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"EXPERIENCES WITH ARCTIC FLYING WEATHER"

by

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"EXPERIENCES WITH ARCTIC FLYING WEATHER"

This talk to you tonight is not technical. It is an account of arctic and polar flying weather as I have experienced it. First, I must point out that I am a navigator and not a meteorologist, and the only training I have had in meteorology has been in conjunction with navigation courses. But I have maintained an interest in meteorology to the extent that it has become almost a hobby.

I was first introduced to high latitude weather when participating on long range research flights in B-29 aircraft. Since those flights, which continued for about three years, I have flown in the Arctic in many types of aircraft of varying range and operating ceiling, and with often limited navigational aids. It is my opinion that an efficient navigator must have a working knowledge of meteorology, and maintain a day to day interest in it. He will find this particularly valuable when flying out of remote bases, many miles from a forecast office.

GENERAL CHARACTERISTICS OF ARCTIC WEATHER THROUGHOUT THE YEAR.

Spring, particularly the month of April, provides the best flying weather in the polar regions of this continent. At this time the centre of the arctic anti-cyclone is north of Alaska, with the arctic front lying across Alaska, veering southeast along the Mackenzie Valley, and then east in the general direction of Great Slave Lake. In this 'high' flying conditions are good, visibility is generally unlimited except for a small amount of haze in the centre or on the west side. Northwesterly winds prevail over the Beaufort Sea and the Arctic Ocean and temperatures are well below zero. Often when flying over the Arctic Ocean near the Alaskan coast, cirrus and alto-stratus can be seen to the south and west, indicating over-running by warm air. Northbound flights, originating in Alaska, and along the northwest staging route will frequently pass through the arctic front. Once beyond this, CAVU conditions generally prevail except for patches of low stratus and haze. Farther to the east, flying conditions are sometimes poor, owing to low pressure systems that move into Baffin Bay. When a 'cold low', circular in shape, moves into the top of Baffin Bay, extensive cloud prevails over most of Ellesmere Island, Axel Heiberg and as far west as Bathurst and Ellef Ringnes. This condition may last for one or two weeks, as it did for example throughout the latter part of April last year. When a 'low' moves from north of Iceland into the polar regions, cirrus and cirrostratus is generally encountered north of Ellesmere Island and extends over the Pole.

In Summer, the arctic anti-cyclone has moved a little farther east, but is very weak. The arctic front has moved northward and is generally located over the Arctic Ocean, Beaufort Sea and the Archipelago. It is however poorly defined. Pressure gradients are weak over the entire arctic and the winds variable and less strong. Cloud is extensive and stratus is frequent over the polar pack and the archipelago. Cirrus and cirrostratus cloud is often found over the arctic whenever tongues of warm air penetrate into the north. Alto-stratus may be encountered at any time and stratocumulus forms over the snow-free islands, especially those surrounded by ice. Severe icing conditions are common, and are important in flight planning, as the freezing level is little more than a few thousand feet above the surface.

In the fall, the anticyclone is still weak and its centre begins to move towards the Siberian coast. Storms are more frequent along the arctic front, and wind velocities increase, frequently bringing extensive cloud conditions, often to considerable altitudes. This season provides the worst flying weather of the year, both inflight and at terminals where the snow-covered terrain and surrounding water combine to produce fog and low ceilings.

By January the centre of the arctic anti-cyclone is at approximately 80N 165E. A succession of storms move along the arctic front, causing high winds and snow. With the exception of these storm periods, the flying weather in the western arctic is good. To the east, however, when warm moist air from the Atlantic moves into high latitudes, extensive cloud forms over the eastern part of the archipelago and the polar region. As a result flying conditions in the Baffin Island, Devon, Greenland coastal areas and the region north and east of Greenland are often poor.

WIND VELOCITIES.

The prevailing wind at flight altitudes over the western part of the North American arctic and polar regions is generally from the west and north and occasionally from the southwest when the arctic front lies north of the mainland. In the eastern Canadian arctic winds are generally from the north and northwest and occasionally east while the northwestern section of the Archipelago and the Arctic Ocean to the north often have winds from the north and northeast.

Throughout the winter with very few exceptions, all winds I have experienced have been from the west, northwest or north. On two occasions a southwest wind was observed at 10,000 feet and on one flight over the northern part of the archipelago a northeast wind was measured. Between 6,000 and 12,000 feet the wind speed ranged from 18 to 55 kts. On one flight at 22,000 feet a 66 kt. wind was recorded. The strongest wind encountered was in February, and had a speed of 118 kts. blowing from the NNE at 12,000 feet about 40 miles off the north coast of Borden Island. At the time light to moderate turbulence was encountered and a layer of cloud extended up to flight level. Wind velocities measured at half hour intervals on either side of this wind were not greater than 45 kts. This exceptionally strong wind has many of the characteristics of a jet stream and may be due to similar causes. At the time there was an extensive low over the eastern part of the archipelago and as far as I can judge from the available data, the arctic front was probably fairly far north. We may have here an indication of a jet stream associated with the arctic front and the absence of previous evidence of this phenomenon may be simply due to the meagre upper air records in high latitudes.

During spring the wind is from the west, northwest and north over the Beaufort Sea and the western section of the archipelago, while farther east and north, northeast and east winds are frequently encountered between 8,000 and 12,000 feet. At 20,000 feet west and northwest winds were always predominant over the Arctic Ocean, Beaufort Sea and the most western islands, but over Axel Heiberg and as far west as Melville Island east and northeast winds were noted. In the lower altitudes wind speeds were seldom over 35 kts. while between 12,000 and 20,000 feet they generally ranged between 25 and 45 kts.

In summer the prevailing wind is westerly but with more southwest winds encountered than at any other time of the year. North of about 75° however they generally veer to the west and northwest. The wind speeds, with the odd exception, are far less in summer than at any other time of the year. The highest recorded was a southwest wind of 50 kts. but at all altitudes between 6 and 20,000 feet wind speeds are generally between 10 and 25 kts. On one flight over the archipelago at 20,000 feet, an east wind of 40-46 kts. prevailed from the Beaufort Sea to the west coast of Greenland.

During fall many south and east winds are measured in the southern sections of the archipelago. Over the northern part of the Beaufort Sea and in higher latitudes they are generally westerly. Wind speeds are much greater than in summer and between 9,000 and 20,000 feet they usually range from 20 to 55 kts.

FOG

Fogs occur in the north at any time of the year, although in general they are more common in summer and early fall.

Coastal fog is common in the arctic. During summer, the snow-free islands are warmed by the sun and warm air from them causes fog when it moves over the cold sea. This is particularly noticeable in such ice-bound areas as Borden, Mackenzie King and Prince Patrick where it lies as a band along the leeward side of the islands. In autumn the sea is warmer than the snow-covered land and warm, moist air from the sea causes fog along the windward coasts. The interior of a large island such as Banks is generally free of fog, or in a high rugged area such as Bylot Island the peaks show above the fog.

Sea fogs are common in Davis Strait, Baffin Bay and the entrance to Hudson Strait during the summer but, as they do not rise many feet off the water, are not an in-flight problem, only affecting flying when they close in the terminals. The Chuckchee Sea, coastal waters of northern Alaska and the Beaufort Sea are similarly affected though to a lesser extent. During summer when a tongue of warm moist air penetrates this area mist, fog and low cloud frequently hang over the sea.

Arctic sea smoke is often observed during winter and is most common in Lancaster Sound, Hudson Strait, and over the wide lead that parallels the west coast of Hudson Bay. Smoke will nearly always be present where there are open leads in the polar pack. When open water areas are large and the temperature well below zero smoke rises to 2 - 3000 feet and lies in a well defined belt down wind from the water.

Under inversions, which are common in the arctic throughout the year, radiation fogs form readily. The valleys of the Mackenzie and the Yukon are particularly noted for this type of fog which is most prevalent during the late summer and fall. During March and April thin layers of radiation fog are also seen hanging over valleys and hollows in the barren lands and over the islands of the arctic archipelago. This type of fog is a hindrance only if airfields are located in these valleys.

Ice fogs form under very low temperatures and calm to light winds. A striking example of this occurred during a February landing at Sawmill Bay. The temperature was -56°F with no wind. The landing and taxiing of the aircraft caused fog to form on the field to such an extent that another aircraft has to remain airborne for almost thirty minutes before this artificially created fog cleared enough for it to land. These conditions are not common but they do occur a number of times each winter and temporarily affect the operation of an airport. The causes and prevalence of this type of fog at various northern airfields are being studied jointly by the Meteorological Division of D.O.T., National Research Council and Defence Research Board. It is hoped that this research project will throw more light on this problem.

A similar type of fog called "ice crystal haze" is quite common during the winter and spring over the whole polar regions, and appears to reach its greatest density when the temperature is about -20°C. This ice-fog seems to form in the early stages of a flow of relatively warm air and persists for from one to two days, gradually disappearing when stratus cloud forms. In the ice crystal haze temperatures are higher than those recorded on the ground at the same time. Since ice crystal haze has been observed up to 22,000 feet, and the stars and sometimes the sun are not clearly visible unless the aircraft is within a few feet of the upper limit of the haze, this type of fog can be considered a navigational hazard, unless the aircraft has a ceiling enabling it to fly above it.

Electronic navigation aids such as loran are adversely affected by this fog especially so if used in high speed aircraft, but search radar is not affected to any extent. In cases of reported failure of search radar under this condition the trouble is usually traced to faulty manipulation of the equipment.

In the centre of the anti-cyclone that lies to the west of the Canadian Arctic Archipelago, a very thin haze is often encountered but visibility is generally good.

CLOUDS.

Cloudiness over the arctic regions is generally greatest in summer and fall and least in winter and spring. In areas under the immediate influence of circulations off large bodies of water, maximum cloudiness occurs in mid-summer, while places where the circulation is off the land have maximum cloud in autumn with a secondary maximum cloud in early summer.

In high latitudes clouds are usually of the layer type though, during summer, cumulus is common over the islands.

Throughout the winter and spring clouds are often diffused and not clearly defined. For example, in flying through a trough at an altitude of 15,000 feet only ice-crystal-fog-like-cloud may be encountered so that the outlines of the ground directly below remain visible. Again in flying through the arctic front at a high altitude, visual contact with the ground may not be lost.

In winter the lack of daylight makes it difficult to observe the extent and type of cloud coverage. As a rule, however, an altitude of 12,000 feet will top the cloud layers. On one occasion off the north coast of the continent a thin layer of altostratus was encountered at 20,000 feet. This cloud was due to the over-running of warm air along the southern edge of the arctic air mass. Fog and low stratus are common along the north coast in the vicinity of Herschel Island.

During spring cloud is at a minimum over the polar pack and the northern islands of the archipelago and a height of 12,000 feet will top the cloud layers until towards the latter part of May, but sometimes over the southern islands of the archipelago altostratus will be found as high as 15,000 - 20,000 feet. As a rule this cloud is thin and diffused. Sometimes ground fog forming small patches of stratus lies in the depressions of some of the islands.

The cloud layer that extends to 12,000 feet during spring gradually builds up during late May and June to 20,000 feet and in summer becomes very extensive and may be encountered anywhere from a few hundred feet up to 20,000. On one flight during July cumulus and stratocumulus was found at 23,000 feet over the archipelago. As a rule, however, a flight altitude of 20,000 feet will be above cloud level. During the latter part of July and August stratus and stratocumulus at 1 - 3000 feet will generally be encountered over the snow-free islands while the surrounding open water or ice will be free of cloud.

Throughout the fall extensive cloud coverage prevails and may be fractostratus or altostratus at 15,000 feet occasionally extending up to 20,000 feet. At this time of the year the islands are snow-covered but there are large bodies of open water. This causes extensive fog and low stratus over the water areas and along the coastlines. Without a doubt this time of year provides the worst flying conditions encountered in the arctic. Polar or trans-arctic flights, however, can be made above 20,000 feet without encountering anything but a thin layer of cirrus.

BLOWING SNOW.

In briefing aircrews I feel that the significance of blowing snow at destination or at alternative landing sites has not always been sufficiently stressed. At briefing the forecast often indicates clear skies and ideal flying weather but no attempt has apparently been made to consider the effect of wind velocity on finely granulated snow. After having perfect inflight conditions it is surprising to find the airfield closed in by a blanket of drifting snow which often extends upward to two-three hundred feet. Under these conditions landings and take-offs are not safe.

On one flight of twelve hours' duration in which I took part last year, terminal conditions according to the forecast appeared good at time of take-off. However, on arrival visibility was zero owing to blowing snow, and the nearest alternative airfield was three hours away.

My personal experience of being grounded on this account never lasted more than four to five days. During the time the outline of the sun could be seen but everything else more than a few feet away was obscured. There are instances, however, when blowing snow has seriously restricted air activity. A good example is the rescue of the scientific party from the Russian cargo ship Chelyuskin when that vessel was held in the ice off Wrangel Island. The decision to remove the party was made February 15th but owing to blowing snow the first successful flight could not be made until March 5th and it was not until the latter part of March that the last of the party was removed.

TEMPERATURE.

During July and August, except on one flight, temperatures have always been below -20°C above 18,000 feet. On one occassion a low of -34°C was recorded at this altitude over the Beaufort Sea, while on another -29°C was measured over Ellesmere Island at 22,000 feet. Below 6,000 feet temperatures are generally above freezing during late July and August. On 13th July + 5°C was recorded at 10,000 feet while flying over the north coast, with the wind from the southwest. This temperature is probably the highest recorded for this altitude on any flight during the past few years.

During September the freezing level is generally 2 - 6,000 feet and only occasionally are temperatures higher than 0°C at 6,000 feet. At 14,000 feet temperatures are generally around -20°C and the coldest I have recorded in this month is -32°C at 20,000 feet.

By November the freezing level has usually lowered to the ground. Occasionally however a -10°C has been recorded as high as

5,000 feet. Temperatures around 10,000 feet are generally between -12 and -25°C. On a flight on 22 November -41°C was recorded at 20,000 feet while on another flight -38°C was encountered.

January inflight temperatures usually run in the -20's and -30's the lowest recorded is a -38°C at 23,000 feet.

February temperatures are very similar to those of January with -20°C and lower always encountered above 8 - 9,000 feet.

Throughout March and April very little change in temperature occurs. The coldest recorded is -43°C at 21,000 feet on 18th March over Committee Bay. Above 12,000 feet all temperatures recorded have been below -20°C. Typical April temperatures recorded over the Pole are as follows: 12,000 feet -29°C; 5,000 feet -22°C; 1,000 feet -27°C. The lowest temperature recorded on this particular flight was -32°C at 12,000 feet over the polar pack at latitude 86°N. During winter and spring inflight temperatures anywhere up to 18,000 to 20,000 feet will usually be higher than those observed on the ground.

By late May an occasional +C temperature is encountered below 6 to 8,000 feet but at 12,000 feet it is generally around -20°C and often lower. Frequently at 20,000 feet a -30°C is recorded.

During June temperatures at 10 to 12,000 feet are nearly always below -12°C and at 20,000 feet about -28°C; on one occassion -41°C was recorded at 21,000 feet over Ellesmere Island.

TURBULENCE.

Turbulence is never as severe in the high latitudes as it is in Southern Canada. It is seldom encountered in the summer except when passing through a front, or at low altitudes over the barren lands. It is more common during late fall and winter, but only when flying over large open water leads amongst the ice. On one flight, when crossing Jones Sound at 12,000 feet with the temperature at -29°C, moderate turbulence was experienced and on another occasion at 9,000 feet while flying over open water near the Belcher Islands in Hudson Bay. From casual observations it would appear that when an open water area is sufficiently large to influence the air above it and temperatures are low, turbulence may be expected to a considerable altitude. These areas are generally covered by a broken layer of stratocumulus above which the air is smooth.

VISIBILITY.

Visibility is generally very good throughout the polar regions. On occasions there are ice-crystal-haze and cloud, but under clear conditions it is possible to see certain types of terrain over one hundred miles away from an aircraft flying at 15,000 feet. During late summer visibility over the barren lands is often greatly reduced by smoke from fires in the Great Slave Lake Area. The smoke from these fires is carried north with a southerly flow of air. On one flight during August this smoke was encountered over Boothia Isthmus at a height of 8,000 feet. It was so dense that at an altitude of 5,000 feet accurate sextant observations of the sun could not be made and at the same time static blanked out all radio contact. Similar conditions have been observed over Alaska, even extending for a short distance out over the polar ice.

FORECASTING WEATHER FOR ARCTIC FLIGHTS.

The great distances between airfields and the importance of astro observations for navigation make weather forecasts particularly valuable for arctic flights. The information available to the forecaster is however extremely limited in comparison with lower latitudes.

Factors that must be considered during briefing for a high latitude flight are:

(a) The type of aircraft - its operating ceiling and endurance.

(b) The type of operation on which the aircraft is proceeding.

(c) Navigational aids available.

Frequently one or more of these are neglected.

The type of aircraft has a great bearing on whether a particular flight is practical or not. For example, the pilot and navigator of a B-29 aircraft on a round-robin exercise of 20 hours duration over the arctic regions would be more interested in terminal and alternative base conditions than a detailed forecast of the weather along every mile of the route. The reason for this is simply that this aircraft is equipped with an abundance of navigational aids and can fly at an altitude where weather conditions are favourable and has sufficient range to reach any number of alternative bases. This kind of weather analysis for a crew of a Dakota or Canso or any of the short range aircraft would be unsatisfactory and to take off without a more detailed study would be fool-hardy, since these aircraft have limited operating ceiling, fewer navigational aids and shorter range.

Aircraft on photographic missions, long range reconnaissance and research flights require detailed forecasting of cloud and terminal and alternative landing site conditions anywhere from 10 - 24 hours after time of departure. In transport flying, emphasis is placed on icing conditions, wind velocities and terminal weather, and cloud extent when the aircraft has limited navigational aids.

If the aircraft is equipped with the most modern aids to navigation, including good gyros and search radar, adverse inflight weather is not a serious handicap to navigation, provided the navigator can get occasional astro checks. If the navigator must depend entirely on astro, a thorough study of cloud conditions should be made before take-off especially if the operating ceiling of the aircraft is limited. Astronomical observations are important in this case, as they are used both for fixing position and checking the aircraft heading, since the magnetic compass is not reliable over a large part of the arctic. Therefore, in briefing the crews of aircraft with a limited ceiling and operating range, the forecaster should give detailed information on cloud extent and altitude and, what is more important, where and at what altitude icing conditions may be expected.

Summer and fall flights into the arctic from southern bases must pass through the freezing level, therefore, during briefing the height at which this condition will be encountered should be clearly defined. If extensive cloud coverage is forecast, an aircraft with low operating ceiling may not be able to climb above the cloud and as the the cloud base, especially during the fall, may be very low, flying below it would be unsafe.

Pilots and navigators operating from isolated bases, where forecast facilities are not available, and radio contacts with forecasting centres uncertain, often have to analyse the weather for themselves. To do this they should have a sound training in certain aspects of meteorology to supplement the practical knowledge which comes with exeprience. On operations of this type, a thorough study of the entire arctic and polar weather situation should be made by the pilot and navigator before departure from the main base, and the latest forecast chart should also be carried.

To overcome the directional problem introduced by the convergency of the meridians, a system of grid direction is used when navigating in high latitudes. In this system a meridian is selected as a reference meridian, grid north is considered to be at an infinite distance along this meridian, and the grid direction of any line is defined as the angle measured clockwise between the direction of grid north and that line. Navigators in the western hemisphere usually select the Greenwich meridian as the reference meridian, grid north being at infinity in a true northerly direction along this meridian, and hence in a southerly direction along the 180th meridian. In this case the following directional formula applies:

Grid Direction = True Direction + W. Longitude (or -E. Longitude)

As grid direction is used in high latitude flying, wind direction also is measured with reference to this grid. Sometimes navigators neglect to convert the grid wind to true when reporting wind direction. If a report has been received in which the wind directions do not coincide with the general circulation anticipated, the forecaster may check the directions by subtracting the W. Longitude (add E. Long.) of the position report from the bearing of the wind. The result will be true direction if grid has been used.

FACTORS THAT HANDICAP FORECASTING WEATHER FOR POLAR AND ARCTIC FLIGHTS.

Aircraft ranges are continually increasing and longer and longer flights are being made; as a result forecasters are being called upon to supply weather information over an ever-increasing radius. Aircraft ranges however have outstripped the weather information readily available to those charged with briefing. The lack of longitudinal spread of information immediately available is not only a handicap in forecasting but greatly hinders flight operations. At the present time forecasts for north-south flights into the arctic regions are available all across the country, but to obtain a detailed briefing for an east-west flight across the arctic on anything short of a 24-72 hour notice is another matter. For instance a forecaster at Whitehorse will not have readily available observations made in the Labrador-Greenland area. However, on short notice an aircraft based at Whitehorse may be assigned an exercise extending into the Baffin Bay area. Much of the meteorological planning in the past with respect to the zoning of forecast areas appears to have been done on maps based on the Mercator projection. In the lower latitudes this has no appreciable effect but in high latitudes, the forecasting zones are too narrow and have not included within them sufficient reporting stations to make accurate forecasting possible for trans-arctic flying.

Insufficient meteorological observing stations greatly handicap the forecaster. Hence, the location of fronts and troughs are not always known and may move many miles before being accurately located. I can recall a flight of over 22 hours duration when a tail wind of 20 kts. was forecast for the last part of the flight, but we actually encountered a head wind of 30 - 40 kts. The high pressure system forecast for the area had travelled so far east before our flight encountered the circulation that we found ourselves flying south for the last eight hours on the west side of the system instead of on the east.

A factor that would improve the forecasting of terminal weather conditions is a better knowledge of the topography surrounding the destination. In general this applies to the entire arctic. Inaccurate forecasting of fog and cloud conditions has sometimes been caused by the lack of sufficient knowledge of the extent of open water or ice coverage. It appears to me that we need a detailed study of ice conditions. Often during fall the lack of information on snow coverage has hindered forecasting cloud and fog conditions in coastal areas.

The establishment of a forecast team at some suitable location to serve the Canadian north would go far to overcome these problems. The need for this unit has been recognized and I understand that the organization is well advanced.

If a comprehensive but simple report sheet could be devised, air navigators might assist forecasting by passing to forecast offices such valuable information as extent of ice-coverage, snow coverage and open water, in addition to purely inflight weather. The POMAR report attempts to cover too wide a field besides not being entirely suitable for high latitude observations. It is also cumbersome and requires far too much time in its preparation, this often introduces errors. As a result, reports are frequently inaccurate and by the time they are transmitted and received by forecast centres additional errors are often introduced and their value is lost. This was well borne out after two years of trials on arctic flights.