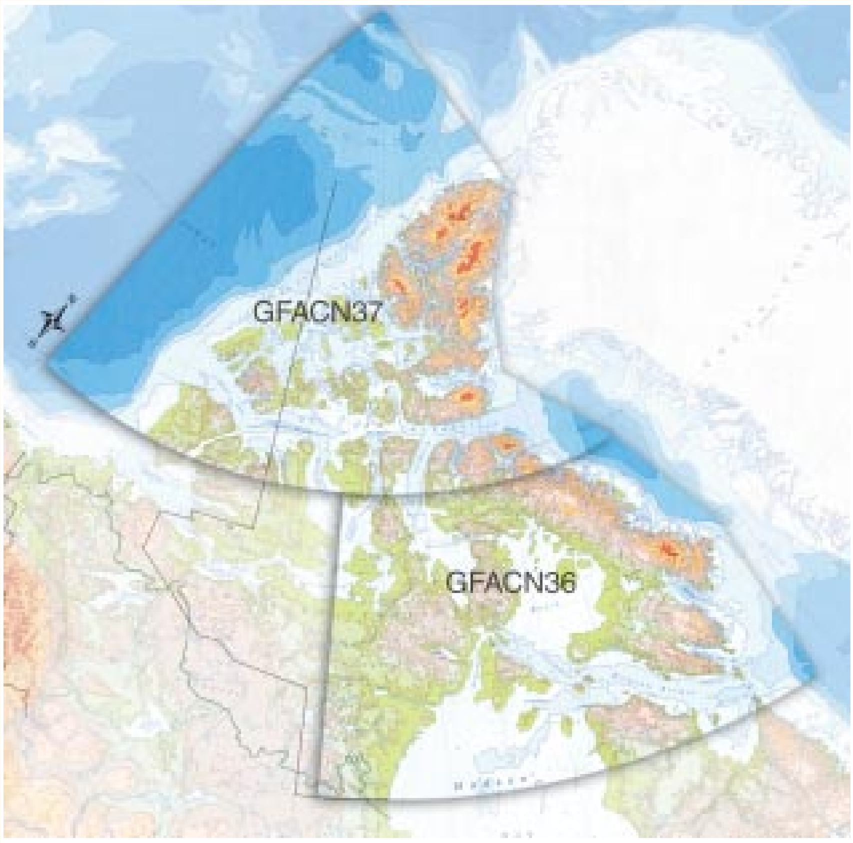
The Weather of Nunavut and the Arctic



Graphic Area Forecast 36 and 37

NAV CANADA

The Weather of Nunavut and the Arctic

Graphic Area Forecast 36 and 37

by
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NAV CANADA

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Preface

For NAV CANADA's Flight Service Specialists (FSS), providing weather briefings to help pilots navigate through the day-to-day fluctuations in the weather is a critical role. While available weather products are becoming increasingly more sophisticated and at the same time more easily understood, an understanding of local and regional climatological patterns is essential to the effective performance of this role.

This Nunavut and the Arctic Local Area Aviation Weather Knowledge manual is one of a series of six publications prepared by the Meteorological Service of Canada (MSC) for NAV CANADA. Each of the six manuals corresponds to a specific graphic forecast area (GFA) domain, with the exception of this manual that covers the combined GFACN36 and 37 domains.

These manuals form an important part of the training program on local aviation weather knowledge for FSS working in the area and a useful tool in the day-to-day service delivery by FSS.

Within the GFA domains, the weather shows strong climatological patterns controlled by season and topography. This manual describes the weather of the domains of the GFACN36 and 37 (Nunavut, arctic islands section of Northwest Territories, and northern Quebec).

The GFACN36/37 domain is bordered with seasonally ice covered waters of 2 oceans (Atlantic and Arctic) and a large bay (Hudson), is treeless except for the extreme southwestern reaches of the GFACN36 domain, and has a mix of low lands (northwest to southeast corridor from the Arctic Islands to the shores of western Hudson Bay) and the highest mountains in North America east of the Rockies (eastern Baffin Island to northern Ellesmere Island).

This manual provides some insight on specific weather effects and patterns in this area. While a manual cannot replace intricate details and knowledge of Nunavut, arctic islands' section of the Northwest Territories, and northern Quebec that FSS and experienced pilots of the area have acquired over the years, this manual is a collection of such knowledge taken from interviews with pilots, dispatchers, Flight Service Specialists, Polar Continental Shelf Project personnel, arctic researchers, National Park Wardens and MSC personnel.

By understanding the weather and hazards in the GFACN36 and 37 domains, FSS will be more able to assist pilots to plan their flights in a safe and efficient manner. While this is the manual's fundamental purpose, NAV CANADA recognizes the value of the information collected for pilots themselves. More and better information on weather in the hands of pilots will always contribute to aviation safety. For that reason, the manuals are being made available to NAV CANADA customers.

Acknowledgements

This manual was made possible through funding by NAV CANADA, Flight Information Centre project office.

NAV CANADA would like to thank the Meteorological Service of Canada (MSC), both national and regional personnel, for working with us to compile the information for each Graphic Area Forecast (GFA) domain, and present it in a user friendly professional format. Special thanks go to Ed Hudson, and his fellow meteorologists John Alexander, Alex Fisher, David Aihoshi, Tim Gaines and Paul Yang of the Prairie Aviation and Arctic Weather Centre (PAAWC), Edmonton, and to Gilles Simard of the Environmental Weather Services Office-East, Rimouski, Quebec. Ed's and his fellow PAAWC meteorologists' expertise for Nunavut, and the Northwest Territories and Gilles' expertise for Nunavik (northern Quebec) have been instrumental for the development of this document. The PAAWC meteorologists advise that they are indebted to the Edmonton-based climate specialists Patrick Kyle and Monique Lapalme for the myriad of weather statistics that they produced for this manual. They are also indebted to two people in particular for photographs: Dave Gartner, Aeronautical Information Services, Nav Canada and Alan W. Johnson, Government of Nunavut, Community Government and Transportation. PAAWC meteorologists Lydna Schuler and Paul Yang, through their diligent editing, contributed significantly to the manuals' content thereby becoming de facto authors. John Mullock's experience and efforts have ensured high quality and consistent material from Atlantic to Pacific to Arctic.

This endeavour could not have been as successful without the contributions of many people within the aviation community. We would like to thank all the participants that provided information through interviews with MSC including pilots, dispatchers, Flight Service Specialists, Polar Continental Shelf Project personnel, arctic researchers, National Park Wardens and MSC personnel. Their willingness to share their experiences and knowledge contributed greatly to the success of this document.

Roger M. Brown
May, 2003

Readers are invited to submit any comments to:

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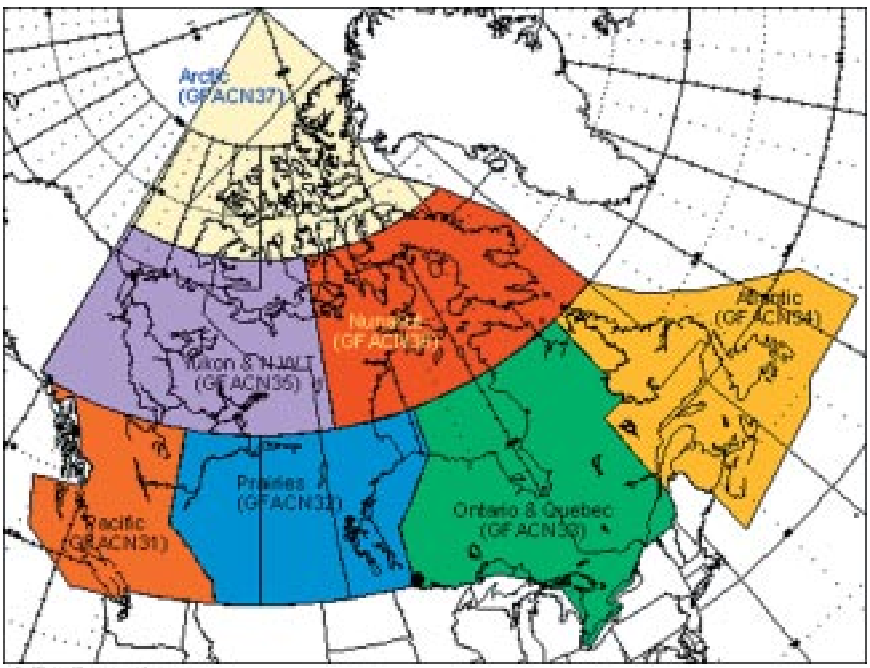
Introduction

Meteorology is the science of the atmosphere, a sea of air that is in a constant state of flux. Within it storms are born, grow in intensity as they sweep across sections of the globe, then dissipate. No one is immune to the day-to-day fluctuations in the weather, especially the aviator who must operate within the atmosphere.

Traditionally, weather information for the aviation community has largely been provided in textual format. One such product, the area forecast (FA), was designed to provide the forecast weather for the next twelve hours over a specific geographical area. This information consisted of a description of the expected motion of significant weather systems, the associated clouds, weather and visibility.

In April 2000, the Graphical Area Forecast (GFA) came into being, superseding the area forecast. A number of Meteorological Service of Canada (MSC) Forecast Centres now work together, using graphical software packages, to produce a single national graphical depiction of the forecast weather systems and the associated weather. This single national map is then partitioned into a number of GFA Domains for use by Flight Service Specialists, flight dispatchers and pilots.



GFA Domains

This Nunavut and the Arctic Local Area Knowledge Aviation Weather Manual is one of a series of six similar publications. All are produced by NAV CANADA in partnership with the MSC. These manuals are designed to provide a resource for Flight Service Specialists and pilots to help with the understanding of local aviation weather. Each of the six manuals corresponds to a specific graphic area forecast (GFA) domain, with the exception of this manual that covers the combined GFACN36 and 37 domains. MSC aviation meteorologists provide most of the broader scale information on meteorology and weather systems affecting the various domains. Experienced pilots who work in or around weather on a daily basis, however, best understand the local weather. Interviews with pilots, dispatchers, Flight Service Specialists, Polar Continental Shelf Project personnel, arctic researchers, and National Park Wardens form the basis for the information presented in Chapter 4.

Within the domains, the weather shows strong climatological patterns that are controlled by season or topography. For example, in British Columbia there is a distinctive difference between the moist coastal areas and the dry interior because of the mountains. The weather in the Arctic varies strongly seasonally between the frozen landscape of winter and the open water of summer. These changes are important in understanding how the weather works and each book is laid out so as to recognize these climatological differences.

This manual describes the weather of the GFACN36 and 37 domains - Nuvavut and the Arctic. This area often has beautiful flying weather but challenging conditions frequently occur particularly in the fall and winter. As most pilots flying in the region can attest, these variations in flying weather can take place quite abruptly.

From the flat treeless barrens to the west of Hudson Bay of the GFACN36 domain to the mountains and glaciers of Baffin Island and the eastern high arctic islands, local topography plays a key role in determining both the general climatology and local flying conditions in a particular region. Statistically, for Canada as a whole, approximately 30% of aviation accidents are weather related and up to 75% of delays are due to weather.

This manual is "instant knowledge" about how the weather behaves in the GFACN36 and 37 domains in a general sense. It is not "experience" and it is not the actual weather of a given day or weather system. The information presented in this manual is by no means exhaustive. The variability of local aviation weather in Nunavut and the Arctic could result in a larger publication. However, by understanding some of the weather and hazards in these areas, pilots may be able to relate the hazards to topography and weather systems in areas not specifically mentioned.

Chapter 1

Basics of Meteorology

To properly understand weather, it is essential to understand some of the basic principles that drive the weather machine. There are numerous books on the market that describe these principles in great detail with varying degrees of success. This section is not intended to replace these books, but rather to serve as a review.

Heat Transfer and Water Vapour

The atmosphere is a "heat engine" that runs on one of the fundamental rules of physics: excess heat in one area (the tropics) must flow to colder areas (the poles). There are a number of different methods of heat transfer but a particularly efficient method is through the use of water.

Within our atmosphere, water can exist in three states depending on its energy level. Changes from one state to another are called phase changes and are readily accomplished at ordinary atmospheric pressures and temperatures. The heat taken in or released during a phase change is called latent heat.

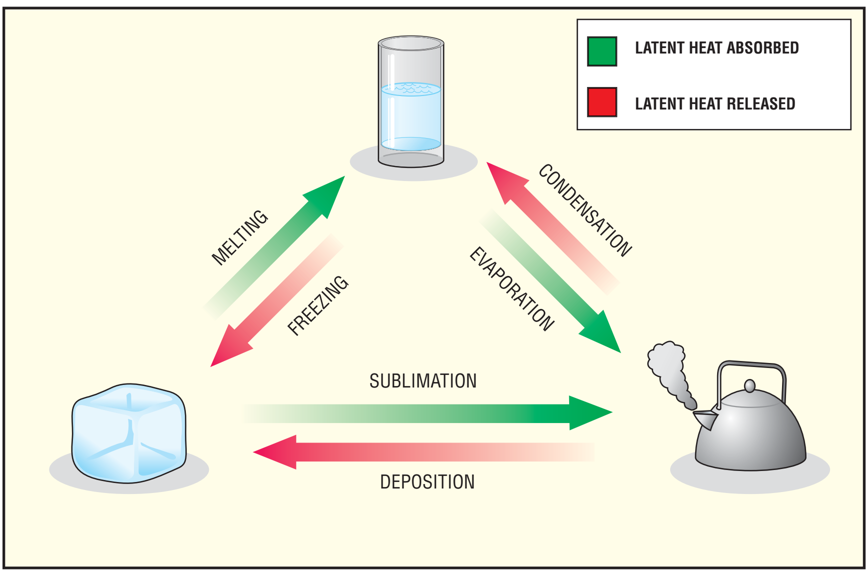


Fig. 1-1 - Heat transfer and water vapour

How much water the air contains in the form of vapour is directly related to its temperature. The warmer the air, the more water vapour it can contain. Air that contains its maximum amount of water vapour, at that given temperature, is said to be saturated. A quick measure of the moisture content of the atmosphere can be made by looking at the dew point temperature. The higher (warmer) the dew point temperature, the greater the amount of water vapour.

The planetary heat engine consists of water being evaporated by the sun into water vapour at the equator (storing heat) and transporting it towards the poles on the winds where it is condensed back into a solid or liquid state (releasing heat). Most of what we refer to as "weather," such as wind, cloud, fog and precipitation is related to this conversion activity. The severity of the weather is often a measure of how much latent heat is released during these activities.

Lifting Processes

The simplest and most common way water vapour is converted back to a liquid or solid state is by lifting. When air is lifted, it cools until it becomes saturated. Any additional lift will result in further cooling which reduces the amount of water vapour the air can hold. The excess water vapour is condensed out in the form of cloud droplets or ice crystals which then can go on to form precipitation. There are several methods of lifting an air mass. The most common are convection, orographic lift (upslope flow), frontal lift, and convergence into an area of low pressure.

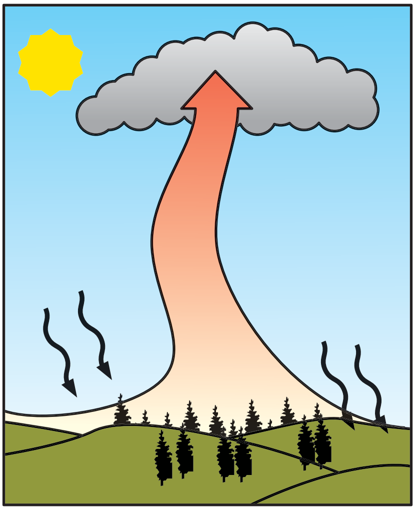


Fig. 1-2 - Convection as a result of daytime heating

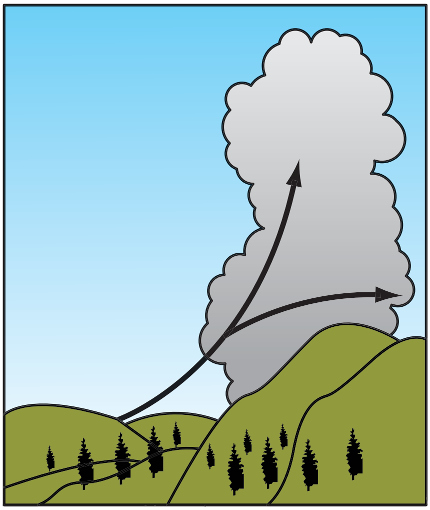


Fig.1-3 - Orographic (upslope) lift

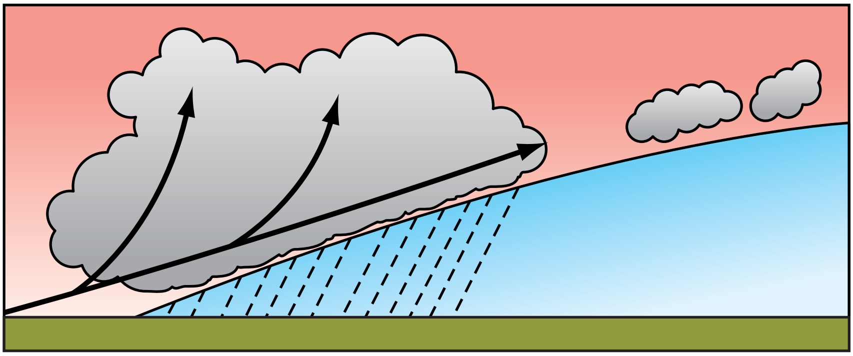


Fig.1-4 - Warm air overrunning cold air along a warm front

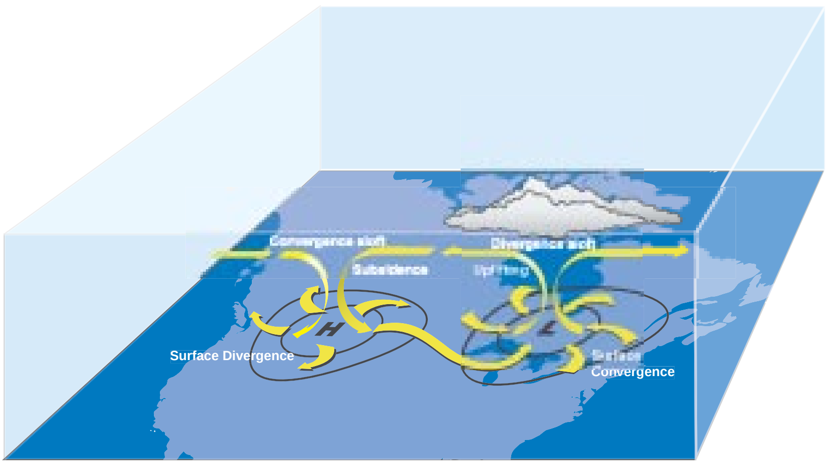


Fig. 1-5 - Divergence and convergence at the surface and aloft in a high low couplet

Subsidence

Subsidence, in meteorology, refers to the downward motion of air. This subsiding motion occurs within an area of high pressure, as well as on the downward side of a range of hills or mountains. As the air descends, it is subjected to increasing atmospheric pressure and, therefore, begins to compress. This compression causes the air's temperature to increase which will consequently lower its relative humidity. As a result, areas in which subsidence occurs will not only receive less precipitation than surrounding areas (referred to as a "rain shadow") but will often see the cloud layers thin and break up.

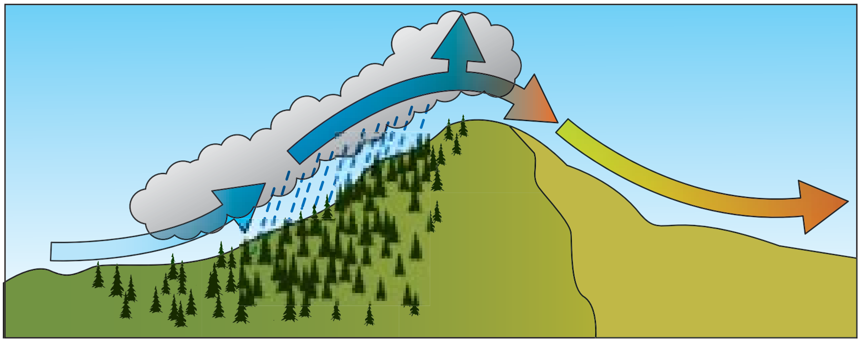


Fig.1-6 - Moist air moving over mountains where it loses its moisture and sinks into a dry subsidence area

Temperature Structure of the Atmosphere

The temperature lapse rate of the atmosphere refers to the change of temperature with a change in height. In the standard case, temperature decreases with height through the troposphere to the tropopause and then becomes relatively constant in the stratosphere.

Two other conditions are possible: an inversion, in which the temperature increases with height, or an isothermal layer, in which the temperature remains constant with height.

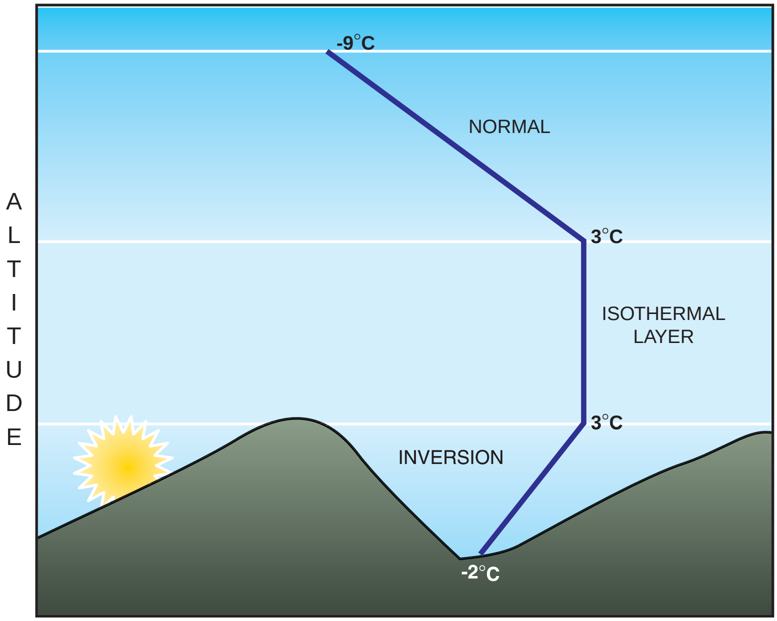


Fig. 1-7 - Different lapse rates of the atmosphere

The temperature lapse rate of the atmosphere is a direct measurement of the stability of the atmosphere.

Stability

It would be impossible to examine weather without taking into account the stability of the air. Stability refers to the ability of a parcel of air to resist vertical motion. If a parcel of air is displaced upwards and then released it is said to be unstable if it continues to ascend (since the parcel is warmer than the surrounding air), stable if it returns to the level from which it originated (since the parcel is cooler than the surrounding air), and neutral if the parcel remains at the level it was released (since the parcel's temperature is that of the surrounding air).

The type of cloud and precipitation produced varies with stability. Unstable air, when lifted, has a tendency to develop convective clouds and showery precipitation. Stable air is inclined to produce deep layer cloud and widespread steady precipitation. Neutral air will produce stable type weather which will change to unstable type weather if the lifting continues.

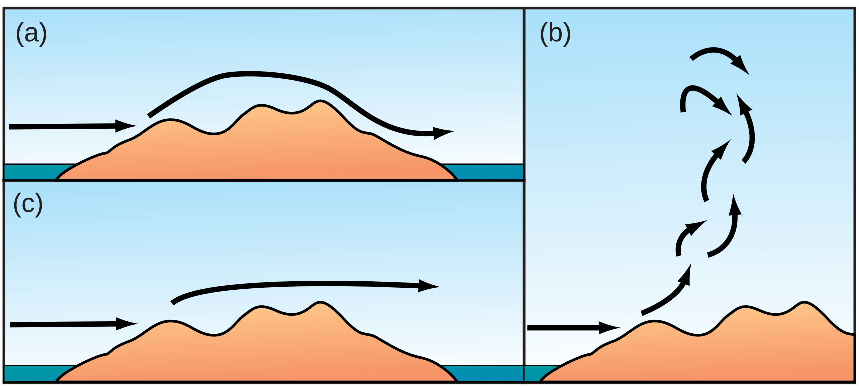


Fig. 1-8 - Stability in the atmosphere - (a) Stable (b) Unstable (c) Neutral

The stability of an air mass has the ability to be changed. One way to destabilize the air is to heat it from below, in much the same manner as you would heat water in a kettle. In the natural environment this can be accomplished when the sun heats the ground which, in turn, heats the air in contact with it, or when cold air moves over a warmer surface such as open water in the fall or winter. The reverse case, cooling the air from below, will stabilize the air. Both processes occur readily.

Consider a typical summer day where the air is destabilized by the sun, resulting in the development of large convective cloud and accompanying showers or thundershowers during the afternoon and evening. After sunset, the surface cools and the air mass stabilizes slowly, causing the convective activity to die off and the clouds to dissipate.

On any given day there may be several processes acting simultaneously that can either destabilize or stabilize the air mass. To further complicate the issue, these competing effects can occur over areas as large as an entire GFA domain to as small as a football field. To determine which one will dominate remains in the realm of a meteorologist and is beyond the scope of this manual.

Wind

Horizontal differences in temperature result in horizontal differences in pressure. It is these horizontal changes in pressure that cause the wind to blow as the atmosphere attempts to equalize pressure by moving air from an area of high pressure to an area of low pressure. The larger the pressure difference, the stronger the wind and, as a result, the day-to-day wind can range from the gentlest breeze around an inland airfield to storm force winds over the water.

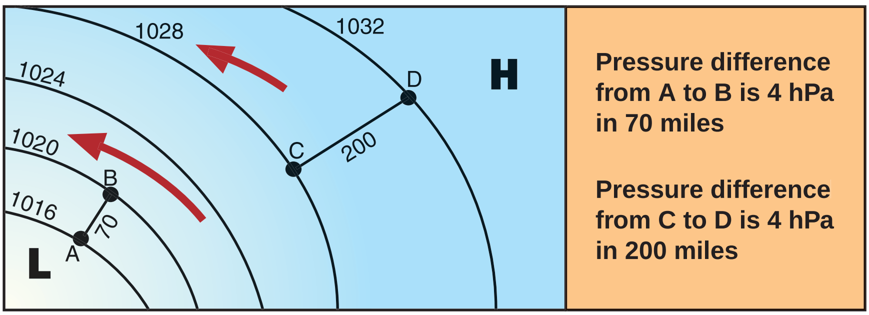


Fig. 1-9 - The greater pressure changes with horizontal difference, the stronger the wind

Wind has both speed and direction, so for aviation purposes several conventions have been adopted. Wind direction is always reported as the direction from which the wind is blowing while wind speed is the average steady state value over a certain length of time. Short-term variations in speed are reported as either gusts or squalls depending on how long they last.

Above the surface, the wind tends to be relatively smooth and changes direction and speed only in response to changes in pressure. At the surface, however, the wind is affected by friction and topography. Friction has a tendency to slow the wind over rough surfaces whereas topography, most commonly, induces localized changes in direction and speed.

Air Masses and Fronts

Air Masses

When a section of the troposphere, hundreds of miles across, remains stationary or moves slowly across an area having fairly uniform temperature and moisture, then the air takes on the characteristics of this surface and becomes known as an air mass. The area where air masses are created are called "source regions" and are either ice or snow covered polar regions, cold northern oceans, tropical oceans or large desert areas.

Although the moisture and temperature characteristics of an air mass are relatively uniform, the horizontal weather may vary due to different processes acting on it. It is quite possible for one area to be reporting clear skies while another area is reporting widespread thunderstorms.

Fronts

When air masses move out of their source regions they come into contact with other air masses. The transition zone between two different air masses is referred to as a frontal zone, or front. Across this transition zone temperature, moisture content, pressure, and wind can change rapidly over a short distance.

The principal types of fronts are:

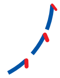
Cold Front - The cold air is advancing and undercutting the warm air. The leading edge of the cold air is the cold front.		
Warm front - The cold air is retreating and being replaced by warm air. The trailing edge of the cold air is the warm front.		
Stationary front - The cold air is neither advancing nor retreating. These fronts are frequently referred to quasi-stationary fronts although there usually is some small-scale localized motion occurring.		
Trowal - Trough of warm air aloft.		

Table 1-1

More will be said about frontal weather later in this manual.

Chapter 2

Aviation Weather Hazards

Introduction

Throughout its history, aviation has had an intimate relationship with the weather. Time has brought improvements - better aircraft, improved air navigation systems and a systemized program of pilot training. Despite this, weather continues to exact its toll.

In the aviation world, 'weather' tends to be used to mean not only "what's happening now?" but also "what's going to happen during my flight?". Based on the answer received, the pilot will opt to continue or cancel his flight. In this section we will examine some specific weather elements and how they affect flight.

Icing

One of simplest assumptions made about clouds is that cloud droplets are in a liquid form at temperatures warmer than 0°C and that they freeze into ice crystals within a few degrees below zero. In reality, however, 0°C marks the temperature below which water droplets become supercooled and are capable of freezing. While some of the droplets actually do freeze spontaneously just below 0°C, others persist in the liquid state at much lower temperatures.

Aircraft icing occurs when supercooled water droplets strike an aircraft whose temperature is colder than 0°C. The effects icing can have on an aircraft can be quite serious and include:

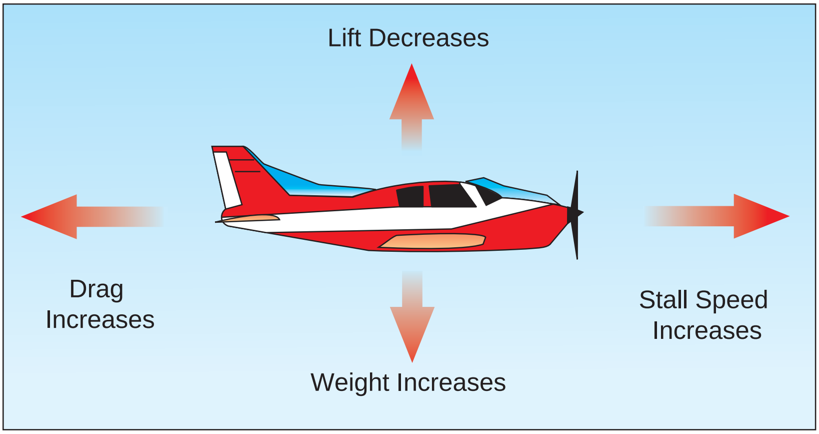


Fig. 2-1 - Effects of icing

- disruption of the smooth laminar flow over the wings causing a decrease in lift and an increase in the stall speed. This last effect is particularly dangerous. An "iced" aircraft is effectively an "experimental" aircraft with an unknown stall speed.
- increase in weight and drag thus increasing fuel consumption
- partial or complete blockage of pitot heads and static ports giving erroneous instrument readings
- restriction of visibility as the windshield glazes over.

The Freezing Process

When a supercooled water droplet strikes an aircraft surface, it begins to freeze, releasing latent heat. This latent heat warms the remainder of the droplet to near 0°C, allowing the unfrozen part of the droplet to spread back across the surface until freezing is complete. The lower the air temperature and the colder the aircraft surface, the greater the fraction of the droplet that freezes immediately on impact. Similarly, the smaller the droplet, the greater the fraction of the droplet that freezes immediately on impact. Finally, the more frequent the droplets strike the aircraft surface, the greater the amount of water that will flow back over the aircraft surface. In general, the maximum potential for icing occurs with large droplets at temperatures just below 0°C.

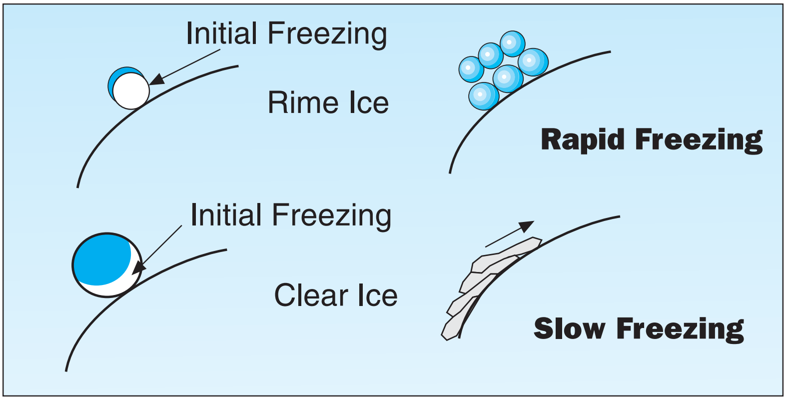


Fig. 2-2 - Freezing of supercooled droplets on impact

Types of Aircraft Ice

Rime Ice

Rime ice is a product of small droplets where each droplet has a chance to freeze completely before another droplet hits the same place. The ice that is formed is opaque and brittle because of the air trapped between the droplets. Rime ice tends to form on the leading edges of airfoils, builds forward into the air stream and has low adhesive properties.

Clear Ice

In the situation where each large droplet does not freeze completely before additional droplets become deposited on the first, supercooled water from each drop merges and spreads backwards across the aircraft surface before freezing completely to form an ice with high adhesive properties. Clear ice tends to range from transparent to a very tough opaque layer and will build back across the aircraft surface as well as forward into the air stream.

Mixed Ice

When the temperature and the range of droplet size vary widely, the ice that forms is a mixture of rime ice and clear ice. This type of ice usually has more adhesive properties than rime ice, is opaque in appearance, rough, and generally builds forward into the air stream faster than it spreads back over the aircraft surface.

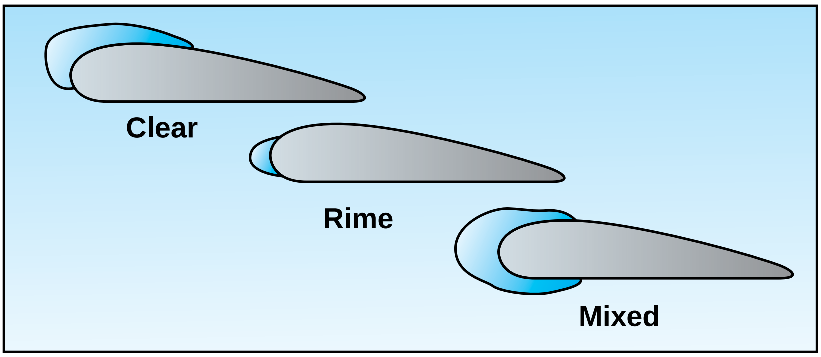


Fig. 2-3 - Accumulation patterns of different icing types

Meteorological Factors Affecting Icing

(a) Liquid Water Content of the Cloud

The liquid water content of a cloud is dependent on the size and number of droplets in a given volume of air. The greater the liquid water content, the more serious the icing potential. Clouds with strong vertical updrafts generally have a higher liquid water content as the updrafts prevent even the large drops from precipitating.

The strongest updrafts are to be found in convective clouds, clouds formed by abrupt orographic lift, and in lee wave clouds. Layer clouds tend to have weak updrafts and are generally composed of small droplets.

(b) Temperature Structure in the Cloud

Warm air can contain more water vapour than cold air. Thus, clouds that form in warm air masses will have a higher liquid water content than those that form in cold air.

The temperature structure in a cloud has a significant effect on the size and number of droplets. Larger supercooled droplets begin to freeze spontaneously around -10°C with the rate of freezing of all size of droplets increasing rapidly as temperatures fall below -15°C. By -40°C, virtually all the droplets will be frozen. The exceptions are clouds with very strong vertical updrafts, such as towering cumulus or cumulonimbus, where liquid water droplets can be carried to great heights before freezing.

These factors allow the icing intensities to change rapidly with time so that it is possible for aircraft only minutes apart to encounter entirely different icing conditions in the same area. Despite this, some generally accepted rules have been developed:

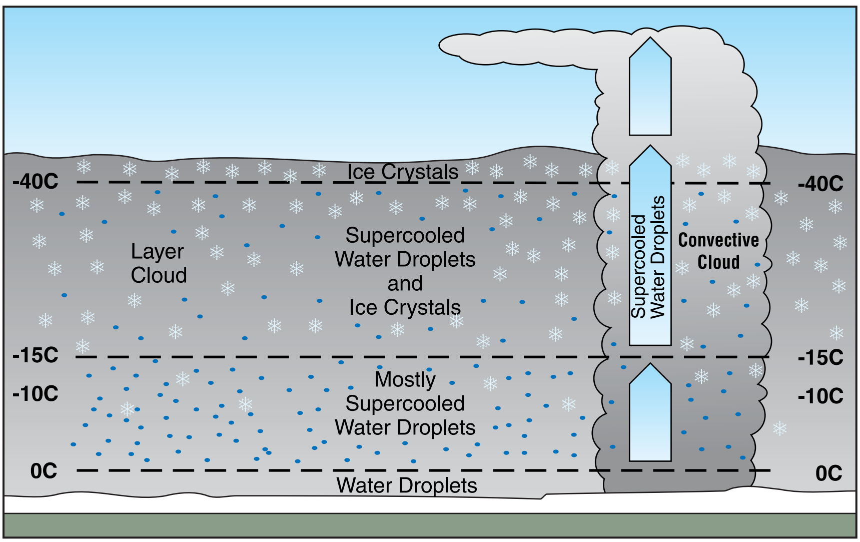


Fig. 2-4 - Distribution of water droplet-ice crystals in cloud

(1) Within large cumulus and cumulonimbus clouds:

- at temperatures between 0°C and -25°C, severe clear icing likely.
- at temperatures between -25°C and -40°C, light rime icing likely; small possibility of moderate to severe rime or mixed icing in newly developed clouds.
- at temperatures below -40°C, little chance of icing.

(2) Within layer cloud:

- the most significant icing layer is generally confined to the 0°C to -15°C temperature range.

- icing is usually less severe than in convective cloud due to the weaker updrafts and smaller droplets.
- icing layers tend to be shallow in depth but great in horizontal extent.

(3) Situations in which icing may be greater than expected:

- air moving across large unfrozen lakes in the fall and winter will increase its moisture content and destabilize rapidly due to heating from below. The cloud that forms, while resembling a layer cloud, will actually be a convective cloud capped by an inversion with relatively strong updrafts and a large concentration of supercooled drops.
- thick layer cloud formed by rapid mass ascent, such as in an intensifying low or along mountain slopes, will also have enhanced concentrations of supercooled drops. Furthermore, there is a strong possibility that such lift will destabilize the air mass resulting in embedded convective clouds with their enhanced icing potential.
- lenticular clouds can have very strong vertical currents associated with them. Icing can be severe and, because of the droplet size, tend toward clear icing.

Supercooled Large Drop Icing

Supercooled large drop (SLD) icing has, until fairly recently, only been associated with freezing rain. Several accidents and significant icing events have revealed the existence of a deadly form of SLD icing in non-typical situations and locations. It was found that large cloud drops, the size of freezing drizzle drops, could exist within some stratiform cloud layers, whose cloud top is usually at 10,000 feet or less. The air temperature within the cloud (and above) remains below 0°C but warmer than -18°C throughout the cloud layer. These large drops of liquid water form near the cloud top, in the presence of light to moderate mechanical turbulence, and remain throughout the cloud layer. SLD icing is usually severe and clear. Ice accretion onto flight surfaces of 2.5 centimetres or more in 15 minutes or less have been observed.

There are a few indicators that may help announce SLD icing beforehand. SLD icing-producing stratiform clouds often occur in a stable air mass, in the presence of a gentle upslope circulation, sometimes coming from a large body of water. The air above the cloud layer is always dry, with no significant cloud layers above. The presence of freezing drizzle underneath, or liquid drizzle when the surface air temperature is slightly above 0°C, is a sure indication of SLD icing within the cloud. Other areas where this type of icing is found is in the cloud to the southwest of a low pressure centre and behind cold fronts where low level stratocumulus are common (cloud tops often below 13,000 feet). Constant and careful attention must be paid when flying a holding pattern within a cloud layer in winter.

SLD icing-producing clouds are common in flows off Hudson Bay, Hudson Strait, and Foxe Basin prior to freeze-up and in flows off open water open leads and polynyas of the waterways of the arctic islands during the fall and winter. These low-level clouds often produce drizzle or freezing drizzle.

The Glory: A Warning Sign for Aircraft Icing

Photo 2-1 - Glory surrounding aircraft shadow on cloud top credit: Alister Ling

The glory is one of the most common forms of halo visible in the sky. For the pilot it is a warning sign of potential icing because it is only visible when there are liquid water droplets in the cloud. If the air temperature at cloud level is below freezing, icing will occur in those clouds that produce a glory.

A glory can be seen by looking downwards and seeing it surround the shadow that your aircraft casts onto the cloud tops. They can also be seen by looking upwards towards the sun (or bright moon) through clouds made of liquid droplets.

It is possible to be high enough above the clouds or fog that your shadow is too small to see at the center of the glory. Although ice crystals often produce other halos and arcs, only water droplets form bullseyes.

Aerodynamic Factors Affecting Icing

There are various aerodynamic factors that affect the collection efficiency of an aircraft surface. Collection efficiency can be defined as the fraction of liquid water droplets that actually strike the aircraft relative to the number of droplets encountered along the flight path.

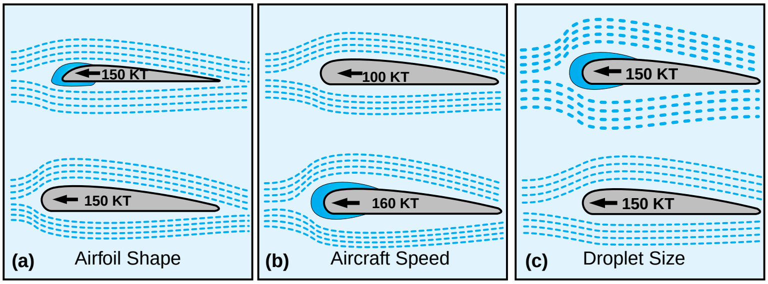


Fig. 2-5 -Variations in collection efficiency

Collection efficiency is dependent on three factors:

(a) The radius of curvature of the aircraft component. Airfoils with a big radius of curvature disrupt the airflow (like a bow wave) causing the smaller supercooled droplets to be carried around the airfoil by the air stream. For this reason, large thick components (thick wings, canopies) collect ice less efficiently than thin components (thin wings, struts, antenna).

(b) Speed. The faster the aircraft the less chance the droplets have to be diverted around the airfoil by the air stream.

(c) Droplet size. The larger the droplet the more difficult it is for the air stream to displace it.

Other Forms of Icing

(a) Freezing Rain and Ice Pellets

Freezing rain occurs when liquid water drops that are above freezing fall into a layer of air whose temperature is colder than 0°C and supercool before hitting some object. The most common scenario leading to freezing rain in Western Canada is "warm overrunning". In this case, warm air (above 0°C) is forced up and over colder air at the surface. In such a scenario, rain that falls into the cold air supercools, resulting in freezing rain that can last for hours especially if cold air continues to drain into the area from the surrounding terrain. When the cold air is sufficiently deep, the freezing raindrops can freeze completely before reaching the surface causing ice pellets. Pilots should be aware, however, that ice pellets at the surface imply freezing rain aloft. Such conditions are relatively common in the winter and tend to last a little longer in valleys than over flat terrain.

(b) Freezing Drizzle or Snow Grains

Freezing drizzle is different from freezing rain in that the water droplets are smaller. Another important difference is that freezing drizzle may develop in air masses whose entire temperature profile is below freezing. In other words, freezing drizzle can occur without the presence of a warm layer (above 0°C) aloft. In this case, favorable areas for the development of freezing drizzle are in moist maritime air masses, preferably in areas of moderate to strong upslope flow. The icing associated with freezing drizzle may have a significant impact on aviation. Similar to ice pellets, snow grains imply the presence of freezing drizzle aloft.

(c) Snow
Dry snow will not adhere to an aircraft surface and will not normally cause icing problems. Wet snow, however, can freeze hard to an aircraft surface that is at subzero temperatures and be extremely difficult to remove. A very dangerous situation can arise when an aircraft attempts to take off with wet snow on the flight surfaces. Once the aircraft is set in motion, evaporational cooling will cause the wet snow to freeze hard causing a drastic reduction in lift as well as increasing the weight and drag. Wet snow can also freeze to the windscreens making visibility difficult to impossible.

(d) Freezing Spray
Freezing spray develops over open water when there is an outbreak of Arctic air. While the water itself is near or above freezing, any water that is picked up by the wind or is splashed onto an object will quickly freeze, causing a rapid increase in weight and shifting the centre of gravity.

(e) Freezing Fog
Freezing fog is a common occurrence during the winter. Fog is simply "a cloud touching the ground" and, like its airborne cousin, will have a high percentage of supercooled water droplets at temperatures just below freezing (0°C to -10°C). Aircraft landing, taking off, or even taxiing, in freezing fog should anticipate rime icing.

Visibility

Reduced visibility is the meteorological component which impacts flight operations the most. Topographic features all tend to look the same at low levels making good route navigation essential. This can only be done in times of clear visibility.

Types of Visibility

There are several terms used to describe the different types of visibility used by the aviation community.

(a) **Horizontal visibility** - the furthest visibility obtained horizontally in a specific direction by referencing objects or lights at known distances.

(b) **Prevailing visibility** - the ground level visibility which is common to one-half or more of the horizon circle.

(c) **Vertical visibility** - the maximum visibility obtained by looking vertically upwards into a surface-based obstruction such as fog or snow.

(d) Slant visibility - visibility observed by looking forward and downwards from the cockpit of the aircraft.

(e) Flight visibility - the average range of visibility at any given time forward from the cockpit of an aircraft in flight.

Causes of Reduced Visibility

(a) Lithometers

Lithometers are dry particles suspended in the atmosphere and include haze, smoke, sand and dust. Of these, smoke and haze cause the most problems. The most common sources of smoke are forest fires. Smoke from distant sources will resemble haze but, near a fire, smoke can reduce the visibility significantly.

(b) Precipitation

Rain can reduce visibility, however, the restriction is seldom less than one mile other than in the heaviest showers beneath cumulonimbus clouds. Drizzle, because of the greater number of drops in each volume of air, is usually more effective than rain at reducing the visibility, especially when accompanied by fog.

Snow affects visibility more than rain or drizzle and can easily reduce it to less than one mile. Blowing snow is a product of strong winds picking up the snow particles and lifting them into the air. Fresh fallen snow is easily disturbed and can be lifted a few hundred feet. Under extreme conditions, the cockpit visibility will be excellent during a landing approach until the aircraft flares, at which time the horizontal visibility will be reduced abruptly.

(c) Fog

Fog is the most common and persistent visibility obstruction encountered by the aviation community. A cloud based on the ground, fog, can consist of water droplets, supercooled water droplets, ice crystals or a mix of supercooled droplets and ice crystals.

(i) Radiation Fog

Radiation fog begins to form over land usually under clear skies and light winds typically after midnight and peaks early in the morning. As the land surface loses heat and radiates it into space, the air above the land is cooled and loses its ability to hold moisture. If an abundance of condensation nuclei is present in the atmosphere, radiation fog may develop before the temperature-dewpoint spread reaches zero. After sunrise, the fog begins to burn off from the edges over land but any fog that has drifted over water will take longer to burn off.

Photo 2-2 - Fog over Slidre Fiord, Eureka credit: unknown

(ii) Precipitation or Frontal Fog

Precipitation fog, or frontal fog, forms ahead of warm fronts when precipitation falls through a cooler layer of air near the ground. The precipitation saturates the air at the surface and fog forms. Breaks in the precipitation usually results in the fog becoming thicker.

(iii) Steam Fog

Steam fog forms when very cold arctic air moves over relatively warmer water. In this case moisture evaporates from the water surface and saturates the air. The extremely cold air cannot hold all the evaporated moisture, so the excess condenses into fog. The result looks like steam or smoke rising from the water, and is usually no more than 50 to 100 feet thick. Steam fog, also called arctic sea smoke, can produce significant icing conditions.

(iv) Advection Fog

Fog that forms when warm moist air moves across a snow, ice or cold water surface.

(v) Ice Fog

Ice fog occurs when water vapour sublimates directly into ice crystals. In conditions of light winds and temperatures colder than -30°C or so, water vapour from manmade sources or cracks in ice-covered rivers can form widespread and persistent ice fog. The fog produced by local heating systems, and even aircraft engines, can reduce the local visibility to near zero, closing an airport for hours or even days. Ice fog is also called habitation fog. The fog may only extend for a few hundred feet.

(d) Snow Squalls and Streamers

Snow squalls are relatively small areas of heavy snowfall. They develop when cold arctic air passes over a relatively warm water surface, such as Hudson Bay, before freeze-up. An injection of heat and moisture from the lake into the low levels of the atmosphere destabilizes the air mass. If sufficient destabilization occurs, convective clouds begin to develop with snow beginning shortly thereafter. Snowsqualls usually develop in bands of cloud, or streamers, that form parallel to the direction of flow. Movement of these snow squalls can generally be tied to the mean winds between 3,000 and 5,000 feet. Not only can snowsqualls reduce visibility to near zero but, due to their convective nature, significant icing and turbulence are often encountered within the clouds.

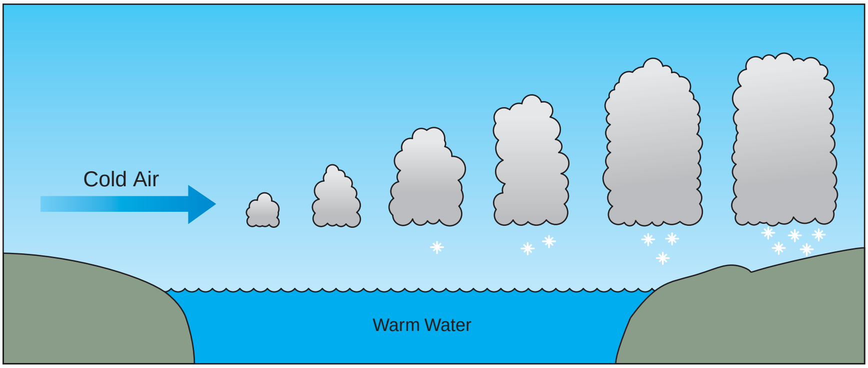


Fig. 2-6 - Snowsqualls building over open water

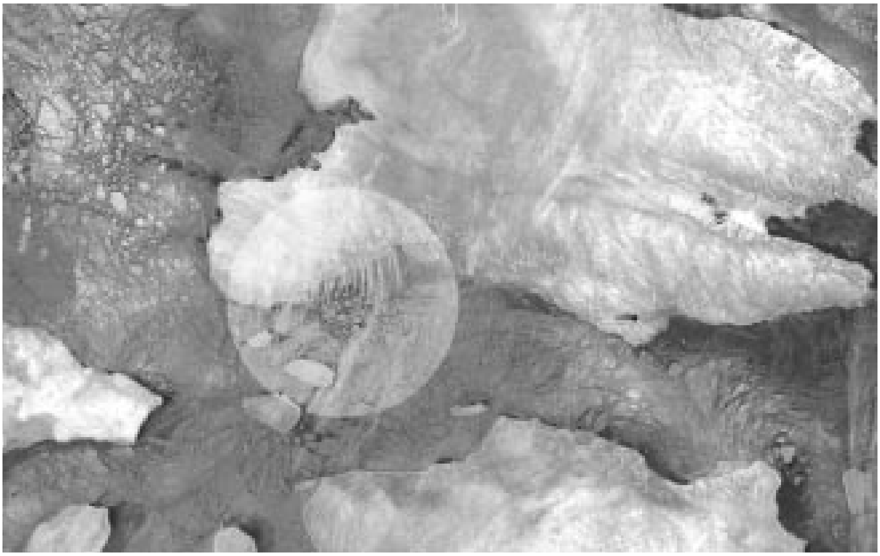


Photo 2-3 - Streamers developing over the open water of Hudson Strait near Cape Dorset in northwest flow per infrared satellite.

Wind, Shear and Turbulence

The "why" of winds are quite well understood. It is the daily variations of the winds, where they blow and how strong, that remains a constant problem for meteorologists to unravel. The problem becomes even more difficult when local effects such as wind flow through coastal inlets or in mountain valleys are added to the dilemma. The result of these effects can give one airport persistent light winds while another has nightly episodes of strong gusty winds.

Stability and the Diurnal Variation in Wind

In a stable weather pattern, daytime winds are generally stronger and gustier than nighttime winds. During the day, the heating from the sun sets up convective mixing which carries the stronger winds aloft down to the surface and mixes them with the slower surface winds. This causes the surface wind to increase in speed and become gusty, while at the same time reducing the wind speeds aloft in the mixed layer.

After sunset, the surface of the earth cools which, in turn, cools the air near the surface resulting in the development of a temperature inversion. This inversion deepens as cooling continues, ending the convective mixing and causing the surface winds to slacken.

Wind Shear

Wind shear is nothing more than a change in wind direction and/or wind speed over the distance between two points. If the points are in a vertical direction then it is called vertical shear, if they are in a horizontal direction than it is called horizontal shear.

In the aviation world, the major concern is how abruptly the change occurs. If the change is gradual, a change in direction or speed will result in nothing more than a minor change in the ground speed. If the change is abrupt, however, there will be a rapid change of airspeed or track. Depending on the aircraft type, it may take a significant time to correct the situation, placing the aircraft in peril, particularly during takeoff and landing.

Significant shearing can occur when the surface wind blowing along a valley varies significantly from the free flowing wind above the valley. Changes in direction of 90° and speed changes of 25 knots are reasonably common in mountainous terrain.

Updrafts and downdrafts also induce shears. An abrupt downdraft will cause a brief decrease in the wing's attack angle resulting in a loss of lift. An updraft will increase the wing's attack angle and consequently increase the lift, however, there is a risk that it could be increased beyond the stall angle.

Shears can also be encountered along fronts. Frontal zones are generally thick enough that the change is gradual, however, cold frontal zones as thin as 200 feet have been measured. Significant directional shears across a warm front have also been observed with the directional change greater than 90 degrees over several hundred feet. Pilots doing a take-off or a landing approach through a frontal surface that is just above the ground should be wary.

Mechanical turbulence is a form of shear induced when a rough surface disrupts the smooth wind flow. The amount of shearing and the depth of the shearing layer depends on the wind speed, the roughness of the obstruction and the stability of the air.

The Relationship Between Wind Shear and Turbulence

Turbulence is the direct result of wind shear. The stronger the shear the greater the tendency for the laminar flow of the air to break down into eddies resulting in turbulence. However, not all shear zones are turbulent, so the absence of turbulence does not infer that there is no shear.

Low-Level Jets - Frontal

In developing low pressure systems, a narrow band of very strong winds often develops just ahead of the cold front and above the warm frontal zone. Meteorologists call these bands of strong winds “low-level jets”. They are typically located between 500 and 5,000 feet and can be several hundred feet wide. Wind speeds associated with low-level jets can reach as high as 100 knots in more intense storms. The main problem with these features is that they can produce severe turbulence, or at least significant changes in airspeed. Critical periods for low-level windshear or turbulence with these features are one to three hours prior to a cold frontal passage. These conditions are made worse by the fact that they occur in the low levels of the atmosphere and affect aircraft in the more important phases of flight - landing and take off.

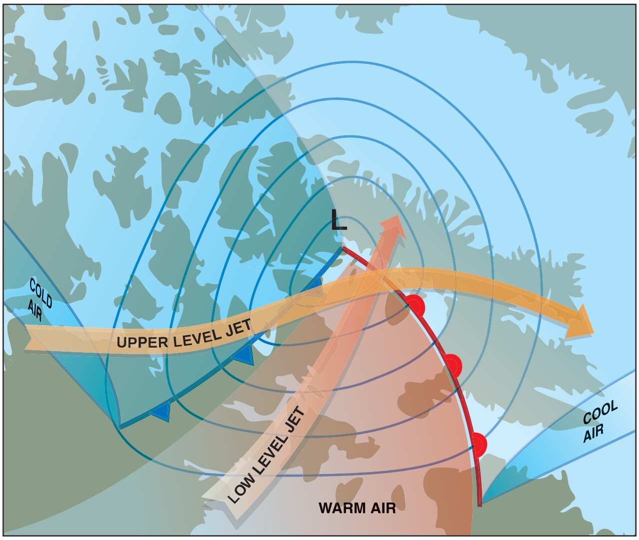


Fig. 2-7 - Idealized low and frontal system showing the position of the low-level and upper-level jet

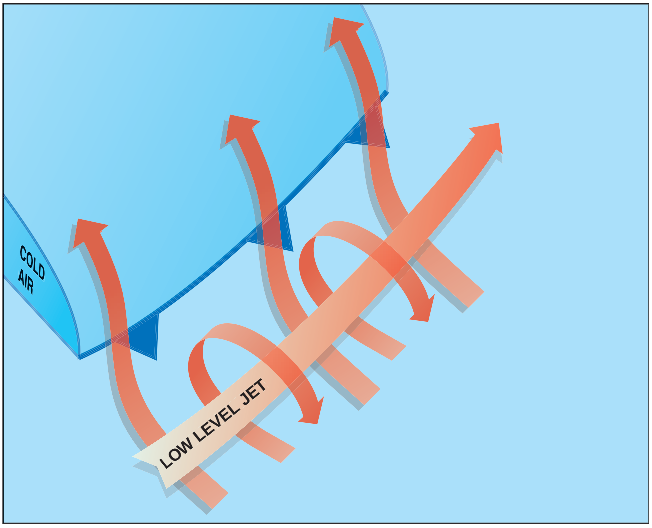


Fig. 2-8 - Complex winds around a low-level jet can result in significant low-level wind shear and turbulence

Low-Level Jets - Nocturnal

There is another type of low-level jet known as “the low-level nocturnal jet”. This jet is a band of relatively high wind speeds, typically centred at altitudes ranging between 700 and 2,000 feet above the ground (just below the top of the nocturnal inversion) but on occasion can be as high as 3,000 feet. Wind speeds usually range between 20 and 40 knots but have been observed up to 60 knots.

The low-level nocturnal jet tends to form over relatively flat terrain and resembles a ribbon of wind in that it is thousands of miles long, a few hundred feet thick and up to hundreds of miles wide. Low-level nocturnal jets have been observed in mountainous terrain but tend to be localized in character.

The low-level nocturnal jet forms mainly in the summer on clear nights (this allows the inversion to form). The winds just below the top of the inversion will begin to increase just after sunset, reach its maximum speed a couple of hours after midnight, then dissipate in the morning as the sun's heat destroys the inversion.

Topographical Effects on Wind

(a) Lee Effects

When the winds blow against a steep cliff or over rugged terrain, gusty turbulent winds result. Eddies often form downwind of the hills, which create stationary zones of stronger and lighter winds. These zones of strong winds are fairly predictable and usually persist as long as the wind direction and stability of the air stream do not change. The lighter winds, which occur in areas called wind shadows, can vary in speed and direction, particularly downwind of higher hills. In the lee of the hills, the wind is usually gusty and the wind direction is often completely opposite to the wind blowing over the top of the hills. Smaller reverse eddies may also be encountered close to the hills.

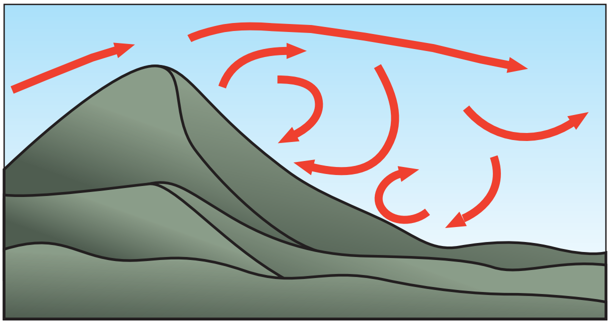


Fig. 2-9 - Lee effects

(b) Friction Effects

The winds that blow well above the surface of the earth are not strongly influenced by the presence of the earth itself. Closer to the earth, however, frictional effects decrease the speed of the air movement and back the wind (turns the wind direction counter-clockwise) towards the lower pressure. For example, in the northern hemisphere, a southerly wind becomes more southeasterly when blowing over rougher ground. There can be a significant reduction in the wind speed over a rough terrain when compared to the wind produced by the same pressure gradient over a relatively smooth prairie.

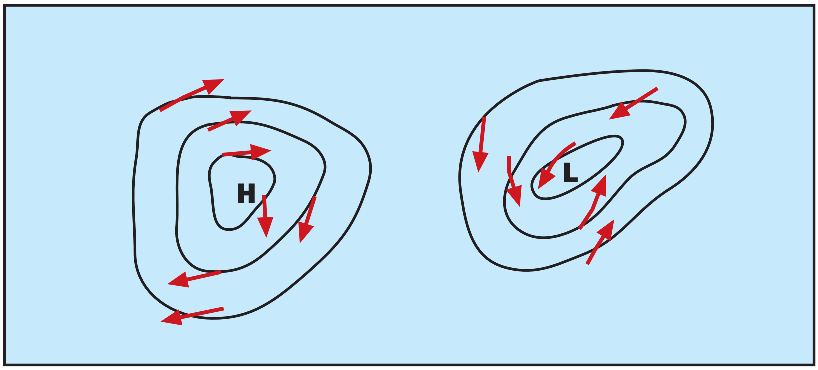


Fig. 2-10 - Friction effects

(c) Converging Winds

When two or more winds flow together or converge, a stronger wind is created. Similar effects can be noted where two or more valleys come together.

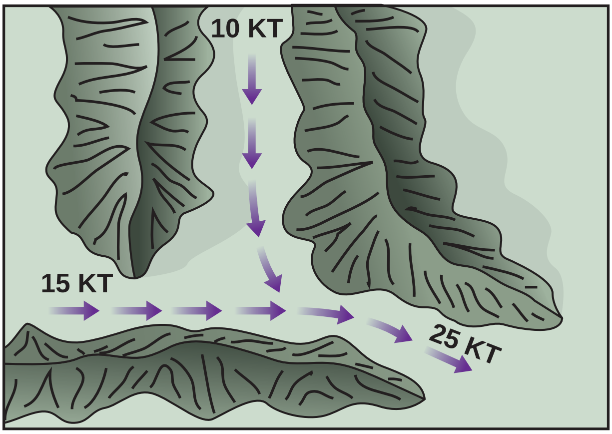


Fig. 2-11 - Converging winds

(d) Diverging Winds

A divergence of the air stream occurs when a single air stream splits into two or more streams. Each will have a lower speed than the parent air stream.

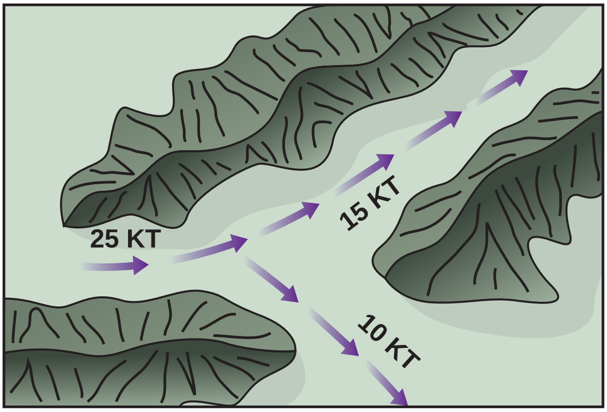


Fig. 2-12 - Diverging winds

(e) Corner Winds

When the prevailing wind encounters a headland, there is a tendency for the wind to curl around the feature. This change in direction, if done abruptly, can result in turbulence.

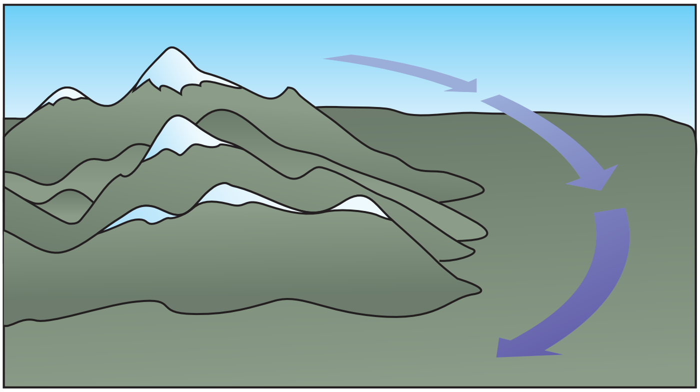


Fig. 2-13 - Corner winds

(f) Funnelled or Gap Winds

When winds are forced to flow through a narrow opening or gap, such as an inlet or narrow section of a pass, the wind speed will increase and may even double in strength. This effect is similar to pinching a water hose and is called funnelling.

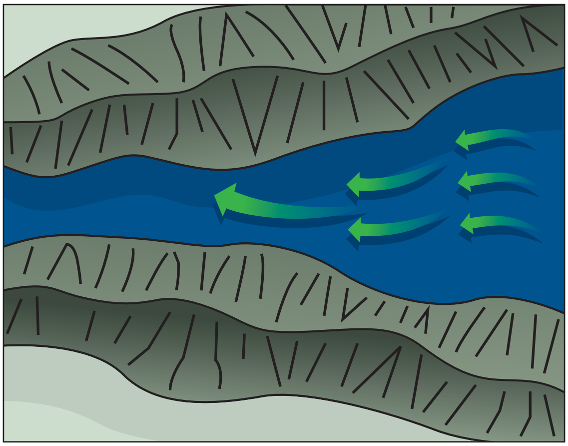


Fig. 2-14 - Funnelled winds

(g) Channelled Winds

The topography can also change the direction of the winds by forcing the flow along the direction of a pass or valley. This is referred to as channelling.

(h) Sea and Land Breezes

Sea and land breezes are only observed under light wind conditions, and depend on temperature differences between adjoining regions.

A sea breeze occurs when the air over the land is heated more rapidly than the air over the adjacent water surface. As a result, the warmer air rises and the relatively cool air from the water flows onshore to replace it. By late afternoon, the time of maximum heating, the sea breeze circulation may be 1,500 to 3,000 feet deep, have obtained speeds of 10 to 15 knots and extend as far as 50 nautical miles inland.

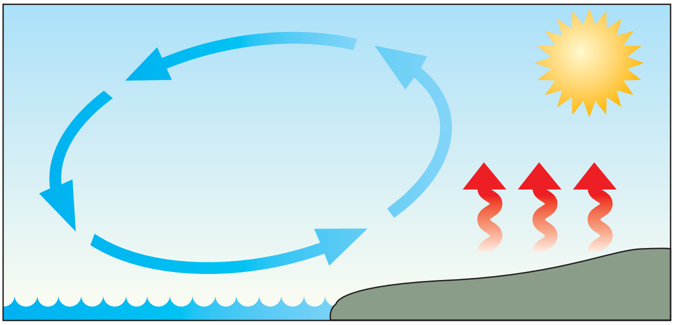


Fig. 2-15 - Sea breeze

During the evening the sea breeze subsides. At night, as the land cools, a land breeze develops in the opposite direction and flows from the land out over the water. It is generally not as strong as the sea breeze, but at times it can be quite gusty.

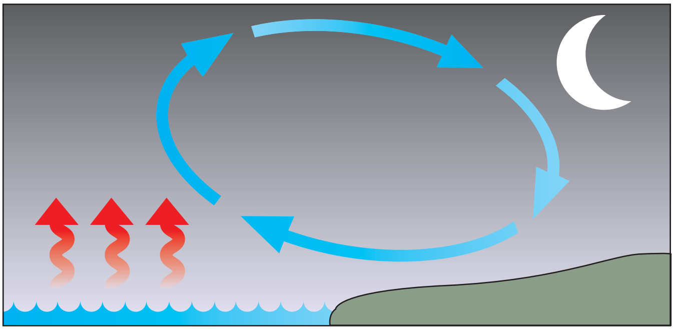


Fig. 2-16 - Land breeze

Both land and sea breezes can be influenced by channelling and funnelling resulting in almost frontal-like conditions, with sudden wind shifts and gusty winds that may reach up to 50 knots.

(i) Anabatic and Katabatic Winds

During the day, the sides of the valleys become warmer than the valley bottoms since they are better exposed to the sun. As a result, the winds blow up the slope. These daytime, upslope winds are called anabatic winds. Gently sloped valley sides, especially those facing south, are more efficiently heated than those of a steep, narrow valley. As a result, valley breezes will be stronger in the wider valleys. An anabatic wind, if extended to sufficient height, will produce cloud. In addition, such a wind offers additional lift to aircraft.

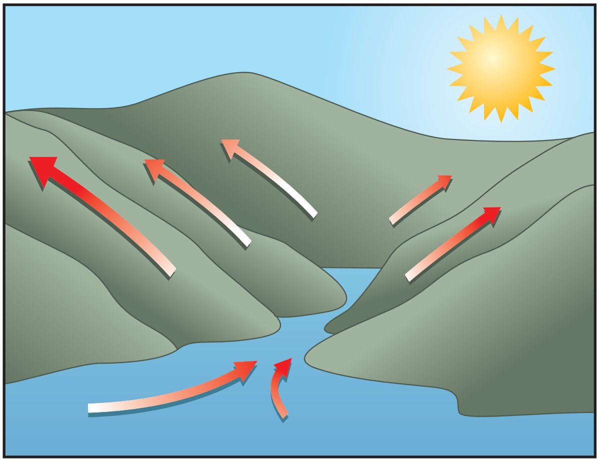


Fig. 2-17 - Anabatic winds

At night, the air cools over the mountain slopes and sinks to the valley floor. If the valley floor is sloping, the winds will move along the valley towards lower ground. The cool night winds are called drainage winds, or katabatic winds, and are often quite gusty and usually stronger than anabatic winds. Some valley airports have windsocks situated at various locations along their runways to show the changeable conditions due to the katabatic flow.

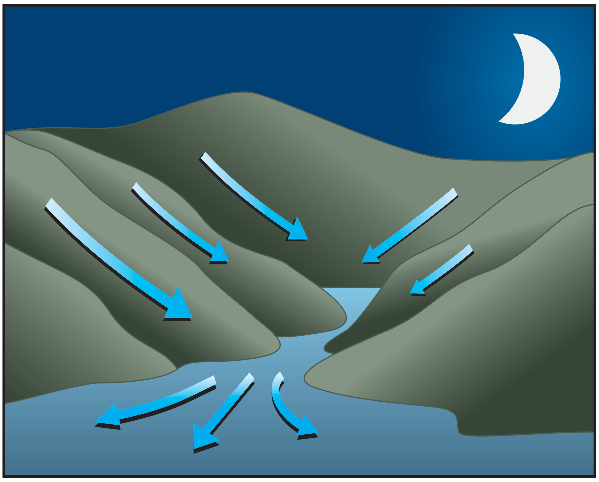


Fig. 2-18 - Katabatic winds

(j) Glacier Winds

Under extreme cooling conditions, such as an underlying ice cover, the katabatic winds can develop to hazardous proportions. As the ice is providing the cooling, a shallow wind of 80 knots or more can form and will persist during the day and night. In some locations the katabatic flow "pulsates" with the cold air building up to some critical value before being released to rush downslope.

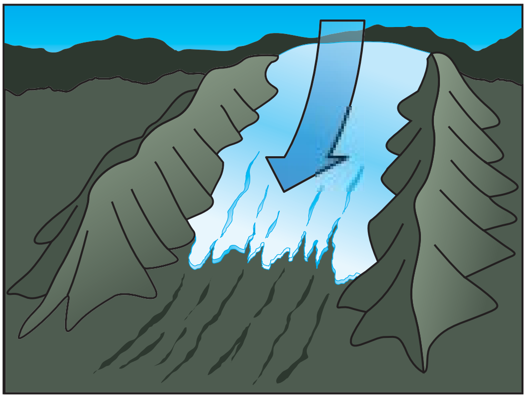


Fig. 2-19 - Glacier winds

It is important to recognize that combinations of these effects can operate at any given time. Katabatic winds are easily funnelled resulting in winds of unexpected directions and strengths in narrow passes. Around glaciers in the summer, wind fields can be chaotic. Katabatic winds from the top of the glacier struggle for dominance with localized convection, or anabatic winds, induced by heated rock slopes below the ice. Many sightseeing pilots prefer to avoid glaciated areas during the afternoon hours.

Lee Waves

When air flows across a mountain or hill, it is disturbed the same way as water flowing over a rock. The air initially is displaced upwards across the mountain, dips sharply on the lee side, then rises and falls in a series of waves downstream. These waves are called "mountain waves" or "lee waves" and are most notable for their turbulence. They can develop on the lee side of the mountains of Ellesmere Island and the mountain along the east side of Baffin Island.

The Formation of Lee Waves

The development of lee waves requires that several conditions be met:

(a) the wind direction must be within 30 degrees of perpendicular to the mountain or hill. The greater the height of the mountain and the sharper the drop off to the lee side, the more extensive the induced oscillations.

(b) wind speed should exceed 15 knots for small hills and 30 knots for mountain ridges. A jet stream with its associated strong winds below the jet axis is an ideal situation.

(c) the wind direction should be constant while increasing in speed with height throughout the troposphere.

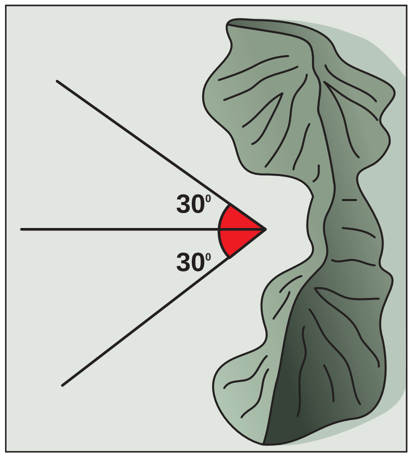


Fig. 2-20 - Angles for lee wave development

(c) the air should be stable near the mountain peaks but less stable below. The unstable layer encourages the air to ascend and the stable layer encourages the development of a downstream wave pattern.

While all these conditions can be met at any time of the year, winter wind speeds are generally stronger resulting in more dangerous lee waves.

Characteristics of Lee Waves

Once a lee wave pattern has been established, it follows several basic rules:

- stronger the wind, the longer the wavelength. The typical wavelength is about 6 miles but can vary from as short as 3 miles to as long as 15 miles.
- position of the individual wave crests will remain nearly stationary with the wind blowing through them as long as the mean wind speed remains nearly constant.

- individual wave amplitude can exceed 3,000 feet.
- layer of lee waves often extends from just below the tops of the mountains to 4,000 to 6,000 feet above the tops but can extend higher.
- induced vertical currents within the wave can reach values of 4,500 feet per minute.
- wind speed is stronger through the wave crest and slower through the wave trough.
- wave closest to the obstruction will be the strongest with the waves further downstream getting progressively weaker.
- a large eddy called a "rotor" may form below each wave crest.
- mountain ranges downstream may amplify or nullify induced wave patterns.
- downdrafts are frequently found on the downwind side of the obstruction. These downdrafts typically reach values of 2,000 feet per minute but downdrafts up to 5,000 feet per minute have been reported. The strongest downdraft is usually found at a height near the top of the summit and could force an aircraft into the ground.

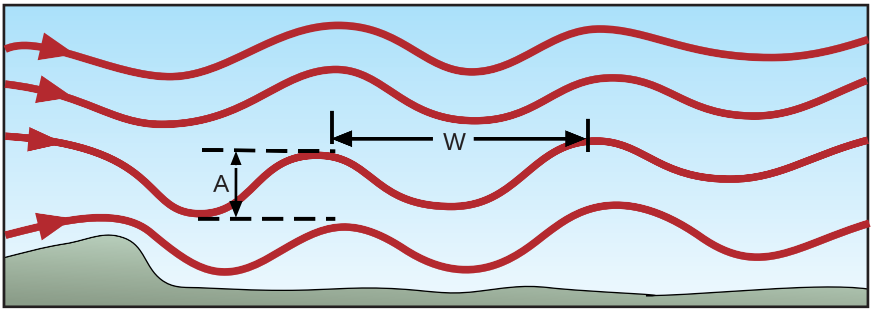


Fig. 2-21 - Amplitude (A) and wavelength (W) in lee waves

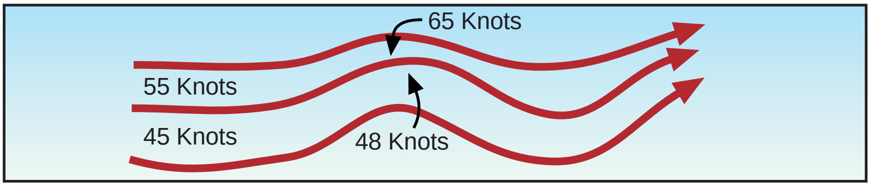


Fig. 2-22 - Stronger wind in wave crest in lee waves

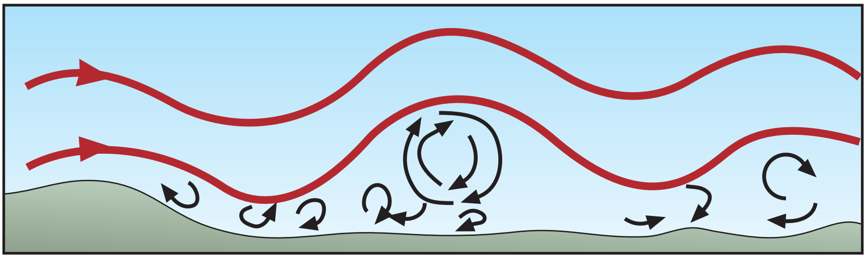


Fig. 2-23 - A rotor may form beneath wave crests

Clouds Associated with Lee Waves

Lee waves involve lift and, if sufficient moisture is available, characteristic clouds will form. The signature clouds may be absent, however, due to the air being too dry or the cloud being embedded within other clouds and not visible. It is essential to realize, nevertheless, that the absence of lee wave clouds does not mean that there are no lee waves present.

(a) Cap cloud

A cloud often forms over the peak of the mountain range and remains stationary. Frequently, it may have an almost "waterfall" appearance on the leeward side of the mountain. This effect is caused by subsidence and often signifies a strong downdraft just to the lee of the mountaintop.

(b) Lenticular clouds

A lens shaped cloud may be found at the crest of each wave. These clouds may be separated vertically with several thousand feet between each cloud or may form so close together they resemble a "stack of plates." When air flows through the crest it is often laminar, making the cloud smooth in appearance. On occasion, when the shear results in turbulence, the lenticular cloud will take on a ragged and wind torn appearance.

Photo 2-4 - Lenticular cloud at Resolute credit: David Schmidt

(c) Rotor cloud

A rotor cloud may form in association with the rotor. It will appear as a long line of stratocumulus, a few miles downwind and parallel to the ridge. Its base will be normally below the peak of the ridge, but its top can extend above it. The turbulence associated with a rotor cloud is severe within and near the rotor cloud.

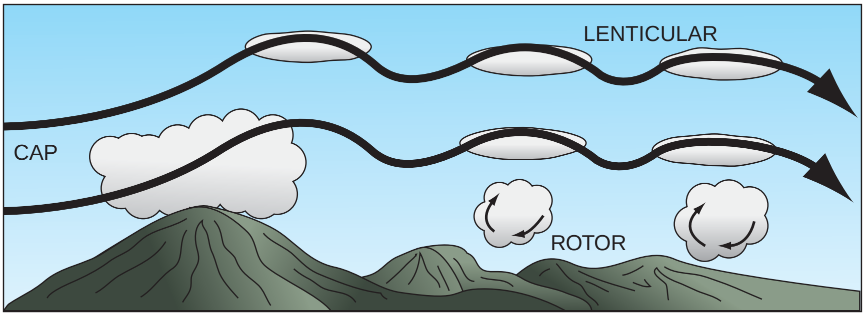


Fig. 2-24 - Characteristic clouds formed by lee waves

Fronts

A front is the transition or mixing zone between two air masses. While only the surface front is shown on a weather map, it is important to realize that an air mass is three-dimensional and resembles a "wedge". If the colder air mass is advancing, then the leading edge of the transition zone is described as being a cold front. If the colder air mass is retreating, then the trailing edge of the transition zone is described as being a warm front.

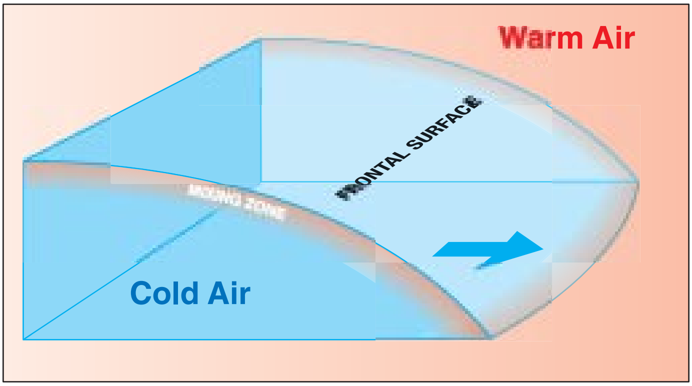


Fig. 2-25 - Cross-section of a cold front

The movement of a front is dependent on the motion of the cold air nearly perpendicular to the front, both at the surface and aloft. When the winds blow across a front, it tends to move with the wind. When winds blow parallel to a front, the front moves slowly or even becomes quasistationary. The motion of the warm air does not affect the motion of the front.

On surface charts, fronts are usually drawn as relatively straight lines. In reality, this is seldom so. Cold air flows across the surface like water. When advancing, it readily moves across level ground but in hilly or mountainous terrain it is held up until it either finds a gap or deepens to the point where it can flow over the barrier. Cold air also readily accelerates downhill resulting in rapid motion along valleys. When retreating, cold air moves slowly and leaves pools of cold air in low-lying areas that take time to modify out of existence.

Frontal Weather

When two different air masses encounter each other across a front, the cooler, denser air will lift the warm air. When this happens, the weather at a front can vary from clear skies to widespread cloud and rain with embedded thunderstorms. The weather occurring at a front depends on:

(a) amount of moisture available
Sufficient moisture must be present for clouds to form. Insufficient moisture results in "dry" or "inactive" fronts that may be marked by only changes of temperature, pressure and wind. An inactive front can become active quickly if it encounters an area of moisture.

(b) stability of the air being lifted
The degree of stability influences the type of clouds being formed. Unstable air will produce cumuliform clouds accompanied by showery weather and more turbulent conditions. Stable air will produce stratiform cloud accompanied by steady precipitation and little or no turbulence.

(c) slope of the front
A shallow frontal surface such as a warm front produces widespread cloud and steady precipitation. Such areas are susceptible to the formation of low stratus cloud and fog and may have an area of freezing precipitation. Passage of such a front is usually noted by the end of the steady precipitation, followed by a slow reduction in the cloud cover.
A steep frontal surface, such as is seen in cold fronts, tends to produce a narrow band of convective weather. Although blustery, the period of bad weather is short-lived and the improvement behind the front is dramatic.

(d) speed of the front
A fast-moving cold front enhances the vertical motion along the front, which, in turn, causes the instability to be accentuated. The result is more vigorous convective-type weather and the potential for the development of squall lines and severe weather.

Frontal Waves and Occlusions

Small-scale changes in pressure along a front can create localized alterations in the wind field resulting in a bending of the front. This bending takes on a wave-like appearance as part of the front begins to move as a warm front and another part moves as a cold front. Such a structure is known as a frontal wave. There are two types of frontal waves:

(a) Stable Waves

The wave structure moves along the front but does not develop beyond the wave appearance. Such features, known as stable waves, tend to move rapidly (25 to 60 knots) along the front and are accompanied by a localized area of heavier cloud and precipitation. The air mass stability around the wave determines the cloud and precipitation type. Since the wave moves rapidly, the associated weather duration tends to be short.

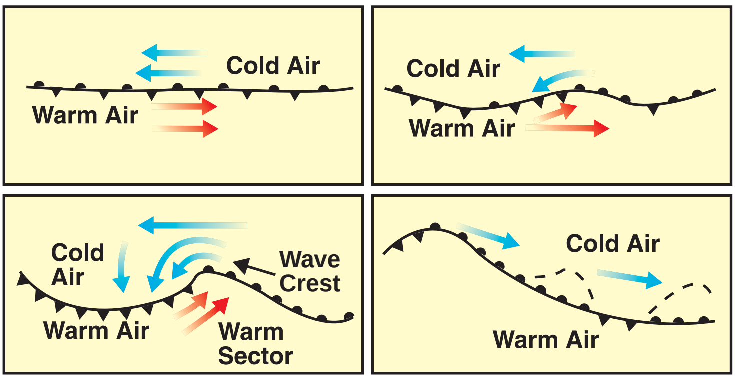


Fig.2-26 - Stable wave

(b) Unstable (Occluding) Waves

Given additional support for development, such as an upper trough, the surface pressure will continue to fall near the frontal wave, causing the formation of a low pressure centre and strengthening winds. The wind behind the cold front increases causing the cold front to accelerate and begin to wrap around the low. Eventually, it catches up with the warm front and the two fronts occlude or "close together." At this point, the low is at maximum intensity.

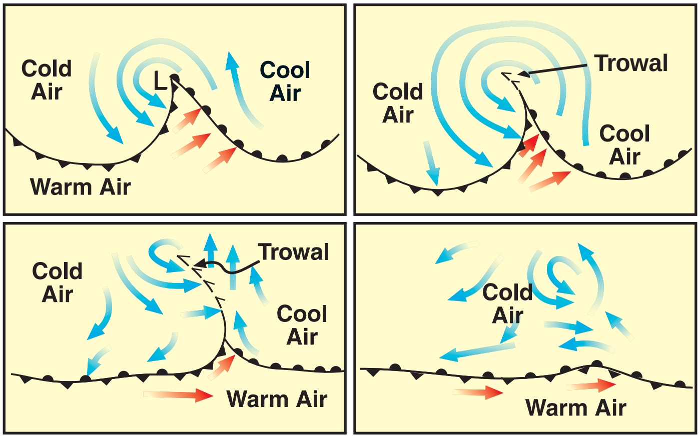


Fig. 2-27 - Formation of an occluding wave

Occlusions occur because the air behind the cold front is colder and denser than the cool air mass ahead of the warm front. Thus, it undercuts not only the warm sector of the original wave but also the warm front, forcing both features aloft. As the warm sector is lifted higher and higher, the surface portion becomes smaller and smaller. Along the occlusion, the weather is a combination of a warm front and a cold front; that is, a mix of layer clouds with steady precipitation and embedded convective clouds with enhanced showery precipitation. Such a cloud mass should be approached with caution as both icing and turbulence can be quite variable. Eventually, the frontal wave and occlusion both move away from the low, leaving only an upper frontal band curling back towards the low. This upper structure continues to weaken as it moves farther and farther away from the low that initially formed it.

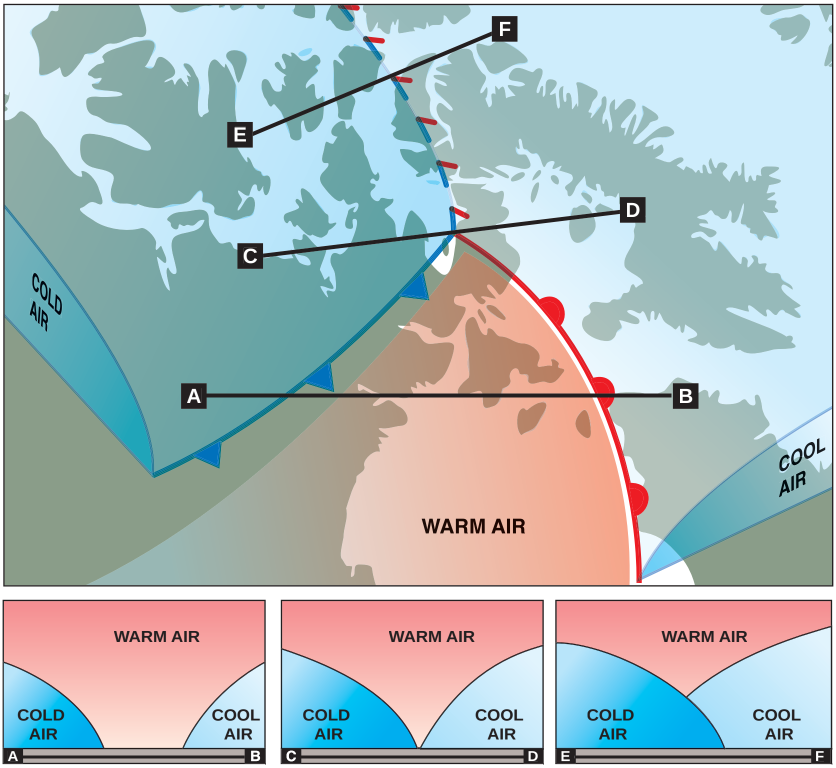


Fig. 2-28 - Frontal cross-sections

Thunderstorms

No other weather encountered by a pilot can be as violent or threatening as a thunderstorm. Thunderstorms produce many hazards to the aviation community, and, it's important that pilots understand their nature and how to deal with them. To produce a thunderstorm, there are several ingredients which must be in place. These include:

- an unstable airmass
- moisture in the low levels
- something to trigger them, e.g. daytime heating, upper level cooling
- for severe thunderstorms, wind shear.

The Life Cycle of a Thunderstorm

The thunderstorm, which may cover an area ranging from 5 miles in diameter to, in the extreme case, as much as 50 miles, usually consists of two or more cells in different stages of their life cycle. The stages of life of individual cells are:

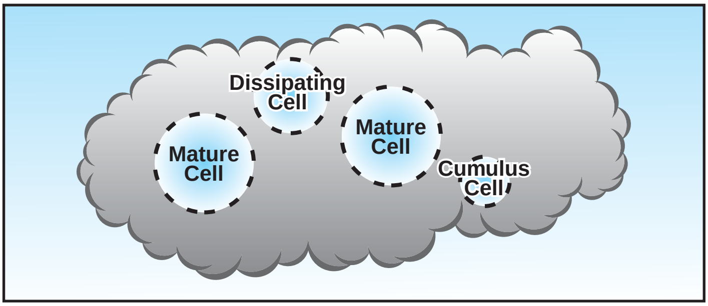


Fig. 2-29 -Top-down view of a thunderstorm "family" containing cells in different stages of development

(a) Cumulus Stage

The cumulus stage is marked by updrafts only. These updrafts can reach values of up to 3,000 feet per minute and cause the cloud to build rapidly upwards, carrying supercooled water droplets well above the freezing level. Near the end of this stage, the cloud may well have a base more than 5 miles across and a vertical extent in excess of 20,000 feet. The average life of this stage is about 20 minutes.

(b) Mature Stage

The appearance of precipitation beneath the base of the cell and the development of the downdraft mark the transition to this stage. The downdraft is caused by water drops which have become too heavy for the updraft to support and now begin to fall. At the same time, the drops begin to evaporate as they draw in dry air from the edge of the cloud, and then fall through the drier air beneath the base of the cloud. This evaporation causes the air to cool and become denser, resulting in a downwash of accelerating cold air. Typical downdraft speeds can reach values of 2,500 feet per minute.

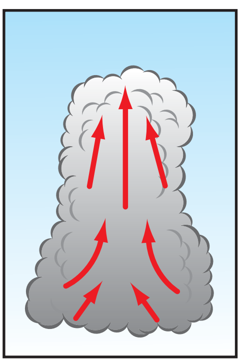


Fig. 2-30 - Cumulus stage

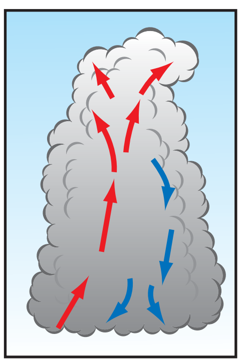


Fig. 2-31 - Mature stage

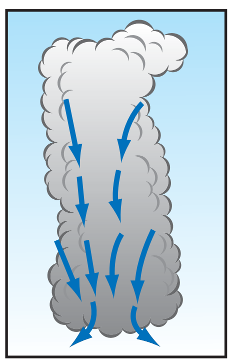


Fig. 2-32 - Dissipating Stage

The downdraft, when it hits the ground, spreads out in all directions but travels fastest in the direction that the storm is moving. The leading edge of this cold air is called the “gust front” and can extend ten to fifteen miles, or even farther, when channelled along mountain valleys in front of the storm. A rapid drop in temperature and a sharp rise in pressure characterize this horizontal flow of gusty surface winds.

At the same time, the updrafts continue to strengthen until they reach maximum speeds, possibly exceeding 6,000 feet per minute. The cloud reaches the tropopause which blocks the updraft, forcing the stream of air to spread out horizontally. Strong upper winds at the tropopause level assist in the spreading out of this flow in the downwind direction, producing the traditional anvil-shaped top. This is classically what is referred to as a cumulonimbus cloud (CB).

The thunderstorm may have a base measuring from 5 miles to more than 15 miles in diameter and a top ranging from as low as 20,000 to more than 50,000 feet. The mature stage is the most violent stage in the life of a thunderstorm and usually lasts for 20 to 30 minutes.

Near the end of the mature stage, the downdraft has increased in size so that the updraft is almost completely "choked off," stopping the development of the cell. However, at times, the upper winds increase strongly with height causing the cell to tilt. In such a case, the precipitation falls through only a portion of the cell, allowing the updraft to persist and reach values of 10,000 feet per minute. Such cells are referred to as "steady state storms" that can last for several hours and produce the most severe weather, including tornadoes.

(c) Dissipating Stage

The dissipating stage of a cell is marked by the presence of downdrafts only. With no additional flow of moisture into the cloud from an updraft, the rain gradually tapers off and the downdrafts weaken. The cell may dissipate completely in 15 to 30 minutes, leaving clear skies or patchy cloud layers. At this stage the anvil, which is formed almost exclusively of ice crystals, often detaches and drifts off downwind.

Types of Thunderstorms

(a) Air Mass Thunderstorms

These thunderstorms form within a warm, moist air mass and are non-frontal in nature. They are usually a product of diurnal heating and tend to be isolated. In the GFACN36 and 37 domains, such thunderstorms are rare.

There is also a second form of air mass thunderstorm that is created by cold advection. In this case, cold air moves across warm land or water and becomes unstable. Of these two, it is the movement of cold air over warm water that results in the most frequent occurrence of this type of thunderstorm. Since the heating is constant, these thunderstorms can form at any time of day or night.

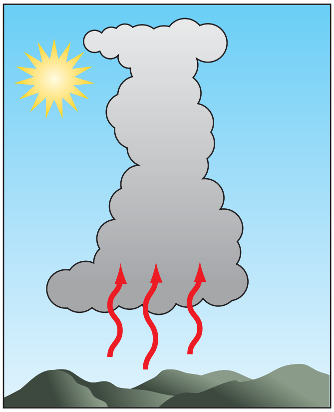


Fig. 2-33 - Air heated by warm land

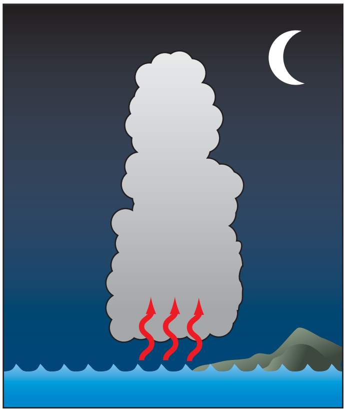


Fig. 2-34 - Cool air heated by warm water

(b) Frontal Thunderstorms

These thunderstorms form either as the result of a frontal surface lifting an unstable air mass or a stable air mass becoming unstable, as a result of the lifting. Frontal thunderstorms can be found along cold fronts, warm fronts and trowals. These thunderstorms tend to be numerous in the area, often form in lines, are frequently embedded in other cloud layers, and tend to be active during the afternoon and well into the evening. Cold frontal thunderstorms are normally more severe than warm frontal thunderstorms.

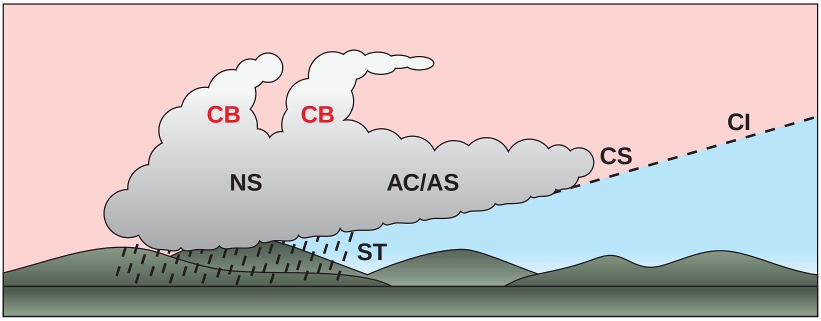


Fig. 2-35 - Warm frontal thunderstorms

(c) Squall Line Thunderstorms

A squall line (or line squall) is a line of thunderstorms. Squall lines can be several hundred miles long and have lower bases and higher tops than the average thunderstorm. Violent combinations of strong winds, hail, rain and lightning make them an extreme hazard not only to aircraft in the air, but also to those parked uncovered on the ground.

Squall line thunderstorms are most often found 50 to 300 miles ahead of a fast-moving cold front but can also be found in accompanying low pressure troughs, in areas of convergence, along mountain ranges and even along sea breeze fronts.

(d) Orographic Thunderstorms

Orographic thunderstorms occur when moist, unstable air is forced up a mountain slope.

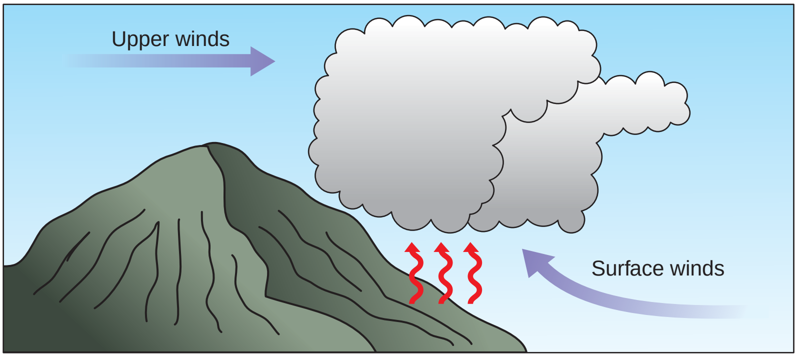


Fig. 2-36 - Orographic thunderstorms

(e) Nocturnal Thunderstorms

Nocturnal thunderstorms are those that develop during or persist all night. Usually, they are associated with an upper level weather feature moving through the area, are generally isolated, and tend to produce considerable lightning.

Severe Thunderstorms

The discussion of the life cycle of a thunderstorm does not fit the case of those that seem to last for extended periods of time and are most prolific in producing tornadoes and large hail. A particular type of severe thunderstorm is known as a "Supercell".

The Supercell storm typically begins as a multi-cellular thunderstorm. However, because the upper winds increase strongly with height, the cell begins to tilt. This causes the descending precipitation to fall through only a portion of the cell, allowing the updraft to persist.

The second stage of the supercell life cycle is clearly defined by the weather. At this stage, the largest hail fall generally occurs and funnel clouds are often observed.

The third and final stage of supercell evolution is the collapse phase. The storm's downdrafts increase in magnitude, and extend horizontally, while the updrafts are decreasing. It is at this time that the strongest tornadoes and straight-line winds occur.

While Supercells do occur over the Southern Prairies, Southern Ontario and Southwestern Quebec, they are rare elsewhere in Canada.

Photo 2-5 - Severe thunderstorm credit: Alister Ling

Any severe thunderstorm should be avoided by a wide margin as all are extremely hazardous to aircraft.

Thunderstorm Hazards

The environment in and around a thunderstorm can be the most hazardous encountered by an aircraft. In addition to the usual risks such as severe turbulence, severe clear icing, large hail, heavy precipitation, low visibility and electrical discharges within and near the cell, there are other hazards that occur in the surrounding environment.

(a) The Gust Front

The gust front is the leading edge of any downburst and can run many miles ahead of the storm. This may occur under relatively clear skies and, hence, can be particularly nasty for the unwary pilot. Aircraft taking off, landing, or operating at low levels can find themselves in rapidly changing wind fields that quickly threaten the aircraft's ability to remain airborne. In a matter of seconds, the wind direction can change by as much 180°, while at the same time the wind speed can approach 100 knots in the gusts. Extremely strong gust fronts can do considerable damage on the ground and are sometimes referred to as "plow winds." All of this will likely be accompanied by considerable mechanical turbulence and induced shear on the frontal boundary up to 6,500 feet above the ground.

(b) Downburst, Macroburst and Microburst

A downburst is a concentrated, severe downdraft which accompanies a descending column of precipitation underneath the cell. When it hits the ground, it induces an outward, horizontal burst of damaging winds. There are two types of downburst, the "macroburst" and the "microburst".

A macroburst is a downdraft of air with an outflow diameter of 2.2 nautical miles, or greater, with damaging winds that last from 5 to 20 minutes. Such occurrences are common in the summer but only rarely hit towns or airports.

On occasion, embedded within the downburst, is a violent column of descending air known as a "microburst". Microbursts have an outflow diameter of less than 2.2 nautical miles and peak winds lasting from 2 to 5 minutes. Such winds can literally force an aircraft into the ground.

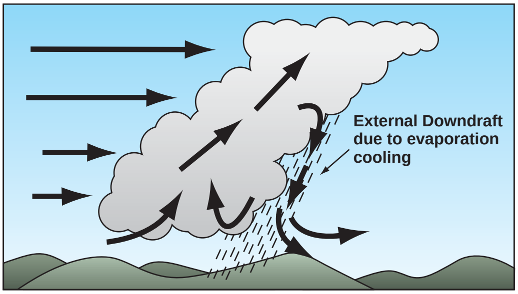


Fig. 2-37 - "Steady state" tilted thunderstorm

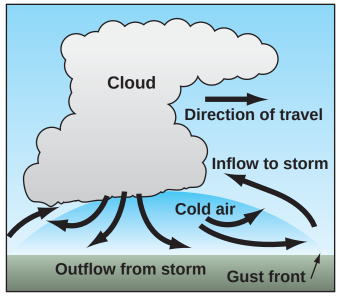


Fig. 2-38 - The gust front

(c) Funnel Cloud, Tornado and Waterspout

The most violent thunderstorms draw air into their base with great vigor. The incoming air tends to have some rotating motion and, if it should become concentrated in a small area, forms a rotating vortex in the cloud base in which wind speeds can exceed 200 knots. If the vortex becomes strong enough, it will produce a funnel-shaped cloud downwards from the base. If the cloud does not reach the ground, it is called a funnel cloud. If it reaches the ground, it is refered to as a tornado and if it touches water, it is a waterspout.

F-Scale Number	Intensity Phrase	Wind Speed (kts)	Type of Damage Done
F0	**Weak** Tornado	35-62	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	**Moderate** Tornado	63-97	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	**Strong** Tornado	98-136	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	**Severe** Tornado	137-179	Roof and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted
F4	**Devastating** Tornado	180-226	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large-object missiles generated.
F5	**Incredible** Tornado	227-285	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-inforced concrete structures badly damaged.

Table 2-1 - The Fujita Scale

Waterspouts can occur over large lakes but are rare. The first sign that a waterspout may form is the cloud sagging down in one area. If this bulge continues downward to the sea surface, forming a vortex beneath it, water will be carried aloft in the lower 60 to 100 feet.

Cold Weather Operations

Operating an aircraft in extremely cold weather conditions can bring on a unique set of potential problems.

Temperature Inversion and Cold Air Outbreaks

Low level inversions are common in most areas during the fall and winter due to very cold outbreaks and strong radiation cooling. When cold air moves out over the open water, it becomes very unstable. Cloud can be seen to almost be “boiling” off the waters surface and forming vortices that rotate upwards. Such a condition can be very turbulent and there is a significant risk of serious icing. At the same time, the convection enhances any snowfall resulting in areas of extremely poor visibility.

Looming

Another interesting effect in cold air is the bending of low angle light rays as they pass through an inversion. This bending creates an effect known as “looming,” a form of mirage that causes objects normally beyond the horizon to appear above the horizon.

Ice Fog and Ice Crystals

Ice fog occurs when water vapour sublimates directly to ice crystals. In conditions of light winds and temperatures colder than -30°C or so, water vapour from anthropogenic sources (man-made) can form widespread and persistent ice fog or ice crystals. In light winds, the visibility can be reduced to near zero, closing an airport for hours.

Blowing Snow

When there is dry snow around, it typically takes about 20 knots of sustained wind to get snow blowing. With 25 knots of sustained wind, poor flying conditions are likey and with 30 knots and greater of sustained wind, visibility of 1/2 n. mile or less are probable. Strong wind in concert with falling snow can readily reduce horizontal visibility at runway level to less than 100 feet and generate obscured snow ceilings of similar dimension.

Whiteout

"Whiteout" is a phenomena that can occur when a layer of cloud of uniform thickness overlays a snow or ice-covered surface, such as a large frozen lake. Light rays are diffused when they pass through the cloud layer so that they strike the surface from all angles. This light is then reflected back and forth between the surface and cloud, eliminating all shadows. The result is a loss of depth perception, the horizon becoming impossible to discern, and dark objects seeming to float in a field of white. Disastrous accidents have occurred under such conditions where pilots have flown into the surface, unaware that they were descending and confident that they could see the ground.

Altimetry Errors

The basic barometric altimeter in an aircraft assumes a standard change of temperature with height in the atmosphere and, using this fact, certain pressure readings by the altimeter have been defined as being at certain altitudes. For example, a barometric altimeter set at 30.00" would indicate an altitude of 10,000 feet ASL when it senses the outside pressure of 20.00".

Cold air is much more dense than the assumed value used in the standard ICAO atmosphere. For this reason, any aircraft that is flying along a constant pressure surface will actually be descending as it moves into areas of colder air, although the indicated altitude will remain unchanged. Interestingly enough, a new altimeter setting obtained from a site in the cold air will not necessarily correct this problem and may increase the error.

Consider:

A pilot obtained an altimeter setting of 29.85" and plans to maintain a flight level of 10,000 feet enroute. As the aircraft moves into an area with a strong low-level inversion and very cold surface temperatures, the plane descends gradually as it follows the constant pressure surface corresponding to an indicated altitude of 10,000 feet. A new altimeter setting, say 30.85 inches, is obtained from an airport located in the bottom of a valley, deep in the cold air. This new setting is higher than the original setting and, when it is entered, the altimeter will show an increase in altitude (in this case the change is one inch and so the altimeter will show an increase from 10,000 to 11,000 feet). Unaware of what is happening, the pilot descends even further to reach the desired enroute altitude, compounding the height error.

If the aircraft were operating in cloud-shrouded mountains, an extremely hazardous situation can develop. There is no simple solution to this problem, other than to be aware of it and allow for additional altitude to clear obstacles.

Volcanic Ash

A major, but fortunately infrequent, threat to aviation is volcanic ash. When a volcano erupts, a large amount of rock is pulverized into dust and blasted upwards. The altitude is determined by the severity of the blast and, at times, the ash plume will extend into the stratosphere. This ash is then spread downwind by the winds aloft in the troposphere and the stratosphere.

The dust in the troposphere settles fairly rapidly and can limit visibility over a large area. For example, when Mt. St. Helens, Washington, erupted, there was ash fallout and limited visibility across southern Alberta and Saskatchewan.

Of greater concern is the volcanic ash that is ingested by aircraft engines at flight level. Piston-driven engines have failed due to plugged air filters while turbine engines have "flamed out."

The volcanic dust also contains considerable pumice material. Leading edges such as wings, struts, and turbine blades can all be abraded to the point where replacement becomes necessary. Windscreens have been abraded until they become opaque.

Deformation Zone

A deformation zone is defined as "an area in the atmosphere where winds converge along one axis and diverge along another. Deformation zones (or axis of deformation as they are sometimes referred to) can produce clouds and precipitation." More simply put, we are referring to areas in the atmosphere where the winds flow together (converge) or apart (diverge), resulting in areas where air parcels undergo stretching along one axis and contraction along another axis. Meteorologically, this is an area where significant cloud amounts, precipitation, icing and turbulence can occur in the induced vertical currents.

For meteorologists, the most common form of deformation zones are the ones associated with upper lows. Northeast of the upper low, a deformation zone usually forms in which the air is ascending. In this area, thick cloud layers form giving widespread precipitation. Depending on the temperatures aloft, this cloud may also contain significant icing. During the summer, the edges of this cloud area will often support thunderstorms in the afternoon. If this area of cloud is slow moving, or should it interact with terrain, the upslope areas can see prolonged precipitation. Wind shear in the ascending air will often give turbulence in the middle and higher-levels.

A second deformation zone exists to the west and northwest of these lows. In this case the air is descending, so that widespread higher clouds usually only consist of whatever cloud is wrapped around the low. Precipitation here tends to be more intermittent or showery. Wind shear can also cause turbulence but most often it is confined to the low-levels.

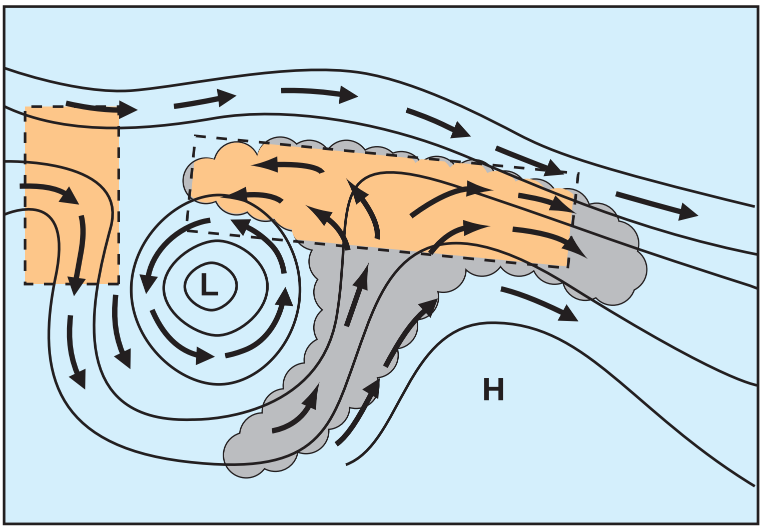


Fig. 2-39 - Deformation zones

Notes:

Chapter 3

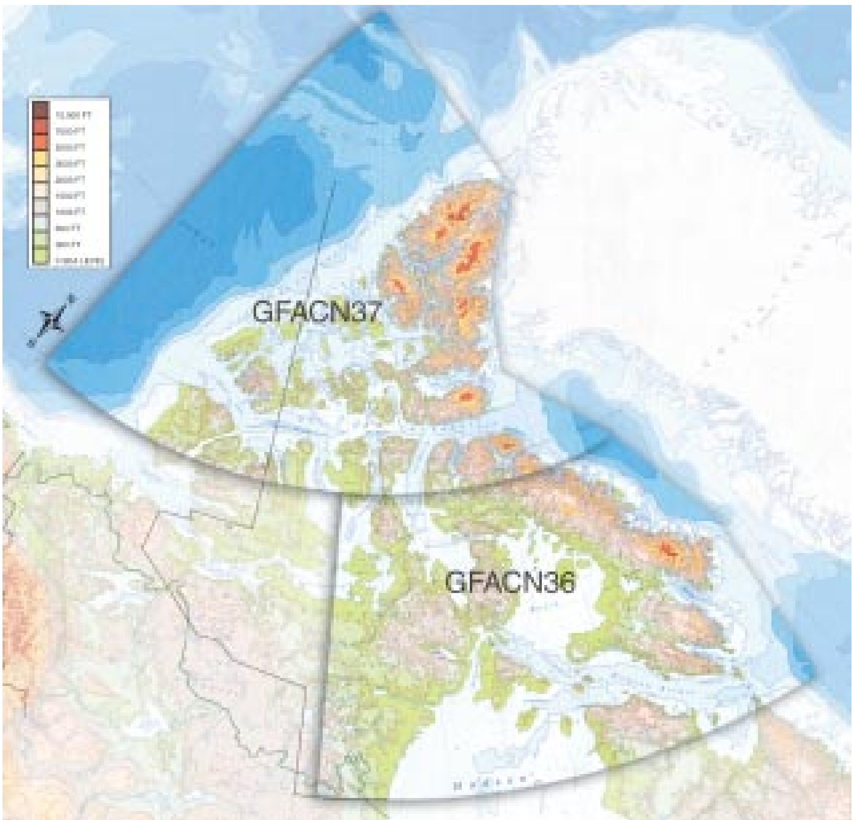
Weather Patterns of Nunavut and the Arctic

Introduction

"Weather is what you get; climate is what you expect."- (anon.)

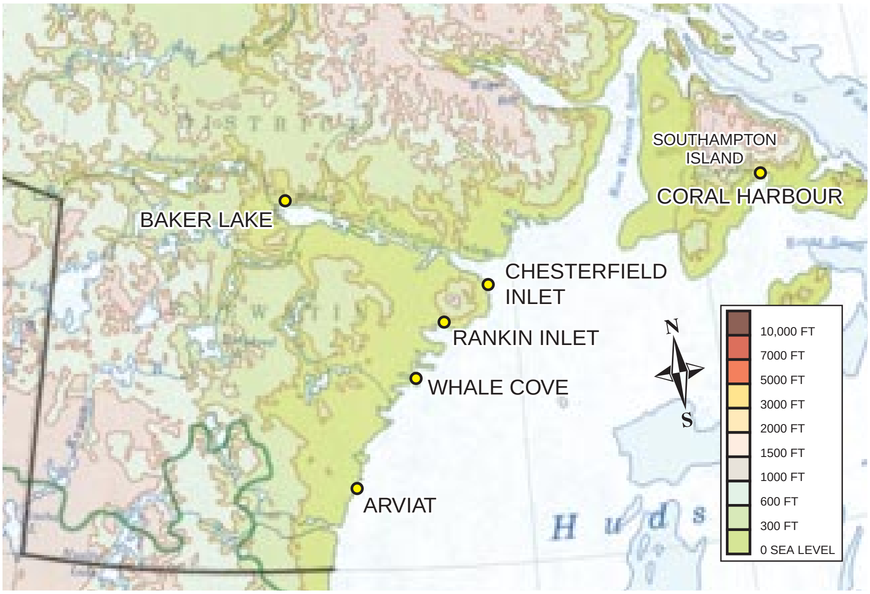
Topography

Seas to Mountain Peaks - The GFACN36 and 37 domains consists of extensive water, lowlands and mountain peaks that are the highest of any in North America east of the Rocky Mountains. Mount Barbeau on northern Ellesmere Island peaks at about 8,500 feet ASL while the ice cap on eastern Devon Island peaks between 6,260 and 6,400 feet. Mount Odin, on eastern Baffin Island, reaches to over 7,000 feet ASL. The water, the lowlands and the mountain peaks each play a role in the flying weather across these domains.



Map 3-1 - Topography of GFACN36 and GFACN37 domains

Topography of the southwestern GFACN36 domain



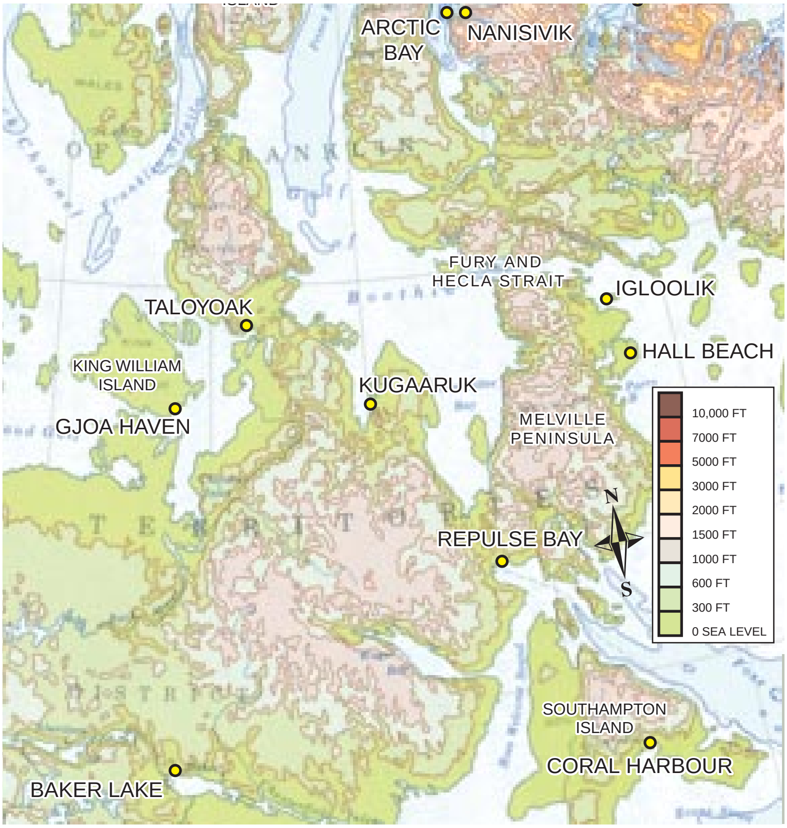
Map 3-2 - Topography of southwestern GFACN36 domain

Mainland - Lowland and then terrain with height - The terrain of the southwestern GFACN36 domain ranges from the waters of Hudson Bay to lowlands that extend inland to varying degrees. These lowlands facilitate low cloud and/or fog moving inland with onshore flows. There is terrain along the west coast of Hudson Bay that rises to about 1,100 feet ASL between Arviat and Chesterfield. Terrain that peaks in the range 1,100 to 1,430 feet lies about 80 miles west of Arviat. North of Baker Lake terrain rises to just over 2,000 feet. West of Baker Lake terrain rises to near 1,000 feet.

Low cloud and blowing snow corridor - Albeit the terrain to the west and northwest of Baker Lake is in places up to 1,000 feet ASL, there is a corridor of relative low terrain northwest of Baker Lake which broadens south through southeast and east of Baker Lake. This northwest to southeast corridor across the area corresponds nicely with a band of northwesterly winds that can extend from the Arctic Islands across the area and into Hudson Bay. These northwest winds bring low cloud into the area during the fall and blowing snow through the frozen months of the year.

Southampton Island - The terrain of Southampton Island is for the most part low but there is terrain in excess of 2,000 feet ASL to the northwest through northeast of Coral Harbour. This terrain is very effective in protecting Coral Harbour from low cloud when low-level winds are from west through north to northeast.

Topography of the northwestern GFACN36 domain



Map 3-3 - Topography of northwestern GFACN36 domain

Water is key and terrain plays a role - The land of the northwestern GFACN36 domain has considerable coastline and the communities lie along these coasts. Igloolik lies on an island that is relatively small. Low cloud and/or fog that exist over the water can readily find its way inland. Taloyoak has a similar problem except that terrain that peaks at just over 2,000 feet ASL north of the community shelters it from northwest winds. Higher terrain that includes a peak to 824 feet to the immediate north of Kugaaruk and high ground that rises to near 1,250 feet about 12 miles south-southeast of the community play a role in the local wind regime. A corridor of low land northwest to southeast makes Repulse Bay vulnerable to low cloud with north-west and southeast winds.

In the general area between Kugaaruk and Baker Lake the terrain peaks at 2,055 feet ASL. Over the Melville Peninsula, the terrain is low on the Foxe Basin side (east) but rises to heights close to 1,300 feet on the Fury and Hecla Strait side (north) and over 1,800 feet on the Gulf of Boothia side (west).

Low cloud and blowing snow corridor - The corridor of northwest winds that sweeps down from the northwest across the lowlands of King William Island and into the mainland south of Gjoa Haven is part of the corridor that extends from the arctic islands southeast across the Baker Lake, Rankin Inlet, and Arviat areas. This is the corridor that with northwest winds favours low cloud in fall and blowing snow during the frozen months.

Topography of northern Quebec and the northern tip of Labrador

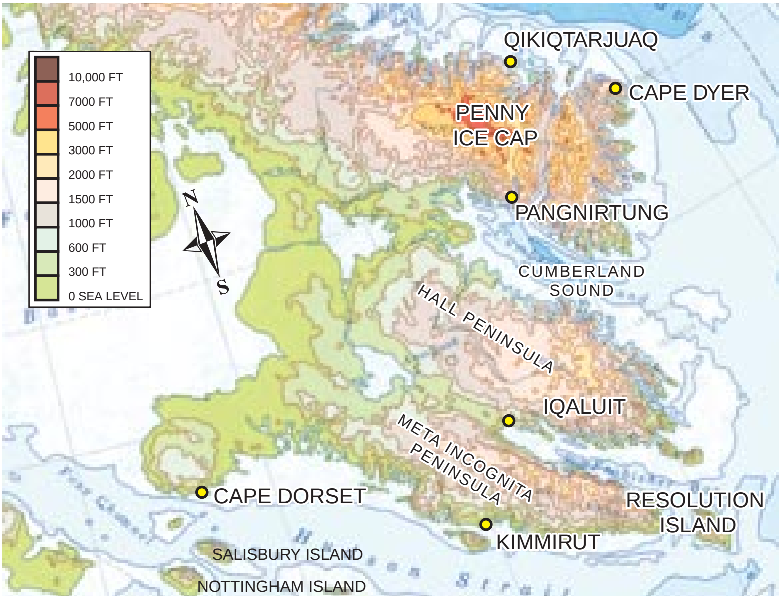
Map 3-4 - Topography of northern Quebec and northern tip of Labrador

Highlands to Hudson Strait coast - The section of northern Quebec that borders on Hudson Strait has high terrain to the coast. Within 2 to 3 miles of the Hudson Strait coast, terrain ranges from 1,200 feet to over 2,000 feet ASL. Inlets and bays are numerous. With southerly wind regimes strong gusty winds are common along this coast particularly out of some of the fiords.

Lowlands Hudson Bay and Ungava Bay but some high terrain - The terrain of northern Quebec that borders on Hudson Bay is low. There is however a band of higher terrain that extends southwest to Akulivik. On Smith Island just to the west-southwest of Akulivik the terrain rises to 1,000 feet ASL. Mansel Island has terrain to 425 feet.

Highlands extreme northeastern Quebec/northern tip of Labrador - The terrain extreme northeastern Quebec/northern tip of Labrador is rugged with terrain up to 2,770 feet ASL.

Topography of southern Baffin Island



Map 3-5 - Topography of southern Baffin Island

Mountains and ice caps - Mountains extend along the entire east coast of Baffin Island with peaks extending from 5,000 feet to over 6,000 feet ASL being common. The highest terrain of Baffin Island is that of - and around - the Penny Ice Cap (67°10' N 66° W), north of Pangnirtung / southwest of Qikiqtarjuaq. The Penny Ice Cap peaks at about 7,000 feet while Mount Odin, about 25 miles northeast of Pangnirtung, peaks at just under 7,044 feet.

Photo 3-1 - Looking northeast from Pangnirtung runway credit: Yvonne Bilan-Wallace

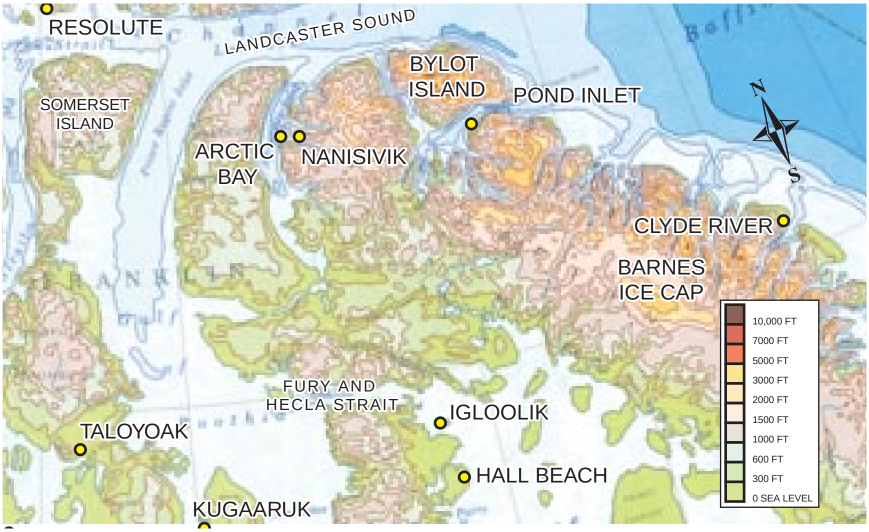
Mountains and fiords - The mountainous terrain along the east coast of Baffin Island is punctuated by inlets and fiords making for complex local weather and wind regimes.

Terrain and weather systems - The terrain on the south side of Frobisher Bay has peaks to 2,800 feet ASL. The terrain between Frobisher Bay and Cumberland Sound has peaks to 2,800 feet on the Frobisher Bay side and peaks to 4,000 feet on the Cumberland Sound side. Weather systems can give strong to very strong easterly winds a few hundred feet off the ground across southern Baffin Island. In such regimes, due to terrain effects, winds at/near ground level at the Iqaluit airport can vary from light northwesterly to light/variable. Complex terrain and the orientation of terrain also affect the wind regime across Cumberland Sound, Pangnirtung Fiord, and at the Pangnirtung airport. Cumberland Sound has a northwest to southeast orientation. Pangnirtung Fiord with a northeast to southwest orientation lies perpendicular to the sound. The valleys between the mountains in the immediate area of Pangnirtung have their own orientations. This can make the wind regime at Pangnirtung complex.

Lowlands and northwest flows - The terrain across western Baffin Island adjacent to Foxe Basin is low. Low cloud and fog from the basin have a ready path to move southeast into and across Baffin Island including spilling from time to time into Iqaluit with a northwest flow.

Lowlands but some terrain - Hudson Strait is a moisture source year round. Kimmirut is sheltered somewhat by terrain from both Hudson Strait weather and wind regimes. Cape Dorset with terrain to 925 feet ASL to the immediate west and terrain to 1350 feet to the north is open to Hudson Strait weather. Salisbury Island has terrain to 1,650 feet while Nottingham Island has terrain to 550 feet.

Topography of northern Baffin Island



Map 3-6 - Topography of northern Baffin Island

Mountains, ice caps and plateau - Mountains extend along the entire east coast of Baffin Island and across northern Baffin Island. They also cover Bylot Island. Peaks from 5,000 feet to over 6,000 feet ASL are common. There are also ice caps and glaciers. For example, the Barnes Ice Cap (70°N 73°15'W), west-southwest of Clyde, rises to 3,684 feet. Elevated flat areas do exist. Nanisivik Airport, for example, lies on a plateau at 2,106 feet. The airport is about 15 miles from the community of Arctic Bay, which lies on the coast. The airport is vulnerable to poor flying conditions as low cloud from below rises to the plateau. It is also vulnerable to strong winds and hence blowing snow during the frozen months.

Mountains and fiords - The mountainous terrain along the east and north coasts of Baffin Island is punctuated by inlets and fiords making for complex local weather and wind regimes. Along the east coast of Baffin Island, strong westerly winds aloft often lead to strong outflow winds from the inlets and fiords.

Lowlands and some highlands - The terrain of the coast of Baffin Island bordering Foxe Basin is low. However, the section of Baffin Island bordering Fury and Hecla Strait has terrain to 2,080 feet ASL.

Topography of southeastern arctic islands

Map 3-7 - Topography of southeastern arctic islands

Devon Ice Cap, Devon Island, Cornwallis Island, and Somerset Island - A prominent feature in this area is the Devon Ice Cap, which covers a large segment of eastern Devon Island. It peaks at between 6,260 and 6,400 feet ASL. The Grinnell Peninsula, northwestern Devon Island, has terrain to 1,850 feet. Cornwallis Island has terrain to 1,125 feet. Somerset Island has terrain to 1,122 feet on its north coast and to 1,500 feet further south.

The Devon Ice Cap and some of the ice caps on Baffin Island are, cloud permitting, recognizable on weather satellite photos.

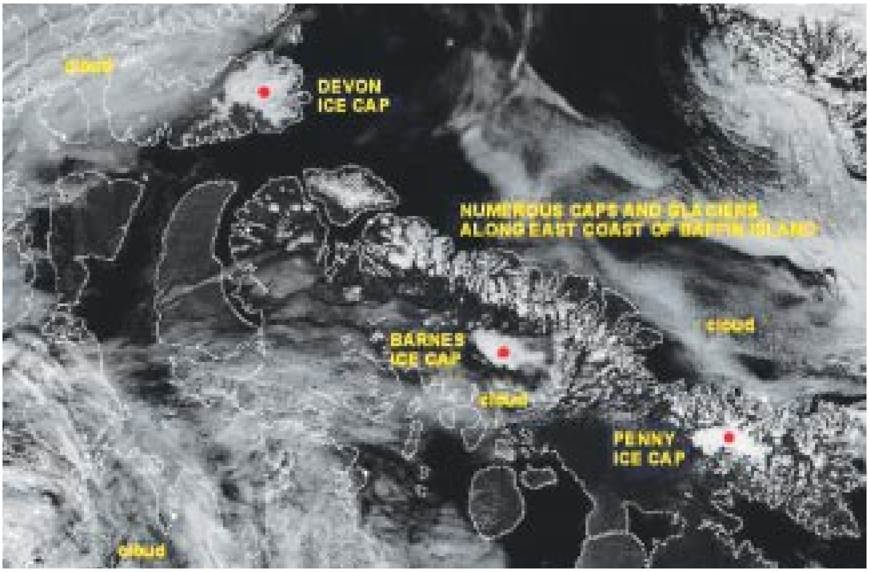


Photo 3-2 - Visible satellite photo 1 September 2002 showing Devon, Barnes, and Penny ice caps

Not big but influencing - The "hills" to the east of the Resolute Airport rise only a couple of hundred feet. However, these hills play a key role in generating strong "pumping" northeast winds at the airport. The term pumping coming from the wind regime reverting at times from strong northeasterly to light to moderate northwesterly then back to strong northeasterly.

Lots of terrain with influence - The terrain of southern Ellesmere Island rises abruptly in places and there are many fiords each interacting with the wind regime. Elevations of 3,000 to over 4,000 feet ASL are common south of about 77° 30'N. North of this the terrain rises from 5,000 to over 7,000 feet.

Terrain around Grise Fiord rises to over 4,000 feet ASL within 8 miles. The wind regime at Grise Fiord is complex. Local weather observers have noted distinctly different winds over the water than that being observed near the runway. Pilots cite that when the surface wind at Grise Fiord is more than 10 knots it's no fly unless one is planning on landing and staying.

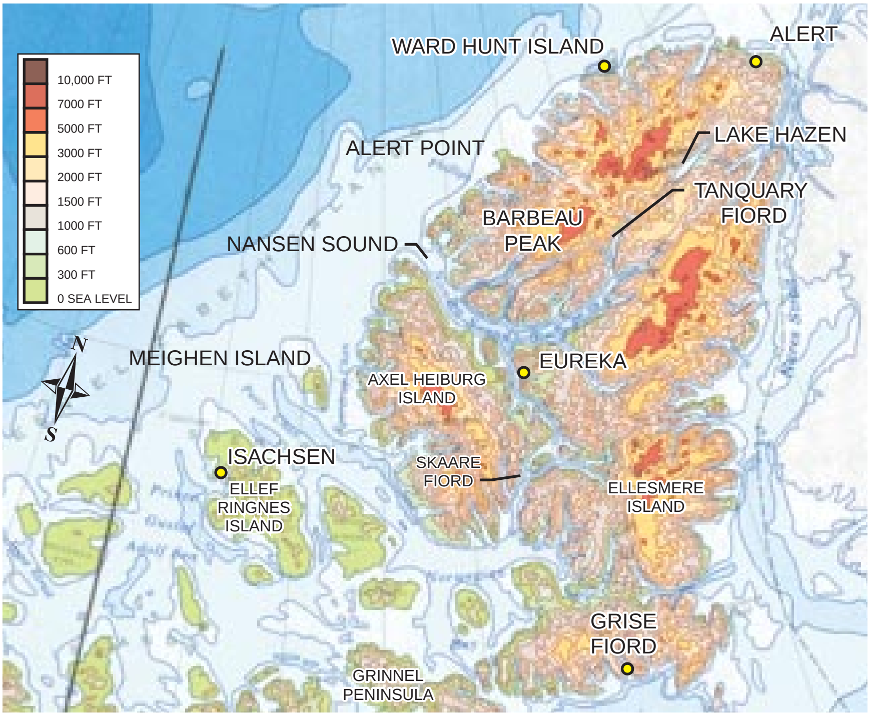
Topography of southwestern/south central arctic islands

Map 3-8 - Topography of southwestern / south central arctic islands

Low cloud and blowing snow corridor - A corridor of low lands and water centered on Rea Point runs in a northwest to southeast direction across the area. This corridor, which favours low cloud in the fall and blowing snow driven by north-westerly winds during the frozen months, extends to Baker Lake, Rankin Inlet, and Arviat area.

Terrain - Western Melville Island, northern Banks Island and northwestern Victoria Island have terrain that peaks at 2,545 feet, 1,530 feet and 1,942 feet ASL respectively. Eastern Melville Island has terrain to 1,430 feet. Bathurst Island has terrain that peaks to 1,351 feet.

Topography of northern arctic islands



Map 3-9 - Topography of northern arctic islands

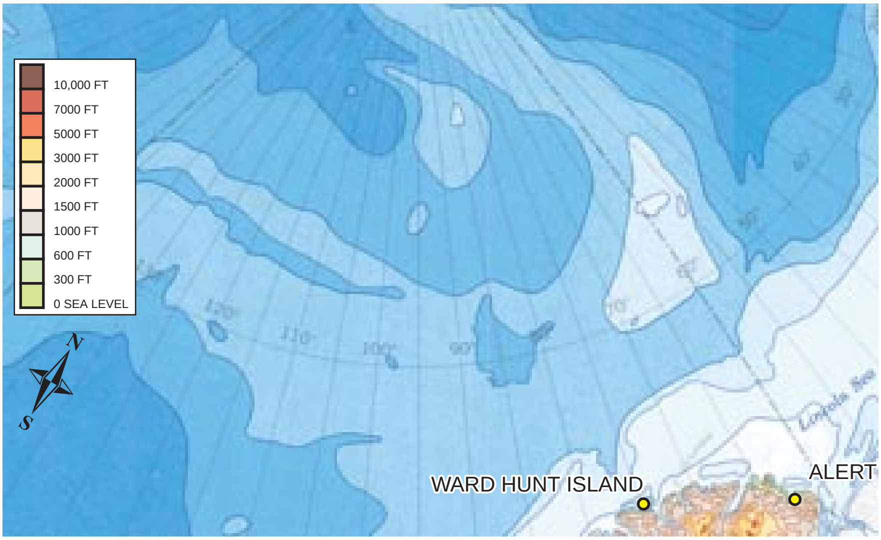
West is low but east has highest terrain in North America east of the Rockies - Barbeau Peak (80°55'N, 75°02'W), on northern Ellesmere Island, peaks at over 8,500 feet ASL and is the highest peak in North America east of the Rockies. Eureka lies in the midst of this high terrain and low cloud from the Arctic Basin has trouble making its way to Eureka.

Photo 3-3 - Glacier flowing into Skaare Fiord, southeastern Axel Heiberg Island credit: Ed Heacock

West, the land bordering the Arctic Basin is low. Low cloud and wind from the Arctic Basin have a ready entry point to the arctic islands.

Photo 3-4 - Looking west along the top of Ellesmere Island. The terrain is Alert Point on the northern end of Wooton Peninsula. In the foreground is Yelverton Bay filled with cloud. To the right is the prevailing low cloud of the Arctic Basin credit: Bea Alt

Topography of the Arctic Basin



Map 3-10 - Topography of Arctic Basin

Ice covered but openings - The topography of the Arctic Basin section of GFACN37 domain is that of a constantly changing ice surface of varied thickness, surface roughness and snow cover. Pilots cite that only a very small percentage of the ice cover on the basin is suitable for landing. The ice sheets slide under each other (rafting), bump into each other or are appended to the outer islands and create ridges both below and above the surface (ridging). Ice sheets routinely obstruct each other's fit into the jigsaw puzzle of ice cover such that cracks and areas of open water develop (leads) and close, at times suddenly. New ice forms. Fortunately, the color of sea ice changes as it thickens. Barring snow cover, the thinnest ice is dark looking. Once ice thickens to about 10 centimetres it becomes gray looking and at 15 centimetres it appears gray-white. Not until the ice has thickened to about 30 centimetres does it look white. The ice of Arctic Basin is also almost always on the move. Ice at the North Pole, for example, makes its way to the Atlantic in less than a year on average. Snow covered ice dominates fall through winter to mid spring. The wind continually redistributes the snow via drifting and blowing snow into rigid snowdrifts. By mid-spring the snow cover disappears and the melting of the ice begins. The ratio of open water to ice increases and the ice thickness decreases into September. A return to below freezing temperatures brings a return of ice growth both coverage and thickness-wise.

Landings on ice including flights to the pole routinely occur March through April and May and occasionally into very early June. During this period, there is 24 hours of daylight, air temperatures are still below freezing, and the ice is at its maximum thickness. Many of these flights use Ward Hunt Island as a staging point.

Photo 3-5 - Twin Otter on ice about 400 miles west of Eureka April 1998 credit: Mark Pyper

Photo 3-6 - Open leads and pressure ridges vicinity North Pole credit: J. Wholey

Tree line and vegetation

An important feature of the GFACN36 and 37 domains is the lack of trees. Only the extreme southwestern section of the GFACN36 domain is tree covered. Trees act as a great snow fence and suppress wind speeds. To the east and north of the tree line, winds are stronger resulting in more extensive drifting and blowing snow.

Map 3-11 - Treeline across GFACN36 domain

Lacking trees, snow fences have been erected upstream of communities such as Baker Lake and Rankin Inlet.

Photo 3-7 - Snow fence at Rankin Inlet credit: Yvonne Bilan-Wallace

Length of daylight June and July

Humidity Recovery - Barring an intrusion of cold air, temperatures inland remain high through the evening and into the night. Assuming that dew points remain constant, the possibility of fog is reduced.

Extended thundershower development - Thundershowers occur over the mainland section of the GFACN36 domain. Across the mainland GFACN36 domain, June and July temperatures remain high through the evening. Thundershowers can occur in the late evening or even after midnight versus the afternoon into evening as is common across the southern latitudes. Elsewhere thundershowers are infrequent in the remainder of the GFACN36 domain and very rare over the GFACN37 domain.

Daylight, twilight, and night

The GFACN36 extends from 60°N to 72°N while the GFACN37 domain continues from 72°N to the north pole - areas known for long summer days and long winter nights. Indeed, the entire GFACN36 domain has periods when the sun does not rise and when the sun does not set. The days are effectively lengthened and nights shortened by periods of twilight as follows:

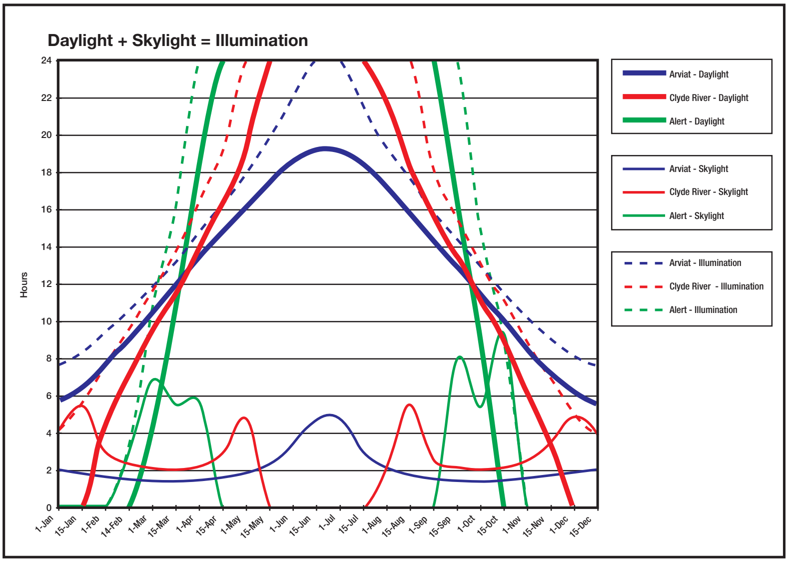


Fig. 3-1 - Hours of daylight and skylight illumination: Arviat, Clyde River and Alert

Civil twilight is defined to begin in the morning, and to end in the evening when the center of the sun is geometrically 6 degrees below the horizon. This is the limit at which twilight illumination is sufficient, under good weather conditions, for terrestrial objects to be clearly distinguished. At the beginning of morning civil twilight, or end of evening civil twilight, the horizon is clearly defined and the brightest stars are visible under good atmospheric conditions in the absence of moonlight or other illumination. In the morning before the beginning of civil twilight and in the evening after the end of civil twilight, artificial illumination is normally required to carry on ordinary outdoor activities. Complete darkness, however, ends sometime prior to the beginning of morning civil twilight and begins sometime after the end of evening civil twilight. Transport Canada allows VFR flight during civic twilight and for aviation purposes night is defined as the period between the end of civil twilight in the evening and the beginning of civil twilight in the morning.

Nautical twilight is defined to begin in the morning, and to end in the evening, when the center of the sun is geometrically 12 degrees below the horizon. At the beginning or end of nautical twilight, under good atmospheric conditions and in the absence of other illumination, general outlines of ground objects may be distinguishable, but detailed outdoor operations are not possible, and the horizon is indistinct.

Astronomical twilight is defined to begin in the morning, and to end in the evening when the center of the sun is geometrically 18 degrees below the horizon. Before the beginning of astronomical twilight in the morning and after the end of astronomical twilight in the evening the sun does not contribute to sky illumination. For a considerable interval after the beginning of morning twilight and before the end of evening twilight, sky illumination is so faint that it is practically imperceptible.

Of course in mountainous terrain there is not a flat horizon, making these definitions somewhat inexact.

North of about 65°30’N 24-hour daylight occurs centred around June 21st. At Clyde River (72° N) the sun rises on May 15th and does not set again until July 29th. In winter, the sun sets November 22nd and does not rise until January 19th. At Alert (82° 31’N) the sun rises April 7th and does not set again until September 5th. At Alert the sun sets October 14th and does not rise again until February 27th.

Even at communities much further south such as Arviat, NU (61°06’N) and Akulivik, QB (60°48’N) daylight on the longest day peaks at over 19 hours.

Ocean currents and tides

Ocean currents and/or tides contribute to the movement of ice through the ice-covered season in, for example, areas such as Hudson Strait and the Lincoln Sea (off northeastern Ellesmere Island). The resultant shifting of the ice leads to ongoing development of areas of open water. The areas of open water are both breeder and feeder areas for low cloud and fog.

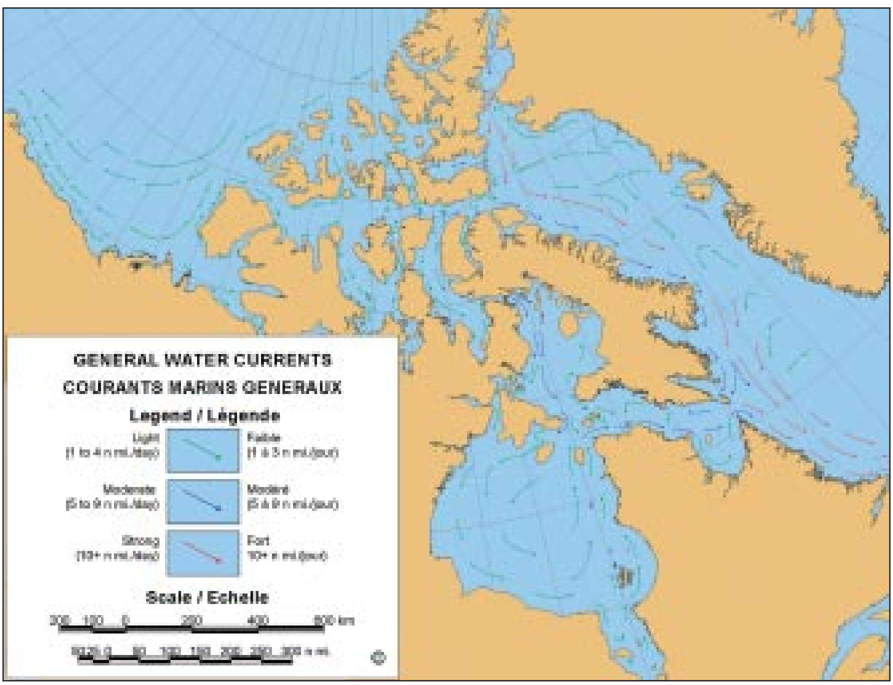


Fig. 3-2 - Ocean Currents credit: Canadian Ice Service

Tides

Tides play a role in ice movement. In rare cases, tides can play a role in the movement of fog. At Iqaluit, the airport elevation is 110 feet and the “35” end of the runway is very close to the bay. A large tide can be 36 feet. Forecasters cite a regime where with a light southeasterly onshore flow, fog was observed cycling onto and then away from the runway according to the tide.

	RANGE	
	MEAN TIDE (FT)	LARGE TIDE (FT)
IQALUIT	25.6	36.4
QUAQTAQ	19.0	27.6
ARVIAT	9.2	12.8
HALL BEACH	3.0	4.6
CLYDE RIVER	3.3	4.3
RESOLUTE	4.3	6.6
ALERT	1.6	2.6

Table 3-1 - Tide Ranges credit: Fisheries and Oceans, Canada

Late to freeze, open water areas, leads, polynyas

Open water areas are a source of moisture and are prone to low cloud and fog throughout the entire year. During the fall and winter, the cloud and fog are often composed of supercooled water droplets and hence capable of giving both freezing drizzle and significant aircraft icing. Low cloud and fog from the open water areas are routinely transported inland on the windward side.

In the fall, winter and spring, there are preferred areas where open water persists and where leads recur with regularity. For example, northwesterly winds routinely pull the ice away from the shores of western Hudson Bay. In some cases, open water areas exist through the entire year defying freeze up. These areas are known as polynyas. Within the GFACN36 and 37 domains, the North Water polynya is often cited. In addition to the recurring leads/polynyas there are areas that are slow to freeze over or are frequently open. Hudson Bay, Hudson Strait, and the Lincoln Sea (off northeastern Ellesmere Island) are such areas.

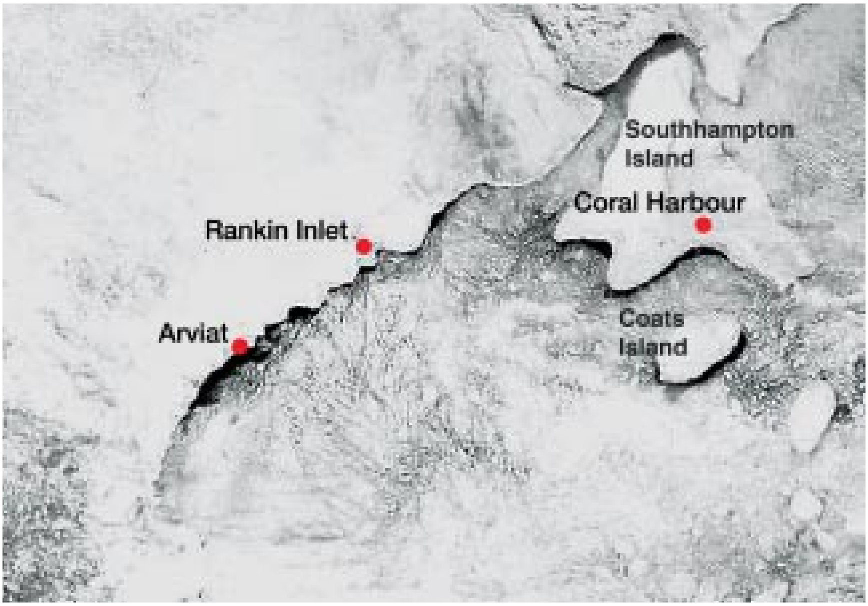


Photo 3-8 - Visible satellite imagery from 5 May 2002 showing shore lead along west coast of Hudson Bay and to lee of Southampton Island and Coats Island (dark areas)

credit: Meteorological Service of Canada

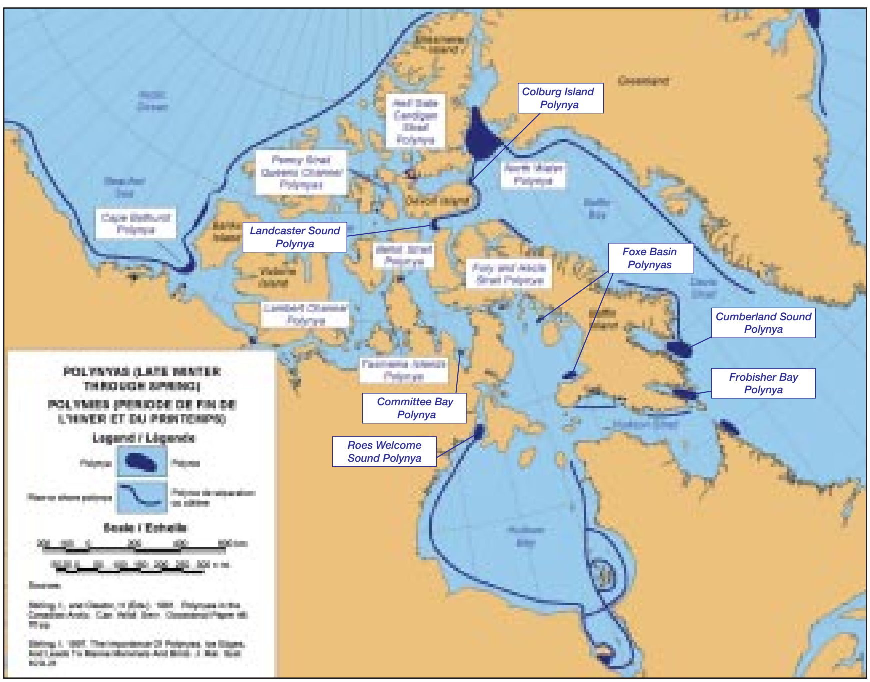


Fig. 3-3 - Polynyas

credit: Canadian Ice Service

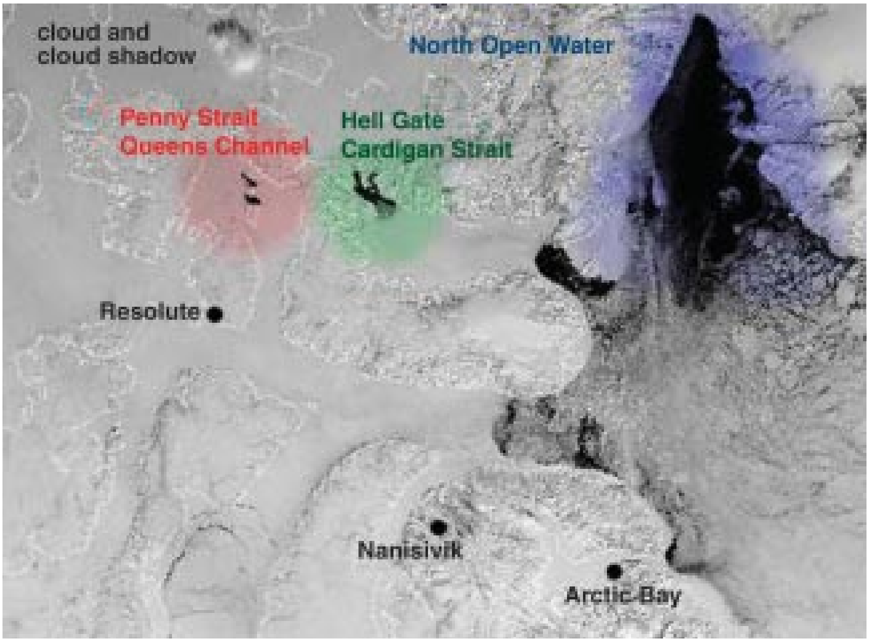


Photo 3-9 - Visible satellite imagery from 3 May 2002 showing some of the GFACN37 domain polynyas (dark areas)

credit: Meteorological Service of Canada

Open water season

Melting begins in early June and puddles are soon very extensive on both the fast and the pack ice.

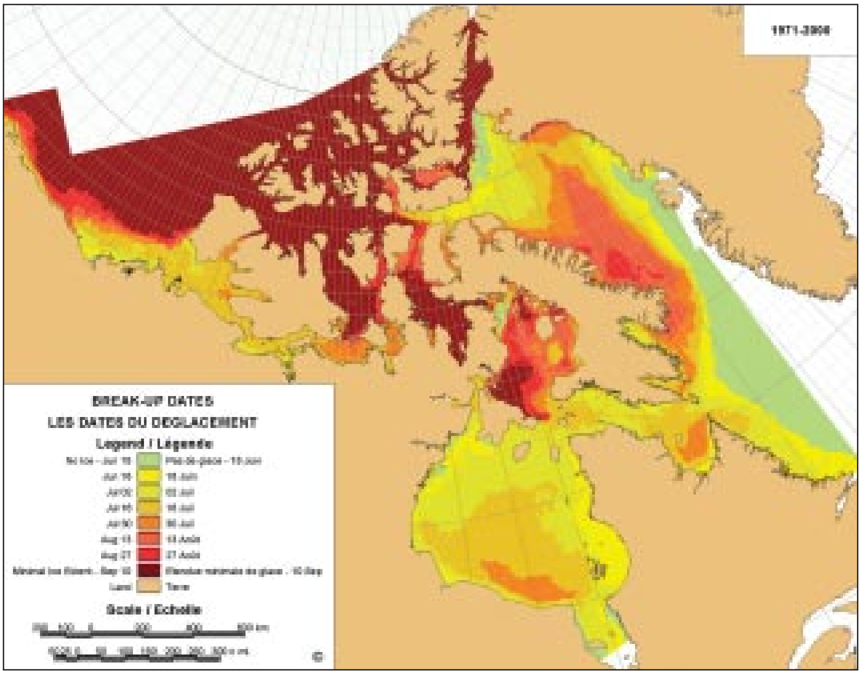


Fig. 3-4 - Break-up dates, 1971 to 2000 data. credit: Canadian Ice Service

Early September typically shows the least ice. Melting has been under way for three months and continues so that even the floes which are present are well weakened by the puddles on them.

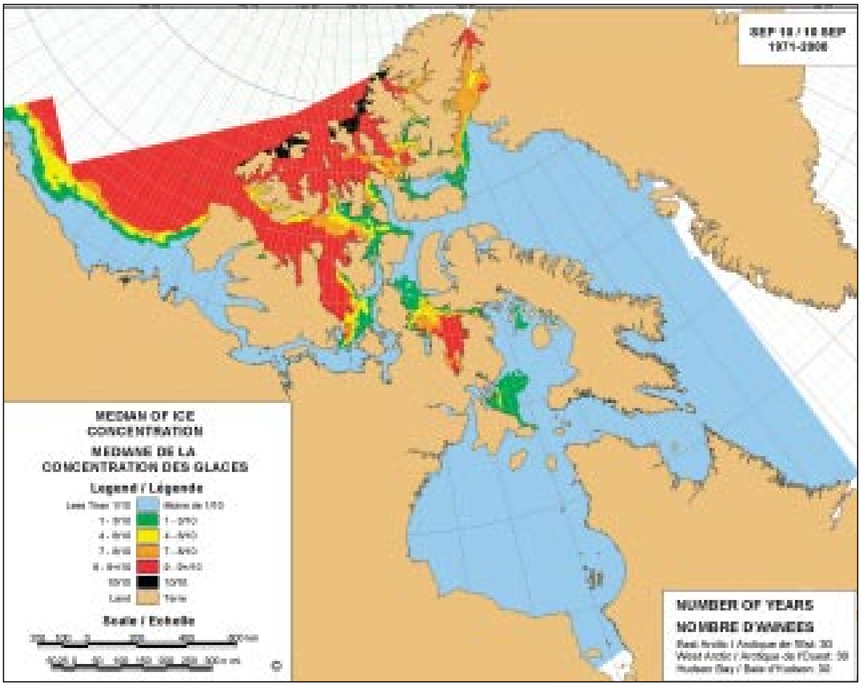


Fig. 3-5 - Median ice conditions 10 September, 1971 to 2000 data credit: Canadian Ice Service

Freeze-up

By mid September freezing air temperatures start generating new ice across the GFACN37 domain and spread into the GFACN36 domain north of mainland Canada. Late October ice starts to develop along the western shores of Hudson Bay. It takes until late November for most of Hudson Bay and Hudson Strait to freeze over.

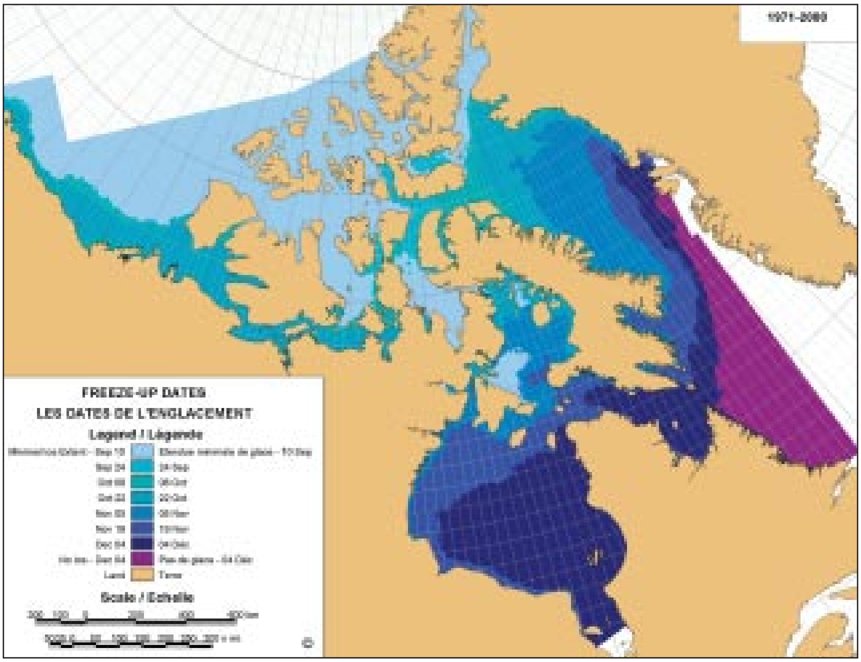


Fig. 3-6 - Freeze-up dates, 1971 to 2000 data. credit: Canadian Ice Service

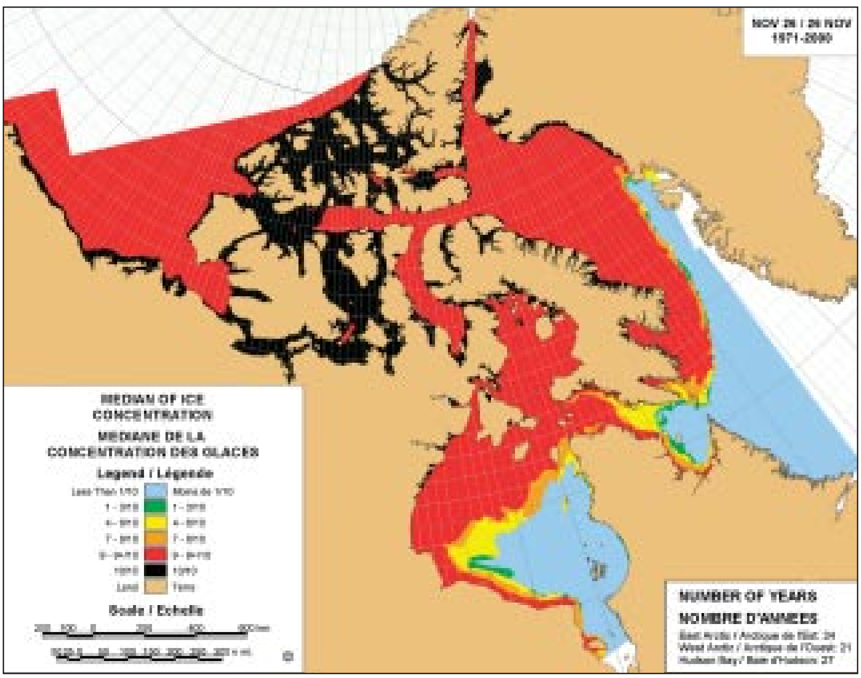


Fig. 3-7 - Median ice conditions 26 November, 1971 to 2000 data credit: Canadian Ice Service

Mean Upper Circulation

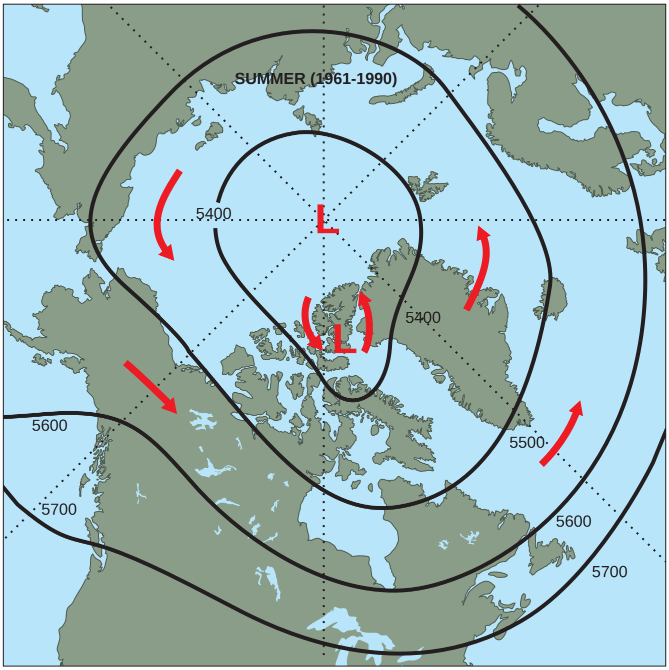


Fig. 3-8 - Mean summer upper winds

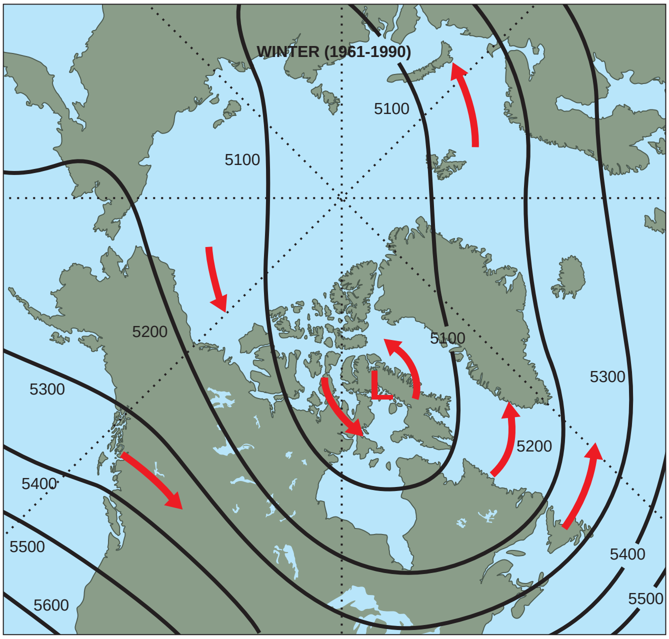


Fig. 3-9 - Mean winter upper winds

Summer - For the GFACN36 and 37 domains, the mean summer circulation aloft has an upper low over the pole with a trough extending southward to another low centre over the arctic islands. The flow aloft across the GFACN37 domain is generally west-northwesterly becoming light over eastern sections. The flow aloft across the GFACN36 domain starts off west-northwesterly western sections and backs to westerly across eastern Hudson Bay and finally west-southwesterly across southern Baffin Island and northern Quebec.

Winter - The upper low whose mean position is over the arctic islands during the summer, intensifies and drops south to northern Foxe Basin for winter. The mean winter flow aloft across the GFACN36 domain is stronger than the mean summer flow and favors northwesterly rather than west-northwesterly. The mean winter flow aloft over the GFACN37 domain is weaker than the mean summer flow during the summer.

Any day of the year - On any given day, the upper flow can be significantly different than the mean flow. The following chart shows the flow aloft the evening of 3 September 2002.

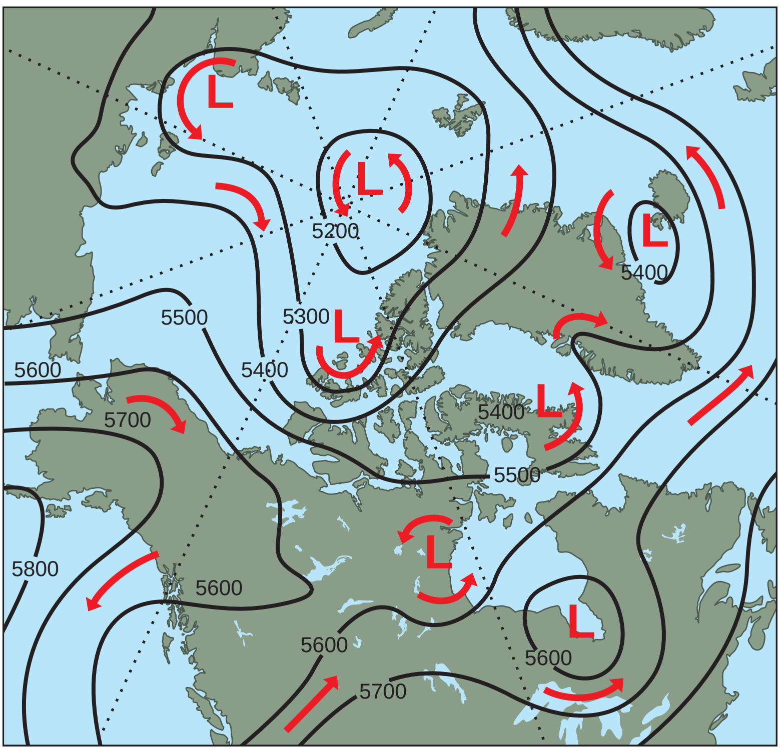


Fig. 3-10 - 500 hPa chart, 0000 UTC 4 Sept. 2002

Upper Troughs and Upper Ridges

The most common features that move with the upper flow are upper ridges and upper troughs. With an upper ridge over an area, the weather becomes stagnant, with light winds at all levels. In winter, skies favour clear but stratus and stratocumulus can be anywhere. Summer weather associated with an upper ridge favours sunny and dry over mainland sections of the GFACN36 domain. Summer weather with an upper ridge is trickier over coastal and offshore sections of the GFACN36 and over the GFACN37 domain where there is so much low-level moisture and hence low cloud and areas of fog.

Upper troughs produce areas of cloud and precipitation. Upper troughs tend to be strongest in the winter and often have broad cloud shields and widespread precipitation, particularly in upslope areas along the windward slopes of the mountain ranges. During the summer months, the cloud shields associated with upper troughs are narrower, usually quite convective and produce mainly showers and occasionally thundershowers across the southern domain and showers across the northern domain. Upper troughs may have a surface low-pressure system or a frontal system associated with them further enhancing the cloud and precipitation.

Clearing behind an upper trough can be gradual in winter but tends to be quite rapid in summer.

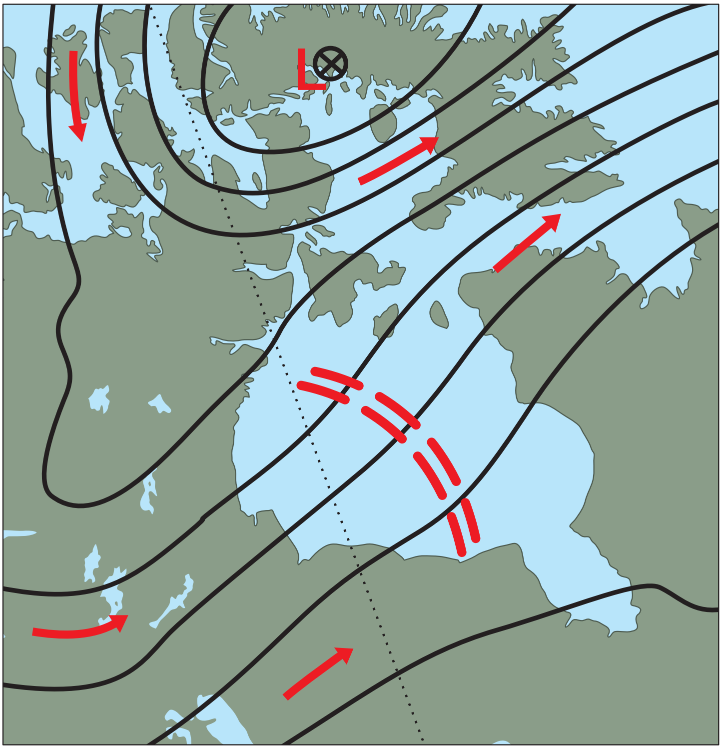


Fig. 3-11 - Upper trough 1200 UTC 21 August 2001

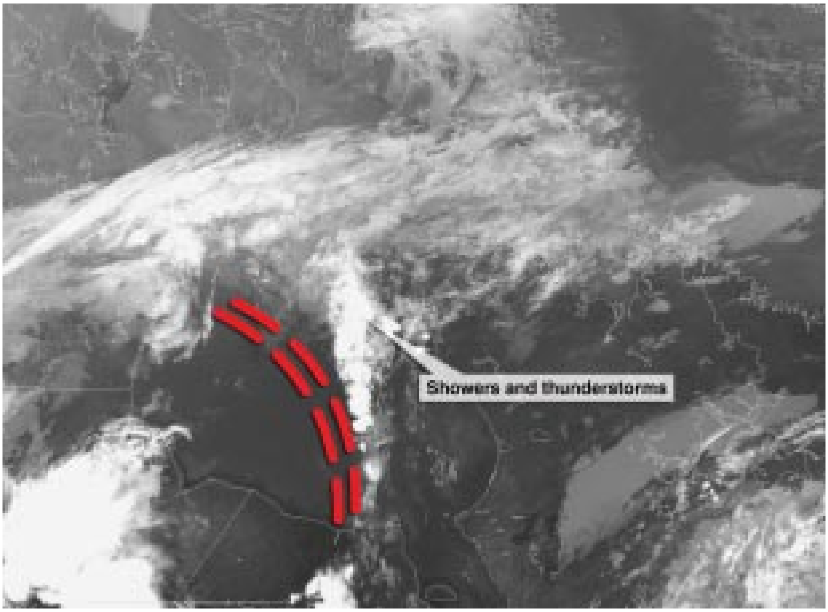


Photo 3-10 - Area of associated showers and thundershowers 1032 UTC 21 August 2001

Polar Lows

Polar lows occur on occasion over Hudson Bay, Hudson Strait and Ungava Bay. They occur more frequently over Davis Strait and the Labrador Sea. They are a fall-into-winter event that need the heat and moisture of open water. Polar lows are very compact and intense low-pressure systems that can form when very cold air exists from the surface to at least 10,000 feet and moves over open water. A typical temperature regime for a polar low event would be -25°C or colder at the surface and again at 10,000 feet.

Once the cold air has been heated and has moisture added over the open water, it is like a helium balloon and can quickly rise to heights that generate towering cumulus and even cumulonimbus clouds. These unstable cloud masses can give heavy snowshowers which the strong surface winds associated with the polar low can churn into blowing snow. Reduced visibilities can be expected with rapidly changing wind direction and severe aircraft icing. Polar lows often move quickly and dissipate rapidly as soon as they move over land or ice packs and hence away from their heat and moisture source. Abrupt changes in surface air pressure or sudden changes in wind speed and direction may flag the presence of a polar low. Often, it is satellite imagery that "exposes" their presence.

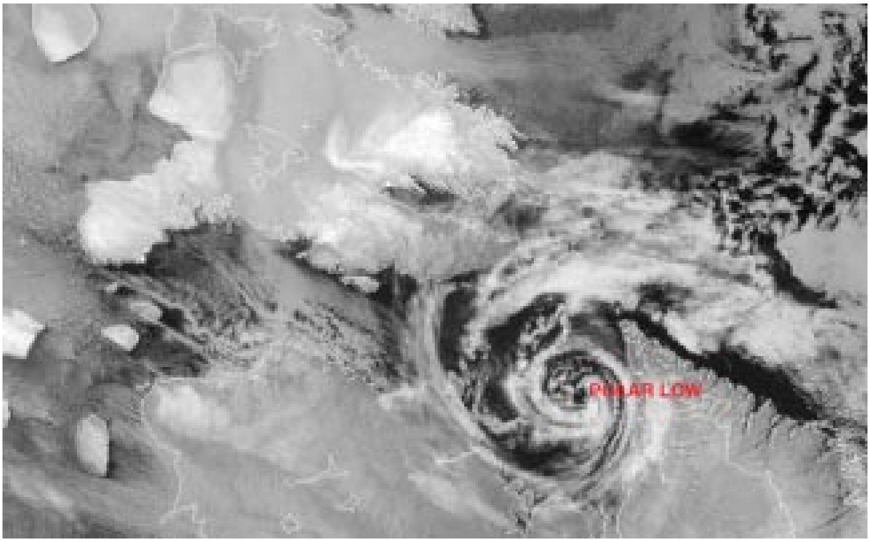


Photo 3-11 - Polar low, Ungava Bay, morning 2 December 2000, infrared satellite photo

Cold Lows

A cold low, or "cut-off" low, is a large, nearly circular area of the atmosphere in which temperatures get colder towards the centre, both at the surface and aloft. It is the final stage in the development of a low and is not reached by all storms. While a surface low-pressure centre may or may not be present beneath the cold low, its true character is most evident on upper charts. The significance of cold lows is that they produce large areas of cloud and precipitation and tend to persist in one location for prolonged periods of time.

Cold lows can occur at any time of the year. They tend to occur more frequently over southern latitudes in the spring, while occurring more frequently over northern latitudes in the winter. During these periods, low-pressure systems will approach the region from the south or southwest and sometimes become “cut-off” from the prevailing circulation aloft as cold air becomes completely wrapped around the low-pressure centre. The overall effect is to produce a widespread area of cool, unstable air in which bands of cloud, showers and thundershowers occur. Cold lows are also a favourable location for aircraft icing. Along the deformation zone to the northeast of the cold low, the enhanced vertical lift will thicken the cloud cover and produce widespread, steady precipitation. Eventually, the low will either weaken to the point that it is no longer detectable on the upper charts, or it will be pushed out by stronger systems approaching from the west.

Storm Tracks

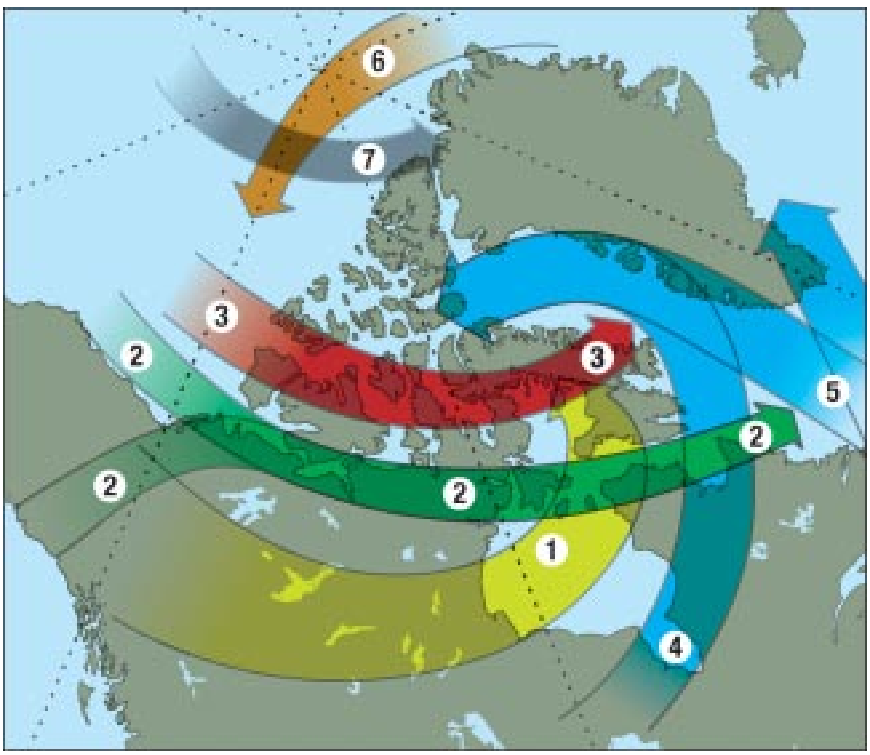


Fig. 3-12 - Storms tracks of the GFACN36 and 37 domains

Storms (low-pressure systems) get to the GFACN36 and 37 domains from many directions and take many paths across the domains. There are paths other than the representative low tracks shown in the figure.

Track 1 - Lows originating over the Prairies begin with warm airmasses but the warm air routinely pulls out when the low is over Hudson Bay. The lows then re-curve northwards toward upper-low centres. Track 1 lows routinely deepen over Hudson Bay. Blizzards are possible both ahead of and behind the lows.

Strong northeasterlies are likely at Coral Harbour as the lows approach from the south. The communities of Cape Dorset, Iqaluit and Kimmirut can receive strong east to southeast winds ahead of these features. Significant snowfalls are possible along the east coast of Baffin Island especially before freeze-up due to onshore winds from open waters of Davis Strait, Hudson Strait and Labrador Sea.

If the upper level trough that supports the low continues northwards across Baffin Island and is strong, a low can re-develop over northern Baffin Bay and cause brief but strong south to southwest winds at Clyde as strong pressure rises spread across the northern sections of the Island. Pond Inlet can receive strong easterly winds as lows track north to Foxe Basin.

Track 2 - As these storms approach an area, there can be strong south to southeasterly winds with possible blizzards. With their passage, northwesterly blizzards are frequent. At Iqaluit, sharp wind shifts to northwesterly can occur as the low passes. For example, a storm close to Thanksgiving Day 1986 which followed this track, temporarily stalled near Cape Dorset as an upper low centre formed and deepened. During this period, pressures were rising sharply at Coral Harbour yet were still falling at Cape Dorset and Iqaluit, thus strengthening the flow to the west of the storm centre. After the storm finally passed Iqaluit, winds shifted abruptly to northwest and gusted as high as 75 knots causing a blizzard.

Track 3 - These storms are generally not as intense as their southern and eastern cousins. However, at Cape Dorset, when these lows cross to the north of the site and combine with a high-pressure area or ridge to the south, strong west to southwest winds result.

Track 3 lows can also generate strong winds at Pond Inlet. For the strong winds to occur, the low centre or trough tracks across northern Baffin Island or even from the central arctic islands to Baffin Bay. As the low passes Pond Inlet, and if the winds at 4 or 5 thousand feet are west to northwest (as they would be for this track), then westerly winds are likely for Pond Inlet. Iqaluit will generally not see strong winds with this track since the gradients are often westerly. However, with strong westerly gradients, low-level wind shears and/or turbulence are possible as the surface reported winds are light and of variable direction.

Track 4 - This is a frequently observed track from lows originating over the U.S. midwest and Southern Ontario/Southern Quebec. At Iqaluit, this is a classical blizzard track. Ahead of the storms, winds are often fairly light as the gradients do not line up well along Frobisher Bay. However, as the lows pass the mouth of Frobisher Bay, winds shift abruptly to northwesterly and frequently are strong enough to produce blizzards. If the lows continue rapidly northeastwards, the strong winds will be short-lived. Weakening and backing of the winds to west-northwest often occurs as the lows pass near latitude 65° N. By this time, the gradients, although still strong, are not aligned as favourably along Frobisher Bay. However, strong northwesterlies can persist when a trough of low pressure remains to the east of the site thereby maintaining the strong north to northwest gradient.

At Cape Dyer and Qikiqtarjuak, northwesterly winds occur as lows approach the area from the south. Following the low passage, winds drop even though weather charts will still show a strong westerly gradient over the area. These storms can also give strong northwesterly winds at Clyde River as they approach when pressures are falling to the southeast of the site. As the low passes, wind speeds drop and directions back slightly.

Track 5 - These low-pressure systems start out over the U.S. east coast and move north across the Maritimes. They then follow a storm track similar to Track 4 and many of the comments about Track 4 lows apply to Track 5 lows. Iqaluit seldom has - but can have - a blizzard with this track. The reason is that the storms are too far east and not large enough in their westward extent. However, these storms frequently catch the east Baffin Island coast. The strong winds of such lows are however not often seen at the airport observing site at Qikiqtarjuaq. Also, the lows can miss influencing the Baffin Coast when the low is a "lee of Greenland" low. Such a low occurs when a small-scale low "squirts" north along the west coast of Greenland as the main low and upper trough swing east of Greenland.

Track 6 - Low-pressure systems do, on occasion, move out of the North Atlantic and westward north of, or across, northern Greenland. Such lows can bring low-through mid-and upper-level cloud to northern Ellesmere Island and the area north of Ellesmere to the pole.

Track 7 - Low-pressure systems can make their way across the Arctic Basin from the other side of the pole and into the Canadian arctic islands. Such lows or upper troughs approaching northern Ellesmere Island from the west generate pressure falls and strong southwest winds at Alert. They can also generate strong southerly winds at Eureka. Such strong wind regimes can give reduced visibility and obscured visibility in blowing snow.

Drifting snow, blowing snow and blizzards

Of the Canadian GFA domains, the GFACN36 domain is the leader and the GFACN37 holds second place with respect to the occurrence of blowing snow and blizzards. Blizzard "season" begins late September and doesn't end until May. Baker Lake is the blizzard capital.

Wind speeds and snow - It takes very little snow on the ground for drifting and blowing snow to occur. As wind speeds increase, the wind is able to get snow moving and then eventually into the air. The progression begins with drifting snow (snow raised to a height of less than 2 metres) then changes to blowing snow (horizontal visibility is restricted to 5 miles or less with the snow particles raised to a height of 2 metres or more). In the case of blowing snow, the particles get entrained by turbulent motions and may rise to 100 metres (300 feet) or more above the surface. To the forecasters working the Canadian Arctic, blowing snow becomes a blizzard when the visibility is restricted by blowing snow (or by blowing snow and falling snow) to 1/2 mile or less, the wind is equal to at least 22 knots, the temperature is 0°C or lower, and these conditions last 6 hours or more.

The following is a rough guide of the winds required for the various stages noting that the snow character and falling snow are factors that influence how readily snow will move and be swept into the air. Factors which affect the ability of snow to get into motion and airborne are temperature and moisture conditions of the snow pack and the age of the snow. Land cover plays a dominant role. The treeless environment north of the tree line (and across the prairies) provides an ideal environment for wind to get - and sustain - snow in motion.

Approximate wind speed for drifting snow, blowing snow, and blizzards during the frozen months across open terrain of the GFACN36 and 37 domains in the absence of falling snow

	Drifting Snow	Blowing Snow	Blizzard
Representative wind speed at least:	12 knots	19 knots	• 22 knots for periods of blizzard conditions • 25 knots for sustained blizzard conditions • 30 knots for near guarantees of experiencing blizzard conditions

Table 3-2 Approximate wind speed for drifting snow, blowing snow and blizzards

Favoured areas for blowing snow

The corridor from the arctic islands southeast to Hudson Bay is particularly blowing snow prone. The figure shows that on average the corridor experiences blowing snow 90 days a year. If one takes the frozen season as being about 270 days, then blowing snow occurs one in three days during the frozen season.

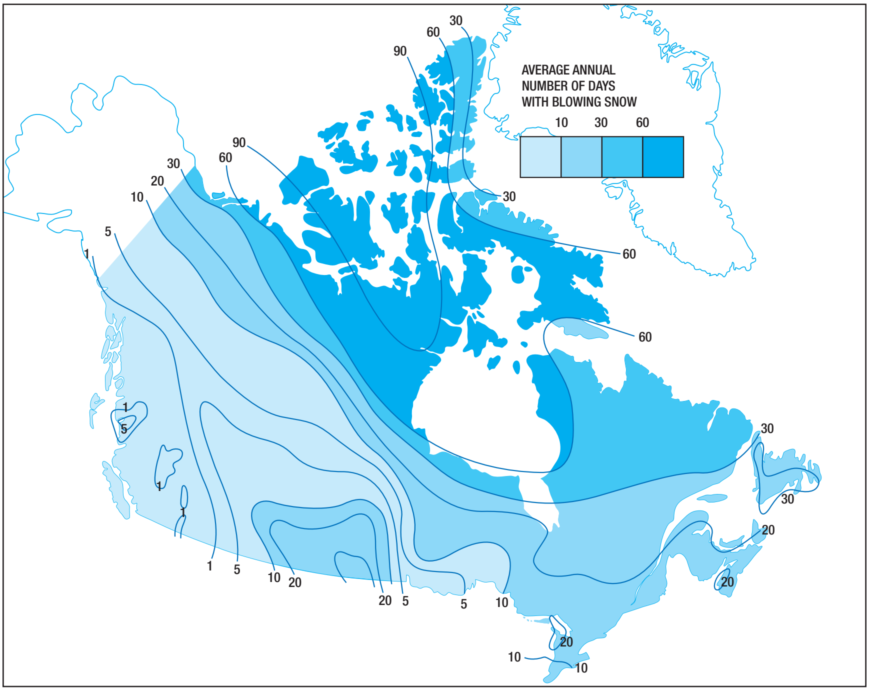


Fig. 3-13 - Average annual number of days with blowing snow credit: David Phillips

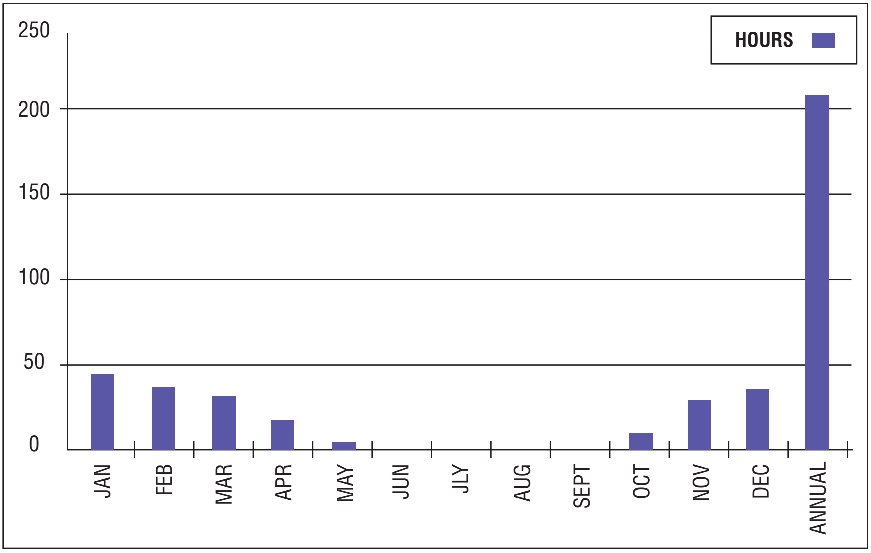


Fig. 3-14 - Average number of blizzard hours by month for Baker Lake

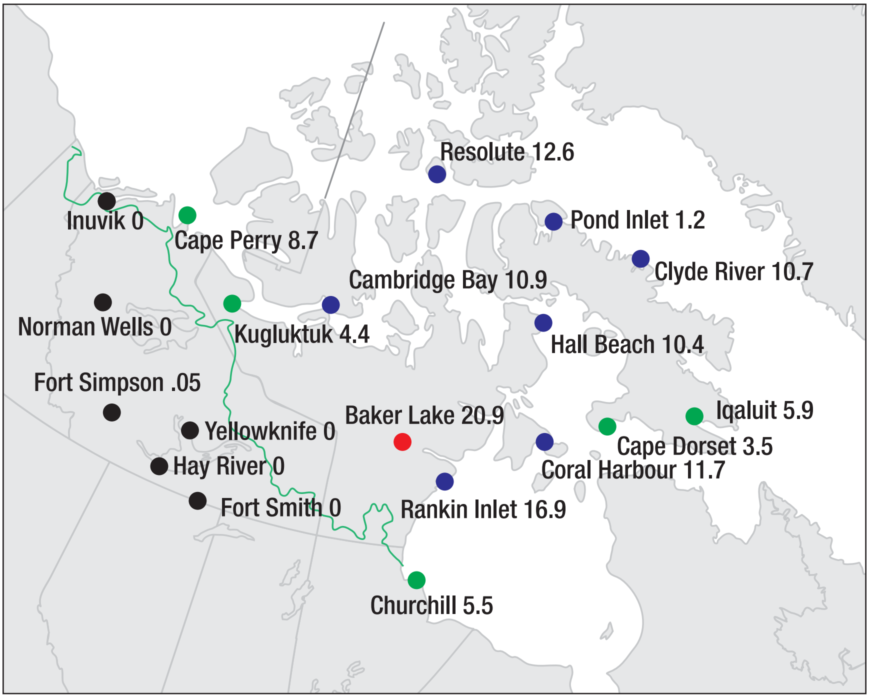


Fig. 3-15 - Average number of blizzard events per year for selected communities in Northwest Territories and Nunavut plus Churchill, Manitoba 1980 to 1999 data except 1982 to 1999 Rankin Inlet and 1985 to 1999 Clyde River and Cape Dorset

Recurring synoptic pattern giving blizzard conditions to the corridor from the arctic islands to the barrens west of Hudson Bay - A favoured pressure pattern for the GFACN36 and 37 domains in the winter is a ridge of high pressure in combination with high centres extending from the Arctic Ocean southeast across the Northwest Territories and into the Prairies. Concurrently, there is routinely an area of low pressure over central or eastern Nunavut. The result is a northwesterly wind regime between the ridge and the low that is often strong enough to generate blowing snow.

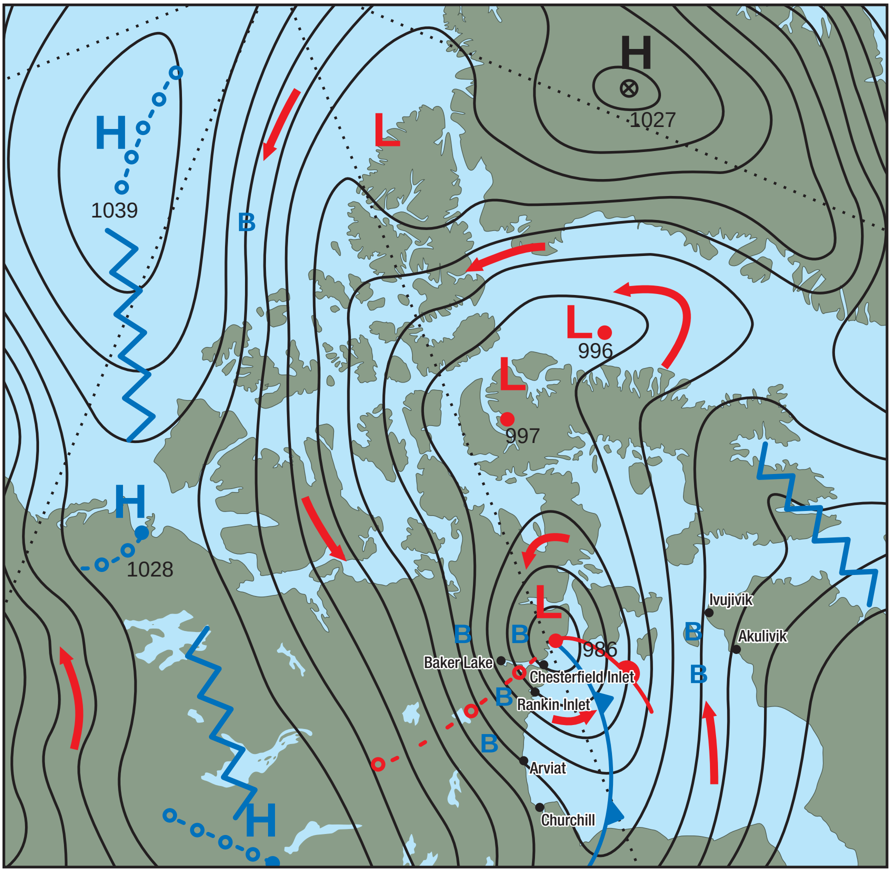


Fig. 3-16 - Sample synoptic (1800 UTC 4 Feb 2002) pattern giving blizzard conditions to many communities of the GFACN36 domain and likely to the Arctic Basin section of the GFACN37 domain (B = blizzard)

Snow at times heavy

Snowfall in the GFACN36 and 37 domains is generally light. However, snowfall events along the east coast of Baffin Island, Devon Island and Ellesmere Island can be significant. The Cape Dyer area of Baffin Island is particularly prone to the type of heavy snowfall events that give obscured ceilings and poor visibilities.

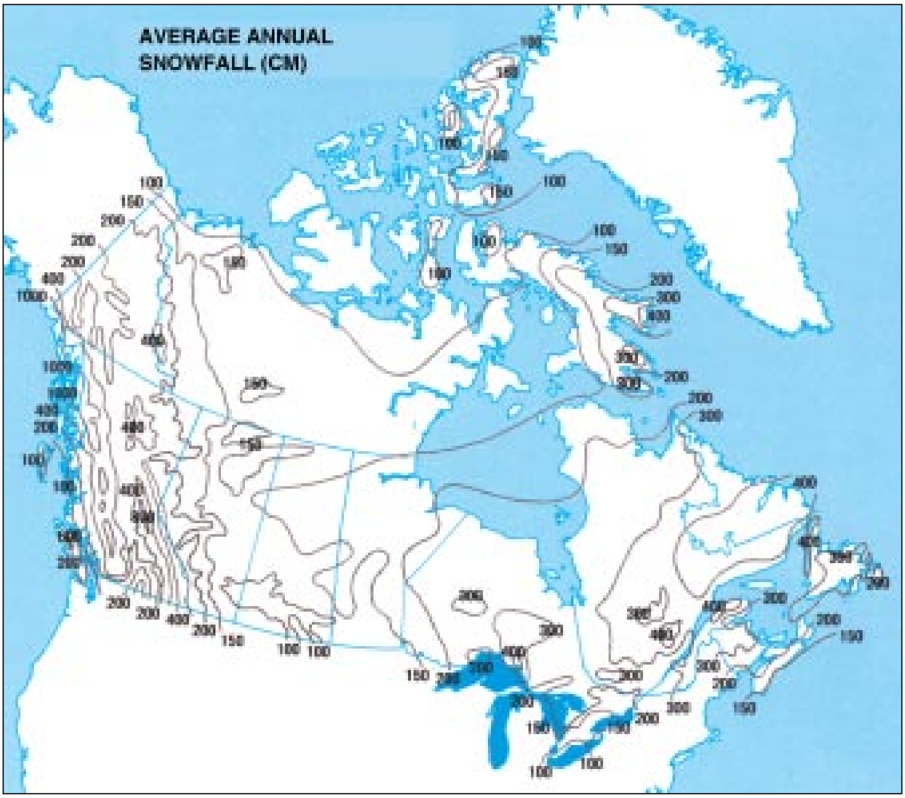


Fig. 3-17 - Average annual snowfall across GFACN36 and 37 domains

credit: David Phillips

Snow lingers across the GFACN36 and 37 domains

Per the figure, snow is the ground cover for the majority of the year across the GFACN36 and 37 domains.

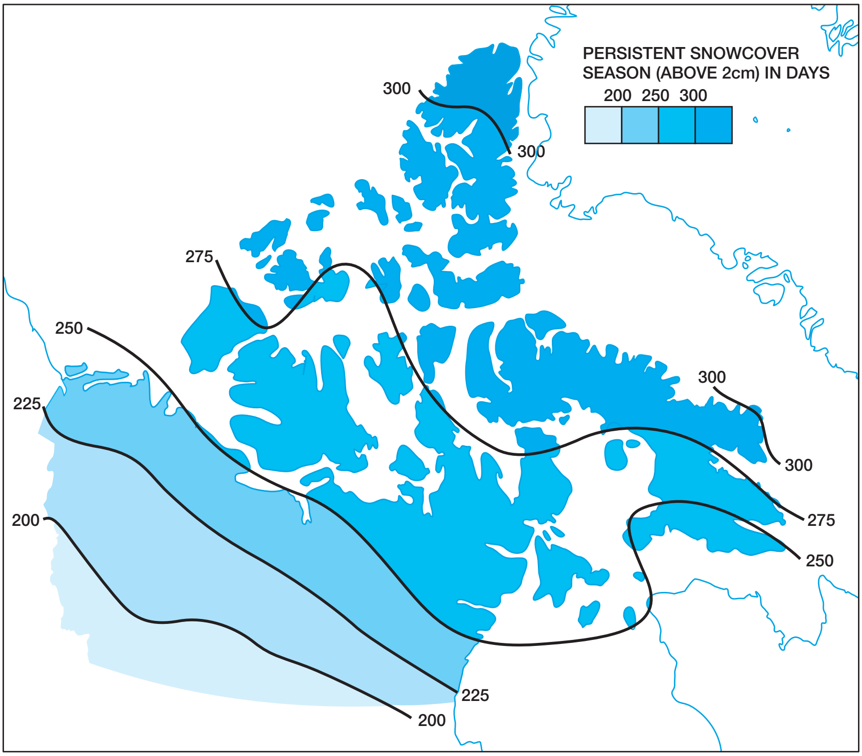


Fig. 3-18 - Persistent snowcover credit: David Phillips

Climate

Temperature - Temperatures across the GFACN36 and 37 domains spend the majority of the year below freezing. On the Arctic Basin section of the GFACN37 domain mean daily temperatures, per the temperature graphing for the north pole are at warmest only a few degrees above 0°C.

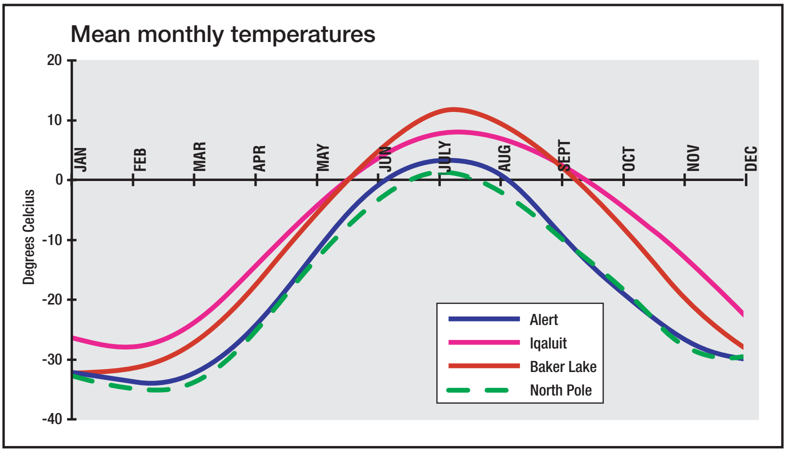


Fig. 3-19 - Mean Monthly Temperature

Precipitation - Snowfall is a 12-month of the year event for the northern reaches of the GFACN37 domain as shown, for example, by weather observations from Alert. That said, rain does occur at Alert during the summer.

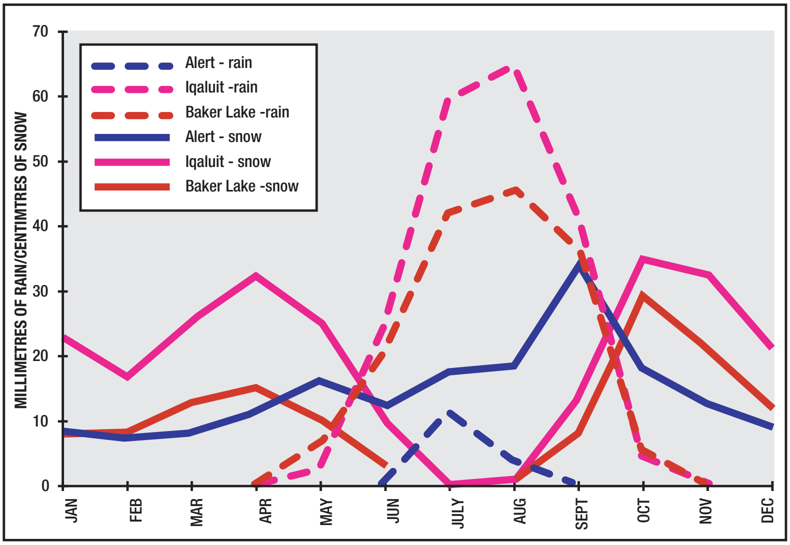


Fig. 3-20 - Rain Versus Snow

Wind chill

The combination of cold temperatures and wind routinely makes for wind chills to the extreme across the GFACN36 and 37 domains.

Wind Chill Calculation Chart
for winds in knots and kilometres per hour

	/T air (°c)	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
	V_{10} (km/h)												
Knots 2.7	5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
5.4	10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
8	15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
10.8	20	1	-5	-12	-18	-24	-31	-37	-43	-49	-56	-62	-68
13.5	25	1	-6	-12	-19	-25	-32	-38	-45	-51	-57	-64	-70
16.2	30	0	-7	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
18.9	35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
21.6	40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
24.3	45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
27	50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63	-70	-76
29.7	55	-2	-9	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
32.4	60	-2	-9	-16	-23	-30	-37	-43	-50	-57	-64	-71	-78
35.1	65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
37.8	70	-2	-9	-16	-23	-30	-37	-44	-51	-59	-66	-73	-80
40.5	75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
43.2	80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

where Tair = Actual air temperature in °C
V_{10} (km/h) = Wind speed at 10 metres in km/h (as reported in weather observations)

Approximate Thresholds:
Risk of frostbite in prolonged exposure windchill below -25
Frostbite possible in 10 minutes at -35 Warm skin, suddenly eposed. Shorter time if skin is cool at the start.
Frostbite possible in less than 2 minutes at -60 Warm skin, suddenly eposed. Shorter time if skin is cool at the start.

Table 3-3 - Wind chill calculation chart

Low Cloud GFACN37 Domain

Summer and fall are prime time for low cloud and fog across the GFACN37 domain. Freeze-up brings improving conditions. Although the following maps show overall cloud cover, much of the cloud is low cloud. The winter chart shows two interesting “bulges” of higher cloud percentages. The first is the bulge that extends from northern Greenland to north of Ellesmere Island. The satellite photo 21 January shows such an area of cloud. The other bulge extends from the south into southwestern arctic islands.

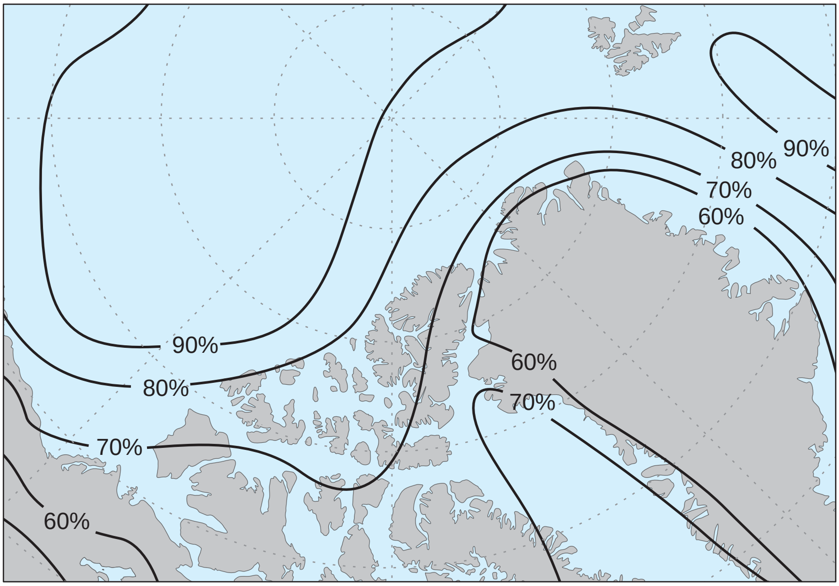


Fig. 3-21 - Summer cloud cover GFACN37 domain

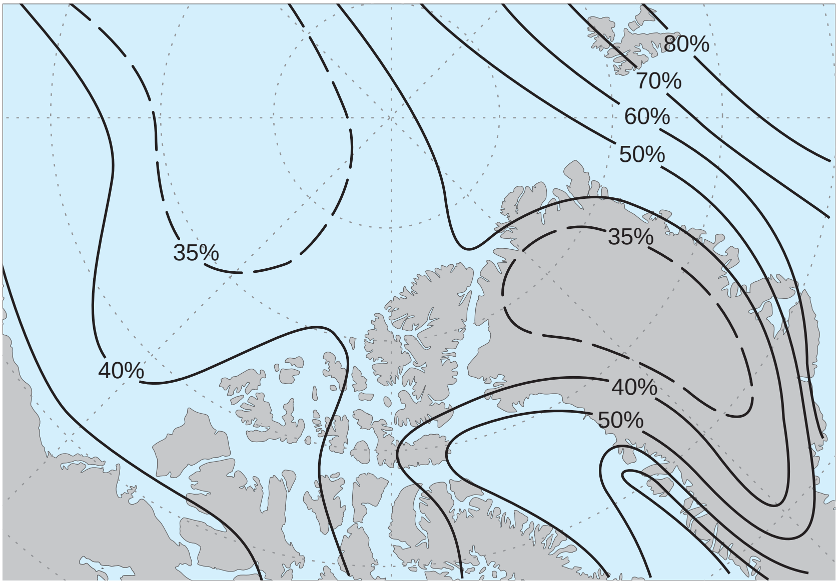


Fig. 3-22 - Winter cloud cover GFACN37 domain

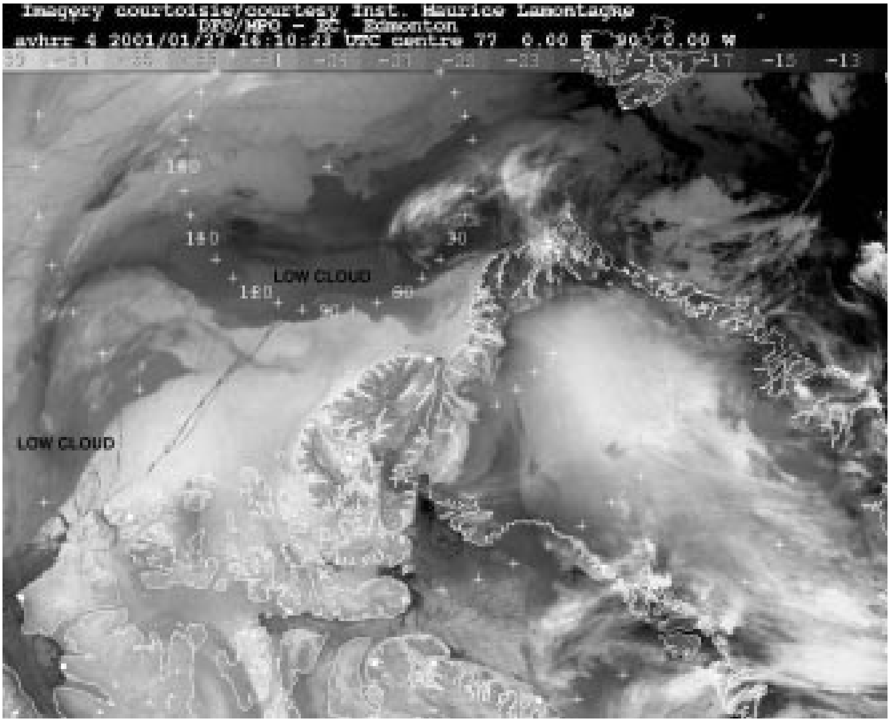


Photo 3-12 - Infrared satellite photo showing low-cloud area (darker area) extending from north of Greenland to north of Ellesmere Island and then wrapping southwestward (27 January 2001)

Low Cloud GFACN36 Domain

There are three common patterns of extensive areas of stratiform clouds across northern Canada and these patterns are related to the upper flow.

Pattern 1 - spring thaw to early fall - In such a pattern the stratiform clouds are confined to the arctic flow west of the trough. There is usually a sharp edge to the cloud deck along the boundary between the Arctic and Maritime streams. The solid deck of cloud ends abruptly at the base of the trough. Only patches of scattered or broken stratocumulus are evident east of the trough. During the period spring thaw to early fall, an extensive low-level moisture source is present due to the vast number of lakes and the Arctic Ocean. The strong upper northwesterly flow is reflected by strong surface winds that produce turbulence to aid in mixing the surface moisture to higher levels. The northerly arctic stream is generally subsiding as it moves southward. The subsiding flow creates an inversion necessary to trap the low-level moisture. Hence stratiform clouds persist.

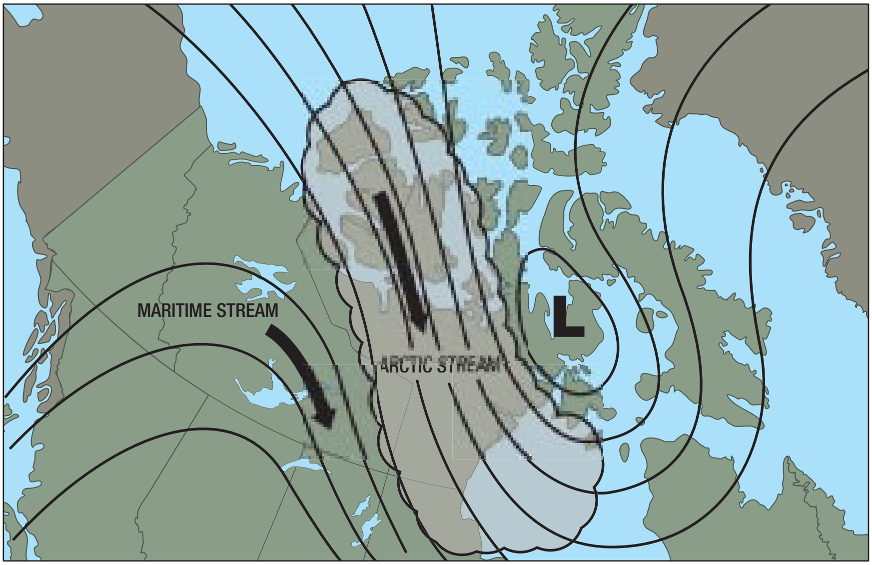


Fig. 3-23 - Spring thaw to early fall upper wind pattern and associated stratiform-cloud area

When the upper flow becomes more west to east, the subsidence decreases until, finally, it is not strong enough to maintain an inversion. This results in the clouds dissipating rapidly.

Pattern 2 - fall, winter, and early spring - This upper flow occurs when a warm moist flow from the Pacific overrides a cold layer of arctic air. This creates a very strong inversion. An upper front exists along the boundary between the warm Maritime stream and the cold arctic stream. The surface front may or may not exist in the area depending whether any of the warm air is able to penetrate to the surface. The deck of stratiform clouds lies to the south of the upper front, trapped under the strong inversion. This upper front exists at the level of the top of the clouds which is typically 5,000 to 6,000 feet ASL.

Since the arctic airmass is dry and cold, the moisture to produce the clouds comes from the Maritime stream. Enough mixing must take place to saturate the cold arctic air. The northern edge of the clouds is usually sharply defined and parallels the northern boundary of the Maritime stream at upper levels. The southern boundary of the cloud is not so well defined, periodically breaking and then reforming.

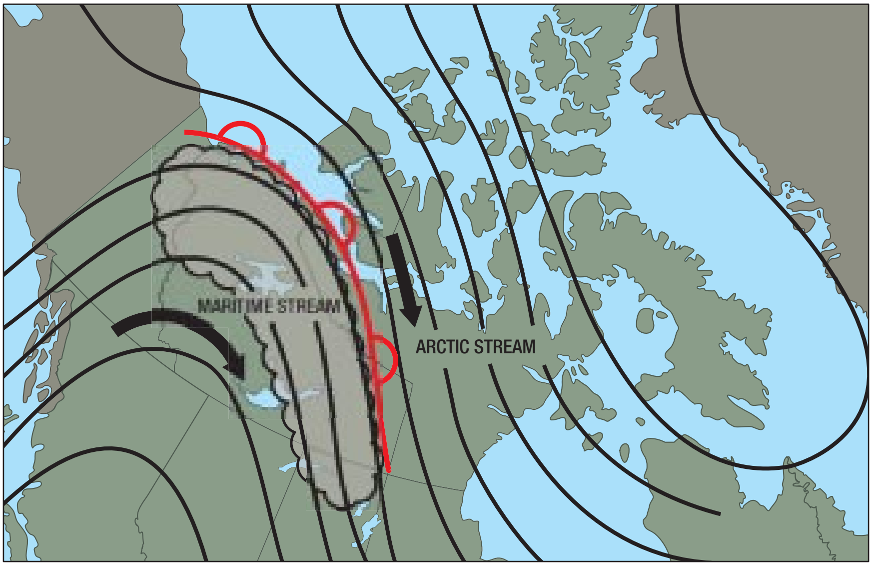


Fig. 3-24- Fall, winter, and early spring upper wind pattern and associated stratiform cloud area

Pattern 3 - The layer of arctic air at the surface encompasses a more extensive area, including most of the Prairies. The over-running Maritime air creates a strong inversion from the northern Mackenzie to the southern Prairies. As a result, an extensive area of stratus and stratocumulus forms beneath the inversion. As with Pattern 2, the northern edge of the cloud is very well defined and parallels the northern boundary of the Maritime stream.

If the southwesterly Maritime flow persists, the warmer air will gradually erode the arctic air causing the inversion to steadily lower. Consequently, the cloud base will also lower. Once the warm air breaks through to the surface, the inversion will no longer exist and the clouds will clear rapidly.

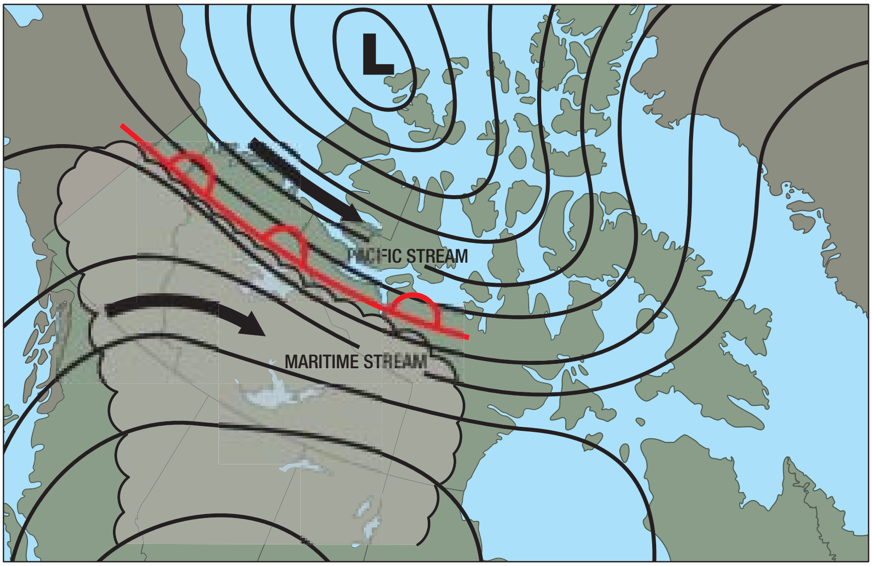


Fig. 3-25 - Fall, winter, and early spring upper wind pattern and associated stratiform cloud area

Seasonal Migratory Birds

Impact with birds can be a hazard - A four-pound bird striking an aircraft travelling at 130 knots exerts a localized force of more than 2 tons. An aircraft travelling at 260 knots and hitting a bird of the same size would receive a localized force of 9 tons.

A.I.P. Canada has maps - Readers are encouraged to consult Transport Canada's Aeronautical Information Publication - TP2300 for spring and autumn mappings of bird migration routes.

Weather plays a role - Associated with seasonal changes in weather, large flocks of migratory birds fly across the GFACN36 domain. "Southern" sections of the GFA domain - northern Baffin Island area, for example - also experience such bird events.

Spring - Migratory birds will not leave a staging area against surface winds in excess of 10 knots. Major movements, involving hundreds of thousands of birds, often follow the passage of a ridge of high pressure. Winds on the west side of a ridge are typically southeasterly and thus favourable for birds heading north. In spring, barring weather influences, migratory birds normally leave their staging areas between dusk and midnight, and during the first three hours after dawn. However, they may leave at any hour of the day or night, particularly after long periods of poor weather.

Autumn - Geese, swans and cranes normally move south when the winds become favourable. For example, they depart from staging areas 12 to 24 hours after the passage of a cold front, especially if there is rapid clearing and there are strong northerly or northwesterly winds behind the front. In the autumn, barring weather influences, migratory birds take off from their staging areas in the late afternoon for night flights. Occasionally, however, they may fly by day as well.

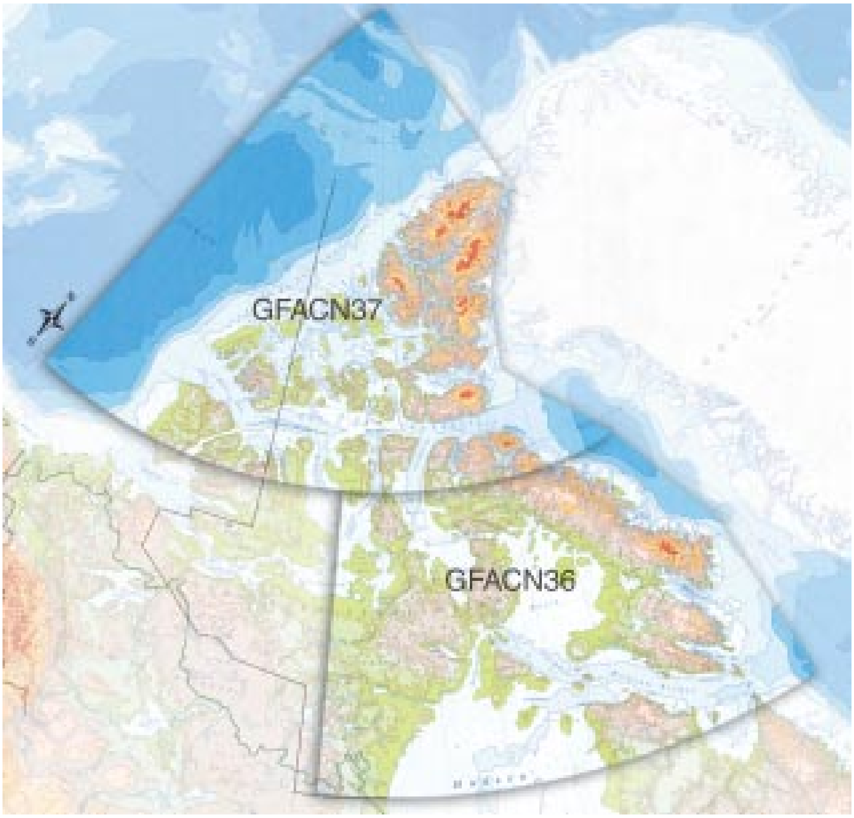
Table 3: Symbols Used in this Manual

	**Fog Symbol (3 horizontal lines)** This standard symbol for fog indicates areas where fog is frequently observed.
	**Cloud areas and cloud edges** Scalloped lines show areas where low cloud (preventing VFR flying) is known to occur frequently. In many cases, this hazard may not be detected at any nearby airports.
	**Icing symbol (2 vertical lines through a half circle)** This standard symbol for icing indicate areas where significant icing is relatively common.
	**Choppy water symbol (symbol with two wavelike points)** For float plane operation, this symbol is used to denote areas where winds and significant waves can make landings and takeoffs dangerous or impossible.
	**Turbulence symbol** This standard symbol for turbulence is also used to indicate areas known for significant windshear, as well as potentially hazardous downdrafts.
	**Strong wind symbol (straight arrow)** This arrow is used to show areas prone to very strong winds and also indicates the typical direction of these winds. Where these winds encounter changing topography (hills, valley bends, coastlines, islands) turbulence, although not always indicated, can be expected.
	**Funnelling / Channelling symbol (narrowing arrow)** This symbol is similar to the strong wind symbol except that the winds are constricted or channeled by topography. In this case, winds in the narrow portion could be very strong while surrounding locations receive much lighter winds.
	**Snow symbol (asterisk)** This standard symbol for snow shows areas prone to very heavy snowfall.
	**Thunderstorm symbol (half circle with anvil top)** This standard symbol for cumulonimbus (CB) cloud is used to denote areas prone to thunderstorm activity.
	**Mill symbol (smokestack)** This symbol shows areas where major industrial activity can impact on aviation weather. The industrial activity usually results in more frequent low cloud and fog.
	**Mountain pass symbol (side-by-side arcs)** This symbol is used on aviation charts to indicate mountain passes, the highest point along a route. Although not a weather phenomenon, many passes are shown as they are often prone to hazardous aviation weather.

Chapter 4

Seasonal Weather and Local Effects

Introduction



Map 4-1 - GFACN36 and GFACN37 domains

This chapter is devoted to local weather hazards and weather effects observed in the GFACN36 and GFACN37 domains. After discussions with weather forecasters, FSS personnel, pilots, dispatchers, scientists, wildlife rangers, park rangers and local residents, the most common and verifiable hazards are listed. Most weather hazards are described in symbols on the many maps along with a brief textual description located beneath it. In other cases, the weather phenomena are better described in words. Table 3 provides a legend for the various symbols used throughout the local weather sections.

The chapter first presents a general overview of the weather across the GFACN36 and 37 domains and then the weather section by section.

Weather of the GFACN36 and GFACN37 domains

Major controlling features - The major controlling features of the weather across the GFACN36 and 37 domains are the state of the ocean/sea and topography. The ocean/sea can be ice covered, in a stage of melt, or ice free. Topography ranges from rugged mountains covering, for example, Ellesmere and Axel Heiberg Islands southwards through eastern Baffin Island to the flat terrain west of Hudson Bay.

Mean pressure patterns and flow favour northwesterly flow - Mean pressure patterns year round generally feature low pressure from the Labrador Sea northward through Davis Strait into Baffin Bay. A ridge of high pressure routinely resides from the Arctic Basin southeastward to the Mackenzie/Great Bear Lake/Great Slave Lake areas. The prevailing flow between the trough and the ridge is north to northwest. There is however often a secondary weak low-pressure area present over Foxe Basin with a narrow surface ridge running along the mountain spine of Baffin Island from west of Pond Inlet to west of Cape Dyer.

This flow often produces very strong north to northwest winds around the eastern headlands of Baffin Island (e.g. Cape Dyer) with slightly weaker winds along the coast northwest of Cape Dyer and northward to the southeast coast of Ellesmere Island. Some locations favour light winds in the predominant northwest flow due mainly to sheltering from mountains. Grise Fiord, Pond Inlet, Pangnirtung are such locations. At places such as Iqaluit, terrain favors northwesterly flows.

Strong northwest winds are a matter of routine - winter particularly - for an area from the Arctic Basin southeast across the central arctic islands and the barrens west of Hudson Bay.

Storms - Throughout the GFACN36 and 37 domains, storms in fall, and to a lesser degree in spring, bring strong winds that favour east and southeast with the approach of the storm and northwest in the wake of the storm. These same storms can bring significant dumps of snow.

Seasonal Comments

Winter

Ice fog, ice crystals, bands of low cloud - The seas of the GFACN36 and 37 domains are generally frozen over and act largely as a relatively smooth land surface, although often slightly warmer than surrounding land as heat transfers through the ice from underlying liquid water. Open leads in the ice are still found, most commonly in the moving polar ice pack and in the shear zone between it and the fast ice amongst the islands of the archipelago. Polynyas are also found in preferred locations providing local moisture sources; more extensive moisture can often be seen downwind of the large polynya in northern Baffin Bay/Kane Basin (the North Water). Leads commonly develop in the pack ice during strong wind events, especially downwind of coastlines. These can create local ice fog and ice crystals or even bands of low cloud.

Ice fog - Cold temperatures (-40°C) can lead to ice fog around habitations/aircraft operations, but the ice fog is usually not persistent at most locations across the GFACN36 and 37 domains.

Snow - Visibility limiting - and at times sky obscuring - snowfall can occur 12 months of the year.

Strong winds and blowing snow - The main winter weather problem is strong winds and the associated low visibility in blowing snow. This happens most commonly when there is a strong high-pressure system extending from the Arctic Basin southeastward to the Mackenzie/Great Bear/Great Slave Lake areas concurrent with a deep low/trough from Baffin Bay to Davis Strait. The band of strong winds and blowing snow routinely occurs in a swath along an axis from Isachsen to Rea Point to Cambridge Bay to Baker Lake and southeastward. Blowing snow is less frequent through mountainous sections further east but becomes locally frequent on the east and south coasts of Baffin Island and along the northern Quebec Coast. Less common but not rare, storm tracks can produce strong winds and blizzards in normally protected locations such as Pangnirtung and Pond Inlet.

Calm winds - In winter, due to strong temperature inversions, some of the communities which experience increased frequency of strong winds, winter versus summer, also experience a significant increase in the percentage of calm winds. At Iqaluit, for example, calm winds go from almost 11 percent in summer to approximately 24 percent in winter while winds of 20 knots or greater increase from nearly 4 percent in summer to 10 percent in winter. At Resolute, the percentage of calm winds goes from 3 percent in summer to just under 10 percent in winter while the percentage of strong winds increases from just over 11 percent to just under 16 percent. At Baker Lake, the percent of calm winds summer and winter is close to 10 percent while the percent of strong winds increases sharply from near 5 percent in summer to 22 percent in winter.

Low level wind shear and turbulence - Moderate to severe mechanical turbulence is common over the rough terrain in strong wind situations. Significant low-level wind shear may be present particularly when surface winds are light. Strong winter inversions help to create local erratic strong winds in some locations, with little significant pressure gradient. These can produce strong low-level wind shear and severe turbulence.

In winter, low-level turbulence can also occur over polynyas and other open water areas.

Spring

Good flying weather but wind, blowing snow, and blizzards persist - In the high arctic especially, spring is often the season of the best flying weather as ice is still frozen and daylight hours increase rapidly. However, wind, blowing snow, and blizzard events persist in most areas.

Heavier snowfalls, icing, freezing precipitation - In southern locations and spreading north, during spring, air mass contrasts increase with warmer/moister air being involved in storms. This brings generally heavier snowfalls, more significant icing and the possibility of freezing precipitation.

Ice melts - Across the Hudson Bay and Hudson Strait sections of the GFACN36 domain, ice may begin to break up/melt in late spring. Across the GFACN37 domain, polynyas tend to expand and leads and puddling starts on the ice.

Stratus and fog - Stratus and fog may increase in frequency with warmer air over cold snow and ice covered surfaces.

Freezing drizzle - Freezing drizzle typically occurs in May in the GFACN36 domain and in June in the GFACN37 domain. Surface air temperatures are usually in the zero to -8°C range during the freezing drizzle events.

Summer

Snow - Over higher terrain, visibility limiting and at times sky obscuring, snowfall can be significant. For example, Cape Dyer located on the Cumberland Peninsula and at an elevation of 1289 feet ASL, shows mean snowfall of 37 centimetres in June, 42 centimetres in July and 48 in August.

Ice melts - During the summer, sea ice melts and breaks up producing cool moist air at low levels over nearby areas. Large areas of low cloud and fog/mist trapped under inversions are widespread over sea and along coasts, and sometimes spreads well inland in persistent onshore flows. Interiors of larger islands and inland sections of fiords/ inlets usually have much better conditions than exposed coasts. Cumulus and some towering cumulus can develop over inland sections of larger islands.

Some thundershowers - Good flying weather dominates the mainland "interior" section of the GFACN36 domain during the summer. Convective cloud becomes more common, with some thundershower activity, southern sections particularly. With sufficient upper level support, thundershowers can persist over, and across, the cold surface of Hudson Bay to reach northern Quebec. Albeit rare, isolated thundershowers have been noted on the islands of the GFACN37 domain, Banks and Victoria Islands in particular.

Weak pressure systems and light winds - Generally, pressure systems through summer are weaker than their winter counterparts. Thus, winds in summer tend to be lighter than those of other seasons.

Fall

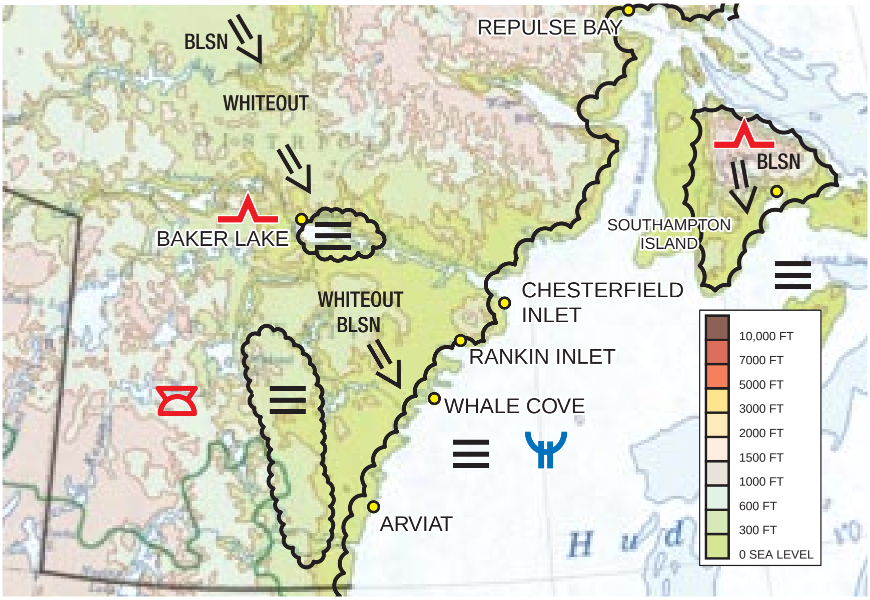
Stormy, heavy snowfalls, low level mixed icing - Stormy, heavy snowfalls, low-level mixed icing - Fall is the stormiest season in general. Air mass contrasts strengthen and open water extent is at its maximum facilitating strong development. Heavy snowfalls can occur with instability and ample moisture supply as cold air moves over open water. Low cloud over the seas is replaced by stratocumulus, cumulus, and towering cumulus with local freezing drizzle. The prime month for freezing drizzle is September across the GFACN37 domain and October across the GFACN36 domain. Surface air temperatures are typically in the zero to -10°C range during the freezing drizzle events. Low-level mixed icing becomes more common.

Strong winds then strong winds with blizzards - Stronger storms produce strong winds, but full blizzards do not usually occur until late fall when the ground becomes fully snow covered and temperatures colder. Low visibilities (blizzards) generally happen only when there is snow falling.

Weather area by area

Southwestern GFACN36

Arviat, Whale Cove, Rankin Inlet, Chesterfield Inlet, Baker Lake and Coral Harbour



Map 4 -2 - Southwestern section of GFACN 36 domain

The majority of the communities of this area lie on the Hudson Bay coast. Baker Lake lies on the shores of a large lake. Coral Harbour lies on Southampton Island. All of the communities are well beyond the tree line which barely extends into the GFACN36 domain from northern Manitoba. The land is relatively flat. The local weather is influenced by the moisture from Hudson Bay and a myriad of inland lakes during the open water period and from the predominant northwest flow over the area in the winter.

Weather by Season

Winter: blizzards - In the winter, strong northwest winds are common across the entire area bringing blowing snow and blizzard conditions. These conditions can last days. After such a strong wind event, an area of open water - albeit new ice is quick to form - develops between the departing mobile ice of Hudson Bay and the ice which is fast along the shore. Onshore flow from the open water brings 'sea smoke' or freezing fog onshore. Additionally, even after the winds have decreased following a blizzard event, visibility may take a few hours to improve as ice crystals suspended in the air take their time to fall out. The average number of blizzard events through the frozen season (fall and winter into spring) ranges from 20.8 at Baker Lake to 16.9 at Rankin Inlet to 14.7 at Coral Harbour.

Spring: low cloud and fog - In the spring, with the breakup of the ice starting in May through July, the addition of moisture to the lowest levels of the atmosphere is substantial creating large areas of low cloud and fog. Easterly flows readily move this low cloud and fog inland. The "flavour" of the easterly winds is critical. For instance, Chesterfield Inlet is more exposed than Rankin Inlet and tends to have poor flying conditions more often than Rankin Inlet. Indeed, Rankin Inlet is situated far enough into the inlet that a northeast flow may help disperse the low cloud as it moves over the land for some distance before reaching Rankin Inlet. Patchy freezing drizzle may be encountered in a low cloud deck. At times in the early spring, low cloud can redevelop inland when the flow is upslope. The aviation community cites such cloud developing inland from Arviat through Whale Cove.

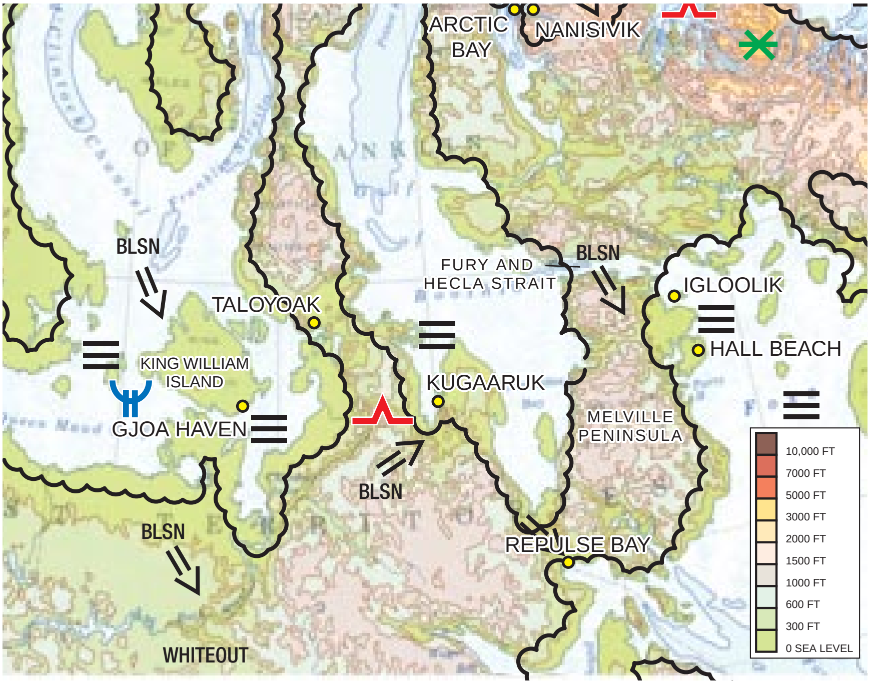
Summer: thundershowers - Conditions slowly improve into the summer months as the ice melts and low cloud disperses more quickly in the morning. Over the mainland, convective cloud becomes more common and the chance of a thunderstorm increases, especially during July. Summer afternoons are the best time to fly along the coast. However, low-pressure systems are often deflected into the area from the south giving rain and fog events along the coast. The summer low-pressure systems tend to be weak in comparison with fall and spring lows.

Photo 4-1 - Rankin Inlet airstrip looking west on a sunny July day credit: Tim Gaines

Fall: storms - In the fall, low-pressure systems become more energetic as the air mass contrasts strengthen and open water is at its maximum. Well defined synoptic storms can inflict the region with rain and snow as well as freezing precipitation. Freezing drizzle is common with the cloud that flows off Hudson Bay. Mixed icing in the cloud can be significant. Winds strengthen and can be very gusty from the southeast ahead of the low and from the northwest behind it. In the late fall, blizzards return.

Northwestern GFACN36

Repulse Bay, Gjoa Haven, Taloyoak, Kugaaruk, Hall Beach, Igloolik



Map 4-3 - Northwestern section GFACN36 domain

Weather by Season

Winter: winds, blowing snow and blizzards - During the winter, local weather is often at the mercy of the strength of the northwest winds with respect to blowing snow. Even after winds have decreased after a blizzard event, visibility may take a few hours to improve as ice crystals suspended in the air take their time to fall out.

Spring: wet snow, freezing rain, freezing drizzle - During the spring, prior to break-up, flying weather tends to be good. Spring low-pressure systems can however be intense and can dump considerable wet snow. On occasion, these spring lows can bring a bout of freezing rain. May into early June is the period for freezing drizzle.

Late spring/summer: low cloud and fog - Very late spring and summer brings ice melt and breakup with open water areas developing. The addition of moisture to the lowest levels of the atmosphere over the open water can be substantial creating areas of low cloud and fog. Onshore flows readily move this low cloud and fog inland. Of the airport sites in this area, Gjoa Haven is the site most vulnerable to poor flying weather while Taloyoak tends to have more favourable flying weather.

Summer: good inland, cloud and fog over water - During the summer, inland areas of the mainland and the interior of islands tend to have good flying conditions. Convective cloud becomes more common. Thundershowers are rare. Over the sea, low cloud is common.

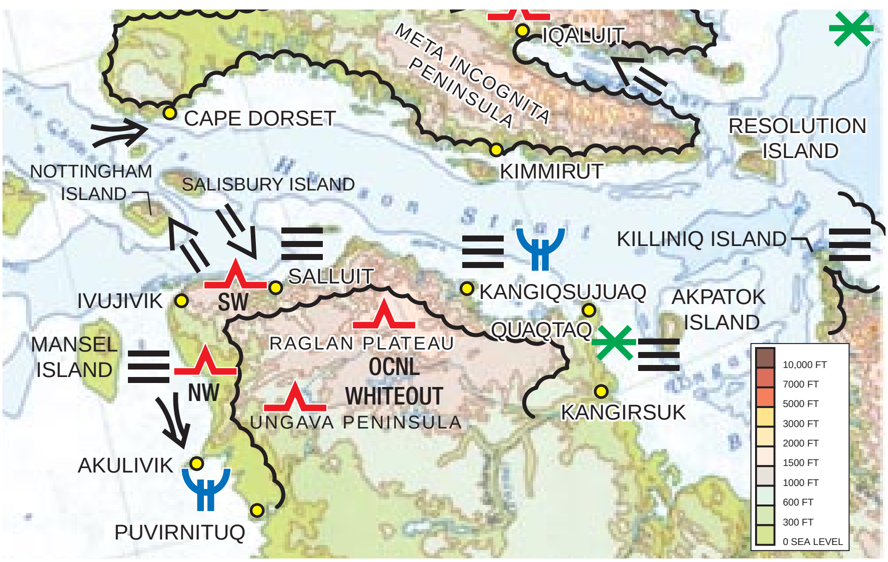
Fall: storms, freezing precipitation - In the fall, onshore flow from open water areas brings 'sea smoke' or freezing fog. Also, in the fall, low-pressure systems become more energetic as the air mass contrasts strengthen and open water is at its maximum. Well defined synoptic storms can inflict the region with rain and snow as well as freezing precipitation. Freezing drizzle is common with the cloud that flows off open water. October is typically the month when most freezing drizzle events occur. Mixed icing in the cloud can be significant. Winds strengthen and can be very gusty from the southeast ahead of the low and from the northwest behind it. In the late fall, blizzards make their return.

Local effects

Kugaaruk - The hills in the vicinity of Kugaaruk are capable of giving low-level mechanical turbulence in strong northwest wind regimes.

Northern Quebec (Nunavik) and extreme northern Labrador section of GFACN36

Puvirnituq, Akulkivik, Ivujivik, Salluit, Kangiqsujuaq, Quaqtaq and Kangirsuk



Map 4-4 - Northern Quebec (Nunavik) and extreme northern Labrador section of GFACN36 Domain

Weather conditions across northern Quebec and extreme northern Labrador section of GFACN36 are strongly influenced by the large saltwater bodies of Ungava Bay, Hudson Bay, Hudson Strait, and the Labrador Sea as well as mountains. Ungava Bay usually freezes over in late October or early November and remains covered until the pack ice goes in late July. Some years, Ungava Bay never freezes over completely and the ice can be all gone early July. Hudson Bay usually freezes much later, usually by the end of December, but never does so completely as the ice shifts continuously under the influence of the wind. Near the coastline, the ice usually melts in late June or early July with the rest of the ice not breaking up until later in the summer. In Hudson Strait, the water usually freezes by the end of November. The main ice pack usually goes away by mid-July leaving floes and small bergs that finally clear out of the strait by the end of July.

Weather by Season

Late winter/early spring: ice covered season

Once the ice pack is well established, flying conditions tend to become more favourable than at other times of the year in terms of ceiling and visibility. This is especially true for the months of February, March and April. Typically, during this time of year, a localized high-pressure system establishes itself over Ungava Bay giving clear skies and good visibility. The area is still exposed to synoptic-scale weather systems that move generally from west to east or from southwest to northeast. In such cases, weather conditions that hit the eastern shore of Hudson Bay usually reach Ungava Bay 24 hours later.

Whiteouts - Weather can rapidly change to whiteout conditions when visibilities fall drastically in ice crystals in the lowest levels of the atmosphere. Whiteouts are frequent north of the tree line, since there are few visual markers and the horizon is easily lost. Whiteout conditions are frequent across the Raglan Plateau, which is at 1,900 feet ASL. Whiteout conditions become generalized as soon as the land is covered by low cloud.

Turbulence - Due to usually stronger winds at this time of the year, and “winter” inversions, turbulence becomes more frequent over - and in the lee of - mountainous terrain. The Raglan Plateau, wave clouds are frequently observed at altitudes of 6,000 to 7,000 feet ASL, indicating the presence of severe lee wave turbulence. Pilots cite that lee wave cloud and turbulence can be found on the northeast side of the Raglan Plateau when the flow aloft is from the southwest and on the southeast side of the Raglan Plateau when the flow aloft is from the northwest. Moderate to severe mechanical turbulence is common with northwesterly winds of 30 knots or more developing after the passage of a cold front. It is also frequent throughout the Ungava Peninsula when the upper winds at 3,000 feet are 30 knots or more. The strong winds also routinely give reduced visibility and at times blizzard conditions in blowing snow.

Icing - Icing can be an issue as most flights are short "hops" between neighbouring communities and tend to be conducted at altitudes of less than 3,000 feet AGL. Significant amounts of ice can then accumulate over aircraft surfaces during such hops. Fog, producing significant icing and very low ceilings and visibilities, forms over any open water and drifts inland, pushed by the wind during colder months. Ice fog also tends to form over villages, when winds are light, due to the moisture contained in the exhaust of building heating systems.

Late spring and early summer: warm air arrives, ice melts

Low cloud and fog - The arrival of warmer air over ice-covered or snow-covered surfaces generally results in the formation of thick fog or low cloud. As a result, low ceilings, poor visibility, and light to moderate rime or mixed icing are common. Conditions improve once the snow melts and the pack ice moves away. The top of the fog layer may reach 500 feet AGL. The fog generally stays over water during the day but the fog can move inland as the ground and air temperatures warm up generating a sea breeze.

Mid to late summer: ice-free season

Fog - Fog is the dominant poor weather giver once the ice is completely gone. The water, although warming, remains much cooler than the air over it. The resultant advection fog routinely gives zero to near zero ceilings and visibilities to areas along the coast. Trapped under an inversion, this fog is reluctant to lift, regardless of how strong the sun. The months of July and August are generally the worst "fog" months.

Rain and thunderstorms - Rain is generally observed with the passage of a weather system. Thunderstorms are rarely observed over northern Quebec. When observed, they are usually associated with an upper trough crossing Hudson Bay from the west. The thundershowers are usually embedded in the general cloud mass associated with the upper trough.

Lee wave turbulence - Strong southerly winds (20-30 knots) are often observed during the summer months as weather systems approach from the west. Lee wave turbulence and lenticular clouds are frequently observed over the Ungava Peninsula, especially over the Raglan Plateau.

Fall transition from mid-September to mid-November

Freezing drizzle and icing - Fog becomes less dominant as the land cools down. However, status ceilings persist and freezing drizzle can result. Freezing drizzle tends to form in onshore/upslope flow off the sea. Icing is common over water and along the coast line. Conditions improve inland.

November to mid winter

Snow squalls, turbulence, icing, and katabatic winds - During the coldest months, prior to freeze-up, snow squalls can develop over Hudson Bay, Hudson Strait, and Ungava Bay and push inland. Severe turbulence and icing, along with whiteout conditions, are usually encountered in these squalls. Strong turbulence can be expected when the wind runs crosswise to the fiord. It will be smoother when a strong, but steady and stable, wind is coming down the fiord. Additionally, strong katabatic winds, which have reached 80 knots on occasions, sometimes develop in various fiords at night.

Depth of winter

Violent winds, turbulence, blizzards - In the depth of winter, violent winds from the southeast, in excess of 50 knots, are observed when an intense low-pressure system moves from Hudson Bay to northern Baffin Island. After the passage of a cold front, northwesterly winds of 50 to 60 knots are often observed, mostly at night. Such winds usually generate significant mechanical turbulence along the coast, especially in Kangiqsujuaq and Salluit, due to the high elevation of their respective runways. These strong winds also give blizzard conditions.

Extreme northern Labrador/extreme northeastern Quebec

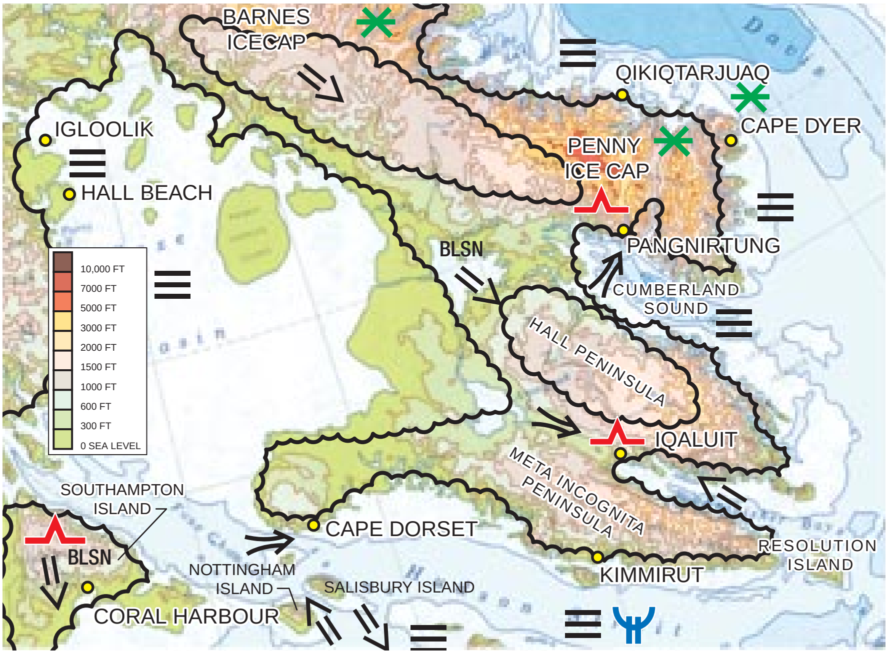
Turbulence, updrafts, and downdrafts - The area commonly experiences very strong wind regimes and resultant turbulence over rugged terrain. Numerous mountains and fiord-like valleys cause an array of local effects such as funneling, channeling and cornering. Severe updrafts and downdrafts are also encountered in the deep valleys and fiords.

Low cloud, poor visibilities, and freezing fog - Across the area, including Killiniq Island, southeast to northeast winds will generally give low ceilings and poor visibility conditions. These conditions will often penetrate deep into the valleys and fiords, depending on the wind. The lowest conditions generally occur in the spring and summer. Freezing drizzle in onshore flow can be a problem particularly in the spring and fall.

Icebergs - Numerous icebergs protrude out of the water creating a “terrain” hazard. The more icebergs and the more ice cover across an area, the greater the occurrence of fog and low cloud.

Southern and southeastern Baffin Island section of GFACN36

Cape Dorset, Kimmirut, Iqaluit, Pangnirtung, and Qikiqtarjuaq



Map 4-5 - Southern and southeastern Baffin Island section of GFACN36 domain

The terrain of the area goes from mountainous with glaciers and ice caps on the Cumberland Peninsula to the seasonally ice covered waters of Foxe Basin, Hudson Strait and Davis Strait. Terrain and its orientation can for example direct the winds or shield a site from onshore flow. Iqaluit lies in a bay/valley combination that runs northwest to southeast with the higher terrain of the Hall Peninsula to the northeast and the Meta Incognita Peninsula to the southwest. One would expect northwest and southeast winds to prevail at Iqaluit and they do. Kimmirut has lots of terrain in the immediate area as well as terrain upstream in all directions except for the southeast quadrant. The terrain shelters the Kimmirut runway from much of the low cloud and fog that exists over Hudson Strait. That same terrain also produces low level mechanical turbulence when it is windy. Similarly, there is considerable terrain in the immediate area of Qikiqtarjuaq that can shelter the community from intrusions of low cloud and fog off the water. Pangnirtung resides in Pangnirtung Fiord which is oriented northeast to southwest off Cumberland Sound and is surrounded by mountains. Cumberland Sound runs northwest to southeast. This combination makes for a complex wind regime at Pangnirtung which at ground level favours light winds but can blow strong from the west-southwest or east-northeast.

Weather by Season

Winter - Winter is the season for snow and blowing snow albeit the heaviest snowfalls occur spring and fall along with blowing snow events. Snow is also a feature of summer weather over the higher terrain of the Cumberland Peninsula. Blowing snow, snow, and fog make the winter period the poorest season with respect to flying weather at Iqaluit. On average, through the frozen period that starts in the fall and extends through the winter into the spring, Iqaluit will experience 5.9 blizzard events while Cape Dorset will experience 3.5 such events. Often the blowing snow events occur when there are clear skies above the surface-based layer of blowing snow. Although the surrounding water is frozen, occasionally open leads will develop courtesy of winds and tides. Patchy fog and stratus from the open water areas can advect over the terminals depending on flow.

Spring - Spring is the start of the melting season and with more moisture available fog and stratus can develop. Freezing drizzle occurs on occasion particularly with cloud that originated over open water. With the longer days and rising temperatures, diurnal effects become more apparent, giving poor flying conditions during the overnight and morning hours. Snow and blowing snow linger.

Summer - Summer brings favourable flying conditions on land while over the open water of Foxe Basin, Hudson Strait and Davis Strait, there is routinely low cloud and patchy fog. Summer shows as having the most favourable flying weather of the seasons for Cape Dorset, Iqaluit and Pangnirtung. At higher elevations, summer can still be winter with snow and even blowing snow. Indeed, at the old Cape Dyer site, (about 1,300 feet ASL) average monthly summer snowfall ranges from 37 centimetres in June to close to 48 centimetres in August.

Average snowfall in centimetres by month (Montreal included for comparison)

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Cape Dorset	24.6	21.0	23.2	33.3	30.3	8.1	0.3	1.1	13.5	41.6	51.6	39.7
Iqaluit	24.0	22.7	23.6	28.5	23.2	8.8	0.2	0.5	13.9	34.8	34.5	24.5
Cape Dyer	66.1	53.0	34.8	41.1	51.4	37.0	41.7	47.9	68.2	92.2	68.8	55.5
Montreal	49.6	43.8	35.0	12.4	0.3	0	0	0	0	2.0	22.6	48.5

Table 4-1 - Average snowfall in centimetres by month (Montreal included for comparison)

Fall - Fall brings a return to more frequent low cloud as available moisture clashes with colder air. Fall snowfalls are routinely the heaviest snowfalls of the year along with periods of freezing drizzle. For the Baffin Coast bordering Davis Strait, a combination of weather systems and upslope flow make for significant snowfalls. Snow streamers off open water can give heavier squalls with visibility approaching zero.

Local Effects

Cape Dorset - The location of Cape Dorset on Cape Dorset Island and the surrounding terrain causes a funnelling effect, giving strong and gusty winds from the west. Being close to Hudson Strait, fog and stratus will readily move over the terminal.

Kimmirut - Winds from the southeast can funnel up through Glasgow Bay into the town and terminal giving gusty winds from that direction. Severe turbulence is common with winds from any direction due to the surrounding terrain, but especially with an easterly flow over the higher terrain of the Meta Incognita Penisula. Being so close to Glasgow Bay and Hudson Strait, fog and stratus can advect into Kimmirut.

Iqaluit - Moderate to severe turbulence and low-level wind shear can occur with an easterly flow. During the ice-free season, low tide at Iqaluit can expose about 1/4 mile of sea floor. When the low tide occurs during the day, heating over the exposed dark sea floor of Frobisher Bay can produce updrafts. These updrafts can give turbulence with a southeast approach to the runway.

Pangnirtung

The runway at Pangnirtung is located in Pangnirtung Fiord, which is narrow and has mountains on either side. Despite what seems to be a sheltered location, flight operations into this airport are affected by the direction and strength of the wind. Wind funnelling from the southwest into the fiord can be hazardous as pilots have to fly into the fiord with the wind and then make a 180-degree turn to turn into the wind to land at the terminal. Long approaches from the east are not recommended due to the terrain. Winds of greater than 12 knots can prevent an airplane from landing at Pangnirtung. Occasionally a storm will track from northern Labrador to southwestern Baffin Island, as far north as Cumberland Sound. These storms can produce very gusty east to east-northeasterly winds that can reach damaging strengths. Indeed a resident of Pangirtung cites that a house was blown off its blocks, even though it was tied down during a storm of this type. A southeasterly flow over the peninsula can give severe turbulence and/or low-level wind shear. In summer, during the open water season and when it's sunny, afternoon sea breezes blowing along Pangnirtung Fiord (westerly winds at about 15 knots) are common.

Higher terrain including Cape Dyer

The higher terrain of the Cumberland Peninsula makes the peninsula vulnerable to snow 12 months of the year and the snow can be heavy reducing visibility to 1/2 mile or less and giving ceilings which are 500 feet or less. The combination of cloud and precipitation readily obscures higher terrain.

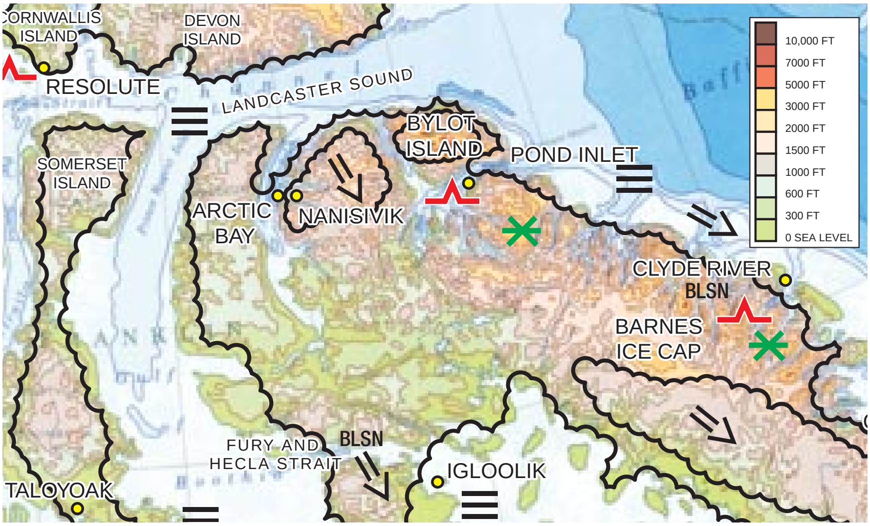
Seasonal charts of ceiling below 1000 feet and/or visibility less than 3 miles for the old Cape Dyer site suggest that spring has the poorest flying weather. Indeed, the charts show the weather meeting these poor conditions about 40 percent of the time by night lowering to 30 percent of the time by day. Values for the other seasons range from 25 to 30 percent by night to 20 percent by day.

Qikiqtarjuaq

Qikiqtarjuaq, located on Broughton Island, is somewhat protected by higher terrain of the island and the presence of Baffin Island to the west. That being said, fog and low cloud do, on occasion, find their way onto the airport. Surrounding hills impact on the winds. Surface winds are rarely strong. However, at times, moderate to severe turbulence and/or low-level wind shear can occur.

Northern Baffin Island section of GFACN36 and GFACN37

Clyde River, Pond Inlet, Nanisivik and Arctic Bay



Map 4-6 - Northern Baffin Island section of GFACN36 and 37 domains

The terrain of the area goes from mountainous with glaciers and ice caps to seasonally ice covered waters. With the exception of Nanisivik, the airports in the area are along the coasts of a bay, fiord or inlet and have other large bodies of water nearby. Nanisivik lies on an exposed plateau of about 2,000 feet ASL.

Weather by Season

Winter - Winter season for this area is the most stable and brings relatively good weather. Although the surrounding water is frozen, occasionally patchy fog and low cloud can move from open leads of eastern Lancaster Sound or Baffin Bay to the communities. Strong winds can give blowing snow/blizzards to exposed terrain.

Spring - Spring is the start of the melting season, and with more moisture available fog and low cloud develop. With the longer days, and rising temperatures diurnal effects become more apparent, with the poorest flying conditions developing overnight and lingering into morning.

Summer - Inland, summer is a time of favourable flying weather. However, over the waterways it is a time of warm air over cold water surfaces, a recipe for low cloud and areas of fog. Coastal communities such as Clyde River are vulnerable to intrusions of low cloud and/or fog. Summer has the poorest flying weather at Clyde River, especially during the overnight period. At Nanisivik, fall and summer are a toss up with respect to having the poorest flying weather.

Fall - Fall brings a return to more frequent fog and low cloud conditions as available moisture clashes with colder air. Before freeze-up, snow streamers develop over Davis Strait with heavier squalls giving at times near zero visibility. Storms consistently track from south to north across Davis Strait to Baffin Bay. These storms routinely cause strong northwesterly winds along the east coast of Baffin Island including at Clyde River.

Local effects

Clyde River - The terrain to the north through northeast and east of Clyde River is flat giving a ready path for fog and low cloud to get to the community. Strong northwesterly winds develop as a low pressure system moves northward through Davis Strait and a ridge of high pressure develops west of Clyde along eastern Baffin Island. Higher terrain to the northwest channels the wind along the coast into Clyde River. The winds usually ease once the low-pressure system has moved to the northeast quadrant from Clyde River. During the "frozen season", the strong gusty northwest winds give blowing snow and at times blizzards. On average Clyde gets 10.7 blizzard events a year. This type of wind can also occur with a trough of low pressure oriented northwest to southeast across Baffin Bay and Davis Strait. Severe low-level turbulence and wind shear especially around Black Bluff, about 3 miles south of the terminal, accompany the strong, gusty northwest surface winds.

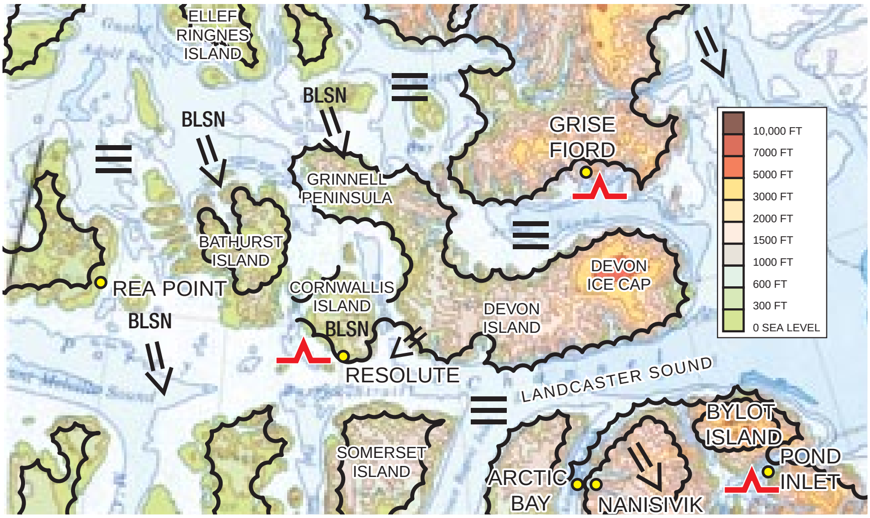
Pond Inlet - Pond Inlet has much better flying weather and a lighter wind regime than Clyde River and Nanisivik. Strong westerly winds can, on rare occasions, be expected. Stratus from Baffin Bay can advect into Pond Inlet with an easterly flow. Moderate turbulence can occur with a northerly flow over Bylot Island.

Nanisivik - Because of its elevation (about 2,000 feet ASL), and the flatness /openness of the plateau on which it resides, Nanisivik airport is exposed to the weather and has a lot of poor flying weather throughout the year. Storms that track from the south-southwest give Nanisivik strong southeasterly winds and low ceilings along with poor visibility. Blizzards are common during the fall and early winter. What is low cloud to the community of Arctic Bay (located at sea level) becomes fog for the Nanisivik airport. With its higher elevation, the weather at Nanisivik shows a diurnal trend with fog being common during the morning hours.

Arctic Bay - The community of Arctic Bay and to a lesser degree, the Arctic Bay airstrip are sheltered from much of the wind and weather that Nanisivik experiences.

Southeastern section of GFACN37

Resolute, Rea Point, and Grise Fiord



Map 4-7 - Southeastern section of GFACN37 domain

The terrain of the area varies from mountainous with glaciers over southern Ellesmere Island to an ice cap eastern Devon Island to seasonally ice covered waters, to the open waters of the North Water and other polynyas.

Weather by Season

Persistent snow cover in excess of 2 centimetres across this section ranges from about 260 to 280 days per year bridging fall, winter, and spring. At Resolute, only the months of June, July and August have mean daily maximum temperatures above zero and of these months, only July also has an above zero mean daily minimum. Ice melt begins in June with the maximum amount of open water occurring in mid September. Summer is the time of 24 hours of daylight (Resolute is at 74°43'N and Grise Fiord is at 76°25'N) while winter is the time of 24-hour darkness.

Frozen season

The frozen season begins in September as new ice forms in coastal areas and skims over the surface of open water areas. The frozen season ends in June. Once the open water areas are ice covered, the abundant source of moisture for low cloud and fog is cut off. Before this happens, a combination of weather systems and open water contribute to make September followed by October the snowiest months. The snow routinely gives obscured ceilings by snow and restricted visibility.

The frozen season is also the blowing snow and blizzard season. The entire western portion of this section is vulnerable to strong northwest winds and blowing snow and is part of the blizzard alley that extends southeast from the Arctic Basin across the central Canadian arctic islands and into the GFACN36 domain (barrens west of Hudson Bay). Resolute Bay experiences on average 12.6 blizzard events during the frozen season. Just as September is the month showing the most snow, September is also the most likely month for freezing drizzle or freezing rain.

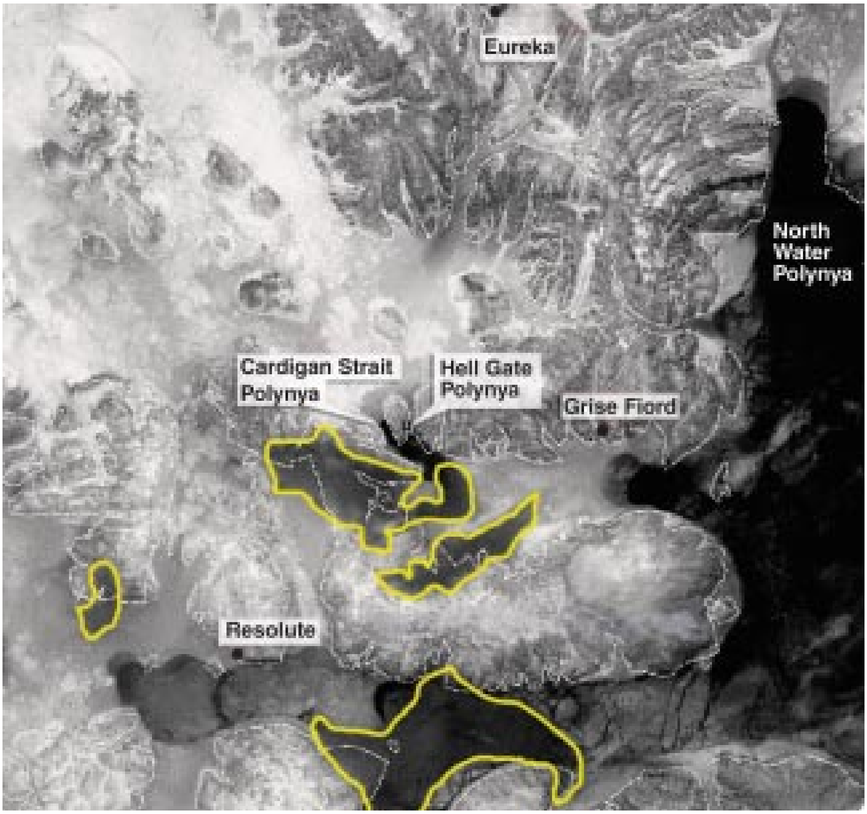


Photo 4-2 - Infrared Satellite photo 26 February 2001 showing low cloud (areas circled with yellow line) that originated over, or still resides over, open water (darkest areas are areas of open water, thin ice, or low cloud)

The winter months December, January and February are a time of strong inversions with the visibility often restricted in ice crystals below that layer. Open water leads, polynyas, moisture associated with heating systems and aircraft exhaust can at times trigger ice fog below the inversion. An approaching upper trough can trigger a layer of ice crystals that extends up to 18,000 feet or more. Under such conditions light snow can fall from skies that have no discernible cloud. This "fluffy" snow readily becomes blowing snow. This ice crystal haze clears with the passage of the upper trough.

The spring months of March, April and May reside in the frozen season. Statistically, they are the months of most favourable flying weather. These months are also the months that the area of 24-hour daylight pushes south and bring about a thinning snow cover. Warmer and moister air masses that have, except for rare occasions, lingered well south, now move into the area. At Resolute for example, average snowfall values go from about 4 centimetres in January and February to values near 6 centimetres in March to near 10 centimetres in May.

Unfrozen season

At Resolute, the months of June, July and August have mean daily maximum temperatures above zero degrees Celsius of these months only July has an above zero mean daily minimum. During the unfrozen season, low cloud and fog are the routine across ice-covered waterways and open water areas. Onshore flows readily bring these conditions inland. During summer, Resolute and Rea Point are vulnerable to onshore flow that moves the cloud easily across low terrain. Summer frequency of ceilings below 1000 feet and/or visibility below 3 miles at both Resolute and Rea Point show values close to 40 percent for the overnight and morning periods. These values drop to near 30 percent during the afternoon and evening. Grise Fiord, with high terrain across the entire north quadrant which blocks intrusions of cloud and fog from those directions, has better unfrozen season/summer flying weather than either Rea Point or Resolute. Summer frequencies of ceilings below 1000 feet and/or visibilities below 3 miles at Grise Fiord peak at about 25 percent which is 15 percent lower than at Resolute or Rea Point.

Local Effects

Resolute and Vicinity - Winter has more stable weather than any other season as cold arctic air pervades over the area. There are small polynyas to the north of Cornwallis Island and with a northerly flow fog and low cloud can make it across the island to Resolute. With a strong northwesterly flow, there can be blowing snow and depending on the amount of snow upstream and the strength of the winds, the blowing snow can constitute a blizzard. Spring brings warmer temperatures and the start of the melting season. As open water develops, fog and stratus can be a problem as it moves into Resolute from the west and southeast particularly. Northwest winds transport low cloud into Resolute, as do the winds from the west and southwest. When the fog and stratus starts to roll in during the late spring, the locals remark that "summer is here." With stagnant weather patterns, the low cloud and fog can persist for days. On occasion, strengthening winds can disperse the fog, but when winds subside, the fog returns. Thunderstorms do occur in Resolute and over the islands such as Prince of Wales Island but this is rare. Local residents have commented that they have heard thunder more frequently over the last few years. Fall brings the return of darkness, colder temperature and more stable weather. As the waterways begins to freeze the chance of fog and stratus developing becomes less.

When air temperatures are below freezing and water upwind is open, freezing drizzle or freezing fog can occur at Resolute. With freezing fog, rime or glaze forms on cold surfaces. Depending on the moisture content of the air, hoarfrost can also develop on cold surfaces with freezing fog. Winds at Resolute can be strong from most directions even when weather charts depict a weak flow. Occasionally observed winds of 15 to 20 knots can abruptly find a few more knots of speed resulting in blizzard conditions. There is often little change in the pressure pattern to tip one off that this is about to happen. In winter, with a pressure pattern that favours north through northeast winds, pumping winds do occur at Resolute. Thus long periods of strong northeasterly winds can, at times, become light and back to the west or northwest, then return to northeasterly. At Resolute, winds from the northeast flowing over the ridge can give severe turbulence and/or low-level wind shear.

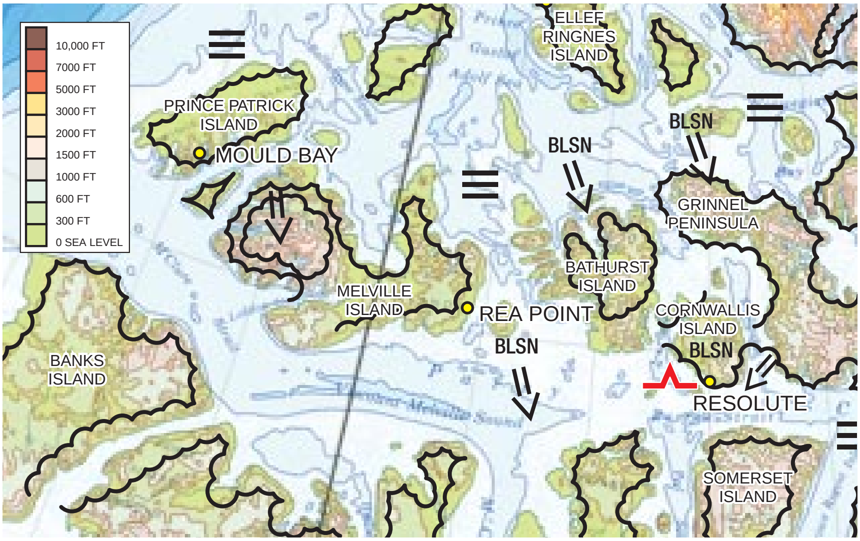
Southern Ellesmere Island - Cold dry arctic air dominates during the winter. However, through the winter the North Water Polynya is a source of moisture for low cloud and fog that can invade the many fiords bordering the open water. Downstream of the North Water Polynya, one can also expect to encounter snowflurries. During the spring with melting occurring and warmer temperatures, fog and stratus will develop over the water and move inland depending on the flow. Upslope flow can produce shelf clouds over higher terrain and also moderate turbulence. In the summer, the weather on land favours scattered cloud. Disturbances however, bring cloud and precipitation on occasion. At higher elevations, the precipitation will be snow. The fall brings a return to colder temperatures and until the water freezes completely, fog and stratus are a problem.

Grise Fiord - The airport is located at the bottom of a valley between two plateaus that rise over 2,000 feet ASL. Pilots cite that with surface winds of only 10 knots, moderate to severe turbulence and low-level wind shear can be expected making landing very difficult. Pilots also noted that they look to see if the local winds are increasing or decreasing. If winds are increasing they do not fly into Grise Fiord. If the winds are decreasing, they will. That said, the wind regime at Grise Fiord is a challenge. Onsite weather observers have cited that they have observed winds over the nearby water of Jones Sound being different from those at the airport which in turn were different from those at the other end of runway. Wind speed and wind direction measurements can fluctuate wildly.

Being adjacent to Jones Sound, the airport is vulnerable to low cloud and fog moving in with a southeasterly wind.

Southwestern section of GFACN37

Mould Bay, Rea Point



Map 4-8 - Southwestern section of GFACN37 domain

The terrain of the area varies from the high terrain of western Melville Island, northern Banks Island, and northern Victoria Island to the generally ice covered waters between islands and the Arctic Basin.

Persistent snow cover in excess of 2 centimetres across this section ranges from about 260 to 280 days per year bridging fall, winter, and spring. At Mould Bay, only the months of June, July and August have mean daily maximum temperatures above zero and of these months, only July also has an above zero mean daily minimum. Ice melt begins in May with puddling on the ice making landing on ice treacherous June through July and August.

Photo 4-3 - Puddled ice, 10 June 1976, at 73°N 130°W during the installation of an automatic weather station about 80 n. miles west of Banks Island. Per the pilots, June is not a good time to land fixed wing aircraft on the ice of the Arctic Basin! credit: Robert Grauman

Climatologically, the amount of open water that develops across this area is limited. There are, however, years such as 1998 when the area of open water is considerable. Summer is the time of 24 hours of daylight while winter is the time of 24-hour darkness.

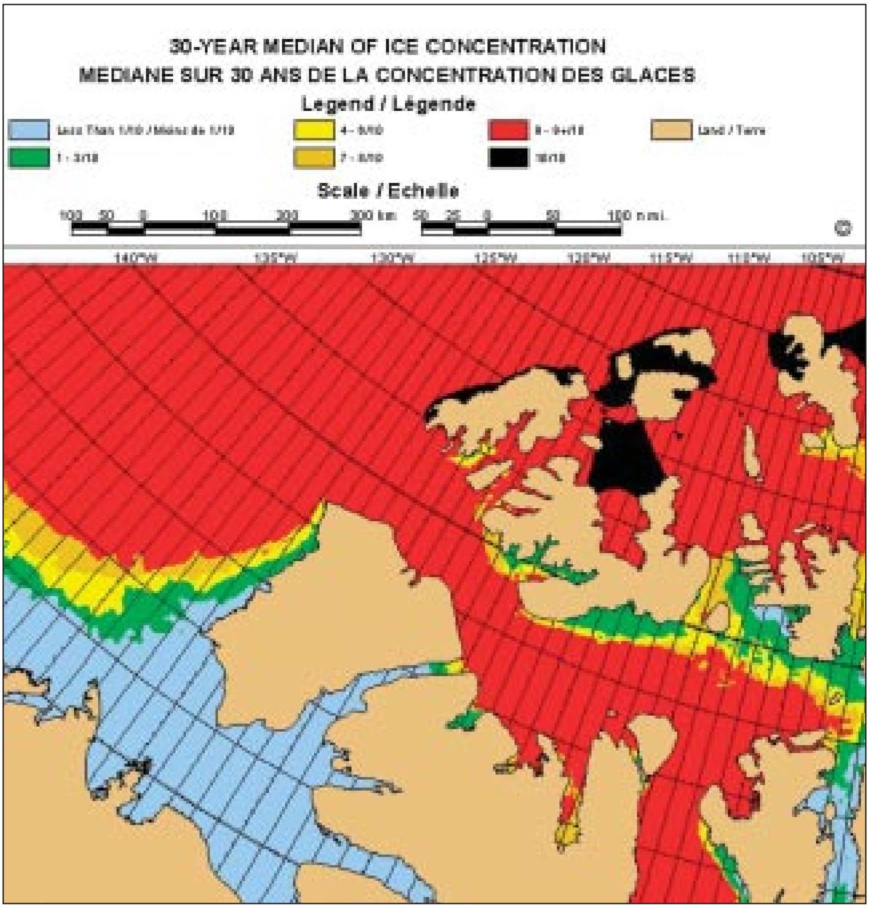


Fig. 4-1 - Median ice conditions for 3 September, 1971 to 2000 data

credit: Canadian Ice Service

Weather by Season

Frozen season

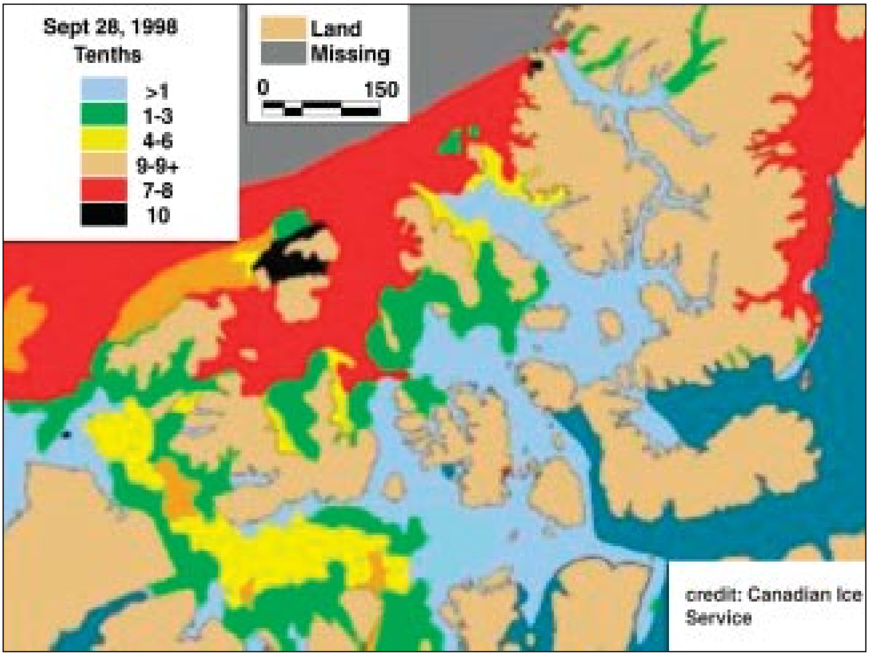


Fig. 4-2 - Ice conditions 28 September 1998

The frozen season begins in September as new ice forms in coastal areas and skims over the surface of open water areas. Before this happens, a combination of weather systems and open water contribute to make September followed by October the snowiest months. The snow routinely gives obscured ceilings and restricted visibilities. The frozen season ends in June. Once the open water areas are ice covered, the abundant source of moisture for low cloud and fog is cut off. That said, low cloud can, on occasion, track hundreds of miles and find its way from, for example, the open waters of the North Atlantic, across the ice north of Greenland and wrap back to the south and east to make its way into the Canadian arctic islands.

The frozen season is also the blowing snow and blizzard season. The entire eastern portion of this section is vulnerable to strong northwest winds and blowing snow and is part of the blizzard alley that extends southeast from the Arctic Basin across the central Canadian arctic islands and into the GFACN36 domain (barrens west of Hudson Bay). Rea Point resides in the blizzard alley while Mould Bay is routinely just west of the alley. The southern Banks Island section of GFACN37 is vulnerable to blizzards with southeast winds as well as with northwest winds. Late August and September are the most likely months for freezing drizzle or freezing rain.

The winter months December, January and February are a time of strong inversions with visibility restricting ice crystals occurring below that layer. Moisture from open water leads, polynyas, heating systems and aircraft exhaust can at times trigger ice fog below the inversion. An approaching upper trough can trigger a layer of ice crystals that extends to 18,000 feet or more while the upper troughs passage will do away with the ice crystal haze. Light snow can fall from skies that have no discernible cloud. This "fluffy" snow readily becomes blowing snow.

The spring months of March, April and May reside in the frozen season. Statistically, these months have the most favorable flying weather. For the area west of blizzard alley including Banks Island, western Victoria Island and Prince Patrick Island, winter flying weather is equally favorable but it is dark! March, April and May are the months that the area of 24-hour daylight pushes south. Warmer and moister air masses that have, except for rare occasions, lingered well south now get to the area. At Mould Bay for example, average snow fall values go from about 4 centimetres in January to values near 7 centimetres in April to near 9 centimetres in May.

Unfrozen season

At Mould Bay, the months of June, July and August have mean daily maximum temperatures above 0° C. July and August have an above zero mean daily minimum. June is the month of rapid snowmelt and sublimation. Month-end snow cover at Mould Bay, for example, decreases from about 22 centimetres end of May to about 2 centimetres by the end of June. July is the month that favours snow-free ground.

During the unfrozen season, low cloud and fog are the routine across the Arctic Basin and the ice-covered or open water areas between islands. Onshore flows readily bring these conditions inland.

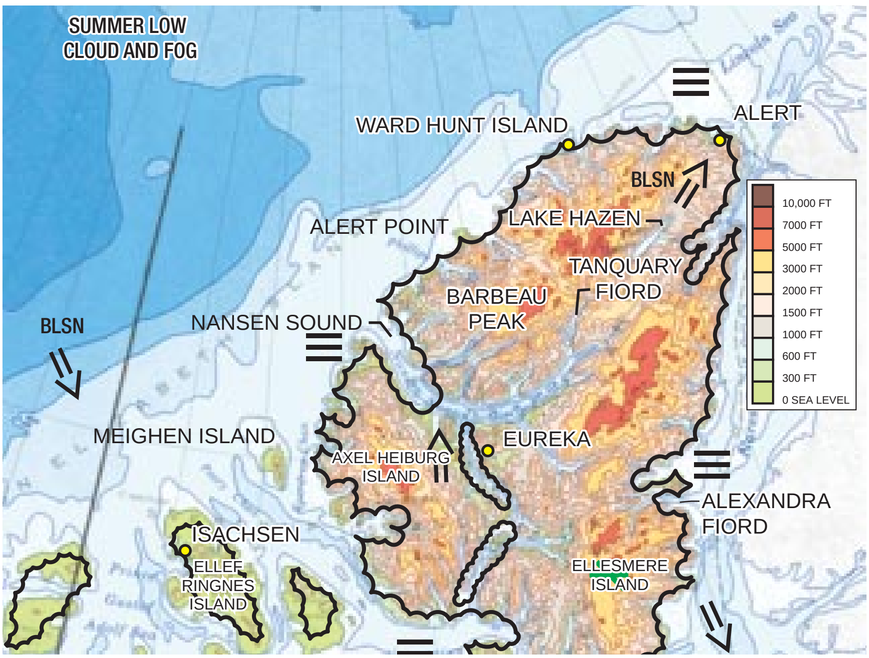
Local Effects

Northern Banks Island/Aulavik National Park

Late June is spring with weather systems bringing precipitation that is an almost equal mix of rain and snow. July is summer with rain about 2 1/2 times more likely than snow. August has the most precipitation and it is almost equally split between rain and snow. During summer, with onshore flow, low cloud and at times fog readily find their way from McClure Strait into northern Banks Island including Aulavik Park. The cloud and fog are at times accompanied by drizzle. Also in summer, albeit rare, thundershowers can occur inland.

Northern section of the GFACN37

Eureka, Alert, Ward Hunt Island, and Isachsen



Map 4-9 - Northern section of GFACN37 domain

The terrain of the area varies from the highest mountain in North America east of the Rockies (Barbeau Peak at 8,583 feet ASL) to the corridor of low lands through the central arctic islands to the generally ice covered waters between islands and across the Arctic Basin.

Persistent snow cover in excess of 2 centimetres across this section ranges from about 280 to more than 300 days per year bridging fall, winter, and spring and catching portions of summer. At Alert, only the months of June, July and August have mean daily maximum temperatures above 0°C and of these months, only July also has an above-zero mean daily minimum.

The amount of open water that develops across this area is limited. There can however be years such as 1998 when the amount of open water is significantly greater.

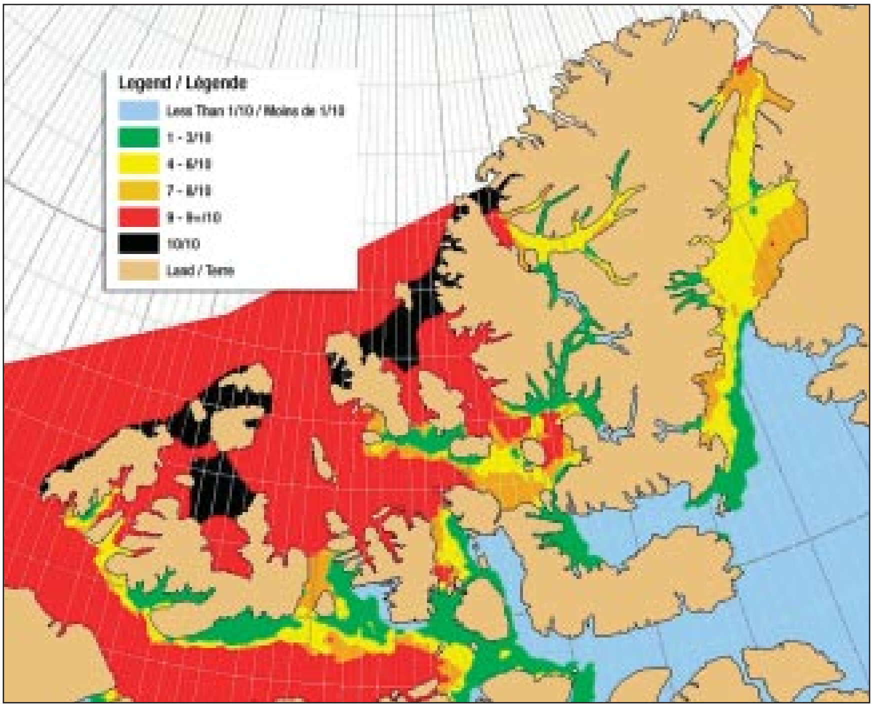


Fig 4-3 - Median ice conditons for September, 1971 to 2000 credit: Canadian Ice Service

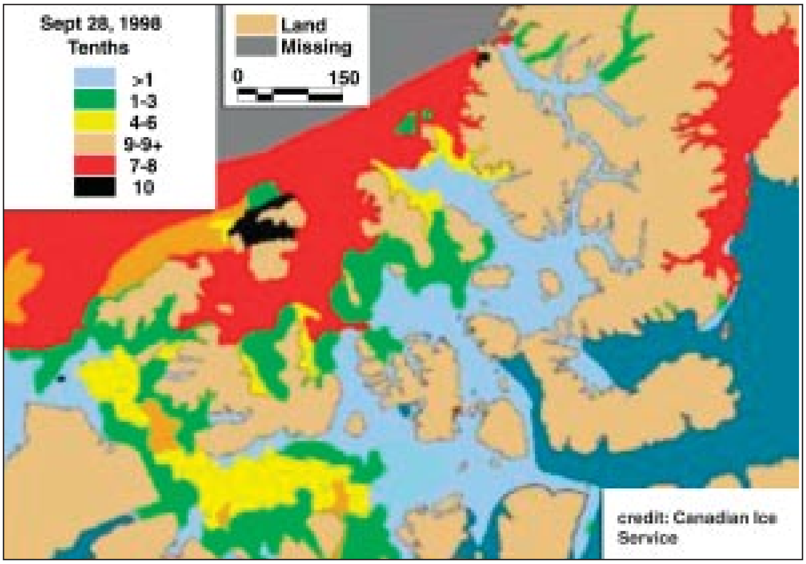


Fig. 4-4 - Ice conditions 28 September 1998 credit: Canadian Ice Service

Summer is the time of 24 hours of daylight (Alert is at 82°30'N and Eureka is at 79°59'N) while winter is the time of 24-hour darkness.


Photo 4-4 - Ellesmere Island near Tanquary Fiord, summer credit: Claude Labine

Photo 4-5 - Alexandra Fiord, Ellesmere Island, summer credit: Claude Labine

Weather by Season

Frozen season

The frozen season begins early September as new ice forms in coastal areas and skims over the surface of open water areas. Before this happens, a combination of weather systems and open water contribute to make September the snowiest month. The snow routinely gives obscured ceilings and restricted visibilities. The frozen season ends in June. Once the open water areas are ice covered, the abundant source of moisture for low cloud and fog is cut off. The Lincoln Sea to the north of Alert and the waterway between Ellesmere Island and Greenland can be slow to freeze over providing a moisture source through the fall into winter. Low cloud can, on occasion, track hundreds of miles and find its way from, for example, the open waters of the North Atlantic, across the ice north of Greenland and wrap back to the southeast to make its way into the Canadian arctic islands. Nansen Sound is a ready path for low cloud to make its way from the northwest into arctic islands. The low terrain west of Axel Heiburg Island (blizzard alley) is another ready pathway for low cloud to stream into the arctic islands from the northwest.

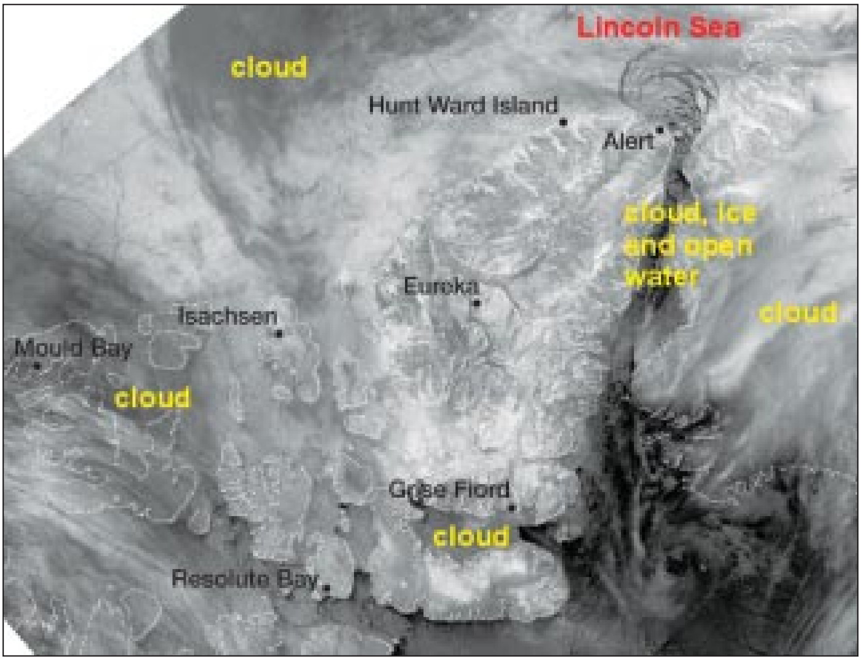


Photo 4-6 - Infrared satellite photo, 21 November 2001: cloud, ice and open water

The frozen season is also the blowing snow and blizzard season. If there is going to be freezing drizzle at Eureka, it is most likely to occur in June. For Alert, if there is going to be freezing drizzle, September is the most probable month.

The winter months December, January and February are a time of strong inversions with ice crystals restricting the visibility below that layer. Moisture from open water, polynyas, heating systems and aircraft exhaust can at times trigger ice fog below the inversion. An approaching upper trough can trigger a layer of ice crystals that extends to 18,000 feet or more while the upper troughs passage will do away with the ice crystal haze. Light snow can fall from skies that have no discernible cloud. This "fluffy" snow readily becomes blowing snow. Winter is the most favourable of the seasons with respect to flying weather for such locations as Alert and Isachen albeit both these sites are vulnerable to blowing snow and it is dark!

The spring months of March, April and May reside in the frozen season. Spring and summer are the best seasons for flying weather-wise at sites such as Eureka. Warmer and moister air masses that have, except for rare occasions, lingered well south now get to the area. At Alert, for example, average snowfall values go from about 8 centimetres in January to values near 14 centimetres in May. Monthly snowfall amounts through the summer range from 12 to 18 centimetres. Snowfall at Alert peaks in September at 32 centimetres. Eureka on average gets about 1/3 as much snow. Rain shows up in May and lingers to September.

Photo 4-7 - Agassiz Ice Cap, Ellesmere Island: Twin Otter and snow frosted instrument, spring

credit: M. Waskiewicz (both photos)

Unfrozen season

During the unfrozen season, low cloud and fog are the routine across the Arctic Basin and the ice-covered or open-water area between islands. Onshore flows readily bring these conditions inland.

Local Effects

Ellesmere Island - Ellesmere Island is the 6th largest island in the world and sports a lot of high terrain. Moderate to severe clear air turbulence can develop over Ellesmere Island when the flow aloft is strong. Similarly, there can be lee wave turbulence. With the approach of an upper disturbance from the west cloud and precipitation can envelop the entire island. The waterway between Ellesmere Island and Greenland routinely experiences strong northerly winds. It is these winds and associated currents that sustain the North Water polynya.

Eureka - Eureka is sheltered from most cloud being to the lee of mountains. As a result the ceiling is rarely low. With weather systems approaching from the west however, ceilings can drop quickly, particularly when the precipitation that the system brings is snow. The passage of the upper troughs usually brings precipitation to an end and promotes rapid thinning of the cloud. The approach of disturbances from the west generates strong southerly winds at Eureka and just as the passage of the disturbance brings clearing, it can also put an abrupt end to the strong winds.

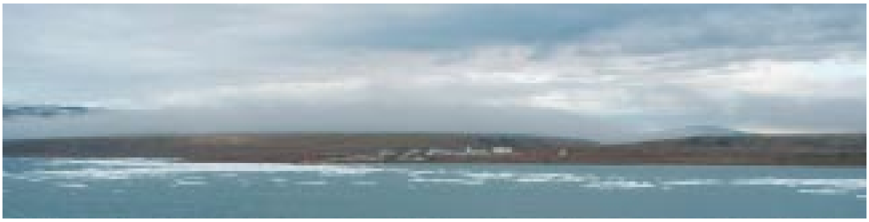


Photo 4-8 - Low cloud and fog hugging the hills above Eureka, August 2001 credit: Brian Kahler

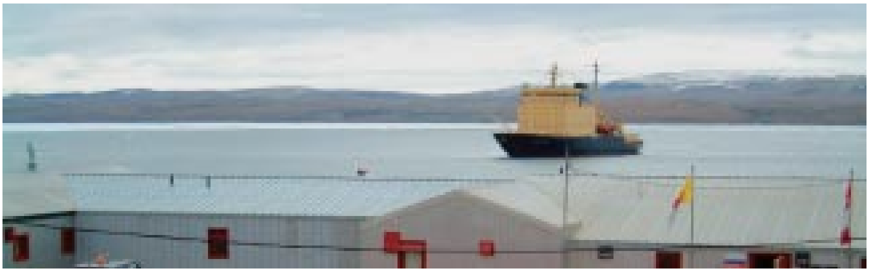


Photo 4-9 - Russian ice breaker Khlebnikov off Eureka, August 2001 credit: Brian Kahler

Alert - Weather systems approaching from the west can trigger strong southwest winds at Alert and, when there is loose dry snow on the ground, blowing snow is quick to lower visibility. Low cloud and fog are routine when there are onshore winds (northerly winds) off the open water areas of the Lincoln Sea. The low cloud can be accompanied by freezing drizzle. With strong wind regimes, surrounding terrain to the west and southeast can give occasional light to moderate turbulence.

Lake Hazen - Located about 2/3 the way from Eureka to Alert, lies Lake Hazen, the largest lake north of the Arctic Circle at about 50 miles by 3 miles. The lake usually melts only partially open. However, since 1994, has been observed to thaw completely open at times. During summer, when the rest of Ellsemere Island is shrouded in cloud, Lake Hazen, like Eureka can be wide open. Winds at Lake Hazen favour southwesterly which is the general orientation of the relatively lower terrain between the mountains of northern Ellesmere Island and the Agassiz Ice Cap. Lake Hazen remains open in the fall for a while after the air temperature has dropped below freezing so that localized heavier cloud results.

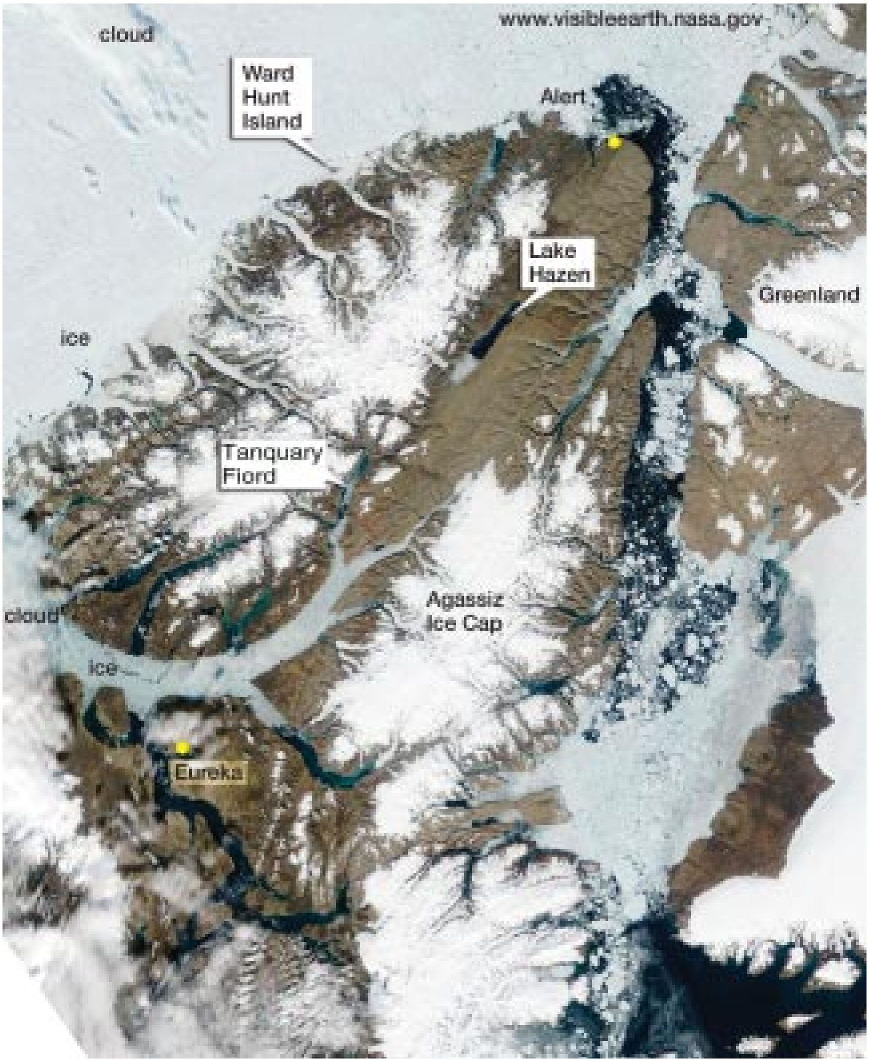


Photo 4-10 - Visible satellite photo, 2 August 2002. credit: NASA
A large portion of Lake Hazen is open

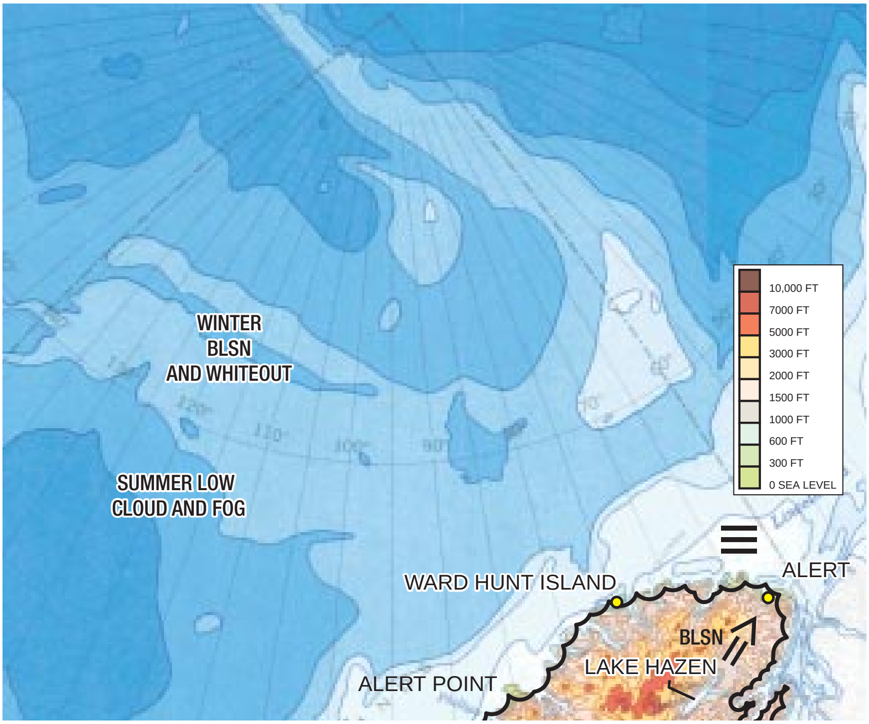
Tanquary Fiord - Barring strong weather systems, the prevailing wind direction in summer is southwest as a sea breeze routinely kicks in. During the winter, drainage northeasterly winds prevail. The Russian ice breaker/cruise ship Kaptain Khlebnikov and from time to time Canadian icebreakers go to the head of Tanquary Fiord.

Per Canada Flight Supplement, "The short, gravel strip near the head of the fiord is not maintained. Runway strength and condition are subject to seasonal and/or climatic variations."

Photo 4-11 - Head of Tanquary Fiord (a part of Quttinirpaaq (Ellesmere) National Park), 1 June 1998 credit: David Schmidt

Meighen Island - The elevation of Meighen Island is just above sea level yet the island sports a permanent glacier. The ice cap on Meighen Island forms the highest terrain on the island peaking at about 870 feet ASL. Whiteout on the ice cap can occur year-round. The island, like other islands bordering the Arctic Basin, is vulnerable to intrusions of low cloud and fog especially during the summer. In summer, cloud/fog from the Arctic Basin is enhanced as it is lifted orographically up the ice cap of Meighen Island that is at 0°C with a melting surface. The cloud/fog sometimes burns off/dissipates by the time it reaches the southern part of the island (south of the ice cap). The cloud streaming off the Arctic Basin onto the waterways between the arctic islands routinely has bases from 500 to 800 feet AGL and tops from 1,500 to 2,000 feet.

Arctic Basin Section of GFACN37 Domain



Map 4-10 - Northern Ellesmere to the pole

Ice covered but openings

The "terrain" of the area is that of a constantly changing ice surface of varied thickness, surface roughness and snow cover. Pilots cite that only a very small percentage of the ice cover on the basin is suitable for landing. Ice sheets slide under each other (rafting) or ice sheets bump into each other to create ridges both below and above the surface (ridging). Ridging across the battleground between the arctic pack ice and the ice that is permanently anchored to northern Ellesmere Island can reach heights of tens of metres. Ice sheets routinely obstruct each other's fit into the jigsaw puzzle of ice cover such that cracks and areas of open water develop (leads) and close, at times suddenly. New ice forms. Snow covered ice dominates fall through winter to mid spring. Wind continually redistributes the snow via drifting and blowing snow. Snowdrifts develop. Melting and sublimation of the snow cover and then the ice begins mid spring. The ratio of open water to ice increases and the ice thickness decreases into September. A return to below freezing temperatures brings a return of ice growth both coverage and thickness-wise.

Landings on ice including flights to the pole routinely occur March through April and May and occasionally into very early June. During this period, there is 24 hours of daylight, air temperatures are still below freezing, and the ice is at its maximum thickness. Many of these flights use Ward Hunt Island as a staging point.

Photo 4-12 - Twin Otter on ice the Arctic Basin, March 1996, for installation of automatic temperature and surface air pressure station

credit: Don Tolhurst and Mark Pyper and Twin Otter C-GNDO, pilots Doug McLeod and Blake Reid

The terrain moves

The ice of the Arctic Basin is always on the move. Statistically, the ice that is at the North Pole at any given time will have moved on to the North Atlantic in one year.

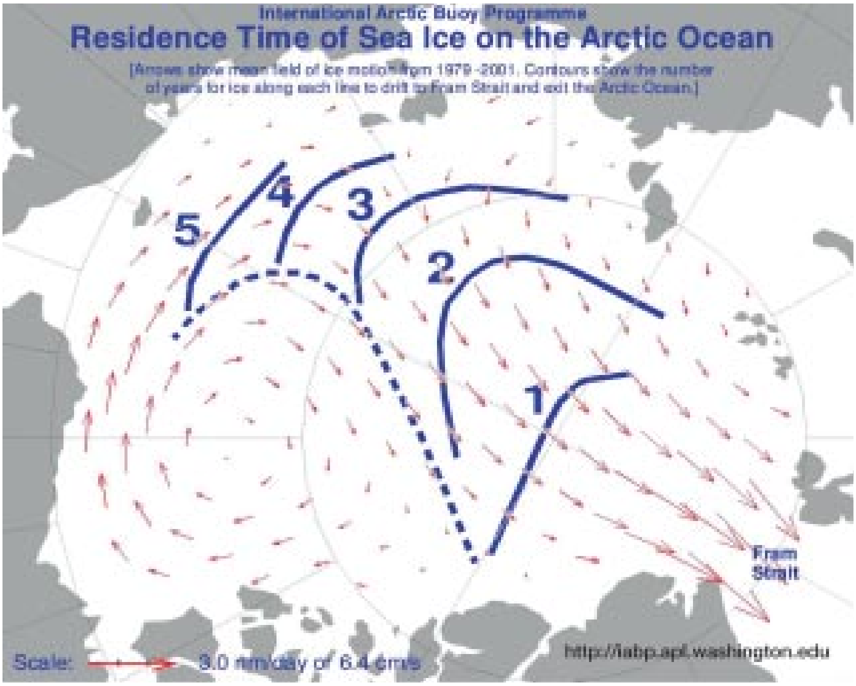


Fig. 4-5 - Resident time of sea ice on the Arctic Ocean

credit: International Arctic Buoy Programme

Flying weather

Winter - Winter is the season of 24-hour darkness where areas of low cloud combine at times with higher level cloud from weather systems, and drifting and blowing snow. The average cloud cover is about 50 percent. Monthly mean daily temperatures range from -31°C to -33°C.

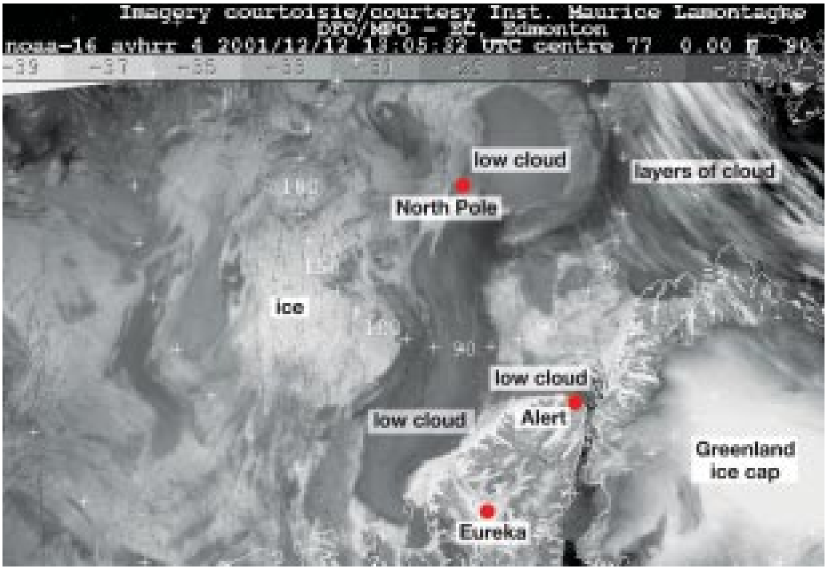


Photo 4-13 - Infrared satellite photo 12 December 2001. showing areas of low cloud just off northern Ellesmere Island and across the Arctic Basin intruding into the Canadian arctic islands.

Spring - Spring is the season of 24 hour sunlight but temperatures that are still below freezing. Sublimation and melt starts to occur putting moisture into the air. The average cloud cover increases from about 50 percent in April to about 80 percent in May. Monthly mean daily temperatures climb from -24°C in April to -11°C in May.

Summer - Summer is the season that temperatures get above 0°C but not by much above zero. The snow cover melts, the ice thins and open water areas that develop between floes stay open. The influx of moisture over the ice and cold water surface leads to a blanket of cloud and fog over the Arctic Basin. The average cloud cover through the summer months is 90 percent. Excluding weather systems with their layers of mid-and upper-level cloud, the cloud over the basin is routinely based at 500 to 800 feet and topped at 1,500 to 2,000 feet ASL. Monthly mean daily temperatures hover just below or near 0°C (-1.8°C June, near 0°C July, and -1.4°C August).

Fall - Fall is the season where open water leads between floes freeze over almost as quickly as they form and the cloud coverage over the basin diminishes. Average cloud cover decreases from 90 percent in September to 50 percent in November. On infrared satellite images, one is once again able to see the “cracks” between floes via the heat that is leaking from them and areas of low cloud show up dark grey or black as long as there is no higher cloud. Monthly mean daily temperatures drop from -8°C in September to -20°C in November and then to -27°C in December.

Chapter 5

Airport Climatology for Nunavut and the Arctic

There are four blocks of sites in this chapter: Sites are listed alphabetically in each block. The first block, TAF sites covers Baker Lake, Hall Beach, Nanisivik, Pond Inlet, Iqaluit, Rankin Inlet, and Resolute Bay. The second block, additional TAF sites, covers Alert, Arviat, Cape Dorset, Clyde, Coral Harbour, Eureka, Gjoa Haven, Ivujivik, Kugaaruk, Qikiqtarjuaq, Quaqtaq, Repluse Bay, and Taloyoak. The third block, other airport sites, covers Akulivik, Arctic Bay, Chesterfield Inlet, Grise Fiord, Igloolik, Kangiqsujuaq, Kangirsuk, Kimmirut, Pangnirtung, Puvirnituq, Salluit, and Whale Cove. The final block, former airstrip sites, covers Isachsen, Mould Bay, and Rea Point.

TAF Sites

Baker Lake

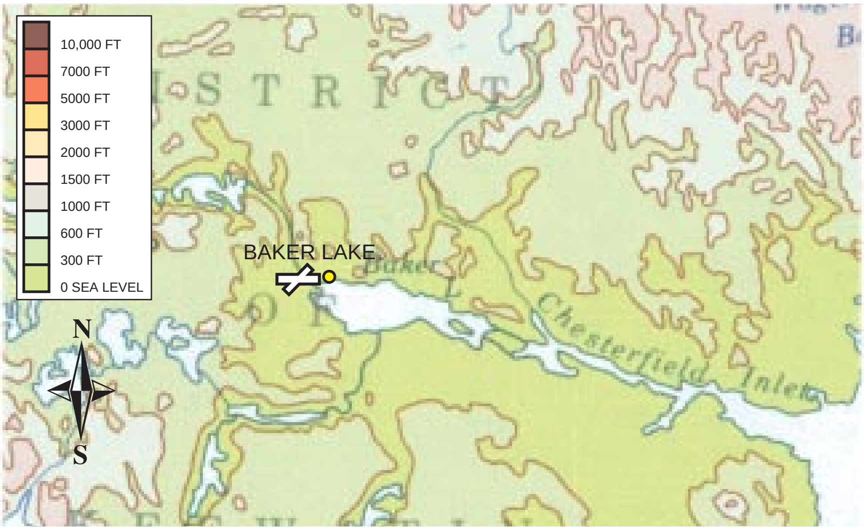


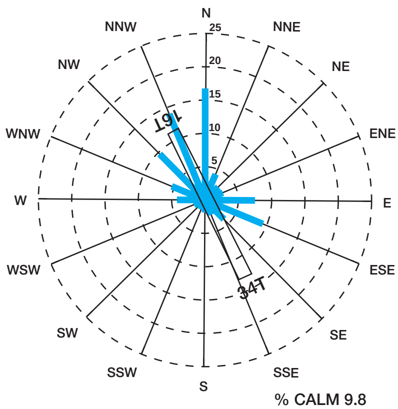
Photo 5-1 - Baker Lake, runway (foreground) and community (background), looking northwest credit: Chris Gartner

Photo 5-2 - Baker Lake community, looking northwest (airport is off left side of photo) credit: Government of Nunavut, Community Government and Transportation

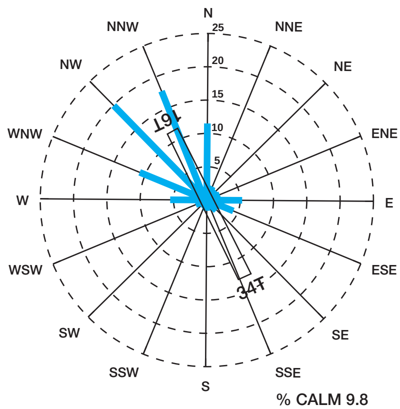
Baker Lake airport (elevation 59 feet ASL) lies at the western end of Baker Lake within the Kivalliq district of Nunavut, 258 n. miles north of the Manitoba border. The community of Baker Lake is about 2 miles northeast of the present airport site. The mouth of the Thelon River, the main river discharging into Baker Lake, lies 4 miles to the southwest of the airport. This river flows south-southeast from Schultz Lake, 44 miles northwest of the airport. Baker Lake, which is 45 miles long and 22 miles wide, empties into Chesterfield Inlet and subsequently Hudson Bay, about 160 miles southeast of the airport. In addition to this major drainage system, innumerable small lakes and rivers are scattered across the region. The surrounding countryside is composed of rolling tundra except for a few willow trees that attain a height of only 3 to 4 feet. Within a few miles of the airport, the highest elevation is that of Blueberry Hill, 430 feet, one mile to the west. However, rising terrain beyond 15 miles to the north and northeast of the site can influence the winds and create mechanical turbulence.

Per Canada Flight Supplement, "Radiosonde balloon launches at 1115Z and 2315Z daily."

Baker Lake
Wind Frequency by Direction
Summer



Baker Lake
Wind Frequency by Direction
Winter

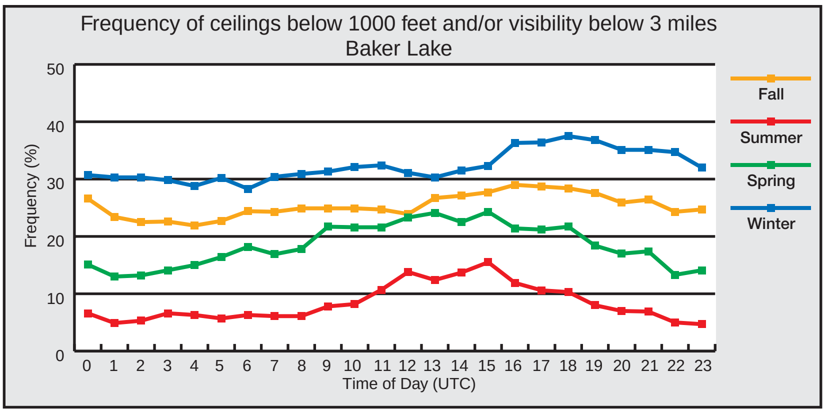


Percent wind 20 knots and greater																Baker Lake
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.1	0.1	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.0	1.6	1.4
WINTER	0.1	0.1	0.1	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.4	2.0	7.1	7.9	3.3

As the wind roses and wind table show, northwest winds are dominant and frequently strong, more so in winter than in summer. Blowing snow is a common problem and many blizzards occur through the frozen months. Indeed, Baker Lake is cited as the "blizzard capital of Canada" posting on average more than 20 blizzard events in a season. The secondary maximum in wind direction is from the southeast. Such winds occur when low-pressure systems approach from the west. Southeast wind events can create blizzard conditions with less wind than the northwest blizzards as there is usually falling and freshly fallen snow to tap. The northwest winds readily tap existing snow on the ground and there can be little, if any, cloud above the layer of blowing snow. The southeasterly blowing snow events are usually of short duration as the low-pressure system passes through.

In the winter months, with a relatively weak gradient from the northwest and a cold airmass, northwest winds can be quite variable. It is thought that the cold air dams up behind the terrain to the north and flows in waves over the site. This results in winds that are at times nearly calm yet burst at times to strong gusty northwest. The southeast direction is more prevalent during the spring, summer and fall as low-pressure systems commonly track through the area.

Occasionally, Baker Lake will have a light southeast flow at the surface with the approach of a low-pressure system. Aloft, the winds can be strong southerly. The difference creates moderate low-level wind shear. The strong winds aloft can also interact with the hills to the north of the airstrip and it can become very bumpy near the top of the inversion when banking over them to make an approach from the northwest.



The diurnal trend of flying conditions is different in different seasons. Usually, during the spring and summer, flying conditions are better in the afternoon than late night and morning. However, during the fall, and in particular during the winter, flying conditions are poorest in the afternoon. This is a common phenomenon in the region.

Of all the arctic sites, Baker Lake has distinctly different flying weather during each season of the year. The summer season is the best with only about 1 day in 10 being below VFR. On the other hand the winter season is the worst time to fly into Baker Lake due to the many strong northwest wind events and consequent bouts of blowing snow/blizzard conditions. There are poor flying conditions more than 30 percent of the time in winter. Fall has worse flying weather than spring probably because more synoptic scale features affect the Barrens in fall.

Freezing drizzle events peak in May (over 4 events on average during the month) and in October (over 6 events in average during the month). The May events show as occurring primarily with northwest winds and with surface air temperatures in the 0 to -7°C range. The October events show as occurring with winds from any direction and with surface air temperatures in the 0 to -12°C range.

Hall Beach

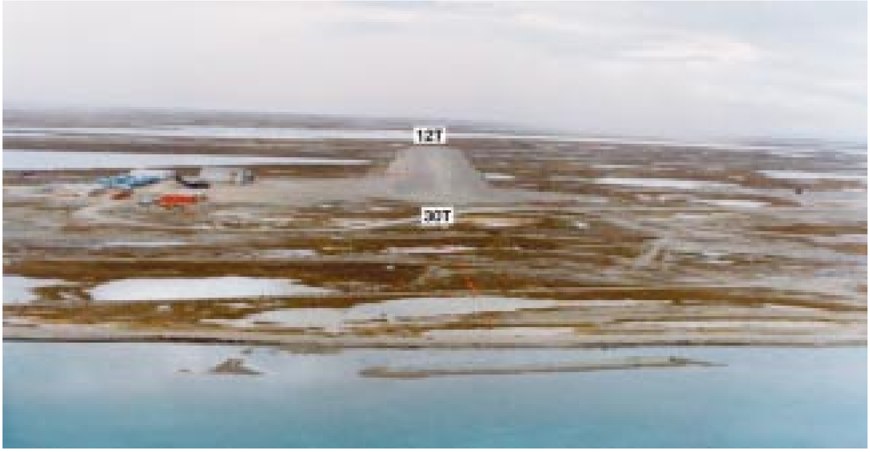


Photo 5-3 - Hall Beach, on approach to runway 30T, September 2000, looking northwest. credit: Yvonne Bilan-Wallace

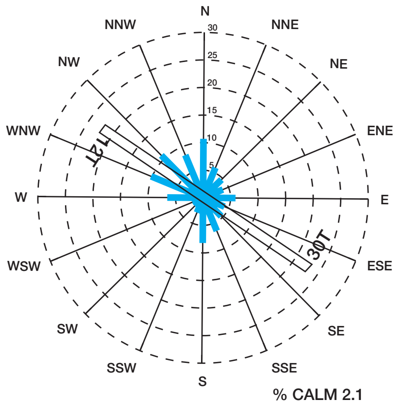
Photo 5-4 - Hall Beach runway and community, looking southwest

credit: Government of Nunavut Community Government and Transportation

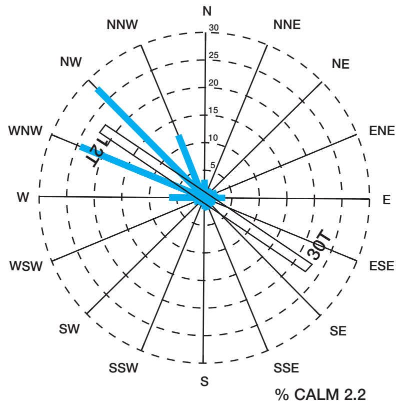
Hall Beach is located along the west coast of Foxe Basin. The terrain in the vicinity of the airport (elevation 27 feet ASL) is fairly flat with a gradual rise in heights to above 100 feet beyond 12 miles to the west. To the north through east to south from the airport, lies Foxe Basin. The airport is exposed to winds from all directions.

Per Canada Flight Supplement, "Radiosonde balloon launches at 1115Z and 2315Z daily."

Hall Beach
Wind Frequency by Direction
Summer

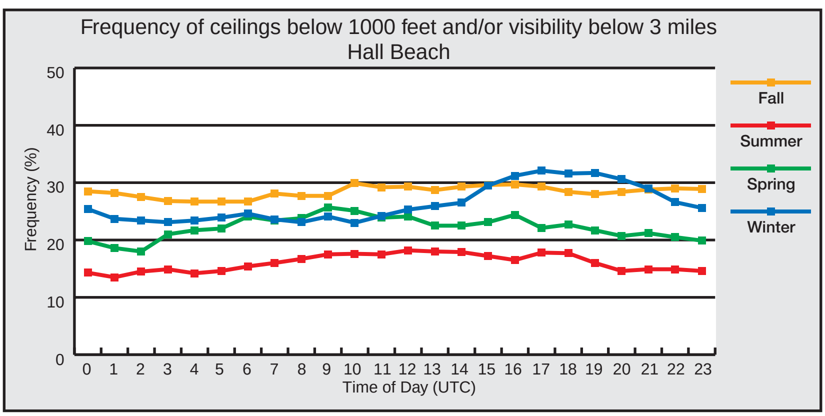


Hall Beach
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Hall Beach
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.5	1.1	1.2	0.7	0.2
WINTER	0.1	0.2	0.3	0.5	0.2	0.1	0.3	0.2	0.0	0.0	0.0	0.2	2.8	2.6	1.1	0.4

The terrain around Hall Beach is flat so that the winds tend to cooperate with the synoptic influences in the region The wind roses and wind table for Hall Beach show a theme that recurs across most of the Nunavut sites. Northwest flow is dominant and frequently strong, especially in the winter months when the arctic vortex sets up over the northern Baffin Island/Foxe Basin area, and is the controlling influence in the flow. Blizzards are common with northwest winds. Calm winds are infrequent.



The open water of Foxe Basin provides a convenient source of moisture for low cloud during the open water season. Open water leads in Foxe Basin (leads can exists to the immediate east of Hall Beach after periods of strong northwest winds) and the Fury and Hecla Strait polynya to the north provide a moisture source during the frozen months. This moisture can result in patches of low cloud and/or reduced visibility in ice fog. Freezing drizzle can occur during spring (May particularly) and fall (October particularly) and is often accompanied by freezing fog. During these periods, loading of the cloud with super-cooled water droplets is common and cloud top temperatures are often near -10°C. Surface air temperatures are usually in the 0 to -8°C range during the May freezing drizzle events and in the 0 to -12°C range during the October events.

The best flying weather is in the summer with only one day in 10 having below VFR conditions and very little diurnal variation. The fall has the worst flying conditions probably due to a mixture of synoptic scale influences and topographical effects. There is almost no diurnal change in poor flying conditions in the fall. In the winter, however, flying conditions deteriorate around noon. The winter hours between 1600 and 2100 UTC show as having the poorest flying conditions of the year.

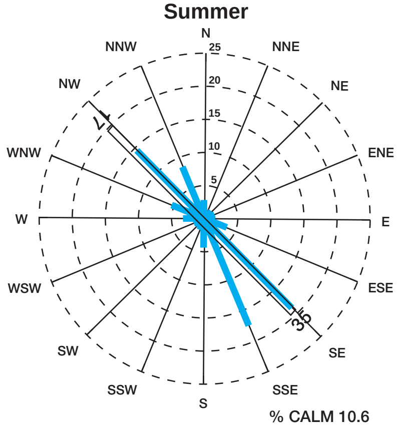
Iqaluit

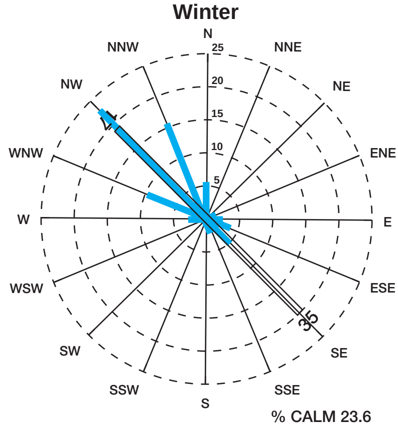
Photo 5-5 - Iqaluit runway June 2000 credit: David Aihoshi

Photo 5-6 - Iqaluit runway and community, looking northwest credit: Government of Nunavut, Community Government and Transportation

The Iqaluit airport (elevation 110 feet ASL) is located just northwest of the community of Iqaluit on southeastern Baffin Island where the Sylvia Grenell River empties into Frobisher Bay. Iqaluit, the capital of Nunavut, lies in the Qikiqtaaluk region of Nunavut. The topography around Iqaluit is variable with hills rising to 800 feet within 5 miles toward the east through north. Approximately 13 miles toward the west across Frobisher Bay, the terrain rises rapidly above 1000 feet. Frobisher Bay runs northwest to southeast and the Sylvia Grenell Valley continues this orientation to the northwest. Not surprisingly, dominant wind directions are northwest and southeast.

Per Canada Flight Supplement, "Prominent terrain bordering runway. Due to surrounding terrain, surface winds may cause windsocks on airport to show different wind directions. Radiosonde balloon launches at 1/4 mile west of threshhold runway 35 climbing 1000 feet per minutes at approximately 1115Z and 2315Z daily."





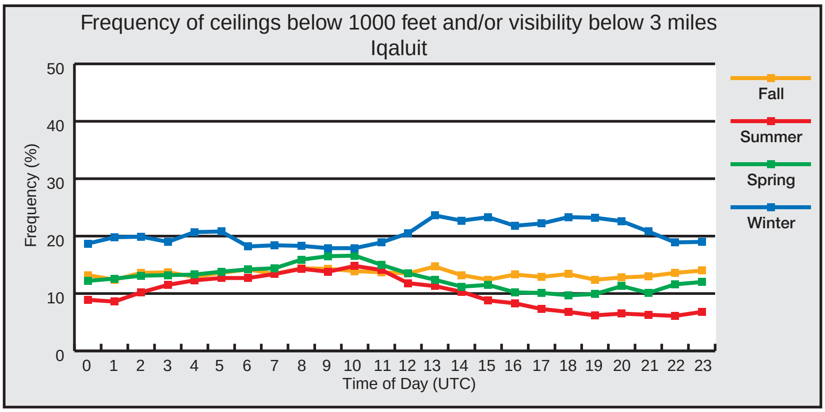
Percent wind 20 knots and greater																Iqaluit
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.0	0.0	0.0	0.0	0.1	0.6	0.4	0.0	0.0	0.0	0.0	0.1	1.5	0.7	0.0	0.0
WINTER	0.0	0.1	0.4	0.2	0.2	0.5	0.1	0.0	0.0	0.0	0.0	0.1	0.3	3.7	3.8	0.6

Northwest and north-northwest winds dominate in winter with respect to strength. Such winds routinely develop after the passage of low west to east across Hudson Strait or Northern Quebec. The lows routinely provide fresh snow which the northwest winds tap to generate blowing snow. Northwest and west-northwest winds can develop once a low has moved north from the Labrador Sea to Davis Strait.

Winds from the northwest and north-northwest can often be gusty and stronger at runway level than the weather map would suggest due to channeling effect induced by the terrain. During the fall, with a cold airmass flowing over the open water of Frobisher Bay, southeast winds can also be gusty.

A direction of note is northeast. Northeast winds, whether aloft or at the surface, have the potential to create turbulence. The hills to the northeast of Iqaluit can shelter Iqaluit airport from these strong winds. Indeed, the "runway" winds in such cases are often northwesterly and much weaker. In such scenarios, there can be a layer of severe turbulence and/or low-level wind shear. On occasion, the strong northeast winds aloft can "surface" at the airport. With the sharp rise of terrain to the southwest, the strong northeast winds sometimes generate a "rotor".

The frequency of calm winds is substantial ranging from 17 to 30 percent.



The variety of weather regimes experienced at Iqaluit is the result of the topography of Baffin Island, its location in close proximity to the marine environment, and its position relative to the major storm track over eastern Canada.

Like many other arctic sites, the worst flying weather is in the winter. Diurnally, the worst flying weather during spring, summer and fall is around 1000 UTC and after this time conditions get better. In winter, the best flying conditions occur around 1000 UTC and then get worse. The worst flying conditions of the year are between 1300 and 2100 UTC in winter.

Occasionally in the fall, prior to freeze-up of the lake, a cold airmass tracking over Sylvia Grinnel Lake will generate snow streamers. In the winter, with Frobisher Bay ice covered and a moisture-laden system approaching from the west-southwest, strong southeast winds can combine with moderate snow to give blizzards. However, blizzards with southeast winds are not as common as those with northwest winds.

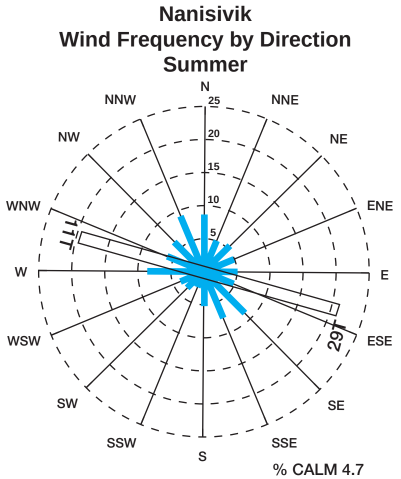
The dominant poor flying conditions occur in the winter with the increase in blowing snow and blizzard conditions. In the fall, and to a lesser extent late spring and summer, stratus and fog can be a problem due to the influx of low-level moisture from Frobisher Bay. In light onshore flow, fog and stratus can advect over the airstrip for many hours. Occasionally, the low cloud and fog do not break up until late afternoon. With a persistent light surface flow, fog and stratus can persist for days only breaking up briefly in the afternoon hours. Freezing rain - and severe clear icing - can occur in the fall when cloud from weather systems that originated over the south overrun the area.

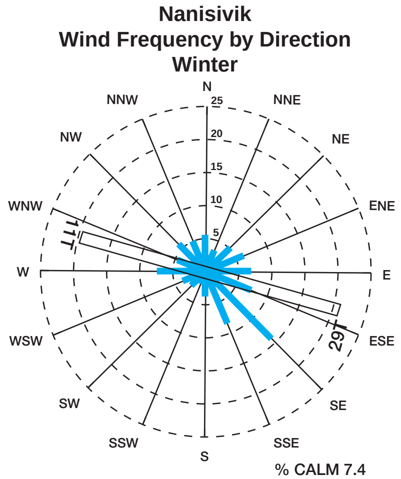
At Iqaluit, the airport elevation is 110 feet. The "35" end of the runway is very close to the bay. A large tide can be 36 feet. Forecasters cite a regime where with light southeasterly winds fog was observed cycling onto, and then away, from the runway according to the tide.

Nanisivik

Photo 5-7 - Nanisivik runway, looking north credit: Chris Gartner

The Nanisivik airport (elevation 2106 feet ASL) is located on an exposed plateau on the Borden Peninsula of northwestern Baffin Island. The terrain drops to sea level within about 7 miles to the north and 5 miles to the south of the airstrip. The near-by community of Arctic Bay is about 12 miles west of the airstrip and at near sea level.

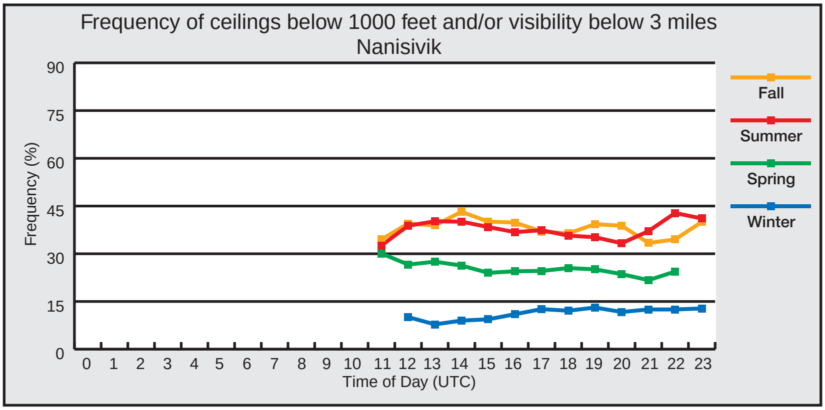




Percent wind 20 knots and greater																Nanisivik
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.3	0.3	0.1	0.3	0.7	1.2	1.1	0.6	0.1	0.1	0.1	0.2	0.1	0.2	0.3	0.2
WINTER	0.1	0.1	0.1	0.2	1.0	2.1	0.8	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1

The airstrip is exposed to strong winds due to its elevation and the flatness of the plateau on which it resides. The most frequent strong wind events are from the south-east. Such winds occur when low pressure systems approach from the west and south-west.

The strong southeast winds give blowing snow and blizzard conditions in winter months across the Nanisivik airport/the plateau. The town of Arctic Bay, sheltered by terrain in most directions on occasion, experiences these southeasterly wind and blizzard events.



Residing on an exposed plateau, Nanisivik experiences a high frequency of poor flying weather.

Very poor flying conditions exist during the summer and fall with about 4 days in 10 having below VFR conditions. Low cloud which becomes fog as it moves off open water and onto the plateau is the prevailing poor weather generator. Winter into early spring has the best flying weather barring occasional bouts of blowing snow.

Freezing drizzle is primarily an August to October event with September experiencing the most events.

Pond Inlet

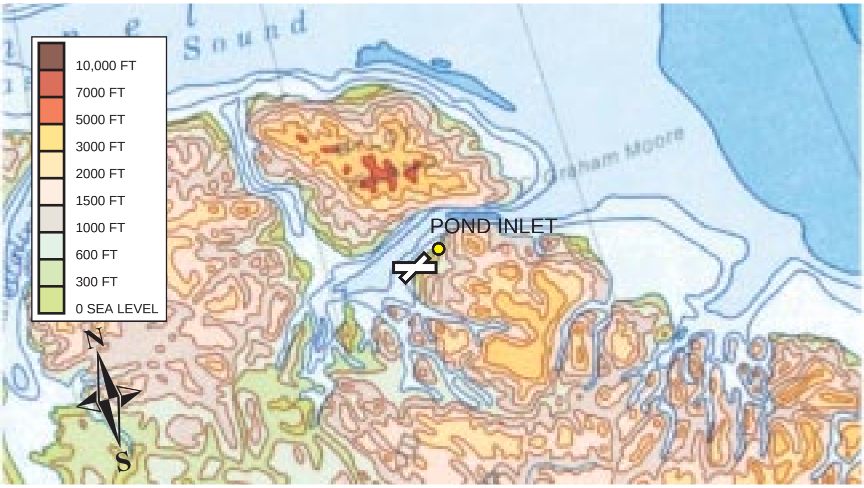
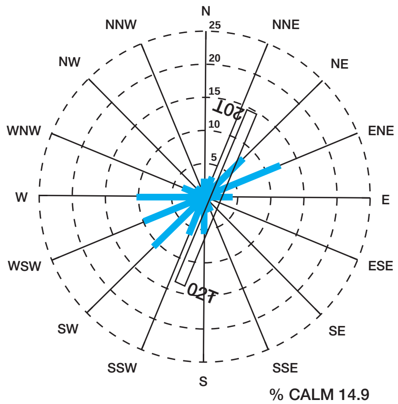
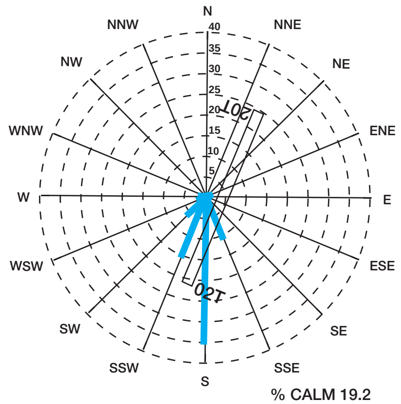


Photo 5-8 - Pond Inlet, looking west

credit: Government of Nunavut, Community Government and Transportation

The Pond Inlet airport (elevation 181 feet ASL) is located on the northern tip of Baffin Island on the shore of Eclipse sound. The site is open to the sea towards the east-northeast through southwest. The glacial cliffs of southern Bylot Island lie nearly 15 miles to the north across the sound. To the east and southeast, a steady rise to 1000 feet occurs within about 4 miles with a nearly 5000-foot peak 10 miles distant. Towards the south to southwest, uniform terrain prevails in the first 8 to 10 miles rising slowly to near 500 feet. Of particular interest to the south is the extensive 2000 foot deep gorge which runs beyond 12 miles south of the site.





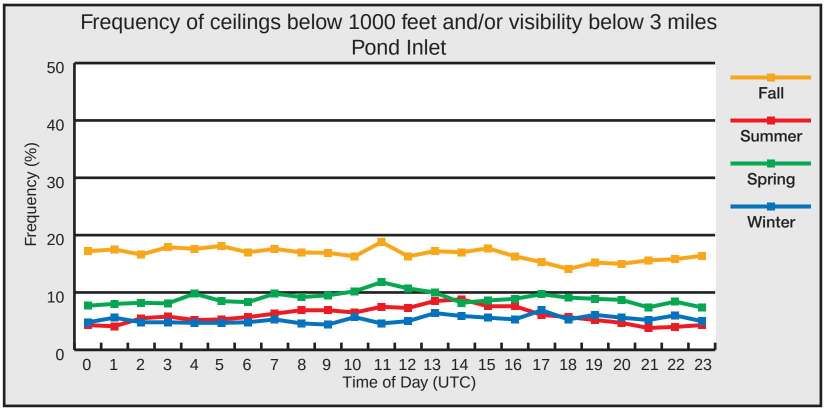
Percent wind 20 knots and greater																Pond Inlet
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.0	0.4	1.3	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
WINTER	0.0	0.3	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Pond Inlet is situated near the Baffin Bay storm "graveyard" yet due to its protected location it rarely experiences strong winds. There are, however, a few rare synoptic situations that can create strong winds at the site.

Overall, only 5 percent of the winds at Pond Inlet are greater than 10 knots. The wind roses show that the prevailing wind direction is from the south-southeast through to southwest as the wind fans out from the gorge over the extensive delta. However, these winds are rarely strong.

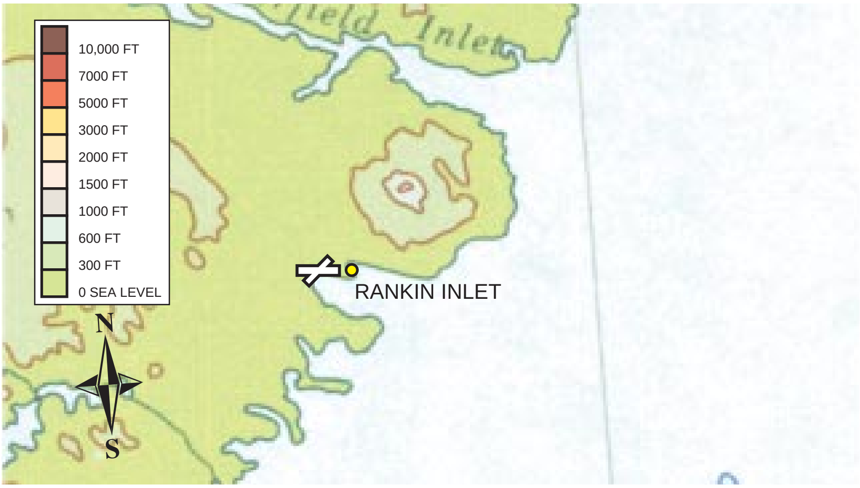
Strong winds, when they do occur, are from the east-northeast direction. With a deep low tracking from the south into Foxe Basin, strong northeast winds can develop as the winds drive along the shore of the inlet separating the southern shores of Bylot Island from Baffin Island. A second pattern that can produce these strong winds is a low moving northward from near Cambridge Bay to west of Prince of Wales Island.

With upper winds from the west to northwest the reported surface winds are generally light and frequently from the south to southwest directions. A rare strong wind event is possible from the west-southwest when there are strong northwest winds aligned aloft from near the surface to about 18,000 feet. Such wind regimes aloft are usually the product of a co-located upper and surface low stalling in Baffin Bay just east of Pond Inlet.



Pond Inlet enjoys flying conditions that overall are significantly better than other communities in the GFACN36 and 37 domains. Due to the proximity to Eclipse Sound to Pond Inlet, fog and stratus can be a problem in the late summer through fall under light flow regimes and cold air masses over open water. The occurrence of poor flying conditions reaches a peak in October. Flying conditions improve as the water surface freezes over.

Rankin Inlet



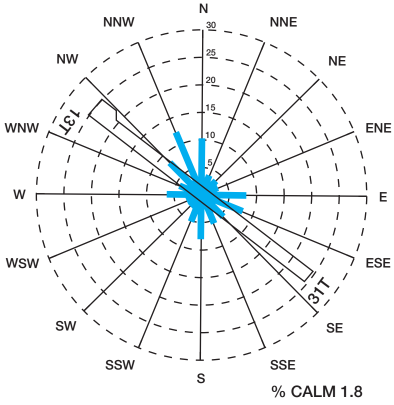
Rankin Inlet airport (elevation 94 feet ASL) is located at the end of Rankin Inlet, on a peninsula, approximately 12 miles west of Hudson Bay. Terrain near the community is relatively flat and devoid of trees. Hills rise to 300 feet about 8 miles to the north with a larger range of hills rising to near 1000 feet about 30 miles northeast. A shallow valley runs northwest from the site.

Pilots cite that the runway at Rankin Inlet often becomes icy during periods of extreme cold, especially if there is open water in the vicinity.

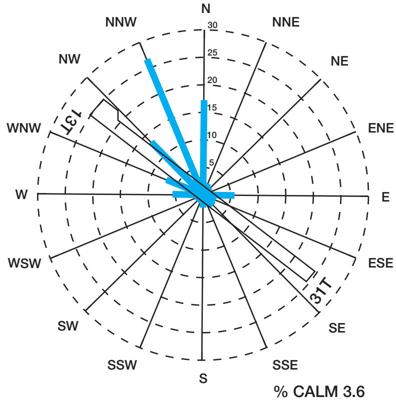
Photo 5-9 - Rankin Inlet looking southwest (runway is just off to the right side of this photo)

credit: Government of Nunvut, Community Government and Transportation

Rankin Inlet
Wind Frequency by Direction
Summer



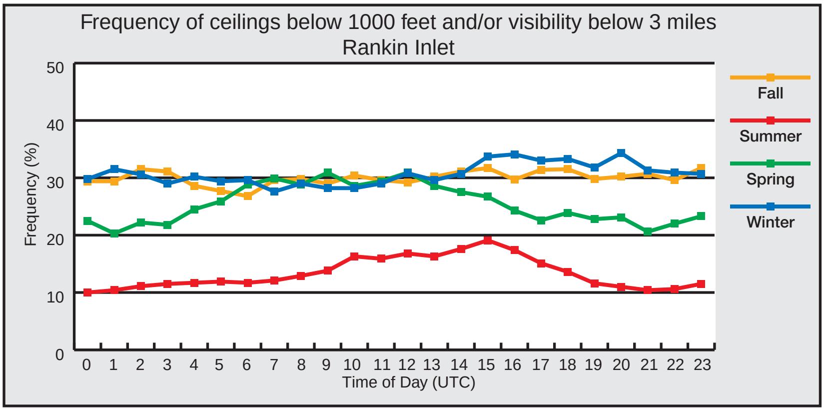
Rankin Inlet
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Rankin Inlet
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.4	0.4	0.3	0.7	0.2	0.1	0.1	0.2	0.1	0.0	0.0	0.2	0.6	1.6	2.2	1.3
WINTER	0.3	0.2	0.2	0.3	0.2	0.4	0.3	0.3	0.1	0.1	0.0	0.2	0.4	3.0	9.1	2.9

Northwest winds dominate with respect to both frequency and strength throughout the year. Indeed, in winter, 27 percent of the winds at Rankin Inlet are from the north-northwest and 1/3 of these north-northwest winds are 20 knots or stronger. The synoptic pattern that drives this wind is the recurring and persistent ridge of high pressure that extends from the Arctic Basin southwest across the Mackenzie/Great Bear/Great Slave area in combination with low-pressure systems over Hudson Bay, Foxe Basin or Davis Strait/Baffin Bay. This flow routinely creates blowing snow and blizzard conditions across the Rankin area/across the entire Kivalliq Region of Nunavut.

Calm winds are rare at Rankin Inlet.



As is common among the Kivalliq Region sites, poor flying weather is more likely during the fall and winter months than during the spring and summer months. Blowing snow is the main causal factor of poor weather through the winter. In fall a combination of blowing snow events with stratus and fog gives low ceilings and visibilities. With its proximity to Hudson Bay, poor visibilities in fog and low cloud can linger for extended periods.

In the spring, with the breakup of the ice starting in May through July, the addition of moisture to the lowest levels of the atmosphere is substantial creating large areas of low cloud over Hudson Bay and along the coast. The cloud can readily move over the airstrip with an easterly flow bringing low ceilings and fog. Summer shows as being the season of best flying weather, however, there can be bouts of fog and/or low cloud with light or onshore flow wind regimes, particularly overnight through to about mid morning. Rankin Inlet is situated a little further away from Hudson Bay than, for example, Chesterfield Inlet. As a result, with northeast winds some of the low cloud that moves inland gets broken up before reaching Rankin Inlet.

Freezing drizzle events favour the months of May and October. May freezing drizzle events are typically linked to northwest winds and surface air temperatures in the 0 to -6°C range. October freezing drizzle events can occur with any wind direction and speed. They tend to be linked to surface air temperatures in the 0 to -9°C range.

Resolute Bay

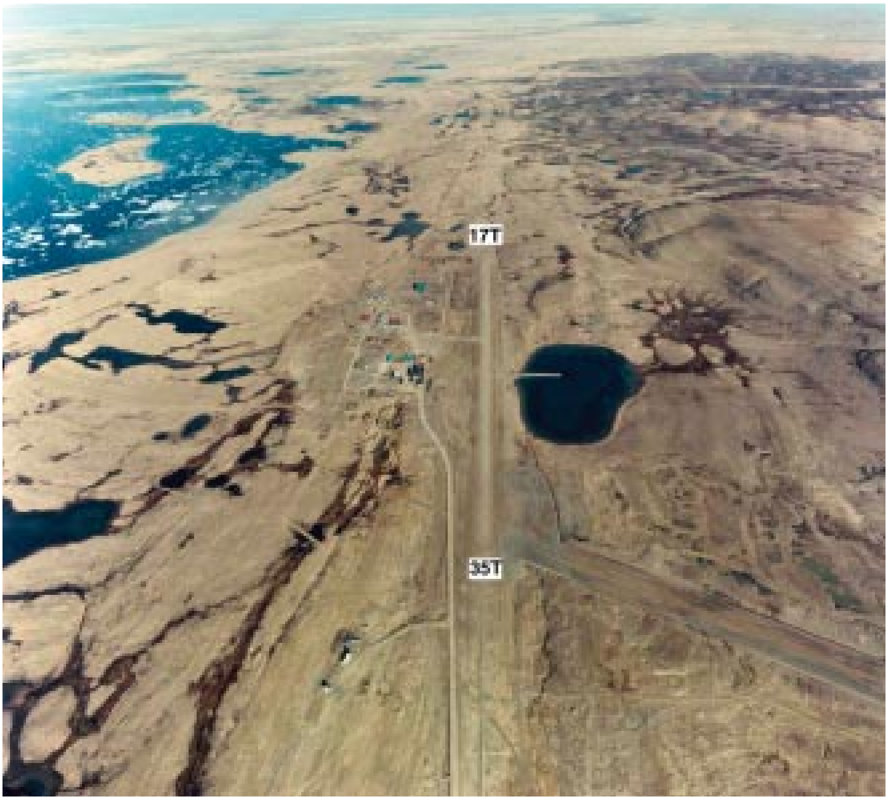


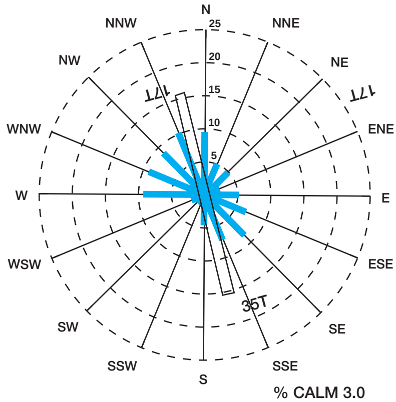
Photo 5-10 - Resolute airport, August 1998, looking north

credit: Government of Nunavut, Community Government and Transportation

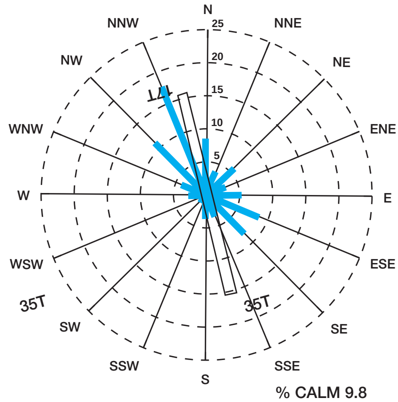
The Resolute Bay airport (elevation 221 feet ASL) is situated on a peninsula on the southern tip of Cornwallis Island, 2 1/2 miles north-northwest of the settlement of Resolute. Salt water lies in close proximity from the southeast through northwest directions. The terrain, which is gently rolling in character, slopes down to the south and west, toward the sea. There is however, a sharp ridge of hills about 1/2 mile to the northeast. These hills rise about 400 feet to an upland plateau with rolling slopes. The ridge/hills to the northeast factor into the wind regime at Resolute Bay. Cape Martyr, a large rounded promontory, 3 miles south-southwest of the station, rises to 570 feet and Signal Hill, 2 miles to the east-southeast, rises to 630 feet.

Per Canada Flight Supplement, "Severe turbulence may occur on approach with gusty easterly winds". Per Canada Flight Supplement, "Radiosonde balloon launches at 1115Z and 2315Z daily."

**Resolute Bay
Wind Frequency by Direction
Summer**



**Resolute Bay
Wind Frequency by Direction
Winter**



Percent wind 20 knots and greater																Resolute Bay
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	1.2	1.0	0.4	1.9	1.8	0.5	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.5	1.5	1.9
WINTER	1.6	3.0	1.1	1.4	2.0	1.4	0.3	0.4	0.1	0.0	0.0	0.0	0.1	0.7	2.2	1.7

Resolute Bay is affected by a wide variety of storm tracks and as a result can experience strong winds from most directions. When winds are northeast in winter, for example, about 1/2 of the northeast winds will be 20 knots or stronger. Indeed, the full gamut of wind directions from southeast through north to northwest show a significant portion being 20 knots or greater.

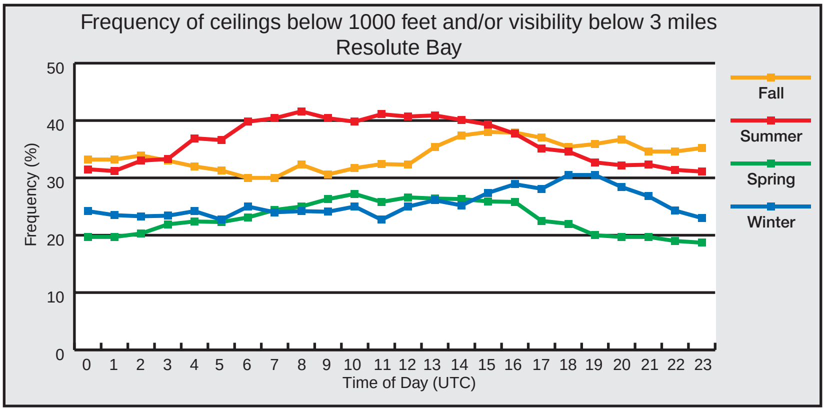
North-northwest/northwest and east-southeast/southeast winds are the most frequent winds.

Winds from the northwest to northeast are the result of storms moving north through Davis Strait to Baffin Bay; at which time the systems often stall and fill. Easterlies and southeasterlies occur when storms approach Resolute Bay from the west to south.

Long periods of strong northeasterly winds can be punctuated with brief “lulls” where the winds decrease dramatically and direction often backs to west or northwest. Such wind changes can be a clue to the presence of turbulence on approach. Strong northeast to east winds coming off the hills to the east of the airport can also create turbulence.

Northwest winds tend to be strong when they are bringing cold air across the Resolute Bay area. During winter, low pressure systems approaching from the south to west often generate strong southeast winds. These same systems can bring falling snow which facilitates development of blizzard conditions. Easterly and southeasterly winds can be of long duration as the lows responsible tend to stall over the Hudson Bay or Foxe Basin areas.

Southwest winds are rare. They are transitory winds, as the winds will back from northwest to southeast when a low pressure system approaches from the west and the ridge moves off.



The months of open water, summer into fall, are the months of poorest flying weather. August into early September, the time of maximum open water for the waterways of the Canadian arctic islands, shows as having the poorest flying weather particularly from 0600 to 1500 UTC. Mid to late September, the return to below freezing temperatures, and the start of freeze-up brings limited improvement to the flying weather. All wind directions can bring low cloud and/or fog to Resolute. Southerly winds tend to have the highest linkage to poor flying weather while northeast winds have the lowest linkage.

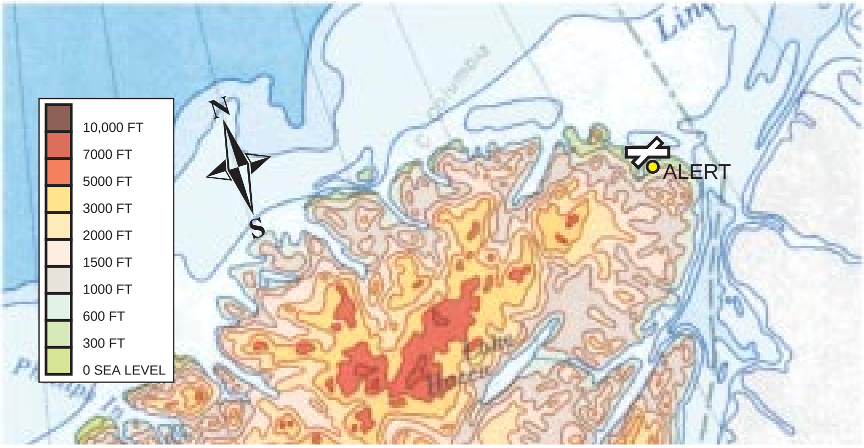
During the winter, poor flying weather primarily results from strong wind regimes and the resultant blowing snow. February tends to have the worst winter weather.

The freezing drizzle period is May through October. June and September are the months when freezing drizzle is most likely to be reported. June events occur with all wind speeds and all directions except northeasterly and surface air temperatures 0 to -8°C. September events occur through all wind directions and speeds and surface air temperatures 0 to -9°C.

The best flying weather is often in spring when the ice is fully frozen and the daylight hours are increasing. However, spring synoptic storms can bring heavy snow and sometimes freezing precipitation.

Additional TAF sites

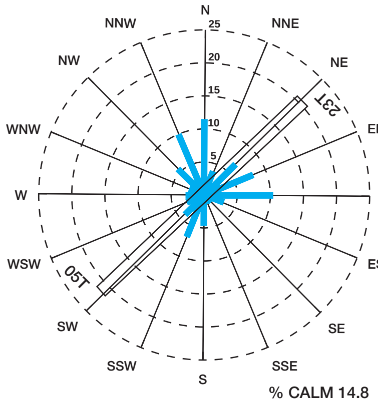
Alert



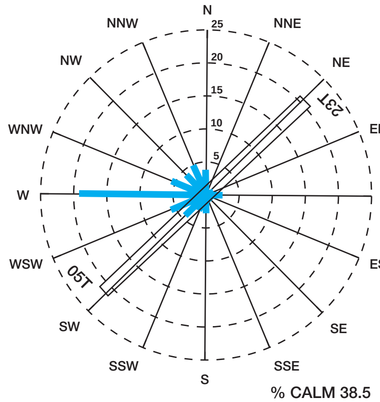
The Alert airstrip (elevation 100 feet ASL) is located on the northeastern tip of Ellesmere Island, 450 miles from the North Pole. The Alert facility is about 2 miles south of the runway. The airstrip is on a peninsula adjacent to Dumbell Bay, which opens up into the predominantly ice-covered Lincoln Sea. The terrain surrounding the site is rugged and rolling, rising frequently to heights of 350 feet as well as plunging into gorges and ravines. South of the station elevations in the Winchester Hills rise to over 1,500 feet, 5 to 7 miles from the site. To the west and southwest of the station, the Wood River gorge flows into Black Cliffs Bay from the Grant Ice Cap. The United States Range rises to the west and southwest to heights above 4,000 feet.

Photo 5-11 - Alert, May 1999, looking northwest credit: Ed Heacock

Alert
Wind Frequency by Direction
Summer

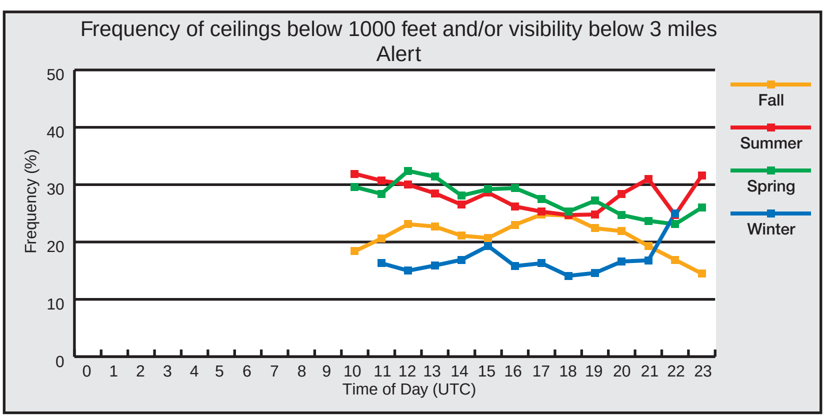


Alert
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Alert
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.3	1.4	0.8	0.1	0.1	0.2	0.2	0.0
WINTER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	1.7	1.2	0.2	0.0	0.2	0.4	0.1

Calm winds dominate at Alert summer and winter. The favoured wind direction is west. The approach of weather systems from the west with resultant falling air pressure is a trigger for the onset of southwesterly winds. Winds from the west-southwest, southwest, and south-southwest are routinely strong. When there is loose dry snow on the ground and the southwest winds are strong, blowing snow is quick to lower visibility. Onshore winds off the Lincoln Sea, spring and summer particularly, bring low cloud and fog. With strong winds, surrounding terrain to the west and southeast can give occasional light to moderate turbulence.



Ceilings below 1000 feet and/or visibility below 3 miles are most common from spring break-up to fall freeze-up. Winter, in spite of the occasional blowing snow or ice fog event, shows as having the best flying weather.

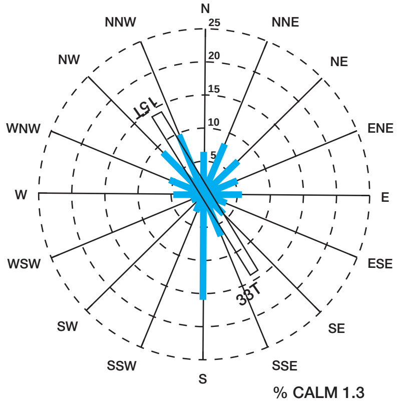
Freezing drizzle, albeit not common, shows up May through October.

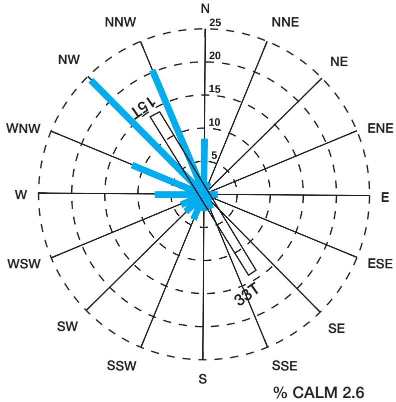
Arviat

The Arviat airstrip (elevation 32 feet ASL) lies near the community of Arviat and is located along the west coast of Hudson Bay. The terrain to the north through west to south is rather flat, only rising to above 100 feet beyond 10 miles from the site. Hudson Bay lies to the east of Arviat.

Photo 5-12 - Arviat community and airport, looking southwest.

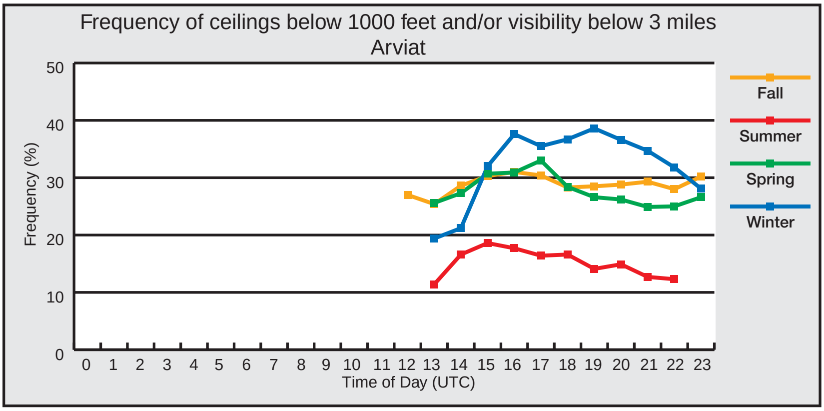
Government of Nunavut, Community Government and Transportation





Percent wind 20 knots and greater																Arviat
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.8	0.4	0.4	0.2	0.1	0.2	0.1	0.4	0.0	0.0	0.0	0.2	0.9	1.9	1.9	0.5
WINTER	0.1	0.1	0.2	0.4	0.3	0.1	0.7	0.8	0.2	0.1	0.1	0.2	1.0	5.6	4.2	0.9

Winds from the north-northwest and northwest prevail both in frequency and in strength. This is the result of a prevailing synoptic pattern that has the arctic surface ridge to the west with a general area of low pressure from Foxe Basin to Baffin Bay. This pattern sets up the "arctic pipeline" which sweeps cold air into the Prairies and Ontario. The northwest and north-northwest winds are particularly strong during the winter. During the frozen season, these strong winds routinely generate blowing snow/blizzard conditions, often with clear skies above. On occasion, intense low pressure systems approaching from the southern Northwest Territories or northern Prairies give very strong and gusty south to southeast winds. In winter, the approaching low routinely brings snowfall to the area. Threshold wind speeds to give reduced visibility in the combination of falling and blowing snow are lower than those where only blowing snow is limiting the visibility. Winds shift to the northwest with the lows passage.



Common to all coastal Kivalliq sites, fog and stratus that arrives with onshore flow off Hudson Bay during the open water season can give poor flying weather. Per the graph, spring and fall have poorer flying weather than summer. Diurnally, the most favorable flying conditions occur in the afternoon. In winter, blowing snow/blizzards with northwest winds are the concern and occur frequently enough to make winter the poorest season with respect to flying weather.

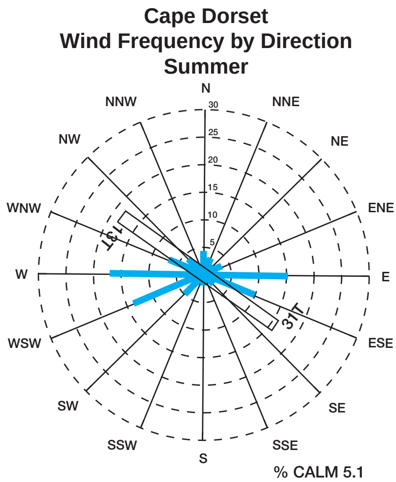
Cape Dorset

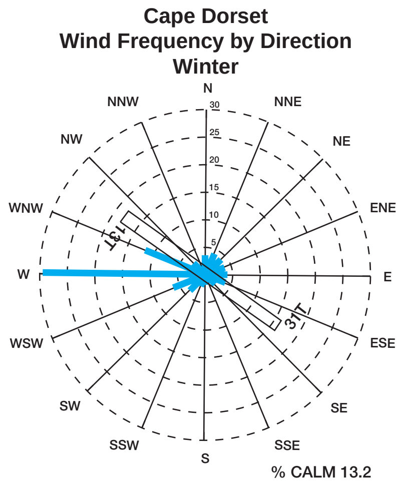
Cape Dorset is located on the northern shore of Dorset Island near the southern coast of Baffin Island. Dorset Island is approximately 4 miles long by 3 miles wide and is dominated by a 600-foot hill 1 mile south and a 500-foot hill 1 mile southwest of Cape Dorset. To the west of the airstrip (elevation 164 feet ASL) is a west-to-east oriented channel between Mallik and Dorset islands extending 2 miles west.

Per Canada Flight Supplement, "High terrain both sides of runway."

Photo 5-13 - Cape Dorset runway and community, looking southeast

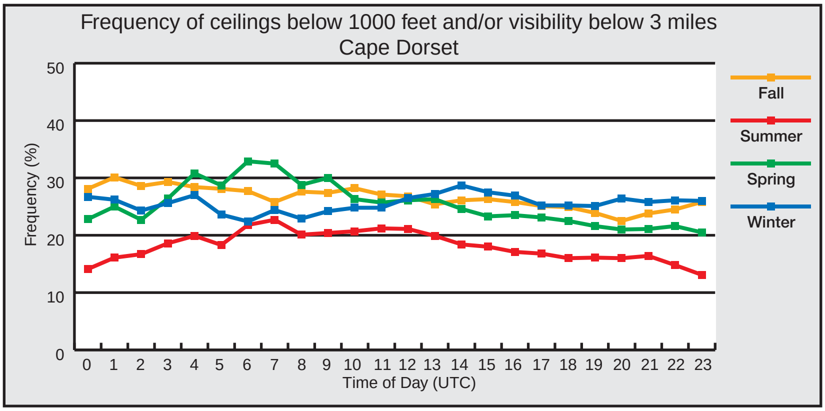
credit: Government of Nunavut Community Government and Transportation





Percent wind 20 knots and greater																Cape Dorset
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.1	0.0	0.1	0.8	0.3	0.2	0.1	0.1	0.1	0.2	1.2	1.5	0.6	0.2	0.1	0.1
WINTER	0.2	0.1	0.1	0.4	0.9	0.4	0.2	0.1	0.2	0.4	0.9	2.8	0.6	0.1	0.1	0.3

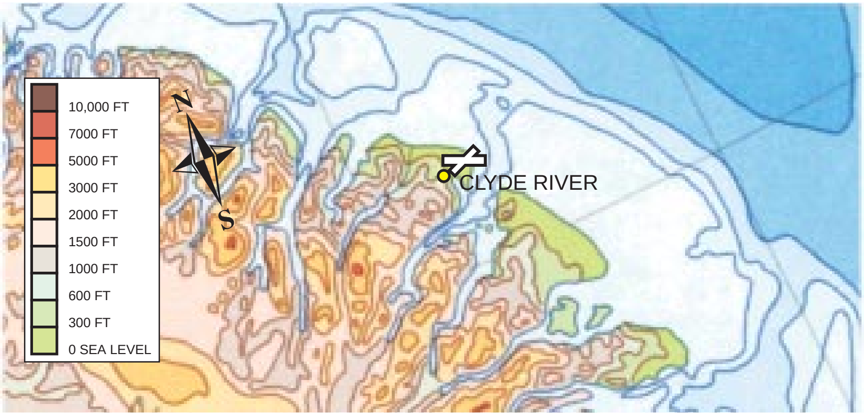
West and west-northwest/west-southwest winds dominate in winter and are still favoured wind directions in summer. Westerly winds, channelled by Mallik and Dorset Islands tend to be strong and gusty. With the unstable regime that arrives following the passage of a low, westerly winds may gust much stronger than expected as they are 'squeezed' through the terrain. It is this pattern that creates winter blizzards. Mechanical turbulence can also be expected.



Cape Dorset's location with respect to the marine regime and the looseness of the ice in Hudson Strait during the frozen season makes the airstrip susceptible to fog and stratus intrusions year round. Flying conditions are at their best through the summer months albeit there is a diurnal trend that shows the best of the summer flying conditions occur in the late afternoon/early evening. With the arrival of fall, conditions deteriorate as the arctic air mass begins to invade the region and low-level moisture is abundant. Intense fall low-pressure systems can give the site strong winds, mixed precipitation and streamers in the cold westerly flow in the wake of the low. In the depth of winter, with full ice cover, it does not take much of a lead/open water area in the ice to produce 'sea smoke' which can easily move over the airstrip.

October and May and to a lesser degree June and September are freezing drizzle months.

Clyde River

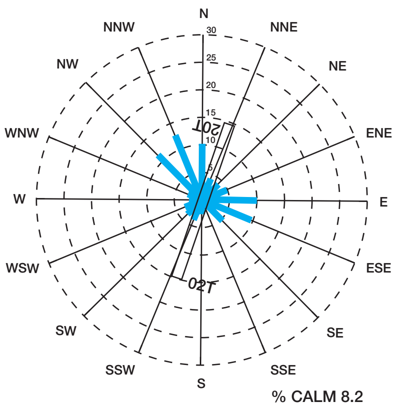


The Clyde airport (elevation is 87 feet ASL) is located less than 2 miles east of the community of Clyde River. It is on the northeast coast of Baffin Island just beyond the foot of Patricia Bay. The waters of Baffin Bay are just over 3 miles east. Terrain in the immediate vicinity is fairly flat except for a hill that peaks at 1,570 feet approximately 4 miles to the south-southeast of the airport. The 500-foot terrain line starts about 2 miles south. Looking west across Patricia Bay, terrain rises to above 500 feet about 4 miles to the west. About 9 miles southwest of the airport, Sawtooth Mountain peaks at 3000 feet. The terrain northwest through north of the airport is fairly flat.

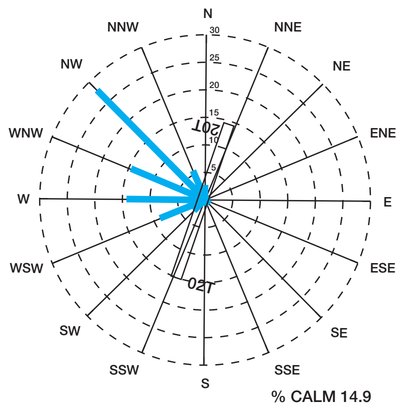
Photo 5-14 - Clyde River, looking west. The airport is just off the photo to the right of the bay

credit: Government of Nunavut, Community Government and Transportation

Clyde River
Wind Frequency by Direction
Summer



Clyde River
Wind Frequency by Direction
Winter

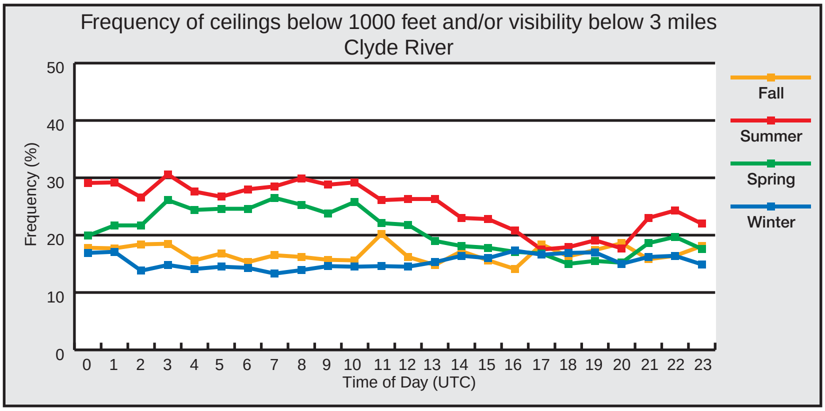


Percent wind 20 knots and greater																Clyde River
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	1.4	0.9	0.1
WINTER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.9	8.3	0.7	0.0

Northwest winds dominate at Clyde River. Winter particularly, strong northwesterly winds develop when a low-pressure system moves northward through Davis Strait and a ridge of high pressure develops west of Clyde along eastern Baffin Island. Higher terrain to the northwest channels the wind along the coast into Clyde River.

The winds usually ease once the low-pressure system has moved to the northeast quadrant of Clyde River.

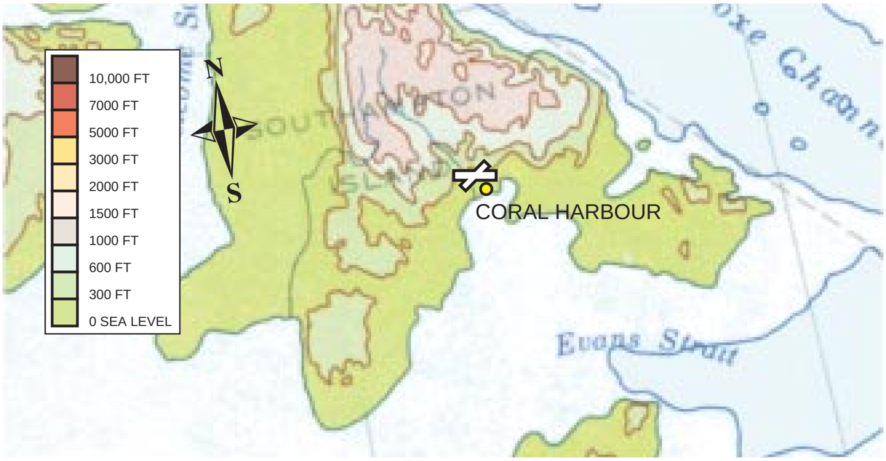
During the frozen season, the strong gusty northwest winds give blowing snow and at times blizzards. On average, Clyde gets 10.7 blizzard events a year. Such north-westerly winds can also occur with a trough of low pressure oriented northwest to southeast across Baffin Bay and Davis Strait. Severe low-level turbulence and wind shear especially around Black Bluff, south of the terminal, can accompany the strong gusty northwest surface winds. Not as common, the passage of a low or trough from west to east over Clyde can bring strong southwesterly winds.



Terrain from northwest through north, northeast and east of Clyde River is flat giving a ready path for fog and low cloud from Baffin Bay to get at the airport. This is a fairly regular occurrence during the open water season; hence the worst flying weather of the year is in summer and, to a lesser extent, in spring. In winter, shorefast ice builds out a distance from Baffin Island into Davis Strait thereby putting open water much farther away.

Diurnally, conditions improve during the day in spring and summer. There is little diurnal variation in fall and winter.

Coral Harbour



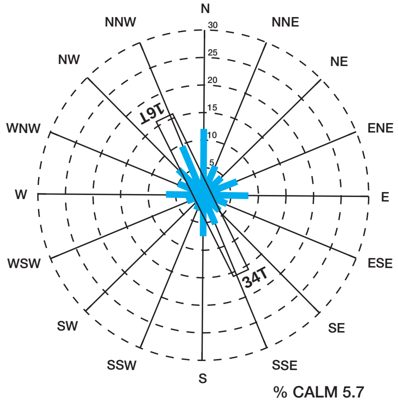
Coral Harbour airstrip (elevation 210 feet ASL) is approximately 2 miles north of South Bay on southwestern Southampton Island. The community is approximately 6 miles southeast of the airstrip. Toward the south through southeast directions, the terrain gradually drops to sea level at South Bay. To the west through northeast, the terrain gradually rises above the 600-foot level beyond about 10 to 15 miles and to 1,500 to 1,800 feet at about 25 miles from the site. The open waters of Hudson Bay lie 155 miles to the south and the Foxe Peninsula on Baffin Island is 170 miles to the east.

Per Canada Flight Supplement, "Radiosonde balloon launches at 1115Z and 2315Z daily."

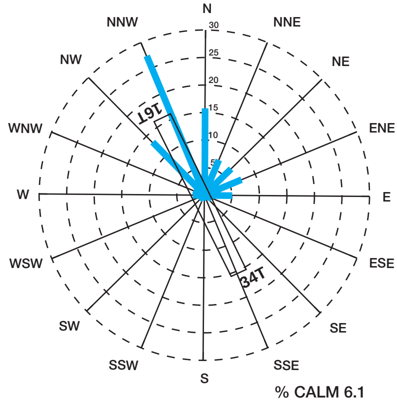
Photo 5-15 - Coral Harbour community, looking northwest toward the airstrip

credit: Government of Nunavut, Community Government and and Transportation

Coral Harbour
Wind Frequency by Direction
Summer

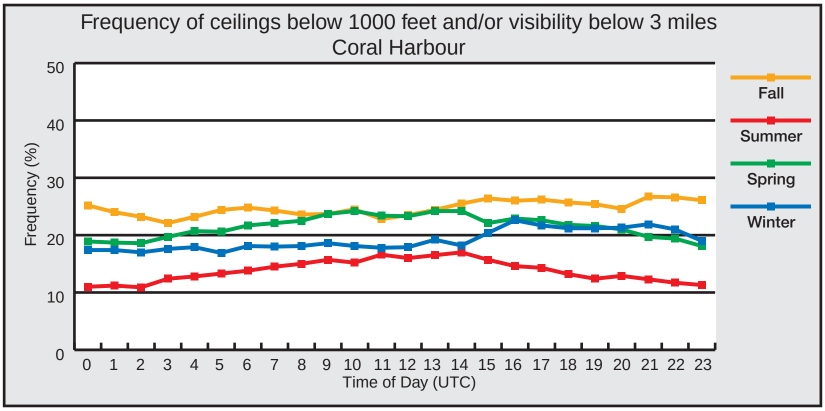


Coral Harbour
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Coral Harbour
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.9	0.8	1.1	0.9	0.1	0.0	0.0	0.1	0.0	0.0	0.2	0.4	0.4	0.6	0.8	1.3
WINTER	1.3	1.3	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.3	1.5

Northwest winds dominate both frequency and strength-wise with their strongest showing in winter. Winds from the east through north-northeast are much less frequent but when they occur they are more likely than winds from other directions to be strong. During the frozen season, strong wind events are routinely accompanied by blowing snow that at times is severe enough to constitute blizzard conditions. Occasionally, a low-pressure system crossing Hudson Bay will cause strong easterly winds and bring low cloud from Hudson Bay across the airport. During such fall events, rain changes to snow as the system passes. Coral Harbour is vulnerable to bouts of low cloud and fog that reside over Hudson Bay when winds are from the southwest through south to southeast.



Weather at Coral Harbour is very much a factor of wind direction and wind strength. Winds off the bay will bring in low ceilings and fog, spring and fall particularly. On the contrary, a northerly flow off the terrain to the north is a subsidence flow that has left most cloud on the north side of Southampton Island. Therefore, even though there may be low cloud encircling the island the Coral Harbour airport site will often have clear skies. Per the graph, there is a tendency during the spring and summer with open water and maximum air-water temperature contrasts, to encounter low ceilings and fog especially during the late night into early morning hours. After a strong blow in the winter from the north or northwest the ice edge will separate from the fast ice and open water is created. Strong northerly winds may also feed a layer of ice crystals across Coral Harbour that lowers the visibility but not to the point that it shows up on the graph. Sea smoke can advect over the site creating ice fog. The graph shows that most favourable flying conditions occur during summer afternoons and early evenings.

October and to a lesser degree May are prime freezing drizzle months.

Eureka

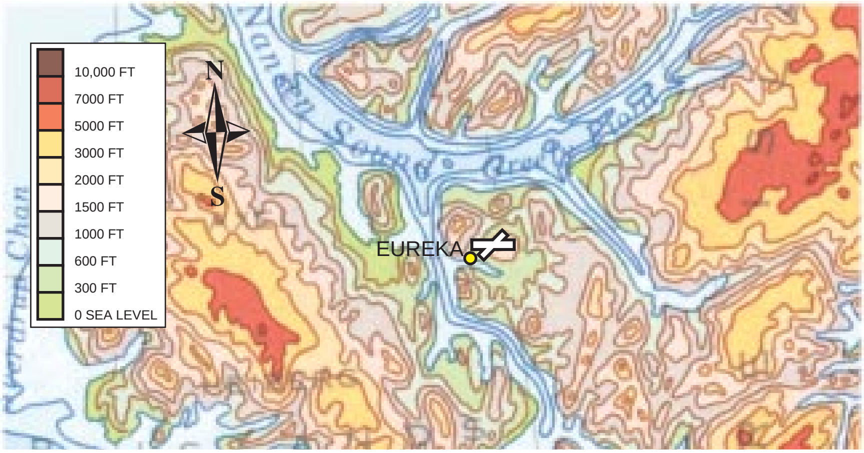


Photo 5-16 - Hercules landing at Eureka, March 2003 credit: Rai LeCotey

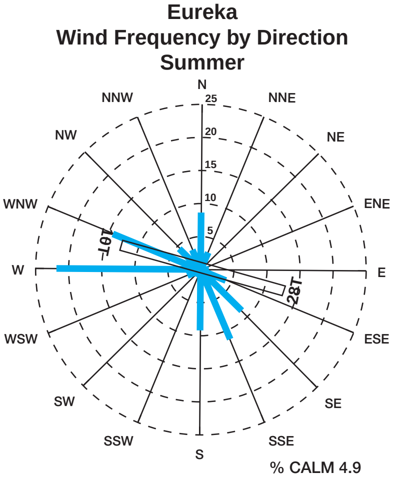
Note: Weather information cited for Eureka is that for the weather station (elevation 46 feet). The airstrip (elevation 256 feet ASL) is just over a mile east of the weather station. Weather from the weather station may not be representative of that at the nearby airstrip.

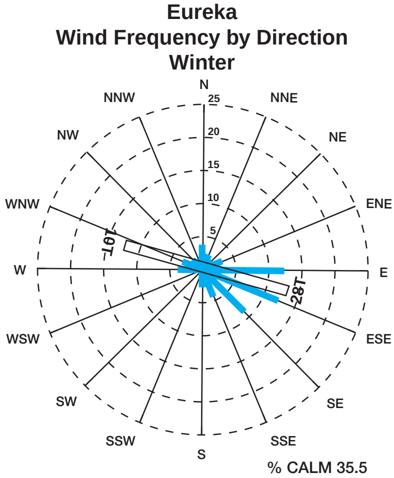
Eureka is a Meteorological Service of Canada weather station located in the northwest section of Fosheim Peninsula, on Ellesmere Island, in the northern Canadian Arctic. The weather station is situated on the north shore of Slidre Fiord, approximately 7 miles east of Eureka Sound. The airstrip is just over one mile to the east. The general terrain in the vicinity of the station is quite hilly with many ridges and valleys. At the mouth of Slidre Fiord, on its southern shore, a ridge rises at Hare Cape and runs parallel to Eureka Sound approximately 15 miles south to Blue Man Cape.

The maximum elevation along this ridge approaches 2,050 feet. The ridge slopes gradually eastwards to a broad valley, south of the head of the fiord, and then rises again to a peak of over 2,250 feet approximately 30 miles east-southeast of the station. To the northwest, the terrain rises to 2,190 feet, about 7 miles from the station and then falls northward toward Greely Fiord, about 12 miles away. To the northeast, Black Top Ridge, aligned in a southwest to northeast direction, reaches a height in excess of 2,775 feet, about 9 miles from the site.

Per Canada Flight Supplement, "Radiosonde balloon launches at 1115Z and 2315Z daily."

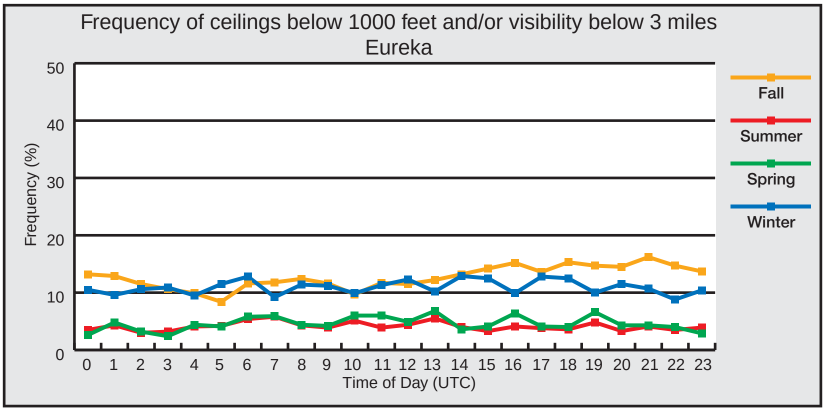
Photo 5-17 Eureka weather station and airstrip, looking northeast credit: Chris Gartner





Percent wind 20 knots and greater																Eureka
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.1	0.0	0.0	0.0	0.1	0.3	0.9	1.1	0.0	0.0	0.0	0.2	0.1	0.1	0.6	0.5
WINTER	0.2	0.1	0.0	0.1	0.2	0.4	0.3	0.3	0.0	0.0	0.0	0.3	0.3	0.1	0.2	0.7

The surrounding terrain and its location along Slidre Fiord influences winds at Eureka. Calm winds dominate. The site is protected from northwesterly winds by hills. The dominant direction in winter is from the southeast while in summer west/west-northwest and southeasterly wind directions share direction dominance. Winds at times blow strong from most directions.



The flying weather at Eureka, when compared with other sites in the Canadian Arctic, is good. Spring and summer show particularly favourable flying conditions. Late summer and early fall, as darkness arrives and cooler air moves over the area, fog and stratus are a little more frequent and there is the occasional period of snow to reduce visibility and lower ceilings.This gives late summer and early fall the worst flying conditions of the year. Once the water has frozen completely things begin to stabilize as cold arctic air takes over for the winter. In winter, light wind regimes and very cold surface temperatures at Eureka make Eureka a prime location for ice crystals and ice fog. Spring brings a return of the sun and the start of the melting seasons. Open leads from the surrounding water can produce fog and stratus which can move into the station from the west or southeast.

Albeit rare, September, during freeze-up is the month for patchy freezing drizzle.

Gjoa Haven

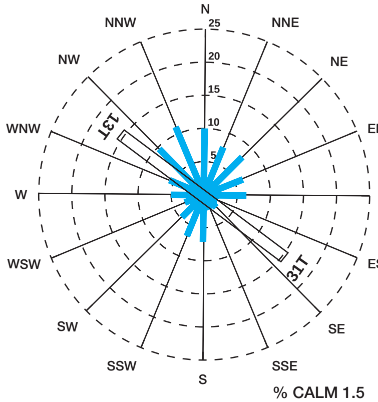
The Gjoa Haven airstrip (elevation 152 feet ASL) is located just northeast of the community. The airstrip and the community lie on the southeast coast of King William Island near the southern tip of the Neumayer Peninsula. Schwatka Bay lies just east of the airstrip while a small bay that borders the community lies just to the southwest of the airstrip. Terrain to the east drops to less than 100-feet while a narrow 100 foot ridge runs north about 7 miles.

Photo 5-18 - Gjoa Haven community and airstrip looking northeast

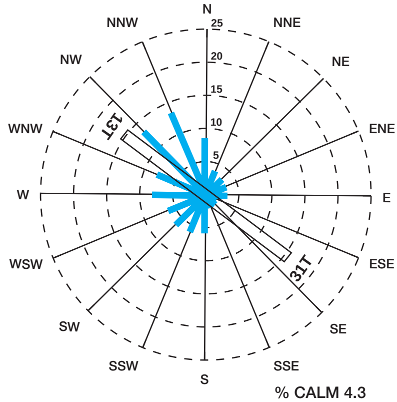
credit: Government of Nunavut, Community Government and

Transportation

Gjoa Haven
Wind Frequency by Direction
Summer

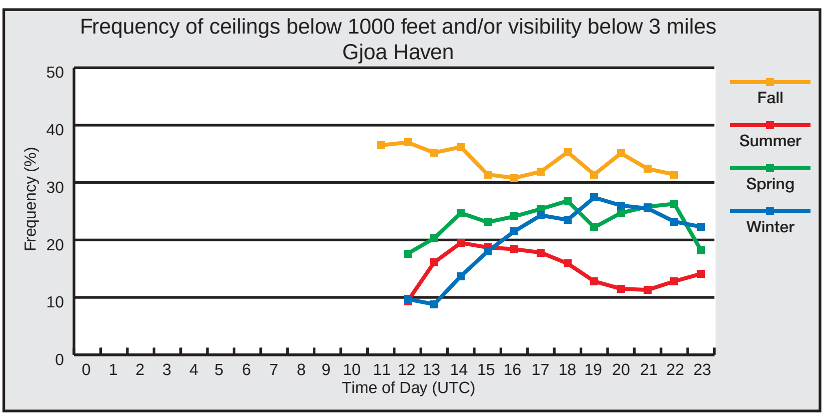


Gjoa Haven
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Gjoa Haven
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.2	0.7	0.6	2.0	2.0	1.2
WINTER	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.5	0.1	0.1	0.0	0.1	0.3	2.1	1.9	0.5

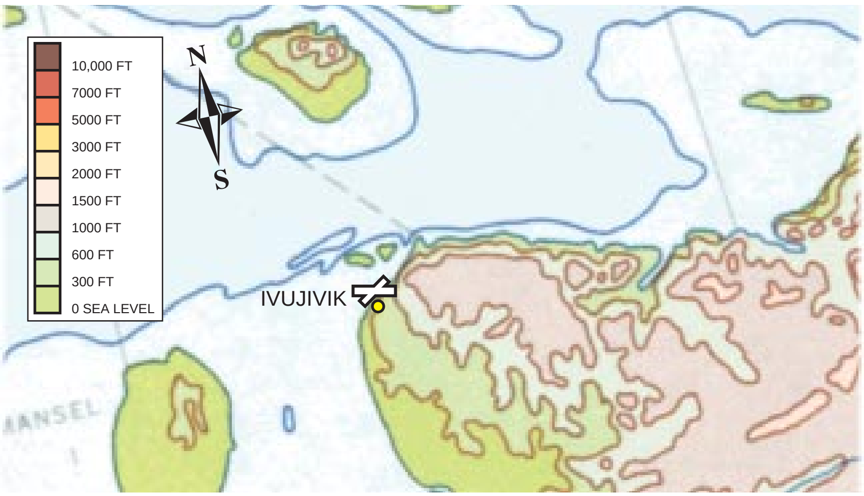
Gjoa Haven is one of the few locations in Nunavut where winds behave based on the synoptic situation due to the surrounding flat terrain. The prevailing wind directions are northwest and north-northwest and these winds routinely blow strong. Blowing snow and blizzard conditions are common in the winter months with these winds.



Ceilings below 1000 feet and/or visibility below 3 miles are most evident during the fall but are quite prevalent during the spring also. In the winter, strong northwest winds and resultant blowing snow/blizzard conditions are the primary causes of ceilings below 1000 feet and/or visibility below 3 miles. Summer afternoons show as having the most favourable flying weather. However, a diurnal trend is evident in the summer with the likelihood of fog and stratus more prevalent in the early morning hours.

October followed by September and then May are the most likely months to experience freezing drizzle.

Ivujivik

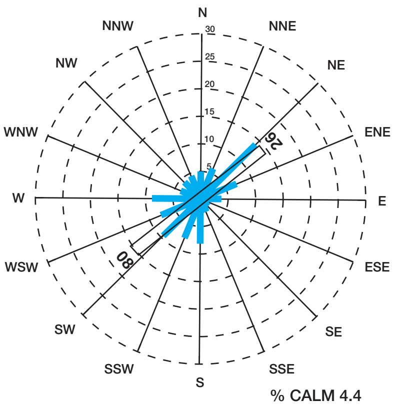


The Ivujivik airstrip (elevation 139 feet ASL) is surrounded in the immediate area by flat land to the south and the east, and with water to the north and west. Higher terrain, rising to 575 feet, lies about 2 1/2 miles southeast.

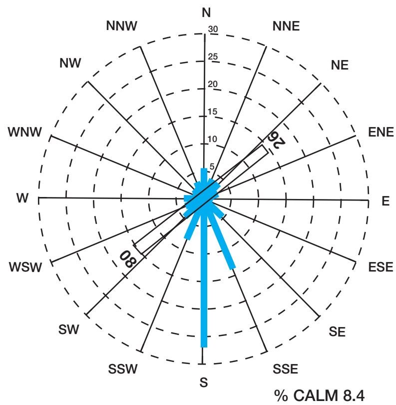
Per Canada Flight Supplement, "Discrepancy between reported wind and actual wind from southern quadrant due to surrounding terrain."

Photo 5-19 - Ivujivik, looking northwest — credit: Transport Quebec, Northern Quebec Region

Ivujivik
Wind Frequency by Direction
Summer

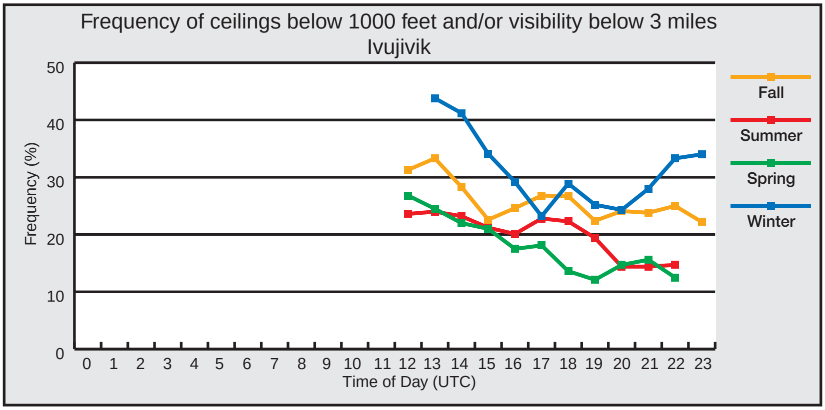


Ivujivik
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Ivujivik
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.4	1.0	0.4	0.1	0.3	0.6	0.5	2.0	1.6	0.7	0.5	0.2	0.1	0.3	0.2	0.1
WINTER	0.7	0.6	0.2	0.1	0.3	1.8	3.4	5.6	0.9	1.0	0.4	0.2	0.2	0.4	0.6	0.7

In winter, south-southeast and south winds are dominant and are routinely strong. Indeed 25 percent of winds from the south-southeast and 21 percent of the winds from the south are 20 knots or stronger. The south through southeast winds result when troughs or lows are approaching Ivujivik from the west or southwest. In summer, northeast winds are the most frequent winds. As in winter, summer winds at Ivujivik blow strong at times from all directions including northwesterly winds behind a cold front. In summer, south winds when they blow show as being 20 knots or more 25 percent of the time while 20 percent of summer south-southwest winds show as being 20 knots or more.



Fog is frequent during the ice-free months. The waters along the coastline freeze solid by the end of January. Spring and summer flying conditions are favourable with the best conditions in April. Ivujivik shows a strong diurnal trend year round with best flying conditions occurring through the afternoon.

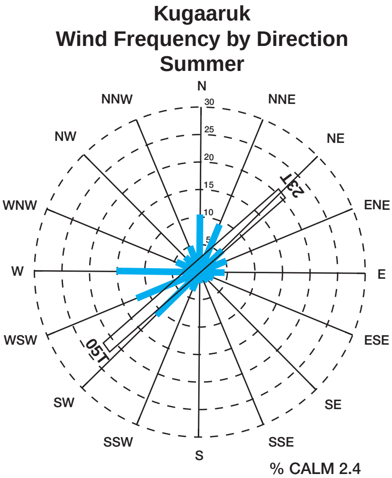
Kugaaruk (Pelly Bay)

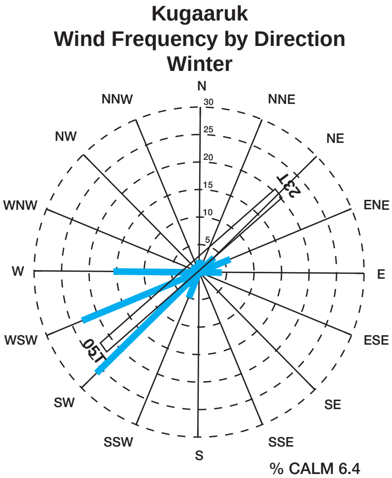
The Kugaaruk airstrip (elevation 56 feet ASL) extends northeast from east of the community. Kugaaruk is located on the western side of Simpson Peninsula. To the west-northwest through south-southwest lies Pelly Bay. About 4 miles north of the site, the terrain rises to 600 feet with the first 300-foot rise occurring in less than

1 mile. To the south-southeast, the terrain rises to 600 feet in less than 2 miles. To the northeast lies a valley with the elevation gradually rising to about 100 feet within 10 miles. As well, a secondary valley lies north-northeast of the settlement.

Photo 5-20 - Kugaaruk community and airstrip, looking southeast

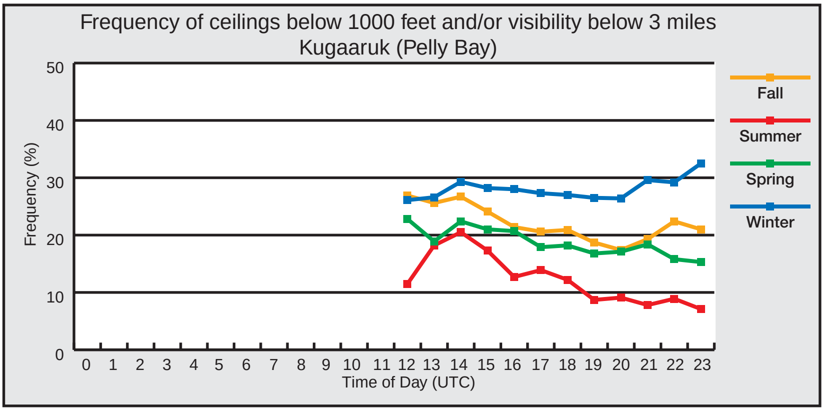
credit: Government Nunavut, Community Government and Transportation





Percent wind 20 knots and greater																Kugaaruk
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.1	0.1	0.2	0.1	0.2	0.3	0.1	0.2	0.1	0.0	0.1	0.5	0.5	0.3	0.3	0.6
WINTER	0.1	0.0	0.1	0.1	0.0	0.2	0.0	0.2	0.4	1.6	0.7	0.8	0.2	0.1	0.1	0.5

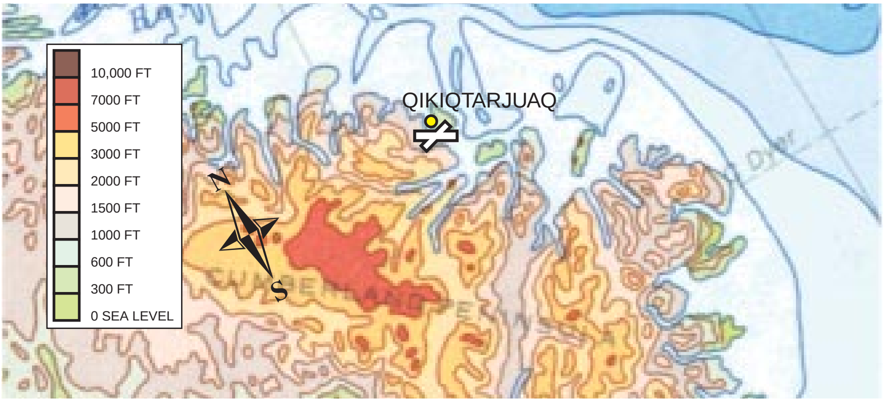
Hills to the north and south of the station deflect wind flow while the terrain to the southwest is relatively flat. As a consequence, prevailing wind directions year-round are west-southwest and southwest. Surface winds from the southwest can readily gust to speeds greater than speeds aloft due to the channelling effect of the southern hills. Blowing snow and blizzards are most frequently linked to strong west to southwest winds. Occasionally, with a low-pressure system southeast of Kugaaruk, easterly winds will give blowing snow.



Ceilings below 1000 feet and/or visibility below 3 miles are most common in the winter months with blowing snow. There is a durinal improvement in ceilings and visibilities throughout the year with the best flying conditions in the late afternoon and early evening.

Albeit rare, May to October are months when freezing drizzle occurs.

Qikiqtarjuaq (Broughton Island)

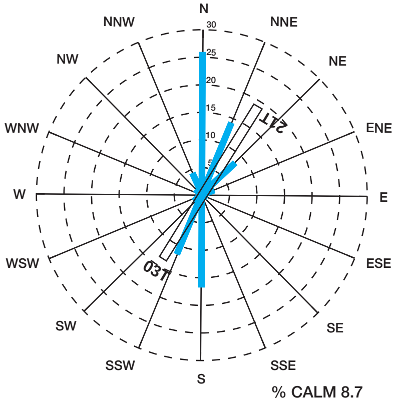


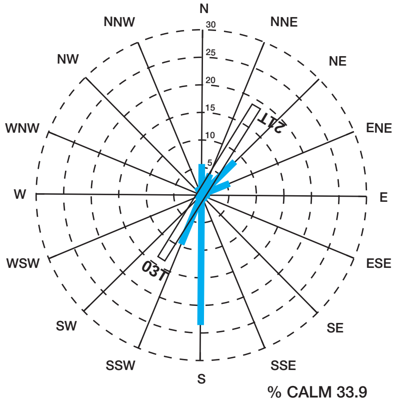
Qikiqtarjuaq is located on Broughton Island on the east coast of Baffin Island adjacent to Davis Strait. The island is about 16 miles long and 14 miles wide rising to a maximum elevation of 2,500 feet ASL. The general terrain is mountainous with several steep slopes. The community is located on the west side of the island, near the airstrip elevation. Several large islands are located to the south of Broughton Island and a large peninsula of Baffin Island projects into Davis Strait approximately 30 miles to the south. The airstrip (elevation 21 feet ASL) is located adjacent to the village on the west side of the island and is oriented in a northeast-southwest direction. Numerous hills around the airstrip tend to make wind observations variable and in strong wind events turbulence may be a problem.

Per Canada Flight Supplement, "Northwest edge of northern apron bordered by water."

Photo 5-21 - Qikiqtarjuaq community, looking east (airstrip starts lower right).

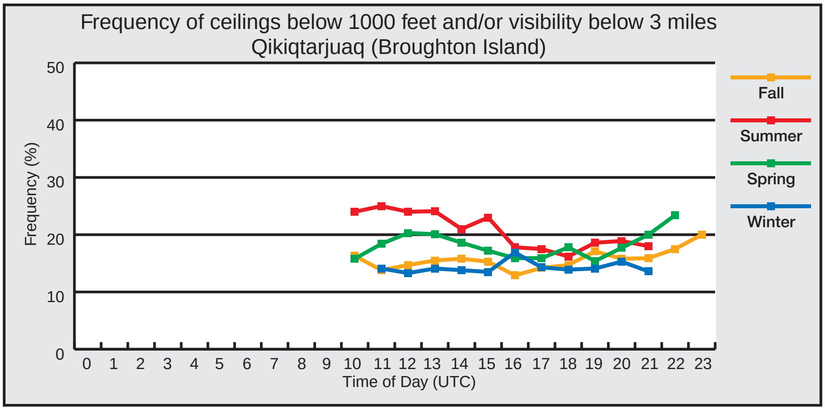
credit: Government of Nunavut, Community Government and Transportation





Percent wind 20 knots and greater																Qikiqtarjuaq
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
WINTER	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2

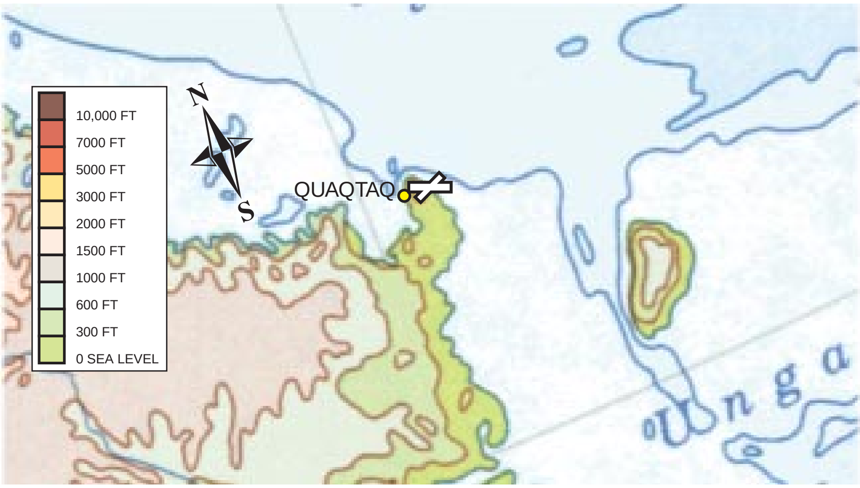
Qikiqtarjuaq is not a windy place in sharp contrast to the winds over adjacent higher terrain where, summer and winter, northwesterly winds that are often strong dominate. At Qikiqtarjuaq, 35 percent of winter winds and 22 percent of summer winds are calm. Winter winds favour south and south-southwest and to a lesser degree northeast directions. In summer, south and south-southeast winds share direction dominance with north, north-northeast and northeast winds.



Only recently has the site started to report 24-hour weather with manned observations and automatic observations during off-hours. During spring and summer, the graphs show a tendency for low ceilings and visibilities overnight and to as lesser degree during the evening hours. The most favourable flying conditions occur during the afternoon hours of all seasons.

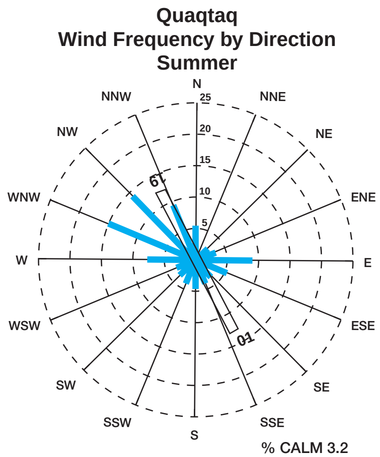
Albeit rare, April to November are months when freezing drizzle occurs.

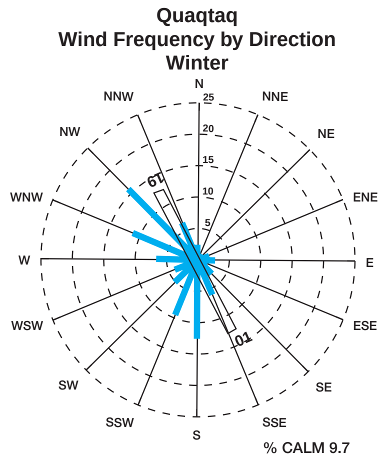
Quaqtaq (YHA)



Quaqtaq airstrip (elevation 104 feet ASL) is situated on the north-western tip of Cape Hopes Point. The waters of Hudson Strait surround it from most directions. Terrain in the area is flat.

Photo 5-22 - Quaqtaq, looking west credit: Transport Quebec, Northern Quebec Region

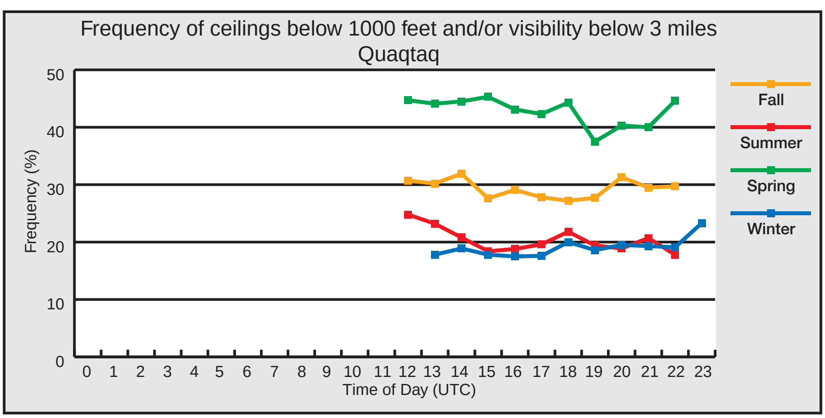




Percent wind 20 knots and greater																Quaqtaq
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.1	0.1	0.5	2.9	0.6	0.2	0.5	0.4	0.2	0.0	0.1	0.1	0.7	0.6	0.1	0.0
WINTER	0.0	0.1	0.6	0.8	0.5	0.3	0.2	0.6	0.2	0.1	0.2	0.3	1.8	4.5	1.5	0.2

Winds at Quataq are at times strong from all directions. In winter, northwest winds are the most frequent followed by west-northwest and south winds. In winter northwest winds occur 16 percent of the time and three-tenths of these winds are 20 knots or stronger. In summer, northwest and west-northwest winds are again dominant direction-wise but tend to be much gentler. South winds which made their presence known in winter, become just one of the crowd of other wind directions. East winds in summer occur about 9 percent of the time and about three-tenths of these winds are 20 knots or stronger

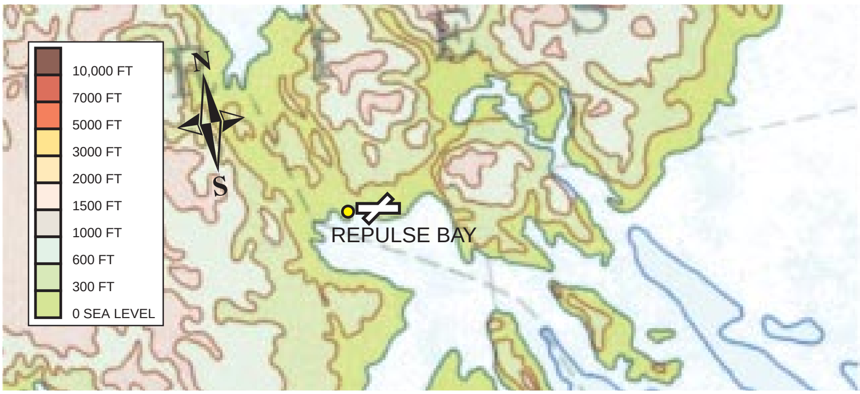
Pilots cite that turbulence occurs very rarely in Quaqtaq.



With Hudson Strait surrounding and low terrain, Quaqtaq experiences extensive fog or low cloud (ceilings 400 to 500 feet AGL) during the ice-free season, with a temperature-dew point spread of only one degree for long periods of time. An inversion tends to persist over the area due to the cold temperatures of the land and water so that Quaqtaq tends to remain shrouded in fog banks even with high winds. Nor does the weather show much of a diurnal trend.

Spring arrives very late, usually in the latter half of June, several weeks after surrounding localities. Icebergs can sometimes be found stuck between Quaqtaq and Hearn Island, or in Diana Bay.

Repulse Bay



The community of Repulse Bay is located along the north shores of Repulse Bay with the airstrip elevation at about 80 feet ASL. Terrain toward the north to east-northeast is the most rugged with several hills and ridges rising above 400 to 600 feet beyond about 10 miles from the site. Beyond about 25 miles in these directions, hills rise above 1,000 feet. To the northwest, lies the Rae Isthmus, a 50-mile strip of land between Repulse Bay and Committee Bay. In the immediate vicinity of the community, there is a valley that runs in a north-to-south direction and a ridge that runs northwest to southeast.

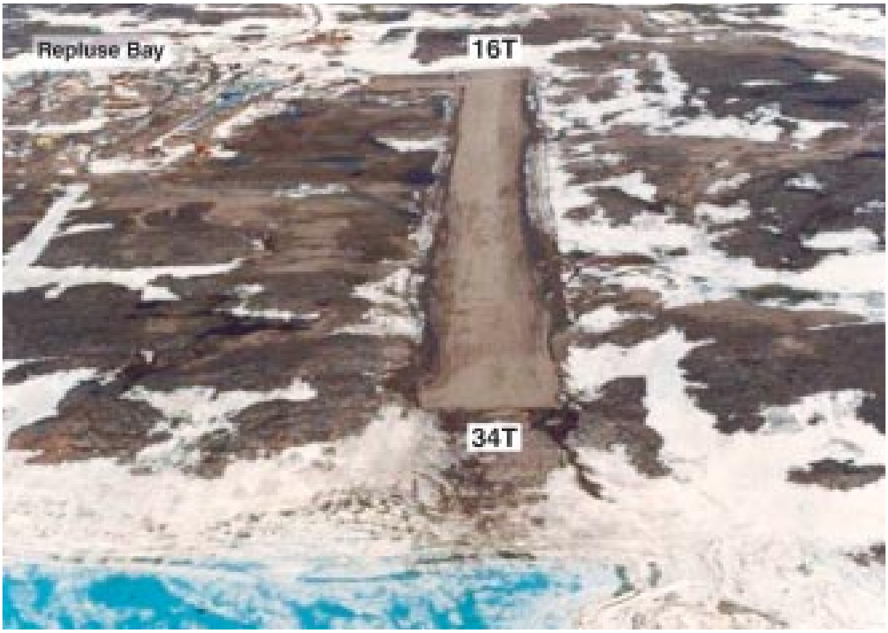
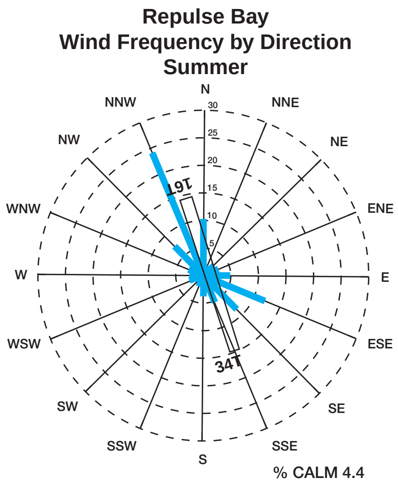
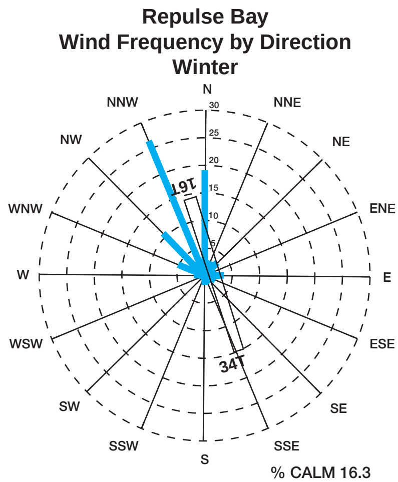


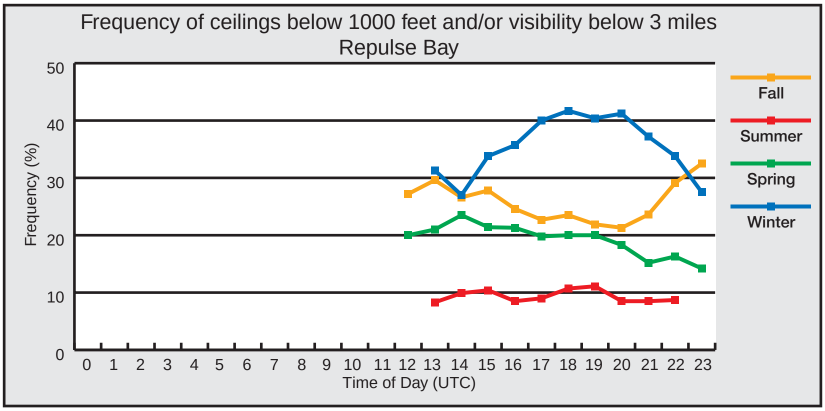
Photo 5-23 - Repulse Bay, looking north-northwest credit: Chris Gartner





Percent wind 20 knots and greater																Repulse Bay
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.1	0.1	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6	4.3	1.2
WINTER	0.1	0.3	0.2	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	8.7	5.2

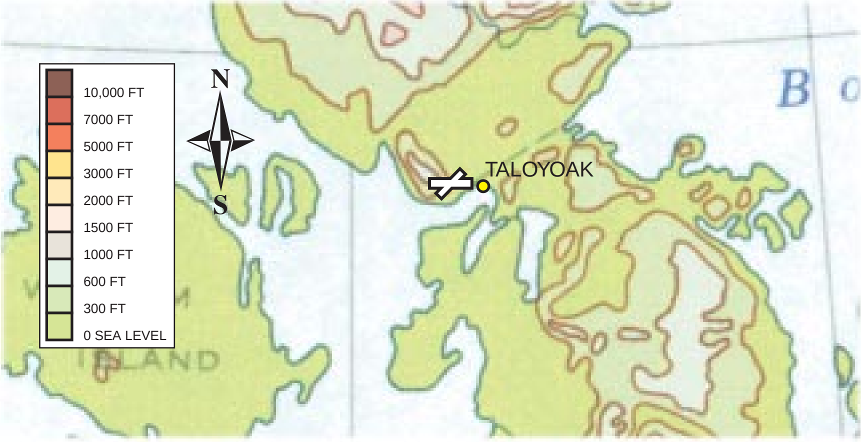
Repulse Bay resides in the area that routinely has high-pressure systems to its west and low-pressure systems to its east. Such a regime favours northwest winds. Summer and winter, north-northwest winds and to a lesser degree north and northwest winds dominate both direction and speed-wise. Thirty-three percent of winter and 18 percent of summer north-northwest winds are 20 knots or stronger. In winter, these northwest winds routinely give blowing snow/blizzards.



The graph shows the dominance of poor flying weather in winter due primarily to blowing snow and blizzards. Similar to many other Nunavut sites, the poorest winter conditions show as occurring mid day. The other seasons show the expected diurnal trend of conditions improving through the morning such that the most favourable flying weather occurs during afternoon hours. The best flying conditions are in the summer with only a 10 percent showing of ceilings below 1000 feet and/or visibility lower than 3 miles.

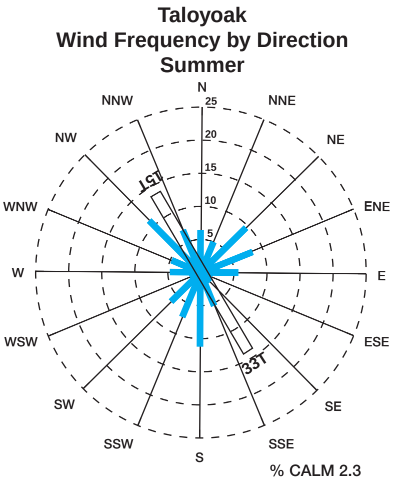
October is the most likely month to experience freezing drizzle.

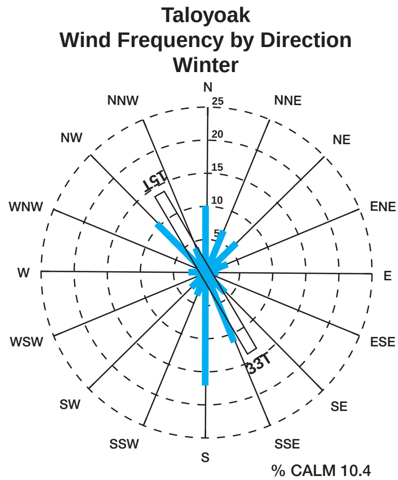
Taloyoak



Taloyoak, formerly known as Spence Bay, airstrip (elevation 91 feet ASL) is located at the northeast end of Spence Bay along the southern tip of the Boothia Peninsula in the area known as the Boothia Isthmus. Several miles to the north, east and south hills rise to near or greater than 1,000 feet. Closer to the community, the terrain rises to above 600 feet about 6 miles to the southeast and a ridge rises above 200 feet to the east. Towards the northeast lies a shallow valley while the terrain rises to just above 200 feet at about 4 miles to the north. Beyond about 10 miles to the west and southwest the terrain rises above 600 feet.

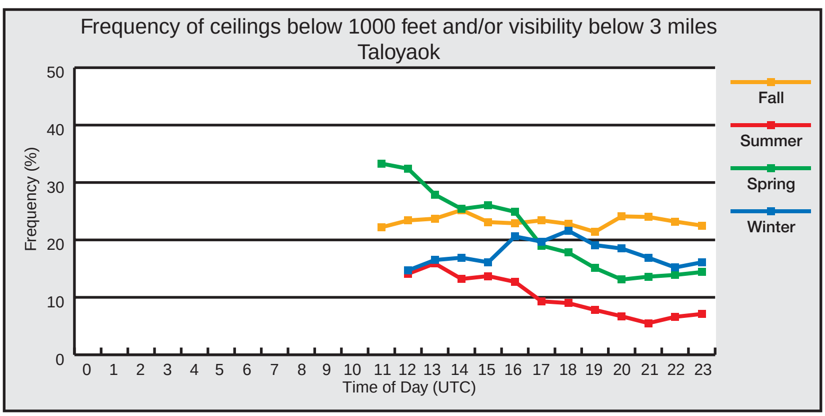
Photo 5-24 - Taloyoak, looking west credit: Chris Gartner





Percent wind 20 knots and greater																Taloyoak
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.3	0.3	0.3	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.4	0.5	2.3	0.8	0.3
WINTER	0.2	0.7	0.5	0.2	0.0	0.1	0.2	0.4	0.1	0.1	0.0	0.1	0.2	3.3	0.5	0.1

The most frequent winds in winter are south winds. However, it is the northwest and north-northwest winds that, when they blow, are routinely strong and generate blowing snow and blizzards. When Gjoa Haven is blizzarding from the northwest, Taloyoak often is not. Rather, it is northeast winds in winter, albeit not common, that often lead to blowing snow/blizzard events as Taloyoak is exposed from that direction. Strong winds, when from the south are often accompanied with precipitation and low ceilings as they are usually linked to the approach of a low-pressure system from the arctic islands or the Mackenzie.

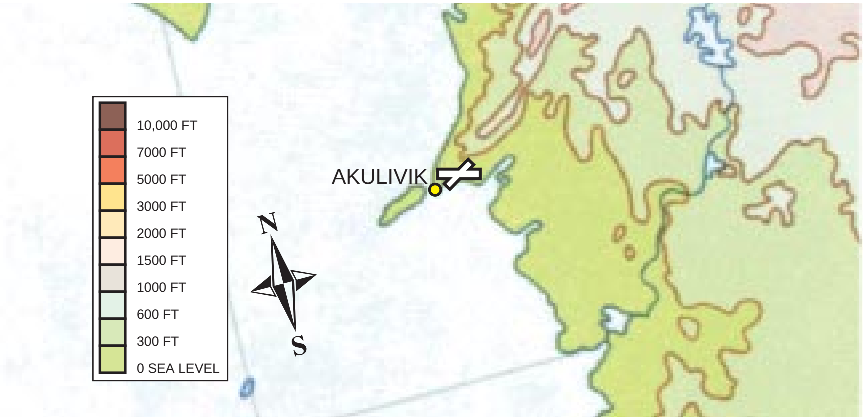


Spring brings warmer air masses and with added moisture over snow and ice covered surfaces, low cloud becomes abundant particularly overnight. Spring shows a strong diurnal trend with conditions improving significantly by mid afternoon. The frequency of low cloud and fog decreases through the summer months especially during the afternoon hours. Fall brings the onset of low ceilings once again as cold air advects down over the relatively warm water creating low cloud in particular. Blowing snow and, to a lesser degree, blizzards contribute to the frequency of poor flying weather in winter.

Patchy freezing drizzle is an October and May occurrence.

Other airport sites

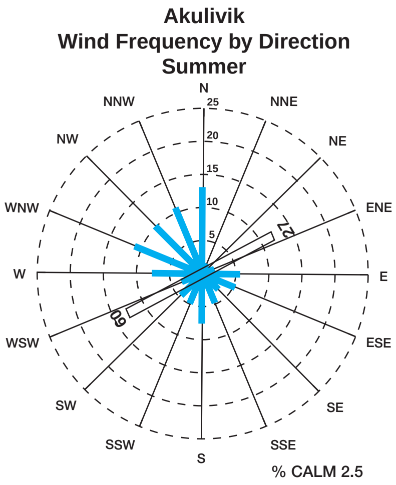
Akulivik

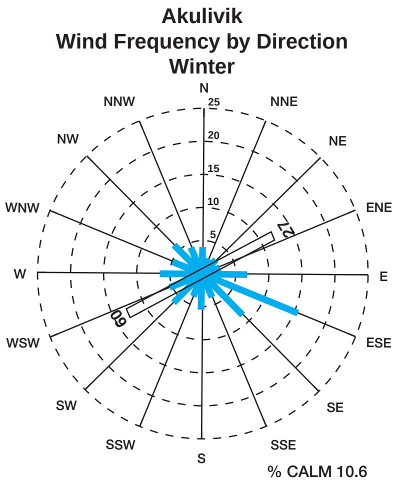


Akulivik airstrip (elevation 66 feet ASL) is situated on Chanjon Point, on the western tip of the d'Youville Mountain Range. The waters of Hudson Bay freeze for a good distance to the west.

Photo 5-25 - Akulivik, looking west

credit: Transport Quebec, Northern Quebec Region

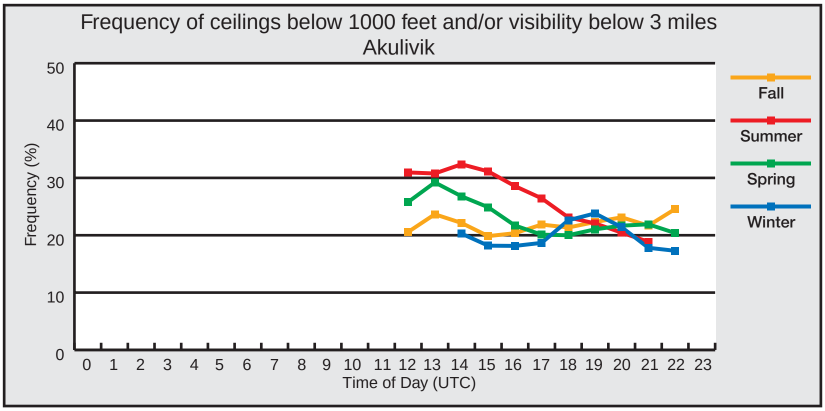




Percent wind 20 knots and greater															Akulivik
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.2	0.1	0.1	1.1	1.1	0.1	0.2	0.6	0.3	0.1	0.1	0.3	0.4	0.5	0.8	1.3
WINTER	0.3	0.1	0.0	1.9	2.9	1.1	0.6	0.7	0.5	0.2	0.4	0.2	0.6	0.9	0.8	0.8

In winter, east-southeast winds are the most frequent and 28 percent of them are 20 knots or more. Winter north through west-northwest winds are less frequent but 13 to 20 percent of them are 20 knots or more.

In summer, close to half the winds come from the north through west-northwest direction and can at times be strong. East and east-southeast winds are much less frequent in summer than in winter. However, they retain a strong inclination to blow strong with about 20 percent of the summer east and east-southeast winds blowing at 20 knots or more.



Stratus ceilings 500 to 600 feet ASL are common, summer overnight and summer morning in particular.

Winter and fall show as having the most favorable flying conditions. Fall storms can however bring bouts of strong winds and visibility restricting snow. Winter brings strong winds and blowing snow that at times meet blizzard criteria.

Arctic Bay

The Arctic Bay airstrip (elevation approximately 100 feet ASL) lies about 4 miles southeast of the community of Arctic Bay. The community lies on the north-northwestern shore of Arctic Bay while the airstrip is on the southeastern shore of the bay. The bay is ringed by mountains ranging in height from about 1,500 feet to 2,170 feet, but opens into Adams Sound to the south, and in turn opens to Admiralty Inlet. About 8 miles away from Arctic Bay airstrip and up on an exposed plateau is the Nanisivik airstrip (elevation 2,106 feet).

There is no weather-observing program at the Arctic Bay strip. Up to the 1970's, there was an observation program done out of the Hudson Bay Company facilities in the community. In 1999, a Meteorological Service of Canada automatic weather station was installed near the fresh water lake where the community draws its water. It is limited to basic weather elements of wind, air temperature and dewpoint.

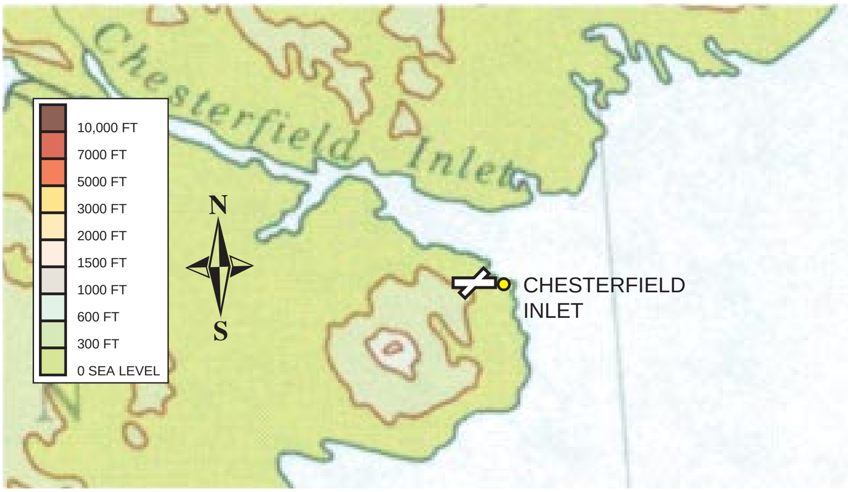
Photo 5-26 Arctic Bay community, looking north. Airstrip lies 4 miles to the right (off photo)

credit: Government of Nunavut, Community Government and Transportation

Intense winds appear to occur in a southeasterly flow and are due to a combination of a strong pressure gradient, channeling down Adams Sound and a corner effect around the edge of King George V Mountain (summit of about 1,900 feet) to the east of the Arctic Bay community/northeast of the airstrip. These intense winds are more marked at the higher elevations to the north and west of the community.

Cloud over the area can routinely give weather that is different at the Arctic Bay airstrip from that at the Nanisivik airstrip. Take for example a deck of stratocumulus cloud based at 1,500 feet and topped at 2,500 feet ASL. This would be a ceiling of 1,400 feet at the Arctic Bay airstrip (elevation 100 feet) but plateau shrouding fog at Nanisivik airstrip (elevation 2,106 feet).

Chesterfield Inlet

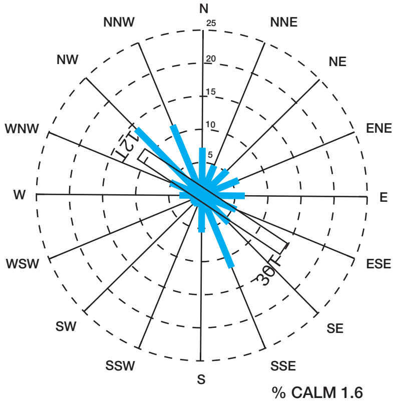


Chesterfield Inlet airstrip (elevation 40 feet ASL) is located on the western shores of Hudson Bay.

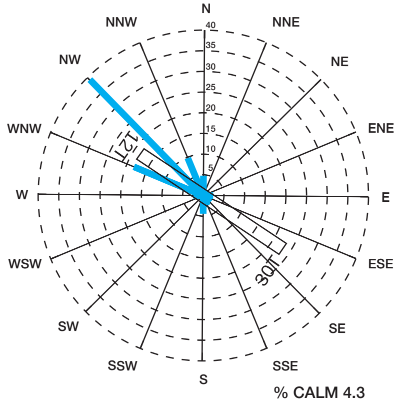
Photo 5-27 - Chesterfield Inlet, looking north credit: Government of Nunavut, Community Government and

Transportation

Chesterfield Inlet
Wind Frequency by Direction
Summer



Chesterfield Inlet
Wind Frequency by Direction
Winter

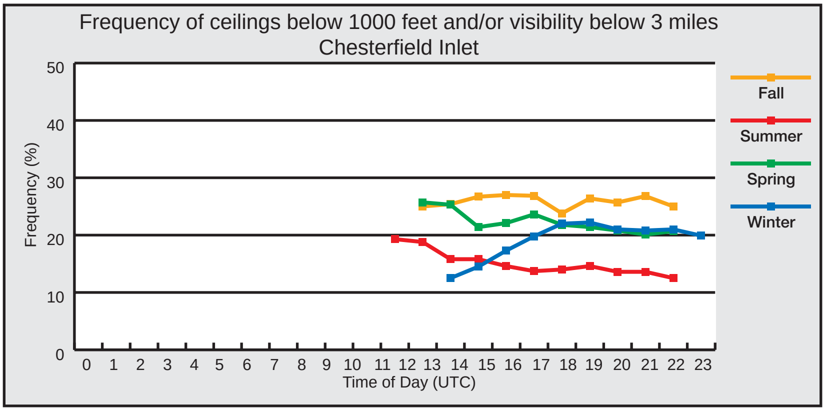


Percent wind 20 knots and greater																Chesterfield Inlet
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.1	0.3	0.6	0.2	0.1	0.1	0.0	0.4	0.2	0.2	0.1	0.4	1.2	2.4	1.5	0.3
WINTER	0.5	0.1	0.2	0.3	0.3	0.4	0.3	0.6	0.1	0.1	0.2	0.5	4.2	7.8	0.9	0.3

In winter at Chesterfield Inlet, west-northwest and northwest wind dominate both direction and speed wise.

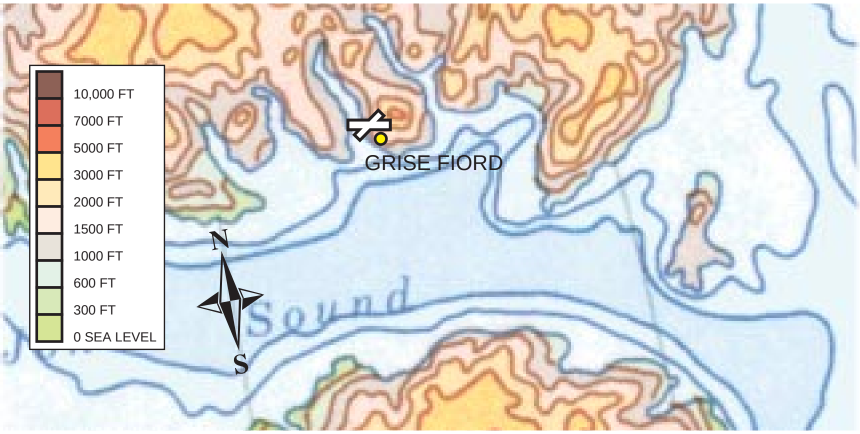
In summer, south-southeast winds of a gentle nature compete for direction dominance. Also in summer, it is north-northwest winds rather than west-northwest winds which join the ever powerful northwest winds in direction and strength dominance.

During the winter, northwest winds occur about 40 percent of the time and about one-fifth of these northwest winds are 20 knots or stronger. During the summer, northwest winds occur about 14 percent of the time and one-sixth of them are 20 knots or stronger.



Summer is the most favorable time of year at Chesterfield Inlet with respect to flying weather. Spring and fall with their bouts of low cloud, and at times fog off Hudson Bay, and winter with periods of blowing snow/blizzards show poorer flying weather. May, October and November are months when freezing drizzle will, on occasion, be experienced.

Grise Fiord



The Grise Fiord airstrip (elevation 146 feet ASL) is located at the bottom of a valley between two plateaus which rise over 2,000 feet and adjacent to Jones Sound. The local wind regime, surface and low level is very tricky and can be dangerous. With strong pressure gradients on the weather map, reported winds at Grise Fiord will be all over the place peaking at times to very strong.

Per Canada Flight Supplement, "Only operators with considerable experience in area should plan on using this aerodrome due to the unusual approach path, surrounding terrain and variable local conditions."

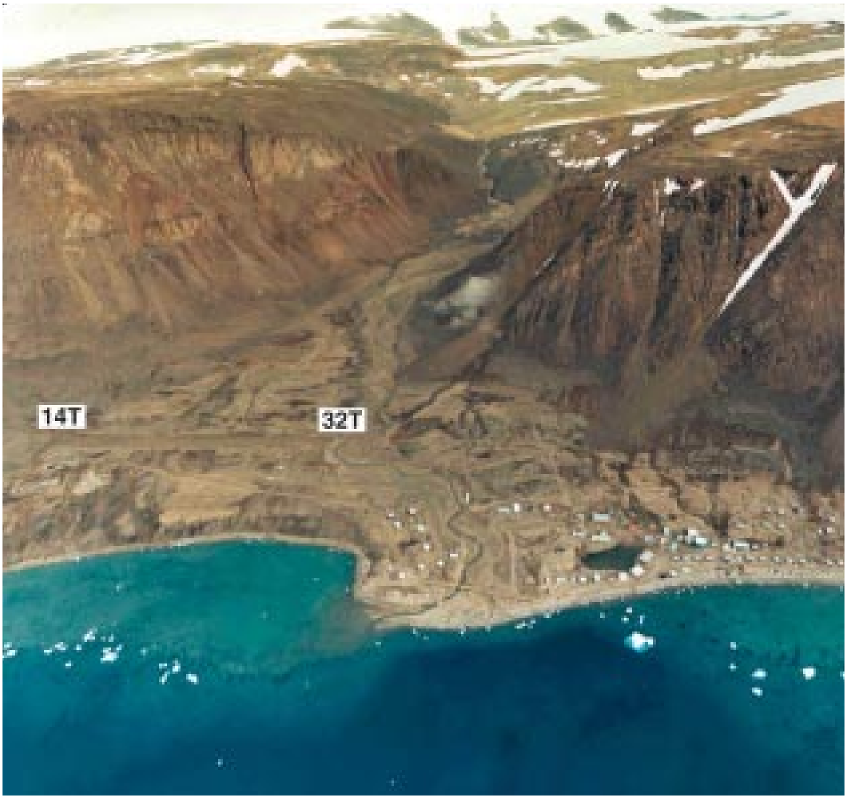
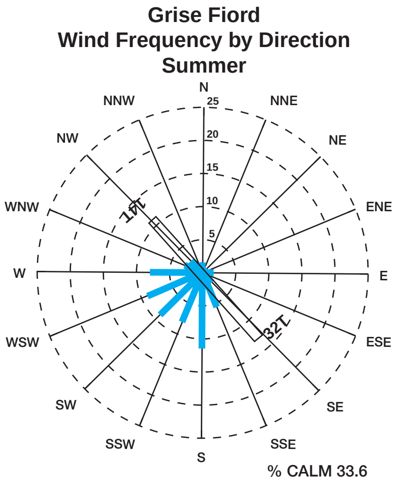
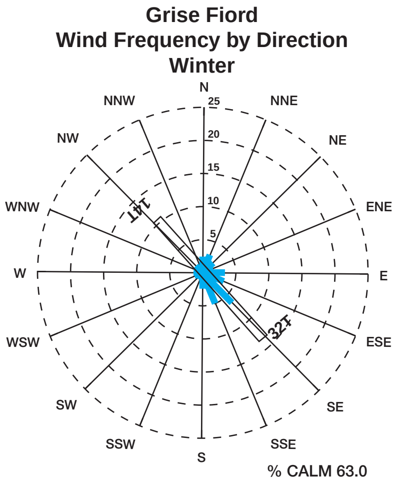


Photo 5-28 - Grise Fiord, community and airport, looking northeast

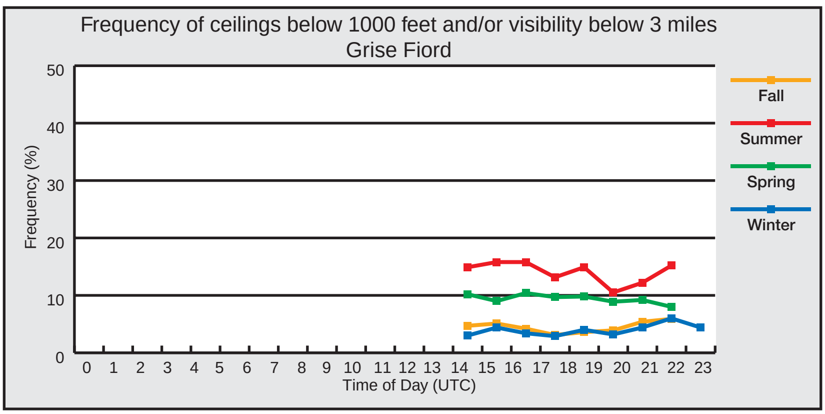
credit: Government of Nunavut, Community Government and Transportation





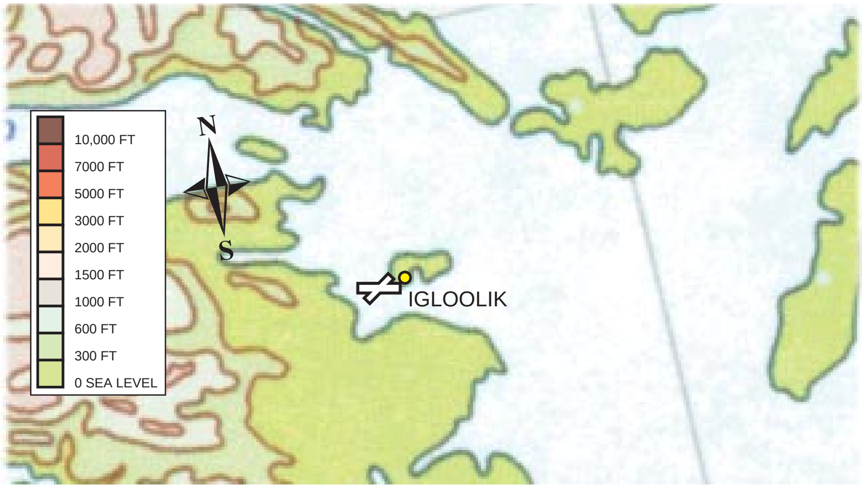
Percent wind 20 knots and greater																Grise Fiord
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.0	0.0	0.0	0.6	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WINTER	0.2	0.0	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

Overall Grise Fiord has good flying weather in the fall and winter. A whooping 63 percent of winter winds and 34 percent of summer winds at Grise Fiord are light! However, pilots cite that with winds of only 10 knots, moderate to severe turbulence and low-level windshear can be expected making landing very difficult. Pilots also cited that they look to see if the winds are increasing or decreasing. If winds are increasing they do not fly into Grise Fiord. If the winds are decreasing, they will. That said, the wind regime at Grise Fiord is a challenge. Onsite weather observers cite that they have observed winds over the nearby water of Jones Sound being different from those at the airport which in turn were different from those at the other end of runway. Wind speed and wind direction measurements can fluctuate wildly. East winds can also at times be strong and very gusty.



Being adjacent to Jones Sound, the airport is vulnerable to low cloud and fog moving in with a southeasterly wind, summer particularly. However, flying conditons are generally good when compared to other sites in Nunavut. Reports of freezing drizzle are rare.

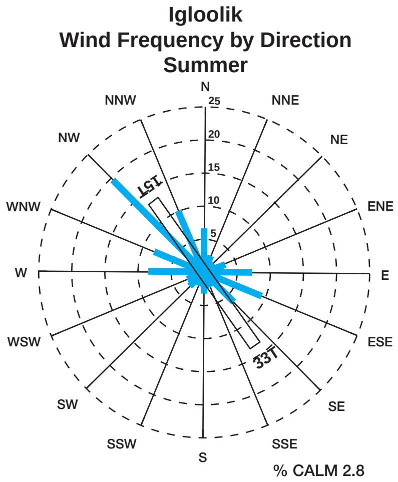
Igloolik

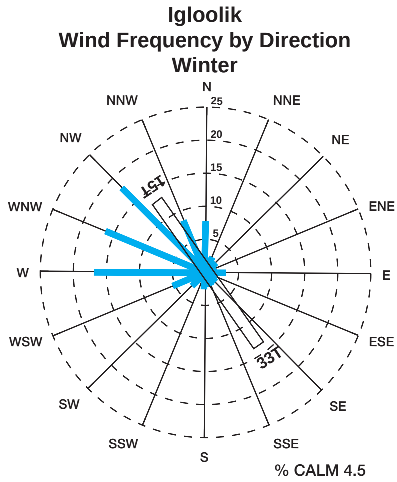


Igloolik airstrip (elevation 174 feet ASL) lies to the southwest of the community on Igloolik Island, northwestern Foxe Basin. The terrain in the area is relatively flat. The Fury and Hecla Strait polynya 10 to 15 miles to the northeast can be a source of winter moisture.

Photo 5-29 - Igloolik, looking west

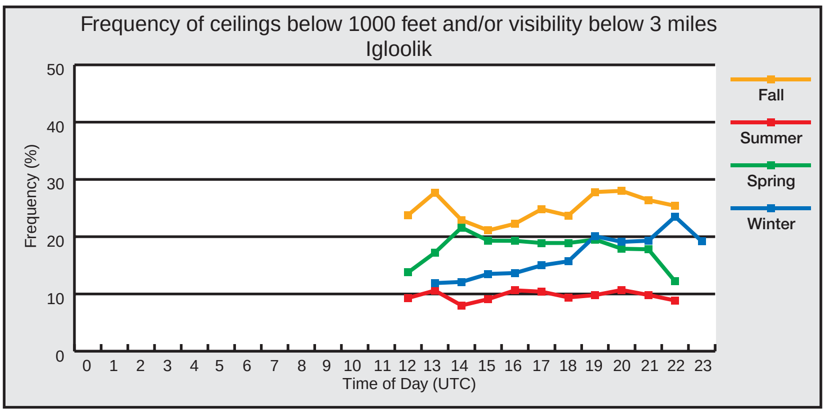
credit: Government of Nunavut, Community Government and Transportation





Percent wind 20 knots and greater																Igloolik
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.0	0.0	0.2	0.3	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.3	1.2	1.4	0.0	0.1
WINTER	0.1	0.1	0.0	0.4	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.3	0.3	0.5	0.1	0.1

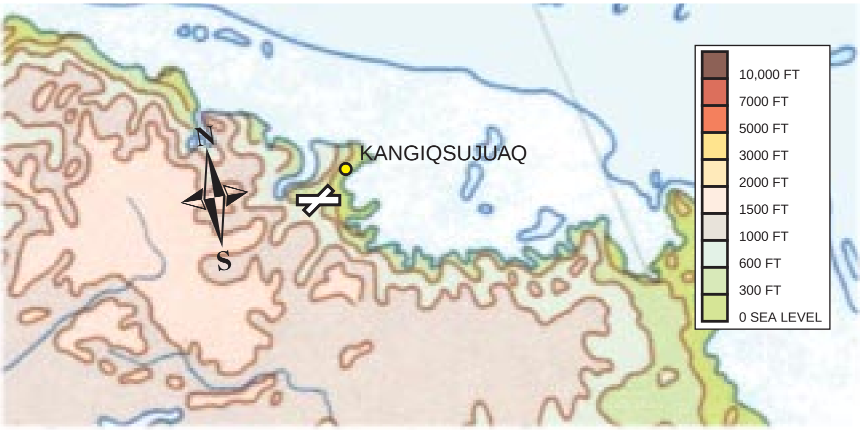
In winter, west, west-northwest and northwest winds dominate direction-wise. Easterly winds are not as common overall but show just as many instances of being strong as northwest winds.



Summer is the most favorable time of year with respect to flying weather. Spring and more so fall with their bouts of low cloud, and at times fog off Foxe Basin or Fury and Hecla Strait, and winter with periods of blowing snow/blizzards show poorer flying weather. The flying weather at Igloolik, is comparable to that experienced at Hall

Beach but tends to be a little more favorable. In winter, for example, northwesterly winds and resultant bouts of reduced visibility with blowing snow at Igloolik tend to be less ferocious than those at Hall Beach.

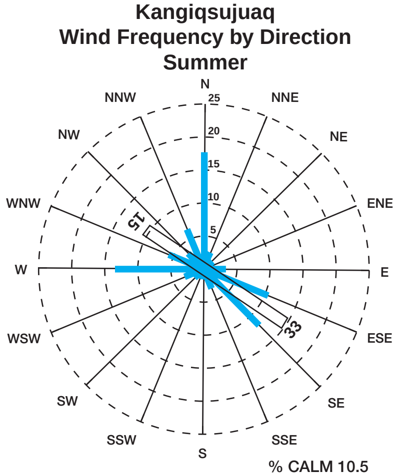
Kangiqsujuaq

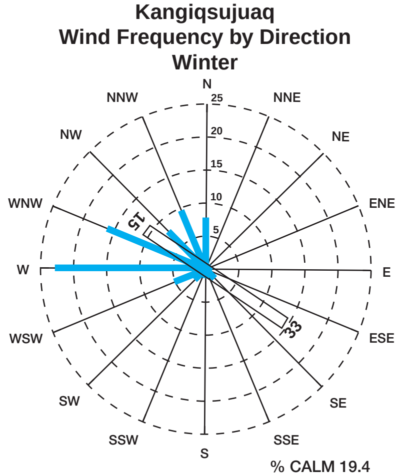


The Kangiqsujuaq airstrip (elevation 511 feet ASL) lies on the southeast shores of Wakeham Bay. Hudson Strait lies about 7 miles north. Terrain in the area is rugged. Mount Qaarntaq, for example, peaks 3 miles north at about 1275 feet.

Per Canada Flight Supplement, "Turbulence and wind shear may be encountered when wind exceeds 20 knots."

Photo 5-30- Kangiqsujuaq, looking southeast credit: Corinne Maussenet





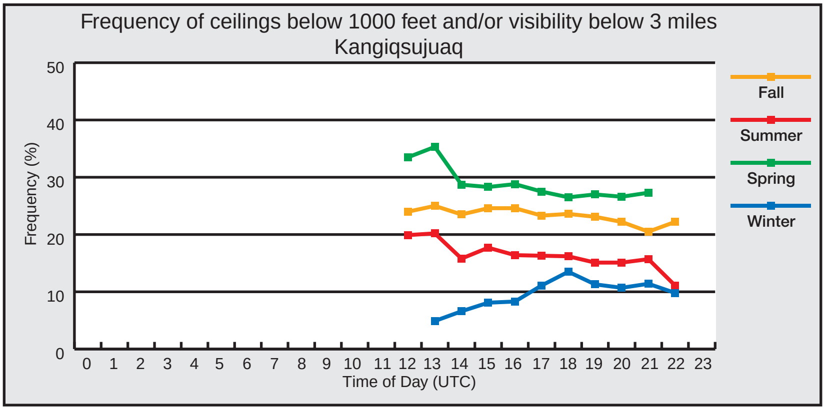
Percent wind 20 knots and greater																Kangiqsujuaq
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.1	0.2	0.3	0.3	0.6	0.2	0.0	0.2	0.3	0.4	0.9	2.1	0.3	0.4	1.4	4.2
WINTER	0.2	0.0	0.0	0.2	0.0	0.2	0.1	0.2	0.2	0.5	1.4	4.7	1.5	0.8	3.1	4.4

In winter, west winds are the most frequent winds, followed by calm winds and then west-northwest winds.

Although not as common, 56 percent of the north winds show as being 20 knots or more while 9 percent of the north winds show as reaching 31 knots or more. Thirty-three percent of north-northeast winds reach 20 knots or more.

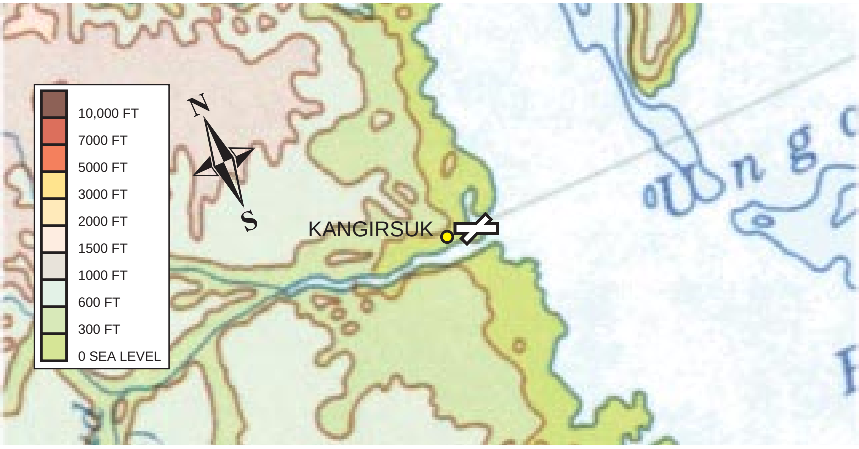
In summer, north winds are the most frequent winds. West, southeast, east-southeast, and calm winds trail with respect to dominance. The strongest winds in summer tend to be winds from the west and west-southwest.

Not as obvious from the statistics, instances in the depth of winter, are cited of violent winds from the southeast, in excess of 50 knots, when an intense low-pressure system moves from Hudson Bay to northern Baffin Island. Also cited are northwesterly winds of 50 to 60 knots after the passage of a cold front, mostly at night. Such northwesterly winds usually generate significant mechanical turbulence along the coast as the wind bangs into the rugged terrain of the area.



Stratus ceilings are common, spring and fall particularly. Winter shows as having the most favourable flying weather although bouts of strong winds can lead to blowing snow that at times meets blizzard criteria.

Kangirsuk



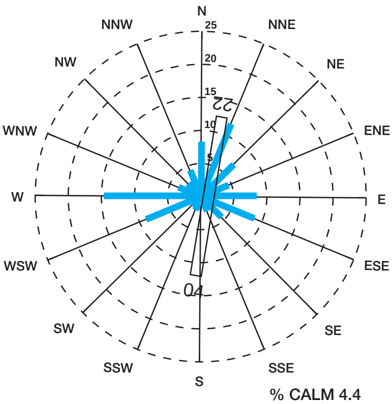
Kangirsuk airstrip (elevation 383 feet ASL) is situated on the north shore of Payne Basin near the mouth of the Payne River. The community lies to the west of the airstrip. Payne Bay, which opens to Ungava Bay, is about 5 miles east. Terrain peaks to about 625 feet 2 1/2 miles west-northwest.

Per Canada Flight Supplement, "Possible discrepancy between reported and actual wind due to surrounding terrain."

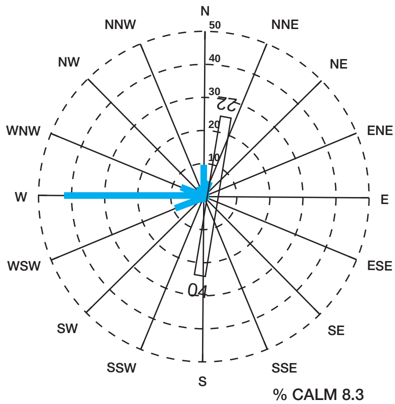
Photo 5-31 - Kangirsuk looking northwest

credit: Transport Quebec, Northern Quebec Region

Kangirsuk
Wind Frequency by Direction
Summer



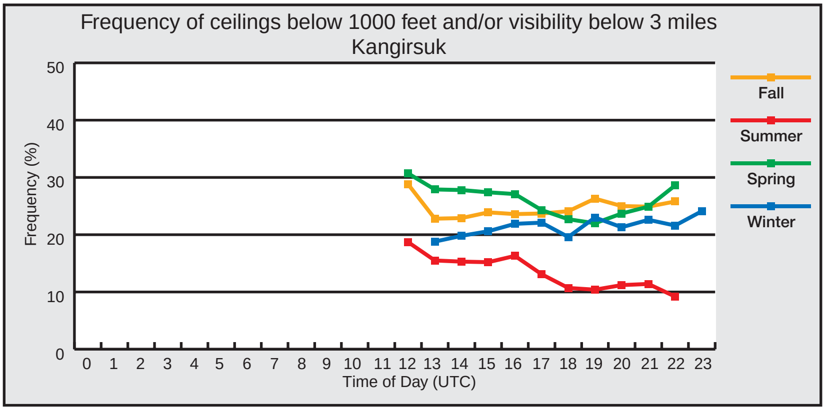
Kangirsuk
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Kangirsuk
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	2.7	0.7	0.1	0.2	0.1	0.0	0.0	0.0	0.2	0.1	0.3	2.3	0.8	0.6	0.9	1.6
WINTER	1.6	0.3	0.0	0.2	0.2	0.1	0.0	0.1	0.0	0.1	0.7	7.5	1.1	0.3	0.9	3.5

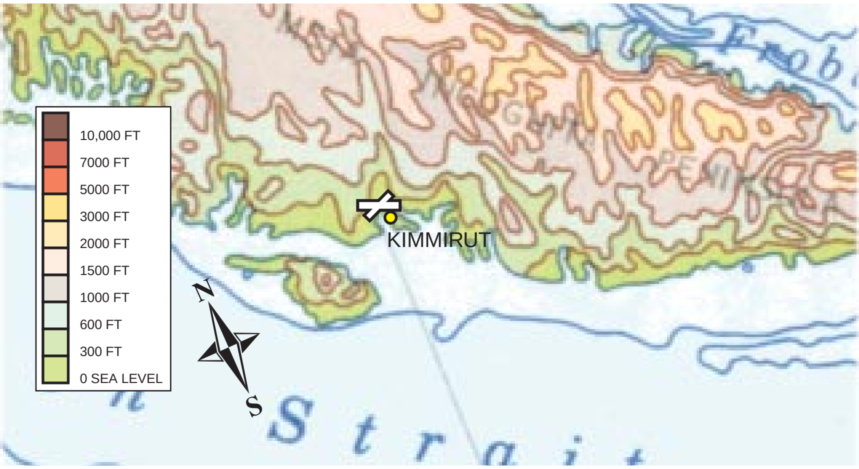
In winter, 42 percent of winds are from the west thereby lining up nicely with Payne Basin, which runs east to west. This fits a pattern where cold air over the Ungava Penisula drains to a warmer Ungava Bay. A significant portion of winds from the west blow 20 knots or stronger. That said the strongest winds tend to be from the north and north-northeast.

In summer, west winds are still the dominant winds direction-wise but to a much lesser degree. Strength-wise, west, north, and north-northeast make a strong showing. West-northwest, northwest, north-northwest winds do not blow that frequently but when they do routinely reach speeds of 20 knots and more.



Summer afternoons into evening show as having the most favorable flying weather. While the river eventually freezes in winter, Payne Bay does not, and the limit of the ice usually ends only a few miles from the airstrip. East or northeast winds continuously bring moisture and very low stratiform clouds with bases between 200 and 300 feet AGL. This results in the runway being in the cloud with zero visibilities due to the runway elevation. In late spring, the arrival of warm air while the ice has not yet cleared the coastal area of Ungava Bay, results in local cooling and poor ceilings and visibilities.

Kimmirut

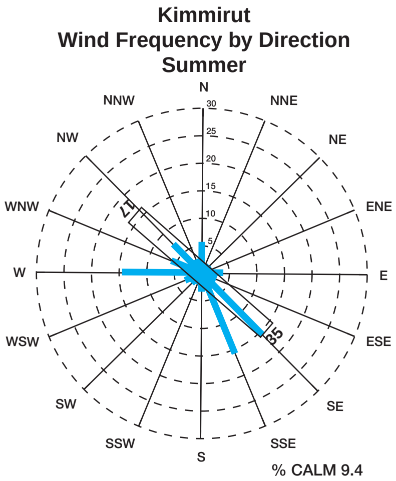


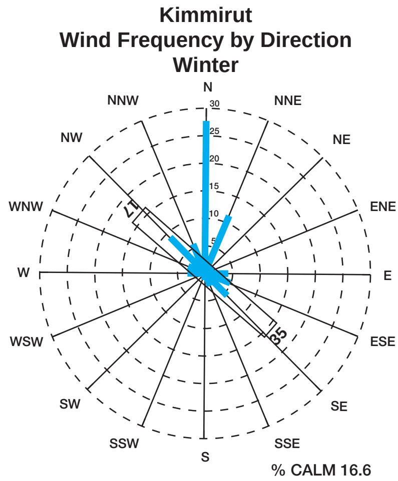
Kimmirut airstrip (elevation 175 feet ASL) lies at the mouth of Glasgow Bay. Pleasant Inlet wraps from south to north and then northwest of the land on which Kimmirut resides. Both Pleasant Inlet and Glasgow Bay are extensions of North Bay which in return is an extension of Hudson Bay. The terrain in and around Kimmirut is rugged. Terrain rises to about 730 feet within 2 miles east. The Meta Incognita Peninsula with peaks to 2,800 feet lies between Kimmirut and Iqaluit to the northeast.

Per Canada Flight Supplement, "High terrain all quadrants. Only pilots with considerable experience with local terrain should use this airport during hours of darkness due to surrounding terrain."

Photo 5-32 - Kimmirut, looking northwest

credit: Government of Nunavut, Community Government and Transportation

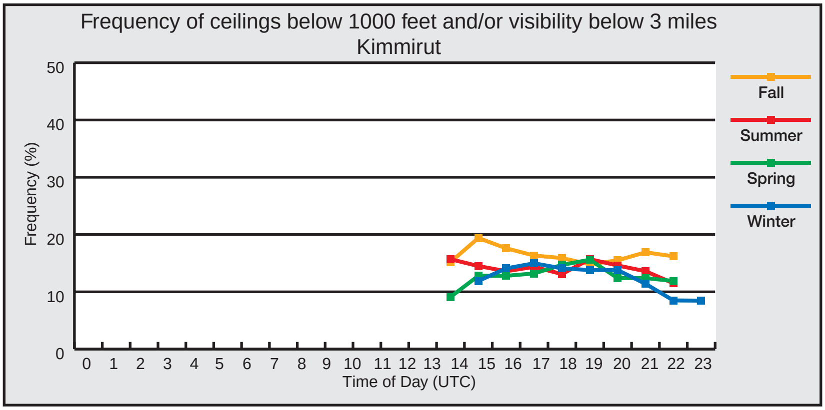




Percent wind 20 knots and greater																Kimmirut
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.3	0.2	0.1	0.1	0.0
WINTER	0.0	0.1	0.1	0.5	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.1	0.1

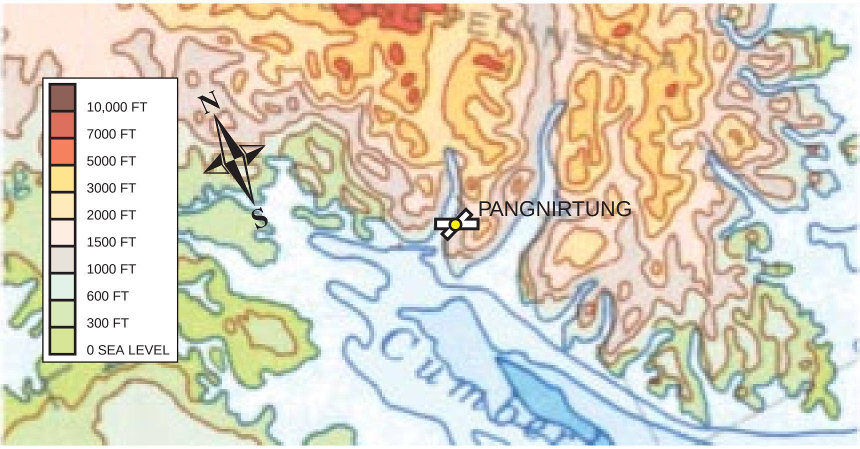
In winter, north winds, and to lesser degrees calm and north-northeast winds, are frequent. In summer, west, southeast and south-southeast winds are common. Kimmirut's location protects the terminal somewhat from strong winds. However, summer and winter, winds from the southeast can funnel up through Glasgow Bay into the town and terminal, giving gusty winds from that direction. Also summer and winter, strong northwest and north-northwest winds can, at times, get into the area.

Severe turbulence is common here in all directions due to the surrounding terrain, but more evident with an easterly flow over the higher terrain of the Meta Incognita Peninsula.



Being adjacent to Glasgow Bay and close to Hudson Strait, fog and stratus can and will advect into Kimmirut. The flying weather, when compared to other sites bordering Hudson Strait such as Cape Dorset and Quaqtaq, is more favorable. Like many of the other sites, fall shows as having the poorest flying weather. The strong wind events/blowing snow/blizzards that affect Iqaluit from time to time through the frozen season are much less frequent at Kimmirut.

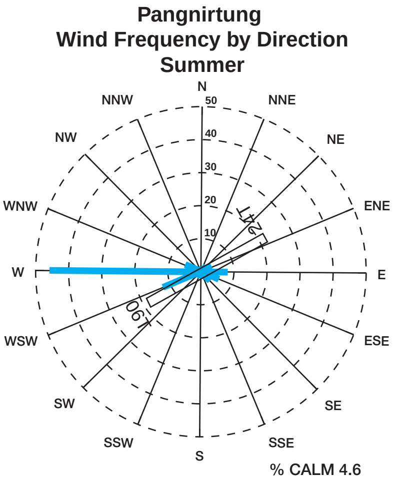
Pangnirtung

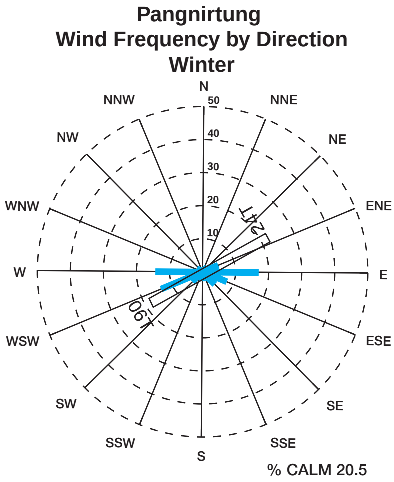


Pangnirtung airstrip (elevation 75 feet ASL) is located on a tundra flat along the south side of Pangnirtung Fiord approximately 5 n. miles from the mouth of the waterway. The Kolik River flows into Pangnirtung Fiord about 1/2 mile east of the observing site. The fiord itself is about 1 1/2 miles wide and opens southwest into Cumberland Sound, which is about 40 miles in width and 130 miles in length and oriented northwest to southeast, along the east coast of Baffin Island. Except at the mouth of some of the larger river valleys, the walls of Pangnirtung Fiord rise steeply to the surrounding mountains, becoming higher and more precipitous towards Pangnirtung Pass beyond the head of the fiord. In that area, there are elevations of over 5,900 feet and extensive snowfields. About 1 1/2 mile east of the site, Mount Duval rises to an elevation of about 2,300 feet.

Per Canada Flight Supplement, "Only pilots with considerable experience in area should plan on using this airport due to surrounding terrain and variable local conditions. Severe turbulence may be encountered. Surrounding terrain may constitute a hazard to night flying."

Photo 5-33 - Pangnirtung, looking south-southeast credit Government of Nunavut, Community, Government and Transportation



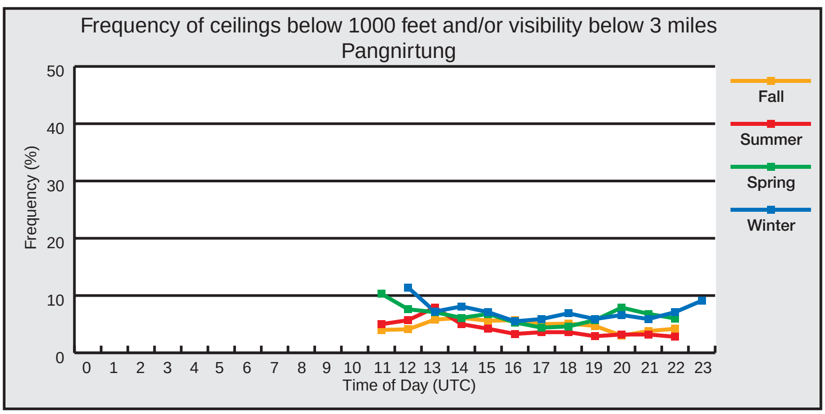


Percent wind 20 knots and greater																Pangnirtung
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.0	0.0	0.0	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0
WINTER	0.0	0.0	0.1	1.8	0.4	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0

In winter, calm winds are most prevalent followed by east, west-southwest and west winds in that order, i.e. directions that correspond to the orientation of Pangnirtung Fiord. In summer, 45 percent of winds are from the west. Funnelling from the southwest into the fiord makes flying into Pangnirtung very hazardous as pilots have to fly into the fiord with the wind and then make a 180-degree turn into the wind to land at the terminal. Long approaches from the other direction are not recommended due to the terrain to the east. Winds of greater than 12 knots can prevent an airplane from landing at Pangnirtung. Occasionally a storm will track to the northwest from northern Labrador to southwestern Baffin Island, as far north as Cumberland Sound. These storms can produce very gusty east to east-northeasterly winds that can reach damaging strengths. One resident in Pangnirtung said, “a house was blown of its blocks, even when it was tied down” during a storm of this type.

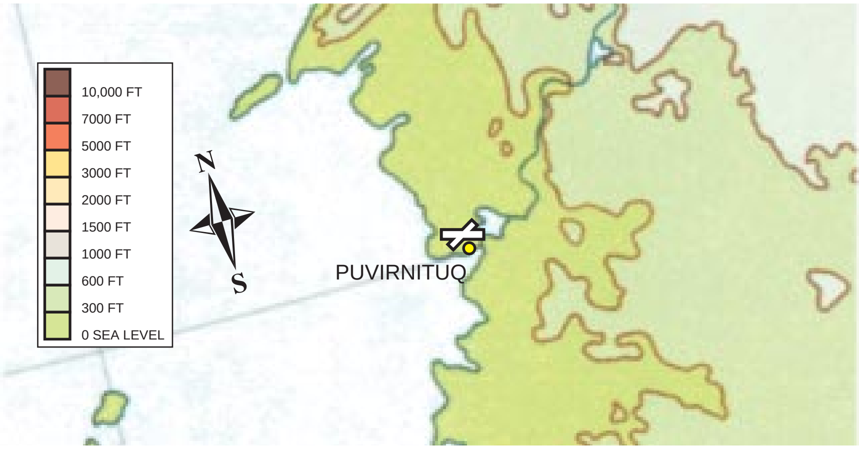
Pilots cite that a southeasterly flow over the peninsula can give severe turbulence and low-level windshear.

Sea breezes enhanced by channelling are common in Pangnirtung during the summer. With sunny skies, westerly winds (260-280°) often strengthen to 12 to15 knots around 1600 UTC and diminish to light between 2100 and 2400 UTC.



Barring the occasional visibility limiting precipitation or fog event, the flying weather at Pangnirtung is good year round.

Puvirnituq



Puvirnituq airstrip (elevation approximately 76 feet ASL) lies just north of the community. It is surrounded by flat lands to the east and Povungnituk Bay to the west. The bay is open to Hudson Bay. In this area, the waters of Hudson Bay freeze for a good distance to the west.

Per Canada Flight Supplement, "Possibility of caribou on runway November to May."

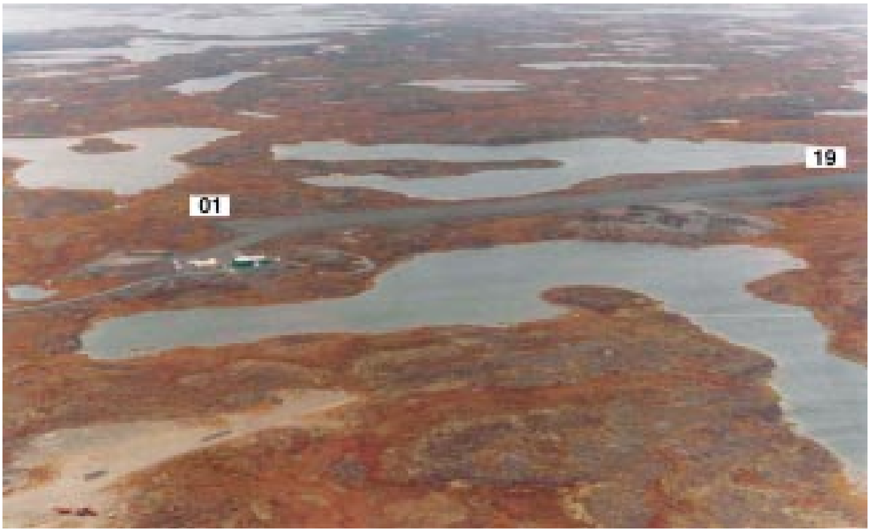
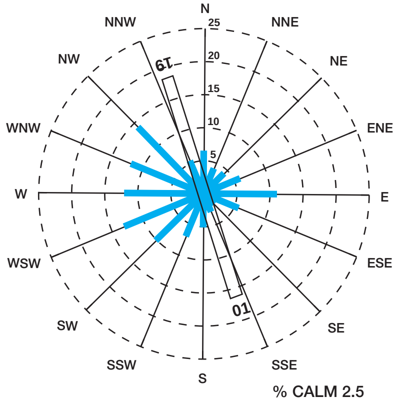
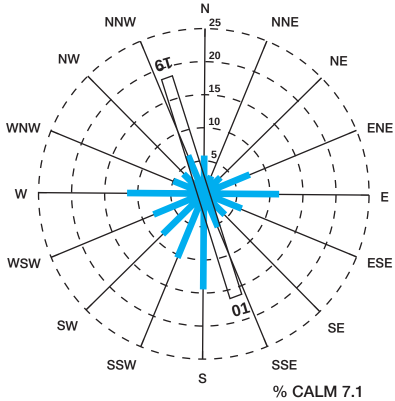


Photo 5-34 - Puvirnituq, looking west-northwest credit: Transport Quebec, Nord-du-Quebec Region

Puvirnituq
Wind Frequency by Direction
Summer

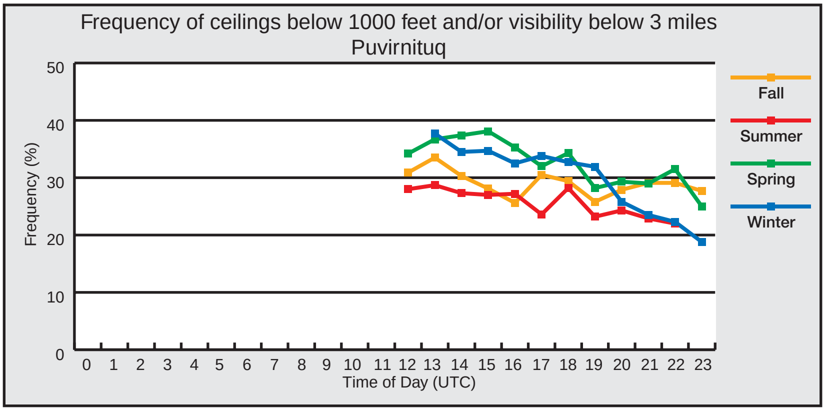


Puvirnituq
Wind Frequency by Direction
Winter



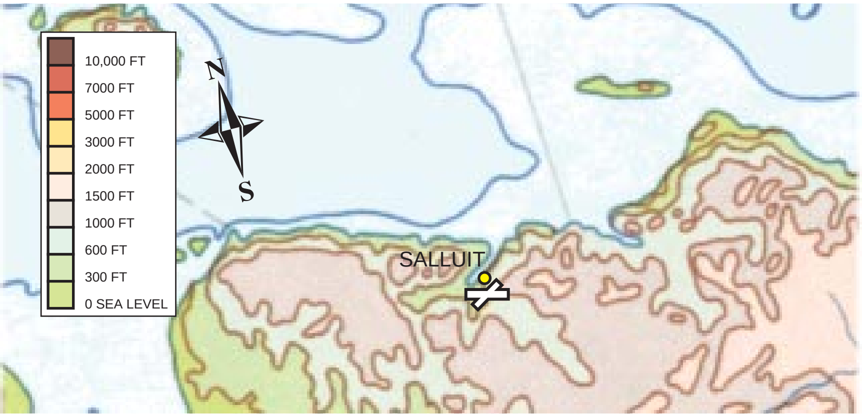
Percent wind 20 knots and greater																Puvirnituq
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.4	0.4	0.8	2.1	0.7	0.1	0.1	0.6	1.3	1.5	1.0	0.9	1.3	1.2	0.5	0.4
WINTER	0.3	0.4	0.4	0.9	0.5	0.1	0.1	1.0	1.4	1.1	0.6	1.0	0.8	0.4	0.5	0.5

In winter, south winds are the most frequent winds. Winds of 31 knots or more are most likely to be from the northeast, south-southwest, west, west-northwest or north-west. In summer, westerly (southwest through northwest) winds are dominant. Winds of 31 knots or more are most likely to be from the east, east-southeast, west-southwest or west-northwest.



Stratus cloud (ceilings 500 to 600 feet AGL) is common, spring particularly. Summer shows as having the most favourable weather. All seasons show a diurnal trend of conditions improving through the day such that the most favourable flying weather occurs during the afternoon into evening.

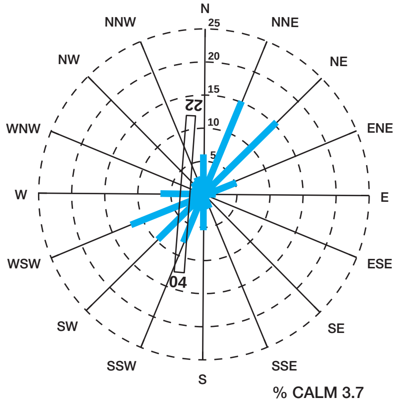
Salluit



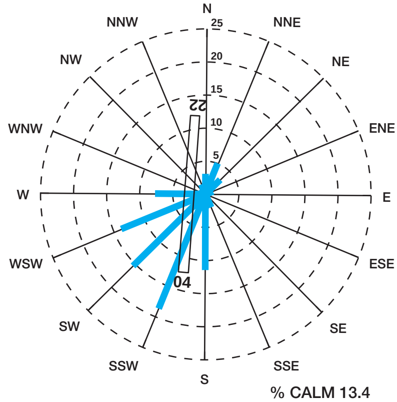
Salluit airstrip (elevation 742 feet ASL) is located about 2 miles south of the village on top of a cliff on the southeast shores of Sugluk Inlet. The inlet is orientated northeast to southeast and has rugged terrain on both sides. Terrain reaches heights of 1,600 feet or more within 5 miles southwest through east of Salluit.

Photo 5-35 - Salluit, looking southwest credit: Transport Quebec, Northern Quebec Region

Salluit
Wind Frequency by Direction
Summer



Salluit
Wind Frequency by Direction
Winter

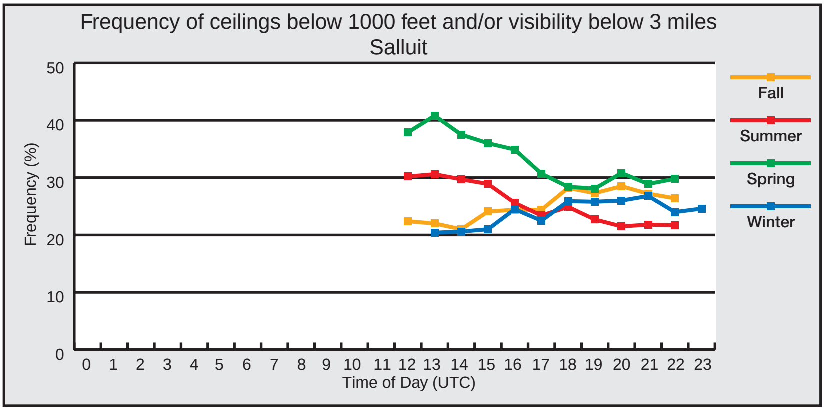


Percent wind 20 knots and greater																Salluit
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.0	0.2	0.0	0.1	0.1	0.2	0.4	1.0	2.0	2.9	2.2	0.6	0.0	0.0	0.0	0.0
WINTER	0.1	0.1	0.0	0.0	0.0	0.2	0.8	2.5	3.8	4.3	2.2	0.1	0.0	0.0	0.0	0.0

In winter, south through west-southwest winds dominate direction and speed-wise. Calm winds are also frequent. Southwest winds routinely post speeds of 31 knots or more. In summer, northeast and north-northeast winds are the most frequent winds. West-southwest and south winds still make a strong showing with respect to both frequency and strength. Once again it is southwest winds which are the strongest.

Pilots cite that for Salluit, the turbulence generated in summer or fall by winds of 20 knots or more, from a direction varying from southwest to west, is often too strong to allow for passenger flights.

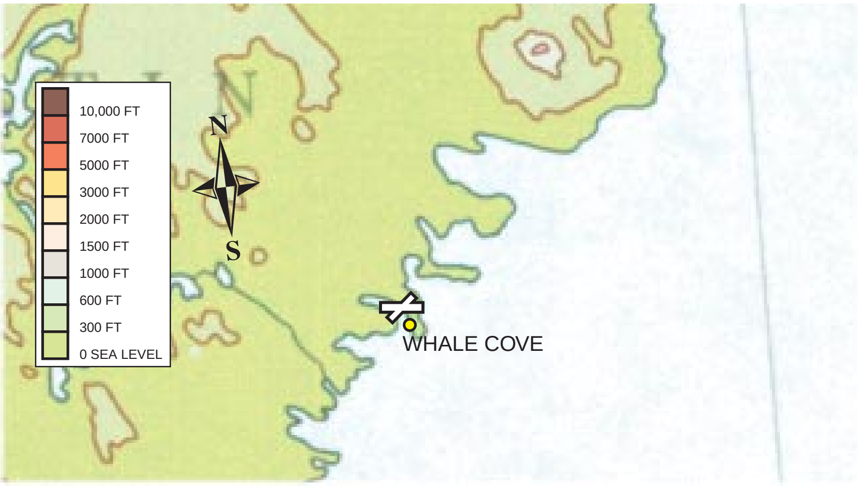
In the depth of winter, violent winds in excess of 50 knots have been observed when an intense low-pressure system moves from Hudson Bay to northern Baffin Island. After the passage of a cold front, northwesterly winds of 50 to 60 knots have been observed, mostly at night. Such winds usually generate significant mechanical turbulence along the coast, including the Salluit area, due to the high elevation of the runway.



Spring shows the poorest flying weather. The most favourable flying weather occurs during summer afternoons. Diurnally, conditions improve morning to afternoon during the spring and summer while, during the fall and winter, conditions deteriorate morning to afternoon. Forecasters note that when weather systems move eastward out of Hudson Bay, it usually takes about three hours for the weather conditions at Ivujivik to move to Salluit.

With northwest winds, the village often experiences a 500-foot AGL stratus ceiling while the runway is shrouded in thick fog. Such a situation can last for three to four days, until the wind direction changes. This can occur anytime during the year.

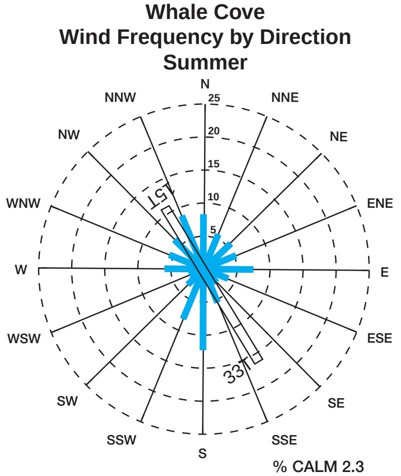
Whale Cove

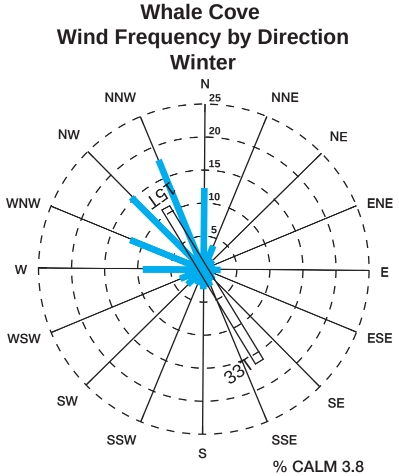


Whale Cove airstrip (elevation 66 feet ASL) lies about 4 miles north of the community of Whale Cove. The community and airstrip lie on a peninsula protruding into western Hudson Bay. Water and low terrain surround the strip although there is some elevated land to approximatelyt 140 feet about a mile southeast of the airstrip.

Photo 5-36 - Whale Cove, looking north-northeast

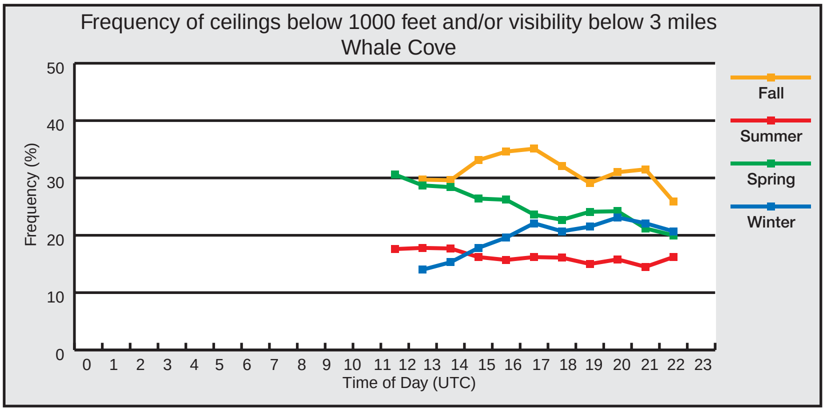
credit: Government of Nunavut, Community Government and Transportation





Percent wind 20 knots and greater																Whale Cove
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.4	0.5	0.3	0.3	0.4	0.1	0.2	0.2	0.2	0.0	0.0	0.4	0.6	1.5	1.5	0.9
WINTER	0.0	0.0	0.1	0.2	0.2	0.2	0.5	0.5	0.2	0.1	0.1	0.2	0.5	1.6	1.5	1.0

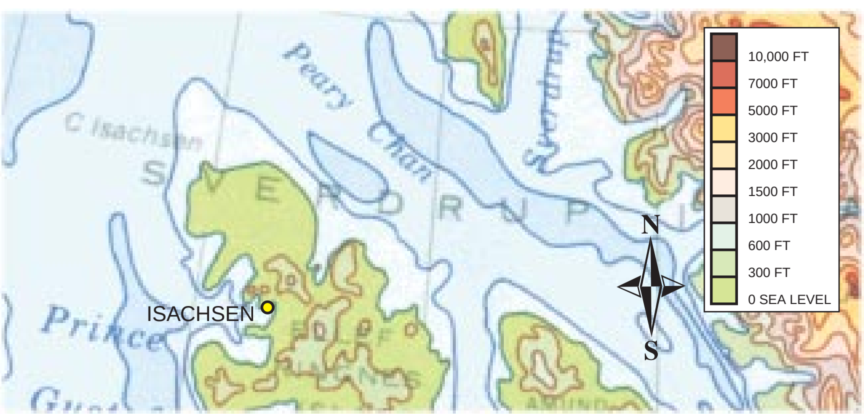
In winter, northwesterlies dominate frequency and strength-wise as they do at all the communities along the west coast of Hudson Bay. In summer, northwesterly winds lose direction dominance to south winds but retain strength dominance.



Summer shows as having the best flying weather of the seasons. Fall, with its bouts of low cloud and/or fog has the poorest flying weather. In winter, bouts of strong northwest winds and resultant blowing snow and at times blizzard conditions affect the flying weather.

Former airstrip sites

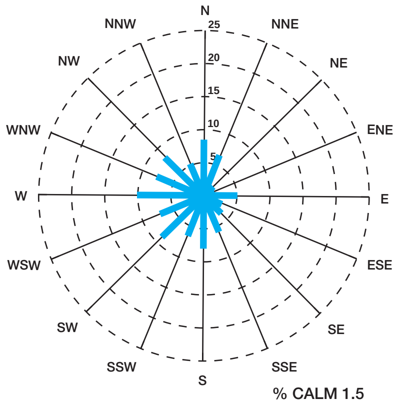
Isachsen (former Meteorological Service of Canada upper air site)



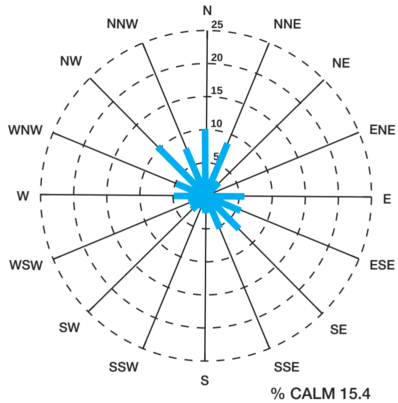
Isachsen is located on the western shore of Ellef Ringnes Island approximately 1/2 n. miles west of Louise Bay. Gently-rolling hills cover the area; however, 500 to

800-foot hills surround the site from west through northeast. Louise Bay, Parachute Bay, and Polar Bear Bay open into Station Bay to the south. Ellef Ringes Island butts against the ice of Arctic Basin. The land generally slopes from north to south and most run-off valleys follow this pattern. These valleys vary in depth from 30 feet near the site to about 200 feet near Rat Lake, approximately 2 1/2 miles to the north. Soil cover is sparse with a composition of clay, shale, and light humus. Local vegetation consists of moss, lichen, and small flowers.

Isachsen
Wind Frequency by Direction
Summer



Isachsen
Wind Frequency by Direction
Winter



Percent wind 20 knots and greater																Isachsen
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.7	0.1	0.0	0.3	0.4	0.3	0.4	0.5	0.1	0.1	0.1	0.6	0.6	0.1	0.8	1.3
WINTER	2.5	0.4	0.1	0.3	0.2	0.9	0.8	0.3	0.1	0.1	0.1	0.3	0.8	4.0	3.6	4.2

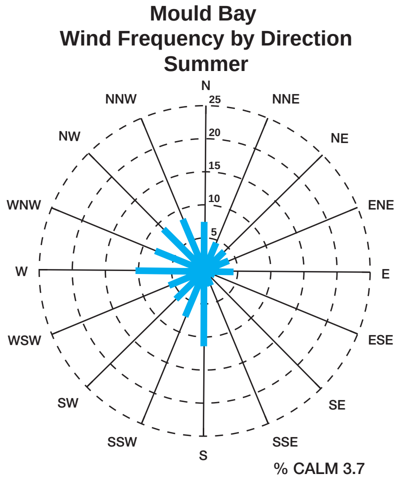
Isachsen lies in the recurring and persistent winter strong wind belt that separates low-pressure troughs that routinely extend northwest from Baffin Bay/Davis Strait and high-pressure areas/ridges that hold sway over the Arctic Basin to the west of the Canadian arctic islands. For example, in winter, north winds occur 10 percent of the time and two-fifths of these winds are 20 knots and more. Four percent of the winter north winds are 41 knots or stronger. In contrast, about 15 percent of winter winds are calm. In summer, west winds make a predominate and the showing of northwest through north-northeast winds is diminished. Summer winds are also not as strong as the winter winds. For example, the mean wind speed of winter north winds is over 18 knots versus the summer mean wind speed for north winds of under 13 knots.

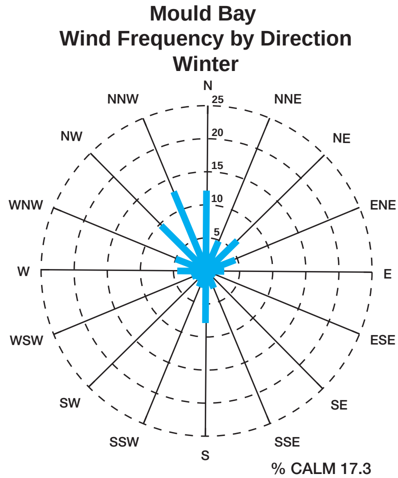
Summer is a season of poor flying weather with its persistent cover of low cloud and periods of fog. The summer conditions show a diurnal trend of deteriorating overnight and improving through the day. Winter, in spite of bouts of strong winds/blowing snow, shows as having the most favorable flying weather.

Mould Bay (former Meteorological Service of Canada upper air site)

Mould Bay is a narrow inlet that extends northward for about 15 n. miles from its mouth located off southeastern Prince Patrick Island. The former upper air site, which bears the same name, is situated on a flat portion of land on the east side of the bay approximately 8 miles from its mouth.

From station level, the terrain rises to a height of about 560 feet ASL approximately 2 miles to the east before sloping downwards towards the Crozier Channel. To the west and about 4 miles across the bay, the terrain rises quite rapidly to a ridge averaging from about 390 to 790 feet.

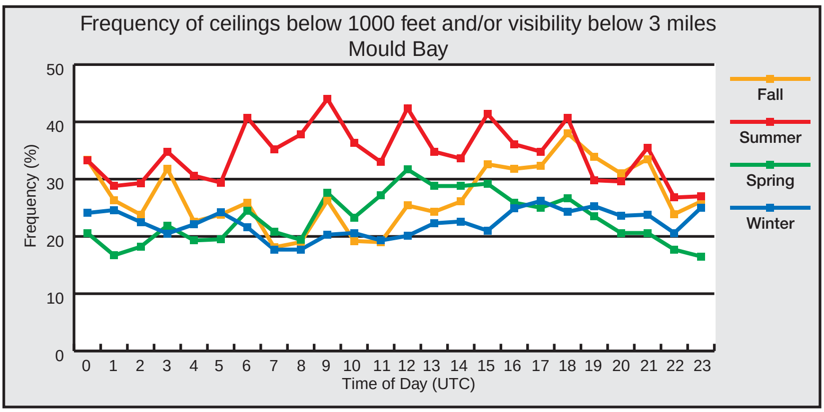




Percent wind 20 knots and greater																Mould Bay
DIRECTION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
SUMMER	0.1	0.2	0.3	0.3	0.0	0.0	0.0	0.4	0.2	0.4	0.5	0.9	0.5	0.3	0.4	0.4
WINTER	0.1	0.2	0.2	0.2	0.0	0.0	0.1	0.7	0.2	01	0.3	0.6	0.6	1.2	1.0	0.8

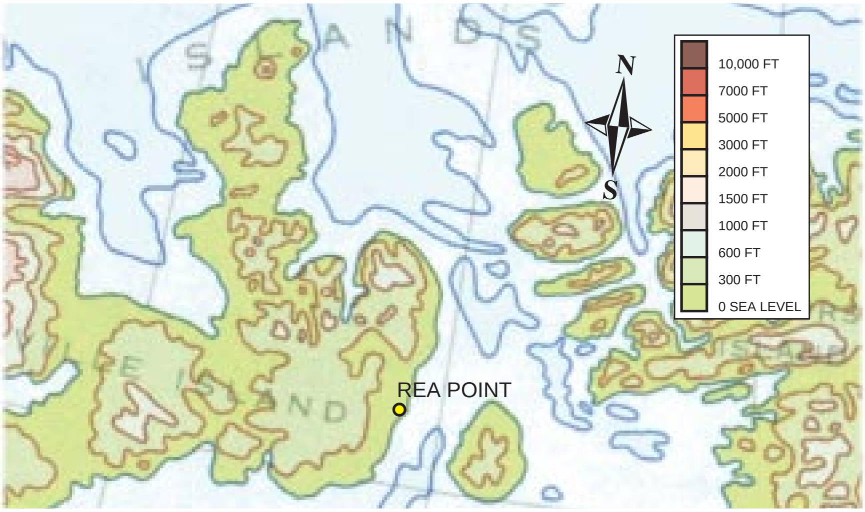
Mould Bay lies on the western edge of the recurring and persistent winter strong wind belt that separates low-pressure troughs that routinely extend northwest from the Baffin Bay/Davis Strait and high-pressure areas/ridges that hold sway over the Arctic Basin to the west of Mould Bay/the Canadian arctic islands. Being on the edge of the strong wind belt and being on the lee side of Prince Patrick Island with respect to northwest winds, the winds at Mould Bay are not as strong as those at Isachsen. At Mould Bay, winter northwest winds post the strongest mean wind of all the directions at 11.6 knots. At Isachsen, winter north and also north-northwest winds post mean wind speeds of 18.4 knots!

In winter, calm winds followed by northwest winds are most common. The strongest winter winds tend to be those from the west-northwest and northwest. In summer, south and west winds make a showing.

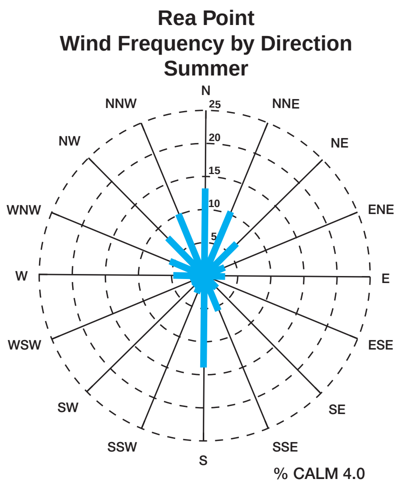


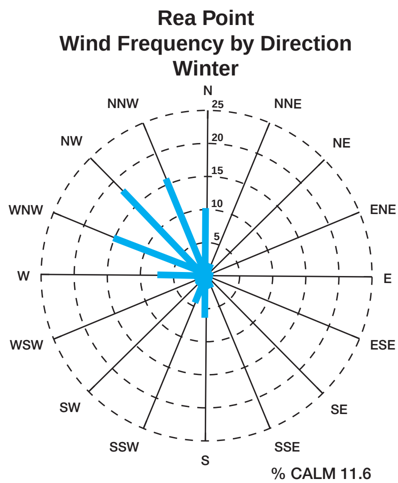
Summer is a time of low cloud and periods of fog making it the poorest of the seasons with respect to flying weather. Summer shows a diurnal trend such that the flying weather improves a little late afternoon into early evening.

Rea Point (1970's oil exploration site)



The Rea Point site was located on a coastal flat on the east side of Melville Island overlooking Byam Channel. The terrain in the immediate vicinity is of a gently rolling nature, rising gradually to the north, west and southwest and reaching a maximum elevation of about 575 feet ASL approximately 8 n. miles from the site.





Percent wind 20 knots and greater																Rea Point
DIRECTION	NNE	NE	ENE	**E**	ESE	SE	SSE	**S**	SSW	SW	WSW	**W**	WNW	NW	NNW	**N**
SUMMER	0.7	0.1	0.0	0.1	0.0	0.1	0.2	0.6	0.2	0.1	0.3	0.8	0.6	1.4	2.0	2.7
WINTER	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.6	0.1	0.0	0.0	1.0	3.0	5.5	4.5	1.3

Rea Point lies in the recurring and persistent winter strong wind belt that separates low-pressure troughs that routinely extend northwest from the Baffin Bay/Davis

Strait and high-pressure areas/ridges that hold sway over the Arctic Basin to the west of the Canadian arctic islands.

Hence, in winter, west-northwest through north winds dominate both frequency and strength-wise. Indeed, within these directions, many of the winds that blow from the northwest and west-northwest are 31 knots or stronger. That said, 11 percent of winter winds are calm.

In summer, the northwest winds lose a little of their punch but southwesterly winds gain in strength. Winds are spread around direction-wise with south winds and north-northeast winds making a showing.

Low cloud and at times fog make a strong showing through the summer making it the poorest season flying weather-wise. Fall flying weather through the day also tends to be poor.

Glossary of Weather Terms

anabatic wind - a local wind which blows up a slope heated by sunshine.

advection - the horizontal transportation of air or atmospheric properties.

air density - the mass density of air expressed as weight per unit volume.

air mass - an extensive body of air with uniform conditions of moisture and temperature in the horizontal.

albedo – the ratio of the amount of solar radiation reflected by a body to the amount incident on it, commonly expressed as a percentage.

anticyclone - an area of high atmospheric pressure which has a closed circulation that is anticyclonic (clockwise) in the Northern Hemisphere.

blizzard - a winter storm with winds exceeding 40 km/h, with visibility reduced by falling or blowing snow to less than one kilometre, with high windchill values and lasting for at least three hours. All regional definitions contain the same wind speed and visibility criteria but differ in the required duration and temperature criterion.

cat's paw – a cat paw-like, ripple signature on water given by strong downdrafts or outflow winds. A good indication of turbulence and wind shear.

ceiling - either (a) the height above the surface of the base of the lowest layer of clouds or obscuring phenomena (i.e. smoke) that hides more than half of the sky; (b) the vertical visibility into an obstruction to vision (i.e. fog).

chinook - a warm dry wind blowing down the slopes of the Rocky Mountains and over the adjacent plains.

clear air turbulence (CAT) - turbulence in the free atmosphere not related to convective activity. It can occur in cloud and is caused by wind shear.

clear icing - the formation of a layer or mass of ice which is relatively transparent because of its homogeneous structure and smaller number and size of air spaces; synonymous with glaze.

climate - the statistical collection of long-term (usually decades) weather conditions at a point; may be expressed in a variety of ways.

cold front - the leading edge of an advancing cold air mass.

convection - atmospheric motions that are predominately vertical, resulting in the vertical transport and mixing of atmospheric properties.

convergence - a condition that exists when the distribution of winds in a given area is such that there is a net horizontal inflow of air into the area; the effect is to create lift.

cumuliform - a term descriptive of all convective clouds exhibiting vertical development.

cyclone - an area of low atmospheric pressure which has a circulation that is cyclonic (counterclockwise) in the Northern Hemisphere.

deepening - a decrease in the central pressure of a pressure system; usually applied to a low. Indicates a development of the low.

deformation zone - an area in the atmosphere where winds converge along one axis and diverge along another. Where the winds converge, the air is forced upward and it is in these areas where deformation zones (or axes of deformation as they are sometimes referred to) can produce clouds and precipitation.

disturbance - applied loosely: (a) any small-sized low pressure system; (b) an area where the weather, wind, and air pressure show signs of cyclonic development; (c) any deviation in flow or pressure that is associated with a disturbed state in the weather; and (d) any individual circulatory system within the primary circulation of the atmosphere.

divergence - a condition that exists when the distribution of winds in a given area is such that there is a net horizontal outflow of air from the area.

downdraft - a small scale downward current of air; observed on the lee side of large objects that restrict the smooth flow of air or in or near precipitation areas associated with cumuliform clouds.

downburst - an exceptionally strong downdraft beneath a thunderstorm usually accompanied by a deluge of precipitation.

filling - an increase in the central pressure of a pressure system; applied to a low.

Föhn wind (foehn wind)- a warm dry wind on the lee side of a mountain range, whose temperature is increased as the wind descends down the slope. It is created when air flows downhill from a high elevation, raising the temperature by adiabatic compression.

front - a surface, interface or transition zone of discontinuity between two adjacent air masses of different densities.

Fujita Scale – a scale used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure (see Table 1).

Table 1 - The Fujita Scale

F-Scale Number	Intensity Phrase	Wind Speed (kts)	Type of Damage Done
F0	**Weak** Tornado	35-62	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	**Moderate** Tornado	63-97	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	**Strong** Tornado	98-136	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	**Severe** Tornado	137-179	Roof and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted
F4	**Devastating** Tornado	180-226	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large-object missiles generated.
F5	**Incredible** Tornado	227-285	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-inforced concrete structures badly damaged.

funnel cloud - a tornado cloud or vortex cloud extending downward from the parent cloud but not reaching the ground.

gust - a sudden, rapid and brief increase in wind speed. In Canada, gusts are reported when the highest peak speed is at least 5 knots higher than the average wind and the highest peak speed is at least 15 knots.

gust front - the leading edge of the downdraft outflow ahead of a thunderstorm.

high - an area of high barometric pressure; a high pressure system.

hurricane – an intense tropical weather system with a well defined circulation and maximum sustained winds of 64 knots or higher. In the western Pacific, hurricanes are called “typhoons,” and similar storms in the Indian Ocean are called “cyclones” (see Table 2 for hurricane intensitites).

Table 2 - Saffir-Simpson Hurricane Scale

Category #	Sustained Winds (kts)	Damage
1	64-82	Minimal
2	83-95	Moderate
3	96-113	Extensive
4	114-135	Extreme
5	>155	Catastrophic

icing - any deposit of ice forming on an object.

instability - a state of the atmosphere where the vertical distribution of temperature is such that a parcel displaced from its initial position will continue to ascend.

inversion - an increase of temperature with height - a reversal of the normal decrease of temperature with height.

isothermal layer - equal or constant temperature with height.

jet stream - a quasi-horizontal stream of wind concentrated within a narrow band; generally located just below the tropopause.

katabatic wind - downslope gravitational flow of colder, denser air beneath the warmer, lighter air. Also known as “drainage wind” or “mountain breeze”. Strength can vary from gentle to extremely violent winds.

knot - a unit of speed equal to one nautical mile per hour.

lapse rate - the rate of change of an atmospheric variable (usually temperature) with height.

lee wave - any stationary wave disturbance caused by a barrier in a fluid flow; also called mountain wave or standing wave.

lightning - any and all forms of visible electrical discharge produced by a thunder-storm.

low - an area of low barometric pressure; a low pressure system.

meridional flow – airflow in the direction of the geographic meridians, i.e. south-north or north-south flow.

meteorology - the science of the atmosphere.

mixed icing - the formation of a white or milky and opaque layer of ice that demonstrates an appearance that is a composite of rime and clear icing.

occluded front - a front that is no longer in contact with the surface.

orographic - of, pertaining to, or caused by forced uplift of air over high ground.

outflow - a condition where air is flowing from the interior land area through mountain passes, valleys and inlets onto the coastal areas; used most commonly in winter when cold Arctic air spreads onto the coastal area and adjoining sea.

overrunning - a condition when warm air overtakes or is lifted by colder denser air.

parcel - a small volume of air, small enough to contain uniform distribution of meteorological properties, and large enough to remain relatively self-contained and respond to all meteorological processes.

plow wind - usually associated with the spreading out of a downburst from a thunderstorm; a strong, straight-line wind in advance of a thunderstorm that often results in severe damage.

precipitation - any and all forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the surface.

quasi-stationary front - a front that is stationary or nearly so; commonly called stationary front.

ridge - an elongated area of relatively high atmospheric pressure; also called ridge line.

rime icing - the formation of a white or milky and opaque granular deposit of ice formed by the rapid freezing of supercooled water droplets.

saturation - the condition in the atmosphere where actual water vapour present is the maximum possible at the existing temperature.

shower - precipitation from cumuliform cloud; characterized by suddenness of beginning and ending, by rapid changes in intensity, and usually by rapid changes in the appearance of the sky.

squall - essentially gusts of longer duration. In Canada, a squall is reported when the wind increases by at least 15 knots over the average speed for a duration of at least 2 minutes and the wind reaches a speed of at least 20 knots.

squall line - a non-frontal line or narrow band of active thunderstorms.

stability - a state of the atmosphere where the vertical distribution of temperature is such that a parcel will resist displacement from its initial position.

stratiform - term descriptive of clouds of extensive horizontal development; flat, lacking definition.

stratosphere - the atmospheric layer above the tropopause; characterized by slight increase in temperature from base to top, very stable, low moisture content and absence of cloud.

subsidence - the downward motion of air over a large area resulting in dynamic heating.

supercooled water - liquid water at temperatures below freezing.

thunderstorm - a local storm invariably produced by a cumulonimbus cloud, and always accompanied by lightning and thunder.

tornado - a violently rotating column of air, shaped from a cumulonimbus cloud, and nearly always observed as “funnel-shaped;” other names are cyclone and twister.

tropopause - the transition zone between the troposphere and the stratosphere; characterized by an abrupt change in lapse rate.

troposphere - the portion of the earth's atmosphere from the surface to the tropopause; characterized by decreasing temperature with height and appreciable water vapour. Often referred to as the weather layer.

trough - an elongated area of relatively low atmospheric pressure; also called trough line.

trowal - a trough of warm air aloft; related to occluded front.

turbulence - any irregular or disturbed flow in the atmosphere.

updraft - a localized upward current of air.

upper front - any frontal zone which is not manifested at the surface.

virga - water or ice particles falling from a cloud, usually in wisps or streaks, and evaporating completely before reaching the ground.

warm front - the trailing edge of retreating cold air.

weather - the instantaneous conditions or short term changes of atmospheric conditions at a point; as opposed to climate.

wind - air in motion relative to the earth's surface; normally horizontal motion.

wind direction - the direction from which the wind is blowing.

wind speed - rate of wind movement expressed as distance per unit time.

wind shear - the rate of change of wind direction and/or speed per unit distance; conventionally expressed as vertical and horizontal wind shear.

zonal wind - a west wind; conventionally used to describe large-scale flow that is neither cyclonic or anticyclonic; also called zonal flow.

Table 3: Symbols Used in this Manual

	**Fog Symbol (3 horizontal lines)** This standard symbol for fog indicates areas where fog is frequently observed.
	**Cloud areas and cloud edges** Scalloped lines show areas where low cloud (preventing VFR flying) is known to occur frequently. In many cases, this hazard may not be detected at any nearby airports.
	**Icing symbol (2 vertical lines through a half circle)** This standard symbol for icing indicate areas where significant icing is relatively common.
	**Choppy water symbol (symbol with two wavelike points)** For float plane operation, this symbol is used to denote areas where winds and significant waves can make landings and takeoffs dangerous or impossible.
	**Turbulence symbol** This standard symbol for turbulence is also used to indicate areas known for significant windshear, as well as potentially hazardous downdrafts.
	**Strong wind symbol (straight arrow)** This arrow is used to show areas prone to very strong winds and also indicates the typical direction of these winds. Where these winds encounter changing topography (hills, valley bends, coastlines, islands) turbulence, although not always indicated, can be expected.
	**Funnelling / Channelling symbol (narrowing arrow)** This symbol is similar to the strong wind symbol except that the winds are constricted or channeled by topography. In this case, winds in the narrow portion could be very strong while surrounding locations receive much lighter winds.
	**Snow symbol (asterisk)** This standard symbol for snow shows areas prone to very heavy snowfall.
	**Thunderstorm symbol (half circle with anvil top)** This standard symbol for cumulonimbus (CB) cloud is used to denote areas prone to thunderstorm activity.
	**Mill symbol (smokestack)** This symbol shows areas where major industrial activity can impact on aviation weather. The industrial activity usually results in more frequent low cloud and fog.
	**Mountain pass symbol (side-by-side arcs)** This symbol is used on aviation charts to indicate mountain passes, the highest point along a route. Although not a weather phenomenon, many passes are shown as they are often prone to hazardous aviation weather.

Appendix


Alert
ELLESMERE
Cape Bourne
HEIBERG IS.
Eureka
ISLAND
Isachsen
ELLEF RINGNES IS.
AMUND RINGNES IS.
BORDEN IS.
MACKENZIE KING IS.
Castle Butte
PRINCE PATRICK IS.
LOUGHEED IS.
Mould Bay
Qaanaaq
Upernavik
BAFFIN BAY
BATHURST IS.
MELVILLE IS.
Rea Point
Polaris
DEVON IS.
Resolute
LANCASTER SOUND
DISKO IS.
Qeqertarsuaq
BANKS IS.
BARROW ST.
BYLOT IS.
Pond Inlet
Peel Point
STEFANSSON IS.
SOMERSET IS.
Elvina Island
PRINCE OF WALES IS.
BRODEUR PEN.
Clyde
Kilian Lake
Gulf of Boothia
BAFFIN
Rimrock Lake
VICTORIA
Holman
McCLINTOCK CHANNEL
Taser Lake
Cape Hooper
Qikiqtarjuaq
Woodward Point
Bray Island
Dewar Lakes
ISLAND
BOOTHIA PEN.
Igloolik
Longstaff Bluff
Cape Dyer
DAVIS STRAIT
Cape Young
Rankin Inlet
ISLAND
Hall Beach
PRINCE CHARLES IS.
Pangnirtung
Byron Bay
Cambridge Bay
Franklin Point
Mackar Inlet
Figgures Point
Kugluktuk
FOXE BASIN
Kipisa
Cape Dominion
Brevoort
Bathurst Inlet
Iqaluit
Lupin
NUNAVUT
Cape Dorset
Kimmirut
SOUTHAMPTON IS.
Coral Harbour
RESOLUTION IS.
HUDSON STRAIT
Lakes
Wekweti
Ekati
Killinek
Kangiqsujuaq
Baker Lake
Salluit
Quaqtaq
COATS IS.
Yellowknife
Ivujivik
MANSEL IS.
PÉNINSULE D'UNGAVA
UNGAVA BAY
Fort Reliance
Shoran Bay
Kangirsuk
Rankin Inlet
Puvirnituq
Fort Resolution
Kuujjuaq
Arviat
Fort Smith
Inukjuak
HUDSON BAY
Schefferville
Churchill
Sanikiluaq
BELCHER ISLAND
Fontanges
Wabush
Kuujjuarapik
La Grande IV
Fort Severn
Peawanuck
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NAV CANADA

10/30/05