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

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

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 northwest 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

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

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.

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

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.

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 northwest-erly 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

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 northwesterly 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

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.
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.
Topography of the 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.
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:
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 consid-
erable 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.

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean Tide (ft)</th>
<th>Large Tide (ft)</th>
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</thead>
<tbody>
<tr>
<td>Iqaluit</td>
<td>25.6</td>
<td>36.4</td>
</tr>
<tr>
<td>Quaqtaq</td>
<td>19.0</td>
<td>27.6</td>
</tr>
<tr>
<td>Arviat</td>
<td>9.2</td>
<td>12.8</td>
</tr>
<tr>
<td>Hall Beach</td>
<td>3.0</td>
<td>4.6</td>
</tr>
<tr>
<td>Clyde River</td>
<td>3.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Resolute</td>
<td>4.3</td>
<td>6.6</td>
</tr>
<tr>
<td>Alert</td>
<td>1.6</td>
<td>2.6</td>
</tr>
</tbody>
</table>

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 deflecting 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
Open water season

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

![500 hPa chart, 0000 UTC 4 Sept. 2002](image)
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.

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**

![Storm Tracks](image-url)

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 south-easterly 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 north-west 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 65º 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.

<table>
<thead>
<tr>
<th>Drifting Snow</th>
<th>Blowing Snow</th>
<th>Blizzard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representative wind speed at least:</td>
<td>12 knots</td>
<td>19 knots</td>
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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. 3-14 - 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.
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.

![Mean monthly temperatures](image)

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.

![Rain Versus Snow](image)

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

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where Tair = Actual air temperature in ºC

\[ V_{10} \text{(km/h)} = \text{Wind speed at 10 metres in km/h (as reported in weather observations)} \]

Approximate Thresholds:
- Risk of frostbite in prolonged exposure windchill below
- Frostbite possible in 10 minutes at
- Frostbite possible in less than 2 minutes at

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<th>°C</th>
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<tr>
<td>Warm skin, suddenly eposed. Shorter time if skin is cool at the start.</td>
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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.
CHAPTER THREE

Fig. 3-21 - Summer cloud cover GFACN37 domain

Fig. 3-22 - Winter cloud cover GFACN37 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.
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.
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 strati- form 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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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| ![Fog Symbol](image) | Fog Symbol (3 horizontal lines)  
This standard symbol for fog indicates areas where fog is frequently observed. |
| ![Cloud areas and cloud edges](image) | 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](image) | 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](image) | 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](image) | 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](image) | 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](image) | 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](image) | Snow symbol (asterisk)  
This standard symbol for snow shows areas prone to very heavy snowfall. |
| ![Thunderstorm symbol](image) | 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](image) | 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](image) | 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. |