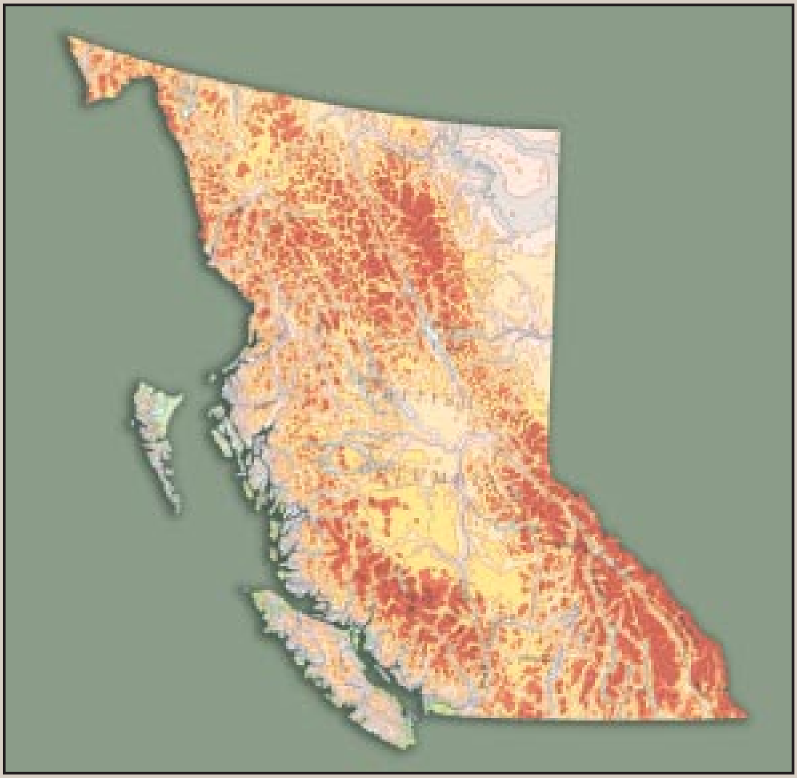
The Weather of British Columbia



Graphic Area Forecast 31

NAV CANADA

The Weather of British Columbia

Graphic Area Forecast 31

by

Ross Klock
John Mullock

NAV CANADA

Ideas in Motion

Design and illustration by
Ideas in Motion
Kelowna, British Columbia
ph: (250) 717-5937
ideasinmotion@shaw.ca

NAV CANADA

The Weather of British Columbia
Graphic Area Forecast 31 Pacific Region

Preface

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

This British Columbia Local Area Knowledge Aviation Weather manual is one of a series of six publications prepared by Meteorological Service of Canada (MSC) for NAV CANADA. Each of the six manuals corresponds to a specific graphic forecast area (GFA) Domain, with the exception of the Nunavut – Arctic manual that covers two GFA Domains. These manuals form an important part of the training program on local aviation weather knowledge for FSS working in the area and a useful tool in the day-to-day service delivery by FSS.

Within the GFA domains, the weather shows strong climatological patterns controlled either by season or topography. This manual describes the Domain of the GFACN31. This area offers beautiful open spaces for flying but can also provide harsh flying conditions. As most pilots flying the region can attest, these variations in weather can take place quiet abruptly. From the rocky coast to jagged mountain peaks, local topography plays a key role in determining both the general climatology and local flying conditions in a particular region.

This manual provides some insight on specific weather effects and patterns in this area. While a manual cannot replace intricate details and knowledge of British Columbia that FSS and experienced pilots of the area have acquired over the years, this manual is a collection of that knowledge taken from interviews with local pilots, dispatchers, Flight Service Specialists and MSC personnel.

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

Acknowledgements

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

NAV CANADA would like to thank The Meteorological Service of Canada (MSC), both national and regional personnel, for working with us to compile the information for each Graphic Area Forecast (GFA) domain, and present it in a user-friendly, professional format. Special thanks also go to meteorologists Ross Klock and John Mullock, Mountain Weather Centre, Kelowna. Ross's regional expertise has been instrumental for the development of the Pacific GFA document while John's experience and efforts have ensured high quality and consistent material from Atlantic to Pacific to Arctic.

This endeavour could not have been as successful without the contributions of many people within the aviation community. We would like to thank all the participants who provided information through interviews with MSC, including flight service specialists, pilots, dispatchers, meteorologists and other aviation groups. Their willingness to share their experiences and knowledge contributed greatly to the success of this document.

Roger M. Brown
January, 2002

Readers are invited to submit any comments to:

NAV CANADA
Customer Service Centre
77 Metcalfe St.
Ottawa, Ontario
K1P 5L6

Toll free phone line: 1-800-876-4693-4
(within North America disregard the last digit)
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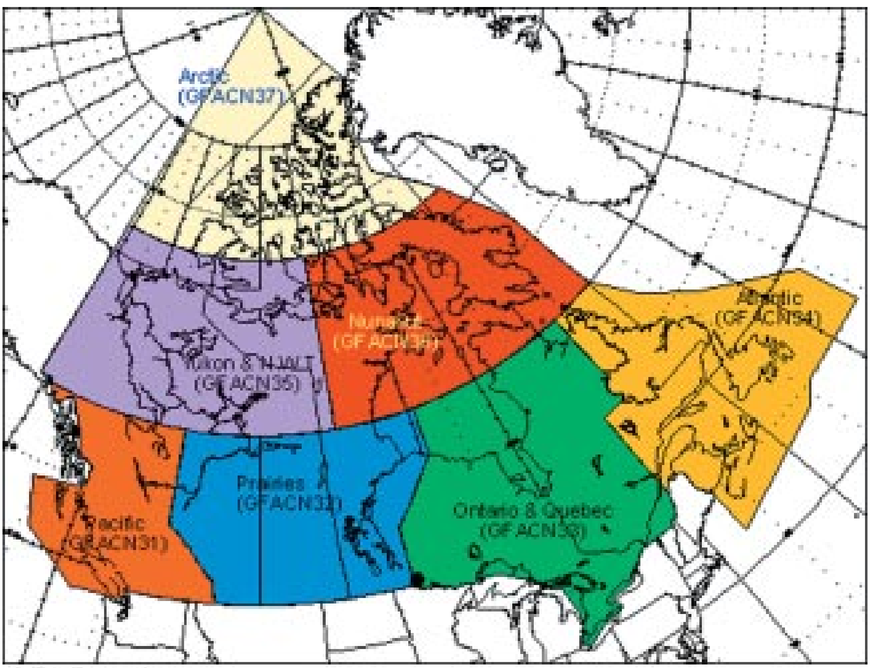
Introduction

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

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

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



GFA Domains

This Pacific Local Area Knowledge Aviation Weather Manual is one of a series of six similar publications. All are produced by NAV CANADA in partnership with the MSC. These manuals are designed to provide a resource for Flight Service Specialists and pilots to help with the understanding of local aviation weather. Each of the six manuals corresponds to a Graphical Area Forecast (GFA) Domain, with the exception of the Nunavut - Arctic manual which covers two GFA Domains. MSC aviation meteorologists provide most of the broader scale information on meteorology and weather systems affecting the various domains. Experienced pilots who work in or around it on a daily basis, however, best understand the local weather. Interviews with local pilots, dispatchers and Flight Service Specialists form the basis for the information presented in Chapter 4.

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

This manual describes the weather of the GFACN31 Pacific. This area often has beautiful flying weather but can also have some of the toughest flying conditions in the world. Shifting dramatically from the dripping, fog-shrouded rain forests of the West Coast, through the parched valley bottoms of the Interior, to the majestic snow-capped peaks and glaciers of the Rocky Mountains, few places in the world offer more visual splendors for a pilot and passengers. At the same time, mountains also evoke rapidly changing weather conditions that all too often have contributed to a tragedy. Between 1976 and 1994, there were 419 flying accidents in British Columbia where weather has been identified as one of the contributing factors. In these accidents, 319 people were killed and 89 people injured seriously. Mountain flying itself is not inherently dangerous, rather it is the weather associated with these areas that tends to be unforgiving of the rash, the negligent and the unlucky.

This manual is “instant knowledge” about how the weather behaves in this area but it is not “experience”. The information presented in this manual is by no means exhaustive. The variability of local aviation weather in British Columbia could result in a publication several times the size of this one. However, by understanding some of the weather and hazards in these areas, pilots may be able to relate the hazards to topography and weather systems in areas not specifically mentioned.

Chapter 1

Basics of Meteorology

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

Heat Transfer and Water Vapour

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

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

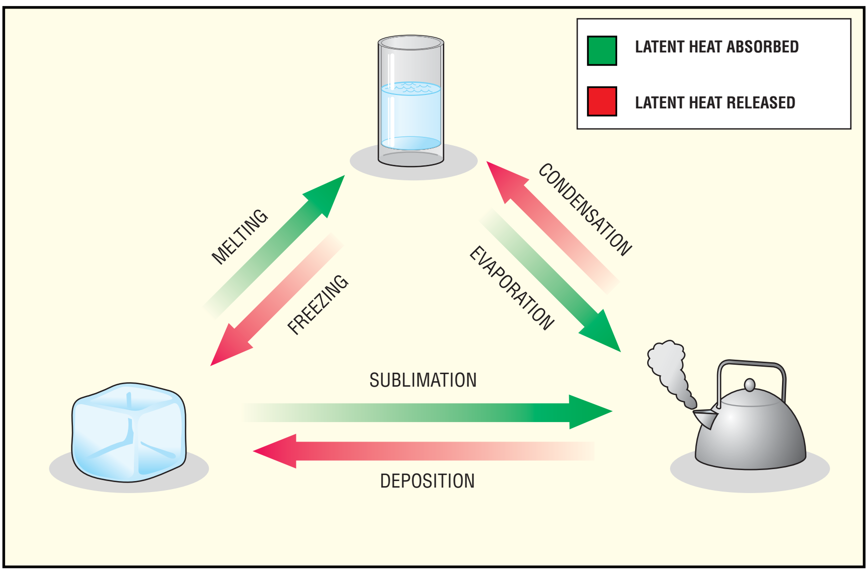


Fig. 1-1 - Heat transfer and water vapour

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

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

Lifting Processes

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

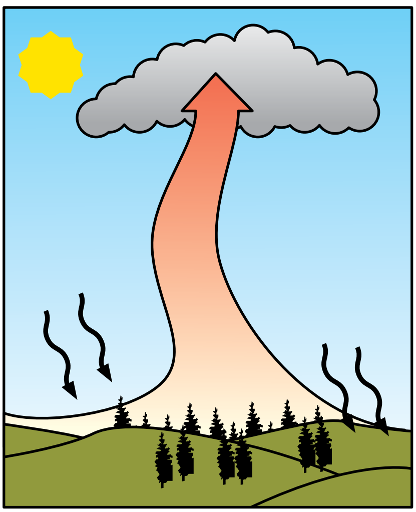


Fig. 1-2 - Convection as a result of daytime heating

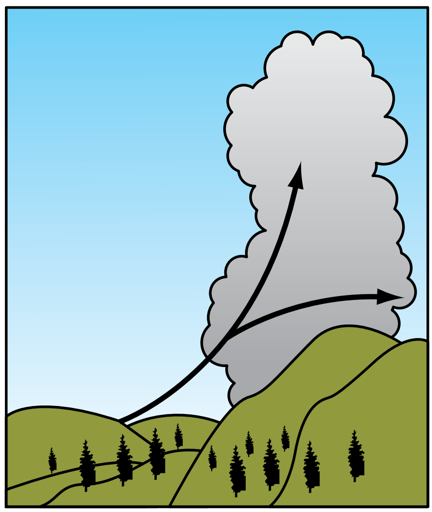


Fig.1-3 - Orographic (upslope) lift

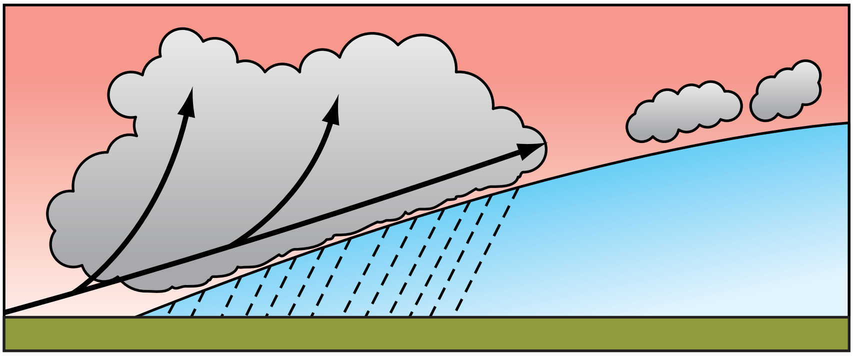


Fig.1-4 - Warm air overrunning cold air along a warm front

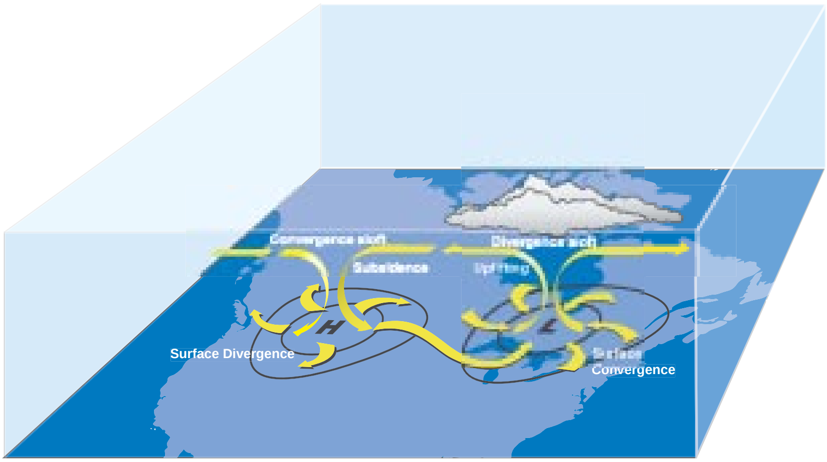


Fig. 1-5 - Divergence and convergence at the surface and aloft in a high low couplet

Subsidence

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

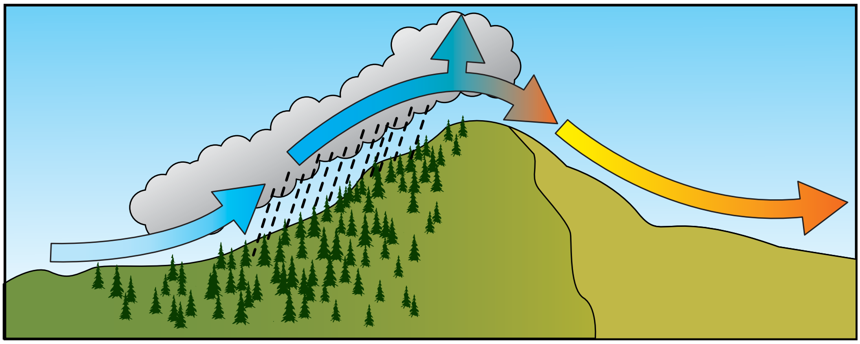


Fig.1-6 - Moist air moving over mountains where it loses its moisture and sinks into a dry subsidence area

Temperature Structure of the Atmosphere

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

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

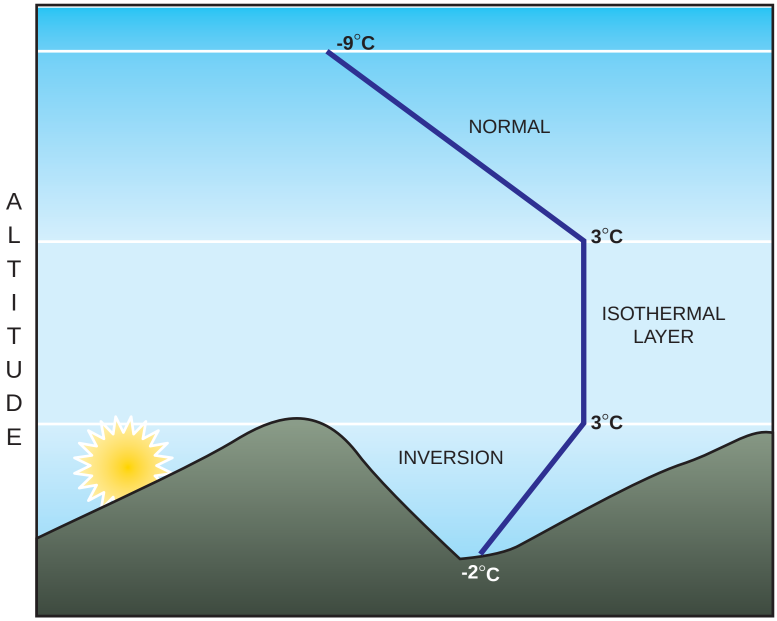


Fig. 1-7 - Different lapse rates of the atmosphere

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

Stability

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

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

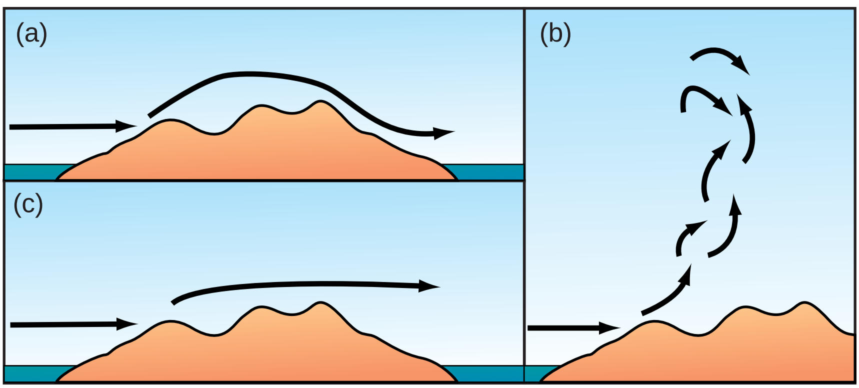


Fig. 1-8 - Stability in the atmosphere - (a) Stable (b) Unstable (c) Neutral

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

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

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

Wind

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

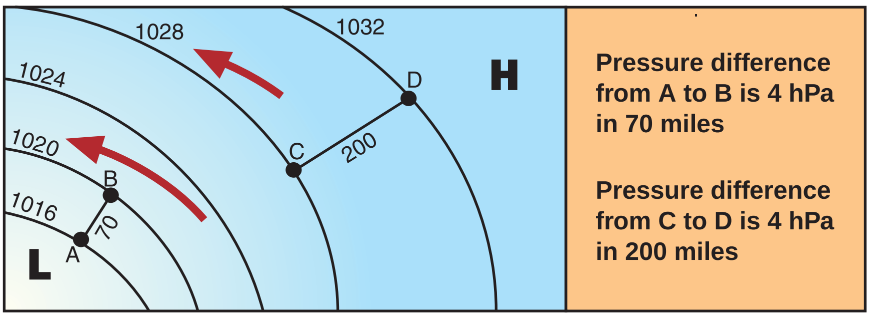


Fig. 1-9 - The greater pressure changes with horizontal difference, the stronger the wind

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

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

Air Masses and Fronts

Air Masses

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

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

Fronts

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

The principal types of fronts are:

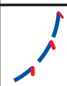
Cold Front - The cold air is advancing and undercutting the warm air. The leading edge of the cold air is the cold front.		
Warm front - The cold air is retreating and being replaced by warm air. The trailing edge of the cold air is the warm front.		
Stationary front - The cold air is neither advancing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

Table 1-1

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

Chapter 2

Aviation Weather Hazards

Introduction

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

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

Icing

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

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

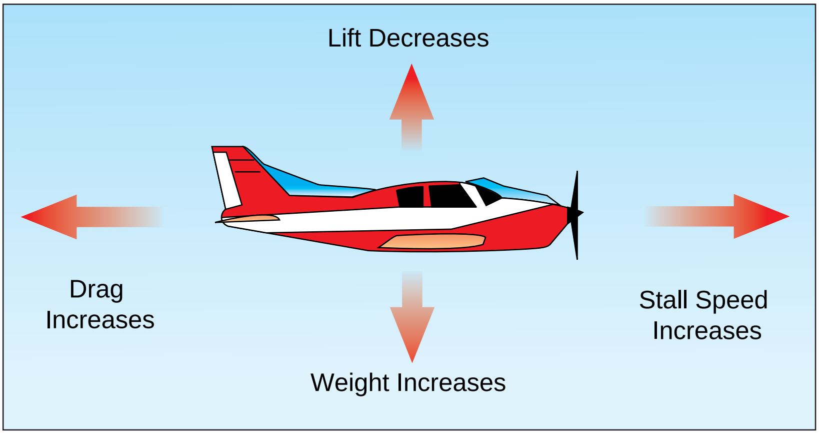


Fig. 2-1 - Effects of icing

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

The Freezing Process

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

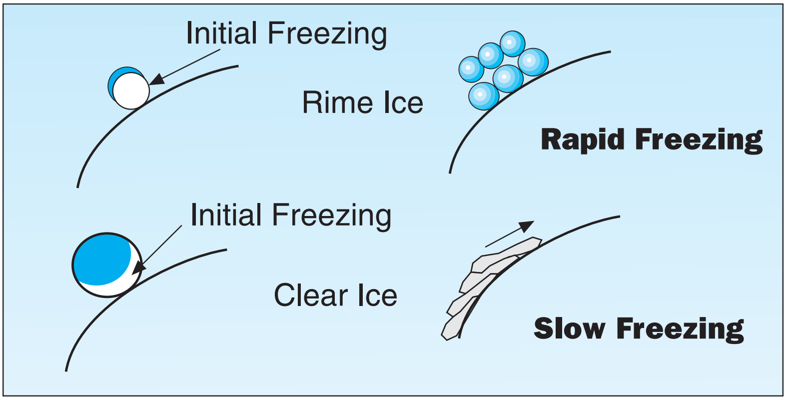


Fig. 2-2 - Freezing of supercooled droplets on impact

Types of Aircraft Ice

Rime Ice

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

Clear Ice

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

Mixed Ice

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

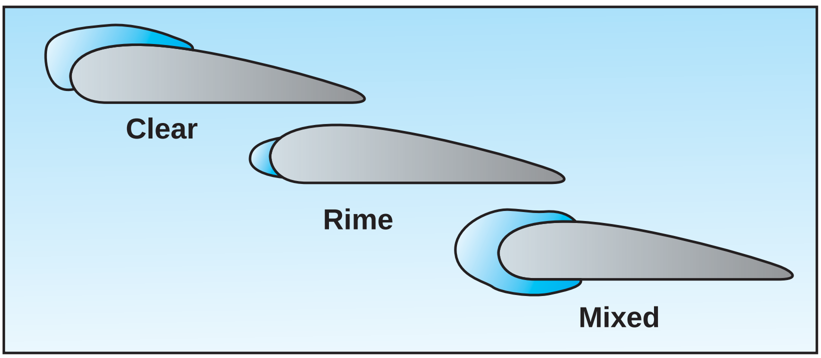


Fig. 2-3 - Accumulation patterns of different icing types

Meteorological Factors Affecting Icing

(a) Liquid Water Content of the Cloud

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

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

(b) Temperature Structure in the Cloud

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

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

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

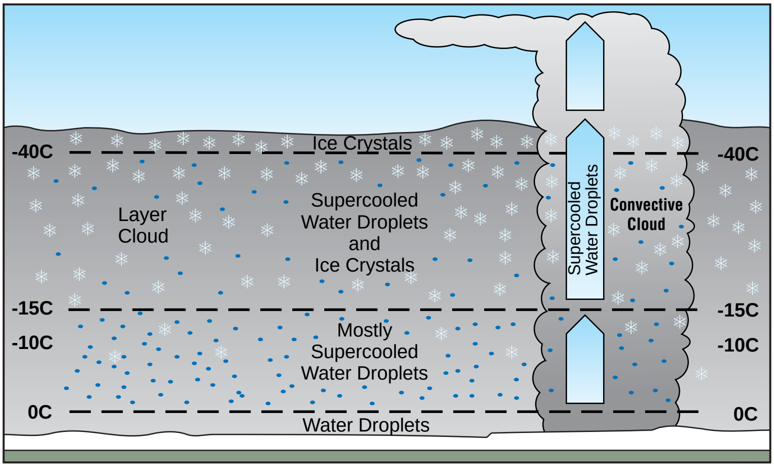


Fig. 2-4 - Distribution of water droplet-ice crystals in cloud

(1) Within large cumulus and cumulonimbus clouds:

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

(2) Within layer cloud:

- the most significant icing layer is generally confined to the 0°C to -15°C temperature range.
- icing is usually less severe than in convective cloud due to the weaker updrafts and smaller droplets.
- icing layers tend to be shallow in depth but great in horizontal extent.

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

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

Supercooled Large Drop Icing

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

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

Over British Columbia, SLD icing-producing clouds are common along the coast with a westerly flow and in the valleys, such as the Okanagan, where they tend to cover the whole valley and lie near the mountain tops. These low-level clouds often produce drizzle or freezing drizzle.

The Glory: A Warning Sign for Aircraft Icing

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

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

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

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

Aerodynamic Factors Affecting Icing

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

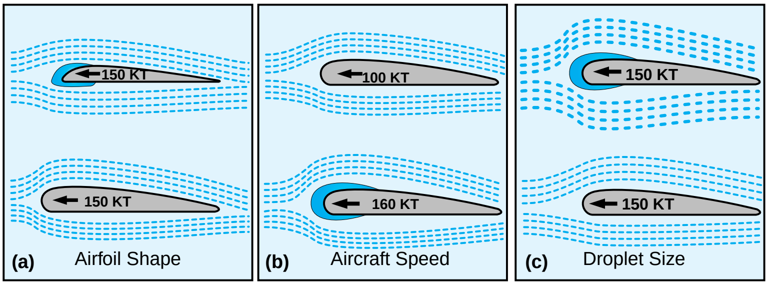


Fig. 2-5 -Variations in collection efficiency

Collection efficiency is dependent on three factors:

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

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

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

Other Forms of Icing

(a) Freezing Rain and Ice Pellets

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

(b) Freezing Drizzle or Snow Grains

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

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

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

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

Visibility

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

Types of Visibility

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

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

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

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

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

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

Causes of Reduced Visibility

(a) Lithometers

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

(b) Precipitation

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

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

(c) Fog

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

(i) Radiation Fog

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

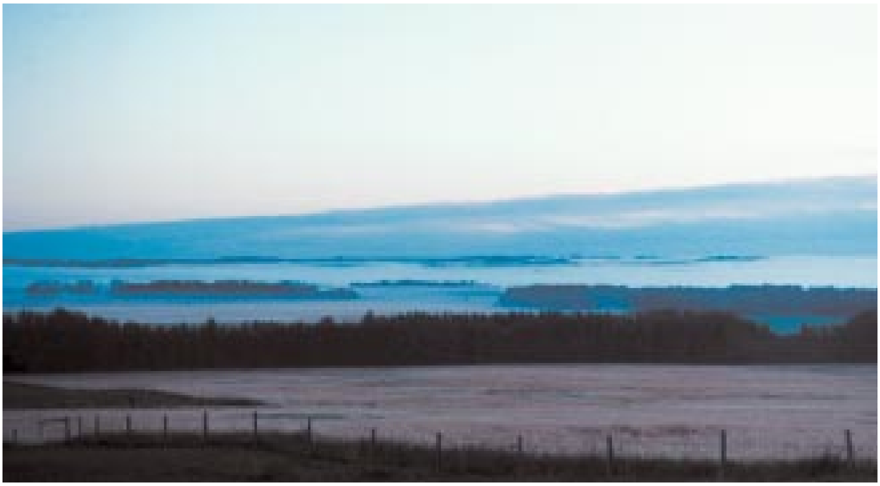


Photo 2-2 - Radiation fog in a valley credit: Alister Ling

(ii) Precipitation or Frontal Fog

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

(iii) Steam Fog

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

(iv) Advection Fog

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

(v) Ice Fog

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

(d) Snow Squalls and Streamers

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

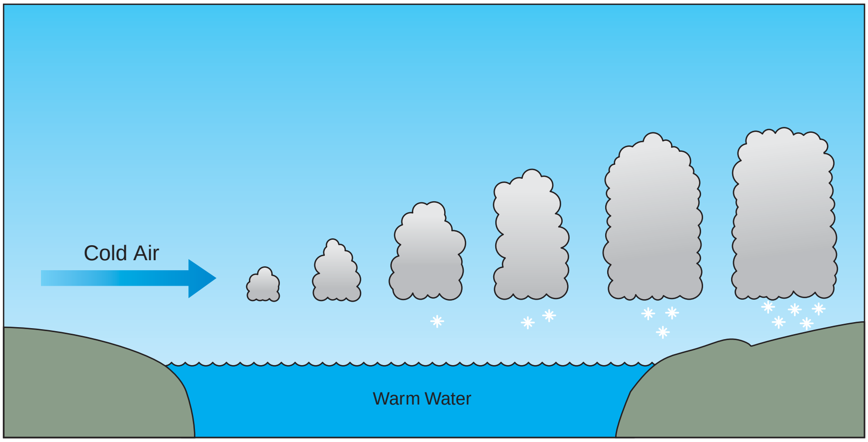


Fig. 2-6 - Snowsqualls building over open water

Wind, Shear and Turbulence

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

Stability and the Diurnal Variation in Wind

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

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

Wind Shear

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

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

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

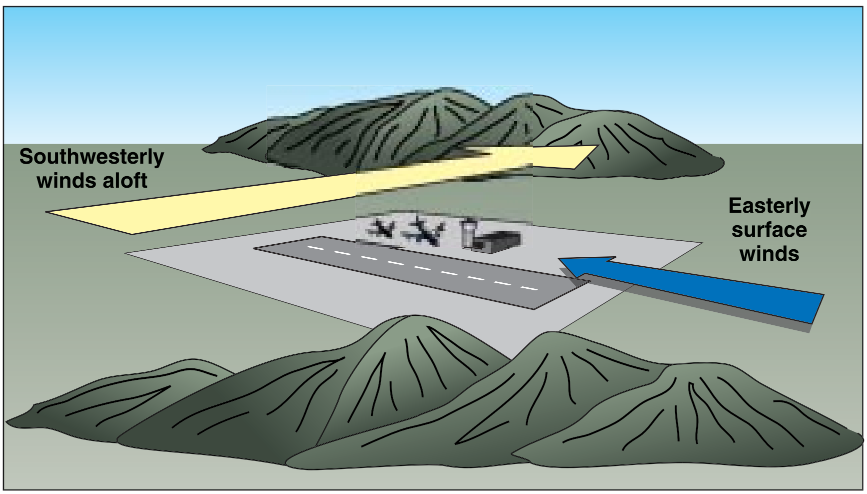


Fig. 2-7 - Wind shear near the top of a valley

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

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

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

The Relationship Between Wind Shear and Turbulence

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

Low-Level Jets - Frontal

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

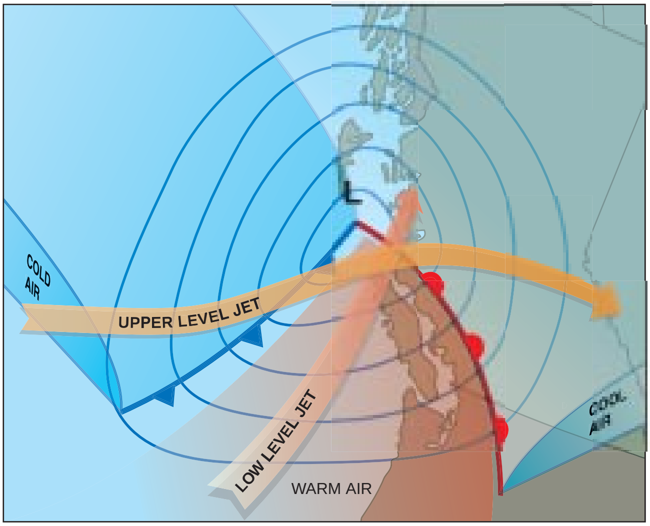


Fig. 2-8 - Idealized low and frontal system show the position of the low-level and upper-level jet

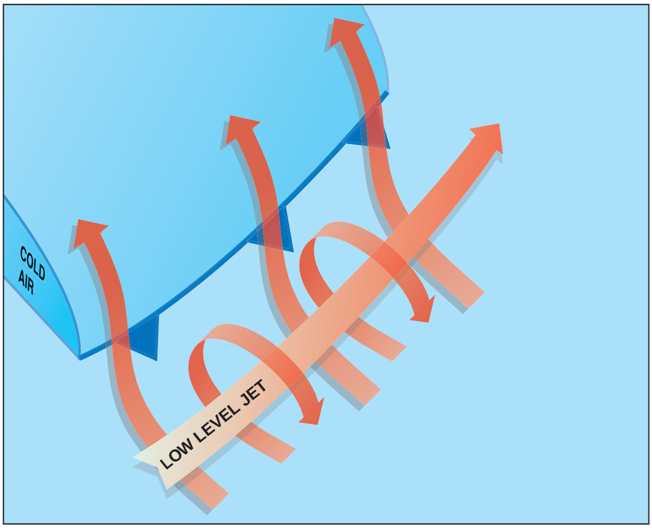


Fig. 2-9 - Complex winds around low level jet can result in significant low-level wind shear and turbulence

Low-Level Jets - Nocturnal

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

Low-level nocturnal jets have been observed in mountainous terrain but tend to be localized in character. The Central Interior of BC is a favoured location for these events.

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

Topographical Effects on Wind

(a) Lee Effects

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

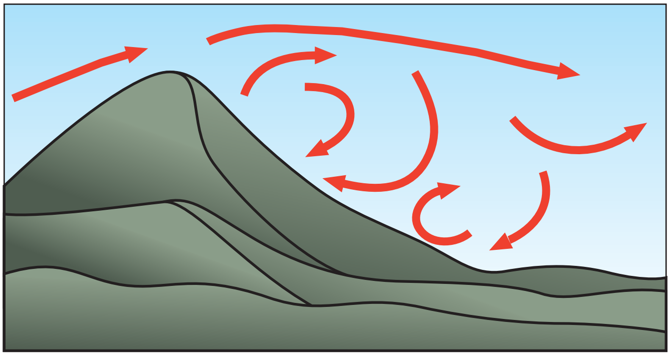


Fig. 2-10 - Lee effects

(b) Friction Effects

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

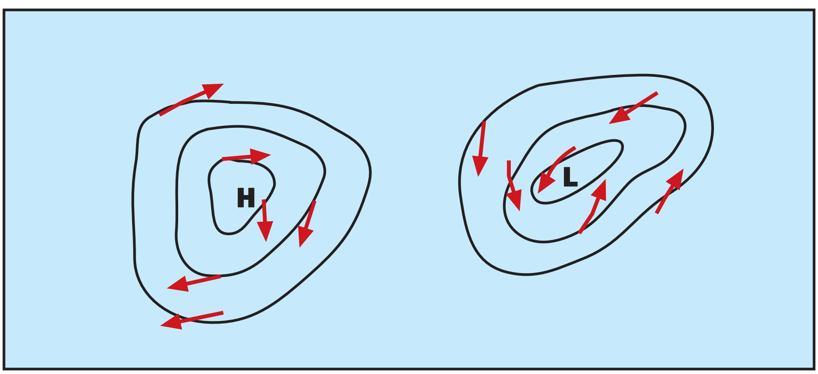


Fig. 2-11 - Friction effects

(c) Converging Winds

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

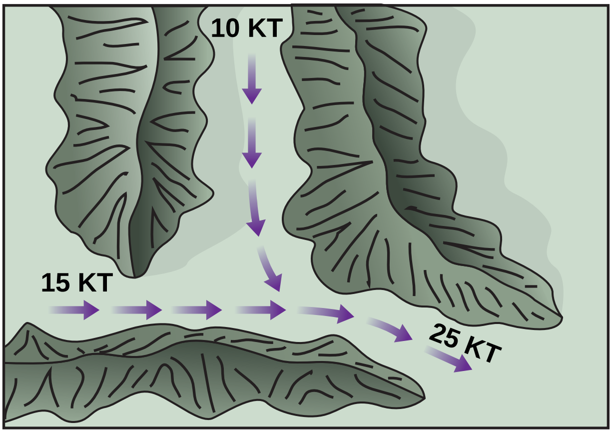


Fig. 2-12 - Converging winds

(d) Diverging Winds

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

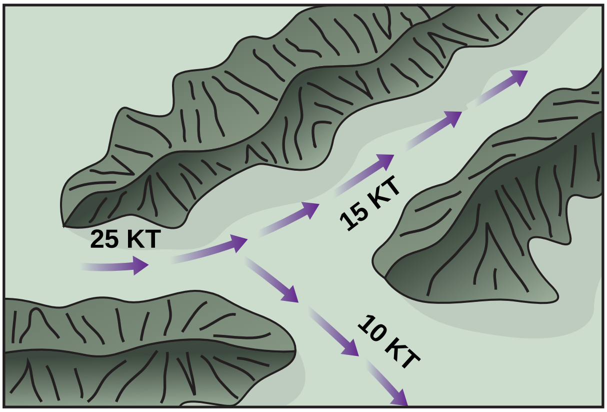


Fig. 2-13 - Diverging winds

(e) Corner Winds

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

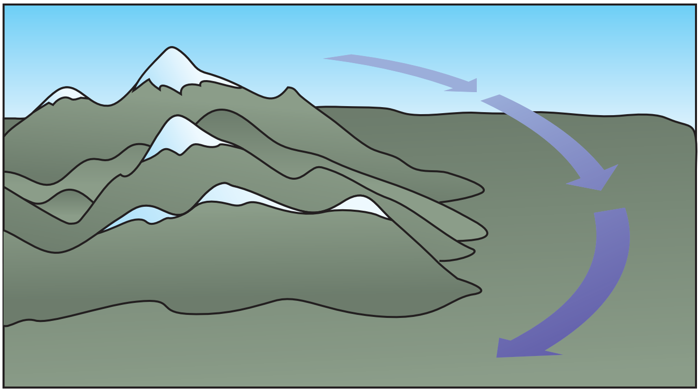


Fig. 2-14 - Corner winds

(f) Funnelled or Gap Winds

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

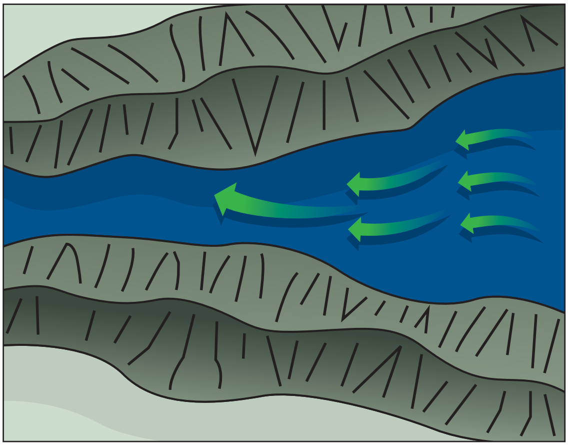


Fig. 2-15 - Funnelled winds

(g) Channelled Winds

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

(h) Sea and Land Breezes

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

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

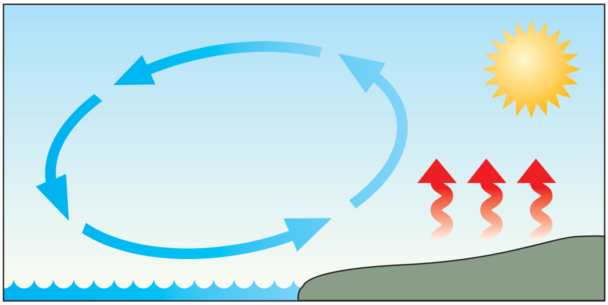


Fig. 2-16 - Sea breeze

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

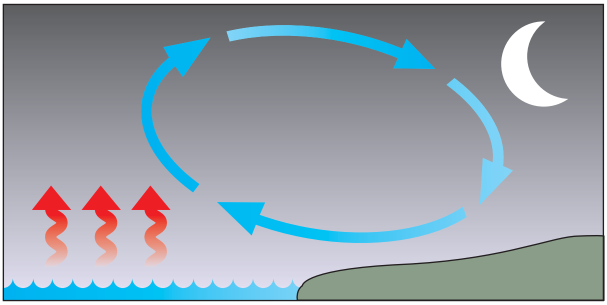


Fig. 2-17 - Land breeze

Both sea and land breezes can be influenced by channelling and funnelling resulting in almost frontal-like conditions, with sudden wind shifts and gusty winds that may reach up to 50 knots. Example of this can be found near the larger lakes in BC are often referred to as "lake effect winds".

(i) Anabatic and Katabatic Winds

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

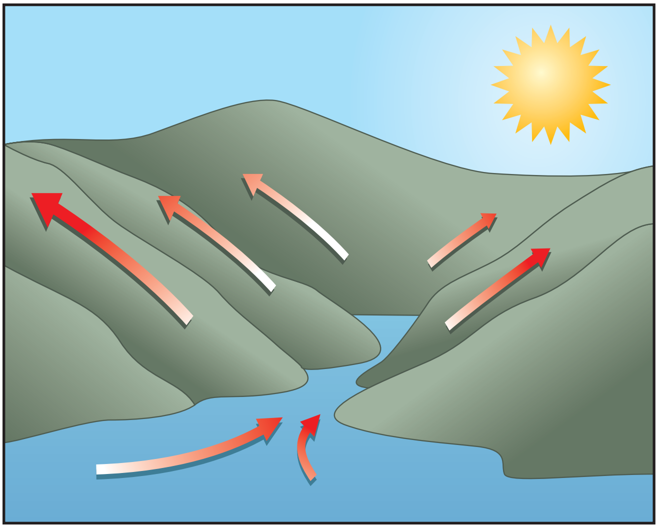


Fig. 2-18 - Anabatic winds

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

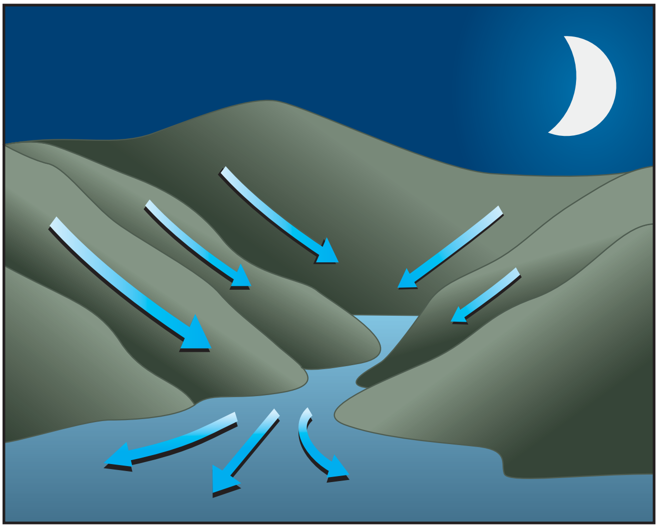


Fig. 2-19 - Katabatic winds

(j) Glacier Winds

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

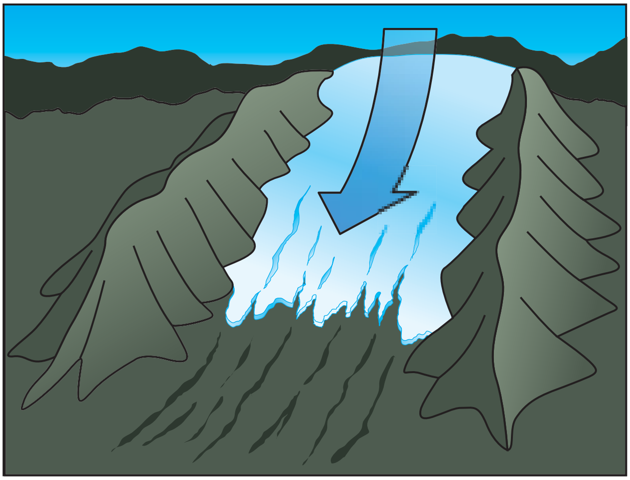


Fig. 2-20 - Glacier winds

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

Lee Waves

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

The Formation of Lee Waves

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

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

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

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

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

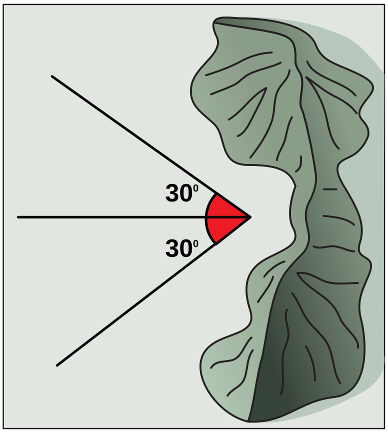


Fig. 2-21 - Angles for lee wave development

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

Characteristics of Lee Waves

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

- stronger the wind, the longer the wavelength. The typical wavelength is about 6 miles but can vary from as short as 3 miles to as long as 15 miles.
- position of the individual wave crests will remain nearly stationary with the wind blowing through them as long as the mean wind speed remains nearly constant.
- individual wave amplitude can exceed 3,000 feet.
- layer of lee waves often extends from just below the tops of the mountains to 4,000 to 6,000 feet above the tops but can extend higher.
- induced vertical currents within the wave can reach values of 4,500 feet per minute.
- wind speed is stronger through the wave crest and slower through the wave trough.
- wave closest to the obstruction will be the strongest with the waves further downstream getting progressively weaker.
- a large eddy called a "rotor" may form below each wave crest.
- mountain ranges downstream may amplify or nullify induced wave patterns.
- downdrafts are frequently found on the downwind side of the obstruction. These downdrafts typically reach values of 2,000 feet per minute but downdrafts up to 5,000 feet per minute have been reported. The strongest downdraft is usually found at a height near the top of the summit and could force an aircraft into the ground.

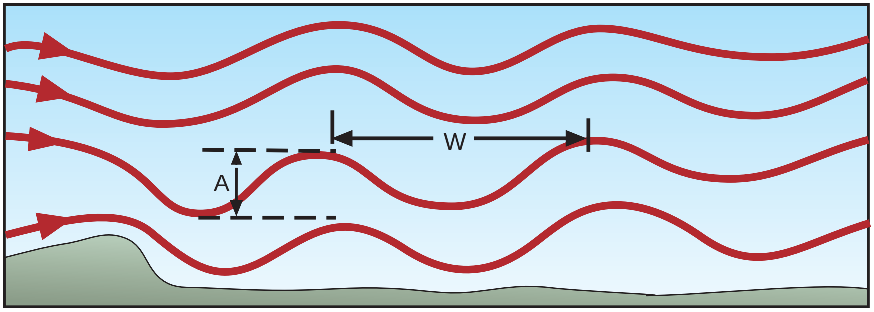


Fig. 2-22 - Amplitude (A) and wavelength (W) in lee waves

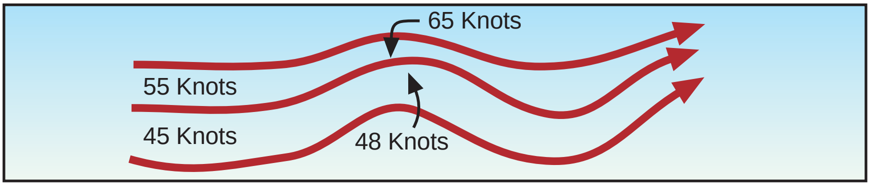


Fig. 2-23 - Stronger wind in wave crest in lee waves

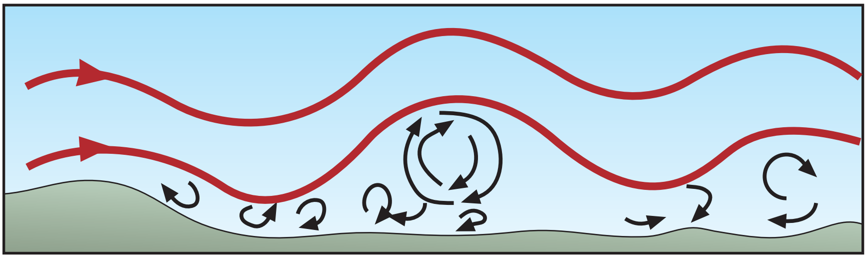


Fig. 2-24 - A rotor may form beneath wave crests

Clouds Associated with Lee Waves

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

(a) Cap cloud

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

(b) Lenticular clouds

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

(c) Rotor cloud

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

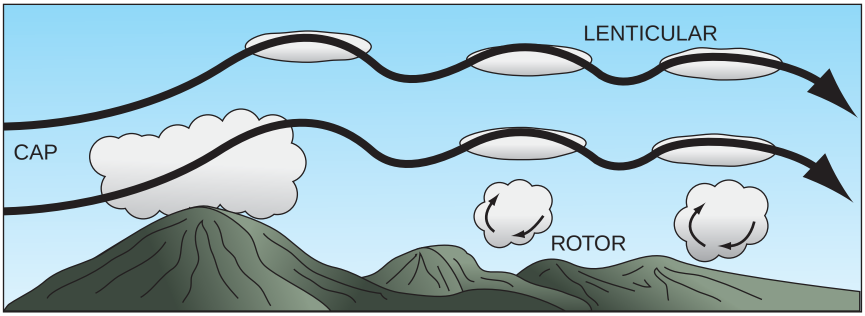


Fig. 2-25 - Characteristic clouds formed by lee waves

Fronts

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

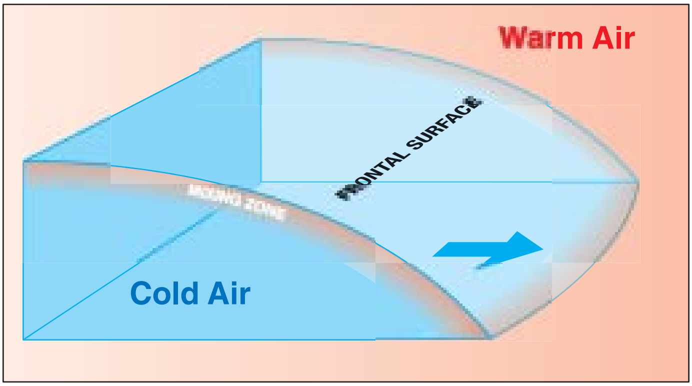


Fig. 2-26 - Cross-section of a cold front

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

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

Frontal Weather

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

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

(b) stability of the air being lifted
The degree of stability influences the type of clouds being formed. Unstable air will produce cumuliform clouds accompanied by showery weather and more

turbulent conditions. Stable air will produce stratiform cloud accompanied by steady precipitation and little or no turbulence.

(c) slope of the front

A shallow frontal surface such as a warm front produces widespread cloud and steady precipitation. Such areas are susceptible to the formation of low stratus cloud and fog and may have an area of freezing precipitation. Passage of such a front is usually noted by the end of the steady precipitation, followed by a slow reduction in the cloud cover.

A steep frontal surface, such as is seen in cold fronts, tends to produce a narrow band of convective weather. Although blustery, the period of bad weather is short-lived and the improvement behind the front is dramatic.

(d) speed of the front

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

Frontal Waves and Occlusions

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

(a) Stable Waves

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

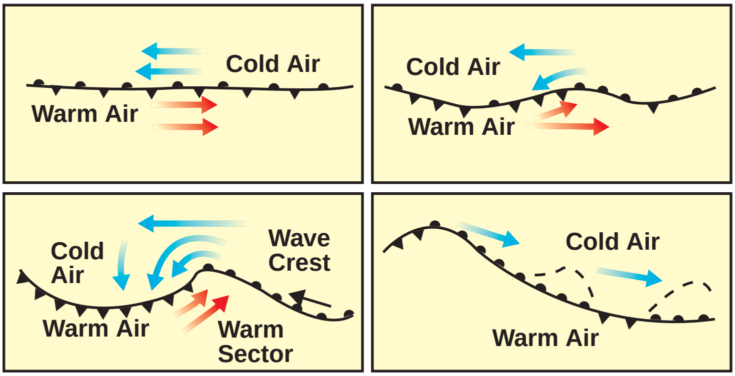


Fig 2-27 - Stable wave

(b) Unstable (Occluding) Waves

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

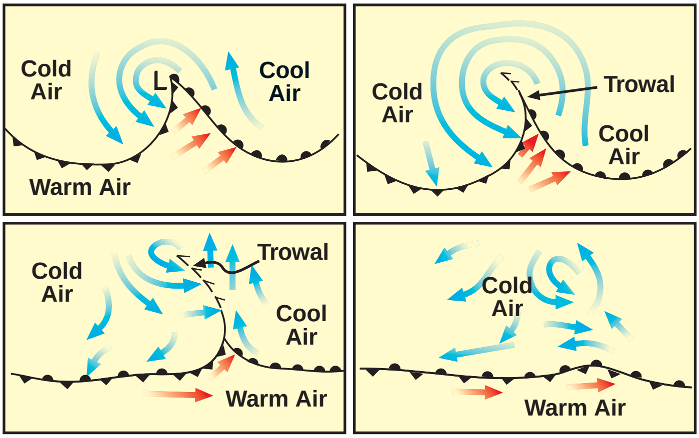


Fig. 2-28 - Formation of an occluding wave

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

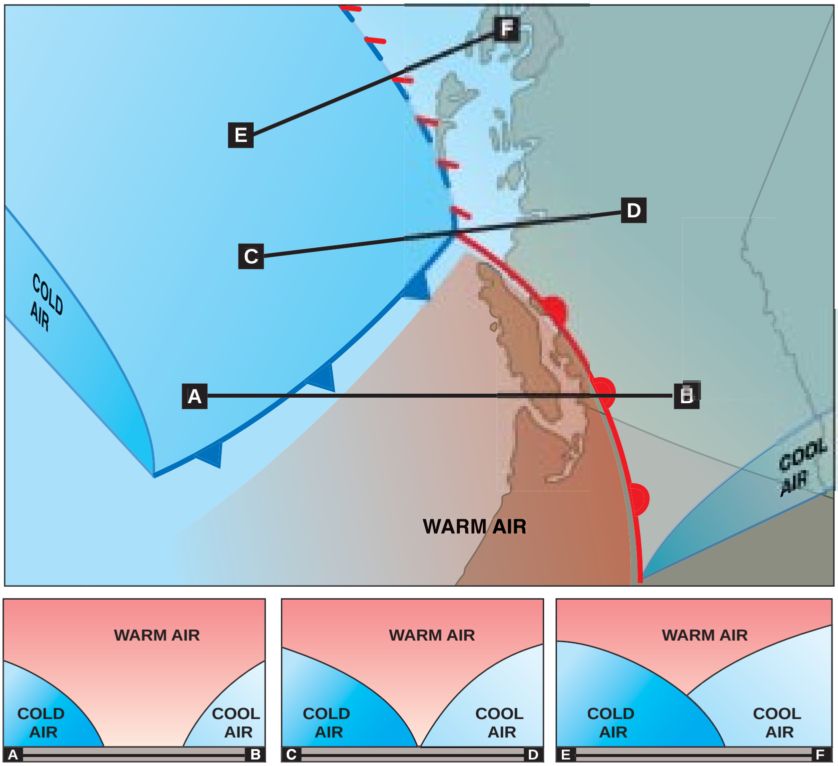


Fig. 2-29 - Frontal cross-sections

Thunderstorms

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

- An unstable airmass
- Moisture in the low levels
- Something to trigger them, e.g. daytime heating, upper level cooling
- For severe thunderstorms, wind shear.

No weather encountered by a pilot can be as unpredictable or as violent as a thunderstorm. There are few severe weather hazards that a thunderstorm does not pack, and with thunderstorms being common, it is important that a pilot understands a little about their nature and how to deal with them.

The Life Cycle of a Thunderstorm

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

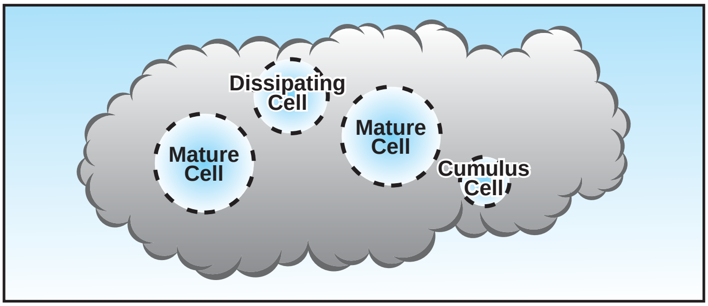


Fig. 2-30 -Top-down view of a thunderstorm "family" containing cells in different stages of development

(a) Cumulus Stage

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

(b) Mature Stage

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

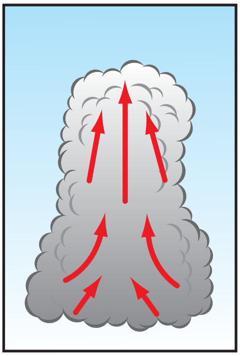


Fig. 2-31 - Cumulus stage

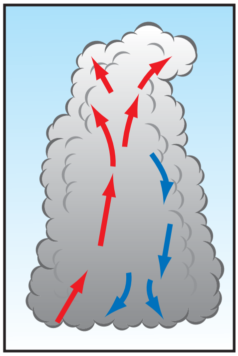


Fig. 2-32 - Mature stage

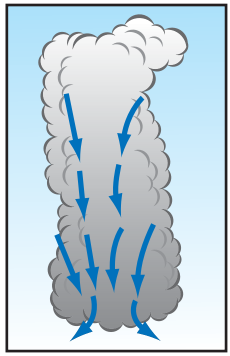


Fig. 2-33- Dissipating Stage

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

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

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

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

(c) Dissipating Stage

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

Types of Thunderstorms

(a) Air Mass Thunderstorms

These thunderstorms form within a warm, moist air mass and are non-frontal in nature. They are usually a product of diurnal heating, tend to be isolated, reach maximum strength in the late afternoon, are seldom violent, and usually dissipate quickly after the setting of the sun. There is also a second form of air mass thunderstorm that is created by cold advection. In this case, cold air moves across warm land or water and becomes unstable. Of these two, it is the movement of cold air over warm water that results in the most frequent occurrence of this type of thunderstorm. Since the heating is constant, these thunderstorms can form at any time of day or night.

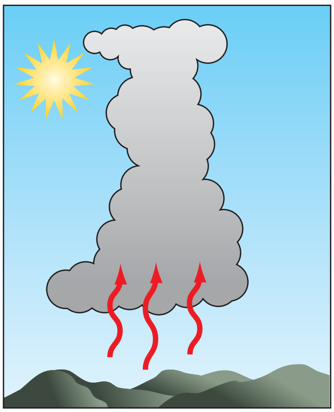


Fig. 2-34 - Air heated by warm land

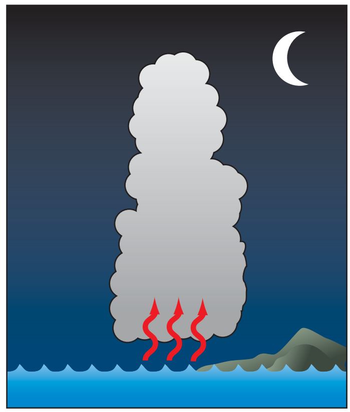


Fig. 2-35 - Cool air heated by warm water

(b) Frontal Thunderstorms

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

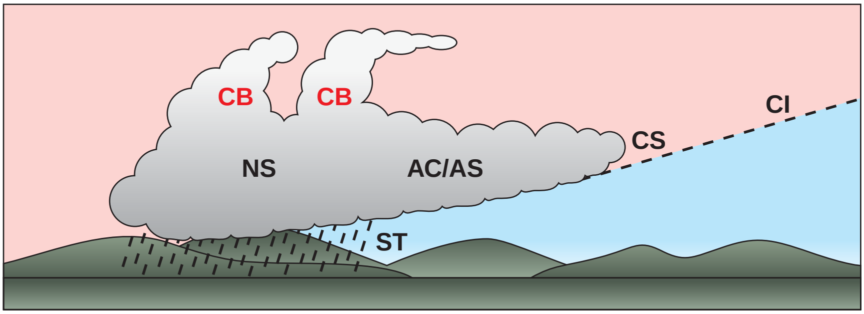


Fig. 2-36 - Warm frontal thunderstorms

(c) Squall Line Thunderstorms

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

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

(d) Orographic Thunderstorms

Orographic thunderstorms occur when moist, unstable air is forced up a mountain slope. These are common along the slopes of the Rocky Mountains where, on a typical summer day, they form due to daytime heating and then move eastward in the upper flow. If conditions are favourable they can persist for several hours otherwise, they dissipate fairly rapidly. Typically they will begin to develop near noon and can continue to form well into the afternoon. In such situations, these storms frequently produce copious amounts of hail.

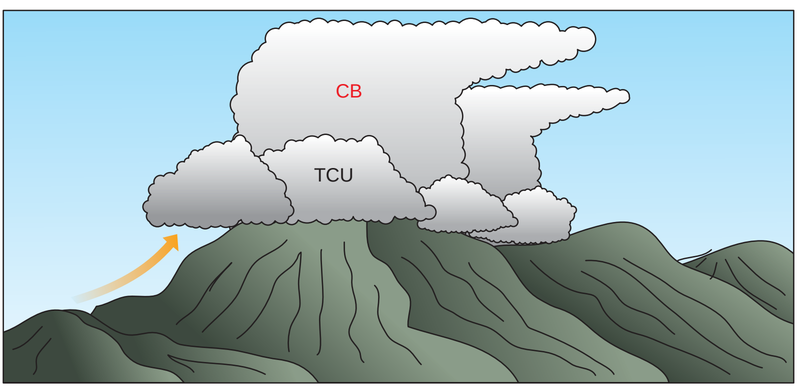


Fig. 2-37 - Orographic thunderstorms

(e) Nocturnal Thunderstorms

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

Severe Thunderstorms

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

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

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

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

Fortunately these types of storms are rare in BC and are almost exclusivily confined to the central and northern part of the province.

Thunderstorm Hazards

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

(a) The Gust Front

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

(b) Downburst, Macroburst and Microburst

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

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

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

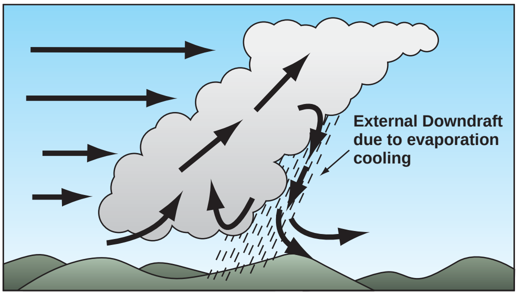


Fig. 2-38 - "Steady state" tilted thunderstorm

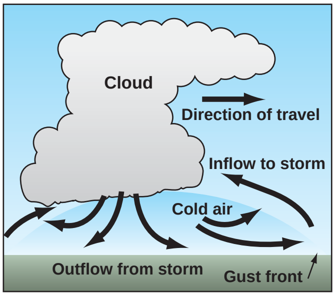


Fig. 2-39 - The gust front

(c) Funnel Cloud, Tornado and Waterspout

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

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

Photo 2-3 - Severe thunderstorm credit Alister Ling

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

Table 2-1 - The Fujita Scale

Photo 2-4 - Waterspout off the west coast of Vancouver Island   credit: Canadian Armed Forces

Waterspouts are most often observed over coastal BC when cold air is moving across warm water. The first sign that a waterspout may form is the cloud sagging down in one area. If this bulge continues downward to the sea surface, forming a vortex beneath it, water will be carried aloft in the lower 60 to 100 feet.

Cold Weather Operations

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

Temperature Inversion and Cold Air Outbreaks

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

Looming

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

Ice Fog and Ice Crystals

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

Blowing Snow

Blowing snow can occur almost anywhere where dry snow can be picked up by strong winds but poses the greatest risk away from the forested areas of the Prairies. As winds increase, blowing snow can, in extreme conditions, reduce horizontal visibility at runway level to less than 100 feet.

Whiteout

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

Altimetry Errors

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

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

Consider:

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

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

Volcanic Ash

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

The dust in the troposphere settles fairly rapidly and can limit visibility over a large area. For example, when Mt. St. Helens, Washington, erupted, there was ash fallout and limited visibility across Washington State, just to the south of the borders.

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

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

Deformation Zone

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

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

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

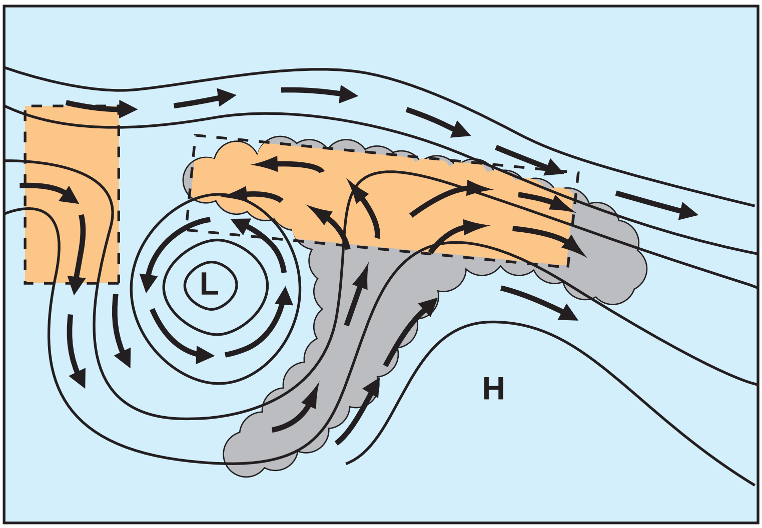


Fig. 2-40 - Deformation zones

Notes:

Chapter 3

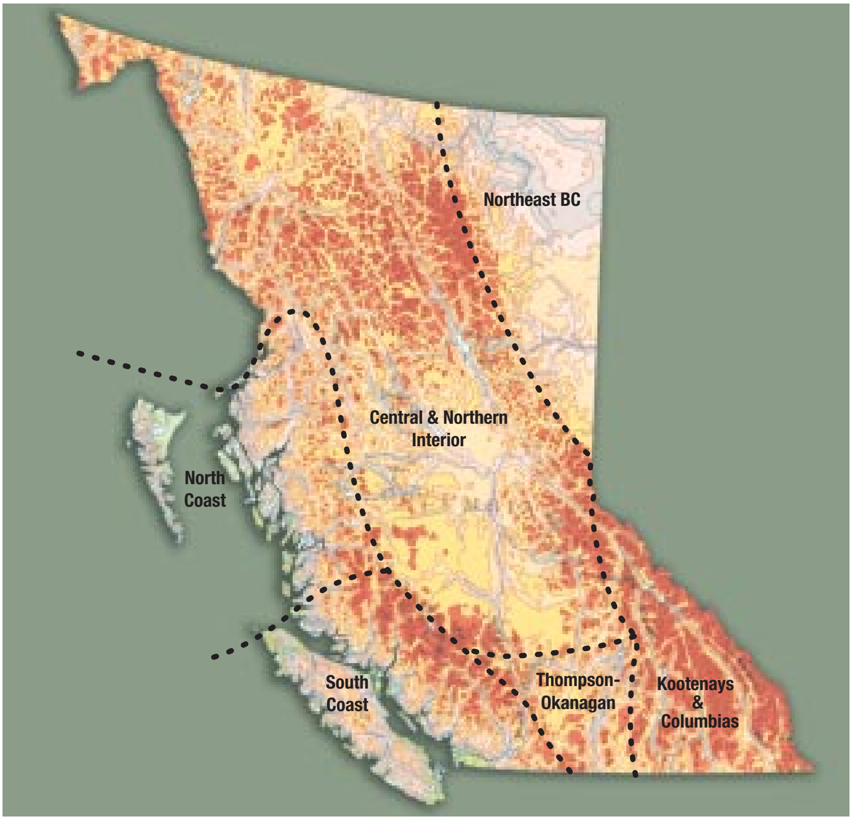
Weather Patterns of British Columbia

Introduction

"Weather is what you get, climate is what you expect."

Weather is what happens. Weather is also transitory, seldom lasting more than a matter of hours. Climate speaks to the weather history of a location, the how and why the weather varies between seemingly identical locations. Why is Abbotsford open when all other nearby airfields are closed in fog? What are the predominate winds at Penticton? Meteorologists use their knowledge of both weather and climate when producing forecasts. This constant conflict between "what you expect" and "what you get" is unending; it is a problem that becomes much more difficult when you have to take mountainous terrain into consideration.

Geography of British Columbia



Map 3-1 - Topography of GFA 31 Domain

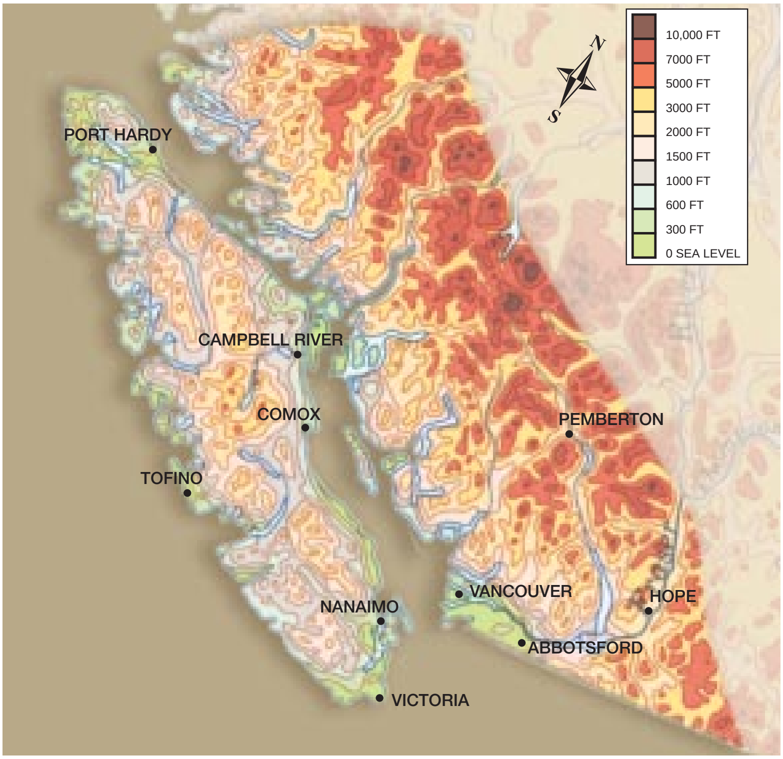
At first glimpse, British Columbia can quickly be divided into two distinctive areas; the coast and the interior. The coast of British Columbia, almost 500 miles in length, lies at mid-latitudes along the western boundary of North America. To the west of it lies the largest ocean in the world, the Pacific Ocean.

The ocean edge is itself dominated by the Coast Mountains that seem to rise right out of the sea. This range of mountains contains numerous valleys, some of which are flooded with water from the ocean resulting in a string of islands and coastal inlets.

On the leeward side of the Coastal Mountains lie the interior regions of British Columbia, a mixture of mountain ranges, deep valleys and plateau areas. The most prominent feature of the interior is the Rocky Mountains. These mountains extend out of the United States along the Alberta - British Columbia border to near Jasper, then continue northwestward to pass just to the west of Fort Nelson.

To the east of the northern Rocky Mountains lies Northeastern British Columbia. An extension to the Canadian Prairies, the terrain here is almost flat, rising steadily in elevation from the Alberta border until it reaches the Rocky Mountains.

South Coast



Map 3-2 - The South Coast

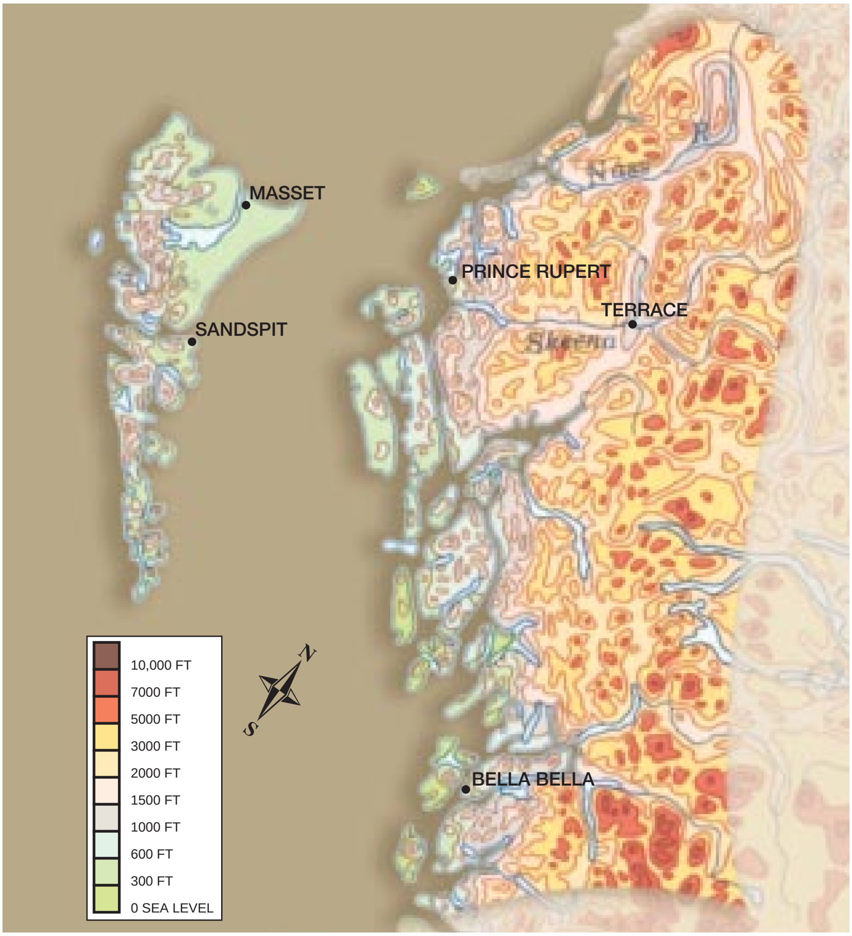
The South Coast runs for approximately 250 nautical miles from the Canada/United States border to just north of Vancouver Island. The general flow pattern is dominated by the westerlies which means that moist weather systems are spawned over the Pacific Ocean and carried into the coast.

The ocean also supplies heat which acts to moderate the temperatures along the coast, as compared to the inland areas. In turn, this moderation of temperature plays a significant role in determining just what type of precipitation will fall over the area. At the same time, the interaction of the warm air with the cold air "energizes" lows. During the winter, a typical low approaching the coast will begin to draw cold air down from the north. This causes the low to intensify resulting in rapidly falling pressures and strengthening winds.

Dividing the moist coastal environment from the dry environment of the interior are the Coast Mountains, which lie along the mainland coast and the Insular Mountains on Vancouver Island. These mountains have an average height of 6,000 to 7,000 feet ASL; however, just to the east of Campbell River the Coast Mountains rise to an average height of 10,000 feet. Along this barrier of rugged, tree covered slopes are numerous valleys, some dry, some flooded, of which the Fraser Valley is the largest and most significant.

Mountains impact significantly on the weather in this area. Storms approaching the coast are lifted rapidly along the windward slopes, resulting in widespread precipitation. Much of the heaviest precipitation occurs along the western slopes of the Insular Mountains and the Olympic Mountains of Northern Washington State (elevation 6,000 to 8,000 feet). The variability in annual precipitation between upslope areas and subsident "rain shadow" areas is significant. Tofino, on the west coast of Vancouver Island, receives an average of 3,000 millimetres of precipitation each year while Nanaimo, on the east coast of Vancouver Island, receives a paltry 1,150 millimetres. The Coast Mountains also serve as a barrier to the arctic air that occasionally moves into the interior so that only the strongest incursion can force its way through the various passes and valleys.

North Coast



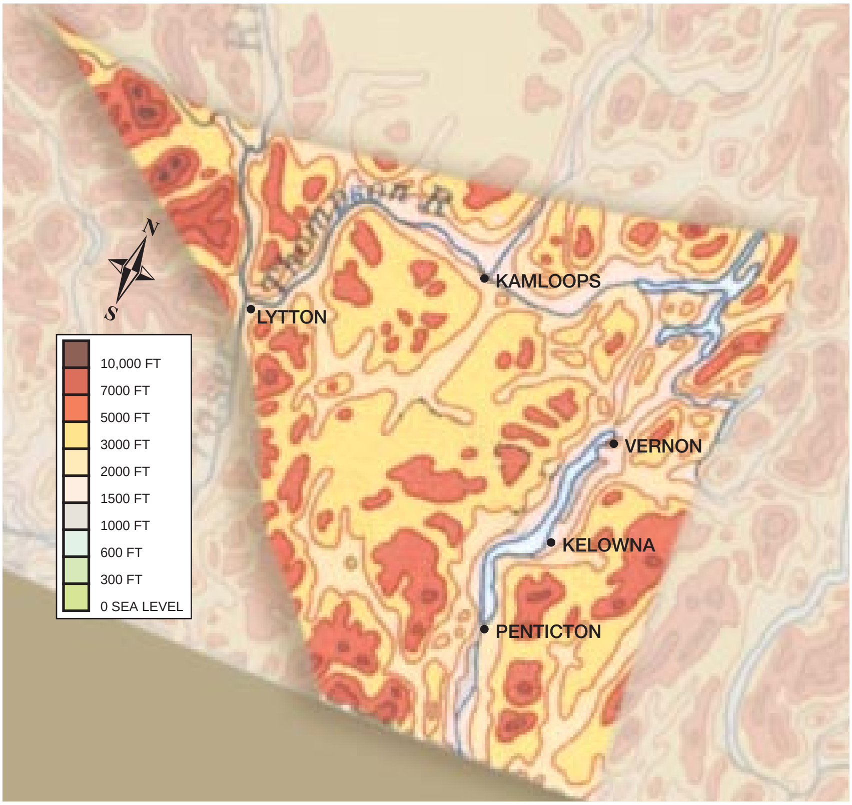
Map 3-3 - The North Coast

The North Coast is approximately 300 miles in length and extends in a north-northwest to south-southeast line from just north of Vancouver Island to Stewart. To the west of these mountains lie the Queen Charlotte Islands and the Pacific Ocean. In many ways the North Coast can be considered as a "nastier" version of the South Coast. Lacking the sheltering bulk of Vancouver Island, ocean storms can run right up onto the coast venting their full fury.

Along the coast runs the northern extension of the Coast Mountains, with a mean height of 6,500 feet ASL. These mountains are carved with numerous flooded valleys, resulting in a string of islands and coastal inlets. Sixty miles off the coast are the Queen Charlotte Islands whose Insular Mountains rise to an average height of 3,000 feet.

The heat from the ocean strongly moderates coastal temperatures; however, outflow winds through the inland valleys can easily carry cold air from the interior. During the winter this clash between warmer coastal air and cold air flowing out of the interior can make for extremely variable precipitation types.

Thompson-Okanagan



Map 3-4 - Thompson-Okanagan

The Thompson-Okanagan extends from the Fraser Canyon in the west to the slopes of the Monashee Mountains in the east, and from the US/Canada border to and east-west line just to the north of Kamloops and Shuswap Lake. The topography consists of a mixture of mountains and valleys. The mountains are largely tree-covered with extensive cut blocks (areas that have been logged) that are in various stages of re-growth. The valley bottoms are dry except for rivers and lakes, and contain some of the largest population centres in the interior.

The weather in this area tends to be benign for the large part and is controlled to a great extend by the Coast Mountains. Sitting to the lee of these mountains, subsidence has reduced the precipitation so that much of the area is arid or semi-arid.

Annual precipitation ranges between 250 and 360 millimetres per year and tends to be divided up nearly equally between the various months.

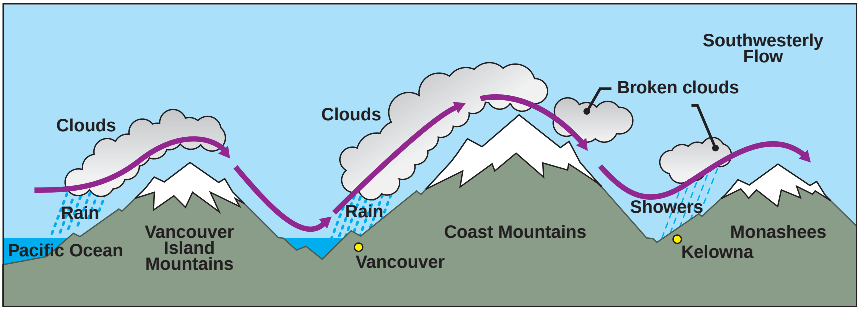
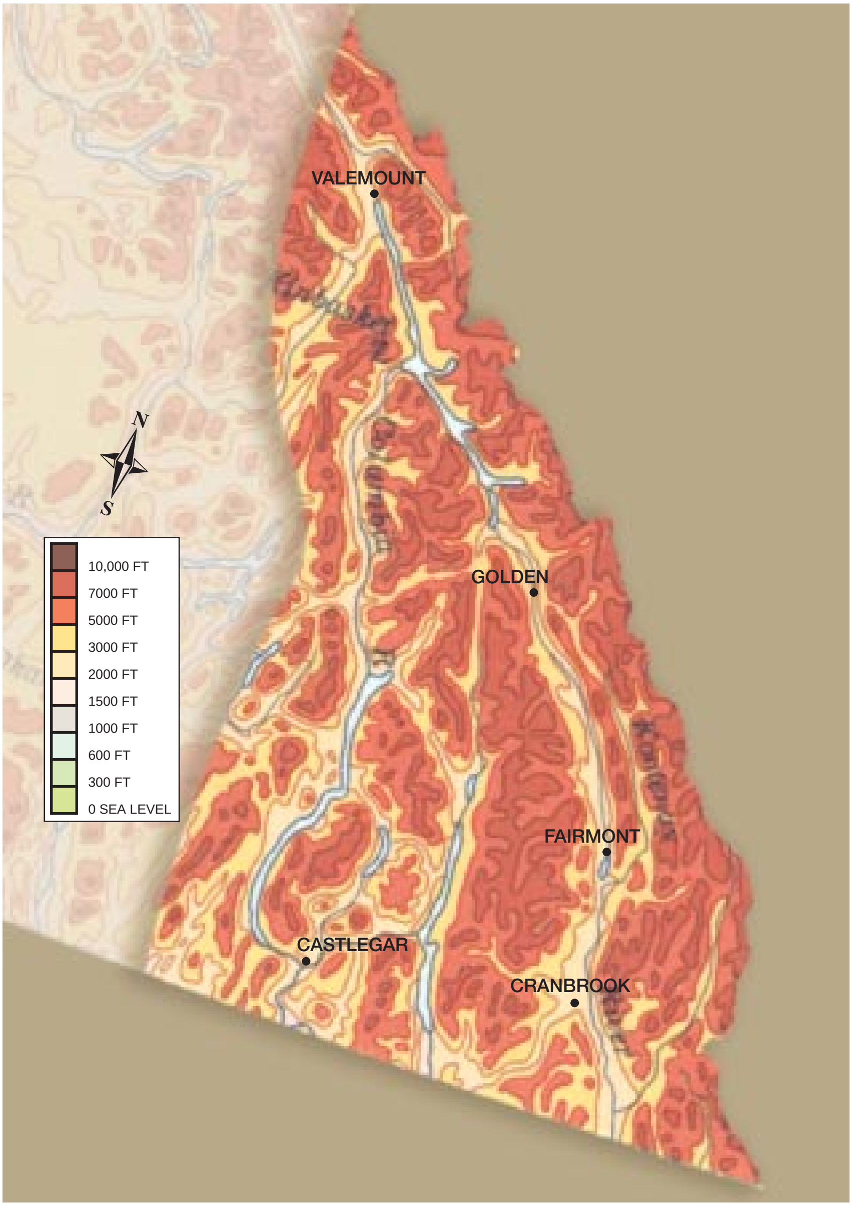


Fig. 3-1 - The most notable effect of mountains is their impact on precipitation

Summer in this area is noted for the incursion of the Pacific High and the development of hot and dry weather. The weather tends to be dry and sunny with late afternoon or evening thunderstorms occurring mainly along the ridges. Eventually, the Pacific High does break down and, when this happens, it is common for widespread thunderstorms to develop as cooler, moist air begins to move into the area.

Winters are a different story. Mountain valleys allow cold air to pool, creating inversions. Most of the valleys have rivers and lakes that seldom freeze up resulting in abundant moisture that the inversion can trap, supporting the development of low "valley cloud". On the positive side, because of its location, only the strongest incursions of arctic air can force its way into this area. This being said, the temperatures in the area do tend to hover around freezing, and the cold surface layer can be difficult to remove, as the warm air moving in from the coast rides over the top of the cold air. The only real warming occurs with southerly winds, but this respite only lasts a few days as cold air is quick to re-establish itself in the valley bottoms.

Kootenays and Columbias



Map 3-5 - The Kootenays and Columbias

The eastern and southeastern section of the interior consists of a mixture of mountain ranges and deep valleys. The mountains are largely tree-covered and the valleys narrow and steeply-sided. The valley bottoms contain rivers and lakes with little in the way of cleared areas other than around towns and forestry cuts.

The most prominent feature in this area is the Rocky Mountains. These mountains extend out of the United States along the Alberta - British Columbia border to Jasper then continue on in a northwesterly direction into the Yukon. Over the southern half of the province, the Rocky Mountains rise to average of 9,000 to 11,000 feet ASL.

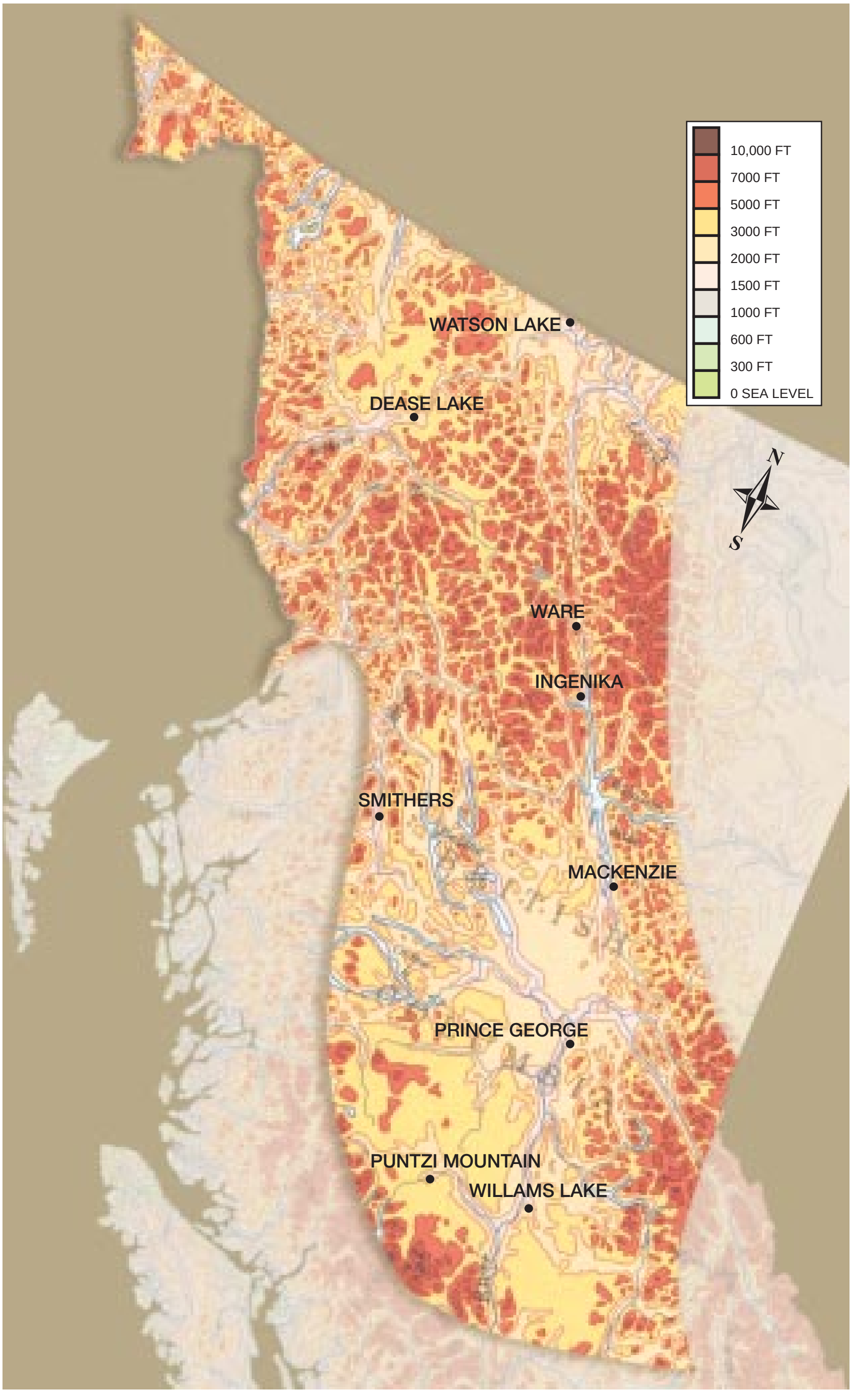
To the west of the Rockies, the area is carved up by a series of other mountain ranges: the Monashees, the Selkirks, and the Purcells, with narrow valleys between them. Most of these valleys contain rivers or lakes, along with the population centres of various sizes.

A prominent feature of British Columbia is the Rocky Mountain Trench. A broad gash in the terrain, the Trench begins in the south near Cranbrook and moves northwestward through Golden and Valemount, passes just to the east of Prince George, then continues north-northwestward.

The pronounced variation in terrain in the Interior has a strong influence on its climate. On the small scale, the changing topographical features such as elevation, orientation to the mean winds, slope, and exposure all combine to alter the local climate. Higher elevations tend to have lower average temperatures and increased precipitation. Low-lying areas, such as valleys, tend to allow cold air to drain into them, creating higher occurrences of frost and fog.

On the larger scale, the Rocky Mountains act as a barrier. All but the strongest incursions of Arctic air are held out of the southern British Columbia interior, maintaining temperatures much above those on the Prairies.

Central and Northern Interior



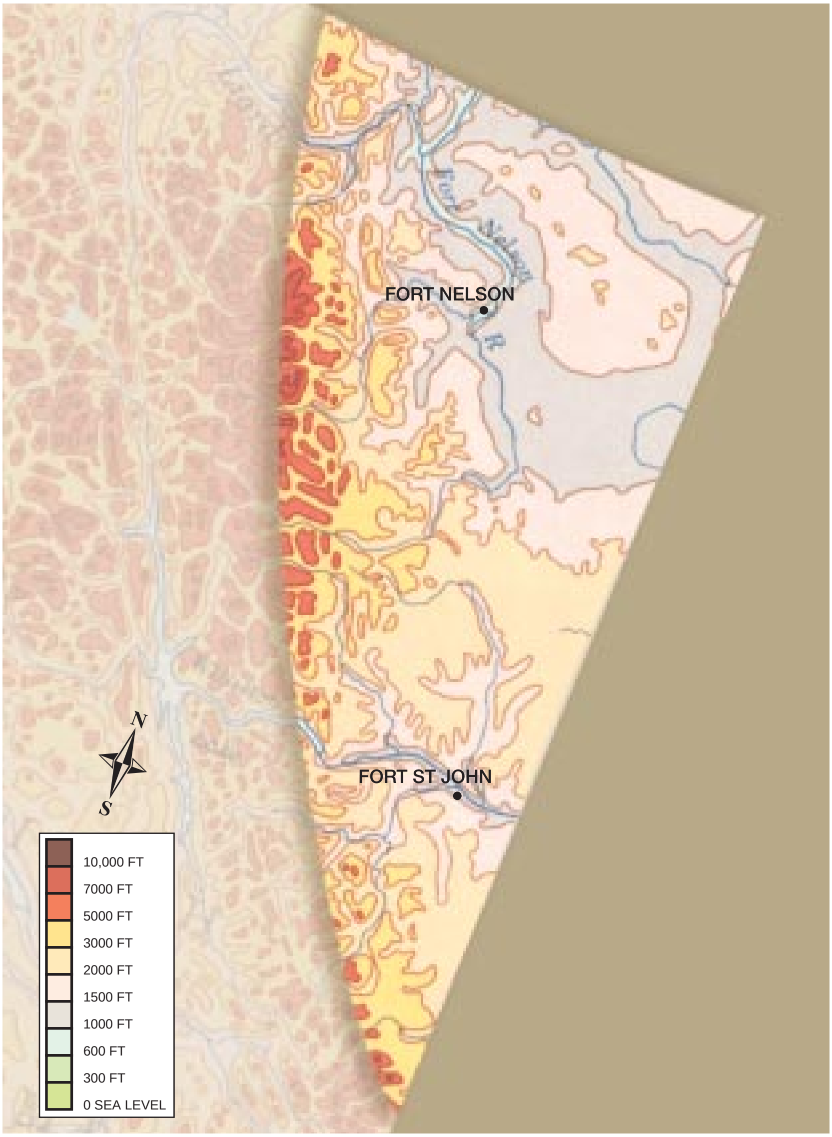
Map 3-6 - The Central and Northern Interior

The Central and Northern Interior, like the rest of BC, are largely mountainous; however, there are two major plateaux located in this area. These are the Central Interior Plateau, west of Williams Lake and Prince George, and the Atlin-Stikine Plateau, over northwestern British Columbia. Throughout the area are a series of rivers and lakes, some of which, such as Quesnel and Williston Lakes, are quite large.

The Rocky Mountain Trench is also prominent in this area. Beginning in the southeast interior, it passes just to the east of Prince George, forms Williston Lake, then narrows and continues northwestward towards Watson Lake in the Yukon.

The plateaux have a significant impact on the weather. During the summer, the flattened terrain can develop significant convection. Moderate to heavy thunderstorms are not uncommon and, on occasion, a tornado or funnel cloud will be reported in the Prince George area. Winter produces its own problems. The incursion of arctic air is fairly common and, this, coupled with moisture from local forestry mills, produces widespread and frequent low stratus and fog. Even when warm air does invade from the Pacific, it frequently flows over top of the cold air at low levels, making it difficult to erode the stratus and fog.

Northeast British Columbia



Map 3-7 - Northeast British Columbia

The western boundary of this area is marked by the Rocky Mountains that lie in a north-northwest to south-southeast line from Jasper to just west of Fort Nelson and then into the Yukon. While not as high as the southern part of the Rockies, they still rise to a respectable average height of 7,000 feet ASL. To the east of the Rockies is an extension to the Canadian Prairies; the terrain here is almost flat, rising steadily in elevation from the Alberta border until it reaches the Rocky Mountains.

The climate here is more like that of Alberta than the remainder of British Columbia. The summer tends to be hot and convective. The occasional cold low does move across the area; however, giving widespread precipitation and cloudy, cool conditions. Winter is cold as arctic air dominates. Warm air moving eastward overtop the cold air will give snow but does little to moderate the temperature. Despite this, a strong southwesterly flow will produce Chinook conditions that drive temperatures, in such places as Fort St. John, above freezing.

Mean Upper Atmospheric Circulation

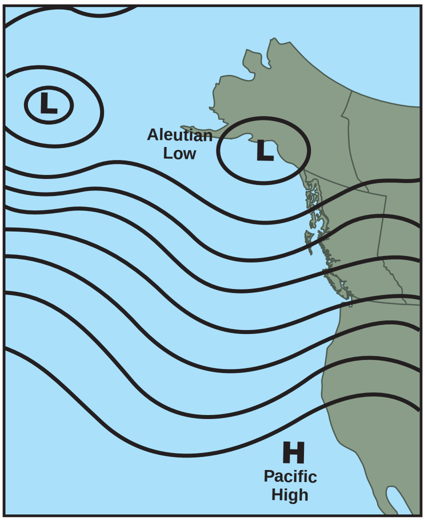


Fig. 3-2 - Typical winter pattern

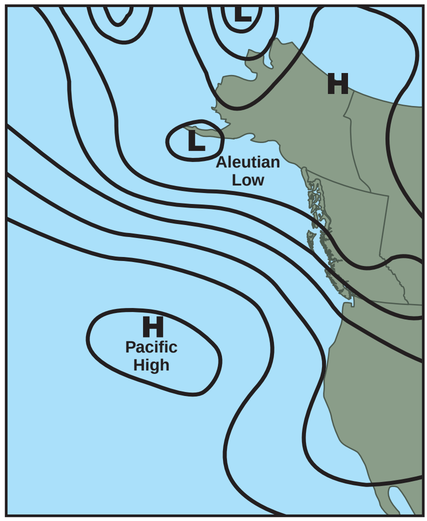


Fig. 3-3 - Typical summer pattern

The mean circulation of the upper level winds over British Columbia is the result of two semi-permanent features. The "Pacific High" extends from the area east of Hawaii to the West Coast of the United States. The "Aleutian Low" occurs in the Gulf of Alaska and over the Aleutian Islands. The combination of the counterclockwise circulation around the Aleutian Low and the clockwise circulation around the Pacific High results in a mean westerly flow onto the west coast of North America.

The Aleutian Low is strongest in the winter, which causes the mean circulation to take on a southwesterly component, while the Pacific High is strongest in the summer causing a more northwesterly flow. Complicating this simple relationship are the upper troughs of low pressure, upper ridges of high pressure and other weather systems that move along with the upper winds, altering or disrupting the normal pattern.

Upper Troughs and Upper Ridges

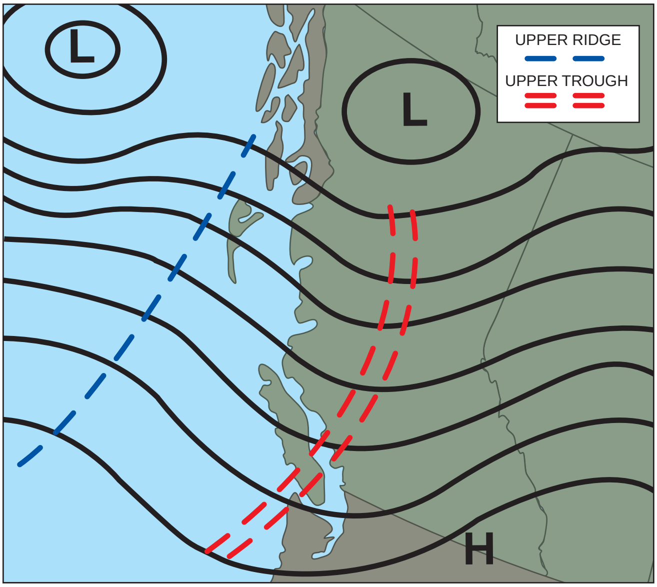


Fig.3-4 - Typical winter pattern with upper troughs and ridges added

Although the mean upper flow is generally from west to east, there tends to be a series of upper troughs and ridges embedded within this flow. Upper troughs induce vertical lift in the atmosphere, which in turn is associated with cloud and precipitation. In the winter, these troughs are at their strongest and frequently create broad areas of cloud with widespread precipitation. This process can be further enhanced if an orographic feature lifts the air mass at the same time. During the summer months, the cloud shields associated with upper troughs are narrower and usually quite convective in nature. The vertical lift and upper level cooling produced by the trough will intensify any preexisting instability in the atmosphere, and some of the worst summertime thunderstorms are produced when such a trough moves over a region that has already been destabilized by daytime heating. If an upper trough crosses an area where strong baroclinicity (temperature gradient) exists, it can set off a chain of events that results in the development of a surface low pressure system and/or frontal wave. These will further enhance the cloud and precipitation. Clearing behind an upper trough can be gradual in the winter, but tends to be quite rapid in the summer.

Any surface pressure system associated with an upper trough moving eastward across British Columbia often fills (weakens) as the system encounters the mountainous terrain.

Upper ridges, on the other hand, are associated with clear skies and good weather as they induce regions of descent within the atmosphere. It is common, both in the summer and winter, to have a large north-south upper ridge sitting over British Columbia. This pattern is frequently stationary for days in a row.

Both the upper trough and the upper ridge interact with the Pacific High and the Aleutian Low. An upper ridge will strengthen the Pacific High and weaken the Aleutian Low. This tends to dissipate or divert cloud northwards away from the British Columbia coast and into Alaska, or across the Yukon. An upper trough will cause the Aleutian Low to deepen and the Pacific High to weaken, so that weather systems will follow a general westerly track over the Gulf of Alaska and into British Columbia.

Semi-Permanent Surface Features:

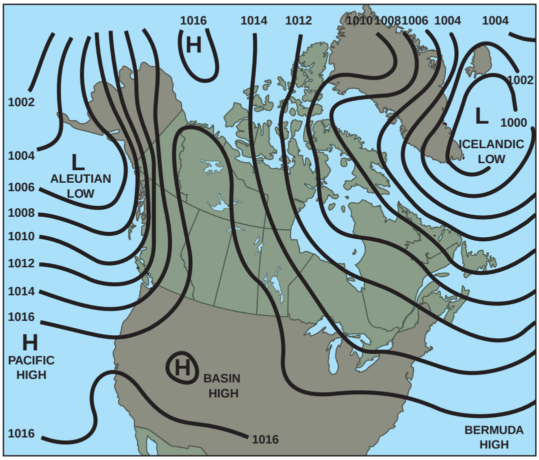


Fig. 3-5 - January mean sea level pressure

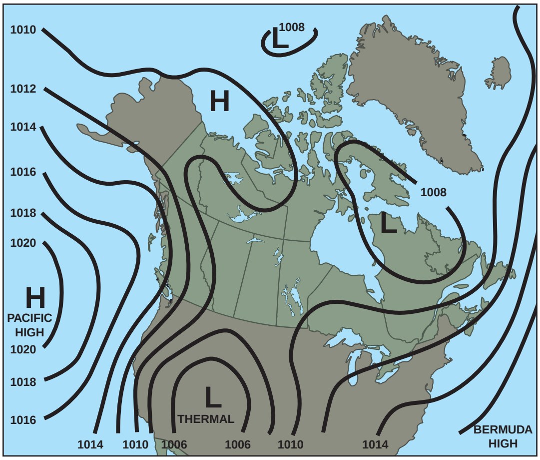


Fig. 3-6 - July mean sea level pressure

There is a tendency for the flow of the atmosphere to conform to certain recurring patterns, partly due to the physical geography of the earth below. In particular, there are four large scale and semi-permanent pressure systems affecting Canadian weather. These features are named for the regions where they normally occur:

1. The Icelandic Low located over the north Atlantic near Iceland.
2. The Aleutian Low located south or southwest of Alaska.
3. The Subtropical High located in the Atlantic near the island of Bermuda.
4. The Pacific High located off the west coast of the United States, sometimes extending inland in the winter forming the so-called "Basin High".

The January mean sea level surface pressure chart shows that the Aleutian low is well out in the Pacific and the Icelandic low is southeast of Greenland. A ridge of high pressure extends from the southwest U.S.A. northwards across Alberta into the Mackenzie River Valley. As the year advances towards summer, both the Aleutian and Icelandic Lows weaken. The July mean sea level surface pressure chart shows that the Pacific High becomes established off the west coast of North America. At the same time, a thermal low forms over the American southwest and extends a trough into the Pacific Northwest. These influences act together to put BC under a weaker, less predictable flow during the summer months.

Migratory Weather Systems

Closer to the surface are the migratory or traveling surface weather systems (low pressure areas, high pressure areas, frontal systems) that are carried into British Columbia and produce the day-to-day weather. These travelling surface weather systems vary in intensity with the seasons and are more frequent in the winter months (Oct. to Apr.). On average, 10 to 15 such storms will occur monthly during the winter.

Winter Storms

During the winter, low-pressure systems develop over the Pacific Ocean and move toward the coast. Most of these storms are either Gulf of Alaska lows, which tend to remain well offshore, or coastal lows which approach the coast before developing rapidly. Coastal lows, while not as powerful as the Gulf of Alaska low, can be quite dramatic in terms of their development and speed of movement.

On a few occasions during the winter, a low will combine the characteristics of both the Gulf of Alaska low and the coastal low. In this situation, the low first moves into the Gulf of Alaska and begins to weaken. The front sweeps over the coast giving strong winds and widespread precipitation, especially along windward slopes. After a time the low, which now sits over the Gulf of Alaska, begins to drift southeastward toward the British Columbia coast and strengthens once again.

The map shows the average tracks that the different types of lows usually follow. The actual track of any individual storm can vary somewhat from those shown.

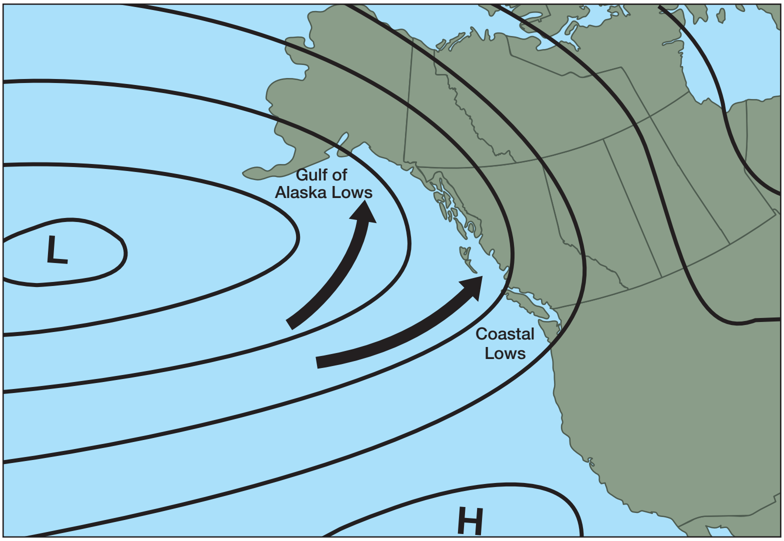


Fig. 3-7 - Principal winter storm tracks are superimposed on a January mean sea-level pressure pattern

Gulf of Alaska Lows

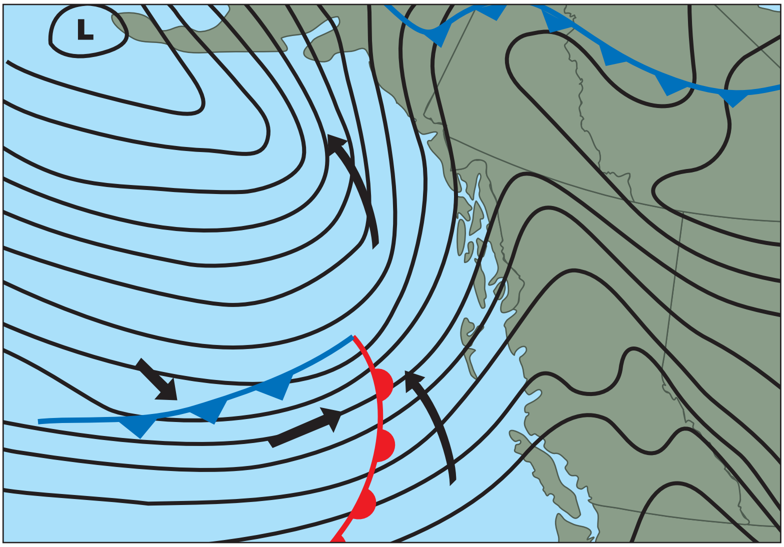


Fig. 3-8 - This sea-level pressure pattern indicates a Gulf of Alaska low with the associatied frontal system approaching the B.C. coast

A Gulf of Alaska low usually forms south of the Aleutians as a frontal wave between the cold northern air and warmer air to the south. Such a wave may travel a considerable distance eastward before it begins to take shape as a low pressure system. Once the low starts to develop, pressures fall rapidly and the entire low pressure system increases in size.

The low, travelling eastwards at typically 35 to 40 knots, reaches its lowest central pressure (970 hPA or lower) over the Gulf of Alaska then turns northeastward toward the northern end of the Alaskan Panhandle. The frontal system that accompanies the low continues eastward onto the coast, bringing widespread cloud, precipitation, and strong winds. Behind the cold front, a period of strong northwesterly winds of 35 to 50 knots heralds the arrival of a colder, unstable airmass.

Coastal Lows

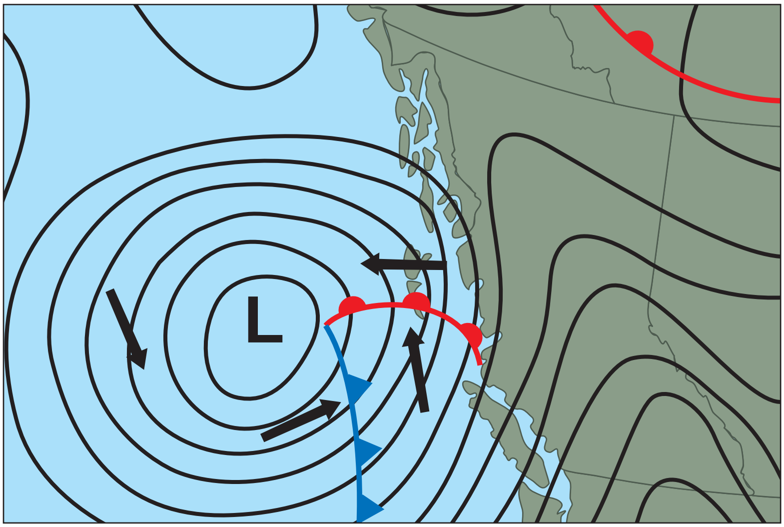


Fig. 3-9 - A typical sea-level pressure pattern for a coastal low and associated frontal system with wind pattern superimposed

Coastal lows usually intensify very rapidly just before they move over the British Columbia coastal waters and can change from a very weak system into a severe storm in as little as 9 hours. Lows which do develop in such a rapid, or explosive manner, are referred to by the forecasters as "bombs." On the coast, very strong winds will occur usually to the east and southeast of the low, just ahead of the associated frontal system. Winds here may reach southeasterly 70 knots with gusts to 100 knots in the most severe storms. Often, a second band of strong winds occur behind the cold front in the area to the southwest of the low pressure centre. Here, winds may range up to 65 knots from the west or northwest. Once the low moves ashore, it will fill rapidly over the Coast Mountains and frequently dissipate before penetrating very far into the interior. On occasion, the low will be able to draw down cold air from the north and maintain its intensity. This results in a strong wind event for the interior.

The coastal lows often move through Queen Charlotte Sound or over the Queen Charlotte Islands. Occasionally, a low will move eastward, passing just south of Vancouver Island. The lows which follow this southern track can bring the strongest winds and heavy rains to the Vancouver and Victoria areas.

Winter Frontal Systems

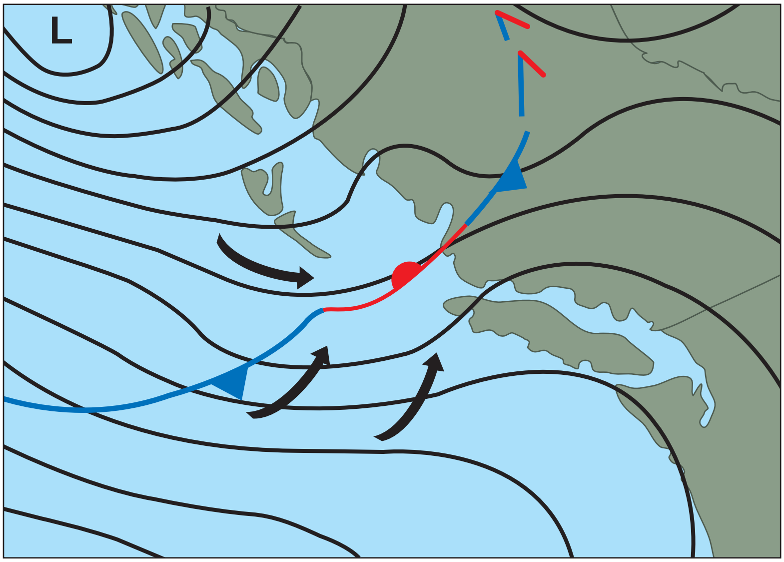


Fig. 3-10 - A typical winter pressure pattern shows a front crossing the coast with an indication of the winds near the front

While low pressure systems either die along the Coastal Mountains, or curl northward into the Gulf of Alaska, the associated frontal systems will push across the coast and inland. The favourite track takes the frontal wave across central British Columbia, with the trailing cold front sliding southward across the South Coast and Southern Interior of British Columbia. An occluded front usually extends northward from the frontal wave and moves across northern British Columbia.

As the front moves inland, it tends to weaken due to subsidence to the lee of the Coastal Mountains but still gives steady or intermittent precipitation that will vary with the local temperatures

Winter High Pressure Systems

Surface high pressure systems are stronger in the winter than in the summer. Along the coast, it is the ridges of high pressure that provide the only break between active weather systems. As the ridge of high pressure approaches the coast, the higher level clouds dissipate and the lower cloud layer break-up, leaving scattered to broken cumulus cloud as the developing surface ridge will cap the deep convection.

In the Southern Interior, areas of high pressure have a lesser impact because of the widespread valley cloud. Cold air stagnating in the bottom of the valleys causes a strong low level inversion to form, which traps any moisture from local sources. Under this inversion, valley cloud will form and show a great reluctance to clear. Higher elevations; however, will be clear and cold.

The northern half of British Columbia is subject to valley cloud only during the early part of the season, as the lakes and rivers generally freeze over completely. Thus, ridges of high pressure during mid and late winter bring widespread clear, cold weather.

Arctic Outbreaks

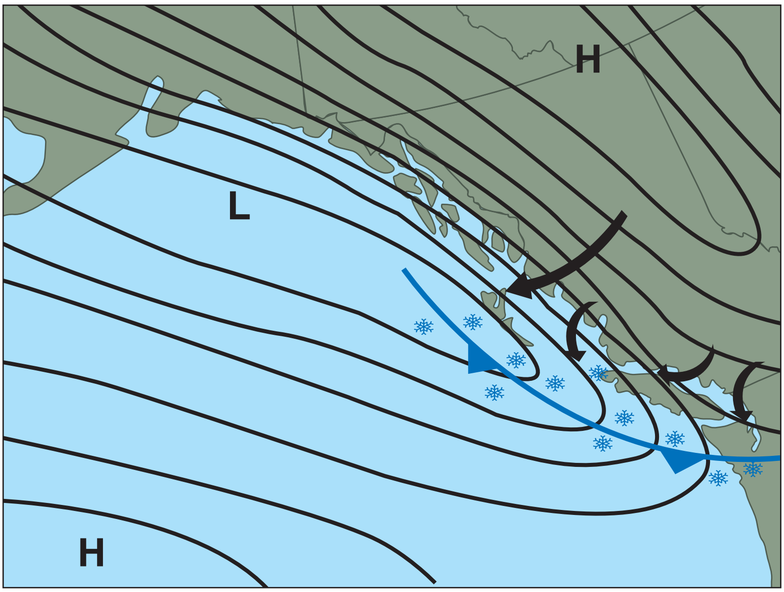


Fig. 3-11 - A ridge of high pressure builds over the province as the cold, arctic air flows into the interior. This pushes the cold front out onto the coast. Strong outflow winds occur through the mainland inlets and near the mouth of the inlets.

During winter, a strong area of high pressure forms in the very cold air over Alaska, the Yukon and the northern end of the Mackenzie River Valley. This cold arctic air moves southeastwards into the Prairies but can also spread over northern and central British Columbia. Most often, the arctic air pushes southward into the Central Interior before coming to rest. At the same time, arctic air also flows through the mountain passes from Alberta and fills the Rocky Mountain Trench. At least once or twice each year, the advance of arctic air is so strong that it spreads into the Southern Interior.

Outflow

If the cold air deepens sufficiently over the interior of British Columbia, it can flow through the coastal mountain passes down the coastal inlets, and cascade out over the coastal waters far enough to cover the Queen Charlottes and Vancouver Island. This condition of cold air spilling through the coastal inlets is referred to as "outflow" and it can persist for days. Outflow is a common occurrence over the North and Central Coast areas of British Columbia and infrequent over the South Coast.

Fig. 3-12 - Strong winds funnel down the mainland inlets often reaching speeds up to 60 knots

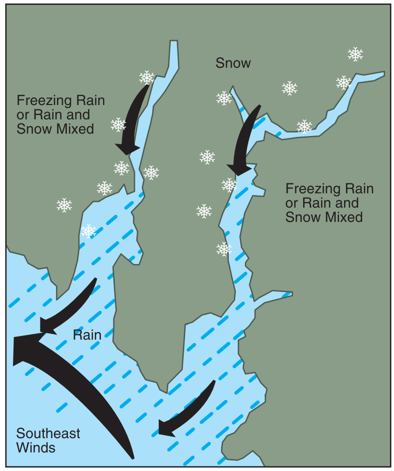


Fig. 3-13 - The end of an arctic outbreak occurs when the cold air is forced back inland by the arrival of warmer air being driven ahead of a Pacific storm

Inflow

The end of an arctic outbreak occurs when the cold air is forced back inland by the arrival of warmer air being driven ahead of a Pacific storm. As the low approaches pressure will begin to fall over the interior. In response to this pressure fall, the outflow winds will gradually ease as the southeast winds strengthen along the coast. Eventually, the pressure falls will induce an inflow of warm air. During this transition time, from cold outflow to warm inflow, precipitation forecasting becomes very difficult. Snow changes to rain but not without the chance of freezing rain.

When a frontal system moves across the coast the rising pressures over the offshore waters induce an inflow wind through the coastal inlets. This inflow carries the post-frontal low cloud into the inlets effectively plugging them in a manner similar to marine stratus. This cloud will dissipate as drying occurs but, for a period of time, the inlet is impassable. This inflow effect occurs year-round.

Summer Weather

In the summer months (May to September) the frequency and severity of the storms are much reduced. Low pressure areas usually remain offshore as the Pacific High strengthens and moves further north. This northward shift causes the main storm track to shift into the northern Gulf of Alaska and across northern British Columbia. South of this track, minor frontal systems, upper troughs and thunderstorms produce most of the weather. In August and September, weeks can pass between weather systems.

Summer fronts

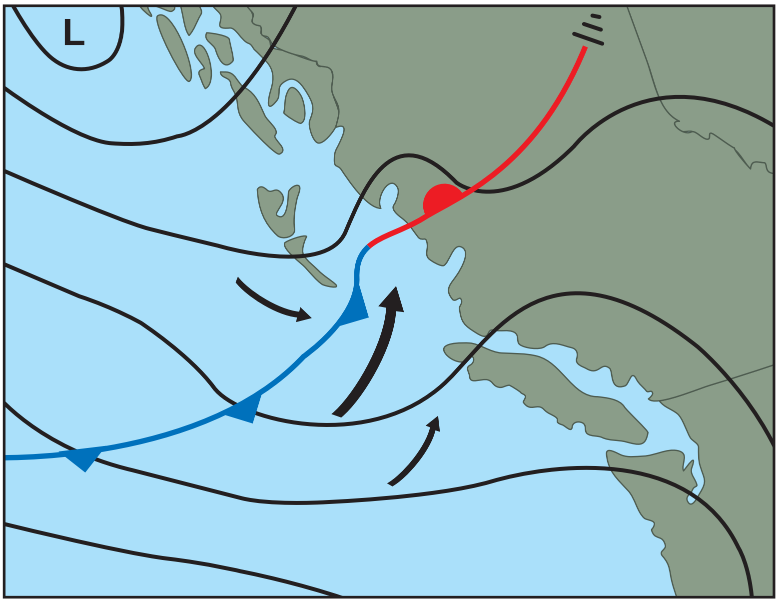


Fig. 3-14 - A typical summer pressure pattern shows a front crossing the coast with an indication of the winds near the front

During the summer months, fronts tend to approach the coast from the northwest across the Gulf of Alaska. Over the northern coastal areas, the front is usually accompanied by a narrow band of cloud and light rainfall. Southeast winds will tend to increase along the coast just ahead of the front, then shift into the northwest with its passage. As the front continues southward and presses further into the Pacific High, the rain area often disappears and the clouds begin to dissipate.

As the front moves inland, it is weakened by subsidence to the lee of the Coast Mountains.

Thermal Troughs

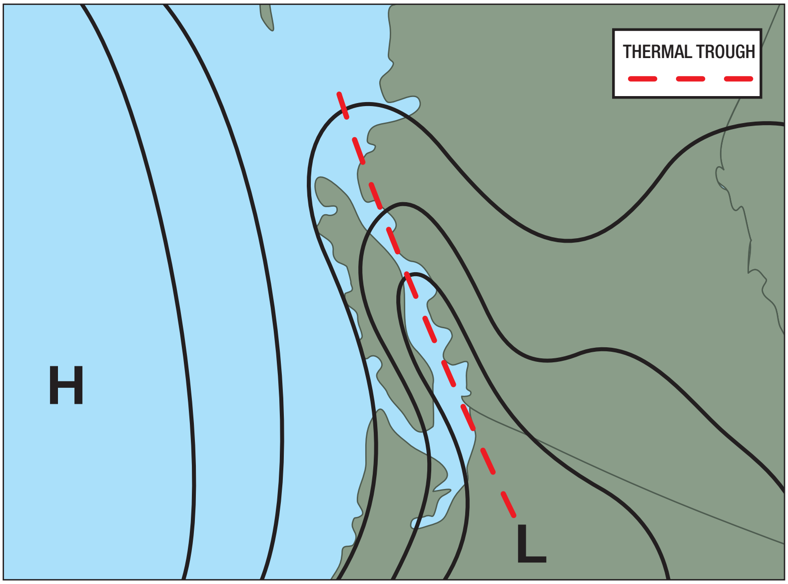


Fig. 3-15 - Thermal trough

The usual summer pressure pattern has a high pressure area over the eastern Pacific and troughs of low pressure in the southern interior of BC This trough forms due to prolonged heating and is referred to as a thermal trough. The effect of this trough is to create a light, disorganized wind pattern as air flows toward the hottest locations. Along the coast, light winds in the morning are replaced by strengthening inflow winds during the afternoon and evening in most inlets and valleys, as the cool coastal air is drawn towards the interior. Locations in BC with marked inflow winds are the Strait of Juan de Fuca, Portland Inlet, Howe Sound, through the Hope area and up the Fraser Canyon.

On occasion, during the summer the thermal trough will move out from the interior and onto the coast. When it does, it normally lies over Georgia Strait causing subsident outflow winds from the interior which gives clear skies and light winds along the coast.

After a few days, the thermal trough will shift back into the interior causing westerly winds of 20 to 30 knots through Juan de Fuca Strait and into southern Georgia Strait. Sea fog and stratus will accompany these winds and may extend as far as Vancouver Airport and Boundary Bay. In the strongest cases, the fog will lift into stratus and spread up the Fraser Valley to Hope.

Cold Lows

A cold low is a large, nearly circular area of the atmosphere in which temperatures get colder toward the centre of the low, both at the surface and aloft. While a surface low pressure centre is usually 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, tend to persist in one location for prolonged periods of time and are difficult to predict.

Cold lows can occur at any time of the year, but the most frequent occurrence, know as "cold low season," is from the end of May to mid-July. At this time, pools of cold air break away from the Aleutian Low and move southeastwards to take up a nearly stationary position off the British Columbia or Washington coast. Once established, the cold low will generate a series of upper cold fronts which will rotate across southern British Columbia. The overall effect is to produce a widespread area of cool, unstable air in which bands of cloud, showers and thundershowers occur. Along the deformation zone to the northeast of the cold low, the enhanced vertical lift will thicken the cloud cover and can produce widespread precipitation. In many cases, the deformation zone is where widespread and prolonged thunderstorm activity occurs.

Eventually, a strong system will approach from the west and will have sufficient strength to force the cold low inland, usually in the form of a strong upper trough. A favourite track is across the northern United States, but alternate tracks are across southern British Columbia or even northeastward along a line from Seattle to Fort St. John. As it crosses the area, widespread cloud, showers, thundershowers, or even steady rain can occur for a period of 24 to 48 hours. Normally, while the original cold low is moving off, the next one is already moving across the Gulf of Alaska on its way to take up residence off the coast.

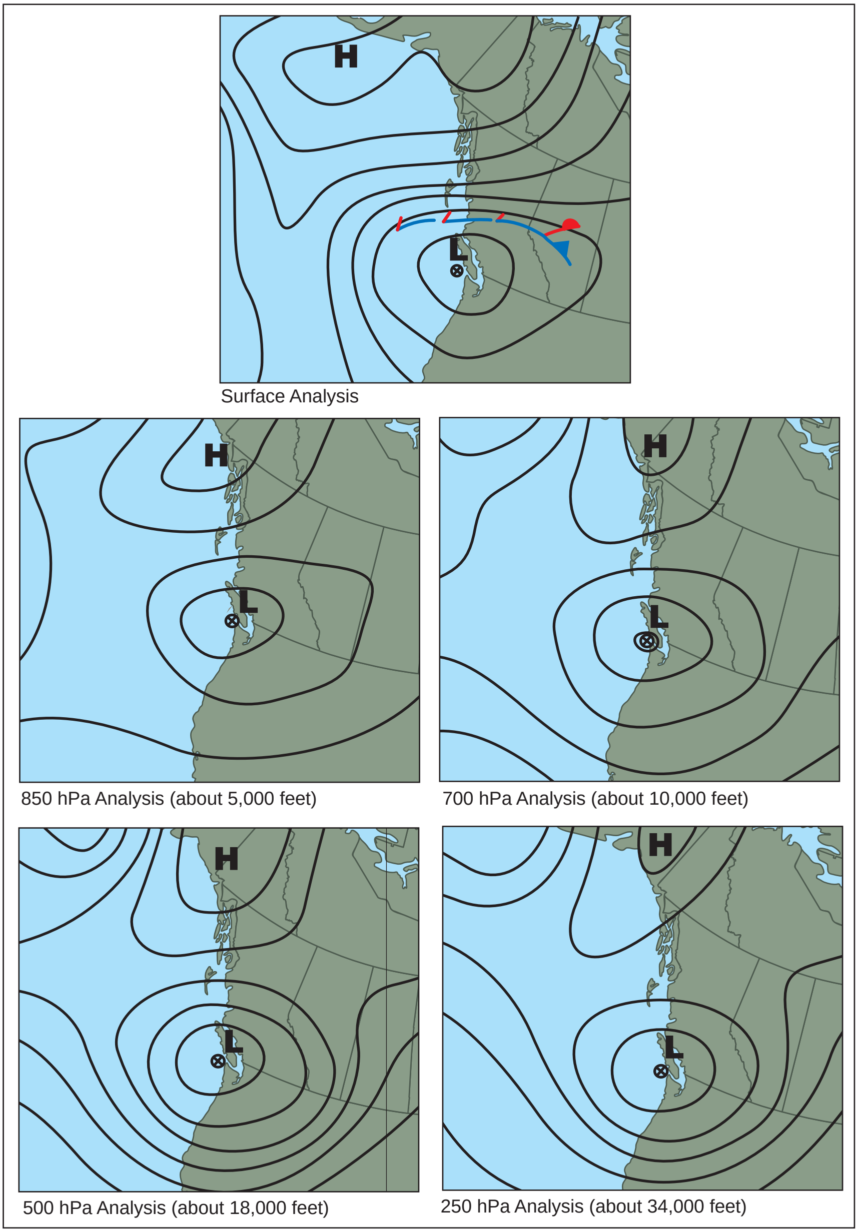
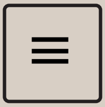
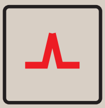
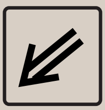
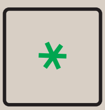
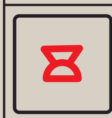
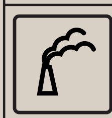
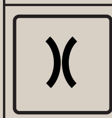


Fig. 3-16 - Typical surface and upper level pattern for a cold low event

Notes:

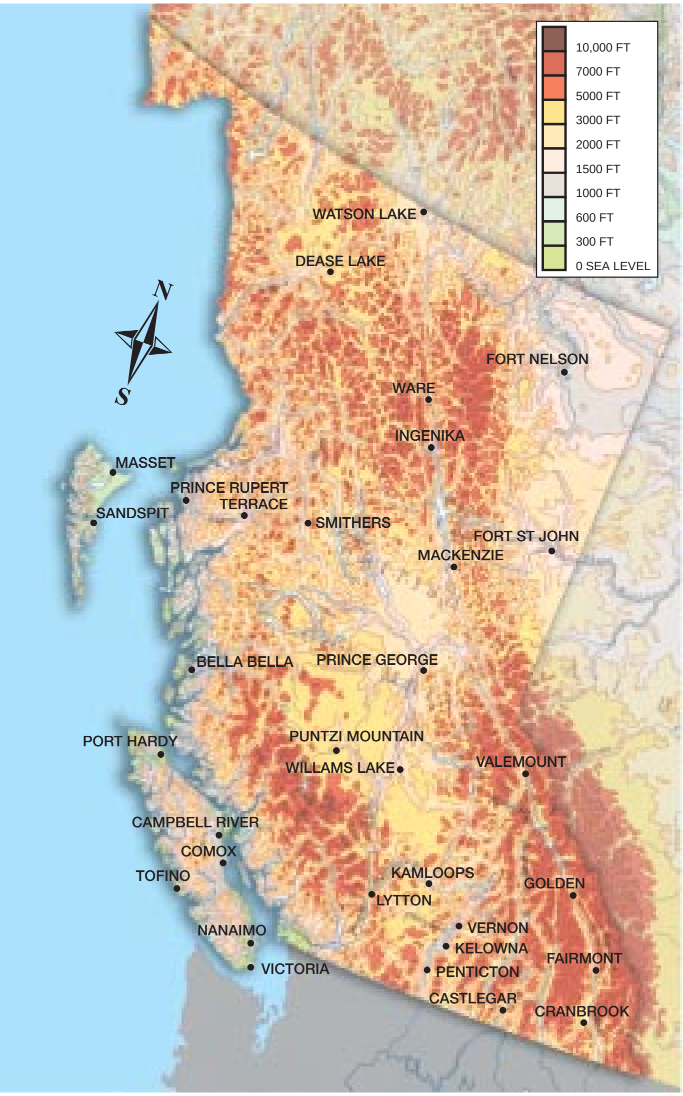
Table 3: Symbols Used in this Manual

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

Chapter 4

Seasonal Weather and Local Effects

Introduction

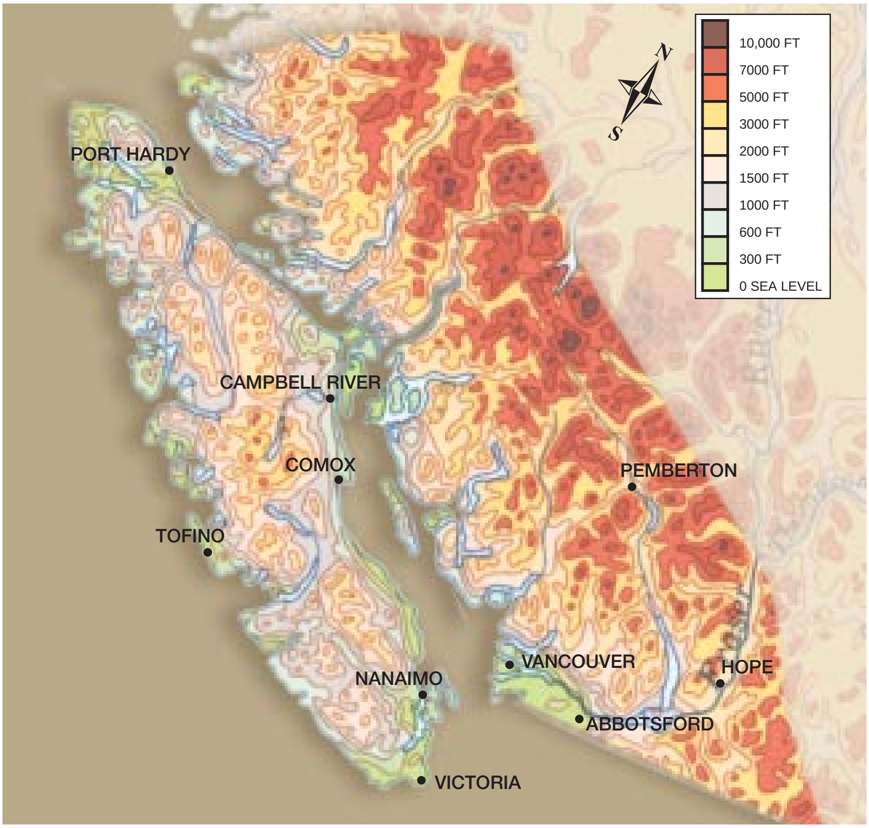


Map 4-1 - Topography of GFACN31 Domain

This chapter is devoted to local weather hazards and effects observed in the GFACN31 area of responsibility. After extensive discussions with weather forecasters, FSS personnel, pilots and dispatchers, the most common and verifiable hazards are listed.

Most weather hazards are described in symbols on the many maps along with a brief textual description located beneath it. In other cases, the weather phenomena are better described in words. Table 3 (page 74 and 207) provides a legend for the various symbols used throughout the local weather sections.

South Coast



Map 4-2 - South Coast

For most of the year, the winds over the South Coast of BC are predominately from the southwest to west. During the summer, however, the Pacific High builds northward over the offshore waters altering the winds to more of a north to northwest flow. Regardless of the direction, the coastal area is exposed to every weather system approaching off the Pacific Ocean. On the plus side, it is the bulk of Vancouver Island that takes the brunt of these storm, ameliorating their effect on the inner waters and mainland areas. Compounding, the problem is the mountainous terrain, that rises abruptly almost from the waters edge, ensuring each system undergoes immediate upslope lift. The question for meteorologists and pilots then becomes not “Will we get precipitation?” but “How much precipitation will we get and what type?” The answer to these questions lies in the seasons of the year.

(a) Summer

Summer over the South Coast tends to be fairly benign, especially when compared to a typical winter. Frontal systems do make an appearance from time to time, but for the most part they make little impression. Approaching from the Gulf of Alaska, but with little in the way of cold air to feed their development, these systems develop slowly and are relatively weak. Typically, a band of cloud and light precipitation over the northern end of Vancouver Island may dissipate to just broken cloud and showers in the south.

Behind these fronts, a ridge of high pressure will build towards the coast. Rising pressures ahead of this ridge will then give a period of brisk northwest winds to the coast. The strongest northwest winds are often reported where the air stream is funnelled between the mountains of the mainland and Vancouver Island. This effect is particularly noticeable in the spring months, as the fronts still retain some of the strength of winter storms.

Traditionally, the latter parts of May and June tend to be a cloudy and wet. During this time, a series of cold lows spawn over the northern Gulf of Alaska and move southward along the coast. Their tracks are difficult to predict but a favourite path is along the west coast of Vancouver Island and then inland, either through the Juan de Fuca Strait or northern Washington State. Either track produces widespread cloud, showers and cool temperatures. Only when the Pacific High builds far enough northward is this pattern cut off.

Although not frequent, thunderstorms do occur along the coast of British Columbia in the summer. Air mass thunderstorms are the most common, tending to develop during the late afternoon or evening and drifting eastward along the sides of inlets or valleys. Although short-lived, they can produce intense hail and lightning. On occasion, frontal thunderstorms will move into the coastal areas. One favourite track is eastward through Juan de Fuca Strait, or northward through Washington, ahead of an approaching upper trough of low pressure.

The scourge of summer over the South Coast is the sea fog and marine stratus that often lies over the cold offshore waters, near the western entrance of Juan de Fuca Strait. When inflow conditions occur, the fog and stratus are frequently drawn into the strait, penetrating as far as the Victoria area. Since inflow is common, fog is frequently found in Juan de Fuca Strait for much of the year.

Many of the mainland valleys experience inflow winds in the summer due to the intense heating of the air over the Southern Interior. As pressures fall over the interior, a flow of cool, moist air begins to flow inland. However, as the thermal trough is forced inland, these inflow winds will occur on a daily basis, drawing low marine cloud into the inner coastal areas and even the mainland valleys.

(b) Winter

Winter is a much more dramatic season. The Pacific High retreats with the sun allowing the Aleutian Low to move back into the Gulf of Alaska. As it does, a strong north to south temperature gradient is established that will provide the energy for significant development of approaching weather systems.

The usual pattern is for a deep low-pressure system to approach from the west to southwest, accompanied by an occluding frontal system. Ahead of the approaching low, a warm front will spread extensive, deep-layered cloud, steady precipitation and strong southeast winds across the area. With the passage of the warm front, the precipitation becomes intermittent or ends completely, the lowest cloud layers break up and the winds shift to a moderate to strong south to southwest direction. The arrival of the trailing cold front is marked by the development of showers, which can be both widespread and heavy in intensity. Finally, behind the cold front, strong gusty northwest winds often prevail. With the most active fronts, warm or cold, the winds can briefly rise to 60 knots with gusts above 80 knots at locations over the northern end of Vancouver Island. Of the two, the southeast winds tend to be the strongest, but they both can be very strong where channelling and coastal convergence occurs.

One particularly wet pattern, known as the "Pineapple Express," occurs when a deepening trough of low pressure offshore causes the frontal system to stall over the South Coast. Eventually, moist, tropical air is picked up by the upper winds from near the tropics and carried northeastward onto the BC coast. The result is extremely heavy precipitation events where local rainfall amounts of 100 millimetres or more can occur..

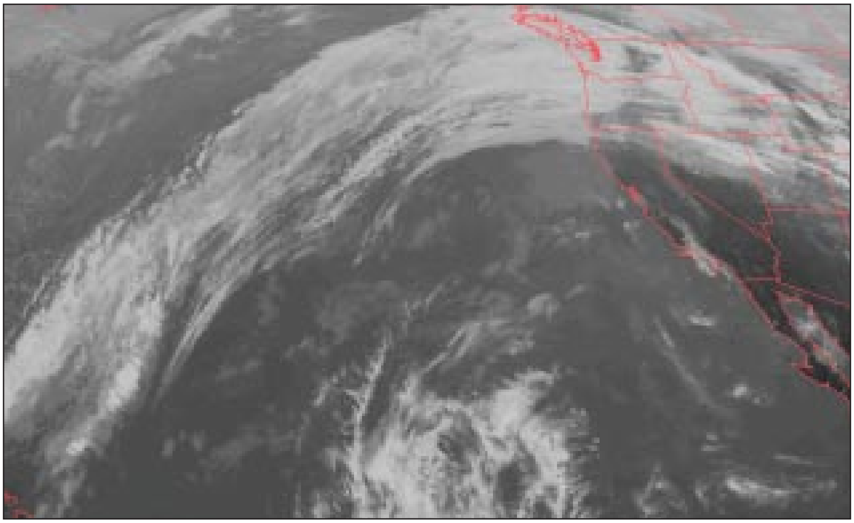


Photo 4-1 - Pineapple Express

Air mass thunderstorms occur most often during the winter, especially in the very cold air that follows the passage of a cold front. This cold air is heated by the ocean and becomes very unstable. As it does, lines of towering cumulus and cumulonimbus cloud develop which then move toward the coast to arrive about 12 to 24 hours after the frontal passage.

Surface high pressure systems, long valued for their generally good weather, are stronger in the winter than in the summer. Along the coast, it is these ridges of high pressure that provide the only break between active weather systems. As the ridge of high-pressure approaches the coast, the higher level clouds dissipate and the lower cloud layer break up leaving scattered to broken convective clouds.

Winter is also the time of “outflow winds”. Although infrequent, if the cold air deepens sufficiently over the interior of British Columbia, it can flow through the coastal passes and along the Fraser Canyon to spill out onto the South Coast through the inlets and valleys. Depending on the weather pattern, this outflow condition can persist for days without respite. The most common case will see the cold air cover the northern half of Vancouver Island but stall over the warmer waters of the Strait of Georgia. Only in the strongest outflow situation will the cold air completely cover Vancouver Island.

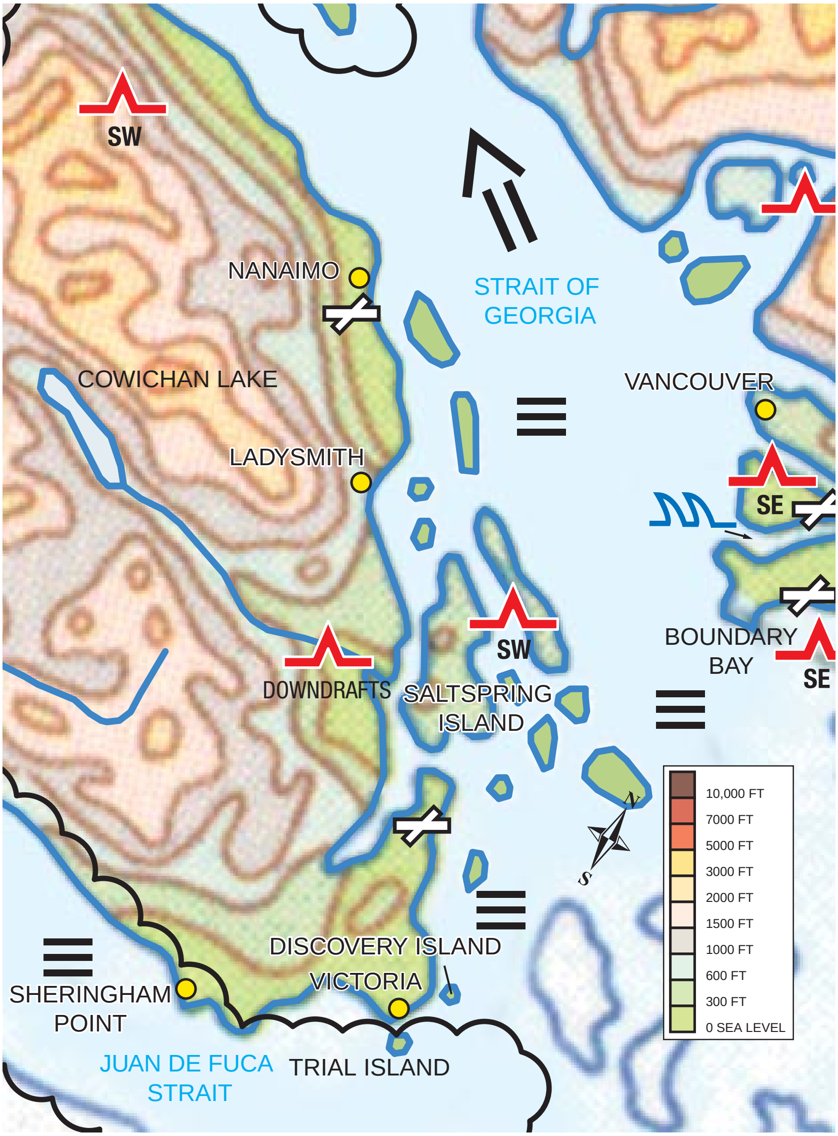
Along the mainland coast, a band of cloud and showers or flurries will accompany the leading edge of the outflow, to be followed by clearing skies. These clear skies will then persist throughout the period of outflow winds. Offshore, the cold dry air flowing over bodies of water, such as the Strait of Georgia or Johnstone Strait, will usually become unstable and will pick up enough moisture to give heavy snow showers along the east side of Vancouver Island.

The strong winds funnel down the mainland inlets often reaching speeds of 25 to 35 knots and occasionally rising as high as 50 knots. When the strong winds flow out from the mouths of the inlets they continue for some distance but gradually fan out and weaken. Extreme caution is advised when crossing coastal inlets during an outflow situation as the winds could increase very abruptly in a narrow band near the mouth of the inlet. One hint is to watch for the telltale ripple or wave pattern produced by these winds.

The end of an arctic outbreak occurs when the cold air is forced back inland by the arrival of warmer air being driven ahead of an approaching storm. With cold air along the coast, the precipitation may start as snow but changes to either rain, or rain and snow mixed, as temperatures moderate. Freezing rain can also occur in the deeper mainland valleys and inlets (including the eastern end of the valley) until the cold air is fully scoured out by the approaching warmer air.

(c) Local Effects

East Coast of Vancouver Island – Victoria to Nanaimo



Map 4-3 - East Coast of Vancouver Island – Victoria to Nanaimo

Summer and autumn weather is more conducive to flying; the main problems this time of year are sea stratus through Juan de Fuca Strait in the summer and sea fog in the fall. The San Juan Islands are more prone to morning fog than the Gulf Islands. The top of the fog usually lies between 1,000 and 2,000 feet AGL while the sea stratus tends to produce ceilings between 1,500 and 2,500 feet AGL. A typical pattern is for the stratus to move inland over succeeding days and become more and more reluctant to dissipate. Stratus typically lies just off Victoria Airport but covers the Gulf Islands. Fog banks off the east end of the runway at Victoria can be blown in as pulses by the sea breeze.

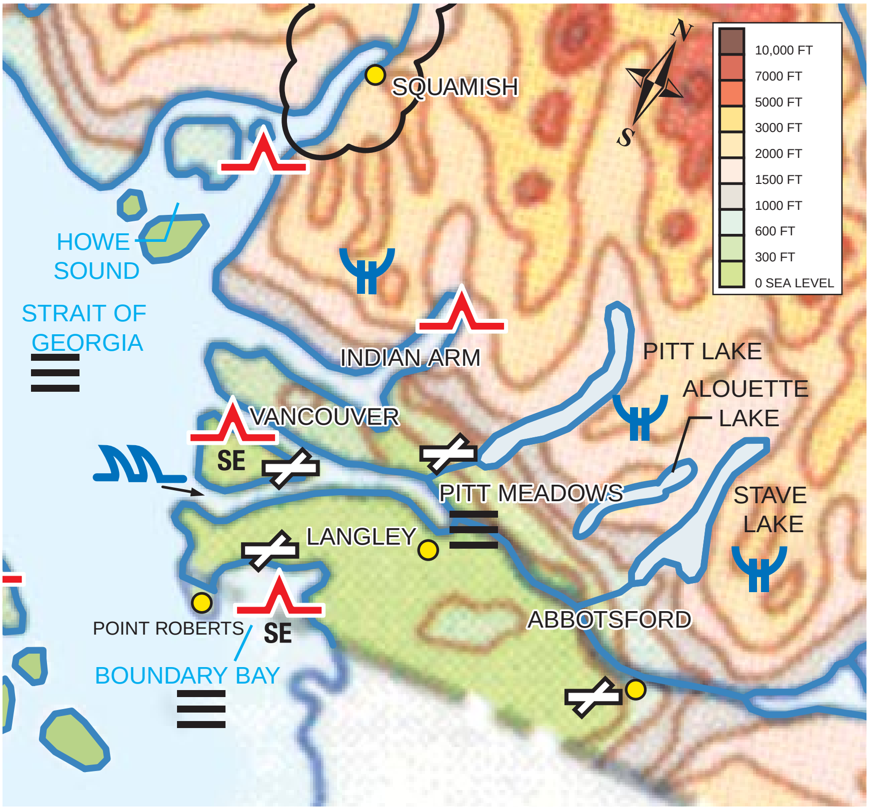
At the Duncan Airport, the runway is oriented 12-30 and lies uphill to the northwest. Westerly winds through Cowichan Valley often turn southward along the runway toward the valley and accelerate (15 knot wind becomes 25 knots). This downflow can be up to 500 ft/min resulting in aircraft landing short.

There are large hills on Pender Island where all winds, except southerlies, flow over hills resulting in downflow winds over the runway.

Nanaimo Airport is situated in a valley with local mountaintops ranging from 700 feet to 4,800 feet. While protected from the stronger surface winds found over the open water, it is susceptible to low-level mechanical turbulence and wind shear when winds aloft are strong. Most common during winter storm conditions, these hazards can be severe. Victoria airport, while somewhat protected from the common southeasterly winds, is more exposed to southerly and southwesterly winds and can experience hazardous wind shear when significant winds aloft are from a conflicting direction.

In addition to the regular METARS, it is worthwhile for low flying traffic over the water to check the marine wind reports from Trial Island just the south of Victoria, Victoria Harbour, Discovery Island east of Victoria Harbour at the south end of Haro Strait, Kelp Reef in Haro Strait east of Victoria Airport, Saturna Island near Active Pass in the Gulf Islands, and Entrance Island north of Nanaimo. Though not certified by Transport Canada for aviation weather, these sites, taken as a group, give a very good indication of the surface winds over the water.

Vancouver Area Including Pitt Meadows, Langley and Boundary Bay



Map 4-4 - Vancouver Area Including Pitt Meadows, Langley and Boundary Bay

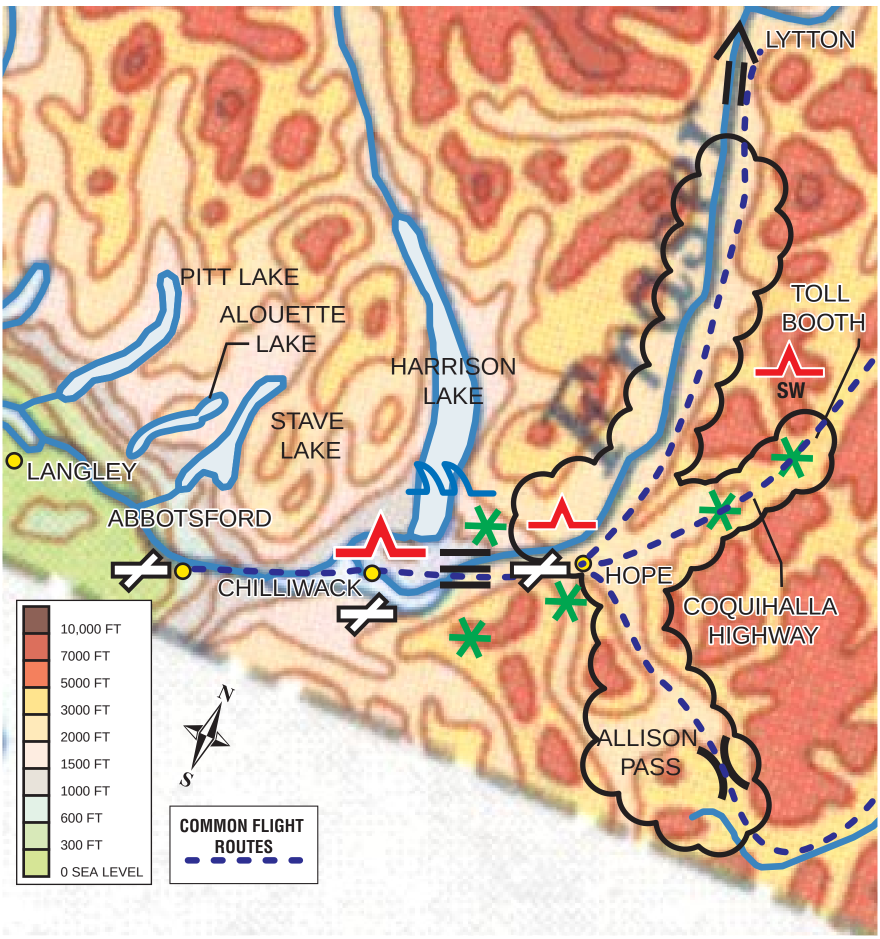
As most systems move over the south coast from the west or southwest (upper flow, not the surface winds), the north side and east end of the Fraser Valley tend, due to upslope, to get greater amounts of cloud and precipitation producing widespread areas of low flying conditions. When icing is indicated, you can expect it to be significantly heavier over the north shore mountains from Powell River to Hope. This includes not only the usual mixed icing in the convective build-ups associated with cold fronts, but also moderate and heavy rime icing with the onset of warm fronts. Pilots report some of the worst icing conditions they've ever experienced occur in this area. Because of this, most choose to ascend to the west over the Strait.

A general sense of the local weather can usually be obtained by making reference to the local METARS as well as the one from Bellingham (KBLI). Radiation fog is common around Langley and Pitt Meadows in the fall due to the low, flat bog land. Abbotsford Airport, however, is seldom a problem. Vancouver and Boundary Bay, on the other hand, are very susceptible to marine stratus/fog advection coming off the straits. This can cause conditions to deteriorate very rapidly. It most commonly occurs in the early morning with inflow conditions [usually with a ridge along the coast], and can last from an hour or so to several hours, sometimes continuing into mid afternoon. When conditions persist over several days, the low cloud/fog tends to persist longer each day.

Strong winds at Vancouver are usually from either the west or southeast with the southeasterlies tending to be gusty and turbulent. West winds can reach speeds exceeding 40 knots on occasion but tend to be stable and relatively smooth.

Tidal currents in the Fraser River can be hazardous for landing seaplanes, especially with northwest winds that oppose the current, producing steep, choppy waves. Similar or worse conditions are observed in the Pitt River, all the way to Pitt Lake.

Abbotsford to Hope



Map 4-5 - Abbotsford to Hope

The worst weather in the Fraser Valley occurs from September to April and is usually associated with precipitation that brings on rapidly lowering ceilings and visibility. The low cloud tends to thicken noticeably near Agassiz and worsens as you go eastward into the mountains. In a southwesterly flow, poor weather piles up along the mountains, with higher ceilings on the south side of the valley.

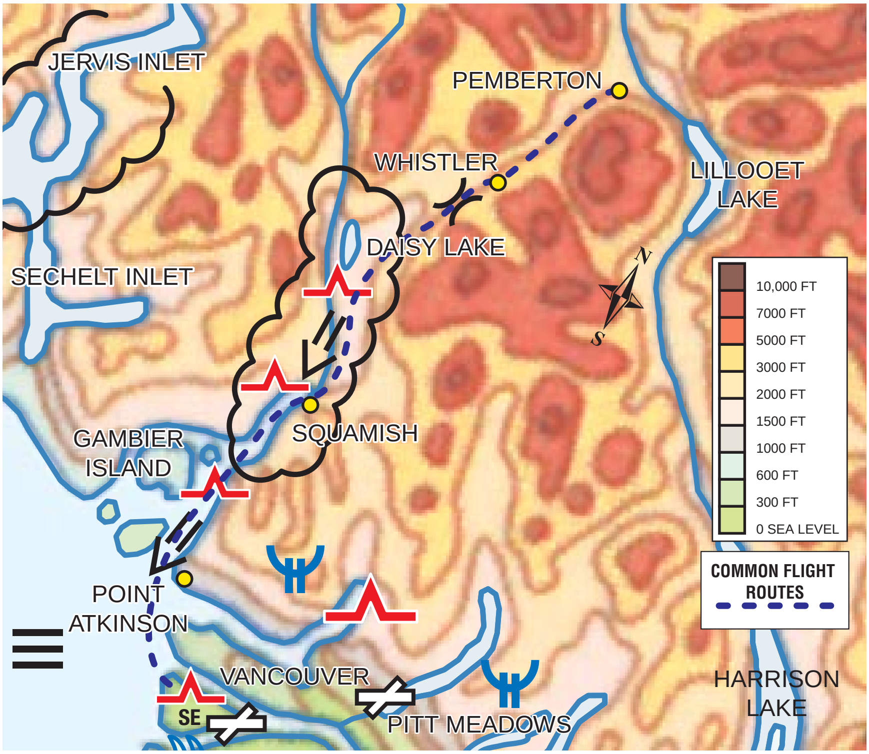
During times of strong northwest winds over the Strait of Georgia, the winds will curl into a strong westerly along the valley. Westerlies of 25 gusting to 45 knots with stronger gusts are common behind cold fronts. If the air mass is cold, snowshowers and very poor visibility will be found along the high ground that rims the eastern end of the valley. During times of strong inflow, anticipate significant mechanical turbulence on the south side of the Fraser River near Hunter Creek, located west of Hope between Laidlaw and Flood. During times of strong outflow the weather will generally be clear, but significant turbulence should be anticipated around Chilliwack and Sumas Mountains below 5,000 feet ASL.

The summer sea breeze channels between Chilliwack and Hope and can be quite strong (20 to 35 knots). Smog (top of layer 1,500 to 2,000 feet) can reduce visibility to 2 to 3 miles at the east end of the valley during warm, summer afternoons. When approaching from higher levels, reflection of sunlight off the smog can make it difficult to view the ground.

Very strong winds are common over Harrison Lake and Harrison River in summer. Over the lake, the worst winds are northerly sea breezes during summer afternoons. These can produce significant turbulence and waves as high as 4 feet.

Low cloud and poor visibility are facts of life in Hope from late fall to late spring. Only during times of dry, cold outflow will the cloud clear from the area. Turbulence is common in the Hope area when strong inflow or outflow winds are occurring. Inflow is common year round while outflow tends be a winter phenomenon. Local pilots report that this turbulence is usually restricted below 3,000 feet AGL. During the winter months, icing in cloud is often significant to the east and northeast of Hope, along the Coquihalla to Merritt route. When checking the local METARS note that Hope Slide is about 10 to 15 miles east of Hope and about one thousand feet higher up.

Vancouver to Pemberton along Howe Sound



Map 4-6 - Vancouver to Pemberton along Howe Sound

There is a high volume of traffic along this route throughout the year. It is possible for pilots to contact others on VHF to determine the weather ahead. However, when the conditions are marginal and pilots fly at low altitudes, radio contact is limited by the terrain to a very small area ([usually only a dozen miles ahead, often much less).

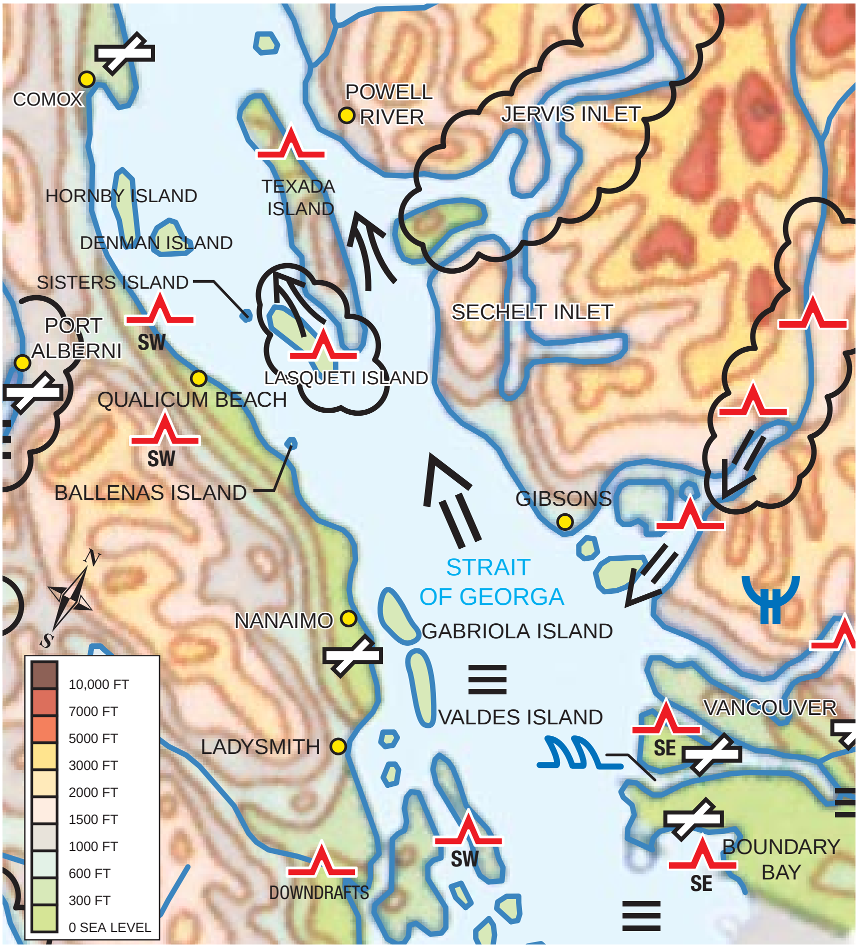
Often used as an alternate route to the interior, this route follows Howe Sound north from Vancouver to Squamish and then follows the Cheakamus River valley to Whistler and Pemberton. Just north of Squamish the valley splits into three valleys, with the largest, the Squamish River valley, opening to the northwest. Experienced pilots tell of frequent navigation errors near Squamish, especially in bad weather.

At the mouth of Howe Sound, near Vancouver, channelling causes outflow winds to increase dramatically. Burrard Inlet runs east-west and meets Howe Sound at right angles just northwest of Vancouver in the Strait of Georgia. When the outflow are strong through Howe Sound and Burrard Inlet, expect at least moderate mechanical turbulence in the immediate vicinity. The winds over the open waters of the southern Strait of Georgia are also often in conflict. When the outflow from Howe Sound is strong and there is a strong southeasterly wind blowing along the Strait, these winds are meeting each other almost head on. Add to this the fact that the upper winds just off the surface are commonly south or southwesterly winds aloft producing a hazardous condition with mechanical turbulence at lower levels and shear turbulence just above the turbulent boundary level winds, starting anywhere from 800 to 2,000 ft MSL. This area lies on busy float plane routes in and out of Vancouver Harbour enroute the Sunshine Coast and Howe Sound.

In the summer, thunderstorms are not infrequent in Howe Sound and tend to move up the sound. Strong inflow winds are common into Howe Sound to Squamish, often exceeding 30 knots. In a strong southeast flow up Howe Sound, there is strong turbulence along the highway where it is cut into the cliffs.

In the winter, during outflow conditions, turbulence to 5,000 feet AGL is common on the route north of Squamish, especially where the valleys narrow. Local pilots report that the bad weather tends to pile up on the east side of the river and recommend staying on the left side with the river to your right. The worst location for low cloud is one to two miles north of Squamish. The low cloud usually ends near Daisy Lake. A second choke point exists near the bend in the road, to the south of Whistler. The valley from Whistler to Pemberton is notorious as one of the last to dry out and clear after frontal precipitation. Also note, there are some very high wires along Highway 99, which are dangerous for fixed wing aircraft following the river.

Strait of Georgia – Vancouver - Nanaimo - Powell River - Comox



Map 4-7 - Strait of Georgia – Vancouver - Nanaimo -Powell River - Comox

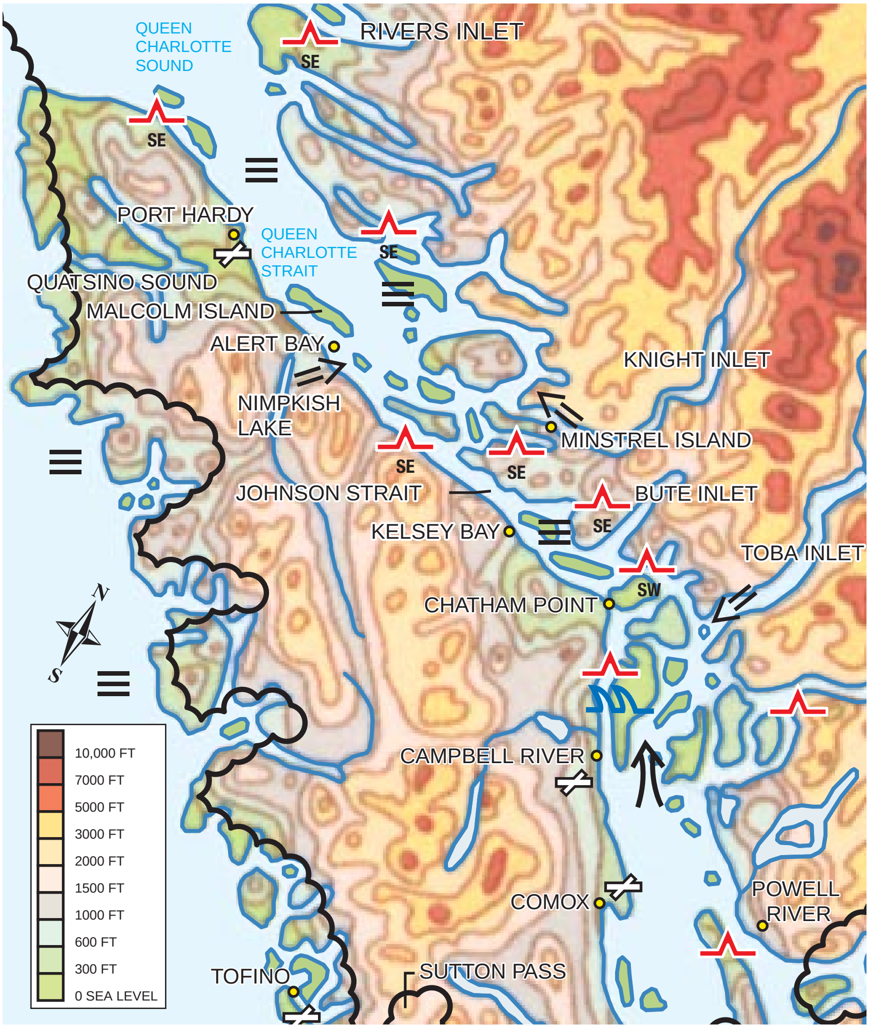
Southeasterly winds are the most significant along the strait and they tend to be gusty. Turbulence along this portion of the strait is generally not significant except for mechanical turbulence in the vicinity of terrain along the coast and the northern Gulf Islands. Channelling and coastal convergence of the surface wind can be severe along either side of Texada Island due to the height of the ridges. Coastal convergence can produce winds of up to 35 knots in the summer near Qualicum Beach. Nanaimo Harbour is almost always calm.

Low cloud and fog tend to persist wherever there are hooks of land to hold it, such as around Nanaimo and between Texada and Lasqueti Islands. In general, fog and low cloud are more persistent over the northern half of the strait. At Nanaimo, fog is much more common over the airport than at the floatplane base.

Powell River can be hazardous in southeast winds with lots of subsiding air near the runway. Hills in the vicinity rise to approximately 3,500 ft. The lake can be especially bad in southeast winds, which swirl around a point of land on the southern end of the lake. Although still dangerous at times, it is often calmer on the north end of the lake, and along the ridge on the west side of the lake.

Once again the unofficial wind reports from the marine bulletins are very useful indicators of surface wind conditions. See especially Grief Point near Powell River, Sisters Island off the southwest tip of Texada Island, Ballenas Island near Qualicum Beach, and Merry Island just offshore from Sechelt.

Inner Straits from Powell River/Comox – Queen Charlotte Sound



Map 4-8 - Inner Straits from Powell River/Comox – Queen Charlotte Sound

As with areas further south, weather in this region tends to be relatively dry as Pacific weather systems are dried as they pass over Vancouver Island. The airport at Campbell River reports considerably more fog than occurs over the Strait, especially during autumn months. The Comox Airport, right along the water, is not affected as much by this fog. Note, however, that if the conditions in the Strait near both Comox and Campbell River involve ceilings or even significant quantities of scattered cloud at 400 feet or below, Campbell River, because of its elevation will usually be in fog. The prevailing southeasterly winds in the winter tend to force low cloud onto the east coast of Vancouver Island, often leaving the mainland half of the Strait less congested.

Bute Inlet is very susceptible to strong outflow with strong vertical eddies over the water. Evidence can sometimes be seen in a "catspaw" area with whitecaps. A very turbulent spot, both on the water and in the air, is Seymour Narrows in Discovery Passage.

In summer, other than the occasional weak frontal system, the main problem is fog, which tends to sit along the coastal areas and over the straits. This situation is very common when there is an area of high-pressure building to the west of the island. The fog and stratus become widespread overnight and generally wrap around the north end of the island, and extend both northwards along the Central Coast and southwards to Malcolm Island, or even as far as Chatham Point. Heating from the sun will dissipate the fog and stratus off the land by late morning; however, fog banks will persist over Queen Charlotte Strait throughout the day and begin to expand once the sun sets. In general, during July and August, conditions tend to be poor in the morning, good in the afternoon and often decrease rapidly after sunset.

The sea breeze activity is pronounced in this area during the summer. Winds over the straits and at Port Hardy will be light in the morning and strengthen to northwesterly 15 to 25 knots in the afternoon. Alert Bay airport has an abrupt drop-off near the northwest end of the runway that induces a downflow in strong southeasterly winds.

Winter storms tend to induce strong southeasterly winds in the straits reaching typical values of 25 to 45 knots in Johnstone Strait and 35 to 50 knots in Queen Charlotte Strait. In such cases, moderate to severe mechanical turbulence is common. Local pilots report that, in a strong east-southeast flow, severe turbulence is common near Actaeon Sound (about 20 miles northeast of Port Hardy), in Sargeant's Pass near Minstrel Island and in Surge Narrows (near Campbell River).

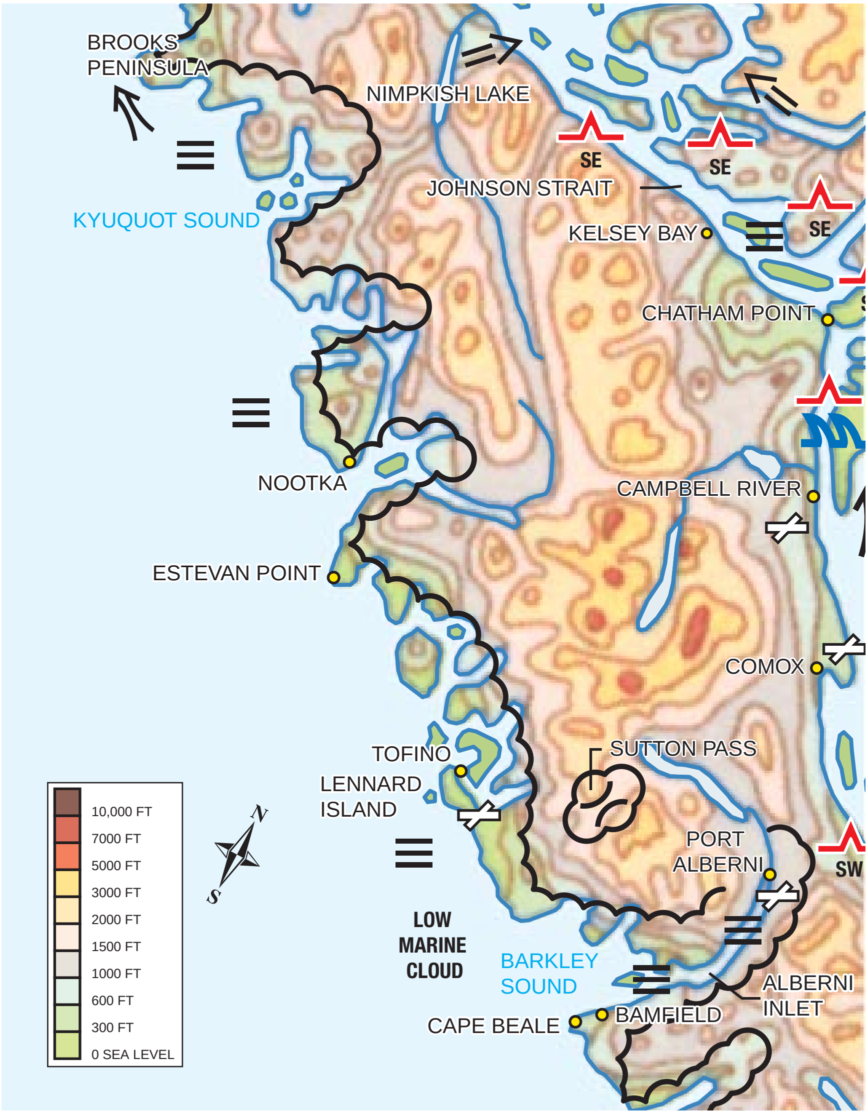
When the upper flow is strong southwesterly (around 50 knots or greater) there is a tendency for strong channelled winds to come out of Telegraph Bay (near Malcolm Island). Also in such conditions strong rotor activity develops in Blind Channel (between Kelsey Bay and Chatham Point) resulting in swirling winds, sheets of water lifting from the surface and even waterspouts.

There is a typical weather regime change at Kelsey Bay with cloud and rain becoming more common further north as wind patterns change. One area with consistently poor weather is along Johnstone and Queen Charlotte Strait, with the area between Chatham and Alert Bay receiving special mention for low hanging cloud.

The ceiling report at Port Hardy is often representative of surrounding land areas, as long as the differing terrain height is considered. If the ceiling is 500 feet at Port Hardy, terrain to the west is most likely obscured. In autumn and winter months, the northern end of the island is often battered by extreme winds reaching 80 knots or more. In such a case, turbulence is often extremely violent in the vicinity of the Brooks Peninsula and near Sartine Island in the Scott Islands Group.

Wind speeds over the water are available from the Marine Bulletins. Near Campbell River see Mudge Island (more indicative of winds at the water aerodrome at Campbell Spit). At the south end of Johnstone Straits, see Chatham Point, at the north end, Helmcken Island. From south to north the winds in Queen Charlotte Sound are found at Pulteney Point, Scarlett Point and Herbert Island. North of Port Hardy are Pine Island and Egg Island.

West Vancouver Island Including Routes to Port Alberni and Tofino



Map 4-9 - West Vancouver Island including routes to Port Alberni and Tofino

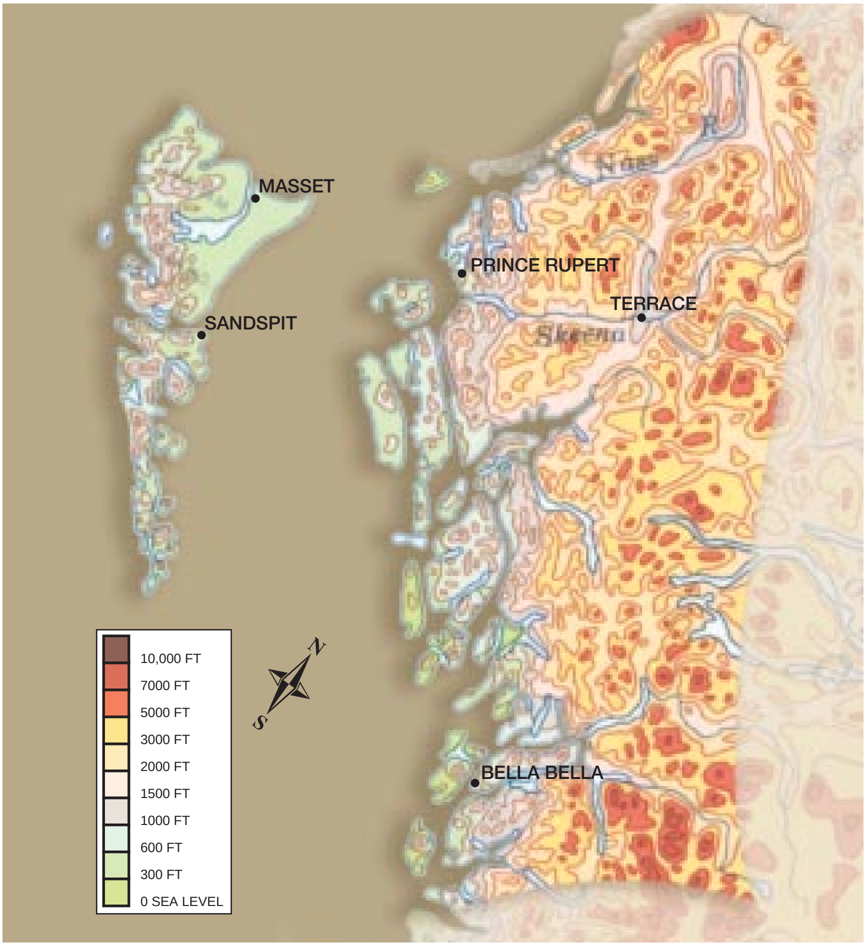
There are a few common routes across southern Vancouver Island. One follows the Cowichan Valley from Duncan west past Cowichan Lake to a pass at Nitinat Lake and thence to the coast. If the ceilings permit it is possible to go north over the mountains from Cowichan Lake directly to Port Alberni, but this route is more commonly used to reach the west coast and points north. Most traffic to Port Alberni takes the route west from the Parksville/Qualicum area. This climbs over a pass to Port Alberni

The route from Parksville to Port Alberni may appear clear until just prior to reaching Port Alberni. Mechanical turbulence is common at the junction of Cowichan Lake Valley and Nitinat Lake Valley, as well as shears occurring at the east end of Cowichan Lake during afternoon, when westerly flow along the valley meets onshore sea breezes. The valley is tight from the southwest end of Cowichan Lake to Port Alberni with low cloud persisting sometimes at the bend in the road, on the west side of the knoll. If flying from Alberni down Sprout Lake, light to moderate turbulence is common near Kennedy River. In a westerly flow, turbulence is frequent over the ridge near Cameron Lake, as well as the area between Horne and Cameron Lakes. In the winter, conditions in Sutton Pass can get very low, especially where the road sits up on the side of the pass. During the winter, snow along the road at the top of the pass is not uncommon.

Some of the worst weather in British Columbia occurs along the west coast and western slopes of Vancouver Island. Strong winds, low cloud, heavy precipitation and fog banks combine to make this a treacherous route year round. Tofino is a favourite place to visit but low cloud and fog frequently sit off the coast and are quick to move over the airport. Local pilots say it is essential to have sufficient fuel to return to an alternate when trying to fly into the area. The observing site at Tofino Airport does not provide an unobstructed view to the sea and, thus, sea fog may not be seen. Lighthouse reports at Amphitrite Point, Estevan Point and Lennard Island are extremely important, especially for float plane activity. If any low cloud is reported at coastal airports, the west coast of the island is likely closed to visual traffic. From the south to north, marine reports on the west coast include Sheringham Point, Carmanah, Pachena Point, Cape Beale, Amphitrite Point, Lennard Island and Estevan Point.

Near Gold River and Tahsis, inflow winds can make water very rough at the seaplane dock. There are also strong river currents near the dock at Gold River. See the marine report at Nootka for an indication of winds in Nootka Sound west of Gold River.

North Coast



Map 4-10 - North Coast

The predominate circulation over the North Coast is from the west. As in the south, the coastal area is fully exposed to every weather system approaching off the Pacific Ocean, and once again the terrain rises abruptly from the water's edge ensuring each system immediately undergoes strong upslope lift. If one observation could be made, it would be that seasonally the North Coast weather tends to be more prolonged and nastier than the southern section. Most of this can be attributed to the fact that the northern storm track tends to lie over this area for much of the year and the fact that there is no sheltering bulk of Vancouver Island to weaken the incoming storms. VFR flight is possible in this area any time of the year, but the combination of rapidly changing weather and a lack of alternate airports can ensnare the unwary.

(a) Summer

During the summer months, fronts tend to approach the coast from the northwest across the Gulf of Alaska. Over the coastal areas, a band of cloud and light rain usually accompanies the front. Winds will tend to increase along the coast just ahead of the front and can be expected to reach values of 30 to 40 knots over some exposed locations around the Queen Charlotte Islands.

Behind the front, pressure rises are fairly strong as the following ridge of high pressure builds towards the coast. This produces strong northwest winds following the frontal passage. The strongest northwesterly winds are often reported along the west coast of the Queen Charlottes.

Although not frequent, thunderstorms do occur over the inland sections of the North Coast in the summer. Air mass thunderstorms are the most common, tend to develop during the late afternoon or evening, and drift eastward along the sides of inlets or valleys. On rarer occasions, frontal thunderstorms will move into the coastal areas.

Sea fog and marine stratus are prevalent over the offshore waters just to the west of the Queen Charlottes and is easily advected into the coastal areas. Once there it will tend to dissipate or thin during the day but then be quick to reform again once darkness falls. This pattern will continue until some kind of pressure system moves drier air into the region.

(b) Winter

Along the coast, approaching frontal systems provide for dramatic weather. Ahead of the warm front, extensive, deep-layered cloud will give steady heavy precipitation and strong southeast winds across the area. With the passage of the warm front, the precipitation becomes intermittent, the lowest cloud layers break up somewhat but the higher cloud layers will persist. At the same time, strong southerly winds usually persist. Frequent showers of rain and ice pellets mark the arrival of the trailing cold front, which can be both widespread and heavy in intensity. Strong west to northwest winds usually prevail, especially around the Queen Charlottes and Dixon Entrance. With the most active fronts, warm or cold, the winds can briefly rise to 60 knots with gusts above 80 knots at locations around the Queen Charlotte Islands.

Air mass thunderstorms occur most often during the winter in the very cold air that follows the passage of a cold front. They often move across the area as squall lines about 12 to 24 hours after the frontal passage.

The only breaks in winter are when ridges of high pressure move across the area, and these tend to be of short duration. As the ridge approaches, the skies tend to clear leaving areas of scattered to broken convective clouds. Usually there has to be a trough to get thunderstorms.

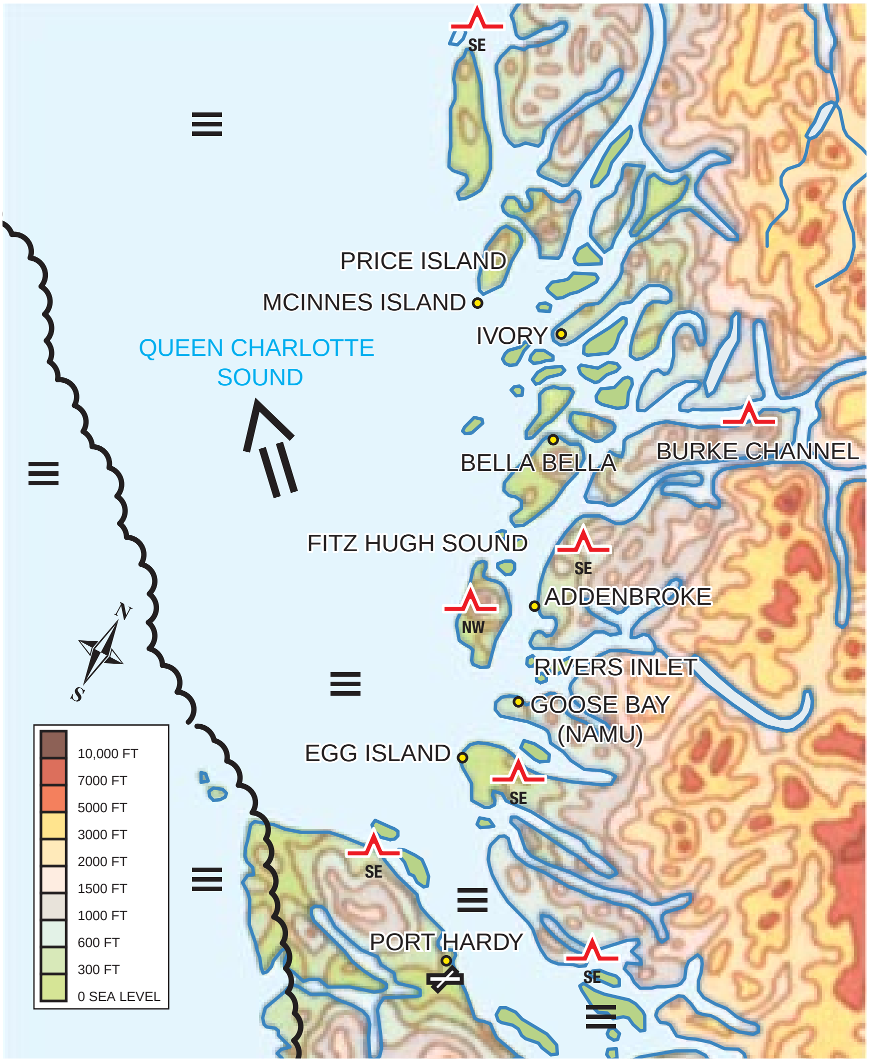
If the cold air deepens sufficiently over the interior of British Columbia, it can flow through the coastal mountains, down the coastal inlets, and cascade out over the coastal waters far enough to cover the Queen Charlotte Islands. This outflow condition can persist for days without respite. The strong winds funnel down the mainland inlets often reaching speeds up to 60 knots and occasionally rising as high as 100 knots. Side tributaries from the main inlets also have strong winds and, where a major side valley joins the main inlet, chaotic conditions are found. When the strong winds flow out from the mouths of the inlets, they continue for some distance but gradually weaken as the flow is no longer confined. Extreme caution is advised when crossing coastal inlets during an outflow situation as the winds can increase very abruptly in a narrow band near the mouth of the inlet.

Outflow conditions bring some of the best flying conditions along the North Coast during the winter. After the initial surge of cold air, accompanied by a band of cloud and flurries, the skies will clear and remain so throughout the period of outflow winds. Offshore, the cold dry air flowing over bodies of water, such as Hecate Strait, will become unstable and pick up enough moisture to give the potential of heavy snowshowers along the east side of the Queen Charlotte Islands.

The end of an arctic outbreak occurs when the cold air is forced back inland by the arrival of warmer air being driven ahead of a storm approaching from the Pacific Ocean. The precipitation with the system frequently starts as snow but changes to either rain, or rain and snow mixed, over the Queen Charlottes and along the coast as temperatures moderate. In the inlets; however, the cold outflow winds will gradually ease as the southeast winds strengthen along the coast. Often rain will be reported at the mouths of the inlets while snow continues further up in the inlet. Freezing rain can also occur in the inlets until the cold air is fully scoured out by the approaching warmer air.

(c) Local Effects

Northern Vancouver Island to McInnes Island



Map 4-11 - Northern Vancouver Island to McInnes Island

The scenery along the Central Coast is considered to be some of the most beautiful in British Columbia. Like the Port Hardy area, the weather in this region varies strongly between summer and winter, and the combination of widely scattered airports, lack of information and the speed at which the weather can change makes this a treacherous place to fly. All pilots who regularly fly this area make the same suggestions - wait for the breaks in the weather, carry lots of fuel and have a viable plan on where to go if the weather closes in.

In summer, the main pattern is the persistence of low cloud and fog banks all along the coast from Prince Rupert to Port Hardy. These fog banks will move offshore with daytime heating but are capable of moving back in abruptly and without warning. Usually the fog will only close the mouths of the inlets, but in the extreme cases the entire inlet will fill up.

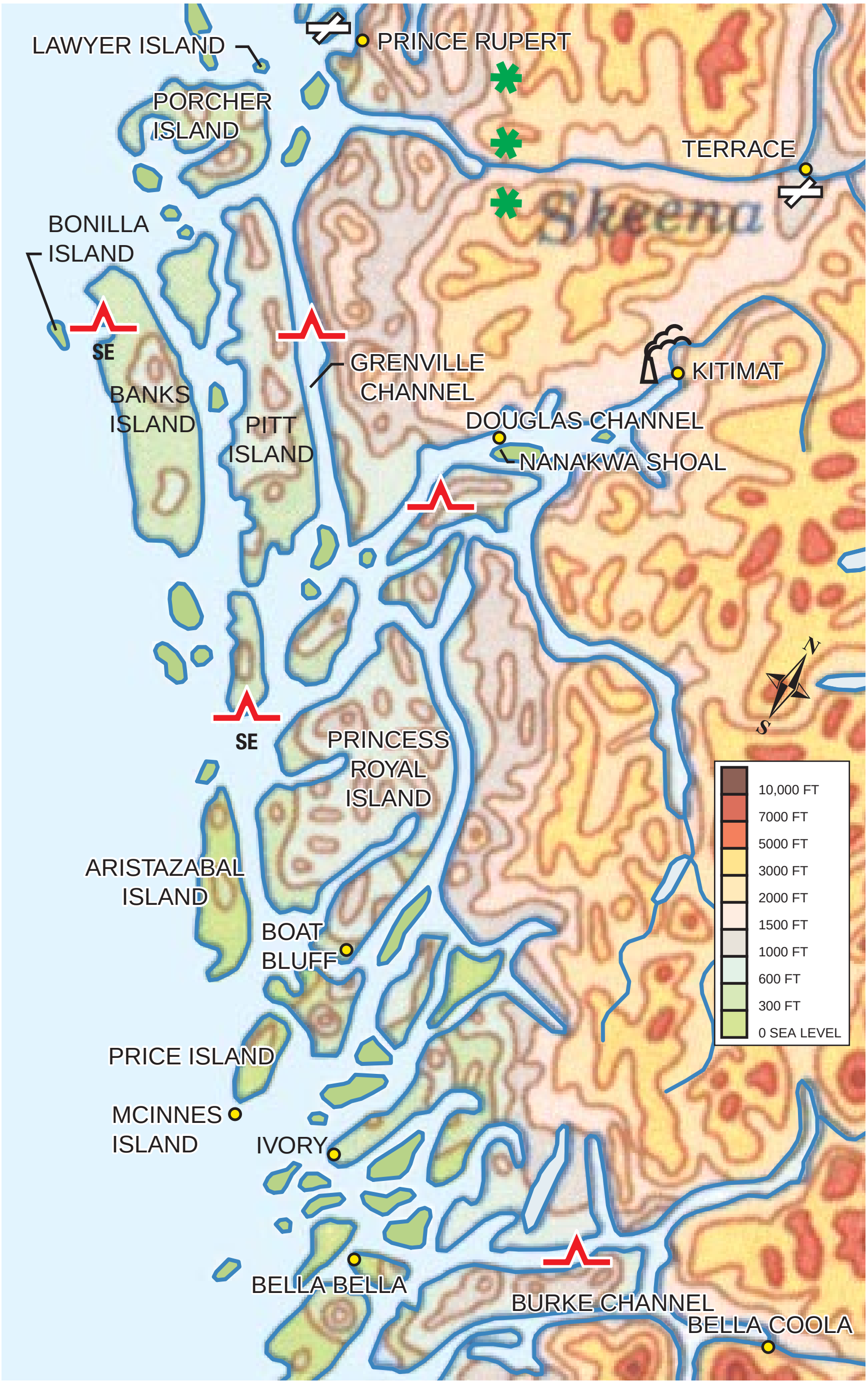
A strengthening afternoon inflow is common in the channels so that by late afternoon the winds are frequently strong and the water too rough to allow floatplanes to land at the head of inlets.

A couple of places have made a name for themselves. Local pilots suggest you stay at least 5 miles clear of the Goose Bay area (Namu) and the big hill on the south side of the mouth to Rivers Inlet when strong southeast winds are blowing (for an indicator of wind strength check the report for Addenbroke). Lee waves are present over top of Rivers Inlet and flight near 500 feet will be extremely rough in windy conditions.

Very strong outflow conditions are common when pressures build over the interior and values in excess of 50 knots are not uncommon near Cathedral Point, in the Burke Channel. These winds are the best indicator of inflow/outflow conditions on the central coast and are worth monitoring on a regular basis. Outflow of cold air will also occur ahead of approaching systems, and in the winter this creates the potential for freezing rain.

The weather report from Bella Coola cannot be used as representing Bella Bella. Bella Coola lies about 70 miles east at the end of an inlet, which penetrates deep into the Coastal Range. Bella Bella, the more exposed marine site, reports much more low cloud and fog. The marine reports from Dryad Point and Ivory Island are more indicative of conditions near Bella Bella. Westerly winds tend to produce severe turbulence over portions of Rivers Inlet, due to the steep bluffs on the west side of the inlet. Sea fog is very common over Queen Charlotte Sound. The lighthouse report from Egg Island is very representative for conditions along the mainland coast. For Rivers Inlet see the report from Addenbroke at the south end of Fitz Hugh Sound. There is also a report from McInnes Island further north.

Bella Bella to Prince Rupert



Map 4-12 - Bella Bella to Prince Rupert

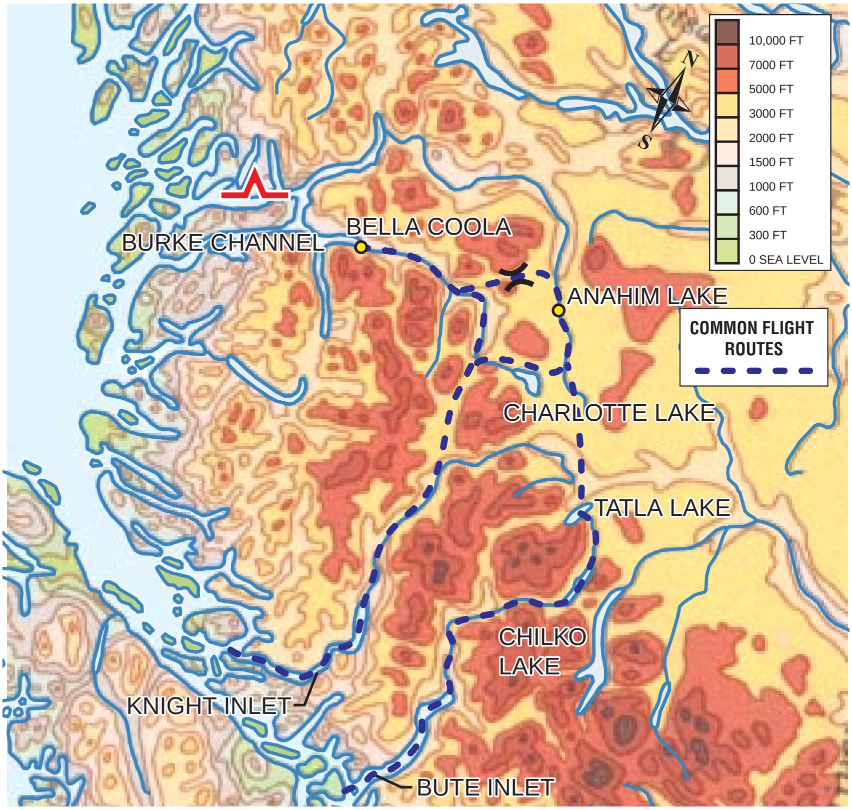
As with most other regions of the coast, weather hazards differ from summer to winter. In winter, Pacific low pressure systems can produce very strong winds, often exceeding 50 knots. When winds exceed 25 knots, moderate or greater turbulence can be expected around virtually all terrain. Channelling and funnelling can produce extreme winds in most inlets. The severity of these winds should not be underestimated. Every winter on the north coast there are occasionally winds extreme enough to induce swirls that can lift water frrom the surface. Note, however, that even when winds reach 35 knots or more in Chatham Sound (see Lucy Island), Seal Cove can be relatively calm.

When the strong southeasterly or southerly winds are blowing, experienced pilots flying between Prince Rupert and the central coast will avoid the inside routes such as Grenville Channel, and take the longer route outside the islands to avoid the heavy turbulence induced by the narrows and terrain. The strong northeasterly outflow winds, common in the winter months, also cause significant turbulence near similar terrain features. The Portland Inlet, just north of Prince Rupert, the mouth of the Skeena River and the Douglas Channel further south between Kitimat and the coast, are particularly affected by outflow winds, often causing turbulence prohibitive of all small aircraft flight. In the summer strong northwesterly winds can cause moderate to severe turbulence and rough sea conditions near Port Simpson just south of the mouth of the Portland Inlet. For indicators of the above conditions see the winds at Grey Island for the mouth of Portland Inlet and Port Simpson, and at Holland Rock for the mouth of the Skeena River. The Nanakwa Shoal winds in the buoy report are indicative of the winds in the Douglas Channel.

Winter systems also bring a lot of precipitation to the north coast. Low ceilings and poor visibilities are a fact of life for much of the winter. Low cloud tends to bunch up against Hayes Mountain and lie over the city of Prince Rupert and the airport on Digby Island. Seal Cove, however, is often less affected and will enjoy somewhat higher ceilings and visibility. Marine weather reports are available for Green Island and Triple Island off shore Prince Rupert in Chatham Sound and for Bonilla Island further south in Hecate Strait.

In summer, two factors dominate local weather: sea fog and afternoon inflow sea breezes. The inflow can reach 40 knots in some inlets. Fog is most prevalent in August and early September. Throughout the summer, the fog can sit over the sea, expanding right to the head of the inlets overnight and retreating during the day. Persistent fog often lies just west of Digby Island and can intermittently roll in and out over the runway or approaches. Fog is more common over Port Edward and Digby Island than over Seal Cove.

Central Coast to the Interior Plateau



Map 4-13 - Central Coast to the Interior Plateau

There are several things that can be said about these routes in general. Firstly, they go from wet coastal weather near sea level between some of the highest peaks in the Coastal Range to dry belt weather on the Interior Plateau in a relatively short distance. Secondly, they are all susceptible to inflow and outflow influences. The coastal inlets and valleys are prone to low cloud during and after precipitation. Inflow winds tend to push this cloud up the valleys toward the mountains. Outflow winds on the other hand bring drier air, but at times can be strong enough to cause significant mechanical turbulence particularly near narrows and rough terrain. Thirdly, these routes weave through a maze of rivers, valleys and passes. In poor weather conditions they lend themselves to navigational errors which are all too often fatal. Pilots who are not experienced and very familiar with their route and its terrain, should not attempt it in low or even marginal conditions. This hazard is increased for west bound flights as the weather conditions encountered from the crest of the mountains west are often considerably poorer than those experienced at the same time on the drier eastern side. Lastly, there is virtually no weather reporting sites anywhere along these routes and conditions can, and often do, change rapidly.

(a) Burke Channel to Anahim Lake

The Bella Coola Valley frequently has fog or low cloud that can persist all day during the fall and winter seasons. When present, this low cloud tends to persist all the way from Bella Coola to the crest of the Coast Mountains. There is a highway along this route, but it is not recommended due to its higher elevation. The preferred route is to follow the Hotnarko and Atnarko River inland due to their lower elevations.

In the winter, high pressure will often dominate over the interior giving outflow conditions. This can produce significant downslope winds and turbulence over eastern sections of the Bella Coola Valley.

(b) Bute Inlet to Chilko Lake/Tatla Lake

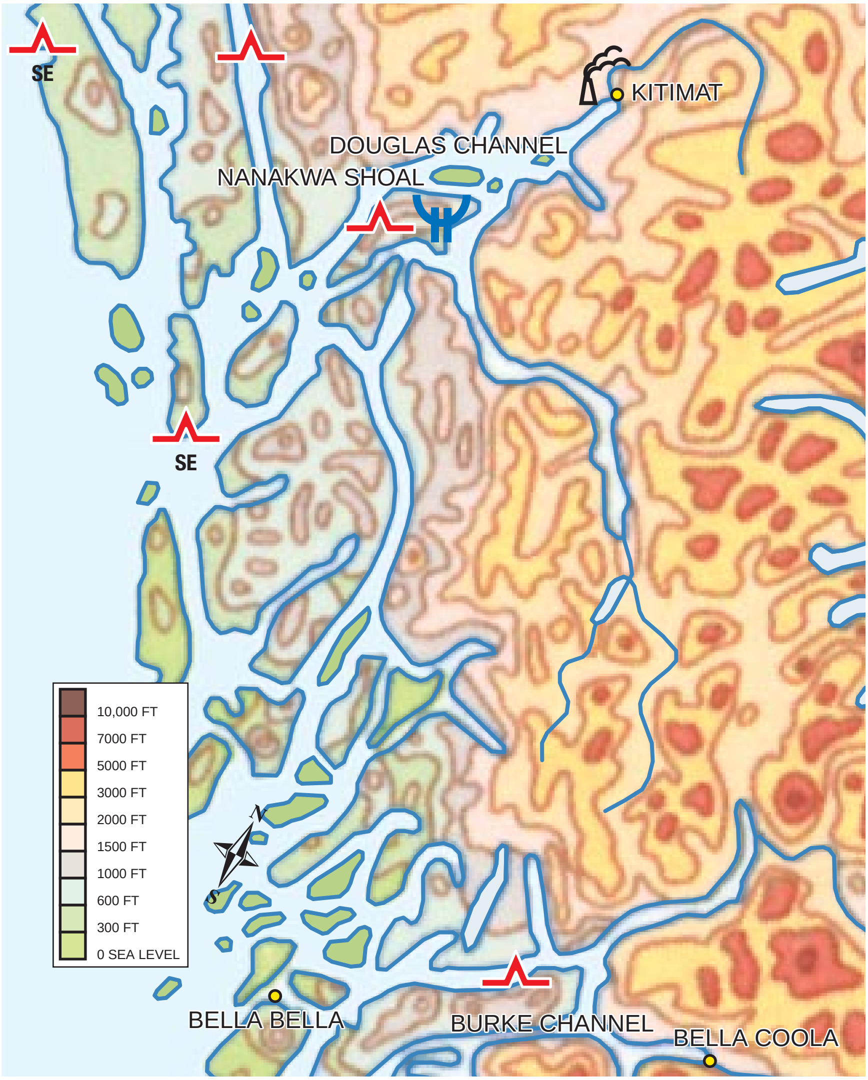
This route follows the Homathko River through the mountains from Bute Inlet. It is a common route for pilots flying to and from the south coast. Again, low cloud at the southwest end of the route and mechanical turbulence in strong outflow winds, are the most common problems.

(c) Knight Inlet To Nimpo Lake/Anahim Lake

This route follows the Klinaklin River from the Knight Inlet to the interior. The same problems with low cloud and outflow turbulence found on the other routes also pertain here. However the terrain along this route involves higher passes than the other routes, and thus this route requires even fairer weather to be flyable.

Coastal lighthouse station reports are available and are especially useful for conditions near the mouths of the inlets. The automatic weather station at Cathedral Point in the Burke Channel is the best indicator of inflow/outflow winds along the central coast.

Bella Bella to Kitimat (Douglas Channel)

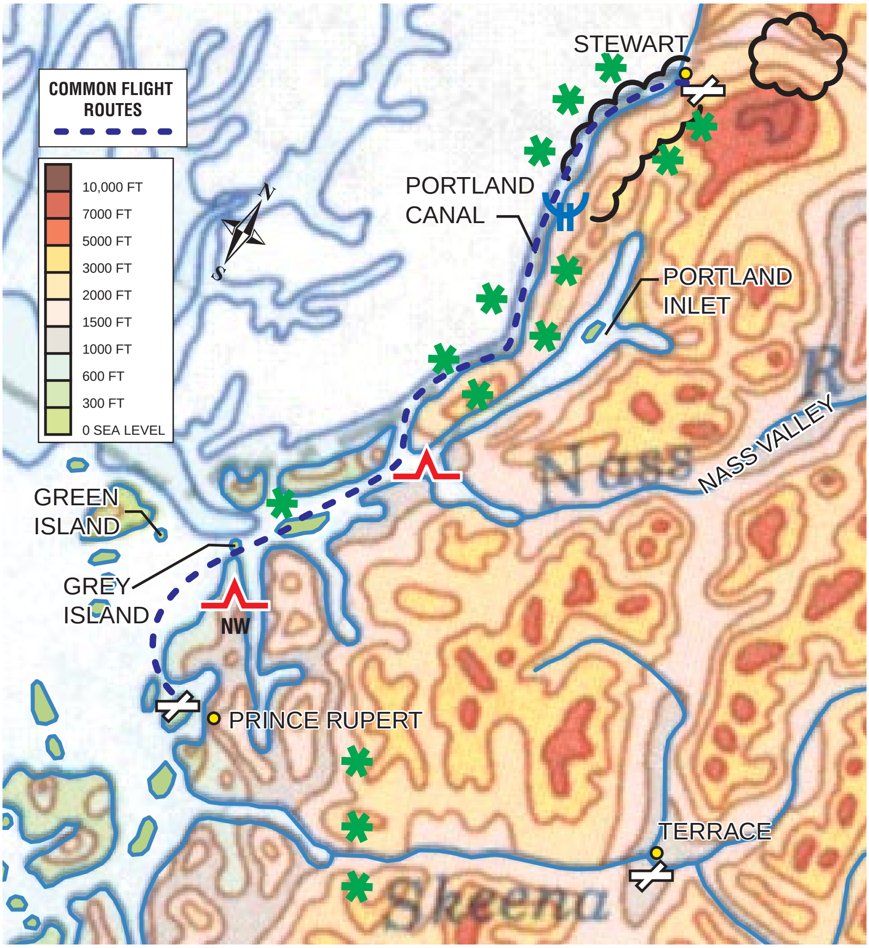


Map 4-14 - Bella Bella to Kitimat (Douglas Channel)

When active storms are moving northward along the Central Coast, there may be rotor turbulence on the east side of the valley, due to the higher southeasterly storm winds interacting with the generally north to south terrain. This turbulence is often severe if a strong southerly inflow is blowing. (For an indicator of inflow/outflow winds see the report from the buoy at Nanakwa Shoal. The worst turbulence is usually found from mid-mountain to peak levels within one or two miles of the slopes. Flight conditions will generally be smoother and safer along the west side of the passage.

This channel is extremely susceptible to freezing rain as the warm air ahead of approaching frontal systems overruns the cold air in the valley bottoms.

Prince Rupert to Stewart

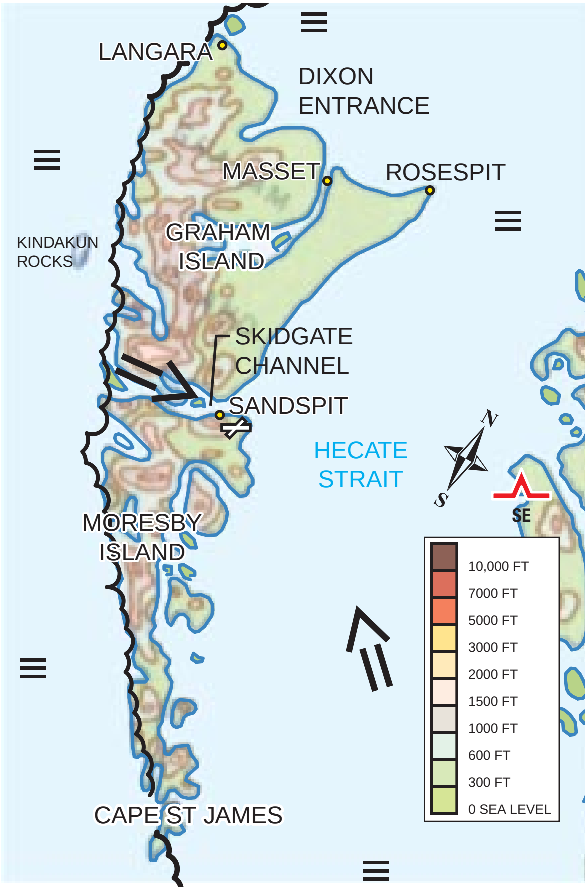


Map 4-15 - Prince Rupert to Stewart

The Portland Canal opens to the northwest just north of Prince Rupert. It runs northwest and then turns north into the Coastal Range to Stewart. The canal cuts through a steady upslope regime from low hills and islands at the coast to peaks either side of the narrow canal in the north ranging from 5 to 7 thousand feet. It is extremely susceptible to heavy snowfall ahead of an approaching frontal system, followed by freezing rain as the warm air overruns the cold air in the valley bottoms.

Significant turbulence is observed with northwesterly winds to the north of Seal Cove. The channel at Kincolith experiences severe turbulence in inflow and outflow patterns. The Portland Canal to Stewart is also often very rough, especially in winter outflows. Above the highest terrain height, this mechanical turbulence is reduced. For indicators of these conditions see the winds at Grey Island at the mouth of Portland Inlet.

Queen Charlotte Islands



Map 4-16 - Queen Charlotte Islands

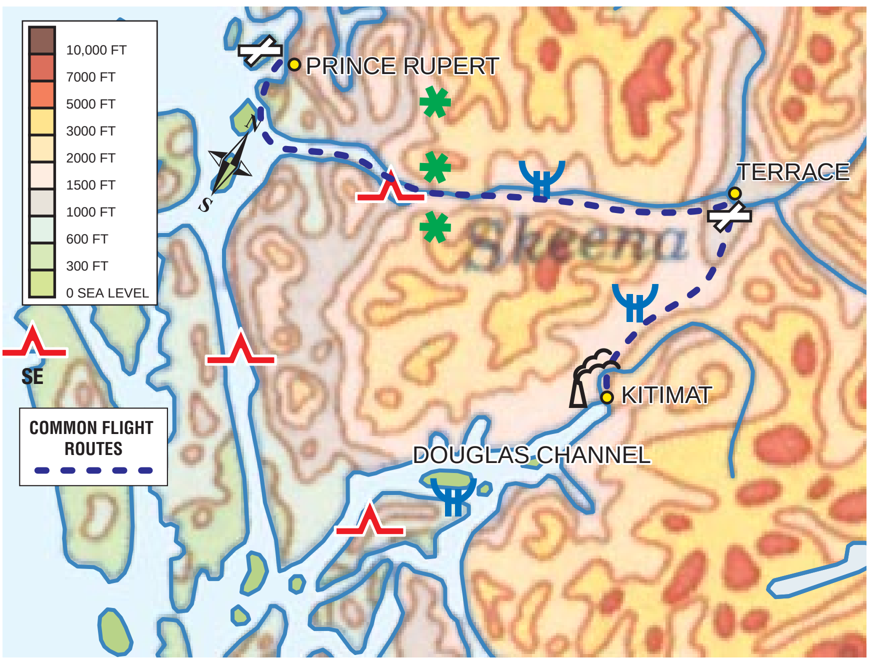
Though a group of many islands, Graham Island in the north and Moresby Island in the south make up most of the landmass of the Queen Charlotte Islands. A narrow channel of water, the Skidegate Channel, separates the two main islands. The two main airports are Sandspit at the northeast corner of Moresby Island and Masset on the north coast of Graham Island.

The Queen Charlotte Islands exhibit many of the weather phenomena common to the rest of the North Coast. Winter brings a seemingly endless procession of fronts off the Pacific accompanied by severe winds, abundant precipitation, low cloud and limited visibilities. Hurricane force winds are a frequent feature of winter storms. In summer the breaks between the systems are longer and sunnier.

Moderate turbulence is often reported to the lee of Tow Hill, east of Masset, during northwesterly or southeasterly winds exceeding 25 knots. Thunderstorms (summer and winter) tend to move through Skidegate Channel on a regular basis, reducing visibility from unlimited to near zero (rain or snow) in a matter of a few minutes.

The only METAR on the islands is at Sandspit. Langara Island and Rose Spit give winds for the northwest and northeast corners of Graham Island respectively. The best indicator of conditions in Masset is a limited marine weather report from Langara in the marine bulletins. Kindakun Rocks gives winds on the exposed west coast as does Cape St. James on the south tip of Moresby Island.

Prince Rupert to Terrace/Kitimat



Map 4-17 - Prince Rupert to Terrace/Kitimat

This route follows the Skeena River. With a fall of less than 200 feet, the Skeena River west of Terrace widens considerably with mountains along either side of the river rising from 5 to 7 thousand feet. It can be very rough behind the mountain shoulders along the Skeena River with Telegraph Point renowned for its severe turbulence. Staying over the river can generally reduce the turbulence. When frontal systems ride in from the Pacific, low cloud will persist in this area until well after the front has passed. As with coastal inlets and valleys in general the inflow conditions which often arise after frontal passage cause low cloud to build up at narrows or where there are bends. The region near Salvus can receive extremely heavy precipitation, due to both convergence at the narrows and lift from the upslope terrain.

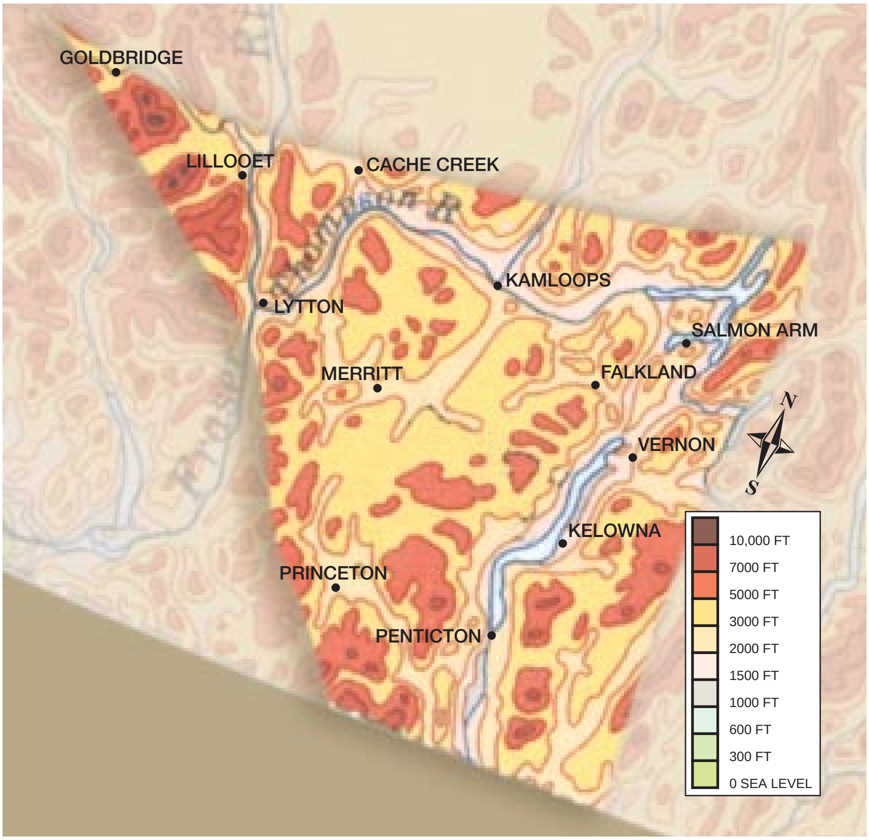
With extensive swampy land and other water sources, the valley near Terrace is very susceptible to fog and low cloud. The airport at Terrace is particularly prone to low cloud and fog due to its elevation, approximately 500 feet above the town and the valley floor. To the south of Terrace, the mills and smelter at Kitimat can reduce visibility and ceilings, particularly along the west side of the valley.

The Douglas Channel south of Kitimat as well as the valleys south and west of Terrace are extremely susceptible to freezing rain as the warm air ahead of approaching frontal systems overruns the cold air in the valley bottoms. The strength of the inflow/outflow winds can be monitored by checking the report from the buoy at Nanakwa Shoal.

Routes Inland from Terrace

For information on these routes please see the Central and Northern Interior Section.

Thompson - Okanagan



Map 4-18 - Southwest Interior

The Southwest Interior, better known as the Thompson-Okanagan, is essentially a mountainous area bounded by the Fraser River, on the west, and the Monashee Mountains, on the east. Most of the population and airports are located in river valleys that have a strong north to south orientation. Only Kamloops, on the northern edge of the area, lies in an east to west valley.

This area has essentially two seasons – summer and winter, with a very short spring and fall to mark the transition from one to the other. The climate of this area is strongly influenced by the Coast Mountains. When the flow aloft is southwesterly, it is common to see Pacific frontal systems produce little or no precipitation over this area. Only when the upper flow turns to the south does significant precipitation penetrate these valleys. The annual precipitation is almost equally split among the months – weather systems providing the precipitation in the winter and convection in the summer.

(a) Summer

Summers in the Southwest Interior tend to be sunny and hot as the Pacific Ridge pushes the main storm track north of the area. Those fronts that do try to move inland are significantly weakened by subsidence to the lee of the Coast Mountains. The cloud cover will develop noticeable breaks and precipitation, if any, will be light. In crossing the Coast Mountains, these fronts often lose their definition or disappear completely.

For the most part the summer is dry and hot with afternoon temperatures reaching into the mid-to-upper 30 degree Celsius range. Under such conditions, deep convection occurs almost every day but, on many occasions, there is insufficient moisture available to support anything but cumulus clouds. Despite this, convective turbulence and even the occasional dust devil can provide for a turbulent ride. At this time of the year, the upper winds are usually light so that non-convective turbulence is at a minimum.

One major exception to this pattern is the movement of a cold low over or near the area. These lows tend to produce broad areas of cool, cloudy weather with frequent shower and isolated thundershowers. While the precipitation is usually light, areas of upslope flow will see larger amounts.

The most active thunderstorms tend to occur when some sort of front of upper trough moves across the interior, producing a band of afternoon or evening thundershowers. These thunderstorms often persist well into the night. Over most regions, the predominant types are air mass and nocturnal thunderstorms and, when they do occur, they generally move along the valleys. The mountainous terrain hinders the full development of thunderstorms so that severe weather is uncommon. When it does, it usually consists of severe lightning, large hail and downburst winds. While thunderstorms can occur at anytime during the summer, the main period is from June to August.

(b) Winter

Winters in the Southwest Interior tend to be a long drawn out cloudy affair because of the frequent frontal systems that move in off the Pacific and the presence of cloud trapped in the valleys. As a front moves inland, it will weaken due to subsidence; however, usually sufficient moisture will persist to give some precipitation. In the case of snow, accumulations are usually light in comparison to the coast. One major concern for meteorologists is the location of the snow level, that is, the level where falling snow changes into rain. It is worth noting here that the snow level is usually found 500 to 1,000 feet below the freezing level. It is not uncommon, especially during late fall and early spring, to have rain falling in the valley bottoms with snow falling just a few hundred feet above the valley bottoms. Fortunately, freezing precipitation is rare; however, icing in this cloud can be significant.

Areas of high pressure, unless accompanied by cold air, tend have a reduced impact because of the widespread valley cloud. Cold air stagnating in the bottom of valleys causes a strong low level inversion to form, which traps any moisture from local sources. This moisture eventually forms cloud, which, despite being only a few thousand feet thick, fills the entire valley and can persist for weeks. Depending on the height of the inversion, the base of the valley cloud may lower enough to bring the airports below alternate or landing limits for prolonged periods of time. This cloud will produce some precipitation, but only light snow, in areas where the moisture supply has been increased. Valley cloud will only move if strong winds develop in the valley, or it will dissipate if the major moisture sources freeze over. Since the larger lakes in the Southern Interior of British Columbia freeze over completely only in the coldest winters, most southern valleys remain susceptible to the development of valley cloud from November to mid-February.

Valley cloud can offer a significant icing threat. With temperatures that are relatively warm, they contain a significant percentage of supercooled water droplets resulting in SLD icing. In addition, these larger droplets have been known to settle out of the cloud, producing freezing drizzle just below the cloud base.

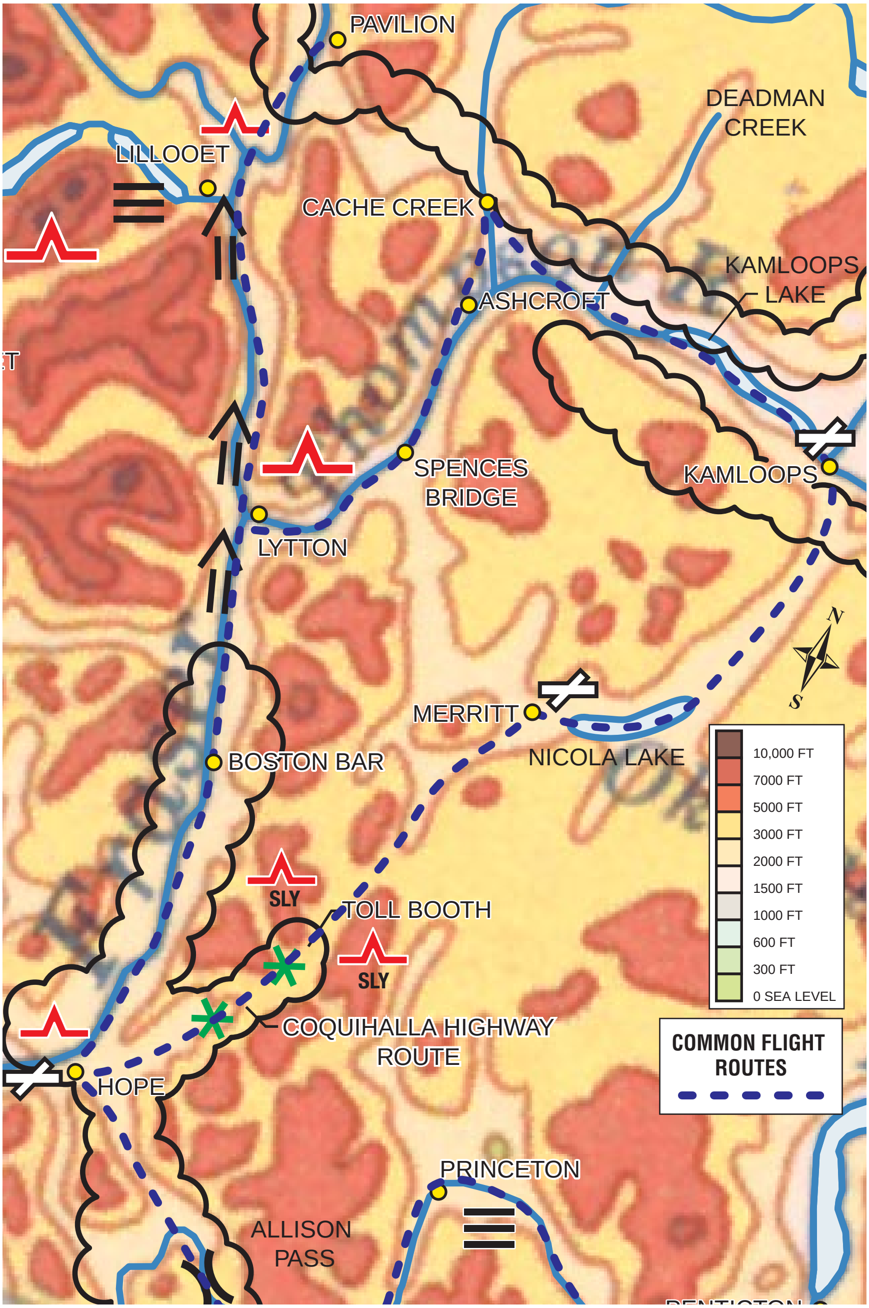
During winter, a strong area of high pressure forms in the very cold air over Alaska, the Yukon and the northern end of the Mackenzie River valley. This cold arctic air moves southeastward into the Prairies but can also spread over northern and central British Columbia. Most often, the Arctic air pushes southward into the Central Interior before coming to rest. At the same time, Arctic air also flows through the mountain passes from Alberta and fills the Rocky Mountain Trench. Depending on the strength of the arctic front, winds can shift abruptly into the northwest with the passage of the front and be gusty for several hours. At least once or twice each year, the advance of Arctic air is so strong in British Columbia that it spreads into the Southwest Interior.

Arctic air over the interior offers little problems other than the temperature. Most of the valley cloud dissipates, giving clear cold days and nights. Over the bodies of water that have remained unfrozen, such as Okanagan Lake, sea smoke will form over the water and lift to form cumulus clouds. These clouds, if there is a significant difference between the air temperature and the water temperature, will be turbulent, contain icing and produce local heavy snow showers. Other than this, good flying conditions will prevail except for some localized problems with stratus.

The upper flow during the winter months is usually a strong southwesterly. This, combining with the local mountains, produces light to moderate, occasionally severe mechanical and lee turbulence across the area. At the same time, the combination of the upper flow and the channelled winds in the valleys will produce wind shears near the top of the valley.

(c) Local Effects

Routes Inland from the Coast



Map 4-19 - Routes Inland from the Coast

Hope – Lytton – Cache Creek

This route follows the Fraser Canyon from Hope to Lytton and then turns north-eastward up the Thompson River Valley past Spences Bridge and Ashcroft to Cache Creek. This has long been one of the primary routes from the coast to the interior of British Columbia.

If the Hope area is impassable, then the Fraser Canyon as far north as Boston Bar will also likely be impassable. During the fall and winter, the route from Lytton south is prone to patchy fog developing overnight, which is slow to dissipate the following day. The lowest conditions usually occur around Yale and improve further north.

Despite frequent reports of strong winds at Lytton, turbulence is seldom encountered south of Boston Bar. However, during times of strong southerly winds (30 knots or greater) severe turbulence should be expected near Lady Franklin Rock (across from the Yale Tunnel). North of Boston Bar, pilots have, despite wind gusts to 60 knots, noticed little turbulence. The area around the Lytton airport can be turbulent at times due to the splitting of the strong winds into the Fraser and Thompson River valleys.

The area to the north of Lytton is extremely dry. Occasional periods of low ceilings and visibility due to system weather can occur year round but, for the most part, the area offers good flying. Like the southern part of the Fraser Canyon, strong winds will occur in the summer giving localized areas of turbulence.

Hope - Princeton

This route climbs eastward from Hope over the Coastal Mountains at the Allison Pass in Manning Park. The route west of the Allison Pass is part of a very wet upslope regime, and is an area known to be slow to dry and become clear of low cloud after precipitation.

Simply put, if Hope is impassable then the Hope-Princeton west of Allison Summit is likely impassable. The Hope Slide area is particularly treacherous as the barren hillside reflects light, especially when snow-covered, causing a "brightening" in the cloud, making pilots think that conditions are improving ahead. Visibility falls rapidly along this route once steady precipitation begins. As little as ten minutes can see the route change from passable to closed.

When travelling eastbound from Hope to Princeton, experts recommend that aircraft pass Hope with sufficient altitude to safely cross Allison Pass. The low cloud tends to lie to the east of the Skagit Valley, but elsewhere it is areas of reduced visibility that remain a problem. Also, east of the Skagit River, the valley rises very steeply to the summit. This gradient exceeds the climb capability of most conventional aircraft, and the rapidly narrowing valley makes safe turning dangerous or impossible.

Hope - Kamloops via the Coquihalla

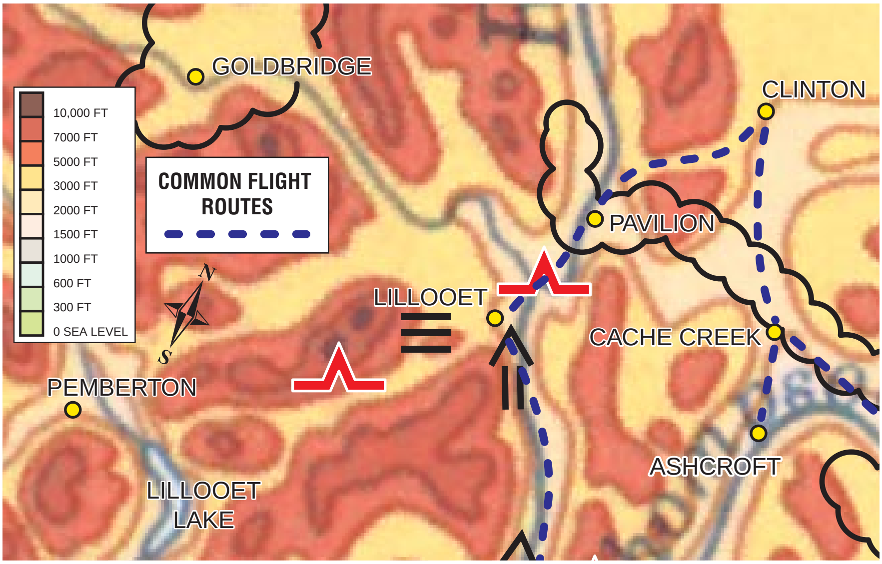
This route follows Highway 5 up the narrow Coquihalla River Valley to a pass near the Toll Booth Plaza. It carries on to the Nicola Valley at Merritt and then climbs over a highpoint at Lac La Jeune before descending into the Thompson River valley at Kamloops. The route from Hope to the Toll Booth Plaza, especially the section from Portia north, is subject to frequent low ceilings and visibility in snow during the winter. Conditions are described as being similar in characteristic to the weather around Hope, but it occurs over a longer run. Precipitation results in a very rapid lowering of ceilings and visibility. Snow showers can result in an instant lowering of the visibility to near zero.

North of the TollBooth Plaza following the highway is generally feasible, but low cloud can build up in the higher ground around Lac La Jeune. A good alternate is to use the Nicola Valley, but be aware that you can run into low cloud over the hills just to the south of Kamloops.

For pilots flying south, even when the northern highpoint is open the Coquihalla Pass and the area south may be closed. Also it is necessary to have scattered conditions or ceilings above 3,000 feet in the Fraser Valley or pilots can find themselves trapped on top.

Low level turbulence is a factor mostly in the southern section of the route from the Toll Booth to Hope where the valleys narrow and the terrain is more extreme. Lee wave turbulence can be encountered near Merritt below 14,000 feet ASL. Also when strong southerly winds aloft are occurring, expect moderate occasional severe turbulence at 6,000 to 7,000 feet near Yahk Mountain and Zopkios Ridge.

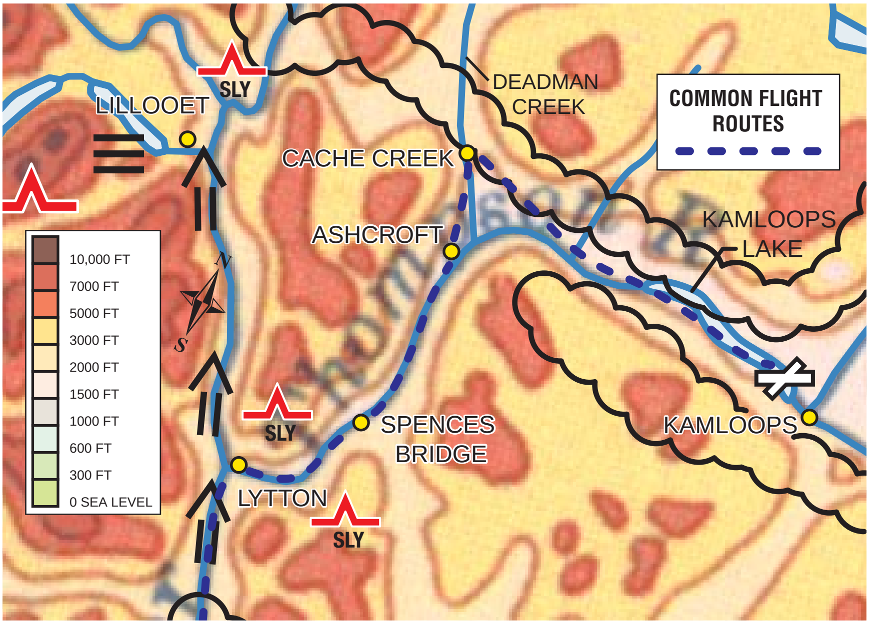
Pemberton, Highway 97 – Lillooet – Cache Creek



Map 4-20 - Pemberton, Highway 97 – Lillooet – Cache Creek

This more northerly route is a popular route to fly as it often avoids the poor conditions and strong winds occurring in the Fraser Canyon. However, low cloud is common near Pavilion. Occasionally in summer, strong thunderstorms can be encountered, and in fall fog can be a problem near the lakes.

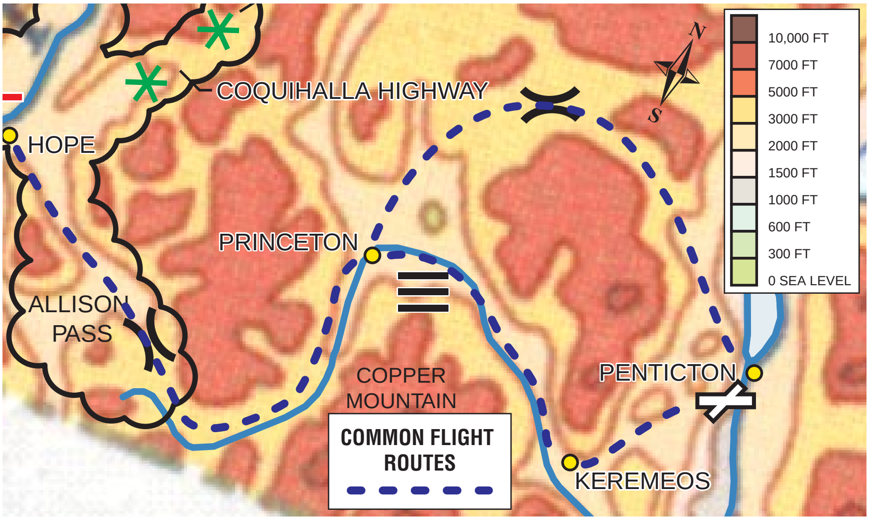
Cache Creek to Kamloops



Map 4-21 - Cache Creek to Kamloops

This route follows the Thompson River valley westward via Kamloops Lake to Cache Creek. Precipitation generally brings low cloud all along the route. Low cloud is slow to dissipate over Kamloops Lake just west of the Kamloops Airport. Kamloops wind strength and direction give an indication as to which end of the lake the cloud will be heavier. If passage is difficult, beware of the sucker hole at the west end of Kamloops Lake. Deadman Creek heads north and usually looks good, but it narrows rapidly and rises into the plateau where ceilings will be quite low. Further west tends to be drier. Remember that the Kamloops Valley, like other valleys in the region, is susceptible to valley inversion conditions.

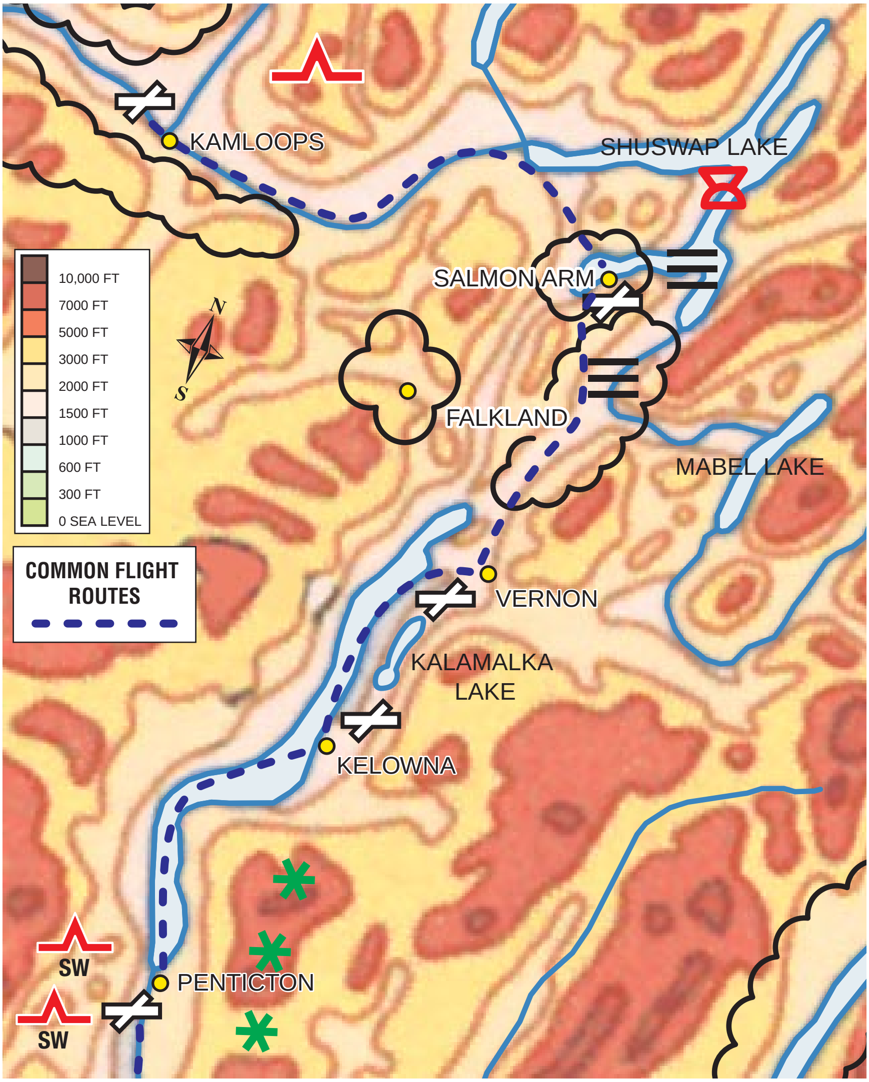
Princeton to Penticton



Map 4-22 - Princeton to Penticton

This route follows the Similkameen River Valley from Princeton to Keremeos, then turns northeast and climbs up the Ollala Valley and over the hills before dropping into the Okanagan Valley. Peaks that are from 3,000 to 4,500 feet higher than the valley floor encircle Princeton. The bowl thus created is often filled with fog during the fall and spring. Fog is not so prevalent during the winter, but low valley-type cloud is often present. The approach into Princeton is quite narrow from the south and blowing snow coming off the ridges can at times reduce visibility significantly. When the surface winds are strong the area around Keremeos is prone to mechanical turbulence at lower levels.

Okanagan Valley - Kamloops - Salmon Arm



Map 4-23 - Kamloops to Salmon Arm

The Okanagan Valley extends in a generally north-south orientation from just south of the Shuswap Lake to the very south of Washington State. It is one of the driest areas in BC with desert conditions south of Penticton. The valley tends to have steep sides with peaks along both sides from 6 to 7 thousand feet. In general, the weather is excellent except when major systems are moving through the area.

Winds and temperatures aloft have a strong effect on flying conditions in the valley. Westerly to southwesterly winds aloft is common, and when strong, cause lee wave turbulence and downdrafts on the west side of the valley. This is aggravated in the summer by a significant loss of aircraft performance when aircraft fly from the cooler air over the lake to the hotter air over the hills (density altitude). It can be very hazardous to try to turn and climb west or southwestward out of Penticton. Particularly in hot weather pilots new to the area should be warned to gain sufficient altitude southbound over the valley before turning westward enroute.

Another effect common to many BC valleys is that of temperature inversion. Often associated with ridges, warmer air aloft traps cooler air in the valley. In the Okanagan the lakes provide a moisture source and radiation cooling overnight aggravates the inversion. Low cloud forms and rises as the day warms up but is capped by the inversion causing ceilings from 1,800 to 3,000 feet. This effectively limits VFR flying to the valley itself. The longer these conditions last the longer the cloud persists each day. After a few days it can often stay overcast until mid afternoon.

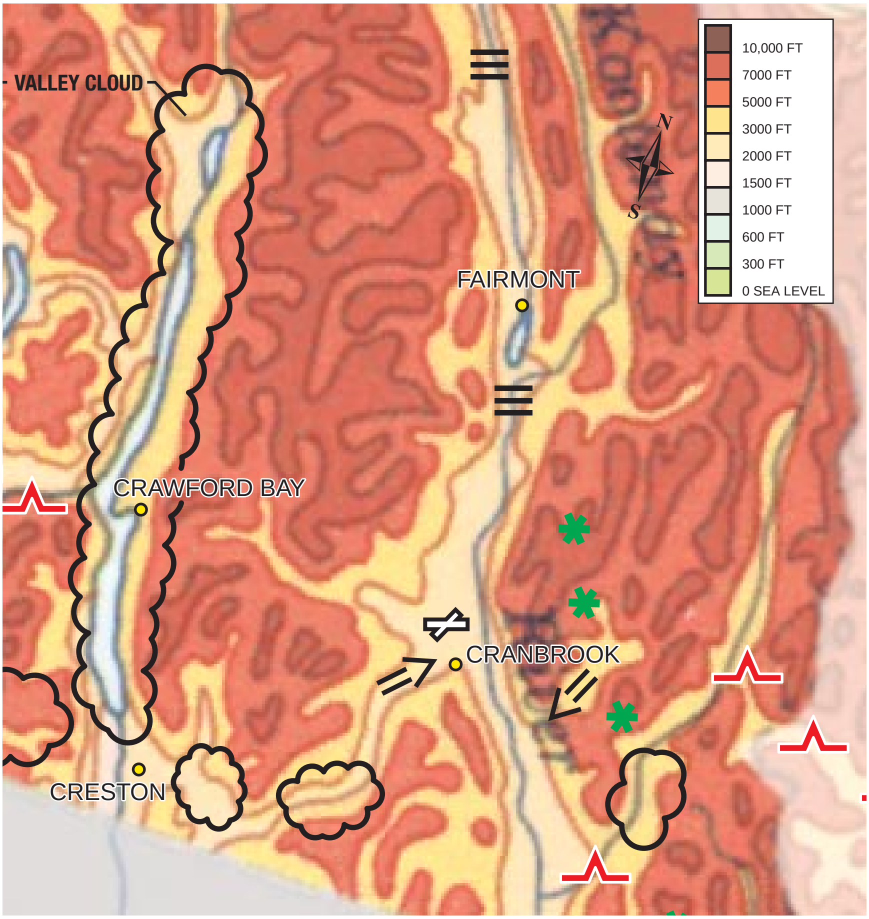
Though it is possible to fly from Kamloops into the Okanagan Valley without climbing out of the valleys, it is a much longer route to do so. It would involve following the South Thompson to Shuswap Lake and then turning south into the Okanagan Valley via Enderby and Armstrong. The more common and much shorter route involves climbing out of the South Thompson valley east of Kamloops at Monte Creek and following the highway through the valley passes of Westwold and Falkland. The area is generally dry but after precipitation low cloud will often remain in the upper valley passes longer than at Kamloops (the only local METAR). With strong winds at 3 and 6 thousand feet expect mechanical turbulence in the passes. It can also be quite turbulent at times in the wide part of the valley just east of Kamloops.

The Sushwap Lake area is a junction for pilots transitioning from the east-west routes to and from Alberta via Kamloops and Golden and the north-south Okanagan route. The base of the valley cloud that extends out of the Okanagan and across the Shuswap area is usually at the same height, except for an area around Enderby/Armstrong and southern Kalamalka Lake, where ceilings can be considerably lower. As you approach Shuswap Lake, low cloud develops as the moisture increases. This is quite common from October to mid-March. It is also worth noting that the arms of Shuswap Lake freeze over but the deep central part usually remains open.

The airport at Salmon Arm is 600 feet higher than Shuswap Lake and can make approaches difficult during times of prolonged low valley cloud.

During the summer months, thunderstorms tend to intensify near Shuswap Lake, and many feel that the lightning capital of BC is the area just east of the lake.

Kootenays and Columbias



Map 4-24 - Kootenays and Columbias

The Kootenays and Columbias consist of the eastern and southeastern sections of the southern half of the province. Being mountainous, with most of the valleys running in a north to south direction, the weather of this area is essentially a wetter, colder version of the Southwest Interior. It is wetter because of the terrain that gradually increases in height from the west until it reaches the crest of the Rockies. Any system that crosses the Coast Mountains on an eastward track will undergo further upslope lift in this area, resulting in additional precipitation. It is colder because of the Arctic air that can seep through the mountain passes from Alberta.

(a) Summer

The weather during the summer is essentially benign. Frontal systems that do move into the Southern Interior and continue eastward will begin to respond to the effects of upslope lift. As it does, the cloud band will thicken and the precipitation becomes heavier and more widespread along the upslope areas. For the most part, the rainfall is persistent but generally light. However, when a cold low moves across the area local accumulations may reach 50 to 80 millimetres.

The majority of precipitation over this area during the summer is convective. For the most part, the mountainous terrain hinders the development of severe thunderstorms. Instead, airmass and nocturnal thunderstorms develop and move along the valleys. Severe convective weather is most often the result of storms moving northeastward out of Washington and Idaho. Even these storms usually produce severe lightning, large hail and downburst winds. Only one tornado, near Cranbrook in 2001, has ever been verified. While thunderstorms can occur at anytime during the spring and summer, the main period is from June to August.

(b) Winter

The most difficult weather in this area occurs in the winter months. Frontal systems are stronger and wetter resulting in widespread cloudiness and precipitation. For the most part, the precipitation will fall as snow resulting in extensive low ceilings and visibility. Accumulations are usually light in comparison to the coast. One notable exception is along the Monashee and Columbia mountains, between Revelstoke and Blue River, where upslope lift often produces significant accumulations.

Areas of high pressure have a lesser impact because of the widespread valley cloud. Cold air stagnating in the bottom of valleys causes a strong low level inversion to form that traps any moisture from local sources. This moisture eventually forms cloud which, despite being only a few thousand feet thick, fills entire valley systems and can persist for weeks. This cloud will only produce light snow in areas where the moisture supply has been increased. Valley cloud will only move if strong winds develop in the valley or it will dissipate if the major moisture sources freeze over. Since the larger lakes and rivers seldom freeze over completely, most valleys remain susceptible to the development of valley cloud from November to mid-February.

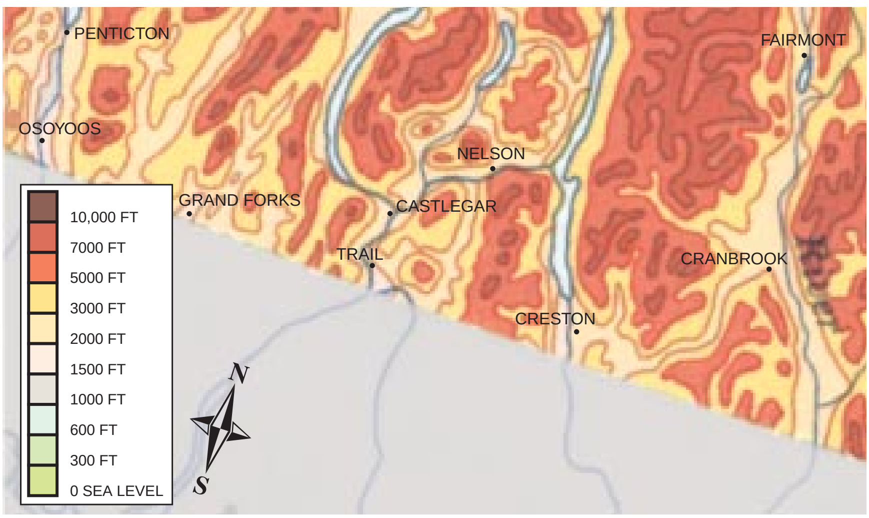
Incursions of arctic air from the north and east are fairly common during the winter. A strong area of high pressure forms in the very cold air over Alaska, the Yukon and the northern end of the Mackenzie River valley. This cold arctic air moves southeastward into the Prairies but can also spread over northern and central British Columbia. Most often, the Arctic air pushes southward into the Central Interior before coming to rest. At the same time, the arctic air also flows through the mountain passes from Alberta and fills the Rocky Mountain Trench. Depending on the strength of the arctic front, winds can shift abruptly into the east with the passage of the front and be gusty for several hours. As the cold air deepens, it will gradually move southward until the entire area is covered. Castlegar is often the last place in the Southern Interior to feel the arctic air.

Arctic air offers little problems other than the temperature. Most of the valley cloud dissipates giving clear, cold days and nights. Over the bodies of water that have remained unfrozen, sea smoke will form over the water and lift to form cumulus clouds. These clouds, if there is a significant difference between the air temperature and the water temperature, will be turbulent, contain significant icing and produce local snow showers. Other than this, good flying conditions will prevail except for some localized problems with stratus.

(c) Local Effects

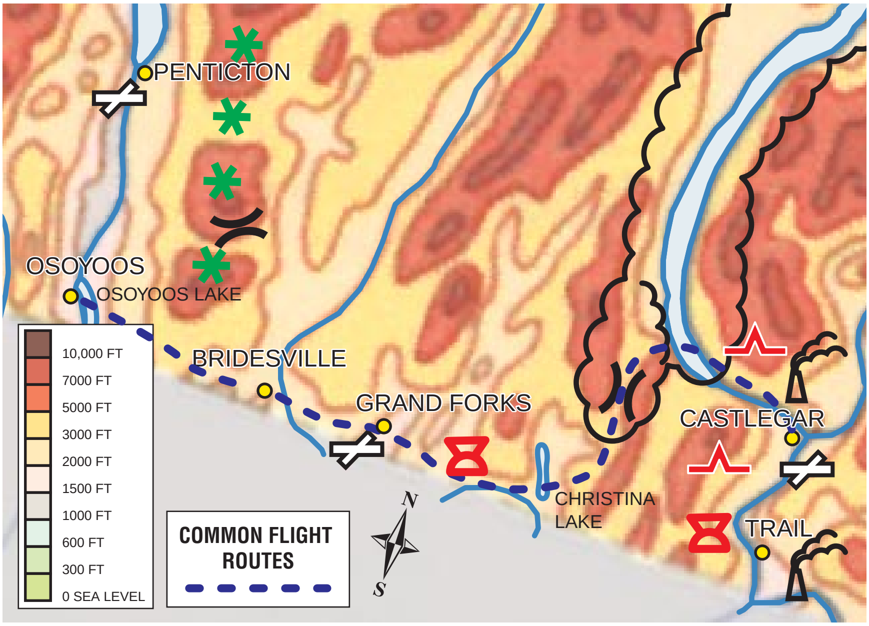
Aircraft movement in British Columbia, unless the weather is very good (clear or high ceilings), tends to be a matter of flying established routes. There is a major route to the north, (Salmon Arm to Revelstoke and Golden), and a southern route from Osoyoos to Cranbrook and eastwards. Aircraft usually change from one to the other using the Okanagan Valley and Rocky Mountain Trench. Finally, there is a well established route northwards along the Rocky Mountain Trench into the northern interior.

Southern Route – Osoyoos to Cranbrook and Eastwards



Map 4-25 - Southern Route – Osoyoos to Cranbrook and Eastwards

Osoyoos to Castlegar



Map 4-26 - Osoyoos to Castlegar

This route climbs out of the Okanagan Valley in a steep climb to the east from Osoyoos near Anarchist Mountain. The route has to clear the Bridesville Pass (5,000 feet ASL) to get to the Kettle Valley from Rock Creek to Midway. It then climbs again to almost 3,500 feet before dropping into the valley at Grand Forks. From there it follows Highway 3 past Christina Lake, rising another 2,000 feet through yet another upslope region with the usual increase in precipitation and cloud, before dropping into the Columbia River valley west of the Arrow Dam and Castlegar. Another option from Grand Forks, is to fly just south of the US border eastward to Northport, Washington and then north up the Columbia River to Trail and Castlegar. This is much drier and lower than the more northerly route.

This route is seldom a problem during the peak of summer except for thunderstorm activity. The area is hot and dry with little weather other than thunderstorms. These thunderstorms usually originate in Washington State and move northwards along the valleys during the afternoon and evening. Most dissipate by midnight but, on occasion, a few nocturnal thunderstorms will last into the early morning.

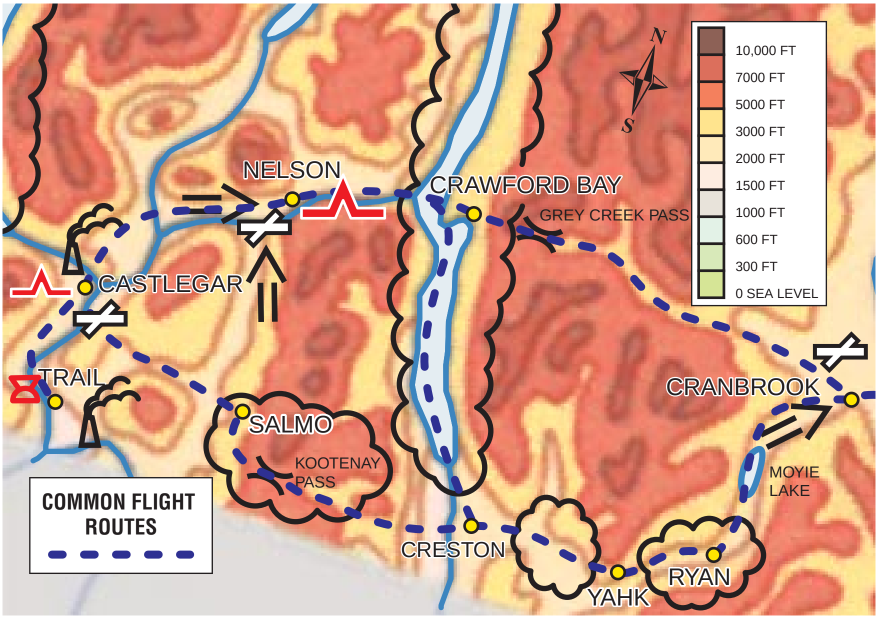
The rest of the year is another story. The combination of a narrow pass near Bridesville and low cloud can make this route treacherous. Upslope lift east of the Okanagan Valley and again just west of Grand Forks causes increased precipitation and cloud and, when applicable, aggravates convective build-ups. The high ground between Osoyoos and Grand Forks is a known snowbelt that extends in a north to south line along the peaks. Generally, when conditions are marginal in Penticton, they are, or soon will be, worse at these points. The route from the Lower Arrow Lake to Christina Lake is very narrow and can also be blocked by low cloud. Movement through here is a matter of waiting for the openings. The more southerly route through Northport, is often a more viable option.

Once into the Columbia River Valley the main problem is the Castlegar area itself. The Arrow Dam where the Columbia River valley narrows is a known area of turbulence in strong winds. There are also the pulp mill, 5 miles west of town and the Cominco Smelter, 10 miles south at Trail, which add condensation nuclei, aggravating the fog and low cloud problems in and around Castlegar. Usually, west of the Arrow Dam, ceilings and visibility improve.

The valley is very deep, with Castlegar below 2,000 feet ASL and peaks all around within 3 miles topped above 8,000 feet ASL. This combination makes Castlegar a prime candidate for valley inversion problems when the right conditions occur, and is also one of the last valleys to “scour out” the cold air after an arctic outbreak. Fortunately being so far south, arctic outbreaks don’t commonly reach Castlegar.

Commercial traffic face special problems with Castlegar due to all the preceding factors. The terrain features mean that the valley can be open to VFR flight while closed to IFR. The approach minima range from around 3,000 feet for the GPS to the more common LOC/DME at about 3,400 feet. As ceilings often hover in this range and change rapidly, commercial pilots often refer to the airport as “Cancelgar”. Being in the middle of an upslope area the Castlegar region is also susceptible to heavy icing, especially in the mid ranges (10,000 to 16,000 feet) thus affecting mostly inbound and outbound traffic or enroute traffic without oxygen equipment.

Castlegar to Cranbrook



Map 4-27 - Castlegar to Cranbrook

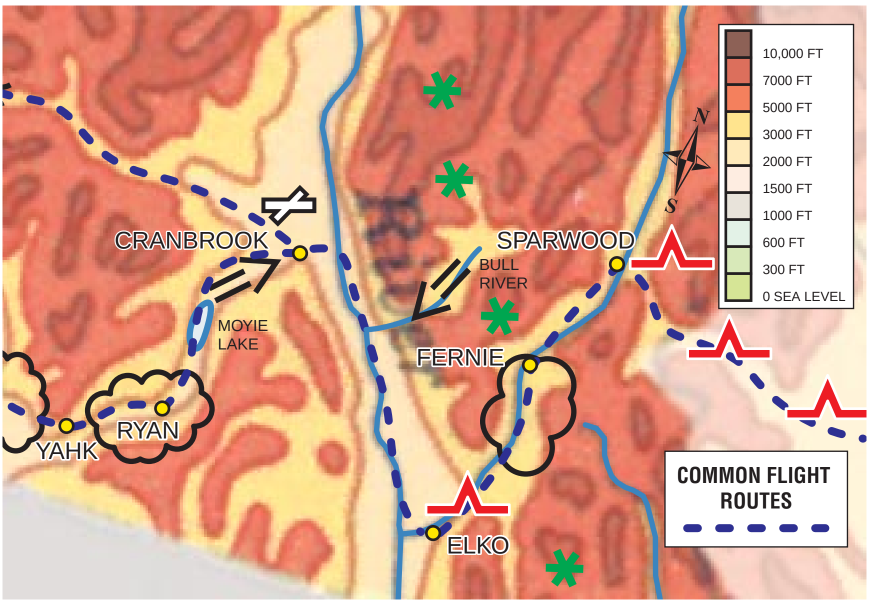
There are several routes that are used, depending on the weather of that particular day. The route from Castlegar to Creston along Highway 3 requires passing through a high mountain pass between Salmo and Creston, which makes this an unpopular route with most pilots. Weather along this route has forced a few emergency landings on the highway. In addition to low cloud, strong winds with wind shear are common.

A second possible route from Castlegar to Creston is to go east past Nelson until you reach Crawford Bay and then turn south along Kootenay Lake. With all mountain routes clouds and winds can be a problem. Low-level winds can be strong in the Kootenay Bay area due to converging winds where the valleys come together. Winds here and at Nelson tend to be worse in a southwest flow. Nelson airport itself is known to have crosswinds on a regular basis. In general, weather is reported to be better east of Nelson than between Nelson and Castlegar. In fact, pilots have reported some of the worst icing ever seen north of the Castlegar Airport, over the Brilliant Beacon. This icing is typically between 10,000 and 16,000 feet ASL.

The trip from Creston to Cranbrook has its own problems. The Moyie River Valley between Yahk and Moyie Lake receives more precipitation than other areas, even during the summer. The corner near Yahk, on occasion, is turbulent and can distract pilots into taking the southern valley into the United States by mistake. There are two areas where low cloud tends to linger. These are between Moyie and Ryan and near the junctions of Hwy. 3 and 95 and extending 5 miles to the west.

The third option involves going directly between Crawford Bay and Cranbrook, and this is the route preferred by many pilots travelling between Castlegar and Cranbrook. The highest point is Grey Creek Pass, approximately 5 miles east of Crawford Bay. In the pass itself, it is recommended that you follow the road rather than the power line. When travelling west to east after crossing the pass, the weather tends to improve along the rest of the route. To get through the pass, ceilings must be higher than 7,500 feet ASL. If the route closes behind you, there is no way out; you are committed to going east into the Trench. When travelling east to west, route finding is more difficult due to the many side valleys.

Cranbrook and eastwards through the Crowsnest Pass

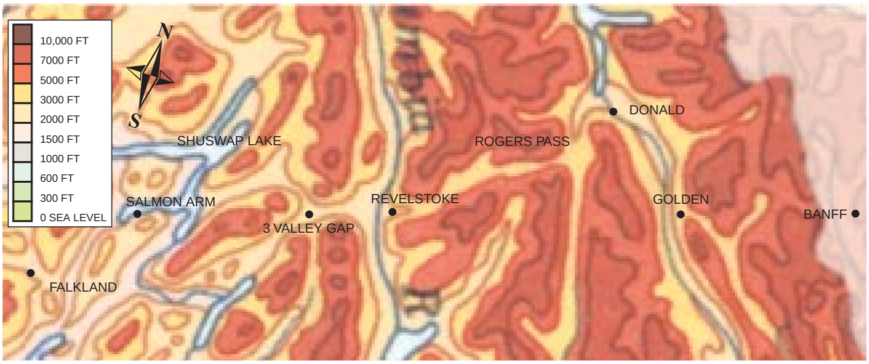


Map 4-28 - Cranbrook and eastwards through the Crowsnest Pass

At the Cranbrook airport itself, although winds are not very strong, the prevailing westerly wind is across the runway. Shear has also been reported as significant within 200 feet above the runway The route from Cranbrook follows the Rocky Mountain Trench south to the Elk River Valley, then turns northeast up the valley to Fernie, Sparwood and east. The weather at Cranbrook Airport tends to be representative of the weather along the Trench. However, low cloud is more common over the Kootenay River. If the weather is bad at the airport, the Trench is more than likely closed.

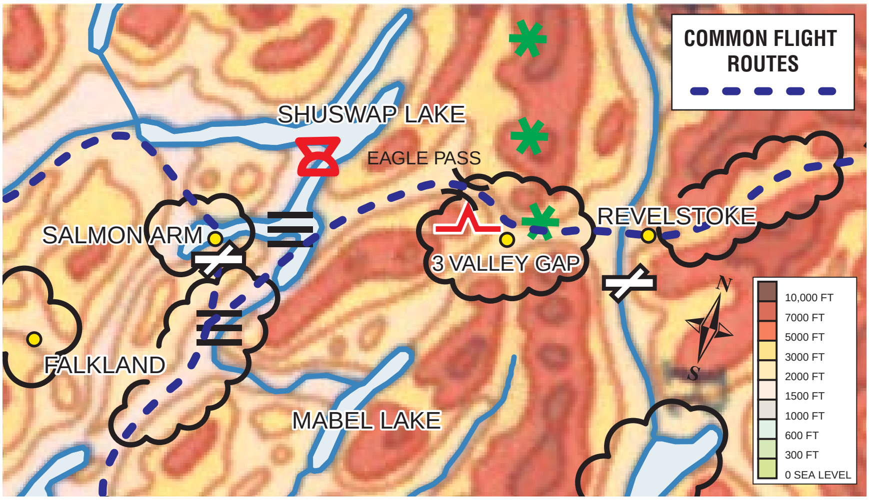
The route up the Elk Valley to Sparwood and on to Blairmore (in Alberta) is well known for its strong winds (up to 80 knots) and turbulence. Planes have been forced down near Blairmore by severe turbulence. Local pilots say, "A nice day in Blairmore is like winning the lottery." On most days, the north side of the valley is less turbulent than the south side. Drier weather is experienced along the Iron Creek from Fernie to Bull River. The pass between Fernie and Bull River is easy to see from just west of Fernie. If this pass is closed, then similar conditions likely exist along the highway to the south of Fernie. A heavy snowbelt runs along the Rockies from the Bull River to the Flathead River. Strong outflow winds are common out of the Bull River valley.

Northern Route – Salmon Arm to Banff



Map 4-29 - Northern Route – Salmon Arm to Banff

Salmon Arm to Revelstoke



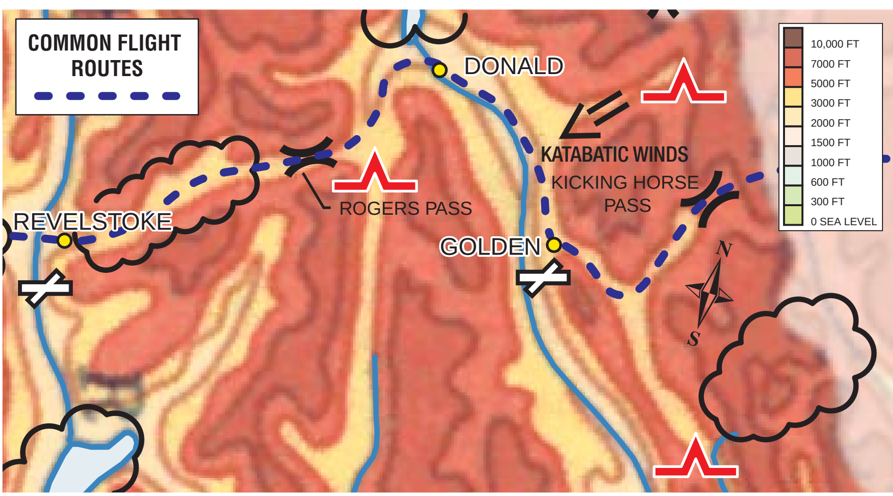
Map 4-30 - Salmon Arm to Revelstoke

This route follows the Eagle River east through the Eagle Pass and then cuts through a north-south range of mountains at Three Valley Gap (note that these are narrow gorges rather than high passes). At Three Valley Gap, the narrow confluence of valleys channels both wind and low cloud and is the usual problem point when conditions are marginal. When winds are strong pilots should assume that there will be significant mechanical turbulence in this area. The upslope lift encountered by weather system approaching from the southwest or west increases the instability and precipitation. This causes ceilings and visibility to be lower in the vicinity of Three Valley Gap than in Kamloops or Salmon Arm. If conditions are low in Salmon Arm, there is a strong chance you won't be able get past this chokepoint. However, when going the other way, if you can get out of Revelstoke, you can usually get to Salmon Arm.

Revelstoke sits in a deep valley with the airport beside a lake. The peaks in the vicinity rise from 8,500 to 10,000 feet above the valley floor. The Revelstoke area, including the valleys immediately to the east and west on this route, is very susceptible to low cloud and fog, especially in the mornings. The most common low visibility is in the flats near the airport. Some mornings, the entire region can be clear while fog closes both approaches to the Revelstoke Airport. Surface winds at Revelstoke can be very strong following an arctic front but, in general, are not usually a hazard to aviation. Note that, as is often the case in BC valleys, when combined with a sufficiently strong valley inversion, the low cloud can persist for much of the day.

At Revelstoke, it is possible to continue eastwards towards Golden or to turn northwards towards the Mica Dam. Of the two, the eastward route is the preferred. Mostly helicopters use the route from Revelstoke north to Mica Dam. The route is essentially two 700-foot steps with ceilings dropping as one travels north. Pilots must be aware that low cloud is common over open water, and beware of the power lines crossing the route several times north of Downie Creek.

Revelstoke to Golden to Banff



Map 4-31 - Revelstoke to Golden to Banff

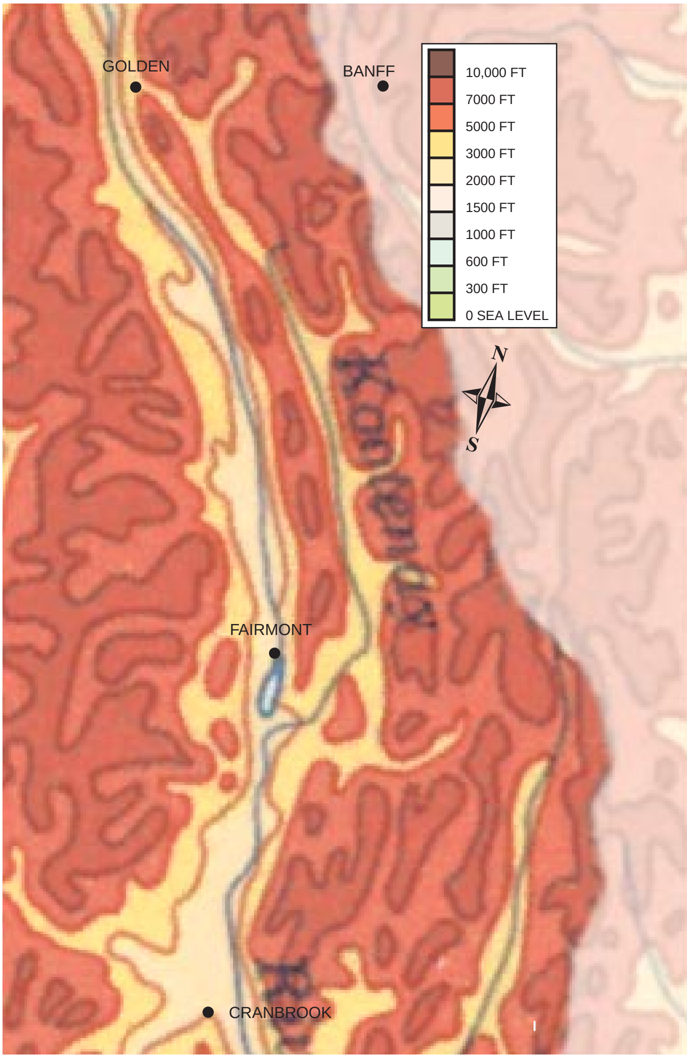
This part of the route climbs eastward through a highpoint at the Rogers Pass. It then drops into the Columbia River valley and Golden. From Golden it follows the Kicking Horse River to Field then climbs over the mountains at the Kicking Horse Pass to Banff in Alberta.

Although a relatively wide mountain pass, the Rogers Pass (elevation 4,534 feet ASL) has intimidated even experienced pilots. Low cloud tends to pile up west of the summit of Rogers Pass making passage difficult. The weather often looks good entering Rogers Pass from the east; however, getting to Rogers Pass summit does not assure passage to Revelstoke. Generally speaking ceilings at Revelstoke and Golden need to be at least 3,000 to 4,000 feet AGL for the likelihood of the pass being flyable. It is rarely open during times of precipitation and should not be attempted when conditions are deteriorating rapidly from the west (i.e. a front moving in).

The route from Golden to Banff crosses a major hydrological regime change over the Continental Divide. Generally from Lake Louise east is relatively drier. Differences in aviation weather along this route can be equally as dramatic. While winds are generally not a major concern between Golden and Kicking Horse Pass, local funnelled winds can provide some turbulence. The pass itself, at 5,350 feet ASL, is dominated on either side by peaks to over 11,000 feet. When the winds are strong, the worst turbulence, often moderate or greater, is usually found to the east of Banff, and can make an otherwise clear day unflyable. Even higher altitudes, say 10,000 to 16,000 feet ASL, often provide no refuge from the turbulence due to the frequency of lee wave activity. A pressure difference on either side of the Rockies usually indicates winds and associated turbulence in the pass and vicinity.

Photo 4-2 - Kicking Horse Pass

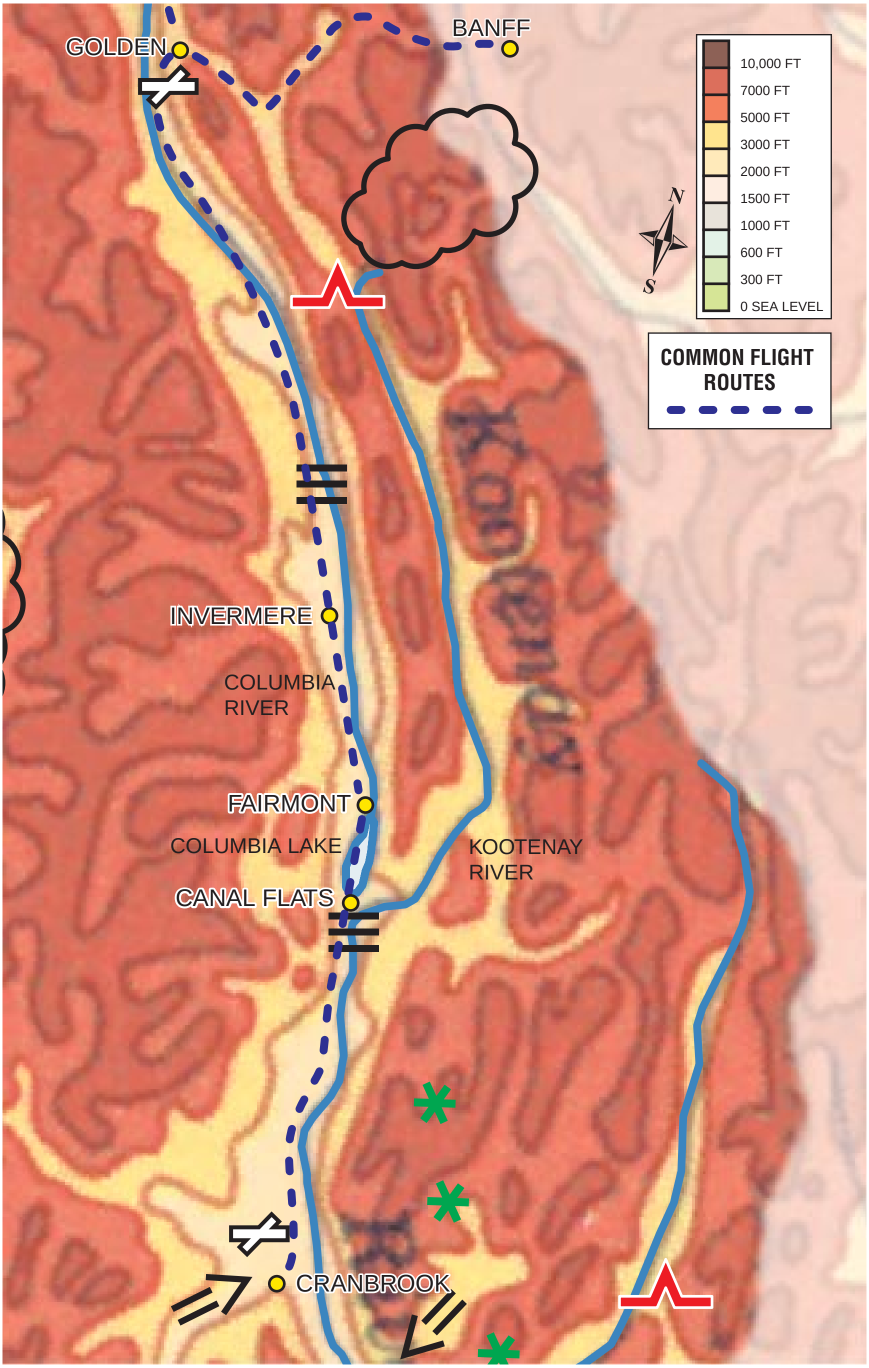
Rocky Mountain Trench



Map 4-32 - Rocky Mountain Trench

The southern portion of the Rocky Mountain Trench follows the Columbia River Valley northwest from the U.S. border past Cranbrook. From here the "Trench" continues past Golden to Kinbasket Lake (created by the Mica Dam). North of Kinbasket Lake, the Rocky Mountain Trench, holding true to its course, continues through Valemount, Mcbride and Mackenzie. From Mackenzie it forms the valley of the Williston Lake and continues northwestward eventually reaching Watson Lake and the Yukon.

Cranbrook to Golden



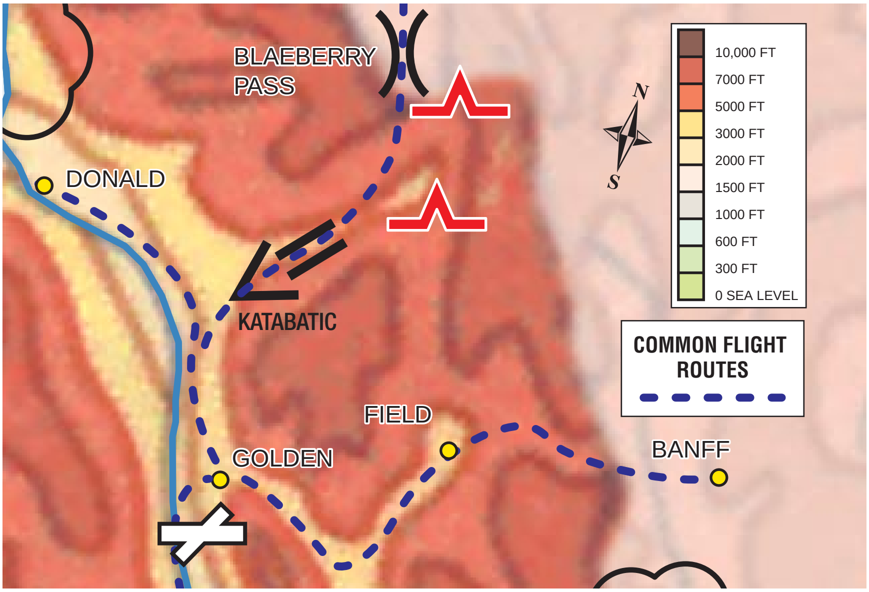
Map 4-33 - Cranbrook to Golden

This route follows the Columbia River valley northwest up the Rocky Mountain Trench to Golden. With the Purcell Mountains to the west and the Rocky Mountains to the east, this route may receive the best aviation weather in all of Western Canada. System weather tends to be lighter in the south and is generally weakened by subsidence. Weather-related hazards are few except for relatively frequent low cloud and fog near Parson. Radiation fog is common under clear skies in autumn although it generally burns off by 10 a.m. In winter, valley cloud between 4,000 and 6,000 feet ASL (ceilings from 1,200 to 2,000 feet) often closes higher routes and produces significant icing. In general when cloudy conditions do prevail, aircraft can encounter heavy icing conditions in the cloud east of Cranbrook and Golden in the upslope conditions of the western slopes of the Rocky Mountains.

Infrequent strong winds do not usually produce significant turbulence due to the wide, linear valley, except where valleys merge with the Trench from the side. With strong winds aloft (west to southwest), occasionally lee wave turbulence will affect flights into and out of Cranbrook.

Golden Airport is not usually representative of the weather along the Trench. It tends to be much drier than areas to the north and south, especially the north. The airport at Cranbrook is on a hill above the town and is often subject to crosswinds from the west. Note that if the weather is bad at Cranbrook it is likely as bad or worse in the Trench between Golden and Cranbrook.

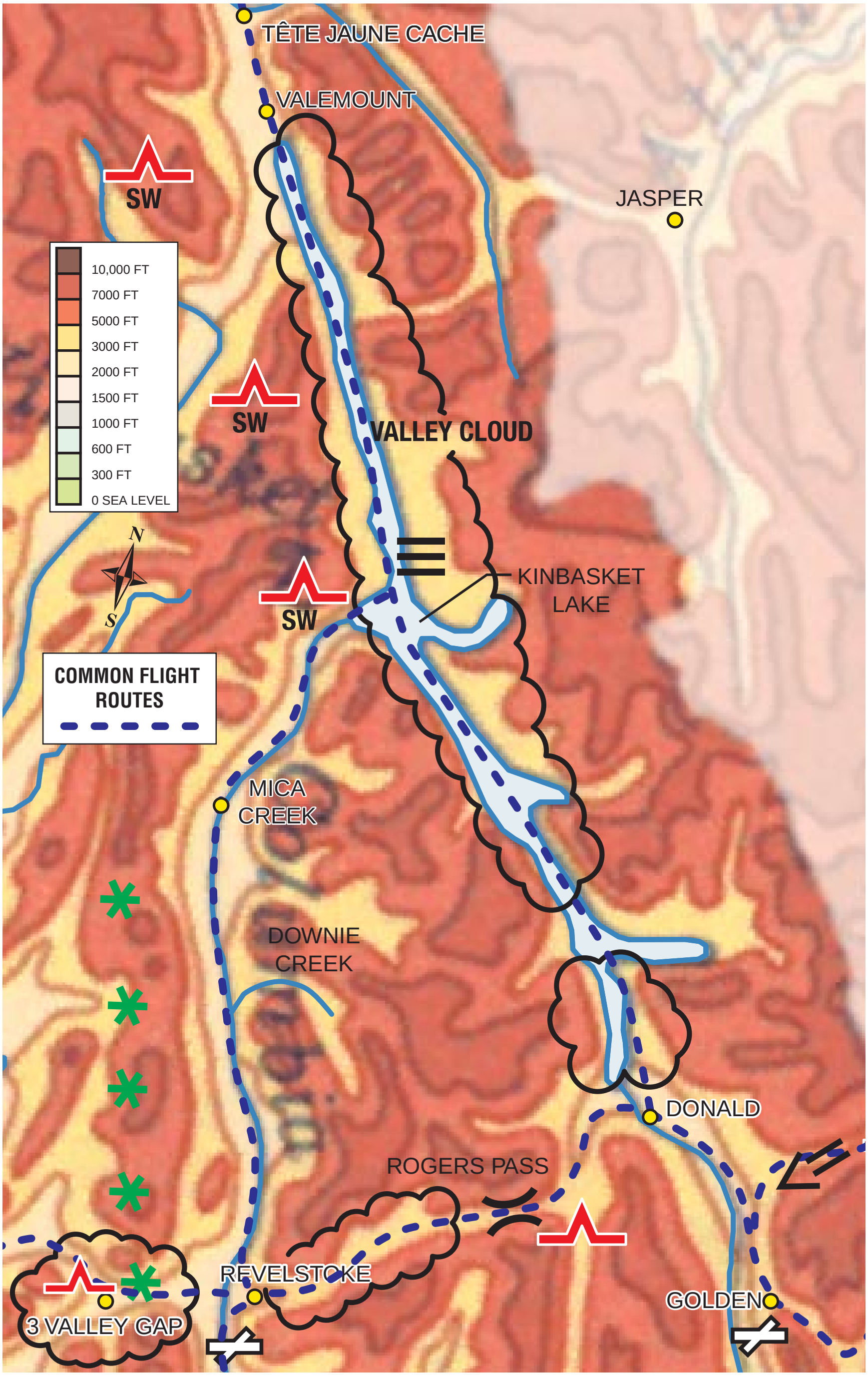
Blaeberry Pass, Golden to the North Saskatchewan Crossing



Map 4-34 - Blaeberry Pass, Golden to the North Saskatchewan Crossing

Another common route out of the Rocky Mountain Trench is Blaeberry Pass along the Blaeberry and Howse Rivers. Opening out of the Rocky Mountain Trench just north of Golden the Blaeberry Valley climbs to the Blaeberry Pass. The valley becomes very narrow and deep as it approaches the pass and has peaks on either side from 8 to 11 thousand feet high. East of the Blaeberry Pass the valley follows the Howse and then the North Saskatchewan Rivers. Beside the usual cloud problems associated with Rocky Mountain passes, this route has the potential for very hazardous wind and turbulence conditions. An extremely bad spot, even for helicopters, is at Mummery Creek. West of this location, winds and turbulence diminish rapidly except for extreme katabatic winds on sunny summer evenings. With the effects of channelling and rugged terrain on valley winds and the katabatic winds off the ice fields and glaciers, wind patterns can be very chaotic. The only way to avoid these conditions is to fly before 10am or after 5pm when surface winds are light or at much higher altitudes when ceilings allow it. Clearly this is not a recommended route for light, low performance aircraft if low level valley flying is involved.

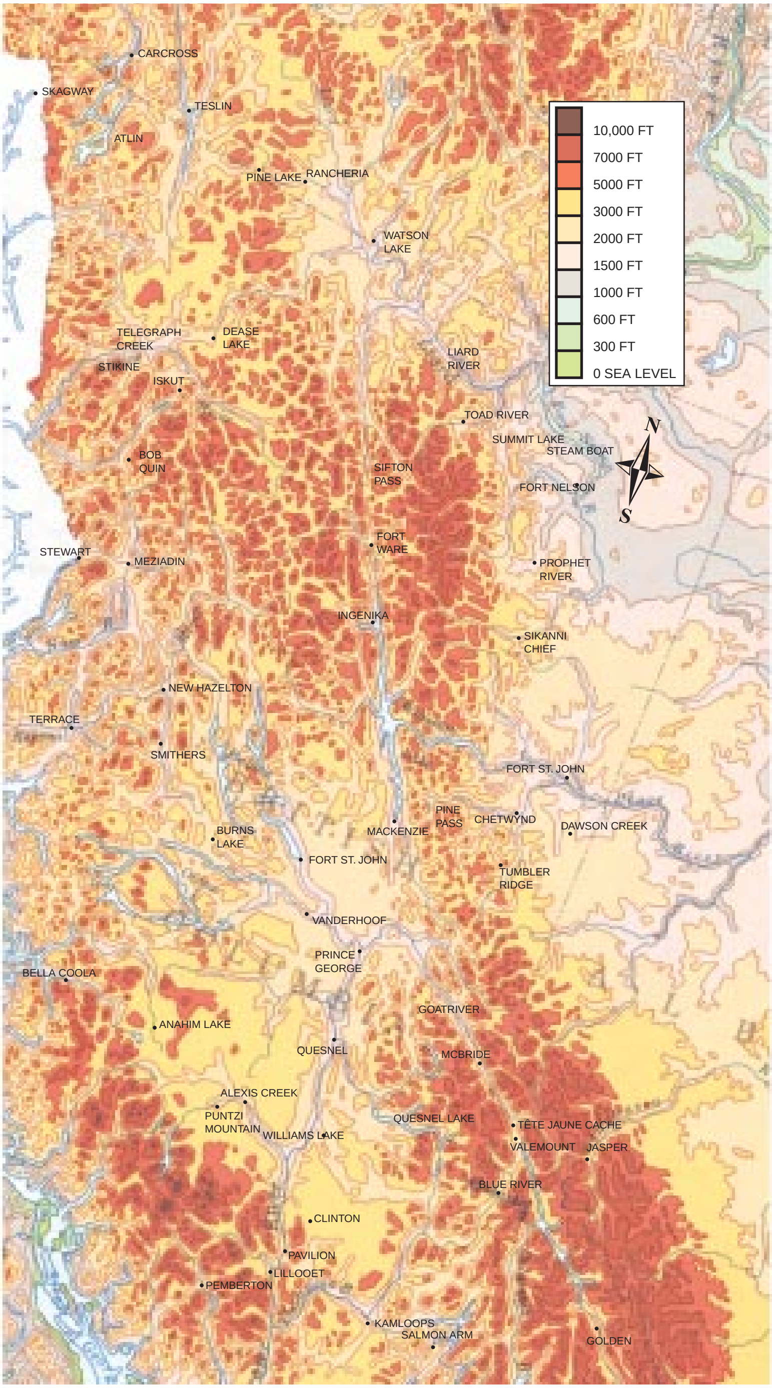
Golden - the Mica Dam – Tête Juane Cache - Jasper



Map 4-35 - Golden - the Mica Dam – Tête Juane Cache - Jasper

This route follows the Rocky Mountain Trench northwest to Tete Jaune Cache where is turns sharply east past Mount Robson and up the Fraser River headwaters to the Yellowhead Pass into Alberta. Although still in the relatively dry Rocky Mountain Trench, this section receives considerably worse weather than areas further south. Just north of Golden the main route along Blackwater Creek is higher than an alternate route which stays over the river and goes around Blackwater Mountain; however, in bad weather, experienced pilots recommend neither route. Winds along the Columbia River are almost always much stronger than those further south at Golden. The water usually freezes by mid winter, reducing the amount of fog and low cloud.

Central and Northern Interior



Map 4-36 - Central and Northern Interior

The Central and Northern Interior occupies the bulk of the BC Interior. The Central Interior is essentially the area from just north of an east to west line through Clinton to a rough east-west line through Mackenzie. The Northern Interior extends from that point to the Yukon border. Bounded to the west by the Coastal Mountains and to the east by the Rockies, the area has an extremely wide variation in climate between summer and winter. Summers tend to be pleasant while winters can range from seasonably cold to outright frigid.

(a) Summer

Like the rest of BC, summer is the benign season where the weather is strongly influenced by the position of the main storm track. During the early part of summer and in the fall, the storm track tends to lie over the Central Interior. This exposes this area to the travelling frontal systems sweeping across the area giving frequent cloudiness and precipitation.

In the middle of summer, low pressure areas usually remain offshore as the Pacific High strengthens and moves further north. This northward shift causes the main storm track to shift into the northern Gulf of Alaska and across northern British Columbia, or even into the Yukon. South of this track, minor frontal systems, upper troughs and thunderstorms produce most of the weather. In August and September, weeks can pass between weather systems.

In the Central Interior of British Columbia and the northern section of British Columbia, the plateau type terrain allows the thunderstorms to reach full intensity. While air mass thunderstorms still remain the predominate type, frontal thunderstorms and nocturnal thunderstorms are common. The typical scenario would see the beginning of thunderstorm activity early in the afternoon and for it to dissipate in the evening. Most often the thunderstorms move towards the northeast and, given the right conditions, their intensity can reach the severe level. Within BC, it is the area around Prince George that has the potential each year to produce tornadoes. The normal thunderstorm season for both areas is June to August.

(b) Winter

As Pacific frontal systems move inland, they do not weaken as much as they do in the south. This is simply because the Coast Mountains are not as high at these latitudes. As such, steady precipitation is to be expected whose type will vary with the local temperatures. Accumulations are usually light, however, local accumulation can be larger especially near the Arctic front.

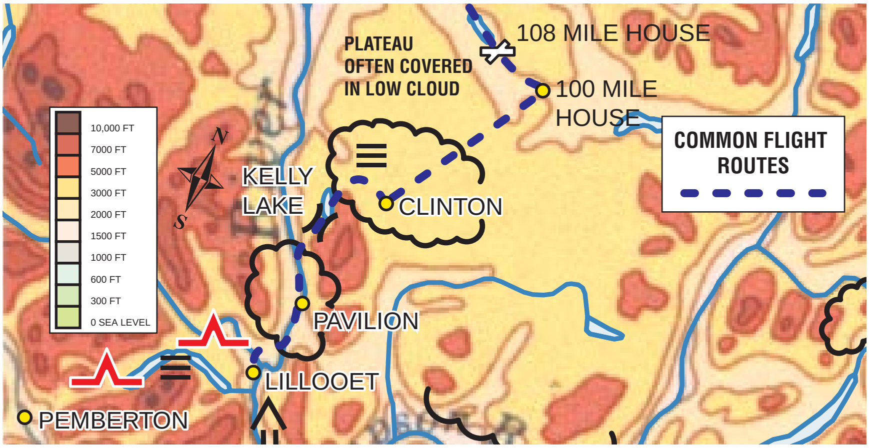
The northern half of British Columbia is subject to widespread valley cloud only during the early part of the season, as the lakes and rivers generally freeze over completely. Thus, ridges of high pressure during mid and late winter bring widespread clear, cold weather.

During winter, a strong area of high pressure forms in the very cold air over Alaska, the Yukon and the northern end of the Mackenzie River valley. This cold arctic air moves southeastward into the Prairies but can also spread over northern and central British Columbia. Most often, the arctic air pushes southward into the Central Interior before coming to rest somewhere near Clinton. At the same time, arctic air also flows through the mountain passes from Alberta and fills the Rocky Mountain Trench. Depending on the strength of the arctic front, winds can shift abruptly into the northwest to northeast with the passage of the front and be gusty for several hours

Arctic air over the interior offers little problem, other than the temperature. Most of the valley cloud dissipates, giving clear cold days and nights. Over the bodies of water that have remained unfrozen, such as Williston Lake, sea smoke will form over the water and lift to form cumulus clouds. These clouds, if there is a significant difference between the air temperature and the water temperature, will be turbulent, contain icing and produce local snow showers. Other than this, good conditions will prevail except for some localized problems with ice fog.

(c) Local Effects

Lillooet - Pavilion - Clinton

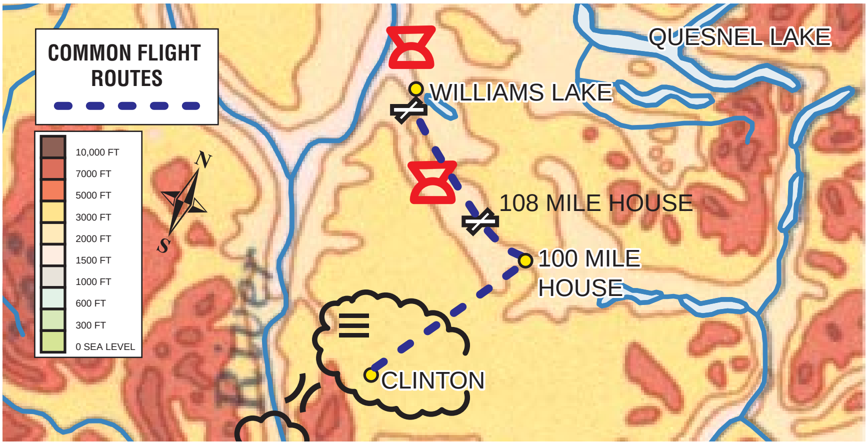


Map 4-37 - Lillooet - Pavilion - Clinton

This is the continuation of the route from the south coast via Howe Sound, Whistler and Pemberton. At Clinton it meets the route which runs north from Cache Creek to Williams Lake. From Pemberton it follows the valley along Anderson and Seton Lakes to Lillooet. It then follows the Fraser River to Pavilion before turning northeastward to climb onto the Interior Plateau at Kelly Lake and on to Clinton.

Low cloud and fog are usually concentrated over the plateau while the lower elevations, such as along the Fraser River Valley, are often below the cloud deck. If the ceiling is too low to get through Pavilion, it is likely the same at Kelly Lake.

Clinton to Williams Lake



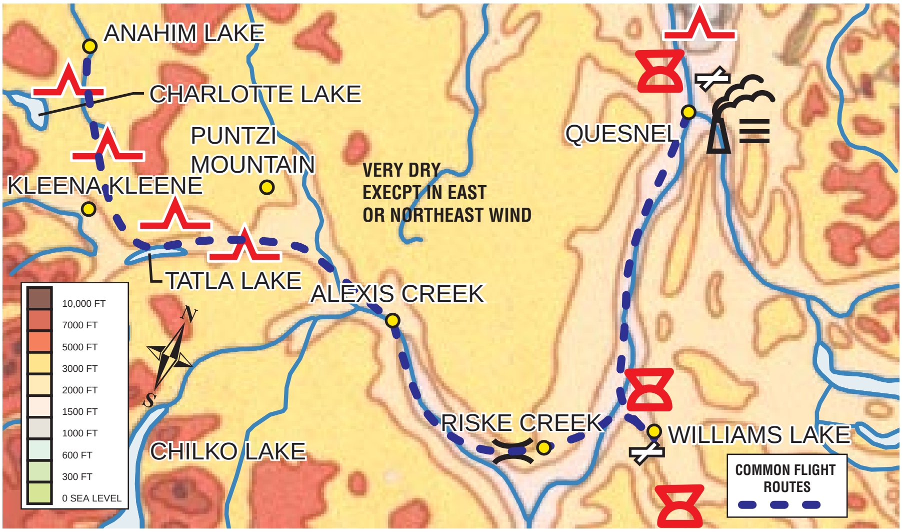
Map 4-38 - Clinton to Williams Lake

This route rises gradually on the Interior Plateau to 100 Mile House. North of 108 Mile Airport it follows a valley again from Lac La Hache to Williams Lake where it rejoins the Fraser River.

Anywhere in the central and northern regions of the province winter weather is greatly influenced by the position of the Arctic Front. During the winter months it will generally be somewhere along this route or just north. Where the Arctic Front combines with a moisture source either on the ground or aloft in the form of frontal activity, expect flurries and low visibilities.

Low cloud develops in the rising ground just south of Clinton and usually extends across the Central Plateau. Conditions along the route between 100 Mile House and Williams Lake tend to be uniform, although ceilings lower as the terrain rises when heading southeast. Ceilings are much lower over the higher ground while fog is more prevalent in the valley.

Williams Lake - Alexis Creek – Puntzi Mountain – Anahim Lake



Map 4-39 - Williams Lake - Alexis Creek – Puntzi Mountain – Anahim Lake

As an alternative route to the coast through the Coastal Mountains, this route crosses the Interior Plateau westward from Williams Lake. Leaving Williams Lake the route runs south before crossing the Fraser River to climb over a highpoint west of Riske Creek at almost 4,000 feet ASL. It then weaves its way west over the high plateau, following the Chilcotin and Chilanko Rivers just south of Puntzi Mountain to Tatla Lake. Then turning more northwest, it crosses the plateau to Nimpo and Anahim Lakes.

Generally, weather systems give more precipitation east of the Fraser River. However, low cloud and fog are common to both areas in the fall and early winter before freeze-up and again during spring melt, especially at the lower elevations. This is also true for the section from Alexis Creek to Puntzi Mountain, especially near the larger lakes until they freeze over. However, low cloud can occur with a moist easterly circulation at any time of year. In this more western section the fog and low cloud are more likely to burn off by late morning.

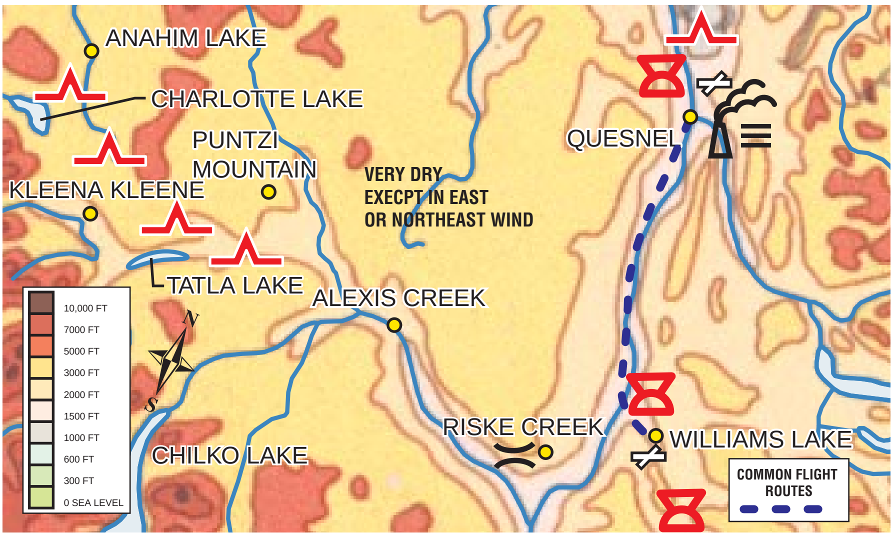
Over the eastern section of the Interior Plateau, light to moderate turbulence usually occurs during the afternoon in the summer season due to convective heating. Thunderstorms are more frequent, especially in the vicinity and east of the Fraser River. West of the Fraser River, cells are generally smaller and in the developmental stage.

Lying immediately to the lee of the Coast Mountains, the region between Puntzi Mountain and Anahim Lake is dry belt country. In the winter severe lee wave turbulence to the east of the Coast Mountains is common with very strong westerly or southwesterly winds aloft. This lee area includes the entire stretch of lakes from Chilko and Tatla in the south, to Nimpo and Anahim in the north. In most cases it is impractical to climb above this turbulence, as it would necessitate ascending to nearly 15,000 feet ASL. Experienced pilots suggest that it is best to stick close to the sides of the valleys.

Anahim Lake to the Coast

See data for this route as described in a previous section under "Central Coast to the Interior Plateau".

Williams Lake to Quesnel



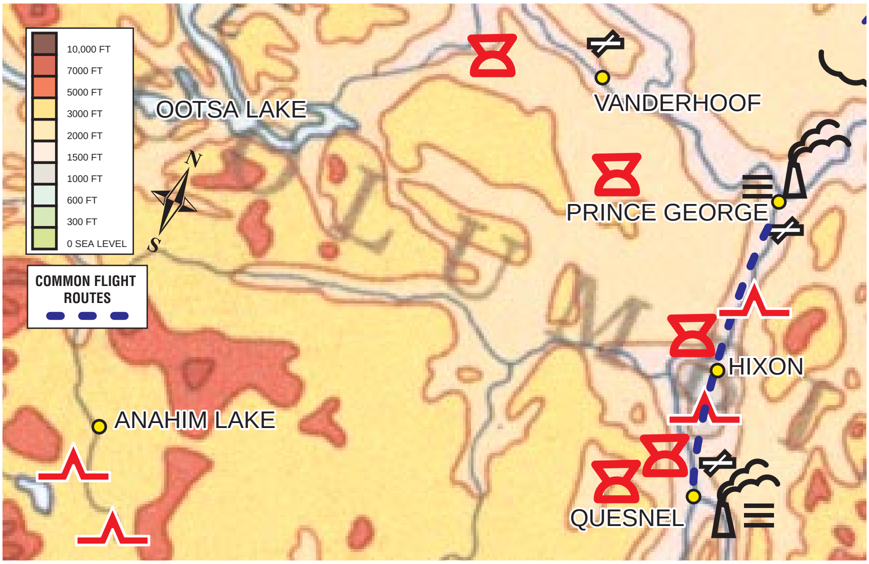
Map 4-40 - Williams Lake to Quesnel

The Fraser River valley from Williams Lake to Quesnel is relatively broad and the grade is gradual. For most of the year, aircraft operations are not hindered excessively by the weather. There is a notable exception during the winter. Whenever the arctic front oscillates back and forth through the area, the front is accompanied by freezing drizzle, low cloud, poor visibility in snow, fog and wind shear. The Cariboo-Central Interior is not prone to winds. However, the Fraser River Valley can be windy, particularly southerly winds, which can exceed 40 knots at low levels, in autumn and winter. Although they are strong and generate high wind shear values, these winds do not generally produce significant turbulence in the Valley.

Fog that fills the valley between Williams Lake and Quesnel is often below the much higher altitude Williams Lake Airport. However, it must be recognized that, in cases of extensive low cloud, the valley may be suitable for VFR flying while the Williams Lake Airport is closed due to low ceilings.

Flight routes east into the valleys of the Cariboo Mountains are common, especially during the summer months. Weather systems impact somewhat harder in these areas, with lower ceilings and visibility. This area is well known for its summer thunderstorm activity with the accompanying gusty winds and turbulence.

Quesnel to Prince George



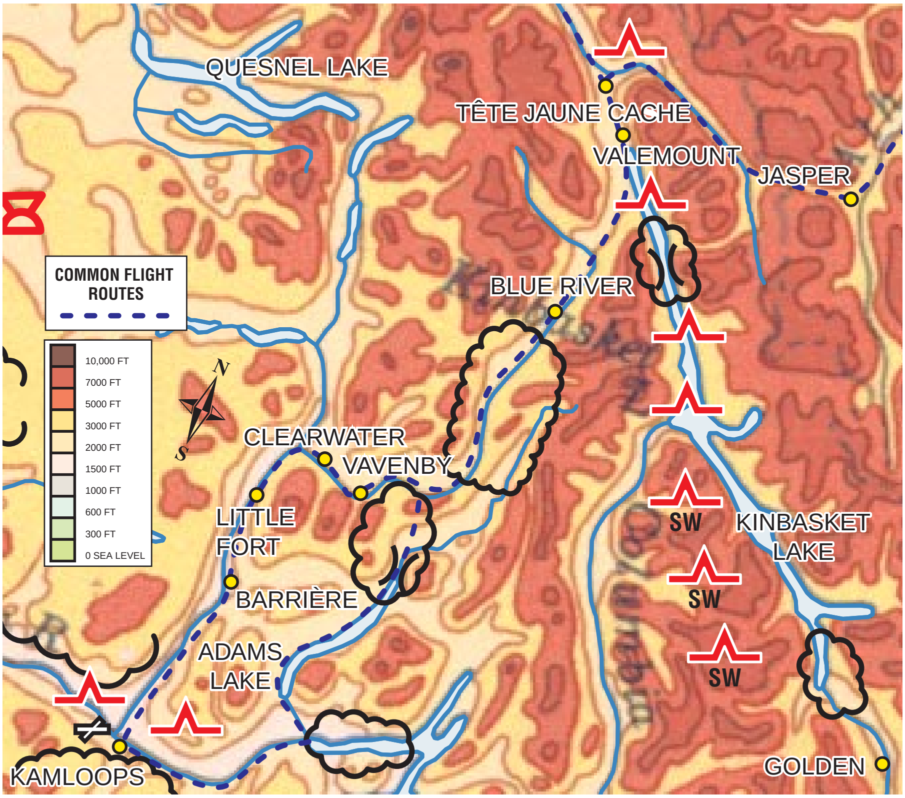
Map 4-41 - Quesnel to Prince George

Fog is relatively common along the valley, especially near Prince George and Quesnel, due to the mills located just north of the Prince George Airport and just south of the Quesnel Airport. Some days, the fog will extend only a few miles from the airports with clear conditions elsewhere. The emissions from the mill stacks often give a visual representation of the low-level vertical wind pattern.

Turbulence is not usually strong along this route, except near Trapping Lake up to 8,000 or 9,000 feet ASL. In summer, convective cloud is most common in a north to south band through Hixon.

The most significant hazard around the Prince George Airport is low cloud and fog, enhanced by the moisture along the rivers as well as the pulp mills north of the airport. Even on a clear day, fog associated with the mills can obscure the approach to runway 15. In this case, the southern approach to runway 33 is generally better. Strongest winds at the airport tend to be from the south. Light northerly winds at the surface often occur in conjunction with strong southerly winds aloft, say at 800 feet. The loss of airspeed on takeoff can cause small aircraft to drop into the river valley, near the bluffs on the north side of the river. This is most significant under morning inversions.

Kamloops –Vavenby – Blue River – Tête Jaune Cache



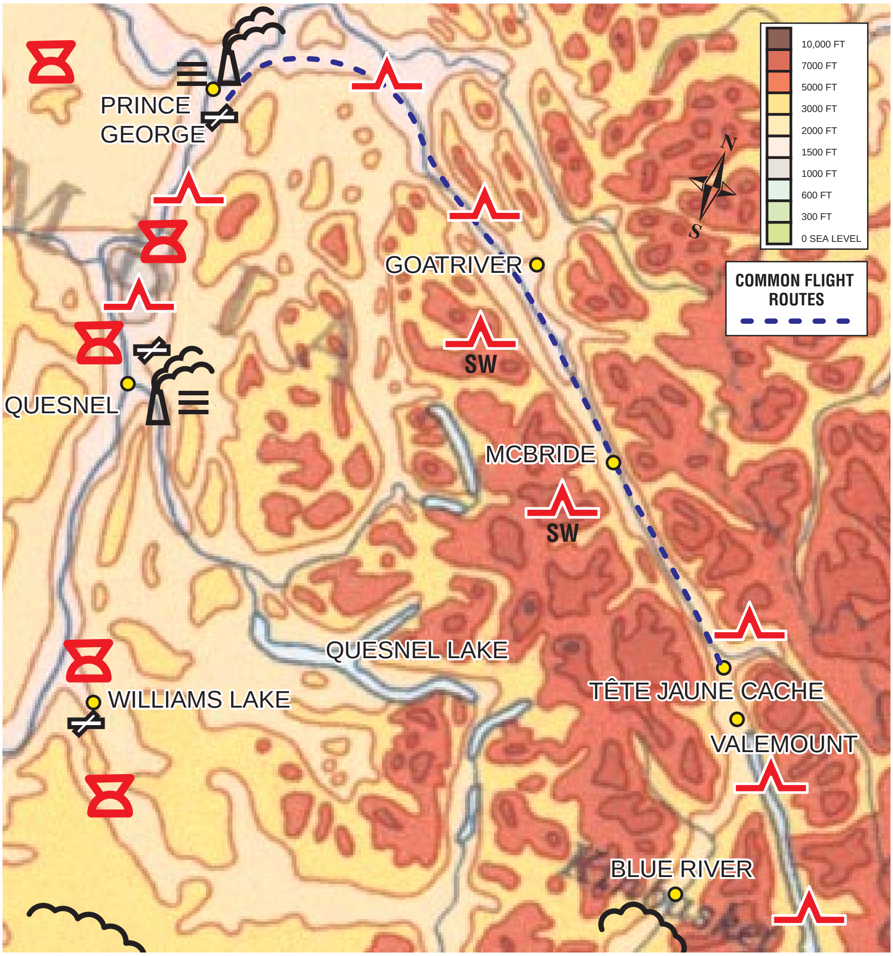
Map 4-42 - Kamloops –Vavenby – Blue River – Tête Jaune Cache

Two routes are commonly used between Kamloops and Vavenby. The first follows Highway 5 up the North Thompson River through Barrière and Clearwater to Vavenby. The second follows the South Thompson River east from Kamloops to Little Shuswap Lake and then turns north up the Adams Lake and River. North of Adams Lake it traverses a narrow pass to emerge into the North Thompson River valley just east of Vavenby. Once north of Vavenby the route follows the North Thompson River past Blue River. The long narrow valley climbs gradually to cross a north/south divide just south of Valemount, where it turns northwest up the Rocky Mountain Trench to Tete Jaune Cache. Here it meets the east-west route which links north central BC with Alberta via Prince George and Jasper, basically following Hwy 16, the Yellowhead Highway.

Both routes from Kamloops to Vavenby can see some low cloud especially during and after precipitation. Just to the north of Adams Lake, the combination of low cloud over rising ground and narrow passes can be quite hazardous. Depending on the moisture and the time of year, ceilings can be right down onto the lake. It should be noted that Adams Lake remains open all year.

North of Blue River tends to be somewhat drier. It should be noted that the Blue River weather observation does not usually report the low cloud that forms over the rising ground just to the south. Note that mountain peaks on both sides of the valley are between 5 and 6 thousand feet south of Blue River while those along the narrow valley to Tete Jaune Cache, are in the range of 8 to 10 thousand feet. North of Blue River, strong winds aloft (6 to 12 thousand feet) out of the west or southwest can cause considerable turbulence in the valley.

Tete Jaune Cache - Mcbride - Prince George



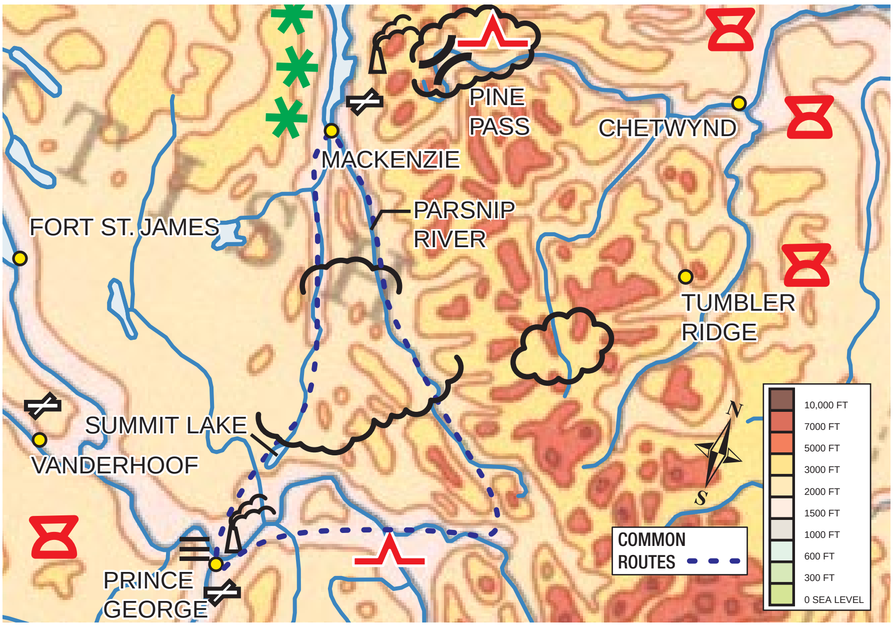
Map 4-43 - Blue River – Valemount - Tete Jaune Cache – Goat River – Prince George

The Rocky Mountain Trench creates a natural route from Tete Jaune Cache to the northwest. The route follows the Fraser River up the Trench to a point about 30 miles east of Prince George then turns west directly to the airport.

Summer convective cloud is common along both sides of the Trench over the higher ground. Severe turbulence often results when strong winds aloft cross the mountains from the southwest. This turbulence does not generally extend above the terrain height, 6,000 to 8,000 feet. Severe turbulence is normal on summer afternoons over the glaciers to the northeast.

In winter low cloud and precipitation move through with frontal disturbances, drying slowly behind them. As is usual in the north, the position of the Arctic Front is pivotal, as there are commonly flurries where there is any moisture along the front and it tends to be colder and drier to the north of the front.

Prince George to Mackenzie



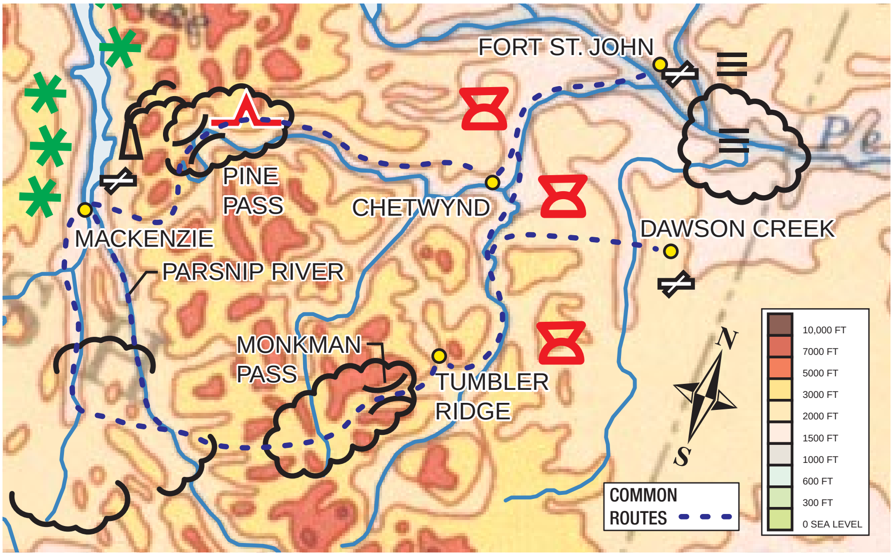
Map 4-44 - Prince George to Mackenzie

Following Highway 97 north, this route passes Summit Lake and continues up the Rocky Mountain Trench to McLeod Lake and Mackenzie. An alternate route leaves Prince George and follows the Fraser River to the north-northeast and then over the hills to enter the Parsnip River Valley. This valley runs parallel and just to the east of the first route, merging with it at Mackenzie.

Low cloud and fog are often encountered near Summit Lake, especially in the fall and spring. Poor conditions will at times extend as far as McLeod Lake. Winds and turbulence are generally light along this route. Low cloud and fog are commonly encountered along the Parsnip River Valley, especially in the fall and spring and often in association with frontal precipitation.

Pilots will sometimes follow the Parsnip River Valley south from Mackenzie, then east along the Fraser River into Prince George.

Crossing the Rockies: Mackenzie to Dawson Creek/Fort St. John



Map 4-45 - Crossing the Rockies Mackenzie to Dawson Creek/Fort St. John

There are two main routes across the Rockies at this point. There is a southern route via Tumbler Ridge and the more direct route via the Pine Pass and Chetwynd following Highway 97. This route climbs the upslope side of the Rocky Mountains to the narrow Pine Pass. It then follows the Pine River out of the mountains onto the plains near Chetwynd. The worst section along this route is near Pine Pass where low cloud, turbulence and very heavy snow are common. The Powder King Ski Hill near Pine Pass receives approximately 1,200 centimetres of snow each winter. This heavy snow occurs in a band from Pine Pass to McLeod Lake. In summer, the Pine Pass area is also prone to thunderstorm activity. As with other locations just east of the Rockies, lee wave turbulence is to be expected in the Chetwynd area when there is a strong southwesterly flow aloft

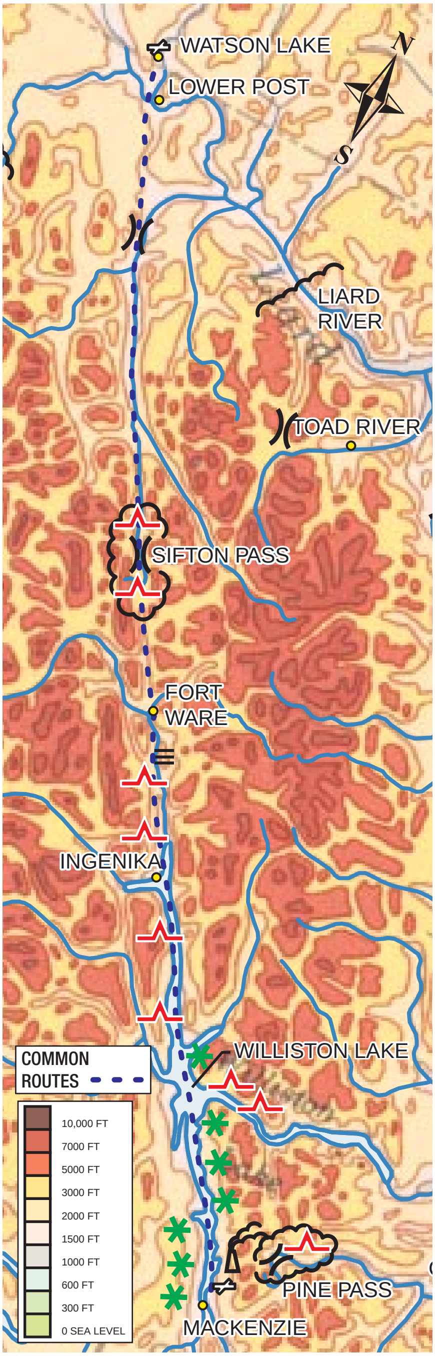
Thunderstorms often form along the foothills in summer months along a line just east of Chetwynd. These convective lines tend to remain relatively stationary while developing in the early afternoon, then tend to begin to move in the direction of the upper level (approximately FL180) winds late in the day.

When flying via Tumbler Ridge, most pilots choose to take the route along the Murray River and the Monkman Pass. Between Tumbler Ridge and points southeast, a route via the McGregor River to Monkman Pass (Monkman Lake), then along the Murray River, is utilised. There are, however, several dangerous canyons that can be mistaken for the main route. When using this route, look for strong turbulence near Monkman Pass. The onset of turbulence can be very abrupt when approaching from the east.

The Murray River and Monkman Pass area generally experiences drier and calmer weather than Pine Pass, throughout the year.

Turbulence in this region is worst in north to south oriented valleys, when the winds are blowing across the mountains from west to east. These winds tend to be strongest in spring and autumn, with associated mechanical turbulence usually below 1,000 feet AGL.

Mackenzie to Watson Lake along the Rocky Mountain Trench



Map 4-46 - Mackenzie to Watson Lake along the Rocky Mountain Trench

Mackenzie lies at the south end of Williston Lake, a long narrow body of water which fills this section of the Rocky Mountain Trench. North of Williston Lake, the terrain begins to rise and the valley narrows. The Trench continues in a near straight line to the northwest past Fort Ware, over the Sifton Pass and on, eventually descending and widening into the basin of Watson Lake.

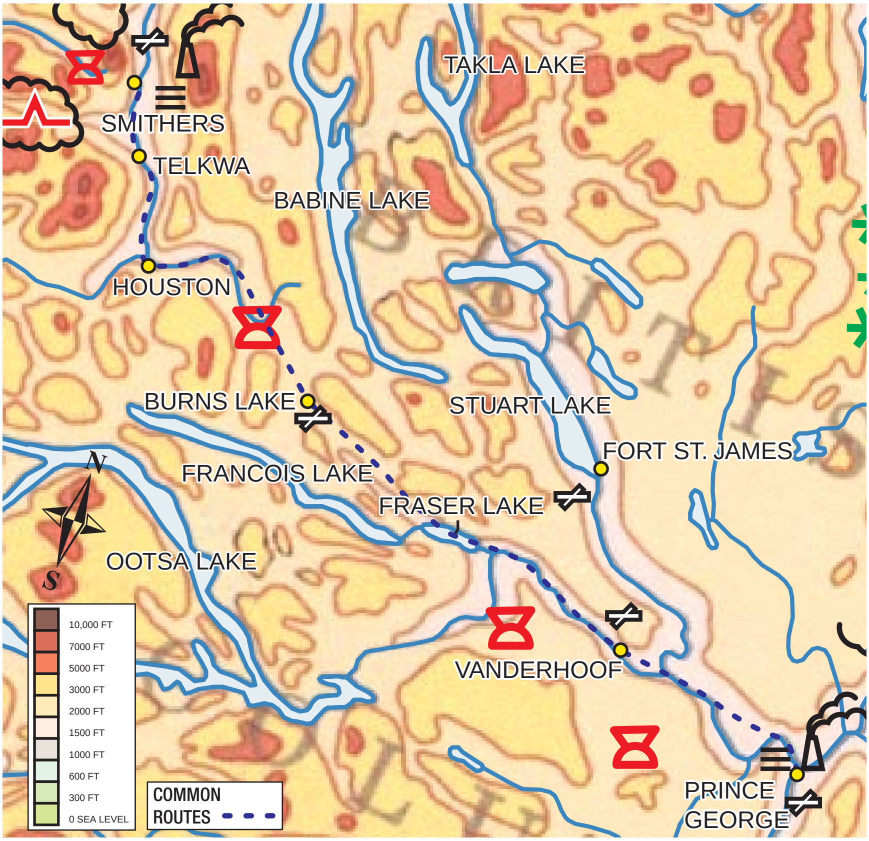
Mackenzie, and the high ground to the east and west of Mackenzie, is located in one of the snow belts of the interior of BC. Smoke from the mills near the Mackenzie Airport can induce the formation of low cloud in the area. Likewise, low cloud and fog are prevalent near and over Williston Lake, particularly from late summer to early winter. Between the north end of Williston Lake and Fort Ware, fog is common in summer and autumn, especially near Finbow. This section, north of Williston Lake, has a higher frequency of low cloud, and the Sifton Pass area, reputedly the worst spot along the Trench, is frequently reported by pilots to be turbulent or have cloud down to the treetops.

Lee wave activity and subsiding air currents are common along the west side of the Trench, due to airflow off the high ground into the valley. The east side can be better, but turbulence can be severe particularly about mid way up Williston Lake, around the entrance and into the Peace and Ospika Arms.

North of the Sifton Pass, southbound pilots must exercise caution not to mistake the Gataga River Valley, which angles off to the southeast, for the Trench. Similarly, northbound pilots often mistake the Kechika River for the more westerly route to Watson Lake.

Though this is a long stretch of territory there are only weather observations available at each end: the one from the automatic weather station at Mackenzie and that from Watson Lake.

Prince George to Smithers



Map 4-47 - Prince George to Smithers

This route follows Highway 16 from Prince George to Vanderhoof, then on through Fraser Lake, Burns Lake, Houston, and the town of Telkwa to Smithers.

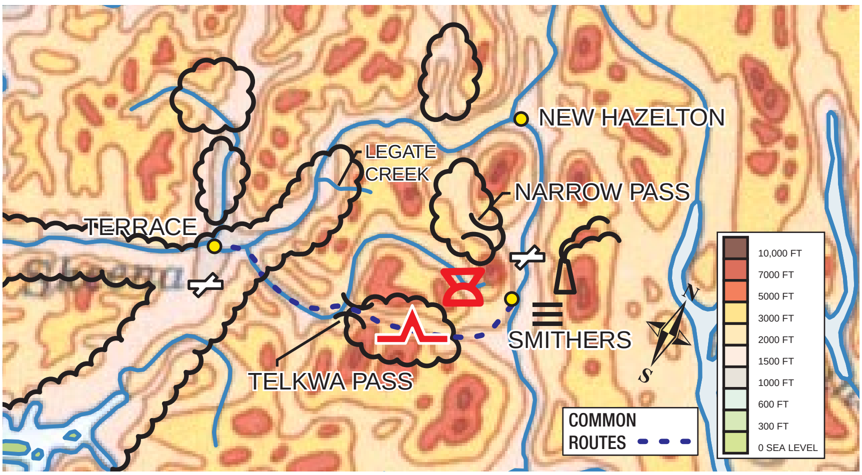
Being east of the coastal mountain range, this route is in the generally drier inland climate region. The lakes are at the lowest points, especially Burns Lake, which sits in a bowl relative to the higher ground all around it. As a result cold air pools there and it is always one of the coldest spots in the region. It freezes over early in the winter and is subject to fog.

This route is fairly dry in the summer, especially between Burns Lake and Smithers. That being said, some of the strongest convection in the BC Interior can be found between Prince George and Burns Lake. Large thunderstorms with strong winds and hail occur, with the occasional report of a funnel cloud or tornado.

Areas of low cloud and fog are a common occurrence along the route between Fraser Lake and Bulkley Lake, during the fall and spring. Strong westerly winds will often result in turbulence between Telkwa and Smithers. In addition, gusty westerly crosswinds often make landings tricky at Burns Lake.

Weather can change very quickly as cloud invades through the valley at Telkwa. Precipitation and westerly winds are more frequent at Telkwa and over the town than at the Smithers Airport. Due to the river just south of the field, fog often lingers, at times almost randomly drifting across the airport. Fog also forms over the small lake to the west and can drift over the airport

Smithers to Terrace via Telkwa Pass



Map 4-48 - Smithers to Terrace via Telkwa Pass

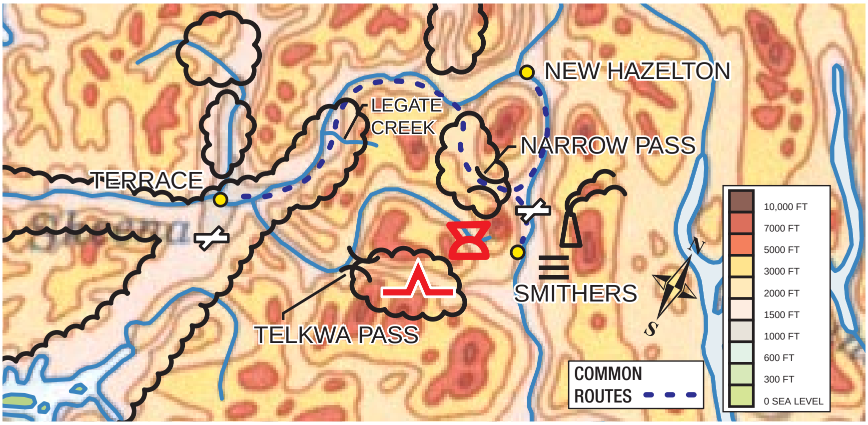
The Telkwa Pass route is the most direct route between Smithers and Terrace. Westbound it starts just south of Smithers and follows the Telkwa River up to the spectacular Telkwa Pass and then follows the Zymoetz or Copper River to where it joins the Skeena just east of Terrace.

The route through Telkwa pass is another of BC's masterpieces during good weather, with hanging glaciers on both sides of the valley. At the pass the valley floor rises to almost 3,000 feet ASL. The peaks on either side of the pass range from 8,000 to 8,500 feet and are part of the north-south range which separates the wetter coastal region from the drier interior region.

When westbound through the Telkwa Pass with low cloud or freezing levels, sudden snow squalls or rapidly lowering cloud can reduce ceiling and visibility to near zero almost instantly. The low cloud or snow will often make dead-end passes appear to be the main route. This pass should be avoided in any weather conditions likely to obscure the route. Note that poor conditions in the pass are usually not observable from either Telkwa or Terrace.

In summer, strong inflow winds can combine with Katabatic winds from the glaciers to cause significant mechanical turbulence. Severe turbulence is also reported to occur during inflow conditions along the ridge, just east of the town of Terrace.

Smithers to Terrace via the Bulkley / Skeena River Valleys and the Shorter Route via the Kitseguecla Valley



Map 4-49 - Smithers to Terrace via the Bulkley Valley and Kitseguecla Valley

By following the Bulkley River Valley up toward New Hazelton and then following the Skeena River Valley to Terrace, a pilot can avoid flying over any higher terrain. This is the longest of the three routes between Smithers and Terrace and because of the lower levels involved, is usually the only option when conditions are marginal.

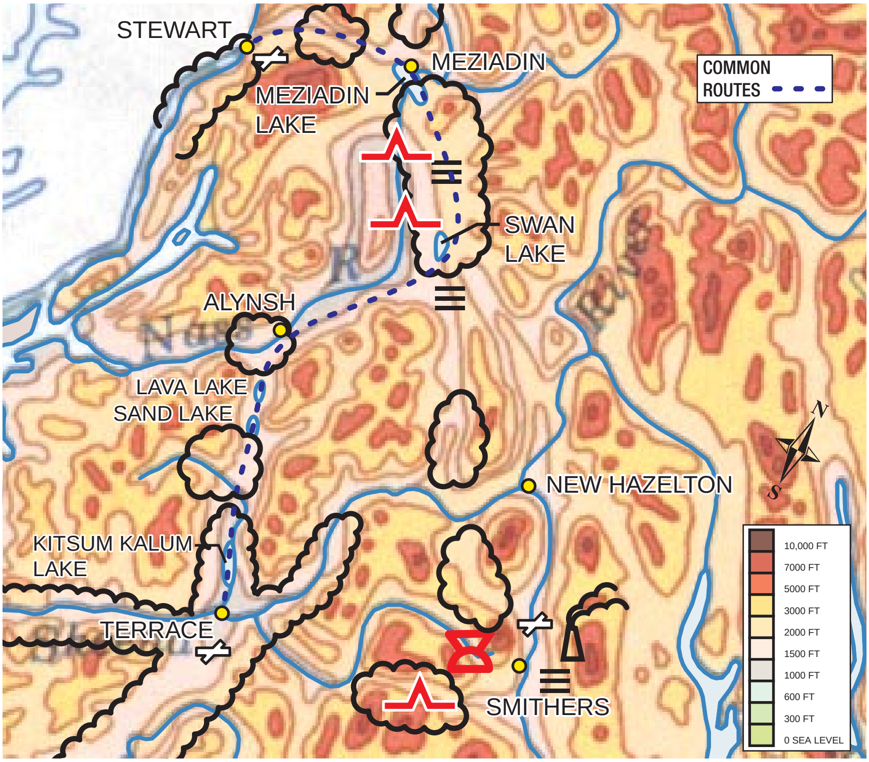
A short cut can be made on this longer route which cuts between the Bulkley and Skeena Valleys well south of New Hazelton. Though shorter than the full valley route it is still considerably longer than the Telkwa Pass route, and it still requires climbing over terrain at 2,200 ft ASL to traverse the Kitseguecla Pass (usually referred to as Kits Pass).

Both the Bulkley Valley and Kits Pass routes provide relatively good weather routes to or from Smithers. The mountains to the west act as barriers to the pacific moisture. Thus there is a significant change in the precipitation regime along the Skeena River. Typical coastal forests change to drier interior varieties just south of Woodcock (southwest of New Hazelton). Low cloud often extends up the Skeena, with Legate Creek a known bad spot. The Terrace Airport weather is generally representative of that up the valley.

This route is sometimes drier and smoother than the Telkwa Pass option, but both routes can deteriorate quickly near Terrace. Intrusions of low cloud and fog with inflow winds are the main weather hazard and, although more frequent in winter, can occur throughout the year. The airport at Terrace is more prone to low cloud due to its elevation, approximately 500 feet above town.

When winds aloft at 6,000 feet exceed 30 knots, moderate turbulence is common throughout the region. Rounding Copper Mountain at the confluence of the Copper (Zymoetz) and Skeena Rivers, there is often a wall of wind giving sudden and unexpected turbulence. This usually occurs when strong inflow winds are experienced at the Terrace Airport.

North from Terrace to the Nass River Valley



Map 4-50 - North from Terrace to the Nass River Valley

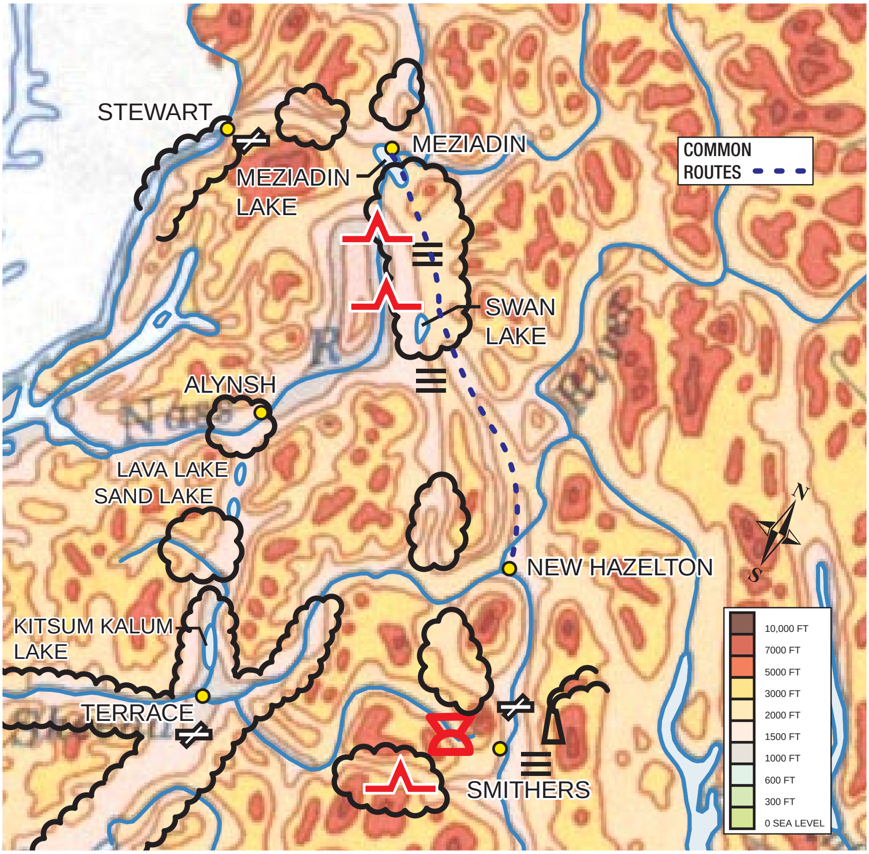
This route follows the Kalum River to Kitsumkalum Lake, then further north up the valley to Sand Lake and Lava Lake, before opening into the broad east-west Nass River Valley south of New Alyansh.

This route is prone to low ceilings. Due to the rise in terrain levels north bound, a southerly flow creates upslope conditions. If even a scattered layer of low cloud below 700 feet is reported at the Terrace Airport when they are reporting a light southerly wind, the Kalum River Valley is likely socked in up to Kitsumkalum Lake. Low cloud also tends to plug this route where the same effect occurs just north of Sand Lake.

The broad Nass River Valley, while generally offering good flying conditions, is subject to low ceilings and poor visibility under a moist southwest flow off the Pacific.

With inflow up the Nass Valley, expect to encounter poor flying conditions just south of New Aiyansh where the route from Terrace enters the Nass Valley.

New Hazelton to Meziadin via the Kispiox River Valley or the Kitwanga River Valley



Map 4-51 - Hazelton to Meziadin via the Kispiox River Valley or Kitwanga River Valley to Dease Lake to Watson Lake

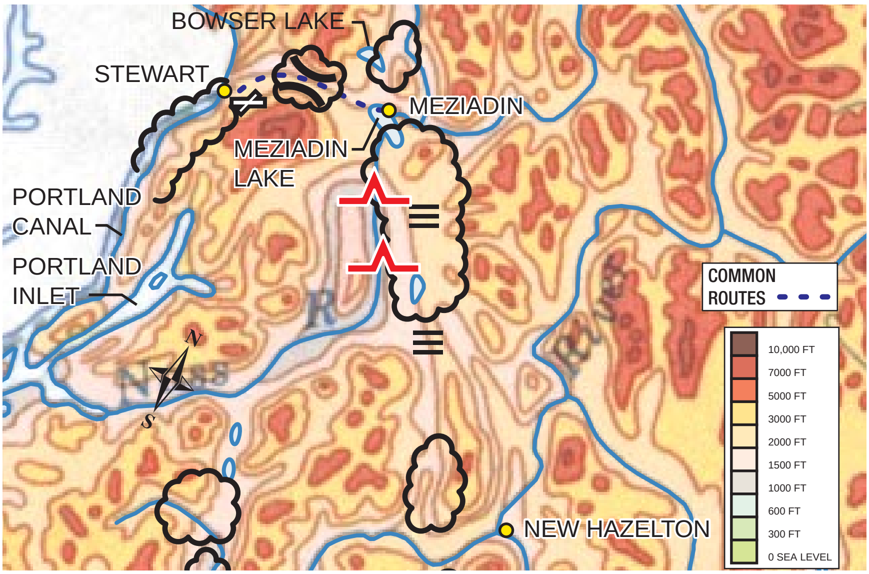
The route goes directly north from New Hazelton follows the Kispiox River Valley to where it joins the Nass River Valley near Swan Lake. The Kitwanga River Valley route starts north from the Skeena River Valley approximately 20 n. miles west of New Hazelton and joins the Nass Valley in the same area. The weather along both the Kispiox River Valley and the Kitwanga River Valley (the route of Highway 37) is relatively uniform, both topographically and meteorologically. Both routes usually offer good flying conditions; however, the area just south of Kitwancool Lake (in the Kitwanga Valley), has been singled out as more prone to low cloud, under a southerly upslope flow.

Both routes north merge in the Cranberry Junction, Swan Lake area of the Nass

Valley. Here the Nass Valley continues north to Meziadin Lake. The terrain is generally flat and fairly swampy and the route is susceptible to low cloud.

The frequent invasions of pacific moisture flowing up the Nass Valley from the southwest, particularly in the fall, often bring low ceilings and poor visibility. Radiation fog is common in autumn, but its frequency diminishes as sources of open water begin to freeze over with the approach of winter. Except in times of dry cold outflow, low cloud is an almost constant problem in fall and winter.

Meziadin to Stewart



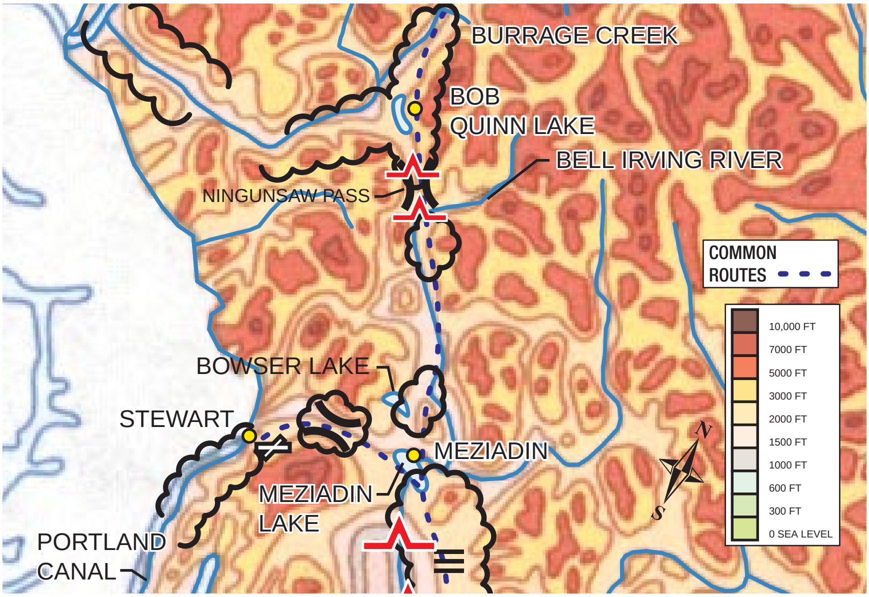
Map 4-52 - Meziadin to Stewart

Though well inland from the coast, Stewart lies just above sea level at the north end of the long Portland Canal. Between Meziadin and Stewart the Bear River Valley cuts through the Coast Mountain Range with peaks either side to almost 9,000 feet ASL.

The Bear River Valley (the route of Highway 37A) from Meziadin Lake to Stewart is spectacular, but, unfortunately, it is often filled with low cloud and fog, as is the Portland Canal south of Stewart. The Bear Pass itself is also very narrow. Fixed wing aircraft cannot usually turn around in the pass and, especially when west bound, should be confident of conditions at the west end of the pass before entering. When there are strong inflow or outflow winds, turbulence should be expected, especially between American Creek and Meziadin,

Weather observation at Stewart should be examined for an idea of conditions near Meziadin.

Meziadin to Bob Quinn Lake



Map 4-53 - Meziadin to Bob Quinn Lake

North of Meziadin the route leaves the Nass Valley and joins the Bell Irving River Valley north to the Ningunsaw Pass. The Ningunsaw River flows down from the pass to the northwest to join the Iskut River Valley just west of Bob Quinn Lake.

Low cloud often closes the route just north of the Meziadin Junction, as well as in the Ningunsaw Pass south of Bob Quinn Lake. Low cloud and fog will frequently linger in the vicinity of Bowser Lake, especially in the fall.

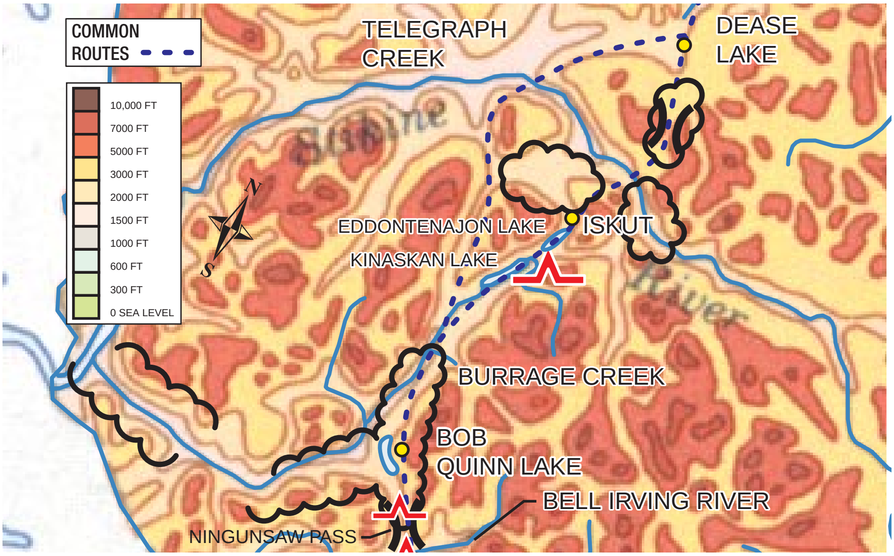
The higher terrain across the Nigunsaw Pass, between the Bell Irving River Valley and the Iskut River Valley, can be a bottleneck along this route due to low ceilings and poor visibility. This usually occurs in conjunction with an inflow of moist pacific air up the Iskut River Valley from the coast.

Pilots usually refer to the two road bridges across the Bell Irving River as Bell 1 and Bell 2, with Bell 1 being the one further south. The valley north of Bell 1 to, and including the Nigunsaw Pass, is in a very heavy snowfall belt. In winter it has been know to receive some of the heaviest snowfalls in northwest BC.

Under inflow conditions, low cloud will often plug the Iskut River Valley south of Bob Quinn Lake and sometimes extend as far north as Burrage Creek, closing the route west to Wrangell. The low cloud tends to envelop this area before it reaches Smithers or even Terrace.

The weather observations at Stewart and Wrangell, though well west of the route, are the only indicators of weather conditions for the route. Any precipitation usually closes these northern valley routes.

Bob Quinn Lake to Dease Lake



Map 4-54 - Bob Quinn Lake to Dease Lake

North of Bob Quinn Lake, the commonly used air route follows the broad flat Iskut Valley north on a gradual climb past Burrage Creek to Natadesleen Lake. The route then branches either to the northeast along Highway 37 to Kinaskan and Eddontenajon Lakes and through Iskut, or north-northwest to meet the Stikine River north of Telegraph Creek.

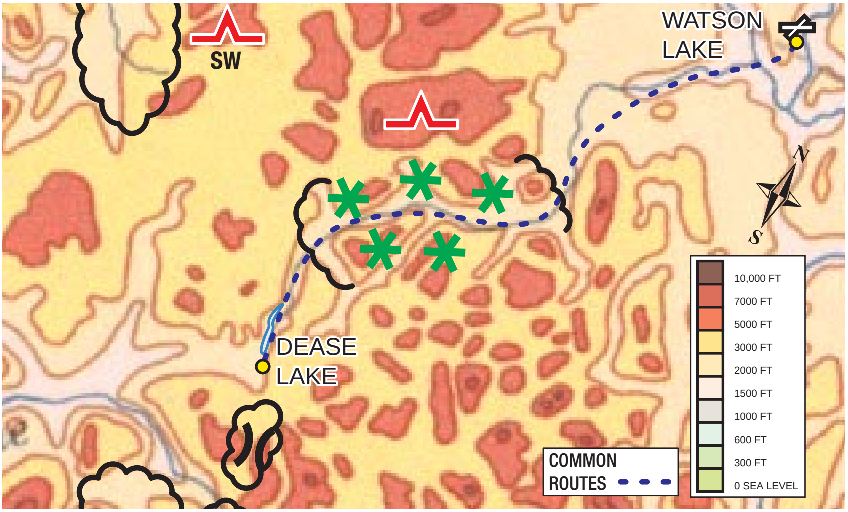
The route north climbs over a pass just north of Iskut and then crosses the east-west Stikine Valley. On the north side of the valley it once again climbs over a pass and drops into the valley at Dease Lake. The more westerly route turns east when it meets the Stikine River and follows its valley and the Tanzilla Valley to Dease Lake.

Inflow up the Iskut Valley often leads to upslope low cloud at Bob Quinn Lake and up the valley to Burrage Creek. The steadily rising terrain along the Iskut route causes ceilings to lower while flying north. Low cloud and fog are frequently encountered in the vicinity and just north of the higher elevation pass, north of Iskut. The high pass just south of Dease Lake can be closed by low cloud with little or no cloud in the surrounding areas. This route is rarely open in marginal conditions.

The alternate route from Natadesleen Lake to just north of Telegraph Creek, then northeastward along the Stikine and Tanzilla River Valleys, is lower in elevation and often avoids the lower cloud and fog blocking the passes.

The weather report from Ketchikan Airport, Alaska can give some idea of the weather in the region of Meziadin. If there is low cloud at Ketchikan along with a westerly wind component, both routes are likely closed.

Dease Lake to Watson Lake



Map 4-55 - Dease Lake to Watson Lake

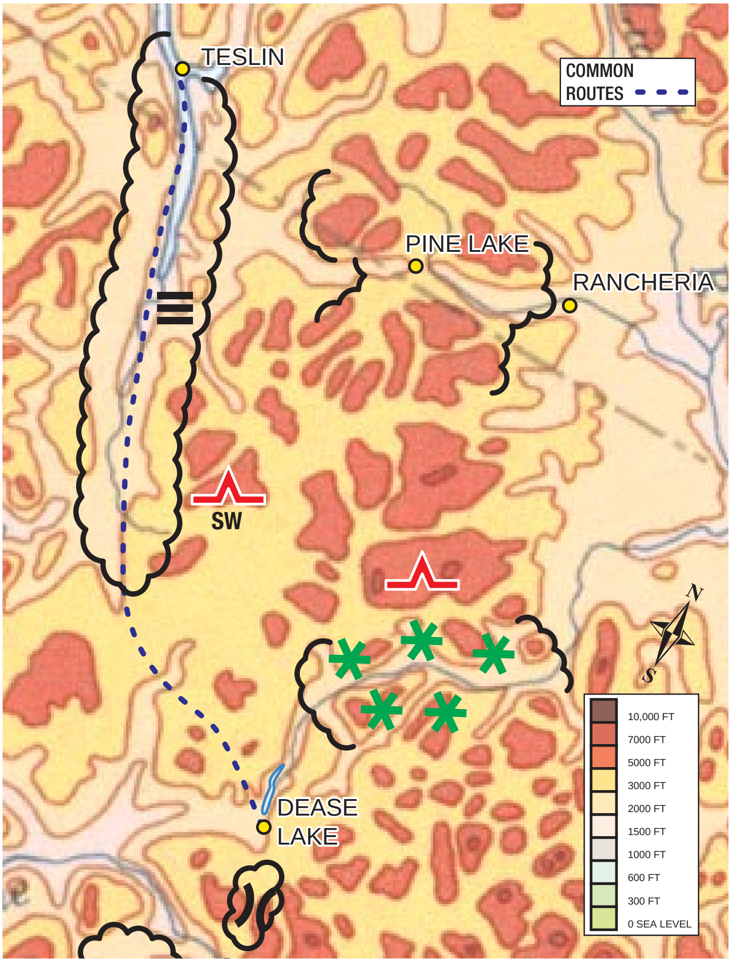
Following the Dease River north, this route climbs over a major upslope regime on the southwest side of the Cassiar Mountains. At the junction of the Cottonwood and Dease Rivers the route follows Highway 37 north as it climbs over the ridge of the Cassiar Mountains. Most aircraft, however, follows the much wider Dease River Valley more to the northeast through the mountains and then curling back to the northwest and out on to the plateau near Watson Lake.

Low cloud and fog are common over Dease Lake in the autumn. With systems tracking in from the west and southwest, heavier precipitation and more frequent cloud are generally experienced in the upslope area on the western side of the Cassiar Mountains. Also a strong southwest flow aloft can generate significant turbulence to the lee of higher terrain just north of Dease Lake, in the area between Joe Irwin Lake and the Cottonwood River.

North of the mountains, near Four Mile River, the floor of the Dease River Valley becomes wide and flat as it opens into the plateau. Fog and low cloud are common over these flat lands and right up to Watson Lake, especially in the fall. However, they occur much less frequently after freeze up.

There is little or no weather information along this route. Any system activity arriving from the Gulf of Alaska will likely cause precipitation in the mountains and close the route.

Dease Lake to Teslin

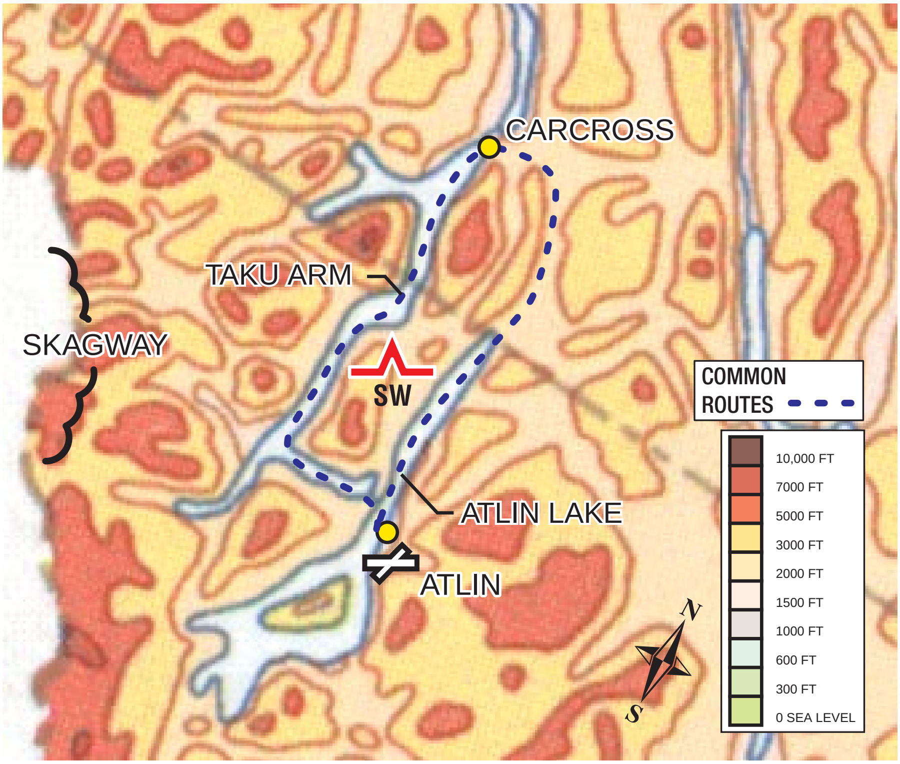


Map 4-56 - Dease Lake to Teslin

Under fair weather conditions, this section of northwestern British Columbia can be scenic and beautiful; however, under poor or deteriorating weather conditions, the daunting reality is that this vast, sparsely populated wilderness area has few airports or roads and little or no reported weather.

Weather permitting, pilots will sometimes fly from Dease Lake northwest to the Teslin River Valley, then northward along the Teslin valley to the community of Teslin. Moisture from the numerous lakes and rivers that dot the Teslin River Valley contribute to frequent low cloud and fog in the fall and spring. Strong west or south-west winds can generate significant turbulence to the lee of the Coast Mountains and higher interior terrain.

Atlin north to the Yukon Border

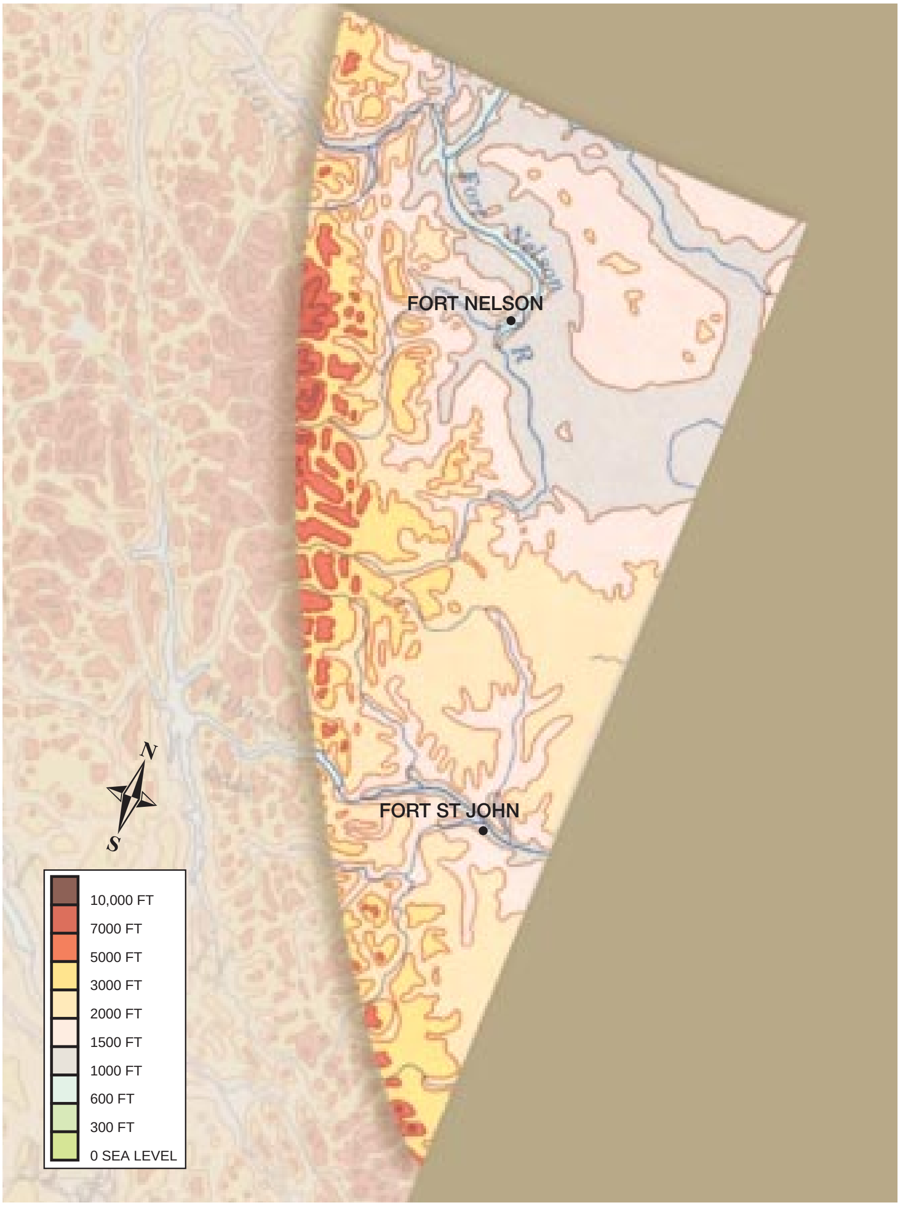


Map 4-57 - Atlin north to the Yukon Border

This route follows the highway north along Atlin Lake to the Yukon border or, alternately, northwest across the pass at Jones Lake to Taku Arm. These large lakes are subject to strong winds and rough surface conditions.

A strong southerly flow does not generally produce significant turbulence; however, a strong southwest flow will usually result in areas of moderate turbulence to the lee of higher terrain along the west side of the Atlin Lake, especially near Atlin Mountain and Mt. Minto.

Northeast British Columbia



Map 4-58 - Northeast British Columbia

Northeast British Columbia is an extension of the Canadian Prairies. As such it experiences weather which can vary between typical mountain weather to Prairie conditions, depending on the overall flow pattern.

(a) Summer

The best flying occurs in the late spring to early fall months. During this period, the weather in general is consistently good for flying. The most prolonged periods of bad weather will often occur when a cold low moves across the Central Interior of BC, producing an easterly upslope flow over the area. At these times, widespread low ceilings and prolonged precipitation will occur and at times will last for twenty-four hours or more.

This area is also marked by frequent thunderstorms which, due to the plateau type of terrain, often reach their full intensity. While airmass thunderstorms still remain the predominant type, frontal thunderstorms and nocturnal thunderstorms are common. The typical scenario would see the beginning of thunderstorm activity early in the afternoon and for it to persist well into the night. Most often the thunderstorms move toward the northeast and, given the right conditions, their intensity can reach the severe level. The normal thunderstorm season for both areas is June to August.

Another phenomenon, which is typical to the prairies, is the development of a low-level nocturnal jet. (Most common in spring and summer months, this feature occurs on clear nights following strong, gusty winds in the previous afternoon.) As the sun sets, a low-level temperature inversion forms. The strong winds remain several hundred feet off the ground while surface winds become calm. In some cases, the winds just above the ground can be stronger than the afternoon gusts. The inversion will often deepen during the night to as high as 1,000 feet above ground, before eroding away the following morning.

(b) Winter

Winter flying conditions can be quite variable. The northeast section of British Columbia is subject to widespread valley cloud only during the early part of the season, usually until the lakes and rivers freeze over completely. Of particular note is the Peace River near Fort St. John, which can remain open for prolonged periods during the winter, resulting in low cloud and fog that can move into the airport with little notice.

Fronts arriving from the coast tend to move across the area and weaken due to subsidence to the lee of the Coastal Mountains. They will; however, still give steady or intermittent precipitation whose type will vary depending upon local temperatures. Accumulation of precipitation is usually light in comparison to the coast. In situations where warm air is overruning entrenched cold air on the surface, status cloud tends to form, often becoming both widespread and reluctant to lift. Patchy freezing rain or drizzle occurs on occasion during the winter months, usually developing east of the mountains, especially near the arctic front when it lies along the Continental Divide.

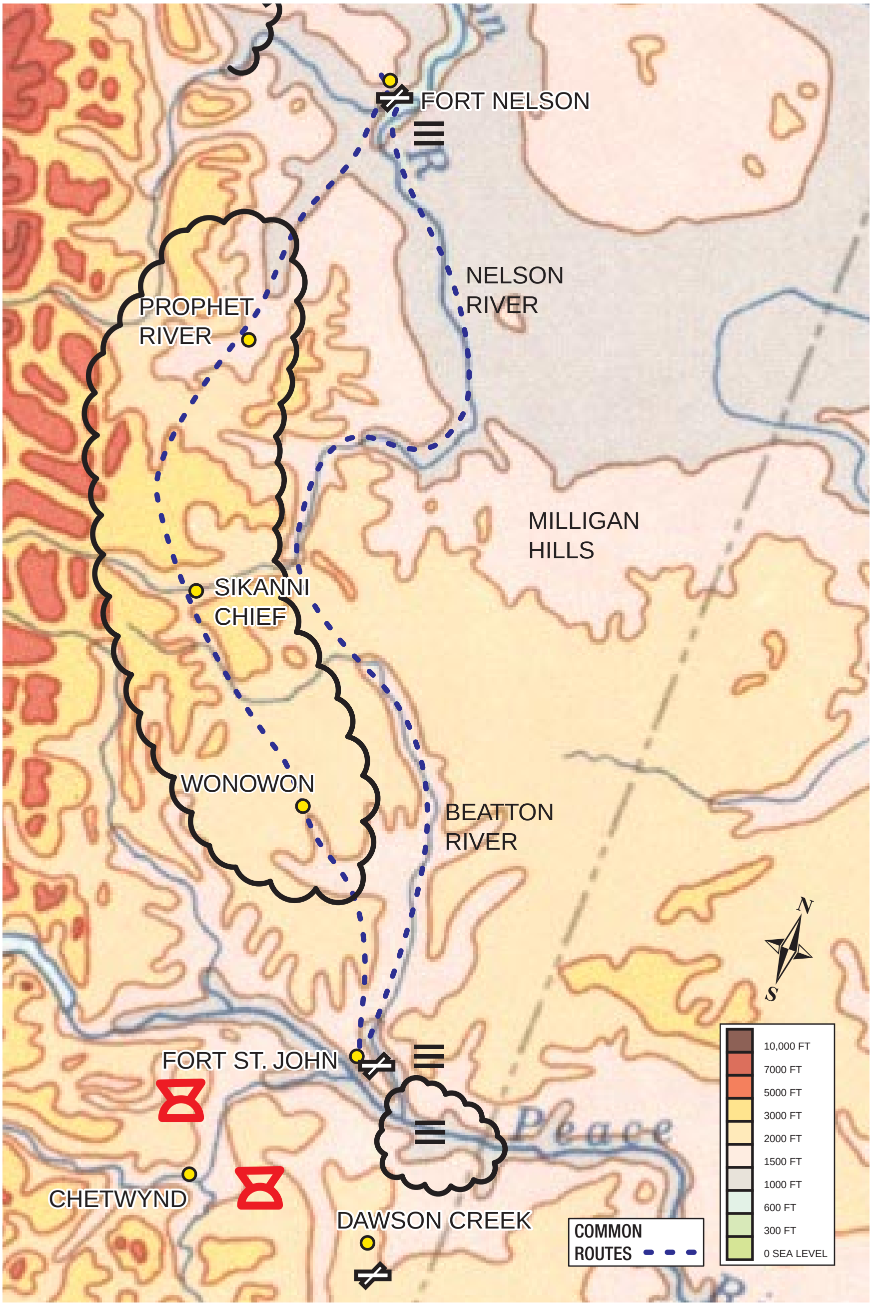
During winter, strong areas of high pressure form in the very cold air over Alaska, the Yukon and the northern end of the Mackenzie River Valley. This cold arctic air moves southeastward across the prairies. Depending on the strength of the arctic front, winds can shift abruptly to the northwest following the frontal passage and be gusty for several hours. This, coupled with local snowfalls, can produce blizzard conditions. Once an arctic ridge is established over the area, widespread clear, cold weather will prevail except for some localized problems with ice fog.

The southern half of this region can experience Chinook conditions, similar to those developing across southern Alberta and northern Montana. The effect is often most pronounced and occurs with greatest frequency close to the Rockies, near Chetwynd. When an arctic high-pressure system lies to the east of the Rockies, an intense shear zone can develop as strong southwesterlies aloft blow over surface based easterly winds. Across the shear zone there is usually a very sharp temperature inversion. In some cases, surface temperatures can be twenty degrees colder than those found several hundred feet above ground. In such cases, even in clear air, frost can form on the plane, particularly on the cockpit windows, while ascending into the warmer air aloft. Chinooks seldom occur in the Fort Nelson area as the arctic air is usually well entrenched. Some of the sharpest low level temperature inversions occur over Fort Nelson in winter, sometimes as much as a 30 degree change in less than one thousand feet. This can cause significant fog or frost on exterior surfaces on ascent. Pilots have reported parallax errors on descent. As you lower through the inversion, the line of sight becomes distorted, with the view appearing to shift and magnify.

The strong southwesterly flow aloft that produces the Chinook conditions also produces lee waves and associated turbulence. However, given that the mountains are slightly lower and the range is considerably wider, these lee waves possess less energy than those found over Southern Alberta. Despite this, the ride will often be very rough, up to approximately 8,000 feet, if winds across the mountains exceed 25 knots. This lee wave activity does not generally extend north of 59 degrees north latitude due to the fact that the mountains lose their linear characteristic.

(c) Local effects

Dawson Creek to Fort Nelson



Map 4-59 - Dawson Creek to Fort Nelson

There are two commonly used routes between Dawson Creek and Fort Nelson. The more easterly one follows the railway line via Beatton River and runs mostly across open plains. The more westerly route via Highway 97 climbs onto a ridge at Wonowon, runs north past Sikanni Chief and then drops back to the plain south of Fort Nelson at Prophet River.

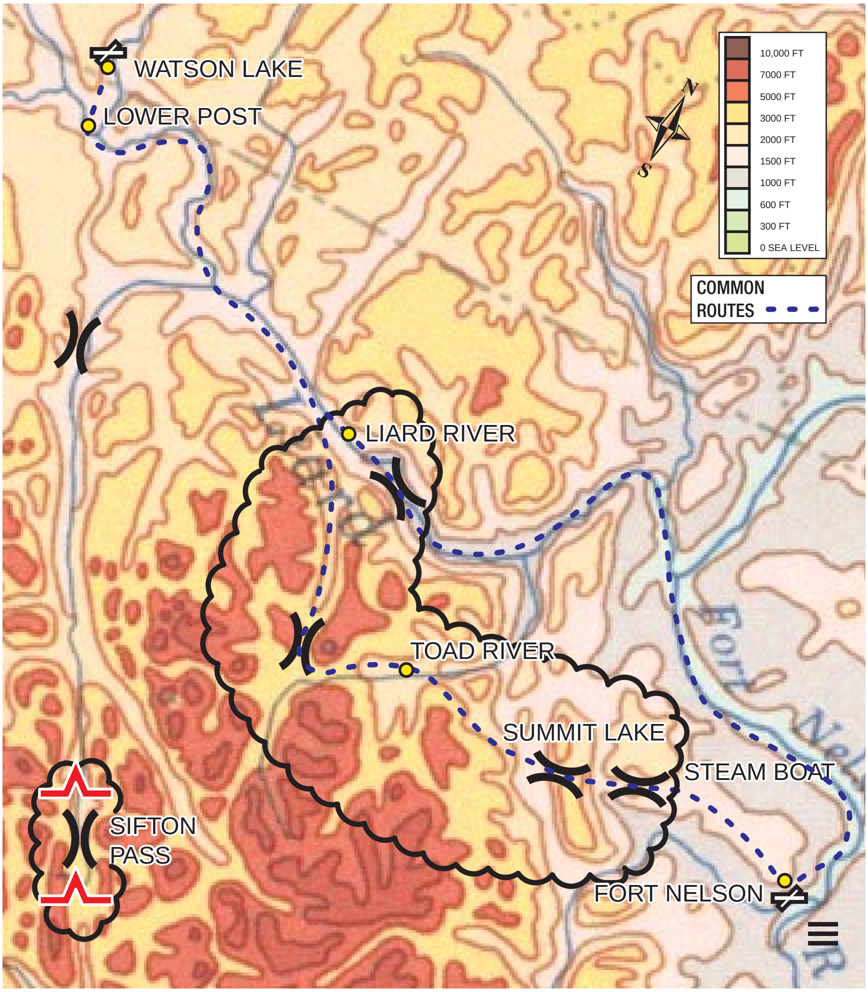
The gently rising terrain 10 to 15 miles south of Fort St. John will at times become shrouded in low cloud. Morning fog, which often forms along the Peace River Valley, tends to be more frequent at Fort St. John than surrounding airports. The fog usually extends to just north of the Fort St. John Airport.

North of Wonowon, the route following Highway 97 runs along the rising ground to the southwest of the open plains. This section is much more prone to low cloud when there is a low-level flow from the northeast quadrant, as these winds cause orographic lift along the upslope terrain. As a result, the high ground between Wonowon and Prophet River may be obscured while Fort St. John and Fort Nelson both report clear conditions.

Hills to the east and mountains to the west form a natural lowland area along the more easterly route via the Beatton River and the railway to Fort Nelson. Many pilots choose this route when the surface winds are from the north to east quadrant, to avoid the conditions of upslope flow further west.

The Fort Nelson Airport is in a hollow at the confluence of three rivers and, thus, experiences more frequent fog than surrounding areas. It also tends to have lighter winds than the surrounding region. However, expect moderate turbulence in the area when the airport reports strong westerly winds.

Fort Nelson to Watson Lake



Map 4-60 - Fort Nelson to Watson Lake

There are two routes commonly used between Fort Nelson and Watson Lake. The one following the Alaska Highway runs west from Fort Nelson into the hills and climbs over a pass at Steamboat of 3,500 feet ASL and then another of over 4,600 feet just west of Summit Lake. It then winds its way through the hills over two lower passes at about 3,600 feet, before joining the Liard River Valley.

The other route follows a northwesterly heading out of Fort Nelson along the Fort Nelson River to where it meets with the Liard River. Pilots then follow the river to Liard River crossing and the highway to Watson Lake. This route avoids the higher passes and is the preferred route when the higher terrain is obscured. Though the preferred route in marginal weather, it passes through very narrow valleys east of Liard

Hot Springs. As it is difficult to turn around in these valleys, pilots should not enter them if they cannot see through them.

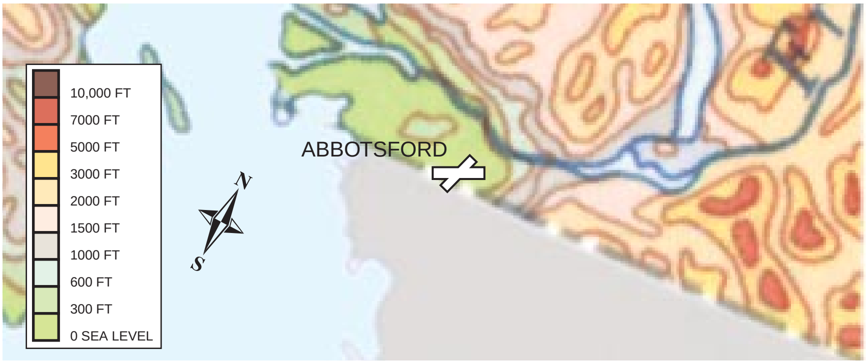
Along the highway route, the weather between Steamboat and Liard River often bears little resemblance to that at either Fort Nelson or Watson Lake. If low cloud is present at Fort Nelson or Watson Lake, this route is almost certainly closed. Even with clear skies at both ends, the route may be impassable. Some of the worst weather is typically encountered between Summit Lake and the pass west of Toad River.

Chapter 5

Airport Climatology

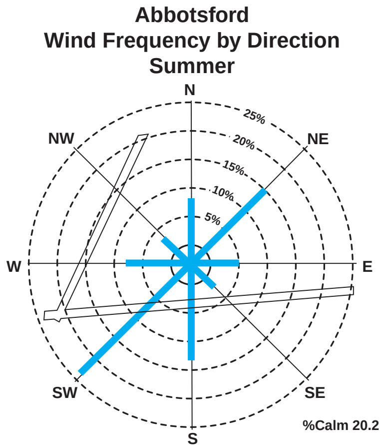
British Columbia

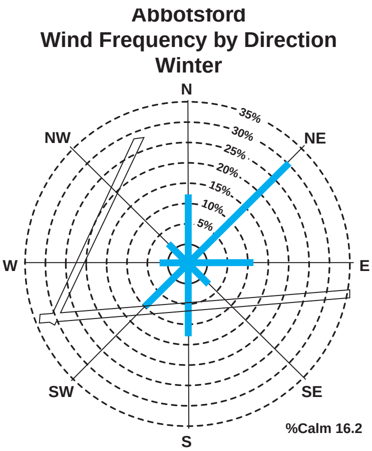
(a) Abbotsford



Abbotsford is located in the Fraser Valley, approximately 30 nautical miles east-southeast of Vancouver. The river valley in which the airport lies is quite broad at this point, with tree-covered peaks ranging from 3,000 to 4,000 feet ASL within 8 to 15 miles northeast into the southeast. Abbotsford International Airport sits on a slight rise of land just to the southwest of the city. Northeast of the airport, across the Trans-Canada Highway, is Sumas Mountain that rises to approximately 3,000 feet.

To the west of the airport is a rolling terrain containing agricultural and urban areas. To the east is a flat plain known as Sumas Prairie, which was formed from an old lake bottom and is now primarily used for agriculture.



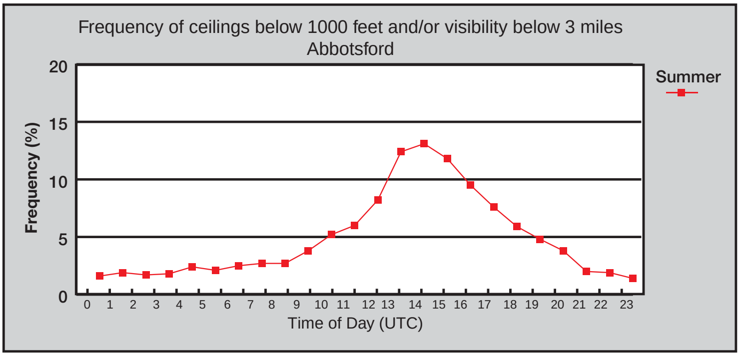


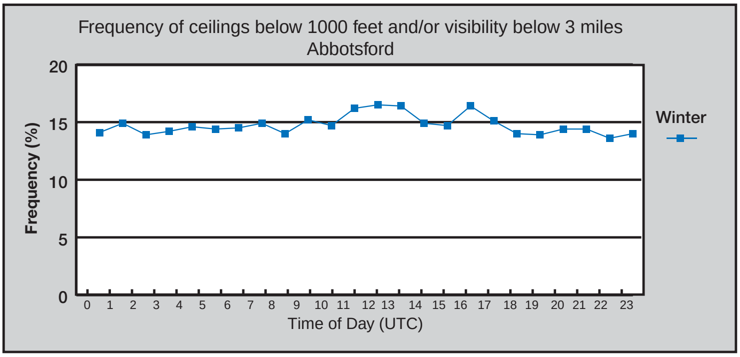
The winter winds show a strong bias to blowing either from the northeast to east, or from the south to southwest. Northeast winds are very common and can be attributed to a cool katabatic flow that comes out from the eastern end of the Fraser Valley and curls around Sumas Mountain. Typically, this wind will only be in the 5 to 10 knots range except in the case of very strong outflow conditions. If it is snowing or there is dry snow on the ground, the winds will produce blizzard-like conditions over the Sumas Prairie with the main core of strong winds passing just to the southeast of the airport. During these events, the winds will typically be northeasterly 10 to 20 knots at the airport. When low pressure systems or fronts approach the South Coast, there is a tendency for these winds to take on a more easterly direction and increase in strength. The south-southwest winds most often occur behind frontal systems as they move eastward into the interior. Other directions can occur but they are infrequent and tend to be light.

The summer winds show the same bias for northeast and southwest direction as the winter winds. However, in this case the most common direction is south to southwest. This is a sea breeze that often sets up in the mid-late afternoon. Frequently in the order of 10 to 20 knots, it will also have slightly stronger gusts. This sea breeze tends to die down in the mid-evening and by midnight the northeasterly katabatic wind will have re-asserted itself. Even the passage of a summer front will show little change in the bias to certain wind directions. Other directions can occur but they are infrequent and tend to be light.

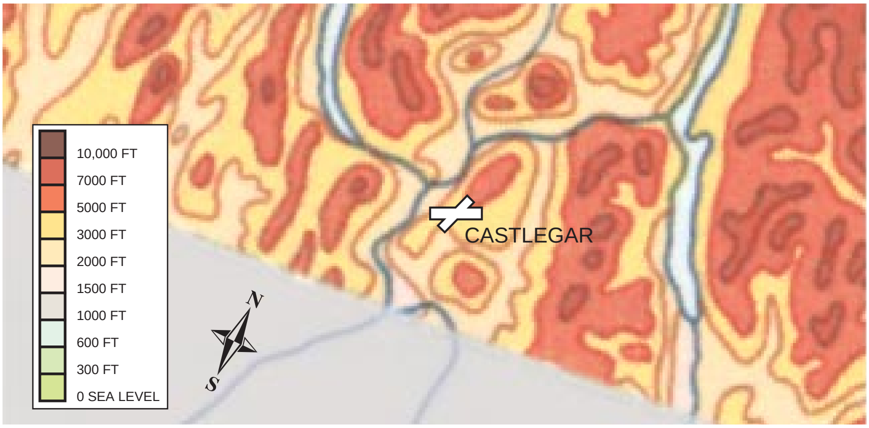
The occurrence of low ceilings and visibility in the winter months is almost uniform for any given hour, somewhere between 14 to 17 percent. This is because the major cause of low conditions is weather systems moving across the area, which have no diurnal pattern. Fog can be a problem at times, especially if it advects up from the Bellingham area in Washington but, for the most part, the most common cause of low ceilings is the frequent and prolonged periods of rain.

Summer tends to be the best time of year at Abbotsford. While cloud ceilings of 2,000 to 4,000 feet can be fairly common, below VFR conditions are rare. For the most part, they are related to passing weather systems with a slight component due to radiation fog.



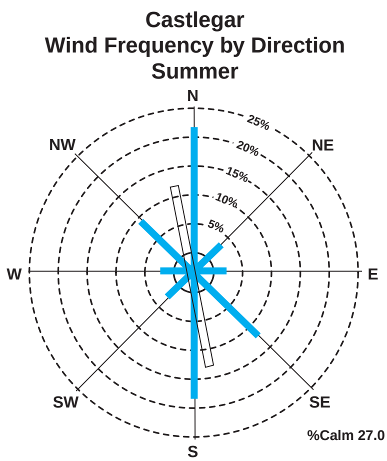


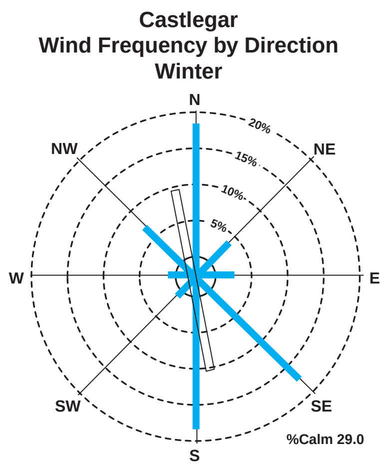
(b) Castlegar



Located in southeastern British Columbia, Castlegar is located in a narrow valley on the east bank of the Columbia River, approximately 2 nautical miles southeast of the city of Castlegar. The Columbia River runs north to south and joins the Kootenay River about 3/4 mile north of the airport. Other communities in the area are Trail (11 miles southwest), Rossland (14 miles southwest) and Nelson (17 miles northeast).

The terrain immediately surrounding the airport is that of a relatively flat bench that falls away to the Columbia River, in the west, and to the Kootenay River, in the north. However, beyond this, the area is hilly, mountainous and thickly wooded. The bases of the mountains are just over 1/2 nautical mile to the east and just under one mile to the west. Significant local elevations are Sentinel Mountain, which rises initially as a 2,500-foot cliff, 1-1/2 miles north-northeast of the runway, then slopes to a peak elevation of 5,645 feet ASL about 6 miles from the airport; Siwash Mountain, 7,600 feet ASL, 7-1/2 miles to the northeast; and Mount Mackie, 7,100 feet, 7-1/2 miles to the west-southwest.

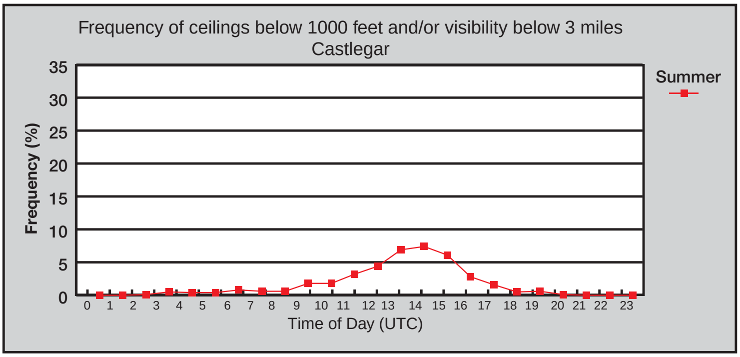


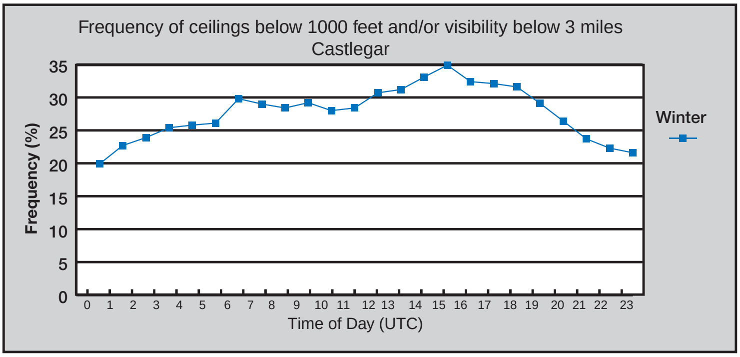


The winds at Castlegar show strong channelling by the terrain, both during the summer and winter. From the graphs, it is evident that the predominant winds are either from the north or south, about 20 percent of the time for each direction. The wind can alter slightly in northwest or southeast directions, with the southeast wind more common in the winter as it moves up the Columbia River Valley. All other directions are rare. It is worth noting that calm winds occur on an average of 28 percent of the time, summer and winter.

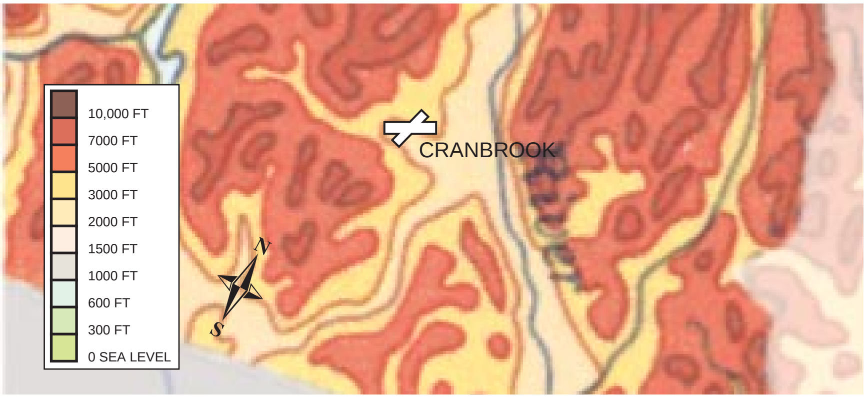
Low ceilings and visibility can be a problem in Castlegar during the winter. Like most of the valleys in the Southern Interior, the presence of water makes valley cloud a common phenomenon. However, with a pulp-and-paper plant along the Columbia River to the northwest and a large smelter operation in Trail to the south, the additional moisture and condensation nuclei make low ceilings a persistent problem. Below VFR conditions occur on an average of 20 to 25 percent for most hours of the day, rising to a peak of almost 35 percent at 1500 UTC, which coincides with the time of maximum cooling. Interestingly enough, the occurrence of ceilings less than 2,500 feet and/or visibility less than 5 miles ranges between 35 and 58 percent, depending on the time of day. This means that Castlegar, with its high landing and takeoff limits, can be closed to commercial traffic for prolonged periods while local pilots are flying VFR under the cloud deck.

The summer is a much more pleasant story. The valley tends to be dry and hot much of the summer. As such, the occurrence of low ceilings and visibility is very low, less than 3 percent, for most hours. There is a slight peak of around 7 percent at 1500 UTC, and most often this is smoke trapped below the nocturnal inversion. This tends to be a short-lived problem and has disappeared by mid-morning.





(c) Cranbrook

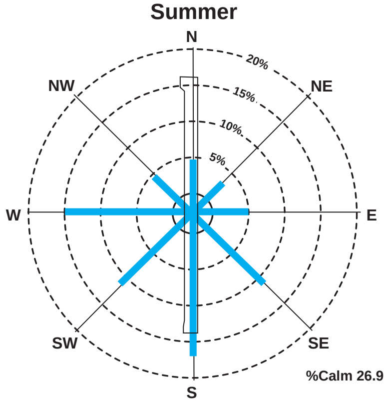


Cranbrook Airport is situated on a rolling plateau, approximately 5-1/2 nautical miles north-northwest of the city of Cranbrook, in the southwest BC Interior. The only other urban centre in the area is Kimberley, 9 miles to the west-northwest.

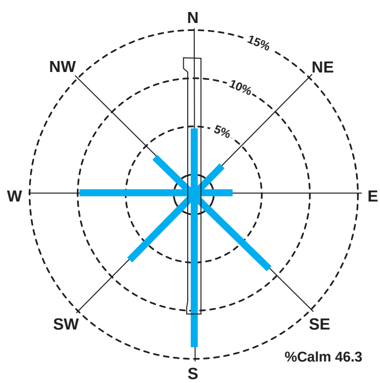
Two main rivers run past the airport, the St. Mary River and Kootenay River. The St. Mary River runs in a general easterly direction and passes one mile south of the airport, while the Kootenay River runs in a general north-northeast to south-southwest direction and passes approximately 5 miles to the northeast. The St. Mary River joins the Kootenay River 6-1/2 miles east of the airport.

Within 3 miles of the airport, the terrain is slightly rolling, then becomes quite mountainous. The Hughes Range, in which Mount Fisher rises to 9,337 feet ASL, is 11 miles east-northeast and dominates the area to the north and east. The McGillivra Range, with a peak height of 7,240 feet, lies 10 miles to the southeast while the Moyie Range dominates the western quadrant, rising to 5,800 feet within 10 miles of the airport.

Cranbrook
Wind Frequency by Direction
Summer



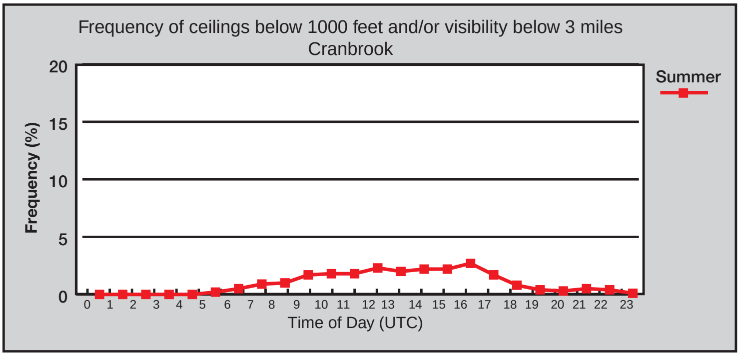
Cranbrook
Wind Frequency by Direction
Winter

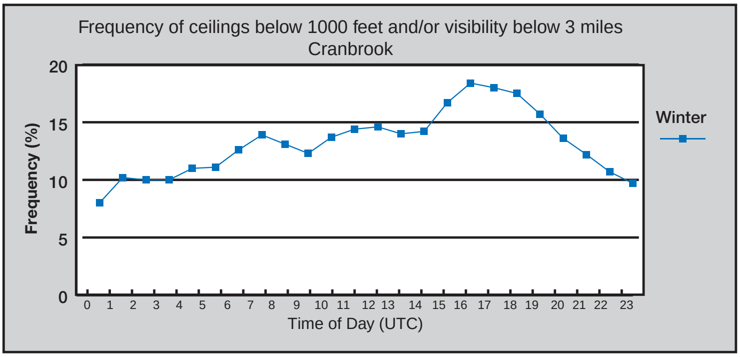


Cranbrook is not a windy location. During the winter months it is calm almost 46 percent of the time and the winds are less than 10 knots almost 90 percent of the time. When the wind does blow it has a strong preference for directions ranging from southeast to west. Winds from the south to west occur most often a few hours ahead and behind frontal systems as they move across the interior. The southeast wind, out of the Rocky Mountain Trench, is often a result of cold air invading from Alberta. This cold air tends to move through the Crowsnest Pass into the Trench. The cold air then tends to flow northwestward filling the Trench.

Cranbrook is slightly windier in the summer, mainly due to local convection, but even so it is calm 27 percent of the time. Like winter, it has a preference for winds from southeast to west. These winds tend to be largely a product of local pressure differences, as well as the movement of frontal systems through the area.

Cranbrook is seldom a problem due to low ceilings or visibility. During the summer, the probability of IFR conditions is less than 2 percent. During the winter, the probability is typically around 10 percent rising to a peak of 20 percent during the morning hours. This increase in probability is a mix between system weather, often snow, and the occurrence of local fog that makes its way onto the airport.





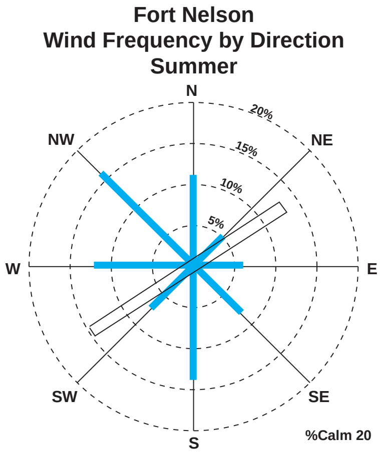
(d) Fort Nelson

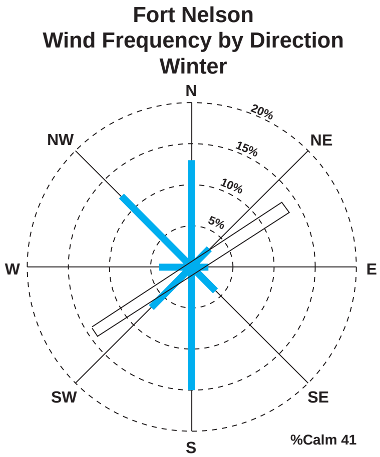
Fort Nelson is situated in the northeast corner of B.C. Straddling the Alaska Highway, it is a favourite stopping point for aircraft following the highway towards Alaska or returning from there.

Situated in a flat valley, the airport is exposed to the full extremes of the Canadian climate. During the winter, arctic air pools in the valley and can hold temperatures at subzero values long after the higher terrain warms up. The sharp inversions these cold pools form are a favourite haunt for widespread low stratus, fog and freezing drizzle.

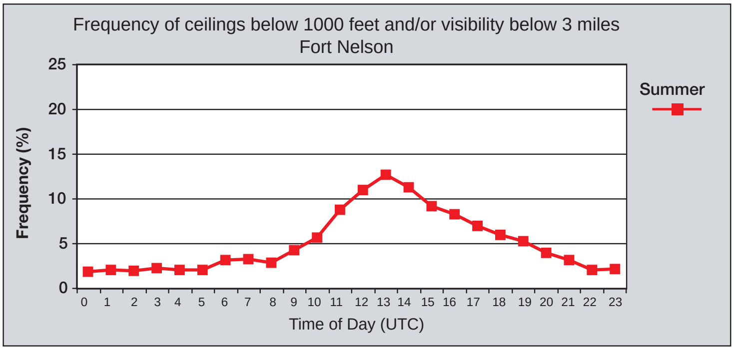
In the summer, the area is also subject to upslope flow resulting in widespread near-IFR conditions. Even when the weather is nice, thunderstorms are a frequent visitor.

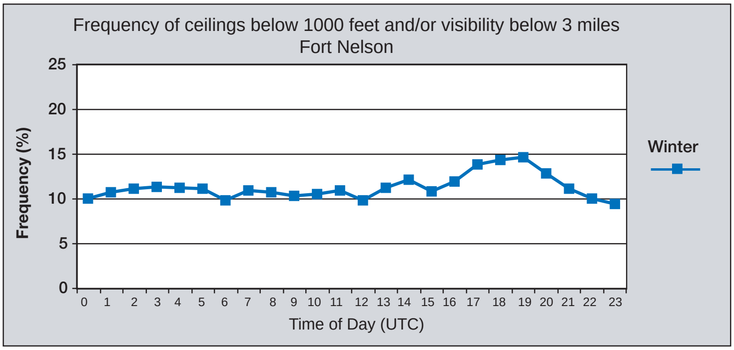
On the plus side, Fort Nelson is not a windy airport. While the winds can blow from almost any direction, about 70 percent of the time they remain at below 10 knots.





It is the low ceilings that offer the greatest difficulty to aviation. While no more frequent than Fort St. John, they can be extremely prolonged at Fort Nelson, going on for days at a time. This serves as a major problem for aircraft wishing to transit through the area.

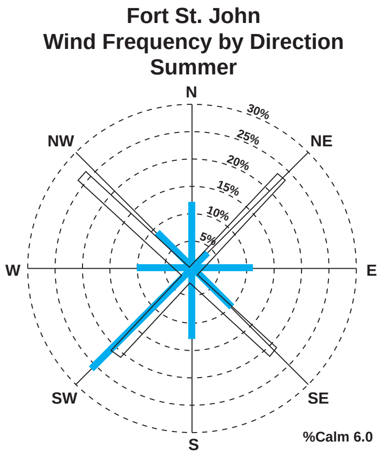


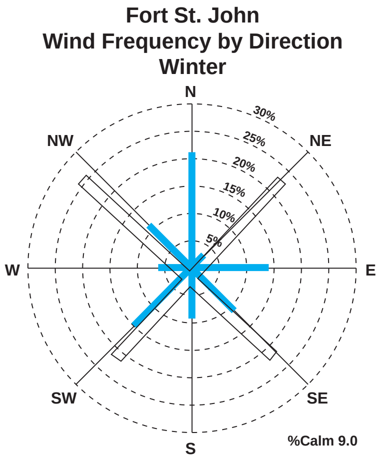


(e) Fort St. John

Fort St. John lies to the east of the Rocky Mountains and shares a climate similar to northwest Alberta. Situated on terrain that slopes gradually towards the east, it is subject to warm, dry summers and cold winters.

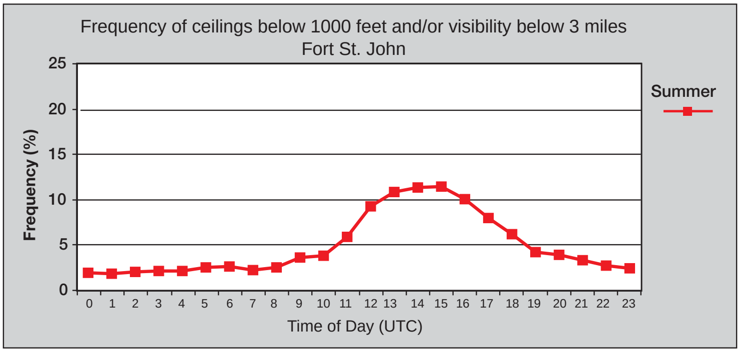
The winds of summer show three distinctive axes. The northerly winds occur quite frequently when a cold front moves southward through Alberta. Confined by the Rockies, the cooler air has little choice but to flow southwards along the mountains. The most common wind, the southwesterly, is a 'chinook-type' flow. Downslope off the Rockies, these winds tend to be strong, gusty and warm. They also usually provide excellent flying weather. The wind that offers the greatest problem is the east or southeast wind. This wind is upslope and often brings with it widespread low ceilings and visibility in precipitation and mist.

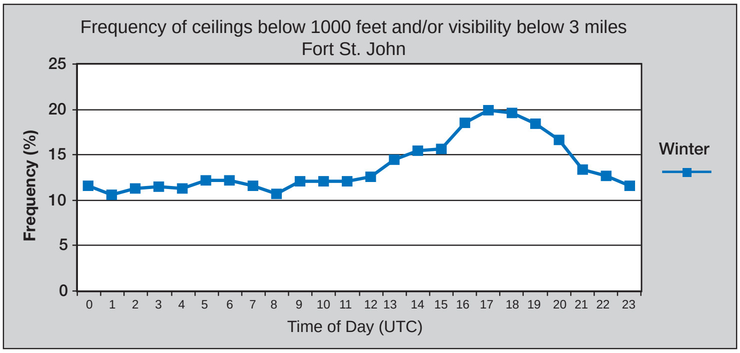




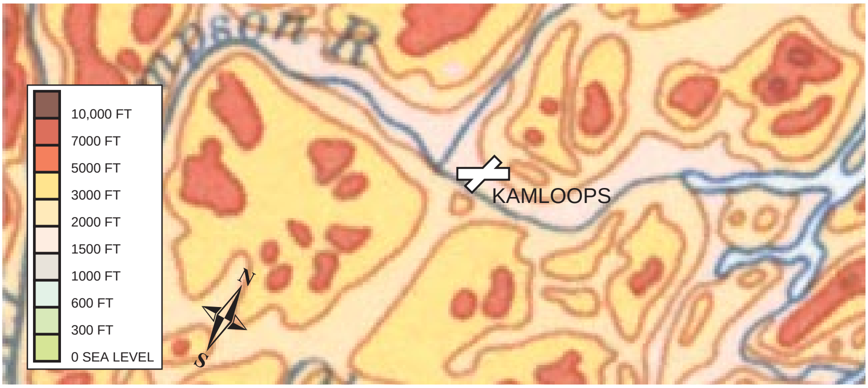
The winter winds show a stronger preference for the cold northerlies, usually associated with the arctic front. Another common wind is the warm southwesterlies. The result is that the entire area is subject to wide swings in temperature. The northerlies can be a problem if the cold air is moving slowly. In such a case, Fort St. John can receive a prolonged period of low ceilings and visibility in snow. Meanwhile, the east or southeast winds continue to be a problem in that there is a river to the southeast of the airport that remains open most winters. Fog banks form over this water and the wind carries it into the airport.

The following ceiling and visibility graph for Fort St. John confirms these periods of below VFR operations but also reveals that the occurrence is not all that frequent.





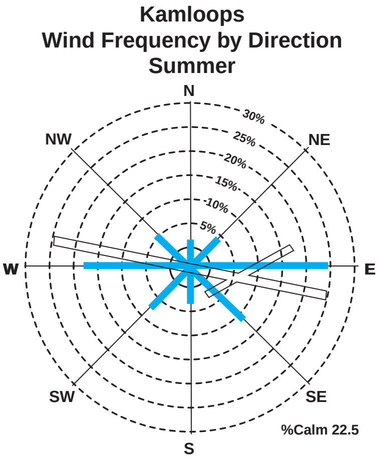
(f) Kamloops

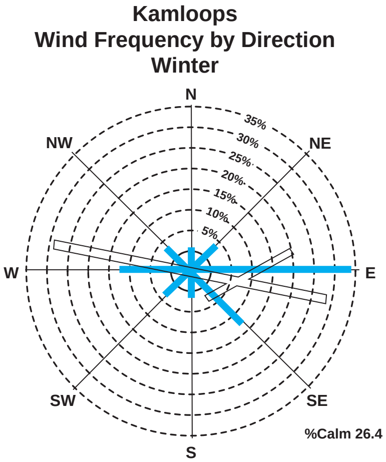


Kamloops Airport lies on the floor of the Thompson River Valley, a deep, narrow valley oriented in an east-west line. The site is about midway between the southern and northern branches of the westerly flowing river. The centre of the city of Kamloops lies approximately 5 miles to southeast, on the southern banks of the Thompson River.

From the valley floor, hills rise rapidly to heights of 3,000 to 4,000 feet ASL, which in turn give way to even higher ridges and peaks beyond 9 miles of the airport. Porcupine Ridge, 19 miles to the north-northwest, rises to 6,100 feet ASL; Mount Lolo, about 13-1/2 miles to the northeast, attains 5,500 feet; Chuwheels Mountain, nearly 11 miles south-southwest of the airport, is 6,233 feet; and, Greenstone Mountain, 9 miles to the southwest, rises to 5,883 feet ASL.

The hillsides up to an elevation of 3,000 feet ASL are grassed, with little or no tree growth. The higher slopes and plateau are where pine and spruce forests thrive.



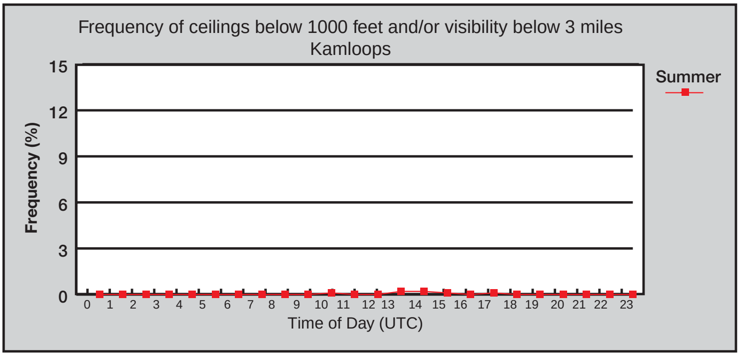


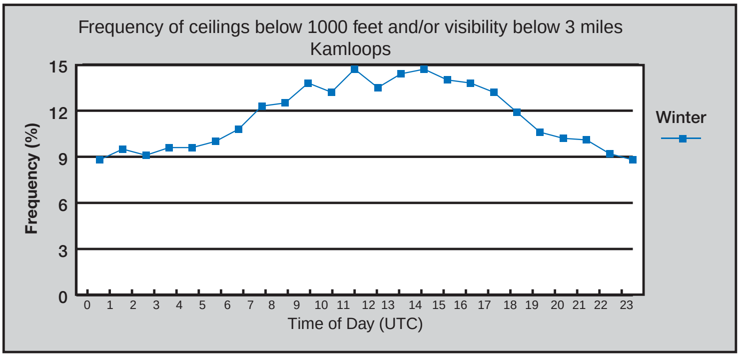
The winds at Kamloops Airport show the effects of the east to west orientation of the Thompson River Valley. During the winter months, the wind is easterly almost 35 percent of the time or calm 26 percent of the time. These easterly winds are a product of katabatic winds that develop along the local slopes most nights, converge in the valley bottom and flow towards Kamloops Lake. Normally these winds are only 5 to 10 knots, but can increase ahead of approaching frontal systems or with very strong drainage of arctic air towards the coast. Westerly winds occur less often and tend to be strong and gusty in the wake of an arctic front.

The terrain continues to influence the direction in the summer but convection gives a larger variation in wind direction. As in winter, the valley has a preference for an easterly drainage wind overnight and during the morning. In the afternoon, convection begins to mix the upper winds down to the surface causing the direction of the wind to shift to westerly. Also, frontal systems which move across the interior at regular intervals, bring wind shifts from east to west with their passage. Some of the strongest westerly winds will occur in this case. It is worth noting that, on occasion, strong subsidence winds aloft are brought down to the surface as south-to-southwest (190-230 degrees true) winds. These winds are not only quite strong but definitely abrupt in their onset.

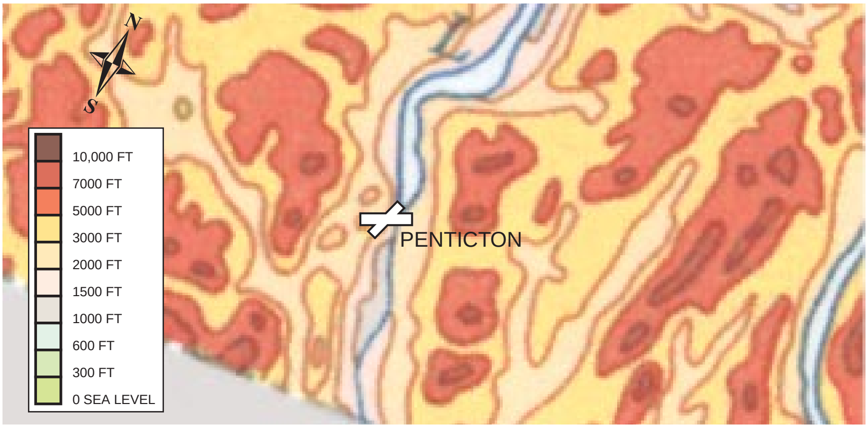
The Thompson River Valley tends to be hot and dry in the summer, creating a need for widespread irrigation. As such, below VFR conditions almost never occur.

The same cannot be said for the winter months. While the area is fairly dry, snow does occur from time to time and valley cloud is all too ready to put in an appearance. Cold air tends to get entrenched in the valley and with it comes valley cloud. Below VFR conditions occur about 10 percent of the time throughout the day with the probability rising to near 15 percent in the early morning, the time of maximum cooling. These statistics do not tell the whole story. The probability of ceilings below 2,500 feet and/or visibility below 5 miles is about 30 to 35 percent and only during the afternoon, the time of maximum heating, does the probability drop to around 20 percent. When you take into account some of the local elevations, this high occurrence of low cloud should make any pilot wary.





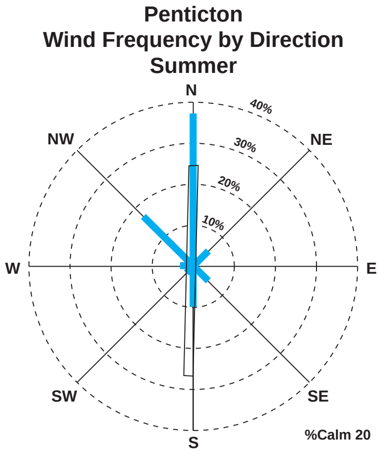
(g) Penticton

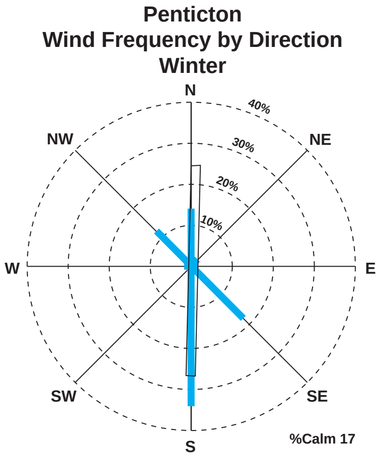


Penticton Airport is located in the Okanagan Valley, a deep, north to south valley in the Southwest Interior of British Columbia.

With such marked terrain influence, it should come as no surprise that most of the time the winds are either northerly or southerly.

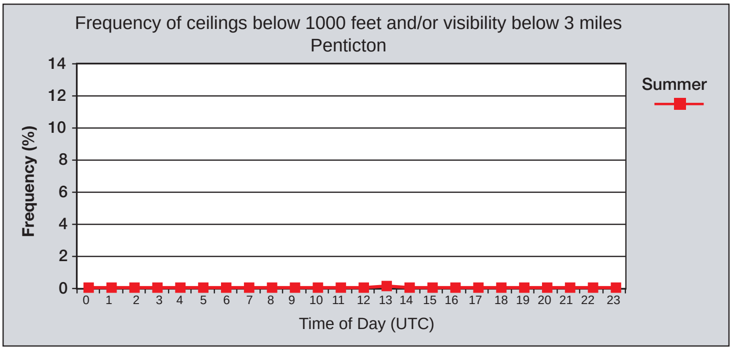
In the summer months, the winds are predominately thermally driven and result in a frequency distribution that is split between north and south. During the day, sunny, hot conditions tend to prevail especially in the south end of the valley. The strong convection produced by this heating eventually carries the predominately southerly winds aloft to the surface, resulting in strong southerly winds that persist into the evening. Overnight, the valley cools but remains warmer in the south, resulting in a weak trough of low pressure. Air begins to drain towards this low resulting in northerly winds that will persist into the morning. On the other hand, if the upper winds are not southerly or very light, a northerly wind will persist for the entire day.

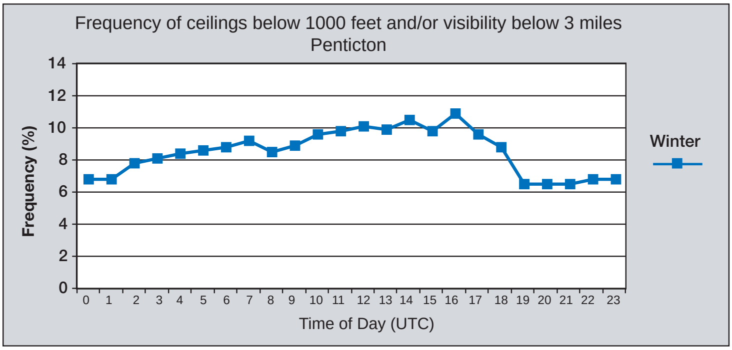




The winter wind pattern is largely driven by pressure gradient. Strong lows and frontal systems moving onto the coast result in significant pressure falls over the province, especially the Central Interior. Strong southerly winds develop through the southern valleys ahead of these systems, especially the trailing cold fronts, then change to a northerly flow in its wake. It should be noted that this wind change will not occur if the pressures to the north of the airport remain lower than those to the south. Northerly winds also occur when cold arctic air spreads into the Southern Interior and drains towards the coast and Washington.

The effects of a drier climate are very apparent in the ceiling and visibility charts for Penticton. Below VFR conditions occur only about 10 percent of the time. Seasonally, these occurrences are almost strictly confined to the winter period and are related to the formation of valley cloud.

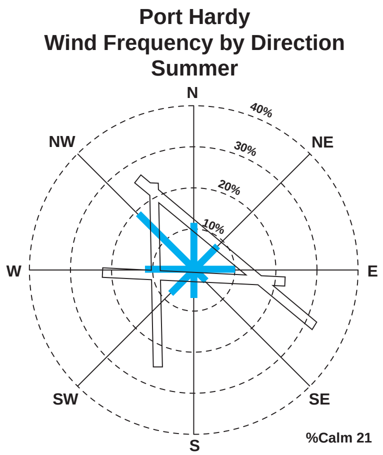


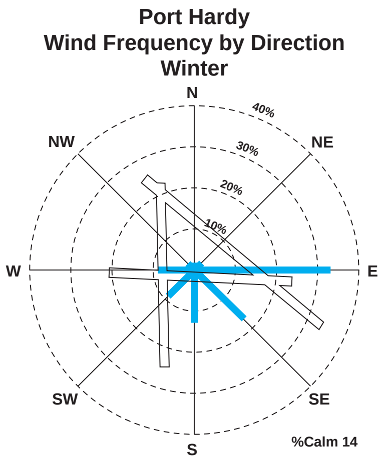


(h) Port Hardy

Port Hardy Airport is located on the northeastern end of Vancouver Island. For aircraft flying north or south along the coast, this airport along with Prince Rupert are key destinations. The airport lies on the western shore of Queen Charlotte Strait with the northern end of the Vancouver Island mountains just to the west of the airport.

Like most other BC airports, the season of the year has a strong influence on the wind. In the summer, the most frequent winds tend to be easterlies that occur just ahead of frontal systems and northwesterlies that occur with its passage. The pressure falls due to the heating over the southern end of the island. This induces a sea breeze that begins as a northwesterly wind over Northern Queen Charolette Strait in the late afternoon, spreads southward and then slackens to light winds near midnight.

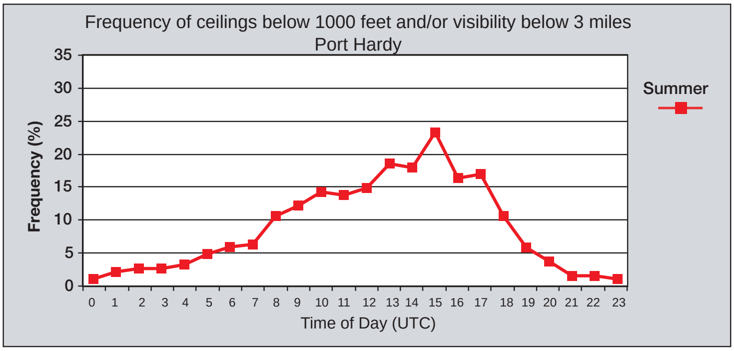


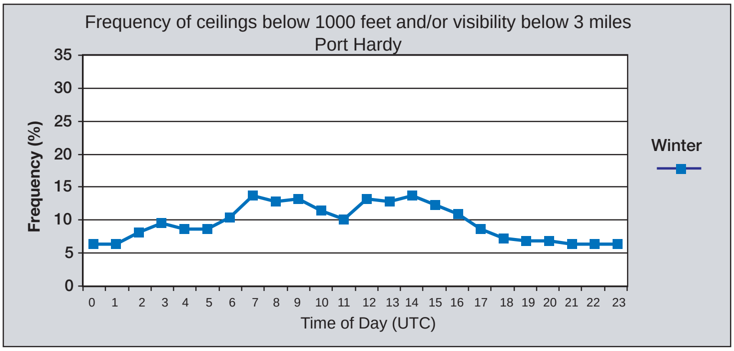


Winter at Port Hardy is a wet, windy time of year. Strong lows and frontal systems move onto the North Coast, generating frequent east to southeast winds up Queen Charlotte Strait and over the airport. While the airport can experience periods when the winds are light or calm, it is worth noting that over 25 percent of the time in the winter the winds are in excess of 10 knots. Very frequently, the winds are much stronger over Queen Charlotte Strait and these winds often move onto the airport a few hours ahead of an approaching frontal system.

Port Hardy experiences below VFR flying conditions any time of the year. During the summer flying is generally good; however, fog banks are often located over Queen Charlotte Sound and often move onto the airport during the early morning.

The worst flying conditions occur during the period of late fall through winter, into early spring. Strong weather systems move up onto the coast resulting in widespread rain and low ceilings. Between the major systems there is a tendency for poor weather to move into Port Hardy just prior to sunrise and often persist into the afternoon. On the plus side, when the strong southeast winds are blowing the airport tends to remain just above the IFR category.



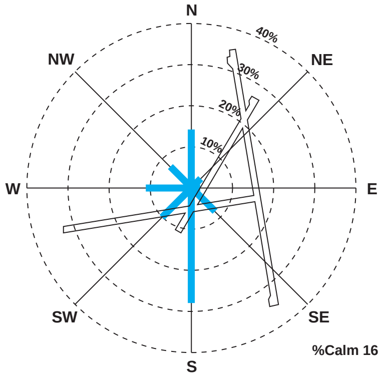


(i) Prince George

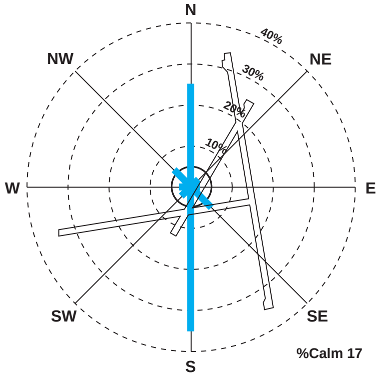
Prince George is the largest city in the Central Interior. The weather here is extremely variable, as the major storm tracks off the Pacific prefer to lie across this area. Cloudy skies and precipitation tend to be common, yet in the summer the days can be hot and sunny with the strongest thunderstorms anywhere in the province. Conversely, the arctic front can sweep across the area bringing clear, frigid conditions.

The wind pattern is fairly uniform across the entire year. Southerly winds tend to develop ahead of weather systems and then become northerly in their wake.

Prince George
Wind Frequency by Direction
Summer

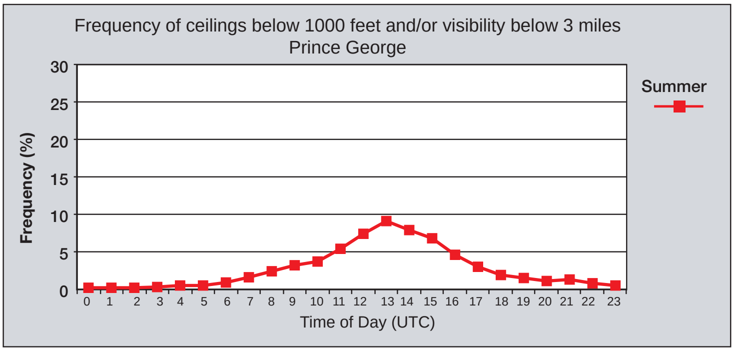


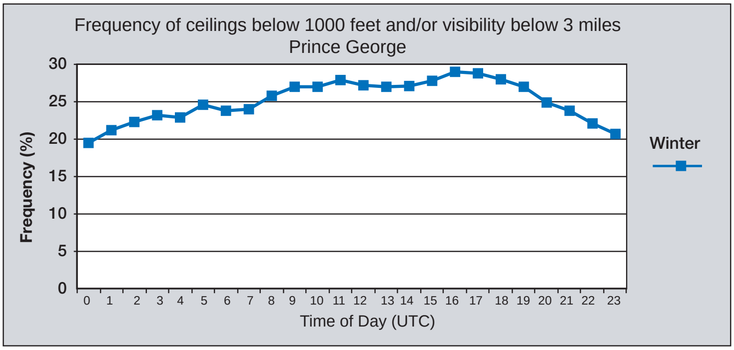
Prince George
Wind Frequency by Direction
Winter



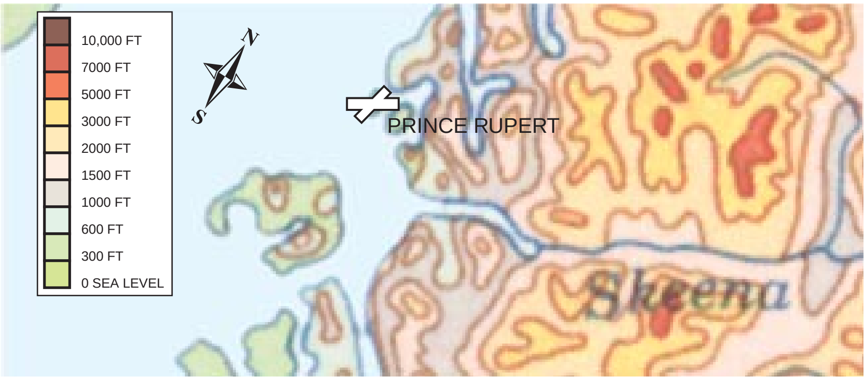
During the summer months, the airmass tends to be fairly convective. Thus, below VFR weather does not occur often except when major systems, such as a cold low, move across the area.

The same cannot be said for the winter. A major influence on weather in the Prince George area is the local forestry mills. There are three forestry mills located to the north of the airport. The combination of the moisture pumped out by these mills and the condensation nuclei provided ensure that low cloud and fog is a real problem. The normal trend is to see the low cloud and fog move into the airport during the night and persist well into the morning. These conditions tend to be episodic in that poor weather will redevelop night after night, until the wind or the airmass changes.





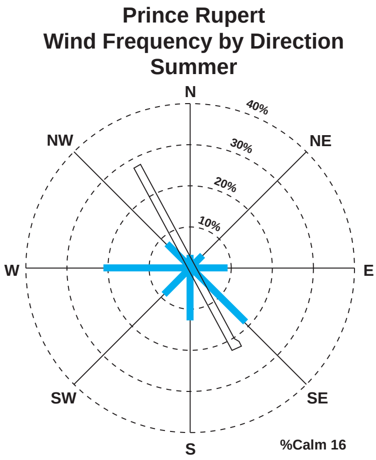
(j) Prince Rupert

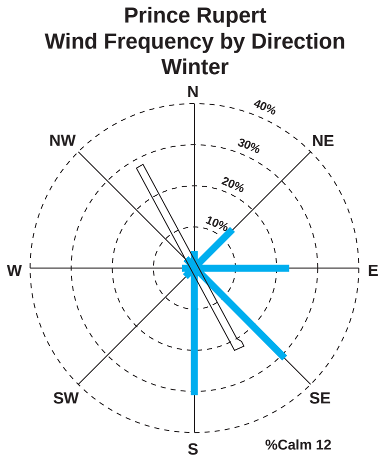


Prince Rupert Airport is located on an island just to the west of the city of Prince Rupert. With the Coast Mountains lying right along the shores of the sea, Prince Rupert is considered by many to be the cloudiest, wettest city in British Columbia.

The winds at Prince Rupert are for the most part light. Even in the winter months when vigourous weather systems sweep into the North Coast, the airport winds are less than 10 knots 75 percent of the time.

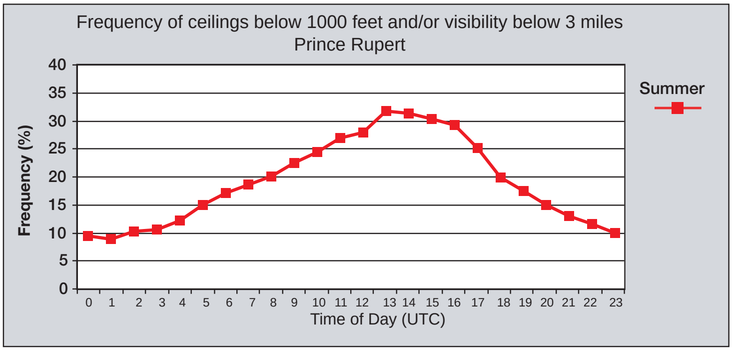
The wind patterns at Prince Rupert show a strong seasonal variation. In the summer months, two predominate wind directions prevail. The marked southeast wind occurs ahead of approaching weather systems. The west winds occurs behind the fronts and with sea breezes.

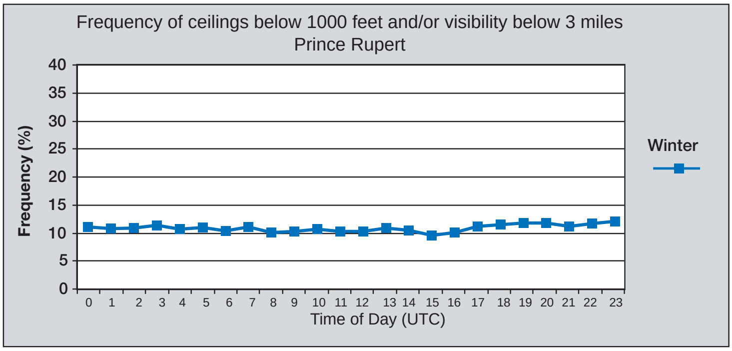




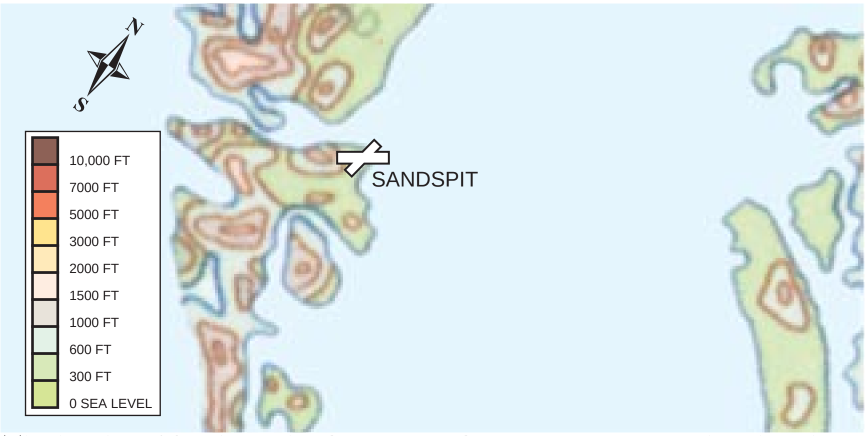
In winter, the strong low-pressure systems that move up across the Queen Charlottes make their presence felt. Almost one-third of the time the winds will blow strongly from the south to southeast.

Prince Rupert Airport is a tough airport even for commercial aircraft. The combination of weather systems crossing the coast in winter, as well as low cloud from the ocean moving onshore, keeps Prince Rupert below VFR conditions 30 to 35 percent of the time. Even in the summer, prolonged periods of rain and fog banks often form in the area or move ashore resulting in below VFR conditions.





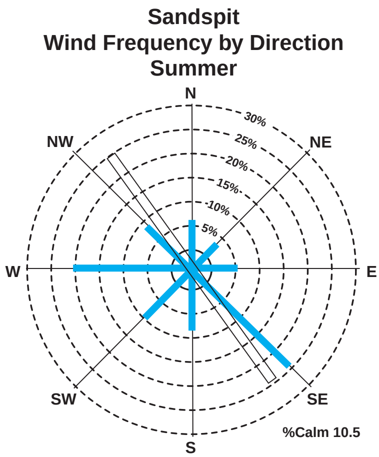
(k) Sandspit

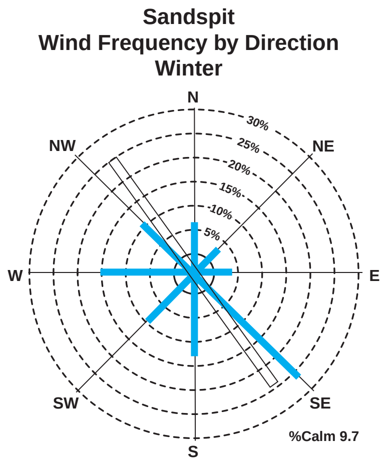


The hamlet of Sandspit, the Gateway to Gwaii Haanas National Park, is located on the The Queen Charlotte Islands, off the north BC coast. The Queen Charlotte Islands consist of several islands of which two of the largest are Graham Island, in the north, and Moresby Island, in the south. Between Graham and Moresby Islands is a narrow channel known as Skidegate Channel that broadens into Skidegate Inlet on the east side.

The only settlement on Moresby Island, Sandspit lines both sides of the low-lying spit of land at the eastern end of Skidegate Inlet. This spit also protrudes out into Hecate Strait, which lies between the mainland coast and the Queen Charlotte Islands. Sandspit Airport is located at the end of this spit, the runway elevation a mere 20 feet above sea level.

The area immediately around the airport is relatively flat with a sandy, grassy covering. To the west, the terrain becomes forested and begins to rise into a set of ridges that rise above 1,000 feet, 10 miles to the southwest of the airport.

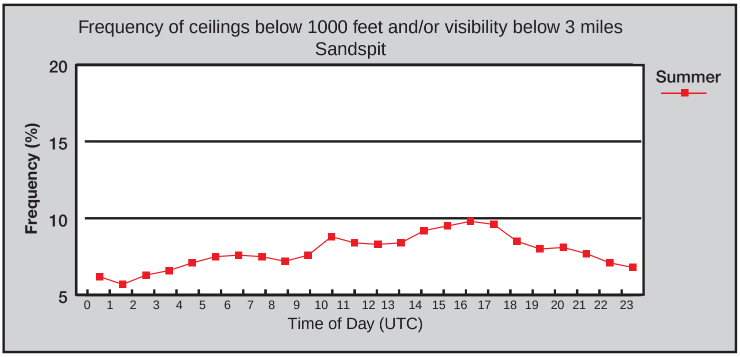


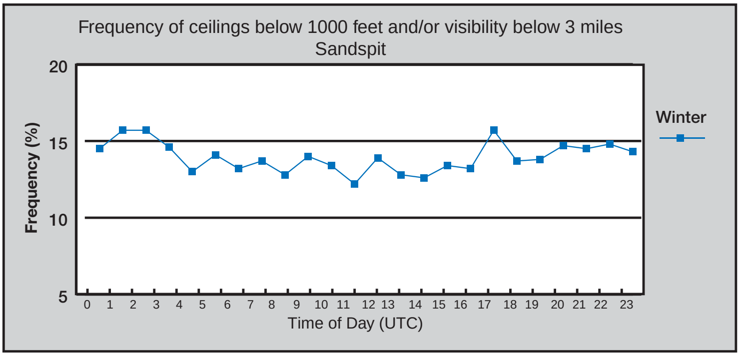


The winds at Sandspit are a product of only a limited number of influences. The southeast winds occur ahead of approaching low pressure systems. Beginning fairly light, these southeast winds will increase as they are channelled between the Coast Mountains and the Insular Mountains. At the peak of a storm, winds can be impressive at Sandspit with the winds being even stronger over Hecate Strait. It has been noted by forecasters that if the isobars on a surface weather map are oriented more northwest-southeast than north-south, then convergence will cause the winds to be strongest over the Sandspit.

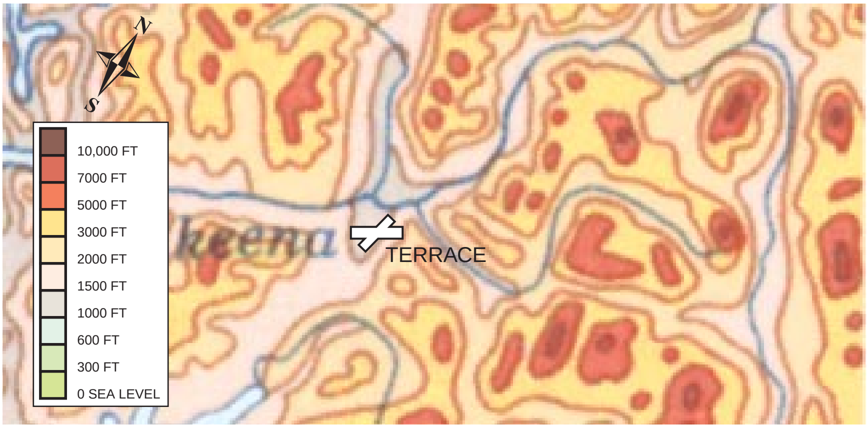
The westerly wind is a channelled wind through Skidegate Inlet. Sandspit Airport will frequently show strong, gusty westerly winds behind a front that will last for several hours, then begin to diminish. These westerly winds will, however, persist until the high pressure ridge that is following the frontal system moves across the area. All other directions can occur but are infrequent.

Sandspit is fully exposed to all of the major systems that move through the area. With rain common in these systems, low cloud ceilings occur frequently. At the same time, the waters around the Charlottes are prone to low cloud and fog whenever warm air moves over the relatively cold water. As a result, below VFR conditions can be expected around 15 percent of the time in the winter and 8 percent of the time in the summer. The nicest conditions in winter occur during times of outflow winds through the mainland inlets, although snow showers can be a problem over Hecate Strait and along the eastern shores. In summer, the best flying weather occurs when strong ridges of high pressure become fixed over the area.





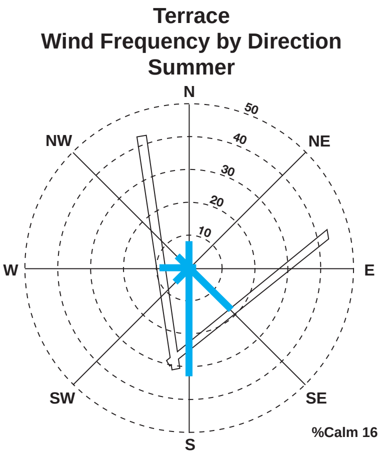
(l) Terrace

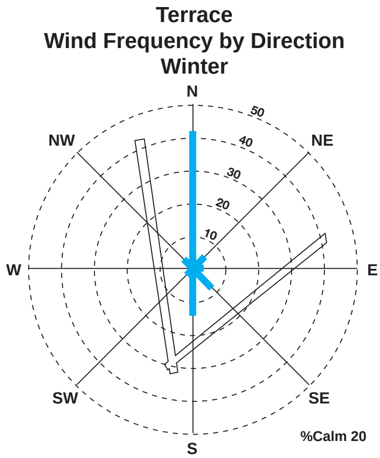


Terrace Airport is located on a plateau across the river just south of town. Despite being located inland from the coast, its weather is all too often a dramatic clash between the moist air from the coast and drier air from the interior.

Situated at the junction of several valleys, the wind pattern at Terrace Airport shows the strong influence of topography and pressure gradient.

During the summer months, the winds are quite variable and blow from almost all quadrants. The most prominent wind is a southerly that blows out of the Kitimat River Valley from Douglas Channel. This wind usually occurs ahead of an approaching frontal system. This southerly wind also occurs in the summer when there is a thermal trough inland and a ridge of high pressure along the coast. The other prominent wind is a northerly drainage wind out of the Kitsumkalem River Valley. The winds do blow easterly and westerly over the airport but are seldom strong.

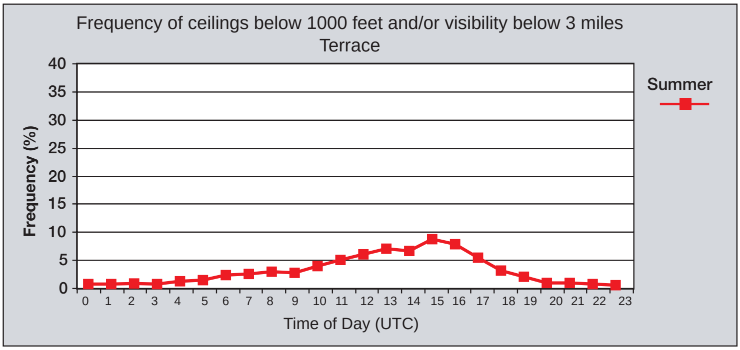


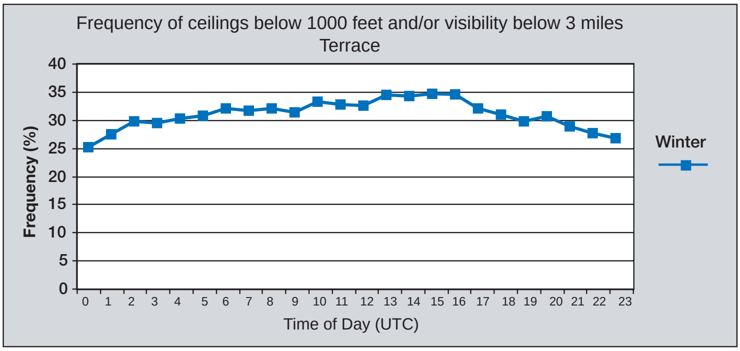


The influence of cold air and falling pressure along the coast ahead of a strong weather system is evident in the winter wind pattern at Terrace. North winds are very common ahead of a weather system. These winds also occur in outflow situations and can result in near blizzard conditions. Just ahead of an approaching frontal system, the winds will often switch to a southerly from the Kitimat River Valley as warm air begins to move into the area from the coast.

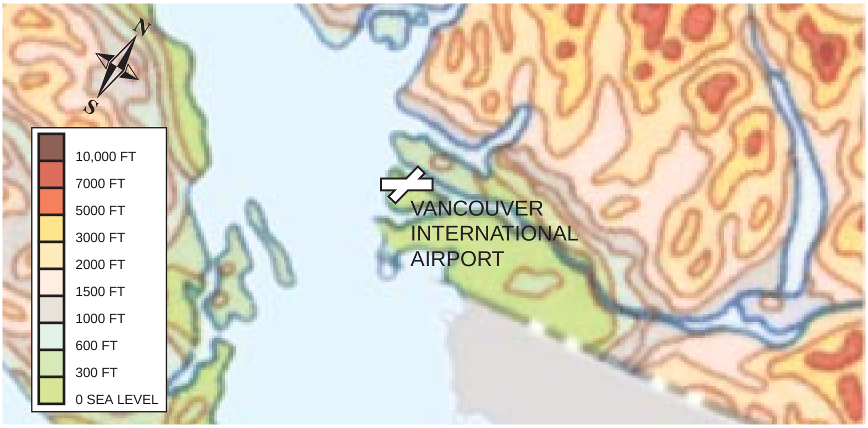
Like Prince Rupert, Terrace can be a very difficult airport for weather forcasting. During the winter, upslope conditions off the coast mixing with cold air from the interior will produce low cloud and poor visibility in rain or snow, depending on the temperature. During the changeover from snow to rain, mixed rain and snow or freezing rain can make flying into this area treacherous. Even when the precipitation stops, all too often radiation fog forms, rapidly producing prolonged IFR conditions.

July and August are the best flying months in this area. Low cloud off the ocean can still be a problem but, in general, conditions remain VFR.



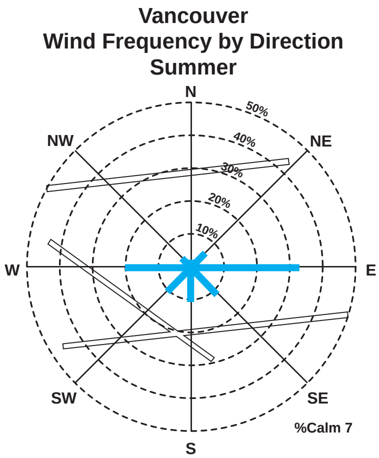


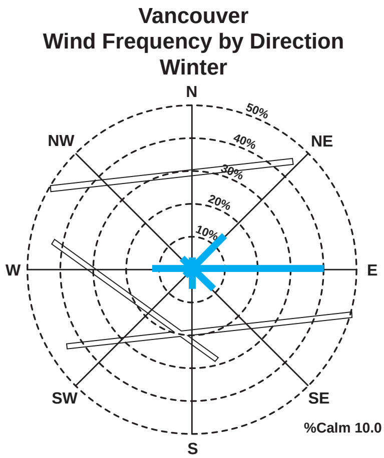
(m) Vancouver



Vancouver Airport is located on an island at the mouth of the Fraser River. With the Fraser Valley extending off to the east and the Strait of Georgia lying in a rough northwest-southeast line just to its west, the winds are strongly influenced by topography and season.

During the summer months, the winds are predominately east or west. The west wind tends to be a sea breeze while the east wind is a drainage wind coming out of the Fraser Valley. Minor frontal systems do move across the area resulting in a southeast wind ahead of the front changing to a northwest wind in its wake. Seven percent of the time the winds are calm and 85% of the time the winds are less than 10 knots. Only on the rare occasion do winds exceed 20 knots.

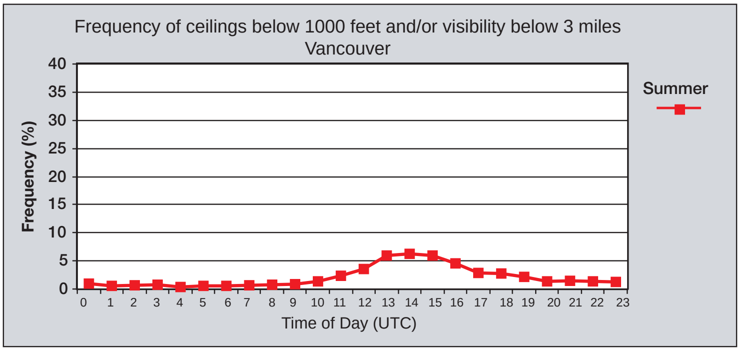


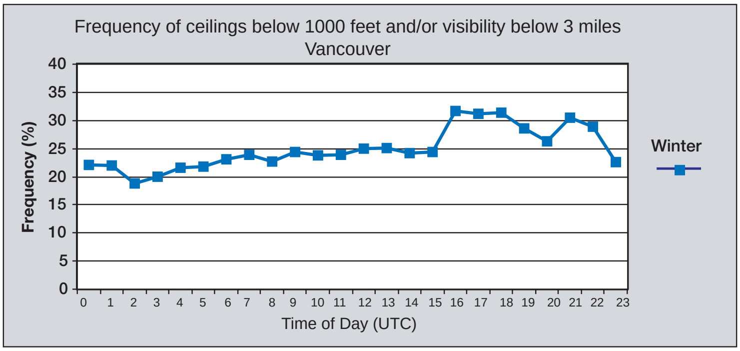


The winter winds show a similar pattern but are stronger in strength. The easterly wind is especially noticeable. Added to the normal easterly drainage wind, that occurs almost every night at Vancouver Airport, is the enhanced easterly winds ahead of approaching coastal lows and arctic outflow winds that occur once or twice per winter.

The summer tends to be the best time of the year for recreational flying. The only real periods of below VFR conditions occur when low sea stratus from Juan de Fuca Strait gets drawn into the area.

The period late fall through winter into early spring is the most difficult time of the year. Strong weather systems move up onto the coast resulting in widespread rain and low ceilings. Between the weather systems, there is a noticeable peak near 1700 UCT which is just after local sunrise in the winter. Frequently at this time, fog or status slides into the airport and does not break up until the sun rises higher into the sky and some heating occurs.

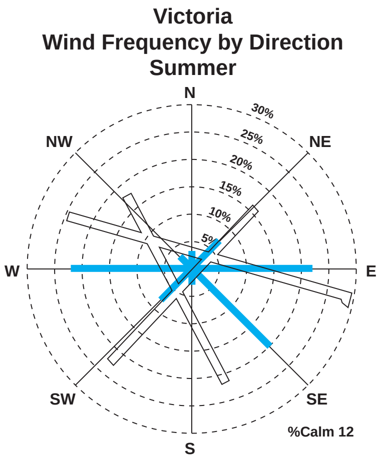


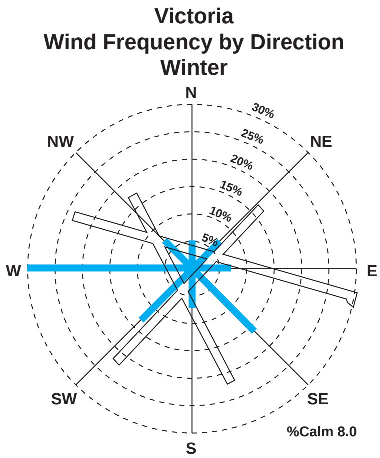


(n) Victoria

Victoria International Airport is situated on Vancouver Island, at the northern end of the Saanich Peninsula, 14 nautical miles north of the city of Victoria, and just to the west of the small city of Sidney. The airport is in close proximity to bodies of water on three sides; Saanich Inlet, one mile west; Satellite Channel, 3 miles to the north; and Haro Strait, 1-1/2 miles to the east. The airport is readily affected by marine influences.

The terrain around the airport is relatively flat except for Mount Newton that rises to 1,000 feet, some 3-1/2 miles to the south-southwest. However, just beyond Saanich Inlet, the Insular Mountains of Vancouver Island rise to 3,000 feet from the southwest to northwest direction.





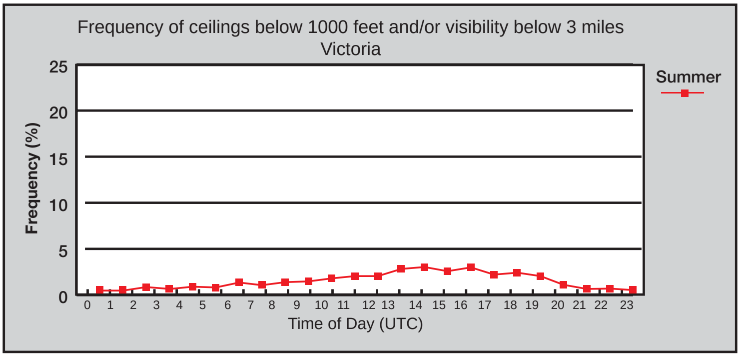
Victoria Airport is not noted for its winds; in fact, about 90 percent of the time the winds are less than 10 knots. In winter, the winds at Victoria Airport are almost equally distributed around the compass, except for a strong preference for a westerly direction. This wind is a katabatic flow off of the Insular mountains, occurs most nights, and tends to be light, 5 to 10 knots. Winds from other directions also tend to be light, except for southeast winds which occur ahead of weather systems crossing Vancouver Island, and southwest winds that occur in the wake of these systems. With the passage of the cold front, a strong, gusty flow through the Strait of Juan de Fuca moves through Victoria Harbour and down across the airport, but it only persists for a few hours.

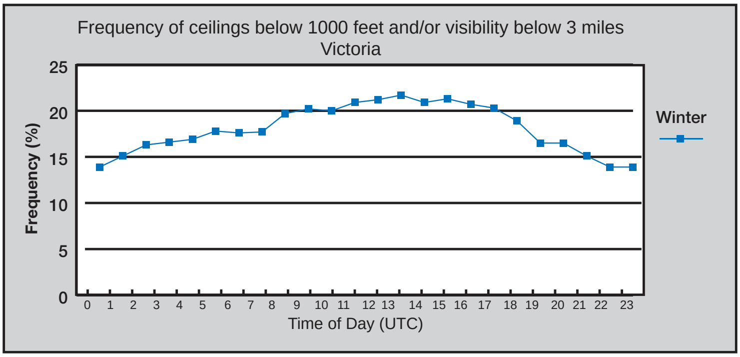
Summer winds are also mainly light and show a similar preference for the katabatic westerly flow. However, there is an increased occurrence of east to southeast winds. These winds are largely sea breeze in nature and occur during the afternoon and early evening.

Victoria is drier than most airports along coastal BC because it lies in the "rain shadow" of the Olympic Mountains. As such, the low cloud in precipitation tends to take longer to form ahead of an approaching frontal system and lifts to above 1,000 feet fairly quickly in its wake. Victoria Airport, being nearly surrounded by water, is quite susceptible to stratus and fog that have formed over the sea. Banks of stratus and fog move onto the airport, particularly those which formed over Pat Bay to the west. In such a case, the katabatic wind tends to carry it onto the airport near 0900 UTC, and it can persist to late morning, 1700 UTC or so.

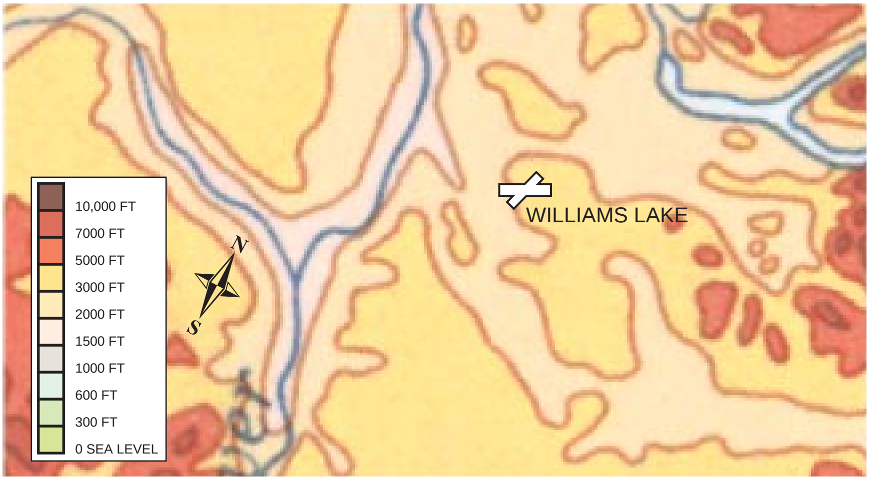
During the summer, the occurrence of low ceilings and visibility is quite low, less than 5 percent. Like winter, occasional fog off the ocean will move into the airport but tends to dissipate quickly after the sun rises.

During the winter, Northeast "Strait effect" winds can bring snow showers and low visibilities as cold air funnels out of the mainland inlets and valleys. Some say that part of the reason that Victoria received much more snow during Storm '96 was due to this local effect.





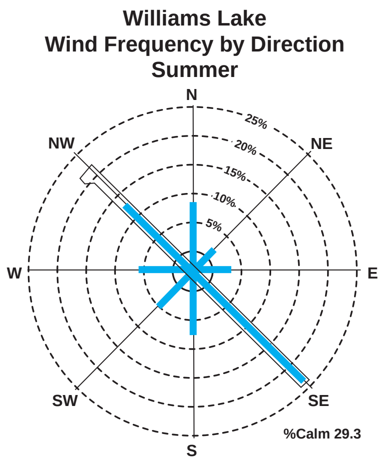
(o) Williams Lake

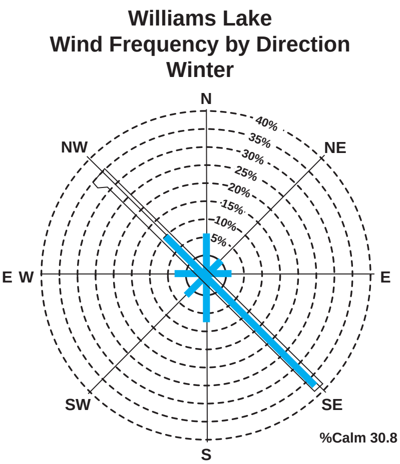


Located in the Central Interior, Williams Lake airport lies 4 nautical miles north-east of the town of Williams Lake. The only other urban centres in the immediate area are 150-Mile House, just under 7 miles to the southeast, and Glendale, about 5 miles to the west-southwest.

The airport is situated on the Fraser Plateau, approximately 7 miles east of the Fraser River. The Fraser River runs in a north-south line and is quite narrow. Four miles to the south of the Airport is Williams Lake, which is about 1/2 mile wide and nearly 4 miles long.

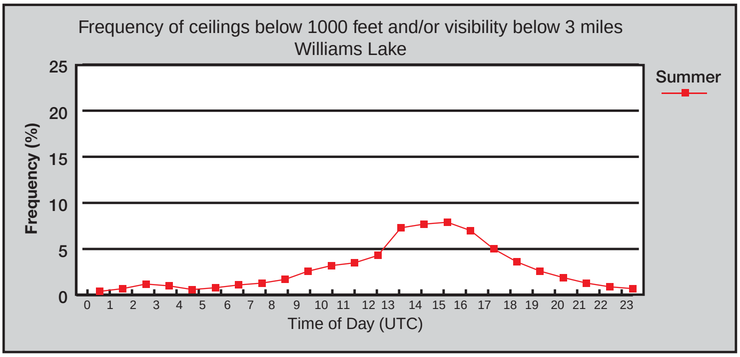
The surrounding countryside is hilly but only lightly wooded. The airport sits on one of the highest elevations in the area although a ridge, elevation just over 3,900 feet, lies 11 miles to the northeast of the airport.

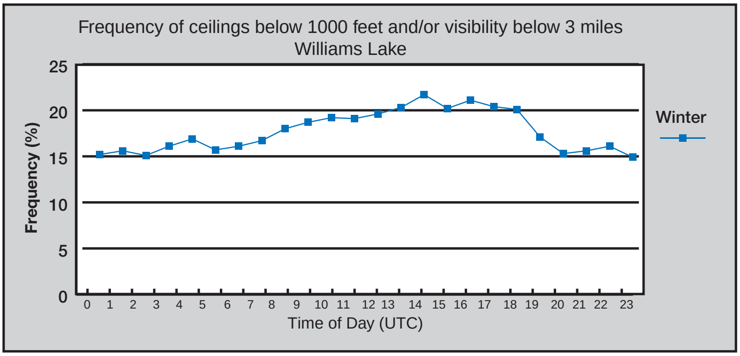




The summer winds at Williams Lake are quite benign, being calm almost 30 percent of the time and less than 10 knots almost 90 percent of the time. When wind does occur, it shows a strong bias to being either from the northwest or southeast. This is usually the result of passing frontal systems and is strongly influenced by the orientation of the local terrain.

Winter is not much different. Winds continue to remain calm almost 30 percent of the time, and less than 10 knots, around 86 percent of the time. Of note is the preference for southeast winds over all other directions. The arctic front takes up a favoured position near Prince George for much of the winter. Ahead of frontal systems, the southeasterly winds frequently develop along the Fraser River and often reach values of 20 gusting to 30 or more knots. However, behind the front, the cold northwesterly winds tend to be confined behind the arctic front.


Frequency of ceilings below 1000 feet and/or visibility below 3 miles
Williams Lake
Frequency (%)
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time of Day (UTC)
Summer


Frequency of ceilings below 1000 feet and/or visibility below 3 miles
Williams Lake
Frequency (%)
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time of Day (UTC)
Winter

Glossary of Weather Terms

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

advection - the horizontal transportation of air or atmospheric properties.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 1 - The Fujita Scale

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

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

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

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

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

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

Table 2 - Saffir-Simpson Hurricane Scale

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

icing - any deposit of ice forming on an object.

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

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

isothermal layer - equal or constant temperature with height.

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

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

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

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

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

lightning - any and all forms of visible electrical discharge produced by a 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 - a condition where air is flowing from the interior land area through mountain passes, valleys and inlets onto the coastal areas; used most commonly in winter when cold Arctic air spreads onto the coastal area and adjoining sea.

overrunning - a condition when warm air overtakes or is lifted by colder denser air.

parcel - a small volume of air, small enough to contain uniform distribution of meteorological properties, and large enough to remain relatively self-contained and respond to all meteorological processes.

plow wind - usually associated with the spreading out of a downburst from a thunderstorm; a strong, straight-line wind in advance of a thunderstorm that often results in severe damage.

precipitation - any and all forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the surface.

quasi-stationary front - a front that is stationary or nearly so; commonly called stationary front.

ridge - an elongated area of relatively high atmospheric pressure; also called ridge line.

rime icing - the formation of a white or milky and opaque granular deposit of ice formed by the rapid freezing of supercooled water droplets.

saturation - the condition in the atmosphere where actual water vapour present is the maximum possible at the existing temperature.

shower - precipitation from cumuliform cloud; characterized by suddenness of beginning and ending, by rapid changes in intensity, and usually by rapid changes in the appearance of the sky.

squall - essentially gusts of longer duration. In Canada, a squall is reported when the wind increases by at least 15 knots over the average speed for a duration of at least 2 minutes and the wind reaches a speed of at least 20 knots.

squall line - a non-frontal line or narrow band of active thunderstorms.

stability - a state of the atmosphere where the vertical distribution of temperature is such that a parcel will resist displacement from its initial position.

stratiform - term descriptive of clouds of extensive horizontal development; flat, lacking definition.

stratosphere - the atmospheric layer above the tropopause; characterized by slight increase in temperature from base to top, very stable, low moisture content and absence of cloud.

subsidence - the downward motion of air over a large area resulting in dynamic heating.

supercooled water - liquid water at temperatures below freezing.

thunderstorm - a local storm invariably produced by a cumulonimbus cloud, and always accompanied by lightning and thunder.

tornado - a violently rotating column of air, shaped from a cumulonimbus cloud, and nearly always observed as “funnel-shaped;” other names are cyclone and twister.

tropopause - the transition zone between the troposphere and the stratosphere; characterized by an abrupt change in lapse rate.

troposphere - the portion of the earth's atmosphere from the surface to the tropopause; characterized by decreasing temperature with height and appreciable water vapour. Often referred to as the weather layer.

trough - an elongated area of relatively low atmospheric pressure; also called trough line.

trowal - a trough of warm air aloft; related to occluded front.

turbulence - any irregular or disturbed flow in the atmosphere.

updraft - a localized upward current of air.

upper front - any frontal zone which is not manifested at the surface.

virga - water or ice particles falling from a cloud, usually in wisps or streaks, and evaporating completely before reaching the ground.

warm front - the trailing edge of retreating cold air.

weather - the instantaneous conditions or short term changes of atmospheric conditions at a point; as opposed to climate.

wind - air in motion relative to the earth's surface; normally horizontal motion.

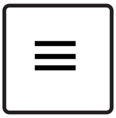
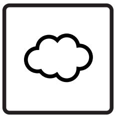
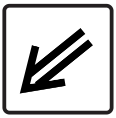
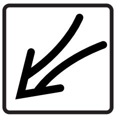
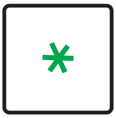
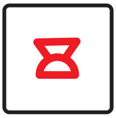
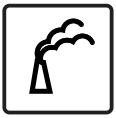
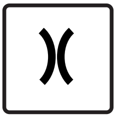
wind direction - the direction from which the wind is blowing.

wind speed - rate of wind movement expressed as distance per unit time.

wind shear - the rate of change of wind direction and/or speed per unit distance; conventionally expressed as vertical and horizontal wind shear.

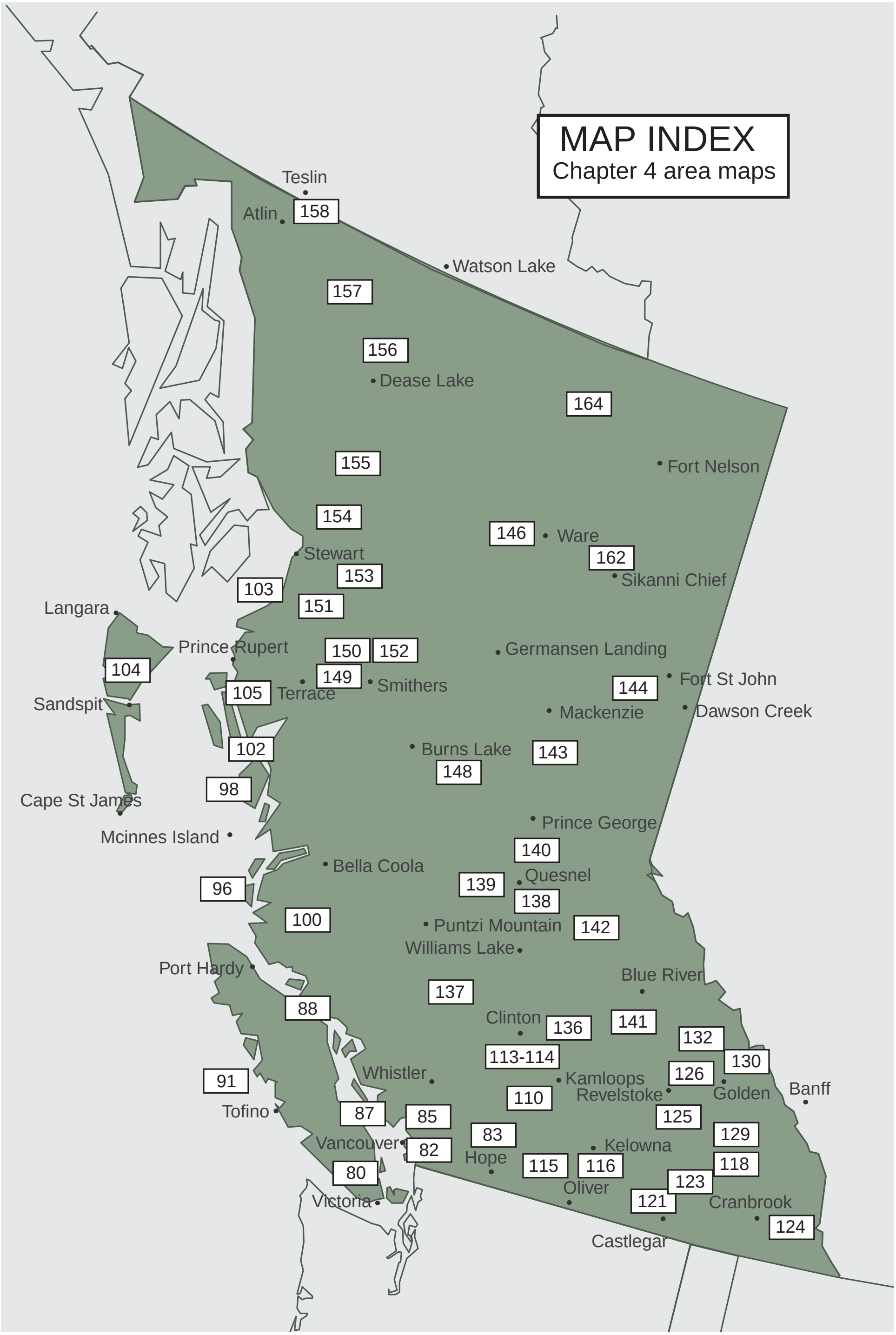
zonal wind - a west wind; conventionally used to describe large-scale flow that is neither cyclonic or anticyclonic; also called zonal flow.

Table 3: Symbols Used in this Manual

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

Appendix


Skagway
Dease Lake
Mucho Lake
Fort Nelson
Ware
Stewart
Sikanni Chief
Langara
Prince Rupert
Germansen Landing
Fort St John
Smithers
Terrace
Sandspit
Mackenzie
Burns Lake
Cape St James
BRITISH COLUMBIA
Prince George
Mcinnes Island
Bella Coola
Quesnel
Puntzi Mountain
Port Hardy
Williams Lake
Blue River
Clinton
Whistler
Revelstoke
Kamloops
Tofino
Vancouver
Kelowna
Hope
Oliver
Victoria
Cranbrook
Castlegar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