Atmosphere

Volume 9 Number 1 1971

Canadian Meteorological Society
Société Météorologique du Canada

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FROM THE PRESIDENT

It is with a great deal of pleasure that I welcome Atmosphere *in its new form and style. This represents the culmination of lengthy consultations, hard work, and much anguish on the part of the executive of the Society and especially Ed Truhlar, our editor. We sincerely hope that you find this to your liking.*

While the change in cover and design of the Journal will be most obvious to you this also marks significant changes in the administration of the Society which will be particularly beneficial. The University of Toronto Press as publishers of Atmosphere *will be responsible for its printing, distribution, mailing and promotion as well as the collection of Society dues and the maintenance of membership lists. Release from these routine chores will permit the executive to function much more actively and effectively in furthering the development of the Society.*

With a bright new Journal available to you it is hoped that you will use it as your forum to present new ideas, to re-examine old concepts and to support the science of meteorology. In the age of environmental concern we must not abrogate our responsibility.

January 12, 1971

D. N. McMullen, *President*
Canadian Meteorological Society

Letter from the Administrator, Canadian Meteorological Service

Dear Mr. Truhlar: January 11, 1971

I am pleased to have this opportunity to congratulate you and members of your Editorial Committee and Staff for your accomplishments in publishing Atmosphere, *and for the efforts you have put into redeveloping its format and appearance. I am sure that the January 1971 issue, the first 'new look'* Atmosphere, *will long be regarded not only as a significant milestone in the development of the publication, but also as a milestone in the progress of the Canadian Meteorological Society.*

Some of your readers may recall that for the first decade after the establishment of the Society's predecessor, the Canadian Branch of the Royal Meteorological Society, there were no Canadian publications. Then in 1950 the Society began to publish, on an individual basis, the papers presented at meetings and 50 of these were published over the next decade or so. In 1963, when the National Executive of the Society was located in Montreal, the periodical Atmosphere *was begun. Looking back I believe that the publication innovations of 1950 and 1963 were quite important to the health and vitality of the Society, and I am sure that, in subsequent years, the changes of 1971 will be recognized in a like manner.*

As well as being an important year in the life of the Society, 1971 will, I believe, be remembered as a significant year in the life of the Canadian Meteorological Service. Not only do we expect to move the Headquarters to its new home at 4905 Dufferin Street, Downsview, during the year, but in addition the Service will formally leave the Ministry of Transport and become part of the new Department of the Environment. While I cannot see any decrease in the demands for meteorological services from transportation interests in the country, it is quite possible that we will be facing new and challenging requests for services and research from other sectors of the new Department having to do with air and water pollution, water resources, etc.

Thus from several points of view, 1971 gives every indication of being a milestone year in Canadian meteorology. I am very pleased that the Society has moved to improve the format of Atmosphere *as a scientific publication, and I want to wish you much success in this and subsequent years. An active and healthy Canadian Meteorological Society is of the utmost importance to the Canadian Meteorological Service in its task of providing meteorological services for the benefit of the people of Canada.*

Yours very truly,

J. R. H. Noble, *Administrator, Canadian Meteorological Service*

A Brief History of Meteorological Services in Canada Part 1: 1839–1930

Morley K. Thomas
Canadian Meteorological Service, Toronto
[Manuscript received 24 December 1970]

ABSTRACT

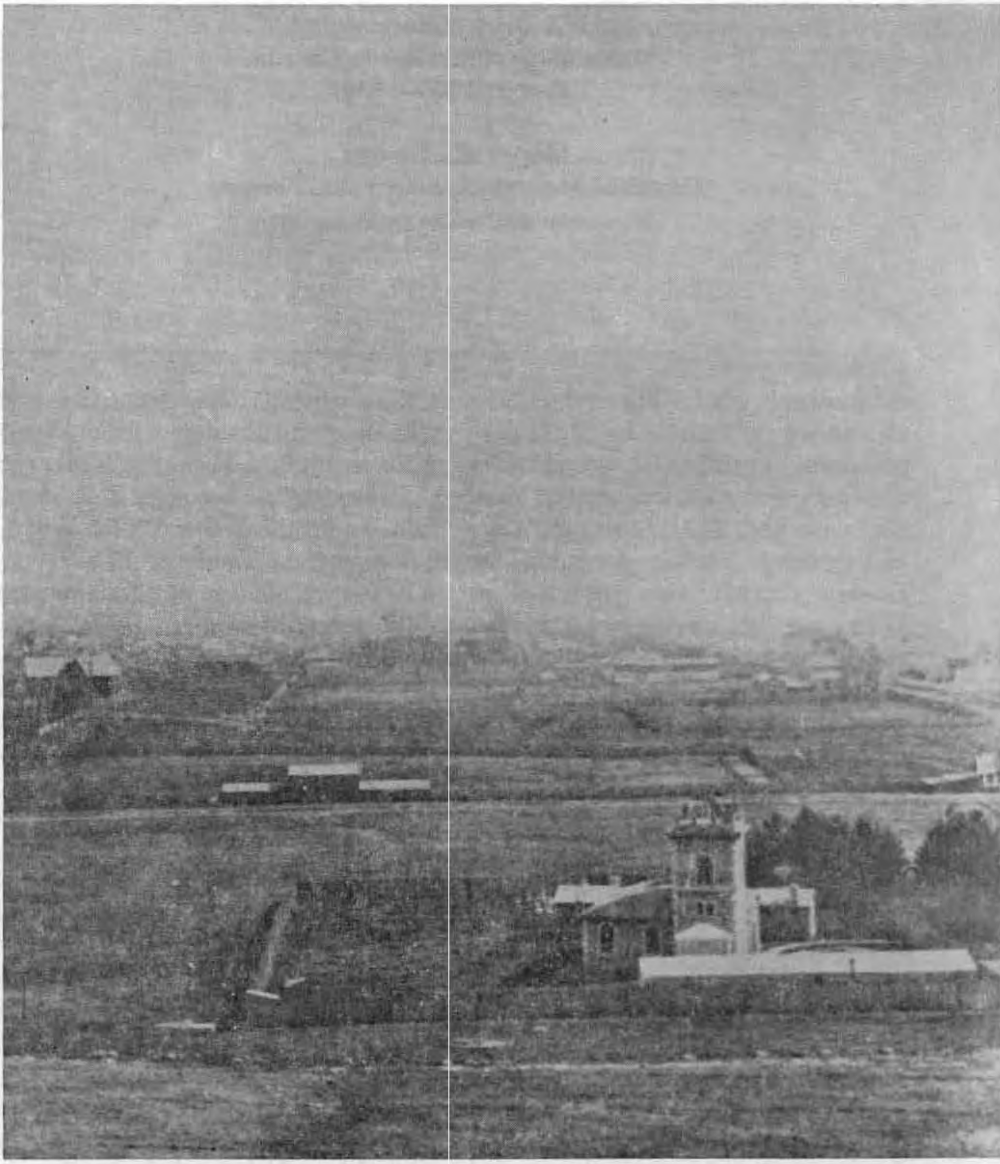
Although an official observatory was established in Toronto in 1839, governmental attempts to organize a national meteorological service were not begun until 1871. Storm warnings and general weather forecasts for Eastern Canada were instituted in 1876, and this service was extended across the West and throughout the settled portions of the country by the early years of the 20th century. Historical climatological data were published annually after 1871, but very little statistical data, delineating the climate of the country, were available prior to 1900. A beginning was made at expanding meteorological activities into the North before World War I, but it was not until the 1920's that a significant number of observing stations were located there. By 1930 the need for extensive aviation meteorological services was becoming apparent, but the economic depression prevented an expansion of both aviation and meteorological services.

1 Introduction

One hundred years ago the first step in establishing a national meteorological service was taken by the Government of Canada when the sum of $5,000 was appropriated to the Minister of Marine and Fisheries to financially support the organizing of a system for the taking of weather observations. No appreciable meteorological services had been provided prior to that time despite the founding of the first official observatory in Canada at Toronto in 1839. The story of meteorological services, as distinct from meteorological research, is the subject of this series of articles. Hence this account will not be a complete history of the Canadian Meteorological Service, but the story of its development and organization must be central to a history of the services it has provided.

2 The Toronto Observatory

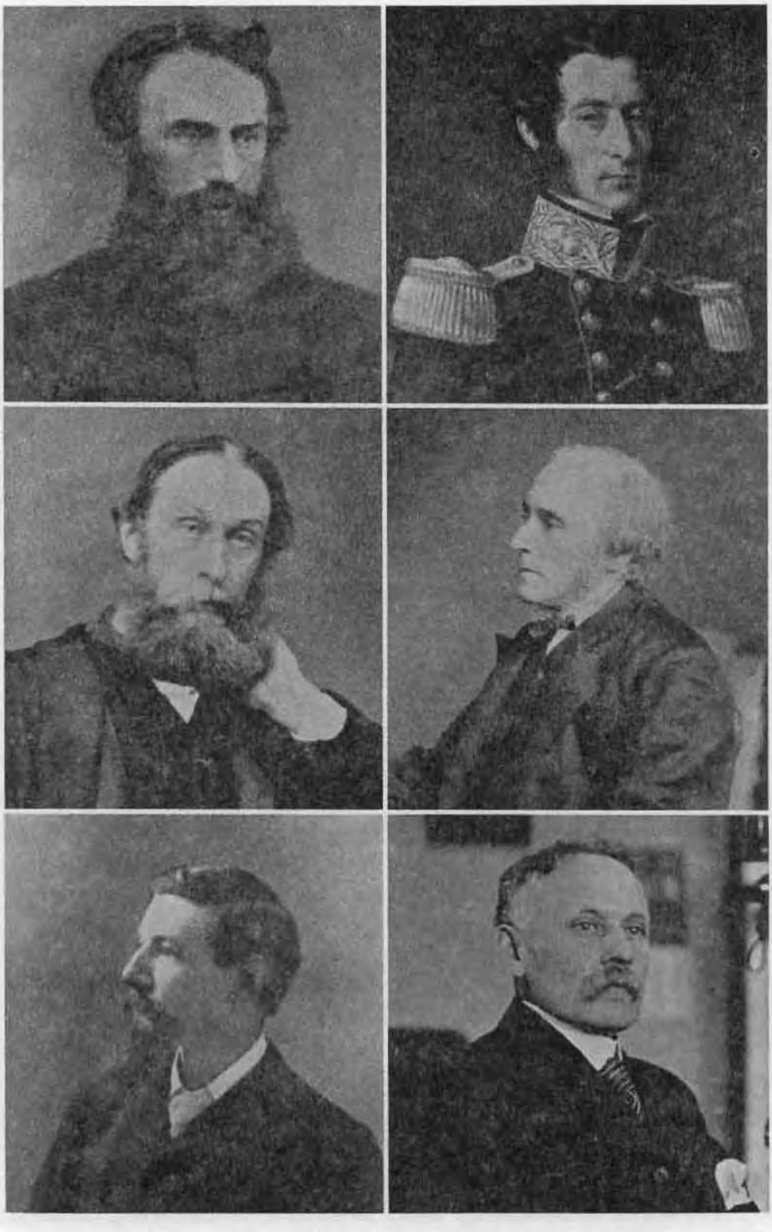
It is interesting to note that official or government-sponsored meteorology began in Canada as the result of international rather than national or domestic influences, and that the prime purpose for establishing the Toronto Observatory was the need for terrestrial magnetism data rather than for meteorologi-



View of the magnetic and meteorological observatory from the main tower of the University of Toronto, 1859. *Photo: courtesy of Metropolitan Toronto Central Library* cal information and forecasts. Scientific weather forecasting, of course, was unknown in 1839, but it did seem that world-wide observations of magnetism would reveal a useful understanding of that subject. During the 1830's, Baron Alexander von Humboldt, the noted German scientist, appealed to the British Government to establish observatories at several locations throughout the Empire, and in 1838 a decision was made to locate one observatory in Canada. On Christmas Day, 1839, the first official meteorological observations were taken at Toronto, Upper Canada, under the supervision of Lieutenant C. J. B. Riddell (Patterson, 1940; Thiessen, 1940, 1941a, 1941b, 1942a, 1942b).

Scientific meteorological observations had been made in Canada prior to 1839, but it is unlikely that the resulting data had ever been put to much practical use. Fragmentary meteorological reports were prepared and published by European explorers in the North American Arctic during the late 16th and 17th centuries, and in the 18th century, meteorological registers were compiled by military personnel at such locations as Fort Prince of Wales and Fort York on Hudson Bay, and at Quebec. When obtainable, these data were doubtless of value to others planning expeditions and forays into a generally unknown country. Early in the 19th century, in the settled part of the colonies, individuals such as Messrs. Kelly and Watt at Quebec and the Reverend Dade at Toronto, were compiling observations which were used and quoted by those who spoke and wrote on such subjects as the encouragement of emigration from Europe and the effect of clearing and cultivation on climate in Canada.

As intimated above, magnetic observations were of prime importance during the early years of the Observatory. In fact, during 1843–44, Lieutenant Riddell's replacement, Captain J. H. (later General Sir Henry) Lefroy, travelled to Hudson Bay and the Mackenzie River valley in northern Canada to observe magnetic phenomena, leaving the new Observatory in the care of his assistant. However, Captain Lefroy and his superior in England, Colonel (later General) Edward Sabine, were enthusiastic scientists and made sure that the observed meteorological data were properly reduced and published. In 1853 Sabine, incidentally, prepared and read before the Royal Society in London the first scientific paper based on meteorological data from the Toronto Observatory (Sabine, 1853). Also in 1853, responsibility for and control of the Observatory passed from the British (Army) Ordnance Department to the Province of Canada. Financially supported by the Legislative Council, the University of Toronto took responsibility for general control and management of the Observatory. Professor Cherriman was provisional director from 1853 to 1855, during which time a stone building, enclosing the original log observatory, was constructed on King's College Road, University of Toronto Campus. In August 1855, G. T. Kingston, Head of the Naval College in Quebec, was appointed Professor of Meteorology at the University and replaced Cherriman as director of the Observatory.



Successive Directors of the Canadian Meteorological Service, from left to right: Lt. C.J.B. Riddell, R.A., 1839–1841, Capt. J.H. Lefroy, R.A., 1841–1853, Prof. J.B. Cherriman, 1853–1855, Prof. G.T. Kingston, 1855–1880, C. Carpmael, F.R.S.C., 1880–1894, Sir Frederic Stupart, F.R.S.C., 1894–1929

3 Prospects for a national system

During the dozen years before Confederation, responsibilities of the Toronto Observatory were limited to the local meteorological and magnetic observations, but the Director began to play an increasingly important role in meteorological activities throughout the British North American colonies. A Montreal scientist, Dr. Charles Smallwood, M.D. (Marshall and Bignell, 1969), established his own observatory at St. Martin's, Canada East, and amateur meteorologists at such places as Quebec, Hamilton and Stratford, began to take weather observations. In 1858, Dr. Egerton Ryerson, Superintendent of Education in Canada West, was successful in arranging for observations to be taken at senior county grammar schools in the province. The program lasted for nearly twenty years, and during this period the historical climatological record began at several Ontario cities and towns. Early scientific publications, such as the *Canadian Journal* (Toronto) and the *Canadian Naturalist and Geologist* (Montreal), carried articles on meteorology as well as tables of climatological data from the official observatory and private observing stations. However, as Professor Kingston was to note in an official report, prior to the autumn of 1869 there were few meteorological observers in the Dominion, there was no true description of the climatology of the country, and the existing agencies were inadequate to remedy the situation. Needless to say, few, if any, meteorological services were being provided.

Abroad, an embryonic meteorological world was stirring as scientists began to realize the possibility of employing the new electric telegraph to collect data from which storms might be predicted. In the United States, where the systematic collection of climatological data had been ordered as early as 1814 by the Army Surgeon General, the Smithsonian Institution in 1849 organized a small telegraphic network "to solve the problem of American storms" (Hughes, 1970). By the early 1850's, daily weather maps, which contained data from a few Canadian and about three dozen American stations, were being displayed in Washington. Finally, after Cleveland Abbe had inaugurated a private weather reporting and warning service at Cincinnati, the United States Congress early in 1870 established a national weather service and made the Army Signal Service responsible for its operation.

4 Organizing the service

Perhaps inspired by developments in the United States, Professor Kingston had begun to correspond with the Honourable Peter Mitchell, Minister of Marine and Fisheries in the new Canadian Government, in an attempt to impress upon him the advantages and value to the country of a network of stations to observe the weather and of a system to issue storm warnings. Early in 1871, Professor Kingston was advised by the Deputy Minister ... *that the sum of $5,000 has been placed in the estimates for meteorological observations with a view of ultimately establishing storm signals* ...[1], and by an Order in Coun-

[1]Letter dated March 24, 1871, to Prof. Kingston from Wm. Smith, Deputy Minister of Marine.

cil, dated May 1, 1871, the proposal was approved by the Government. This act effectively established a national meteorological service in Canada, and Professor Kingston was authorized to proceed with its organization.

A century later, the amount of money appropriated to organize a service seems quite inadequate, but it must be noted that the government was already supporting the Magnetic and Meteorological Observatory at Toronto, and observatories at Quebec (Capt. Ashe), and Saint John, N.B. (G. Hutchinson), where time services were furnished to shipping. In addition, the observatories at Queen's College in Kingston, and McGill College in Montreal received allowances. Also by 1871 there were scores of Marine Department lighthouses, several of which Professor Kingston considered for use as observation stations, although the lack of communications at many of these isolated locations made them unsuitable for climatological, let alone telegraphic, reporting stations. Starting late in 1869, and continuing during 1870, Professor Kingston had corresponded extensively with all those whom he knew were interested in meteorology. He received much valuable assistance from the railroad and steamship companies, and in their regions, Mr. F. Allison of Nova Scotia and the Reverend Père Bonneau of Quebec were helpful.

5 The first forecasts

Because of the lack of trained scientists and money, and because Professor Kingston believed that the organization should be developed gradually, the new Canadian Service during the first few years of its existence did not prepare any weather forecasts, but on occasion relayed storm warnings from the U.S. Signal Service to other Canadian centres, usually lake and sea ports. A storm warning was defined as ... *a publication of an opinion to the effect that shortly after a time specified or implied, a storm will probably occur in some portion of a certain region within a radius of 100 miles of the port warned.*[2] In 1874, there were 35 of these storm warning stations in eastern Canada, and on 56 individual days during that year storm warnings were dispatched to the proper towns. With increased resources, however, additional staff were hired and trained, more observed data were imported from the United States, and on October 1, 1876, the first Canadian prepared *probs* were issued for Ontario. An indication of the Service's instant success was the following resolution passed in Toronto: *The Marine Exchange cannot close its meetings for 1876 without putting on record its appreciation of the services rendered by the Meteorological Department during the past season in accurately forecasting the weather.*[3]

During these early years two types of forecasts were issued – the cautionary storm signals or storm warnings described above, and the daily probabilities. By 1879 the daily probabilities were telegraphed to 125 places from Ontario eastward to Prince Edward Island at 10 a.m. daily, were posted in the local

[2] *Fourth Report of the Meteorological Office*, December 1874, p. 5.
[3] *Sixth Annual Report of the Meteorological Service*, December 1876, p. xii.

telegraph and post offices, and were published in the evening editions of the various papers in eastern Canada. The work of a meteorologist, in preparing these forecasts at the Central Office in Toronto during the first decade of the Service's existence, would not seem strange to any meteorologist recruited during World War II: *... the information received is entered on a map of the continent prepared specially for the purpose. The map is then examined by the officer whose duty it is to make out the probabilities and issue warnings when required. In order to do this satisfactorily, it is necessary not only that he should know such laws as have already been established relative to the movement of the various kinds of atmospheric disturbances, but he must also be familiar with a long series of previous weather charts so that he may be able to supplement the conclusions drawn from theory by a practical knowledge of what has followed similar conditions on previous occasions and thus tell at a glance what conditions are likely to prevail during the 24 hours following ...*[4]

Appreciation of the dual value of weather observations and the recognition of the value of climatic data and information, as well as weather forecasts, were apparent in the early days of the Service:

Although the weather predictions are immediately founded on the reports received by telegraph ...

... the returns of these observations are of great value in dispelling the erroneous notions regarding the climate of certain districts, and in aiding farmers and others interested in agriculture to select the crops most suited to the climate, while they furnish intending settlers with data to aid them in choosing localities adapted for general purposes.[5]

Few, if any, applied meteorological studies were undertaken and none was published, but by the volume of correspondence handled through the Central Office it is apparent that at least some information and advice were supplied to the public during these years. Since publication of the Annual Report, which contained considerable historical climatological data, was often considerably delayed, the Service instituted the preparation and publication of the *Monthly Weather Review* in 1877 which contained condensed statistics and information and was available a week or so after the close of every month.

6 Expansion of service

Upon Professor Kingston's retirement in 1880, Mr. C. Carpmael became the new Director, and a period of expansion for the new Service began. During the early 1880's the Canadian Pacific Railway and its telegraphic lines were pushed across Western Canada allowing the establishment of telegraphic weather reporting stations and many climatological and precipitation reporting stations. In Eastern Canada during the summer of 1881 the Service began

[4]*Eighth Annual Report of the Meteorological Service*, December 1878, p. 418.
[5]*Ibid.*, p. 422.

to issue forecasts at midnight so that these might be published in the morning newspapers and also be displayed at telegraph stations as soon as they were opened each morning.

Another innovation of the early 1880's was the dissemination of weather predictions by means of display discs attached to railway cars. The signal word to be displayed was telegraphed each day at about 1 a.m. to the railway agents who would change the signs on cars each morning in an attempt to provide a reliable weather prediction service for the farming community along the lines of the railway. However, through neglect, the local train hands did not always keep the signal discs up-to-date, and this arrangement had to be dropped after a decade or so.

The processing and publishing of climatological data during the early years of the Service presented problems not unlike those experienced today. Checking data was a tedious chore, hardly as glamorous as participating in the preparation of weather forecasts, and when manuscripts were ready there remained the administrative task of finding funds to publish. Official historical data publications had been issued for each year from 1872 to 1890 when lack of both staff and funds forced a postponement which has resulted in a gap in the series of data publications from 1891 to 1895. In 1892, however, the Director was primarily concerned with the possibility of preparing statistical climatological data, that is, the reduced and summarized data based on an accumulated twenty years of data, to form an authoritative government publication on the climate of Canada. Despite special appeals for additional funds to carry out this work, the project did not get underway until well after the turn of the century: the *Climate of British Columbia* and the *Climate of the Prairie Provinces* were published in 1915 and 1920, respectively; the *Climate of Ontario* was prepared but never published; and it is uncertain whether or not the manuscripts for Quebec and the Atlantic Provinces were ever completed.

An Annual Report of the early 1890's mentions that forecasts of the weather were, as usual, asked for by many persons whose avocations were affected by changes in the weather – shippers, brewers, fishmongers, fruiterers and proprietors of skating rinks. In 1886, the Superintendent was able to claim that whenever a storm of any magnitude occurred, due warning was given to shipping. Also at this time railroad companies asked for and received special forecasts of winter snowstorms and thaws. Co-operation with the Canada Department of Agriculture began in 1889 when personnel at four new experimental farms began to observe and report the weather.

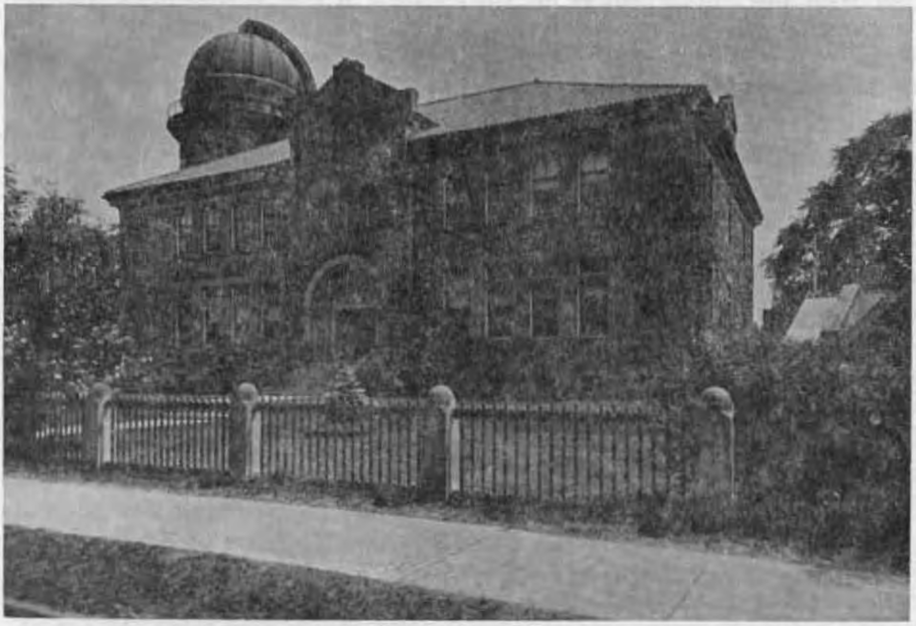
As an increasing amount of weather information was being received from Western Canada it was possible to begin issuing forecasts for Manitoba on August 26, 1899, and in July 1903 this service was extended to that part of the Northwest Territories that is now southern Saskatchewan and Alberta. In an Annual Report the Director pointed out that the increased demand for forecasts of the weather was an indication of the reliance placed in them by the public. City dwellers as well as farmers were beginning to ask for more services. For example, in his 1894 report, C. H. McLeod, the Superintendent of the McGill College Observatory in Montreal, pointed out the need for a local forecast office in Montreal. In these early years the Service was the only "scientific institution" in the Department of Marine and Fisheries, and because of this became involved in new scientific activities such as seismology and tidal and hydrographic surveys as well as maintaining the magnetic and astronomical observational work, the provision of time services, etc. Important as these activities were, the Meteorological Service's involvement in them must have detracted considerably from the provision of meteorological services.

In October 1894, upon the death of Professor Carpmael, R. F. (later Sir Frederic) Stupart became Director. Stupart, in 1872, at the age of 15, had been one of the first to join the Service as a map draughtsman after Kingston had been authorized to organize a national service. The *Monthly Weather Map* – a narrative and tabular description of the previous month's weather – was instituted in 1894, and during the following year staff at the Central Office in Toronto also began to prepare and mimeograph a daily weather map for distribution. Until this time all weather forecasting for Canada had been carried out in Toronto, but with the expansion of the observing network into the West and North, staff at the chief station in British Columbia, Victoria, began to forecast the weather for the southern part of that province.

7 The pre-war era

By early 1905 the Service had grown to employ 185 people, including 20 at the Central Office in Toronto. Most of the staff outside Toronto were employed on a part-time basis for either observing the weather or displaying storm signals. There were 374 observing stations, of which 34 telegraphed reports twice daily to Toronto. Forecasts were issued at 10:30 a.m. and p.m. The evening forecasts were published in nearly every morning journal in the Dominion, and in addition were posted at all telegraph offices. The morning forecasts were published in the afternoon papers and were posted at conspicuous places in shipping ports, while in many of the large cities of Canada a weather bulletin was duplicated and distributed to business houses and shippers of perishable goods. It is interesting to note that at this time, thirty years after the establishment of the Service, practically all the forecasting was done by the Director and his deputy, B. C. Webber, and although two assistants were employed, they were rarely allowed to issue the bulletins. Further, it was then the policy that the forecasters should inspect the outside stations in order to ... *have a perfect knowledge of the country, and also a complete change from the very trying work of issuing bulletins which were sure to be duly criticized by the public.*[6] In British Columbia regular daily forecasts were

[6]*Thirty-Fourth Annual Report of the Meteorological Service*, June 1905, p. 126.



TOP: The Toronto Observatory 1854–1907 and Headquarters of the Canadian Meteorological Service 1872–1907, situated 27 feet from Convocation Hall at the University of Toronto until 1908. *Photo: University of Toronto Archives, c. 1922*

BOTTOM: Headquarters of the Canadian Meteorological Service, 315 Bloor Street West, erected 1909. *Photo: University of Toronto Archives* issued from Victoria by E. B. Reed and F. M. Denison with a gratifying degree of success – ... *notwithstanding the difficulties to be contended with in forecasting on the Pacific coast, the percentage of verification obtained is most creditable.*[7]

Early in this century the Central Office outgrew the original observatory building, and in September 1909 the staff moved into a newly built Meteorological Office at 315 Bloor Street West. Also during the first decade of the century three young men, who each was to leave his mark on Canadian meteorology, joined the Service. In 1901 F. O'Donnell was appointed to the staff as a clerk. He worked his way through the ranks and on retirement in 1946 had been head of the Forecast Section for a number of years. In 1907, an M.A. graduate, A. J. Connor, was employed as a part-time forecaster but primarily to undertake the special studies in climatology mentioned earlier. He soon became known as the Dominion Climatologist and was in charge of this branch of the science until his retirement in 1950. In 1910, John Patterson, M.A., a Canadian meteorologist who had been in the Indian Meteorological Service, joined the Service as a meteorological physicist, and the following year began to explore the upper atmosphere by means of balloons and kites. Patterson's scientific and administrative abilities quickly became evident and later in his career he was to lead the Service for nearly twenty years, including the difficult and expansive war years of the 1940's, until his retirement in 1946.

There was further expansion in each province during the early years of the century as chief meteorological stations were set up to which persons seeking information could either visit or write. By 1914, in addition to the Victoria Office, such offices were located at Edmonton and Moose Jaw in the West, and a local meteorological office had been established in Vancouver, while in the East the observatories at Montreal, Quebec, Saint John and Halifax continued to function as both observing stations and information centres. At the Central Office in 1914, a new branch of the Service was inaugurated for the study of agricultural meteorology in general and specifically to cooperate with the Dominion Experimental Farm system in field experiments on spring wheat in relation to weather. About this time an improved method of providing forecasts to the public was introduced by which the latest forecasts were delivered to the telephone exchanges in a large number of towns in Ontario so that subscribers on rural lines could obtain them by calling their local exchange. It was still felt, however, that forecasts could best reach the largest number of people by being published in newspapers, and since rural mail routes were becoming more numerous, increased attention was paid to the preparation of the 10 p.m. forecasts which appeared in all morning papers. Although meteorological activities were somewhat curtailed during the period of the first World War, a new office was established in the Winnipeg Grain Exchange in 1918 to provide climatological information and forecasts to those active in the grain trade.

[7] *Ibid.*, p. 129.

8 The Twenties

By the early 1920's the availability of weather forecasts in the daily newspapers was an accepted part of Canadian life. Forecasts were issued twice daily at 10 a.m. and 10 p.m., each for the ensuing 36 hours, based on data from about 36 Canadian, 5 Newfoundland, one Bermuda and 100 American stations. In addition to the availability of the forecasts in the press and at telegraph offices, the new government wireless stations had begun broadcasting forecasts for the benefit of shipping on the Great Lakes and along the Atlantic coast.

In July 1929, Sir Frederic Stupart retired and was replaced as Director by John Patterson. It is interesting to note that Sir Frederic was active as a weather forecaster until his retirement. In 1876, the young Stupart had issued the first storm warnings prepared in Canada, and the system of analysis and forecasting he helped to develop in the 1870's remained virtually unchanged throughout his career. In the decade before his retirement a new scientific and physical approach to meteorology was under development in Europe, and the Service was to find that many highly trained meteorologists would be required to carry on the work begun by the retiring Director and other veterans.

Directors Kingston and Stupart were in charge of meteorological activities in Canada for 60 of the 74 years between 1855 and 1929. Kingston came to the directorship as a mature and trained scientist, and it was through his planning and efforts that the Toronto Observatory became the hub of the new service and that forecasting was started in Canada. Stupart was the first Canadian-born meteorologist, received his training on the job and presided over an orderly expansion of services. While Kingston had wide scientific interests and can be called the Father of Canadian Meteorology, there is little doubt that Stupart was Canada's first operational weather forecaster and administrator of meteorology. Each man was a giant in his time and today's Canadian Meteorological Service bears their imprints.

9 Services for aviation

During the 1920's the need for meteorological services by aviation was slowly becoming apparent. Prior to this time aviators had given little thought to meteorology, but with the possibility of air transport becoming apparent, aviation began to realize its dependence on the science. An aviation section was set up in the Central Office at Toronto in 1928, and during a short period from that year until 1932, when an attempt was made to establish an air mail service in the country, some new airport observation stations were opened and additional technical personnel were employed.

It was, however, the voyage of the airship R-100 from Britain to Canada in the summer of 1930 that first required significant meteorological organization for aviation. As the Canadian Service was to be responsible for meteorological advice along the flight route west of longitude 35°, the forecast staffs at Toronto Central Office and at the newly opened Montreal St. Hubert Airport office maintained a 24-hour service. Many observing stations in eastern Canada were asked to transmit 2 a.m. observations, necessitating the special nighttime opening of telegraph offices, and thus allowing the preparation and transmission of special information and forecasts to the airship. The airship remained for about two weeks in Montreal, with a side trip to Toronto before returning to England in mid-August. Meteorological services for the flight were generally considered satisfactory, but the experience did point out the need for trained personnel, more observations, better communications, and better methods of short-period forecasting.

10 End of an era

The demands by aviation for services in 1930 presented a new challenge to Canadian meteorology. Fortunately, as a result of the development of new theory and techniques by the Scandinavian school of meteorologists, weather forecasting could now proceed on a much better scientific basis than that previously used. The scientific prospects for meteorology were excellent and aviation was beginning to call for meteorological services in a clearer, louder voice than that ever used before by marine, agricultural, forestry or transport interests or by the general public, but unfortunately the country was sliding into a great economic depression. It would be a few years before the forward thrust could be picked up again, but in the meantime the old era – the leisurely nineteenth century "horse and buggy days" in meteorology – was over.

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Atmospheric Electricity Measurements at Toronto[1]

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[Manuscript received 4 December 1970]

ABSTRACT
Atmospheric electricity measurements made during July–December, 1968, at the Meteorological Research Station, Toronto, are reported. Diurnal and weekly variation of the Ohm's law parameters, the role of wind speed in the fair weather definition, and the fulfillment of Ohm's law are studied.

1 Introduction

The classical global concept of atmospheric electricity visualizes the earth and the ionosphere as two highly conducting plates separated by an imperfectly insulating atmosphere. The electrical current which flows within this capacitor is considered to be controlled and maintained by worldwide thunderstorm activity. This electric circuit governs the atmospheric electricity variations at globally representative stations during fair weather. Land stations, such as the Meteorological Research Station, Toronto, are not suitable for studying the global circuit (Israel and deBruijn, 1967; Bhartendu, 1969a and 1971a) but are useful in studying the local electric circuits and the relationship of atmospheric electricity and meteorology (Dolezalek, 1967).

Similiar to the study of meteorological elements for climatic description, electric potential gradient, air-earth current density and conductivity measurements can be used to describe the atmospheric electric climate. This paper presents the atmospheric electricity measurements for six months during 1968 made at the Meteorological Research Station, Toronto, about twenty miles northwest from the heart of the city. Although these data are insufficient for establishing an atmospheric electric climate at the station, they should be enough to indicate a trend. Hourly diurnal variation and daily variation for each day of the week are studied in addition to the study of Ohm's law in the atmosphere and the effect of different fair weather criteria.

2 Instrument and site

The potential gradient was measured by a radioactive collector using a few micro curies of Americum^{241} and an electrometer. The radioactive collector

[1]Part of this paper was presented at the Fourth Annual Congress of the CMS, held at the University of Manitoba, Winnipeg, June 17–19, 1970.

was installed at 1 metre above the ground but this height was changed to 0.5 metre or less when the potential gradient was high, particularly during winter months. The antenna for the air-earth current density measurements consisted of a galvanized iron screen of 1/2 m^2 area mounted on three insulators. As it was not possible to place the screen flush with the earth's surface on account of the interference from rain and snow, the screen was mounted at a height of 19 cm above the ground; and to avoid the distortion of field lines (Chalmers, 1967, p. 218) a metallic grounding frame was placed around the screen at this height. The antenna was connected to a vibrating capacitor, for the measurement. The conductivity was measured by a Gerdien condenser and vibrating capacitor. A detailed account of these instruments has been published by Saxer and Sigrist (1966).

The recording site (43° 48′ 25″N, 79° 33′ 5″W; elevation 189 m) was the Meteorological Research Station, Toronto (Woodbridge). Care was taken that protruding objects near the potential gradient and the air-earth current density antennae were situated at distances at least five times as much as their heights. The map of the surroundings of the atmospheric electricity station has been published elsewhere (Bhartendu, 1971b).

3 Results

a *Diurnal Variation*

The diurnal variation of the fair weather atmospheric potential gradient, air-earth current density and conductivity (sum of positive and negative conductivities) for July–December, 1968, is shown in Fig. 1. As expected, the behaviour of the conductivity is opposite to that of potential gradient and the variation in potential gradient and conductivity is larger than in the air-earth current density which depends ideally on the potential difference between the ionosphere and the ground and the columnar resistance. In practice, the convection occurring within the austausch layer (Kraakevik, 1958) is also important in influencing the air-earth current density variation.

The mean potential gradient for six months (July–December) in 1968 was 172 Vm^{-1} which compares favourably with 174 Vm^{-1} observed during 1967 for the same period (Bhartendu, 1969b). The mean air-earth current density for the period was 4.2×10^{-12} Am^{-2} and the mean conductivity 1.6×10^{-14} $\Omega^{-1}m^{-1}$.

The potential gradient curve (Fig. 1) shows two maxima (the smaller maxima are statistical deviations). The first maximum occurs at 15–17 GMT and falls within the time (14–19 GMT) considered the global maximum time from 1968–1969 ocean measurements (Takagi and Kanada, 1970). The air-earth current density shows a maximum at 15 GMT and the conductivity a minimum at 18 GMT. These also fall within the global maximum time. The potential gradient maximum at 21 GMT appears to be a local maximum. The conductivity shows a small minimum at this time but it is far too small to be statistically significant. Thus, it is difficult to say with present data whether or not

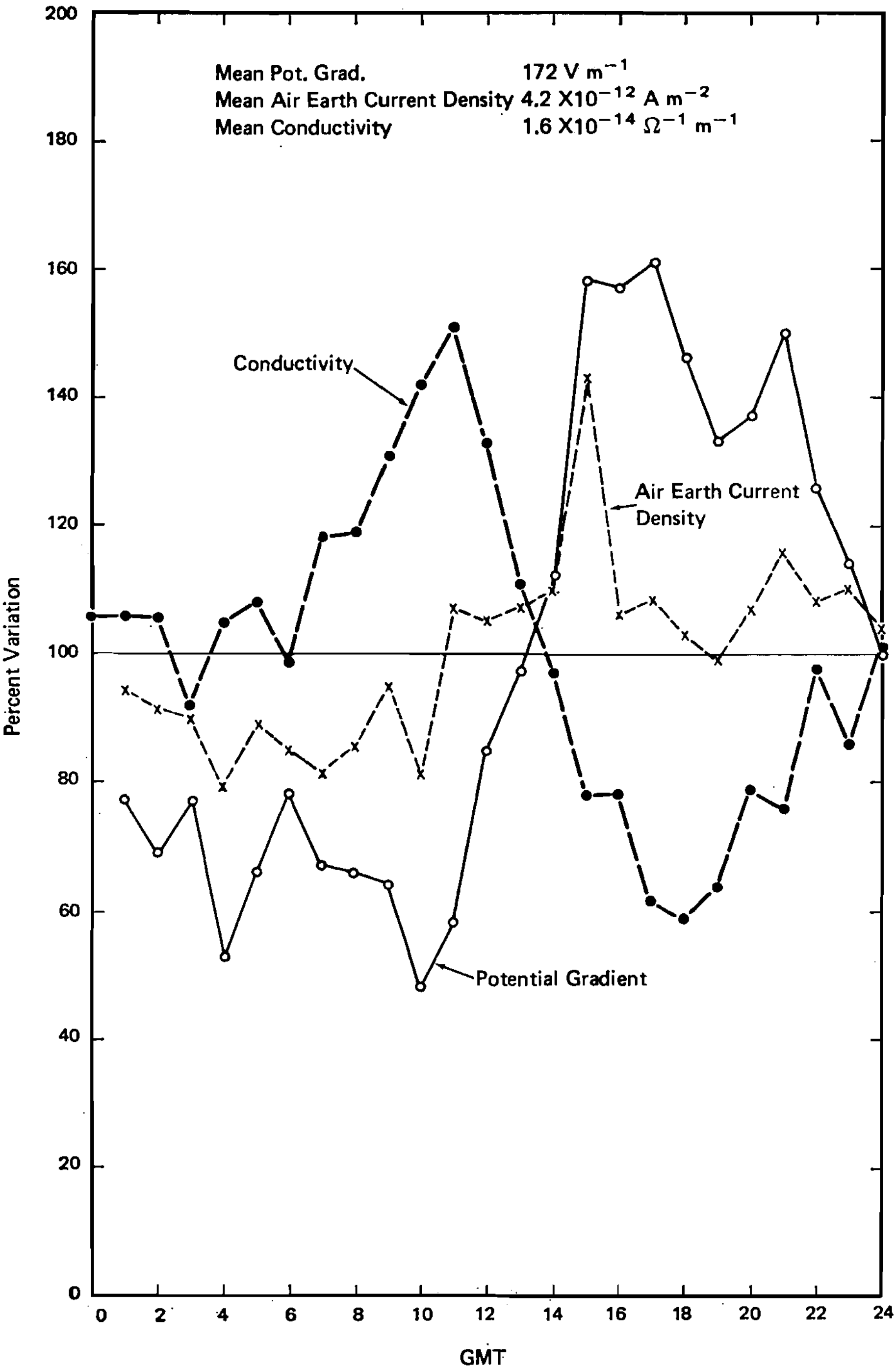

Fig. 1 Mean diurnal variation of the potential gradient, air-earth current density, and conductivity at the Meteorological Research Station during July–December, 1968. The ordinate shows the percent variation from the mean.

the second maximum of the potential gradient is due to the local conductivity change.

The effectiveness of an atmospheric electricity station for studying the global circuit is usually measured by comparing the results with the average curve of Carnegie ocean measurements taken over half a century ago. This practice is obviously in error as the measurements of fifty years ago are no longer representative of the present time. Modern industrial society is steadily increasing anthropogenic production of particulates with which the natural processes of aerosol removal are unable to cope. A decrease of about 20% in conductivity has been found in the North Atlantic by Cobb and Wells (1970) in 1967, due to pollution. Furthermore, recent ocean measurements also exhibit large fluctuations (Mühleisen, 1968) and thus a comparison of results at a station with a mean sea curve involves ambiguity. If any meaningful comparison is to be made, it should include data for the same period and thus it was considered worthwhile to compare our results with the Japanese measurements of 1968–1969 at sea. Fig. 2 shows the potential gradient variation at Toronto and in the Pacific Ocean, at 23° N, 173° W, for December

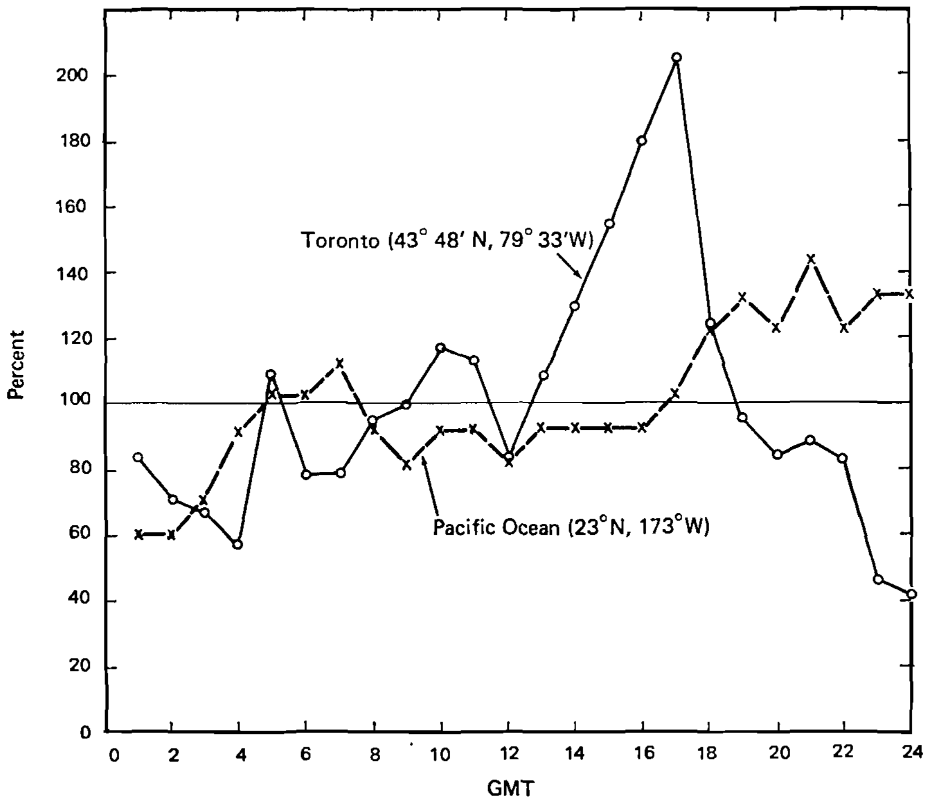

Fig. 2 Diurnal variation of the fair weather potential gradient at the Pacific Ocean and Toronto on Dec. 18, 1968. The ordinate indicates the percent variation from the mean.

18, 1968, the only date for which fair weather was observed for twenty-four hours continuously at Toronto. The correlation coefficient for the two curves is −0.40, while the limiting value of the correlation coefficient at the 1 percent probability level is 0.48. For the same date the correlation coefficient for the potential gradient at sea with air-earth current density at Toronto was −0.38. A comparison for only one day is insufficient for any firm conclusions. The noteworthy observation is the absence of the well-known distinct maximum in the ocean curve and the presence of the large maximum in the Toronto curve. It may be pointed out that this comparison need not be interpreted as an effort to legitimize the procedure of comparing sea and land values to extract the global circuit but should be viewed only as an attempt to show that data to be compared for sea and land stations should be of the same time duration, preferably one year of data.

b *Weekly Variation*

Several researchers (for example, Sapsford, 1937; and Mühleisen, 1953) have found differences between the potential gradient variations on Sunday and weekdays and have attributed these differences to local pollution. Fig. 3 shows the variation of Ohm's law parameters for each day of the week and as evi-

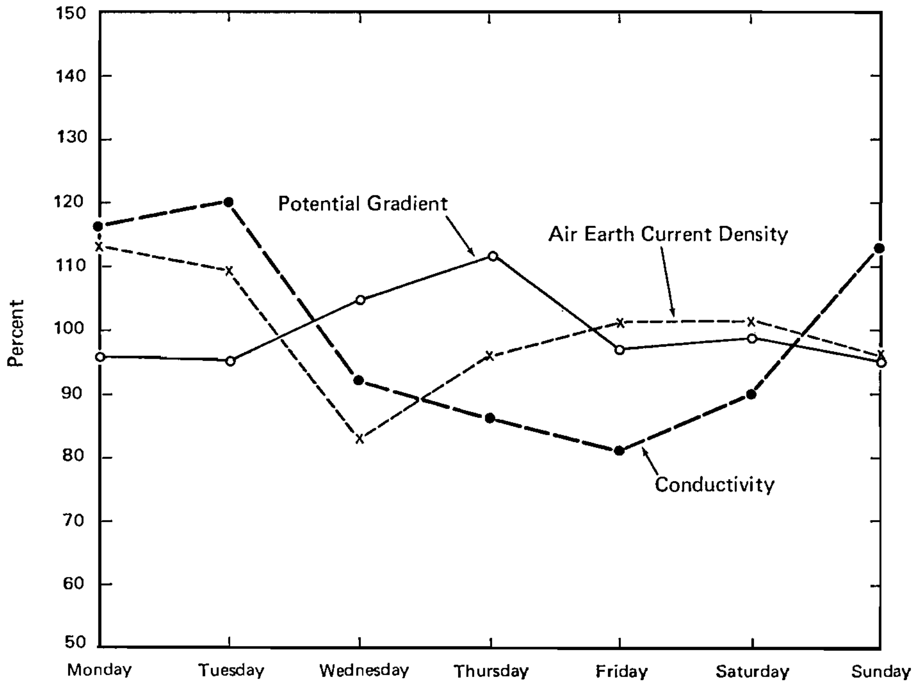

Fig. 3 Weekly variation of the potential gradient, air-earth current density, and conductivity at the Meteorological Research Station during July–December 1968. The ordinate shows the percent variation from the mean.

dent from the figure there does not appear to be any striking difference between the Sunday and weekday values. Thus, it appears that the industrial pollution of Toronto does not have an appreciable effect on the atmospheric electricity readings at the Meteorological Research Station. This is likely due to the direction of the prevailing winds. Climatological studies (Richards and Phillips, 1970) show that winds in the area are mostly from the following directions: N, NW, W, and SW. The industrial Toronto area is situated mostly southeast of the station and thus pollution does not reach the station frequently.

c *Fair Weather Criterion*

Theoretically, fair weather is defined as the period during which the effect of local generators at a station is negligible as compared to the influence of the global generator. In practice, separation of the contributions of the two generators is extremely complicated and hence it is difficult to find a practical definition of fair weather. The Joint Committee on Atmospheric Electricity of the International Association of Meteorology and Atmospheric Physics (see circular letter No. 5 of the Working Group I, IQSY/IGC of the Joint Committee on Atmospheric Electricity of the IAMAP/IAGA, 1966) recommends that an hour should be considered to have fair weather if there are no hydrometeors, cloudiness is less than 30% and the wind speed is less than 3 on the Beaufort scale. This definition was adopted at our station with the more precise wind speed criterion of 10 miles per hour.

The effect of the wind criterion was studied and Fig. 4 shows the potential gradient variation for two months for the strictest fair weather criterion and for the less strict fair weather criterion (when no account of wind speed is taken into consideration). During August, both curves are almost superimposed on each other and there is no significant departure in the mean values. This is in agreement with East's observation (1966) for Montreal where he does not find the wind to be an important factor in the fair weather criterion. On the other hand, during December the two curves are dissimilar and the mean value for the less strict case is lower by 43 Vm^{-1} than the mean value for the strictest case. Examination of results for other months indicates that the difference between the two cases is small in summer and large in winter. It appears that during winter, when the ground is covered with snow, high winds may blow the snow and this could reduce the potential gradient values. Detailed measurements are under way and will attempt to determine the validity of this interpretation.

d *Ohm's Law*

A dimensionless quantity, Ω, is defined by $\Omega = (I/E(\lambda_+ + \lambda_-))$, where I is the air-earth current density, E the potential gradient and λ_+, λ_- are respectively the positive and negative polar conductivities. The quantity Ω gives an absolute measure of the fulfillment of Ohm's law (Dolezalek, 1960). A quantity $\Omega_{\%}$ defined by $\Omega_{\%} = (\Omega/\bar{\Omega}) \times 100$, gives the relative deviation of Ohm's law.

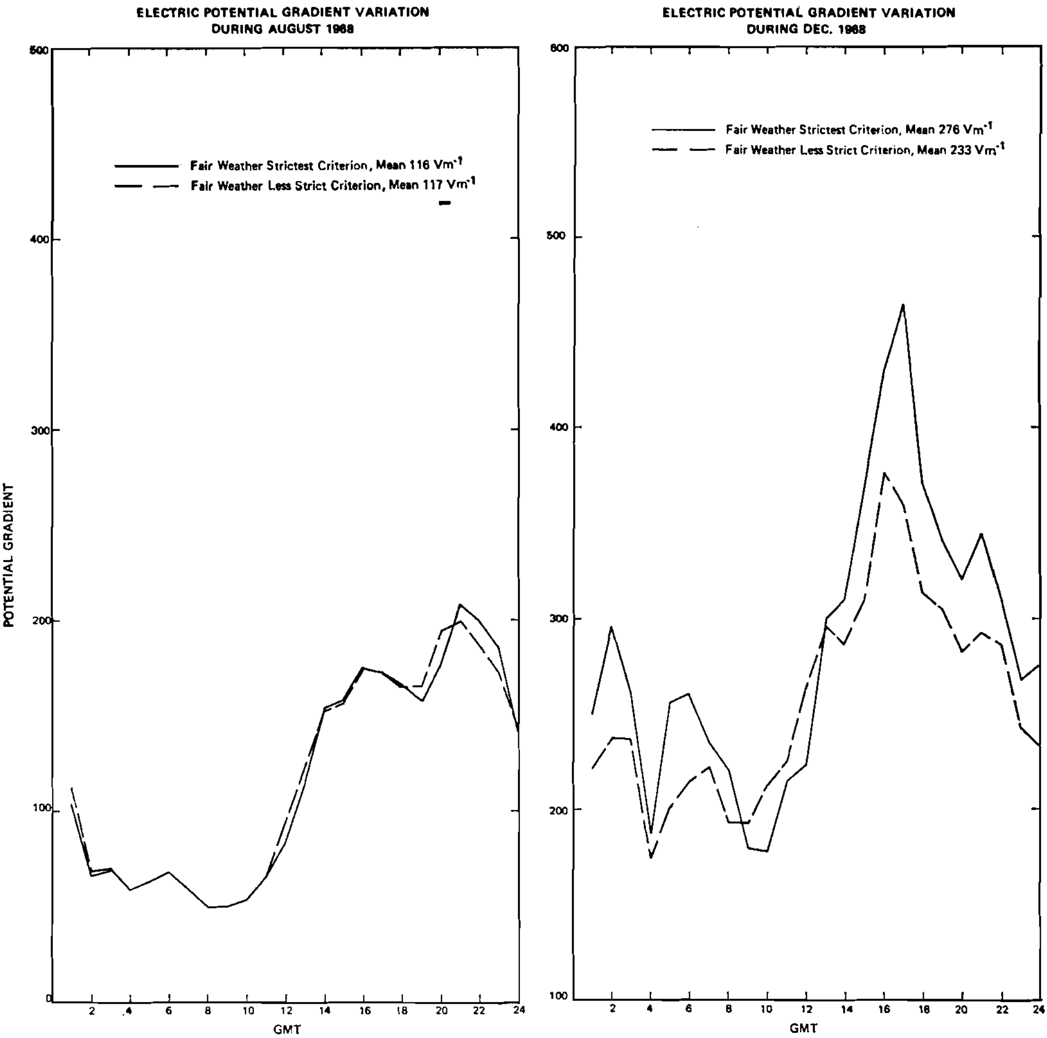

Fig. 4 Diurnal variation of the potential gradient during August and December 1968 at the Meteorological Research Station. The units of the ordinate are volts per metre.

Fig. 5 shows the variation of $\Omega_{\%}$ for five months. The mean value of Ω is indicated for each month. Neglecting the mean for November where values for all twenty-four hours are not available, Ω varies from 1.6 to 2.9. The mean Ω for Aug.–Dec. is 2.5. This value compares favourably with the July–November 1957 mean value of 2.0 for Aachen and Jan.–June 1958 mean value of 2.2 for Heidelberg reported by Dolezalek (1960).

Fig. 6 shows the diurnal variation of Ω for two fair weather days. As evident in the figure, the day-time variation is less than the night-time variation and this indicates that the electric current due to atmospheric convection is important, but the manner in which it influences the results is not certain.

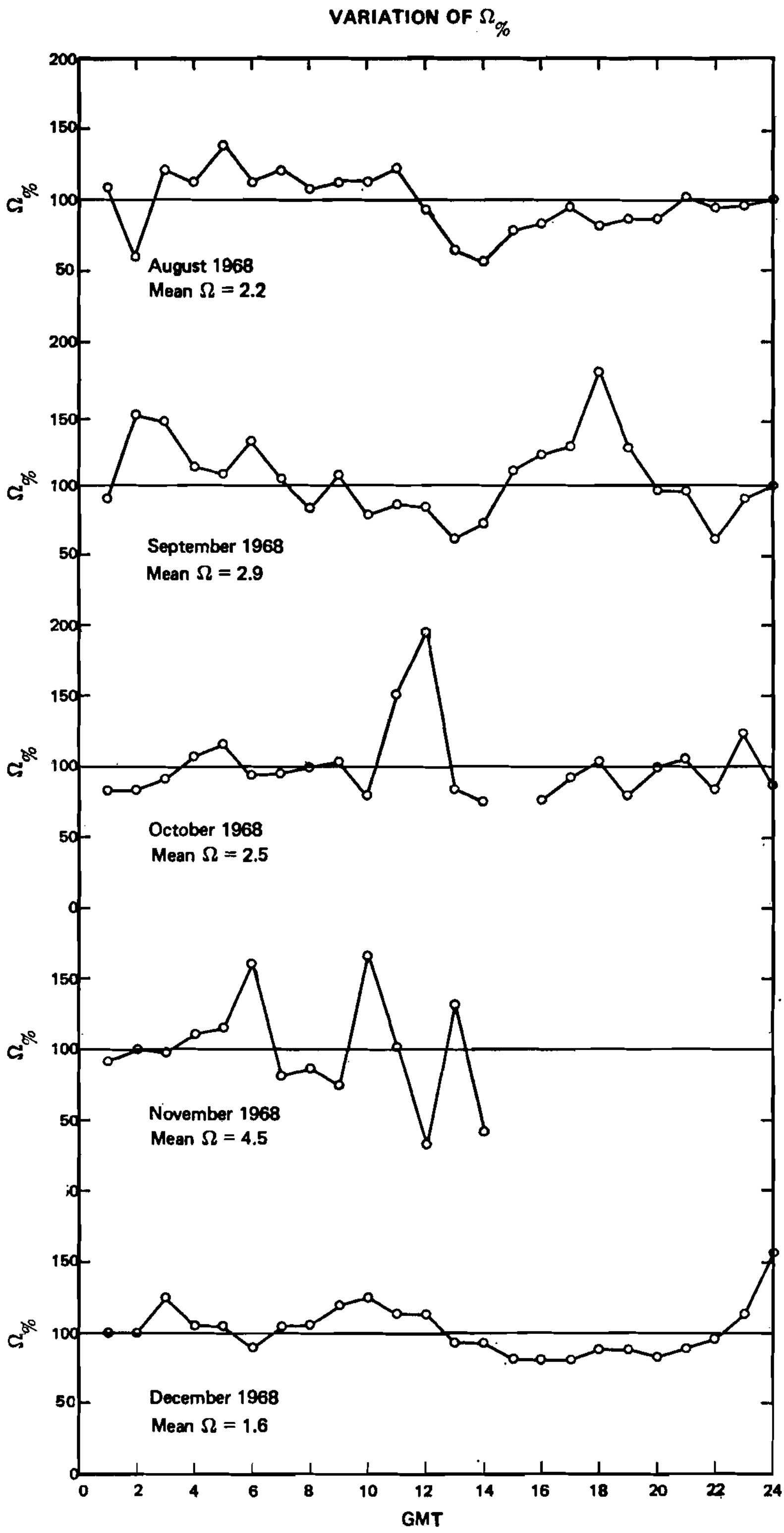

Fig. 5 The diurnal variation of $\Omega_{\%}$ for each month from August to December 1968 at the Meteorological Research Station.

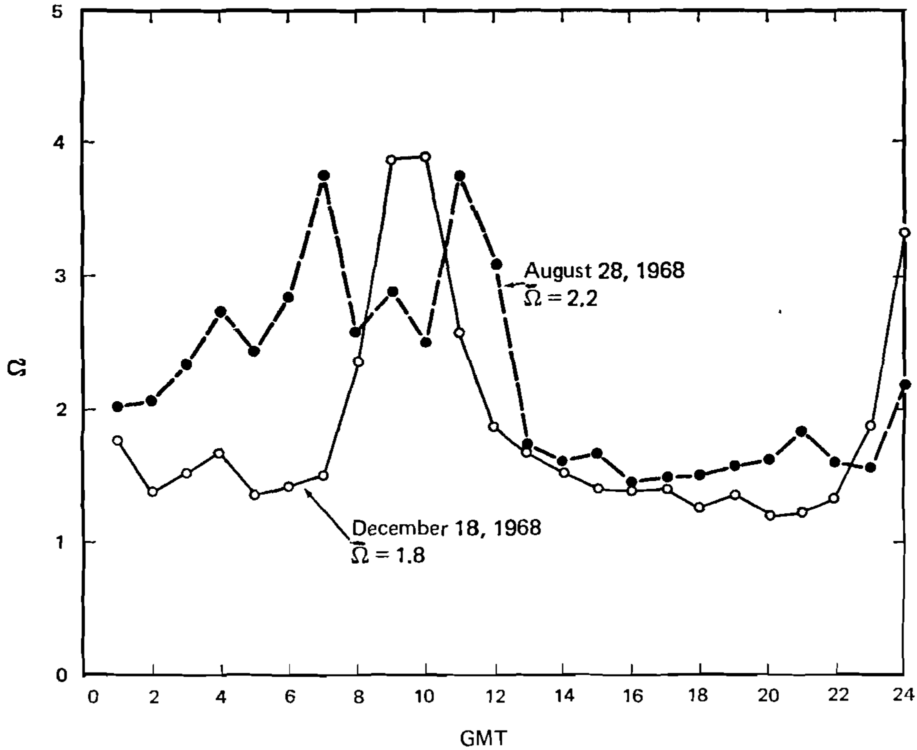

Fig. 6 The diurnal variation of Ω for two fair weather days during 1968 at the Meteorological Research Station.

4 Conclusions

The mean values of the Ohm's law parameters at the station during July–December 1968 are: potential gradient 172 Vm^{-1}, air-earth current density 4.2×10^{-12} Am^{-2}, conductivity 1.6×10^{-14} $\Omega^{-1}m^{-1}$. Although the short period of study precludes firm conclusions, the present investigation indicates the similarity of the weekday and Sunday results, the importance of the wind criterion in the fair weather definition during winter, and the non-fulfillment of Ohm's law at the station.

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Ph.D. Program at the University of Alberta

The Division of Meteorology, Department of Geography of the University of Alberta announces that it is prepared to accept candidates for the degree of PH.D. The program for the degree M.SC. (Meteorology) began in 1966. With the appointment of a fourth meteorologist to the staff, the Division will initiate a PH.D. program in September of 1971. The development of the Institute of Earth and Planetary Physics, of which Meteorology is a part, will assist in the progress of the PH.D. program. The current staff of Profs. K.D. Hage (PH.D., Chicago), R.W. Longley (M.A., Toronto), and E.R. Reinelt (PH.D., Alberta) will be increased when they are joined by Dr. E.P. Lozowski (PH.D., Toronto). These will be assisted in their research by Research Fellows attached to the Institute, Dr. J.L. Honsacker (PH.D., California Institute of Technology), and Dr. M.L. Khandekar (PH.D., Florida State) who joins the Institute in April 1971. Major interests in research are in low-level turbulent exchange processes, the influence of the Rockies on weather patterns, and studies of convective activity leading to hail. In this latter topic, they will co-operate with the Alberta Hail Studies of the Research Council of Alberta.

A Review of Some Recent Observational and Dynamical Studies of Lake-Effect Winter Disturbances

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University of Waterloo
[Manuscript received 5 January 1971]

ABSTRACT
Studies of lake-effect storms from 1928 to the present are summarized. Early investigations dealt mainly with conditions favourable for the creation of the disturbances (cold air outbreaks to the rear of the cyclones). Radar studies showed that their average vertical extent is about 3 km. Comparison is made of storms associated with the Great Lakes and the Sea of Japan. In the latter case, a large increase in wind shear with height ($\partial^2 v/\partial z^2$ exceeding 10^{-7} cm^{-1} sec^{-1}) appears to be necessary. However, this is not essential for Great Lakes storms. Recent efforts made to simulate lake-effect systems numerically are also discussed.

1 Introduction

Meteorologists generally agree that the Great Lakes and similar inland waters exert a modifying influence on the weather systems in their vicinity. Worthy of special mention are the mesoscale snow storms which are responsible for about one half of the total amount of snow over some areas. The northern islands of Japan also experience such mesoscale winter storms. In the following is presented a general summary of the observational, kinematic and dynamic studies of these mesoscale disturbances.

2 Definition and characteristic dimensions

The term lake-effect disturbance denotes chiefly the local, but heavy, snowfalls that are observed over the lee shores of the Great Lakes during polar outbreaks. Because of their small size they are not treated properly by the current atmospheric prediction models. A proper parameterization of these phenomena must wait till their dynamics are better understood.

According to Falconer, Lansing and Sykes (1964), McVehil and Peace (1965) and Peace and Sykes (1966) these storms are characteristically shallow, about 3 km in the vertical capped by an inversion. They consist mostly of a single convective band about 100 km long and 20 km wide. Sometimes two bands might coexist over a single lake.

[1]Present affiliation: St. Louis Univ., St. Louis, Mo. The early part of this work was done by Dr. Rao while an NRC post-doctoral fellow with the Canadian Meteorological Service, Toronto.

3 Their climatological importance

According to Muller (1966), stations in the vicinity of the Great Lakes receive their winter (November through March) precipitation primarily due to four factors: 1) warm frontal activity associated with large-scale vertical motion, 2) passage of cold fronts accompanied again by large-scale motion, 3) mesoscale lake-effect storms, and 4) orography influencing the precipitation due to 1), 2) and 3) above. While the bulk of the snow over certain areas of the Great Lakes may be due to synoptic-scale systems, only half or even less of the total amount over certain other areas is attributable to these systems (Richards and Derco, 1963). A thickly populated urban centre suffers severely when receiving several feet of snow as a result of lake-induced storms. The large precipitation amounts yielded by these storms arouse great public interest.

4 Early studies

Dole (1928) observed that snow squalls usually occur in winter after the passage of a low pressure system across the Great Lakes. He commented that a rising barometer, which elsewhere would indicate clearing, signals just the opposite in the Lakes region. He also noted that the convective clouds were more vigorous during the day than at night.

Later, the influence of Lake Erie on local snows attracted the interest of Sheridan (1941) and Remick (1942a, 1942b). According to the former, a well-developed quasi-stationary low pressure system situated over the Georgian Bay region with surface temperatures 20C colder than Lake Erie was an important factor in causing these storms. According to the latter, three factors, namely frictional, thermal and orographic influences, act together in generating these storms. Wiggin (1950) was one of the first to recognize the importance of the length of fetch over water. Recently Thompson (1969) studied the lake-effect storms in southern Ontario. According to him when the mean flow is strong, inland displacement of heavy snow is likely to occur, and when the mean flow is light the snow is confined to regions immediately downwind from the lake. The confluence of the surface streamlines was used as an indicator for the inland displacement of snow. However, the authors believe this surface confluence to be more likely a consequence of the lake-effect storms than their cause.

5 Studies of the mesoscale winter disturbances of the Japanese coast

The heavy precipitation from mesosystems is not only experienced by the leeward Great Lakes stations but also by those on the northern islands of Japan. Polar outbreaks from the U.S.S.R. were found to produce cloud streets. The general formation of cloud streets was studied by Kuettner (1959) who noticed that for a favorable production of these streets the vertical variation of the wind shear (i.e., $\partial^2 v/\partial z^2$) has to exceed 10^{-7} cm^{-1} sec^{-1} in the lower troposphere. According to Higuchii (1962, 1963), whenever heavy mesoscale snowfalls occurred over Hokkaido island, this critical value was exceeded. Further, Higuchii (1962) tried to ascribe the growth of these disturbances to

Kelvin-Helmholtz instability. He observed the distance between two precipitating cells to be 6 km, roughly in accord with that given by the theory for representative values of vertical shear and density contrast. In actual situations, of course, several important modifying influences are present making the simple theory often inadequate.

The upper-level structure of the mesoscale systems is not well understood mainly because of the paucity of data. Fukuda (1966) made an attempt to show the influence of kinematic divergence (i.e., computed from observed winds) and 600-mb temperature on the amount of snowfall over northern Japan. He found that heavy snowfalls were associated with convergence in the low levels, divergence in the 500–400 mb layer and then convergence above. These fields, however, were derived from observations about 400 km apart and they may not be representative of the mesosystems. Furthermore, since wind errors increase with height, the high-level convergence may be questioned.

Matsumoto and Ninomiya (1969) regarded the snow squalls line as a gravity wave and studied the effect of momentum transfer by convective clouds on this wave. Numerical experiments with a 2-layer model indicated that downward momentum transport intensified the low-level convergence. They admitted, however, that the calculations are very approximate, and to obtain more realistic results they have to include moist adiabatic processes as well.

6 A comparison between the Great Lakes storms and the mesoscale disturbances of the Japan coast

Some of the features documented by Higuchii (1962, 1963) and Fukuda (1966) are not observed for the Great Lakes storms. Preliminary investigations indicate that large vertical wind shear does not always exist in Great Lakes storms. On the other hand, dynamical studies by Lavoie *et al.* (1970) and Rao (1971) show that strong convergence exists in the low levels with divergence in the middle and upper levels. This is somewhat similar to Fukuda's findings.

A harbinger of the snow squalls over the Great Lakes is the development of a surface pressure trough. This development is a result of the warming of the cold air. In the low levels there is a strong cross-isobaric flow over and to the lee of the lakes. Both Higuchii (1963) and McVehil and Peace (1965) reported this. According to Rao (1971) this low level cross-isobaric flow is quite important in producing mesoscale ascent.

7 Some kinematical and dynamical studies of the lake-effect storms

Meteorologists agree that it is proper to introduce heat sources and sinks in diagnostic and prediction studies of the atmosphere. Petterssen (1956) showed that nonfrozen inland water bodies are active cyclogenetic areas during winter. Further, in an approximate manner Petterssen and Calabrese (1959) isolated the influence of the Great Lakes on cyclogenesis. According to them a cyclonic vorticity of about 10^{-4} sec^{-1} is produced by the warming of the lakes. This production takes place in about two days and any further production is compensated by increased dissipation. Besides the orographic band of precipitation, they noticed another band of precipitation about 30 km from Lake Michigan over essentially flat terrain. Since this finding was based on an average of several days' observation the common observational errors were believed to be at a minimum. The inland displacement of precipitation was ascribed to nonadiatatic cooling and the spatial variation of static stability as the air moves inland from warm water. A similar study was made by Williams (1963) who found the precipitation along a wind-shift line roughly parallel to Lake Michigan but displaced inland about 10 miles over Chicago.

Because of the intensive efforts of various groups,[2] the structure of lake-effect storms became better known in the Sixties. Radar proved to be an invaluable tool in this respect. According to McVehil and Peace (1965), and Peace and Sykes (1966), whenever the upper winds at Buffalo are 280°, i.e., directed at a small angle to the southern shore of Lake Ontario, a "shore line band" occurs over the downwind shore. On the other hand if these winds become more west-southwesterly the convective band is likely to move over the lake and become an "over lake band".

Peace and Sykes (1966) made a case study of these storms over Lake Ontario. They used special observations and radar photographs to present the mesoscale structure. According to them the surface convergence line is very sharp with a width of about 1 nautical mile. Winds shifted by as much as 30° across the line. The pressure gradient was found to be stronger to the south of the lake than to the north. However, no significant surface temperature or dew-point contrast was found. According to them, the airmass is warmed by the lake in the low levels and ascent is developed. The upper-air flow is, however, important in controlling the shape, location and movement of the storms. Shoreline frictional convergence and orography came into play later in modifying the inland precipitation amounts.

Lavoie (1968) appears to be the earliest to study Lake Erie storms following a dynamical-numerical approach. He based his model mainly on the assumption that the lake-effect storms develop in a well-mixed layer topped by an inversion. He used the momentum, thermodynamic and continuity equations to parameterize friction and heating in a suitable form. Focussing his interest on the inversion surface he studied its spatial distribution after quasi-steady conditions were attained. His model was further modified by Lavoie *et al.* (1970). In this modification, which included an explicit equation for water vapor, latent heat of vaporization also was considered. The deformation of the inversion surface was believed to be better represented although the precipitation amount was still underestimated. The assumption of horizontal homogeneity used in both the 1968 and 1970 studies was admittedly a poor

[2]These include the Cornell Aeronautical Laboratory, The State University of New York, The Pennsylvania State University and the Canadian Meteorological Service.

approximation. In the latter work, the authors introduced a cross-section model which calculates physical variables in a vertical plane parallel to the long axis. They employed a 6-km horizontal grid and 50-mb vertical spacing and integrated the model until a quasi-steady state was obtained. The inversion surface became less deformed than before due, apparently, to inadequate parameterization of momentum transfer. Perhaps a numerical model with improved horizontal and vertical resolution and with real data as input would provide a more realistic simulation of the lake-induced disturbances.

A diagnostic approach in this direction was made by Rao (1971). He analyzed subjectively a potential snow squall situation over Lake Ontario using a ten-level numerical model with a horizontal grid distance of 20 km and a vertical separation of 100 mb. Maximum ascent occurred at 900 mb over the south-central part of the lake. The ascent was caused primarily by the destabilizing influence of the lake. The mesoscale ascent was not found to be too dependent on orography, at least initially. It appears that favorable conditions for mesoscale cyclogenesis exist over the lake first. Frictional and orographic influences act later to modify these disturbances situated already over the lake.

8 Conclusions

It is apparent from the above summary that our understanding of the mesoscale lake-induced winter storms has increased considerably. However, the physics of clouds associated with these storms must be better understood to effect any modification of them. Laboratory studies (McVehil *et al.*, 1969; Lavoie *et al.*, 1970) show that by properly seeding these storms it is possible to carry the snowfall farther inland. It is recognized, however, that knowledge of the natural life cycle of these storms has to be improved to appreciate the results of any modification experiment. Numerical and analytical attempts with improved horizontal and vertical resolution have to be made to simulate these storms in a more realistic sense.

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The following were elected to membership at the January 7, 1971 meeting of Council:

Member Alfred Abe Warkentin

Student Member

Terrance Roger Allsopp
John C. Anderson
Norman Paul Barber
Leonard Arthur Barrie
Philip Alan Davis
Gary James Fuller
Ronald Nicholas Kickert
Pete John Kociuba
Joel Morton Isaac Kurtz
Keith Graham McNaughton
Andre P. Plamandon
Ajmer Singh
Kong-Sin Tan

FIFTH ANNUAL CONGRESS

Second Canadian Conference on Micrometeorology

The Second Canadian Conference on Micrometeorology, and the Fifth Annual Congress of the Canadian Meteorological Society will be held May 10–12 and 12–14, respectively, at the Macdonald College Campus of McGill University.

The Campus, which houses the Faculty of Agriculture, is located at Ste. Anne de Bellevue, at the western tip of the island of Montreal, about twenty miles from downtown Montreal, and about twelve miles from Montreal International Airport, Dorval. It can be easily reached from downtown Montreal, and from the airport, via Highway 2 and 20, and via the Trans-Canada Highway (number 40).

Double occupancy rooms, and meals, are available on the Campus for approximately \$10 per day per person. There are a number of motels and restaurants within a radius of 5–10 miles, the nearest restaurants being in Ste. Anne de Bellevue, a 10- to 15-minute walk from the Campus.

The Annual General Meeting of the CMS will be held on the evening of Wednesday May 12, and a banquet on the following evening, Thursday, May 13. Details concerning registration, program, etc. will be announced later.

Centre de Québec

La troisième réunion d'information de la Société de Météorologie de Québec pour la présente saison a eu lieu mardi, le 1[er] décembre dernier. Le conférencier invité pour cette réunion fut le docteur Edward J. Langham, physicien-météorologue, diplômé de l'Imperial College de Londres. Le docteur Langham nous a entretenu des recherches hydrométéorologiques dans les Prairies. On sait que le docteur Langham fut chargé du programme de recherche hydrologique au *Saskatchewan Research Council*, avant de se joindre au Centre Québécois des Sciences de l'Eau comme professeur et chercheur.

Fort de cette expérience, il nous a fait voir les problèmes reliés aux mesures hydrométéorologiques et en particulier à celles de la neige dans les Prairies, où les conditions topographiques particulières entraînent une accumulation de neige assez différente de celle avec laquelle nous sommes familiers dans le Québec.

Le conférencier fut présenté par M. J.-G. Fréchette, vice-président de la Société de Météorologie de Québec, et remercié par M. J.-P. Fortin du Centre Québécois des Sciences de l'Eau.

ANNOUNCEMENTS

International Geographical Congress

The 22nd Congress of the International Geographical Union will be held in Montreal, Canada, Aug. 10–17, 1972. The scientific program will be divided into thirteen Sections, one of which will be of interest to meteorologists.

Section II: Climatology, hydrology and glaciology

- **a** Heat and moisture balance of the whole earth, including new instrumentation,
- **b** Climatic models and climatic variations,
- **c** Heat and moisture balance of the tropical world,
- **d** Heat and moisture balance of the Arctic and Sub-Arctic,
- **e** Plant-climate relations,
- **f** Man-climate relations: perception and modification of climate,
- **g** Urban and pollution climatology,
- **h** Economic and applied aspects of the water balance.

Deadline for submissions of papers is Sept. 1, 1971. Instructions regarding submission of papers are contained in the *Second Circular*, which may be obtained from

Executive Secretary, 22nd International Geographical Congress,
Box 1972, Ottawa, Canada

The Fifth Symposium on Temperature

The 5th Symposium on Temperature, Its Measurement and Control in Science and Industry will be held in Washington, D.C., June 21–24, 1971. Sponsored by the American Institute of Physics, the Instrument Society of America, and the National Bureau of Standards, U.S. Department of Commerce, the Symposium is expected to attract over 1000 experts on thermometry from around the world.

The theme of the conference is carried in its title, Temperature, Its Measurement and Control in Science and Industry. Some of the technological areas of thermometry that will be developed at the Symposium include: temperature scales, radiation pyrometry, resistance thermometry, thermocouples, magnetic or quantum electronic thermometry, potentiometers and bridges, automated measurements, geophysical and space, biological, special thermometric devices, and temperature controls. The Proceedings will be published, as were those of three of the previous symposia.

For further information, as it becomes available, write to:
Vincent J. Giardina
Instrument Society of America
530 William Penn Place, Pittsburgh, Pa. 15219

Scheduled National Meetings of the American Water Resources Association

June 21–23, 1971

NATIONAL SYMPOSIUM on *Social and Economic Aspects of Water Resources Development.*

Sponsored by AWRA, hosted by Cornell University, Ithaca, New York. Contact: Professor Leonard B. Dworsky, Director, Water Resources and Marine Sciences Center, Cornell University, Ithaca, New York 14950. Tel.: (607) 256-1000. (Papers by invitation; participation open to Members and Nonmembers.)

October 25–28, 1971

SEVENTH ANNUAL AMERICAN WATER RESOURCES CONFERENCE, Statler Hilton Hotel, Washington, D.C.

Sponsored by the American Water Resources Association. Contact: Dr. F. E. McJunkin, Deputy Director, Department of Environmental Sciences and Engineering, University of North Carolina, Chapel Hill, North Carolina 27514. Tel: (919) 966-2129. (Papers by invitation but mainly by contribution. Send 2 pages of summary of papers to Dr. F. E. McJunkin, before April 1, 1971. Participation open to Members and Non-members.)

June, 1972

AWRA RESEARCH CONFERENCE

Sponsored by the American Water Resources Association and the University of Wisconsin-Milwaukee, Milwaukee, Wisconsin. Contact: Dr. G. Karadi, General Chairman and Professor, Department of Applied Science and Engineering, University of Wisconsin-Milwaukee, Wisconsin 53201. Tel: (414) 228-4964.

June 19–23, 1972

NATIONAL SYMPOSIUM on *Watershed Hydrology*, Colorado State University, Fort Collins, Colorado.

Sponsored by the American Water Resources Association, hosted by Colorado State University, Fort Collins, Colorado. Contact: Mr. Arnold I. Johnson, Chief, WRD Training Center, U.S. Geological Survey, 4200 Ammons, Wheat Ridge, Colorado 80033 Tel: (303) 233-3611.

Fall, 1972

EIGHTH ANNUAL AMERICAN WATER RESOURCES CONFERENCE, St. Louis, Missouri.

Sponsored by the American Water Resources Association. Contact: Dr. Frank C. Foley, Director, Kansas Geological Survey, University of Kansas, Lawrence, Kansas 66045. Tel: (913) 864-3101.

Man And His Environment

Volume 1: *Proceedings of the First Banff Conference on Pollution*, edited by M. A. Ward, Department of Civil Engineering, University of Calgary, Alta.

The First Banff Conference on Pollution was held May 16 and 17, 1968, at the Banff School of Fine Arts, Banff, Alberta. The purpose of the Conference was to bring together all parties who have an interest in pollution but at different levels: the politicians, the planners, the industrialists, the engineering profession, the biologists and the medical profession. It was hoped that the interchange of ideas between the various groups would lead to a clearer understanding of the whole problem by all and thus assist in its solution, in any given circumstances.

Seventeen invited papers were presented which covered a wide range of topics dealing with air and water pollution. Two keynote papers were delivered to give some thematic order to the Proceedings in the water and air pollution sessions by Dr. E. F. Gloyna, University of Texas, and Dr. A. T. Rossano, University of Washington, respectively. Each of these review papers introduced a session in which a number of research and practical papers were presented and discussed.

Approximately 150 registrants attended the conference. The majority of participants came from the prairie provinces, British Columbia and the northern U.S.A., but others attended from many points in North America.

The complete program follows:

Session 1 – General

The provincial government's role in environmental quality maintenance.

J. D. Ross, Minister of Health, Province of Alberta.
The quality of man's environment. J. B. Cragg, Director, Environmental Sciences Centre, Kananaskis, The University of Calgary.
Progress toward control of air pollution in the United States. D. J. Borchers, Special Assistant to the Director of Air Pollution Control, Dept. of Health, Education and Welfare, White House, Washington, D.C.

Session 2 – Water Pollution

Liquid waste in the pulp and paper industry. D. R. Stanley, President, Stanley Associates Engineering Ltd., Edmonton.
Petrochemical waste disposal. E. E. Kupchanko, Head, Water Pollution Control Section, Dept. of Public Health, Government of Alberta, Edmonton.
Pollution from municipal sources. P. D. Lawson, Reid, Crowther and Partners Ltd., Calgary, and K. J. Brisbin, Underwood and McLellan Assoc. Ltd., Calgary.
Unsolved engineering problems in water quality. E. F. Gloyna.

Sessions 3 and 4 – Air Pollution and Urban Waste

Fundamental concepts of atmospheric pollution. A. T. Rossano.
Meteorology and air pollution. R. E. Munn, Canadian Meteorological Service, Toronto.
Ventilation and mixing in Alberta cities. Profs. K. D. Hage and R. W. Longley, University of Alberta.
Wind-tunnel modelling of stack gas discharge. Profs. G. R. Lord and H. J. Leutheusser, Dept. of Mechanical Engineering, University of Toronto.
Numerical simulation of atmospheric pollution from industrial sources. D. G. Colley and Prof. K. Aziz, Dept. of Chemical Engineering, The University of Calgary.
Air pollution from bivalent sulfur compounds in the pulp industry. F. E. Murray, British Columbia Research Council, Vancouver.
Management views on pollution control. J. E. Baugh, Canadian Fina Oil Ltd., Calgary.
Effects of air pollution on health. A. J. De Villiers, Dept. of National Health and Welfare, Ottawa.
A systems engineering approach to urban solid waste collection and disposal. J. W. MacLaren and D. P. Sexsmith, James F. MacLaren Ltd., Toronto.
Pollution control and abatement within the planning process. W. T. Perks, Chief, Long Range Planning, National Capital Commission, Ottawa.

Copies of the Proceedings are available at $12.00 per copy and may be ordered from:
Dr. M. A. Ward
Department of Civil Engineering
University of Calgary, Calgary 44, Alta.

INFORMATION FOR AUTHORS

Articles may be contributed either in the English or French language. Authors may be members or non-members of the Canadian Meteorological Society. Manuscripts for *Atmosphere* should be sent to the Editor, *Atmosphere*, P.O. Box 851, Adelaide Street Post Office, Toronto 210, Ontario. After papers have been accepted for publication, authors will receive page proofs along with reprint order forms.

Manuscripts for *Atmosphere* should be submitted in duplicate, typewritten with double-spacing and wide margins, each page numbered consecutively. Headings and sub-headings should be clearly designated and distinguished. Each article should have a concise, relevant and substantial abstract.

Tables should be prepared on separate sheets, each headed with a concise explanatory title and number.

Figures should be provided in the form of two copies of an original which should be retained by the author for later revision if required after review. A list of legends for figures should be typed separately on one or more sheets. Authors should bear in mind that figures must be reduced for reproduction, to be printed alone or with other figures. Labelling should be made in a generous size so that characters after reduction are easy to read. Line drawings should be drafted with India ink at least twice the final size on white paper or tracing cloth, and adequately identified. Photographs (half tones) should be glossy prints at least twice the final size.

Units. The International System (SI) of metric units is preferred. Units should be abbreviated only if they are accompanied by numerals, e.g., '10 m,' but 'several metres.'

Footnotes to the text should be avoided.

Literature citations should be indicated in the text by author and date. The list of references should be arranged alphabetically by author, and chronologically for each author, if necessary. Forms of abbreviation may be obtained by studying past issues of *Atmosphere.*

Italics should be indicated by a single underline.

The Canadian Meteorological Society
La Société Météorologique du Canada

The Canadian Meteorological Society came into being on January 1, 1967, replacing the Canadian Branch of the Royal Meteorological Society, which had been established in 1940. The Society exists for the advancement of Meteorology, and membership is open to persons and organizations having an interest in Meteorology. There are local centres of the Society in several of the larger cities of Canada where papers are read and discussions held on subjects of meteorological interest. *Atmosphere* is the official publication of the Society. Since its founding, the Society has continued the custom begun by the Canadian Branch of the RMS of holding an annual congress each spring, which serves as a National Meteorological Congress.

For further information regarding membership, please write to the Corresponding Secretary, Canadian Meteorological Society, P.O. Box 851, Adelaide Street Post Office, Toronto 210, Ontario.

There are three types of ordinary membership – Member, Student Member and Corporate Member. For 1971, the dues are $14.00, $2.00 and $40.00, respectively. *Atmosphere* is distributed free to all types of member. Applications for membership should be accompanied by a cheque made payable at par in Toronto to the Canadian Meteorological Society.