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THE ROLE OF METEOROLOGY IN THE NATIONAL ECONOMY[1]

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The Science Council of Canada published in October, 1968, their Report No. 4 entitled "Towards a National Science Policy for Canada" which contained the first steps in the development of a comprehensive national science policy from which, hopefully, both Federal and Provincial Governments, universities and industry will derive their own pragmatic operating science policies.

For many this marked the first time they had been introduced to the concept of a science policy. It is to a considerable extent a post-World War II phenomenon. It can most simply be described as the combination of broad future-oriented strategies for the health and development of science and future-oriented and broadly-based strategies for the use of science and technology, including engineering, in attaining national social and economic goals and in the solution of social and economic problems.

The realization of the importance of a national science policy arose from two considerations: the general political and public desire that existed to a very modest extent before the war to support science for science's sake as a cultural pursuit of the highest order and as an indispensable component of education, gave way during the war to a feeling of relief, and gratitude and derived strength as science in Germany and science in the Allied Forces struggled with move and counter move and greatly enhanced the Allies ability to prevail. When the generation of those who had fought the war returned to the business world they could no longer look at science as a purely cultural pursuit but were well aware of the important role of science and technology in the solution of almost any social or economic problem with which they were confronted. At the same time, the growing cost of the performance of research and development was becoming a matter of public concern.

1. Theme paper presented at the Third Annual Congress of the CMS, held at the University of Toronto, May 27-29, 1969.

The immediate post-war result of these forces was a tremendous emphasis on research and development in the natural sciences to increase the scientific and technological capability of the industry of the developed nations,and a number of well meaning but rather inept attempts to carry Western technology to the developing nations.

More recently, governments, by virtue of the increasing demands for public money in the support of research, development and innovation, and in part because of public demands for government action on social problems, have themselves become greatly concerned about the state of science, and I suppose as a reflection of this it has become one of the central activities of OECD.

The mechanisms within Canada for the development of this science policy, that is, of the strategies for the successful development of science and technology and for the successful use of science and technology, are first, a Science Council which is now set up as a Crown Corporation so that it has a considerable measure of independence from the Government and is overtly invited by the Government to be critical of their own actions and to take a national view of problems, and second, a Science Secretariat which is the in-house science arm of the Privy Council Office giving day-to-day support to the work of Cabinet and its Committees to make sure that the scientific and technical alternatives are presented to Cabinet or its Committees on each agenda item.

The Science Council has the responsibility for the development and enunciation of a national science policy for Canada and the maintenance of an overview of the health of all branches of science of importance to Canada and an overview of the extent and success of the use of science and technology in reaching the social and economic goals and in the solution of social and economic problems. In effect, then, the Science Secretariat work behind the closed doors of Cabinet whereas the Science Council is working in the public domain, and the more the channels of communication between the Council and the scientific community and between the Council and the general public can be improved, the better.

One of the first things that came to the attention of the Council as it developed the framework for a national science policy was that a growing imbalance in the performance of research and development in Canada was a matter of major concern. Science in government has developed considerable strengths and abilities and has over several generations, through grants and other means, nurtured the development of science in the universities, until the universities are now strong and can be compared favourably in both quality and quantity of scientific activity with those in most other countries. With this development and with the obligation of the government to continue to support university research it is important that science in government turns specifically to reinforce its new goal of mission-oriented research and development. The real crisis is with the level of research and development in industry which is well below that of any of the other major advanced countries and is away out of balance with our research and development efforts in universities and in government.

The correction of this imbalance is not going to be easy but must be tackled urgently, intelligently and with resolution. The first attempts by the government were through industrial incentive programs such as PAIT and IRDIA. These do not appear to have worked and figures published in the Third Annual Report of the Science Council show that over the last three years the actual number of man-hours of research and development in industry has declined in spite of the best efforts of those in government who are promoting and administering these industrial R & D incentive programs. We must therefore look for other solutions.

At this point I would like to make a statement which I hope you will all remember. Most of the balance of my talk is going to be concerned with applied meteorology or applied research, in other words,with this strategy for the use of science, technology and engineering. I would like you to remember my opening statement that a science policy is concerned both with that,and with the strategy for the health and development of science. We must never lose sight of the need to support interest-motivated research and to support it well. It is amenable to judgment on a merit system. We need also to support good graduate training at those universities with the qualifications and the desire to embark on this demanding and expensive level of education. Any country that loses sight of the need to support without question those of its generation capable of interest-motivated research and those of the next generation with the desire and ability for doctoral level training dooms itself to mediocrity.

Most of this research will be carried out at the universities because it is inseparable from good graduate training but this does not deny the opportunity for a small amount of interest-motivated research in government laboratories, and indeed in industry,but in saying this we must bear in mind that the principal concerns of these latter two are the missions, the services and the products which in the case of government are expected of them by the people,and in the case of industry are necessary if they are to be economically viable and return a profit to their shareholders.

It is also to be hoped that the interest-motivated research and graduate work at universities will be done in cooperation with government and industry in the use, where appropriate, of the latter's equipment, people and environment in a manner so as to enrich the total environment to which the graduate student is exposed during the course of his tutelage.

One other major imbalance we have in Canada (but it is not peculiar to Canada) is a very poor state of development of the social sciences and we could add to that, the humanities. Economics has perhaps fared the best, but the behavourial sciences and our whole understanding of education and society have lagged disgracefully. It is urgent that they be given all possible help to catch up, but it is going to be a slow business and money alone will not do the job.

We should bear in mind the relative costs of the innovative cycle, i.e.,basic research, applied research and development. The U.S. National Science Foundation figures on their 1968 operation shows that out of every dollar for research and development, 13 cents goes to basic research, 20 cents to applied research and 67 cents to development. These have to be added to the figures published by industry in the United States which tend to show that the research and development phase of a new product accounts for only about 10 per cent of the total cost of getting that product into production.

Turning now to meteorology,I think we have a branch of science that has developed very much along the lines that I have outlined as the Canadian norm; that is, for many years the bulk of the R & D was carried by the Meteorological Service of Canada. But as a post-war phenomenon resulting from government finance and assistance, albeit much of it coming from the United States, a healthy diversity of research and teaching programs has developed at a number of universities, particularly McGill, Toronto and Alberta, with specialized efforts such as the high-level work at Saskatchewan and the agro-meteorology at Guelph. Canadian industrial effort in the field of meteorology, particularly meteorological instruments, is weak and must be strengthened.

We have the ingredients for success because on the one hand we have people,money and programs, and on the other we have universities, government and industry, all concerned with the field of meteorology. What we must develop and develop without delay are the strategies to ensure the ongoing health of the science of meteorology and its technological and engineering aspects. We must develop much stronger strategies for the use of our meteorological knowledge in meeting the social and economic goals and helping to solve the social and economic problems of Canada, and we must, in doing this, attempt to so deploy our people, our money and our programs to bring about a balance between the efforts in universities, government and industry. Let us not forget that it is the profits from industry that provide to a large extent the tax base for the support of our research and development in universities and government labs.

Our national goals, as stated by the Science Council, are national prosperity, health, education, freedom, security and unity, leisure, personal development and world peace, and I think we could add to that, a decent environment. I think if you examine each of these goals you will see that meteorology has something to say about each.

With regard to national prosperity our record in encouraging the development of industry in the field of meteorology in Canada is deplorable, even though I think industry has the skills and abilities to produce particular meteorological instruments and sell them around the world. We have a better record in helping to maximize our climatic advantages and minimize our climatic disadvantages for various forms of industry. If we are to maintain a high rate of economic growth and obtain reasonably-priced ability, we must expand and improve this service. The development of a Canadian Meteorological Rocket and the work on hail suppression are two specifics. Let us put more effort into those projects which have a chance of high payoff.

In the domain of health, we have done very little in the field of bio-meteorology and bio-climatology. In fact, some people hardly feel it is a respectable area of concentration and yet we can look elsewhere around the world and see the warnings of atmospheric pollution. Another warning was contained in a paper by Robinson and Robins in the April 15, 1969, Journal of Geophysical Research where measurements of carbon monoxide in the atmosphere taken in the north central portion of the Greenland icecap showed very clearly that air which reached that remote area after passing over the industrial complex surrounding the Great Lakes, even when it arrived over the Greenland icecap, had a concentration of carbon monoxide five times that contained in air arriving with other trajectories. We have the rape of the Sudbury countryside and numerous other examples, and we have the pollution levels in our major cities. Perhaps people have not died of these effects as yet and they can be classed as little more than a nuisance, but people in other countries have died unnecessarily as a result of atmospheric pollution. I think it is incumbent upon those of us in meteorology who have something to say to the public and who elect to devote an appreciable part of our scientific efforts to these matters to take an active and an aggressive role. We live in an era of confrontation. Any attempt to follow a passive role is tantamount to abdication.

Let us turn to the nonsense perpetrated by architects and engineers in designing greenhouses in the guise of human habitation and a thermal holocaust in the guise of air-conditioning. Have we as meteorologists put the right amount of scientific and professional attention on these matters or have we been sitting passively by as arm chair critics while these other worthy professions perpetrate their recurring nonsense? Do we really know what the optimum atmospheric conditions inside a building are to maximize human abilities? I would like to suggest that as far as temperature goes the air near the floor should be the warmest and the air near the ceiling the coolest, so that the head is always cooler than the feet, sitting or standing. How many buildings achieve this and how much research is being done on it? There is some research supported by ASHRAE but they are hardly a meteorological society. How much are we doing with regard to materials research? Some of you may say, well that is not meteorology; but for any material which is to be used in a manner that exposes it to the atmosphere I would ask whether the main degrading effects are atmospheric or not. If they are, should we be leaving the materials research to others? Why should every flat roof in Vancouver when it is first constructed leak? Is it because we as meteorologists have had little to say to architects and engineers on the possible combinations of snow and rain and wind and that given the right conditions water can run up hill in large quantities?

Turning to the public and industrial use and abuse of water, as meteorologists we have much to say about the hydrologic cycle, so I think we must also be concerned about the problems of fresh water. I saw some recent figures which claimed that in the United States the use of fresh water by the population had risen 15 per cent in the past five years, that people now used 310 billion gallons per day, of which 75 billion gallons per day were evaporated and 235 billion gallons were returned in an unclean condition. This is still small compared with other uses. For example, the development of hydro-electric power uses 2.3 trillion gallons per day but it is returned in a clean condition. Surely with increasing populations and increasing use per capita of population there is sufficient warning to us as scientists that there is a problem about which we as meteorologists have something to say and we should be saying it with increasing vigour. I am encouraged that we will do this in Canada with a meteorologist, Jim Bruce, in charge of the Burlington lab* but he cannot do it single-handed.

In the field of education, I think meteorology and meteorologists have a major role to play. We keep on paying lip service to the need to teach the social scientists and the humanists something about science. Maybe the inner workings of an atom is particularly unexciting to the historian or the English scholar but I would defy him to be unexcited about the environment in which he is destined to live and I would defy him to be unexcited about the degradation of our environment; and yet have we done much about making the courses of science for the humanist in our educational system, courses dealing with the world around us, which includes the atmosphere. I suggest that by being asleep we are allowing things to head in the wrong direction. UNESCO recently sponsored a conference on the biosphere and there was really no mention of meteorology at all. One junior representative from WMO did turn up as an after-thought invitation and yet somehow in my peculiar biased attitude I have always considered the atmosphere as rather an important part

*Canada Centre for Inland Waters

of the biosphere. Neither biologists nor the organisms they study could exist for long without it. Was there a Canadian on the delegation who was identified in the field of meteorology? Should we blame the biologists or is it our own fault for not talking to the biologists and letting them know what we have to say that would be of importance to them? Would it surprise you if I told you that the department in which I lectured at Simon Fraser University was the department of biological sciences and that the course was a senior-level course on the environment?

Freedom, security and unity. We are fortunate in Canada in having few of the really destructive attributes of the atmosphere as normal components of our climate. There are few severe tornadoes; hurricanes are rare visitors; we have learned to cope with blizzards; but deaths still occur from meteorological hazards and man's travel is still periodically disrupted or rendered uneconomical. Our services in this direction have been central to our efforts for years. While stressing these other areas in which I think we have been far too passive, I want to re-emphasize the need for continual vigilance and progress in our forecasting services.

Leisure and personal development, one would be inclined to say, is a goal remote from meteorology,but tourism is not unrelated to the manifestation of climate and the weather and if tourism is to prosper, recreational facilities appropriate to the climate must be developed. And let us never forget man's desire for change. Just as Canadians throng to the Southern latitudes in the winter to get some sun, so those in Southern latitudes move north in the summer to get some cool, and man's engineering capabilities now can do things that would be looked upon as stupid a few years ago. Would anyone laugh at a declared intention to build a mountain in order to have skiing, or dig a lake to provide swimming and boating?

Finally, we come to world peace. Meteorology has been an area of international cooperation for generations. Let us make sure we keep it this way not only for the good of the meteorological services to mankind but as a scientific springboard maintained in good condition in case it can ever be used for the solution of less tractable political problems. Also let us remember that perhaps the greatest long-term threat to world peace is that we are not solving the problems of the less developed nations. In spite of the best efforts of the United Nations and the cooperating countries in the First Development Decade the gap between the rich and the poor nations has widened, there is more ignorance and more total illiteracy now than there was ten years ago and there is more hunger and more outright starvation in the world today than there was ten years ago. Certainly the situation would have been a lot worse had the UN Development Decade not taken place, and the situation might be different if there had not been the world population explosion at the same time, but the cruel facts are that the gaps in ignorance and hunger and in wealth have widened. And let us not forget that most of the underdeveloped nations are underdeveloped because of their weather and their climate. In the jargon of today, they have a meteorological hangup. I suggest therefore that we as meteorologists must redouble our efforts with the developing countries in the UN Second Development Decade.

Turning now to fitting our people, our money and our programs into our university, government and industrial sectors in meteorology, I have not much worry about the universities, providing we have the intelligence to fund their programs and the gall to criticize and heckle so that they seize a greater and greater role and bring the aeronomists and others back into the fold, so that meteorology is truly the study of the gaseous envelope surrounding the sun in which the planets are imbedded.

I think meteorology in government must become much more aggressive, must make some painful choices on areas of concentration and must take the lead in encouraging the rapid development of a meteorologically-based industry in Canada, and I hope that all of you will take from what I have to say not criticism of the past but direction for the future. I think meteorology in government should look at everything they are doing to see that those things which can be contracted out, are contracted out, to build industrial competence and develop skills and products that would have an international market. I am conceited enough to think that our meteorological instruments are some of the best in the world, and yet, as long as we do not transfer to industry the know-how that is a part of the Instrument Division of the Meteorological Service of Canada, the international market will continue to be dominated by instruments obtained for more money from American suppliers. To stimulate industrial activity it may be necessary to actually loan people to industry. There is nothing surprising or shocking in this. In fact, in examining the reasons for the fantastic success of the development of science-based industries in the United States, one cannot help but be impressed with the role played by scientists moving from the lab to develop and innovate their ideas onto the product line. We have one Canadian company with, I think, the ideas and many of the skills that would produce meteorological rockets which would outperform and undersell their American competitors, but it is only going to do this if Canadian Meteorology gets behind it, perhaps even loaning some key people; and certainly we must have the wisdom to buy and use the rockets ourselves. How can a Canadian company expect to sell abroad if we in Canada refuse to use their products? I think government agencies in Canada must take a much more active role in pushing for and supporting the development of domestic industry, through purchasing and through cooperation, and in case you think this sounds like socialism let me tell you that in that bastion of capitalism known as the United States, 50 cents of every industrial R & D dollar comes from the U.S. government. Industrial R & D in the United States amounts to some 70 dollars per head, man, woman and child, per year, of which 35 dollars comes from the U.S. government. In Canada our record is a paltry 20 dollars of which four comes from government sources, so we have a long way to go to even be competitive with the United States.

Finally there has been a ground swell of misinformation recently that we are, through the expansion of graduate work in science in the universities,in danger of an oversupply of people with Masters and Ph.D. degrees in the sciences.

I think this is patent nonsense because if it was true, is there anything desperately wrong about a Ph.D.in science not being immediately employed in a research position in the sub-area in which he did his thesis? Would it be a tragedy if he joined External Affairs and brought a little science into that bastion of the humanities? Would it be a tragedy if he entered the secondary school system? Would it be a tragedy if he entered industry in other than a research position, possibly prepared for management by an MBA program? We seem to have a national hang-up wherein an historian can be employed in External Affairs where he will not engage in scholarly history for the rest of his career, and we say how wonderful and how strong this will make External, and the man is congratulated on his appointment, whereas if the scientist or engineer accepts employment outside the laboratory and outside the narrow field in which his thesis was developed, he is looked upon almost as a leper or at least as a social outcast and a failure. I think this is a stupidity which we must exorcise from the scientific community but let me not fill you full of my personal biases, let me quote from two external sources. First, Dr. Swinton of the Editorial Board of the Canadian Scientist, in an article entitled "A Surfeit Surveyed",said the following:

> "One way or another in these formative years, there can never be too many scientists in Canada, and it is only timidity to deny that many of them will make jobs for themselves and their fellows and for a better Canadian way of life";

and more recently, the distinguished National Science Board of the United States said in their publication "Towards a Public Policy for Graduate Education in the Sciences", the following:

> "Today as man's problems and his awareness of these problems multiply, there is an ever-increasing need for the highly-trained scientists and engineers that graduate institutions provide";

> "..........a doubling of the graduate student population by about 1980";

> "..........(It) is now a stated national policy to provide to all citizens the educational opportunity to develop their individual capabilities to the fullest".

Mr. Chairman, ladies and gentlemen, if I have annoyed, goaded or stimulated all of you, if a good number of you think that I have been unfair, then I have accomplished my purpose and I stand ready to be attacked, but I feel we in Canada have the people, we have the money and we have the programs and we have strengths either in existence or ready to be developed in the universities, in government and in industry. If we can seize this opportunity and become active rather than passive, the field of applied meteorology in Canada will know no limitations and the rewards, both nationally and internationally, will exceed our wildest dreams, but it will only happen if we get up off our backsides and get to work.

INTER ALIA

Dr. Giuseppe Drufuca of the University of Milan is a visitor at the Stormy Weather Group, McGill University.

Dr. T. Takeda from Nagoya University, Japan, has completed an 18-month Visiting Professorship at McGill University's Meteorology Department. During his time he extended his work on the numerical modelling of convective storms.

NEWS ABOUT MEMBERS

J. Derome and I.Rutherford are now staff members of the Operational Development and Evaluation Unit, Central Analysis Office.

André Robert has joined the Department of Meteorology at McGill University.

D.N. McMullen, Hydrometeorologist with the Ontario Department of Energy and Resources Management,was elected Vice-President at the twenty-seventh meeting of the Eastern Snow Conference held at the State University of New York at Albany in February, 1970.

The Eastern Snow Conference is an international organization in eastern Canada and the north-eastern United States concerned with origin, precipitation, accumulation, character, melt and runoff of snow from the viewpoint of Meteorology, Power Generation, Conservation, Engineering, Forestry and related fields.

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A PRELIMINARY SURVEY OF SOME LIGHTNING - HAILSTORM RELATIONSHIPS

By

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INTRODUCTION

A thunderstorm has been defined to be a violent atmospheric phenomenon during which there occurs "one or more sudden electrical discharges, manifested by a flash of light (lightning) and a sharp or rumbling sound (thunder)" - W.M.O. (1956). Lightning, in its turn, is an electrical discharge of very brief duration, during which a breakdown occurs between two regions resulting in a current flow between them. The breakdown potential in air is so high that vast quantities of electrical charge must be separated for this to occur. Since charge has to be carried on finite-sized particles ranging all the way from diameter 10^{-8} cm (small ions) to 5 mm (large raindrops), the charge separation mechanism must be intimately connected with both the precipitation mechanism and the dynamics of the thunderstorm. In the past, there has been a tendency to regard the electrical activity of thunderstorms as a subject distinct from the precipitation process and a vast amount of literature has grown around these two fields with little overlap between them. It is the purpose of this article to examine features of a thunderstorm in its entirety in the hope that the dynamics and the precipitation mechanism of storms may be better understood in terms of the electrical activity and vice versa.

THE THUNDERSTORM

The thunderstorm, in its classic form,has already been studied comprehensively in the Thunderstorm Project (Byers and Braham, 1949). A typical thunderstorm consists of a cell or number of cells,each of which may evolve through three stages.

(i) Cumulus stage (developing)

A large layer of unstable air is required so that cloud air is accelerated upward. The updraft increases with elevation and the cloud builds rapidly to heights where the temperature is well below freezing. Large amounts of cloud droplets, raindrops and snowflakes accumulate in

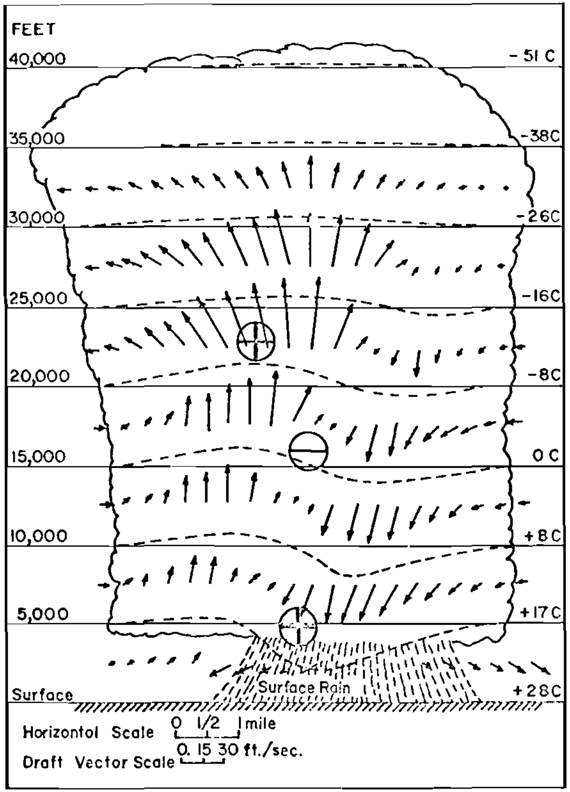


Fig. 1. A thunderstorm in the mature stage (after Byers and Braham, 1949); positive and negative charge centres are circled.

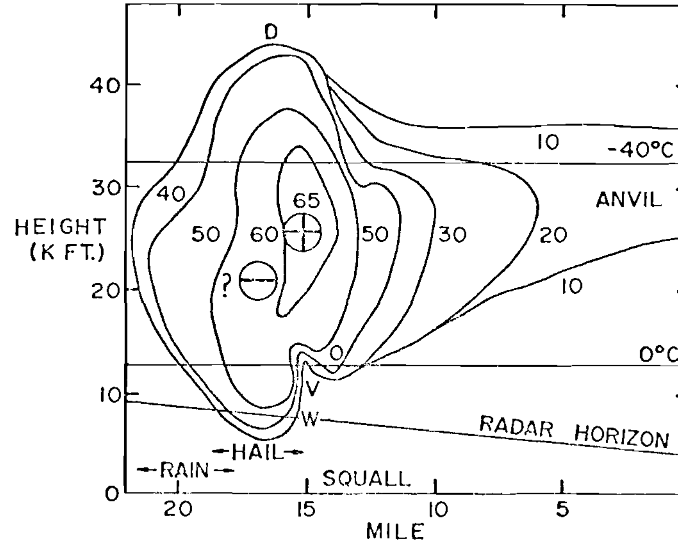


Fig. 2. Features of radar echo structure in the Wokingham storm during its intense phase, shown on a range height section through the approaching storm. Isopleths are drawn of 4.7 cm reflectivity expressed as 10 log Z_e ($mm^6 m^{-3}$). Letter D indicates position of highest echo top; W, echo "wall" associated with large hail; O, "forward overhang", and V, "echo-free vault". Suggested charge distribution centres are circled; position of negative charge centre is speculative. (diagram adapted from "Severe Local Storms", Am. Met. Soc. Meteorological Monographs, No. 27, Sept. 1963, p. 15)

the cloud. Finally, growth mechanisms produce elements that are too heavy to be supported by the updraft and water begins to fall through. The frictional drag exerted by the falling water turns the updraft into a downdraft and a heavy downpour sets in, this marking the beginning of the mature stage.

(ii) Mature stage

Updrafts and downdrafts exist side by side. The onset of the downdraft at the ground is sharp, with strong gusty winds and heavy rain. The downdrafts gradually increase in strength over that of the updrafts and this event marks the beginning of the dissipating stage.

(iii) Dissipating stage

Downdrafts predominate. The cloud exhausts its water supply, the rain intensity decreases and the cloud dissolves or disintegrates.

Lightning does not generally occur until the temperature of the cloud top is about -28°C. The charge centres are near -15°C and -4°C for the main positive and negative charge centres respectively (Fig. 1). The greatest lightning activity is in the region of the downdraft and heavy rain.

THE STEADY STATE STORM

The classical concept of the thunderstorm has been modified recently to include another type of storm which occurs predominantly in the U.S.Midwest and much more rarely in the British Isles. These storms, called SEVERE LOCAL STORMS, are characterized at the surface by torrential rain, large hail, strong gusty winds and tornadoes. At upper levels, a strong horizontal wind shear exists, with a stable layer trapping warm humid air beneath cold dry air aloft. This pattern is sketched by the radar echo structure shown in Figure 2 for one of the particular storms on which the model is based.

In the severe storm, the mature stage takes on a new lease on life; a much larger "supercell" with an intense updraft and downdraft coexisting in a more nearly steady state (up to periods of an hour or more) evolves, with updrafts generally penetrating into the stratosphere. Tornadoes are found in the region of strong cyclonic shear at the foot of the updraft where the cold air from the rain area undercuts it.

While electrical charge distribution in these storms has not been studied, it is possible to estimate roughly where these might lie (Fig. 2). Secondary charge centres may also be present.

THE CHARGE SEPARATION PROCESS

The charge separation process may be affected by different factors. On a microphysical scale, the physical state of the hydrometeors, and, on the macrophysical scale, temperature gradients, updraft speeds, wind flow patterns are all important.

(i) Microphysical factors

Precipitation may be initiated both from the ice and water state and a vast number of electrical effects may be associated with both of these.

Electrical effects may be obtained from:

a) ice impact,

b) ice contact with different temperature gradients,

c) freezing,

d) riming,

e) glazing,

f) melting,

g) sublimation and deposition,

h) evaporation and condensation,

i) splashing.

A summary of the results of these effects is presented in Chalmers(1967, pp. 75-84). It seems entirely possible that a number of processes may be operative at different times in any one storm. However, from analysis of actual storms, it is possible to set conditions that any charge generating process (or combination of processes) must meet. Chalmers (1967, p. 402) lists the following requirements:

a) The process must produce a positive upper charge and a negative lower charge;

b) The process must produce a rate of separation of charge of up to several amperes;

c) The process must operate at temperatures below the freezing point;

d) The process must be connected with precipitation in the solid form;

e) If the process operates in nimbo-stratus clouds,it must do so much less effectively than in cumulo-nimbus clouds.

Mason (1965) makes the following observations:

a) The average duration of precipitation and electrical activity from a single thunderstorm cell is about 30 minutes;

b) The average electric moment destroyed in a lightning flash is about 110 Coulomb-km, the corresponding charge being 20-30 Coulomb;

c) The magnitude of the charge which is being separated immediately after a flash, by virtue of the fall speed v of the precipitation elements, is of the order of 8000/v Coulomb, where v is the fall velocity of particles relative to the air, in m/sec;

d) In a large, extensive cumulus, this charge is generated and separated in a volume bounded by the $-5^{o}C$ and $-40^{o}C$ levels within an average radius of perhaps 2 km;

e) The negative charge is centred near the $-5^{o}C$ isotherm, while the main positive charge is situated some kilometers higher up;a subsidiary positive charge may also exist near the cloud base, being centred at or below the $0^{o}C$ level;

f) The charge generation and separation processes are closely associated with the development of precipitation, particularly in the form of graupel. The precipitation particles must be capable of falling through updrafts of several metres per second;

g) Sufficient charge must be generated and separated to produce the first lightning flash within 12-20 minutes of the appearance of precipitation particles of radar-detectable size.

(ii) Macrophysical Factors

Workman and Reynolds (1949) observed a number (12) of thunderstorm cells both visually and by radar. For 11 storms, initial electrical activity consisted of a cloud-to-cloud stroke and, on the average, the initial cloud-to-ground discharge took place 6 minutes after the cloud-to-cloud stroke. The initial electrical activity also occurred some 12 minutes after the appearance of the initial radar return. About the same time as the electrical activity and visible precipitation began, the top of the radar echo started to descend.

Reynolds and Brook (1956) concluded that precipitation is a necessary,but not sufficient,condition for the onset of thunderstorm electrification. A further condition appears to be rapid vertical development, and when this exists from early stages, the time interval between the first appearance of precipitation and of precipitation echoes is negligible.

Moore, Vonnegut and Botka (1958)showed that there could be electrification within the cloud considerably earlier than the time that it was detectable at the ground. They suggested that the electrification might be due entirely to the rapid vertical development and that precipitation may be the consequence rather than the cause of electrification.

Vonnegut and Moore (1958) reported that "storms that produce tornadoes are generally more vigorous, larger and more electrically active than ordinary thunderstorms". Estimates of one tornadic storm gave lightning stroke rates of 10 to 20 per second with most of the strokes occurring inside the cloud.

Moore, et al., (1962), in examining the rain gush effect,found that a new radar echo, indicating large drops, often appeared shortly after a lightning flash and that heavy rain fell some minutes later. This seems to indicate that lightning causes the heavy rain rather than the reverse and it was suggested that the electric field increases the probability of drops coalescing.

Shackford (1960), in an investigation of New England storms found that:

(i) the lightning stroke rate tends to increase with maximum radar-echo height. While there are instances of low lightning rates associated with high echoes,the reverse situation does not occur;

(ii) in 60% of cases where hail reached the surface, the lightning stroke rate exceeded 100 per hour and no hail was reported with lightning rates less than 10 per hour;

(iii) lightning stroke rates increased with increasing radar reflectivities in the 15,000-40,000 ft. layer.

Shackford speculated that higher radar reflectivities and lightning stroke rates were associated with larger particle sizes, a more intense updraft and rapid rate of supply of liquid water.

Ludlam and Macklin (1959),using the results of Horner, showed that, during a storm in southeast England, the electrical activity remained high while the storm gradually produced hail in increasing size (up to 7-8 cm diameter). As the storm died and a sharp decrease in hail size occurred, the electrical activity still was very high. However, as hail size fell below ½ cm, there was a sharp decrease in electrical activity.

Ludlam (1959), noted complex electrical discharges at the summit of the cloud at a rate of 1 per second in an Italian storm at its peak activity (hail, maximum updraft speed, etc.).

More comprehensive investigations into lightning-hail relationships have revealed some curious results.

Sansom (1966)in Kenya found that 37% of storms with frequent lightning as compared to 68% of the storms with infrequent lightning and 79% of the storms with no lightning at all were classed as damaging storms, i.e., ones producing significant hail damage to local crops.

Blevins and Marwitz (1968) in Colorado found that:

(i) as the rate of lightning strokes increased, the percentage of cases which produced hail increased until the number of strokes exceeded 70 per minute. Beyond 70 strokes per minute no hail was reported;

(ii) there was a significant decrease in the proportion of strokes that were cloud-to-ground as the total number of strokes increased;

(iii) large hail occurs with low lightning stroke rates and small hail with higher lightning stroke rates.

Smith (1968) in Nebraska found that:

(i) hail occurs in almost 40% of the storms with only occasional lightning. Only about 13% of the heavy lightning cases produced hail;

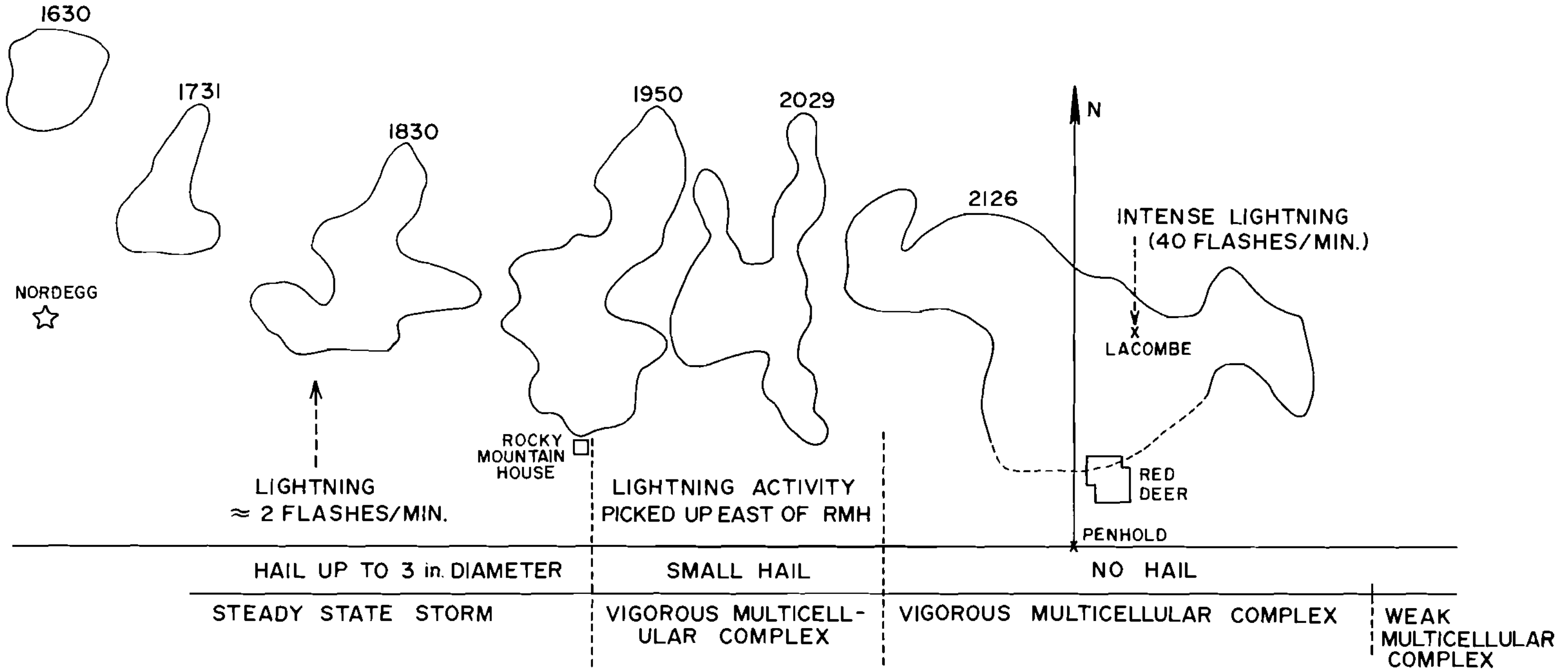


Fig. 3. Lightning-hail-radar echo relationships of the storm of July 28, 1968. Times shown above radar echoes are in Local Standard Time.

(ii) intermediate lightning stroke frequencies are a more favourable condition for moderate or heavy hail than either infrequent or very frequent lightning.

From these reports, it can be concluded that:

(i) the interaction between precipitation and electrification is yet little understood;

(ii) the hail storm is different in its electrical structure from a normal thunderstorm. Whether this is a result of microphysical or macrophysical processes exclusively or a combination and interaction of the two can only be left to speculation.

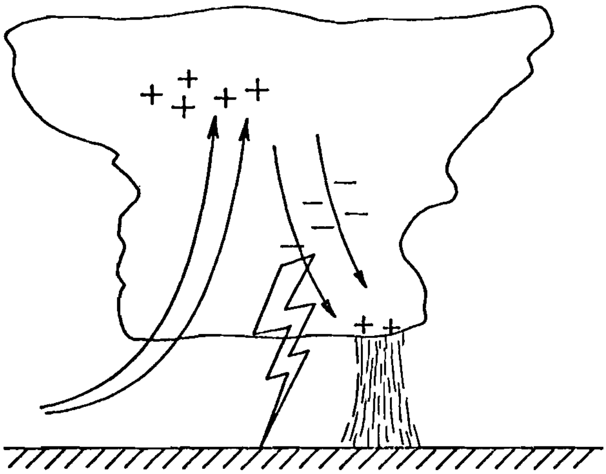
THE ALBERTA STORM OF JULY 28, 1968

A case study of this storm has provided some useful results. The storm evolved at the foothills of the Rockies, developed into a steady state storm (supercell), then broke loose from the foothills. At Rocky Mountain House (R.M.H.),the storm broke up into a vigorous, tightly knit multicellular complex, and, by the time it moved past Lacombe, consisted of only a disconnected number of weak cells.

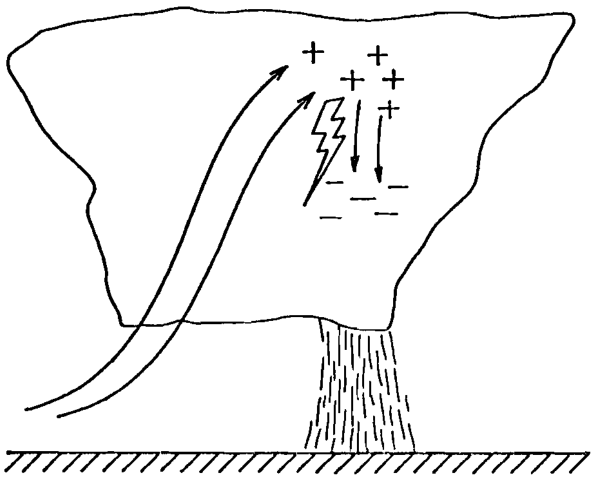
Hail falling ranged in size as follows: from the foothills to R.M.H., up to 2½ inches in diameter; then gradually decreased in size past R.M.H., until at Lacombe and farther to the east no hail was reported.

Lightning flash rate was 1-2 per minute at the foothills (visual reports), gradually picked up past R.M.H. (visual reports) to a value of 40-60 per minute at Lacombe (electric field mill records). Figure 3 shows these results diagrammatically.

The electrical behaviour of the storm seems to bear out some of the earlier findings of others. With very large hail, little lightning activity is observed; as the total rate of hail fall from the storm diminishes, lightning activity increases. However, the very high rate of lightning flashes at Lacombe does not appear to have been due to single cells alone but to groups of cells with a good likelihood of many flashes between cells (cloud-to-cloud). This may account for the report of Blevins and Marwitz that the proportion of cloud-to-ground flashes diminishes with higher flash rates. In this case, the phenomenon would not be due to changes in some physical characteristic of the storm but is a consequence of the fact that a violent storm (excepting the steady state storm with little lightning) is multicellular, with its lightning activity being contributed by different cells rather than by one cell producing a high flashing rate.



TYPE 1 THUNDERSTORM



TYPE 2 THUNDERSTORM

Figure 4. Thunderstorm types (after Takeuti, 1966)
Type 1. - Normal thunderstorm with predominantly cloud-to-ground flashes; strong downdraft.
Type 2. - Thunderstorm with predominantly intra-cloud discharges; strong horizontal wind shear; weak downdraft with little charge separation.

CONCLUSIONS

The preliminary results obtained from the storm of the 28th of July, 1968 are not sufficient to provide any physical storm model incorporating electrical structure. At the usual thunderstorm levels (Lacombe and east) of 5,000 - 8,000 ft. for the base and up to 25,000+ for the top, a normal positive bipolar electrical structure was evident but no actual quantitative measurements were made at the foothills on the steady state storm.

Purely by physical reasoning,it appears that the dynamics and microphysics of a severe local storm may change its electrical structure from that of a normal thunderstorm. From observations on a steady state storm, a few distinctive features can be recognized:

(i) a strong horizontal wind shear between the top and bottom of the cloud, e.g., Newton (1967),

(ii) a tilted updraft, e.g., Newton (1967),

(iii) a high liquid water content, LWC, at extremely high levels, e.g., Marshall (1961),

(iv) very large hail.

Each of these features can be compared with that of a normal thunderstorm and qualitative reasons suggested for the difference in electrical structure.

(i) Wind Shear

Takeuti (1966)has suggested that there exists two types of thunderstorms, depending on the wind shear. (Figure 4)

It appears that the type 2 storm model may apply to Alberta steady state storms,with the small charge separation resulting in few lightning flashes.

(ii) Tilted Updraft

This also helps in explaining the type 2 steady state model. When the tilted updraft, which is the principal feature of this model, ceases to exist (through some dynamic, macrophysical feature), and the precipitation particles carried in the downdraft fall into the updraft, the storm tends to break up into a normal multicellular thunderstorm complex.

(iii) High LWC

The storage of large amounts of water at higher levels may be a reason why the charge separation mechanism is not effective until the steady state storm breaks up. The resulting normal thunderstorm has its liquid water content more evenly distributed over the entire vertical section of the storm (charge centres well separated and strongly charged).

(iv) Very Large Hail

The fact that the liquid water is concentrated in a few large hail stones (low density of precipitation particles) as contrasted with a normal thunderstorm (higher densities of precipitation particles) may imply that the volume of separated electrical charge is much smaller in a steady state storm, thus resulting in fewer electrical discharges. It is also entirely possible that once large hail has been released and the storm begins to break up,a different charging mechanism (on a micro-physical scale) may be operative.

This qualitative examination of storm features points out the lack of information about the electrical structure of severe storms. When rates of electrical discharges in these storms,coupled with measurements of the electric field under it have been obtained, a quantitative model of the electrical structure may then possibly be postulated.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. P.W. Summers for the opportunity of working with the Alberta Hail Studies during 1968. The many visual reports on lightning supplied by personnel from the University of Wyoming,the Desert Research Institute (University of Nevada) and Alberta Hail Studies were invaluable,as was the help of C. McKenzie. Discussions with A. Chisholm have always been a rewarding pleasure. A grant from the Meteorological Branch, Department of Transport sustained the project.

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SEASONAL TRENDS IN THE FREQUENCIES OF STRONG WINDS OVER LAKE SUPERIOR AND THE GULF OF ST. LAWRENCE

R.E. Munn
Meteorological Service of Canada, Toronto

1. INTRODUCTION

The Marine Branch of the Department of Transport is interested in the frequencies of high waves on Lake Superior and the Gulf of St. Lawrence. The Load Line Regulations are under review, and one of several questions being asked is whether there is a seasonal trend in high-wave frequencies. Because the atmospheric general circulation strengthens in autumn, the frequencies of gales and of high seas certainly increase at that time of year. However, there are no quantitative estimates of the trends.

Only a few years of wave data are available, not enough to define seasonal trends. For use as an indirect indicator, therefore, this note presents some data on frequencies of strong winds at two lighthouses.

2. METHOD OF ANALYSIS

Strong winds cause high waves. To be more quantitative, however, other factors must be considered (fetch, water depth, duration of strong winds, etc.). Because the relationships are complex and not well understood in fetch-limited areas, only a very simple index is used in the following analysis, namely the frequency of speeds (regardless of direction) of at least 25,35 and 45 mph.

Caribou Island in Lake Superior and Grindstone Island in the Gulf were selected for study because their anemometer exposures are reasonably representative of over-water flow and because relatively long periods of records are available. Lakehead Airport winds were also analyzed as a matter of interest.

Each month was divided into three 10-day periods, and the 31st days of July, August, October and December were omitted to simplify comparisons. For Lake Superior, the months July to November, inclusive, were analyzed. In the case of Grindstone Island, the month of December was added because of the longer shipping season in the Gulf. The results

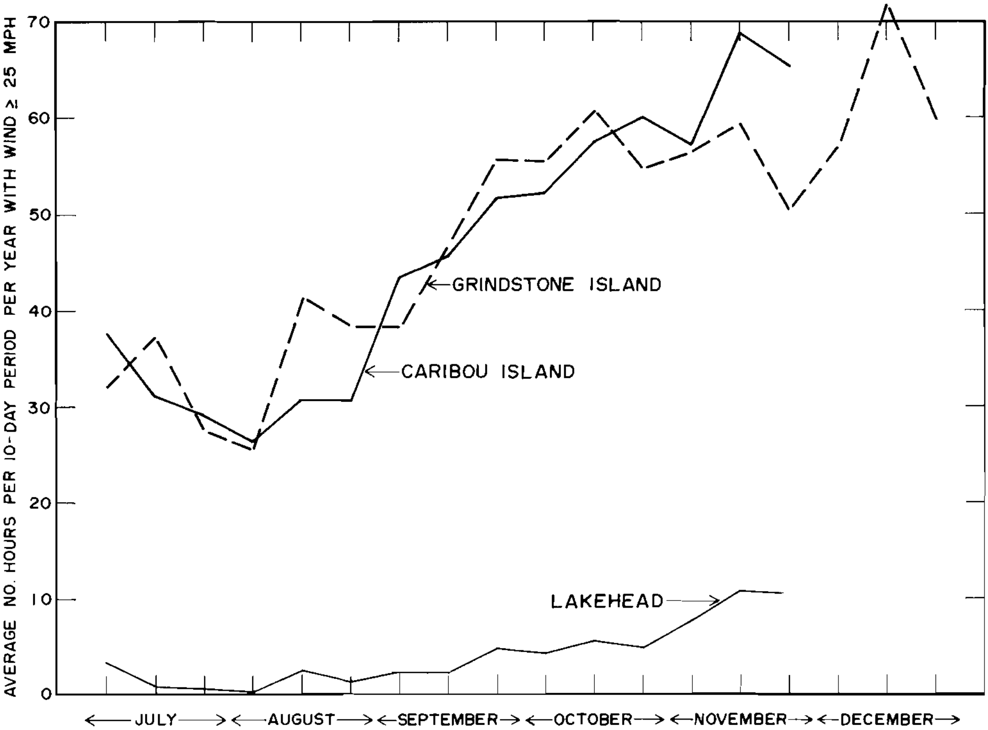

Figure 1

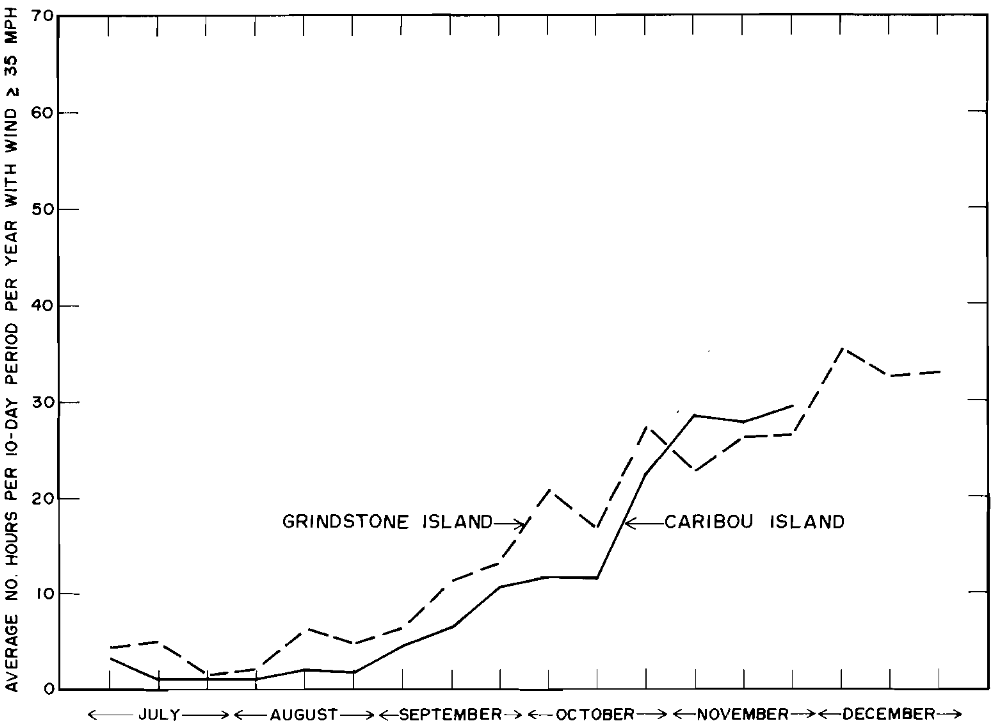

Figure 2

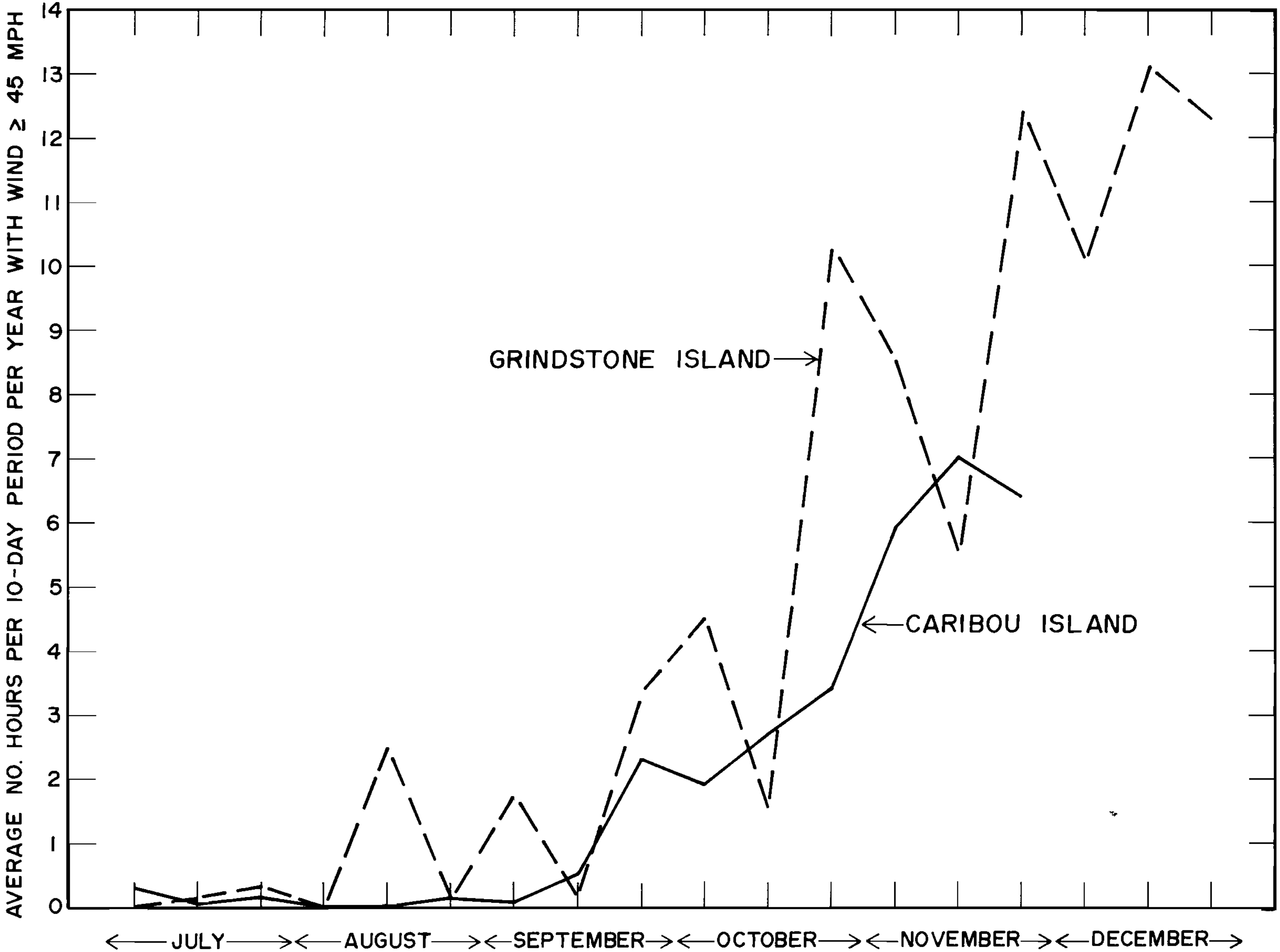
AVERAGE NO. HOURS PER 10-DAY PERIOD PER YEAR WITH WIND ≥ 45 MPH
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
GRINDSTONE ISLAND
CARIBOU ISLAND
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

Figure 3

were normalized to number of hours per 10-day period per year.

Periods of record were as follows:

Caribou Island	-	1942, 1963, 1965-1968 (26 years)
Lakehead Airport	-	1957-1966 (10 years)
Grindstone Island	-	1942-1951, 1953-1954, 1958-1968 (23 years)

3. RESULTS

The results are given in Figs. 1-3. At Lakehead, occurrences of winds of 25 mph and greater were too few to permit inclusion in Figs. 2 and 3. Note also that the ordinate scale in Fig. 3 has been expanded.

The similarity of trends at the two lighthouse stations suggests that the primary cause of the autumn increase in the frequencies of strong winds is the strengthening of the atmospheric general circulation. There is an increase also at the land station (Lakehead Airport) but the frequencies are much lower than they are at the island locations.

For winds of 25 mph or greater (Fig. 1) the average numbers of occurrences in late October are about double the numbers in late August. For winds of 35 mph or greater (Fig. 2), the increase is about fourfold, while for winds of 45 mph or greater (Fig. 3), an increase of about tenfold is indicated.

4. APPLICATION TO LOAD-LINE REGULATIONS

Assuming that Figs. 1-3 are representative of long-term climatic conditions and that they are meaningful indices of frequencies of high seas, the diagrams suggest that in Lake Superior, the Load-Line Regulations should be made more stringent about mid-September and again in late October: in both Figs. 2 and 3, there is a plateau in early autumn (about Sept. 15-Oct. 15) at the Caribou Island station.

In the Gulf of St. Lawrence, Load-Line Regulations should probably be made more stringent about mid-August and again in early October. The Grindstone Island storminess frequencies show greater variability than those at Caribou Island but nevertheless, a trend is discernible: the seasonal increases commence sooner in the Gulf than over Lake Superior. Both the greater variability and the earlier arrival of increased storminess are due in part, undoubtedly,to the occasional northward intrusions of hurricanes into the Canadian Atlantic coastal waters.

METEOROLOGICAL BRANCH RESEARCH AND TRAINING DIVISION RE-ORGANIZATION

A re-organization has taken place in the Research and Training Division of the Meteorological Branch which should be of interest to the readers of Atmosphere. Prior to this change there were three Sections in the Division, namely the Central Analysis Office (CAO) in Montreal, and the Atmospheric Research Section and Training Section in Toronto. Although the major research and development activities of the Division were carried out in the Atmospheric Research Section there were two Units, one in each of the other two Sections,which had a development and quasi-research function. The Operational Development and Evaluation Unit (ODE)of the CAO carried out studies in Numerical Weather Prediction in support of the CAO and the Scientific Development and Evaluation Unit (SDE) of the Training Section was responsible for making new and better forecast techniques available to the Forecast Offices.

The organizational structure was based on the 'stage-phase' concept where separate components were given responsibilities in respect to basic research, applied research and developments and as each unit fulfilled its role the idea was that it passed its results down the line toward operations. This concept has merits in some kinds of activities but it has defects in respect to research. Firstly, it is difficult to draw the line between the various stages of activities and this resulted in duplication of effort and, secondly, scientists who carried out research with direct practical benefits were often the logical people to develop them for introduction into the forecast system. There was an additional defect in the organizational structure and this went right to the heart of the role of research in a national meteorological service. The trouble was that the channels to bring the requirements of the forecast system into focus in the research effort and the parallel problem of bringing the results of the research into effect in the forecast system did not function well enough.

As a result of substantial deliberations on the above questions the decision was taken that a mission-oriented Divisional research component was needed which could plan the applied research and development effort in an integrated fashion with provision for adequate input from the operational Divisions and Regional Offices and with an advisory role in bringing the results to operational fruition. The organizational action taken was to create a fourth Section in the Research and Training Division to be known as the Forecast Research Section. The Atmospheric Research Section under Dr. W.L. Godson would continue to carry out basic research and certain other research functions involving disciplines such as micrometeorology,cloud physics,atmospheric dynamics,upper atmospheric studies, radiation, etc.

The Forecast Research Section was basically formed from the ODE and SDE Units of the CAO and Training Sections respectively and the Synoptic Research Unit of the Atmospheric Research Section. It has been organized into four Units: (a) the Dynamic Prediction Research Unit based in Montreal and responsible for research in NWP and in forecasting by dynamic-numerical procedures; (b) the Forecast Development Research Unit responsible for supporting forecast office scientific and technological operations and research into synoptic-statistical techniques and related problems; (c) the Mesoscale Prediction Research Unit which will carry out research and development in mesometeorology, aeronautical meteorology and network design and will support users of such studies; (d) the Observational Services Unit will be a service unit to operate the Section's observational facilities which include the Satellite Data Laboratory, the Malton Mesometeorological Network and an advanced Data-Logging System. In addition, this Unit will study the upgrading of such facilities and their operational counterparts and will provide support for observational and field studies for the Section and other Branch and non-Branch users as required.

Dr. Joseph Clodman who has been named Superintendent of the new Section is well-known to most readers of Atmosphere. He has been with the Meteorological Branch since 1943 and acted in various forecasting capacities until 1952 when he joined the Research and Training Division as a research meteorologist. He obtained a Ph.D. in meteorology at New York University in 1961 and shortly thereafter was appointed Supervisor of the Synoptic and Dynamic Research Units of the Atmospheric Research Section. Mr. M. Kwizak will be Supervisor of the Dynamic Prediction Research Unit which basically is an extension and expansion of his former role as Supervisor of the ODE Unit. Mr. F.B. Muller who has been a research meteorologist since 1961 and has made significant contributions in synoptic-statistical research has been named Acting-Supervisor of the Forecast Development Research Unit and also the Mesoscale Prediction Research Unit.

S C I T E C

A new national organization, SCITEC, representing the entire Canadian scientific, engineering and technological community, was formed at Ottawa on January 17, 1970. Your President attended these meetings, endorses SCITEC,recommends that our Society consider affiliation as soon as the necessary information and details are available, and suggests that many of our members might be interested in individual membership.

The motion founding the new organization resolves "That there be established a national organization known as SCITEC whose objective is to marshall the scientific, engineering and technological community to provide leadership, to communicate, co-operate, and work within itself, with government and the public in the national interest in those areas in which it can make a competent contribution". SCITEC has been formed with the full co-operation and encouragement of the government-sponsored Science Council and Science Secretariat. SCITEC is a non-government organization. It will represent scientific organizations and individual scientists and will speak on science policy mainly to the government but also to the public at large. By participating in SCITEC, meteorologists will have the opportunity of expressing the meteorological viewpoint on those science policy items with which we are concerned either as a Society or as individuals.

Since the l'Association Canadienne Francaise pour l'Avancement des Sciences (ACFAS) already exists, the organization of SCITEC is somewhat more involved than one might expect. Societies such as the Canadian Meteorological Society, and individual members may join SCITEC, and will be represented at the SCITEC Congress which will consist of about 200 members. A 29-member SCITEC Council will be chosen by selecting 22 members from Congress and 7 from l'ACFAS. A six-man executive committee will administer the organization between meetings.

As a society which participated in the organizing of SCITEC, the Canadian Meteorological Society might be considered to have a seat in the provisional congress. When the organization of SCITEC is complete, representation will vary with the size of affiliated organizations, and in addition, some Congress members will be elected at large to represent individual members. It is expected that societies with memberships of between 100 and 1000 will each hold one seat in Congress if they elect to become affiliated.

The interim organization for 1970 has been completed, and the first president is Dr. Norman Grace, President of the Chemical Institute of Canada, and General Manager of the Dunlop Research Centre at Sheridan Park. One of the Vice-Presidents is Dr. Donald Betts of the University of Alberta, who is currently President of the Canadian Association of Physicists.

One of the first duties of the new Council and Executive will be to determine the procedures under which organizations, such as ours, may become affiliated with SCITEC. Finances will be an important item, and it will probably cost a fixed sum per member to be affiliated. However, it is expected that up to one year will elapse before participating society relationships with SCITEC are processed, and in the meantime as many people as possible are requested to join as individual members. The individual subscription rate for 1970 has been established at $10.00. Your President will be pleased to supply application forms and provide further details upon request. Your Executive will follow developments closely, and you might expect to receive another report when organizational details of SCITEC have been formulated.

M.K. Thomas,
President.
February 10, 1970

INTER ALIA - continued from Page 130

CHANGING ROLE FOR THE METEOROLOGICAL SERVICE IN THE SEVENTIES

To meet the social and economic challenges of the next decade, four operating Administrations have been created in the Department of Transport, dealing with Marine Transportation, Air Transportation (both paralleling existing Services), Surface Transportation and the Arctic (both new Administrations). This reorganization, starting in 1970, would also bring about the separation of the Canadian Meteorological Service from Air Services and thereby facilitate the provision of a more balanced service to the total transportation complex and to the national economy as a whole. Full implications of this separation on meteorological operations have yet to be realized.

- continued on Page 158

BOOK REVIEW

INSTANT WEATHER FORECASTING IN CANADA

By
Alan Watts

General Publishing Company, Toronto, 64 pages ($3.95)

J.N. LeMay
Meteorological Service of Canada
Toronto, Ontario

This publication is intended as a guide for short-range weather prediction based largely on cloud observations for use by non-meteorologically oriented readers.

An interesting method of storm movement forecasting is presented using an adaptation of Buys Ballot's law and the upper wind as implied by the middle and high cloud movements. However, in the description of this method the phrase "isobars of wind" is introduced without defining "isobar". A common shortcoming throughout this book is the use of basic terms undefined in the glossary. On the other hand the glossary contains some unnecessary terms.

For a book aimed at Canada there are surprising errors in terminology. For instance, the list of air masses included cP, cT and rmP--terms not used in Canada. One finds the statement "Most land areas experience more occlusions than other types of front." with no mention of the TROWAL. The author is not aware of Canadian terminology and there is nothing in the book that is specifically applicable to Canada.

The cloud photographs together with an explanation of probable developments are quite interesting, but terms not used in official cloud nomenclature such as "fractostratus" still appear.

While readers who are willing to do a lot of "digging" could learn something from this book, it is not recommended for self-instruction in weather forecasting. It falls short of its objective of providing instant forecasting rules for Canada. It is certainly not a "brilliant new approach to forecasting" as claimed on the cover jacket.

MONTREAL CENTRE CMS

SEPTEMBER 30, 1969

Dr. Fred Bushby, Meteorological Office, Bracknell, England, spoke on "Recent results with a ten-level model suitable for detailed weather prediction". The model which included moisture and precipitation and used a 50-km grid size, is currently being evaluated by the British Meteorological Office.

OCTOBER 21, 1969

Dr. B. Machenauer of the University of Copenhagen discussed the theory of planetary fluctuations based on spherical harmonics. His most significant result was that moderately fast-moving planetary waves can be explained by the gravity-inertial oscillations of a homogeneous incompressible fluid on a sphere.

DECEMBER 2, 1969

Mr. A.J. Chisholm of McGill University described the operational aspects of the Alberta Hail Studies project and his own research into the structure of severe hailstorms,including the microphysics of precipitation occurring within them.

JANUARY 27, 1970

The Centre held a special gala night to which wives and friends were invited. Dr. Victor E.F. Solman of the Canadian Wildlife Service gave an interesting talk on the meteorological aspects of forecasting the migration of birds. He also discussed the problem of bird strikes on aircraft and showed examples of the resulting structural damage. Movies of migrating birds as detected by radar were shown. Afterwards, wine and cheese were served.

CENTRE DE QUEBEC

7 octobre 1969

La Société de Météorologie de Québec a commencé sa série de réunions d'information pour la saison 1969-70, le 7 octobre, en présentant comme conférencier le docteur André Hufty, professeur à l'Institut de Géographie de l'Université Laval.

Sa causerie portait sur "Les climats thermiques du Québec méridional". Il s'agit d'une division climatique du Québec méridional élaborée par le docteur Hufty et qui est basée uniquement sur des considérations thermiques. L'auteur en arrive à identifier des zones climatiques nettement marquées. Son travail a déjà fait l'objet d'une communication à l'A.C.F.A.S. et d'une publication dans "Les Cahiers de Géographie de Québec".

Le conférencier a été présenté par M. L.-E. Hamelin, directeur du Centre d'Études Nordiques de l'Université Laval et remercié par le président de la Société de Météorologie de Québec, M. Rénald Naud.

L'auditoire était d'environ 25 personnes.

4 Novembre 1969

La Société de Météorologie de Québec a tenu sa deuxième réunion d'information le 4 novembre dernier à la faculté d'Agriculture de l'Université Laval.

Le docteur Jean-Louis Tremblay, M.S.R.C., conférencier-invité, a traité d'"Océanographie et Météorologie". Il a fait une intéressante révision de ce domaine, en nous présentant une série de diapositives illustrant les interactions terre-mer. L'auditoire d'environ 25 personnes a vivement apprécié la discussion et les commentaires du conférencier, en réponse aux questions.

Le docteur Tremblay a été présenté par le docteur Villeneuve, directeur du Service de Météorologie du Québec, et remercié par M. Raymond Perrier, du même Service.

REGINA CENTRE

The Regina Centre of the C.M.S. held its first meeting of the 1969-70 season on Monday,November 3, 1969,in the Weather Office Library, and was attended by a select group of eight members.

The meeting was held to hear a report by Mr. L.S. Meeres, O.I.C. of the Regina Weather Office, on the A.M.S. Third Conference on Weather Analysis and Forecasting held at Virginia Beach, Va.,from September 3-5, 1969.

Following the formal part of the meeting,the group adjourned to the Prairie Hydrometeorological Office for coffee and informal discussion of the implications raised by Mr. Meeres' presentation.

TORONTO CENTRE

CARBON DIOXIDE AND ALL THAT

Carbon dioxide was described as the "in gas" by Dr. F.K. Hare of the Department of Geography, University of Toronto in an address to the Toronto Centre C.M.S. on November 10th. Since about 1880, the concentration of this gas in the atmosphere has been steadily increasing. Because of a parallel trend in global mean temperature (+0.6^{o}C by 1940 in the Northern Hemisphere), renewed interest has been sparked into the role played by carbon dioxide in atmospheric heating and ultimately in climatic change. Dr. Hare attributed this rise in carbon dioxide content to the increasing use of fossil fuels.

However, scientists have noted that since 1940,this global temperature trend has reversed (estimated -0.3^{o}C between 1940 and 1970) despite a continued increase in carbon dioxide content of the atmosphere. Dr. Hare suggested that this might be due to the rapid increase, in recent years, of the concentration of dust particles in the atmosphere; in fact, he emphasized that this is the only known external mechanism that could account for this reverse.

The role of dust in atmospheric heating has been largely ignored by meteorologists. "We may well be significantly changing our climate", he added, "for the global temperature changes observed are large relative to those associated with paleoclimatic change (about 5^{o}C)".

1970 LECTURE TOUR

Professor Tim Oke of the Department of Geography at McGill University has been engaged by the Meteorological Branch to carry out a tour of the country and to speak at Centres of the Society. Prof. Oke's subject is "Urban Climate and Air Pollution" and it is expected that he will visit most of the major cities of the country discussing this subject with Regional Meteorologists, university and government scientists and officials, and the Society members.

Prof. Oke toured the four Western Provinces during the week of January 25. Reports from the Regional Meteorologists reveal that both Prof. Oke and his subject were popular. The British Columbia Centre drew 60 members to a meeting at Simon Fraser University on January 26th, and 60 also attended a meeting of the Alberta Centre at the University of Alberta in Edmonton on January 27th. Total attendance was 42 at the Regina Centre's meeting on January 29th at the University of Saskatchewan, including four visitors from Moose Jaw and one from Saskatoon. At each Centre a record in attendance was set - a further indication that the lectures were well received and of wide interest.

The tour schedule for the eastern part of the country includes visits to four Centres: Ottawa on March 3, Quebec on March 16, Halifax on March 18 and Toronto on April 9.

SOMAS MEETING 30 OCTOBER 1969

The 19th meeting of the NRC Subcommittee on Meteorology and Atmospheric Sciences was held at Ottawa on October 30, 1969.

SOMAS encouraged the Associate Committee on Geodesy and Geophysics to send the latter's resolution on legislation concerning weather modification activities in Canada to the provincial governments and the Science Council. The Committee noted that much legislation concerning this field of activity was being proposed: a bill by the Government of Quebec and Private Member's bills in the Federal Parliament and the Ontario Legislature.

Although travel funds from NRC were limited, SOMAS considered that at least one member from the meteorological community should attend particular meetings in 1970: the GARP Planning Conference (at Brussels in March); the WMO/IAMAP Symposium on Higher Education and Training (at Rome in April-May); and the COSPAR Symposium on Remote Sensing (at Leningrad in May).

SOMAS received a report concerning support of GARP research projects in the NRC program of awards to university staff. No extra funds are available for GARP, but grant applications within this field will be considered by a special selection committee before going through the regular awards procedure.

SOMAS resolved to publish a Canadian plan for participation in GARP for the succeeding meeting in February.

The activities of the Meteorological Service were reported to SOMAS. Austerity will prevent expansion of services. The rocket program has been shelved. Development work will concentrate on: local forecasting models rather than hemispheric; improvement of the forecast system output because of the associated economic benefits to be obtained.

Concerned that NRC block computing grants would be phased out within two years, SOMAS resolved to bring this to the attention of Meteorological Branch so that research grants may be increased as appropriate.

SCHEDULED NATIONAL MEETINGS OF THE AMERICAN WATER RESOURCES ASSOCIATION

June 15-19, 1970

AWRA RESEARCH CONFERENCE on "Evaluation Process in Water Resources Planning".

Sponsored by the University of Wisconsin-Milwaukee and the American Water Resources Association, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin. For information contact: Dr. G. Karadi, General Chairman and Professor, Department of Applied Sciences and Engineering, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201.

Participation by invitation or by Application. Request Application Form from Dr. G. Karadi or from the AWRA Headquarters, P.O. Box 434, Urbana, Illinois 61801.

June 24-27, 1970

NATIONAL SYMPOSIUM ON HYDROBIOLOGY' "Bioresources of Shallow Water Environments".

Sponsored by AWRA, Hosted by Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, Florida, to be held at the Deauville Hotel, Miami Beach, Florida. For information contact: James C. Warman, General Chairman and Director, Water Resources Research Institute, Auburn University, Auburn, Alabama 36830. Papers by invitation; participation open to Members and Non-members.

October 26-30, 1970

SIXTH AMERICAN WATER RESOURCES CONFERENCE. Sponsored by AWRA in co-operation with other National Scientific Societies. For information contact: Dr. William S. Butcher, Chairman of the Program Committee, Civil Engineering Department, University of Texas at Austin, Austin, Texas 78712. Tel: (512) 471-3181. Papers by invitation but mainly by contribution. Participation open to Members and Non-members.

INTER ALIA - continued from Page 151

NEW JOURNAL FOR OCEANOGRAPHERS

The American Meteorological Society began publication of the Journal of Physical Oceanography in 1970. This new research quarterly, under the editorship of Professor Robert O. Reid, is devoted to the communication of knowledge concerning the physics and chemistry of the oceans and of the processes coupling the sea to the atmosphere. The subject matter of the journal includes observational and theoretical aspects of such topics as:

Ocean circulation
Surface waves
Internal waves
Inertial oscillations
Oceanic turbulence
Turbulent mixing
Thermo-chemical properties of sea water
Interpretive regional studies
Tracer techniques and application
Non-linear coupling of modes of motion
Vertical convection processes
Oceanic tides and other long-wave phenomena

The associate editors of the journal include a number of distinguished scientists, including a CMS member, George L. Pickard of the Institute of Oceanography at the University of British Columbia.

Manuscripts should be submitted to Robert O. Reid, Editor, Department of Oceanography, Texas A&M University, College Station, Texas 77843, U.S.A.

The annual subscription rate is $20.00 to non-members and $10.00 to members of the AMS. Subscription orders should be addressed to American Meteorological Society, 45 Beacon Street, Boston, Massachusetts 02108.

NOTES FROM COUNCIL

The following were elected to membership at the December 8, 1969 meeting of Council:

Member

Thomas Andrew Black
Susan Patricia Boville*
David Bann Fraser*
William L. Gutierrez*
Ronald Harold Loucks*
James W.A. Low*
Lawrence Chima Nkemdirim*
Leo D. O'Quinn
Norman Harold Thyer

Graduate Student Member

William Stuart Appleby*
Normand Brunet
Merton Horita
Graydon Douglas Lally
Patrick Louis Joseph Morin
Conrad Kristian Odegaard
Doris Sylvia Quinn
Joseph Thomas Steiner

Undergraduate Student Member

Gerald Vincent Price*

*1970 Membership

The following were elected to membership at the February 3, 1970, meeting of Council:

Member

Stuart Nelson Edey
Stephen Fogarasi
Ralph Douglas Hierlihy
Alstair Kenneth MacPherson
David Mudry
Peter H. Schuepp

Graduate Student Member

Brian Lovern Barge
Geraldine Mae Henrikson
George Alexander Isaac
Daniel P. Lafleur

Undergraduate Student Member

Donald Emil Petzold

The following were elected to membership at the February 18, 1970, meeting of Council:

Member

Calvin J. Baker
Jacques Florian Derome
Archibald D. Gates
James Freeborn McKee
Bela Istvan Szucs

SECOND ANNOUNCEMENT, FOURTH CMS CONGRESS

Winnipeg, June 17-19

The first day of this conference will be devoted to the theme "Meteorological Education". The morning session will feature four invited speakers describing the present state of professional training in meteorology, both from the point of view of the University as the supplier and that of the Meteorological Branch as the chief user of meteorological talent. The afternoon session will begin with shorter invited papers on other aspects of meteorological education - technician training, meteorological requirements for other disciplines, and general teaching schemes in the high schools and colleges. The last portion of the afternoon will be set aside for a panel discussion on the problems and future of education in meteorology.

The second and third days of the conference will be devoted, as in the past, to technical sessions each of 6 to 8 contributed papers. While the themes of these four sessions (it is hoped that concurrent sessions may be avoided) will be determined by the nature of the submissions,there are presently sufficient papers to have sessions on hydrometeorology, forecasting, and physical (and/or dynamical) meteorology. The C.M.S. annual general meeting is scheduled for Wednesday evening, June 17.

NOTICE TO MEMBERS

Membership dues for 1970 stand as follows:

Member	...	$ 8.00
Graduate Student Member	...	$ 2.00
Undergraduate Student Member	...	$ 1.00
Corporation Member	...	$25.00

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.

Schedule Of Charges For Reprints

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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.