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A Brief History of Meteorological Services in Canada Part 3: 1939–1945

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ABSTRACT

When the concerns of the Meteorological Division turned from peace to war in 1939–40 the Division was in the midst of a major expansion to meet the needs of Trans-Canada Airlines. Civil air requirements for meteorological services continued to increase, and to these were added the meteorological needs of the Royal Canadian Air Force for operations and for the British Commonwealth Air Training Plan, the Royal Air Force and the United States Army Air Force for their ferrying activities over the Atlantic Ocean and to Alaska, and the much smaller needs of the Royal Canadian Navy and the Canadian Army. By developing an analysis and forecasting system based on several forecast centres previously planned for civilian aviation, by setting up still more forecast centres for military purposes and by staffing nearly 100 "dependent" forecast offices at training and operational military stations, the wartime meteorological needs in Canada were largely met, although in northern Canada the United States assisted by establishing many observing stations and some forecast offices. To do this it was necessary for Canada's national service to recruit and train 350 new meteorologists and a large number of assistants during a period of extensive manpower scarcity. Services to the public were greatly curtailed and for a period both the broadcasting and publishing of weather information were prohibited. At the end of the war the Meteorological Division was faced with the major task of reorganizing in order to provide, to the public, services commensurate with the wartime advances in meteorological theory and practice.

1 Autumn 1939

In 1939, the Meteorological Division, Air Services Branch, Department of Transport, was expanding rapidly to provide the meterological services required by commercial aviation – principally Trans-Canada Airlines. Meteorologists at aviation forecast centres across Canada were forecasting for the TCA terminals and routes extending from Victoria, B.C. to Moncton, N.B. A fledgling trans-Atlantic aviation forecast office existed at Gander, Nfld. Public weather forecasts and storm warnings were issued from Victoria, B.C. and from Head Office in Toronto – public services that had been routinely provided for several decades. Climatological data and information were prepared and issued regularly from Head Office in data periodicals and on request.

It had been a hundred years since the opening of the Toronto Magnetic and Meteorological Observatory, and nearly 70 years since a national meteorological service was first organized. The Service had expanded during periods of national prosperity and had been cut back during periods of economic depression – especially in the early years of the decade just coming to a close. Meteorology had not "gone to war" in 1914–18 – would meteorological services be required this time or would meteorology drift into another austere period?

Immediately with the outbreak of war the broadcasting of weather information and the publication of weather reports and forecasts in the newspapers of central and eastern Canada was prohibited for national security reasons. While continuing to forecast for the airways, the Meteorological Division was asked to provide operational weather services for the Royal Canadian Air Force and the Royal Canadian Navy, and was soon to begin planning for the provision of meteorological instruction and weather forecasting services for units of the British Commonwealth Air Training Plan.

2 Civil airways services

By 1940 the Meteorological Division was supplying a 24-hour aviation weather service for the Trans-Canada Airlines route across the country from aviation forecast centres located at Vancouver, Winnipeg, Toronto/Malton, and Montreal/St. Hubert (to be relocated at Dorval in 1941). Synopses and forecasts were mainly based on surface synoptic weather analyses since there were no Canadian upper air stations. Hourly reports, or "sequences", as well as all Canadian surface synoptic and pilot balloon observations were made available, along with surface and upper air data from the United States, by means of a teletype system which extended from the Pacific to the Atlantic. Late in 1939 a new aviation forecast centre to service the RCAF and Navy had been organized at Halifax, and early in 1941 a new centre was established at Lethbridge, Alta. to provide additional services for TCA.

In 1940, trip forecasts were issued for each TCA scheduled flight, and regional aviation forecasts valid for the next 8 hours were issued every 6 hours. In addition to their analyzing and forecasting duties the M.A. meteorologists at the forecast centres were responsible for personally briefing TCA pilots and dispatchers to assist them in planning and carrying out the scheduled flights. Although the aviation forecast centres were established primarily to serve civil aviation, analyses and forecasts originating at these centres were most essential to the large organization that was built up to provide services for the Armed Forces. Officers-in-charge at the main forecast offices during most of the wartime period were A.R. McCauley at Vancouver, D.H. Smith at Lethbridge, D.M. Robertson at Winnipeg, W.E. Turnbull at Toronto, F.J. Mahaffy at Montreal, and Dr. M.J. Oretzki at Moncton.

3 British Commonwealth Air Training Plan

In December 1939 Canada accepted responsibility for a major share in the British Commonwealth Air Training Plan which called for establishing 58 flying schools to train air crew in Canada between April 1940 and April 1942. It was estimated that 26 of these schools would each require a meteorologist, and the following quotation is from a letter dated March 20, 1940, written by the Acting Deputy Minister of National Defence to the Deputy Minister of Transport. *It is requested that your Department provide the Meteorological Instructors that will be necessary under the British Commonwealth Air Training Plan at Service Flying Schools, Air Observers' Schools and Air Navigation Schools and a Meteorological Advisor at Air Force Headquarters. These gentlemen will be required not only to carry out normal forecasting and reporting duties, but to lecture pupils passing through the Schools on the subject of Meteorology ....* Accordingly, in April 1940, J.R.H. Noble went from Toronto Head Office to RCAF Headquarters in Ottawa as Meteorological Advisor, while D.B. Kennedy was posted to the Trenton RCAF Station, and W.J. Green to Camp Borden.

However, as the war situation deteriorated during 1940 and the training program accelerated, it was soon found that the meteorological requirements of the BCATP were increasing markedly. Many RAF-staffed schools were moved to Canada from the United Kingdom, overlapping courses were brought into the schools and several meteorologists were required at most schools to handle the lecturing, forecasting and briefing duties. The Meteorological Division was then forced to markedly increase recruiting of qualified men and to introduce an intensive training program for meteorologists. Instead of the 27 meteorologists originally requested, more than 300 civilian Department of Transport meterolologists served with the RCAF and RAF at 68 different BCATP stations during the war.

Although professional meteorologists ultimately provided service at nearly a dozen different types of schools under the BCATP, most served at Air Observer and Service Flying Training Schools, the former to train observers and navigators, and the latter pilots. Working within guidelines sent by teletype from the district centres and from a special centre at Rivers, Man. the meteorologists analyzed weather maps, provided local forecasts and briefed the pilots, both students and instructors, before flight training commenced each day and night. As another major responsibility they gave ground school instruction in meteorology to student air crew. At all times the meteorologist-in-charge at each station served as advisor to the Officer Commanding on all meteorological matters.

Late in 1942, the divisional liaison officer at RCAF Headquarters, Mr. Noble, advised of the desirability of appointing meteorologists to the different RCAF Commands to supervise all meteorological activities throughout the Force. However, at this time the RCAF was organizing "navigation visiting flights" and ultimately a meteorologist was appointed to each of these. Meteorologists such as R.H. Craddock, H.V. Tucker, W.G. Clark, and F.M. Kelly, conducted inspection visits during the next two or so years as members of these visiting flights and contributed considerably to standardizing the presentation of services at the schools as well as providing Head Office with full reports on field activities. The British Commonwealth Air Training Plan formally ceased at the end of March 1945, and by early 1946, only 7 RCAF flying training schools remained at which meteorological personnel were stationed.

4 RCAF operational units

Within a few weeks of the outbreak of war in September 1939 the Meteorological Division, acting on requests from both the RCAF and the Navy, set up a forecast office at the Eastern Air Command Headquarters in Halifax, N.S. Analyses and forecasts were issued for flying patrols and for convoys leaving from and arriving at Halifax. As patrol flying increased in 1941, dependent offices were set up at 4 bases, while in Newfoundland the forecast centre at Gander expanded to service the RCAF needs. By 1943, however, with the increasing submarine menace several more dependent forecast offices were installed, and additional forecast centres were organized at Gander and Goose Bay to service the RCAF. In September 1944 there were 50 meteorologists posted at 12 RCAF operational units along the east coast.

In 1941 civilian meteorological observers were sent to a few new RCAF seaplane patrol bases following the establishment of a forecast centre at Western Air Command Headquarters in Victoria, B.C. In April 1943, the main forecast centre was moved to Vancouver leaving a smaller forecast centre at Victoria and meteorologists were posted to most of the bases. Exclusive of those at the Western Air Command Headquarters forecast office, there were in September 1944 nearly 40 meteorologists on duty at 10 RCAF units in British Columbia.

RCAF activities in central Canada were largely in connection with the BCATP, but there was sufficient long-range flying from Ottawa to require the establishment of a forecast centre at Rockcliffe, and for limited periods at Kapuskasing, Ont., and at Montreal/St. Hubert, while an office at North Bay, Ont. provided services for the RAF Transport Command Training Centre. Duties of meteorologists at these operational units were to provide weather analyses and forecasts, to brief operational personnel on anticipated weather over their routes, and to provide general meteorological advice to the RCAF.

Canadian meteorologists did not have an opportunity to participate in the RCAF's United Kingdom and European operations during World War II. Official policy was changed in 1945, however, and several dozen meteorologists had either joined the RCAF, or were about to, for service in the Pacific area when the war ended.

Where forecast centres had been established primarily to provide services to the military there was the tendency for the RCAF to look to the meteorological officer-in-charge as a staff officer responsible for any problems with services in that area. This was the situation at both Vancouver and Halifax where the officers-in-charge were G.L. Pincock and R.A. Hornstein. Civil aviation forecast offices had less responsibility for meteorologists serving the RCAF, but in the Prairie Provinces, D.C. Archibald, who had organized aviation services in that area a decade earlier, acted as western superintendent during the early war years as well as officer-in-charge of the Winnipeg forecast centre.

5 Trans-Atlantic Ferry Command

Civilian overseas flights from Newfoundland were severely restricted during the summer of 1940, but in the fall of that year plans were made for ferrying long-range bombers from mainland America to Europe via Newfoundland. The organization of a proper weather service for this proved to be most difficult on account of the lack of observations, not only over the Atlantic but also in Quebec and Labrador, the necessity to code all radio signals and the general lack of land-line communication facilities. However, regular meteorological services for the oceanic flights were commenced in the fall of 1940. As ferrying activities were stepped up in 1941, meteorological advice and forecasts became more important, and as the flying range of the new bombers increased, the headquarters for ferrying operations was shifted to Montreal's new Dorval Airport. In January 1942, the Royal Air Force Ferry Command took over responsibility for all ferrying operations and the Dorval Meteorological office began preparing the main forecasts for trans-Atlantic operations, while the staffs at the Gander and the newly established Goose forecast centres tailored the forecasts to operational plans if necessary and briefed flying crews.

During the next three years Ferry Command operations expanded to include the northeast route through Greenland to the United Kingdom, the direct route from Goose or Gander to the United Kingdom, a middle route through the Azores to the Mediterranean and North Africa, and a southern route through the West Indies to South America and across to central Africa. Dr. P.D. McTaggart-Cowan, Meteorological Officer-in-Charge, first at Gander and then at Dorval, was principal meteorological advisor to the RAF Ferry Command and played a very significant role in organizing the necessary meteorological services for these operations. Other senior meteorologists who subsequently were in charge at Gander and Dorval were H.H. Bindon and K.T. McLeod.

6 Navy and Army

During the war the Meteorological Division provided a limited amount of meteorological services for both the Canadian Army and the Royal Canadian Navy. Early in the war Naval requirements were met by the preparation of Fleet Synoptic Messages containing weather data and forecasts for broadcast. Both the Royal Navy and the United States Navy traditionally employed meteorologists, and in 1942 the Royal Canadian Navy recruited a number of former departmental meteorologists. The Meteorological Division continued to provide the basic service, however, and these men were used primarily for briefing and liaison duties within the Navy. With the use of smaller vessels for anti-submarine patrol in the St. Lawrence River and Gulf in 1943, and the increasing importance of weather on convoy activities the Ottawa/Rockcliffe, Sydney, N.S., Victoria, B.C. and Halifax offices provided extensive services for the Navy during the final two years of the war.

Services for the Canadian army were largely limited to the provision of surface and upper air data and forecasts for artillery units on the coasts and at training camps in central Canada. The Division provided personnel for a research station at Suffield, Alta., where confidential wartime research work was carried out. Division personnel also participated in Army cold weather tests conducted during the winter of 1943–44 in Newfoundland and Saskatchewan, and for two exercises – Eskimo and Polar Bear, carried out during the winter of 1944–45 in Saskatchewan and British Columbia, respectively, where experience was gained in moving men, equipment, and supplies over difficult terrain in severe winter weather.

7 Northwest staging route

Planning for inland air routes through northwest Canada to connect Alaska and the Yukon with central Canada and the United States began in 1940. Early in 1942 meteorologists were posted to a few stations on the route and forecast centres were opened at Edmonton and Whitehorse to provide services for the RCAF and for civilian aviation companies providing military transport. The United States Army Air Force stationed meteorological staff at all airports used by that organization to provide meteorological information and forecasts to their air crew.

When the airway to Alaska became of the utmost importance to the United States, and after the decision to build the Alaska Highway was made, it was found that it would be quite impossible for the Meteorological Division to provide the required observations and services. Accordingly, in 1942 the USAAF was authorized to open and operate several dozen supplemental observing stations throughout the Northwest complete with the necessary communication facilities. Operation of the basic meteorological service along the route continued to be carried out by the Meteorological Division led by Dr. T.G. How, Officer-in-Charge of the Edmonton forecast office. In 1944 a third Canadian forecast centre was opened at Prince George, B.C., and late in 1945 the USAAF turned over to the Canadian Service those stations and facilities that the Meteorological Division thought necessary for peacetime operations, while the other stations were abandoned.

In conjunction with the operation of the Staging Route it was decided in 1942 to build a pipe line from the Norman Wells, N.W.T. oil fields to a Whitehorse, Y.T. refinery in order to guarantee Alaska sufficient fuel for military and civilian purposes. Accordingly, the USAAF was granted permission to establish a number of supplementary observing stations in order to support this CANOL Project and to establish a forecast office at Norman Wells. The USAAF abandoned the project late in 1944 as the war situation in the Pacific improved and several stations were taken over and operated by the Meteorological Division and the Royal Canadian Corps of Signals, an organization that had provided most pre-war arctic and sub-arctic observations for the Division. Also incorporated into the system in 1945 were several USAAF stations in northern Manitoba and that part of the Northwest Territories west of Hudson Bay.

8 Public weather

In contrast to the remarkable expansion in aviation weather forecasting, public weather forecasting was curtailed during the war years. In 1939, forecast offices at Toronto Head Office and Victoria, B.C., using analysis methods developed by Stupart, Webber and others in the past century, were responsible for all public forecasting. The forecast services were of such significant value, however, that although the publishing and broadcasting of forecasts were prohibited in eastern Canada, many special arrangements were made to supply forecasts to government officials, fishermen, fruit growers, resort operators, etc. With the outbreak of war in the Pacific in December 1941 the broadcasting of weather information and forecasts was prohibited throughout the entire country, although brief district forecasts were published in the local press in central Canada. It was not until the end of the war in Europe that Canadian newspapers were again permitted to publish any weather information they wished, and radio stations, to broadcast reports and forecasts.

In addition to the public forecasts prepared at Toronto and Victoria, the Gander Trans-Atlantic Forecast Office had become responsible for public weather forecasts in Newfoundland during 1939. Late in 1940 the military aviation forecast office at Victoria, which moved to Vancouver in 1942, became responsible for public weather forecasts in that province. On the Prairies the Lethbridge Forecast Centre provided warnings of severe storms likely to affect ranchers in Alberta, and the Winnipeg Grain Exchange Office was maintained to provide weather information to agriculturalists and others on the prairies. Beginning in 1940 the military forecast office in Halifax became responsible for storm warnings on the Atlantic coast and, in the spring, for special forecasts for the Annapolis Valley fruit growers of Nova Scotia. In British Columbia each spring a special office was set up to provide a frost warning service for the Okanagan and other fruit growing valleys. Fire weather forecasts for portions of Ontario, Quebec and New Brunswick, continued to be prepared and issued from Toronto each summer directly to the proper authorities.

9 Climatological services

Basic climatological information services were provided, principally from Head Office under A.J. Connor and C.C. Boughner, during the war years as data were urgently required to assist in the planning and building of new airports and other defence installations. The *Monthly Weather Map*, and in season the weekly *Weather Summary for the Prairie Provinces*, were issued regularly, but publication of the *Monthly Record* fell several years in arrears. In 1941 the publication of a *Monthly Meteorological Summary* was begun at Toronto Head Office and within a decade there would be more than two dozen such local summaries published across the country. The total number of weather reporting stations in Canada remained at about 950 during the war years. Although reports were received from the new military stations the number of ordinary civilian climatological stations decreased due to lack of programs for station inspection and observer recruiting. There was a marked increase in the demand for climatological data and information towards the end of the war as former military air crew and engineers, who had come into contact with meteorology for the first time, began to realize the value of both weather services – climatological data and information in addition to weather forecasts – for peacetime pursuits.

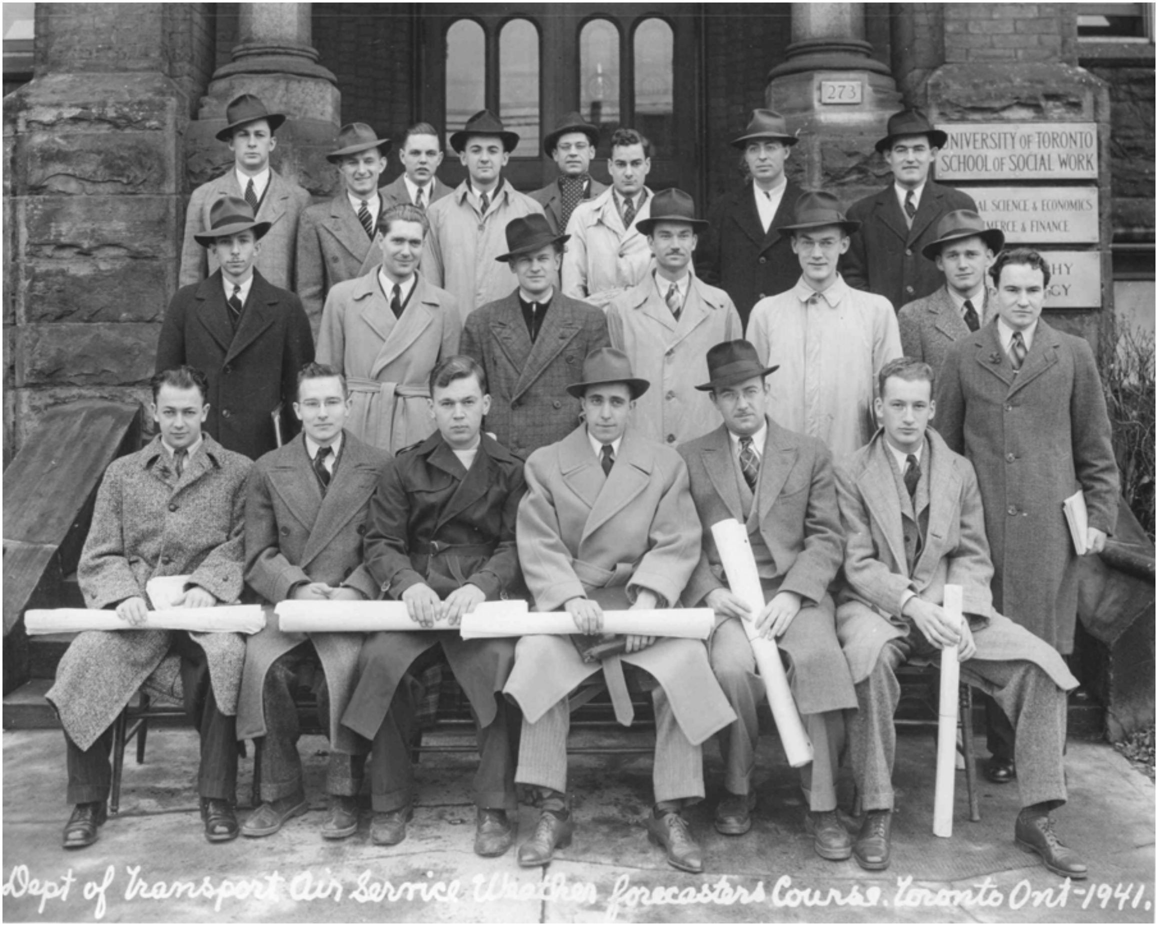
10 Technical developments and research

It was extremely fortunate for the development of wartime meteorological services that the Meteorological Division was already well into an expanding phase to service the requirements of the new Trans-Canada Airlines in 1939. Several new observing stations had been opened each year since 1935, both along the airways and in northern Canada, and on September 1, 1939 the teletype system had become transcontinental. Pilot balloon observations were taken at 22 Canadian stations in 1939, and aeroplane soundings at 3, while good progress had been made in the development and testing of a radiosonde instrument.

There was a great expansion of synoptic and hourly station networks and communication facilities during the war years. From 128 synoptic stations in early 1940 the number was more than doubled to 270 by March 1944, of which 61 were USAAF operated. There were no radiosonde stations in early 1941, but by March 1945 there were 25 in Canada, of which 12 were USAAF operated. The USAAF installed major weather communication circuits in both the northwest and northeast portions of the country which helped to expand the teletype mileage from less than 3000 in 1939 to 14,200 in early 1946. Isolated observing stations in northern Canada, however, were never incorporated directly into these networks but used short-wave radio to transmit observational data to the nearest relay point or terminal on the teletype system.

Because of the critical demand for meteorological services there were few meteorologists or resources available for research during the war. Fortunately the Division had begun using the new air mass and frontal analysis methods for instructional purposes in 1933, and later for aviation forecasting, and the rapid expansion of the Division during wartime allowed the new M.A. graduates to test and develop all aspects of the new methods. In 1939 Dr. E. W. Hewson was honoured by the Royal Meteorological Society for his contributions to research in air mass properties and during wartime published his research into atmospheric pollution. In addition, Hewson and R.W. Longley, both engaged in training and instructional duties during most of the war period, wrote and published *Meteorology: Theoretical and Applied* which was used as a text for many years after the war. Others were able to find time in the midst of their wartime duties to carry on investigations into upper air characteristics, temperature frequencies, aircraft icing, precipitation variability and forecasting techniques that were published in the meteorological journals of the time.

Selected Meteorological Division meteorologists also participated in classified research into the anomalous propagation of radio waves, weather radar, gas warfare, and the Japanese fire balloon problem. Early in the war W.E.K.



Intensive Training Course IV for Meteorological Assistants, Gr. III, held at the Meteorological Division from October 15, 1941 to January 31, 1942.

Middleton published books on instruments and visibility, and for the next several years, with R.C. Jacobsen, led research and development on the Canadian radiosonde instrument, an automatic weather reporting buoy, a new thermometer screen ventilating system and a new ceiling projector.

11 Personnel training

In September 1939 the full-time staff of the Meteorological Division numbered 213, of which 51 were meteorologists and 57 were meteorological observers. Over the next 6 years the Division was to recruit and train an additional 350 meteorologists and a large number of assistants in order to open and operate an additional dozen forecast centres and to maintain dependent weather offices at several dozen air training schools and operational war units. At the end of the war the total full-time staff of the Meteorological Division numbered 900 persons.

In planning for the provision of meteorological services to the Armed Forces it was decided to send to the military stations only those meteorologists who had had some experience at civil aviation forecast centres. This quickly proved to be impossible and it became necessary to recruit university graduates with a background in mathematics and physics and to give them a short Intensive Course in Meteorology lasting 3½ months. The first such course began in November 1940. The need continued and one course followed another until 12 had been given and 350 graduates produced by 1944. Lacking an M.A. in meteorology, these men were classified as Meteorological Assistants, Grade III, and although they remained civilians, most were stationed at military establishments during the war.

The University of Toronto's graduate course in meteorology, begun in 1933, was terminated with an early graduation of the 1941 class because of the urgent need for graduates in the field. Although there was no longer sufficient time to conduct the M.A. course, the Division did have an increasing need for independent forecasters, and so the first Advanced Course, some 4 months in length, was begun in the fall of 1941 for meteorologists who had already successfully completed the first course. Six Advanced Courses were held in wartime from which 92 meteorologists graduated. By March 1946, 117 meteorologists of both categories had been released to return to their former professions or to other employment. Chief instructors during wartime included D.B. Kennedy, E.W. Hewson, J.M. Leaver, R.W. Longley, and A.M. Crocker.

The recruitment of meteorological observers proved to be very difficult because of wartime manpower regulations. While military deferments were possible for wartime professionals in meteorology, these were not granted to technicians, even those in isolated postings. Men were usually recruited locally and trained at an aviation forecast centre before being sent out to the observing stations. At military stations all assistants were in the RCAF so there was not the manpower problem that occurred at civilian stations. Early in 1942 the RCAF began to employ women as observers and plotters and they proved to be most efficient at the work. Late in 1943 the Meteorological Division undertook to train airmen and airwomen assistants for the RCAF, and several courses were conducted at Toronto in 1944. At the end of the war many of these military assistants were recruited for regular civilian employment with the Division.

12 Administration

From the vantage point of the 1970's it appears that meteorological services were provided in Canada during wartime by an organization with a uniquely simple structure. While the Meteorological Division of 1939 had most of its professionals concentrated in the Toronto Head Office, those in charge of the branch offices and the airways forecast centres reported directly to John Patterson, the Controller (as the Director was called at that time). Over the next five years as hundreds of meteorologists were recruited and trained and a dozen more forecast centres and more than 60 other offices were established, these were administered without the building of a modern administrative organizational structure. Meteorologists across Canada knew that all authority came directly from Toronto and that practically every piece of correspondence from Head Office would be signed "J. Patterson".

Controller Patterson did, however, have valuable assistance at Headquarters in administering the provision of meteorological services. The Assistant Controller, Andrew Thomson, devoted full time to this work, while several of the meteorologists responsible for the training courses also assisted. In addition, other meteorologists were brought to Headquarters from time to time to assist in the never ending administrative work of transferring personnel from station to station as requirements changed and training courses were completed. But it was doubtful if any decision of importance was made that was not formulated by, or did not carry the approval of, "J. Patterson".

13 The challenges of peace

Military requirements for meteorological services began to decrease early in 1945 and by autumn of that year had been reduced to a small fraction of the previous year's demands. Approximately a third of the wartime meteorologists left the Service, while the remainder were about to be absorbed into the organization to undertake those jobs that had been neglected during the war. However, the challenges of peace were to be great, for the public was demanding a service equal to that provided to the Armed Forces during wartime. Should the Service be decentralized? How should a revitalized public weather service be organized? What percentage of resources should be spent on long neglected meteorological research? These were the "challenges of peace" which faced the leaders of government meteorology in Canada late in 1945.

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FIFTH ANNUAL CONGRESS

The Fifth Annual Congress of the C.M.S. was held in the pleasant surroundings of the Macdonald College campus, Ste. Anne-de-Bellevue, Quebec, May 12–14, 1971. The staff and officials of the College helped contribute to the successful outcome of the Congress by providing all the necessary facilities and associated arrangements.

This proved to be a banner year for the Society – not only did the Fifth Annual Congress serve as a host for a variety of speakers, but also co-sponsored with NRC a conference* (May 10–12) which culminated in joint meetings on Wednesday May 12 devoted to the timely theme *Meteorology and the City.*

Urban Meteorology

The first session was chaired by M.K. Thomas. Dr. H.E. Landsberg of the University of Maryland delivered an invited paper "The urban area as a target for meteorological research". He emphasized that although most people live in cities (70% now, increasing to 85% by 2000 A.D. in U.S.A.), their needs as consumers of meteorological information have not been satisfied. This is evidenced by the high demand for news from many sources such as TV, Radio, TAS and APC officers. The city affects climate in many significant ways: roughness length for turbulence increases; its impermeable surface floods after heavy rains; a heat island is produced (even for one block); trees are cooler at night; thermal circulation brings back air pollution and causes more rainfall; without an *episode*, more SO_2 leads to more deaths even at 8 pphm. Temperature doesn't drop off at night as in suburbs, leading to breathing problems. Perhaps the effective temperature may also be correlated with riots, e.g., as in Watts in Los Angeles area. Unfortunately the present small grid size (200 km) used in NWP programs are too coarse to make useful predictions for cities.

Nocturnal temperatures in Edmonton was the subject of a paper by Professor K.D. Hage who investigated the annual cycle of the city suburban temperature differences. For the limited number of cases studied these were most intense with S or SW winds, with peaks in July and February amounting to as much as 5°F. On a daily basis maximum and minimum values occurred at 2100 and 1300 MST, respectively, except for June and July when maxima occurred at 0100. Vertical temperature measurements showed that the inversions broke down from 0100–0300 MST, perhaps due to shearing instability with moderate winds. This is consistent with the already observed fact that inversions break down in steps with the associated low level jet moving upward as the inversions re-form.

Fr. C. East spoke in French about his research activities with a helicopter to measure the temperature structure of the Montreal boundary layer up to 300-m height. Traverses were made parallel and at right angles to the major axis of Montreal Island. The temperature data were used to calculate the heat budget. The urban heat production was found to be proportional to $(1 + V)(65 - T)$

*Second Canadian Conference on Micrometeorology – a report will appear in *Atmosphere*, **9**, issue No. 4.

where T and V are the ambient temperature (°F) and the wind speed (m/sec), respectively. The annual heat production estimated from this equation amounts to 40×10^{16} cal. which is about 5 times greater than that from commercial or residential sources. This difference may be attributed to the input of solar radiation.

Since radiation is an important part of the city's heat budget, the studies reported by Prof. T. Oke (working with R.F. Fuggle) were timely, and especially because realistic data input for computers has been lagging behind model development. Automobile traverses in Montreal were made along elevated Rte. 40 with a Swissteco net radiometer to measure downward long-wave radiation $L\downarrow$ in conjunction with an aspirated temperature sensor. On several nights when strong heat islands were formed the $\Delta L\downarrow$-values (city/suburbs) increased with COH-value and decreased with wind speed. $\Delta L\downarrow$ is hard to measure because instrument accuracy was only within 5–10%. $L\downarrow$ was also computed from the well-known formulas of Brunt, Ångström and Swinbank, using temperatures at the surface (assumed a blackbody) and agreed within 5% of the measured values. It was concluded that increases in $L\downarrow$ are not caused by the heat from the pollution dome, but rather by other sources inside the city which alter the vertical temperature structure, e.g., the city has a plume aloft while the countryside has warmer air aloft.

Wind tunnel studies at the NAE in Ottawa were described by N.M. Standen who worked with R.J. Templin to generate shear layers by using 4-ft spires in testing flows at 50 ft/s over scale models. This technique was compared with that for 3-inch cubes. Power law index α varies with wind direction and has a discontinuity for the model studied at a particular height. Peak of turbulent intensity is greater for spires. Reynolds shear stress increases (rather than dropping off) near the top of the shear layer, perhaps due to vortex shedding. Power spectral density curves lie between those for the 2/3's law and for 3-inch cubes. Spires are very useful in providing greater details of the wind flows for larger models.

Professor A.G. Davenport was co-author of a paper with M. Hogan, N. Isyumov and T. Jandali of the University of Western Ontario. Various aspects of the wind structures of cities were considered. Once in 50-year wind speeds are greater in a city than at nearby airport observing stations. Peaks of wind speed occur at 4 days, 1 day and at 1 or 2 minutes. Climatic average winds can be obtained by suitably combining wind tunnel data with meteorological data. Since available climatic data in an area are measured at various heights, topographic models must be used. Ratios of winds at different locations must be calculated to adjust values from a model back to actual conditions. Such adjustments may be quite large. However, the data are crucially required by building engineers and architectural designers.

Human Responses

The two afternoon sessions convened at the Otto Maass Building, McGill University, with J.L. Knox as chairman.

A. Auliciems presented a very interesting paper (co-authored by Prof. F.K.

Hare) about winter clothing requirements for Canada. By using climatic averages of observed solar radiation, air temperature, and wind speed with average values of skin temperature and metabolic rate (including all relevant energy balance terms) and suitable thermal and reflective properties of clothing, Canadian values could be calculated. Day/night clo maps were drawn and analysed (1 clo ≡ 1 business suit; 3 clo is approximately a maximum). 14°C corresponds to 1.5 clo for southern areas. The N-S variation is 4.75–2.75 clo in January and depends partly on variations in solar radiation, e.g., the clo-value for London is reduced by 0.5.

Dr. R.G. Steadman next dealt with indexes of wind chill for clothed persons. Older wind chill concepts (based on data for freezing cylinders of water) were reasonable for frost bites but did not agree with those derived from the author's own experience. For example, breathing is an important metabolic quantity which is independent of wind speed or clothing. Exposed facial area (3% of total possible) accounts for 15% of body's heat loss. Two indices should be calculated: one for exposed body surfaces, the other for clothing thickness requirements. Maps were shown for these indexes assuming average climatic conditions.

Dr. F.H. Fanaki spoke about the effects produced by fluctuating winds on man in his natural environment. Wind profiles around and between actual buildings are quite complex and can enhance or decrease speeds by a factor of 2. Theoretical calculations were made assuming that the wind speed varies periodically in time. The effect on a simple model of a human with average metabolic characteristics is to produce a lagged periodicity with larger amplitudes for smaller frequencies. As expected the exposed skin temperature drops with wind speed, but it was stressed that a greater knowledge of the micrometeorology of the streets is needed to study the effects adequately.

In a stimulating change of pace, Dr. G.R. McBoyle recounted forcefully the results of a sociological survey carried out to determine the average person's perception of climate in Aberdeen, Scotland. Answers to questionnaires revealed a number of significant facts: city pollution, warmth and windiness were underestimated when compared with countryside conditions. Differences are due to lack of mobility and familiarity of the city as a whole. Warm and cold areas were accurately discerned – day better than night (45% of population is over 50 years of age and don't move around as much). 79% of the population chose the windiest area correctly; 82%, the coastal district as foggiest. High percentages chose the wettest and driest areas as well as the life span of snow (the latter indicated a good knowledge of its connection with topography). There were mixed results for choosing calm areas and general precipitation. It is important that the public receive more information on climate since there is a lack of communication from the scientist. This benefits the latter's self-interest since the public can veto the government and eventually the funds required for research.

Urban Air Pollution

A simulation model for air pollution over Toronto was the subject of a paper given by A.E. Boyer in a group study with N.E. Bowne, D.G. Cooper and L. Shenfeld. An inventory of pollution sources was made including mobile sources, area sources (33,000 commercial establishments and 400,000 residences) and 250 large point sources. For SO_2 the following distribution of source output was found: Hydro, 80%; big industries, 10%; residences, 4%; and 33,000 commercial plants, 2%. CO is produced mainly by cars and Hydro; NO_2, by all sources. The most important and sensitive predictive parameter in the model is wind direction, since a change of only 10° can alter the calculated amount of pollution by a factor of 14. In Toronto the topography and lake breeze both affect wind direction significantly. However, the model is flexible enough to allow hand-analysis input of data. Initial experience shows that SO_2 predictions are reasonably good with occasional overpredictions.

A multi-media presentation was next on the program. Prof. J. Havlena discussed time-lapse photography of air pollution over Calgary; he was assisted by the co-author, M.F. Mohtadi, who displayed charts for the study area. When time was up, slides, movies and verbal commentary were all in action simultaneously. Time-lapse shots with a 37° field of view were taken 9.2 miles from the centre of Calgary at intervals ranging from 1 to 100 seconds. Inversions, their heights, main sources of pollution, their times of formation, as well as changes in turbidity can be detected readily, and are much more useful than spot sampling. The frames can be measured densitometrically for correlation with meteorological and spot sampling data. Also the indexes of haze factor (depending on visibility) and cloud density which can be evaluated are better for studies of distributed sources.

Dr. Peter Barry closed off the day's sessions with his usual refreshing and candid philosophic comments. "He came to impart wisdom rather than facts." It is obvious that meteorologists must communicate with engineers, architects, etc. This had been highlighted by his own liaison efforts between design engineers and meteorologists. Scientists have compartmentalized their thinking about problems to their own detriment as well as to those for whom they provide advice. This is an attitude problem which must be changed – scientists must learn to cooperate, appreciate each other's problems and spread their horizons.

Numerical Weather Prediction I

Thursday morning and afternoon sessions were devoted to Numerical Weather Prediction and the first of eleven papers was delivered by the day's chairman, Dr. André Robert, who discussed the current status of weather forecasting by numerical methods. Canadian efforts are mainly directed towards improving the quality of 2- and 3-day forecasts through the elimination of specific errors rather than of the total error ($\simeq$70 m for the model tested). Experimental 36-hr forecasts at the 500-mb level were performed with a 4-level model having a 381-km grid spacing. An error analysis of results shows: 17% are due to errors arising from observations; 50%, to computational procedures; and 33%, to improper modelling of the atmosphere. Computational errors can be eliminated by using more levels and grid points as better and faster computers become available. Afterwards physical process errors (radiation – 10%; boundary layer, 8%) can be reduced. The simple parameterization of surface drag may be sufficient for long-range forecasting. Although growth of inaccuracies in the initial data is a small source of error in the above scheme (5%), the error of ±15 m doubles every 2½ days and equals the average variation of the flow (≃120 m) after about 10 days when the forecasts become useless.

Next, Dr. Dave Davies reported on his development work to improve the numerical forecasting of precipitation. The basic CAO 1968 baroclinic model has been refined to include: eddy diffusivity of potential vorticity instead of smoothing; time dependent boundaries; error field corrections; 12-hr NMC P.E. forecast instead of initial 200-mb field; better terrain term; empirical terms for radiation and ocean heating; eddy diffusion for vertical motion; non-linearity in large-scale precipitation formulas. Present activity is concentrated on a fine-grid model with a variable eddy diffusion coefficient; diabatic effects, e.g. latent heat; and feedback of precipitation effects for each time step. Time did not permit discussion of detailed forecasts with the model.

Results of truncation experiments with a spectral model were described by Dr. P.E. Merilees of McGill. These studies were an important contribution to the design of GARP in order to help determine the type of model and the resolution required. A hemispheric spectral barotropic model with a non-linear advection term was integrated over a 5-day period for 6- and 9-day initial data resolutions and for varying resolutions for integration (6 to 18 and 9 to 21 in cases studied above, respectively). RMS differences between an integration at maximum resolution and that at a smaller resolution were computed. Results showed that the rate of growth of the differences increase with greater data resolution (by about a factor of two) while the spectrum truncation error decreases with increasing resolution for integration. Error variances are exchanged between different wave numbers in the spectrum, but these can likely be parameterized since they are essentially related to a physical process in the mathematical model used.

Dr. M.B. Danard of Waterloo University discussed the effects caused by physical processes on an 8-layer P.E. model. Since the grid size (even at 190 km) was too coarse to assess the influence of the Great Lakes on wind flow and heating effects, the results were suggestive rather than quantitative. Long-wave and solar radiation were considered along with friction, latent heat and the surface boundary fluxes of heat and water vapour (both assumed $\propto C_D$ ($=1.3 \times 10^{-3}$) and decreasing upwards). In the case study for the storm of 26 Feb. 1965 0000Z which deepened greatly, the new model predicted higher temperatures (relative to the simpler model); and lower winds to just northwest of the low and then further northwestwards again.

Horizontal truncation errors were evaluated by C. Chouinard by comparing results from a model containing finite difference derivatives with those from a spectral model and with statistical auto-correlation values. The quality of the discrete model improved as grid size was reduced. For a second-order F.D. the following errors were found for 400- and 50-km grids, respectively: in vorticity, 10 and 0.15%; vorticity advection, 41 and 0.5%; tendency, 13 and 0.2%.

All are in good agreement with statistical auto-correlation values. For a fourth-order scheme (comparing 400- and 140-km grids) some other errors are: vorticity, 2 and 0.2%; Jacobian, 18 and 0.5%; tendency, 4 and 0.05%.

The final paper of the morning session was delivered by Dr. R. Asselin who integrated (for a 60-hr period) a 5-level P.E. model to determine the errors caused by initialization procedures. It was concluded that the use of a non-linear balance equation was not necessary except for longer-term forecasts. The removal of the initial divergence and its tendency produced no significant change and only yielded errors amounting to about 60 m after 9 days.

Numerical Weather Prediction II

The second session began with two papers from the Dynamic Prediction Res. Unit of the Central Analysis Office, Montreal. Dr. I.D. Rutherford presented the opening paper, co-authored by Dr. R.J.M. Asselin, which dealt with preliminary studies on utilising satellite data to supplement synoptic radiosonde observations. The assimilation of non-synchronous data into special test integrations of the DPR primitive equations model was found to induce anomalous gravity waves. These were eliminated by the use of a time filter.

In the second paper W.S. Creswick described the pioneering work he and M.P. Olson had carried out on the use of time-dependent boundary conditions. He explained how hemispheric integrations of a baroclinic model for a given synoptic time can be used to provide boundary information for limited area integrations of the same model as soon as the early radiosonde transmissions are received at the next synoptic hour. This technique is of great practical importance and has been applied successfully in the operational run at the CAO for over a year. The operational version of the baroclinic model also features several other recent innovations. These include the introduction of eddy diffusion terms, and an error feedback technique to compensate for the omission of radiation and ocean heating.

The third speaker was A.L. Friend of the U.S. Air Force, Offut, Nebraska. His paper summarized the main features of an operational eight-level numerical model simulating the boundary layer from the surface to 1600 m. Especially noteworthy is that every attempt is made to handle the physical effects in a very comprehensive fashion. The horizontal grid spacing is currently one half the standard size, but some experimental integrations are being made with a one-quarter gridlength mesh. A very impressive list of by-products from the model included one item which greatly disturbed some members of the audience: target forecasts for south-east Asia. This aspect of the paper was pounced upon by the very first questioner, who rather appropriately had an American accent. He asked: "In view of the current concern of physical scientists with the moral implications of their work, have you given any consideration to the fact that your forecasts are being used to aid B52 bombers drop napalm on Vietnam?" The speaker replied: "I have given the matter very serious consideration." The propriety of this question was discussed at some length outside the lecture halls for the remainder of the conference. Further questions brought out the point that the accuracy of the predictions is limited by that of the forecast winds specified as input to the model at the top of the boundary layer. At the moment these are provided by a filtered equations baroclinic model integrated over a standard grid mesh.

Next, M.W. Balshaw described how the Prairie Weather Central's CDC 6500 computer is used operationally to provide diagnostic fields for the boundary layer including low-level divergence, orographic lift, turbulent mixing, low-level temperature advection, available moisture, potential temperature, geostrophic wind and wind trend. One of the principal features of the techniques is that derivatives are evaluated over variable distances which depend on the available data coverage. This allows sub-synoptic systems to be depicted in areas where there are many reporting stations, and therefore greatly facilitates the preparation of short-range forecasts for such areas. Mr. Balshaw illustrated his talk with case studies on hinged sets of transparencies which permitted him to instantaneously display overlay charts, without the usual pause for lining up.

The final speaker, Dr. M. Shabbar of the Canadian Meteorological Service, Toronto, reported on the results of a second-order approximation analysis of a side-band resonance mechanism in an atmosphere supporting Rossby waves. He concluded that a fully non-linear wave package with a small spread can feed energy to the mean zonal flow with weak shear.

Radiation

Father Conrad East was chairman of this session which was also held on Thursday afternoon. The first two papers indicated the increasing involvement of research groups at York University in using the laser to study the atmosphere. Prof. A.I. Carswell reported on his joint work with A.K. McQuillan and R. McNeil to investigate LIDAR as a remote probing technique for eventual application to satellites. The ground-based instrument (CRESS LIDAR) was operated at 10 pulses/min; each 18-ns pulse had a length of 6 m; the narrow beam width of 10^{-3} rad provided good spatial resolution. Preliminary results from six-months' work in the field showed that various atmospheric features can be detected including: structure of clouds; change in cloud structure; diffuse and thick aerosol layers; type of precipitation by means of Rayleigh/Mie scattering (through polarization effects); species of molecules (by means of Raman scattering).

R.G. Quiney presented a paper outlining his work in conjunction with Dr. Carswell to measure the light scattered by aerosols inside a relative humidity/fog chamber. Light from a He-Ne laser was scattered into a polar nephelometer attached to a rotating table to measure the variation of the four Stokes intensity parameters. RH-changes are measurable over the range 15–99%. Measurements, however, must be very accurate but more information can be obtained by using more components in the intensity matrix. Several theoretical models of cloud and haze were set up for calculation of scattering by means of computer. These showed more structure for cloud than for haze. Results should be compared with simple calculations made for distributions of known droplet size range.

Measurements of net radiation at Waltair, India, provided the next speaker, Dr. Padmanabhamurty, with data to correlate with evaporation and soil moisture. The energy budget technique was used for bare red sandy loam (semi-arid region), since for these conditions photosynthesis was zero. Soil and air temperatures were measured with fine thermocouples. Wind speed data for several levels allowed the aerodynamic equations to be used for estimating the heat fluxes for evaporation, conduction and eddy production; net radiation was measured by a Beckman and Whitley net radiometer. Results indicated that the heat flux required for evaporation was linearly proportional to the soil moisture at one-foot depth in agreement with the ideas of Thornthwaite.

Professor Garnier discussed his continuing work on the estimation of the spatial distribution of radiative energy received over complex terrain under various weather conditions. Measurements of the global solar and diffuse sky radiation are required at a representative point in an area so that the atmospheric transmissivity can be evaluated. A good linear relation exists between computer calculations and measured values of radiation when slope aspect and orientation and albedo are included ($r = 0.98$, at 3% variance). Test results for Barbados under assumed atmospheric conditions on an hourly basis show that eastern slopes heat rapidly to a certain value and remain there until late afternoon. A highly variable pattern dies away after 10 a.m. These effects are more pronounced at the times of the equinoxes. The transmissivity decreases in the afternoon so that afternoon heating values are not as high as those in the morning. It is hoped that this type of detailed computation scheme may be useful in the BOMEX studies.

D. Storr then outlined a method of estimating net radiation values for a rugged terrain, the Marmot Creek Basin which is a 3½ mi^2 pear-shaped area of lodgepole pine, spruce and alpine larch. Radiation values are needed in water balance calculations (spruce as a standard), however only two instruments are on site above the canopy to measure solar and net radiation. Both yield data for a non-realistic horizontal surface. Assumptions therefore had to be made to relate the net radiation to global solar radiation under clear sky conditions, since the latter can be estimated in a way similar to that of the preceding paper, if the slope aspect, orientation and albedo are known for each section of the watershed. This simple relation can then be extrapolated to all weather and sky conditions.

Preliminary measurements made with the Barnes PRT-5 infrared radiometer to investigate spruce budworm infestation in New Brunswick were reported by R.B.B. Dickison (co-worker, D.O. Greenbank). By mapping the canopy temperature climate from aircraft overflights the areas of defoliation should be detectable from the temperature variations. Most of the effort so far has been expended to gain experience with instrument performance and to correlate changes in the radiation record with variations in the surface characteristics as well as with the time of day.

The final speaker, Prof. E.R. Reinelt of the University of Alberta, dealt with radiation of a different kind, the sound radiated from explosive tests carried out at Suffield over a 10-year period. The major Oil Companies made their seismic equipment available in what became an extensive outlying network. Observed data were used to calculate the angles of descent. In one shot on July 17, 1964, there was no sound detected to the east of the blast. Prof. Reinelt refined and extended the previous computations of G.H. Gilbert with the result that the zones of computed sound were broadened.

Hail and Fog

On Friday morning Prof. Walter Hitschfeld (who was also session chairman) reviewed the growth and accomplishments of the Alberta Hail Studies Project. R.H. Douglas, a DOT meteorologist seconded to the Stormy Weather Group, helped to set up the hailstorm project with ARC. Starting with 3-cm radar in 1957 and correlating measurements with data from postcards mailed by farmers, it was discovered that hail size increased with height of cloud top as does the probability of hail (82% for 40,000 ft); also as storms progressed their high intensity cores move across their tracks with about 20-minute lifetimes. In 1967, 10-cm radar gave great results: PPI pictures at different levels showed that a Weak Echo Region (WER) is capped with a relatively high intensity region, an updraft zone with low residence time; hail areas may be discovered by means of echo intensity and depolarizing properties of precipitation; Alberta hail freezes at warmer temperatures than elsewhere and water from melted hail does the same relative to rain collected in the same area. Two-dimensional simulation at McGill on model storms has shown that strong wind shear (with a jet) near the ground is required for a persisting storm. Three-dimensional hailstorm growth models allow hail trajectories to be computed in good agreement with the WER storm; computed tops also agree with those observed by radar, so that storms may now be classified objectively.

Dr. A. Chisholm described radar characteristics and airflow for a "typical" Alberta storm. Simple 6–8-hour (yes/no) forecasts have an accuracy at present of 80–85% (skill score, 0.7). However, type, location, structure, etc., are still hard to forecast. Heavy convection in the foothills in mid morning leads to CB at noon and afterwards. Storms move E with complexes lasting for 3–5 hours. South winds enter from the SE quadrant over 4 mi^2 area at 6–8 m/sec. Since updraft has drops $<100\text{-}\mu$ size which cannot be detected by radar, the WER must be used as a tracer. A micro-cold front helps to channel air into the updrafts, which lean downwind (and towards N, but depending on entrance direction). Wind structure determines shape and characteristics of the storm: no shear in vertical – WER lasts 4 min and storm 36; moderate shear – storm sheared downwind, and WER lasts 9–15 min; extreme shear (with 80 m/sec jet) – WER lasts 1 to 1½ hours. In the latter case, the negative buoyant region can go into the anvil with fallout occurring alongside the updraft region so that a steady state is produced. Larger particles are positioned near core of updraft at WER.

In 1962 ALHAS became the major responsibility of Dr. P.E. Summers, the next speaker, who outlined the activities to develop effective hail suppression. Hail damage amounts to $20 M annually in Alberta and 20% of this loss can occur on one day. Previous studies had shown that injection seeding with AgI gave best results. The south edge of a cloud should be chosen when WER was weak and updrafts were small so as to reduce embryo size by 1/100 thus leading hopefully to the production of grape size (at most) hail or even rain. A T-33 aircraft was used to drop 200-gm AgI flares (including radar chaff in some cases) at −5 to −12°C level through 7000 ft; these were released every 1000 ft. Data from a 40-channel recorder (for time and meteorological observables) were correlated with cloud photos and field observations. 31 cores were tracked for a storm on July 11, 1970, in which continuous development occurred on the southern edge of the complex. Although there were 500 hail reports, much confusion resulted because several cells crossed the same points within a few minutes. Warmest nucleating temperature and high concentrations of AgI were found downwind of the two seeding sites. AgI also was present in precipitation. In a separate seeding, glaciation started after one hour.

A severe storm which lashed the Montreal area on August 1, 1969, with large hailstones and blew over a wall killing a man, was described by C. Warner of McGill. He analysed hail and radar data in conjunction with Marianne English. 115 large aspherical stones were collected having an average diameter ratio of 0.61. The drag coefficient is much larger than for spherical stones so that they can fall slower and grow larger in the same time period. Computed growth trajectories showed that: 2–3 cm stones can grow in one pass; 2-gm, in 15 min; 93-gm (large oblate), in 24 min. In some cases the horizontal paths can cover 5 km.

Results from another severe storm were discussed by Dr. L. Rogers who worked with Dr. Summers. On August 4, 1969, $5–6 M damage was caused by a hailstorm which moved towards the NE over the south side of Edmonton. Golf-ball size and larger hailstones fell and a funnel cloud was observed in the evening (0630–0700). There was a strange pattern of hail: two areas started on either side of the path and moved inwards (faster on west side later during the fall). Thus two distinct regions resulted: hail was more rounded in the west; more spiked with odd shapes (except cones), in the east. It was suggested that some mechanism was operating to cause the hail to fall out in the overhang region at the leading edge of the storm.

The 1970 fog dispersal program at Vancouver International Airport was summarized by Wm. C. Thompson. Morning radiation fog was a recurring problem for aircraft operations during the months from September to February; warm-type fogs were also troublesome. A DC-3 dispersed polyelectrolyte material (calgon) on several foggy occasions. However, no definite conclusions have so far been drawn from the seeding runs. In one case although improvement (as shown on recorder traces) may have occurred after about 15 minutes, visual observations did not confirm this. In addition the amount, concentration and properties of the calgon material were not known sufficiently well enough to allow correlations to be made.

Professor K.D. Hage read a paper dealing with the frequency of fog at Edmonton where the main contributor is the burning of natural gas. Major point sources of heat and water vapour are the city's central power plant and the eastern industrial complex. Data from 7 thermographs recording temperature within the city were correlated with visibility measurements made at the Industrial Airport. The peak frequency moves to lower visibilities as temperature decreases; frequency of ice fog drops off as temperature increases for visibility <0.5 km; but frequency depends on wind direction – more fog occurs for east winds. Calculations were made to find out how the air would be modified as it moved across the city assuming values of the estimated input from the heat and water vapour sources (with no fallout). These lead to a predicted water vapour content of 0.14 gm/m^3 excess at the airport and a vertical temperature gradient consistent with observed values.

Hail and Cloud Physics

This afternoon session with Professor Roland List as chairman was dominated by two research groups, one based at the Research Council of Alberta, the other at the University of Toronto. James Renick of the first group illustrated the structure and motion of a multicellular hailstorm by means of data obtained from time-lapse movies of clouds and radar PPI. Profiles of radar reflectivity versus time were shown for individual cells in a storm complex. These profiles, which appear to be related to the hailstone sizes that developed within a particular cell, will be used as part of the operational evaluation scheme for cloud seeding experiments in Alberta.

Professor List of the University of Toronto reported on his work in conjunction with W.A. Murray and Carole L. Dyck to measure the concentration and size distributions of air bubbles in the opaque and clear layers of hail stones. Size was found to be linearly correlated with cumulative occurrence (on lognormal probability scale). Concentration or opacity do not affect slopes of lines produced. Formation of both types of shells appear to be time dependent allowing a history of hailstone development to be deduced from the bubbles.

Dr. L. Rogers, the final speaker from ARC discussed a technique for locating AgI nuclei in hailstones. Thin sections of hailstones were treated with supersaturated solutions of AgI which cause the implanted particles to grow enabling them to be classified as nucleating or non-nucleating depending on their positions in the stone. Examples of these sections were shown followed by a discussion of the detection of cloud seeding effects.

The freezing of water droplets at terminal velocity was the subject of a paper by W.A. Murray who worked with Dr. List in a joint attempt to simulate hailstone shells and to study the conditions required for the formation of air bubbles as bearing some relationship to those for actual bubbles observed in hailstones. Freezing took place asymmetrically; the ice mass increased linearly with time; amount of air in the frozen drops decreased to 70% of its initial value in water; sizes of bubbles and crystals decrease as rate of freezing increases at lower air temperatures; and crystals are smaller in impure than in pure water.

The session closed with the delivery of two papers by Prof. J.V. Iribarne on the charge separation produced during the splashing of droplets on rotating spheres. In the first study with H.G. Hengeveld and P.Y.T. Louie supercooled droplets were splashed on ice spheres and produced a positive charge ($\sim 10^{-5}$ e.s.u.) for 360–500 μ-diameter droplets for the range of conditions employed. For lower temperatures (< -15C) and larger drops the sign was reversed. In the second investigation with J.B. Maxwell, large drops were studied. Although impact velocity does not affect the sizes of the saturation charges, the latter vary with the surface characteristics, the composition of the liquid and the electrical field strength.

General Meteorology

R. Fichaud chaired a parallel session on Friday afternoon. C. Baynes reported on his work with Prof. A.G. Davenport to map gradient winds for the 500- and 300-m levels. These are useful for the design criteria of engineers, since the winds can easily be extrapolated downward to the surface. Slides and coloured movies showed maps of the vector mean wind and the standard vector deviation. Extreme wind occurrences were also mapped including: Weibull probability distribution; 30-year return periods; and cumulative probabilities (mode and dispersion at 300 m only). Thunderstorm gust and tornado wind data were not used to obtain the statistics.

Dr. J.M. Richards presented a simple numerical formula suitable for EDP programs to calculate the vapour pressure of water p (mb) as a function of air temperature T (K):

$$p = p_s \exp(13.3185x - 1.9760x^2 - 0.6445x^3 - 0.1299x^4).$$

Here $x = (1 - T_s/T)$ and the subscript s refers to the steam point. The error of the formula lies within the error band of the standard complex Goff Gratch formulation (maximum differences are 40 μb and 0.01K for p and T, respectively), and has a derivative with an error $<10^{-3}$ over the range -50 to -120C.

A paper on an operational method of total instability analysis was delivered by W.S. Harley. This work was an extension of the Winnipeg Weather Central's experiment to develop a computerized system for weather forecasting. The basic techniques for severe weather forecasting were developed in the U.S.A. It was hoped that these might be expanded to include all bad weather conditions. The new system described is simpler: one index to represent mathematically all layers with full hydrodynamical freedom (rather than with parcel or slice methods). Also included as necessary parameters are the differential advection (causing destabilization), low-level moisture below 850 mb, low-level jet and the low-level moisture ridge.

An interesting analysis of tower wind and temperature data used to determine the speed, slope, thickness and passage of a cold front was given by Dr. R.W. Shaw (co-author, M.S. Hirt). The CBC tower at Toronto and another smaller one in the suburbs 22 km away provided the data on a day when the city was 10C warmer than the lake. A simple frontal model was used as the basis of calculations: land and lake air bracketing a transitional zone. An intense inversion occurred at the CBC tower at noon with the passage of the front. The speed of motion was determined with considerable uncertainty (50%), since only hourly winds were available from the Island Airport weather station and since the front was assumed to move parallel to the shoreline with the same speed at both tower locations.

J. Emslie stressed that although temperature range forecasting is better than spot forecasting, the representativeness of the range must be chosen carefully for an area with rugged terrain and topography. Striking examples were given for Vancouver and environs where mountains, deltas and the sea are in close proximity with sharp climatic contrasts. In this small area there occur sea breezes, cold air drainage and the heat island effect. Also there is more cloud and precipitation in the north. Since the extreme temperature differences in the July maximum and the January minimum can range from 10 to 25°F, it was concluded that the official weather station at the airport was not really representative and should be replaced by a station situated further inland and northward. Also temperature ranges (10°F for min. and 5°F for max.) should be forecast rather than spot temperatures.

The tragic and bizarre results of an unusual arctic storm (September, 1970) were discussed by H.P. Wilson. The storm system of a type occurring once in a blue moon was essentially vertical having a steep lapse rate up to 500 mb. Winds at Barter Island and Inuvik attained speeds up to 60–80 knots (as confirmed by the displacements of large ice floes) contributing to some loss in life. The speaker mentioned a few factors which likely caused the storm to deepen (e.g., passage over open waters) and indicated that further knowledge is evidently required before similar storms can be forecast with some assurance of success.

In Appreciation

Thanks are gratefully extended to Dr. Dave Davies and James Renick for their assistance in recording details of several sessions of the Fifth Annual Congress for inclusion in this issue of *Atmosphere*.

ANNUAL GENERAL MEETING

About 60 members reconvened on Wednesday evening at 8:00 p.m. in a spacious new meeting room of the Burnside Building which had been graciously provided by the University of McGill. The highlight of the discussions centred upon budgetary considerations, especially those connected with the operation of *Atmosphere*. There was a sense of history in the event with the discussion of vital matters intimately affecting the future course of the Society. Before the first issue of *Atmosphere* was born in 1963, it had been conceived and edited by members of the Montreal Centre of the Royal Meteorological Society, Canadian Branch, who were then located at McGill.

The Minutes of the 4th Annual General Meeting held in Winnipeg on June 17, 1970 were approved along with other Society reports including: Annual Report of the CMS; the Treasurer; Nominating Committee; the Editor; Awards Committee; and reports from local Centres.

Two Society prizes were presented: the Prize in Applied Meteorology, to Mr. N. Yacowar of the Canadian Meteorological Service, Montreal, for his work in developing the objective temperature forecast procedures used operationally by the Service; the Graduate Student Prize (as indicated by a letter) to Mr. N.A. McFarlane of McGill University for his M.SC. study of atmospheric stability. Two other prize winners were not able to attend to receive their awards: Dr. R.E. Munn, Canadian Meteorological Service, Toronto who was awarded the President's Prize for his important work and contributions to micrometeorological and environmental problems, and particularly for his book *Biometeorological Methods*; Mr. J.A. Fitzgerald, University of New Brunswick, who was awarded the Dr. Andrew Thomson Undergraduate Student Prize for his work on evaluating forecast accuracy.

Considerable discussion was generated by the proposed budget for 1972. Implications of the amount spent to produce *Atmosphere* were becoming critical. The balance between income and expenditure would likely reach the borderline stage within a year or so. Since finances depended on the success of the promotional campaign to increase the number of institutional subscribers, it was still premature to forecast future development from the present stage of the publication's growth. Two or three years would be required to build the subscription list up to the 400 level. Most members agreed that at least a full year's joint operation with the U of T Press was needed in order to gauge whether the new cooperative arrangements would really be satisfactory. With this consideration in mind a motion that Society fees for 1972 remain unchanged from present values was approved.

Members also discussed the aims and objectives of SCITEC and decided that more experience should be gained through practical involvement in the new organization's affairs before determining what the future CMS relationship with SCITEC should be. It was therefore moved and carried that the CMS pay SCITEC a sustaining membership fee of ten cents per member as of June 1, 1971.

Edmonton was announced as the location of the 6th Annual Congress to be held on May 31, June 1 and 2, 1972.

Other motions were made and carried: that the 7th Annual Congress be held at Halifax in 1973 with the Halifax Centre as host; that a vote of thanks be given to the Nominating Committee; that Council instruct the Nominating Committee of the 1972–73 Executive to consider re-implementing the principle established earlier of rotating the Executive among suitable Centres or combinations of Centres in Canada; that the Executive consider the establishment of committees to aid in communication and coordination between various groups involved in research in Canadian Meteorology.

After the outgoing Executive were given a vote of thanks by the members, the new Council members for 1971–72 were welcomed. Then the meeting was turned over to the incoming President who called for adjournment at 10:20 p.m.

ASSOCIATED EVENTS

On Wednesday after the sessions had ended for the day, members reassembled outside Burnside Hall where a brief ceremony was conducted to help commemorate the one hundred and fiftieth anniversary of McGill. The Principal, Dr. R.E. Bell, officially opened the new building with gusts of approval not only from the crowd attending but also from the lowering skies which threatened rain. Burnside Hall provides new facilities for the Departments of Meteorology, Geography and Mathematics as well as for the School of Computer Science and the Computing Centre. Afterwards there were informal tours of the new quarters followed by a cocktail party enjoyed by all.

The Annual Banquet was held on Thursday evening in Stewart Hall. Dr. H.G. Dion, Vice-Principal, Macdonald College and Dean of the Faculty of Agriculture officially welcomed the CMS members.

Mr. J.S. Dickson of the Canadian Meteorological Service was presented with the Patterson Medal Award by Mr. C.C. Boughner for his many accomplishments in the field of practical electronic instrumental design, testing and development. These included the final development of the Service's Automatic Weather Reporting Station (MARS) and instrumentation for automatic telemetering of data on precipitation, snow pack and melting from remote and isolated areas.

The Centennial of the Canadian Meteorological Service was saluted by Morley K. Thomas who highlighted the major achievements gained during the past 100 years.

Finally the guest speaker Prof. Roger Bider, a small-animal-ecologist in the Department of Woodlot Management, Macdonald College, delivered an interesting talk on "The ecology project on the new Montreal International Airport". He emphasised that the interdependence which exists between living creatures also serves to affect airport operations. A multi-disciplinary team of investigators (including social psychologists) was established to study the interrelationships between humans, animals and plants around the site of the new airport. Land use was dictated by complex patterns of socio-economic development. This in turn affected the nearby or immediate animal populations whose sizes became important only when the bird population increased so as to become a hazard to aircraft operations. The possibility of bird strikes was of prime concern in the investigation. The lecture was a refreshing change of pace after a heady day of meteorological sessions, perhaps because the methods of scientific research were different. For example, covered pathways in the wooded areas, dusted with powder for tracing, enabled small animals to be counted and tracked (even a spider's movements could be readily detected).

BOOK REVIEW

PRINCIPLES OF CLIMATOLOGY. By Hans Neuberger and John Cahir. Holt Rinehart and Winston of Canada, Ltd., Toronto, 1969, 178 pp., $4.35.

The authors of *Principles of Climatology* aim their text at, in their words, "the gap in existing text material used for earth science courses that are ordinarily offered in schools of education, state colleges, liberal arts colleges and community colleges." The one hundred and thirty-one pages of liberally illustrated text fulfil that aim well. In a logical layout, the chapters proceed from the global scale controls of climate through the intermediate scale land-sea effects to the local topographic and urban controls.

Throughout, physical reasoning is used to explain the observed climatological effects, without recourse to more than very elementary mathematics. Climate at any location is treated as a composite of functional relationships involving such things as radiation, atmospheric circulation, air-sea interactions, topography and urbanization. The point of view of the authors is that if the underlying principles are well understood, classification of parameters in the "Köppen" sense becomes redundant, a view with which Köppen apparently agreed.

Although climate data is used, its purpose is primarily to illustrate the principles involved. Examples are drawn largely from American sources, however, the rest of the globe is not ignored. There are discussions of tropical storms, Indian monsoons, temperature regimes over Europe, radiation budgets over the Arctic and other far ranging examples.

Effective use has been made of visual data provided by space exploration. In a discussion of earth albedo a view from Apollo 8 showing the earth above the lunar horizon is presented. Atmospheric circulation is illustrated by a full earth picture taken from a geostationary satellite. Land-water contrast is well demonstrated by a manned space-flight photograph of cumulus development over the Florida peninsula. These and other illustrations and tables are spaced throughout the text in a pleasantly formatted and easy to locate manner.

A series of four appendices follow the seven chapters of text. These include sections on simple experiments, instruments and observations, the uses of climate data and a number of review questions. The review questions add to the fifty short exercises which are interspersed throughout the book. The authors consider these exercises to form an integral part of the text, which serve to involve the student more directly in the teaching-learning situation.

From the point of view of the professional meteorologist *Principles of Climatology* does not offer material which has not been encountered elsewhere. However, the work must be considered on the basis of the group to which it is directed. From that point of view it is well written, well illustrated, and, in a non-mathematical way, gives sound insight into the underlying principles controlling climate. For the meteorologist it does present a handy description of the "basics" as well as several unique and interesting examples.

D. Garry Schaefer
Atmospheric Environment Service
Toronto

CORRESPONDENCE

Monsieur le secrétaire-correspondant:

Permettez-moi quelques commentaires en marge d'un texte de M. N.-H. Thyer de Nelson, C.B., paru en pages 60–62 du volume 9, numéro 2, 1971, de la revue *Atmosphere*.

M. Thyer est découragé, il montre du pessimisme au premier échec et, à l'occasion d'une hausse de cotisation, se déclare même "hérétique" devant les membres de la Société canadienne de météorologie. Tout de même, le texte qu'il nous présente prouve qu'il est encore jeune, qu'il n'en est qu'aux premières expériences de sa vie professionnelle, qu'avec les années il apprendra graduellement le métier d'homme et, qu'en tout, il faut aimer son travail, besogner dur et être tenace.

Tous les météorologues d'un certain âge peuvent raconter à M. Thyer leurs nombreux déboires. S'ils avaient démissionné au premier échec, nous ne pourrions pas célébrer cette année le centième anniversaire du Service Météorologique du Canada.

Personnellement, je peux affirmer qu'il m'a fallu attendre 18 ans avant de voir se réaliser mon rêve d'un *Service Provincial de Météorologie* au Québec. Durant cette période, je profitais de l'arrivée d'un nouveau titulaire au ministère des Terres et Forêts du Québec pour présenter un rapport à cette fin. Ce n'est qu'après le cinquième rapport qu'on a bien voulu m'écouter. Ce pèlerinage à tous les quatre ans me permettait tout de même de présenter d'une fois à l'autre des arguments plus solides et plus nombreux. Et le plus cocasse de l'affaire, c'est que le Service de Météorologie a été créé au ministère des Richesses Naturelles et non pas au ministère des Terres et Forêts: preuve que la météorologie a sa place partout ...

En 1950, lorsque les premiers numéros du *Feuillet Météorologique* ont paru, mon patron d'alors m'avait dit que ce journal était tout simplement une perte de temps. Devant cette critique décevante, j'ai cru bon de présenter, dans le numéro suivant du Feuillet, le curriculum vitae du patron accompagné de forts coups d'encensoir. A partir de ce numéro, le Feuillet a eu sa raison d'être. Il est actuellement distribué à plus de 3,200 destinataires.

En 1964, lorsqu'il s'est agi de fonder la Société de Météorologie de Québec, mes collègues et moi avons rencontré des "objecteurs de conscience". Nous avons procédé quand même à la fondation en ayant soin d'inviter comme conférenciers les plus réfractaires à la nouvelle société. Aujourd'hui, la Société de Météorologie de Québec, qui est en somme le Centre de Québec de la Société Météorologique du Canada, possède une santé florissante et reçoit même la bénédiction des gens qui voulaient empêcher sa naissance.

Ce sont là quelques faits qui prouvent que la tenacité vient à bout de tout. Tout les météorologues, qui se sont dévoués dans le passé, et ne cessent encore de se dévouer à la cause de leur discipline, peuvent raconter des faits analogues. Mais, ils aiment leur métier, ils montrent de l'enthousiasme et ils sont tenaces. En général, on ne raconte pas ses échecs, mais ses réussites. Et pour une seule réussite, n'y a-t-il pas parfois cinq ou dix échecs qui l'ont précédée?

M. Thyer, retroussez vos manches, continuez vos efforts, don't say: "Go", say: "Let's go".

G.-Oscar Villeneuve
Québec, P.Q.

NOTES FROM COUNCIL

The following were accepted as members by Council:

August 19, 1971

Member	Colin Edward Banfield David Brice Frost	Robert Duncan Peterson Peter Ross Scholefield
Student Member	Balaram Dey	Bryan Richard Kerman

October 5, 1971

Member	Arthur John Lewis*
Student Member	Stephen Harold Clodman
Sustaining Member	Air Canada

*1972 Membership

CALL FOR NOMINATIONS – 1971 AWARDS

Nominations are requested from members and Centres for the 1971 Society Awards to be presented at the 1972 Annual Meeting. Four awards are open for competition: 1) the President's Prize for an outstanding contribution in the field of meteorology by a member of the Society; 2) the Prize in Applied Meteorology for an outstanding contribution in the field of applied meteorology by a member; 3) the Graduate Student Prize for a contribution of special merit by a graduate student; and 4) the Dr. Andrew Thomson Undergraduate Student Prize for a contribution of special merit by an undergraduate student. The awards will be made on the basis of contributions during the 1971 calendar year. Nominations should reach the Corresponding Secretary not later than March 1, 1972.

SCITEC Annual Meeting – The President Reports

The CMS is supporting SCITEC as a member society (levy of 10¢ per member) and some individual members have also taken membership in SCITEC. Consequently your executive decided that the CMS should send a representative to the SCITEC annual meeting held in Ottawa on June 28–29, 1971. The meeting was attended by about 75 representatives of scientific societies as well as individual scientists.

SCITEC – The Association of the Scientific, Engineering and Technological Community of Canada – was founded *to marshal the scientific, engineering and* *technological community to provide leadership, to communicate, cooperate and work within itself, with government and the public in the national interest in those areas in which it can make a competent contribution.* The general objectives of SCITEC are to improve communications between science, government, industry and the public; to foster greater social responsibility among professional scientists for the uses of technology, for science policy and for environmental improvement, etc.; and for other similar problems. One certainly can support these objectives and the general concept of SCITEC.

The meetings discussed problems such as the Lamontagne Report, the crisis in the employment of highly qualified manpower and the development of communication channels between the scientific community and the government. In addition, of course, much time was spent on the structure, financing and development of SCITEC as a viable organization. Resolutions were passed relating: the formation of Standing Committees on Parliamentary Liaison, Science Policy, Highly Qualified Manpower, Environmental Officers; communication with the new Minister of State for Science and Technology; the question of optimum utilization of scientific and technological manpower; and numerous other related and organizational matters.

SCITEC is in financial difficulties and needs to stimulate both individual support and support from other scientific societies. Fees for member societies will likely need to be raised.

Can SCITEC succeed? One might also ask, does a consensus exist in the Scientific Community? Can SCITEC present a consistent approach or give consistent advice? The opinion formed from the attendance at meetings was that the problems would be difficult and that the results to date are not inspiring but a year or two is, after all, insufficient to build such an organization and to determine its direction. SCITEC merits our continued support both as a member society and as individuals. The CMS, however, should continue its own efforts to improve public and scientific communication and to develop social responsibility among its members through its local centres as well as through the Standing Committees on Public Information and on Scientific and Professional Matters. We would, however, concern ourselves mainly with atmospheric and environmental problems. SCITEC, on the other hand, would take a broader view and could involve the whole scientific community. Although the CMS is a small society in the SCITEC community, the support of all segments of the scientific community will be necessary for a viable SCITEC.

CALL FOR PAPERS – SIXTH ANNUAL CONGRESS

The Sixth Annual Congress and Annual General Meeting of the Canadian Meteorological Society will be held at the University of Alberta, Edmonton, Alberta, May 31–June 2, 1972. *Meteorology of the North* is the tentative theme of the Congress and session topics will include Hail, Numerical Weather Prediction, Instruments, Marine Meteorology, Applied Meteorology and Micrometeorology.

Members and others wishing to present papers at these meetings should send titles and definitive abstracts (preferably less than 300 words) to the Program Chairman, Professor K. D. Hage, Department of Geography, University of Alberta, Edmonton 7, Alberta.

The Local Arrangements Committee is already hard at work under the direction of A.F. Ingall of the Edmonton Centre, and information regarding registration, activities etc., will be provided as arrangements proceed.

ANNOUNCEMENTS

International Hydrological Decade
Symposia on the Role of Snow and Ice in Hydrology

Two IHD Symposia on the Role of Snow and Ice in Hydrology will be held at the Banff School of Fine Arts, Banff, Alberta, from September 6–20, 1972. Technical sessions are planned for September 6–13 inclusive, followed by field excursions from September 14 to 20.

Both Symposia are organized with the collaboration of WMO and UNESCO, the Canadian National Committee for IHD, and the International Association of Scientific Hydrology.

Several experts will be invited to present papers covering major sections of the program. Papers will also be accepted from participants at large. The full program is outlined below.

Symposium on Properties and Processes (convened by UNESCO)

1. Physics of Snowfall and Snow Distribution in Space and Time
   atmospheric — transport phenomena
   physiographic — physical changes
2. Conditioning, Ripening and Melting of Snow Cover
   total energy exchange at air-snow interface (including meso-scale approach)
   heat and mass (water) flux through snow cover
   metamorphism and changes in physical properties
3. Ground Conditioning and Water Movement
   as above, both on and in the ground including frozen soil and permafrost
4. Properties and Processes of Glaciers
   those specific to glaciers
5. Properties and Processes of River and Lake Ice
   formation and metamorphism — movement
   dissipation — physical properties

Symposium on Measurement and Forecasting (convened by WMO)

1. Measurement in Space and Time
   snow cover — other elements (i.e., radiation, etc.)
   snow melt — new techniques
   runoff

2. Forecasting Runoff
    the forecast problem, theoretical
    operational practices – regional
    special purpose forecasting – small scale
    new techniques
3. Measurement and Forecasting Specific to Glaciers
4. Measurement and Forecasting Specific to River and Lake Ice
5. Modification of Snowfall, Snow Cover and Ice Cover
    both operational and theoretical, including scientific techniques

All correspondence concerning the Symposia should be addressed to:

Dr. I.C. Brown
Secretary, Canadian National Committee for the International Hydrological Decade
C/O Department of Energy, Mines and Resources
No. 8 Building, Room G–29
870 Carling Avenue
Ottawa 1, Ontario, Canada

Eastern Snow Conference

The Eastern Snow Conference is an international organization in eastern Canada and the north-eastern United States concerned with origin, precipitation, accumulation, character, melt, and runoff of snow from the viewpoints of meteorology, power generation, conservation, engineering, forestry and related fields.

The 29th Annual Meeting of the E.S.C. will be held at the Holiday Inn, Oswego, N.Y. on February 3–4, 1972.

For further information contact:

Mr. D.N. McMullen
President, E.S.C.
Conservation Authorities Branch
Department of the Environment
880 Bay Street
Toronto, Ontario

NEW POSTAL ADDRESS FOR C.M.S.

Correspondence dealing with Society activities and affairs should be directed to the Corresponding Secretary, Canadian Meteorological Society at the following *new address*:

P.O. Box 41
Willowdale, Ontario
Canada

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 the discussions held on subjects of meteorological interest. *Atmosphere* is the official publication of the Society and is distributed free to all members. 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.

Correspondence regarding Society affairs should be directed to the Corresponding Secretary, Canadian Meteorological Society, P.O. Box 41, Willowdale, Ontario.

There are three types of membership – Member, Student Member and Corporate Member. For 1971, the dues are $14.00, $2.00 and $40.00, respectively. Libraries and Institutions can subscribe to *Atmosphere* at the annual subscription rate of $10.00.

Correspondence relating to CMS membership or to library or institutional subscriptions should be directed to the University of Toronto Press, who have been engaged by the Society to collect membership and subscription fees, to maintain all mailing lists, as well as to print and distribute *Atmosphere*. Cheques should be made payable to the University of Toronto Press and sent to the University of Toronto Press, Journals Department, Front Campus, Toronto 181, Ontario, Canada.

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 41, Willowdale, Ontario. After papers have been accepted for publication, authors will receive galley 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 (halftones) 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.