 2009 budget for search and rescue operations in Nunavut was already surpassed in March (Direction of Protection Services, personal communication). Thus, there is an essential need for a platform through which local weather knowledge can be shared among all residents in Iqaluit, and Arctic communities in general.

Anthropological research suggests that public understanding and potential use of weather forecasts can be increased by addressing cultural and linguistic issues in the process of generating and disseminating forecasts (Pennesi 2007; Pennesi 2011). The recommendations we present below are the result of this type of exploratory study and require additional refinement and protocol development. They are some first steps toward increasing the scope and types of weather forecast information provided to Iqaluit residents to help reduce some of the risks and impacts of hazardous weather. These suggestions for improvement are based on the insights and observations brought up in the interviews and in correspondence with personnel from the Meteorological Service of Canada, as well as on the information gathered through participation in community and land-based activities. It is recognized that many of these recommendations would require significant additional resources for implementation. Logistics and the costs of doing business in the Arctic are significant obstacles that require consideration. Critical to improving the value of weather-related information is the involvement of the community with representation from various user groups.

### 5.1 Form a weather hazards impact advisory group

The formation of a weather hazards impact advisory group, with representation from diverse interests in the community, is proposed with the objectives of assessing weather event impacts on the community and of providing mitigation recommendations. The resulting recommendations may also offer additional direction for the long-term objectives of hazardous weather research and for the transferability to other communities. The exact composition of this group would be determined by community members, but could be formed through cooperation among the Nunavut Research Institute, Nunavut Tunngavik Incorporated, Search and Rescue, MSC and local groups, including hunters and trappers, fishermen, outfitters and guides. This advisory group could play important roles in the further clarification and implementation of several of the following recommendations. The local group members could also play a ‘public advocacy’ role that would help to provide the financial support needed to implement several of the recommendations.

### 5.2 More formal and consistent documentation and dissemination of local knowledge

Local weather knowledge, like that obtained from long-term Iqaluit residents, can help address forecasting challenges in remote regions such as the Arctic and save lives if made available to all residents, particularly those with few land-based skills and experience. Local indicators based on local knowledge, such as the locations of important seasonal trails and routes, decision-makers’ needs, and residents’ attitudes towards weather, can be incorporated into weather service practices to provide higher value predictions that are more useful to those whose well-being and livelihood depend on knowing the weather in locations away from the community (e.g. Morss and Ralph 2007).

Active hunters, boaters, snowmobilers, and recreational enthusiasts rely heavily on real-time weather reports from people on the land because these reports are perceived to be the most reliable form of weather information. The weather hazards impact advisory group should, therefore, lead an initiative to include such local information as supplemental information in forecasts. This could be transmitted to the weather office by telephone or CB radio. Protocols would need to be developed for soliciting, verifying and translating these observations, and for communicating them effectively in real-time as part of local weather forecasts.

### 5.3 Provide hazard maps and marking of hazardous locations

Maps of seasonally hazardous areas on the land and in Frobisher Bay, similar to the maps some provincial ministries of transportation have for winter road conditions, would be very beneficial. Windy, protected, shallow, and rocky areas, as well as areas that are prone to strong currents and thin ice, could all be documented and these maps could then be made widely available. A team of ArcticNet researchers is currently working towards creating hazard maps for the Iqaluit area (Ford 2010). In order for the maps to be most effective, they would have to be a collaborative effort between the community and the governments. Discussions among a variety of government agencies would be needed to decide which would be responsible for preparing maps and distributing and maintaining the markers.

Maps could be made available online, on television as part of the weather forecast, and even printed and posted in the government office and Hunters and Trappers Association office in town. One area of particular concern is the inner Bay. Seasonal hazard maps of the Bay could be useful to both new and long-term residents and it would be most beneficial if the maps were continually updated with input from active hunters, boaters, and snowmobilers. This is important due to the often rapidly changing conditions. The Inuit Sea Ice Use and Occupancy Project, which uses both Inuit and scientific knowledge to document and map local sea ice expertise and the impacts of climate change, has produced the Atlas of Inuit Sea Ice Knowledge and Use (SIKU) which documents Inuit knowledge of sea ice and some changing weather conditions around Baffin Island, Nunavut (Krupnik et al. 2010). Combining the results from this study and the ongoing Iqaluit Land-Use Mapping Project (Ford 2010) could be an important contribution to the Atlas.

Physical markers indicating unsafe locations both on land and in the Bay would help prevent newcomers and other inexperienced residents from severely damaging their equipment, becoming stranded, lost, injured, or even killed. Many participants express great concern regarding the absence of markers in the Bay, especially in shallow areas, where high speed boaters travel over extensive areas and the large number of new residents travel. A wind forecast, for instance, becomes much more useful and relevant when possible implications of wind speed and direction at different locations on the land are provided with the meteorological information.

### 5.4 Integrate weather-related information sources

There should be one source which provides all available weather-related information in multiple formats. Taking steps towards a formal and consistent platform by which local weather knowledge as well as MSC and related forecasts can be accessed and used by all residents will help reduce vulnerability to hazardous weather by providing residents with more information on which to base their decisions related to travel and hunting activities. It would be helpful for residents to be able to access all the weather-related information for

their community from one source. Currently on MSC's weather office website, satellite information, weather, sea ice, and marine forecasts are all separate links which require navigation to obtain the information for Iqaluit. Since participants report that the most hazardous weather conditions in all seasons relate to wind, wind forecasts would be much more useful and relevant if possible implications of wind speed and direction at different locations on the land were provided. Tidal information is also important. Similar issues exist for other forecast distribution systems (e.g. radio, television, automated telephone service). This important recommendation would require cooperation across several government agencies; a single website would be possible but providing information to those on the land and those without access to the internet is problematic. To address this, the same information could be provided by this single source through multiple formats such as television, radio and phone services. Thus, individuals can choose the most convenient format through which to access the information and be assured that they were receiving the most complete and up-to-date data. A single source of integrated information should also improve the credibility of the forecasts because deficiencies in one source of knowledge could be offset by competency in another.

Another recommendation is for the activation of a volunteer weather watcher network in the southern Baffin Island area. Meteorologists at the Prairie and Arctic Storm Prediction Centre highlighted the importance of real-time weather reports from people on the ground. This volunteer network could be used to gather information supplementary to that of employees of local businesses and nursing stations which provide weather reports. These community contacts are not standardized or consistent across the north but when used in conjunction with the limited number of web cameras in the north, often provide forecasters with invaluable weather information and are critical to issuing reliable forecasts in the Arctic where data are scarce. An additional benefit would be the identification of key informants in the community with which to maintain an ongoing interaction.

### 5.5 More sharing of information across language groups

This study reveals that although information on hazardous weather and environmental conditions is shared among residents who are active on the land, have access to various social networks and who speak Inuktitut (or are close to someone who can translate), this information is largely inaccessible to Anglophone and Francophone communities, as well as to the population of newcomers to Iqaluit who want to get out on the land. For those who do not have the community contacts, the Inuktitut broadcast of dangerous ice and trail conditions by the Hunters and Trappers Association should be made available in all official languages. Inuit participants expressed concern that the marine forecasts are only available in English. Despite the relatively high proportion of non-Inuit in Iqaluit, mainly older Inuit participants expressed the need for Inuktitut marine forecasts. It is important to note, however, that information given in one language is not necessarily the same information when translated.<sup>4</sup> Researchers across the Arctic are working on preserving this knowledge but the loss of language among Inuit youth and the changing linguistic and cultural composition of the community are compounding the impacts of hazardous weather by restricting access to this critical information. Thus, care would have to be taken with translation and be done by people rather than automated translation systems.

<sup>4</sup> See Henshaw's (2006b) study on the use of toponyms in the southern Baffin Island area as navigational aids and for cultural preservation.

## 6 Conclusion

This paper provides local perspectives on what should be done to improve the usefulness of weather services in the North as one strategy for improving adaptation to climate change. The focus is on the particular case of Iqaluit because of its unique demographic composition and its frequent exposure to hazardous weather. The benefit of a case study approach is that, even with a small number of participants and a short time frame, we are able to gain a deeper understanding of how scientific weather services are accessed and used, and how the information is incorporated into local forms of knowledge. Although the study is limited to only one community, in a larger context, the experiences and recommendations reported by Iqaluit residents are relevant to other Arctic communities who also need improved strategies for undertaking land-based activities in hazardous conditions.

The major findings of this study, which should be of interest to those living and working in Arctic regions outside Canada, are summarized below. First, we found that while some scientific information on weather hazards is widely available to most community members, it is limited in scope and there are important gaps that should be filled according to local needs. Furthermore, accessibility could be improved by providing translations for all information in the local languages. Second, we found that local knowledge of weather and environmental conditions is both reliable and useful, but some sectors of the population lack access to this knowledge, notably youth and newcomers. Third, we conclude from the first two points that integrating local and scientific knowledge in the most widely accessible formats would be most effective in improving risk assessment and decision-making, thereby reducing vulnerability to weather related hazards. Fourth, in order to achieve such an integration of systems for generating and transmitting knowledge, local people (indigenous and non-indigenous) must be involved in the entire process, and not just employed as consultants from whom information is extracted and added to current scientific and bureaucratic models. This last point has been made in other contexts and is fundamental. For example, Nadasdy (1999) demonstrates that when “traditional” knowledge is integrated with scientific knowledge but incorporated into existing bureaucratic and technical systems, power is concentrated in administrative centers, while indigenous people remain “informants”. The hazardous weather impacts advisory group we are proposing attempts to address this potential problem by ensuring that local people are able to express themselves on their own terms and in relation to their own beliefs and practices, to inform fellow community members as well as scientists.

This study indicates that both indigenous and non-indigenous people need access to both local and scientific knowledge in order to be best prepared for going out on the land, even for short trips. The two types of knowledge can be complementary (though sometimes conflicting), filling in gaps of scale, scope or quality inherent in one or the other. The local knowledge that circulates in town among the experienced hunters is a reliable source of weather-related information. If one has access to this knowledge, understands the information, and takes the appropriate action, vulnerability to hazardous weather can be greatly reduced. Forming a community group to work together with scientific forecasters and government agencies, advising them on hazardous weather and making recommendations, can contribute to an integrated weather service that helps reduce the annual number of search and rescue operations, as well as weather-related injuries and deaths. Implementing recommendations suggested in this research will make hazardous weather information more accessible and useful to northerners and improve longer-term involvement of northern communities in, and support for, these types of hazard-awareness initiatives. The insights of long-term northern residents gained in this study offer a unique contribution to our

understanding of how weather services can be improved for use in the north and make steps towards a future where we move beyond the ‘one size fits all’ forecasting framework.

This is an exploratory, preliminary study and future work is needed to yield further insights. For example, we need to look at how factors such as ethnicity, language, age, length of residence, and the nature and extent of land-based activities influence perceptions and uses of weather information, as well how weather forecasting interacts with Inuit environmental decision-making. Another important step in expanding this research is to work with the MSC to carefully examine how the current forecasting system works, in order to determine how some of the recommendations outlined here could be implemented and to identify further obstacles and possible solutions. The proposed weather hazards impact advisory group should be involved in reviewing and recommending actions and in monitoring how they are carried out. In this, we agree with Ford and colleagues (2010:188) that “interventions will be more successful if they are identified and developed in co-operation with local actors and policy makers, who will be more likely to trust them, find them consistent with their goals, norms, and policy objectives.” As they note, “recommendations that have not been identified and developed in collaboration with communities or policy makers are unlikely to have the required legitimacy and integration of Inuit knowledge that are essential to decision making in the new North or understanding of how adaptation links into the policy process” (Ford et al. 2010:188). The participation in this study of Inuit residents, non-Inuit residents, local government representatives and MSC personnel is moving us toward more effective weather services and better adaptive strategies.

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## Appendix

The following questions are taken from the interview schedule used in this research to illustrate the kind of data the project generated.

Participant background:

1. How long have you lived in Iqaluit?
2. Do you get out on the land with work? Pleasure? Both?
3. How often do you get out on the land? How long are the trips?

Hazardous weather in different seasons or pertaining to various activities:

1. What would you consider to be hazardous weather?
2. In the summer (fall, winter, spring), what kind of weather poses a concern?
3. Are there certain months or times of the year when you will avoid travel?
4. When you travel by boat/snowmobile are there certain routes that are more/less hazardous?

Impacts of hazardous weather and related events:

1. Have abrupt changes in the weather ever left you stranded out on the land?
2. Have you ever experienced damage to your property (e.g. house, cabin, equipment, building materials) due to storms or other bad weather?

Weather information:

1. How do you receive weather information (including your own knowledge)?
2. Do you share/listen to weather updates on your CB radio?
3. When on the land/in town is there any information that you don't have but wish you did?
4. If you saw that Environment Canada was predicting a storm/strong winds, etc. do you sometimes use your own discretion and go out anyway?
5. How do you keep watch of impending hazardous weather when on the land?
6. What are some suggestions you think would help improve access to weather information?

Social networks and communication of information:

1. Do you feel that you have a lot of people you can turn to here for help in times of hazardous weather?
2. Do you consult with others about the weather?
3. Are there certain people you would ask for advice before going out on a trip?

Preparedness:

1. Do you think the City of Iqaluit is prepared to deal with weather-related emergencies?
2. What do you do to prepare for bad weather when a storm warning is issued?
3. When you're going out on the land, what kind of things do you do to prepare?
4. Do you bring a CB radio or other communication devices?

Hazardous weather in town versus on the land:

1. Have you experienced weather in town that poses a threat to you and/or your family?
2. How have closures (of institutions, offices) had an impact on your day-to-day life/your business?
3. Is weather experienced out on the land different than what is forecast for Iqaluit (the town)?

Changes in hazardous weather and related events:

1. Have you noticed changes in the weather?
2. Is predicting or forecasting the weather different today than it used to be?

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