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METEOROLOGY IN WATERSHED RESEARCH IN ALBERTA

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NEED FOR WATERSHED RESEARCH

Canada has a worldwide reputation for being rich in fresh water. School children are taught that we have one quarter of the world's total. However, in some parts of our country, agricultural and industrial development is limited by inadequate or unreliable supplies. As an example, in the dry year of 1962, every acre-foot which came down the Bow River at Calgary was "spoken for" for irrigation and industry; there was none left for expansion. Obviously, then, an increased or more stable water supply is necessary. Dams and other "plumbing fixtures" are expensive, have limited capacity, and in high sediment areas, have a relatively short life. Studies in other parts of the world have shown that intelligent management of the headwaters of a river can increase the annual flow.

The East Slopes (Alta.) Watershed Research Program was therefore established in 1960 to study the hydrology of the area with the aim of evaluating and improving land management practices for water production (Jeffrey, 1965). Increased total run-off is not the only goal. Because peak water demand is in July and August, it would be an important achievement if the peak on the hydrograph could be smoothed out or delayed from its usual June occurrence.

Three experimental basins were established in the South Saskatchewan headwaters in representative vegetative types; Marmot Creek in spruce, Streeter in aspen-rangeland, and Deer Creek in lodgepole pine. In 1967, the terms of reference of the program were enlarged to include all Alberta, and there are now ten projects of various sizes studying various problems in the hydrologic cycle in the province. Thirteen federal and provincial agencies are involved in the program on a co-operative basis, so administration frequently involves more tact and diplomacy than in a single agency project! However, administration is not the theme of this article.

THE WATER BALANCE APPROACH

The familiar water balance equation:

Precipitation = Run-off + Evapotranspiration ± Increase in groundwater and soil moisture storage,

provides a convenient means of illustrating the division of responsibility among the research agencies studying a basin's water balance. Input by the various agencies varies from basin to basin depending on the purpose of the study, but let us examine Marmot Creek as a good example.

Precipitation is naturally the responsibility of the Meteorological Branch and I will deal with this more fully later. Run-off is measured by Water Survey of Canada as the competent authority and five weirs have been installed in the basin. Department of Energy, Mines and Resources also measures sediment load and water quality. Measurement or estimation of evapotranspiration is a joint responsibility of the Meteorological Branch and Canada Department of Forestry since it is a function of both weather conditions and plant physiology. Changes in groundwater storage are the responsibility of Groundwater Division of Alberta Research Council, and a network of wells and piezometers is being established for this purpose. Department of Forestry studies changes in soil moisture using neutron probes and electrical resistance units.

There is one other field of investigation not covered by the water budget equation, that of snow hydrology. The study of snow accumulation patterns and melt rates with respect to elevation, slope, aspect, vegetation types and density, and forest removal practices as influenced by variations in radiation and sensible and latent heat fluxes is a joint responsibility of Meteorological Branch and Department of Forestry. I think this field holds the key to success of the entire program. It may be possible to partially control snow accumulation by forest harvesting practices. Pre-selected accumulation zones, relatively sheltered from sun and wind would have reduced evaporation and melt rates. While the total basin run-off might be increased slightly, the snowmelt flood peak could be reduced, thus decreasing erosion and increasing usable run-off.

The water balance approach also provides both a goal for which to aim and a check on the accuracy of each term. For instance, it would be very embarrassing if the precipitation measured was less than the run-off from the basin! Run-off is the only term which can be measured precisely. The others have varying degrees of difficulty of measurement and correspondingly large errors are possible.

DESCRIPTION OF MARMOT CREEK WATERSHED

Before delving more deeply into the meteorological input into the Marmot Creek study, a description of the basin is necessary. It is located about 50 miles west of Calgary on the west side of the Kananaskis Valley between the Fisher Range and the Continental Divide. Figure 1 is an aerial view looking westward to the divide in the background. Elevation ranges from 5200 to 9200 feet MSL, giving an average slope of 39% over its 3.6 square miles and creating severe access problems to the higher elevations. The lower reaches are covered with a dense stand of lodgepole pine, then mature spruce up to 100 feet tall extends to treeline at about 7500 feet. In the alpine area, shrubs and grasses give way to bare rock and talus.

METEOROLOGICAL RESPONSIBILITIES AND PROBLEMS

The meteorological responsibilities in the program may be summarized in the following table:

Hydrological Component		Meteorological Parameters Required
Precipitation	....	Rainfall, snowfall, rainfall intensity.
Evapotranspiration	....	Solar radiation, air temperature and relative humidity, wind, pan evaporation.
Snow Accumulation and Melt	....	Snow depth, density and temperature, wind, radiation, air temperature and humidity.

To measure each of these parameters for each of the sub-basins at Marmot, two questions must be answered. First, how accurately can it be measured at a point? Secondly, is there a consistent pattern for it over the area, and at how many points must it be measured to determine that pattern? For practical reasons, a third question dominates the other two - where is an instrument which, operating without electric power, will measure and record the parameter accurately without attention for at least a month at a time?

For some of the questions I have partial answers. The rainfall pattern has been reasonably well defined as seen in Figure 2, the summer rainfall in 1965 (Storr, 1967). This is measured with a network of 33 raingauges. It is quite consistent from year to year and we are now trying to improve the accuracy of point measurements. The variation in

FIGURE 1: Aerial Photograph of Marmot Creek Watershed

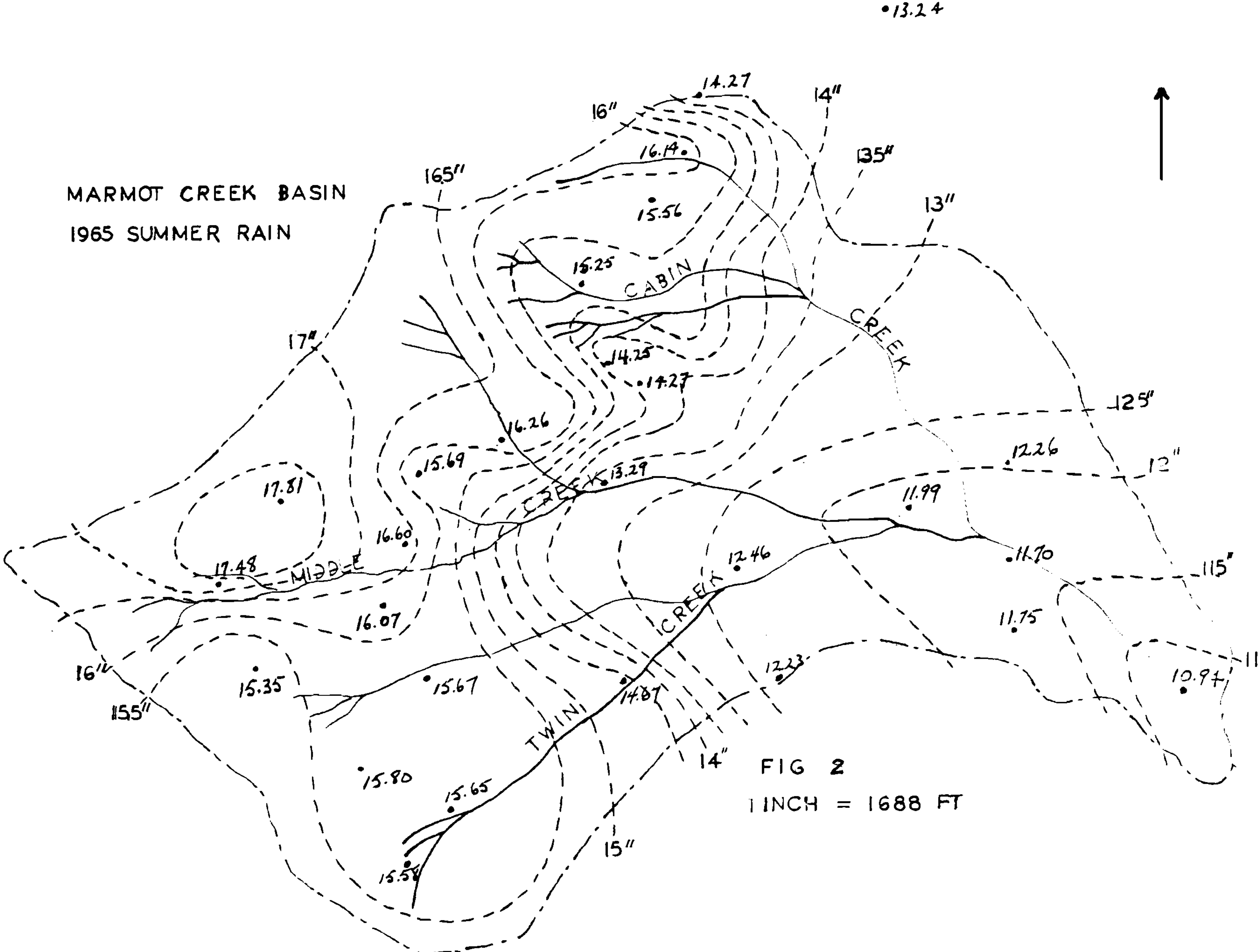

FIG 2
1 INCH = 1688 FT

total summer rainfall of almost seven inches in about $2\frac{1}{2}$ miles makes the rainfall maps in some climatic atlases seem very inadequate.

Snowfall measurements are a problem, and no final answer is in sight. Storage gauges undercatch by an unknown percentage because of exposure problems, and snow courses can't measure accumulated melt or evaporation. The best solution available is an approach that combines gauges and surveys.

The temperature pattern in summer is becoming established from thirteen hygrothermographs in Stevenson screens. Because of the access problem, we know practically nothing about winter temperatures or humidities.

A well defined valley wind has been noted at several places in the basin and documented on a few occasions (MacHattie, 1968; Munn and Storr, 1967; Storr, Tomlain, Cork, and Munn (under review)). It is of importance as a transport mechanism for heat and water vapor, but nothing is known about its frequency, areal variability or vertical extent. Also required is a wind analysis by direction and speed for periods of snowfall to aid in the design of forest cuts to trap the snow.

Net radiation has been observed above the forest canopy for four years, but the problems and frustrations that accompany radiation measurements of any kind have been experienced. Detailed maps showing theoretical spatial and temporal variations of clear-sky insolation have been prepared by Ferguson, Cork, Anderson, Mastoris and Weisman (in review), but have not yet been verified by actual observation. In the field, attempts will be made to measure all components of the radiation balance, but it seems clear that it will be necessary to resort to theory for some matters in order to produce detailed maps of net radiation. In 1967, an energy budget study produced some very interesting data on Bowen's ratio (for the apportionment of net radiation between latent and sensible heat) and its dependence on wind and weather conditions. If a replica of this study can determine the areal variations, if any, in the ratio we can use the net radiation map to produce a detailed daily map of evapotranspiration for the basin.

In the field of snow hydrology, we have derived a considerable amount of knowledge from 20 snow courses, but they do not give an adequate areal coverage of the basin, so supplementary measurements will be taken at a series of grid points. To help evaluate the sublimation of snow (especially under Alberta's famed chinooks) a project making periodic weighings of snow-filled pans will be started this winter.

CONCLUSION

I have tried to show the role of meteorology in watershed research in Alberta, using Marmot Creek as an example only. Some of the problems are sublime (sublimation of snow), others ridiculous (how to prevent porcupines from eating Stevenson screens). Of one thing I am sure--I don't have to look far for an unsolved one.

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THIRD ANNUAL CONGRESS

The Third Annual Congress of the Society was held May 27-29, 1969, at the University of Toronto. Congress Sessions were held independently of the Learned Societies this year, and demonstrated to a modest degree the growing maturity of the C.M.S. as a scientific body.

The facilities provided by the University were excellent. Scientific sessions and the Annual General Meeting were chiefly held in the Lecture Wing, McLennan Physical Laboratories; overlapping sessions, in the Undergraduate Wing. As meteorological providence (luck, that is) allowed, almost perfect summery weather blessed the proceedings and the bright,sunny skies heralded and presaged a triduum of meetings and activities, which were the most enjoyable and rewarding in the experience of the Society to date.

SCIENTIFIC SESSIONS

M.K. Thomas, President of the Canadian Meteorological Society, welcomed those attending the Third Annual Congress. He pointed out that this was the fifteenth such gathering,the first twelve having been under the predecessor of the C.M.S., the Canadian Branch of the Royal Meteorological Society. Furthermore, while the emphasis this year was on the applied aspects of the science, there was ample time set aside for research papers.

The first day of the Congress was given to the theme: "The Atmosphere as a Resource". The chairman for the morning session, J.R.H. Noble, introduced Dr. P.D. McTaggart-Cowan who was to deliver the theme paper: "The Role of Meteorology in the National Economy". Well-known to all present as former Director of the Meteorological Branch and President of Simon Fraser University,he is now Executive Director of the Science Council of Canada.

The speaker defined applied meteorology as the application of meteorological knowledge to any of man's economic or social goals or activities. In October, 1968, the Science Council published "Towards a National Science Policy", and he would use this as a frame of reference against which judgements could be made. A science policy can be defined as a strategy for assuring the ongoing health of science, and a strategy for the use of science and technology to reach social and economic goals and to assist in solving social and economic problems. Because of the success of applied scientific research during the past world war, the physical sciences had been emphasized while the social sciences had been ignored. It was now recognized that social scientists must form part of the scientific team applying science policy.

Dr. McTaggart-Cowan proceeded to list the national, social and economic goals--national prosperity, health, education, freedom, security, unity, increased leisure, including its proper use, maximum opportunity for individual development, world peace, and a decent environment (the latter his own addition to the list)--and showed how the application of meteorological knowledge, experience and skills could make a contribution to achieving each. In particular, he noted that Canadian industry should be encouraged to develop exportable capabilities. For example, Canadian meteorological instruments are among the best in the world, but few are being sold outside Canada. The government should be prepared to buy from private industry, if necessary lending skilled people to assist in setting up the manufacturing capability needed to start production. Another major point made by the speaker was that Arts students must be given some appreciation of science during their formal period of education, so that they may recognize that all scientists are not "lackeys of the military and industrial complex". Meteorology would be a good science in which to start because it relates to something that they can see and thus can be communicated to them more easily, than say, particle Physics.

The importance of applying meteorology to the planning of agricultural resources in Canada was emphasized by Dr. W. Baier, who stated that Canada was one of the few countries in the world with plenty of water resources and 40 million acres of land still to be developed. By combining climatic data, meteorological statistics and knowledge about plant physiology, it is now possible with the aid of computers, to estimate soil moisture, areas of drought, annual wheat yields and other quantities useful in studies of agricultural productivity. This can be of real help to supply the growing demand for food throughout the world. For example, soil moisture values, estimated from simple equations compare favourably with observed values; these equations may be used with climatic data as input instead of observed soil moisture data. Thus the potential utility of climatology may be realized in ways similar to this.

John Maybank represented nine other Canadian scientists in presenting an outline of a survey of weather modification as applied to Agriculture, which had been prepared for the National Committee on Agricultural Meteorology. Following a brief review of the conclusions which must be drawn from the work accomplished to date on the subject of precipitation modification,Dr. Maybank stressed several significant points: because rain cannot be induced any time, a drought cannot be ended any time; any possible increase in rainfall would not be a valuable asset in well-irrigated agricultural areas such as the Okanagan; in other places rain may or may not be beneficial depending on the crop, its stage of development, etc. But there will always be conflicts of interest whenever a rainfall increase helpful to one would be harmful to another; haying operations and grain-growing would conflict in this way. The timing of rainfall is also very important, as shown by a study made of the effect on prairie farming produced by increasing June precipitation by thirty per cent. Assuming that this rain could be created, only areas of southern Alberta and extreme south-western Saskatchewan would benefit significantly, but over large portions of this region, significant decreases in crop yield would result at the same time. As a final point, he stated that before any policy was established on attempts to modify precipitation distribution or type, other interests concerned, including those in forestry and recreation, must be consulted.

The socio-economic value of snow as a natural resource was discussed by Dr. G.O. Villeneuve of the Service de Météorologie de Québec. A unique information service on snow conditions prevailing across the Province really developed to a major operation just after World War II, from a modest start in 1940. This service was needed to overcome twisted facts, late reports and the rivalry between ski resorts for the best snow conditions. Currently, the Meteorological Service operates about 50 stations (climatological data) and observations from these are supplemented by snowcasts provided by ski monitors and instructors. Skiers are informed about the age, depth, condition, distribution of snow, air temperature, highway conditions, and special weather elements which may affect ski races, viz., sunshine and winds. Information is distributed, in co-operation with the Provincial Tourist Bureau, to airlines, stores, railways, Press, TV, and various cities outside Quebec (including 55 in the U.S.A.). The Sport of Skiing is a great source of revenue to the small towns and the whole Province. Cost of the service is borne by the Quebec Meteorological Service.

Session 1 continued in the afternoon with T.L.Richards in the Chair for the first three papers (before coffee), and F.W. Benum, for the last two. J.P. Bruce added to the sessional theme with his paper on "The Role of Meteorology In Canadian Water Resources Problems". He pointed out that in 1970, the estimated annual capital expenditures in Canada for dams, sewage systems, water works and the like will be one billion dollars, and that during the following decade this will likely double. Meteorology will have a major impact on most of these capital works. Of the other areas in the planning and management of water resources, he noted that the International Field Year on the Great Lakes (now being planned for 1971-72 on Lake Ontario),should help provide answers to some of the crucial problems.

D.K.A. Gillies next gave many examples of ways in which weather affected the capabilities of and demands upon electrical utilities. Among the former are the changes in the character of the run-off in spring; an obvious need exists to forecast reliably the critical time when this run-off increases rapidly. Other meteorological elements having critical effects on the operation of an electrical utility were discussed, including illumination, temperature and ice in the rivers.

Mr. D.W.Boyd outlined how the weather criteria in the building code evolved. Studies have shown that snow loads caused the critical stresses on roofs in many parts of Canada. Similarly, it was a combination of wind and rain that caused the most critical conditions of moisture loading for walls. Design rainfall for a drainage system has been established to be the maximum 15-minute rainfall with a 10-year return period. Calculation of heating and cooling requirements, and the turbulent effects of winds on tall slender buildings were other examples of problems in design which depended on meteorology for effective solutions.

The last two contributions for the day both dealt with weather and transportation. According to K.T. McLeod, the economic benefits of forecasting the main hazards of land transportation (snow, ice and fog), depend on reliability. Snow removal costs are high, e.g., $2 million for one particular snowfall in Montreal; $200 million annually for the snow regions of Canada. Construction and industrial labour deployment may be affected due to overtime, special duty crews, selection of equipment, etc. All forms of transport including pipelines depend on environmental conditions, such as, sharp falls in temperature. Specialized problems of the user must be identified before service can be provided by forecasters, but the necessary information is at present usually unknown due to a lack in communication. It is, furthermore, impossible to forecast the transportation needs of the future; however, for the welfare of Canada the meteorological services must change their functional structures to meet these needs.

The present and future transport requirements of the arctic were discussed by E.R.Weick,in his paper,co-authored with J.W. Hawryszko and R.J. O'Regan. The present transport system is a low volume, high cost, highly seasonal, unidirectional (to North) system. It was initiated by major military construction (especially DEW-line) and was makeshift in using dubiously adapted vehicles designed for other climates. A good supply system was required to support the northern communities which had no economic base. One side-effect of this was the change in Eskimo community patterns. The future transport system will be high volume, still costly, unidirectional southwards (mainly), with little seasonality, but employing better-designed vehicles. A new total transport system needs to be developed and this must include support of increased meteorological services to overcome environmental problems associated with weather. Large volumes of minerals will be transported by pipelines, hovercraft, under-ice tankers. The 113,000-ton USS Manhattan will voyage into arctic ice-filled waters this summer to test the feasibility of this method of supply. Problems of vehicles and pipelines ruining the permafrost, the natural courses of environmental run-off and the migration routes of animals may require new legislation. In the discussion at the end of the paper, it was stressed that long-period inversions common to the arctic may cause serious air pollution problems in the vicinity of active industrial sources.

There were concurrent sessions on Wednesday morning; Session 2 on "Turbulence and the Boundary Layer",chaired by Dr. A.W. Brewer;Session 3 on "Observations and Forecasting", chaired by H.H. Bindon. The first of these was re-arranged at the last minute because of the illness of Dr. M. Miyake, who was involved in the presentation of three papers, which were subsequently delivered by G. McBean, also of U.B.C. He described the BOMEX Project in general and outlined the many ships, aircraft and buoy facilities which had been brought together to stage the program. The boundary-layer aspects of the program were particularly emphasized along with the special instrumentation used by U.B.C. aboard the NCAR aircraft "Queen Air" to obtain certain flux measurements (work by Miyake and Donelan). His own paper described FLIP along with its instrumentation, but he pointed out the difficulty in removing from the observed data effects caused by the motions of FLIP. He also expressed disappointment that the air-sea climate experienced on-site was limited to 2 to 3 meter waves and wind speeds up to 10 meters per second.

Mr. O. Koren next described some wind profiles resulting from data observed by means of the 96-meter tower at Suffield. The power "law" profile fit the data reasonably well,but the log-linear "law" was generally better for near-adiabatic conditions than any other tested. J. McCallum read the paper by Johnson and Larson who analysed data measured on a mast at Suffield also; he then presented his own paper on the cloud-generation effects produced by the explosion of 500 tons of TNT; these effects were deduced from photographs taken at one-second intervals over an eight-minute period. E.G. Morrissey completed this session by outlining the limitations of an aircraft, both to serve as a platform for a wind sensor, and as a wind sensor itself. The response of the aircraft (and its pilot) to vertical wind components is the source of not inconsiderable errors in estimating these same components in various wavelength bands.

K.P. Thompson started Session 3 with his report on his work with Prof. A.W. Brewer at Toronto University to develop a vacuum radiometer. By measuring the downward flux in the IR rotational bands of water vapour, details of the stratospheric radiation budget may be determined. Novel features of the balloon-borne instrument package include: a liquid nitrogen cryostat for cooling the detector; an electronic computer to facilitate changes in gain every 8 seconds; and a special filter (polyethylene plus BeO and carbon black) to reflect selected wavelengths. Although the radiometer has been tested in the laboratory at temperatures down to -57°C, no flights have yet been made.

The application of remote sensing techniques to determine hydrological elements was next reviewed by A.D.J. O'Neill. Contact sensors on balloons and aircraft may be used to measure radiant energy and moisture fluxes, for example, while remote sensors on satellites (along with the equipment already mentioned) may be used to determine albedo, ice and snow cover, snow depth, break-up and freeze-up, soil moisture, thermal pollution, stream flow, water temperatures, and also the temperature and humidity structure of the atmosphere. Satellite photographs of mid-Canada were digitized for computer analysis in order to correlate actual albedo and snow depth measurements with those estimated empirically from the satellite observations. In this special study the estimated snow-line position in southern Saskatchewan/Manitoba was within 30 miles of the actual line; snow depth values were reasonably accurate for snow depths less than 4 to 5 inches.

The historical growth of the Meteorological Rocket Network (MRN) was outlined by R. Van Cauwenberghe in the absence of J.Ray, the author. Although there were no MRN rocket firings in 1959, nine countries are now actively engaged in making 2000 flights each year at 20 stations, including 2 Canadian sites (Churchill and Cold Lake; the latter has 3 firings per week). When approved, rockets will be fired at Resolute once each week starting in the Fall of 1970. Slow growth of the network is likely due to the high cost of each flight: $2000 for the ARCAS rocket, and about $1000 for the Boosted Dart. Current flights reach an apogee of about 60 km. Reflecting devices and instrument modules are tracked by radar: chaff and parachute give windspeed to within 3 m/sec; falling sphere, density to ± 2½%; and thermistors, temperature to ± 2°C.

H. Gerger summarized recent efforts made by Instrument Division of the Meteorological Service to improve the instruments required to measure basic weather elements at the surface. Particular mention was made of devices to measure precipitation, including the tipping bucket, the weighing gauge and the Fischer-Porter gauge. Even the common copper rain gauge has been simulated by a larger plastic container, which will eventually replace the existing network gauge at 3000 to 4000 stations. Problems involved in the remote operation of snow gauges was beautifully illustrated by a coloured slide showing one such gauge encrusted with a deep blanket of snow.

The ice observing and reporting program of the Meteorological Service of Canada was surveyed by E. Stasyshyn. This program requires the deployment of aircraft, training of observers and the publication of analyses of ice conditions. Canada is a world leader in ice observing. Modern navigational aids (ASTRO, LORAN, OMEGA) pinpoint flight positions of long-range aircraft; radar is used for in-cloud measurements. Shipboard and shore observations are limited to the determination of ice texture and thickness; satellites, to discover where ice is or is not located (low resolution cannot give necessary fine details). Other measuring techniques are being operationally evaluated, e.g., the laser, IR-scanning, and the panoramic camera.

Communication was the key-word in K. McGlening's paper which proposed changes in the wording and dissemination of public weather forecasts. The present ambiguous and complex language should be replaced by simple expressions and meaningful weather elements that actually merit comment to the users who are from every walk of life. He stated that words should be consistent with the layman's definition, e.g., "showers" should be replaced by "rain" as often as possible; also probability of occurrence would be desirable. Precise temperature values are fictitious and should be prefixed by "near" or "about". In order to distribute weather information effectively, there was a growing need to utilize, for example, auto-telephone systems, and assigned FM frequency bands for an exclusive weather radio network, all these, in addition to the regular means of Press, TV and Radio. Further discussion on this paper predicted that satellites and cable TV will soon be used for communication leading to print-out devices in each home and visual real-time display of weather information.

The final contribution to Session 3 was made by J.L. Knox who examined the need to introduce probabilistic factors into the public forecasts of precipitation. U.S. Weather Bureau has used these factors nationally since 1965, but not without unfavourable reaction; Ontario agricultural forecasts have just started to use them; British Columbia radio stations and agricultural interests would also like to use such a system to please their consumers or to plan activities. Mr. Knox outlined the basis for an objective scheme, incorporating NWP prognostics and statistical-climatological regressions, needed to calculate the factors. A special problem arises at Vancouver because of the extreme variation of precipitation over a small area, but this may be rationalized by using the concept of precipitation-days, which has little spatial variation. As yet a pilot project has not been set up to evaluate the feasibility of such a scheme, but its potential usefulness to the public makes it more urgent every day.

On Thursday morning, Sessions 4 and 5 on "Human Aspects" and "Pollution", respectively, were chaired by Prof. Hitschfeld and ran concurrently with Session 6 on "Dynamic Meteorology". Session 4 contained two papers. In the first of these, Prof. Burton outlined research appropriate to present-day "snow-managers"; past studies have been mainly meteorological and climatological, stressing physical factors, but the need now is for research to explore the economics and social factors involved in handling snow. Forecasts of the joint probability of snow amounts, winds, etc., are needed to plan intelligently proper courses of action. In this context, more data on the economic impact of snow is also required. Finally, a pilot study on human response to snow in Toronto (conducted via questionnaire) was described.

Dr. R.E.Munn introduced his paper on "Weather and People" by thanking Dr. McTaggart-Cowan for concluding that "biometeorology" was becoming respectable. Since biometeorology dealt with people, many scientific disciplines must become involved. As an example, he noted that comfort was a complex function not only of meteorology, but also of age, state of health, emotional state, adaptation, etc. This interaction was illustrated by reference to heat stress, damp cold and wind chill. His final point was that the resultant of two stresses applied simultaneously could not be predicted from the effects of each stress applied individually. This effect, called synergism, would always tend to complicate studies in biometeorology.

Mr. L. Shenfeld, who was the first speaker in the session on pollution, pointed out that before pollution potential could be evaluated, a complete knowledge of topography, type of pollutant, types of pollution, source, etc. was needed. To this date two divergent schools of thought concerning the meaningful evaluation of incipient pollution have developed. According to one school, the amount of pollutant in the stack is the critical factor, while to the other, only the pollution amounts received at ground level are important. In either case, only high pollution potential could be mapped from meteorological factors alone.

In presenting his paper on a study made in collaboration with C.I. Taggart, Dr. J. Clodman emphasized the menace of air pollution to human health,a problem which should be at the head of the list in public concern. Areal mean pollution concentrations for the eastern industrial U.S.A. and adjacent areas were studied by means of satellite photographs for three separate cases "carefully chosen at random". In the first case, the area of suspected pollution which correlated well with visibilities reported as less than 6 miles, was steadily dragged into the circulation around hurricane FAITH, and spread into mid-Atlantic where even after 3 days a large concentration of pollution could still be detected. All cases had weak circulations aloft with a stagnant high or ridge at the surface. These dynamic circulation features of low humidity (and water vapour) prevented outflow aloft and outscouring by rain. Thus, such a stagnant weather pattern remaining for weeks could accumulate extremely dangerous amounts of air pollution. Although this study did not positively identify the nature of the pollutants, circumstantial evidence discounts haze as a cause. Instruments are now becoming available, capable of discriminating between pollutants and other atmospheric constituents.

Another interesting study of air pollution and boundary layer conditions was reported by Dr. C. East of the University of Montreal. A helicopter was instrumented to record the SO_2 concentrations and the temperature profiles. By flying at speeds greater than 20 mph, the wake from the copter blades spread behind the sensor probes which were located below and in front of the vehicle. Thus the readings were undisturbed. It was found that the SO_2 was a maximum above ground in the morning, but moved upward in the afternoon, when it became more evenly distributed in the vertical,except that no SO_2 appeared above the inversion. Strong winds also distributed the SO_2 in the boundary layer. Very little SO_2 came from the countryside surrounding Montreal, but much from the oil refineries and the downtown area. Some striking colour slides showed the pollution hoods and layers overlying the city, as well as the streaming of well-defined rivers of emission from stacks and chimneys. One slide gave evidence that smoke above an inversion moved independently from the underlying smog, and stressed the importance of building stacks high enough so that pollutants may be emitted above the surface inversion layer.

Water pollution was also a subject of meteorological concern,according to Dr. R.A. Vollenweider, who showed maps displaying the yearly deposition of algal nutrients for northern Europe and the U.S.A. Phosphorous is one such problem nutrient occurring in such alarming amounts (50 - 100 mg/m^3 and more) that leeching by a single rainstorm can eutrophicate a lake that is not too deep. Industrial wastes, sewage and agricultural run-off are also major sources of these troublesome factors. There is a serious need to set up a good network to measure these chemical substances; no measurements have been made in Canada, and none since 1958 in the rest of North America.

Session 6 on the subject of Dynamic Meteorology was also labelled the "Montreal Session" because every speaker was, in one way or another, associated with McGill University or Central Analysis Office or both.

The session attracted only a minority of interest, presumably because research in dynamic meteorology is becoming so highly specialized that papers are generally extremely difficult to follow by those who are not actually working in this field unless extraordinary efforts are made by authors in their presentations. Notwithstanding this, and as was pointed out by session Chairman Dr. D.P. McIntyre, the range of applications is very wide and, in this era of computers, growing rapidly.

There were only two papers in which the author was effective in establishing a framework for application at the outset; these were the papers presented by Mr. D. Davies and Dr. J.H.S. Bradley. The listener who persevered was,in most cases, rewarded with an application somewhere during the presentation or during the discussion period. The main criticism of the session would therefore have to be that the authors did not, in general, take the theme of the Congress very seriously.

Dr. G. Paulin spoke on the calculation of the energetics of the high atmosphere. The application here seems to be the setting of standards for prediction models.

The paper by R. Asselin, presented by Prof. B.W. Boville, was a good example of a highly specialized study. It dealt with a quasi-geostrophic initialization procedure for numerical prediction. It was not made entirely clear in the paper whether the primary goal was to improve predictions, to shorten computation time, or to do both.

I.D. Rutherford spoke effectively on the very important problem of the upward propagation of disturbances from low to high levels of the atmosphere. Sudden stratospheric warmings are puzzling phenomena, and this study was an attempt to reconcile theory and observation by producing a similar effect through the integration of a simplified numerical prediction model.

Mr. D. Davies, 1968 winner of the CMS prize in Applied Meteorology, gave a progress report on his precipitation project. His numerical precipitation forecasting scheme, which operates in sequential mode with the baroclinic model, has been in routine use for 18 months. The accuracy of the second-day predictions are significantly inferior to those of the first day and depend on the accuracy of the 48-hour contour predictions. He summarized the main results of a pilot project on parallel operation, and discussed his current experiments to introduce a variety of physical effects into the CAO baroclinic model, also in a parallel mode of operation, with the objective of improving contour and precipitation forecasts simultaneously. An interesting point that came out in the discussion was that precipitation probability should be related to the statistical error in low-centre positioning capability of the model rather than to climatological statistics.

Second-generation meteorologist Susan Boville presented an interesting paper on a third-generation objective analysis method which involves the application of spherical harmonic functions to geopotential height observations. While fantastic errors were noted in sparse data regions, the quality of the analysis in dense data regions was comparable to that of grid-point methods. The method, while clearly not suitable for the analysis of data from the conventional network, shows great promise as an analysis tool to handle the vast amounts of geopotential height data which will soon become available from satellites through IR techniques.

Dr. J.H.S. Bradley delivered with skill and wit his paper on the characteristic pattern method of correlation field analysis. He demonstrated that the method has wide application in meteorology, including objective analysis. It was revealed during the discussion that the CAO objective analysis scheme could act as a suitable vehicle for testing applications to objective analysis.

Incorporation in the CAO scheme of a method for generating the relevant autocovariance fields, in conjunction with application of the characteristic pattern method, would leave no doubt as to the superiority of this scheme in relation to others. Another interesting potential application of the method is in the optimum location of new radiosonde stations, and this was also the means by which the National Environmental Satellite Center was able to solve for the 1000-mb geopotential in the Nimbus 3 global 3-D geopotential observations.

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INTER ALIA

20TH ALASKA SCIENCE CONFERENCE

The 20th Alaska Science Conference will be held August 24-27, 1969 at the University of Alaska Campus, near Fairbanks, under the auspices of the Alaska Division,American Association for the Advancement of Science. Conference symposia and panels will be organized around the theme "Change in the North: People, Resources, and Environment".

The focus of the conference is on requirements and effects of petroleum development, and their implications, with emphasis on the Arctic Slope; on the ecological impact of development; and on the changes taking place with respect to the native people of the north. Key issues to be dealt with include: what kind of development versus how much conservation, the economic and political basis for decisions about resources development, settlement of native land claims, and the integration of Alaska natives into the socio-economic structure of the state. The purpose of exploring these and other issues will not be to reach a consensus, but to evaluate existing knowledge,identify priorities and needs,and open the way toward more effective research and policy development in the future.

The conference will bring together social and physical scientists, representatives of government and industry, and affected and interested citizens. Participants will come not only from Alaska and northwestern Canada, but will include also those from the non-north who can bring new and better insight to those directly concerned with northern resources, environment, and people.

For information about submission of papers or attendance, write:

> Victor Fischer
> Conference Chairman
> 20th Alaska Science Conference
> University of Alaska
> College, Alaska 99701.

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LAPWINGS IN NEWFOUNDLAND

J.J. Moakler
Meteorological Service of Canada, Toronto

Early in 1966, while working in Gander, I became aware through a Halifax newspaper article that my native Island of Newfoundland had just recently (January) been invaded - by Lapwings - a species of birds whose natural habitat is in Europe and Western Asia, with normal migrations ranging from the Mediterranean to the Faeroes and the European arctic mainland; also that a previous large-scale migration to North America had taken place in December, 1927. Although my interest was aroused, the news cutting lay to one side for two years before my casual backfiling system disgorged it.

My own library contained a 1947 volume on Bird Recognition - Sea Birds and Waders - and from this I gathered that the Lapwings are about a foot in length, with rather distinctive colouring, and that flocks are generally very large. The volume made reference to an article by Mr. H.F. Witherby (1928) on "A Trans-Atlantic Passage of Lapwings".

A first step was to have a look at the weather systems over the Atlantic in December 1927. The surface charts showed a dominant low pressure system over the Atlantic in December, 1927, with a prolonged easterly circulation stretching from the British Isles to Newfoundland (Figure 1).

Next, I wrote the Editor of the Halifax Herald for some information from their 1927 files, but drew a blank.

As well, I wrote the Editor of the Evening Telegram in St. John's, Newfoundland, and sent along copies of the newspaper article that I had been hoarding, and copies of some December, 1927 weather charts. The Editor was kind enough to feature my request in his issue of April 26, 1968, along with my mailing address. (The Headquarters PR issue of IN THE PUBLIC SERVICE for May, 1968, carried the Evening Telegram article in its entirety.)

Shortly afterwards I received a reply from a former member of the Gander weather staff, and now living near Bonavista, Newfoundland. He had discussed the 1927 occurrence with older members of his community and learned that - "the Lapwings had shown up in Elliston just before Christmas 1927 and had all died off by mid-January when the unseasonable mild spell came to an end. Near our old homestead was sort of a marshy brook and this was one of their favourite feeding places. This area was always a hard knot for Jack Frost to overcome and it was not until mid-January that it succumbed. With this and similar feeding places gone, they quickly died off and many dead ones were found, particularly when the spring breakup came and the fishermen turned their boats to an upright position. The poor things had chosen that enclosed area, common to smaller fishing craft and known as the "cuddy", to rest and had there died of starvation and the cold."

From the several replies, my most welcome correspondent was Dr. Leslie Tuck, a Research Scientist with the Canadian Wildlife Service in St. John's, Newfoundland, who stated that Lapwings occur in Newfoundland with some regularity every two to three years, although the 1966 flight, and more particularly the 1927 flight, aroused considerable comment. He sent along on loan his copy of THE LIVING BIRD, an annual issued by the Cornell Laboratory of Onnithology, Ithaca, New York, publication date November 1, 1967. This book contained a very detailed and well-documented account entitled "Factors Affecting the Occurrence of the Eurasian Lapwing in Eastern North America" and written by Aaron M. Bagg, complete with a selection of weather charts for December, 1927 and January, 1966, and tables of occurrences dating back to 1883.

Dr. Bagg notes that in the 1927 migration hundreds of Lapwings reached Newfoundland while other birds reached Labrador, New Brunswick and Nova Scotia, and single specimens were obtained in Quebec and Maine. After the 1966 flight some thirty Lapwings were recorded in the vicinity of the Gulf of St. Lawrence.

The Author cites from some thirty-five pieces of literature dating from 1886 to 1966, and from numerous pieces of personal correspondence with ornithologists and knowledgeable bird-watchers on both sides of the Atlantic. His approach is both documentary and scientific, with diligent tracing of both supporting and conflicting evidence to particular sources.

He identified the Lapwing as a large Palearctic plover which breeds in northern and central Europe and in Asia, and he concentrated on that portion of wintering ground which included England, Wales and Ireland, as well as adjacent areas of continental Europe. He noted that it is a short-range migrant, although forced migration of wintering birds occasioned by severe weather, a so-called hard-weather movement, results in much longer migratory tracks. His source for much of the earlier documented evidence was H.F. Witherby, whose one article on the same subject was a reference in my own book on Bird Recognition, while other writers supplied additional material.

He quoted A.L. Thomson who had written in 1926 that "in severe winters the weather movements in west-central Europe give rise to an immigration of Lapwings on the southern section of the east coast of England, the birds afterwards spreading westward across the country".

Now and then these birds get into trouble as they move westward in hard weather, and they overshoot the coast of Ireland. Evidence, prior to 1929, showed Lapwings arriving in Iceland, where there were numerous records between September and March. North American sightings also fall within the period September-March, with the great majority of occurrences concentrated in the three months of November-December-January. Most of his records are from Eastern Canada, with Newfoundland as the focal point.

Witherby had noted that banding of nestlings revealed a tendency for Lapwings from Northern England and Scotland to appear in Ireland in late September and in October. For later in the season there is banding evidence that birds of continental origin were recovered in Ireland in Winter, so that Ireland appears to be the critical area in analyses of trans-Atlantic flights of these birds. One of the Lapwings shot at Bonavista, Newfoundland, on 27 December, 1927, had been banded in northwest England in May, 1926.

Witherby had concluded that for the period 16-20 December there was a very cold spell over much of England and Scotland, with the temperature remaining below the freezing point day and night. Because of the severely cold weather the ground was frozen and food difficult to obtain. The main body of Lapwings appeared to have departed northwest England about 7 pm December 19, bound for central or southern Ireland, and this move coincided with an exceptionally high easterly wind. Since the wind strength was close to, or greater than, the birds' air speed, the Lapwings could only continue downwind in an airflow which enabled them to travel 2,000 miles and touchdown in Newfoundland before exhaustion and starvation overtook them. There was a great deal of observer evidence as to the size and timing of the flock movements.

The author gives the Lapwings a flying speed of 45 mph, and from weather charts concludes they were in an airflow from the east at near 55 mph, giving the birds a ground speed close to 100 mph, and so allowing for the east-west crossing in close to 24 hours. In corroboration of the wind speed, the weather chart for 1 pm 20 December, 1927, carried two mid-ocean shipboard surface wind reports of 39 and 54 mph respectively, from the east.

Other weather maps provide sufficient circumstantial evidence to justify the belief that off-shore winds frequently drift migrating birds seaward, and that many of them fly downwind, in the direction of the airflow. Winter weather patterns, of such a nature as to carry numbers of

Lapwings to Iceland, develop relatively often over the years, far more frequently than patterns which carry them to North America.

During January, 1966, at the time of the second memorable trans-Atlantic Lapwing migration, it is significant that there appeared to be no Lapwing invasion of Iceland. Figure 2 shows the synoptic situation at that time.

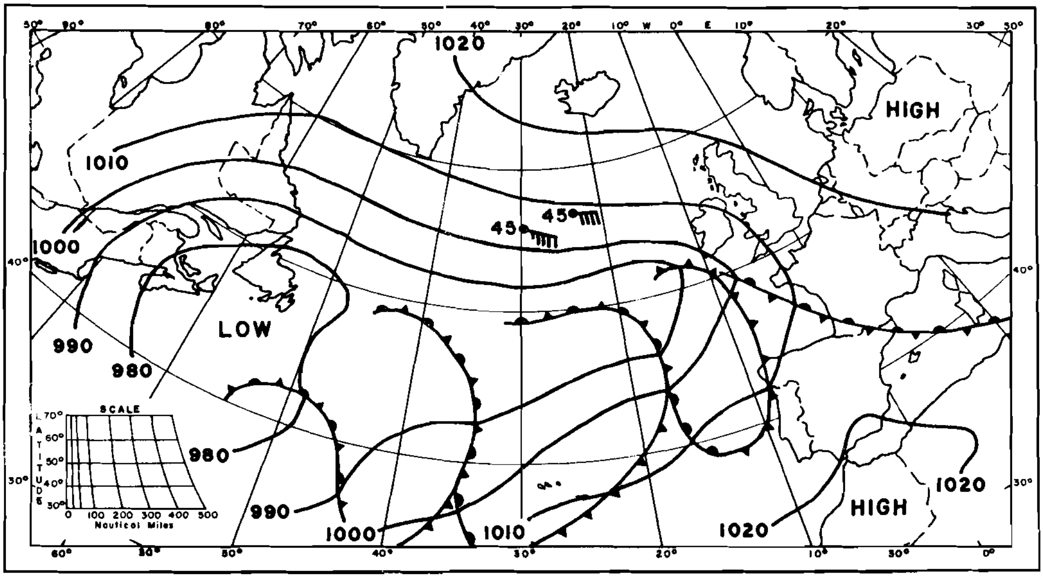

Figure 1. Surface analysis, 1300 GMT, December 20, 1927, including air temperatures in mid-Atlantic

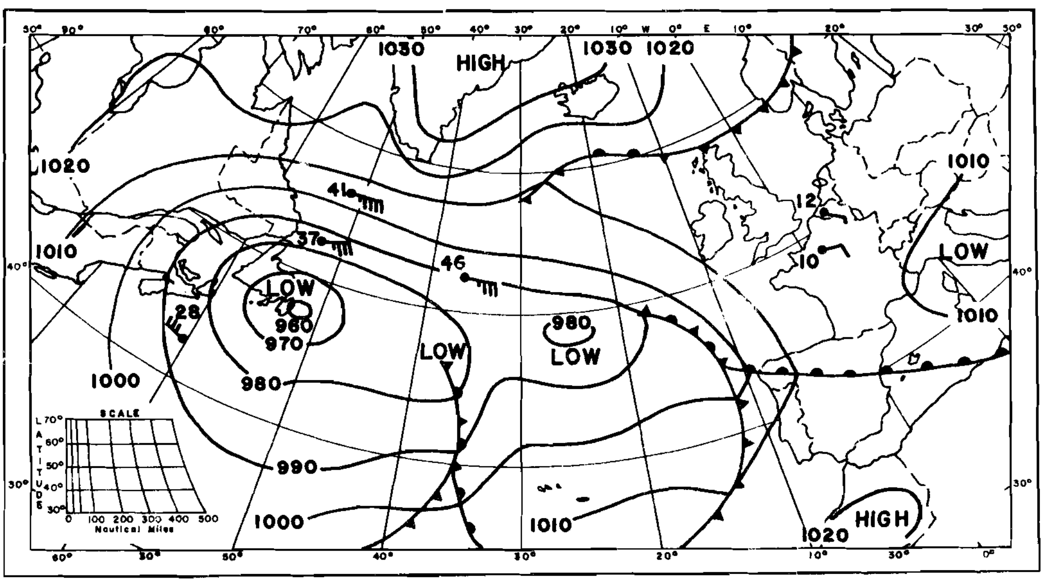

Figure 2. Surface analysis, 0000 GMT, January 18, 1966, including air temperatures over the Atlantic and in Western Europe.

THE WINTER OF 1968-69 IN THE LOWER FRASER VALLEY OF BRITISH COLUMBIA

By

Norman Green*

One of the severest winters on record in the Lower Fraser Valley, has just concluded. Based on the mean temperatures for December, January and February, only one (1949-50) was much colder, while another (1889-90) was slightly colder. January was the third coldest on record, just behind 1950 and 1916.

The past winter was unusual in several respects. A very long cold period occurred between December 26 and February 7, with severe cold for the first week. Heavy snow fell; severe drifting was experienced; and there was a record period of snow cover.

The first appreciable snow arrived December 21-22; 9.7 inches fell at Aldergrove. Over the next two days, 1.64 inches of rain almost washed the earlier fall away, but on Boxing Day, a severe outflow of Arctic air began. Snow was generally light with 2 to 3 inches at Aldergrove but many areas had none. With no snow for protection, serious damage to strawberries, roses and other susceptible plants was experienced and water pipes in many buildings froze. The temperature remained at or below zero Fahrenheit for 84 hours continuously with strong easterly winds blowing to add to the discomfort.

The three-day period, December 28 to 30, was the coldest in the valley since the record cold spell of January-February, 1893. On the 28 and 29, the temperature reached only 4 and 5°F respectively, while minima were below zero. On the 31st, temperatures moderated as a disturbance from the Pacific brought over 15 inches of snow in 17 hours. Light

*Mr. Green has been a co-operative climatological observer since 1953. His station is 5 miles north of Aldergrove, 30 miles west of Vancouver Airport near the geographical centre of the Lower Fraser River Valley. He has built up a large personal library of climatological data, and is very interested in comparing the current weather with unusual past occurrences.

freezing rain over the next 36 hours made roads almost impassible,giving rise to the quietest New Year ever.

Heavy rain began on January 3, and 3.26 inches fell in 32 hours. The temperature reached 49 degrees on the 4th, and the mild, wet weather reduced snowcover to about 5 inches by the morning of the 8th. A further 10.7 inches fell that day in the start of a 13 day period with a total accumulation of 42.4 inches. Maximum depth of snow on the ground was 26 inches on the 16th and 17th. On the 19th, a further 5 inches fell, and because of strong accompanying winds, the drifting was so bad that roads again became impassible. The remainder of the month was dry, but winds continued moderate to strong, with a continuation of some of the worst drifting ever experienced in the valley. Maximum temperatures remained below 20°F for the period January 26 to 30, with minimum temperatures between the 22nd and the 30th below 10°F on seven of the nine days. Coldest reading during that period was -3°F on the 23rd.

Many of the schools to the east of Aldergrove were closed for up to 3 weeks because the buses could not operate. Milk tank trucks had extreme difficulty in making their much-needed calls to area farms. For the first time, snow-blowers were brought in from the interior to clear district roads; they could make little progress until the winds dropped off on January 31.

Daybreak on February 1 was cold, with a temperature of 12° at Aldergrove. The day however, was sunny, and the temperature rose to 42°, normal for the date. The real cold had ended, and while more snow was to fall, there were no more Arctic outbreaks, and no day failed to reach at least 39°F. Last appreciable snow fell on February 7, when almost 6 inches accumulated in 7 hours. The depth of snow on the ground climbed back to 21 inches, but an inch of rain over the next week accompanied by above normal temperatures gave the melt period a good start. Because the rest of February was dry and sunny with frequent frosts, the thaw proceeded without flooding.

Several records of note were established. The old records are shown in brackets.

Lowest December temp.	-4°F on the 29th	(-2°F in 1964)
Lowest January temp.	-3°F on the 23rd	(-1°F in 1952)
Coldest January (mean)	23.3°F	(26.4°F in 1957)
Longest period below freezing	14 days, Jan. 18-31	(11 days in 1954 and 1964)
Most frosts in one month	30 January	
Most consecutive days with snow on the ground	72	(57 days in 1964/65)

The winter snowfall was the second highest on record, 91.6 inches; average is 37 inches. The record was 96.3 inches in 1964/65. With a snowfall over twice average in 1965/66, the Lower Fraser Valley has experienced three extremely snowy winters in the last five years.

The heavy snow loading on buildings, fences and other structures caused considerable structural damage. Agricultural losses were high, both due to frost damage to crops, and the failure of tank trucks to reach farms during drifting. There was much time lost from work; mills and logging camps had to remain closed for appreciable periods. All in all, the residents in the valley are not unhappy to see this past winter over, and hope that they will be spared such severe conditions for a long time in the future.

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MEETINGS

TORONTO CENTRE

On March 25, the Toronto Centre was privileged to hear a talk by Professor J. Tuzo Wilson on "The Current Revolution in the Solid Earth Sciences". Prof. Wilson, who is Principal of Erindale College, University of Toronto, was introduced by Prof. A.W. Brewer. With the aid of colour slides and cardboard models, the speaker demonstrated the principles of the theory of continental drift. The "current revolution" referred to is, in part, a result of the fact that the existence of the world's largest mountain system has stimulated new thinking since it was recognized only eleven years ago. This mountain chain is composed of ridges in the mid-ocean floors. It is 40,000 miles long and in places 3 miles high. Dr. Wilson touched on some of the common interests shared by solid earth scientists and meteorologists, including climatic change, the earth's magnetic field and the applications of Lagrangian and Eulerian mechanics. Prof. Wilson is the owner of a Hong Kong Junk called "The Mandarin Duck". The Chairman of the Toronto Centre, Mr. Roy Lee, in thanking the speaker, presented him with a model of a duck bearing the inscription, in Chinese characters, "May you always make good progress with fair winds".

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MONTREAL CENTRE, FOURTH MEETING 1968-69

On January 28, Dr. J. Brown of the National Meteorological Center addressed the Montreal Centre on the subject HYDRODYNAMIC INSTABILITY OF THE QUASI-GEOSTROPHIC ATMOSPHERE.

Dr. Brown presented the results of experiments he has performed concerning the instability of zonal wind systems with respect to perturbations which are constrained to be quasi-geostrophic in nature. Since analytical techniques fail in all but the most simple cases, the problem was approached as an initial value problem, rather than as an eigenvalue problem. This method has the disadvantage of only giving the most unstable mode. Among the very interesting results that were obtained was that the B-term not only stabilized the long waves, but also destabilized the short waves.

Since the zonal flow systems have horizontal shear,there also exists barotropically unstable waves. Under certain circumstances there were two wavelengths of maximum instability,the longer associated with barotropic instability.

P.E. Merilees
Chairman, Montreal Centre

MONTREAL CENTRE, FIFTH MEETING 1968-69

Dr. M. Garstang addressed the Montreal Centre on February 26. The subject of his talk was THE BARBADOS EXPERIMENT.

The purpose of the experiment was to observe the fluxes of energy in the lower atmosphere and to study their interaction with meteorological phenomena of various scales. These interactions are very important because the energy fluxes in the boundary layer are the most significant source of energy to the atmosphere.

A very comprehensive and elaborate observational program was undertaken to obtain data from the micrometeorological up to the planetary scales. Both meteorological and oceanographic parameters were measured from instrumented aircraft, ships, buoys, towers, balloons and kites. Weather satellites and radar gave added information. A very stable type of buoy was used to obtain accurate measurements over sea.

Dr. Garstang explained that only a few preliminary results were available as the analysis of this massive amount of data was not yet completed. The implications are highly significant. Indications are that the latent and sensible heat fluxes are much higher than expected. Also the measured long wave radiation divergence differs systematically

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FINAL REPORT OF PROJECT MAMEX

Gratefully submitted to the Canadian Meteorological Society, Montreal

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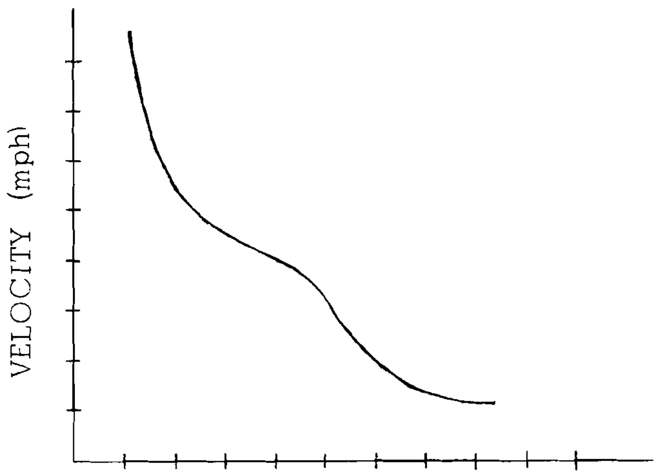
Enlightened and inspired by their first exposure to meteorological research activities (they attended the February meeting of the Montreal Centre, at which Dr. M. Garstang of Florida State University spoke on the Barbados Meteorological Experiment (BOMEX)), two gay young visitors, Martha and Mandy, teachers from the USA, applied their holiday technical enrichment to the following report, describing their return trip by car to Connecticut. The Montreal Centre is pleased to have this evidence of the success of our meetings in bringing advances in the atmospheric sciences to the attention of the layman.

PURPOSE:To calibrate and digitally compute the total vehicular displacement in an unstable field from Montreal, Quebec, to Glastonbury, Connecticut, on 27 February, 0900 to 27 February, 1600, with an eye to minimizing pitch and roll.

REPRESENTATION OF LEVELS OF INSTRUMENTATION: The total system of sonic anemometry relied on the radiometer to parametize the drop sounds. In addition, the 20 centimeter tracking towers were the mainstay of the 10 cc acquisition system. Thus, using co-spectrum techniques the system was able to collect untampered data in an orbital fashion, without the need to dust the tape. The high-frequency albedometer gimbeled to the thermometer yielded the flux values of the latent and sensible heat, which were ambient. As our back-up system (15% of total cost) ambulated, we untethered the nuclear buoyant balloon to calibrate turbulent states in the interface. However, as we neglected to interrogate this aerial system, the data are unknown.

PROCEDURE: After painting the town red and giving our colleagues a brisk digital display which they returned, we painted the runway white to the border where an anomaly occurred in the form of a cross-gradient divergence on a mean and nasty trajectory giving rise to an M-33 Complex which left the experimenters .989 on the adrenalin scale. We lacked the proper equipment to read the stress in CGS units. Awaiting data from Florida State University which we will forward. However, we measured a discreet heat change produced in the total systems of MAM (Martha and Mandy) which was measured at 2 degrees per 1000 feet all the way up the mean and nasty trajectory. We were given security clearance to continue experimenting and in order to influence the total atmospheric structure more positively, we painted the runway black south of the U.S.-Canada border. In this new terra firma environment, the lack of ground clutter (as indicated in near-surface measurement) positively correlated with the forward motion velocity of our little red car. This conclusion is illustrated by the figure below which articulates the lapse rate of the multiple quasi tropiquars.



It might be expected that Ellsaesser would pooh-pooh the idea as it is contrary to his time series resolution of the sub-cloud area on the leeward side of the trade winds. However, our theory supports Gilley, Rogers, Jacobs and Shapley in their various explorations of the climatological effects of pronounced diurnal fluctuations. The black runway did not prove to be the total solution as we encountered an organized atmospheric disturbance which left mean splatters on the windshield.

CONCLUSION:The experiment was concluded to our satisfaction upon arrival at pre-determined terminal point. Progress was made at the rate of 346 Langley's per day in spite of the resistance. The formula used in our digital analog computer for determining Resistance: GC = Ground Clutter, VWP = Vertical Wind Pressure, SCV = Sub-Cloud Velocity, PN = Precipitation Network, R = Resistance.

$$R = \frac{\Sigma GCg \times \frac{1}{2} VWP + \int SCV^1}{\sqrt{PN}}$$

The thermal tests indicated that we had lost our jazzy carbon strip hydristors due to momentum exchange. The deployment of the Miser scale indicated that the quasi-steady state field trades were uniform in relief. Therefore it can be said with reasonable accuracy that it rains at night at least one-half the time on the Barbados.

The authors will gladly entertain written comments on questions pertaining to the validity of the document. Letters must be postmarked on or before midnight 10 March, 1969. All queries must be accompanied by a self-addressed, stamped envelope.

Respectfully submitted,

Martha and Mandy

In an effort to preserve the relative non-technicality of this report, we respectfully include a selected glossary to terms used herein:

Total system = thing

mean = evil

representation = look

interrogate = ask

articulate = show

digital display = wave bye-bye

anomaly = goof

cross-gradient divergence = skid

untether = cut the string

pooh-pooh = foreswear, denigrate, heap derision upon

trajectory = way

Organized atmospheric disturbance = snow flakes

References:
Project BOMEX

c/c
ICAO, att. Schwarz
U.S. Weather Service
Library of Congress
FSU, attn. Garstang
McGill University
Glastonbury Public Schools
American Meteorological Society
Frank Blair, c/o NBC
Gordon Barnes
Ripley's Believe It or Not.
Playboy
True Confessions
Readers Digest (Unforgettable Incident Dept.)

Movie rights have been sold to Darryl F. Zanuck under the title "Sex and the Naked Ape",starring Desmond Morris and Raquel Welch, to be premiered the week of 22 April at the Cafe Martin, Montreal, P.Q., Canada.

EXPERIMENT IN POLLUTION TRANSPORT DURING PEEL COUNTY CLEANER AIR WEEK CAMPAIGN

M.S. HIRT[1] AND S.E. DINNING[1,2]

INTRODUCTION

The transport and dispersion of air pollutants from a point source such as a smoke stack can be approximated by the motion of a large number of balloons released simultaneously from a selected site. during their Cleaner Air Week Campaign, Peel County, Ontario, released 200 balloons a day during the period of October 23 to October 27, 1967, inclusive.

The balloons used in this experiment were No. 16 paddle balloons, inflated with 50% helium and 50% nitrogen. Attached to each balloon was a postcard with return address so that the finder could inform the Peel County Air Pollution Control of the date and location at which it was found. When released, the balloons appeared to level off at a height of about six hundred feet.

From the one thousand balloons released during the week of the campaign, fifty cards were returned. These cards were sorted as to date and time of release.
Surface and 850 mb charts from the Central Analysis Office in Montreal were used to relate the large-scale weather patterns to the motions of the balloons. Vertical temperature profiles were obtained from radiosonde flights at Buffalo, New York, on October 23, 24, 26, and 27. Data from the meteorological instruments on the 200-ft. towers at Sarnia, Hamilton, and Ottawa were also consulted.

RESULTS

The locations where the balloons were recovered from each of the releases were plotted on a single map (Fig. 1). It is interesting to note that under large-scale weather changes for the above five-day period, the balloons were fairly well-dispersed over the entire eastern

1. Meteorological Service of Canada

2. Visiting University of Waterloo Co-op Student

part of Ontario, western Quebec, and northeastern United States. The synoptic influences occurring during the above 5-day period were related to the balloon trajectories.

There were 18 cards returned for October 23; the release took place in Brampton. As can be seen in Fig. 1, the balloons were found along a line from Stouffville, just northeast of Toronto, to Farelton, just north of Ottawa, in Quebec.

On the next day two releases were made. The noon release from Clarkson, and the 1600 EST release from Port Credit. The six balloons recovered from the 1200 EST release all landed relatively near the launch site, the farthest landing at Uxbridge, approximately 50 miles away. The five balloons from the 1600 EST release, however, were scattered fairly closely along a line running northeast from the launch site for about 140 miles.

On October 25, two releases were made, one at 1400 EST from Streetsville and the other at 1845 EST from the intersection of Mississauga Road and the Queen Elizabeth Way. There were, respectively, three and eight returns. The three returns from the 1400 EST release were found about 150 miles from the release site and widely separated laterally. The results from the latter release, however, seem to follow a curve extending northeast to north from the release site (Fig. 1).

On October 26 there were only three returns. The balloons travelled almost due east across Lake Ontario. All three were recovered in the United States, the farthest approximately 330 miles, near Hancock, Vermont. On the next day there were seven returns from a late afternoon release. The farthest return was from the Lake Nipissing area, approximately 150 miles north of the release site.

COMMENTS

With each of the above releases, the directions of the surface and upper winds were very nearly the same. The balloons were all carried along in the general direction of these winds.

Inversion conditions were most prominent on the morning of October 23, although it is possible that the inversion had broken down due to daytime heating by the time of the release. Under these conditions, the balloons travelled with very little lateral dispersion. On the following day the inversion broke down more completely. The inversion re-appeared on the 26, but following the passage of an occlusion on the 27, lapse conditions existed.

The balloons released on October 24 were either brought quickly to the ground (1200 EST release) or widely scattered (1600 EST release); on

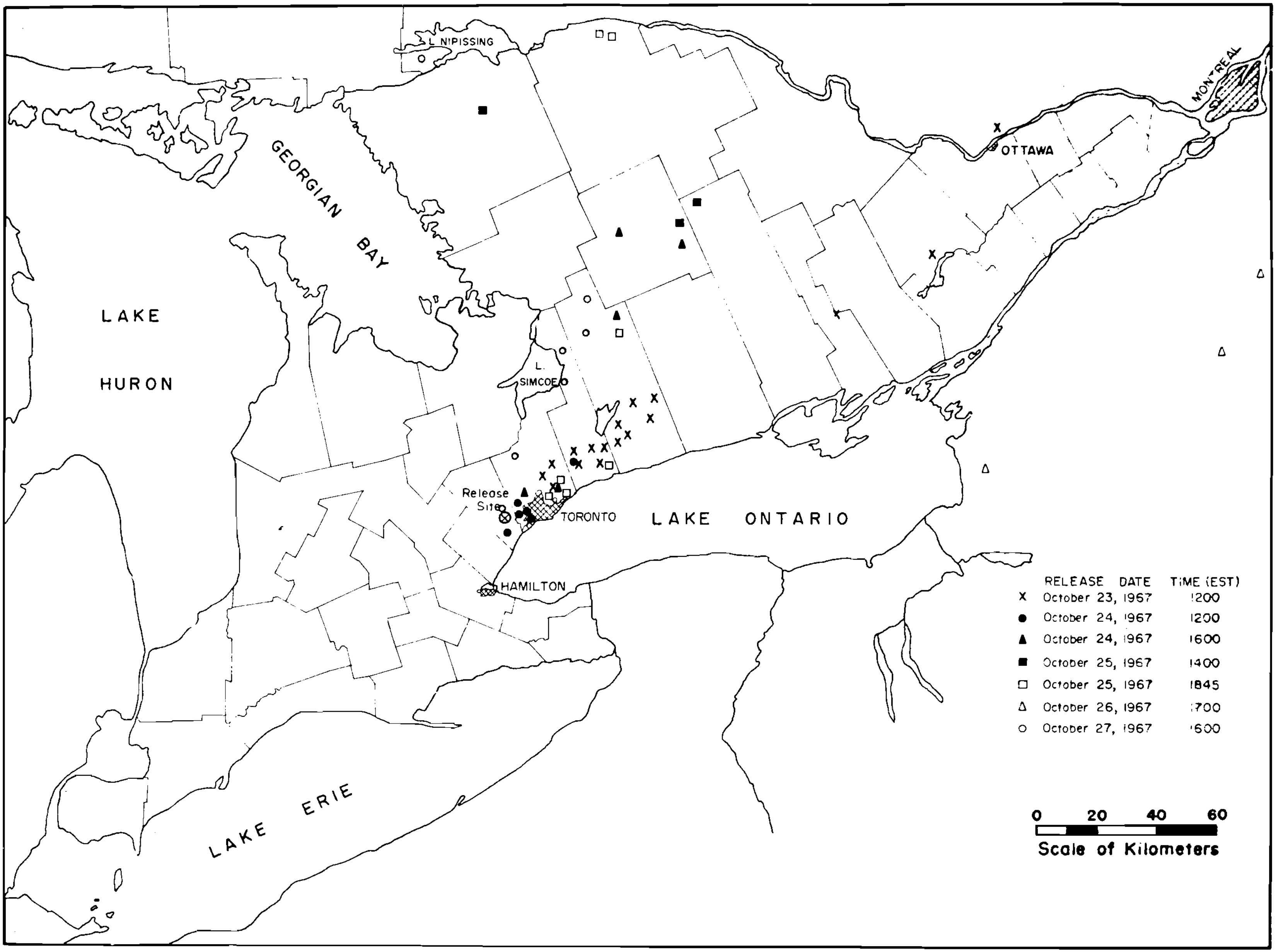


Figure 1: Composite map showing the release site of the balloons and the locations where the balloons were found.

the 26 under stable conditions the balloons travelled with the mean flow with very little scatter.

CONCLUSION

The main results of this experiment are the observations that the direction in which the balloons travel is the same as the direction of the wind which carried them; with stable conditions dispersion of the balloons was at a minimum; with lapse conditions turbulence either brought the balloons quickly to the ground or dispersed them over a wide area.

The small number of balloons returned to the authorities is not a large enough sample to estimate the statistical characteristics of the total population with any confidence. There appears to be a strong correlation between the number of returns and the population density of the areas over which they were carried. Finally, the temperature profiles are for Buffalo, New York, and may not be entirely accurate for the release areas in Peel County.

ACKNOWLEDGEMENT

We would like to thank Mr. Sydney Newdick who was in charge of the Peel County Clean Air Week and who provided the data.

INTER ALIA - continued from Page 66

from the calculated. The sign of the low-level mass divergence over the island is opposite to what is expected from a simple heat-driven system.

The complete results of the analysis should be most interesting. The observational program will continue in the summer of 1969 to support an ESSA sponsored project.

S. Woronko
Secretary, Montreal Centre

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On Thursday afternoon parallel sessions also continued. Mr. D.M. McMullen was chairman of Session 7 on "Climatological Analyses" which consisted of three papers. "A Hailfall Climatology of Southern Alberta" by A.H. Paul was presented by R. Lawford. This paper noted marked regional differences in the character of hailstorms in Alberta, e.g., in the southern section, the median hail day (June 29) occurs 13 days earlier than that in the middle region.

Mr. S.I. Solomon discussed extreme value statistics, which had been broached at some length on the first day of the Congress. But his main topic dealt with the estimation of hydrologic parameters from climatological analysis. For example, river flow had been rather successfully synthesized with the use of precipitation and temperature data. However, the hydrologic picture was complicated by the non-stationarity of many of the climatic fields. Forest fires and urbanization are just two of the many factors which produce trends or sudden jumps in the values of the hydrologic variables.

In the last paper of this session, Dr. Reinelt remarked that precipitation was certainly affected by the presence of higher ground, but that Alberta was in the rainshadow of the Rockies only in winter. Moreover, significant precipitation was caused by upslope conditions on the east side of the mountains.

Three papers were also presented in Session 8 on "General Meteorology". Mr. C.M. Penner was chairman. Prof. B.J. Garnier of McGill University outlined an empirical approach to compute potential evapotranspiration, Ep, which he defined as a function of three factors: the radiation budget, which depends mainly on the net radiation at the surface; the turbulent energy required to remove moisture, which is a function of wind speed and surface roughness; and the resistance to the removal of moisture (stomata, for example), a property depending on the vegetative cover. The first and major factor can be calculated fairly simply on a topographic basis, while the other two may be replaced by suitable topoclimatic indexes which serve as small corrections to Ep. In order to estimate Ep meaningfully, topographic calculation should be used rather than simple interpolation between widespread observing stations. Such a method precludes the need for a dense network of radiation stations, and wards off the danger of becoming data mad (compared with 19th century scientists who discovered much with little data).

In describing his studies on the hourly pressure data for Alberta and B.C. stations, Prof. R.W. Longley started by saying that they were of no practical value. This,perhaps, is a very modest claim, since even for the research worker there is "Scientia gratia Scientiae". At any rate, his analyses showed that maximum and minimum pressures occurred daily at 10 a.m. and 4 p.m., respectively. Diurnal pressure changes have amplitudes in central B.C. of 1 mb in January, but more than twice that in July. There are smaller changes with altitude. Fourier analysis yields a 12-hr. wave with its maximum pressure occurring four hours later than that for the 24-hr. wave.

Preliminary results of a study of circulations in vertical planes normal to fronts, were reported by Dr. G.V. Rao. A simple numerical model was developed to incorporate local flow parameters which may be measured from synoptic-scale charts, e.g., pressure gradient in the warm air, speed and slope of front, and potential temperatures in the cold and warm air masses. Only flow in the transition layer was considered. Calculations were made for an ana-frontal situation (more ascent in the warm air) when a warm front passed through Shilo, Manitoba in November, 1963. The vertical motions consisted of rotating cells above and below the frontal surface. Double theodolite measurements have yet to be examined with reference to the passage of a cold front.

The finale to the Congress was a panel discussion in Session 9 on "The future of Applied Meteorology". Panel members spoke for about ten minutes each, and helped generate the animated discussion which followed from the floor. The first panelist, G.A. McKay offered the quotation: "Operations without research is blind. Research without purpose is sterile", which he off-handedly remarked as being the words of one J. Stalin. Mr. McKay went on to state that applied meteorology was on the threshold of an explosive growth and had an infinite potential, in that meteorology was so vital in everything we do. This growth is not controlled by meteorologists alone, so that cross-discipline co-operation is necessary among many groups including economists, sociologists, etc. Meteorologists must bear part of the blame if benefits from their own research experience have not been passed on to these other disciplines. As Prof. Hare stated in his address at the Annual Dinner, we must now take an active role in society. One of the reasons we must do this is to demonstrate how meteorology fits into national, social and economic goals, because otherwise,we shall be unable to convince government that our research deserves financial support. There are several logical steps in doing this. We must get out of our self-imposed ghettos, and place a greater emphasis on consulting roles. We must keep up with instrument developments. We must move along in the educational field. Furthermore, we must become better organized, and establish priorities, since spreading funds across the whole field of activity only leads to fragmentation. We must improve our data processing techniques and output formats so that our work may be utilized more easily by others. Finally, meteorologists must help shape science policy, and the C.M.S. should promote this course of action by issuing policy statements.

Prof. Walter Hitschfeld followed next with the statement that before we can do these things we must decide why we are in meteorology and firmly establish the real aims of meteorology. He noted that meteorologists are on the threshold of a break-through, and are now very close to solving some very big problems. For example, we now have the ability to incorporate some very high-class technology into our research to handle enormous amounts of data and to observe hitherto inaccessible regions of the atmosphere (e.g., the tropical stratosphere and the interiors of thunderstorms). Prof. Hitschfeld wondered whether or not a meteorologist could really participate in inter-disciplinary projects. Meteorological input must definitely be provided to these undertakings, but he felt that we must be very careful how we become involved in them.

Dr. J. Maybank claimed to have detected some fuzziness in the definition of applied meteorology. He felt that there were really two distinct cases: applied (as opposed to fundamental) meteorology within the discipline of meteorology; and applied meteorology as it relates to another science. It is possible for a meteorologist to have good scientific rapport with a scientist working in another field, but it would be better if each shared knowledge of each other's discipline. The C.M.S. should encourage inter-disciplinary training at universities, but not to the extent of forming students to become experts in more than one science, but rather to obtain an appreciation of sciences allied to his own specialty. The C.M.S. should encourage diversified membership from the allied research fields requiring meteorological input.

Mr. J.P. Bruce, the final panelist, noted that (earlier in the Congress) Mr. Gillies had stated that meteorologists, to be effective, must work right inside industry. In water resources research, considerable work is currently being done by contract with outside consultants, who have inter-disciplinary experience, whereas in meteorology little of this has been done. Such a system is good for the economy in developing independent expertise outside the government that can be exported. Furthermore, we should be selective in employing our capabilities, by concentrating on those areas in which we can make a real contribution and by ignoring the trivial.

The ensuing discussion from the floor was, to say the least, spirited. Dr. Clodman suggested that we are mis-using a lot of our meteorologists in operations. They could be released for work in applied meteorology after being replaced by computers to do the forecasting. Mr. Muller proposed that we should draw up an inventory of our skills for the information of other scientific professions as well as the public. Dr. Bradley noted that the U.S. Weather Bureau in re-organizing its functions had ended up with much surplus staff, and had successfully re-educated them. In this regard, all scientists should recognize the need for continuing education throughout their careers. Dr. Maybank thought that the education process had been helped by the Congress, but not by meetings at some of the C.M.S. Centres, perhaps because these latter were in-house gatherings. Therefore, local meetings should be well publicized to attract interested scientists outside the field of meteorology. Dr. Munn pointed out deficiencies in our supply of data available for research, particularly in regard to the urban environment. Finally, Dr. McTaggart-Cowan re-affirmed two ideas from his key-note address. Firstly, the Canadian Meteorological Society has a great role to play in planning the strategy for the health and development of meteorological science; and secondly, we must concentrate on those activities that we should be able to do more competently in Canada than anywhere else, e.g., dealing with problems of the cold weather environment.

The chairman finally closed the panel discussion and the Congress with the statement that it had been one of the best to date.

ANNUAL GENERAL MEETING

Following the busy first day of scientific papers, members assembled in the New Physics Building at 7 p.m. on Tuesday evening for the Annual Business Meeting. The opening remarks of the President, Mr. M.K. Thomas, held out hopes for an early adjournment, so that the festivities of the scheduled wine and cheese party could be enjoyed at the earliest moment possible. But even this expectation could not dampen some of the lengthy discussions generated by the reports and motions presented during the meeting.

Approval was given to the Minutes of the Second Annual General Meeting, to the reports of the Executive Committee, the Treasurer, the Nominating Committee, the Editor, the Local Centres, as well as to the proposed amendments to the By-laws.

In the discussion on the Report of the Editor, a motion to discontinue the practice of providing fifty free reprints to authors was carried. After considerable discussion about the 1970 budget as proposed by the Treasurer, an amendment was moved from the floor to change the fee structure. This motion was also carried, so that: members fees are increased to $8.00; there are now two classes of student membership and fees, viz., Graduate Student Member, $2.00 and Undergraduate Student Member, $1.00.

The president stated that further growth of the Society was necessary in order to obtain funds to provide paid assistance to the Executive. He therefore requested that a Society Development Committee be appointed, comprising members from the Meteorological Branch, the Universities and Private Industry. A motion to form such a committee was accepted by the members.

The Meeting was adjourned at 9:20 p.m., and members attended the long-awaited and highly enjoyable wine and cheese party in the faculty room of the New Physics Building.

ASSOCIATED EVENTS

Mid-way through the Congress sessions, three happenings produced informative and entertaining changes-of-pace. On Wednesday afternoon, many members attended a show entitled, "Mars, Planet of Mystery", at the McLaughlin Planetarium, and toured the meteorological laboratories in the New Physics Building. Laboratory research was concentrated in the fields of U.V. sky spectroscopy and cloud physics. For the studies of clouds and hail the extensive equipment included a cold chamber and wind tunnel to investigate the freezing of droplets, and liquid and wind tunnels, to study idealized models of hailstones.

In the evening the Annual Dinner was held in the Great Hall of Hart House following a social hour in the Quadrangle. At the Banquet the President's Prize was presented to Prof. A.W. Brewer, Past President of the Society; the Prize in Applied Meteorology, to Mr. D. Davies; and the Dr. A. Thomson Undergraduate Student Prize, to Mr. I.R. Graham.

Another highlight was the presentation of the Patterson Medal Award for 1968 to Dr. Warren L. Godson, Superintendent of Atmospheric Research, Meteorological Branch. Dr. D.P. McIntyre presented the award on behalf of J.R.H. Noble, Director of the Meteorological Branch, who was in Geneva.

Speaker at the Dinner was Prof. Kenneth Hare who recently joined the Geography Department at Toronto University. He reiterated one of the major ideas stated by other speakers at the Congress, namely, that the scientist must become involved and take his place in present-day society.

INTER ALIA - continued from Page 73

IN APPRECIATION

Several members of our editorial staff have resigned after contributing many years of service to the task of publishing "Atmosphere" for the benefit of all our Society members. Derek Aston has helped with the proof-reading; Dave Carr, with the distribution and mailing; Des O'Neill, with the general administration and day-to-day responsibilities required to keep the whole operation running smoothly.

We are grateful for their enthusiasm and devotion to tasks which are in a sense unrewarding because unseen, but also fulfilling because necessary in a successful publication effort. Best wishes to each and all in their future endeavours.

NOTES FROM COUNCIL

The following were elected to membership at the April 2, 1969 meeting of Council:

Member	Student
John H. Junson	John J. Pellegrini
Allan Hunt Murphy	
Raymond J.A. Perrier	
Prem Shanker	
Val Vitols	

The following were elected to membership at the April 29, 1969 meeting of Council:

Member	Student
Ronald W. Burling	Douglas Stewart Davison
George Lawson Pickard	Kenneth Leslie Denman
Edward Clarence Rhodes	Federic William Dobson
Stuart Durnford Smith	Mark Anthony Donelan
Robert W. Stewart	James Arthur Elliott
	Gillian Hope Elliott
	Frederick Ernest Jerome
	Richard E. Thomson

The following were elected to membership at the June 16, 1969, meeting of Council:

Member	Student
Jean-Louis Bisson	Giles Desautels
Frederick Kenneth Hare	Barry Dale Greer
Alfred Frederick Ingall	Paul Lamb
Joseph MacDowall	William Stanley Lawson
John Francis McMorran	Donald Carl MacIver
Aldo Missio	James Edwin Pakiam
Kenneth C. Spengler	

EDITORIAL

"SIGNS OF THE TIMES"

One theme accentuated at the recent Third Annual Congress of the Society was the need for a concerted multi-disciplinary scientific approach to solve problems of the atmospheric environment. Thus, meteorologists would need to co-operate with sociologists and economists in the future, along with the agriculturalists, hydrologists, oceanographers, etc., who have already been actively engaged in projects of mutual benefit and interest.

This common evolution and convergence towards intense co-operative effort may be enlikened to a secular "scientific ecumenism" which thrives and grows on dialogue and on direct participation in studies of far-reaching human value. The quasi-independent or unitary approach in scientific research is seen to be a barrier to progress, with real development arising from the "synergistic" approach. The age of analysis is over. The age of human scientific symbiosis has begun in earnest.

This trend to an integrated total effort is a "sign of the times"--the result of man's ever-continuing self-reflection on his own existence. According to McLuhan modern man's deeper self-awareness and human involvement ("the global village")was produced by electrical technology: a membrane covers the earth as an extension of man's central nervous system. This is also suggestive of the noosphere of Teilhard de Chardin, as a consequence of the evolution of human consciousness.

Meteorology is obviously participating in this evolution. The routine utilization of data from the satellite observing system elicits a psychosomatic response in man himself. Man's spirit is expanded (almost infinitely) because his physical sensory involvement in the universe has increased indefinitely without seeming limit.

It is our hope that "Atmosphere" will contribute to the growth of man's scientific interdependence and to the realization of his potentialities. These results (although modest at first) can be achieved progressively by providing a forum for inter-disciplinary studies, reports, discussions and reviews, but only with the co-operation of all our members.

INSTRUCTIONS TO AUTHORS

1. Manuscripts shall be submitted in duplicate, typed doubled-spaced on $8\frac{1}{2}$ x 11" bond, with the pages numbered consecutively.

2. Two copies of figures shall be submitted with the manuscript. The originals should be retained by the author until it is established whether or not revisions will be required. A list of the legends for figures shall be typed together on a separate sheet.

3. Authors shall keep in mind when labelling that figures will require reduction to 5" x 8" (full page) or smaller. Photographs shall be glossy prints with good contrast. Other diagrams shall be drawn with pen and ink and be in final form for photographing.

4. Literature citations in the text shall be by author and date. The list of references should be primarily alphabetical by author, and secondly chronological for each author.

5. Units should be abbreviated only if they are accompanied by numerals. For example, 10 km, but several kilometers.

6. Tables shall be prepared on separate pages each with an explanatory title. Only essential vertical and horizontal ruling will be included.

7. Metric Units are preferred.

8. Footnotes to the text should be avoided.

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THE CANADIAN METEOROLOGICAL SOCIETY
La Société Météorologique du Canada

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

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

There are three types of membership - Member, Corporate Member and Student Member. For 1969, the dues are $7.50, $25.00 and $1.00, respectively. Atmosphere is distributed free to all types of member. Applications for membership should be accompanied by a cheque made payable to The Canadian Meteorological Society, with exchange added for non-Toronto Banks.