

THE JOINT ARCTIC WEATHER STATIONS: SCIENCE AND SOVEREIGNTY IN THE HIGH ARCTIC, 1946-1972

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Background: The Long Build-Up

The science of meteorology, particularly that phase dealing with weather prediction, has been advanced only as communications facilities have permitted the rapid collection of simultaneous weather observations from larger and larger portions of the earth's surface and upper atmosphere.

Irving Krick (1945)¹

Far to the north of our country lies an archipelago of gigantic islands comprising an area half as large as the United States, separated from continental America by wide bays and narrow straits, bounded on the east by Baffin Bay and the adjacent shores of Greenland and on the north by the Arctic Ocean. A century ago the famous Franklin expedition was lost in the heart of that vast archipelago, and in subsequent decades many explorers went in search of survivors or vestiges that would tell of their fate. Consequently the archipelago is remarkably well mapped for so large and inaccessible a region, but still its intricate coastlines are so extensive and so remote that their geography is but crudely delineated, while the interior is largely unknown. This great land of islands might have been of vital importance in World War II; it may yet be a key to the prevention of World War III.

Alexander Forbes (1953)²

Today, Inuit Nunangat — the Inuit homeland in Arctic Canada — encompasses the entirety of Canada's Queen Elizabeth Islands. The historical record (both oral and archaeological) of human habitation, however, reveals that the human presence in the High Arctic region reflected a process of expansion and contraction in response to changing climatic conditions. Anthropologist George Wenzel has consolidated data from palaeoclimatology, physical oceanography, biology, and archaeology to characterize how two major past climatic shifts — the Neo-Atlantic Period (also known as the Medieval Warm Period), ca. 1000–1300 CE, and the Neo-Boreal Period (or Little Ice Age), which lasted from ca. 1550 to 1850 — influenced Inuit material subsistence and cultural adaptation. During the Neo-Atlantic Period, warming temperatures across the North American Arctic reduced annual sea ice coverage and produced prolonged periods of open water during the summer. Thule people (ancestors of modern Inuit), with centuries of whale-hunting expertise, spread eastward more than 8,000 km from what is now Alaska to the Canadian High Arctic and Greenland to pursue bowhead whales and other migratory marine mammals that entered newly-accessible High Arctic waters. The Thule rapidly displaced the people who Inuit remember as Tuniit and who archaeologists refer to as the late Palaeo-Eskimo or Dorset culture, which had occupied most of the Canadian North and Greenland for nearly 2,000 years. This dramatic human migration brought technological adaptations such as the bow and arrow, dog sled, *umiaq* (whaling boat), *qayaq*, and semi-subterranean whalebone and boulder dwellings to the High Arctic islands.³

The significant cooling of the High Arctic during the Little Ice Age ultimately forced Inuit to withdraw from the northernmost islands in the North American Arctic Archipelago. As the length of ice-free waters in summer shrank and bowhead whales ceased travelling to the High Arctic, Inuit lost access to large supplies of food, fuel, housing, and sled materials. Smaller, extended family encampments living in tents and snowhouses ("igloos") replaced larger Thule villages as Inuit became less sedentary. By 1600, Inuit had abandoned the High Arctic islands in pursuit of seasonally-available smaller game (primarily caribou in summer, ringed seals at their breathing holes in winter, and Arctic char in the spring and autumn) as well as walrus, beluga whales, and narwhal in more southern regions with less severe climatic conditions. Thus, when European

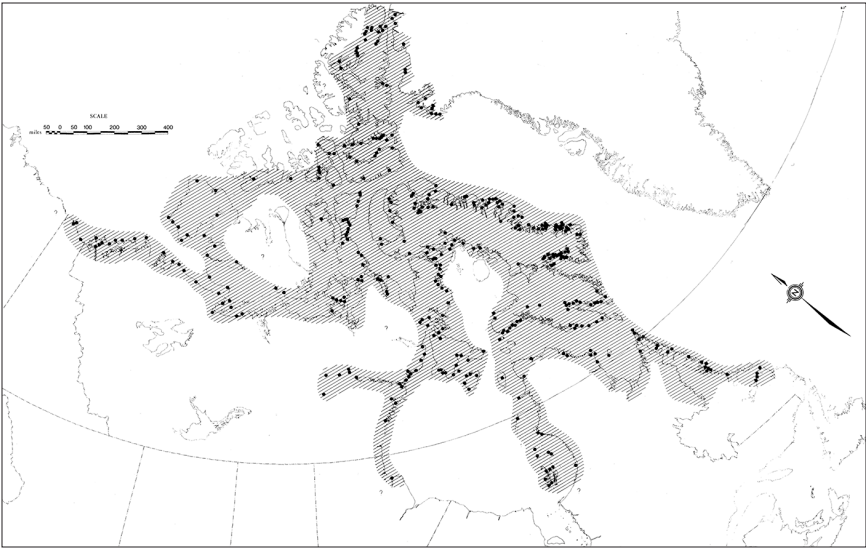


FIGURE 1-1. Thule site locations and presumptive land use. Based on the *Report of the Inuit Land Use and Occupancy Project*, vol.1 (1976). Jennifer Arthur-Lackenbauer based on Inuit Land Use and Occupancy Project (Queen’s Printer, 1976).

explorers seeking the Northwest Passage ventured into the northern North American Arctic from the seventeenth century onwards, they met Inuit in Greenland but not in the archipelago north of Lancaster Sound, Parry Channel, and M’Clure Strait. Indigenous peoples’ climate-related adjustments had led them to migrate southward, leaving the High Arctic islands uninhabited except for periodic hunting trips undertaken by Inughuit across Davis Strait and Inuit from the southern Arctic islands.⁴

European polar explorers were drawn to the “New World” Arctic in the sixteenth century not to exploit its riches but to pass through it as a commercial route to elsewhere. Their search for a Northwest Passage to the Orient treated the Arctic not as a *place* of inherent value but as a transient *space* — an obstacle to be circumvented. Nevertheless, their voyages opened up a new frontier to the mental maps of Europe. In 1576, Sir Martin Frobisher sailed across the southern end of Davis Strait and “discovered” the bay on western Baffin Island that bears his name. John Davis pushed further north eleven years later, reaching about 73°N before

returning south and mapping his namesake strait that would lead his successors into the islands of the archipelago. Over the next century, most British efforts to find a Northwest Passage concentrated further south in Hudson Bay. Nonetheless, the 1616 expedition led by Robert Bylot and William Baffin sailed as far north as 78°N, exploring and naming Smith, Jones, and Lancaster Sounds, and completing the delineation of Baffin Bay's shoreline.⁵

The early history of meteorological observations in the North American Arctic closely parallels this history of exploration. When Europeans encountered what they perceived to be a "hostile environment," they noted the severe weather and ice conditions with which they contended. The pantheon of explorers from Frobisher onward contributed to the early meteorological knowledge of the Arctic, recording weather observations at brief intervals depending upon the route they took and the duration of their stay. These observations not only added to heroic depictions of their voyages, they also slowly contributed to understandings of the Arctic climate, mainly of the archipelagic waters and the coasts and inlets of the islands themselves.⁶

In the broader Canadian context, these expeditionary narratives were supplemented by those produced in fixed locations. In French and British North America, garrison soldiers, traders, and missionaries noted the weather in diaries, letters, and official reports. "The first Europeans who came to Canada, whether to explore and conquer, to teach and Christianize, or to trade and settle, learned the meteorology and climatology of Canada by hard experience," summarized Morley Thomas, the foremost historian of Canadian meteorology. Borrowing from Indigenous knowledge, immigrants to northern North America adapted their diet, clothing, buildings, customs, and habits to the new climate.⁷

This was particularly true of the Hudson's Bay Company (HBC). The Company's 1670 charter included a provision to search for a Northwest Passage, but its practical focus on the subarctic fur trade meant that such forays were half-hearted (and even counterproductive to its corporate strategy). For more than a century, none of the HBC personnel ventured into the Arctic Archipelago, an area that lay beyond their vision of a trans-continental commercial empire; however, the establishment of permanent posts and forts along Hudson and James Bays produced some of the first

systematic weather data from the North American Arctic. During the eighteenth century, personnel based at these remote outposts of the Empire compiled meteorological registers that contributed more to longitudinal climate study than the fragmentary records produced by European explorers to that time. “When obtainable,” Thomas noted, “these data were doubtless of value to others planning expeditions and forays into a generally unknown country.”⁸

With the dawn of the nineteenth century came a new wave of British exploration in the North American Arctic. After the Royal Navy prevailed at the great naval battle of Trafalgar in 1805, thus securing supremacy over sea lanes of communication, it sought new ways to expend its energies after 1815. Charting a navigable Northwest Passage would increase British power and world commerce, as well as serving several additional purposes. Historian Hugh Wallace summarized:

National prestige would be served if Great Britain completed the quest, and harmed if some other nation did so. Russia was already a competitor in the Arctic and the United States might be increasingly so. Naval service amidst arctic snows would be good for the national character. It would also give a new officer class an avenue to promotion. And there was also widening geographic and scientific interest.⁹

Whalers’ reports fed a hypothesis that the ice barrier in the Arctic was shrinking, which dovetailed with Admiralty interests. It entrusted John Ross with an 1818 deep sea expedition to sail around the extreme northeastern coast of America to Bering Strait, noting the currents, tides, and state of ice and magnetism, and collecting specimens relating to the natural sciences. The purpose was no longer discovery in itself, but systematic surveying and knowledge building as well.¹⁰

Explorers revealed the path through the Arctic islands in haltering fashion. Commander John Ross’s controversial 1818 voyage rediscovered Jones and Lancaster Sounds but did not examine them, owing to Ross’s mistaken declaration that they were inlets enclosed by mountains. Lieutenant William Parry’s subsequent voyage, which reached farther west than any other expedition originating in the Atlantic during that century,

considerably extended geographical knowledge of what would later be named the southern group of the Queen Elizabeth Islands. In mid-May 1819, he pressed through the pack ice of Baffin Bay and landed on Bylot Island. "Sir James Lancaster's Sound was now open to the westward of us," he noted, "and the experience of our former voyage had given us reason to believe that the best two months in the year for the navigation of these seas were yet to come."¹¹ After tracing the southern coast of Devon Island, the *Hecla* and the *Griper* rounded Beechey Island, noted Wellington Channel to the north, and proceeded westward into Barrow Strait. On September 6, Parry crossed the 110th meridian (an achievement that secured his crew a reward of five thousand pounds from British parliament) and continued to make slow progress along the coast of Melville Island before stopping at 112°51'W. Given "the incredible rapidity with which the young ice formed," Parry turned back to settle in at Winter Harbour for the frozen season. From this hub, Parry led a small party on a two-week exploration of the island the following spring.¹²

Parry's expedition was exploratory and scientific, with the Admiralty placing a higher priority on the latter than previously. Through the winter of 1819–20, the officers and crew made detailed magnetic and meteorological observations. These activities tested the limits of their instruments — and their bodies. On 29 November, for example, the mercury used in the artificial horizon froze into a solid mass at -36°F (-38°C) after four hours' exposure in open air.¹³ During their stay, crew members recorded air temperatures every two hours, discovering that the amplitude of the diurnal (daily) variation in temperature was barely perceptible in January and largest in April.¹⁴ That month, Captain Edward Sabine, Parry's science officer, tested the effects of solar radiation by suspending an exact pair of mercurial thermometers with unprotected bulbs on a line, one exposed to the sun and the other in shade, six or eight inches above the snow at about noon. Conducting science of this sort required accepting the rigours of the northern environment. The wind posed the biggest challenge. Even during "the most intense degree of cold marked by the spirit thermometer during our stay in Winter Harbour, not the slightest inconvenience was suffered from exposure to the open air, by a person well clothed, as long as the weather was perfectly calm," Parry noted. When people walked into even the lightest wind, however, "a smarting

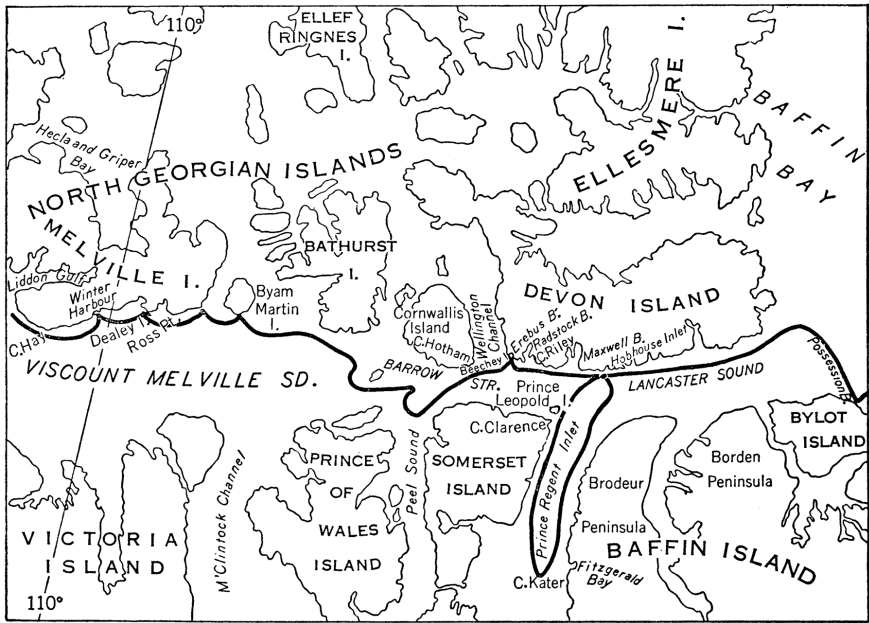


FIGURE 1-2. High Arctic voyages of Lieut. W.E. Parry, Royal Navy, 1819–20. Andrew Taylor, *The Queen Elizabeth Islands* (Queen’s Printer, 1955).

sensation was experienced all over the face, accompanied by a pain in the middle of the forehead, which soon became rather severe.”¹⁵

On August 1 the following year, Parry’s ships weighed anchor and tried to push west and finish the previous year’s attempt at the Passage. Stymied by heavy ice, he conceded by August 10 that “there was something peculiar about the southwest extremity of Melville Island, which made the icy sea there extremely unfavourable to navigation, and which seemed likely to bid defiance to all our efforts to proceed much further to the westward in this parallel of latitude.” His expedition made it as far as 113°48W before returning eastward toward England. During his voyage, he had explored and named Devon, Cornwallis, Bathurst, Byam Martin, and Melville Islands. Parry’s first voyage, which proved him to be the leading ice navigator of his generation, “was the apex of his accomplishments in the Arctic Archipelago,” polar expert Andrew Taylor concluded. “He had penetrated westward into the unknown region a distance of 630 miles

to M'Clure Strait, and had carried out surveys along the great sounds as to create a geodetic network upon which all subsequent discoveries in the region were based. Sailing west through more than 30 degrees of longitude, Parry had made the Northwest Passage a more tantalizing goal than it ever had been before." The explorer's recommendation that future expeditions should concentrate on routes in lower latitudes, along the continental coastline where possible, "set the pattern of marine exploration for the Canadian Arctic for the next quarter century."¹⁶ Parry's later voyages contributed less to the map of the Arctic but continued to add meteorological knowledge. For example, he and Rev. George Fisher recorded the first known upper-air observations in the Canadian Arctic in 1822–23.¹⁷

By mid-century, the principal arguments for further Arctic exploration were scientific rather than political or military. An Arctic sea route to Asia remained commercially unappealing given the existing state of icebreaking technology (although whaling in Arctic waters would soon attract American and British ships), but naval officers could make meaningful contributions to astronomical and geophysical sciences. The *Admiralty Manual of Scientific Enquiry* highlighted the importance of keeping a detailed and systematic "meteorological register," noting the readings of weather instruments at regular hours throughout the day as well as "occasional and remarkable phenomena." This register, "steadily and perseveringly kept throughout the whole of every voyage," supported "the development of the great laws of this science." The navy was well suited for this work. Historian Trevor Levere explained that:

What did matter, apart from the disciplined cooperation of the observers, was a good set of instruments, and the knowledge of how to use them. The instruments included a good barometer, appropriately suspended, with an attached thermometer; a delicate and precise reference thermometer, against which to check other thermometers, among them a self-registering thermometer (e.g. Six's), and a thermometer for solar radiation, having its bulb blackened with India ink; hygrometers, of which the best and sturdiest type used two thermometers, one with a dry bulb, the other being wet; a rain

gauge; an anemometer ... and actinometers, for occasional use to measure solar radiation.

Arctic navigators and explorers faithfully recorded this data during their expeditions. Although inadequate to predict weather, these observations fit with “the quintessentially Humboldtian character of meteorology, its conformity to early Victorian norms of Baconian science, and its ready involvement of the disciplined amateur.”¹⁸

Sir John Franklin’s ill-fated attempt to conquer the Northwest Passage in 1845, and the subsequent searches to determine what happened to an expedition that seemed to vanish from the face of the Earth, unveiled much more of the North American Arctic map. Historian William Morrison questions why Franklin and his crew mounted an expedition that sought to conquer the Arctic environment rather than adapt to it. “The ships carried all sorts of modern amenities: a library, fine china for the officers, steam radiators, and so forth,” he highlights. “What the crew lacked, however, were the means of survival that the Inuit had developed: they had no skin clothing, no sleds, no dogs, and they had no Native people with them to hunt seals and other animals.”¹⁹ In his brilliant study of British exploration during the mid-nineteenth century, Hugh Wallace observed:

as exploration had advanced towards the centre of the North American Arctic it had been thrown out of focus. Normally, discovery vessels were not only a means of finding new lands but were also surveyors’ platforms and scientific laboratories. Now, however, ice and the archipelago in the central Arctic had forced a separation of these two elements, placing marine discovery and marine surveying in conflict. The navy had ignored the possibility that the prompt and realistic way to find a passage might be to send to the Arctic a scouting party by land or small vessels to test and sail it. Instead, the Franklin expedition had gone into the Arctic in the manner of hydrographers, land surveyors, military map readers, or even settlers, not of discoverers — and the results had matched the method. The party had surveyed a Northwest Passage, not discovered it; they had seen it, but

not reported it — so news had not been conveyed to London. Indeed, now it was necessary both to find the discoverers and also, so far as possible, what it was that they had found.²⁰

The search expeditions criss-crossed the waters at the heart of the archipelago by ship and sledge, filling in much of the Arctic map. For example, when Captain Henry Kellett's ships settled in for winter quarters at Dealy Island, at the entrance to Bridport Inlet (after ice blocked their access to Winter Harbour in August 1852), they used this as a base for spring journeys by sledge. Captain Francis Leopold M'Clintock's epic 105-day, 1,408-mile trip in April 1853 traversed Melville Island and led him to Prince Patrick Island where his party gorged on muskox, covering 768 miles of previously undiscovered coastline.²¹ HBC factor Dr. John Rae, during his lengthy journeys along the mainland coast from 1845–54, recorded observations of temperature, air pressure, wind, weather, cloud cover, ice thickness, and solar radiation at hourly (or other consistent) intervals for eight months to twenty-seven months at a time.²² This accumulation of scientific knowledge left a lasting legacy, and the expeditions searching for Franklin ultimately uncovered half of the Canadian Arctic and three Northwest Passages.²³

The Franklin search also internationalized activities in the North American Arctic. Americans turned their primary focus to the path to the North Pole. Dr. Elisha Kent Kane's 1853–55 expedition, sponsored by the US Navy, sought the answer to Franklin's fate by pushing northward to the "open sea" along the west coast of Greenland, pressing deep into Kennedy Channel before ice and scurvy forced their retreat. Dr. Isaac Hayes sought "to complete the survey of the north coasts of Greenland and Grinnell Land" in 1860–61, crossing the Greenland ice cap before working his way up the Ellesmere Island coast to Lady Franklin Bay (81°35N at his calculation), the "most northern land that has ever been reached."²⁴ After the British, exhausted by the Franklin search, ceased their Arctic exploration efforts, American Captain Charles Francis Hall sailed north from Washington on the reconditioned steam-tug *Polaris*, reaching 82°11N at the northern entrance to Robeson Channel in 1871.²⁵ The quest for the North Pole would continue to entice Americans to the

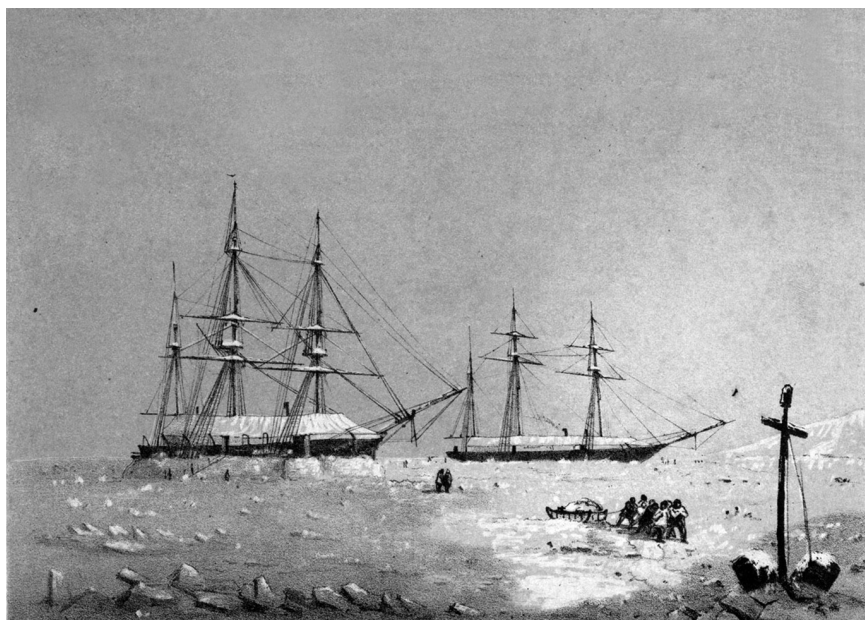


FIGURE 1-4. HMS *Resolute* and *Intrepid* in winter quarters, Melville Island, 1852. National Maritime Museum, Greenwich, London.

northernmost reaches of North America through the turn of the century, seeking prestige and, by extension, clarifying cartographic and scientific understandings of the continent.

Meteorology as Science in Nineteenth-Century North America

The development of meteorology as a science went hand-in-hand with instruments capable of numerically describing elements of the weather that emerged during the scientific revolution of the seventeenth century. Although people had determined wind direction and recorded precipitation for centuries, the thermometer, barometer, hygrometer, as well as wind speed and direction indicators were essential tools to collect data and bring scientific respectability to the field. Technological innovations, such as the visual and electromagnetic telegraphs of the nineteenth century, eventually facilitated the transmission of synoptic data from dispersed collection points to a centralized bureau where it could be collated

to predict storms. This played an important role in the development of meteorological theory and synoptic weather charts. By the late nineteenth century, scientists used kites, balloons, and eventually “balloonsondes” (small coal-gas-fired balloons carrying self-registering thermometers and barometers) to gather upper altitude data on a more frequent basis. Meteorologists recognized moving air masses as carriers of local weather, with information about wind speed and direction, pressure, temperature, and humidity used for weather forecasting elsewhere. Nevertheless, meteorology failed to produce the mathematical precision and predictability of “exact sciences,” and “farmers continued to have more confidence in the Farmer’s Almanac.”²⁶

Along with its territorial expansion, the United States produced more formal networks and systems for collecting weather data. During the colonial era, individual, isolated diarists kept local weather and climate records. This changed as scientific societies, college professors, and federal officials recognized the value in systematically collecting statistics from across their expanding country. The General Land Office began amassing precipitation and temperature records at local offices across the country in 1817, and military posts began recording observations two years later. In 1841, the Patent Office organized volunteer “weather correspondents” to pass along systematic observations. A typical observer, armed with a thermometer, wind vane, and rain gauge recorded surface weather conditions and reported them by mail at the end of each month. This system did not provide current weather data, but it did facilitate retrospective inquiries into storm patterns and the development of theories about atmospheric dynamics. The Smithsonian Institution, created in 1846, began collecting telegraphic reports of simultaneous observations using standardized forms and schedules in 1857; it supplied calibrated instruments to some observers, and its first secretary, science professor Joseph Henry, used this system to prepare weather maps and forecasts. This service continued until the outbreak of the Civil War, which interrupted the system for a decade.²⁷

A similar (but more modest) shift towards systematic observations occurred in Southern Canada in the nineteenth century. Various observers gathered and cited weather data to encourage emigration from Europe and stimulate agricultural development on the Canadian frontier. The Toronto Magnetic and Meteorological Observatory, the first official weather station,

began taking terrestrial magnetism and weather observations in the early winter of 1839–40. In 1853, the observational program passed from the British Ordnance Department to the Province of Canada, which in turn delegated responsibility to the University of Toronto. Private observing stations (including at senior county grammar schools across Upper Canada) built up the climatological record in British North America. The central collection of data began in 1863 when the Toronto observatory collected the first outside climatological report and thus began ongoing data collection, processing, and archiving work. Soon after Confederation, George Templeman Kingston, the first Professor of Meteorology and Director of the Toronto observatory, noted that there were few meteorological observers in the new country, “there was no true description of the climatology of the country and the existing agencies were inadequate to remedy the situation.”²⁸ He promoted a broader “Canadian contingent” of weather observers that could make a more robust contribution to the “common intellectual property” about meteorology — a burden placed on each country “according to the opportunities afforded by its geographical position and physical peculiarities.”²⁹

The United States had its geographical and physical peculiarities, as well as its internal political ones. The bitter Civil War experience transformed the country into “a shaped and disciplined nation,” aware of the need for a culture of organization, planning, and control through national networks. These ideals influenced its evolving approach to meteorology. Early in 1870, Congress turned to the US Army Signal Service, which had created an extensive communications network during the war, to operate a national storm warning and telegraphic weather service.³⁰ The service soon grew beyond simply issuing storm warnings to assist navigation to meeting public demands for climatological data, weather forecasting to support commerce and agriculture, and the dissemination of current weather information. Military and commercial telegraph networks linked the weather service to Washington, D.C., binding the country together, while connecting it to the rest of the world.³¹

The development of these transcontinental networks had transnational effects. Morley Thomas observed that these American developments pushed the Canadian government to action. In 1871, the cabinet authorized the creation of the Meteorological Service of Canada under

the direction of the Department of Marine and Fisheries to maintain a network of observation stations and to issue storm warnings. Lacking trained scientists and sufficient funding, the Canadian weather service did not prepare weather forecasts in its early years. Professor Kingston hoped to amass observational data from stations or observatories in Montreal, Quebec City, Saint John, and Halifax for at least five years before publishing forecasts. This contrasted with the situation south of the border, where the US weather service established an operational forecasting system immediately. Accordingly, Kingston arranged for synoptic weather observations in southern Ontario, and forwarded these telegraphic reports to Washington beginning in 1872. In return, he received daily data from American stations as well as the US Signal Service's predictions of storm warnings for Canada, which he then relayed to cities and ports. Thus began the continuous, daily exchange of weather data between Canada and the United States.³²

While weather patterns (and meteorology) transcended the national border, Canadian nationalists used climatology and other natural sciences to bolster arguments for northwestern expansion. "Victorian science, in particular, transformed British North Americans' vision of the land they inhabited," historian Suzanne Zeller notes. "It broadened their horizons and emboldened their expectations, breeding confidence in the potential future of a transcontinental nation designed to emulate the rapid industrial and material progress of Great Britain and the United States."³³ Meteorology contributed to a growing sense of Canadian manifest destiny, helping to "create the intellectual climate which made such ideas appear sensible and perhaps even inevitable," and tied settlers into a scientific network with Canada at the core.³⁴ In 1876 and 1877, the Canadian service issued its first storm warning and general forecast. The Toronto hub telegraphed daily probabilities to large cities and towns across the country, which were displayed in local post offices and telegraph offices, shown in "conspicuous places in shipping ports," and printed in newspapers (a method of dissemination that continued until the Second World War). As the Canadian Pacific Railway pushed westward (with its accompanying strand of telegraphic lines), weather, climatological, and precipitation reporting stations began sending information eastward. By early 1905, the

Meteorological Service of Canada boasted 374 reporting stations, thirty-four of which telegraphed reports twice a day to Toronto.³⁵

Meteorology and Arctic Stations

The North American Arctic remained beyond the practical reach of nineteenth century nation-building programs. Russia, fearful of losing its American holdings to Britain without compensation in a future conflict, sold Alaska to the United States in 1867. The purchase, championed by Secretary of State William Henry Seward, was controversial. To critics, “Seward’s Folly” squandered an admittedly paltry \$7.2 million on useless wasteland (twice the size of Texas) that would require much larger annual administrative burdens in the future. Supporters pointed to northern resources and future economic benefits — a prescient prediction proven in the twentieth century.³⁶ The confederation of British North America that same year created the Dominion of Canada, whose aspirational motto proclaimed that the country would extend “from sea to sea.” In 1869, the HBC surrendered its vast territories (Rupert’s Land and the Northwest Territory) to Great Britain, and Canada accepted them the following year. While visionaries of a transcontinental empire in the north connected the Atlantic to the Pacific, they did not yet realize the significance of a third ocean — the Arctic Ocean — to the north.

The full extent of Canada’s dominion, moreover, was unclear — particularly the northern limits of the territory it inherited from the HBC. The status of the islands north of the Canadian mainland became a source of considerable concern because of two innocent requests for concessions of Arctic territory in 1874: one was made by a British subject to establish temporary fishing buildings and the other by an American for a mining operation. After extensive deliberations, the British approved an order-in-council on 31 July 1880 stating that “all British territories and possessions in North America, and the islands adjacent to such territories and possessions which are not already included in the Dominion of Canada, should (with the exception of the Colony of Newfoundland and its dependencies) be annexed to and form part of the said Dominion.” By this act, Britain gifted to Canada whatever territories or territorial rights it had in the Arctic archipelago. The completeness of Britain’s own title at that time, and the extent of its territories, remained questionable.

“The Imperial Government did not know what they were transferring,” Canadian associate archivist Hensley R. Holmden quipped in 1921, “and on the other hand the Canadian Government had no idea what they were receiving.”³⁷ Fortunately for Canada, no foreign state raised questions about the transfers — or made firm claims to the unoccupied islands. For its part, Canada — hesitant to take steps “for the good government of the country until some influx of the population or other circumstance shall occur” — did little to consolidate its administrative or practical control over the region for the next fifteen years.³⁸

While foreign explorers continued to explore the Arctic archipelago after the Franklin searches (with all the competitive aspects to exploration and scientific work that such voyages entailed), a new current of transnational interest in geomagnetism and other scientific questions requiring systematic and standardized investigation encouraged nascent international cooperation.³⁹ Eight nations cooperated in the First International Polar Year (IPY) in 1882–83, the first organized effort to make synoptic meteorological observations based on a clear sampling protocol and high-quality, well-calibrated instruments. Arctic scientists set up fifteen data collection points around the Arctic rim to record systematic and simultaneous geophysical observations over an extended period, thus building a database useful for studying the Arctic environment.⁴⁰ Three of these Arctic stations were organized in the Canadian North. Canada and Great Britain jointly managed the station at Fort Rae on Great Slave Lake, and a German party studied weather conditions at Kingua Fjord in Cumberland Sound, Baffin Island.⁴¹ Finally, US Army Lieutenant Adolphus W. Greely commanded a twenty-five-man scientific expedition that established a meteorological base at Fort Conger (Lady Franklin Bay) on the northern coast of Ellesmere Island and achieved a new northern record of 83°24N. When his party was forced to retreat after its second winter, Greely took copies of his condensed meteorological observations of barometric pressure, air temperature, wind, clouds, and weather conditions in three tin boxes (fifty pounds each) in lieu of extra rations — thus ensuring the expedition’s scientific legacy, although only seven men survived the ordeal. Greely went on to preside over the Signal Corps when it transferred the US weather service to the civilian

Department of Agriculture, where it became an independent scientific organization free from military regulations, in 1891.⁴²

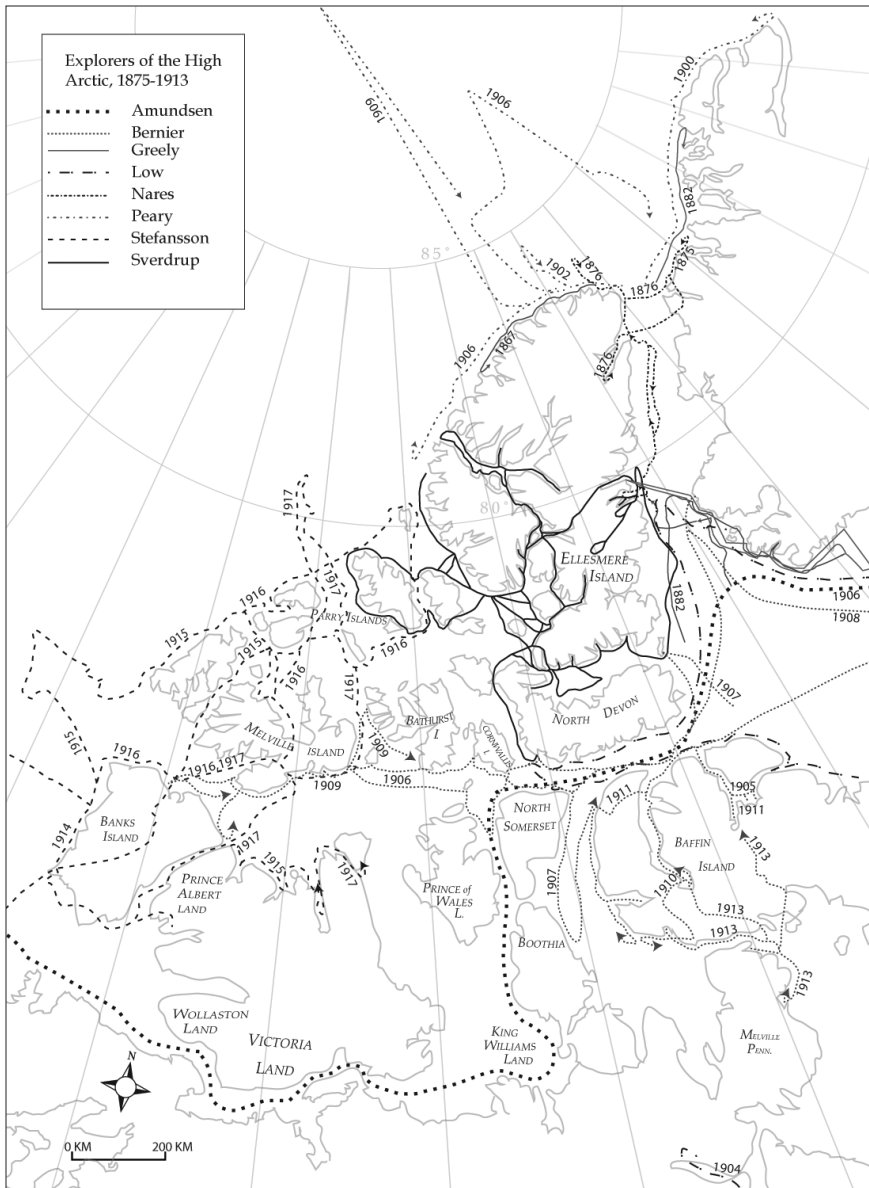
Scandinavian initiatives filled in the Arctic map around the turn of the century.⁴³ Finnish-Swedish explorer-scientist Adolf Erik Nordenskiöld achieved the first complete crossing of the Northeast Passage along the northern coast of Eurasia in 1878–79, and Norwegian explorer Fridtjof Nansen drifted across the Arctic Ocean onboard the *Fram* from 1893–96. Then Captain Otto Sverdrup led the *Fram* on a scientific expedition to northwest Greenland and into Canadian waters from 1898–1902, over-wintering amongst Inuit, surveying the coasts of Ellesmere, Axel Heiberg, and Amund and Ellef Ringnes Islands, and recording weather and other scientific observations at locations along the way. During Norwegian Roald Amundsen’s successful navigation of the Northwest Passage between the Canadian mainland and the southern archipelagic islands in 1904–06, engineer Peter Ristvedt conducted nearly two years of continuous meteorological observations from Gjoa Haven. This contributed significantly to climatological knowledge about the central Arctic. Like the other data, however, this information was not collected simultaneously with other expeditions, and this lack of coordinated data gathering limited the value of the observations for understanding the climatology of the Canadian Arctic more generally.⁴⁴

The United States established its footprint in the region during the so-called “American era” in Arctic exploration, concentrating their efforts on “the royal road to the North Pole” along the western coast of Greenland in the late nineteenth century.⁴⁵ “The transformation of the Arctic from an arena for heroic adventures to a northern Mediterranean Sea had begun with American expeditions at the turn of the century,” historian Nancy Fogelson suggests. American interest grew when Robert E. Peary extended his 1898 Greenland expedition to Ellesmere Island and repatriated papers belonging to the abandoned American IPY base at Fort Conger. Two years later, Peary extensively surveyed west Grinnell Land (Ellesmere) before mapping northern Greenland. Although the US War Department boasted that Peary should acquire Greenland “by right of conquest,” it made no such statement about Ellesmere. For his part, Peary had his eyes on being the first man to the North Pole — an accomplishment that would realize America’s “manifest duty and privilege.” He fell short in 1903, but he

managed to map Ellesmere's northern coast and sighted new islands that, "if confirmed, would add to the list of American prizes."⁴⁶

Fortunately for Canada, the United States never claimed these "prizes." Although the young dominion's gaze was fixated on the "new north-west passage" linking the Atlantic to the Pacific by a transcontinental railroad, Ottawa launched its first Arctic expeditions in the 1880s. The earliest surveys were more concerned with navigational conditions than meteorology, but accompanying observers recorded conditions at various sites along the northernmost parts of the Canadian mainland and its southernmost Arctic islands. During the voyages of the *Neptune* into Hudson Strait and Bay in 1884–85 and 1886, for example, meteorologists maintained weather stations at several points during the two intervening winters.⁴⁷ Canada's gradual "program of action," historian Gordon W. Smith explained, was "rather limited but nonetheless designed to solidify and consolidate Canadian sovereignty over the territories in question."⁴⁸ As North West Mounted Police outpost stations expanded to Herschel Island, the District of Mackenzie, and eventually as far north as Fullerton Harbour in Hudson Bay in 1904, the government took advantage of this official presence to collect meteorological data. It also sought similar data from fur trading posts and missions to accumulate a broader climatic picture of the Canadian North.⁴⁹

Ambiguity remained about how far Canada actually extended to the north, prompting state efforts to clarify its High Arctic claims. The chief astronomer of Canada admitted in 1905 that "Canada's title to some at least of the northern islands is imperfect."⁵⁰ Simply drawing lines along Canada's east and west coasts and extending them up to the North Pole, thus delineating a "sector claim" to the Arctic, seemed an attractive and inexpensive option — even if it did not have a firm basis in international law. The origins of this idea are well documented.⁵¹ On 20 February 1907, Senator Pascal Poirier presented a motion to the Senate asserting that "the time has come for Canada to make a formal declaration of possession of the *lands and islands* [emphasis added] situated in the north of the Dominion, and extending to the North Pole." Poirier asserted that Canada, as successor to the rights of the HBC, could claim as its territory all of the islands lying between 141°W and 60°W longitude up to the Pole.



He referred to a meeting of the Arctic Club in New York the previous year, attended by Canadian Captain Joseph-Elzéar Bernier, where:

it was proposed and agreed — and this is not a novel affair — that in future partition of northern lands, a country whose possession today goes up to the Arctic regions, will have a right, or should have a right, or has a right to all the lands that are to be found in the waters between a line extending from its eastern extremity north, and another line extending from the western extremity north. All the lands between the two lines up to the north pole should belong and do belong to the country whose territory abuts up there.⁵²

Although the speech has assumed great significance, Senator Poirier's motion was neither seconded nor debated, and Canada did not incorporate the sector principle in statute, but it proceeded, "by a series of semi-official and official actions and pronouncements, to stake out a sector claim."⁵³

In the first decade of the twentieth century, Canadian explorers William Wakeham, Albert Peter Low, and Joseph-Elzéar Bernier — mentioned above — patrolled the waters of Hudson Bay and the Arctic islands, imposing licences upon Scottish and American whalers, collecting customs duties, conducting scientific research, and performing ceremonies of possession to assert national sovereignty. For his part, Bernier zealously planted the Canadian flag at every landing he made on the Arctic islands until 1 July 1909, when he revived the idea of a Canadian sector by installing a plaque on Melville Island taking sweeping possession of the "whole Arctic Archipelago lying to the north of America from long. 60°W to 141°W up to latitude 90°N."⁵⁴ Although this dubious act may have done little to perfect Canada's claim to the archipelago in international law, it served as an important symbol in national sovereignty narratives. Bernier's ship also served as a moving platform to collect weather data over an expanding area, thus contributing to scientific knowledge concurrent to its primary sovereignty role.⁵⁵

The First World War and its immediate aftermath were marked by a general lapse in northern activity, but a clear exception was Manitoba-born Vilhjalmur Stefansson's two-pronged Canadian Arctic Expedition,



FIGURE 1-6. Captain Joseph-Elzéar Bernier and his team at Winter Harbour, Melville Island, 1 July 1909. LAC, MIKAN 3652544.

which operated in the western Arctic from 1913 to 1918. The last of the “old-fashioned expeditions,” the main purpose of Stefansson’s northern party was to “discover new land along the 141st Meridian” and to map the edge of the continental shelf in the Beaufort basin. In the end, the intrepid explorer discovered and took possession of several islands for Canada, adding several thousand square kilometres to the country’s territory, while clarifying cartographically ambiguous ones such as Prince Patrick Island.⁵⁶ He also brought back some of the first meteorological information from the western Arctic. The leader of the southern “scientific” party, Dr. Rudolph Martin Anderson, had devoted time in Washington and the Dominion Meteorological Bureau in Toronto prior to leaving for the Arctic to learn formal techniques of magnetic and meteorological observation. William Laird McKinlay, a teacher of mathematics and science in Glasgow, served as the expedition’s magnetician and meteorologist. Despite the southern party’s vast scientific achievements, Stefansson’s tireless self-promotion and geographical discoveries attracted the most

popular attention. Stefansson sought to recast the image of a *Friendly Arctic* — a resource-rich region that Canada could not retain simply by colouring it “red in Atlases published in Canada.” He preached the gospel of effective occupation, with science playing a vital part in demonstrating national interest and control.⁵⁷

The character of Arctic exploration changed rapidly and dramatically after the First World War, transitioning from an emphasis on new geographical discovery to scientific exploration. Furthermore, as meteorologist Sverre Orvig notes, “permanent settlements began to grow and, with the introduction of radio and aircraft, it became possible and necessary to exchange weather information on a routine basis.” Observational networks expanded alongside the establishment of new settlements, police outposts, and radio stations in the Canadian North, although not to the uninhabited sections of the Far North.⁵⁸ Nevertheless, theoretical innovations in the interwar years, based on mathematical modelling and new demands for accurate weather forecasts associated with the advent of the air age, heightened the demand for reliable data.⁵⁹

Weather, the Great War, and the Air Age

By the end of the nineteenth century, meteorologists still struggled to discern laws of atmospheric behaviour that governed weather patterns, and many compiled climatic averages rather than building analytical models to predict current weather trends. Accordingly, at the start of the Great War, forecasting methods remained simple, linear extrapolations of existing atmospheric pressure systems. Although radio allowed ships to transmit observations, thus synchronizing ocean and overland data on upper atmospheric conditions, the general forecasts seldom extended beyond twenty-four-hour periods. The exigencies of war and technological innovation encouraged the “militarization” of climatology and local meteorology. Forecasts for air operations advanced beyond surface weather predictions to include cloud thickness and amount, upper air winds, and temperatures. Nevertheless, a major gap remained between the desire for long-range forecasts based on climatic data to support strategic planning and actual operational forecasts useful to execute specific missions.⁶⁰

Wartime lessons highlighted the importance of meteorological data. Historian Robert Marc Friedman observes that “wartime experience had

taught meteorologists that, to be effective for aviation, forecasts had to be much more geographically precise and detailed than traditional predictions and had to emphasize the short-term changes of weather conditions two to six hours in advance.”⁶¹ Relevant forecasting for aviation depended upon rapid communications with airfields, which wartime advances in telephone and wireless telegraphy facilitated. Furthermore, militaries required timely, all-weather information about winds, atmospheric temperature, pressure, and humidity at various altitudes across wide areas to produce reliable synoptic weather maps. This led to increased government funding for meteorologists, but also civilian pressures emanating from the agricultural and transportation sectors, which sought more accurate forecasting. The US Signal Corps recruited the famed physicist Robert A. Millikan during the war to lead a new “Army Meteorological and Aerological Service.” Working collaboratively with the civilian weather bureau in the Department of Agriculture and European colleagues, these military meteorologists pioneered the new fields of aviation meteorology, “battlefield climatology,” and local forecasting. By war’s end, several hundred American officers and enlisted men had received meteorological training.⁶²

Technological innovation played a pivotal role in modernizing atmospheric science. At the end of the war, most measurements were still made from the ground or using balloons and kites at low altitudes. Airplanes offered a platform to conduct observations, but they embodied an obvious contradiction because their safe use depended upon the results of the information that they were supposed to collect. The invention of wireless telegraph (radio) helped to solve this dilemma and led to a natural evolution in meteorological instrumentation. Marconi had succeeded in transmitting radio signals across the Atlantic in 1901, but radio was not practically applied to meteorology until after the First World War. Balloons had proven an ideal platform to collect synoptic data for decades, but they were limited because it took several days to retrieve released balloon-sondes and return them to a central bureau. Radio telemetry offered an obvious solution to this time-delay problem. The booming hobby of amateur radio not only propelled technological innovation after the war, but also made vacuum tubes and other components commercially available at a reasonable cost. This encouraged pioneering researchers to create the

first radiosondes: balloon-borne instruments that wirelessly transmitted atmospheric data to a receiver-recorder on the ground.⁶³

The radiosonde was the necessary breakthrough. This device, consisting of a small box with temperature, humidity, pressure instruments, as well as a miniature transmitter, is carried aloft by a large gas-filled balloon and is returned to the ground by parachute after the balloon bursts. While airborne, instruments measure the weather elements and the radio transmits the data to a ground receiving station. The *RAOBs* (the records from the radiosonde) are therefore available for immediate use, providing systematic and reliable data on upper-air conditions.⁶⁴ During the 1930s, the US and Canadian weather services (and those of almost every industrialized nation) adopted this practical tool, which contributed more than anything else to the systematization of weather observations. Historians at the Smithsonian Institution concluded:

Thanks to data provided by the radiosonde from a range of altitudes, synoptic weather maps were vastly improved. These data, in turn, provided the means to generate timely, accurate forecasts based upon the motion and evolution of the air masses. As radiosonde technology and data collection improved in the 1940s, scientific meteorology finally matured. Deterministic modeling of the atmosphere, based upon the physical laws of gas dynamics and heat transfer, although appropriate, had long been considered futile because measurements on a sufficiently large scale and at high enough resolution to establish initial conditions for the equations could not be made. The availability of large amounts of data from radiosondes and the emergence of electronic computers in the late 1940s helped to forge a new branch of science in practical modeling of the atmosphere. Modeling, together with skillful interpretation of data, has promoted a steady improvement in our understanding of the atmosphere and its dynamics.⁶⁵

The radiosonde greatly improved the accuracy of weather forecasting, with direct benefits to agriculture and aeronautics, and laid the foundation for modern analog telemetry systems.⁶⁶

Technological innovation was matched by theoretical innovation in atmospheric science beginning in the early 1920s. At the end of the First World War, Scandinavian researchers (led by Vilhelm Bjerknes) devised a new conceptual foundation that became known as the Bergen School of Meteorology. Their theoretical work on air masses, fronts, polar fronts, and evolutionary cyclones provided the first comprehensive science of weather. “The special forecasting goals arising from the onset of commercial aviation, the rapid exchanges of weather data and predictions afforded by advances in wireless telegraphy, and the new cyclone model combined to form a single perspective for meteorological discourse,” Friedman explains. These innovative models owed much to the Great War, both materially (forecasting systems were possible because of communication networks developed during the war) and discursively.⁶⁷ The Bergen school appropriated the language of “fronts,” describing how polar and equatorial air attacked and counterattacked, their clash a “battle line” (*kamplinje*) or “battlefront” (*kampffront*) around the hemisphere:

We have before us a struggle between a warm and a cold air current. The warm is victorious to the east of the centre. Here it rises up over the cold, and approaches in this way a step towards its goal, the pole. The cold air, which is pressed hard, escapes to the west, in order suddenly to make a sharp turn towards the south, and attacks the warm air in the flank: it penetrates under it as a cold West wind.⁶⁸

The idea of a polar front (the boundary separating warming tropical air from cold polar air in the mid-latitudes and thus affecting global weather patterns), in particular, laid the foundation for major innovations in practical weather forecasting.⁶⁹ Thus, the field of long-range forecasting began to take shape, particularly in Russia, Germany, and America, with applied air mass and frontal analysis and an extension of the observational nets to the upper air.⁷⁰

Translating these conceptual developments into improved forecasting demanded more meteorological data from the Arctic. Dr. George Simpson, the director of the British Meteorological Office of the Air Ministry, observed in 1929 that most scientific work had been a by-product of quests

for the Pole. “If scientific work is to continue in polar regions it must now be for its own sake,” he explained, citing in particular the “great blank from 20°, more or less around the north pole,” which “every meteorologist” dreamed of filling up. To identify and address this gap, he laid down three propositions:

1. Our knowledge of polar meteorology is such that little further advance can be made by spasmodic meteorological observations;
2. We need observations taken simultaneously in all parts of the polar regions, so that the actual conditions existing at any one time over the whole polar region can be studied in detail;
3. We need observations at a few representative positions, which will give unbroken records extending over many years.⁷¹

Most of the meteorological stations established in the Arctic in the nineteenth and early twentieth centuries took reports for climatological records. Without reliable communications, they could not be transmitted south in a timely manner to use for synoptic purposes. Accordingly, expanded meteorological capacity directly correlated with technological innovation and improved communication systems. “The period of modern meteorological observations can be said to date from the introduction of the radio in the North,” Andrew Thomson later noted. The primary purpose of the Northwest Territories and Yukon Radio System — the first chain of government wireless stations in the territorial north, which began operations in 1925 — was to gather and transmit meteorological data for the Canadian Meteorological Division. By 1941, major HBC trading posts in the Northwest Territories also had short-wave key and telephone transmitters, while flying and mining companies had radio equipment. This communication network allowed personnel of the Meteorological Division, the Royal Canadian Corps of Signals, the Radio Telegraph Branch of the Department of Marine and Fisheries, the Royal Canadian

Mounted Police, HBC factors, missionaries, and employees of commercial and mining companies to pass along observations.⁷²

The main driver of this demand was a growing sense of “air-mindedness”: national excitement about the prospects for aviation, based on its capacity to push back the “veil of ignorance” that had previously obscured the North.⁷³ Dramatic advances in aviation technology during the Great War and in the interwar years propelled interest in and access to the region; developing safe and reliable northern air routes further required aerial surveys, accurate mapping, climatology studies, and meteorological data.⁷⁴ Visionaries such as Royal Canadian Air Force (RCAF) squadron leader Robert A. Logan anticipated the role of aircraft in orderly Arctic development, while American air power advocate Billy Mitchell emphasized how aviation amplified the strategic importance of the region, famously describing before the US House Committee on Military Affairs that Alaska was now “the most important strategic place in the world.”⁷⁵ Vilhjalmur Stefansson popularized a similar, albeit civilian and commercial vision through his proclamations of a commercial “polar Mediterranean.” Because the Arctic offered the shortest potential air routes between the largest cities in the world, he touted that Canada could become a great power if it (as part of the British Empire) controlled and exploited the region.⁷⁶ RCAF pilots began the enormous task of aerial photography to support mapping the entire North, and Army Survey Establishment cartographers helped to make the North legible for the extension of state control and development.⁷⁷ The RCAF also conducted the first aerial ice reconnaissance in Davis and Hudson Straits in 1927–28, studying ice, weather, and navigation conditions along the new grain route from Churchill on Hudson Bay to the ports of Europe.⁷⁸

Aviation also reshaped expectations and practices of modern Arctic exploration, holding out the possibility that the airplane offered a mechanical solution to the longstanding problem of polar transportation.⁷⁹ “For aviation, the 1920s and 30s were decades of glamor, accelerating technology, and — most of all — personalities,” historian Patrick Hughes summarizes. The US Weather Bureau initiated daily national flying weather forecasts for the army and the postal service in 1919. In the years ahead, well-publicized cross-country flights and transatlantic attempts immortalized fliers such as Charles Lindbergh and Wiley Post, and added to

the clamour for weather information and special observation stations near airways.⁸⁰ In due course, aviators cast their attention northward in hopes of conquering hostile Arctic environments. For example, the American Geographical Society sponsored Australian Hubert Wilkins' expeditions of 1926–28 from Barrow, Alaska, over the Arctic Basin, to Spitsbergen (Svalbard). “Long-distance flying in the Arctic is not more hazardous than long-distance flying in other regions,” he suggested in his contribution to *Problems of Polar Research*. Although he failed to discover any new Arctic lands, he made important meteorological observations during his flight over Ellesmere and dismissed the idea of a hypothetical “Crocker Land” supposedly lying to the west of it.⁸¹ “By raising its passengers above the obstacles of the Arctic ice and thereby fundamentally redefining the relationship between the explorer and the environment,” historian Marionne Cronin observes, “it seemed as if aircraft had eliminated the danger and hardship that formed the heart of heroic exploration.”⁸²

Arctic aviators took to the skies at a time of lingering Canadian concern about sovereignty and increased Canadian government activity in the North. The immediate postwar catalyst for action was Danish explorer Knud Rasmussen's alleged denial of Canadian sovereignty over Ellesmere Island, and the Danish government's apparent endorsement of his stance. Stefansson, in an early articulation of a “use it or lose it” doctrine, urged that if Canada did not occupy the northern islands of the archipelago it might lose them. Stefansson sought to organize an expedition for this purpose, but it did not materialize. “Fear about what Denmark might do in the archipelago was gradually replaced by concern over what Canada herself ought to do,” Smith observed, leading the government to institute ship patrols of the eastern Arctic in the old tradition of Low and Bernier, now on an annual basis, and to expand the Mounted Police permanent presence along the Arctic coast and on the Arctic Islands, beginning with new posts at Pond Inlet on Baffin Island and Craig Harbour on Ellesmere Island in 1922.⁸³ As the Canadian government took action to solidify its Arctic claims, however, other countries lost interest in pursuing their own. Denmark let the issue of Ellesmere Island drop and, at least tacitly, accepted Canadian sovereignty. Lingering questions about Norwegian claims to the Sverdrup Islands surfaced in 1924, but Norway formally recognized Canadian sovereignty over the Sverdrup Islands in 1930.⁸⁴

Canada remained wary about the United States' interests in the North American Arctic, given the power asymmetry between the two countries. Although American-sponsored expeditions "were less attempts to claim territory than to reaffirm that the United States intended to continue to consider territory it crossed or explored as open area," Fogelson observes that "by insisting on equal access throughout the Arctic, the United States hoped to deter other countries from establishing spheres of influence."⁸⁵ American newspapermen and international lawyers persisted in asking embarrassing questions about Canada's Arctic sovereignty, leading Ottawa officials to anticipate possible conflict with the United States. The controversy surrounding the US Navy-sponsored Byrd-MacMillan Expedition in 1925 was the clearest case. American explorer Donald B. MacMillan failed to secure the necessary permits from Canada before entering the archipelago to conduct scientific experiments, and then lied about it to the crew of the Canadian Eastern Arctic Patrol. Facing weather and mechanical problems, the Americans now faced a political storm. Canadian authorities submitted an official protest to the American government that, in turn, formally requested a permit. Subsequent American expeditions fulfilled the proper licencing requirements and, from this point onward, the US government avoided publicly appearing to challenge Canada's sovereignty over the Arctic islands.⁸⁶

The tempo of American Arctic exploration activity declined in the 1930s, pushing to the back burner any lingering suspicions about whether the United States accepted all of Canada's Arctic claims for the time being. In March 1933, V. Kenneth Johnston argued optimistically in the *Canadian Historical Review* that foreign claims in Canada's Arctic archipelago had disappeared and that Canada's own claim had been established.⁸⁷ The Permanent Court of International Justice's decision in the Eastern Greenland case between Norway and Denmark the following month indicated lessened requirements for sovereignty over remote, inaccessible, thinly settled, or even uninhabited territories.⁸⁸ Nevertheless, the judicial nature of polar sovereignty remained ambiguous, and the United States' Hughes Doctrine insisted that proclamations, transient visits, temporary outposts, and symbolic acts of control were insufficient bases for a state to claim sovereignty over polar territory. The contrast between this approach and Canada's "sector principle" could not have been starker.⁸⁹

Although the Great Depression put a damper on sovereignty-related activity in the North American Arctic, the future opportunities for air transport in opening the region remained apparent — as did the reliance of aviation upon science. In 1928 the Meteorological Service of Canada's central office in Toronto set up an aviation section, which demanded reliable weather data to produce forecasts based on the latest scientific methods.⁹⁰ The director of the Service, Sir Robert Frederic Stupart, lobbied for Arctic stations that would produce regular weather observations, rather than merely collecting climatological data.⁹¹ The network of observing stations slowly expanded into northern Canada, particularly west of Hudson Bay and up to the Arctic coast (see fig. 1-7).⁹² Nevertheless, accumulating useful weather data from the region remained problematic. Different stations, unevenly scattered across the country's vast northern territories, often made their observations at different times of the day. Observations of humidity during the winter months, using dry- and wet-bulb thermometers, proved unreliable. (The bulb of a wet-bulb thermometer is dipped in water and the resulting evaporation or sublimation around the bulb generally produces a cooler result that is used to determine dew point, relative humidity, and vapour pressure.) Andrew Thomson recalled that the difficulty in transporting mercurial barometers to the North, coupled with “the lack of communications for long periods, rendered the establishment of satisfactory pressure stations, especially in the early days, almost impossible. Errors were not known until data were received many months after observations.” Personnel changes, untrained observers, delays in replacing broken instruments, and the lack of inspections by headquarters staff compounded problems.⁹³ Furthermore, the Arctic Archipelago remained “a large blank spot on the weather maps,” but the cost and effort required to secure information from this remote space would remain prohibitive until another world war reshaped the geostrategic significance of the region.⁹⁴

With lowered demand for meteorological services during the Depression, senior officials in the Meteorological Service focused their energies — and limited resources — on training, research, and development. This paid off, Thomas argued, and “by the end of the decade an excellent foundation had been laid upon which the Service would be able to respond to the tremendous demands to be placed upon it by commercial and military aviation.” Improvements in weather forecasting required

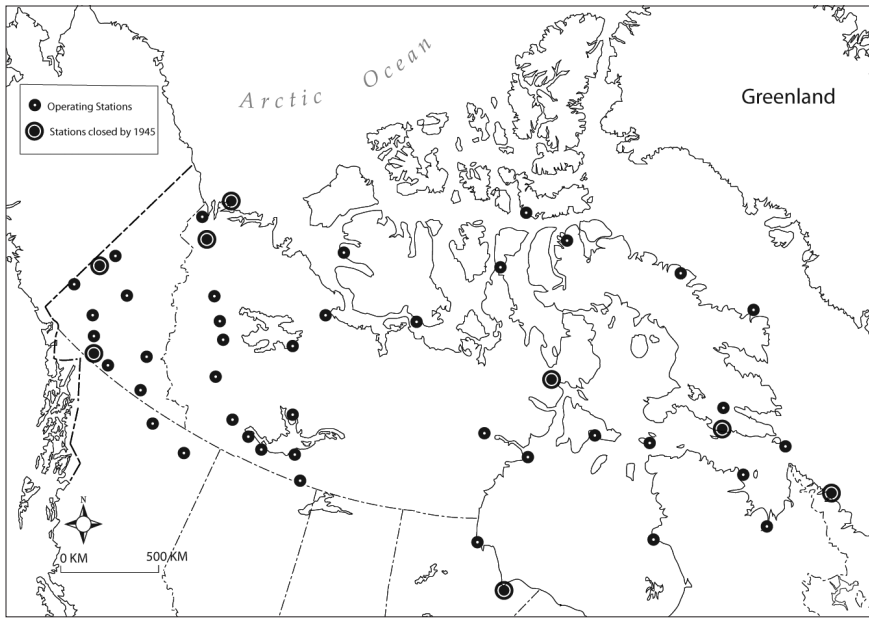


FIGURE 1-7. Dating from the 1880s, a series of meteorological stations were progressively opened in the Arctic. Some, such as Lake Harbour, operated for a few decades before being closed. Most, however, continued to gather observations to create a continuous dataset. Jennifer Arthur-Lackenbauer

improved awareness of new air mass analysis theories and their adaptation to North American conditions. In this context, the Meteorological Service recruited Andrew Thomson, a Canadian with experience in New Zealand and the South Pacific, to head up its Physics Division in 1932. Several young Canadians pursued graduate studies in the United States and Europe, where they were exposed to international innovations in meteorological science. In partnership with the weather service, the University of Toronto developed a graduate program in meteorology, which adapted European theories to North American weather. In the ensuing years, these developments fostered a cadre of professionals who had ample opportunity to test and refine their modern methods during the Second World War.⁹⁵

In Canada, weather services were a civilian endeavour. Reflecting the close relationship between meteorology and aviation, the Meteorological

Service of Canada became the Meteorological Division of the Air Services Branch of the new Department of Transport in November 1936. (The Royal Canadian Air Force did not perceive the need for a regular, full-time meteorological service, and did not request regular forecasts and professional services for their units until 1938.)⁹⁶ In the United States, the 1926 Air Commerce Act — “the legislative cornerstone for the development of commercial aviation in America” — vested the US Weather Bureau with responsibility for weather services to civilian aviation, leading to a dramatic expansion of the Bureau and its services.⁹⁷ Francis Wilton Reichelderfer, a longstanding naval aerographer (meteorologist) and officer who was a strong proponent of the Bergen School of meteorology, left the US Navy to take the helm of the Weather Bureau in 1938. Given his deep knowledge of aviation meteorology, he was an ardent proponent of advanced scientific methods of forecasting and recognized the need for worldwide weather services.⁹⁸ By 1939 forecasters had telegraphic data available from 275 observing stations in North America, 135 of which were Canadian (compared to 70 in 1930).⁹⁹

When the clouds of war gathered in Europe in the late 1930s, reciprocal defence pledges meant that continental collaboration in civilian pursuits, such as meteorology,¹⁰⁰ were now complemented by closer bilateral collaboration in continental defence. “We as good neighbors are true friends,” American President Franklin D. Roosevelt assured Canadians in 1938. He promised that the United States would “not stand idly by” if any foreign power threatened Canadian territory. The Monroe Doctrine of 1823, which pledged that the US would respond to any external aggression in the Western Hemisphere, extended north as well as south. Even Canada’s Prime Minister William Lyon Mackenzie King, wary of foreign commitments that could divide a country with a complicated array of national, imperial, and continental allegiances, welcomed this promise. Size dictated that the Americans would assume primary responsibility for continental defence, and geography tied Canada’s security to that of its southern neighbour. For his part, Mackenzie King declared that Canada also had its obligations as a friendly neighbour and would ensure that no enemy forces would ever pass through the dominion on their way to the United States. These were easy promises to make while the likelihood of invasion remained remote. When war broke out, strategic thinkers assumed that

the Arctic was a natural defensive barrier. “On the Dominion’s northern territories those two famous servants of the Czar, Generals January and February, mount guard for the Canadian people all year round,” historian C.P. Stacey wrote in his 1940 study of Canadian defence policy. Aircraft could make the Arctic and subarctic regions more strategically significant, he concluded, but hardly constituted an immediate, practical threat to or through the region.¹⁰¹

The Second World War, Meteorology, and a New Northern Focus

“Modern meteorology really came of age during the Second World War,” official US Weather Bureau historian Patrick Hughes observes. Soon after the war began, it “became obvious that success in this war, more than in any previous war in history, would often depend on whose side the weather was on.”¹⁰² The science of weather forecasting had particular importance for air operations. Air force historian Jonas Jonasson explained:

Just as a ground commander must know the terrain over which his troops and supplies move, so did the successful air commander of World War II depend upon uninterrupted and fresh intelligence regarding the atmospheric “terrain” in which his forces operated. The vertical dimension of his three-dimensional battlefield was no less significant than its length and breadth. Atmospheric conditions thousands of feet above the ground determined the pathways open to his aircraft, and weather hundreds of miles away could be of greater military significance than a storm over his own headquarters. For this indispensable information the air commander relied on the delicate instruments and skilled personnel of his weather services. By the end of the war those services had come almost to be taken for granted, so much so that little thought was any longer given to the near-miracle they represented.¹⁰³

This truly global war touched the remotest outposts of the planet, arousing new interest in the North American Arctic and drawing it into the web of militarism.

The onset of war in September 1939 presented challenges for the Canadian Meteorological Division. Already overstretched to accommodate commercial aviation needs, the military now called upon it to provide weather services for Royal Canadian Air Force and Royal Canadian Navy operations off the east coast. When Prime Minister William Lyon Mackenzie King outlined his “limited liability” war effort the following year, its heavy emphasis on the British Commonwealth Air Training Plan as Canada’s primary contribution to the Allied war effort meant that a much larger cohort of professional meteorologists was needed to train air crews, analyze weather maps, generate local forecasts, and brief pilots. Rather than developing its own cadre of forecasters, as originally planned, the RCAF continued to rely on civilian “metmen” (meteorological technicians) and meteorologists in the Meteorological Division to meet its needs throughout the war.¹⁰⁴ While the former specialize in gathering meteorological observations, the latter focus on the science of meteorological analysis and forecasting.

In September 1939, Reichelderfer ran into his friend John Patterson, the director of the Canadian Meteorological Service, in a hallway at the US Weather Bureau headquarters in Washington. Canada was at war while the United States remained officially neutral, and this situation forced adaptations. Canada would no longer broadcast its weather reports in the “clear,” meaning they would be encoded and provided to the Americans for official use only. In turn, managing this sensitive information forced the US to better coordinate civilian and military weather activities. Its weather services were dispersed, with civilian and military elements, compared to the civilian Canadian system. In 1940, the US government transferred the Weather Bureau to the Department of Commerce, which held responsibility for aviation expenditures — a reflection of the disproportionate appropriation to aviation matters compared to agriculture or any other economic activity.¹⁰⁵ While the Bureau remained the primary agency for collecting and disseminating meteorological information between the wars, the US Army and Navy had maintained “skeletal weather organizations” that could be quickly recruited to strength in wartime.¹⁰⁶ These armed services, which established weather centres in Washington in 1940, formed the Interdepartmental Committee on Meteorological Defence Plans with the US Weather Bureau the following year. By early

1942, it evolved into the Joint Meteorological Committee of the US Joint Chiefs of Staff, with Reichelderfer playing a prominent role.¹⁰⁷

The war proved to be a watershed in Canada-US relations, leading Canada down the “forked road” towards enhanced continental integration, and a watershed in bilateral engagement with the Canadian Arctic. Neither country was eager to look “down north.” The US Signal Corps Meteorological Service, never with more than eleven officers during the interwar years, did not have a single station in Alaska. But as the winds of war in Europe and Asia gained strength in 1939, the United States Navy began building operating bases in Alaska to defend its isolated, rugged coastline and stationed its first weather unit in its northernmost territory. The Pacific remained comparatively quiet for two years, however, while the military storm brewed in Europe and bombers flew from Newfoundland to Britain to help stem the Nazi tide at the English Channel. With Britain’s survival in doubt, Prime Minister King and President Roosevelt signed the Ogdensburg Agreement in August 1940, establishing a bilateral Permanent Joint Board on Defence to oversee the defence of both nations. The United States also tightened its military cooperation with Britain when it reached the landmark Lend-Lease agreement in March 1941, formalizing its official aid to the Allies and securing ninety-nine-year leases to air and naval bases in Newfoundland. From this point, the US assumed responsibility for ferrying its own planes and materiel to Britain. American weather personnel arrived at Gander, Newfoundland, to work alongside Canadian personnel on anti-submarine patrols. “Within two months they were turning out synoptic maps of the North Atlantic,” the US official history noted, and Gander became “the nucleus of a weather net that reached from North America to the British Isles.”¹⁰⁸

This transatlantic path included Arctic stepping-stones. Two renowned Arctic specialists, the “fiery and voluble” geologist William H. Hobbs and aviation expert Bernt Balchen, lobbied the State, Navy, and War Departments to expand the North Atlantic air route through the Arctic.¹⁰⁹ The region boasted few air facilities, and maps still included large areas of “either blank spaces or indefinite dotted outlines of rivers, lakes, and even long stretches of coastline.”¹¹⁰ Nevertheless, strategists and defence planners began to assimilate the North American Arctic into their mental maps of the wartime world. Historian Shelagh Grant aptly observes

that there were really two “Arctics” involved: first, the treeless barrens of the High Arctic (Greenland, the Canadian archipelago, its adjacent mainland, and Ungava), and second, the subarctic regions of northern Quebec, Alaska, the Yukon, and the upper Mackenzie Valley.¹¹¹ In both areas, the Americans built an expanding network of weather stations in remote and sparsely populated areas. These were not envisaged as independent projects, but as supporting elements in larger military developments. New airports (generally doubling as weather stations, recording, reporting, and forecasting local weather conditions) served an ever-increasing stream of aircraft being ferried to Britain and the Soviet Union. “When flying the northern route became a routine operation,” William Carlson observed, “much of the credit belonged to the weathermen.”¹¹²

The northeastern route created the impetus to build weather installations in or near the North Atlantic. These projects fit with the development of the massive subarctic airbase at Goose Bay, Labrador in 1941, and the prospect of a Greenland-Iceland route to Britain that avoided the ubiquitous fog off the Newfoundland coast. Although the United States opposed Canada’s “imperialist” plans for Greenland, it assumed responsibility for the Danish colony in April of that year and the US Army Air Forces (the new name of the Air Corps in June 1941) established a base command there.¹¹³ Commander Donald MacMillan came out of retirement to lead an American task force that set up an airfield and weather station at Narsarsuak on the southern tip of the island, followed by another at Søndre Strømfjord (Kangerlussuaq) on the west coast. All told, the US established thirteen weather stations in Greenland during the war. Concurrently, the Americans secured Canadian consent to build “Crystal” stations at Fort Chimo (Kuujuaq), Frobisher Bay (Iqaluit), and Padloping Island as radio, weather, and emergency outposts. All had favourable locations to observe the movement of polar air masses, thus contributing to improved weather forecasting and safer air operations.¹¹⁴

The arduous experience of building stations in remote Arctic regions anticipated postwar challenges even further north. The situation in the summer of 1942, when a convoy of cargo ships and trawlers carrying men, equipment, and supplies set out for Fort Chimo, Frobisher Bay, and Southampton Island, was a case in point. Air force Lieutenant-Colonel Alexander Forbes and veteran explorer Captain Bob Bartlett led the way,

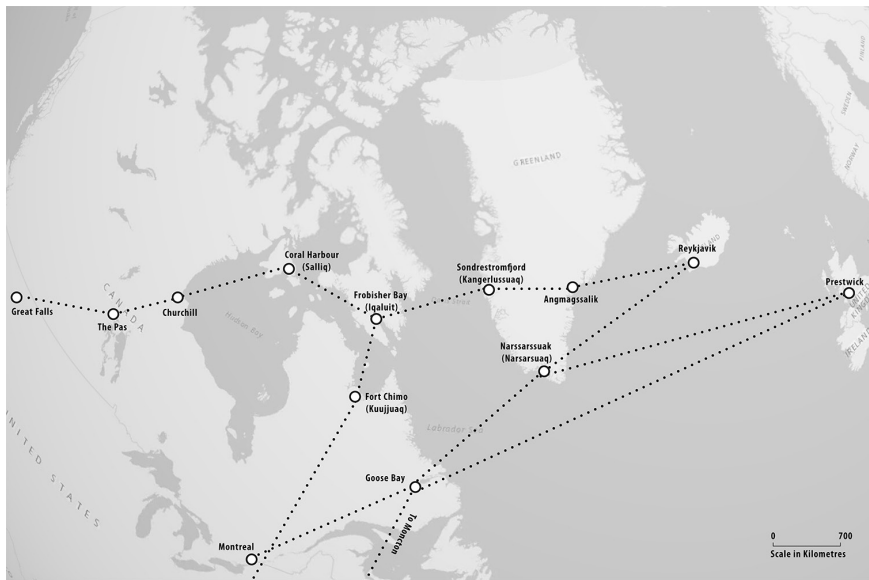


FIGURE 1-8. North Atlantic Air Routes during the Second World War. Jennifer Arthur-Lackenbauer

charting the waters of Frobisher Bay and then transferring the men and equipment from a temporary station on Crowell Island to a permanent location near the mouth of the Sylvia Grinnell River. Unfortunately, a German U-boat sunk one of the cargo ships off Labrador, thus delaying the flotilla. It finally arrived in August, importing 350 men, building materials, and heavy construction equipment to what had been, up to that point, a temporary fishing spot for the Inuit of southern Baffin Island. By October, the Americans had built a prefabricated village, including barracks, officers' quarters, a hospital, general store, mess hall, generator stations, assorted hangers, and warehouse facilities, and bulldozers were hard at work clearing the runway.¹¹⁵ The weather officers and men posted to these remote strands in the North Atlantic weather web faced their own set of challenges, given their lack of contact with the outside world for long periods, as well as extreme weather that affected housing and equipment designed for use in more temperate climates.¹¹⁶ When close to existing (or emerging) Indigenous communities, these facilities also

served as sites of cross-cultural contact.¹¹⁷ The scale of human impact in the eastern Canadian Arctic, however, was small compared to that left by the mega-projects in the Northwest.

The meteorological story in the northwestern corner of Canada was largely connected to the establishment of the Northwest Staging Route for aircraft flying between the continental United States and Alaska. By September 1941, aircrews could rely upon a series of airfields to navigate the main route from Edmonton to Whitehorse.¹¹⁸ Once the US entered the war, however, it found the situation insufficient. After the Japanese invaded the Aleutian Islands in April 1942, the Americans kicked their Alaskan defence projects into overdrive.¹¹⁹ Worried by the prospect that the enemy could cut off the sea link between Alaska and the lower forty-eight states, the United States hastily constructed the Alcan (Alaska) Highway — a herculean construction feat — with Canadian consent.¹²⁰ It roughly followed the route of the Northwest Staging Route, which General H.H. “Hap” Arnold was intent to convert into “the handle of a two-pronged pitchfork that would prod the Axis.” The two countries signed a revised agreement whereby Canada would pay for the airfields and other permanent infrastructure that served its long-term interests, with the US paying for all extensions and improvements that exceeded Canada’s postwar requirements. Carlson concluded that “it was a generous arrangement on the part of the United States, but the Canadians had never shown any desire to make unjustified profits out of joint efforts.... After some of the red tape was cut by conferences and directives, Canadian efforts began to make themselves known.”¹²¹

Although the Canadian Meteorological Division posted meteorological technicians and assistant observers to the existing airports along the Northwest Staging Route, it was still constrained by civil service hiring regulations and did not have the capacity to meet the growing demand. Initially, the US Weather Bureau assisted by loaning weather observers who were flown in and out of the Canadian stations by the RCAF. Soon the United States Army Air Forces (USAAF) decided to post its own meteorological staff at all airports that it used, and it received permission to open and operate several dozen supplemental observing stations throughout the Northwest, complete with communication facilities. Other stations served the Canadian Oil (Canol) project, launched in 1942 to build

a pipeline from Norman Wells to Whitehorse that would provide Alaska with a secure energy supply if the enemy managed to cut off sea access. That summer, the USAAF militarized all of its activities along the staging route (and the last American civilian meteorological personnel withdrew from Canada)¹²² and set up the 16th Weather Squadron, responsible for the Pacific Northwest of both the US and Canada.¹²³

Weather station personnel comprised a tiny percentage of the more than 40,000 American military personnel who worked on the wartime projects in the Canadian Northwest — three times the prewar population of the region.¹²⁴ In due course, this foreign presence generated serious sovereignty concerns in Ottawa. Although Prime Minister King had allowed the Americans onto Canadian soil with few constraints, he was always suspicious of their intentions. As early as March 1942, King told British High Commissioner Malcolm MacDonald that the Alaska Highway “was less intended for protection against the Japanese than as one of the fingers of the hand which America is placing more or less over the whole of the Western hemisphere.”¹²⁵ Yet, at this stage, the prime minister did not deem the situation serious enough to assert more Canadian control. However, when “northern nationalists” like MacDonald reported ominous developments in 1943 that apparently threatened to undermine Canadian sovereignty, the government shook its “fit of absence of mind” and took an increasingly assertive course of action.¹²⁶ King’s government appointed Brigadier W.W. Foster as a special commissioner to oversee the defence projects in the northwest, blocked some American initiatives to build more roads and air-staging routes, and secured assurances that the American troops would depart from the North after the war. Furthermore, the Canadians made plans to buy back from the United States those facilities and installations that were already built or in progress in the North.¹²⁷

The Americans welcomed Foster’s appointment and agreed (or at least complied) with Canada’s requests — an indication that their allegedly pernicious designs for Canada’s North had been overblown (and still are in much of the historiography).¹²⁸ Although impatient with and often frustrated by Canadian rejections or delays in approving what Americans considered to be vital wartime projects, officials in Washington acknowledged that they had to respect their northern neighbour’s interests — and its chronic insecurities. A State Department intelligence report, produced in

1942, suggested that “Canada has always suffered from an inferiority complex about her southern neighbour” and was envious of the “wealth and vast scale of American enterprise and industry.” Another study concluded that the average Canadian had a “conservative mind” that sought to avoid “dramatic pronouncements” and foreign policy commitments. Bilateral cooperation was possible, “as long as Americans are careful to remember the susceptibilities and sensitiveness of a small, but proud people.”¹²⁹ These principles would guide postwar relations as well.

Despite the Americans’ willingness to modify or confirm earlier agreements to accommodate Canada’s sovereignty concerns,¹³⁰ Canadian officials remained nervous about the vast network of American-controlled weather stations that extended into remote and sparsely populated areas. During a meeting at RCAF headquarters in late January 1944, for example, officers indicated that Canada was “prepared to accept full responsibility for the provision of meteorological facilities within her borders” and recommended that “Canada be responsible for providing and operating all installations which are an essential part of the general meteorological system of Canada or which Canada intends to retain after the War.” Not only would the Americans have to obtain permission for any stations on Canadian soil, the minutes reiterated, but the US should be limited to installing and operating “supplementary meteorological facilities only.”¹³¹ In short, given the heightened importance that the Canadian North would play in postwar aviation, senior officials emphasized that any expansion of weather services in the region should fall under Canadian control “to avoid any possible future difficulties with the United States.”¹³² The Cabinet War Committee concurred and began to move in this direction as the context of the war allowed.

As the tide of the war changed in 1944 and the perceived threat to North America declined precipitously, the US Army Air Forces sought to reduce the number of airfields that it maintained in the Canadian North, as well as related meteorological activities. It abandoned the Canol project, transferring several stations to the Canadian Meteorological Division and the Royal Canadian Corps of Signals and closing others. By 1945, the Canadian civilian weather service assumed control of most other USAAF stations and facilities that it deemed necessary for peacetime operations. Other stations were closed when the Allies abandoned particular air

routes. The Americans reduced their sprawling wartime presence to a small footprint at war's end, and Canada secured full ownership of all permanent facilities on its territory by purchasing them from the United States. The Americans also agreed that, prior to initiating any project on or over Canadian territory, they needed to secure the Canadian government's approval. The ownership of permanent facilities passed into Canadian hands, and negotiations with the United States yielded various provisions indicating that Canada needed to be consulted and agreements reached before activities could be undertaken on or over its territory.¹³³

Despite persistent Canadian concerns about their northern sovereignty, the wartime experience suggested that senior-level American officials did not harbour any surreptitious desires to permanently take over Canada's northlands. The future, however, remained uncertain, and questions remained unanswered. In February 1944, J.G. Wright, a member of the Northwest Territories Administration, had noted that "it is the far [northern] and western islands, which are reached by our administration mostly in theory, where our claims to sovereignty are most likely to be questioned." Wright observed that Russia had strengthened its claims to its Arctic possessions by establishing scientific and weather stations in the area and suggested that Canada might do the same. Such a course fell "outside the scope of the existing U.S. weather stations [in northern Canada], which are all in regions where no one is likely to question our sovereignty."¹³⁴ Malcolm MacDonald, a consummate prognosticator of concern about Canada's Arctic sovereignty, observed that the Americans now "treated ... with indifference the obstacles which Nature — whose sovereignty in the Arctic is even more supreme than that of the Canadian Government — put in their way."¹³⁵ Thus, while the Government of Canada had never invested in permanent scientific installations in the High Arctic, expanding American interest in this isolated region generated new pressures to take some form of action.

"It may be said that meteorological observations have kept pace with geographical exploration," Andrew Thomson noted soon after the war. Explorers had already "discovered" most of the islands of Canada's Arctic Archipelago by the late nineteenth and early twentieth centuries, but the larger question of what practical use they might be to Canada remained

open to debate. The perceived need to conscript them into the continental science and security web after the war reflected technological and theoretical advances in the first half of the twentieth century, as well as the rise of aviation and concomitant demand for meteorological services:

The maintenance of an arctic network of meteorological stations is exacting and expensive. Nevertheless, it must be not only continued but expanded. The consensus of meteorological opinion the world over holds that in the arctic data lies the clue to both more accurate short-range forecasts and to the development of long-range forecasting techniques. To this must be added a recent requirement for meteorological services to new trans-arctic air-routes. The responsibilities of Canada in this connection are definite and unavoidable — it may be safely said that her meteorological eyes are and will be turned to the Arctic for several years to come.¹³⁶

Synoptic data, obtained simultaneously over a wide area that provided a comprehensive portrait of the state of the atmosphere and could be used for more reliable global weather forecasting, thus supported transcontinental science imperatives as well as continental security considerations associated with aviation in the atomic age.

By the spring of 1945, the US Army Air Forces operated about 900 weather stations, more than two-thirds of which were outside of the continental United States.¹³⁷ Having shed its interwar isolationism and emerging from the war as a global superpower, the US needed access to long-range weather forecasting over much wider areas. “The weather requirements for a war in the foreseeable future will be different from those of World War II,” American meteorologist and inventor Irving P. Krick explained in December of that year. “Even from a defensive point of view data from the world is essential if adequate policing by the Air Forces is to be accomplished.” The “strategic bombing of small pin-point targets by piloted aircraft, and the occupation of enemy territory almost solely by airborne armies” would necessitate forecasts of cloud thickness at the target area, icing in the clouds, and winds at altitude. In the atomic age, wars might not last long enough to require collecting ongoing data over enemy

territory, but militaries needed to anticipate any contingency.¹³⁸ The Arctic now assumed a significant role given the likely trajectory of flights and missiles over the North Pole, but equally important was the influence of Arctic weather systems on global systems.

Improved knowledge about the polar air mass, which shaped atmospheric circulations in the Northern Hemisphere, was essential to produce accurate three-dimensional forecasting and long-range projections (geographical and temporal). National and international long-range air operations would depend upon such meteorological research. In the civilian realm, improved weather forecasting would bring a host of national economic benefits — from farming to industry — and local Arctic observations and forecasts would lay the foundation for the development of the great Arctic circle route envisaged by Stefansson. For military planners, the Second World War had demonstrated the strategic utility of air power and how modern methods of transportation, communication, construction, and subsistence could support the collection of data from isolated northern areas. Wartime exigencies demanded urgent action rather than the careful contemplation of long-term meteorological research programs. The facilities established by the US Army Air Forces and the Canadian weather service “provided a network of bases for northward progress,” a wartime report noted, “but there still remains a vast area beyond the arctic circle which is as yet meteorologically unexplored.”¹³⁹

If wartime imperatives during the war had pushed American meteorologists, and thus the Canadians, on a northward march into the archipelago, to even contemplate extending meteorological networks into its farthest reaches required a deep faith in the ability of modern technology to overcome some of the harshest environmental conditions on the planet. Whereas prewar explorers and bush pilots had opened the North on a modest scale, wartime advances in technology, logistics, and communications opened possibilities for an unprecedented degree of development. “Because of the war, the United States had developed the capability to construct bases almost anywhere in the world, and this was not an opportunity to be missed before that knowledge was gone,” geographer Peter Johnson recalls. To provide aircraft to build and supply remote stations that could not be serviced by ship, American planners soon “adapted lessons learned in the Pacific and Europe in transporting men and equipment to open up

the north.”¹⁴⁰ People who had participated in the development of the war-time air routes through the Arctic, and celebrated their conquest of a hostile environment, also acknowledged that the region’s relevance remained only partially understood. “It was an important war for the knowledge of the Arctic that we gained,” Colonel Bernt Balchen, the author of *War Below Zero*, noted:

Some day our whole conception of geography will be changed; the earth itself will be rolled over on its side, and the spindle of the globe will run, not from Pole to Pole, but from one side of the Equator to the other. Then the Arctic will be the very center of our new world; and across Greenland and northern Canada and Alaska will run the commercial airways from New York to London, from San Francisco to Moscow to India.¹⁴¹

To begin realizing the possibilities of this “new world,” with its civilian and military benefits, senior officials in Washington would need to convince their Canadian counterparts that the project was both feasible and respectful of Canadian sovereignty. The primary promoter of this vision was Charles John Hubbard.

