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FOURTH ANNUAL CONGRESS

The Fourth Annual Congress of the C.M.S. was held in conjunction with the Conference of the Learned Societies of Canada at the University of Manitoba in Winnipeg, June 17-19, 1970.

Centennial weather and fair skies greeted the participants not only on Wednesday but also throughout the whole course of the meetings and activities sponsored by the Society. The modern facilities of University College were the setting for the scientific sessions which had the first-day theme, "Education in Meteorology", one in keeping with that of 1970's World Meteorological Day, "Meteorological Education and Training".

SCIENTIFIC SESSIONS

The Fourth Annual Congress was opened by President M.K. Thomas who stressed the importance of a complete educational program in which the roles of research and services were integrated to meet national requirements. In addition to formal education, the mass media - newspapers, TV and books - must be used if meteorology is to achieve its proper role in Canadian economic and social development. Educators must also give increased attention to applied meteorology and, in particular, to the training of administrators of meteorological services. Ultimately many meteorologists will become administrators and their decisions will be of critical importance to Canadian meteorology.

Dr. John Gregory chaired Session 1 which was devoted to the topic, "Education in Meteorology - Professional Aspects". Considerable divergence of opinion was evident in the discussion of university training programs for meteorologists. The contentious point was "should the universities provide only classical fundamentals, or should the training program take into account the needs of future employers?"

The universities are perhaps more aware of the changing needs of our times than any other organization. The student revolt against archaic methods has had a profound effect on the educational system and has stirred our social conscience. Dr. Boville saw the meteorologist improving our troubled political climate through his imaginative, international scientific effort. Meteorology is a truly geophysical science which relies on global networks, orbiting satellites and highly sophisticated computers. To fulfil this role, today's meteorologist must have a thorough grounding in the principles of classical physics, the language of applied mathematics and, above all, training, experience and motivation in tackling large-scale problems. At McGill the most profitable learning is considered to be "through direct involvement in large experiments through research". This involvement is often missing in undergraduate years since at that time universities are teaching fundamentals, and undergraduate students are often "turned off or turned aside" by the diet of fundamental discipline.

Projected employment of McGill graduates is as follows:

	Federal Government	Universities	Industry	Foreign Students, etc. -Misc.
M.Sc.	47	10	3	25
Ph.D.	12	20	3	1

How do you train a meteorologist? If the educational institutions were clairvoyant and planned to meet the needs of the day precisely, the training program of the mid-sixties would include management; 1969 - French; and the 1970's - pollution and Arctic meteorology. Clearly a training program cannot vary with each temporary crisis,but must contain a sound, broad basis which will permit the meteorologist to respond in a prudent scholarly fashion to the vacillating demands of our times.

Dr. Allan Brewer stressed that students should not be given too much "candy floss", stating that they respond better to a meaty diet. Newton had a sure-fire training formula: progressive learning in using hands,mathematics,physics and then in making application as in celestial physics. The University of Toronto has attempted to emulate Newton's approach, teaching first of all fundamental mathematics and physics by following a course initiated by Drs. A. Thomson and B.Haurwitz more than 35 years ago. The course is Spartan in nature, but Dr. Brewer felt that the students are over-lectured and over-examined. The students give a high rating to a course which presents timeless fundamentals,followed by detail. Much credit was given to the Meteorological Service training personnel for their invaluable contributions to the training program,and also to Dr. F.K. Hare, who has added another dimension to meteorological training within the University.

Mr. C. Penner, Superintendent of Training in the Meteorological Service described the present role of the meteorologists and evaluated the effectiveness of present training on the basis of fulfilling this role. Tribute was given for training programs to date,however, considering present and future requirements, these have serious shortcomings. Education must train students to fulfil their future tasks. Over-training leads to frustration and dissatisfaction; under-training leads to incompetence. A meteorologist's training must be just right, i.e., tailored to give full satisfaction in his chosen career.

The role of the meteorologist has changed drastically within the past 50 years. At one time he undertook almost every task related to weather services and research. Nowadays this is impossible and a team concept has evolved in which he works along with other professionals, technologists and technicians. Within this new role he is required to provide leadership, to apply new techniques and data, and to innovate - quickly. Other major roles are those of decision-making, consultation and management. These require broad knowledge so that interdisciplinary gaps may be bridged and consultation be given with understanding. Mr. Penner noted that few techniques are ever exploited to their potential because of our lack of stress on innovation. Another failing of meteorologists is to hang on to methods or responsibilities which are properly technical - differential analysis was cited as an example.

Present programs are producing good research scientists,however the other needs, such as management, are being mainly ignored. Educators were accused of attempting to create carbon copies of themselves rather than satisfying student requirements. The tendency to make the M.A. degree highly specialized,or a training ground for the Ph.D., was viewed with alarm. Master's degree students must be given training of sufficient depth and breadth to enable them to practise as consultants and to work with scientists in other disciplines. Training must be relevant to today's and tomorrow's operational programs, to produce innovators and the managers of 1990. Professorial interests should not take precedence in the training program over those of the future employer.

The University of Alberta's meteorological program is making great strides with three meteorologists now on staff and five expected by 1971. Professor R.W. Longley described the varied activities, on-campus and within the Province,which show the interdisciplinary and economic importance of meteorology. Among the services provided to date are:

- advice to geographers, such as on the agricultural potential of east-central Alberta, e.g.,the precipitation regime and evapotranspiration,
- training of graduates of other Departments, e.g., Engineering and Biology Department students working on thermal heat loading of reservoirs and algae growth,
- representation on the Water Resources Institute,
- membership on committees and shaping public opinion relating to cloud seeding, etc.
- participation in co-operative research projects through assignment of students, e.g., hail and forest fire research.

These varied services show the community and the University the value of applied meteorology. In addition to its graduate course, the Department of Geography is giving a 3rd year undergraduate course on General Meteorology.

Session 2 under the Chairmanship of Mr. D.B. Kennedy, continued the Congress Theme of "Education in Meteorology" with emphasis on "Technician Training and General Education".

The first paper, by Mr. J.R. Lauder, described training for Canadian Armed Forces meteorological technicians. This is performance-oriented to ensure immediate and effective employment following the training. Training is given only for the job to be done. With the adoption of this method failure rates during training have decreased markedly.

The second paper, by Mr. M.F. Dolan, described training for Meteorological Service technicians. There is now a career plan within the Meteorological Service which enables technicians to perform many tasks formerly carried out by professional employees. The various courses to permit advancement of technicians to the required levels of technical proficiency were then described. Existing courses are changed and new courses are designed as the need arises. Syllabi are in accordance with W.M.O. standards.

Professor K.M. King described the W.M.O. syllabi for instruction in Agricultural Meteorology. He then outlined the courses currently being given at the University of Guelph to undergraduates in agriculture and also to students in the Ph.D. program in agrometeorology. The latter are designed individually to overcome deficient areas of the students, either in meteorology or in the biological sciences. He also pointed out the need for short courses in meteorology for agricultural research workers, for agricultural personnel taking extension courses, for geographers and for ecologists to permit better exchange of ideas between meteorologists and those working in these fields.

In the last formal paper of the Session, Mr. L.K. McGlening described the publications provided to schools by the Meteorological Service. He pointed out that education in meteorology within the school systems of Canada should be encouraged by all possible means, that courses should be related to the importance of weather to life and that they should begin in the elementary grades.

A panel discussion on "Present Problems and Future Developments in Meteorological Education" closed off Session 2 in the afternoon. Mr. D.B. Kennedy, the moderator, opened the discussion by suggesting that their immediate aim should be for dialogue rather than confrontation. He hoped that the audience would participate fully and indicated that education of the consumers or users should be considered as well as education in the more formal sense. He then called on each of the panelists to make a preliminary statement of their views.

Mr. G. McKay, the first panelist, felt that there is an unjustified complacency on the part of the Universities and the Meteorological Service in assuming that the meteorological educational program is optimum. He urged that the new roles of the meteorologist be examined and that the educational curricula be made more relevant to the important place a meteorologist must take in economic and community affairs.

Mr. G. Pincock agreed with Mr. McKay, but felt that one aspect of education which is being overlooked is that for the adult. Many courses are available to adult Canadians to enrich their knowledge, but very few courses in understanding and using meteorology are available.

Dr. P. Summers, while agreeing with the need for more education in meteorology for adults in general and users of weather information in particular, felt that this area should be undertaken by "private enterprise" and not necessarily by the Meteorological Service, or the Universities.

The last panelist, Dr. J. Gregory, expressed the opinion that the primary role of the University is to provide short-term service training (MSc) to meet operational needs; on the other hand the training of PhD's is for the purpose of acquiring new knowledge and should not be directed to filling an operational (short-term) need. He felt that both the Universities and the Meteorological Service are not prepared for the future developments in new meteorological knowledge.

A free-wheeling exchange of ideas between the panel members and the audience was then set in motion. Dr. Boville pointed out that many graduating PhD's are producing theses with practical applications. A review of theses titles in recent years would bear this out. Mr. Powe expressed the opinion that training in forecasting is being neglected and that the training program should "get down to earth". Mr. Johns stated that the motivation of MSc graduates is not towards operations, but throughout their University and later their Meteorological Service training the assignment to research activities is presented as the preferred occupation. Mr. Muller pointed out that the role of the meteorologist in operations is changing. Most of the forecast output is automated and requires monitoring only, with the meteorologist stepping in to take control when the unusual occurs. More and more of the operational meteorologist's time will, in fact, be available for research. Dr. Bradley expressed the opinion that the Meteorological Service was showing an admirable willingness to be practical, a contrast to conditions some years ago.

Several other members of the audience made additional and lively comments, and at the conclusion of the discussion the moderator remarked on the difficulty of summarizing such a spectrum of opinions,but thanked the panelists and audience for taking such an active part in the dialogue.

Session 3 on "Winds", chaired by S.J. Buckler, was divided into two distinct parts separated by coffee and characterized by levels. Prior to the coffee break the papers were concerned with winds in the very lowest levels of the atmosphere; after coffee the levels under consideration began at 500 mb and ended near 100 km in the last paper.

In the first paper, Dr. H.C. Martin dealt with forest winds. The speaker stressed the problems involved in micrometeorological studies over surfaces far removed from the usual "infinite" plane. Results of studies into the power-law exponents for this type of natural surface were presented. The relationship between the wind direction above and below the trees was also discussed.

The next paper was also concerned with power-law profiles. H.M. Fraser who collaborated with P. Bellan discussed their joint studies which were initiated to investigate stresses on transmission lines. Three levels of sensors were used, though because of instrument incompatibility only two could be employed in the power-law study. The data and results showed that the power-law exponent varied with wind speed and time of day. Each instrument was mounted on a separate tower but closely-spaced to the other towers. However, the larger towers affected the wind measurements made on the smaller towers. It was also pointed out that many of the wind sensors in common use are incompatible.

Another application of meteorology to an allied discipline was presented by E.G. Morrissey who discussed a method of predicting peak gusts for urban stolport design problems. His study was based on model power spectra and climatological data. During discussion of the paper the question of the use of real data was raised. The non-availability of such data prompted further discussion about the suitability of standard wind sensors and recording systems.

Mr. Fraser presented a second paper which described some interesting observations of very low frequency power-line oscillations in the vertical under extremely light wind conditions. He suggested that these might be caused by buoyancy-induced vertical winds. Further lively discussion gave rise to several alternate theories. (Co-author was W.I. Lowe).

The first paper after coffee was presented by Dr. E.R. Reinelt who investigated the relationship between hail storm occurrence and the 500 mb wind flow over Alberta. Although much of the observed hail falls coincided with cold air advection at upper levels the author made the point that a more complex relationship is evident involving other meteorological parameters.

The next paper also dealt with Alberta winds. Dr. N.H. Thyer reported on his measurements of terrain/thermally-induced winds on the eastern slopes of the Rockies. Wind circulations were detected from averaged rawinsonde data. No correlations were discovered between these circulations,as given by the single ascents,and the occurrence of hail.

The last presentation of the session dealt with winds at levels not usually considered by meteorologists. Dr. J.B. Gregory began his paper, co-authored with D.K. Rees, by explaining why winds at these levels were being studied. They were needed to solve problems connected with the general circulation above 50 km and the transport of short-lived chemical compounds at these levels. After briefly describing his method of measuring the winds using radio techniques, he showed how the measurements agreed well with rocketsonde data at lower levels (60 km) and the meteor-radar data at higher levels (above 100 km). Dr. Gregory went on to emphasize that this system was relatively inexpensive and therefore suited to regular network deployment.

G.A. McKay was chairman of Session 4 on "Precipitation"; papers dealt mainly with applied problems in engineering design, agriculture, forestry and forecasting.

Dr. John Hay found it necessary to prepare maps of precipitable water for Canada as part of a study of Canadian radiation climatology. His maps showed the influence of both atmospheric and topographic controls. The January gradients are strongest along the coasts; the greatest resulting from the co-location of the western Cordillera and the mean position of the Arctic front. By July the two controls are separated and a shear zone extends from Barrow passing through Normandin to Goose Bay, i.e., along the mean position of the Arctic front. It was interesting to find that the mass of precipitable water in summer in the Mackenzie Valley and southeastern prairies is quite comparable to that found in the "more humid" southern portions of Ontario and Quebec. Values are depressed over the Cordillera in all seasons and near the Great Lakes in summer. Dr. Hay's maps were based on both upper air measurements and values empirically deduced from screen measurements of vapour pressure. Relationships between these two sets of data were obtained using data for 62 locations in Canada and the contiguous United States. Slopes and intercepts of the regression equations also showed relationships to continentality, elevation and topographic features as those evident in the completed precipitable water maps.

The development of an objective aid in the forecasting of precipitation was described by N. Yacowar in a joint paper (with D.E. McClellan, D.E. Page and R.H. Robinson). Objective techniques help the meteorologist sort our the most relevant factors and assign proper emphasis to them in the prediction process. The method made use of "dummy"variables i.e., grouped information which can be used as a predictor of the probability of an occurrence. Statistical tests are applied to determine group bounds. If one selected group is found to be not significantly different from another at the 95% level,the two are combined to form one group, and this process is continued until all groups are scanned. The same procedure is used to derive two-dimensional predictors which satisfy two conditions simultaneously. Compared to linear regression, in which all values are used in the prediction process, the proposed artificial predictor takes on a value of one or zero depending on whether it falls within a certain range or not. Values such as wind direction and speed, vorticity, geopotential height and thickness anomalies, advection, tendencies, persistence and upstream terms are used as dummy variables in regression equations which predict the probability of occurrence when group conditions are satisfied.

Dr. J. Bradley described some of the problems facing the design engineer in using climatological information. Included among the many applications of precipitation information is the problem of attenuation of microwave radiation. The probable serviceability of a communication linkage or communication network may be computed if point and areal variabilities of high intensity rainfall are known. Extreme value statistics is the conventional tool in treating with the precipitation extremes which limit microwave communication. The statistical methods have been satisfactorily developed, however, the data were found wanting. The statistics of interest in attenuation studies are the 5-min. or shorter-period precipitation rate. These periods are near or exceed the limits of the MSC tipping bucket gauge, and as a consequence published 5-min. values may be quite misleading to the practising engineer. The prorating of standard precipitation gauge measurements, while generally practical, may lead to absurd values when very short durations are considered.

Dr. Peter Summers presented a paper co-authored with Bill Thompson on "The Influence of Upper Winds on Hailfall Patterns in Central Alberta". Using 36,000 hail reports submitted by farmers to the Alberta Hail Studies (ALHAS) Project during the period 1957 to 1968, inclusive, each day was classified according to the type of hailfall pattern at the ground. It was found that hail in long, well-organized swaths occurred most frequently with strong westerly winds aloft and a reversal of wind shear direction about 1500 feet above the ground. The average swath orientation was about 25° to the right of the mid-tropospheric wind flow. Poorly-organized swaths and scattered hail patterns were associated with lighter winds aloft and no shear reversal. These results used in conjunction with convective indices should help improve forecasting the type of hail activity expected on any given day.

A procedure for quantifying the damage potential of a hailstorm based on size and total mass per unit area was presented by Dr.P.Summers and L. Wojtiw of the Alberta Research Council. By analyzing information contained in the "additional remarks" portion of the Alberta Hail Research Project, it was possible to derive a damage equation which should prove very useful in future comparisons. Hail report cards have been used by ALHAS since 1956,and it is now possible to correlate damage with several factors. The correlation coefficient between damage and each of maximum hail size, modal hail size,mass per unit area and impact momentum is about 0.50. That for impact energy is 0.40; softness, 0.19; and number of days after June 1, 0.16. The simplest multiple regression equation having a high multiple correlation coefficient (0.59) involves expressions of the modal hail size and mass per unit area.

With hail sizes of the shot or pea dimensions, no damage is most probable and chances of severe damage are slight. With golfball or larger hail there is nearly a 50 per cent chance of severe damage. As one would expect, soft hail is less damaging than hard hail. An analysis of impact energy showed the changing susceptibility of crops to damage as the growing season advanced. In June the probability of no damage remains near 100% until the impact energy exceeds 10 joules per m^2. In August, the probability of no damage is less than 50% by the time the impact energy exceeds 1 joule per m^2.

The average annual economic loss due to forest fires is $3.7 million. Nearly 45% of Alberta fires are caused by lightning. Accurate prediction of high risk areas, and of thunderstorm activity can aid in the location of fire-fighting resources and thereby appreciably reduce forest fire losses. R.G. Lawford described a climatographic approach to the understanding of thunderstorm development over Alberta Forests. His results showed the importance of synoptic or sub-synoptic scale processes, and topographic features in initiating thunderstorms. Seasonal variations indicate that latitude was a factor to be considered.

Thunderstorm probability maps for June, July and August clearly showed the influence of topography. In particular the alignment of isopleths along the Continental Divide suggested a strong orographic factor in the growth of thunderstorms. July is the peak risk month and activity decreases rapidly by August. Onset isochrones indicated the northwestern Slave Lake Forest to lag eastern areas by about three hours; suppression of thunderstorm activity in this area by mountain-induced subsidence was postulated as a cause. Earliest "median-thunderstorm-days" occurred in northwest Alberta about June 30th; over most of the province the median occurs between the 15th and 25th of July. Other interesting statistics described the changing angle of attack of thunderstorms as seen from lookouts, and wet-and-dry storm frequencies relative to distance from the Continental Divide. Both indicated that southern and southeastern slopes are the preferred areas for thunderstorm development.

Session 5 on Friday was devoted to papers on "Climatology and Physical Meteorology". Professor Longley was in the chair. Frank Thompson's paper on the analysis of meso-scale weather using climatological records was very ably read by Clive Jarvis. This study concentrated on southern Ontario and one of several interesting applications was for a snow shadow in the lee of the Bruce Peninsula under northwest winds.

Norman Powe from the Montreal Weather Office wished for a return to the days when the forecaster was in closer contact with his consumers. He conjured up visions of irate pilots chasing poor trainee meteorologists around the tunnels and corridors at Dorval. More seriously, his work on climatological aids for forecasts at small local airports should lead to improvements in forecast reliability. His comments on the training of forecasters were not received too well by some sections of the audience, but this was due to a misunderstanding.

The next three papers dealt with idealised models of the atmosphere. Dr. F.H. Fanaki reported on some of the results obtained in his water tunnel and their relation to convection processes in the lower troposphere. The model attempts to simulate a turbulent flow in the atmosphere by means of a laminar tank flow. Some problems arise with the scaling of the Reynolds number, for which a value of turbulent eddy viscosity is used for the atmosphere while a laminar molecular viscosity is used for the tank. Comments on his slides, which were reminiscent of Beardsley's drawings, varied from "fascinating" to "obscene" but they, and the paper, generated considerable discussion.

Yves Delage gave a joint paper (with Peter Taylor) on his numerical model of urban heat island circulations. The model which uses the assumption of a hydrostatic pressure distribution caused some dissent from the McGill contingent. However, it is used to predict airflow and inversion bases in, at present, rather idealised situations.

Roger Daley talked about his convection model which considers bubble convection using numerical methods based on the spectral technique. In this case the vertical and horizontal dimensions are of the same order of magnitude and dynamic pressures are included.

F.B. Muller next spoke about the sophisticated statistical methods that he has been developing for the analysis of meteorological data. Finally, J.A. McCallum presented a joint paper (with O. Johnson, B.R. Larson and W.D. Simpson)on a recent series of puff dispersion tests carried out at Suffield. This was essentially a supplement to the work which they discussed at Calgary in 1968 and which now included several cases with stable thermal stability.

Concurrent sessions were held on Friday afternoon. Dr. John Maybank chaired Session 6 on "Electrification and Cloud Microphysics". Seven papers were presented, covering a rather wide range of fields. The first three on electrification, another three on microphysics and one on storm water budget.

The first paper, by Bhartendu, was read in his absence by J.D. Holland. It described records of simultaneous measurements of atmospheric electricity, including air-earth current density, electric field and polar conductivity. The main point, clearly demonstrated in this paper, is that the practice of deriving one of the three parameters from the other two by Ohm's law is not supported by the evidence;in fact the ratio of current density to the product of field times conductivity varies with the time of the day and with the season, and is considerably higher than unity (2.6 for 1968 mean values).

The second paper by D.R. Lane-Smith reported measurements of electric field and precipitation current. The response of the current to field change due to lightning and recovery was discussed and an explanation was proposed, based on induction effects during splashing and the fall of charged droplets into the precipitation receiver.

The third and last paper devoted to electrification was presented by S.R. Shewchuk (with J.V. Iribarne as co-author) and was concerned with the physical basis of charge separation during splashing on solid surfaces at high impact velocities. The experimental results led the authors to an explanation based on the shearing of existing electrical double layers of ions at interfaces.

R.L. Drake of NCAR gave a review on the coagulation terms that might be included in comprehensive computational cloud models. The time was scarcely enough for this extensive survey which was eloquent of the degree of sophistication at which modellists are aiming.

The next two papers dealt with microphysical problems related to precipitation. J.D. McTaggart-Cowan reported on a study made in conjunction with C.F. MacNeill and R. List. With the aid of high-speed camera techniques they investigated the products of break-up following the coalescence of two raindrops. Experimental results showed that the number of fragments ranged from 1 to 10, with an average value between 4 and 5. In another joint study (with R. List) R.S. Schemenauer presented results from water tank experiments made using regular cameras to measure the drag coefficients and to determine the falling modes of snow crystal and graupel models. The results of both papers contribute to the experimental knowledge so badly needed if the computational cloud models are to be improved realistically.

The final paper of the series, by Dr. C.D. Holtz, represented the opposite approach to the study of clouds: it dealt with the mass balance in a storm cloud rather than with any of its microphysical mechanisms. Radar data were used to analyze carefully the water, vapour and air budgets of a storm, as a function of time throughout its life cycle. Thus this interesting study contributes to an empirical description of storms, to which convection models will have to conform. In the absence of Dr. Holtz, the paper was read by Mr. Morrissey.

Seven papers were also presented in Session 7 with J.J. Labelle as chairman. Again a broad range of subjects was covered in the fields of "Forecasting and Synoptic Meteorology".

Mr. C.D. Henry discussed an objective method of forecasting middle cloudiness for 36 hours, based on a multiple regression analysis using vertical velocity, 1000-to-500 mb thickness, mean relative humidity and mean sea level pressure from the past 3 days' Primitive Equation model forecasts. A statistical screening was used which involved a backward elimination technique and forecasted fields were accepted as dependent variables at the 95 percent confidence level for predicting cloud amounts. Skill scores obtained using forecasted fields were not noticeably different from those obtained using initial data for generating the regression equation. On the basis of cloudy or not cloudy, the objective middle cloud forecasts were correct 59 percent of the time, which is about 5 percent lower than scores obtained using conventional subjective methods.

Dr. P. Merilees delivered a paper by Dr. G. Paulin on the use of grids 1/2 and 1/4 the conventional grid-spacing of 381 km to make predictions for an Alberta-type low of small horizontal dimensions giving more detail and better displacements than baroclinic models using the regular grid-spacing. With the potential vorticity equations as a basis, a 4-level quasi-geostrophic model was used, to overcome some of the difficulties incurred with operational forecasts due to large horizontal space truncation errors and coarse finite-difference smoothing.

Mr. C. Jarvis reported on the use of a direct objective analysis program to generate kinematic analyses from hourly weather observations. A frontal index, based on the classical definition of a surface front, forced ascent caused by sloping terrain, and forced ascent caused by divergence of wind in the planetary boundary layer were all found to correlate well with boundary-layer weather. A method for accounting for the occurrence of boundary-layer cloud,on the basis of the height of the planetary boundary layer lying above the lifting condensation level, was also discussed.

A paper by Dr. A.K. MacPherson and Mr. G.V. Price, and delivered by Mr. Price, compared three numerical circulation models. Using the same set of initial data, geopotential heights were predicted for relatively short time periods using the 1-level geostrophic barotropic model, the Phillips model and the Mintz-Arakawa model. These three models were used in the study because they approximate presently-used techniques. The effects produced by the physical assumptions used in the three models and the abilities of the models to reproduce troughs and centres of low geopotential height were discussed. Plans to use a carefully selected and screened set of hemispheric data for extending the forecast period were also discussed.

Mr. A.F. Davies described an operational program for producing working charts from the early transmissions of radiosonde data, using available computer facilities and based on existing and anticipated operational needs. The forecaster can select those charts, of the more than 25 that are available, for programming on a particular day. Output is in the form of plotted data and indices at stations,extrapolated data fields, such as forecast tephigrams, and forecast parameters such as indices of instability, hail size, Cb tops and surface wind gustiness.

Prof. Longley, of the U. of Alberta, presented a progress report on the use of measured winds to compute horizontal divergence using 3 radiosonde stations around Hudson Bay. He was skeptical of the use that has been made in the past, of rawinsonde reports for computing horizontal velocity divergence. Computations of the inflow from the surface to 50 mb in the triangle of stations led to excessive surface pressure tendencies, and vertical velocities became very high in the upper levels when the inflow was used to compute vertical velocities. The discrepancies were too large to be explained entirely by wind errors. Another source of error appeared to be rapid wind changes in space so that winds cannot be interpolated over distances of several hundred kilometers, as required using the available data network.

A paper on modelling the radiation climate of Canada was presented by Dr. John Hay of the University of Canterbury, New Zealand. Except for 34 stations which measure incoming short-wave radiation, the data sampling network is not sufficiently dense to allow reasonable patterns to be drawn. However by employing a number of theoretical and empirical relationships between the radiative fluxes and other meteorological parameters including cloud amount and albedo, the radiation climate could be estimated in far greater detail. The accuracy of the predicted values fell within instrumental limits about 60 per cent of the time. Charts were constructed for the incoming and outgoing short- and long-wave radiative fluxes as well as for the net radiation and using estimated values are given for clear, overcast and average sky conditions.

IN APPRECIATION

Many thanks are especially accorded to the following CMS members who attended the 4th Annual Congress and recorded details of the sessions for inclusion in this issue of ATMOSPHERE:

J.V. Iribarne	E.G. Morrissey
E.C. Jarvis	G.L. Pincock
L.K. McGlening	P.A. Taylor
G.A. McKay	

ANNUAL GENERAL MEETING

Members reassembled again in the evening after the first full day of sessions and subsequently dealt with as much or more important Society business in three hours as had been handled at the Annual General Meeting at Sherbrooke in 1966 when the CMS was founded. Several Executive reports were approved and these marked points of departure for future growth and development of the Society. Perhaps the expansive and open mood which engendered these epoch-making results was due to the Western hospitality or the centennial atmosphere. But whatever the causes, history can only analyse the effects rather than determine the underlying motivations. Evidently the time was ripe for a new thrust in the Seventies.

The Minutes of the 3rd Annual General Meeting held at Toronto in 1969 were approved; also various Society reports: the Annual Report of the CMS, the Treasurer, the Nominating Committee, the Editor, The Prize Committee, and the reports from Local Centres; as well as the proposed amendments to the By-Laws.

During the discussion on the Annual Report of The CMS, a motion to contribute the sum of fifty dollars to the 1971 Science Fair along with the regular book prizes was accepted.

The Society prizes were awarded at the Meeting. The Graduate Student Prize was presented to Mr. T. Warn of McGill by Mr. M.K. Thomas for his thesis study of special problems in numerical weather prediction. The President-Elect D.N.McMullen presented the new Past-President (M.K.Thomas) in turn with the Prize in Applied Meteorology for his extensive contributions and enthusiastic promotions in this field. Two other Society awards were forwarded to prize-winners who unfortunately were not present: the President's Prize to Dr. G.T. Csanady of the University of Waterloo; and the Dr. A. Thomson Undergraduate Student Prize to T. Agnew of the University of Toronto.

Two Executive Committee proposals arising from the report of the Development Committee (set up by the 1969 Annual General Meeting) were given considerable and lengthy discussion by the membership because of their importance to the future growth of the Society as a responsible and effective social-scientific organization. Both were approved in essence. The first one encouraged the Executive Committee to appoint standing committees on:

1) Scientific and Professional Matters
2) Public Information

and others, from time-to-time as may be expedient for the effective operation of the Society.

The second proposal accepted was one to improve the format of ATMOSPHERE as a scientific publication by making use of the facilities of the University of Toronto Press for printing, distributing and billing. To realize this goal a motion that the 1971 membership fee be increased to $14.00 was carried.

Other motions were made and carried: that the CMS affiliate with SCITEC and make a founding grant of $100 during 1970; that the invitation extended by the University of Alberta to hold the 1972 Congress at their campus in Edmonton in conjunction with the meetings of the Learned Societies be accepted; and that the 1971 fee structure should be amended: fees for all Student Members would be $2.00;for Corporate Members,$40.00.

The outgoing members of the Executive were then given a vote of thanks by the members. Finally Mr. M.K. Thomas welcomed the incoming Council members before the Meeting was adjourned at 11:10 p.m.

ASSOCIATED EVENTS

After the first day's sessions were finished, a reception hosted by the President of the University of Manitoba was held on the plaza and in the foyer of University College.

In the evening of the second day, members and friends were taken up the river in a novel way. The Annual Banquet took place on board a Red River paddle-boat. Dr. P.D. McTaggart-Cowan presented a special account (well illustrated with slides) of the efforts required to clean up the pollution caused by the rupture and sinking of the oil tanker Arrow on the Nova Scotia coast.

Also during the cruise-banquet the Patterson Medal Award for 1969 was presented to Dr. G.O. Villeneuve, Director of the Quebec Meteorological Service,by Mr. C.C. Boughner, Acting Director of the Meteorological Service of Canada.

A PRELIMINARY CLIMATOLOGY OF GROUND-BASED INVERSIONS IN CANADA

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1. INTRODUCTION

The frequency of ground-based inversions* is one climatological index of pollution potential. Other factors are equally important, of course, such as the thickness of the daytime mixing layer and the mean wind speed throughout this layer (Holzworth 1967). Inversion frequencies may be useful, however, for preliminary regional comparisons.

Based on data from the Canadian network of rawinsonde stations, this paper presents maps of frequencies of ground-based inversions for the two release times and for the period July 1965-June 1968, inclusive. The paper also includes comparisons with data from a few stations in the Canadian tower network. Finally, a qualitative summary of the inversion climatology is given separately for each region of Canada.

2. SOURCES OF DATA

(a) The Canadian rawinsonde network

Temperatures at the surface and at the first significant level above the surface for the period July 1965 to June 1968 have been used to determine the frequency of ground-based inversions (including isothermal layers) at 33 sites comprising the Canadian rawinsonde network. These frequency values are plotted on Figs. 1-8. General information as to location, elevation, instrumentation and procedure pertaining to Canadian upper air stations is available in any January issue of the "Monthly Bulletin Canadian Upper Air Data", published by the Canadian Meteorological Service

*A summary of the meteorological causes of inversions has been given by Munn (1966, page 45).

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Determination of the existence of a ground-based inversion from significant-level data rather than from the complete temperature profile for each ascent is considered satisfactory. Since significant levels by definition must produce the temperature profile to within 1 degree C of the actual observed value, only those ascents with near isothermal conditions off the surface might receive an incorrect classification, and it is unlikely that a significant bias would be introduced.

Of more importance is the limitation inherent in rawinsonde instrumentation that dictates that all data recorded within 10 mb of the surface (i.e., in the lowest 300 feet approximately) must not be evaluated because of the unreliability of such recorded data. Because of this limitation, a rawinsonde ground-based inversion occurs only when the air at the first significant level above 300 feet is warmer than the surface air. In a sense, this is not a disadvantage for industrial applications because chimney-height designers seek information about this deeper layer.

(b) United States radiosonde data

Hosler (1961) has discussed the climatology of low-level inversions in the United States. In an appendix, he has included frequencies of inversions based below 500 feet for the period June 1957 to May 1959, inclusive. These values have been plotted on Figs. 1-8 for a selection of radiosonde stations just south of the Canadian border and have been used as aids in the construction of isopleths. Examination of the statistics from a few Canadian rawinsonde stations has revealed that there is an insignificant number of inversions reported as being based below 500 feet but not at the surface.

(c) The Canadian meteorological tower network

The "Quarterly Meteorological Tower Bulletin" published by the Meteorological Service of Canada contains 10-minute average values (centred on each hour) of vertical temperature differences from a number of television and special 200-ft towers. Details of location and instrumentation are given in the Winter 1968 Bulletin. Many of the stations are in built-up areas where the urban heat island reduces the frequency of inversions (Munn and Stewart,1967), and only in a few cases are the "exposures" comparable with those of rawinsonde stations.

The tower data used in Section 4 include Sarnia,Ottawa,Chalk River, Whiteshell and Resolute Bay. The periods of record are the same as for the rawinsonde observations except in the case of the IGY/IGC Resolute Bay tower data,which are for the months Sept. 1957 to Aug. 1959, inclusive. In addition, some inversion frequencies have been obtained from Mr. O. Johnson (Defence Research Establishment, Suffield) for a short tower at Suffield, Alberta for the period 1961-65. These are based on hourly values of temperature difference.

Table 1. Comparison of tower and interpolated isopleth (Map) frequencies of ground-based inversions

	GMT	Winter		Spring		Summer		Autumn	
		Tower	Map	Tower	Map	Tower	Map	Tower	Map
Sarnia	23	51	25	32	5	30	5	74	20
	11	53	40	62	62	73	68	71	60
Ottawa	23	48	28	37	15	50	15	74	38
	11	40	35	50	45	62	49	72	45
Chalk River	23	17	28	8	12	19	12	24	35
	11	30	37	52	47	27	50	19	45
Whiteshell	23	37	35	10	5	24	5	24	15
	11	54	55	56	59	65	60	47	47
Resolute Bay	23	99	69	35	39	10	5	84	46
	11	96	72	77	64	43	27	96	46
Suffield	23-00	73	40	18	5	6	4	66	15
	11-12	84	65	87	70	88	82	91	70

Table 2. Difference between tower and interpolated isopleth frequencies

	Winter	Spring	Summer	Autumn	Average
2300 GMT					
Sarnia	26	27	25	54	33
Ottawa	20	22	35	36	28
Chalk River	-11	-4	7	-11	-5
Whiteshell	2	5	19	9	9
Resolute Bay	33	-4	5	38	18
Suffield	23	13	2	51	22
1100 GMT					
Sarnia	13	0	5	11	7
Ottawa	5	5	13	27	12
Chalk River	-7	5	-23	-26	-13
Whiteshell	-1	-3	5	0	0
Resolute Bay	24	13	16	50	26
Suffield	19	17	6	21	16

3. METHOD OF ANALYSIS

Figs. 1-8 present isopleths of inversion frequencies for the two times of dav and for the four seasons (Dec-Feb.,Mar.-May, June-Aug., and Sept.-Nov.). Isothermal conditions are counted as inversions. The diagrams include lines of whole numbers of hours before and after sunrise or sunset for Jan. 15, Apr. 15, July 15 and Oct. 15 (based on release times of 2315 and 1115 GMT). Although rawinsonde times are nominally 0001 and 1200 GMT, the releases usually take place at 2315 and 1115 GMT.

The isopleth pattern is based primarily on the inversion frequency values available from Canadian rawinsonde stations. Insofar as possible, the lines were drawn to fit the plotted values. Considerable smoothing was undertaken in areas of sparse data, however, in order to simplify the overall pattern. In these regions, no attempt was made to alter the isopleths to conform with physical expectations (mountain and coastal effects, for example).

In addition to the sparseness of the network, the validity of the charts is affected also by the "representativeness" of the sites. Stephenville, with prevailing winds off the Gulf of St. Lawrence, for instance, probably has an inversion climatology considerably different from that of most of inland Newfoundland. Inversion frequencies at a particular station are influenced by many factors - local terrain, proximity to large bodies of water, and the presence of hills or valleys - to name only a few, and such factors may or may not be common to the surrounding region. In particular, extrapolation to metropolitan areas is not possible because of the existence of urban heat islands.

The relatively short period of record (3 years) also contributes to uncertainty in the charts. Because of the sparseness of the network and the possible non-representativeness of some sites,however,any inadequacy in the period of record probably is not too significant. This question is considered in Section 5.

4. THE TOWER NETWORK

Inversion frequencies obtained from tower data at several sites are compared in Table 1 with frequencies obtained by interpolation between isopleths in Figs. 1-8. Because the tower observations were not examined prior to the construction of the figures, the two sets of data are independent. The levels of measurement were as follows:

Sarnia	20 to 200 ft	(rural)
Ottawa	20 to 200 ft	(suburban)
Chalk River	30 to 250 ft	(rural valley)
Whiteshell	20 to 200 ft	(rural)
Resolute Bay	6.4 to 100 ft	(Arctic) (1957-1959)
Suffield	4 to 40 ft	(rural) (1961-1965)

Table 2 has been prepared from Table 1 to show differences between tower and interpolated isopleth frequencies. The hour 2300 GMT is near sunset at most locations in most seasons, when ground-based radiation inversions are shallow and frequently not detected by the rawinsonde. The 2300 GMT differences in Table 2 are therefore generally positive, although two exceptions are of interest:

(a) Chalk River has fewer inversions than would be expected from the isopleths. Because the tower is located on sloping ground on the side of the Ottawa river valley, drainage winds probably inhibit inversion formation on many occasions at this site.

(b) Resolute Bay and Suffield have many more tower inversions in autumn and winter than would be expected from the isopleths. In spring and summer,on the other hand, there is reasonable agreement between the two sets of data. A likely explanation is that in spring and summer, the time 2300 GMT is at least 3 hours before sunset (Suffield) or time of minimum sun elevation (Resolute Bay), and radiation inversions have not yet begun to form.

The hour 1100 GMT, on the other hand, is in general near sunrise when radiation inversions have, on the average, reached their maximum intensity. Table 2 indicates that at that time of day,there are negative differences at Chalk River, near-zero values at Whiteshell, and positive differences (particularly in autumn and winter) at the other stations; the differences, however, are not as large as at 2300 GMT.

In summary, frequencies of tower inversions at most locations are higher than those interpolated from Figs. 1-8, the effect being more marked in autumn-winter than spring-summer and at 2300 GMT than at 1100 GMT.

5. COMPARISON OF 1965-68 WITH 1950-59 FREQUENCIES AT SOME ARCTIC STATIONS

Bilello (1966) has summarized the frequencies of ground-based inversions at 6 Canadian radiosonde stations for the 10-year period from 1950 to 1959, using only the evening ascents. The release times changed on June 1, 1957 from 0215 GMT to 2315 GMT but Bilello did not subdivide his data. A comparison with the 1965-68 frequencies is shown in Table 3.

In winter and autumn, there are no significant differences between the two sets of data. In spring and summer, the agreement is also satisfactory at the three most northerly stations - Clyde, Mould Bay and Alert. For Coppermine in spring and for Churchill and Coral Harbour in spring and summer, however,inversions are about 20% more frequent during the earlier period than in 1965-68. A plausible explanation for this

Table 3. Comparison of the percent frequencies of ground-based inversions at 2315 GMT for the years 1965-68 with those given by Bilello (1966) for the years 1950-59 (0215 GMT until June 1, 1957; 2315 GMT thereafter).

		Winter	Spring	Summer	Autumn
Churchill	65-68	46	17	10	17
	50-59	50	39	32	25
Coral Harbour	65-68	82	43	4	44
	50-59	85	65	23	46
Clyde	65-68	60	45	25	34
	50-59	64	56	26	28
Coppermine	65-68	61	25	28	31
	50-59	74	45	30	32
Mould Bay	65-68	83	43	10	51
	50-59	76	50	15	44
Alert	65-68	80	66	20	66
	50-59	84	72	30	66

difference can be found in Figs. 3 and 5 from an examination of the hour of observation relative to sunset. A time shift from 2315 to 0215 GMT places the ascents in the transitional period between day and night when inversion frequencies are increasing.

6. INTERPRETATION OF FIGS. 1-8

(a) General

The isopleth patterns in Figs.1-8 result from the combined effects of meteorology and solar time. The diagrams represent conditions at only two discrete hours of the day, whereas there is a strong diurnal cycle in inversion frequencies at most locations. This is illustrated in Fig. 9, which shows the hourly percentages of inversions at Sarnia for the months June through August. Fig. 9 is characterized by two regimes, day and night, with transition periods of approximately 3 hours in the morning and again in the evening.

Examination of the time of day relative to sunrise and sunset in Figs. 1-8 reveals that this effect is not important in only two of the figures:

Fig. 2: Winter, 11 GMT, when all of Canada is in darkness,
Fig. 5: Summer, 23 GMT, when all of Canada is in daylight.

Assuming a two-regime diurnal pattern as at Sarnia, Figs. 2 and 5 may be used to study regional differences. Examination of data from the tower network supports this assumption, although as pointed out by Hosler (1961), the diurnal cycle is likely to be different at coastal locations during seasons when warm-air or cold-air advection occurs frequently. In summer at Sable Island, for example, there are high frequencies of inversions at both 23 and 11 GMT (Figs. 5-6). In winter, on the other hand, frequencies are low at both hours.

(b) Fig. 2 (Night-time winter)

Inversion frequencies are relatively low along the Atlantic and Pacific coasts. Over the rest of Southern Canada, the isopleths are widely spaced, with a slight "ridge" extending from Montana through Edmonton to Fort Nelson. This ridge-line of high frequencies just east of the Rockies occurs on other maps (Figs. 1, 2, 4, 6, 8) and therefore seems to be a characteristic feature.

In the far north, inversion frequencies increase, exceeding 80% at some arctic locations. North of 70°N latitude, the isopleths agree with those given by Vowinckel (1965), who has analyzed the data from the North Pole-4, -6, -7 and surrounding IGY stations. Vowinckel has drawn a 90% isopleth over the pole circling down over Siberia.

No synoptic-scale explanation can be found for the high frequency at Coral Island. The anomaly occurs also at 1100 GMT (Fig. 1) as well as in the 1950-59 data (Table 3). The observing site is about 2 miles inland at an altitude of about 150 feet.

(c) Fig. 5 (Day-time summer)

Inversion frequencies are low from British Columbia through Ontario to western and northern Quebec. Frequencies are higher in the Atlantic Provinces, exceeding 70% at Sable Island. Proximity of observation time to sunset may be a contributing factor but coastal warm-air advection is believed to be the primary reason for the large frequencies. Undoubtedly also, the variability in this region is far greater than indicated by the isopleths on Fig. 5.

Inversion frequencies are low in the Yukon and in the southwestern part of the Northwest Territories. The northern and eastern Arctic, on the other hand, are characterized by considerable variability, with values of less than 10% at Resolute, Isachsen and Coral Harbour, and more than 40% at Hall Beach.

(d) Figs. 1, 3, 4, 6, 7, 8

Inferences concerning regional differences in inversion frequencies can be made from only parts of Figs. 1, 3, 4, 6, 7 and 8. Isopleth patterns have therefore been disregarded in areas where the balloon release times were from one hour before to two hours after sunrise, and from two hours before to one hour after sunset. Elsewhere,the assumption has been made that the inversion climatologies can be characterized by separate day and night regimes, as suggested by Fig. 9.

The resulting regional values are summarized in Table 4, which is the essential result of this paper. In some regions, supplementary frequencies have been obtained from tower observations.

Table 4 reveals a consistent seasonal cycle in inversion frequencies through Southern Canada. Night-time inversions are most prevalent in summer and least likely in winter. The nights are shorter in summer but there is less cloudiness and lighter winds than in winter.

Table 4. Climatological estimates of inversion frequencies by region (in %).

	Winter		Spring		Summer		Autumn	
	Day	Night	Day	Night	Day	Night	Day	Night
Newfoundland	20	20	-	-	10-60	-	•	15
Maritime Provinces	-	35	-	-	-	-	-	-
Southwestern Quebec	10*	35	5*	65*	10*	90*	20*	75*
Northern Quebec	-	45	-	-	8	-	-	-
Southwestern Ontario	10*	35	5*	75*	5	90*	5*	60
Northern Ontario	-	45	-	-	10	-	-	50
Manitoba	30*	55	5	60	5	70*	20*	50
Saskatchewan	-	60	3	70	4	-	-	60
Alberta	-	60	3	70	2	80	-	70
Inland British Columbia	-	50	3	60	2	80	8	65
Coastal British Columbia	-	40	3	40	5	50	10	50
Yukon	-	60	3	55	2	65	10	50
Mackenzie River Basin	-	50-65	5	60	3	-	-	50
Eastern Arctic	-	60-80	-	-	5-50	-	-	30-70

*Estimated from tower data

7. GENERAL FEATURES OF THE INVERSION CLIMATOLOGY OF CANADA - RELATION TO HIGH POLLUTION POTENTIAL

(a) General

A qualitative description of the inversion climatology of each region is given below. It seems appropriate not only to discuss average conditions but also to indicate the synoptic patterns that create high pollution potential.

(b) The Atlantic Region

Inversions occur rarely in winter because the air is generally colder than the coastal waters, skies are frequently cloudy and wind speeds are above average. Strong-wind chimney downwash may occur rather frequently, however, unless careful attention is paid to chimney height and siting in relation to the geometry of local buildings and terrain features.

In late spring and summer at coastal locations, inversions occur frequently both day and night, associated with off-water winds. Although horizontal ventilation is often good on such occasions, vertical mixing is strongly inhibited,and the plume from a tall chimney at the coastline may fumigate to ground-level a few miles inland.

In autumn as in other parts of Eastern North America, there are occasional periods of high pollution potential caused by warm stationary anticyclones and associated subsidence inversions.

(c) Southern Quebec and Southern Ontario

Except during cloudy or windy periods, there is a regular cycle of night inversion and day lapse conditions in this part of Canada. Only rarely does a surface inversion persist for 24 hours.

Three special problems should be noted:

(1) the spring and summer lake inversion, which creates locally poor vertical diffusion within a few miles of the Great Lakes shorelines.

(2) the warm stationary anticyclone and accompanying subsidence inversion, which occasionally shrouds the region in haze, particularly in autumn (during the Grey Cup football game at Toronto in 1962, for example),

(3) the frontal inversion over the St. Lawrence and Ottawa river valleys, mainly in autumn and winter. Cold air is occasionally trapped in these valleys, producing a high pollution potential sometimes after only a few hours.

The occurrence of any of these three synoptic situations with sunny skies in midsummer creates a high oxidant potential, e.g., Mukammal (1964).

(d) Northern Ontario and Northern Quebec

There is insufficient information in Table 4 or elsewhere to permit discussion of this region.

(e) Manitoba and Saskatchewan

These two provinces have a typically continental climate, with inversions on most nights and lapse conditions during the day. Because the underlying surface is relatively uniform, there are few local effects. The most serious pollution potential occurs in autumn and winter when a stagnant continental arctic airmass lies over the region.

(f) Alberta

The comments in (e) apply also to Alberta. There is, however, an additional synoptic pattern creating high pollution potential. The Chinook sometimes traps shallow surface pools of cold air,particularly in valleys.

(g) British Columbia

Many local effects exist in British Columbia and in Alberta on the East Slopes of the Rockies. The diffusion climatology of the Columbia River valley has been documented by Hewson (1945) but little information is available for most other areas. Hewson's studies indicate that although ground-based radiation inversions may dissipate almost every morning (see also Table 4) the pollution potential of a deep valley may become very high during periods when there is not an adequate exchange rate with cleaner air aloft,due to a capping inversion, weak upper winds or insufficient daytime convection. At such times, pollution may drift up and down the valley over a 24-hour period with very little net transport.

Near the coast, the diffusion climatology is even more complex than inland, with interactions between sea-breezes and slope winds. The stationary anticyclone, traditionally associated with high pollution potential, may permit the development of strong mesoscale wind flows and good ventilation at some locations. The possibility of high oxidant potential in summer should also not be overlooked.

The advice of Scorer (1968) is recommended. When undertaking a chimney-height design study in British Columbia,the local meteorologists should be consulted for information on regional and mesoscale weather patterns.

(h) The Yukon and the Mackenzie River Basin

Summer conditions in this area are similar to those in comparable (i.e., with the same terrain) parts of British Columbia and Alberta. Daytime inversion frequencies are very low (Fig.5) and no serious pollution potential situations should develop despite the fact that inversions occur at least 60% of the time at night (Fig. 6).

In winter, despite the long hours of darkness, night-time inversion frequencies are no greater than in summer. Because rawinsonde release times are at night (11 GMT in Fig. 2) and near sunset (23 GMT in Fig.1), there is unfortunately no direct indication concerning whether inversions break up during the day, a critical consideration in deciding whether serious pollution potential develops during spells of clear skies and light winds. Indirect evidence, however, suggests that inversions may indeed persist through the day. First, there is a well-recognized winter pollution problem at Fairbanks, Alaska at the same latitude(Benson 1970) (Porteus and Wallis 1970). Secondly, winter surface temperatures in this region frequently show a small diurnal amplitude. The question is sufficiently important, however, that the recommendation is made that at Whitehorse and Norman Wells, a few supplementary early afternoon ascents be made on winter occasions when the 11 GMT temperature profile reveals an intense ground-based inversion.

(i) The Eastern Arctic

In winter,a radiation inversion may persist for days in the eastern Canadian arctic, to be interrupted only by occasional stormy periods. A ground-based inversion is to be expected 70-80% of the time, creating a very high pollution potential.

In summer, radiation inversions are absent or weak. Whenever the air has had a recent trajectory over open water or over snow and ice patches, however, there is a possibility of an advection inversion.

The potential for poor air quality is so great in this part of Canada that special precautions should be taken to control future emissions. In particular, temperate-zone methods cannot necessarily be extrapolated to arctic conditions. In the first place, chimney-height design formulae are largely irrelevant during prolonged spells of atmospheric inversion and stagnation conditions. Secondly, because arctic vegetation and wild life are in critical equilibrium with the harsh environment,threshold pollution concentrations causing ecological damage may be lower than in the temperate zone.

8. CONCLUSION

A preliminary estimate has been given of the frequencies of ground-based inversions across Canada. The source data include vertical temperature differences from rawinsondes and from meteorological towers. Because the measurements were made at open countryside locations, the regional estimates of inversion frequencies (Table 4) should not be extrapolated to locations subject to topoclimatological or urban influences. With these reservations, the study suggests that the Canadian arctic in winter is of most serious concern because of the great risk of high pollution potential. Radiation inversions may persist there for relatively long periods. Elsewhere, special problems that have been noted include the coastal advection inversion in spring and summer, the trapping of cold pools of air in the Ottawa-St. Lawrence valleys and in the Rockies, stagnant anticyclones, and the Chinook inversion in Alberta.

To supplement this investigation, a climatology of mixing depths and of other appropriate ventilation indices should be prepared.

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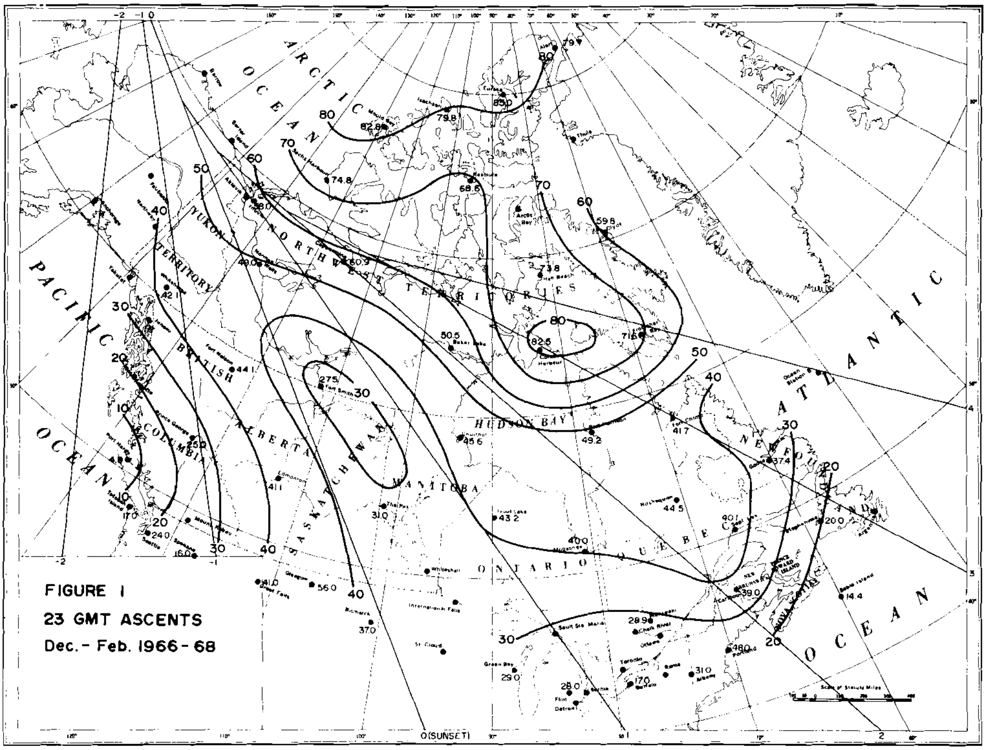


FIGURE 1
23 GMT ASCENTS
Dec.- Feb. 1966-68

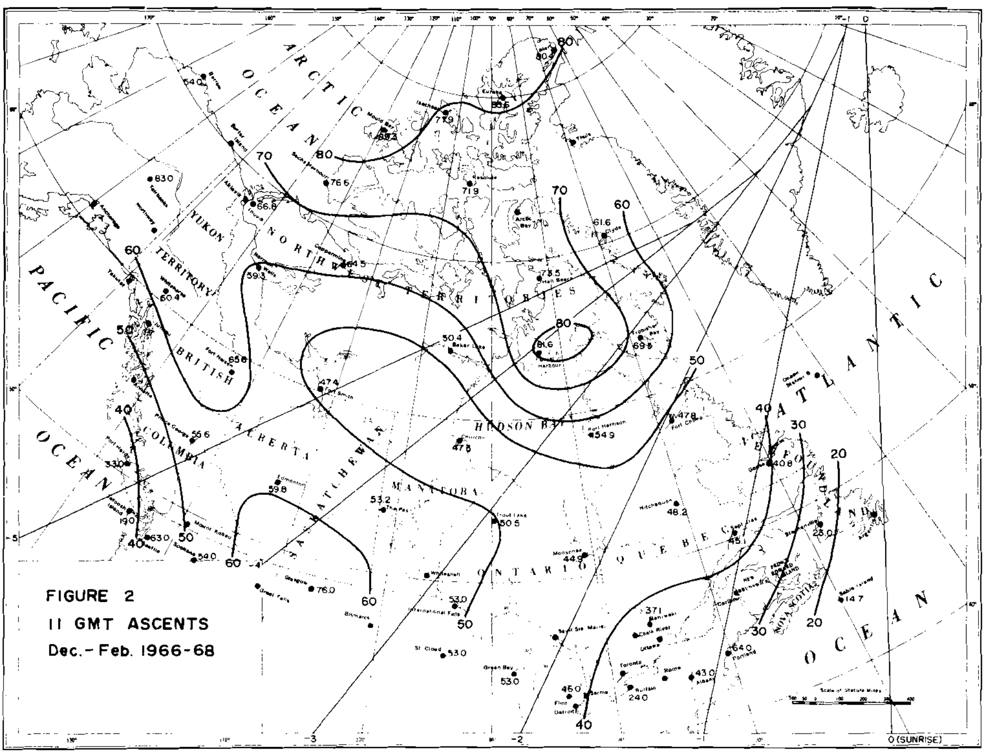


FIGURE 2
11 GMT ASCENTS
Dec.- Feb. 1966-68

Percentage frequencies of ground-based inversions. Hours of day, relative to sunset or sunrise, are given by thin straight lines in upper or lower figure respectively.

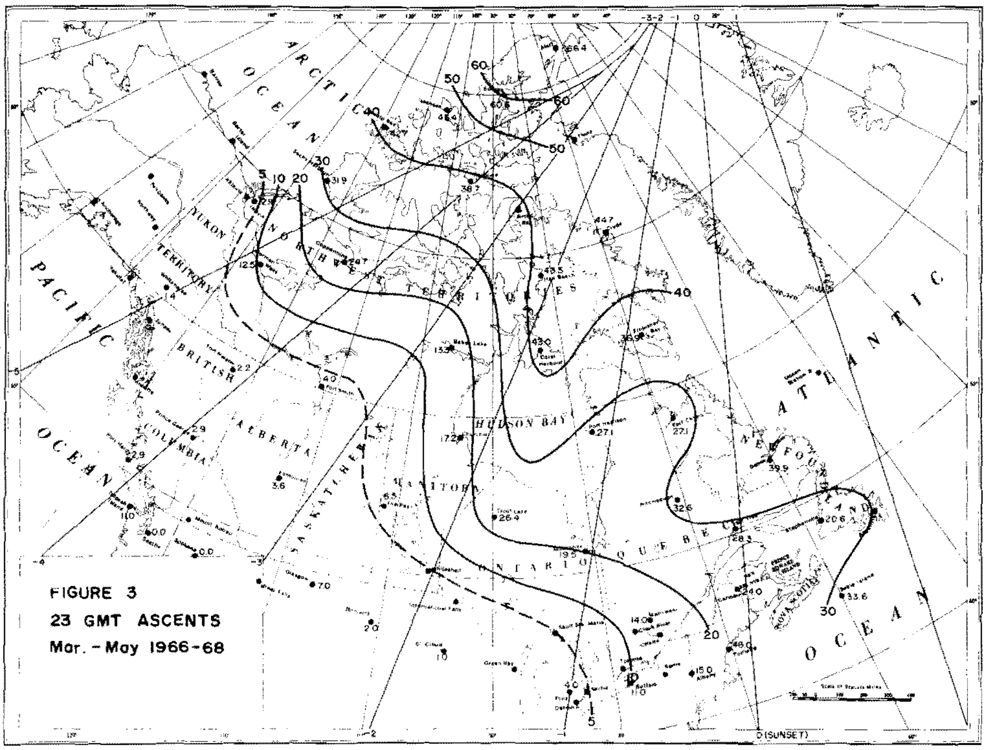


FIGURE 3
23 GMT ASCENTS
Mar. - May 1966-68

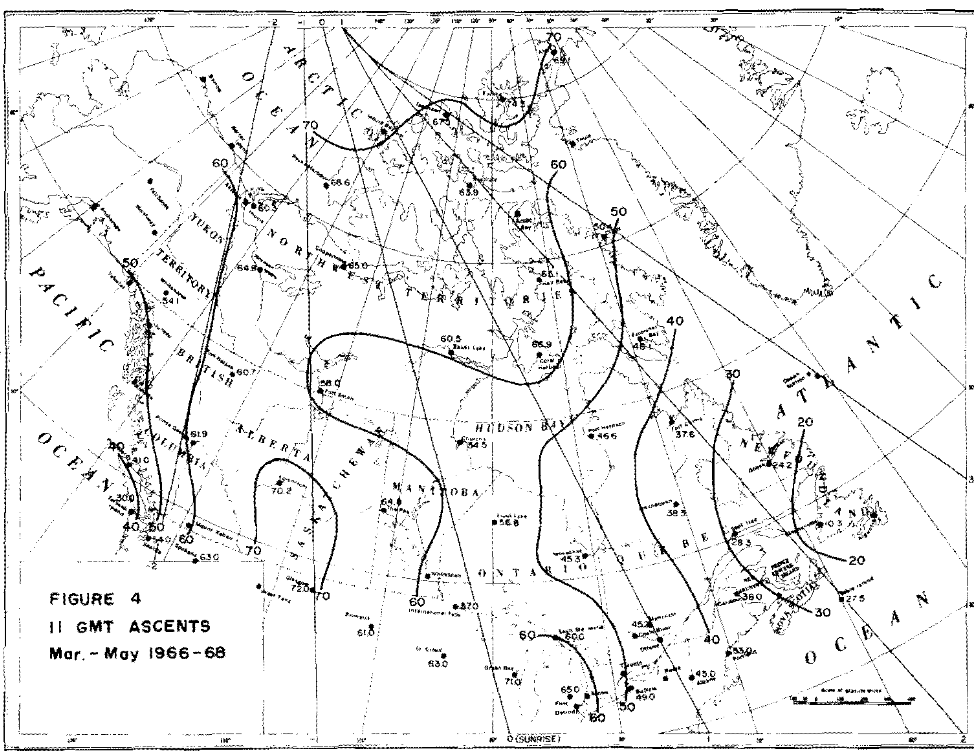
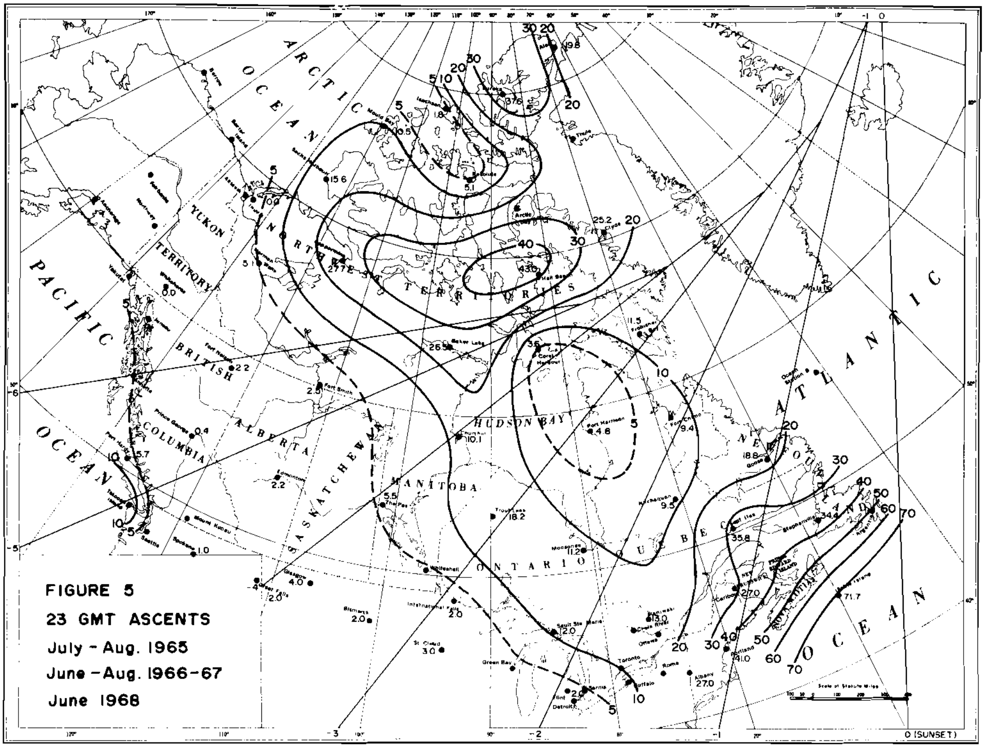
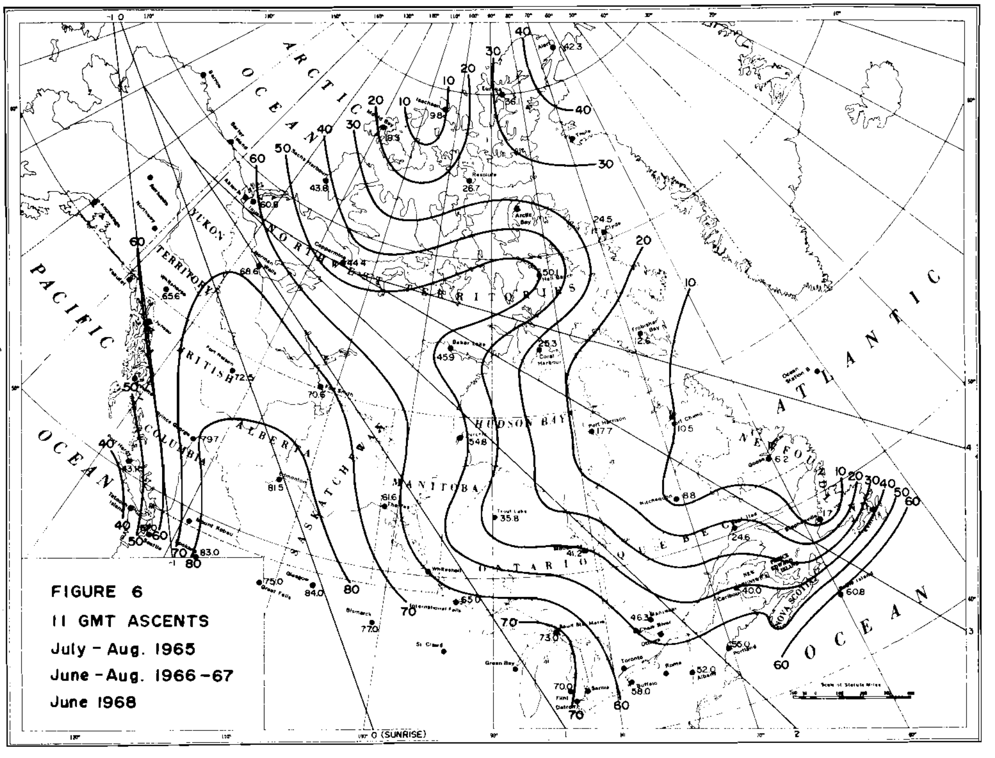


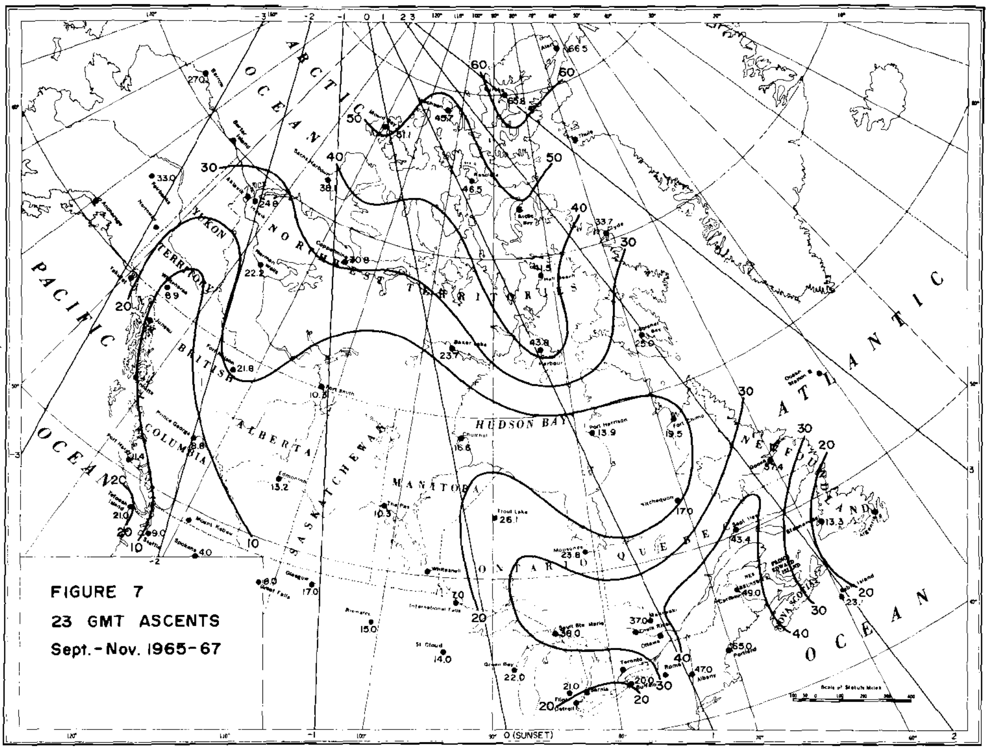
FIGURE 4
11 GMT ASCENTS
Mar. - May 1966-68

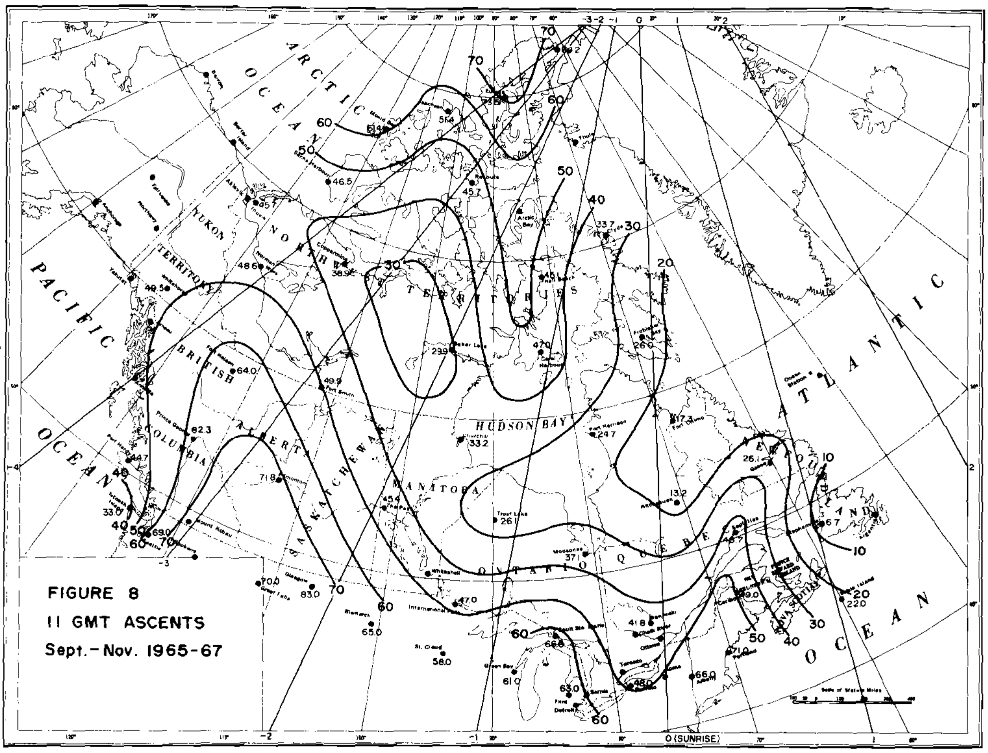
Percentage frequencies of ground-based inversions. Hours of day, relative to sunset or sunrise, are given by thin straight lines in upper or lower figure respectively.





Percentage frequencies of ground-based inversions. Hours of day, relative to sunset or sunrise, are given by thin straight lines in upper or lower figure respectively.





Percentage frequencies of ground-based inversions. Hours of day, relative to sunset or sunrise, are given by thin straight lines in upper or lower figure respectively.

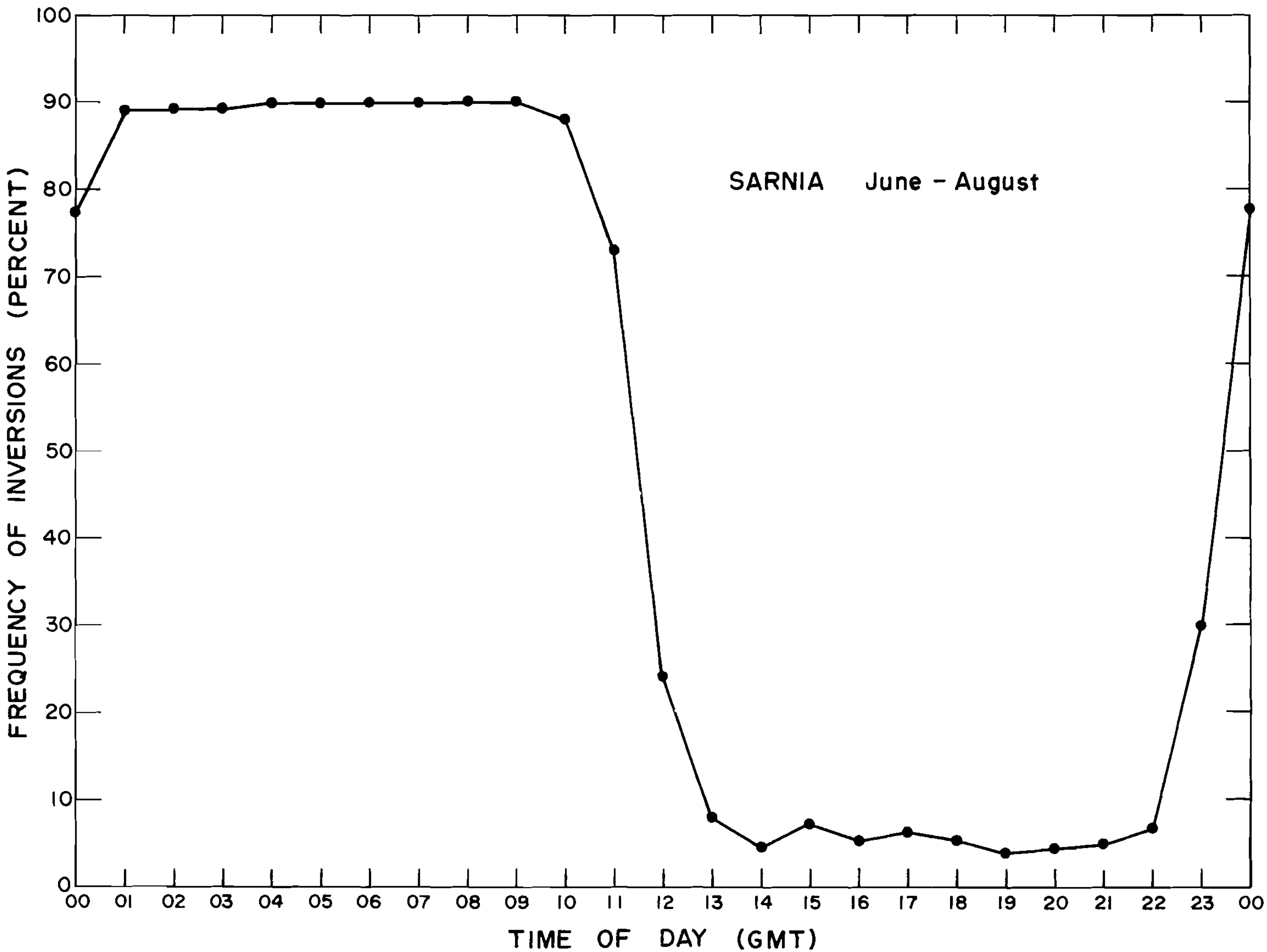


Fig. 9. Frequencies of ground-based inversions by hour of the day at Sarnia, Ont., July-Aug. 1965, June-Aug. 1966-67, June 1968.

AN AIRFLOW PROBLEM

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There appears to be an irreconcilable difference between Queney's theory of airflow over a broad mountain (1948) and the brief treatment of this subject on pages 356-7 of Haltiner and Martin (1957). To describe the lack of agreement, one can consider how a uniform wind from the west may be changed by the presence of a mountain oriented in a north-south direction,a few thousand feet high, and about 300 kilometers wide. Queney has shown that the airstream is diverted to the north so that each streamline, at the crest of the mountain,is about 300 km north of its location in the undisturbed flow, for the set of conditions he used. On the other hand, in Haltiner and Martin, the text and diagram suggest that trajectories over the mountain and on the lee side are everywhere south of initial latitudes. These two descriptions are so different that it seems highly improbable that both can be correct.

Would anyone care to comment?

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INTER ALIA

NEWS ABOUT MEMBERS

During the summer of 1970 two members have taken up new appointments in the Departments of Geography at other institutions of higher learning. Dr. JOHN E. HAY moved back to his native New Zealand by joining the University of Canterbury at Christchurch. Dr. T.R. OKE has become a staff member at the University of British Columbia.

After serving with the Meteorological Service for over 35 years, MURRAY N. MONSINGER, Superintendent of Surface Weather in the Basic Weather Division, retired during July, 1970. He was a member of the very first graduating class in Meteorology from the University of Toronto in 1934. His meteorological responsibilities have grown from that of looking after the meteorological observations,records and statistics for the Toronto Weather Office to that of administering the operational standards for all Canadian observing stations on land and sea along with the ice observing programme. He and his wife have embarked on a world trip in which they intend to spend most of their time travelling in the southern hemisphere.

Dr. R.E. MUNN, Assistant Secretary of IAMAP, has been appointed directly by ICSU to serve with 18 other prominent scientists on SCOPE. Special Committee on Problems of the Environment. Dr. Munn is well-known for his studies in the fields of air pollution, turbulence and micrometeorology. The first meeting of SCOPE with Dr. J.E. Smith of Great Britain as chairman took place in Madrid on September 19-20, 1970,just prior to the ICSU General Assembly (Sept. 24-29).

Professor R.W. STEWART of the Institute of Oceanography at UBC has been elected a Fellow of the Royal Society of Great Britain, an honour shared by a total of only 28 Canadians.

OBITUARY

CMS members who were colleagues of Professor SAMUEL M. NEAMTAM were saddened at his death on July 31, 1970, at the age of 56. He served with the Meteorological Branch for 9 years after obtaining his M.A. in Meteorology at Toronto in 1938. Professor Neamtam was born in Montreal and had been awarded the Ph.D. degree in Physics at McGill in 1937. He joined the University of Manitoba in 1946 and participated in the founding of the Department of Mathematical Physics which he headed until 1964 when it was combined with the Department of Physics. Since that time he has been Professor of Physics.

ICSU PUBLICATIONS

"TENTATIVE LIST OF PUBLICATIONS OF ICSU SCIENTIFIC UNIONS, SPECIAL AND SCIENTIFIC COMMITTEES AND COMMISSIONS OF ICSU, YEAR 1969,AND CORRECTIONS AND ADDITIONS TO THE 1968 LIST."
(May 1970, 44 pp. Price U.S. $5 plus mailing charges)

"SURVEY OF THE ACTIVITIES OF THE ICSU SCIENTIFIC UNIONS, SPECIAL AND SCIENTIFIC COMMITTEES AND COMMISSIONS OF ICSU IN THE FIELD OF SCIENTIFIC INFORMATION DURING THE YEAR 1969."
(May 1970, 365 pp. Tables, Price U.S. $12 plus mailing charges)

This report describes briefly the activities of ICSU Bodies in the field of scientific information, and is published regularly each year since 1965.

More than 170 Commissions or Committees are listed;for each of them general information is given(name of the Commission,Chairman, Secretary, periodicity of meetings, etc...) as well as a general description of the activities of the Commission and a summary of its activities during the year 1969.

These publications are on sale and may be obtained from the ICSU AB Secretariat, 17 rue Mirabeau, Paris 16e, FRANCE.

CANADIAN WATER, a digest in quick-to-read newsletter form, will collect current pertinent information and then package this material into letter-size pages for filing and fast, easy reading.

Typical subjects covered are:

Status of the new Canada Water Act;

New water developments such as: the Prairie Provinces Water Agreement, the Prairie Water Board, the Saskatchewan-Nelson River Basin Study, the Federal-B.C. Okanagan Water study, The Ontario-Manitoba water agreement, and the Churchill Falls development;

Reports from the International Joint Commission;

New water management programs;

House of Commons debates on water;

Viewpoints on water exports, on international water control, on water pollution, on recreational vs. industrial use; with opinions from Ottawa and Washington, D.C.

Subscription fee for CANADIAN WATER is $10.00 per year for 12 issues, or $6.00 for six issues. Publisher is:

C.L. Sibbald Agribusiness Ltd.
Ste. 1 - 1609 A Centre St. North
Calgary 41, Alta.

NOTES FROM COUNCIL

The following were elected to membership at the June 25, 1970, meeting of Council:

Member

Yvon Bernier
Clarence Clarkson Boughner
Paul Wayne Galbraith
Nicholas Clement Turko

Graduate Student Member

Paul Yok Tong Louie

Undergraduate Student Member

Pierre Erroll Keevil

The following were elected to membership at the August 13, 1970, meeting of Council:

Graduate Student Member

Fred N. Alyea
Auguste Blanchais
Theodorus Johannes Simons

EDITORIAL NOTE

Before the first issue of ATMOSPHERE appears in its new format in the first quarter of 1971, the two remaining issues for 1970 should be distributed as follows: No. 3 in November, 1970 and No. 4 in January 1971. In this way the publication will be back on schedule.

Schedule Of Charges For Reprints

The first 500 pages	Cost	4 cents per page	-	\$20.00
The next 500 pages	Cost	3 cents per page	-	\$15.00
The next 500 pages	Cost	2 cents per page	-	\$10.00
All additional pages	Cost	1 cent each		
Cover Pages	Cost	3 cents each		

(orders must be in units of fifty)

Example: A seven-page article for which 250 additional reprints are required - total 1750 pages -

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	(Next 500 pages)	-	$10.00
	(Additional)	-	$ 2.50
	(Cover Pages)	-	7.50
	TOTAL:	-	$55.00

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 four types of membership - Member, Corporate Member, Graduate Student Member and Undergraduate Student Member. For 1970, the dues are $8.00, $25.00, $2.00 and $1.00, respectively. Atmosphere is distributed free to all types of member. Applications for membership should be accompanied by a cheque made payable at par in Toronto to The Canadian Meteorological Society.