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AIR CONNECTIVITY AND AIRPORT INFRASTRUCTURE IN NORTHERN CANADA

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FOREWORD

THE CANADIAN NORTHERN CORRIDOR RESEARCH PROGRAM PAPER SERIES

This paper is part of a special series in *The School of Public Policy Publications*, investigating a concept that would connect the nation's southern infrastructure to a new series of corridors across middle and northern Canada. This paper is an output of the Canadian Northern Corridor Research Program.

The Canadian Northern Corridor Research Program at The School of Public Policy, University of Calgary, is the leading platform for information and analysis on the feasibility, desirability, and acceptability of a connected series of infrastructure corridors throughout Canada. Endorsed by the Senate of Canada, this work responds to the Council of the Federation's July 2019 call for informed discussion of pan-Canadian economic corridors as a key input to strengthening growth across Canada and "a strong, sustainable and environmentally responsible economy." This Research Program will benefit all Canadians, providing recommendations to advance the infrastructure planning and development process in Canada.

This paper, "Air Connectivity and Airport Infrastructure in Northern Canada", falls under theme *Geography and Engineering* of the program's eight research themes:

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Program Director, Canadian Northern Corridor Research Program

AIR CONNECTIVITY AND AIRPORT INFRASTRUCTURE IN NORTHERN CANADA

Alexandre G. de Barros, Marcela Coelho Lopes and Iyad Sahnoon

EXECUTIVE SUMMARY

To analyze the existing air transportation services and infrastructure along the Canadian Northern Corridor, a list of remote communities was obtained and investigated. A total of 182 communities have been assessed by Transport Canada or the provinces and territories, of which 146 are located inside the notional Canadian Northern Corridor area. These communities are the focus of our study to answer the following questions:

1. What is the current level of air transportation infrastructure and services?
2. What are the existing federal and territorial policies regarding Northern and Arctic air connectivity?
3. What is the potential impact of climate change on air transportation systems in Northern Canada?

POLICIES AND LEGISLATION

In Canada, air transportation is regulated by the federal government. As such, there are no provincial or territorial policies regarding air transportation. Air transportation services in Canada are not subject to any economic regulations. Airlines and aircraft operators in general are free to set routes and fares as they wish — subject to operational safety regulations. As such, air services in the North are generally subject to supply and demand.

The Airport Transfer (Miscellaneous Matters) Act that created the National Airports System made no special provisions for airports in Northern Canada.

The Civil Air Navigation Services Commercialisation Act transferred the operation of air navigation services to a private, not-for-profit corporation named NAV Canada. The act includes provisions for the continuance of air navigation services in northern and remote communities, requiring NAV Canada to give advance notice of any changes in service that could affect those communities. If the communities affected reject the proposed change, it will require approval by the minister of transportation.

In 2016, the Government of Canada initiated discussions to set a framework for a specific policy for Canada's Arctic and Northern Region. The work on that framework has identified better airport facilities as one of the key infrastructure needs in the region. To the time of writing of this report, no specific policies had been set to address these needs.

ACCESSIBILITY OF REMOTE COMMUNITIES TO NEARBY AIRPORTS

One hundred and forty of the 146 remote communities in this study are each served by an airport nearby. Three communities are served by water aerodromes. Only three communities in BC were found not to have an airport or aerodrome nearby.

Most communities have paved and/or gravel road access to their airports. Communities with nearby airports have fair distances to their respective airports, ranging from 0 to 20 km. The exceptions are the remote communities of Keno, which is more than 50 km away from Mayo Airport in Yukon, and Iskut, located 86 km from Dease Lake Airport.

AIRPORT INFRASTRUCTURE

In general, the existing airport infrastructure provides adequate service to the remote communities in Northern Canada. Three of the 146 communities included in this study do not have access to a nearby airport, and three others can only be accessed by seaplanes. Two are accessible by road with distances between 50 and 90 km. All other 138 communities are served by an airport located within 20 km or less.

Improvements may be required to several airports to ensure year-round, all-weather accessibility and convenience. Forty-two per cent of the airports are not equipped for instrument flights and can only be used under visual flight conditions. It should be noted that the mere availability of instrument approach procedures does not guarantee service, as those procedures also require trained pilots and aircraft equipped with instruments. Only 85 per cent of the runways are not paved, which affects aircraft maintenance and durability. Thirty per cent of the airports do not offer winter maintenance, which can affect their availability during and after snow and ice storms. Twenty per cent of the airports do not feature a terminal building, leaving the processing of passengers and cargo subject to inclement weather. The costs and benefits of such improvements are likely to vary from airport to airport and should be evaluated in more detail on a case-by-case basis.

AIR CONNECTIVITY

Compared to other communities, the majority of the remote communities in the northern parts of the provinces are generally well connected, with scheduled services connecting them to regional and international airports. There are, however, several airports with limited or no commercial services. Eighteen per cent of the airports in this study have no commercial services that connect them regularly to other communities. Seven airports are only served by charter services. Even in the case of the 109 airports that do have regularly scheduled services, the flights are infrequent and costly — it should be noted, however, that this study did not include an assessment of the prices of air tickets serving the northern remote communities.

One other limitation of this study is the absence of information on cargo and ambulance services. For the latter, the existing runway infrastructure — in terms of length and surface — is sufficient to accommodate aircraft with sufficient ranges to connect them to a larger airport and/or community. Cargo, however, is severely limited by the size of the aircraft that can operate on the existing runways. Only 44 per cent of the airports can accommodate jet and larger turboprop aircraft. Once more, an economic analysis of cargo operations and the improvements required to improve them is beyond the scope of this study.

This study is also limited to an evaluation of air services in northern remote communities from a purely air-services perspective. Even though a large portion of the communities have adequate services from that point of view, it should be noted that this by no means implies that their transportation needs are being met. Even in large communities and urban settlements, the transportation of goods and people relies mostly on ground transportation, with air transportation providing faster connections for higher valued travel.

For future studies, we recommend a deeper comparison of the costs and benefits of implementing a northern corridor with the existing air services.

IMPACT OF CLIMATE CHANGE ON NORTHERN AIR OPERATIONS

A weather study conducted for twenty-one select airports, using cloud ceiling data — one of the critical factors in determining the ability of pilots to land at an airport — showed no evidence of impact of climate change in airport operational availability over the last seventeen years. At 60 per cent of the airports, the number of annual inoperative hours shows a slight negative trend. In the summer, 60 per cent of the airports have shown a slight increase in the number of inoperative hours, whereas in the winter the trend is mixed, with 50 per cent of the airports with a negative trend and the other 50 per cent showing a positive trend.

Flying an aircraft is a very complex operation that is affected by many factors. Climate change can affect not only cloud coverage but also runway visual range, precipitation (snow and rain), runway surface condition such as snow and ice, wind speed and direction, and other factors that can affect an aircraft's ability to operate at an airport. However, most of these conditions are correlated. Although a deeper investigation may find stronger evidence that climate change has impacted airport operations in other ways, the fact that cloud ceiling was not found to be affected does not indicate that climate change has significantly affected air access to the northern remote communities.

KEY FINDINGS

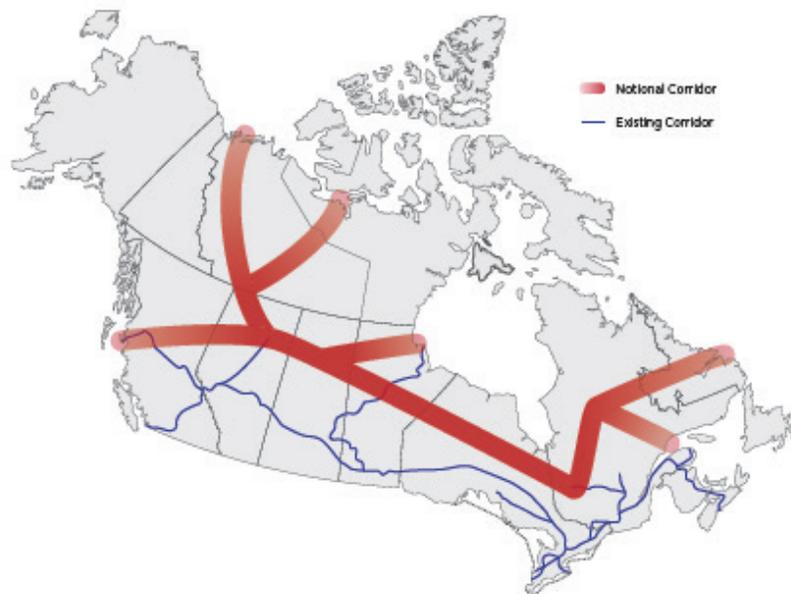
- A total of 146 remote communities in Canada were identified in this study. All but eight of those communities are served by an airport located within 20 km by road from the community.
- Eighty-three per cent of airports have a single gravel or crushed-rock runway, 15 per cent have paved runways, and 2 per cent have turf or sand runways. Eleven per cent of airports have a runway that is long enough to accommodate only aircraft with up to twenty seats, 45 per cent can accommodate aircraft with up to fifty seats, and the remaining 44 per cent can accommodate larger, longer-range aircraft.
- Generally, the remote communities located in the provinces are well connected by air, with services to regional and international airports.
- There are 116 airports (82 per cent) with regular charter or scheduled flight services. Twenty-six airports (18 per cent) do not currently have any regular flight services, twelve of which airports are in the territories. Of the airports with regular flight services, 109 have scheduled flight operations and seven have only charter services. For the twenty-six airports without regular services, sixteen have no scheduled services accessible by road to an alternative airport.

- Fifty-nine airports (42 per cent) have published instrument-approach procedures and can potentially accommodate flight operations in low visibility. The remaining airports can accommodate flights only during visual meteorological conditions.
- Twenty-nine airports (20 per cent) do not have terminal buildings.
- From an analysis of recent historical flight data, 62 per cent of airports had daily or quasi-daily flights year-round over the past two-and-a-half years.
- No relevant policies were found regarding air services to northern remote communities in Canada. In general, air services to those communities are of a commercial nature and determined by supply and demand.
- A weather study conducted for twenty-one select airports, using cloud ceiling data — one of the critical factors in determining the ability of pilots to land at an airport — showed no evidence of impact of climate change in airport operational availability over the last seventeen years. Other factors, such as runway visual range — which is generally correlated to cloud ceiling — and runway surface condition were not investigated.

INTRODUCTION

The Canadian Northern Corridor (CNC) is a concept that aims to study the feasibility, acceptability and desirability of a coherent and unified approach to national and regional infrastructure development in Canada, responding to Canada's need to increase interregional and international trade and provide services to northern communities (School of Public Policy 2022). The notional corridor consists of establishing a multimodal transportation system through the northern part of Canada, from east to west across provinces (Sulzenko and Fellows 2016). The infrastructure includes road, rail, pipeline, communication and electricity transmission (Boardman, Moore and Vining 2020). This notional corridor would be a solution to the challenges presented by the limited access and infrastructure of northern and remotes communities in Canada (Fawcett, Pearce and Ford 2020). Figure 1 depicts the notional corridor's alignment.

Figure 1: Canadian Northern Corridor (Source: Sulzenko and Fellows 2016)



To assess the existing air transportation services and infrastructure along the Canadian Northern Corridor, a list of remote communities was obtained and investigated. Transport Canada (2021), along with the provinces and territories and Indigenous partners, has identified remote communities in Canada to ensure they receive the essential transportation services, food and medical supplies, and other services they need. A total of 182 communities have been assessed by Transport Canada or the provinces and territories, and 146 of these are located inside the notional Canadian Northern Corridor area. These communities are the focus of our study to answer the following questions:

1. What is the current level of air transportation infrastructure and services?
2. What are the existing federal and territorial policies regarding Northern and Arctic air connectivity?
3. What is the potential impact of climate change on air transportation systems in Northern Canada?

This research paper is organized as follows. In the next section the framework for the data collection and analysis are described. The section focuses on the remote communities explored in this study and their socioeconomic characteristics. Then the access to those communities by air transportation is assessed. The section also discusses characteristics of the airports at remote communities in the Canadian Northern Corridor, the availability of airline services and connectivity to those airports.

The following section of the report focuses on federal, provincial and territorial policies and regulations that might affect the transportation systems on the Canadian Northern Corridor. Finally, the impact of climate change on air transportation in the Canadian Northern Corridor is discussed.

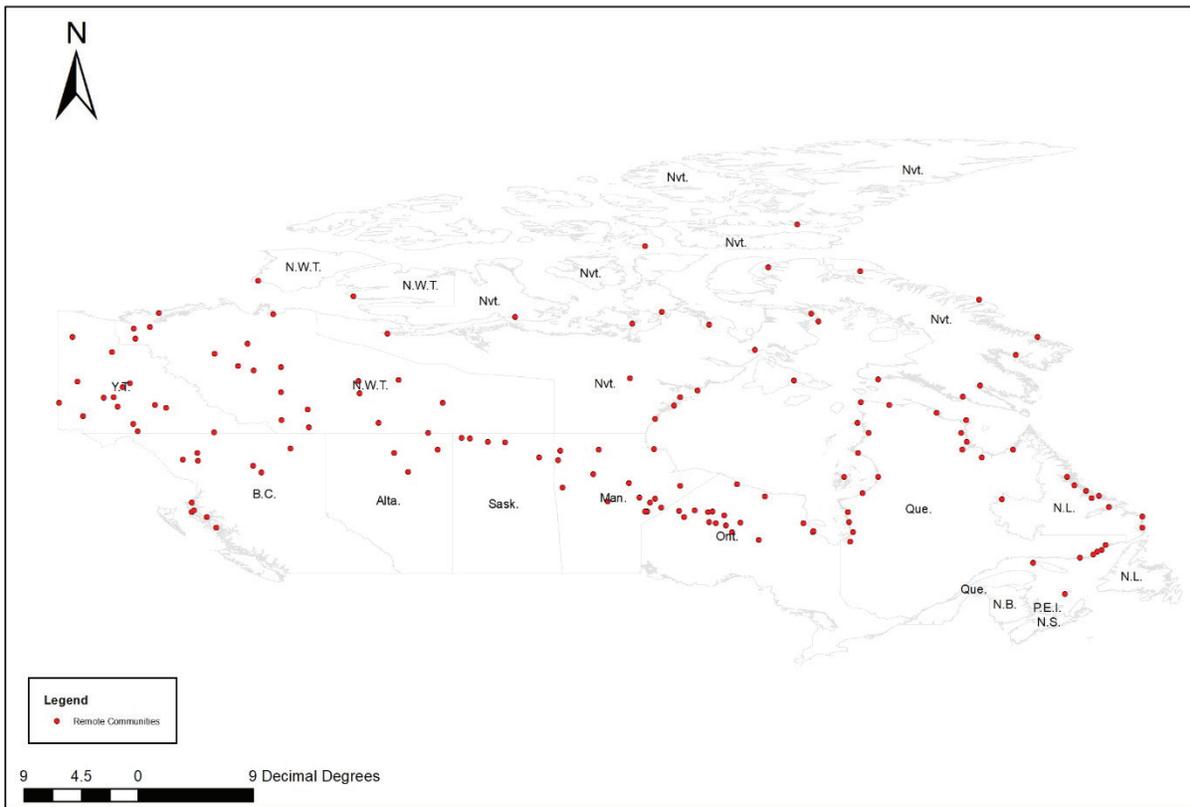
DATA ANALYSIS FRAMEWORK

Meeting the objectives of this research involved intensive data collection and analysis. The data analysis performed was both qualitative and quantitative. The qualitative analysis covers the characteristics of the remote communities assessed, the airport infrastructure and air connectivity. The quantitative assessment consisted of weather analysis, impact of climate change on the air transportation system and the existing airport infrastructure. Most of the numerical analysis was done using Microsoft Excel, while the spatial analysis was performed using mapping tools and services such as ArcGIS, Google Earth and Google Maps.

REMOTE COMMUNITIES IN NORTHERN CANADA

Transport Canada (2021), the provinces and the territories have listed a total of 182 remote communities in Canada. For those communities, air transportation is the only mean of accessibility. Also, some communities may have limited access to seasonal ice roads or other slow and unreliable modes of transportation (e.g., gravel road and ferries). Considering the pre-defined Canadian Northern Corridor boundaries, 146 localities shown in Figure 2 were chosen in the current study to be further assessed.

Figure 2: Remote communities included in the study



Socio-economic data on these remote communities was collected from Statistics Canada and includes population density of all communities in the Canadian Northern Corridor polygon, population average age and average income.

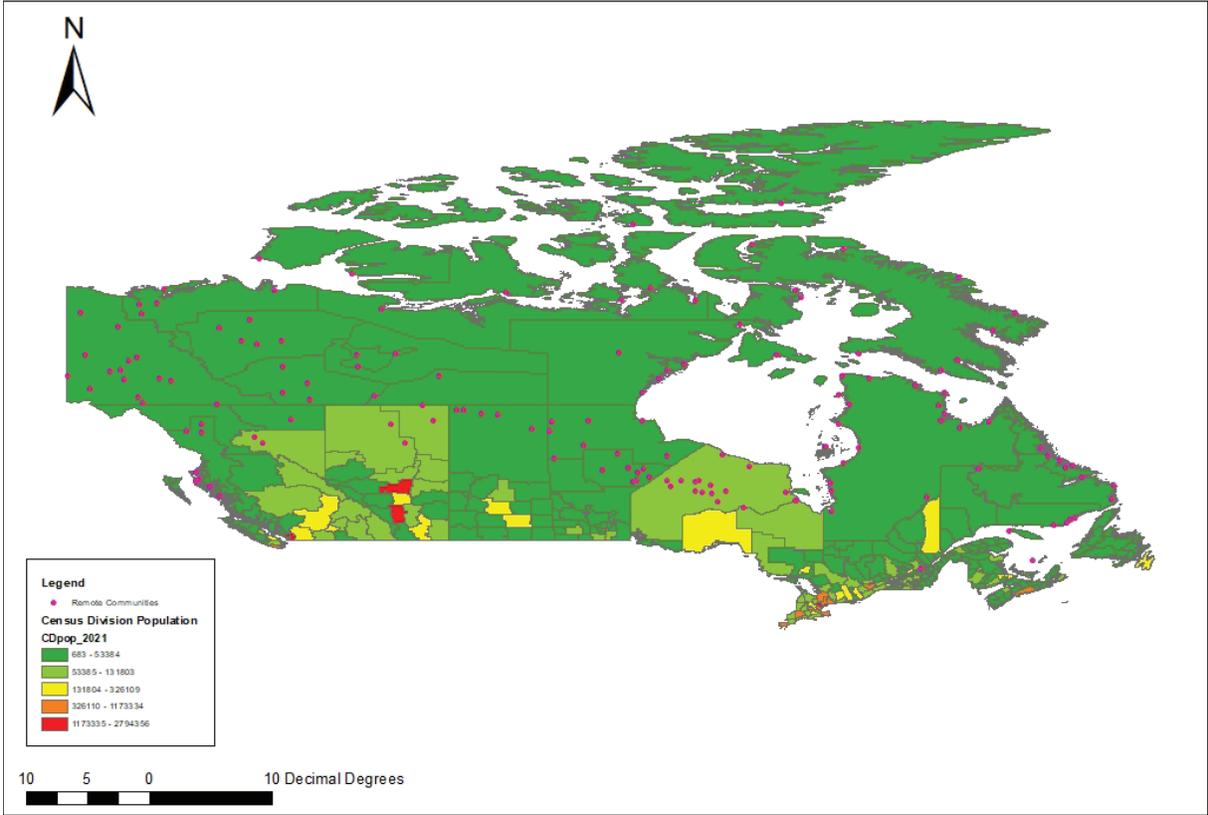
Population data was obtained from Statistics Canada and then imported into ArcGIS 10.8.1 to calculate the population density over the bounded area of the Canadian Northern Corridor. Table 1 summarizes the population and population density per square kilometre of all remote communities in each province and territory. Note that the most recent population data found for the remote communities is for 2016. A map that presents population of census divisions in 2021 is shown in Figure 3.

The highest population density of all communities bounded by the Canadian Northern Corridor is found in Alberta, followed by Quebec, British Columbia and Ontario, with values of 0.54, 0.31, 0.29 and 0.19 persons/km² respectively. Although these provinces have the highest population densities of all communities bounded by the Canadian Northern Corridor, they comprise only around 40 per cent of the studied remote communities in Canada. In addition, most of the provinces' areas, especially the southern ones, are well connected by air through international and regional airports.

Table 1: Population data for communities on the Canadian Northern Corridor

Province/ territory	Population 2021	Population density (2021) of all communities (per km ²)	Population density (2016) of "remote" communities (per km ²)
Alberta	136,675	0.54	0.011
British Columbia	142,220	0.29	0.011
Manitoba	46,916	0.13	0.029
Newfoundland and Labrador	26,655	0.07	0.009
Northwest Territories	41,070	0.03	0.012
Nunavut	36,858	0.02	0.016
Ontario	66,000	0.19	0.027
Quebec	425,130	0.31	0.022
Saskatchewan	35,986	0.16	0.006
Yukon	40,232	0.08	0.054

Figure 3: Canada’s census divisions population (2021)



The average age (census data of 2016) and income (2015 data) of remote communities’ population in each province and territories are shown in Table 2. It can be seen that Yukon territory has the highest average age of population (i.e., 40.5 years old) followed by Newfoundland and Labrador and the Northwest Territories (i.e., thirty-five years old). On the other hand, Nunavut, Ontario and Manitoba have the lowest average ages (i.e., twenty-seven, twenty-eight, and twenty-nine, respectively). In 2015, Yukon’s remote communities had the highest average income for individuals aged fifteen years and over in private households (i.e., \$1,750), while Saskatchewan had the lowest income value (i.e., \$238).

Table 2: Average age and income of individuals in remote communities

Province/ Territory	Population mean age (2016)	Annual Average Income (2015) \$
Alberta	30	915
British Columbia	34	536
Manitoba	29	472
Newfoundland and Labrador	35	384
Northwest Territories	35	553
Nunavut	27	892
Ontario	28	373
Quebec	33	923
Saskatchewan	32	238
Yukon	40	1,750

ACCESSIBILITY OF REMOTE COMMUNITIES TO NEARBY AIRPORTS

There are over 1,800 aerodromes in Canada, including large airports and water aerodromes (Natural Resources Canada 2010). Bouchard (2020) surveyed the existing airports located in the Canadian territories – Nunavut, Yukon and the Northwest Territories – with their respective runway surface types and existing commercial services. Since the CNC would also serve communities located within the provinces, this research paper includes airports along the notional corridor in the provinces. Other important airport characteristics not assessed by Bouchard (2020) are included, as described below.

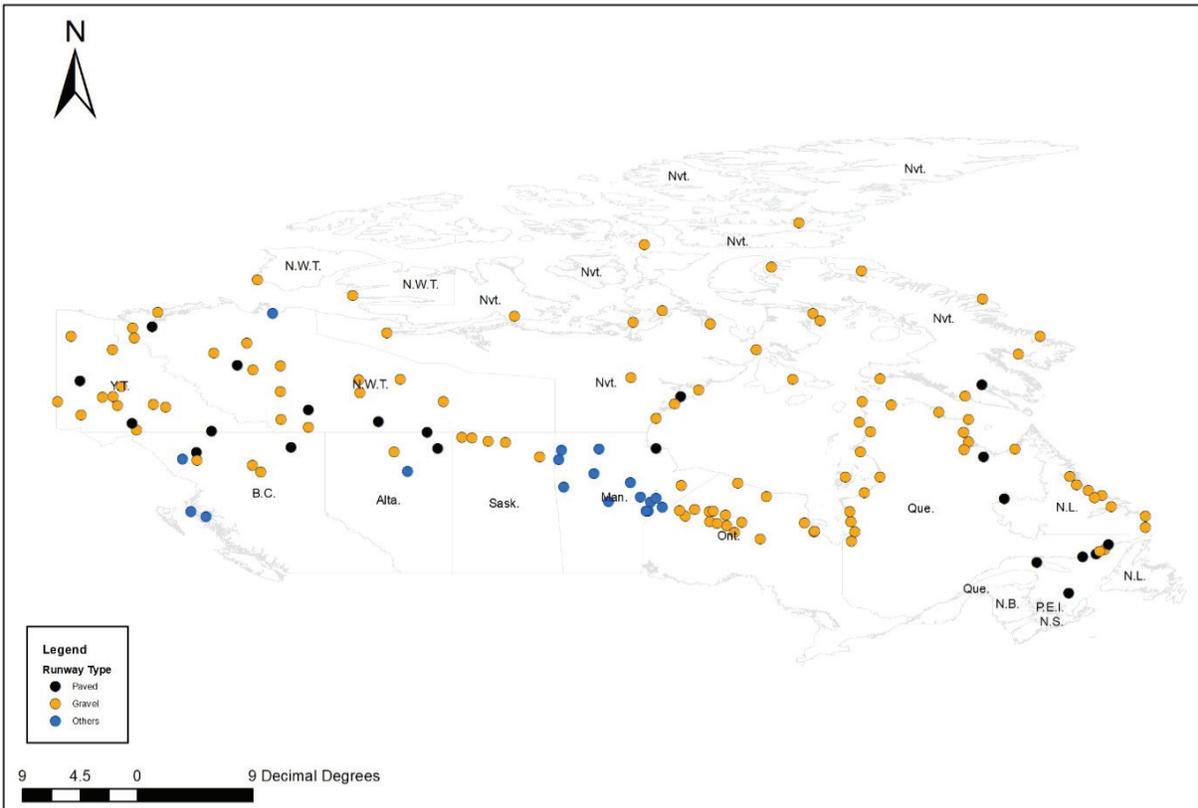
For each remote community inside the Canadian Northern Corridor polygon, Google Earth and other online resources such as the Canadian Flight Supplement, Canadian Airport Chart, the websites of provinces and territories and the FlightAware website were used to identify the following:

1. Airport location (coordinates);
2. International Air Transport Association (IATA) and International Civil Aviation Organization (ICAO) codes, and the Transport Canada location identifier;
3. airport characteristics such as runway pavement and dimensions, airport elevation, availability of a passenger terminal building, flight approach conditions (lighting and instrumental);
4. access roads;
5. airlines operating from/to these airports;
6. aircraft types operating at the airport and
7. airport connections with other hubs.

(NAV Canada 2022a, NAV Canada 2022b, Flight Aware 2022a, Flight Radar 2022a, Sky Vector 2022, Government of Yukon 2022, Explore North 2022, Government of Nunavut 2022, Flight Plan Database 2022, and Airport Guide 2022). Figure 4 shows the locations of these airports with runway type.

One hundred and forty of the 146 remote communities in this study are served by an airport nearby. Three communities are served by water aerodromes. Only three communities in BC were found not to have an airport or aerodrome nearby.

Figure 4: Remote Communities Near Airport Locations



Road pavement condition and distance, in kilometres, from each remote community to the nearest airport were assessed using Google Maps. There are two communities in Manitoba — Island Lake and St. Theresa Point — that are geographically near airports but do not have direct access to them, as the nearby airports are located on islands and are separated by water from the communities. Twelve remote communities have airports, but their connecting routes were not clear on the maps at the time of observation. Most of the remaining communities have paved and/or gravel road access to the airport. Communities identified with nearby airports have fair distances to their respective airports — up to 20 km. The exceptions are the remote communities of Keno, which is more than 50 km away from Mayo Airport in Yukon, and Iskut, located 86 km from Dease Lake Airport. The average distance for each province from the remote community to the closest airport is shown in Table 3.

Table 3: Average distance between airport and community by province

Province/ Territory	Average distance (km)
Alberta	4.07
British Columbia	2.25
Manitoba	1.99
Newfoundland and Labrador	2.13
Northwest Territories	3.71
Nunavut	2.23
Ontario	3.73
Quebec	3.23
Saskatchewan	3.49
Yukon	9.73

AIRPORT INFRASTRUCTURE

The airport infrastructure characteristics assessed included:

- Existence of a terminal building;
- availability of instrument approaches;
- runway dimensions and pavement type (asphalt, gravel, turf);
- runway lighting and
- availability of runway winter maintenance.

Information on the items above was collected from various sources, including Canadian Airports Charts, FlightRadar, Skyvector, Nunavut and Yukon websites (NAV Canada 2022a, NAV Canada 2022b, Flight Radar 2022a, Flight Aware 2022a, Sky Vector 2022, Flight Plan Data base 2022, Government of Yukon 2022, Government of Nunavut 2022, Explore North 2022, and Airport Guide 2022).

Passenger Terminal Building

The availability of a passenger terminal building affects the interest of airlines in establishing regular flight operations at the airport. Airports without passenger terminal buildings are more likely to be limited to general aviation aircraft, which are operated by private operators.

For information on the presence of a terminal building at the airport, the Canadian Airport Charts (NAV Canada 2022a) and Google Earth were used. Twenty-six airports do not have terminal passenger buildings, as can be seen in Table A.2.

Instrument Approaches

Under visual meteorological conditions, pilots can take off and land from/at an airport runway using visual cues. Generally, minimum runway visual range and cloud ceiling thresholds for visual flights are 2,600 feet and 800 feet, respectively. When the minimum

visibility thresholds are not met, landing is only possible if one or more instrument approach procedures is available.

Only fifty-nine airports have runways with instrument approach procedures. Eighty airports can only accommodate visual operations. The absence of instrument approaches at an airport will prevent operations during low visibility caused by bad weather, reducing the airport's availability.

Runway Markings for Nighttime Operations

The ability to operate on a runway during nighttime can be critical for emergency operations, and are of crucial importance during the short winter days in northern communities. Runway nighttime operations require reflective markers and maintenance procedures to ensure nighttime visibility to pilots.

The Canada Flight Supplement (NAV Canada 2022b) was consulted for information on the availability of night operation at the airports included in this study. Most airports were found to be equipped with runway lighting and/or reflective markers. The lack of availability for nighttime operations can be a significant hindrance to the communities' access to and from other communities, especially during winter, when days are very short.

Runway Dimensions and Surface

The dimensions of a runway, together with its pavement type and strength, determine the type and size of aircraft that can operate on it. Even in cases where pavement type does not prevent operations of a specific aircraft, it may affect the aircraft's performance, maintenance and life cycle, thereby affecting the aircraft operator's cost.

Eighty-three per cent of the airports within the Northern Corridor alignment have gravel or crushed rock runways, 15 per cent have asphalt runways, and 2 per cent have turf or sand runway. The vast majority of the airports (approximately 96 per cent) have single runways.

The International Civil Aviation Organization's Annex 14 (ICAO 2018) uses a system based on aircraft dimensions and approach performance parameters to categorize runway dimensions. Aircraft – and the runway where they operate – receive a number code ranging from 1 to 4, representing runway length required for takeoff; and a letter code ranging from A to F representing the aircraft size – wingspan, length and wheel track. Airports with lower reference codes are capable of serving only smaller aircraft, whereas airports with higher reference code can handle larger aircraft.

From the reference codes and airport infrastructure presented above, sixteen airports have reference codes 1B / 1C / 1D and are able to operate only small aircraft. All of those sixteen airports have gravel runways. These airports typically are not capable of accommodating scheduled or charter flights larger than twenty seats, and operate mostly general aviation aircraft.

Sixty-two airports in this research are code 2B / 2D, and the vast majority of those also have gravel runways. Those are capable of operating Scheduled or charter flights with larger passenger and cargo capacity. Typically, these aircraft have turboprop engines and a seat capacity up to fifty passengers. The DHC Q300 and ATR 42 are examples of aircraft often used for scheduled flights between small Canadian airports.

From the 141 airports in Northern Canada's remote communities, forty-nine are code 3B / 3C / 3D. Most of those airports have gravel runways, and some have paved runways. Code 3 airports have the capability to operate even larger aircraft due to their runway length — paved runways can accommodate even small jet operations.

The remaining fourteen airports are code 4C / 4D / 4E. Most of the airports in remote communities of Northern Canada that are code 4 have paved runways, with one exception. Out of the fourteen airports, four have more than one runway, where the second runway is typically gravel. These airports are capable of accommodating jet aircraft, such as the Boeing 737 and the Airbus A320, which can carry over one hundred passengers.

Runway Winter Maintenance

In the winter months, runways must be properly maintained to allow the safe operation of aircraft. Runway winter maintenance may consist of snow removal and/or compacting snow for operation of ski-equipped aircraft.

The Canada Flight Supplement (NAV Canada 2022b) provides runway winter maintenance for all airports in Canada. We found that approximately 30 per cent of the airports in this study do not provide winter maintenance, which could severely limit their availability in poor winter weather conditions. The other 70 per cent provide runway winter maintenance, although many of them do so only during specific times of the day and days of the week.

COMMERCIAL AIR SERVICES

More than 80 per cent of the airports evaluated can receive scheduled flights, with runways able to operate aircraft with fifty seats or more and with landside infrastructure (a terminal building). Not all those airports currently operate scheduled passenger flights.

Data on existing flight services was collected from Flight Radar (2022a) and Flight Aware (2022a). One hundred and sixteen airports (82 per cent) have regular charter (seven) or scheduled (109) flights, while the remaining twenty-seven (18 per cent) are not currently served by commercial flights.

The number of airports with and without scheduled services by province or territory, as well as the number of connections, are shown in Table 4.

Table 4: Number of airports with and without scheduled flights in each province/territory

Province	Number of airports without scheduled routes	Number of airports with scheduled routes to			
		One airport	Two airports	Three airports	Four or more airports
Alberta	1	1	3		
British Columbia	3	4			1
Manitoba	6	7	3		1
Newfoundland and Labrador	1		6	1	
Northwest Territories	5	7	3	4	4
Nunavut		8	9	6	2
Ontario	3	1	11	4	1
Quebec		2	12	7	8
Saskatchewan	1	1		3	2
Yukon	8	3	1	2	1

From Table 4, it can be seen that 18.9 per cent of the airports are not connected (i.e., do not have scheduled routes), 23.8 per cent of the airports are connected only to one airport, 31.5 per cent are connected to two airports, and 25.8 per cent are connected to three or more airports.

For the airports without any regular commercial services, the alternative airport — i.e., the nearest airport with regular commercial services — was searched. Flight Radar (2022a) provides an alternative nearest airport option with respective distance. However, the site provides only distance by air, and there is no road access from the community to the alternative airport. Moreover, some of the alternative closest airports provided by Flight Radar do not have scheduled flights either, so they are unable to serve the community with scheduled flights. For sixteen airports, no alternative airports accessible by road and with scheduled flights were found.

For each airport, our search included the range of the largest operating aircraft and the type of aircraft used (turboprop or jet). For the airports with only turboprop operation, the nearest airport with jet services was searched, along with the number of flight legs required to get to there. Only nine of the 116 airports with commercial services have jet services; 87 need one or two flight legs to access an airport with jet services, and 14 need more than two legs. Six airports are connected only with other small airports, with no connection to larger airports with jet services.

The summary, by province, of the number of airports that serve the remote communities in terms of the characteristics described above are shown in Table 5.

The air connectivity for the airports in this study is also summarized in Figure 5, where grey dots are airports with scheduled or regular routes, and red dots are airports without regular routes. The grey routes represent scheduled commercial flights and black routes are regular charter. The blue polygon represents the boundaries of the Canadian Northern Corridor study.

Table 5: Scheduled Services at Airports serving the Northern Remote Communities

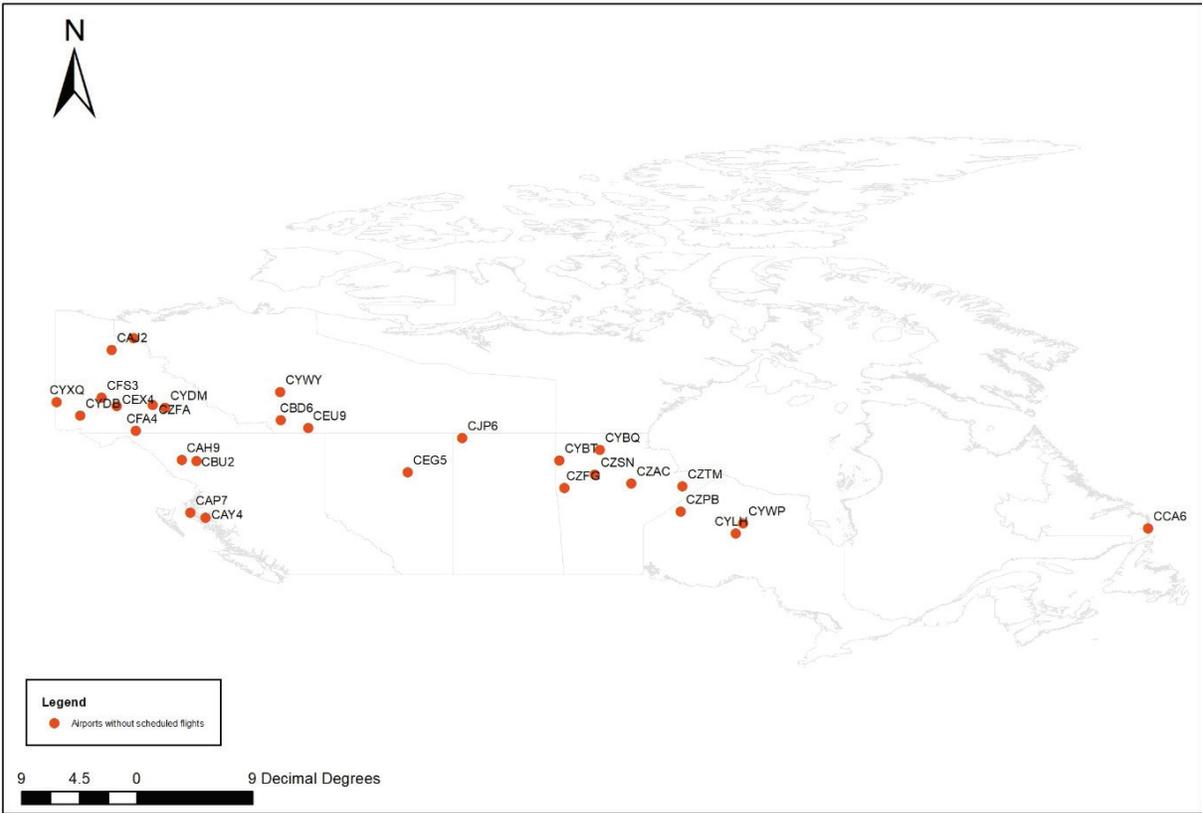
Province	Number of airports								
	Scheduled flights		Aircraft type		Largest aircraft range		Flight legs to airports with jet services		No connection to airports with jet services
	Scheduled Airlines	Charter Airlines	Jet	Turboprop	under 2,000 km	over 2,000 km	1-2	3-4	
Alberta	1	1		2	1	1	2		
British Columbia	3	1		4		4	4		
Manitoba	7	2	1	8	1	8	2		6
Newfoundland and Labrador	7			7	7		4	3	
Northwest Territories	17	1	2	16	6	12	16		
Nunavut	25		3	22	2	23	20	2	
Ontario	14			14	1	13	9	5	
Quebec	26		2	24	13	13	21	3	
Saskatchewan	4		1	4	1	3	3	1	
Yukon	5	2		6		7	6		
TOTAL	109	7	9	107	32	84	87	14	6

Figure 5: Connectivity map for northern airports



Figure 6 highlights the airports that are not currently served by any scheduled services.

Figure 6: Airports without scheduled flights



History of Flights to/from Remote Communities

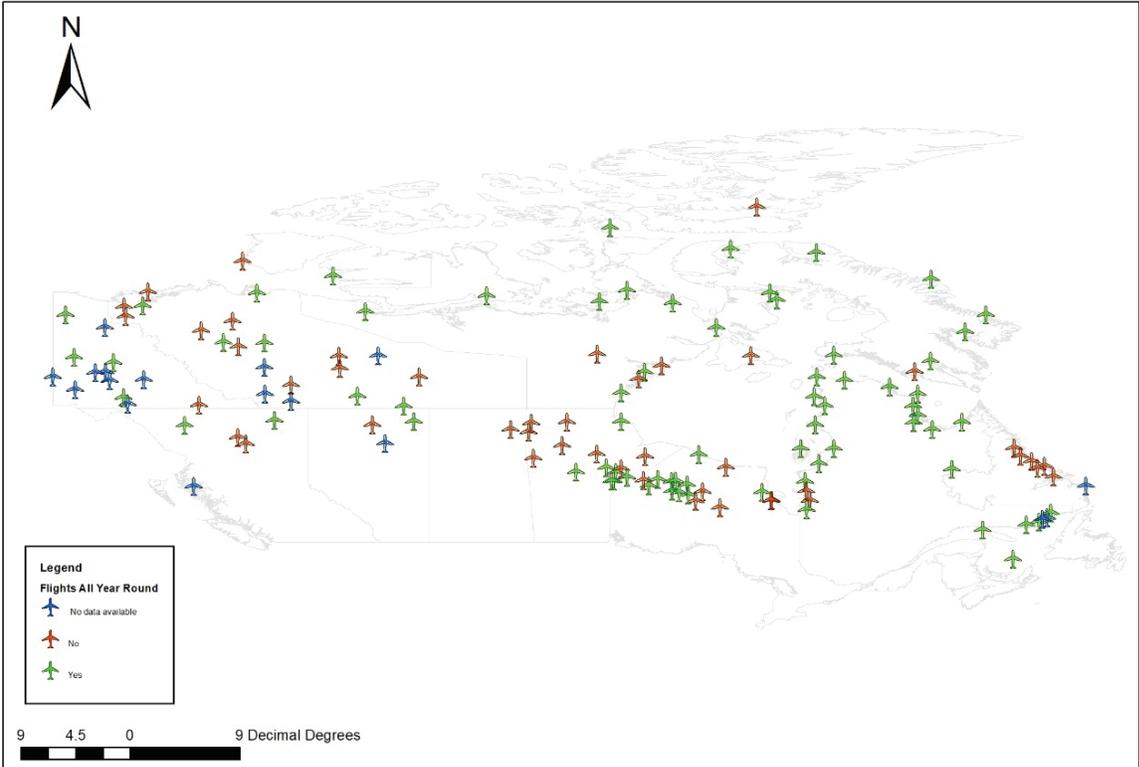
Flight Aware (2022b) was consulted to collect daily arrivals and departures data from January 2020 to July 2022 for the airports included in this study. Some airports were missing data and, therefore, were not included in the discussion.

Two main observations were collected from the data: the occurrence of flights in most days in a single year and any differences between flight services in summer and winter. These observations are presented on maps as shown in Figure 7.

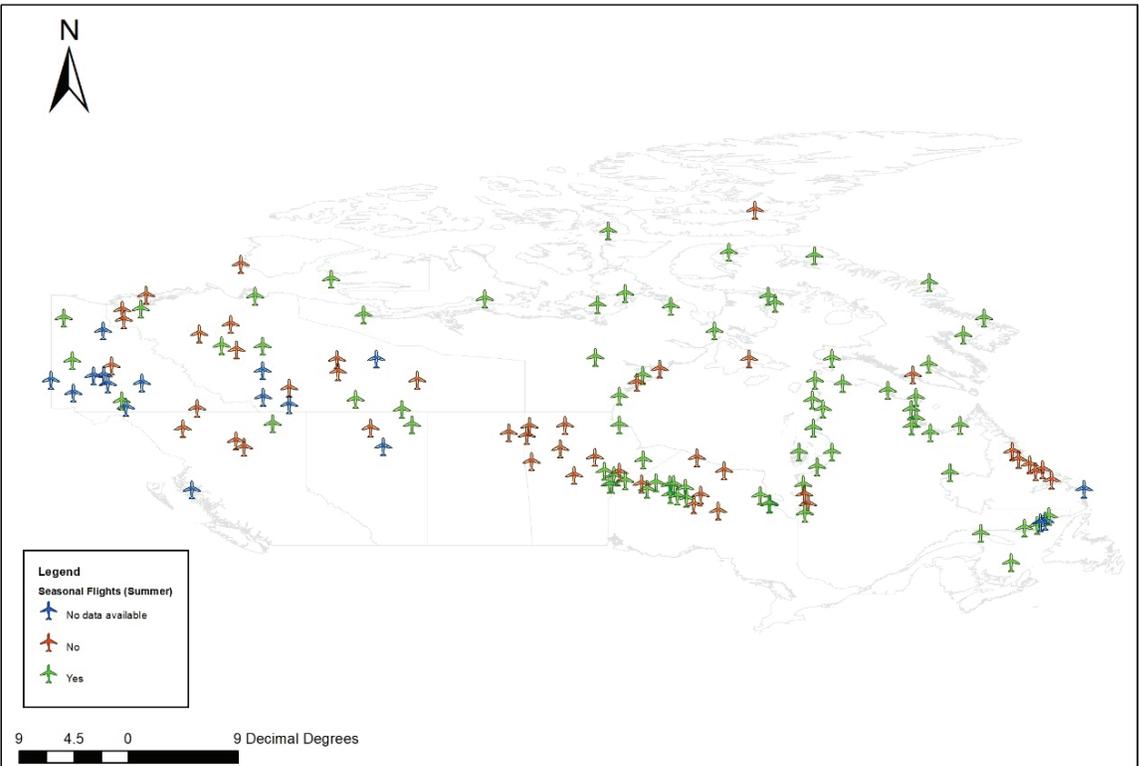
The data collected includes the start of the COVID-19 pandemic (early 2020 in Canada). Some flights that might have been available on a regular basis before the pandemic may have had to be suspended. This data was also collected while the pandemic effects continue to be a challenge for air transportation. So far, the industry has not recovered to the same levels as 2019.

Figure 7: Airports with air services (a) all year round, (b) summer seasonal, and (c) winter seasonal

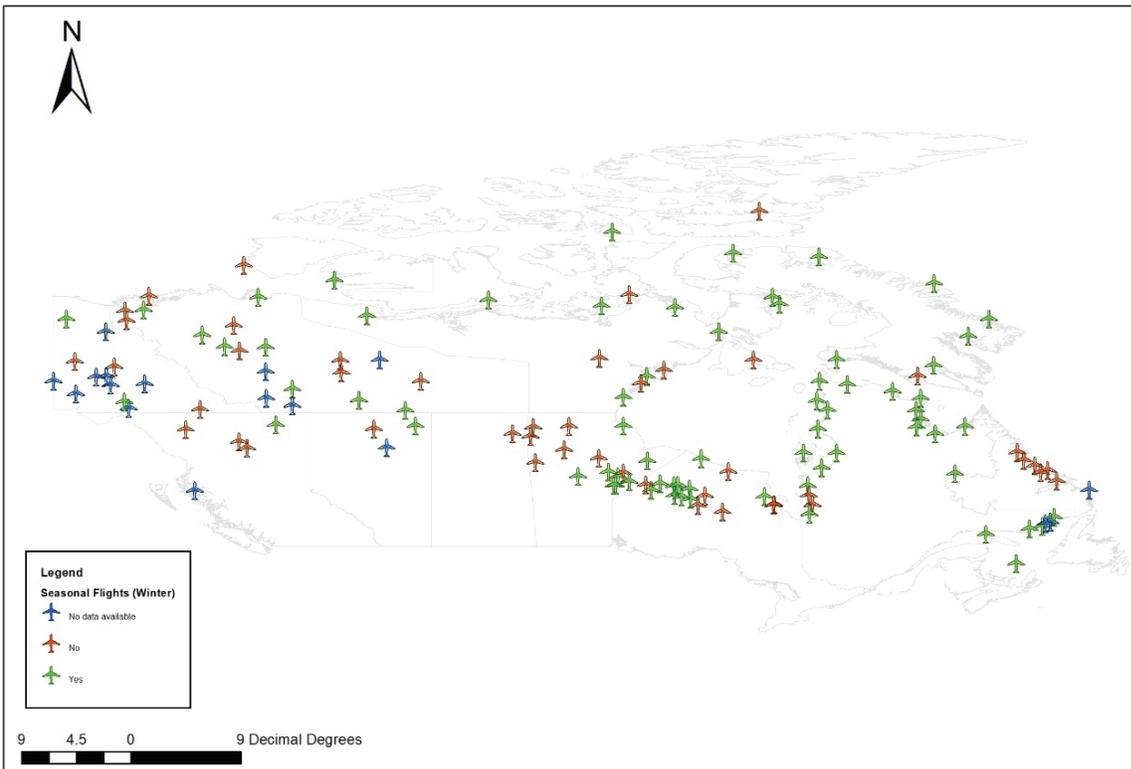
a.



b.



c.



From Figure 7, it can be observed that there are no significant changes in occurrence of flights in the summer vs. winter. Seventy-two airports — 62 per cent of the 117 for which data was available — had daily or quasi-daily flights year-round over the past two-and-a-half years. Two airports had flight operations mainly during the summer, and three mainly during the winter. At the remaining airports, the frequency of flight operations was quite irregular.

POLICIES AND LEGISLATION REGARDING AIR TRANSPORTATION IN NORTHERN CANADA

A review of air transportation policies and legislation for Northern and Arctic Canada was performed by Tretheway et al. (2021). In Canada, air transportation is regulated by the federal government. As such, there are no provincial or territorial policies regarding air transportation. That study also found that, even in the federal jurisdiction, there are very few notable provisions in the federal policies and legislation regarding air transportation in the North.

The Airport Transfer (Miscellaneous Matters) Act (Department of Justice 1992) created the National Airports System, with twenty-three airports leased to Canadian airport authorities and three — Iqaluit, Whitehorse and Yellowknife — operated by their respective territorial governments. With few exceptions, all other airports were transferred to the provincial and territorial governments. No special provisions were made for airports in Northern Canada.

Air transportation services in Canada are not subject to any economic regulations. Airlines and aircraft operators in general are free to set routes and fares as they wish — subject to

operational safety regulations. As such, air services in the North are generally subject to supply and demand. There are no federal policies regarding essential air services as some countries have (Tang 2015), although the federal government has provided ad-hoc funding in specific cases (Government of Ontario 2021).

The Civil Air Navigation Services Commercialization Act (Department of Justice 1996) transferred the operation of air navigation services to a private, not-for-profit corporation named NAV Canada. The act includes provisions for the continuance of air navigation services in northern and remote communities, requiring NAV Canada to give advance notice of any changes in service that could affect those communities. If the communities affected reject the proposed change, it requires approval by the minister of transportation.

In 2016, the Government of Canada initiated discussions to set a framework for a specific policy for Canada's Arctic and Northern Region (Crown-Indigenous Relations and Northern Affairs Canada, 2022). The work on that framework identified better airport facilities as one of the key infrastructure needs in the region. To the time of writing of this report, no specific policies had been set to address these needs.

IMPACT OF CLIMATE CHANGE ON AIR TRANSPORTATION IN NORTHERN CANADA

The impact of climate change for the notional Canadian Northern Corridor has been assessed in depth by Pearce et al. (2020). The infrastructure in Northern Canada is already facing the impact of climate change, and there is a highly likelihood that with the projections of climate change, existing and new transportation infrastructure not only require construction and maintenance, but face greater risk of damage. The impact of climate change in Northern Canada is due to an increase of annual average temperature in the order of 2.3 °C, with an increase of 4.3 °C during winter months, along with a 20 per cent increase in precipitation, including snowfall. Because of temperature increases in Northern Canada, the permafrost temperature has also increased (Pearce et al. 2020).

The increase in temperature, precipitation and permafrost thaw can have a great impact on airports and availability of transportation services. Permafrost thaw in particular affects runway and taxiway pavement structures (Doré et al. 2012).

Since air operations are heavily dependent on weather conditions, climate change plays an important role in airport availability. Under visual meteorological conditions, pilots can take off and land from/at an airport runways using visual cues. Generally, minimum runway visual range and cloud ceiling thresholds are 2,600 ft and 800 ft, respectively. When the minimum visibility thresholds are not met, landing is possible only if one or more instrument approach procedures are available. Even so, there will still be operational minima that need to be met. The minimum runway visual range and cloud ceiling for instrument approaches vary with a number of factors and are typically 1,200 ft and 500 ft, respectively. Other conditions such as precipitation, ice and crosswinds can also affect an aircraft's ability to take off and land on a runway.

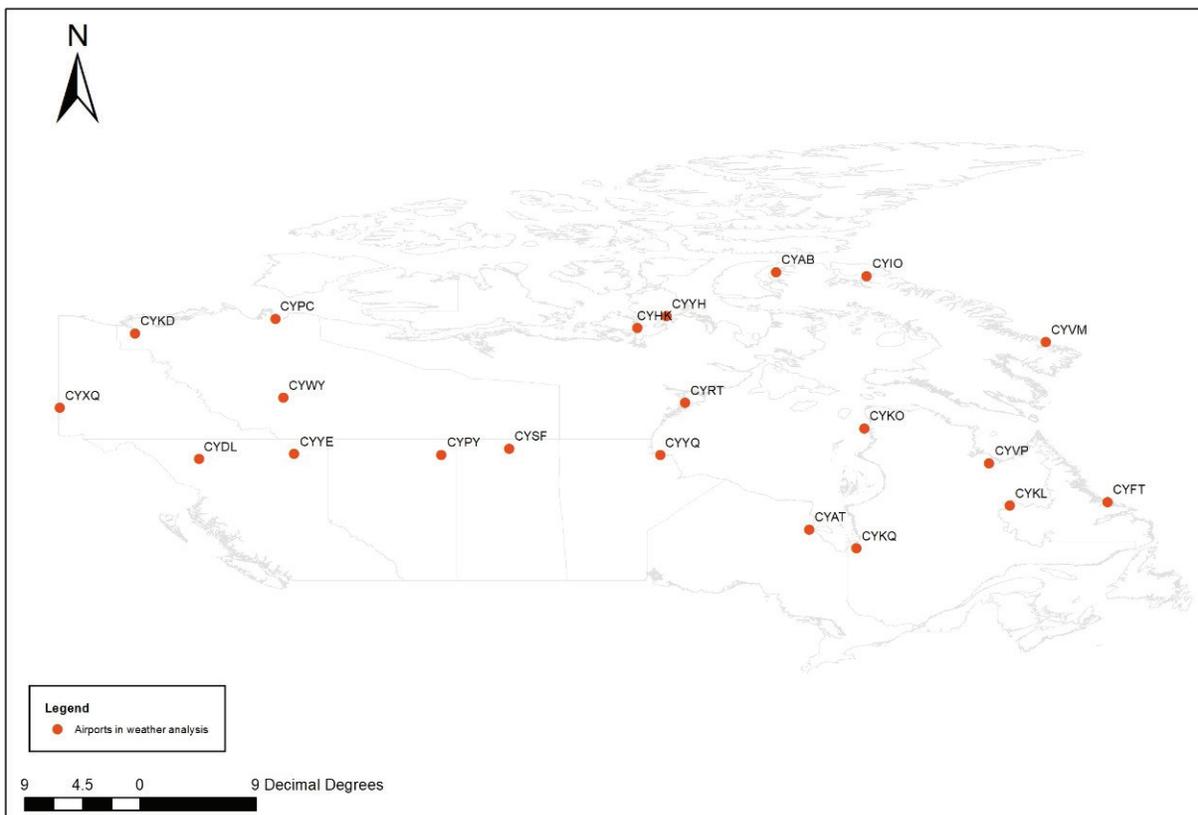
Aircraft operators use meteorological terminal air reports (METAR) to assess the weather conditions at an airport or at weather stations in the airport vicinity. METAR reports consist of alphanumeric codes that when decodified provide the following information: station

identifier (location), date and time, wind conditions (speed, direction and wind gusts), visibility, weather conditions (precipitation), sky conditions (cloud coverage), temperature and dew point, altimeter setting and special remarks.

A critical condition for airport operations comprises the sky conditions in terms of cloud coverage. There are four categories of cloud coverage used in METAR reports: scattered, few, broken, and overcast; the last two are considered 'ceiling.' Typically, if the cloud ceiling is below 800 ft, the airport cannot be used for visual landings.

Of the 143 airports, twenty-one were selected for the weather analysis. All the airports selected for the weather analysis have ICAO codes – to enable us to search for their data – and cover most of the area inside the Canadian Northern Corridor polygon. The airports chosen for the impact of climate change on air transportation in Northern Canada evaluation are shown in Figure 8. For most airports, the METAR data collected covers the period from 2005 to 2021 (seventeen years); however, a few airports have gaps in the data. The data was collected from Oгимet (2022).

Figure 8: Airports included in the weather analysis



The information used in this analysis was cloud ceiling (broken/overcast cloud conditions), the respective height and the duration of the cloud coverage condition. For this analysis, it was assumed the cloud condition remained constant from one report to the next. Typically, METAR are issued every hour. Some METAR information appeared as not available for some reports. In those cases, it was assumed that there were no ceiling restrictions.

The parameter calculated for the weather analysis was the number of hours per year when the cloud ceiling was below 800 feet. Statistical analyses were performed on the data. Time series models using both linear and polynomial fits were developed for each airport, using moving averages for two years, three years, four years, and five years. The best fits were sixth-order polynomial with moving averages for three and five years, in which the r-squared values were the highest.

Even though the year-round polynomial time series for three- and five-year moving averages provided good fits, summer and winter trends were also tested to investigate seasonal patterns. For the purpose of this analysis, summer is defined as the second and third quarters of each year, while winter consisted of the first and fourth quarters. For some airports, winter and/or summer models had better fits than the year-round models. The graphs for the moving average time series for each airport are shown in the appendix.

From the analysis performed, one cannot clearly identify a change in cloud ceiling patterns. At 60 per cent of the airports the number of annual inoperative hours shows a negative trend. Seasonal models were also developed to investigate seasonal patterns. In the summer, 60 per cent of the airports show an increase in the number of inoperative hours, whereas for the winter the trend is mixed, 50 per cent of the airports with a negative trend and the other 50 per cent showing a positive trend.

Flying an aircraft is a very complex operation affected by many factors. Runway visual range, cloud ceiling, precipitation (snow and rain), runway surface condition such as snow and ice, wind speed and direction, and other matters can affect an aircraft's ability to operate at an airport. However, most of these conditions are correlated. Although a deeper investigation may find stronger evidence that climate change has impacted airport operations in other ways, the fact that cloud ceiling was not found to be affected does not indicate that climate change has significantly affected air access to the Northern remote communities.

SUMMARY AND RECOMMENDATIONS

POLICIES AND LEGISLATION

After reviewing the existing policies and legislation related to air transportation and to Northern communities, we found no relevant policies or legislation relating the two. Provision of airport infrastructure and services is generally the responsibility of the provinces and territories. Air services are completely deregulated in terms of routes, fares and capacity. There are no essential air services policies in place in Canada. We recommend developing clearer, specific policies to address this shortcoming.

AIRPORT INFRASTRUCTURE

In general, the existing airport infrastructure provides adequate service to the remote communities in Northern Canada. Three of the 146 communities included in this study do not have access to a nearby airport, and three others can be accessed only by seaplanes. Two are accessible by road with distances between 50 and 90 km. Each of the other 138 communities is served by an airport located within 20 km or less.

Improvements may be required to several airports to ensure year-round, all-weather accessibility and convenience. Fifty-eight per cent of the airports are not equipped for instrument flights and can only be used under visual flight conditions. It should be noted that the mere availability of instrument approach procedures does not guarantee service, as those procedures also require trained pilots and aircraft equipped with instruments. Only 85 per cent of the runways are not paved, which affects aircraft maintenance and durability. Thirty per cent of the airports do not offer winter maintenance, which can affect their availability during and after snow and ice storms. Twenty per cent of the airports do not feature a terminal building, leaving the processing of passengers and cargo subject to inclement weather. The costs and benefits of such improvements are likely to vary from airport to airport and should be evaluated in more detail on a case-by-case basis.

AIR CONNECTIVITY

Compared to other communities, the majority of the remote communities in the northern parts of the provinces are generally well connected, with scheduled services connecting them to regional and international airports. There are, however, several airports with limited or no commercial services. Eighteen per cent of the airports in this study have no commercial services that connect them regularly to other communities. Seven airports are served only by charter services. Even in the case of the 109 airports that do have regularly scheduled services, the flights are infrequent and costly — it should be noted, however, that this study did not include an assessment of the prices of air tickets serving the northern remote communities.

One other limitation of this study is the absence of information on cargo and ambulance services. For the latter, the existing runway infrastructure — in terms of length and surface — is sufficient to accommodate aircraft with enough ranges to connect them to a larger airport and/or community. Cargo, however, is severely limited by the size of the aircraft that can operate on the existing runways. Only 44 per cent of the airports can accommodate jet and larger turboprop aircraft. Once more, an economic analysis of cargo operations and the improvements required to improve them is beyond the scope of this study.

This study is also limited to an evaluation of air services in northern remote communities from a purely air services perspective. Even though a large portion of the communities have adequate services from that point of view, it should be noted that this by no means implies that their transportation needs are being met. Even in large communities and urban settlements, the transportation of goods and people relies mostly on ground transportation, with air transportation providing faster connections for higher valued travel.

For future studies, we recommend a deeper comparison of the costs and benefits of implementing a northern corridor with the existing air services.

IMPACT OF CLIMATE CHANGE

A weather study conducted for twenty-one select airports using cloud ceiling data — one of the critical factors in determining the ability of pilots to land at an airport — showed no evidence of impact of climate change in airport operational availability over the last seventeen years. At 60 per cent of the airports, the number of annual inoperative hours shows a slight negative trend. In the summer, 60 per cent of the airports have shown a slight increase in the number of inoperative hours, whereas in the winter the trend is mixed, with 50 per cent of the airports showing a negative trend and the other 50 per cent showing a positive trend.

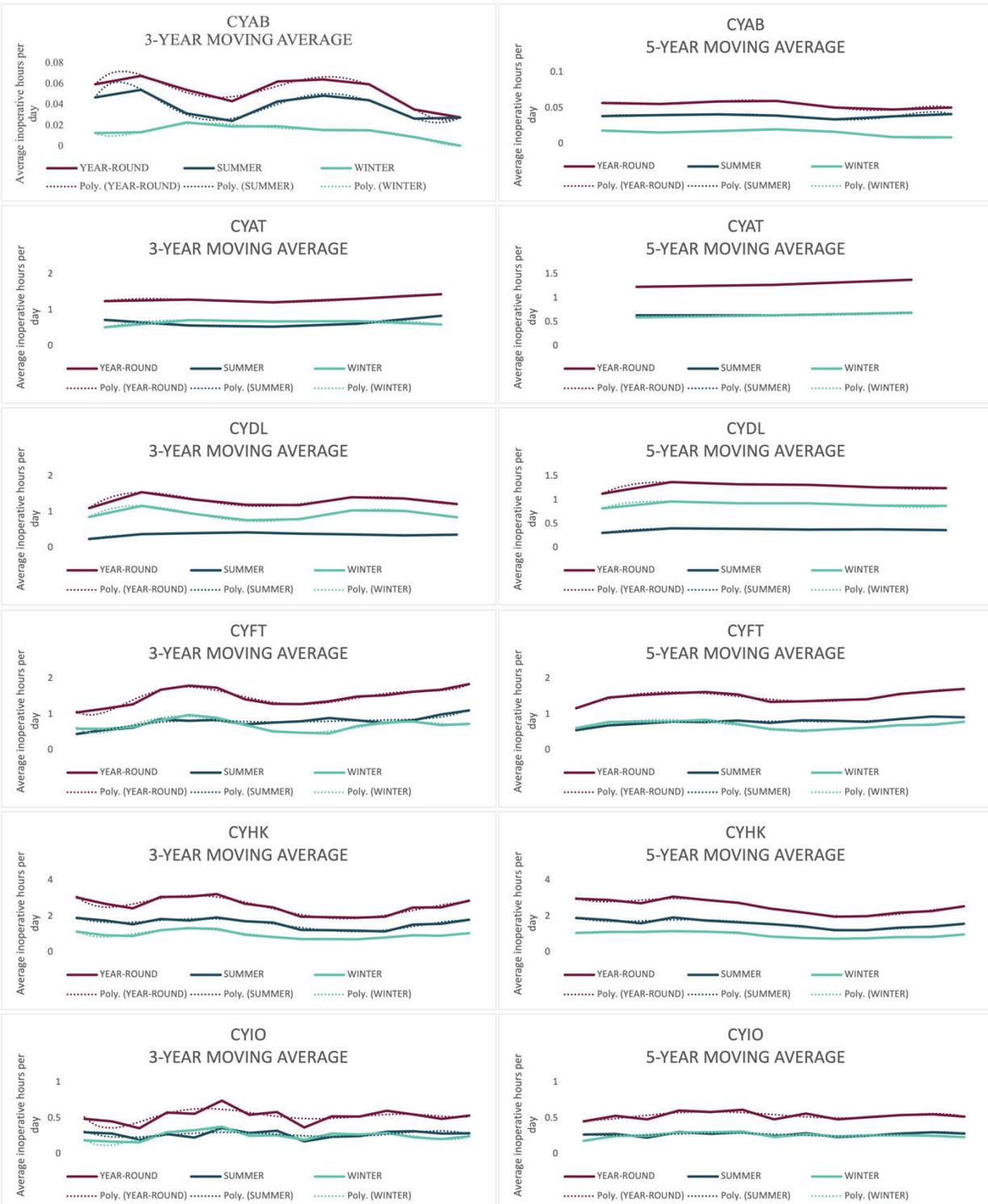
Flying an aircraft is a very complex operation that is affected by many factors. Climate change can affect not only cloud coverage, but also runway visual range, precipitation (snow and rain), runway surface conditions such as snow and ice, wind speed and direction, and other factors that can affect an aircraft's ability to operate at an airport. However, most of these conditions are correlated. Although a deeper investigation may find stronger evidence that climate change has impacted airport operations in other ways, the fact that cloud ceiling was not found to be affected does not indicate that climate change has significantly affected air access to Canada's northern remote communities.

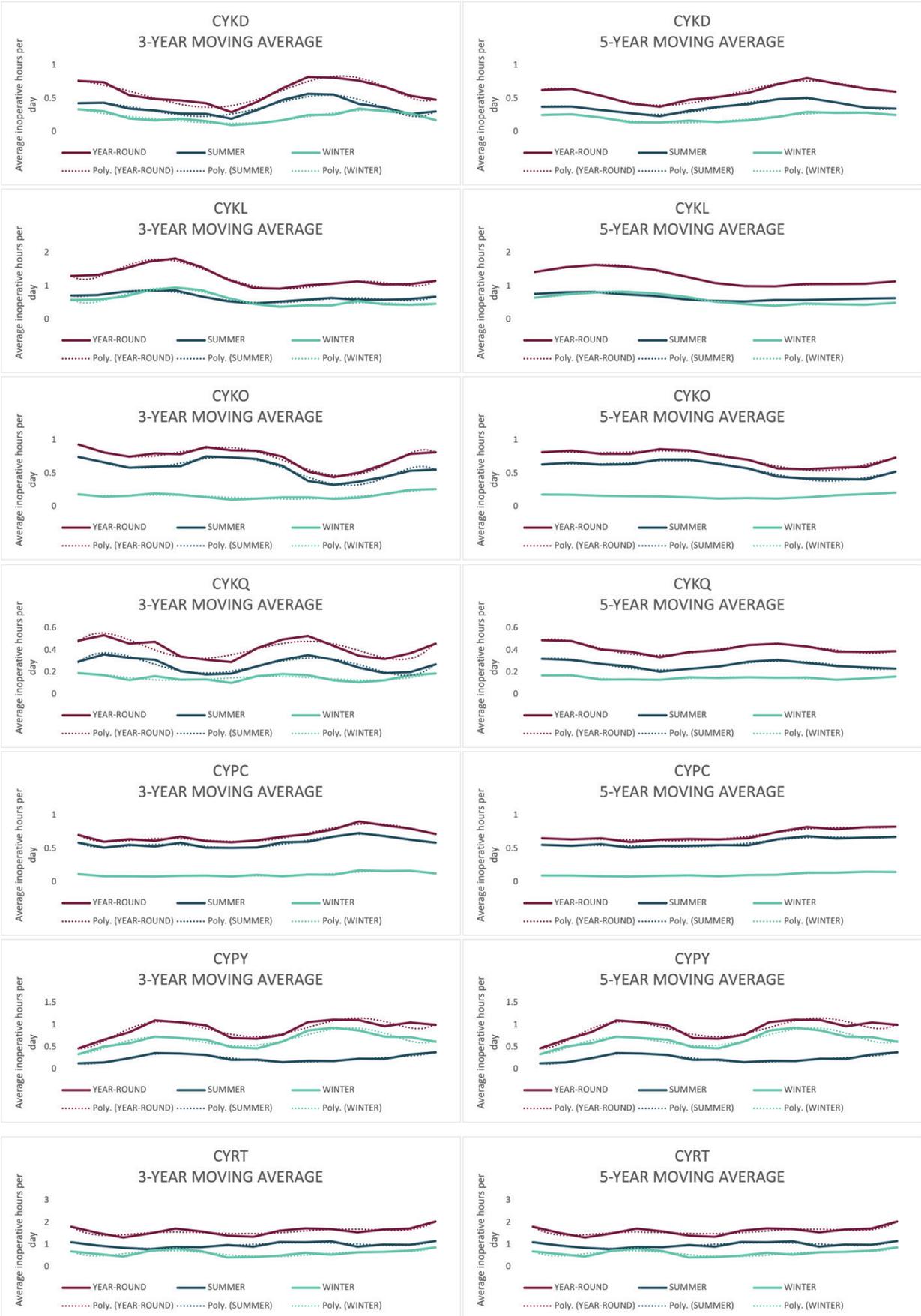
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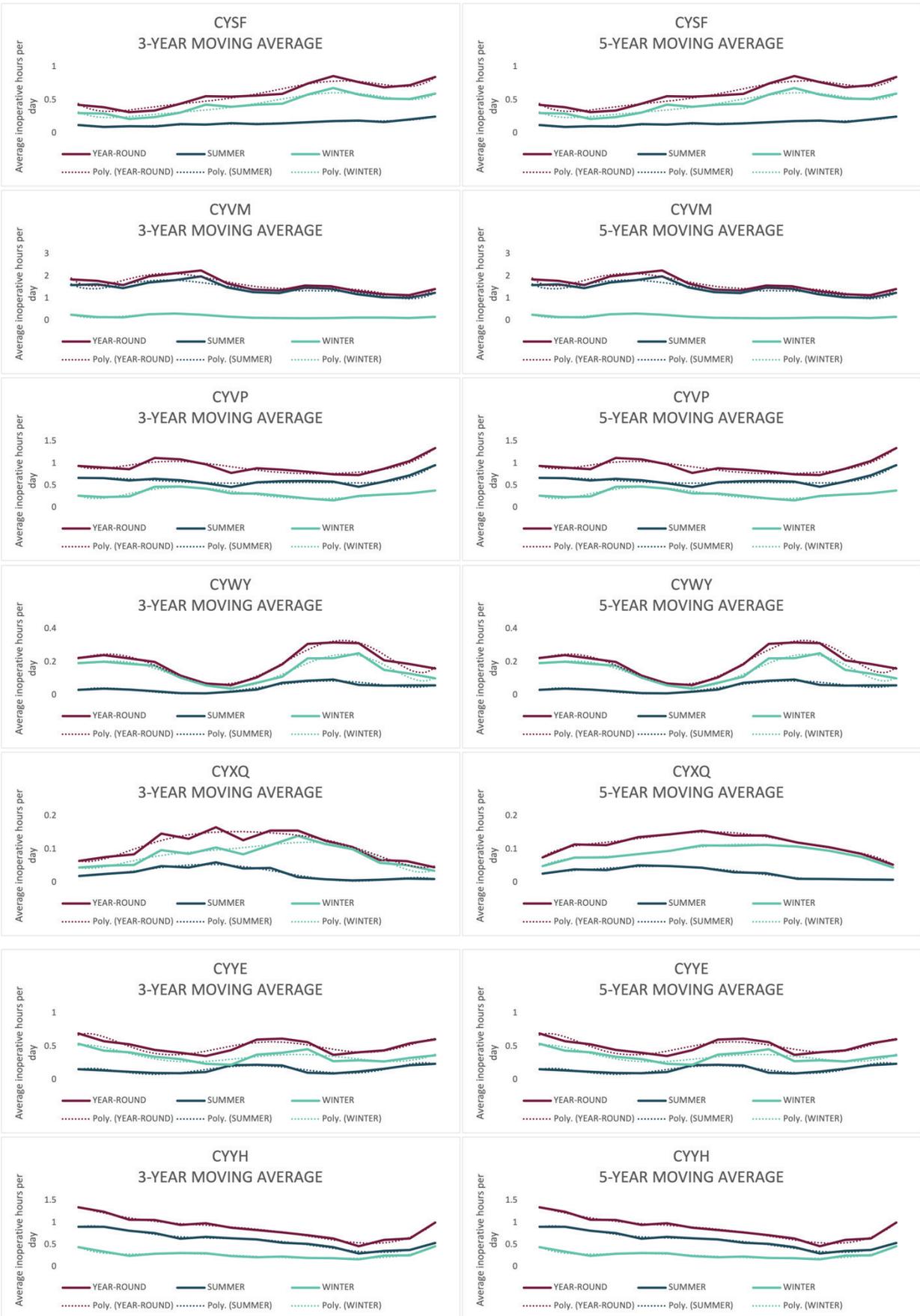
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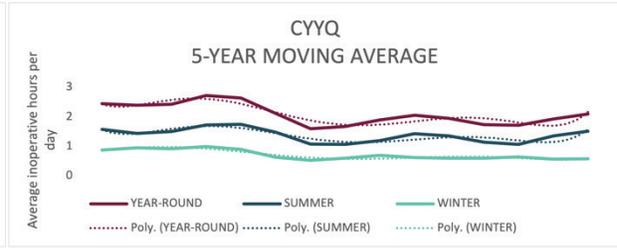
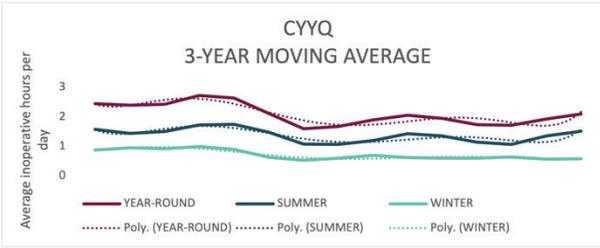
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APPENDIX: TIME SERIES OF AIRPORT INOPERATIVE HOURS PER DAY









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Alexandre G. de Barros is a Professor of Civil Engineering (Transportation) at the University of Calgary. He has a unique combination of local experience both in Canada and Brazil, as well as global experience in transportation infrastructure planning, operations, economics and regulation. He is a former Director (Airports) of the Brazilian National Civil Aviation Agency where he was responsible for regulation and oversight of airport standards, operations and safety. He has an extensive academic record in the field of transportation engineering, with many academic research projects and publications. He also has an extensive global career working on infrastructure projects such as the airports in Toronto/Pearson, Montreal/Trudeau, Atlanta, New York/JFK, Washington/Reagan, Seattle/Tacoma, Hong Kong, Seoul/Incheon, Rio de Janeiro/Galeão, São Paulo/Guarulhos, and Campinas/Viracopos, as well as the establishment of Network Rail in the UK.

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