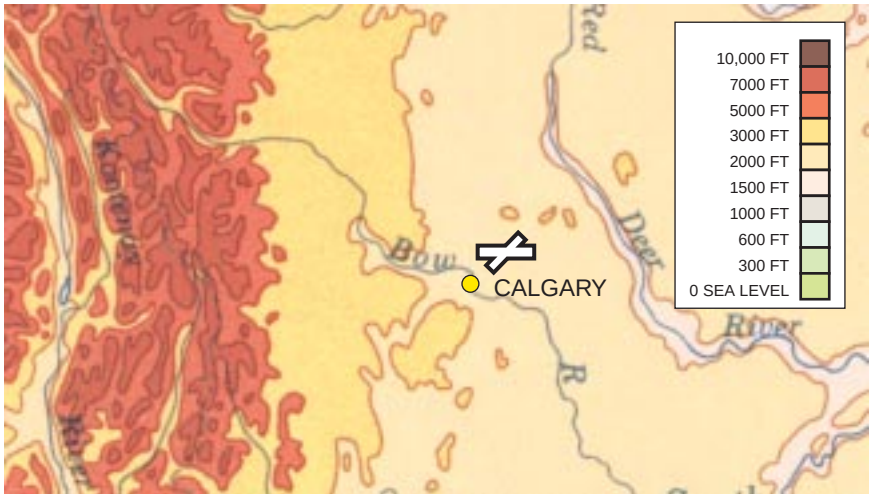
Chapter 5

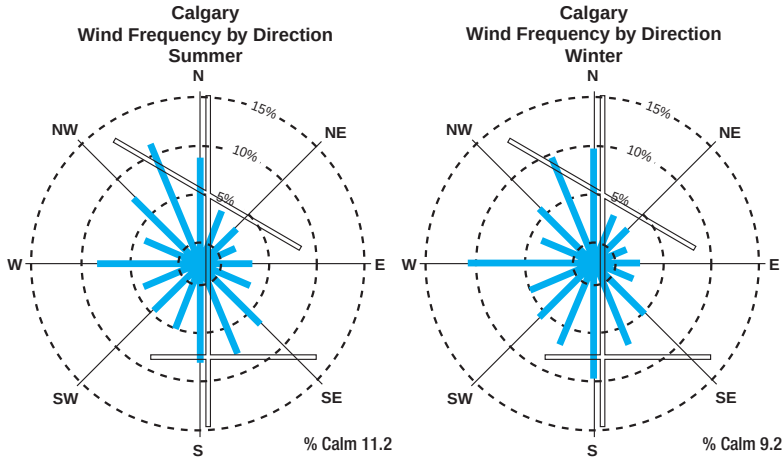
Airport Climatology

Alberta

(a) Calgary

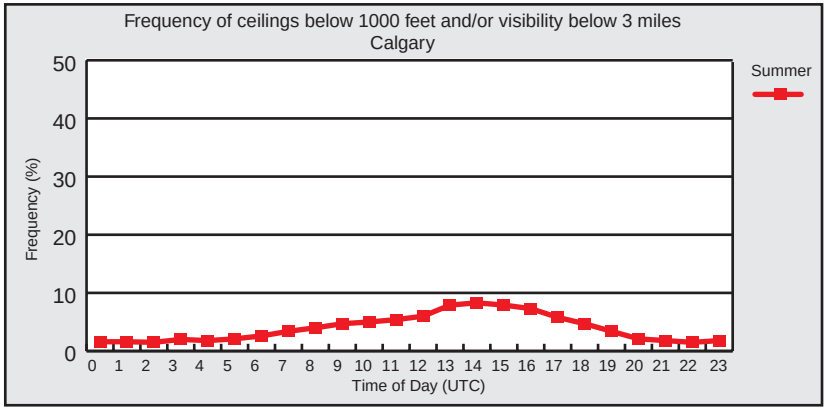


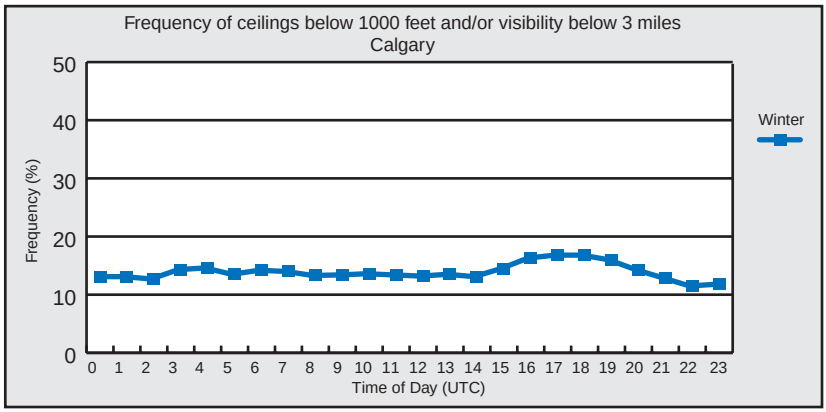
Calgary lies about 40 miles to the east of the Continental Divide, at the union of the Bow and Elbow River Valleys, in southern Alberta. In a large treeless tract of grassland, the river valleys provide the only strong physical relief. The airport is situated on a nearly flat tableland, 3 miles northeast of the centre of the city of Calgary. From the airport the land falls away to the valley of Nose Creek, about one mile to the west and then rises sharply to the crest of Nose Hill, a little over 3 miles west of the airport, which has an elevation 500 feet higher than the airfield. To the west of Calgary, the land rises steeply into the foothills of the Rocky Mountains. To the east, the land slopes away, generally from northwest to southeast. Southward the land slopes gradually to the Bow River, whose easterly flow bisects the city, until a sharp southerly bend, 3 to 4 miles south-southeast of the airport. Despite the fact that the local elevations are around 3,600 feet above sea level, the proximity to the Rocky Mountains allows it to benefit from the moderating effect of mild Chinook winds during the winter.



Calgary is in the zone of the upper-level westerlies which produces predominantly northerly or northwesterly winds in the winter and a more westerly or southwesterly flow in the summer. There are slightly more southwest winds in winter than summer, hinting that there may be more intrusions of warm pacific air in the winter than at other times of the year. In extreme summer cases, southerly winds can carry moist tropical air from the Gulf of Mexico into the area.

In the wintertime, the westerly winds can be produced by Chinooks and are frequently quite turbulent. Since the Chinook arch always accompanies this phenomenon, it can be used as a good indicator in timing the associated turbulence. Also, at any time of year, it is possible to set up lee or mountain waves, which will cause low-level wind shear and turbulence. While the lee waves are frequently indicated by lenticular cloud in the area, this is not always present, and in these cases, the lee wave turbulence can be quite hazardous. Of all the major cities in Canada, Calgary is most likely to be affected by this phenomenon.



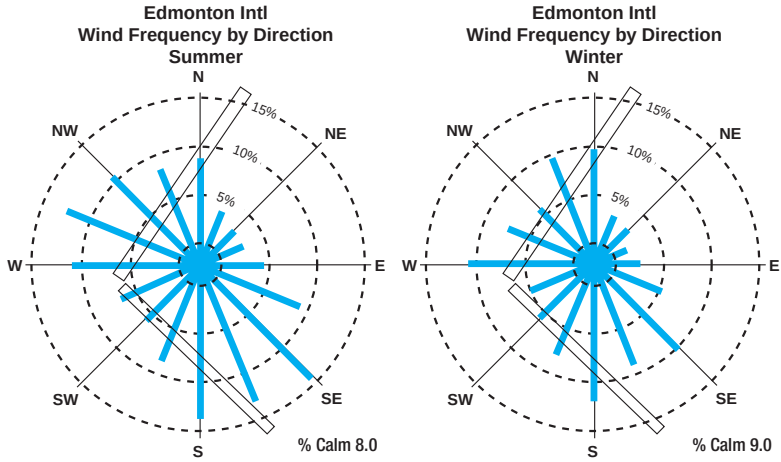


Summer, typically, has very good flying weather. The main concern is on warm days when thunderstorms can develop. Usually, thunderstorms form in the foothills to the west of the city and move eastward. Many of these dissipate before reaching Calgary but for those that don't, strong winds, heavy rain, hail, lightning and even tornadoes are possible. The frequency of low conditions increases after dark in summer, up to a maximum at 1400 UTC, and then improves.

Fog is mostly a wintertime event. The average number of fog days per month peaks at 2 or 3 in November, February, March and April. Poor flying conditions, when they occur in the evening, continue through the night with little change. Then, just after sunrise and probably due to the increases in aircraft movements providing a spike in low level moisture, the frequency reaches a maximum late in the morning after which conditions improve.

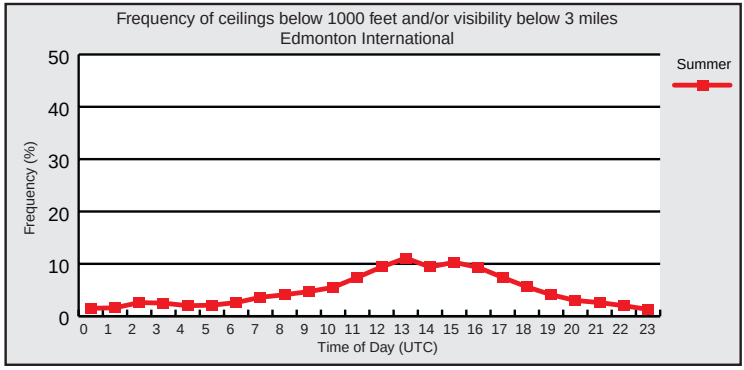
(b) Edmonton International

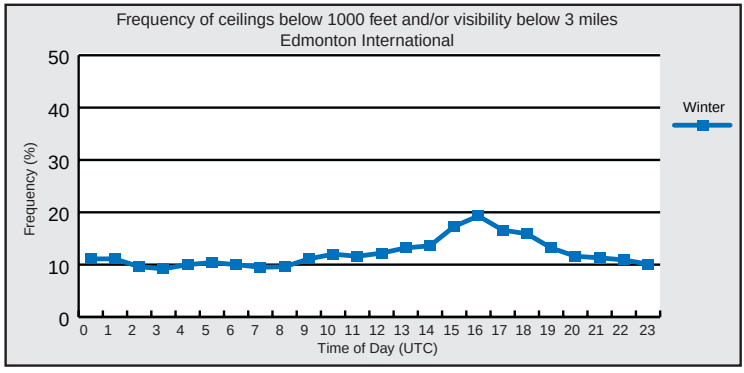
The city of Edmonton is situated along the North Saskatchewan River in central Alberta, and is located in the transition zone between prairie grassland and northern forests. The International airport is located near Leduc, about 9 miles to the south of the Edmonton city limits. The area surrounding the airport consists of generally flat farmland with the occasional wooded area. The North Saskatchewan River flows northeastward approximately 5 miles northwest of the airport.



Edmonton is in the zone of the upper level westerlies, a large-scale atmospheric circulation that streams generally in a west to east direction. In the winter, this flow shifts to northwesterly or northerly which allows for frequent invasions of cold Arctic air. In the summer, a more westerly or southwesterly upper flow allows for incursions of moist Pacific air.

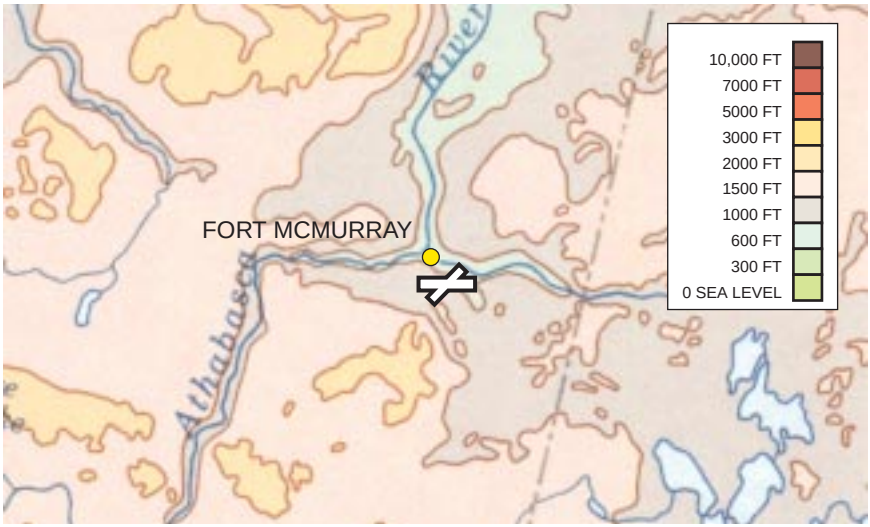
Winds are typically lighter in winter than those during the rest of the year. However, a combination of fresh snow, wind and cold temperatures may result in blizzard conditions, but these events are rare in Edmonton. The winds become somewhat stronger in the spring and summer and favour a west to northwest direction.



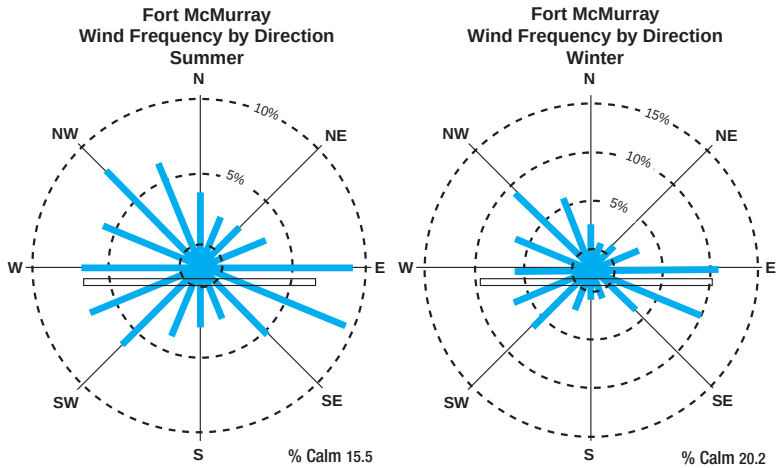


In Edmonton, throughout the year, the predominant west to northwest winds generally are associated with good flying weather. A prolonged easterly (northeast - southeast) flow is normally associated with the development of stratus and fog and the poorest flying conditions.

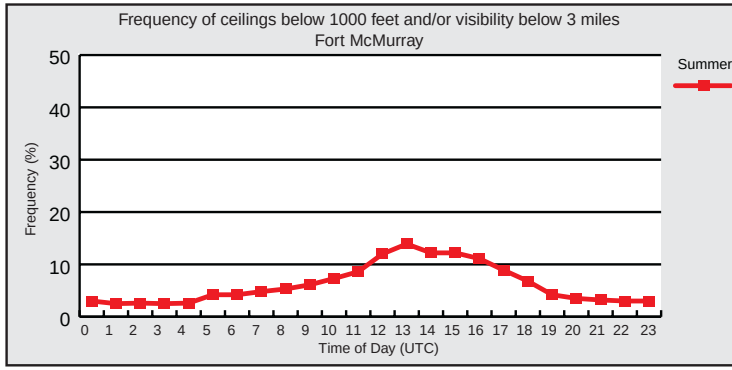
(b) Fort McMurray

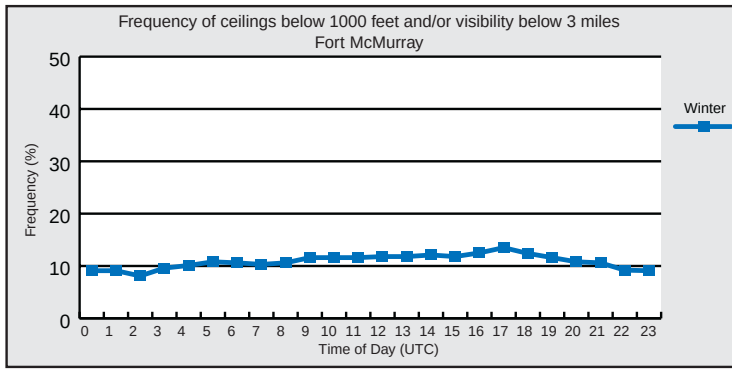


Fort McMurray is located at the confluence of the Athabasca and Clearwater Rivers, and the airport is located 7 miles southeast of the city. The Clearwater River passes within 2 miles north of the airport before joining the Athabasca River in town. The slightly rolling terrain rises moderately to the north and to the south of the Clearwater River valley.



The prevailing winds flow either up or down this river valley with very little difference from summer to winter. There is a secondary wind maximum from the southwest and there is a high percentage of calm winds.

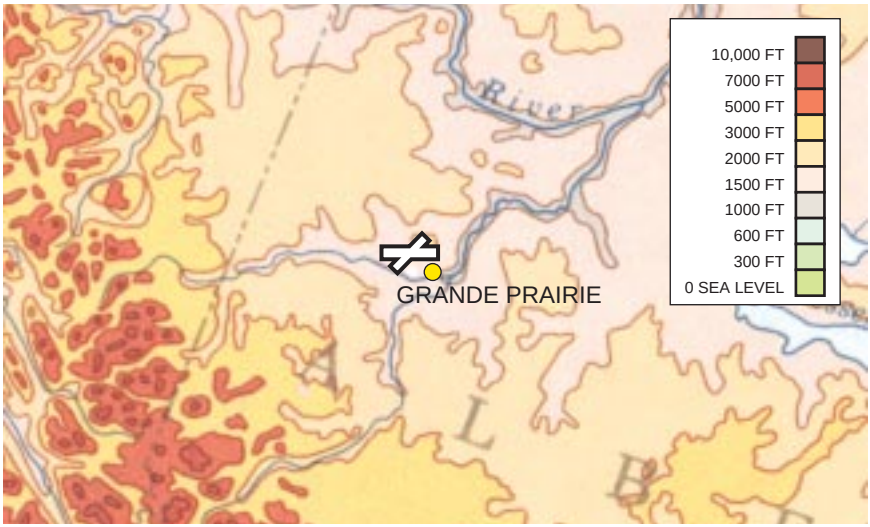




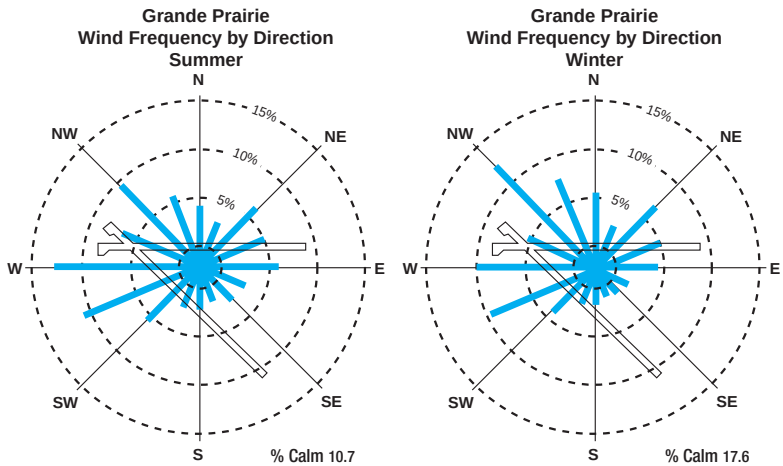
Summer flying conditions in Fort McMurray are generally very good but, after dark, the frequency of low ceiling and poor visibility conditions increases to a maximum near 1300 UTC. After this time conditions improve. There are a lot of small lakes and stretches of muskeg in the area that promote fog formation, even in the middle of summer and especially after a thunderstorm. In a northerly flow, it is possible to get "Syncrude Smog" advected into town and to the airport.

In winter, conditions are best in the late afternoon but deteriorate slightly during the evening and overnight. They get worse just after sunrise, for an hour or two, before starting to improve. This is due to aircraft movements generating significant amounts of low level moisture, and ice fog which is slow to clear in light wind situations.

(c) Grande Prairie

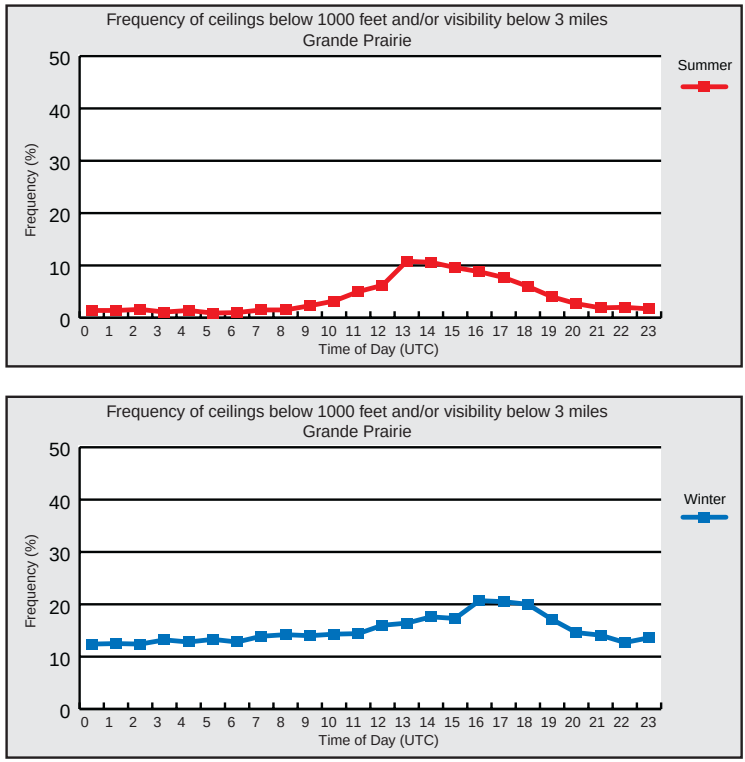


Grande Prairie is located about 43 miles east of the BC border in west central Alberta. The airport is located 2 to 3 miles west of the city of Grande Prairie on comparatively flat farmland which is generally free of trees. The Bear River drains Bear Lake, located about 5 miles northwest of the airport, and passes within about 1 mile east of the airport. The Saddle Hills lie on an east to west line about 19 miles north of Grande Prairie. The highest elevation in the Saddle Hills is White Mountain at 3,400 feet, located 19 miles northwest of the airport.



The winds at Grande Prairie favour the western quadrant, the result of funnelling around the Saddle Hills to the north and the Rocky Mountains to the south. With the approach of a synoptic scale high from the west, westerly winds predominate for

some time until the high moves past. The winds then shift to an easterly direction. There can be brief but very strong westerly wind events after cold frontal passages associated with a migratory low, especially if the pressure is rising sharply behind of the front. Southerly and northerly winds are quite rare.

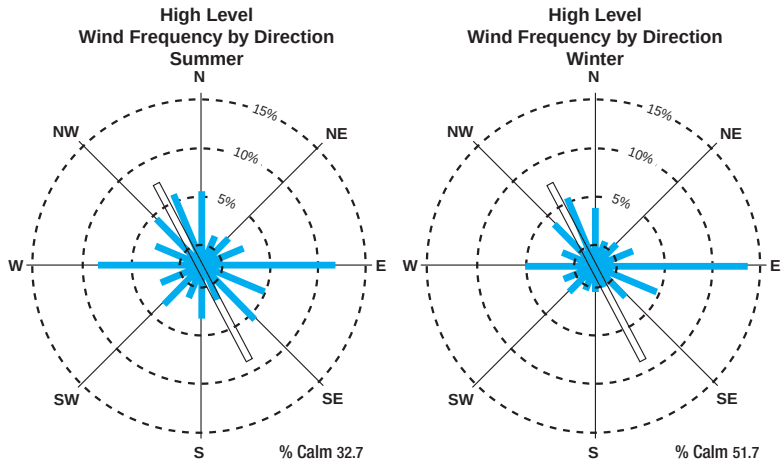


Flying weather in Grande Prairie in the summer is normally very good during daylight hours. After dark, the frequency of below VFR conditions increases up to 1300 UTC and then decreases for the remainder of the day. In winter, this frequency rises fairly steadily all night, peaks just after sunrise for a few hours and then decreases.

Shallow inversions, bolstered by light easterly or calm surface winds, are frequent year round and trap moisture in the low levels. As a result, overnight fog tends to persist here longer than at other sites in the region, especially from late fall to early spring.

(d) High Level

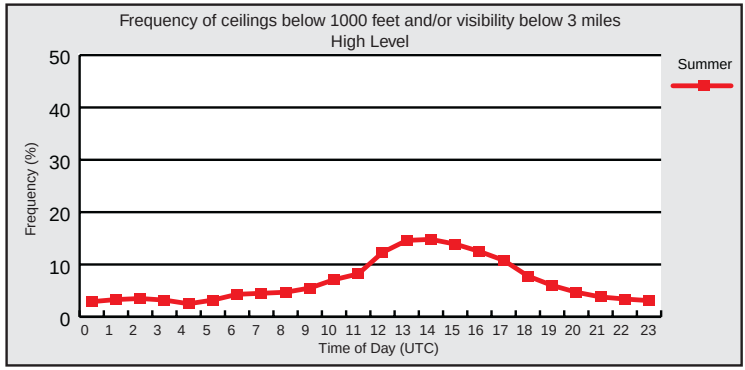
This site is located at an Alberta Forestry Service airport adjacent to the eastern shore of Footner Lake. A level forested area of aspen and spruce surrounds the site. Only enough clearing was done to maintain minimum clearance at the airport and so there are trees within 1/2 mile of the runway. Mount Watt, a ridge oriented in a southwest to northeast line, is located 12 miles west-northwest of the airport. The peak of Mount Watt is 2,500 feet ASL while the airport is 1,150 feet. The Caribou Mountains are located 17 miles northeast and are 3,300 feet high. High Level is situated in the bottom of a basin about 50 miles in radius that opens to the east. On a topographical map of Alberta, the Buffalo Head Hills are to the southeast, Caribou Hills to the northeast, Cameron Hills to the northwest and the Naylor Hills to the southwest.

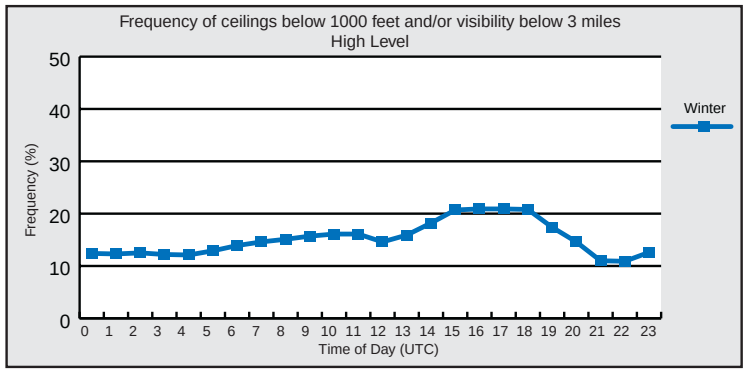


The hills present openings to the east and west and, as one would expect, the prevailing winds blow from these directions. There is also a secondary wind maximum from the north or northwest which would be the most common direction during a cold outbreak in winter.

During the winter, the airport can be enveloped all day in stratus while the town is clear, especially in a light easterly flow. There is a large percentage of calm winds both in the winter and summer here. The basin noted above allows for the formation of persistent inversions all year long.

Wind shear on descent below the treetops is a big concern at the High Level Airport. If the winds are blowing across the runway, an inbound aircraft cannot straighten out until below tree level. The subsequent loss of airspeed, occurring about 50 feet above the ground, is a hazard.



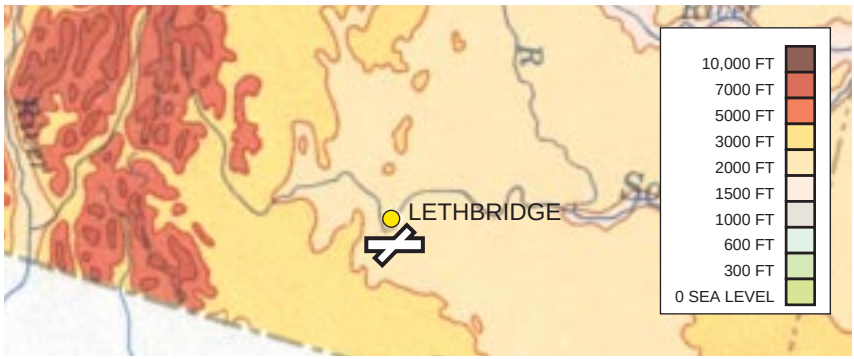


High Level usually has very good daytime flying weather in the summer. The surrounding hills provide some protection from thunderstorms during the season. It is rare to have thunderstorms approaching from the south. Cells that do hit High Level usually come off the Naylor Hills to the southwest and down the Chinchaga river valley. Thunderstorms in a westerly flow are diverted to the north or south by Mt. Watt and often miss High Level. Rarely do they traverse Mt. Watt to the airport area. After dark, conditions are likely to deteriorate. The highest frequency of low ceilings and poor visibility occurs near 1300 UTC after which time there is an improvement.

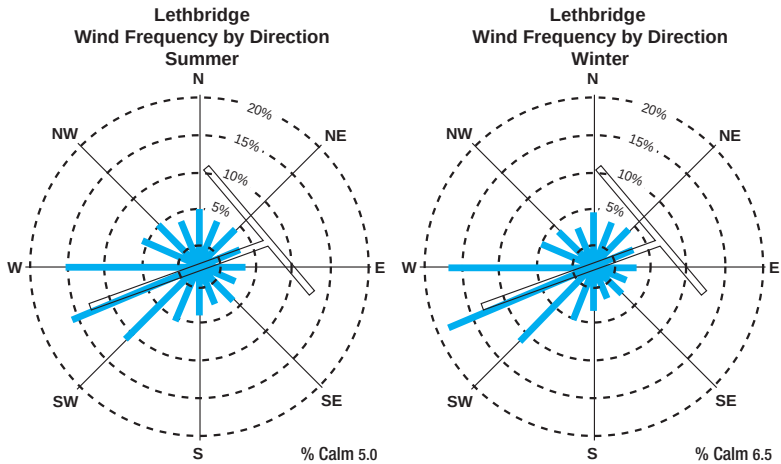
In the winter, the frequency of poor flying conditions is fairly steady from early

evening through the overnight period, but near sunrise, conditions deteriorate. The worst weather usually occurs between 1500 and 1900 UTC before improvement early in the afternoon.

(e) Lethbridge



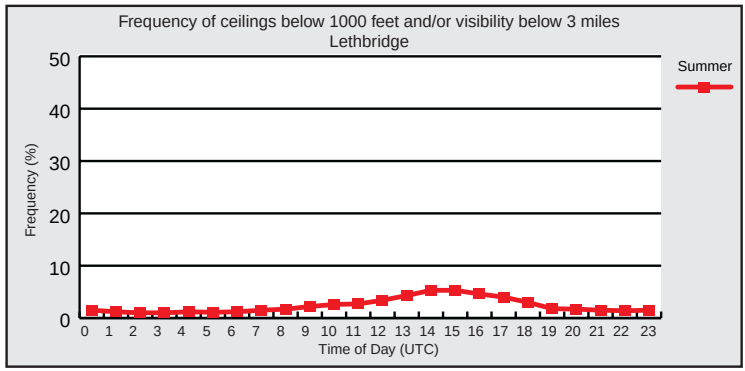
The Lethbridge Airport is located about 3 miles to the south of the city of Lethbridge, and is situated on a huge plain with a modest rise to the west and southwest. The Rocky Mountains are about 43 miles west of the airport. The Oldman River passes within 1 mile northwest of the airport as it meanders off to the east. About 21 miles to the south-southeast lies the Milk River Ridge, which rises about 1,300 feet above the surrounding terrain.

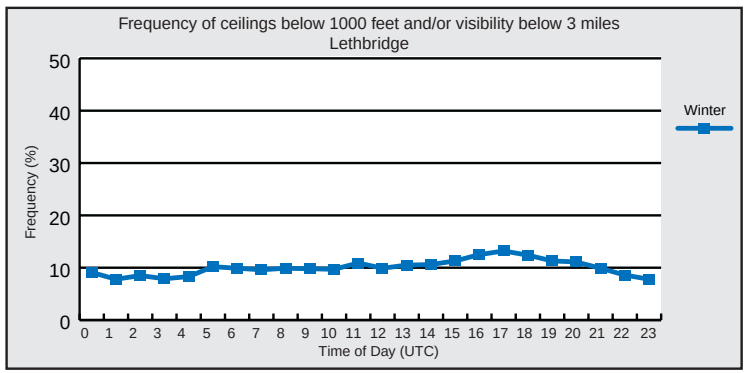


The winds at Lethbridge strongly favour the west and southwest. These are also the preferred directions for strong Chinook winds that frequently occur in Lethbridge during the winter. Marginal flying conditions associated with the southeasterly flow ahead of the Chinook Arch change for the better behind it.

While the flying conditions may be good west of the Arch, the strong westerly flow

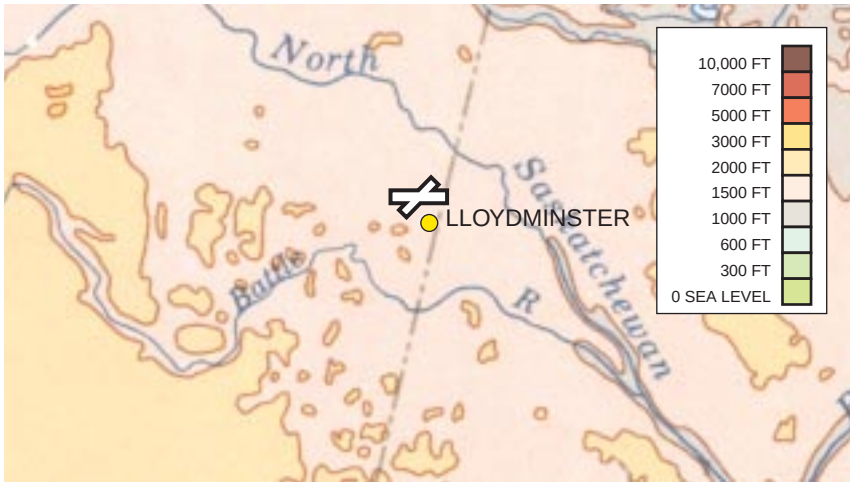
associated with the Chinook can be quite turbulent. Wind events from other directions are evenly distributed, but not very frequent.



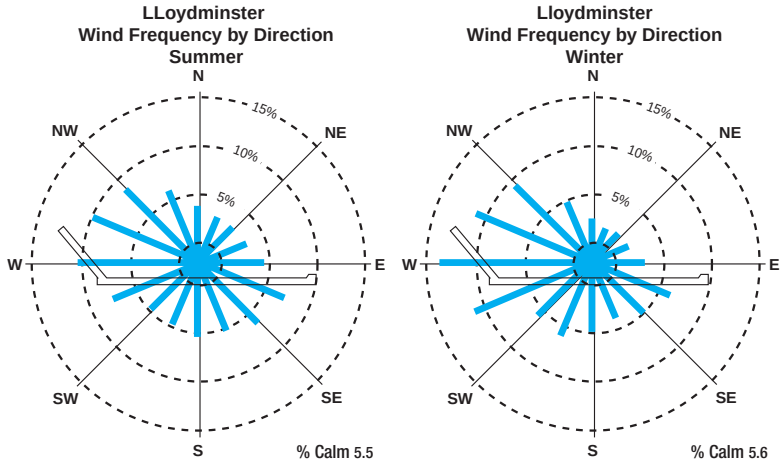


The frequency of good flying conditions in Lethbridge is similar to that of Calgary, but Lethbridge has the best weather of all the major Prairie aerodromes. Only one poor flying day in 20 can be expected in summer and one day in 8 in the winter. After dark in the summer, statistics show a gradual increase in the chance of below VFR conditions, reaching a maximum at 1400 UTC. In winter, the probability of low conditions remains fairly constant all night, spiking at 1700 UTC and then diminishing. Easterly winds are not frequent but when they do occur there is a good chance of low ceilings or poor visibility.

(f) Lloydminster

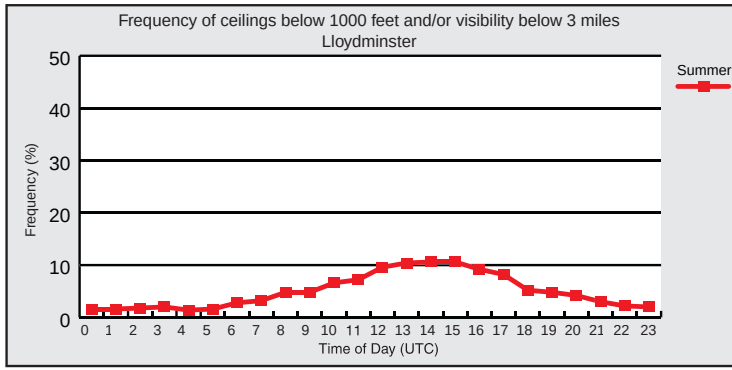


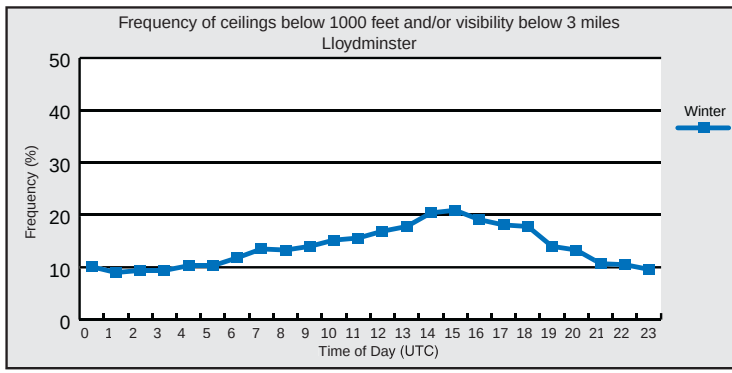
Lloydminster is located on the Alberta - Saskatchewan border between the North Saskatchewan River, to the north, and the Battle River to the south. These two rivers often channel the winds from either the west or northwest or from the southeast. A synoptic scale ridge of high pressure approaching from the west will usually generate westerly winds at Lloydminster. After the high goes by, the winds shift to the southeast.



In summer during the day, good flying weather can be anticipated around Lloydminster. During the night, there is a gradual increase in the probability of poor flying conditions, up to a maximum of 10 percent from 1300 to 1700 UTC. Once fog or stratus arrives, the Big Gully Lakes and pollution sources in town are able to provide enough moisture and particulate to maintain or enhance the low flying condi-

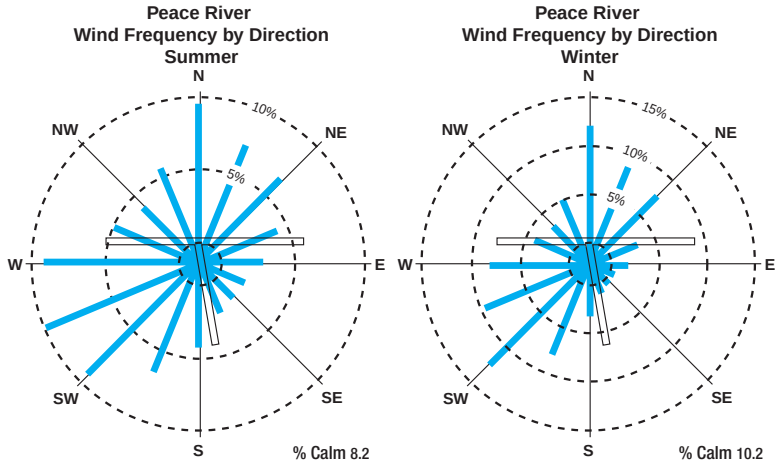
tions. In winter, there is a steady increase in below VFR frequency up until about sunrise and then a gradual decrease.





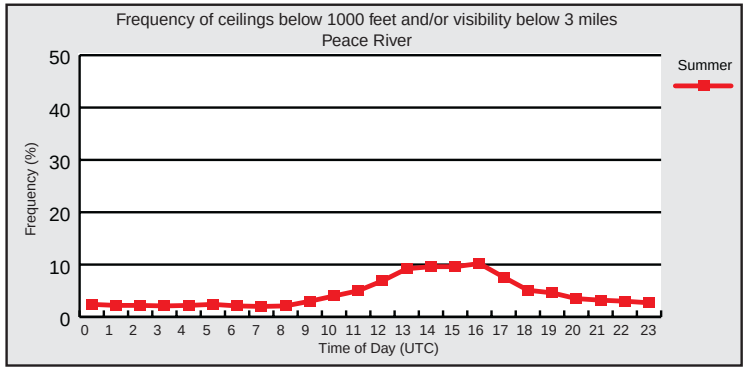
(g) Peace River

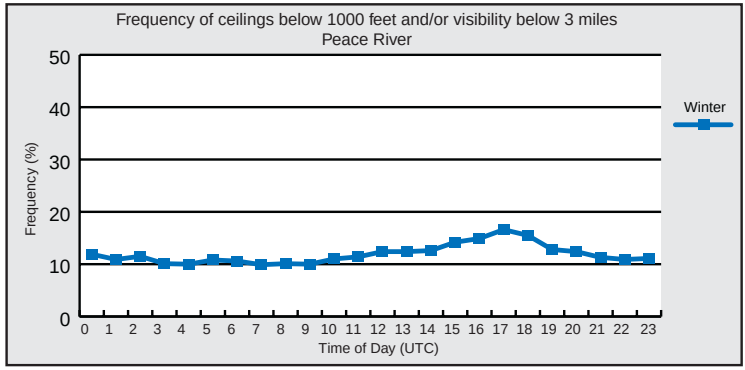
The airport is located midway between the town of Peace River to the east and Grimshaw to the west. The main topographical feature in the area is the Peace River valley that lies in a southwest to northeast orientation. The bottom of the Peace River Valley is 770 feet below the level of the observing site. The Smokey River, also boasting an impressive river valley, discharges into the Peace about 6 miles west of the airport.



Due to cold air drainage, the river valley is often completely filled with stratus and fog while the airport is clear. Winds in town are biased towards the northeast or southwest (along the Peace River Valley) while winds at the airport can be quite variable. During both summer and winter, the winds at the airport are mostly from the southwest or north. The passage of a migratory low to the north of Peace River will

cause southwest winds to shift around to the north. Once the low has moved far enough to the east, rising pressure ahead of the next high or ridge approaching from the west will cause the winds to shift back to southwest again.





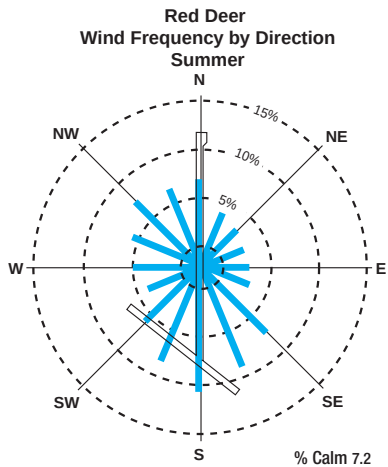
As with most of the airports on the Prairies, flying weather during summer daylight hours is typically very good. After dark, the probability of low ceilings and poor visibility increases to a maximum at 1300 UTC and is constant for several hours afterward. Once stratus or fog forms in the area, it is slow to clear, even in summer.

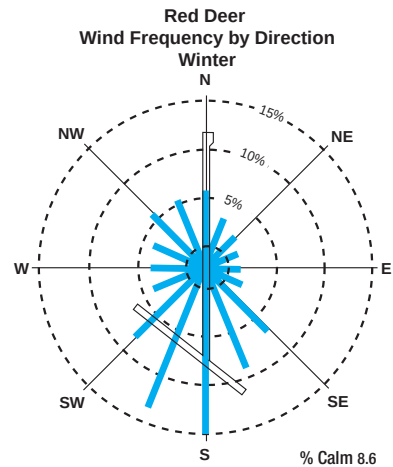
In winter, there is a gradual increase in the frequency of below VFR conditions from evening to about 2 hours after sunrise, after which conditions tend to improve.

(h) Red Deer

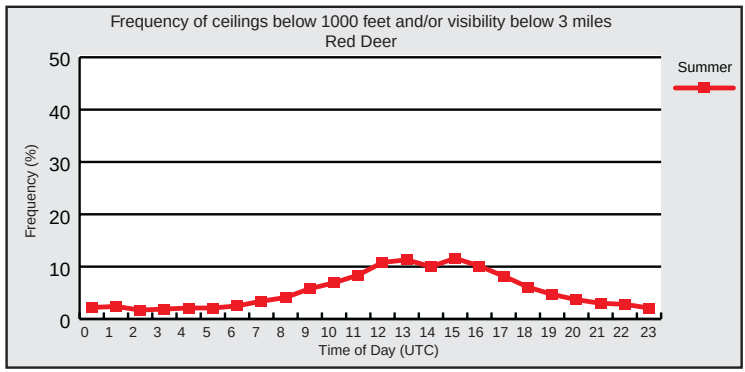
The Red Deer airport is located 6 miles southwest of the city. The Red Deer River flows northeastward across western Alberta and courses within 3 miles of the airport, which was built in a bowl-like depression in the terrain and therefore has poor drainage of air and moisture. With a light flow from any direction, fog tends to form easily here and is slow to dissipate. The terrain to the west of Red Deer and Rocky Mountain House is a genesis area for thunderstorms. If convective cells form over the foothills in the morning, they frequently move through the Red Deer area later in the day.

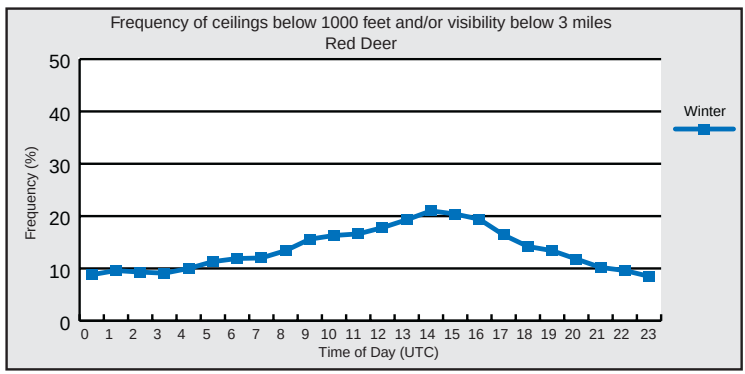
In the wake of a winter cold front, stratocumulus or stratus cloud, based between 1,000 to 3,000 feet above ground, can be very persistent. As the cold front pushes up into the Rockies, the area will experience a northeasterly upslope flow which augments cloud formation. This low cloud will remain in the area until an Arctic high becomes established and clears it out.





The winds here tend to follow the orientation of the Red Deer River Valley, so are generally from the northwest or south all year long. In the winter, there are more southerly winds than northwest winds, which is a reflection of the climatological average pressure pattern that shows a ridge of high pressure over the central Prairies. Since the airport is built in a bowl, there is a high occurrence of calm winds. This is especially true during inversion events in the winter, as weak air mass erosion allows cold air to remain while warm air glides over top.





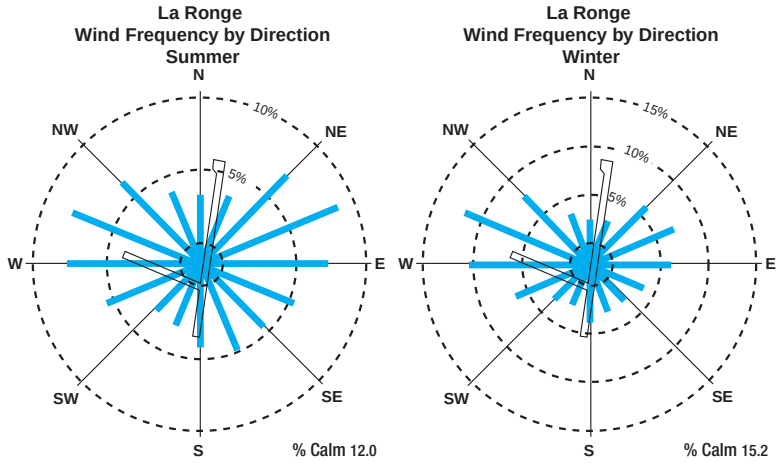
As with many other stations across the Prairies, Red Deer, in summer, enjoys very good flying weather during the day with few cases of low ceilings and visibility. After dark, the frequency of low conditions increases to a maximum near 1200 UTC and is slow to decrease until after 1500 UTC.

The fact that the airport is in a bowl means it is also subject to local water drainage. This, coupled with the increased occurrence of inversions, causes fog to form more readily overnight in the spring and fall, especially after precipitation episodes. The Red Deer River is also a good source of moisture for fog formation.

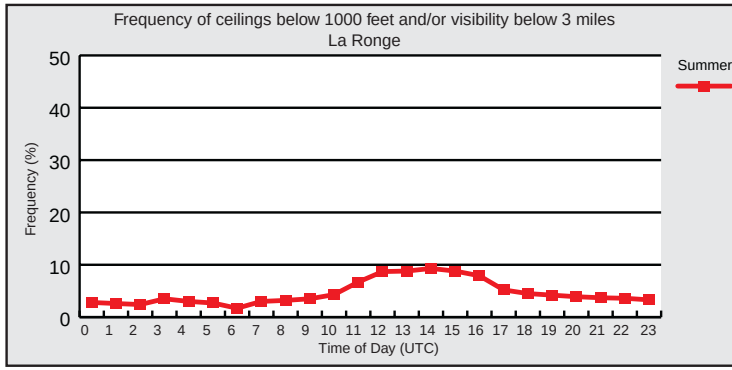
Saskatchewan

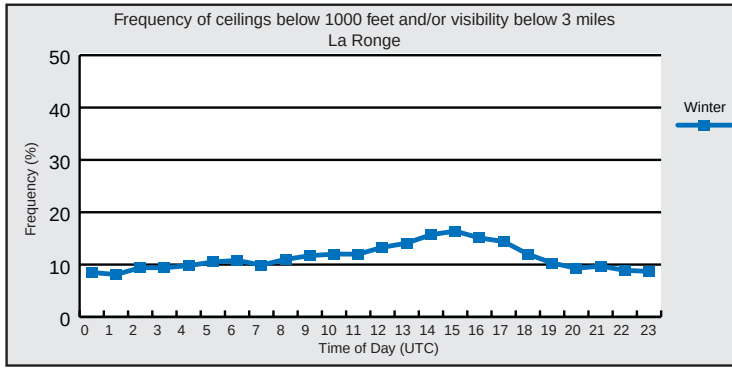
(a) La Ronge

The town of La Ronge is located on the western shore of Lac la Ronge while the airport is a few miles to the north. This part of north-central Saskatchewan is characterized by small, rolling hills, several large lakes and open boreal forest.



The winds here favour westerly throughout the year with a secondary maximum from the east-northeast. This is the result of being near the centre of the climatological high pressure area which resides over this part of the Prairies. When the centre of high pressure is approaching from the north, the winds are easterly and, after it goes past, the winds shift to westerly. When the high is nearby, the winds under the accompanying inversion are frequently calm.

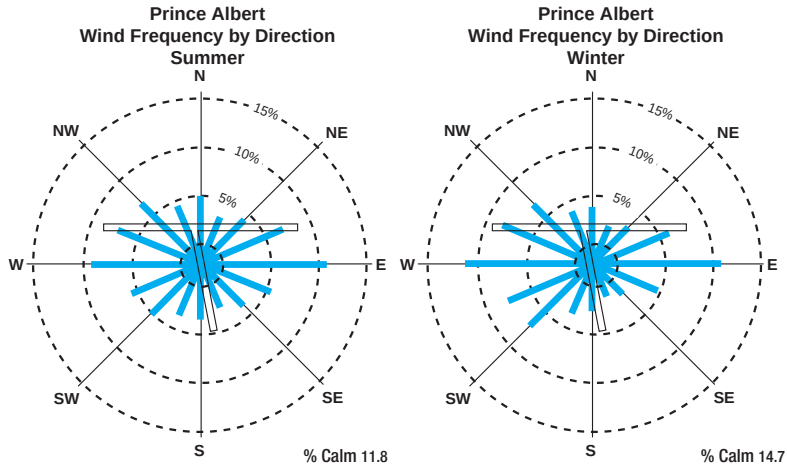




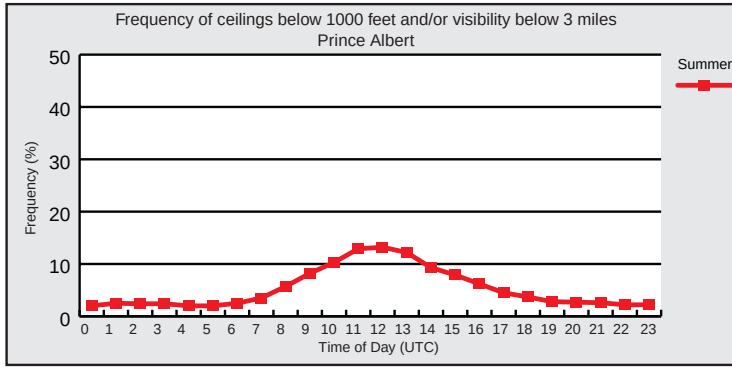
In summer, there is a gradual increase in the frequency of low ceilings and/or poor visibility through the night, up to a maximum near 1200 UTC. Improvement after this time is very slow, exhibiting the influence of Lac la Ronge. Moisture from the lake can reinforce stratus and fog formation at this time or, at least, slow the dissipation process. In winter, there is a gradual increase in the frequency of below VFR conditions to a maximum near 1500 UTC and a gradual decline after that time.

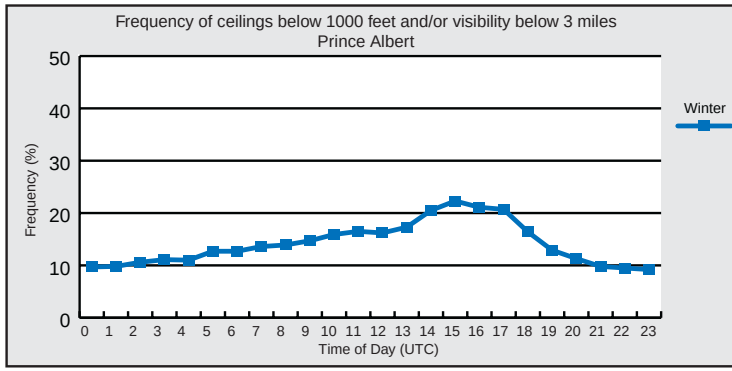
(b) Prince Albert

The Prince Albert Airport is located on a flat plain in the valley of the North Saskatchewan River, about one mile east of the city. The river itself approaches from the west, bends around the south side of the facility and exits to the east, but the valley is oriented more or less west to east. There is a gradual rise in terrain from the southeast to the northwest.



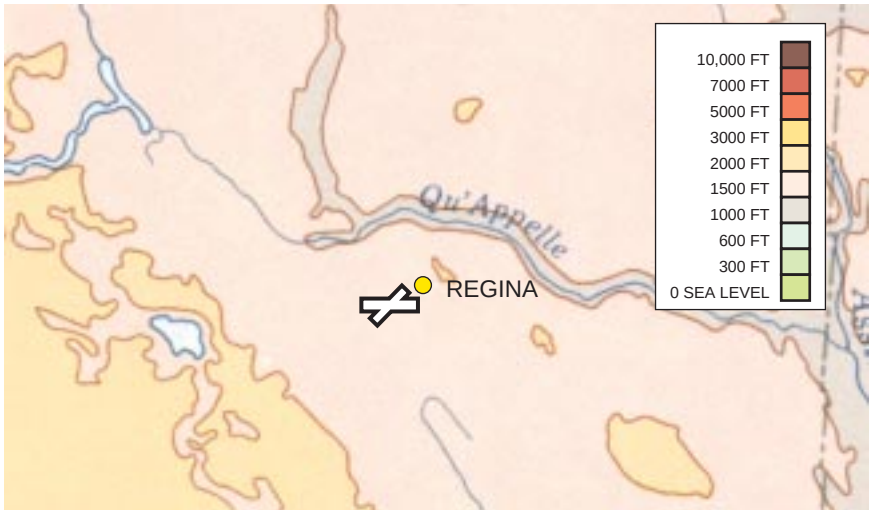
Most of the prevailing winds here are either westerly or easterly. North and south winds greater than 10 knots are much less common. The location in the river valley, and a local source of abundant moisture, make Prince Albert a prime candidate for radiation fog on clear skies with light winds.



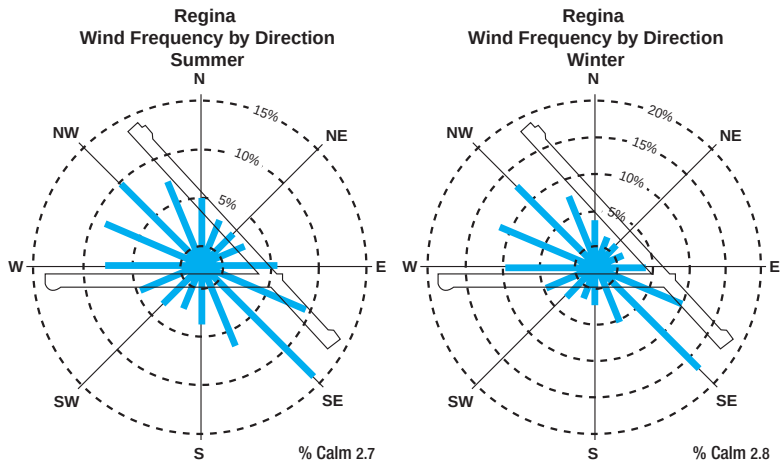


Even with all of these weather parameters working to form low cloud and fog, Prince Albert has very good flying weather during the summer. Overnight, the frequency of low flying conditions increases to a maximum at 1200 UTC and then conditions tend to improve. Radiation fog becomes a concern in August and September when the nights are longer and there is still abundant moisture. If stratus forms over the city during the evening, it is a good indication that Prince Albert will fog in overnight. There is a pulp mill located to the northeast of the airport and, in a northeasterly flow, pollutants from this mill can create fog that will eventually advect over the runway. In winter, the probability of poor conditions increases as night progresses. There is a jump in this trend near sunrise due to aircraft movements and a maximum of 22 percent near 1600 UTC. After this time, conditions tend to improve.

(c) Regina

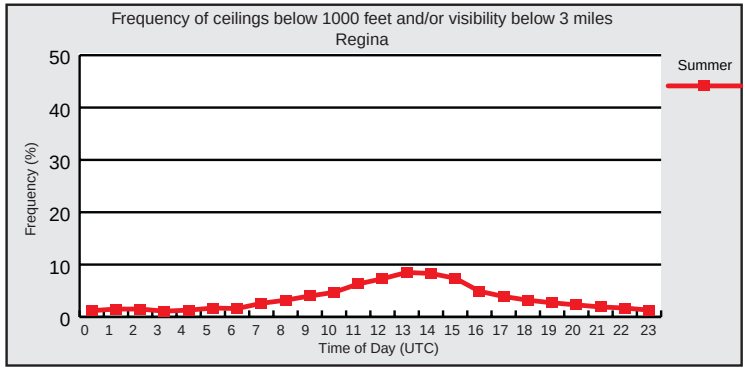


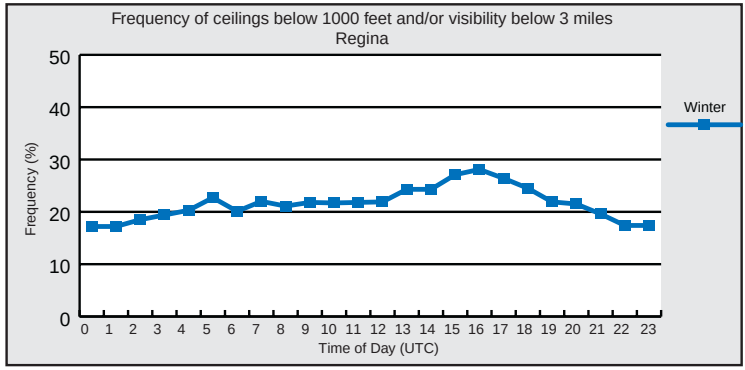
The airport is located on a level plain at the southwest edge of the city of Regina. The city is located on the banks of Wascana Creek, which lies in a very shallow basin running southeast to northwest. The land rises slowly to the northeast and peaks at an elevation of 2,300 feet, about 19 miles northeast of the airport. The Qu'Appelle River, 32 miles north of the airport, meanders in an easterly direction in a very deep narrow valley.



The winds for Regina strongly favour southeast and northwest directions throughout the year. This is a reflection of the orientation of the Wascana Basin which directs the synoptic scale winds to flow either up or down the valley. Funnelling acts to strengthen such flows, and blowing snow is fairly common in the Wascana Basin as a

result. The southeasterly flow, which can sometimes produce blizzard conditions across southern Saskatchewan, will not affect the airport at Regina because of the sheltering effect of the city. Northeast and southwest winds do not occur very often.

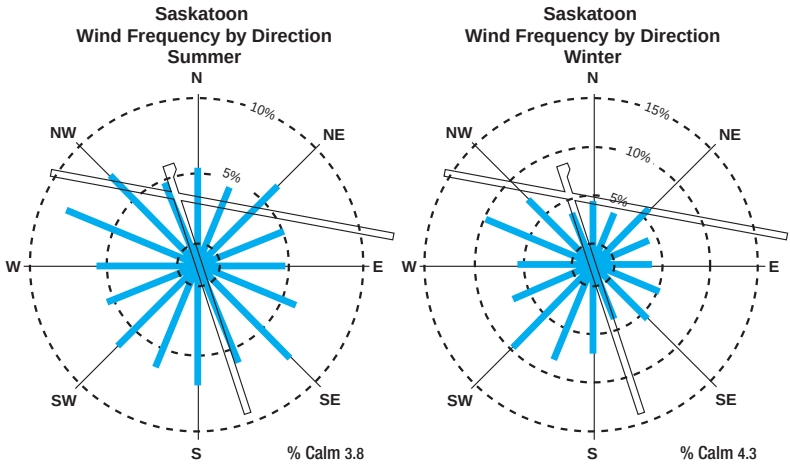




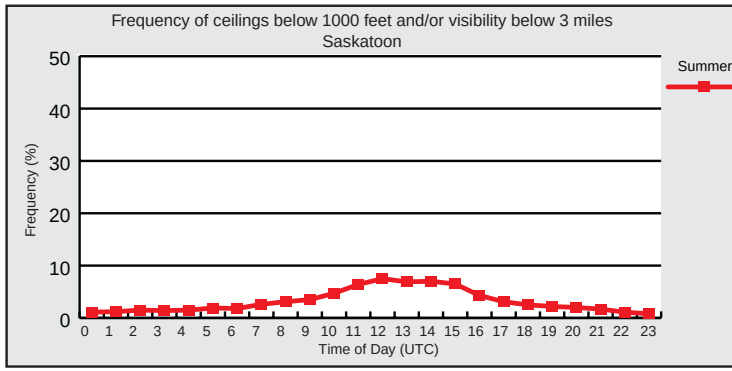
In the summer, the flying weather at Regina is very good most of the time, but there are rare dips below VFR limits. In winter, the frequency of low conditions remains fairly constant through most of the evening and overnight. Near sunrise, the frequency increases more rapidly to a maximum near 1700 UTC, and then diminishes.

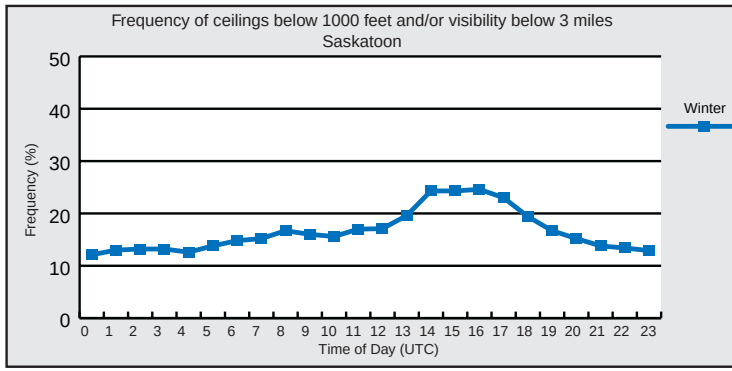
(d) Saskatoon

The airport at Saskatoon is located on the plain of the South Saskatchewan River, about 2 miles north-northwest of the city centre. The terrain in the immediate vicinity of the airport is relatively flat. The South Saskatchewan River flows through the city in a northeast direction and passes within 2 miles east-southeast of the runway complex. The terrain to the east of the airport reaches a height of 1,900 feet in the Minichinas Hills, about 8 to 9 miles away. To the southeast, the nearest significant topographical feature is the Allen Hills, about 17 miles from the airport.



Although Saskatoon has no preferred wind direction, the highest average wind speeds (10-12kts) occur from the west-northwest. There is a secondary maximum in wind direction from the southeast that is more obvious in the summer than in the winter. In the wintertime, southwest is another preferred wind direction.



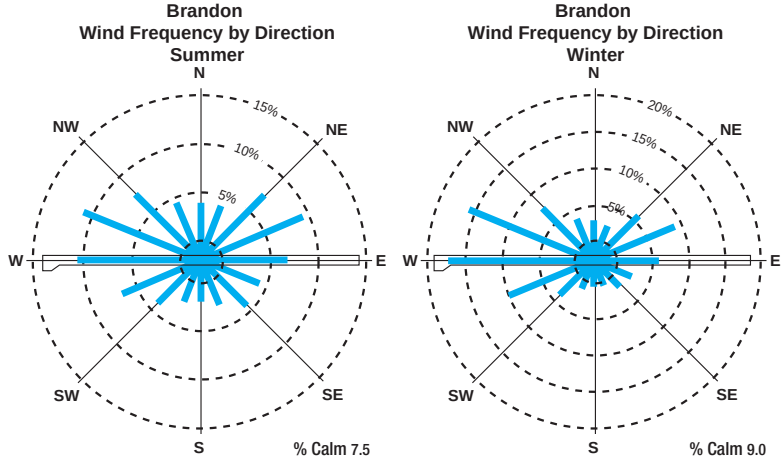


The "Frequency of ceilings below 1000 feet and/or visibility below 3 miles" charts for Saskatoon shown above are much like those for most other sites on the Prairies. In the summer, the flying weather is very good most of the time. Episodes of low conditions tend to occur most often between 1200 and 1500 UTC. Improvement afterward occurs fairly rapidly. In winter, the frequency of low ceilings and poor visibility remains fairly constant through most of the evening and overnight. The frequency increases quite rapidly between 1200 and 1400 UTC (near sunrise), remains high for about 3 hours and then drops.

Manitoba

(a) Brandon

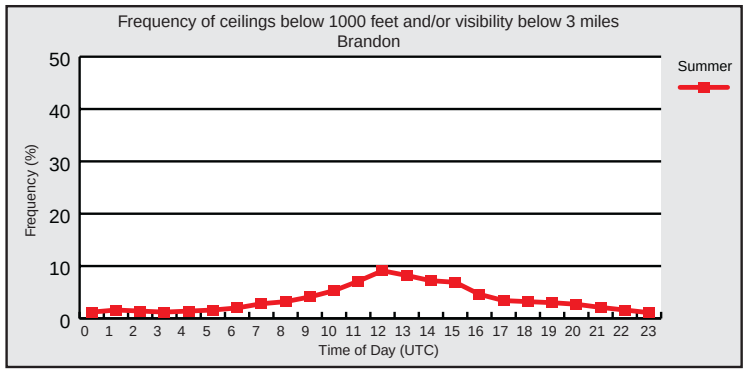
The city of Brandon is situated in the Assiniboine River valley about 3 miles south of the airport. The terrain to the north of Brandon rises slowly but steadily, peaking at 2,400 feet in the Riding Mountains 49 miles north of Brandon. South of the city, the terrain rises slowly to heights between 1,600 and 1,700 feet in the Brandon Hills, some 13 miles south of the city. Further to the south, near the Canada - U.S. Border, are the Turtle Mountains.

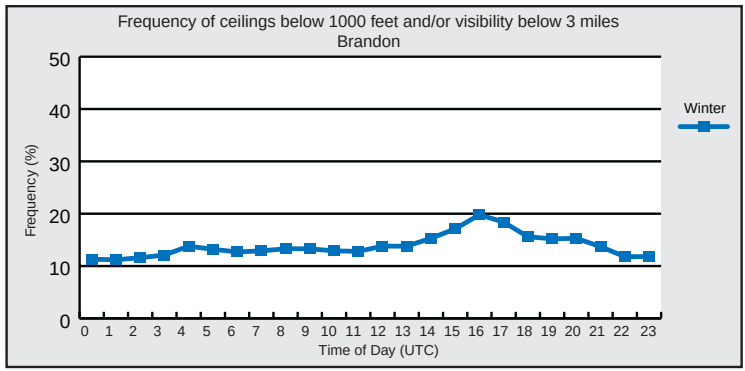


The Assiniboine River Valley forms an east to west channel between the Riding Mountains and the Turtle Mountains. Because of this, Brandon winds blow most often from the west or east. The most common wind is westerly around 10 knots.

Northwesterly winds tend to be stronger than the gradient would suggest, and this is also due to the funnelling effects of the local terrain. In summer, westerly winds are

the most frequent, closely followed by those from the east and northeast. Northerly winds are uncommon and southerly winds are even more rare. Calm conditions occur 8 percent of the time in summer. In winter, westerly winds occur more often than in the summer but there is no real increase in easterly winds. A westerly flow is downslope for Brandon and a northwest flow off the Riding Mountains is even more subsident. Since these are the two most common wind directions for Brandon, overall conditions tend to be good. With easterly and northeasterly flows in spring and fall, stratus and fog are a common occurrence. The winds are calm at times at the airport and, hence, radiation fog occurs fairly regularly at the airport. Because of the influence of the river valley, radiation fog will be even more common in town.



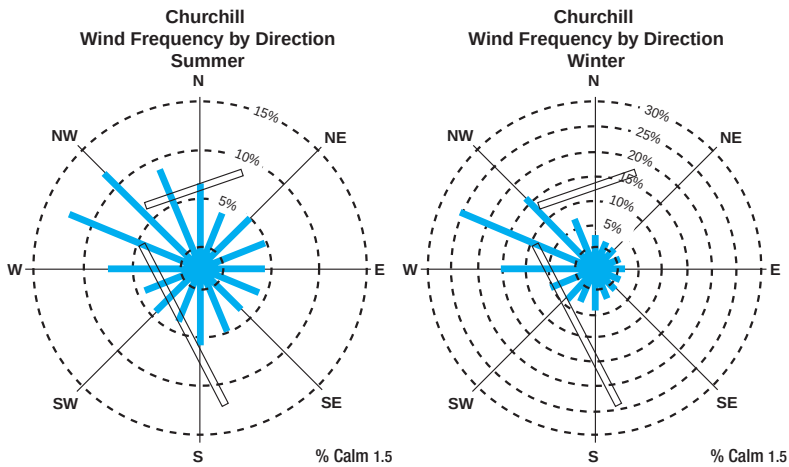


Although flying conditions in Brandon are generally reliable in summer, the chance of poor conditions increases steadily after midnight up until 1200 UTC when it peaks at about 9 percent. There is a gradual decrease in probability after this time. In winter, there is an 11 to 13 percent chance of low ceilings or poor visibility occurring at almost any time of day. There is a higher probability between 1400 and 2000 UTC, with a peak of 20 percent around 1600 UTC.

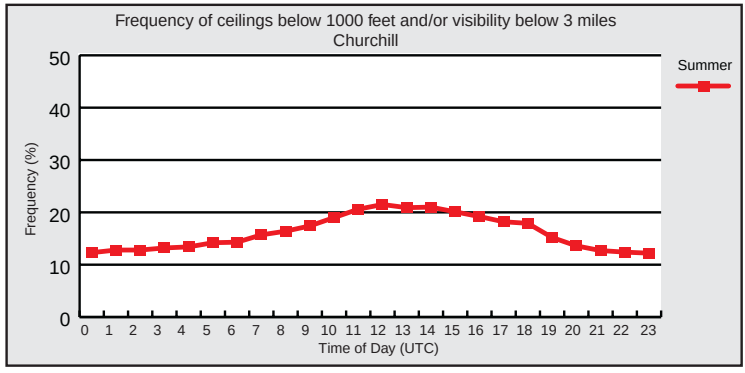
A typical start for fog dispersal in summer is 1300 UTC, while in winter, dissipation commences around 1700 UTC. The increase in aircraft movement near sunrise, and the delay in sunrise itself, form the best explanation of this phenomenon.

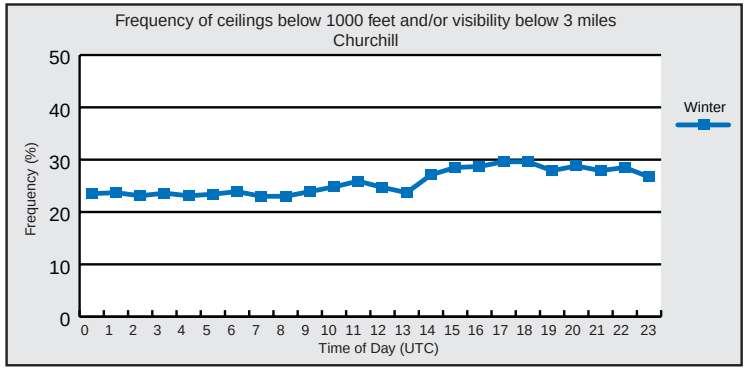
(b) Churchill

The town of Churchill is located on the Hudson Bay coast. The airport itself sits on a bluff a little over 90 feet above Hudson Bay and roughly one n. mile south of the water's edge, and 3 miles east-southeast of the town. The coastline runs about 27 miles due east to Cape Churchill, then south-southeastward toward the mouth of the Nelson River. Just to the west of the airport, the northward flowing Churchill River spills into the bay. A few miles further west is Button Bay, an inlet about 5 miles across.



Once again, the climatological ridge of high pressure over the central Prairies is responsible for the much of the bias in wind direction at Churchill. During the summer, the winds favour the northwest but any direction is possible at least part of the time. In the fall, flows off Hudson Bay can advect marine stratum over the airport. In winter, the dominant ridge of high pressure over the central Prairies produces northwest winds twice as often as in summer. Strong northwest wind events can produce blowing snow over the nearly treeless coastal area, and this is a major contributor to the high frequencies of poor flying conditions in winter. In spring, these northwest winds can bring in stratus from open water on the Churchill River. The winds are seldom calm at Churchill.



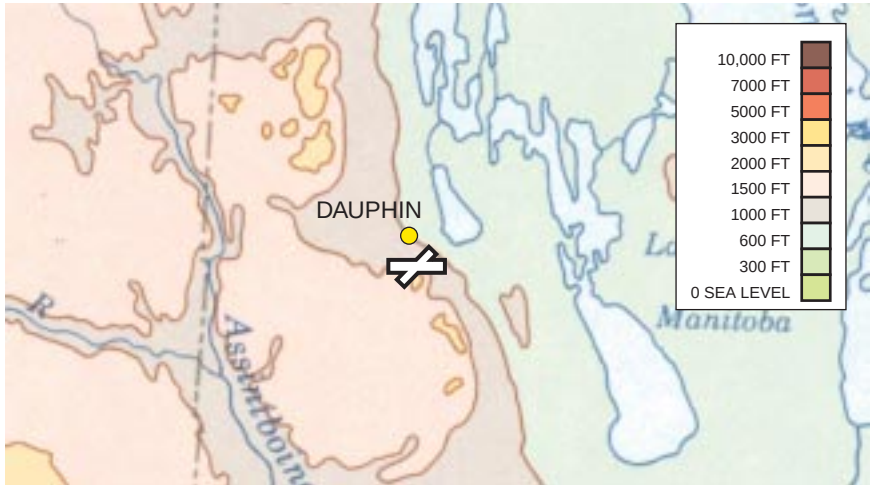


Throughout the year, conditions with low ceilings and visibility are fairly common at Churchill. In the summer, from about 2000 UTC to about 0700 UTC, conditions are poor 12 percent of the time; a frequency more than 4 times higher than at airports further south or inland. While Hudson Bay is the principal source of moisture for low cloud formation in the area, it is not the only one. Even in a westerly or southwesterly flow, it is possible to tap moisture from the Churchill River, Button Bay or any of the myriad of lakes and swamps dotting the region. After about 0700 UTC, the chance for below VFR conditions increases, peaking at 1200 UTC, and then slowly decreases.

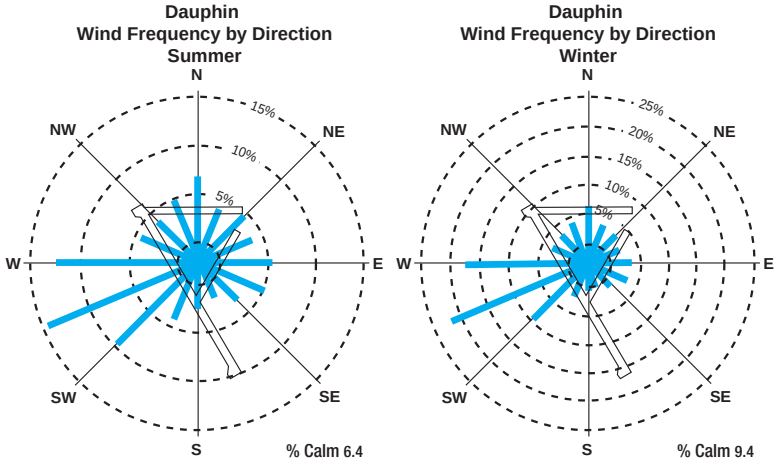
Again, in a northwesterly flow in spring, open water at the mouth of the Churchill River can produce a good deal of stratus. If the temperature is just below zero, freezing drizzle is a good possibility. If the winds shift from northwesterly to northerly, then the stratus drifts southward past the airport. In the fall, any wind direction from the northwest through northeast to the southeast can produce stratus as this flow is, for the most part, directly off the bay.

The likelihood of below VFR conditions in winter at Churchill is the greatest for any major site on the Prairies by far. During the night, poor flying weather occurs 24 percent of the time, which is nearly one day in four. Interestingly, the frequency increases to almost 30 percent in the morning and remains at that level throughout the day. This trend is opposite to that normally seen at other sites on the Prairies. Hence, if weather conditions are marginal or poor in the morning at Churchill in the winter, they very likely will remain poor or get worse through the afternoon and evening.

(c) Dauphin

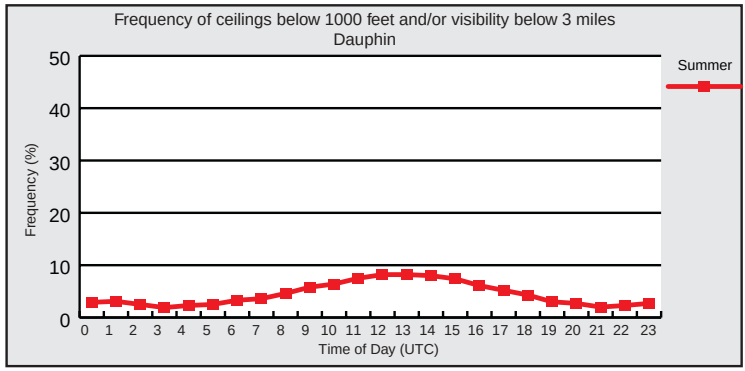


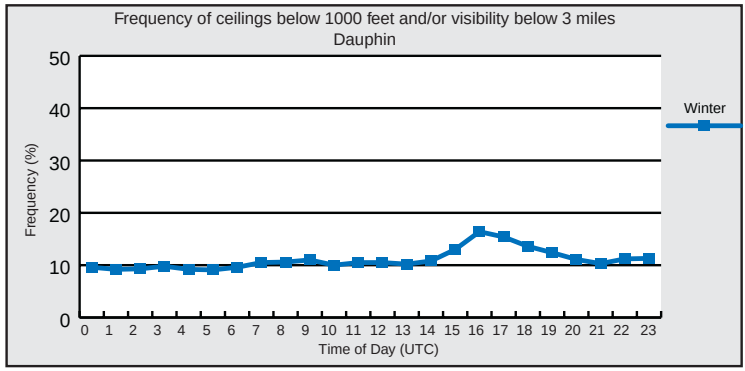
The Dauphin Airport is situated about 3 miles south of the town of Dauphin, and about 8 miles west of Dauphin Lake. Several creeks and rivers, which originate in the Riding Mountains to the south, flow northeastward into Dauphin Lake, which drains into Lake Winnipegosis to the north. The Dauphin area is a broad, flat valley bounded by the Duck Mountains to the northwest and the Riding Mountains, which extend from southeast around Dauphin to the west-southwest. The northern escarpment of the Riding Mountains begins 5 miles south of the airport and the highest peak (2,200 feet), is about 9 miles south. The valley floor slopes gently away to the north and east towards Lake Winnipegosis and Lake Manitoba.



The wind record at Dauphin reflects the strong channelling effect of the valley between the Riding and Duck Mountains. With a high over the central Prairies, the winds generated by the northwesterly gradient over this area are backed significantly by the valley. Winds from all other directions occur with about the same frequency (3-5 percent) with a secondary maximum from the north, indicating that when low pressure systems pass to the east of Dauphin, there is some diversion of the flow around the Duck Mountains to the north of town. South to southeast winds do not occur very often at all.

In winter, the winds favour the west to southwest directions even more strongly; the result of more and stronger highs or ridges over the central Prairies and a northwesterly gradient across Manitoba. Winds from other directions occur even less in winter than in the summer and south and southeasterly winds are very rare.

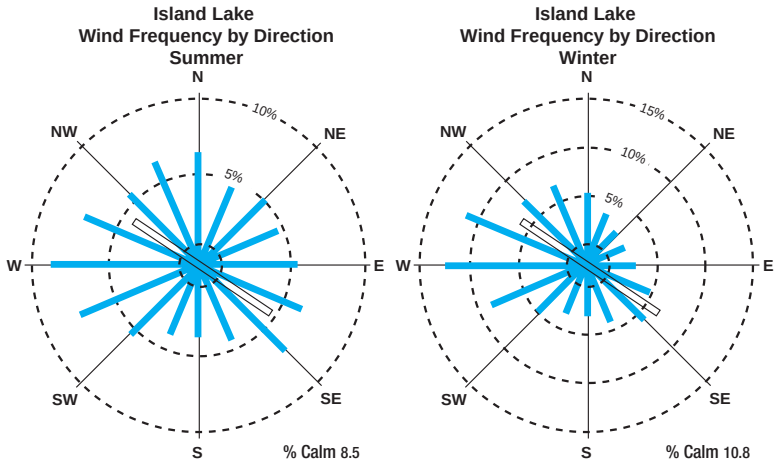




In summer, good flying conditions are the norm in Dauphin. Overnight, there is a gradual increase in the chance of low ceilings and visibility, reaching a maximum near 1300 UTC, after which there is an equally gradual decrease through the morning into the early afternoon. During the evening and overnight in winter, poor conditions occur 10 percent of the time from hour to hour with very little variation. Near, or just after, sunrise the frequency jumps quite quickly to a peak of 17 percent at 1600 UTC, then returns to the normal 10 percent by 2100 UTC.

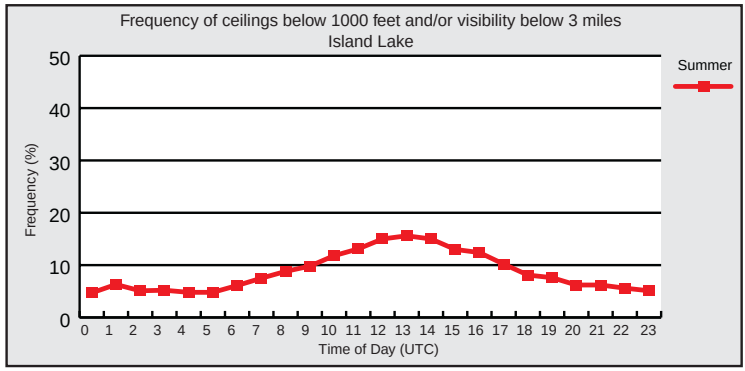
(d) Island Lake

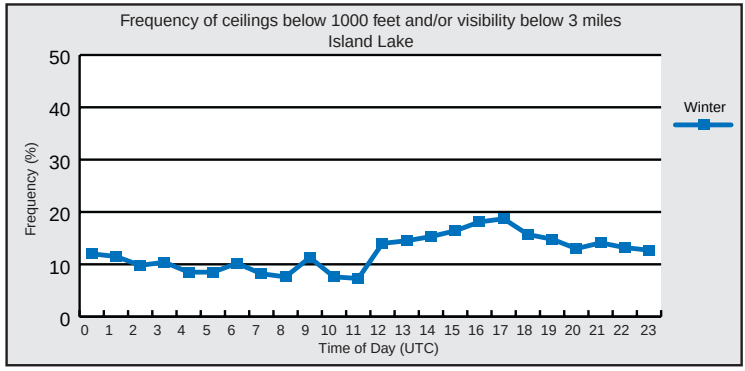
Like most of the sites in central and northern Manitoba, Island Lake is located on the very flat, open forestland of the Canadian Shield with its many lakes and sloughs. True to its name, the airport is located on Stevenson Island and completely surrounded by water. Three miles to the northeast, and about 100 feet higher, is the village of Garden Hill. There are open stretches of water to the northwest, west and southeast. These compass points coincide with the most common wind directions.



In summer, occurrences of below VFR weather are more frequent at Island Lake than at sites further south, no doubt due to the site being totally encircled by water. The frequency of low flying weather increases during the evening, and overnight, to a maximum at 1300 UTC (near sunrise) and then decreases during the morning. During the winter, there is no strong diurnal increase in the frequency of low ceilings

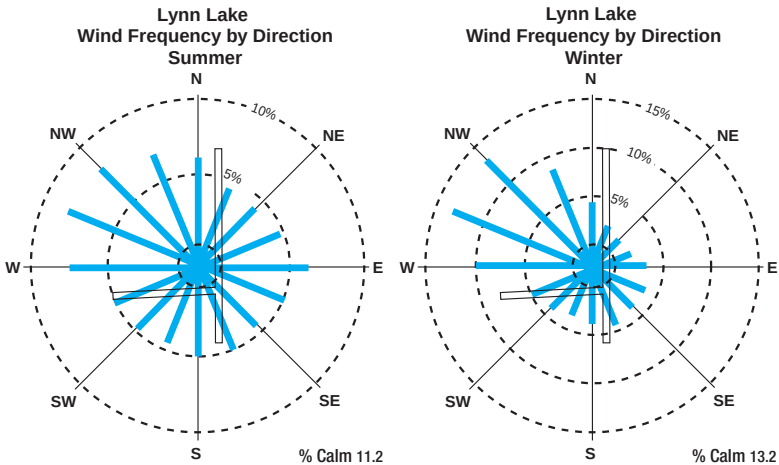
and visibility until about 1200 UTC, or just before sunrise, when it increases sharply. Probabilities increase until about 1700 UTC and then decline fairly rapidly. These summer and winter sunrise peaks are similar to those at other sites in this part of Manitoba. However, a completely different trend is shown at places further south and away from the effects of local large bodies of water.



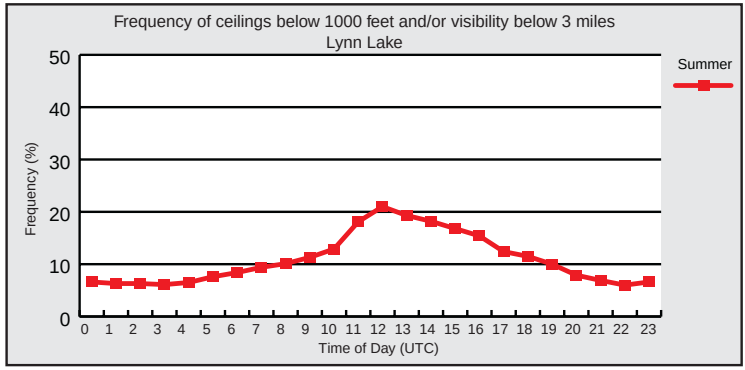


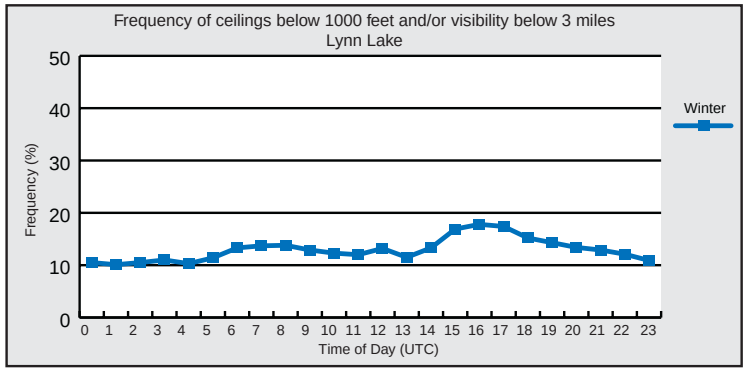
(e) Lynn Lake

Lynn Lake is located in the forested region of the rocky Canadian Shield that covers northwestern Manitoba. The rolling terrain is home to a profusion of lakes and muskeg that provide (when they are not frozen) lots of low level moisture for stratus and fog development.



Winds can occur from any and all directions, but there is a noticeable maximum from the northwest, particularly in winter when the climatological ridge is in place. Because Lynn Lake is in a forested area, there are frequent occurrences of calm winds.

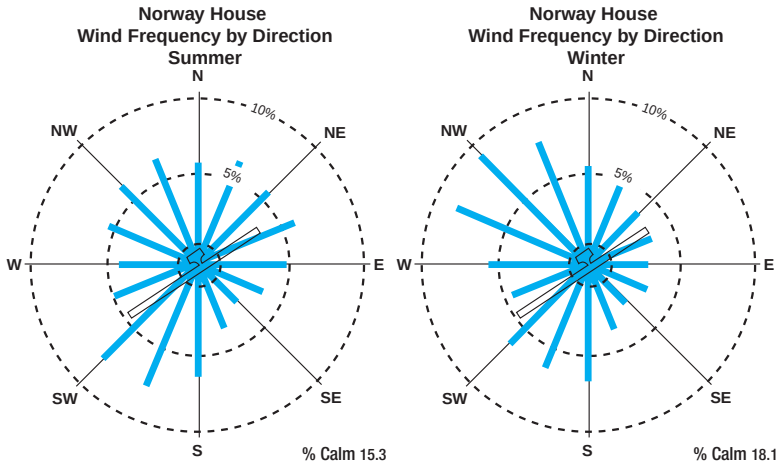




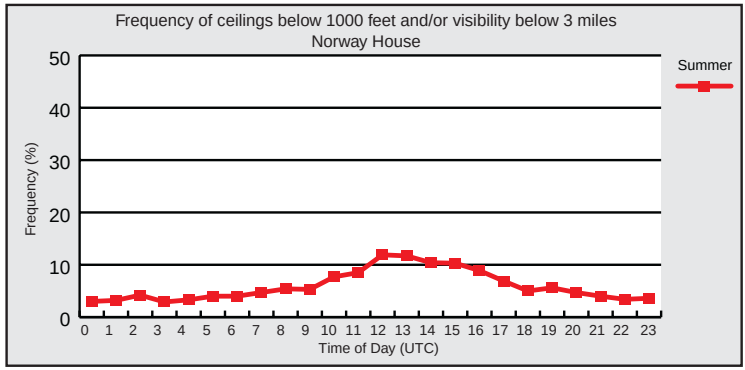
The proximity of water plays a role in the occurrence of low ceilings and poor visibility. Like many other sites with lakes nearby, the probability of poor flying weather in summer at Lynn Lake increases during the night to reach a maximum near 1200 UTC and falls off after that. In winter, the frequency of poor conditions is fairly steady at 11 to 14 percent, from sundown right through the night. After sunrise, conditions tend to be worse until about 1600 UTC, then slowly improve through the afternoon.

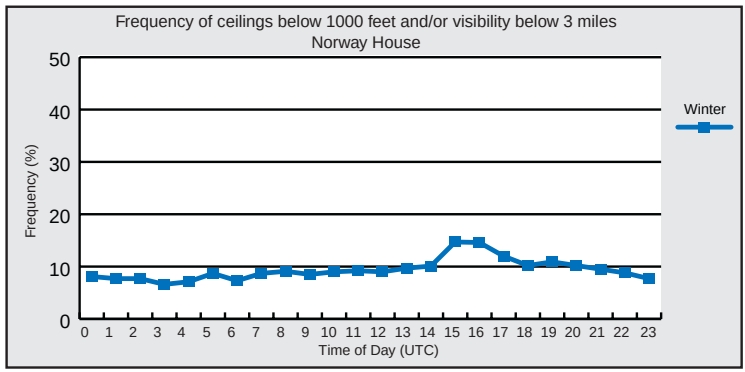
(f) Norway House

Norway House is located about 13 miles north of Lake Winnipeg in a flat, forested area of the Canadian Shield. There are many smaller lakes and muskeg in the area which can provide low level moisture for stratus formation when not frozen. When stratus ceilings are observed in the fall with a southerly flow, freezing drizzle is likely when the temperature is just below freezing, due to the additional moisture provided by Lake Winnipeg.



Winds blow from all directions at Norway House with about equal likelihood. In summer, there is a slight southwesterly maximum. In winter, a similarly weak preference for the northwest is shown. The east channel of the Nelson River lies in a southwest to northeast orientation through Norway House and provides some funnelling for the southwest flows. Although this effect also occurs in winter, the climatological high over the central Prairies provides a greater number of northwesterly wind events.

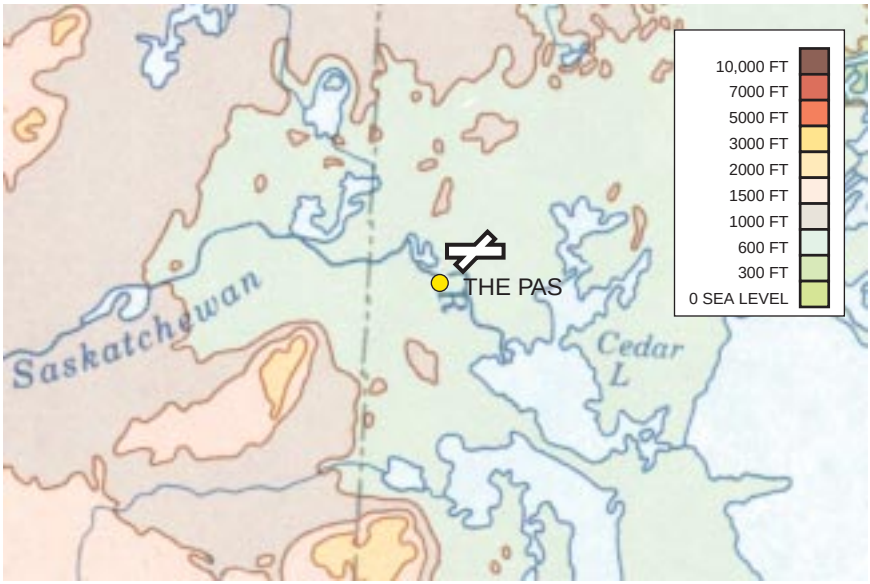




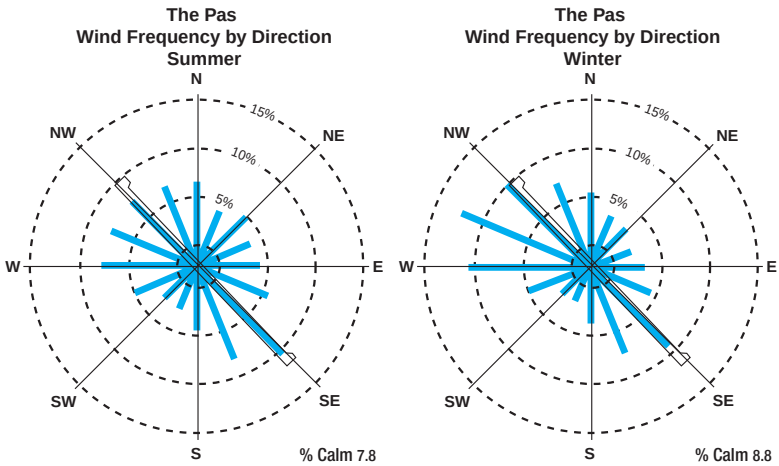
There is a high percentage of calm winds at Norway House, due in part to its forested location and partly because thermal inversions are common, especially in winter.

In general, Norway House has good flying conditions. Early on summer mornings, there is a maximum frequency of low flying conditions near 1300 UTC. In winter, the same "after sunrise" increase in the possibility of low ceilings and visibility occurs here, in much the same way as it does at many other sites in northern Manitoba, and elsewhere on the prairies, for that matter.

(g) The Pas



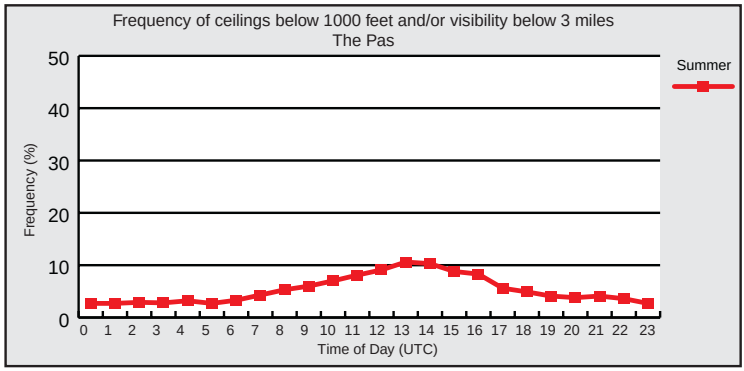
The Pas Airport is located at the southern end of Clearwater Lake, on the very flat terrain of west-central Manitoba. The town itself is about 13 miles to the southwest on the banks of the Saskatchewan River. There are many other large lakes in the area, all great moisture sources for stratus when they are not frozen.

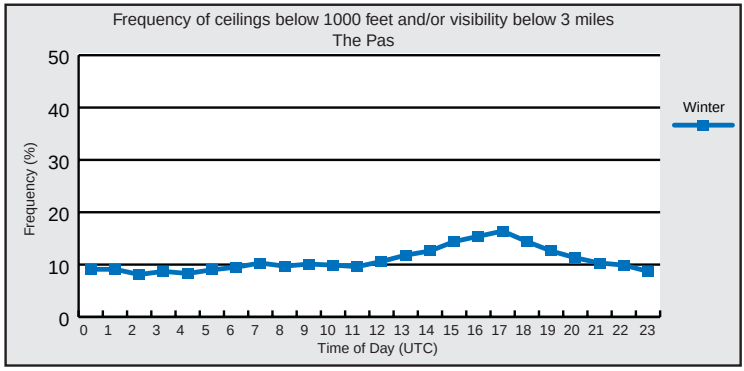


The winds at The Pas favour either northwesterly or southeasterly directions. The northwest winds result from having a ridge of high pressure located to the west or northwest, providing a suitable gradient over the area. The southeasterlies occur during the transits of low pressure systems to the south of The Pas. The Pasquia Hills,

part of the Manitoba Escarpment, rising 1,500 feet above the surrounding terrain 46 miles southwest of The Pas, probably play some part in producing this northwest to southeast preference in wind direction. Another topographic feature that may play a role is a prominent terminal moraine left by the most recent ice age. The Pas Moraine extends southeastward from west of Clear Lake, arcs between Cedar Lake and Lake Winnipegosis, and extends out into Lake Winnipeg forming Long Point.

There is a stronger northwesterly maximum in winter, the result of having high pressure most often to the west (the climatological ridge) during this season.

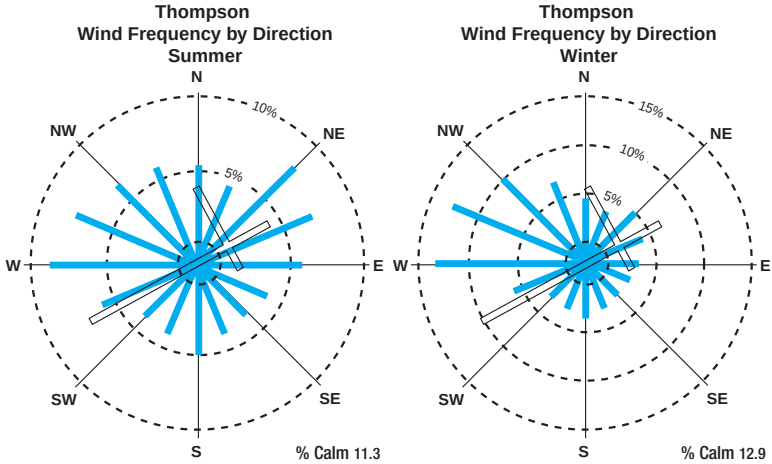




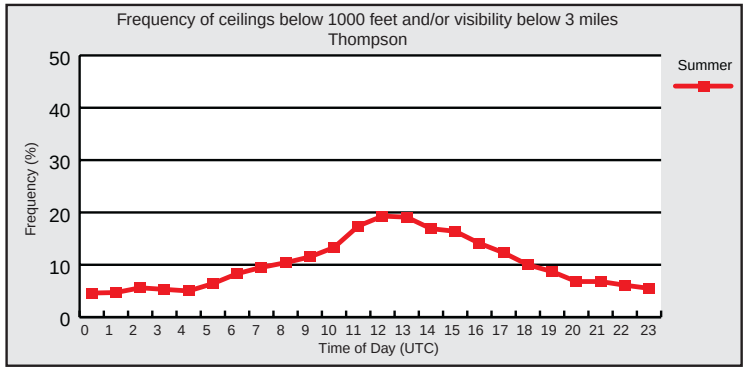
In summer at The Pas, poor conditions do not occur very often, despite having several sources of low level moisture nearby. The period where frequencies are higher than 5 percent extends from 0800 to 1700 UTC, with a peak of 10 percent at 1300 UTC. During winter, the chance of below VFR weather for a given hour hovers around 10 percent from 2100 to 1100 UTC. A peak of 17 percent occurs around 1700 UTC.

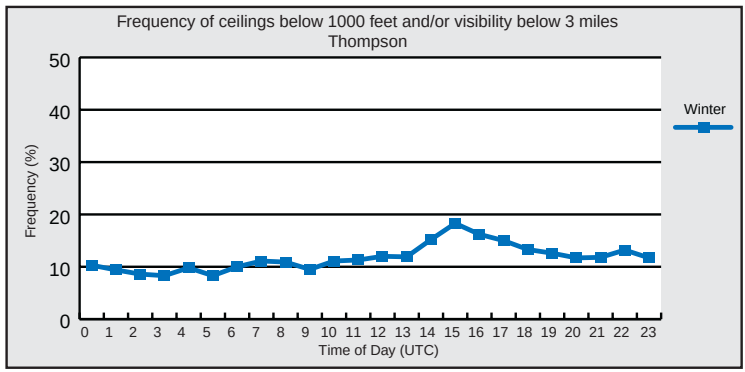
(h) Thompson

Thompson is the transportation hub of northern Manitoba. The city's airport is the second busiest in the province with several companies providing scheduled and charter service to and from Winnipeg, and to many other communities in northern Manitoba and southern Nunavut. Thompson also boasts an active float plane and helicopter base on the Burntwood River and is a principal railway depot on the line serving Churchill. A huge nickel mine and smelting operation, located on the southern outskirts of the city, is a major industry.



Thompson is located in north central Manitoba in the middle of the gently sloping Canadian Shield. There is an abundance of lakes, rivers and trees in the immediate vicinity ready to supply moisture to the local atmosphere. With few topographical features of any significance in the area, winds are a reflection of the synoptic scale weather systems that affect the area.



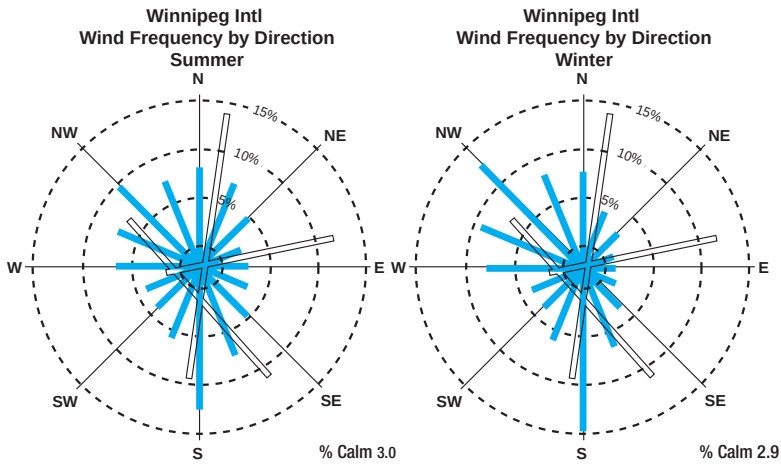


In the summer, there is an equal likelihood of having high pressure to the west generating a west or northwest flow as there is of having an east to northeasterly flow associated with low pressure to the south. During winter, the more common occurrence of a stronger high over the central Prairies produces a west to northwesterly maximum in the wind climatology.

In summer, during the late afternoon and evening, low ceilings or visibility occur at Thompson only about one day in 20. After 0400 UTC, the chances of poor flying conditions increases to one day in 5, or 20 percent, by 1200 UTC. In the winter, low ceilings or poor visibility conditions occur 10 percent of the time during most of sthe day and night. Just after sunrise, conditions get worse until about 1500 UTC, reaching a peak of close to 19 percent. It is interesting to note that there is a slightly higher chance of having poor flying conditions in the summer than in winter. Within the Canadian Shield, the familiar mixture of light winds, clear skies and abundant low-level moisture makes this possible at any time of the year.

(i) Winnipeg

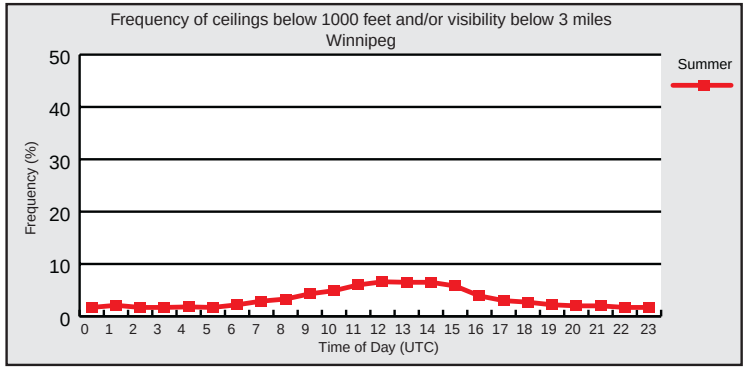
Winnipeg is situated in the broad, flat valley of the Red River where it courses northward toward Lake Winnipeg. The airport is located about 4 miles west of the downtown core of Winnipeg. The surrounding countryside is smooth prairie with almost no change in elevation for nearly 11 miles in any direction. The only exception to this is the Assiniboine River Valley that runs into Winnipeg and joins the Red River in the middle of town.

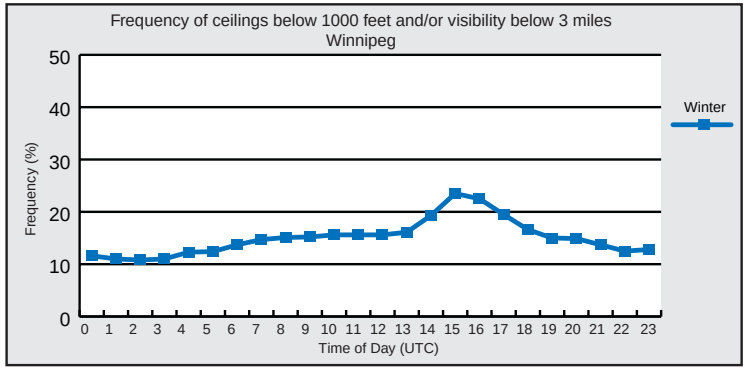


Since the average annual synoptic surface pressure pattern shows an area of high pressure over the central Prairies, there is a northwesterly maximum in wind frequency in Winnipeg. There is another sharp peak from the south which reflects the channelling efficacy of the Red River Valley, especially with flows ahead of a migratory low pressure system. When one of these lows passes to the south, the winds tend

to blow out of the south longer than might be anticipated, based on the large-scale flow. Southwest and easterly winds are not nearly as common. Calm winds seldom occur which is why radiation fog is a very sporadic event.

In winter, the preferred directions from the south and northwest are more pronounced than in summer. The previously mentioned climatological high over the Prairies is more dominant, and normal winter storm tracks carry more migratory lows along the path. This produces strong southerly winds down the Red River valley. Also in winter, hoarfrost will occur, at times, with ice fog and, when it does, the ice fog is slow to clear. This is possibly due to the sublimation of the hoarfrost and subsequent increase in low level moisture after sunrise. With a southerly flow, stratus is frequently reported at Grand Forks, North Dakota. If this flow persists, the stratus will be advected across the border into Gretna and eventually into Winnipeg, often much quicker than expected. Once the fog has arrived, it requires a westerly flow to clear it out.





Good flying weather is commonplace in Winnipeg during the summer. The maximum hourly frequency of below VFR conditions is only 7 percent and occurs between 1100 and 1500 UTC. If fog or stratus does happen to occur during the night, one can expect it to begin to dissipate by 1600 UTC. In the wintertime, poor flying weather occurs much more frequently. During most of the day, the hourly chance of lower conditions ranges from 10 to 15 percent. However, between 1300 and 1900 UTC, the probability jumps sharply, peaking at 24 percent near 15 UTC. Since Winnipeg is a major airport, the high number of aircraft movements at this time of day no doubt augments low level moisture content and the typical maximum expected around sunrise.

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 electromagnetic 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 blizzard, in general, is 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 have a 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 - generally, 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 - in general, 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 thunderstorm.

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 - generally, 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 change 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.

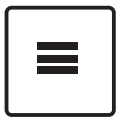
wind direction - the direction from which the wind is blowing.

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.

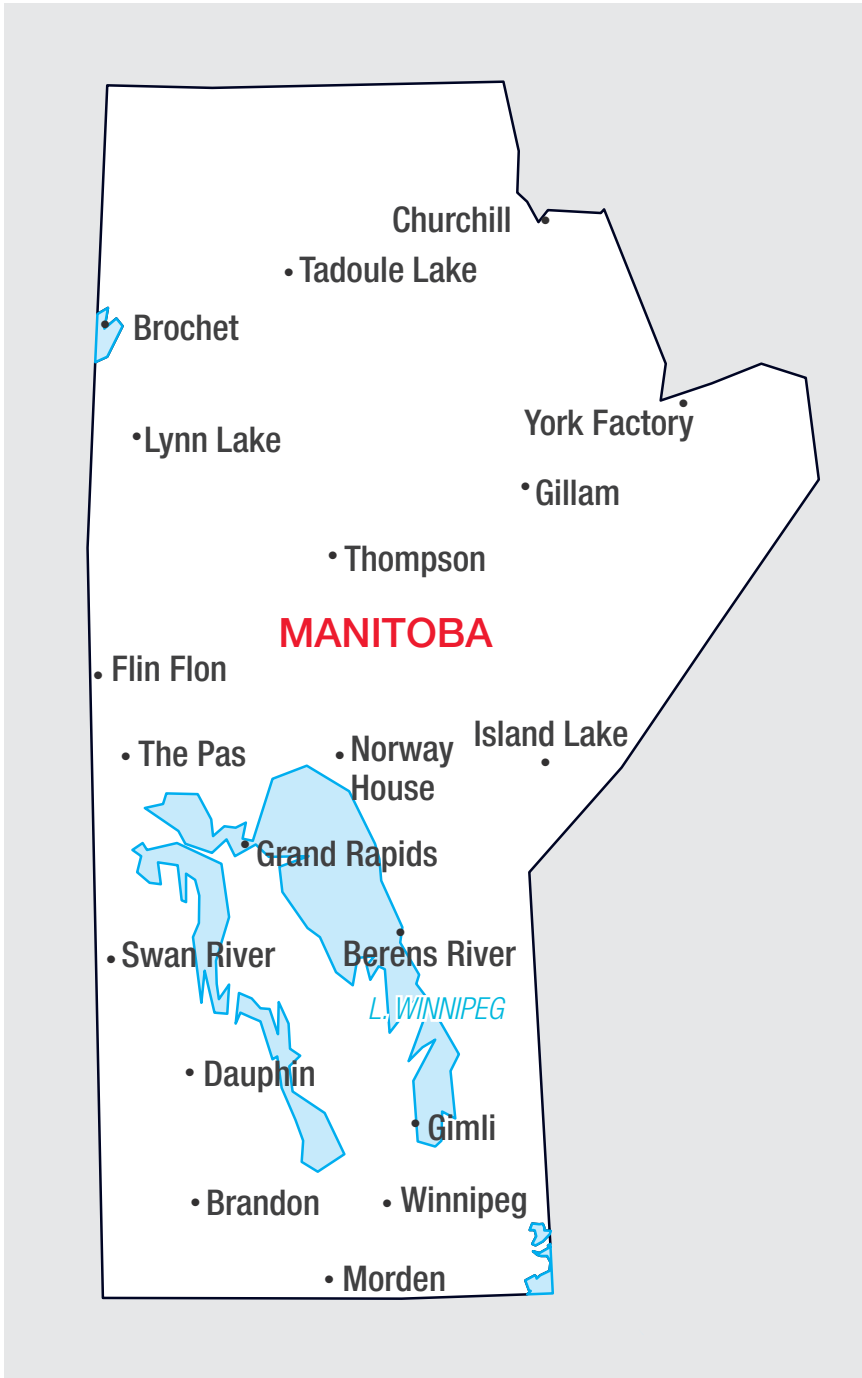
Table 3: Symbols Used in this Manual

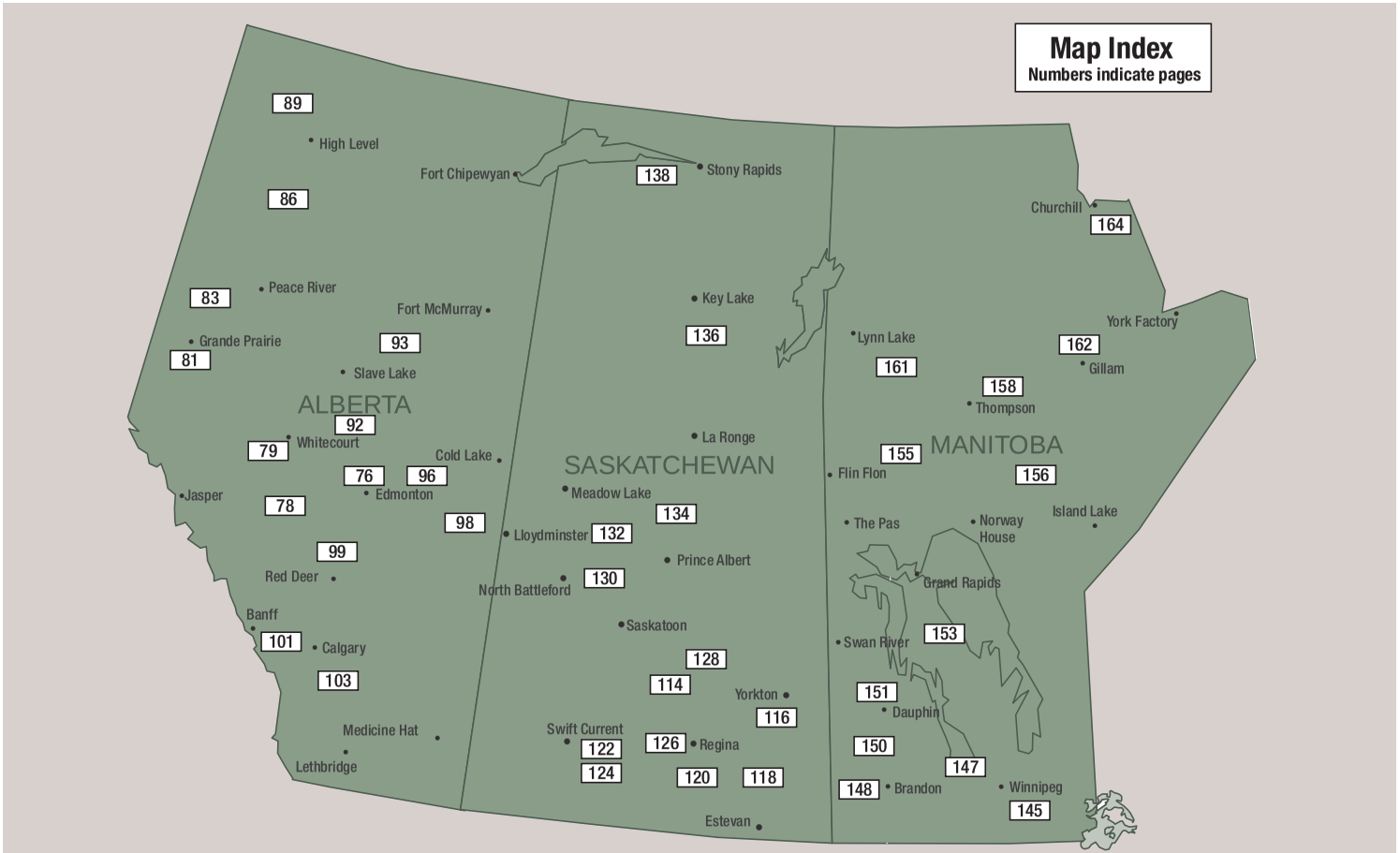
	**Fog Symbol (3 horizontal lines)** This standard symbol for fog indicates areas where fog is frequently observed.
	**Cloud areas and cloud edges** Scalloped lines show areas where low cloud (preventing VFR flying) is known to occur frequently. In many cases, this hazard may not be detected at any nearby 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


High Level
L. ATHABASCA
Fort Chipewyan
Peace River
Fort McMurray
Grande Prairie
Slave Lake
ALBERTA
Grande Cache
Whitecourt
Cold Lake
Edson
Jasper
Edmonton
Red Deer
Coronation
Banff
Calgary
Empress
Medicine Hat
Lethbridge


Stony Rapids
Collins Bay
REINDEER L.
Key Lake
Buffalo Narrows
La Ronge
SASKATCHEWAN
Meadow Lake
Lloydminster
Prince Albert
Nipawin
North Battleford
Saskatoon
Kindersley
Yorkton
Swift Current
Regina
Broadview
Shaunavon
Assiniboia
Estevan


Churchill
Tadoule Lake
Brochet
Lynn Lake
York Factory
Gillam
Thompson
MANITOBA
Flin Flon
The Pas
Norway House
Island Lake
Grand Rapids
Swan River
Berens River
L. WINNIPEG
Dauphin
Gimli
Brandon
Winnipeg
Morden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