Connecting Community Observations and Expertise with the Floe Edge Service

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All photos by G. Laidler, unless otherwise specified

Workshops held in:
Cape Dorset, Pangnirtung, and Igloolik, Nunavut

Workshops held on:
November 1, 8, and 15, 2007

*Workshops hosted by the **Hamlet Office** in each community, and funded by the **Northern Ecosystem Initiative** (Environment Canada) and the **Inuit Sea Ice Use and Occupancy Project** (Government of Canada International Polar Year Program)*

Northern Ecosystem Initiative

Carleton UNIVERSITY

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Table of Contents

Background

Building on previous collaborative research in the Nunavut communities of **Cape Dorset, Igloolik,** and **Pangnirtung** (**Gita Laidler**) and extensive research experience on similar issues (**Chris Furgal**, in Nunavik and Nunatsiavut), these workshops on ***Connecting Community Observations and Expertise with the Floe Edge Service*** were organized to further explore the nature of sea ice and weather change with the three collaborating communities. These workshops also enabled more community-specific discussions to expand upon the ***Community-based Inuit Qaujimajatuqangit (IQ) weather and sea ice forecasting workshop*** held from March 5 - 6, 2007, in Iqaluit, Nunavut (hosted by Environment Canada (EC) and Indian and Northern Affairs Canada (INAC), with three community representatives from each of Cape Dorset, Igloolik, and Pangnirtung present). Specific emphasis was placed on connections between Inuit and scientific knowledge to improve northern community, and EC capacity to monitor and predict weather/sea ice conditions. This involved close collaboration with the EC Science Assessment and Integration Division (**Darrell Piekarz)**, the Canadian Ice Service (**Roger DeAbreu**), and Noetix Research Inc. (**Tom Hirose**).

With funding and support from the **Northern Ecosystem Initiative**, and the **Inuit Sea Ice Use and Occupancy Project**, the **Polar View Floe Edge Service** (www.noetix.ca/floeedge) was expanded to the communities of Cape Dorset, Igloolik, and Pangnirtung by **May, 2007**. In **November, 2007** we wanted to follow up with local information sessions and a research workshop in each community to introduce the service, get feedback on initial products, and conduct preliminary evaluations. Gita Laidler and Mark Kapfer were in Cape Dorset and Pangnirtung for these meetings, and Gita Laidler and Tom Hirose were in Igloolik. Our goals for these trips included to:

1) **hold two public information sessions** about the expansion of the Polar View Floe Edge Service (i.e. satellite image products of regional sea ice and floe edge conditions); and,
2) **conduct a workshop** with the local hosts of the Floe Edge Service (i.e. Hamlet employees), several local sea ice experts, and several other community members that may be able to help provide access or interpretation support for community members. This was meant to tailor the service to community needs and priorities, as well as to learn more about local knowledge and uses of sea ice at different times of year, including weather prediction techniques that provide indicators for safe sea ice travel or hunting.

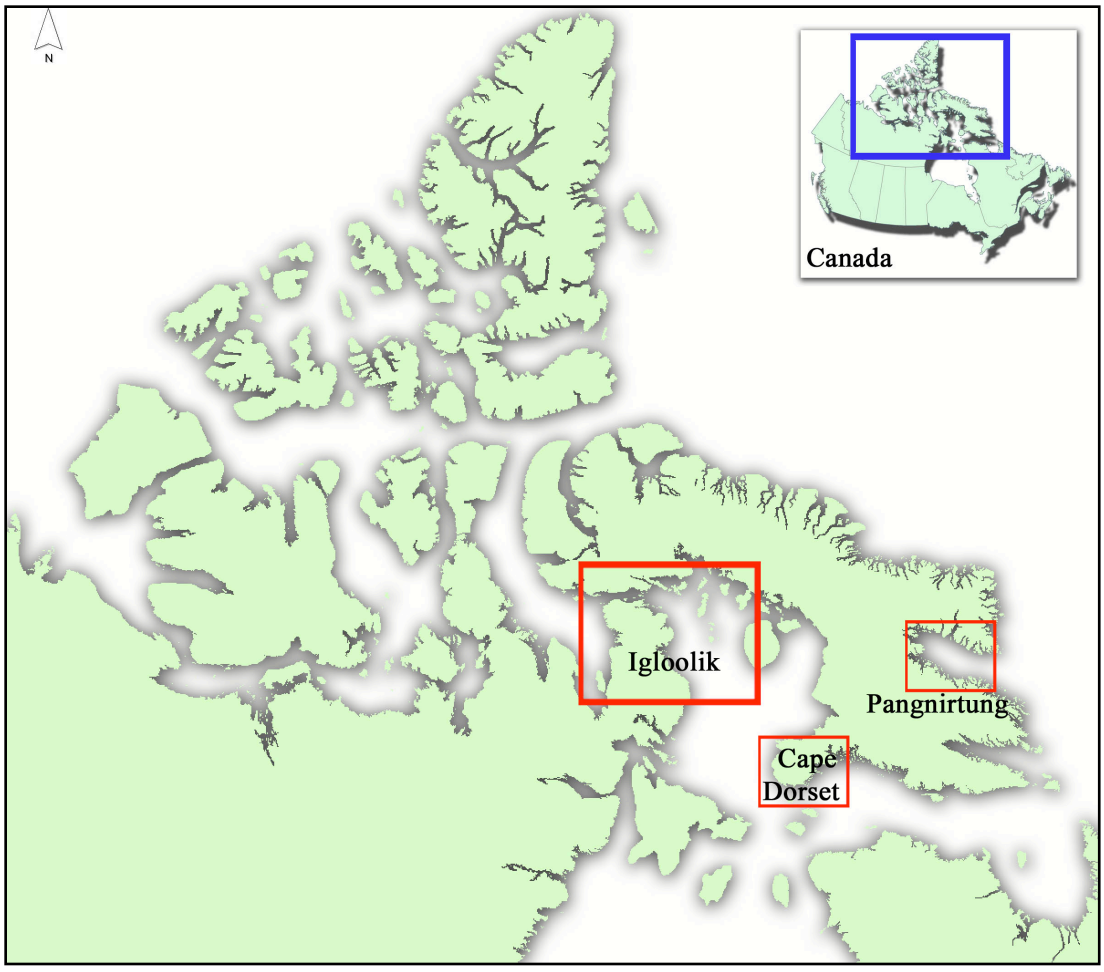
The **information sessions** drew a total of approximately 13 people in Cape Dorset, 16 people in Pangnirtung, and 23 people in Igloolik. Those that came seemed happy that the Floe Edge Service was now provided locally, and asked a lot of questions regarding access and interpretation of images. The **workshops** were critical in defining appropriate subset regions for the provision of image products that show areas of interest for community travel and hunting activities, identifying considerations for weather forecasts, and better understanding local needs and uses in accessing such imagery. Therefore, this report summarizes the discussions held in each of the community workshops held in November, 2007, in order to develop a more cohesive depiction of user-needs, as well as practical recommendations for:

i) improving the delivery of Environment Canada (EC) weather forecasting products (i.e. the northern-specific indicators that address local needs with regards to weather variables important for safe travel and navigation); and,
ii) refining sea ice satellite imagery products (i.e. type of information, and frequency of delivery) for community use.

Combined, these initiatives aim to enhance the user-friendly nature of forecasting products, and to improve region-specific services and information access for travel, land/sea ice use, and safety of northern community members.

Map of collaborating communities and associated Floe Edge Service Regions

(where workshops were held and areas covered by 2007 Floe Edge Service Expansion)



Cape Dorset Discussions

To access imagery, create an account at:
www.noetix.ca/floeedge/
OR visit the Hamlet Office to view regular image postings.

Cape Dorset Contributors

(Hamlet Chambers, November 1, 2007)

- **Atsiaq Alasuaq** (Elder's Committee, hunter)
- **Lucassie Aningmiuq** (Canadian Rangers, Search and Rescue, hunter)
- **Pootoogoo Elee** (Interpreter/Community Researcher)
- **Etulu Etidlouie** (Elder, hunter)
- **Matthew Saveakjuk Jaw** (former Mayor, hunter)
- **Mark Kapfer** (Facilitator/Noetix Research Inc.)
- **Gita Laidler** (Facilitator/Carleton University researcher)
- **Serge Lampron** (Hamlet Economic Development Officer)

Communicating about weather/sea ice conditions

One of the most prominent means of acquiring information about weather and sea ice conditions is over the local radio. Environment Canada (EC) weather forecasts are frequently consulted (based on the regular CBC North weather updates), but they are generally considered only "semi-accurate" and so hunters also seek out other sources of information in making decisions about travel and safety conditions. The lack of confidence in EC weather forecasts stems from:

- differences between locally observed conditions and EC-generated forecasts
- lack of timeline for forecasts (i.e. what time of day certain conditions could be expected)
- inaccurate translations (from English to Inuktitut) which can cause misleading interpretations, for example:
  - the forecast may say it is a nice day in Inuktitut, and then also say that there are 30km/h winds (*iquliaqtuq* is "nice and calm", so then you can't have winds (*anuriit*) as well)
  - at night when conditions are indicated as "clear", it will be translated as "sunny" in Inuktitut, which doesn't make sense to people
  - the sky may be described as *allarijuq* (no clouds), but then the announcer will add "a little bit cloudy" as well – people wonder which one is it?

Beyond the EC weather updates, the local radio is also an important medium for local elders and hunters to communicate their own observations of weather and sea ice conditions. Those who are travelling a lot, or who were at a particular location most recently, tend to go over the radio and warn others to avoid certain areas due to dangerous ice conditions, and they will describe the specific places of concern. Furthermore, it seems that the radio is increasingly used to communicate about ice conditions due to changes being observed, especially in transition times, but perhaps most in the spring (March/April) when sea ice is starting to deteriorate and the largest numbers of community members are travelling on sea ice.

Important local sea ice/weather indicators

There are many locally important weather and sea ice indicators used by experienced hunters and local elders in making their own predictions about seasonal shifts, the onset of bad weather, or the safety of sea ice conditions. These issues have been discussed in previous collaborative, community-based

sea ice research (see previous reports and publications at www.straightupnorth.ca), but specific to these workshops additional indicators were identified, including:

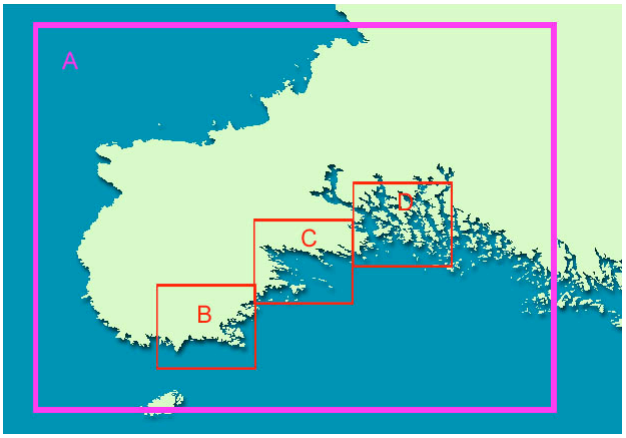
- Salisbury Island *(Akulliq)* - is located South of the island of Cape Dorset in Hudson Strait, and is used as a benchmark for when ice would begin to form in the Strait in the fall (i.e. the amount, or movement, of ice people can see in relation to the distant peak of the island)
- clouds - to scope distant ice formations, the reflection of water (dark) or ice (light) in the clouds is a common indicator employed by hunters
  - when the clouds are higher, can usually expect rain or snow (usually darker clouds)
  - 3 different levels of clouds that can be read to see what kinds of weather will come, and to make longer-term predictions
  - if it is windy and the water is rough, but it is quite cloudy and all the clouds are flat on the bottom, the weather will be nice and the water calm in the next day or two
- snow - large snowflakes falling in association with a southern wind is an sign of dangerous conditions to come, a big storm or the ice might break off (but large snowflakes in association with northern wind is of little concern)
- moon - a ring around the moon (*avaluarutsi[juq]*) is a sign of bad weather to come
  - at full or new moon, currents are usually stronger, so sea ice (and even river or lake ice) can be affected (i.e. thinner, or deteriorated from underneath)
- wind - when travelling along the west coast of Foxe Peninsula and the wind picks up from the west, it is an indication that a cold wind will be coming into the area
  - if the wind is coming from the south, it makes the water calm along the shore
- wildlife - if a *qaqsauq* (red-throated loon) or *tuuli* (regular loon) starts screaming a lot, bad weather is coming (mostly related to rain, in summer)
  - a *mitiq* (eider duck) will make a lot of noise when the winds will be picking up
  - when it is nice outside and *natsiit* (ringed seals) start to shake on the ice, it is a sign that it will begin snowing soon
- inlets - smaller inlets are the first to start freezing in the fall, but if the entrance to the inlet is large it will take longer to freeze than if it was narrower
- multi-year ice - helps make the water calm along the shore if the wind is from the south – links to weather forecasts (winds will be weaker than what the forecast says if there's a lot of ice in the area)

Potential local applications of the Floe Edge Service

After the introduction and overview of the Polar View Floe Edge Service provided by Mark Kapfer we: i) reviewed large format radar images of the Hudson Strait area to identify key areas of interest to provide relevant subsets of the regional image products based on important destinations or dangerous areas; ii) discussed the ways in which image products might be used locally; and, iii) discussed linkages between locally observed conditions and the types of conditions shown in the imagery.

The image subset areas were mainly defined by areas of use, and include:

Kinngait (B)	***Kangiak (C)***	***Kangiqsikutaq (D)***
• to cover *Tellik Inlet* and areas directly surrounding the community	• to cover Andrew Gordon Bay, the area with the largest extent of ice formation and important travel routes to reach cabins, fishing lakes, and geese hunting areas	• to cover *Saqvaq Inlet* and the frequently travelled route (by snowmobile and boat, in different seasons) to the soap stone mine, and connections to the community of Kimmirut



Map showing: A) region of Floe Edge Service coverage around Cape Dorset; B) Kinngait subset area; C) Kangiak subset area; and, D) Kangiqsikutaq subset area.

Interestingly, the western portion of Foxe Peninsula was not of much interest for satellite imagery coverage, since it was acknowledged that very few families travel west from the community around the peninsula. Usually there are very low tides in that area, and the ice frequently breaks off (i.e. not forming much extent beyond the shoreline), so land travel to the west is more common than boat or sea ice travel. Nevertheless, it was ensured that this area was still covered within the regional overview image for the few families that do use this area, and because there are specific tourist attractions along the west coast for which tour operators had expressed interest in having a view of ice conditions.

Workshop participants felt that access to satellite imagery would be useful as a way to monitor changes over time. Mark noted that he monitors the time series of imagery and tends to flag any noticeable changes in the image products. However, it is essential to maintain two-way communication with those travelling on, and observing, the ice regularly to help identify what is going on in areas where potential changes have been flagged. This kind of regional monitoring was deemed especially useful around Cape Dorset where there is so much influence of ocean currents, and a lot of ice movement in Hudson Strait. Participants were interested in seeing where the ice is moving, as well as the progression of the floe edge formation in the fall. They were also happy to have regular access to imagery, but felt strongly that this technology - as well as the traditional navigational, prediction, and survival skills - be taught to youth.

Resources requested

In addition to consulting the image products (either online, or when printed by the Hamlet and posted in the main office), strong interest was expressed in the ability to download image products onto a Global Positioning System (GPS) in order to have this information accessible while people travel. Also, the large image printouts used for discussion purposes were very useful, and hunters could intuitively interpret these images after orienting themselves; however, it was a common comment that on the actual Floe Edge image products it was not possible to zoom in enough, and that the printouts were really too small to see some of the specific features of interest.

Pangnirtung Discussions

To access imagery, create an account at:
www.noetix.ca/floeedge/
OR visit the Hamlet Office to view regular image postings.

Pangnirtung Contributors

(Hamlet Chambers, November 8, 2007)

- **Lena Angnako** (Hamlet Economic Development Officer)
- **Mark Kapfer** (Facilitator/Noetix Research Inc.)
- **Gita Laidler** (Facilitator/Carleton University researcher)
- **Sheena Machmer** (*1/2 day*, Qikiqtani Inuit Association Community Liaison Officer)
- **Jamesie Mike** (Elder, hunter)
- **Jooeelee Papatsie** (Search and Rescue, hunter)
- **Peterosie Qappik** (Hunters and Trappers Association Chairman, elder, hunter)
- **Eric Joamie** (Interpreter/Community Researcher)
- **Sakiasie Sowdlooapik** (Wildlife Officer)

Photo: M. Kapfer

Communicating about weather/sea ice conditions

The radio, both within the community and the short-wave radio that people use while travelling, is an effective and commonly used method for hunters to inform the rest of the community about current ice conditions, such as: the position of the floe edge, the stability of the *uiguaq* (new ice formation along the floe edge), newly frozen areas, dangerous areas, areas melting quickly in the spring. This form of communication is not necessarily used at a particular time each day, or by the same people, but it is used regularly and relatively frequently by those who are travelling on, and using the ice, the most. It is a means of conveying the conditions people have encountered while travelling, and thus different people will convey such information for differing parts of Cumberland Sound, and in different seasons, depending on their travel habits. Such announcements are completely voluntary, and are meant to benefit the community, but are most beneficial for other hunters who can plan according to these public updates. It was noted, however, that communicating about weather and sea ice conditions over the radio seems more frequent now, and is done year-round, because of the changes and dangers that people are encountering (a changing trend that was attributed to climate change, including the length of time it takes for the sea ice to solidify and the increased unpredictability of conditions. In fact, there would probably be more discussion of this over the radio if the community radio was open longer hours. People are lobbying for extended radio hours beyond the limited lunch and dinner radio air time, as one means of hearing more environmental information.

Some hunters and elders in Pangnirtung have also been accessing satellite imagery with the help of those who have internet access, and thus have been printing out available imagery from Environment Canada, the Canadian Ice Service (CIS), and NASA websites. However, there were frequently issues related to the currency of the images, and often the more frequent imagery is optical imagery (meaning that in bad weather, cloudy conditions, or darkness these images are not able show the sea ice or ground surface). Nevertheless, hunters here are already consulting satellite imagery of various kinds to evaluate

sea ice conditions before travel, or changes over time, and discussing these images with other hunters is another way they are communicating about sea ice and weather.

Important local sea ice/weather indicators

There are many locally important weather and sea ice indicators used by experienced hunters and local elders in making their own predictions about seasonal shifts, the onset of bad weather, or the safety of sea ice conditions. These issues have been discussed in previous collaborative, community-based sea ice research (see previous reports and publications at www.straightupnorth.ca), but specific to these workshops additional indicators were identified, including:

- temperature - interesting distinguishing between average winter temperatures and the temperature on the sea ice (warmer than on the land)
  - the freezing of the sea ice in Cumberland Sound begins at the north end (i.e. from the landmass), and so even in the middle of winter there will be a noticeable temperature difference between the north (colder) and south (warmer) end of the Sound
  - there is a noticeable temperature change when travelling even between *Qulliq* (River) and out of Pangnirtung Fiord (past *Nasauja* point)
  - an indicator from the past (1950s-60s) is that when you had a fairly good fall then you would know it would be a good/solid winter (not too stormy), and that if you had a bad summer the winter tended to be better (and people didn't get a lot of berries in the summer of 2007)
- wind - you can tell if the fall has been windy when you see that more *nigajutait* (localized areas of delayed freezing) have occurred, and also more winds in the fall means that the ice conditions form more poorly, so the timing of breakup is likely to occur earlier than normal
- snow - if more snowfall occurs during the fall, it means that by the spring time the sea ice will not be as solid, which means more dangerous conditions later in the year; therefore, it is always important to keep in mind the areas with more snow accumulation (drifts)
  - while the ocean is freezing up, former seal breathing holes become plugged and pressurized air forms within pockets between the top and bottom of the ice (i.e. if you poke a hole in it it "blows up" with water)
  - where the ice has recently frozen it is usually nice and flat, and once snow falls it covers any air pockets that have formed, but if that snow were to blow away you could see them clearly as the snow would stick to these pockets (soaked in due to the air bubble)
  - a great deal of snowfall in the spring (during seal pup season) can mean more water on the older ice underneath, and as the snow melts air pockets tend to form where the thin surface layers refreeze (this can be scary, when you go through an air pocket you think you're falling right through the ice, but there is still solid sea ice underneath)
- waves - if the ice has formed solidly at the mouth of Cumberland Sound, then you will have less ripple effects of the waves coming into the Sound, which means less breakup in early spring (i.e. the ice will remain intact longer)
- algae - algae tends to grow more in polynyas, or areas with stronger currents (growth rates are higher with more water movement), the algae discolours the sea ice and thus contributes to earlier melt because it floats up under the ice and sticks to the bottom of the ice, contributing to enhanced melt from the top and bottom of the ice surface
  - seeing algae below the ice is usually a good indicator of thin and dangerous ice, and tends to occur in areas already considered dangerous (e.g. polynyas, and areas that melt early)
  - algae growth under the ice is particularly prominent during the spring, when the seals are basking on the ice

- seasonal predictors - it was frequently mentioned that winter ice conditions were used to predict spring ice conditions, for example:
  - *nunniq* is when Cumberland Sound freezes over uniformly, and covers a large extent of the Sound; however, if it was windy during freeze-up (i.e. causing a lot of waves), it affects how well the fast ice will freeze onto land (e.g. during winter 2006/07, the floe edge was fairly close to community all through the winter, due to strong winds at the southern end of Cumberland Sound, creating a lot of movement and leading to improper solidification of the sea ice)
  - winter ice conditions can also be used as an indicator for what kind of conditions to expect for spring (i.e. the further the ice forms to the South, and the more solidly attached to land in the North, the longer the ice will last in the spring)
  - if there is enough good solid/compact snow on ice it influences how well the ice can form, less of that kind of snow means the ice deteriorates faster in the spring

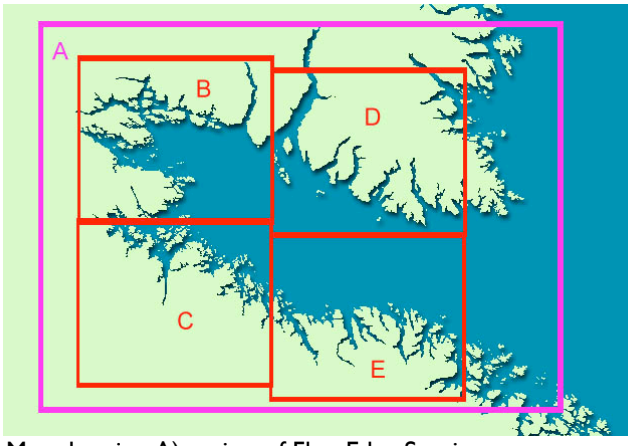
Potential local applications of the Floe Edge Service

After the introduction and overview of the Polar View Floe Edge Service provided by Mark Kapfer we: i) reviewed large format radar images of the Cumberland Sound area to identify key areas of interest to provide relevant subsets of the regional image products based on important destinations or dangerous areas; ii) discussed the ways in which image products might be used locally; and, iii) discussed linkages between locally observed conditions and the types of conditions shown in the imagery.

The image subset areas were mainly defined by areas around important traditional camps, and areas still frequently used at present, and include:

Nunataaq (B)	***Iqalulik (C)***	***Kikirtan (D)***	***Umanaqjuaq (E)***
• to cover key fall and winter ice use/travel routes, freeze-up and break-up progression	• to cover key winter and summer ice and boat use/ travel routes	• to cover key winter ice use/travel routes	• to cover key summer ice and boat use/travel routes and areas outside Cumberland Sound

There is interest in the community in the use of radar imagery for monitoring regional ice conditions, and one of the key potential applications was for use in search and rescue operations. For this purpose, participants conveyed that it would be especially useful to have an overview image of the entire area, as well as the ability to download (or "zoom into") more specific subset areas of interest. Due to the shape of Cumberland Sound, however, it is difficult to capture the entire area in one or two images, so several discussions centered around appropriate subset areas to provide since the orientation/size of the images acquired cannot be changed.



Map showing: A) region of Floe Edge Service coverage around Pangnirtung; B) Nunataaq subset area; C) Iqalulik subset area; D) Kikirtan subset area; and, E) Umanaqjuaq subset area.

The limitations that the hunters identified in using this satellite imagery were that, first and foremost, it cannot help to tell you what is going on underneath the ice (i.e. the very dangerous areas where the currents are eating away the ice from underneath, especially under snow-covered sea ice). or under the snow on the ice surface (e.g. air pockets). Mark noted though, that it is possible to identify snow that is melting on the ice, due to the increased moisture on the ice surface (appearing darker in the

image), and by learning about where the air pockets may form it might be possible to identify them. It was also emphasized by participants that it is important to ensure that Inuit knowledge is taken into consideration when interpreting imagery and determining subsets, since they know exactly where dangerous areas, polynyas with high currents, tidal cracks, floe edge breaking points, and recurring ice features occur. Therefore, through the collaboration of the meeting it was possible to refine the product regions of focus to target key areas of interest and use throughout the year, in Cumberland Sound. Furthermore, the Floe Edge Service was identified as a helpful tool, but it was reiterated that the imagery cannot replace the essential knowledge and experience needed to travel, hunt, and survive on the sea ice, it is mainly a form of supplementary information to be used as an additional means of interpreting the sea ice, or monitoring longer term change, but that the imagery itself cannot tell you exactly what areas are safe, or how to navigate your snowmobile while on the ice. So the Floe Edge Service can contribute an additional component to an already very diverse set of tools and information that people account for when preparing for - and undertaking - travel on the sea ice.

Resources requested

In addition to consulting the image products (either online, or printed by the Hamlet and posted in the main office), strong interest was expressed in the ability to download image products onto a Global Positioning System (GPS) in order to have this information accessible while people travel. Again though, the use of GPS as a tool for navigation is acknowledged as very helpful, but nevertheless it is no substitute for years of practical experience and proficient survival and navigational skills. There are always problems when people try to rely on GPS as the only means of navigation. As participants warned, it is not failsafe (e.g. if batteries run out or the unit breaks), and it does not tell you about the ice conditions you are travelling on, or towards. Therefore, when people only rely on GPS they can end up in dangerous situations, since it does not give you all the information you need (e.g. a few young guys travelling with GPS from Iqaluit to Pangnirtung hit the edge of the floe edge while navigating by GPS, and another example was someone relying only on GPS and ending up in a crevice, lost). It is certainly a useful tool, but just important to understand its limitations.

An additional concern was the frequency that imagery would be updated for use, since it could be out of date within a 12hr period as ice conditions can change quickly. Therefore, there is enhanced interest in acquiring as close to real-time weather and sea ice information as possible to help people in planning trips. The frequency of updates also affects the utility of imagery for search and rescue. It would even help to have image subsets that varied by time of year (e.g. time of use), but due to the automation of the process of creating and posting the products online, this is likely not feasible based on Noetix operations. However, if a particular area needs to be changed over the longer term, it is essential that community members tell Noetix about this (via the Hamlet Office) so that they can continue to tailor products to community needs as much as possible. People were also quite keen to add the names of key dangerous areas to the Floe Edge Service image products (e.g. whirlpool areas with strong currents, where only snow may cover the water and you would fall right through).

It was highlighted as essential that when thinking of technological sea ice products, you cannot just deal with the floe edge, it is important to be looking at dangerous areas in relation to tides (currents, polynyas) as well. It would be important to cover these areas with the imagery, especially for younger hunters who are not aware of the high tide or current areas, and that perhaps talking about these kinds of dangers in the schools, based on imagery and Inuit knowledge, would be helpful to teach the kids who are not asking these sorts of questions. It will also be important to maintain access to the hard copy printouts of image products for those who do not have access to a computer, and thus the relationship between the Hamlet (as host of the service) and Noetix (as the provider of the service), is quite important to ensure that products are continually improved based on local feedback.

Igloolik Discussions

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OR visit the Hamlet Office to view regular image postings.

Igloolik Contributors

(Hamlet Chambers, November 15, 2007)

- **Tom Hirose** (Facilitator/Noetix Research Inc.)
- **Theo Ikummaq** (Interpreter/Community Researcher)
- **Mike Immaroituk** (Hamlet Lands Officer)
- **David Irngaut** (Elder, hunter)
- **Gita Laidler** (Facilitator/Carleton University researcher)
- **Levi Qaunaq** (*1/2 day*, Search and Rescue, hunter)
- **Anthony Qrunnut** (*1/2 day*, elder, hunter)
- **Sidonie Ungalaq** (Qikiqtani Inuit Association Community Liaison Officer)

Communicating about weather/sea ice conditions

The local community radio is commonly used to communicate sea ice and dangerous travel conditions, and is frequently accessed to hear Environment Canada (EC) weather forecasts. Hunters and elders in Igloolik have also been consulting the EC weather office website for imagery of ice conditions or aerial photos, as well as Canadian Ice Service (CIS) ice charts occasionally. They are also keen to access bathymetry maps, but the air photos and bathymetry maps were noted as being rather out of date (5-10 years old).

Important local sea ice/weather indicators

There are many locally important weather and sea ice indicators used by experienced hunters and local elders in making their own predictions about seasonal shifts, the onset of bad weather, or the safety of sea ice conditions. These issues have been discussed in previous collaborative, community-based sea ice research (see previous reports and publications at www.straightupnorth.ca), but specific to these workshops additional indicators were identified, including:

- currents - always be aware of the influence of currents wearing away the ice from underneath
  - when travelling on the ice in Richards Bay last fall one of the participants noticed little bits of water coming up out of the ice as he was travelling (in a place that had been solid enough earlier that day), and then all of a sudden his snowmobile went down...this was due to the thinning of the ice from currents underneath
  - strong currents are particularly influential on sea ice and travel safety between the Islands of Igloolik and Nirlirnaktuk, in Labrador Narrows (and most narrows, especially shallow ones, for that matter), and generally at the time of the monthly new and full moons
- ice pile-ups - where ice is pushed together and piled high (likened to a shear), such as the annual formation of *Aggiupiniq* (where "it grinds") just north of Igloolik, this can form important lookouts to assess the floe edge position/stability, look for polar bears, or look for smooth ice to travel on
- snow - is an important indicator of potential danger, especially with overcast conditions and fresh snowfall on thin ice in the fall

  - even though the snow prevents you from seeing the ice underneath, you know it will be dangerous due to the temperature change (with overcast conditions generally warmer, and with snow cover insulating the sea ice from the cold air the warmer ocean underneath can melt the ice from the bottom, an effect called *uqurusirtuq* in Inuktitut)
  - the timing of freeze-up depends a lot on the amount and timing of snowfall during the fall
- multi-year ice - the amount of multi-year ice that piles up on nearby reefs is a useful indicator of the position (and stability) of the floe edge for the winter (i.e. more ice piled on the reefs acts as a stabilizer, and the floe edge tends to extend further, less ice on the reefs and the floe edge is more prone to breaking off and thus not extending as far from Igloolik)
  - without enough moving or multi-year ice present in the summer the water is much rougher, and more waves make boat travel more difficult
  - at low tide free-floating ice spreads out, at high tide the ice is brought together in higher concentration (i.e. increased chance of being trapped within the ice, when travelling by boat)
  - if a person is stranded on moving ice in the winter, it is important to go further into the moving ice (to rougher ice), because new ice forming along the edges will be too thin, and waiting it out in the middle of the thickest ice the currents will usually carry you to shore near Hall Beach
- wind - wind direction and strength is an important determinant of break-off events at the floe edge in any season
  - some areas closer to town are used as indicators of what other areas further away from town might be like (e.g. potential to break off, melting early in the spring, being influenced by strong currents, rough travel due to pile-ups along the floe edge, etc.)

Potential local applications of the Floe Edge Service

After the introduction and overview of the Polar View Floe Edge Service provided by Tim Hirose we: i) reviewed large format radar images of the Foxe Basin area to identify key areas of interest to provide relevant subsets of the regional image products based on important destinations or dangerous areas; ii) discussed the ways in which image products might be used locally; and, iii) discussed linkages between locally observed conditions and the types of conditions shown in the imagery.

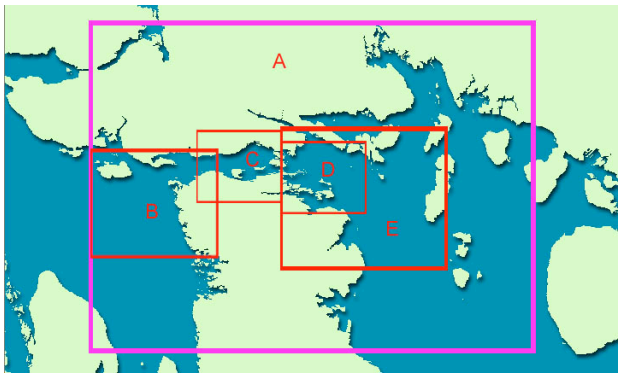
The image subset areas were mainly defined by areas of use, and include:

Aggu (B)	***Salliarusiq (C)***	***Ikiq (D)***	***Salliq (E)***
• to cover key fall, winter, and spring ice use and travel routes, Gulf of Boothia ice conditions, and multi-year ice conditions (which then tend to come through Labrador Narrows into Fury & Hecla Strait (*Ikiq*)	• to cover key winter ice use/ travel routes, multi-year ice conditions coming through Labrador Narrows	• to cover year-round ice and boat use/travel routes, the position of the floe edge and new ice formation along the edge, smooth travel conditions, Gifford Fiord and Murray Maxwell Bay, as well as connections to Melville Peninsula, seasonal sea ice progression	• to cover key winter and summer ice and boat use/travel routes, monitor moving ice patterns of motion, Rowley Island, Steensby Inlet

There is interest in the community in the use of radar imagery for monitoring regional ice conditions, specifically in being able to identify (before travelling) ice conditions that would facilitate or hamper ice travel, such as:

- areas of rough or smooth ice
- large ice pileups
- the path, concentration, and sizes of moving ice pans (or multi-year ice)
- conditions relatively far away, to the west or east
- the position of the floe edge, and any fractures along this edge, as well as proximity of moving ice to this edge
- early signs of spring break-up

Hunters were adept with their intuitive interpretation of radar imagery, especially in relation to the influence of wind direction on moving ice or ice formation. However, there were also a lot of questions that arose around the capabilities of the imagery to: i) see through snow; ii) identify when the ice is cracking; iii) identify dangerous ice conditions when covered by snow (i.e. when wearing out due to currents underneath); and iv) differentiate compact vs. less compact/dense ice.



Map showing: A) region of Floe Edge Service coverage around Igloolik; B) Aggu subset area; C) Salliarusiq subset area; D) Ikiq subset area; and, E) Salliq subset area.

Workshop contributors felt that access to such satellite imagery, especially covering high traffic areas and important hunting grounds, would be valuable because it enables people to get a sense of the ice conditions ahead of time, and perhaps even choose routes based on that. Normally hunters have to get on the ice to assess the conditions, so imagery helps with some initial assessment. Access to imagery could also help decrease the worry of search and rescue operations, as it could help evaluate conditions before launching a rescue operation, and to better estimate where lost or stranded people might be. Furthermore, having a log of imagery year after year was recognized as a useful way to compare ice conditions over time. Nevertheless, it was emphasized that the imagery is not sensitive enough (i.e. limited by resolution) to tell if the ice is thick enough to walk on the ice versus drive on the ice. Participants and facilitators alike, thus reiterated that the imagery is no substitute for being on the ice, evaluating by sight and especially using a harpoon to test ice safety and thickness. Satellite imagery is only a complementary element to the years of experience that allow hunters to evaluate ice conditions by accounting for a multitude of interrelated factors.

Resources requested

Besides the interest expressed in the utility of the Floe Edge Service to provide more frequent and reliable access to radar imagery of regional ice conditions, there were also many questions posed in regards to image product capabilities, accuracy, views, and timing of coverage. In discussions centered on product capabilities the limitations of sensor resolution were acknowledged. There were several questions about being able to "zoom in" further on the products, to see more details, but this is only possible to a certain point before the image becomes pixelated (i.e. when you start seeing a lot of squares instead of more detail). However, the quality of the product is also limited by the quality of the printer, for which a laser printer would provide a much clearer output than an older ink jet printer. There is also the limitation of paper size, which is difficult to avoid, and products were tailored as best as possible to be printable and readable on standard letter paper size. Interest was also expressed in being able to access the imagery using current GPS units.

Questions around the accuracy of the imagery related to its potential use for navigational purposes, and if it would be as good as a GPS. In short, no, this imagery is not as capable or accurate as a GPS. Because of the resolution of the imagery (100m pixels) a feature would generally have to be at least 300m in size to be able to distinguish the feature in the image. Therefore, it was again reiterated that this imagery is only a tool, a complement to peoples' extensive practical knowledge and experience, it could never be a replacement for being out there. The imagery provides a coarser view of ice conditions, but it can certainly help with an overview of regional ice conditions before travelling. And, it does provide a general sense of where the ice is, which a GPS does not. The example of the November 11 storm was used, where the imagery could "see through" the storm and highlight the extent of breakup of the newly formed ice around Igloolik, and where the broken ice had moved. This is one of the valuable aspects of radar imagery, it ability to acquire images in the dark, and despite bad weather or clouds, because it does not rely on visible light to record the images.

Key Themes

Several overarching themes of interest were raised in discussions in each community workshop.

Inter-generational, and inter-cultural communication and knowledge exchange

An important element of communicating about weather and sea ice conditions was highlighted as being the transfer of local expertise to the younger generation of Inuit. While there is considerable community interest in incorporating technology - such as satellite imagery and weather forecast information - into local evaluations of sea ice safety, experienced hunters warned against relying solely on technology, and felt strongly that the youth should be taught valuable traditional observation and prediction skills. A gap in knowledge transfer was identified, in that with elders passing away there are less people teaching these skills (and some traditional observation/prediction methods are hardly being used anymore), so there is an increased need to discuss these issues and to develop ways to engage youth in practicing and learning these techniques through regular activities. It was very important to workshop participants to be teaching community members and youth about these traditional skills, and not just to the *qallunaat* (southerners such as government workers or researchers) who are asking about these issues.

An important aspect of such inter-generational communication was raised in Pangnirtung. Some of the middle-aged hunters noted that although they are experienced, they know far less than the elders who were participating in the workshop. However, they described a key factor of learning as being a matter of asking the right questions. Often the older hunters are very modest and they will not just come out and describe their understandings unless they are asked. Since many younger people are not asking, it can be difficult to create a dialogue between generations around these important issues. As some of the elders described, when they were growing up their play time as kids was all about growing and learning for future use. They learned survival skills throughout every day life and interactions with the land, wildlife, weather, sea ice, seasons, etc. Their play, observations, experiences, and involvement in daily tasks were preparing them for the future. So, in that sense learning was inherent in everyday life, and now with learning centered mainly in schools it means that learning land skills somehow ends up needing to be more formalized in order for youth to gain the necessarily survival skills to travel, especially in current conditions.

Workshop contributors also discussed communicating their years of accumulated knowledge to scientists. For some, skepticism has developed around sharing information with government scientists because it is felt that what they have shared in the past has been used against them enough times that they are now starting to withhold information. So, they only share this kind of information beyond the community when they feel it will help the community, and help the youth. Therefore, especially wildlife issues are rather delicate topics. However, discussing the Floe Edge Service, and building on the previous sea ice project was seen as beneficial to the community, especially because participants were keen to record their knowledge and ensure that it would be shared back in ways and formats that are locally useful. As one elder noted, the knowledge is in their head and if they wrote down all that information they would be rich! It was also interesting to note that as researchers, when asking these (seeming silly...at times) questions, people are more likely to answer than if the local researchers (also acting as facilitator/interpreter at the workshop) were to ask the same thing, because they are expected to know better. Ultimately through, it was acknowledged that the progress and products would move faster and be more comprehensive if there was more ongoing collaboration when the university researcher was not around - i.e. finding a way to ensure continuity and more local ownership by more regular research undertaken locally.

Sea ice has a "life of its own"

The sea ice (among other aspects of environmental systems) was identified as having an unknowable element, characterized as having "a life of its own." Based on Inuit knowledge the ice is respected as a living entity unto itself. So, no matter how much you study it, or use it, or learn about it, especially Igloolik hunters and elders warned that the ice has its own living form/force and there is an inherently unpredictable aspect to it (i.e. can break off even on a very calm day when it looks quite solid...it breaks off when it wants to break off at times). One example used was the case of the ice in the Gulf of Boothia, where even if the wind is blowing strongly from the NW and the current is going out, the ice can still move in (upwind, up current). Thus, it is seen as having a life of its own. In addition, Cape Dorset elders talked about large icebergs as being alive, describing them as squeamish of wildlife since typically no wildlife are found on icebergs. So in the past, people would put a lemming on an iceberg to scare it away.

Technological limitations

There was a great deal of interest in all three communities to be able to **access imagery or Floe Edge Service products directly on their GPS**. The main challenge here is the limitation of the GPS to handle the large file sizes of the satellite imagery. At the moment, this does not seem feasible; however, it could be feasible to make the floe edge line delineation into a shapefile (a specific mapping format) that could be downloaded onto a GPS for use while travelling. This capability would also depend on the model and capabilities of the GPS unit itself. It may also be helpful to have the Inuktitut placenames available for use on the GPS, latitude/longitude gridlines (for navigation or search and rescue purposes), as well as perhaps the sea ice features/dangers/routes documented based on hunters' and elders' knowledge around each community (as part of Laidler's previous and ongoing collaborative sea ice mapping project with the community), and coastlines to ease the interpretation of images. Another consideration for use of imagery on GPS units is that once the person is outside the community, there is no way to get updated imagery without paying for expensive data plans on a satellite phone.

Another issue that was commonly raised was about the **posting frequency of Floe Edge Service image products**. Most hunters explained that daily coverage would be helpful, since ice conditions can change within hours. However, it was confirmed by Noetix staff that the highest frequency (in transition times and the summer season) would be 3 - 4 times a week, while at some points of the year (especially winter), images are often updated only 1 a week or once every 2 weeks. This was deemed insufficient by most hunters, but Noetix is also bound by what the Canadian Ice Service (CIS) provides them. However, with each new image acquired the related Floe Edge Service product is posted within hours of that time.

Many questions arose around the **capabilities of radar imagery**, and what it can actually "see", or "see through." These were addressed as best a possible during the meeting, but a descriptive summary of tips to help interpret radar imagery was also developed by Noetix as a result (and is attached to this report as **Appendix B**). In addition, Noetix is developing an online interactive tutorial to provide additional help and visual demonstrations to help more accurately interpret what the black and white radar imagery is actually showing about seasonal ice conditions. Additional training would thus be helpful for people to become more comfortable and familiar with image interpretation. However, this continues to be challenging with the turnover rates of Hamlet staff and the continuity of training from a distance.

Another frequent request was to be able **"zoom in"** further on the image products. Most hunters and elders wanted to be able to see more detail about the ice conditions. Through these questions it was identified that generally the Hamlet printers were not providing sufficient contrast and

sharp definition for the letter-sized paper printouts. The image products were designed to be printed on regular sized paper, but this does also come with the tradeoff of losing some of the detail. The large format posters were preferred for interpretation, but are not accessible in most communities. As one contribution to help address this issue project funds were approved to purchase new laser printers for each of the collaborating Hamlets, to enable them to provide the best printouts possible. The identified subset areas are also meant to provide a more focused version of the image products, along with the regional overview. One interesting option proposed was to make the image products available for viewing via local cable TV where the resolution would be better (but saving or printing would not be possible). In addition Noetix is working on the ability for zoom and pan functions to be available for the image products. Nevertheless, the quality of the printouts will always be limited by the actual image resolution, which is 100m, as that is the standard image acquisition mode that CIS uses, and it is CIS that is ultimately providing all the images that Noetix then transforms into the Floe Edge Service products.

Information technology infrastructure in these communities, and similarly across many communities in the Canadian Arctic, is limited. Thus, Floe Edge Service products have been designed with the aim of being accessible with basic computing hardware and software, along with limited bandwidth). There is interest in moving towards more web-based interactive technologies, but there is concern that sufficient and reliable community access to such improvements would not yet be feasible. Harsh climate conditions as well as long travel distances also push the limits of portable technology (such as GPS units), and in most cases standard equipment is no rugged enough, so there is the ongoing challenge of maintaining battery life and space for data storage.

It was reiterated often in each community, that ultimately these new technological tools are all very helpful, but they cannot be used without adequate traditional, navigational, and survival skills, because technology alone cannot tell you where it's safe to travel or help you find your way. So, it's people who are out travelling and hunting on the ice frequently and who are very familiar with sea ice conditions, dynamics, and seasonal changes that can most effectively interpret and use the imagery. Ironically, this same group of people are also those who really do not need to use the imagery, and it is often the younger or less experienced hunters who rely on the technology to a greater extent (sometimes with tragic consequences). This brings us back full circle to the first issue of inter-generational communication, and the communities finding appropriate ways to address this challenge locally.

Recommendations

Several recommendations emerged from these collaborative community-based workshops that aim to address some of the challenges, concerns, and interests expressed by local hunters and elders, researchers, and Noetix staff, including:

1. **higher product clarity** is required from the ScanSAR imagery (for better print and viewing quality)
2. **higher resolution** image products would be desirable to see more detail in the images (potential to use Standard and Fine beam modes)
3. **colour products** would be useful to make the image interpretation more intuitive
4. significant effort needs to be made to ensure **accurate and representative translation** of weather and sea ice forecasting terminology into meaningful Inuktitut to avoid confusion and misunderstandings
5. new options for **technology transfer** must be investigated (e.g. accessing image product interpretation such as the floe edge "line" on a handheld GPS unit)
6. **higher frequency** of image product provision is required
7. **two-way communication** between the local Floe Edge Service hosts (the Hamlet Office in Cape Dorset, Pangnirtung, and Igloolik) needs to be improved so that Noetix staff can continue to refine image products to better meet local needs
8. **a system for local observations** of ice conditions to be recorded and provided to Noetix staff and researchers needs to be established, in order to improve image interpretation, to provide more meaningful products to the communities, and to evaluate important indicators over seasons and over time (e.g. i) a paid **ice observer** who would record - or communicate their observations to a local researcher - their observations in writing as well as document various ice conditions during their travels with GPS points and digital photos; ii) **volunteers** who would communicate their occasional or unique observations to the Hamlet Office who would then pass this on to Noetix staff; and/or, iii) establish a **community ice monitoring program** that includes ice, snow, and temperature measurements at specific locations each year)
9. **locally designed and run activities/programs** to help facilitate enhanced inter-generational knowledge transfer of traditional, navigational, and survival skills for safe sea ice use
10. additional and ongoing **training** in image interpretation
11. researchers and Noetix staff need to continue **learning about sea ice in a more holistic manner** to appreciate all the complex interactions with related environmental, human, and wildlife systems
12. **sustained long-term funding** for the Floe Edge Service is necessary to ensure the continuity of image product provision and the improvement of products over time (best suited to core funding in a governmental or land claims organization annual budget)

Appendix A: Workshop Agenda

Morning

Review of previous community-based sea ice research results (9am – 10:15am)

- Introduction of facilitators and contributors
- Brief review of Floe Edge Service
- Discussion on how community members currently use satellite image products or weather service information
- Discussion on goals of the workshop:
    - Review/improve previous research results
    - Identify community priorities in terms of using the Floe Edge Service, what ice conditions of interest the imagery can already detect, and what aspects of the image products can be improved to meet community needs
- Overview of previous results on sea ice terminology, phases of freezing, dynamic processes, and phases of melting
- Overview of previously compiled maps depicting ice conditions and uses around the community

Review stages of freeze-up and consolidation (10:30am – 12:00pm)

- As the ice begins to freeze in the fall:
    - Review available satellite images
    - What do people mention on the radio to watch for?
    - What are people looking for in terms of starting to use the ice?
    - Phases of freezing – add to/edit previous work as we go
    - Influential weather during freezing stages and throughout the winter
    - Main areas/purpose/mode of transport of use during various stages
    - Key indicators, ice features, routes, etc. during various stages
    - Would satellite imagery be useful during freezing stages, and what kinds of things would you hope to see in image products?
    - Have any phases/indicators/timing changed, and how people have responded?

Afternoon

Review stages of melting and break-up (1:00pm – 2:45pm)

- As the ice begins to melt in the spring:
    - All the same discussion topics as above, but for melt stages and throughout the summer

Developing community-based ice/weather monitoring programs (3:00pm – 5:00pm)

- Review of workshop goals
- Discussion on developing community-based ice/weather monitoring for this ice season
- Discussion on evaluating the utility of the Floe Edge Service for this ice season
- Discussion on future project goals, towards enhanced collaboration

Appendix B: Understanding the Noetix Research Floe Edge Service

There are **two types of imagery** that the Floe Edge Service uses to create a product. **SAR** (synthetic aperture radar) imagery, the black and white images, and **optical imagery**, the coloured products added when they become available. The **Noetix Research Inc.** Floe Edge Service (www.noetix.ca/floeedge/) mainly relies on SAR imagery. The **Canadian Ice Service**, where the Floe Edge Service receives the majority of its imagery from, uses imagery acquired from Canada's RADARSAT-1 satellite to monitor shipping lanes throughout the year. The SAR imagery is then sent to Noetix for interpretation where the current floe edge location and the historical floe edge location are added and then made available for Floe Edge subscribers. SAR Imagery is also received from the European ENVISAT ASAR satellite which carries a sensor similar to RADARSAT-1.

The SAR products are used more frequently than optical ones because a SAR, or **radar, can see through stormy weather, darkness, and clouds**. The way it works is that the SAR satellite sends pulses of invisible microwaves from the satellite to the earth's surface. Those pulses hit the surface and a portion bounces back towards the satellite where they are received and converted into digital values. The amount of the signal received by the sensor is determined by the surface roughness, composition of the ice and snow, and the presence of liquid water.

In some regions, **ice development (freezing)** begins in sections, usually from the coast outwards (**Figure 1**). Sometimes, two existing ice sheets may freeze together. In the process of freezing together, tidal currents or winds may cause the two sheets to grind or push up against one another to create a ridge where they meet. These features appear as thin, linear bright features on the imagery. If **new ice** forms under high wind conditions, the surface of the ice will be rougher than ice formed under calm conditions so these will appear gray on the imagery (**Figure 2**). It does not take much roughness (around 5 cm) to cause a relatively strong reflection back to the satellite.

Areas of **open water in light wind conditions**, or **smooth first-year ice**, will reflect more of the pulses away from the sensor, making these features appear dark (**Figure 1**). This helps explain why the **floe edge** itself can be clearly seen in the imagery. The brighter area, near the edge of the ice are made up more of a hard, rough ice and looks brighter in the image while the open water area reflect the pulses away from the satellite and it looks darker. When the wind speed is low, open water appears dark (**Figure 2**). Since thin, smooth, new ice is also dark it can sometimes be difficult to distinguish between the two. However, when there is a moderate wind speed, small ripples form on the water and are detected by the radar as a lighter tone. As the wind increases, more of the signal is reflected back to the radar and the tones become brighter. In fact, under high winds, the affected open water areas can have a similar tone to rough ice.

As the winter progresses, it becomes possible to see **floes**, which can be trapped within the **floe edge** itself (**Figure 3**), and this can stay there throughout the season. For **travelling** purposes, locating these bright areas is a good idea. The bright signatures within the imagery are a good indicator of areas to avoid due to their large and rough nature that will make travel difficult. Once the floe edge begins to **deteriorate** and possibly break off (**Figure 4**), the imagery begins to look washed out since temperatures are rising above zero and the water content on the ice has increased. Eventually, the ice will **break up** and remnants of the floe edge will remain, along with open water (**Figure 5**).

Clouds and weather don't affect the radar imagery because the pulses of microwave energy simply pass through them. The **optical satellite that is used (MODIS) works more like a camera** in the sky and because of this, anything in the way of it and the ground, like clouds, will be captured in the image as well. If the area that is being covered has clouds completely above it, then this satellite won't see anything on the ground. This is one of the main reasons SAR imagery is used. **Images can be captured at any time of the day, any time of the year and during any weather event.** This is especially important in arctic regions where periods of darkness occur during winter months, where no imagery could be recorded.

A Season at a Glance

Starting from Freeze up to the eventual breakup and summer month, the following shows how SAR imagery will see these events.

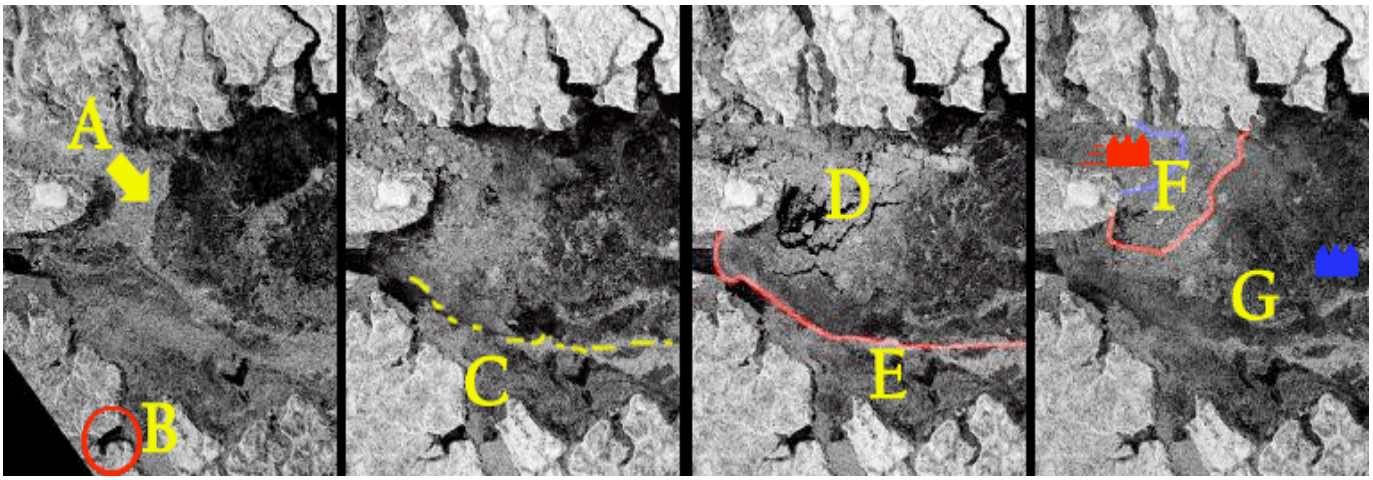


Figure 1. Jones Sound, November, 2007. A) The Northwest Channel in Jones Sound where much of the multi year ice flows in from. B) An inland bay that has frozen over. There was little wind or wave factors in the rapid freezing process that occurred. Note that he bay is seen as quite dark in the imagery. C) As the moving ice floes move into the Sound, they begin to crash in along the southern shoreline. As the temperature drops, the ice starts to consolidate for what is the first part of the developed floe edge. D) The North West channel contains a polynya, and as the winter season progresses, the polynya plays a factor in keeping the channel open and dangerous throughout the season. Using multiple images, it is clearly seen that the area does not freeze over entirely. E) The first floe edge is now frozen and secure and the fast ice has formed. F) Even as the rest of the Sound has frozen over, the polynya is still showing to be unstable. G) A second layer of the initial floe edge had formed, but now the entire Sound has consolidated. RADARSAT-1 data © Canadian Space Agency/agence spatiale canadienne 2007. Processed and distributed by MDA Geospatial Services.

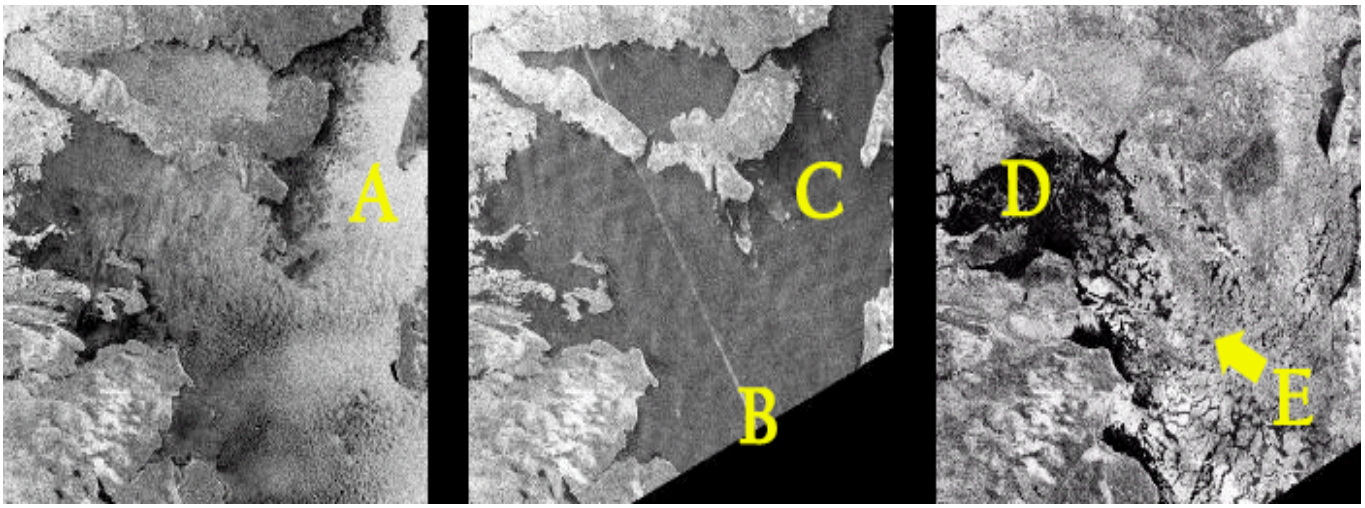


Figure 2. Igloolik October to November 2007 A) Open Water B) The line seen in this particular image is part of the image processing that occurs to produce the image. It is a tie in between two images to give the bigger, overall image as seen. C) Similar to A, this is an open water area with variation in the signal. D) Dark tones suggest that this area is freezing over and is calm with limited wind and waves. E) This shows floating ice that is moving towards Igloolik from Foxe Basin. RADARSAT-1 data © Canadian Space Agency/agence spatiale canadienne 2007. Processed and distributed by MDA Geospatial Services.

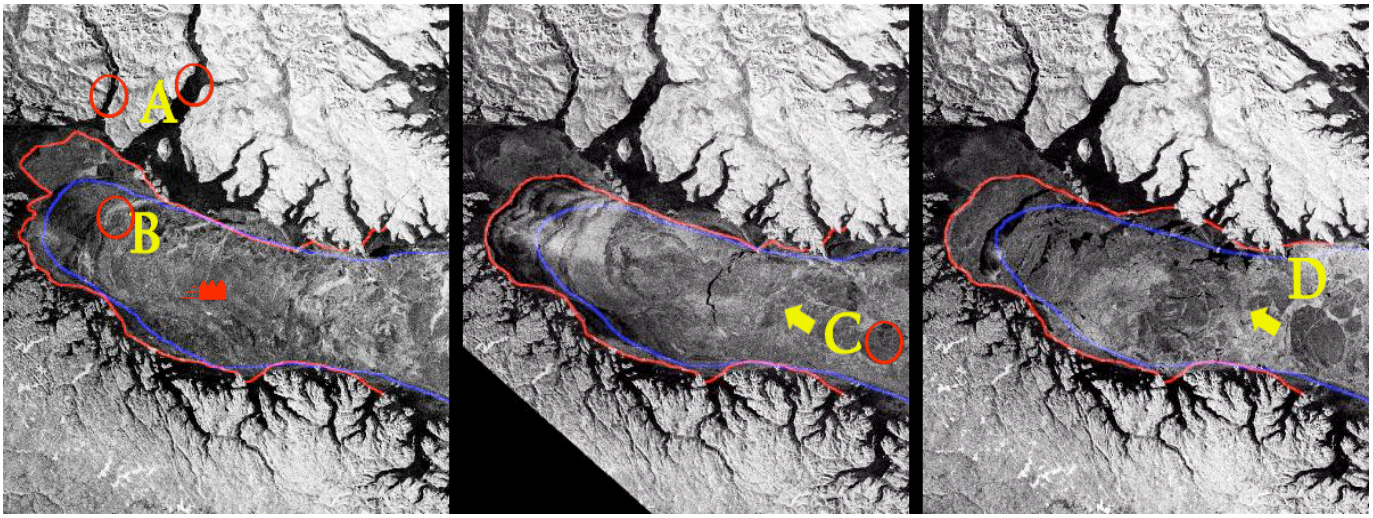


Figure 3. Pangnirtung, February to March, 2008. A) Smooth first year ice that has frozen in back bays in Cumberland Sound. Since the ice was quickly formed in the calm bays, the ice is scene as a dark signature. B) Rough ridges of Multi Year Ice crashing into one another. Note the bright signatures. As these large ice floes enter bodies of water, such as Cumberland Sound, they can be monitored and their eventual location that they will freeze for the season can be noted. C) First or Multi Year Ice that has made its way into Cumberland Sound. D) More First or Multi Year Ice continues to flow into the Sound. The shape is distinctive and will not change from scene to scene. The travels of these large pans of ice can be monitored easily. RADARSAT-1 data © Canadian Space Agency/agence spatiale canadienne 2008. Processed and distributed by MDA Geospatial Services.

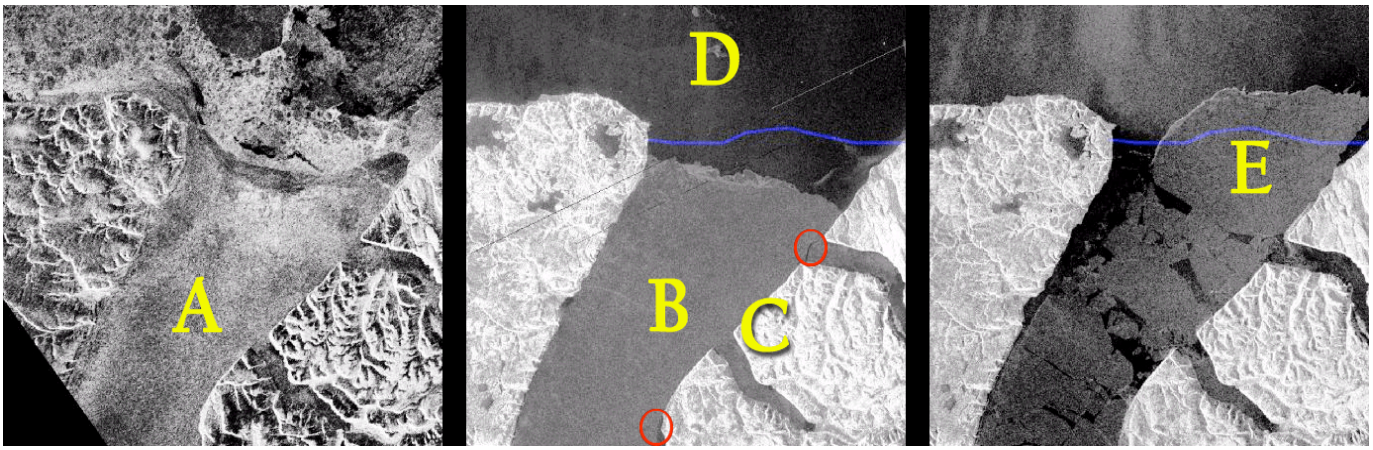


Figure 4. Admiralty Inlet, June 15, July 14, and July 18 2008. A) Shows floe edge at the late stages of winter and at the point where the onset of melt is beginning. B) Shows the floe edge during melt. Temperatures now vary to the point where they are above 0'C. The fast ice is deteriorating and image now looks washed out Tones of trapped pieces of new and multi year ice fade. C) Shows two highlighted areas (red circles) where open water is now apparent. These areas are hazardous and help to demonstrate the weakening of the floe edge, especially at the small bays along the coastline. D) Shows that the open water area of Lancaster Sound now contains limited amounts of moving ice. Compared to the imagery from 1 month previous, the change is evident. E) Shows the floe edge break apart and a large sheet of ice is now moving towards Lancaster Sound. The imagery from 4 days before gave warning signs of such an event. Thos pieces can be monitored as they move out into Lancaster Sound. RADARSAT-1 data © Canadian Space Agency/agence spatiale canadienne 2008. Processed and distributed by MDA Geospatial Services.

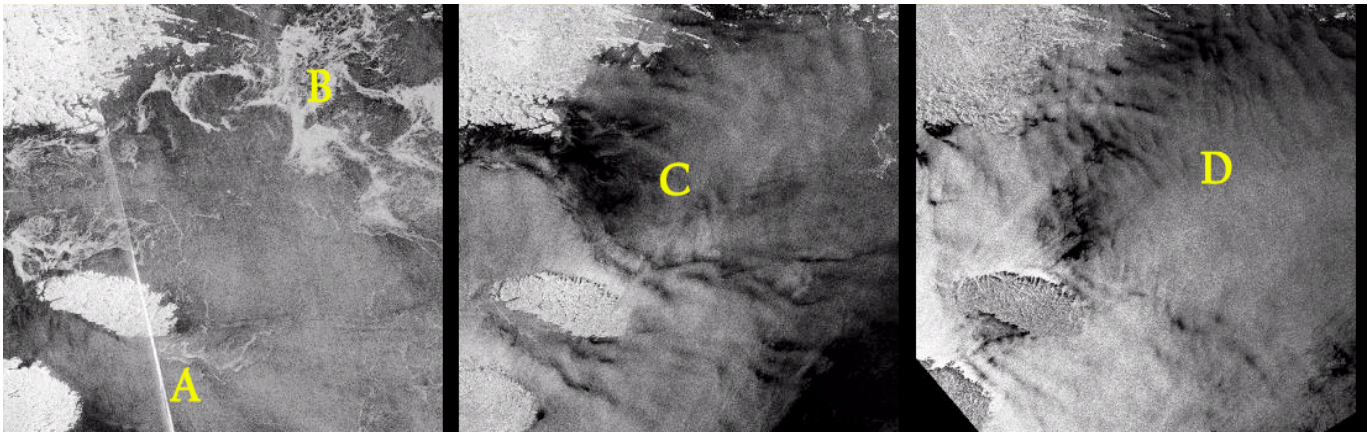


Figure 5. Cape Dorset, July to August 2008. A) The line seen in this particular image is part of the image processing that occurs to produce the image. It is a tie in between two images to give the bigger, overall image as seen. B) The last remaining ice floes as the break up progresses. The contrast between this ice and the open water is noticeable. C) Varying tones of open water D) Varying tones of open water. This image helps show the effects of winds and currents on the imagery. RADARSAT-1 data © Canadian Space Agency/agence spatiale canadienne 2008. Processed and distributed by MDA Geospatial Services.