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Report from the President

on the

4th Annual Congress

The Fourth Annual Congress and General Meeting of the Society, held in Winnipeg in June, will long be remembered for the elements of high drama which pervaded the proceedings. There was a feeling of excited enthusiasm for positive action to develop a vibrant Society, but tempering this was a deep sense of social concern over the seriousness of Canada's environmental problems. It was a time to be aware.

For background to highlights of Congress activities, reference should be made to documentation for the Annual General Meeting which appeared in the Congress issue of ATMOSPHERE. Statements presented therein clearly indicate the concern of the Executive Committee and Council regarding the need to strengthen the Society's publication and at the same time to provide more effective assistance to the general administration of the Society. The proposal to take full advantage of the University of Toronto Press services to improve ATMOSPHERE was felt to be suitable to meet our necessary requirements. The members enthusiastically endorsed this proposal,and indicated their desire for immediate action on the matter by their overwhelming support for a motion to set the annual fees for 1971 at fourteen dollars,with the increase above the current eight dollars to be directed to the development of ATMOSPHERE.

In supporting this motion, Dr. Boville reminded the members that "it's between the covers that the significant action takes place", and that they must make available for publication in ATMOSPHERE a continuing supply of scientific articles and papers.

The need for involvement of the CMS in the public debate on Canada's environmental problems was recommended in the report of the Development Committee. Members fully supported this need for professional relevancy in society at-large, and by motion advised the Executive Committee to appoint Standing Committees on:

1) Scientific and Professional Matters,

2) Public Information,

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

Congratulations and thanks are due to Dr. John Maybank, the program chairman of the Congress, for a well-balanced and well-organized program; to Mr. Eric Dexter, chairman, and members of the Organizing Committee, for the excellent arrangements and their untiring efforts to ensure that everyone enjoyed their visit to Winnipeg; and to all the speakers who by their competence maintained the high scientific calibre expected of the Annual Meteorological Congress.

June 18, 1970

D.N. McMullen
President

INTER ALIA

Canadian Meteorological Society

Meet the New President

Mr. Donald N. McMullen is hydrometeorologist with the Conservation Authorities Branch, Ontario Department of Energy and Resources Management, in Toronto. His responsibilities are concerned with the field of flood forecasting, river control and water management.

His career as a meteorologist began in 1940 when he joined the Meteorological Branch, Canada Department of Transport. After a period as meteorologist-in-charge at the Air Training School in Winnipeg, he was transferred to Vancouver - first to the Western Air Command and subsequently to the Main Meteorological Office. In this latter position he was, for ten years, meteorologist-in-charge of the Frost and Wind Warning Service, a special service of the Meteorological Branch to the fruit industry of the Okanagan Valley of British Columbia.

In 1958 he was seconded to the Ontario Government as hydrometeorologist and in December, 1969 resigned from the federal government to join the provincial government.

Mr. McMullen is a graduate of the University of Manitoba. He is currently chairman of the Toronto Hydrology Group, vice-president of the Eastern Snow Conference, and secretary, Ontario Committee, International Hydrological Decade. He is a Fellow of the Royal Meteorological Society, and a member of the American Meteorological Society and the American Geophysical Union.

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METEOROLOGICAL ASPECTS OF AIR POLLUTION CONTROL*

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1. INTRODUCTION

Meteorological factors have an important effect on the amount of pollution in the atmosphere. Temperature and solar radiation affect the quantities of pollutant emitted by their influence on the amount of space heating required. Sunshine is required in a photochemical production of oxidants forming smog. The wind velocity, turbulence and stability affect the transport, dilution and dispersion of the pollutants. The rainfall has a scavenging effect in washing out ("rainout") particles in the atmosphere. Finally, the humidity is a frequent and important factor in determining the effect that concentrations of pollutants have on property, vegetation and health.

In view of these effects, meteorologists are involved in the following aspects of air pollution control:-

1) Forecasting air pollution potential (Stackpole, 1967) so that air pollution control agencies may alert industry to carry out temporary abatement action.

2) Selecting sites and designing emission systems for large industrial sources.

3) Establishing air monitoring surveys.

4) Carrying out research in air pollution control methods.

*Paper presented at the Joint Conference of the Chemical Institute of Canada and the American Chemical Society at Toronto on May 26, 1970, the 25th Anniversary of the CIC.

2. CLASSES OF SOURCES OF POLLUTANTS

The sources of pollution in an urban area may be divided into two classes:-

1) Low-level emitters - vehicles;combustion sources for space heating houses and small commercial buildings; and, privately owned incinerators.

2) High-level emitters - stacks serving: industrial sources; central heating systems for industrial, commercial and institutional multi-building complexes; and municipal incinerators. These emitters are stacks at least 50 meters high.

Meteorological parameters affect differently the ground or "living" level concentrations of pollutants which are produced by these two classes of emitters. A knowledge of the micrometeorology and topography of the area, as well as the characteristics of the principal sources of emissions of pollutants and their locations in the area,must be known in order to provide satisfactory forecasts of air pollution potential.

3. METEOROLOGICAL FACTORS WHICH AFFECT CONCENTRATIONS OF POLLUTANTS

The meteorological parameters which have the most important influence on the diffusion of pollutants in the atmosphere are wind direction and speed, turbulence and stability.

(a) Wind Direction

The wind direction and its persistence are very important factors in predicting the air pollution potential of an area when the principal sources of the pollutants are high-level emitters located near each other in an industrial-zoned portion of the city. These factors are not important for areas in which low-level emitters cause the greater proportion of the pollution.

Since the wind directs the travel of the pollutants, the expected persistence of the wind direction,as related to the topographic features and the locations of the receptors, must be considered both in forecasting the air pollution potential as well as in selecting sites for plants.

For example, in an area which has the principal source of a pollutant on a lakeshore site, high air pollution potential conditions could be expected only when persistent on-shore winds are forecast. For a city such as Sarnia which has most of its large industries located to the south, the concentrations of pollutants are not high except during periods with persistent southerly winds.

Topographical features such as valleys cause winds to persist in certain directions much more frequently than in others. Obviously, such localities should be avoided, if possible, in selecting sites for large industries.

(b) Wind Speed

The effect of an increase in wind speed on the concentrations resulting from low-level sources of emissions is to dilute the pollutants - the concentration of pollutants in a downwind location from a ground-level source is inversely proportional to the wind speed. High air pollution potential forecasts for most large urban areas where low-level emissions are the principal sources of pollution include light wind speed as one of the criteria.

In contrast, with high-stack sources of hot emissions, an increase in the wind speed will lower the plume rise,and tend to increase ground-level concentrations. There is a critical wind speed for each stack design at which concentrations downstream reach a maximum. Air Management Branch approval of a stack requires air quality criteria (Ontario, 1970) to be met at this critical wind speed, which may range between 5 and 40 miles per hour depending on the stack design (Nelson and Shenfeld, 1965)and the height of and distance to the receptor. The equations given below, used in the computation of plume rise and dispersion, are not considered accurate for wind speeds lower than 5 miles per hour.

(i) Holland (1953) Plume Rise Equation

$$\Delta H = (v_s d/u)(1.5 + 0.00268pd(T_s - T_a)/T_s) \qquad (1)$$

where ΔH is the plume rise (m), v_s the gas exit velocity (m/sec), d the diameter of the top of the stack (m),p the atmospheric pressure (mb),u the wind speed at the top of the stack(m/sec), and T_a,T_s the temperatures of the air and the gas at exit, respectively (K).

(ii) Pasquill (1962) - Gifford (1961) Dispersion Formula

$$C = (Q/2\pi u\sigma_y\sigma_z)\left\{\exp\left[-1/2\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-1/2\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}\left\{\exp\left[-1/2\left(y/\sigma_y\right)^2\right]\right\} \qquad (2)$$

where C is the concentration at point of impingement (gm/m^3), Q the rate of emission (gm/sec), z the height of receptor (m), H the effective stack height(height of stack h+plume rise ΔH), u the wind speed as for Eq. (1), and y the distance from the centre line of the plume (m). σ_y ,σ_z the standard deviations of the plume concentration distributions in the horizontal and vertical, respectively, (m) are functions of the stability of the atmosphere and the distance from the source, x.

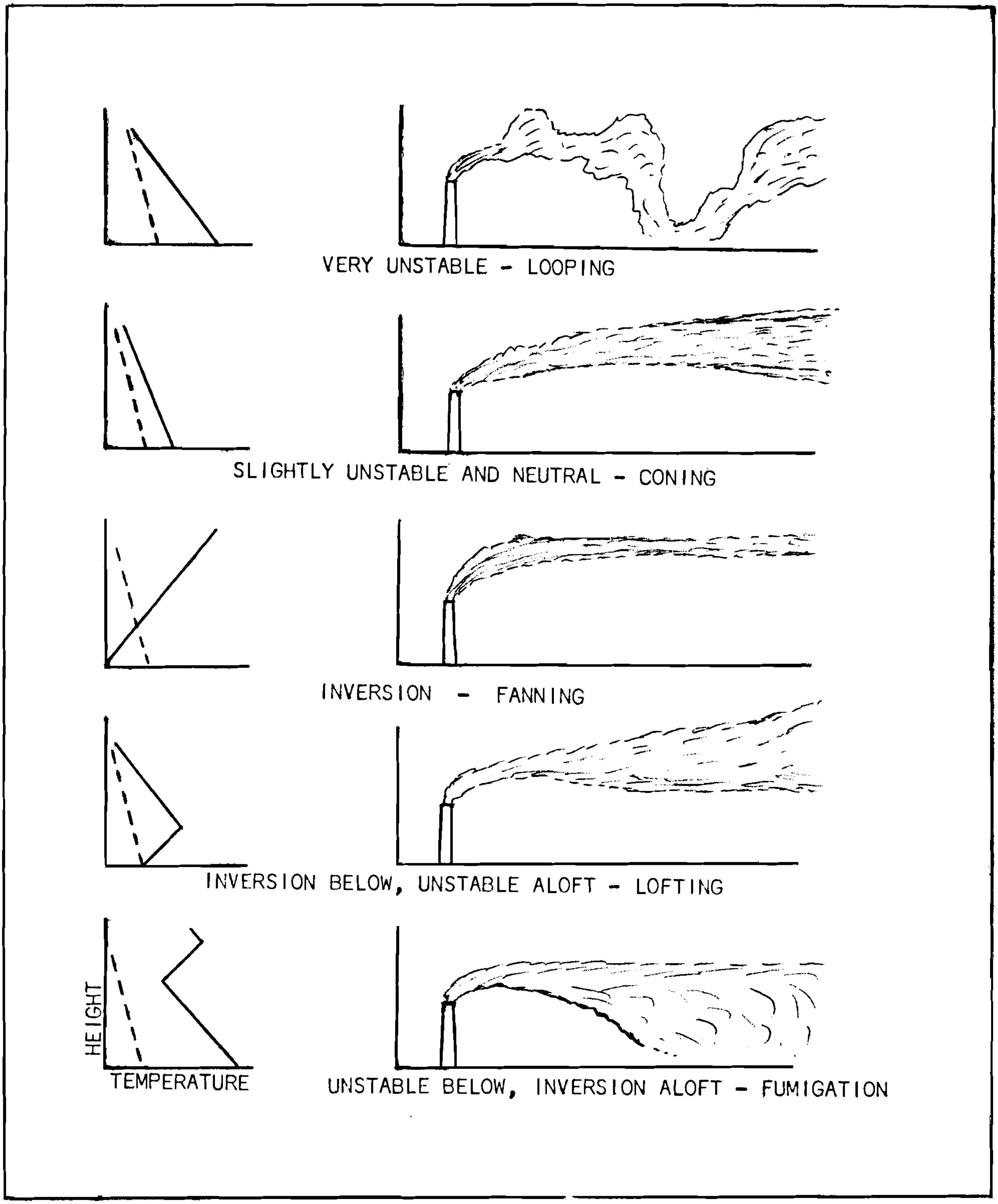

FIGURE 1: Atmospheric Stability Effects on Plume Behaviour

An approximation to the maximum concentration of a pollutant at ground level along the centre line of the plume may be computed from the following equation:

$$C_{max} = 0.1657Q/uH\sigma_y \tag{3}$$

with the maximum occurring at a distance from the source such that

$$\sigma_z = 0.707H. \tag{4}$$

By assuming that

$$\sigma_y / \sigma_z = \text{a constant} , \tag{5}$$

the critical wind speed u_c may be obtained by solving the equation $d(C_{max})/du = 0$. Ground-level concentration will be a maximum when the plume rise, ΔH, is equal to the stack height, h. Thus,

$$u_c = (v_s d/h)(1.5 + 0.00268pd(T_s - T_a)/T_s) \tag{6}$$

$$C_{max} = 0.1657Q/2u_c h\sigma_y \tag{7}$$

Ontario law requires standards to be met not only at ground level but at any point of impingement by the plume. Equation (2) is used by the Air Management Branch with varying values of x, z and u to predict the maximum concentration. The computation has been programmed for a computer to predict concentrations resulting from single or multiple stack sources.

(c) Stability and Turbulence

The lapse rate is the parameter which perhaps has the most important effect on the diffusion of the effluent. Figure 1 shows the behaviour of a plume under various lapse rate conditions (U.S. Weather Bureau, 1955).

1) LOOPING - Superadiabatic lapse rate; highly unstable. Good diffusion with high concentrations occurs only momentarily near the source.

2) CONING - Slightly unstable. Ground level concentrations from high-stack emitters may be predicted more successfully for this type of condition.

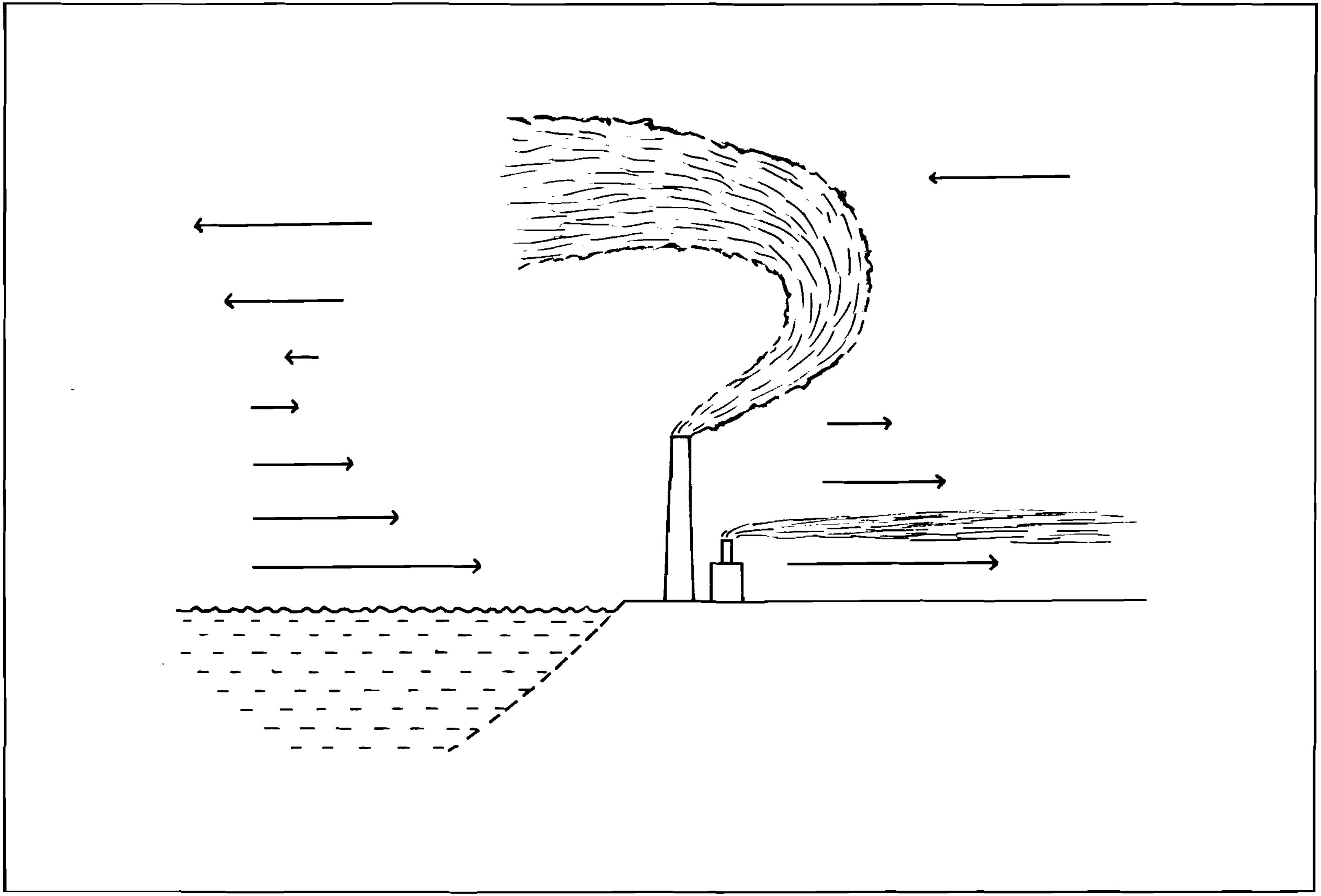

FIGURE 2: Plumes From High and Low Level
Emitters During a Lake-Breeze

3) FANNING AND LOFTING - Inversion conditions; very stable. There is little vertical motion. With light winds the plume meanders. Concentrations resulting from near ground-level sources will be highest for this condition. In contrast, the plume from high-stack emitters does not reach the ground until the inversion breaks down. During the morning, due to solar heating, thermal turbulence will cause high concentrations at ground level for short periods of time along the length of the plume. This condition was designated "fumigation" by Hewson (1945).

The highest concentrations of pollution occur with lapse conditions near the ground and inversions aloft. The height of the base of the inversion is called the "mixing depth" and concentrations due to emissions released within the depth will vary inversely with its thickness. Estimates of the mean maximum depths have been determined by Holzworth (1964) for many locations in the United States for each month of the year.

Large-scale pollution involving thousands of square miles occurs when a high pressure area (normally the western extension of the Azores anticyclone), stagnates over the industrial regions of eastern North America. High concentrations will then occur over urban and valley locations where there are large pollution sources. Associated with this synoptic situation, there is little ventilation since light winds occur not only near the surface but also aloft. Korshover (1957) determined the frequency of these stagnation conditions for the period 1936-1956.

Lake breezes cause inversions to persist along shoreline localities during the spring and early summer when water temperatures are comparatively cooler. The average depth of these inversions is about 100 meters. The existence of a lake-breeze is thus a cause of high pollution concentrations for low-level sources. Hewson (1967) has pointed out that plumes from high-stack sources will normally penetrate the inversion layer or be emitted above it. It is very important that industrial sources located on a lakeshore have stacks at least 150 meters in height (cf. Figure 2).

4. CONTROL OF POLLUTION

The maximum concentration of pollution downstream from a source is seen from equations (3), (4) and (5) to be directly proportional to the emission rate of the pollutant Q and inversely proportional to the effective stack height, H. Pollution can thus be controlled by reducing Q or increasing H. The first method is by far the preferred and most effective control. Removal of most of the particulates may be achieved by

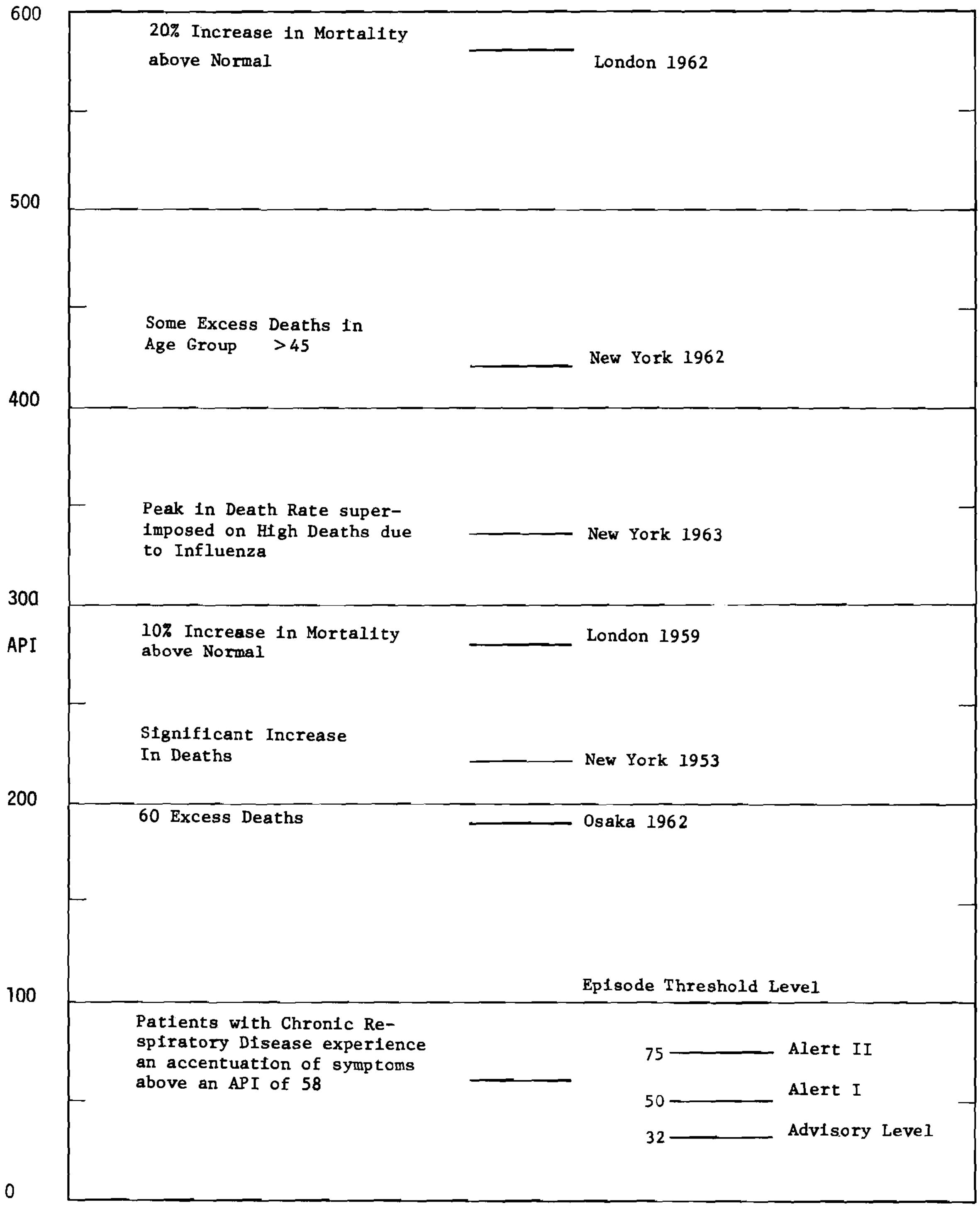

FIGURE 3: Levels of the Air Pollution Index During Episodes and Ontario Alert System

means of efficient precipitators. Sulphur dioxide emission may be reduced by the consumption of fuel with a lower sulphur content. The effective stack height may be increased by:

(a) increasing the height of the chimney
(b) increasing the exit gas velocity
(c) combining the effluents from more than one source into one larger diameter stack
(d) increasing the temperature of the flue gas emitted.

5. ONTARIO AIR POLLUTION INDEX

Most of the existing sources of air pollution in Ontario are now controlled by abatement programmes. For large industries the installation of control equipment will take several years to complete. However, even the most advanced control of sources may still be insufficient to prevent air pollution build-ups during the worst weather situations.

An Air Pollution Index was established by the Ontario Government in April 1970 to provide the public with a day-to-day knowledge of the pollution levels and was designed to be readily comparable with the levels which were reached during "air pollution episodes", a few of which are given in Figure 3. During these episodes (which occurred in other parts of the world), air pollution caused an increase in human sickness and mortality for people with respiratory problems.

Epidemiological studies (Brasser et al., 1967; U.S. Public Health Service, 1969a, 1969b), indicate a relationship between the severity of unhealthy effects and the degree of air pollution as indicated by measured concentrations of particulate matter and sulphur dioxide. Extensive data were available for analyses of the concentrations of these pollutants for the episodes,but only a little information concerning the other pollutants. For this reason (at least for the present), the Index cannot be expressed as a function of the concentrations of the other constituents although this would seem to be desirable also.

The Air Pollution Index is utilised by the Air Management Branch as a basis for action in an Alert System for the prevention of an air pollution episode in Ontario's communities.

Legislation in the Province of Ontario (Ontario, 1970) authorises the Minister of Energy and Resources Management to order the curtailment or shutdown of any source not essential to public health or safety should the pollution reach a level which would be injurious to the health of the citizens in the community. In order that the Index may be used as one of the bases of such control, it was designed to relate to pollution levels which could cause severe health effects such as those occurring during air pollution episodes. The other basis of control depends on the persistence of high pollution potential conditions for at least six hours as indicated by the meteorological forecast.

The Air Pollution Index equation for Toronto is:

$$API = 0.2\left[30.5(COH) + 126.0(SO_2)\right]^{1.35} \tag{8}$$

where COH is the 24-hour running average index of the suspended particulate matter in the atmosphere expressed as Coefficient of Haze per 1,000 linear feet; and SO_2 is the 24-hour running average of sulphur dioxide concentrations in parts per million.

6. THE ALERT SYSTEM

An Air Pollution Index of less than 32 is considered acceptable. At these levels, concentrations of sulphur dioxide and particulates should have little or no effect on human health. At the Advisory Level at which the Air Pollution Index is equal to 32 and meteorological conditions are expected to remain adverse for at least six more hours, owners of significant sources of pollution in the community may be advised to make preparations for the curtailment of their operations.

The First Alert occurs when the Air Pollution Index reaches 50 and is forecast to continue for more than six hours. Owners of major sources may be ordered to curtail their operations. Studies (Lawther, 1958) have shown that at levels over 50, patients with chronic respiratory diseases may experience an accentuation of their symptoms.

If the abatement action does not succeed in lowering the levels of the Index, the Second Alert will be issued when the Index of 75 is reached and is forecast to continue. Further curtailment of the operations of sources producing emissions of pollution will be ordered.

At the air pollution episode threshold level when the Index reaches 100 and is forecast to continue, owners of all sources not essential to public health or safety will be ordered to cease operations. At this level the conditions could have mild effects on healthy people and seriously endanger those with severe cardiac or respiratory diseases.

The Index has been computed for past air pollution episodes. Figure 3 shows the locations where these occurred,the peak reached by the Index and the effects of the pollution.

The Index and Alert System have been in operation in the City of Toronto beginning in April 1970. Owners of sources of pollution have co-operated in decreasing their emissions when advised that levels of the Index were at 32 and meteorological forecasts indicated adverse weather continuing. These temporary abatement actions have assisted in maintaining lower levels of pollution in this City.

REFERENCES

Brasser, L.J., P.E. Joosting and D. Von Zuilen, 1967: Sulphur dioxide, to what level is it acceptable? Rept. G-300, Research Institute for Public Health Engineering, Delft, Netherlands, 21-39.

Gifford, F.A.,1961: Use of routine meteorological observations for estimating atmospheric dispersion. Nuclear Safety, 2, 47-51.

Hewson, E.W., 1945: The meteorological control of atmospheric pollution by heavy industry. Quart. J.R. Met. Soc., 71, 266-282.

Hewson, E.W. and L.E. Olsson, 1967: Lake effects on air pollution dispersion. J. Air Poll. Cont. Assoc., 17, 757-761.

Holland, J.Z., 1953: A meteorological survey of the Oak Ridge area. U.S. At. Energy Comm. Rept. ORO-99, Oak Ridge, Tenn., 554-559.

Holzworth, G.C., 1964: Estimates of mean maximum mixing depths in the continguous United States. Mon. Weath. Rev., 92, 235-242.

Korshover, J., 1957: Synoptic climatology of stagnating anti-cyclones east of the Rocky Mountains in the United States for the period 1936-1956. Tech. Rept. A60-7SEC, Robt. A. Taft. Sanit. Eng. Center, Cincinnati, Ohio, 15pp.

Lawther, P.J., 1958: Climate, air pollution and chronic bronchitis. Proc. Roy. Soc. Med., 51, 262-264.

Nelson, F. and L. Shenfeld, 1965: Economics, engineering and air pollution in the design of large chimneys. J. Air Poll. Cont. Assoc., 15, 355-361.

Ontario. Laws, Statutes, etc., 1967: Regulations made under the Air Pollution Control Act 1967. Ontario Regulation 133/70,Schedule I.

Pasquill, F., 1962: Atmospheric Pollution. D. Van Nostrand Co., Ltd., New York, 297pp.

Stackpole, J.D.,1967: The air pollution potential forecast program. U.S. Weather Bureau Tech. Mem. NMC-43, Suitland, Md., 8pp.

U.S. Public Health Service, 1969a: Air quality criteria for particulate matter. Department of Health, Education and Welfare, 148-176.

-------, 1969b: Air quality criteria for sulphur oxides. Department of Health, Education and Welfare, Wash., D.C., 117-162.

U.S. Weather Bureau, 1955: Meteorology and atomic energy. Rept. AECU-3006, U.S. At. Energy Comm., Wash., D.C., 56-61.

THEORETICAL METEOROLOGY AND THE OPERATIONAL METEOROLOGIST[1]

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1. INTRODUCTION

The provision of weather services is a complex scientific task which can best be performed by a team consisting of scientists and support staff at various levels. It requires large computer facilities and world-wide weather networks. The determination of educational and training requirements for positions on such a team requires a careful job analysis which will give full consideration to the changing technology and the changing role of the scientist in that technology. The top member of this team is the graduate professional meteorologist.

Fifty years ago it was widely believed that the professional meteorologist should take his own observations, plot his own charts and then proceed to analyze and forecast. Twenty-five years ago, or less, one might have heard that only a professional meteorologist should be permitted to give weather briefings to pilots. Now it is said that soon there will be no human intervention between data and the completed forecast,and that the whole process can be computerized and automated and there will be no need for a professional operational meteorologist at all.

If one employs overtrained and/or overeducated (for that job) people in the performance of routine duties, the employee is not challenged. He is dissatisfied and does not perform well or leaves his job for other fields. This employment practice is an expensive one and results in chronically poor performance. On the other hand, if the employee is undereducated and/or undertrained for the job that is expected of him, he cannot perform at the required standard and so he tends to pull the job down to his level. The net result is that the service that is needed is not being provided. Remedial action becomes necessary or the service deteoriorates below acceptable standards. This too becomes an uneconomical and ineffective operation.

1. Paper presented at the WMO/IAMAP Symposium on "Higher Education and Training in Meteorology", Rome, Italy, April 27-May 2, 1970

To provide optimum service then:

1) The employee must be educated, trained and retrained to the level needed in the job, and optimum use must be made of his education and training, through proper job design and motivational environment.

2) There must be sufficient flexibility and mobility in the careers permitting employees who rise above their job levels or challenges to progress to successively higher levels of responsibility.

2. THE ROLE OF THE PROFESSIONAL IN OPERATIONS

Let us examine the role that we expect the professional to play in the provision of meteorological and weather forecasting services.

A professional should perform those tasks for which a broad scientific and general knowledge background is required. He should not perform developed routines no matter how complex they may be. A routine which can be programmed in a series of logical steps can be performed by a technologist or a technician with the necessary training and guidance.

The functions that require a background of academic and theoretical knowledge are many and varied. They may be categorized under the following broad headings.

1) Guidance of the Operations Team

Routines are carried out by support staff who need guidance in: the conduct of routines; applications to unusual situations; the use of computer products and analyses; etc. Good scientific leadership by professional personnel is necessary for efficient operations.

2) Training of Support Staff

New techniques, new data sources and changing technology require almost continuous training and on-the-job updating of support staff.

Such training can only be performed by the professional who knows the language of the science and can select and interpret the relevant information from the literature.

METEOROLOGISTS - CLASS 1

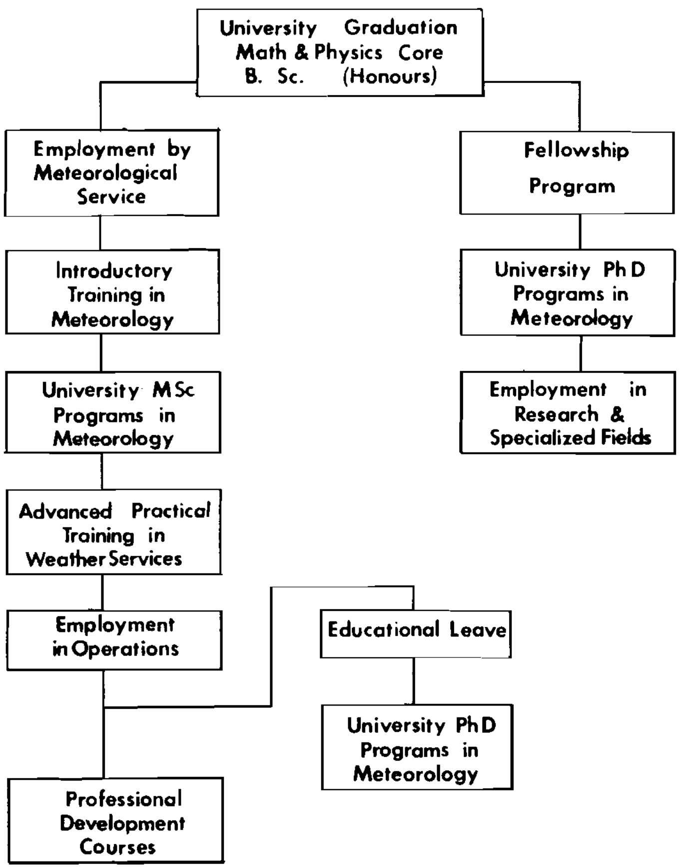

Figure 1

METEOROLOGISTS - CLASS 1 - ALTERNATE PROGRAM

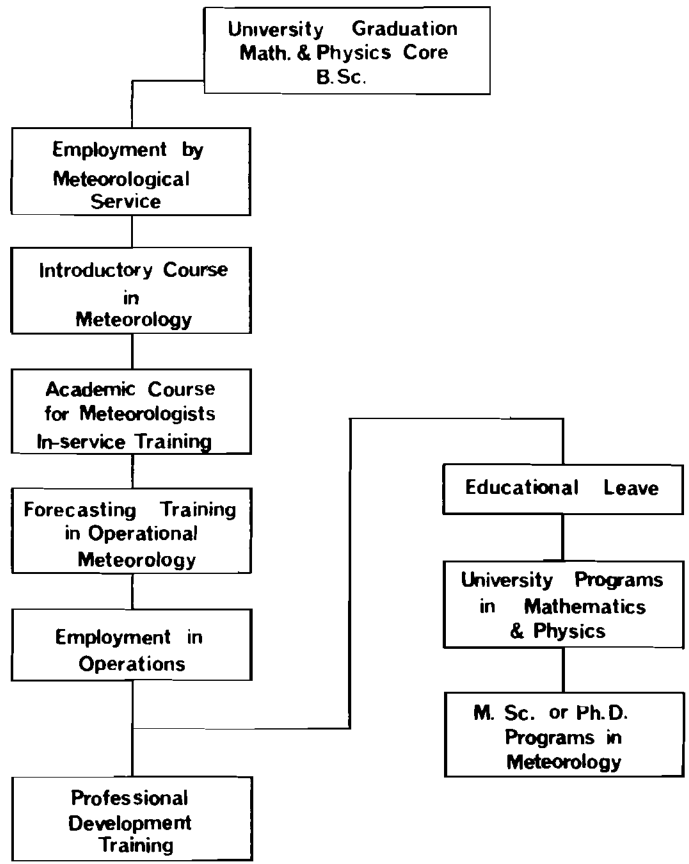

Figure 2

3) Innovation

The rapid changes that occur continuously in our science and technology must be introduced into the forecasting and operational routines with a minimum of delay. Only the academically trained can read and interpret the literature of the science, can understand and interpret innovations or solve problems that would arise in introducing them. Thus the professional in operations must play a leading role to ensure that optimum use is made of innovations and that their use results in improved service.

4) Development and Creativity

The professional must be creative in applying and developing methods and techniques useable in his area of endeavour. There is no practical impact on operational practices if the results of research are allowed to lie fallow in a scientific journal. They must be engineered or developed to the point where they may be used to provide weather services. The development of new techniques, their testing and evaluation can only be performed by the creative professional with a high motivation and orientation toward operations. Once a technique has been developed and programmed, the routine application can be performed by support staff with proper training and guidance.

5) Decision-Making

Scientific operational tasks requiring a large element of judgement and decision-making must be performed by the professional. These cannot be performed or established as a routine. Whether these decisions are in the area of forecasting or in the area of providing weather services to other disciplines, the professional's judgment is needed on-the-spot in the operational environment.

6) Consultation

The professional is a consultant not only to his support staff but to the consumer of the weather services and to the operational scientists in other professional fields who require some expert advice and assistance in the atmospheric sciences. This professional must be able to bridge the interdisciplinary gap between sciences because meteorological problems occur in all environmental sciences. The nearest scientist will be the one who is consulted for on-the-spot advice. Only the professionally, academically trained meteorologist who knows the language of the science and has a broad but rigorous academic background is competent to provide this advice.

7) Management of the Scientific Enterprise

The man who ultimately manages, controls and directs a large scientific operation must know and understand the operation by having had direct contact with the work. He must also have the scientific background and education as well as management ability that will enable him to take his role as a manager.

3. THE EDUCATION OF THE PROFESSIONAL

Figures 1 and 2 show several alternative programs by which Class I meteorologists are trained in Canada. It will be noted that the program consists of:

1) University Degree Programs
2) Professional In-service Training.
3) Training in Applied Meteorology.
4) Continuation of Professional Development Training of the Career Employee.

4. THE SYLLABUS FOR THEORETICAL METEOROLOGY

1) The Mathematics and Physics Core

For education in theoretical meteorology a prerequisite is the Mathematics and Physics Core represented by a University degree in Mathematics and Physics. This is provided entirely by the university mathematics and physics departments. It is better that way. The education of the meteorologist in mathematics and physics must be sufficiently broad and in-depth to enable him to adapt to changes in the next 10 or 20 years. It is therefore undesirable to limit the mathematics or physics education to that which the current consensus believes will be of direct use in professional meteorology. The professional meteorologist needs an education in the science which frees the mind,broadens his horizons and develops his creativity for the future. The operational skills required by the professional can come later. What is important is that the professional has learned to think using the language and techniques of mathematics and physics as tools. The education of the meteorologist in mathematics and physics is thus a function of the universities and it is therefore impossible and undesirable to prescribe a detailed syllabus, setting forth the requirements of the moment. One must also guard against over-specialization. The future meteorologist must be enough of a generalist in the interdisciplinary sciences so that he can keep pace with the changing needs of meteorology.

2) The Essentials of a Dynamic Meteorology Syllabus

Education of the professional meteorologist in theoretical meteorology (dynamics, thermodynamics, kinematics and mechanics, numerical models and computations) must be at a rigorous level and so should not begin at an early stage in the university studies. By force of circumstances it is begun generally at the postgraduate level in Canada. Table 1* gives an outline of the "Essentials of a Dynamic Meteorology Syllabus" for operational meteorology. It is conceived to be a course which can be covered in about 75 lecture hours plus some laboratory work provided that the students begin with Honours graduation in Mathematics and Physics. Details are not included in this table but the course is conducted at a postgraduate level.

In general, there are constraints in the design of a standard syllabus and the objectives of the training must be achieved under these constraints. The constraints that determine the objectives that may be achieved are:

(a) The student's present knowledge in mathematics,physics and meteorology.
(b) The student's ability for advanced study.
(c) The time available to fulfil the syllabus.
(d) The subject matter the student is being taught simultaneously in other courses and laboratories.
(e) The facilities and staff available to give the training.

Without a knowledge of the constraints which are operative,details become meaningless in a syllabus.

The development of a subject in a course can be at various levels: (1) simple familiarity with the subject matter; (2) knowledge and understanding of concepts leading to insight and independent thinking; (3) a solidly-based knowledge and understanding which enables the professional to apply the knowledge with assurance and use it in real problem solving, and in operations or research.

A good syllabus or course must never consist of a collection of miscellaneous, unrelated and unstructured principles. The ideal course in theoretical or dynamic meteorology for the operational meteorologist would first relate the facts to synoptic-scale systems. Thus from the outset there is an immediate emphasis on the concept of scale analysis and synoptic-scale approximations and a rigorous analysis of numerical

* page 22

forecast models. The entire subject must have a logical development and be treated with mathematical rigour. For example, coordinate systems must be applicable to a sphere or to a map projection even though certain terms may become negligible under synoptic-scale approximations. A student should never have to depart from basic principles because of mathematical expediency or unlearn something before he proceeds to more advanced studies or specializations. He must leave the basic course in theoretical meteorology with a coherent set of ideas and a logical structural framework of knowledge on which he can build in the future and which he can apply in the present.

5. THE TEACHING OF DYNAMIC METEOROLOGY

The following are some basic techniques used in postgraduate instruction in Dynamic Meteorology.

1) The Lecture Program

The lecture method is the most common form of communication in transferring information to the student. It can be supplemented by automated presentations consisting of co-ordinated slides and taped commentary, with films or with video-taped television presentations. The lecture, however, does not provide for a good means of interaction between the student and the teacher. So the teacher must organize discussions and present examples where students have difficulty with concepts.

2) Audio-Visual Techniques

The proper use of audio-visual techniques can speed up the learning process and make the lecturer more efficient. A most useful lecture aid is the overhead projector and a photocopy machine which can make transparencies directly from printed or written copy or books. Transparencies can then be prepared in a few minutes for immediate use in a lecture. Maps and meteorological charts and diagrams can also be prepared on a transparency in this way for use in lectures, laboratories or map discussions.

3) Films

Films should be used particularly where they can augment a lecture presentation by presenting laboratory models in hydrodynamics. This kind of material can never be presented by a lecturer without films.

4) Laboratory Exercises

These must be coordinated with lecture programs and there must be no artificial division of the material into separate compartments of theoretical principles and practical applications. The latter often helps in the understanding of physical principles. Thus the student should perform practical numerical experiments in such things as the geostrophic thermal wind, deviations from geostrophic conditions, computations of divergence, vorticity, advections, Laplacians, etc. by graphical and finite difference techniques; relaxation solutions in simple barotropic models by hand computation; programming of simple models for computer; computation of vertical velocities, heating rates, latent heat release, etc. The list is by no means complete but principles taught in dynamic meteorology must continually be applied in the laboratory exercises to reinforce the learning process.

5) Student Participation

Students should be required to prepare and deliver lectures on some topics themselves and should be expected to prepare a few assignments that might involve considerable searching of the literature. This has the advantage of familiarizing students with library research and organizing knowledge independently.

We have experimented with videotape and programmed instruction in other areas of meteorological training but have not yet used it in training of advanced theoretical concepts.

6. SPECIALIZATION

It has already been suggested that the lecture method does not provide for enough interaction between the student and the teacher. Also it does not provide for enough initiative and independence of the student. It is, no doubt, necessary to some extent in the basic course. When the student has completed his fundamental education he must branch out on his own.

Specialization should therefore be accomplished by:

1) Guidance of the student by a specialist through the relevant current literature.

2) Seminars conducted by students but with specialists present who participate in the discussions and counsel students.

3) By performing research in the specialty under the guidance of a research worker in the field and by writing papers or theses on the research work produced.

Therefore it is doubtful that specialist lecture courses with predetermined syllabi, for example in Numerical Models, General Circulation Models, etc. are necessary. This specialized learning should be achieved through seminars, discussion groups and above all research.

In the case of the operational meteorologist who is to take the role outlined for him here, a narrow specialization is undesirable. Such a professional meteorologist will more and more need to become an interdisciplinary scientist with broad knowledge in many fields. Such knowledge must not be in the form of a purely descriptive science but rather a coherent, relevant body of knowledge solidly based on dynamic and mathematical theory.

Table 1. THE ESSENTIALS OF A DYNAMIC METEOROLOGY CURRICULUM FOR OPERATIONAL METEOROLOGISTS

1. Fundamental equations of theoretical meteorology
2. Horizontal motion in the atmosphere
3. Vorticity and divergence equations
4. Vertical motion in the atmosphere
5. Dynamics of discontinuity surfaces
6. Synoptic scale motion systems
7. Atmospheric wave motion
8. Numerical prediction models
9. Operational numerical prediction model
10. Atmospheric turbulence and diffusion
12. Atmospheric energetics
12. General circulation studies

A NOTE ON THE BREAK-UP OF LAKES AND RIVERS AS INDICATORS OF CLIMATE CHANGE

by

G.P. Williams
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Historical records of the dates when ice completely clears from a lake or river have been useful indicators of past climatic variations in Europe and Japan where records have been kept for several centuries (Hutchinson, 1957). Long-term records are much more limited in North America because break-up dates have been recorded continuously at only two or three locations for a little over a hundred years. The purpose of this note is to examine the long-term records that are available for evidence of climatic variation.

Figure 1, a plot of some long-term river and lake ice break-up records obtained from the literature (Canada, Met. Branch, 1959; Ragotzkie, 1960; Sokolov, 1955) shows deviations of average dates of break-up for consecutive ten-year periods from the long-term average for: the River Neva, USSR; Lake Kallavesi, Finland; Lake Mendota, Wisconsin; and the Saint John River, New Brunswick. These break-up records are compared with long-term ten-year moving means of spring air temperatures at Toronto compiled by Thomas (1968).

This plot shows that ice tended to clear from lakes and rivers at these four locations about 10 to 15 days earlier in the 1950's than in the 1870's. Spring air temperatures at Toronto have also increased significantly during generally the same period, even after allowance for possible urban warming effects.

These relatively short-term changes in climate are of interest not only to climatologists but also to all concerned with the development of Canada's northern resources. Changes in climate sufficient to affect break-up dates are probably sufficient to significantly affect navigation conditions in ice-covered Arctic waters. It is hoped that improved methods of observing ice by aircraft and satellite will improve the historical records of freeze-up and break-up, particularly at locations not likely to be affected by future man-made changes.

REFERENCES

Canada, Meteorological Branch,1959: Break-up and freeze-up of rivers and lakes in Canada. Circular-3156, Ice-2, 92 pp.

Hutchinson, G.E., 1957: A Treatise on Limnology. Chapter 7, The Thermal Properties of Lakes. John Wiley & Sons, New York, 1015 pp.

Ragotzkie, R.A., 1960: Compilation of freezing and thawing dates for lakes in north central United States and Canada. Tech. Report No. 3, Univ. of Wisconsin, Dept. of Meteorology, 61 pp.

Sokolov, S.S., 1955: Decreasing duration of freeze-up as related to the warming of the climate. Translated from PRIRODA, 7, 96-98, by E.R. Hope, Defence Research Board, Canada, DRB, T197R, 3 pp.

Thomas,M.K., 1968: Some notes on the climatic history of the Great Lakes Region. Proceedings, Entomological Society of Ontario, 99, 21-31.

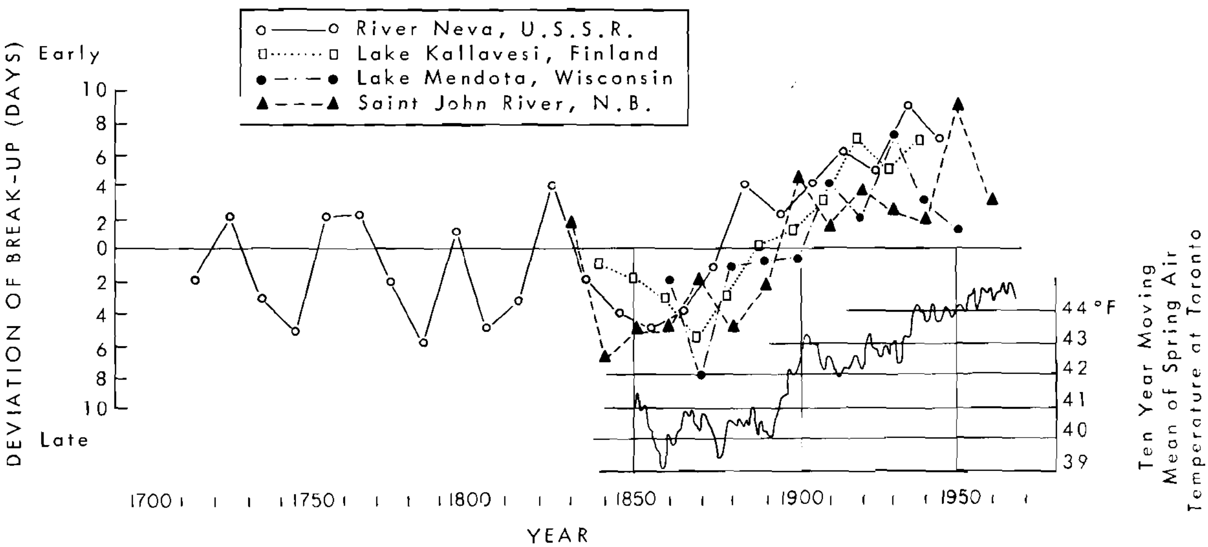

Fig. 1 PLOT OF DEVIATIONS OF BREAK-UP (AVERAGED FOR CONSECUTIVE 10 YEAR PERIODS) FROM AVERAGE FOR PERIODS OF RECORD.

METEOROLOGY AT THE UNIVERSITY OF ALBERTA

Early in 1970, approval was given by the Board of Governors to initiate a program leading to the Ph.D. degree in meteorology. Before this is implemented, it will be necessary to add another instructor to the present staff of three meteorologists and one climatologist. Plans are being made to appoint another man to begin work here in July 1971.

The National Research Council and the University of Alberta have jointly announced an award of a Major Development Grant of $700,000 to be used in research in three fields: solid earth, the lower atmosphere (meteorology), and the high atmosphere. The research planned for meteorology is a study of the influence of the Rocky Mountain region on meteorological phenomena and a study of the transfer of heat over the area to the east of the Rockies. Dr. K.D. Hage, who has been the representative of meteorology in the planning, will be directing the meteorological research and will be Acting Associate Director under Prof. J.C. Jacobs during the coming year. To carry out the program, it will be necessary to add another research meteorologist to the staff of the university.

John Wiley and Sons has announced the release of Prof. Richmond W. Longley's book, "Elements of Meteorology". This book is designed for an undergraduate class. Although it does not demand any knowledge of calculus or university physics, it involves more use of high school mathematics and physics than many similar texts.

Because of the growing importance of meteorology within the university, the administration is formally recognizing a situation which has existed for some time. As of 1 July, 1970, there will be a Division of Meteorology, still within the Department of Geography. The link with the geographers has been pleasant and profitable for both parties and therefore there is no consideration of forming a separate Department of Meteorology.

R.W. Longley

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KEITH THOMPSON McLEOD, Superintendent of Weather and Ice Services, in the Meteorological Service of Canada, retired in April, 1970, after a distinguished career spanning over 30 years. From 1950 he was in charge of the Service's public weather program which expanded under his creative leadership to meet the ever-growing needs of agriculture, forestry, resource development, and marine activities.

In 1960, Mr. McLeod accepted a two-year appointment on the Secretariat of the WMO in Geneva where he acted as Executive Assistant to the Secretary-General and as Chief of the Administration Division. This was the highest-ranking position in the WMO Secretariat ever held, before or since, by a Canadian. In 1964 he was elected to a four-year term as President of the WMO Commission for Maritime Meteorology.

Since May he has been continuing in the field of international cooperation on taking up a short-term appointment with the Food and Agricultural Organization in Egypt as a U.N. expert.

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MEETINGS

REGINA CENTRE

An evening meeting of the Centre, held at the University of Saskatchewan, Regina Campus, was planned to coincide with World Meteorological Day, March 23, 1970.

Mr. E.H. Einarsson, meteorologist on the staff of the Prairie Weather Central at Winnipeg, spoke on the subject "Wind Tides on Some Prairie Lakes". He has made a continuing study of seiches on the Manitoba lakes for many years, and has recently extended this study to include Diefenbaker Lake and Last Mountain Lake in Saskatchewan.

The meeting was attended by approximately 30 persons, including local members, representatives from the staff of the University of Saskatchewan, Saskatchewan Water Resources Commission, Inland Waters Branch of D.E.M.R., P.F.R.A. and a university class studying climatology and micrometeorology.

Arrangements for holding the meeting at the University were completed with the cooperation of Dr. Dale, Chairman of the Geography Department.

TORONTO CENTRE

At the Business Meeting held on Wednesday, June 17, 1970 at 1:00 p.m. the Annual Report and the Treasurer's Report were received, and the following officers were elected for 1969-70:

Chairman	:	C.I. Taggart
Secretary	:	D.G. Schaefer
Treasurer	:	D.M. Sparrow
Program Chairman	:	D.W. Phillips

SOMAS MEETING 19 February, 1970

At the 20th meeting of the NRC Subcommittee on Meteorology and Atmospheric Sciences held in Ottawa on February 19, 1970, three new members were appointed to serve from April 1, 1970 to March 31, 1973: Mr. D.N. McMullen, Prof. R. List (University of Toronto) and Prof. M. Miyake (University of British Columbia).

It was reported that a "blue book" on GARP activities in Canada was being prepared and should contain about 25 projects for which NRC grant applications had been received.

A report was made concerning the activities of the GARP Coordinating Committee whose members believed that the 1971-72 fiscal year as well as subsequent years should involve more NRC funds in support of GARP projects; but if these were not forthcoming, then Canada should indicate that it is not willing or able to participate in the GARP effort.

Because apparent inconsistencies have occurred in the way NRC grant awards for meteorology are split between the Earth Sciences and Space Research and Astronomy committees, SOMAS passed a resolution requesting that the NRC Grants Office review the method in which Meteorology applications are divided between grant award committees.

SOMAS approved a motion to hold a joint symposium with the Subcommittee on Aeronomy in February 1971 on the dynamic and thermodynamic coupling of the high and low atmosphere. It was noted that the IUGG General Assembly would convene in Moscow, July 30-August 14, 1971.

In regard to the re-organization of the Meteorological Service of Canada, the Subcommittee recommended that continuing consultation and collaboration between the Meteorological Branch and the scientific community be adequately provided to ensure the fullest use of developing scientific knowledge.

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GARP DOCUMENTS

The following list of GARP documents which should be available as indicated may be of interest to CMS members:

1. Joint GARP Organizing Committee

   Report of the First (Second, Third) Session.
   The three mimeographed reports are available free from:

   Director, Joint Planning Staff (for GARP)
   c/o WMO Secretariat
   Caisse Postale No. 1
   Ch-1211
   Geneva 20, Switzerland

2. "Program on the Planning and Implementation of the Global Atmospheric Research Programme" by Bert Bolin REPORT DM-1, Sept. 1969.

   Available free from:

   International Meteorological Institute
   P.O. Box 19111
   S-104 32, Stockholm 19
   Sweden

3. GARP Publication Series

   No. 1 An Introduction to GARP

   No. 2 COSPAR Working Group VI Report to JOC - System Possibilities for an early GARP Experiment

   No. 3 The Planning of the First GARP Global Experiment

   No. 4 The Planning of GARP Tropical Experiments

   These publications are on sale and copies can be obtained from:

   WMO Secretariat
   Caisse Postale No. 1
   Ch-1211
   Geneva 20, Switzerland

   No. 1 and No.2 5 Swiss francs (about $1.25 Canadian)

   No. 3 10 " "

   No. 4 No price available (probably in excess of 10 Sw.fr.)

NOTES FROM COUNCIL

The following were elected to membership at the April 1, 1970 meeting of Council:

Member

Raymond J. Fichaud
Donald Graham McCormick
Kenneth Charles Morris
Charles Eugene Ouellet

Undergraduate Student Member

D.J. Nicol

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

Member

Alexander James Chisholm
John Anthony Davies
John Dmytriw
Leonard Feldman
Sepp J. Froeschl
John Richard Lauder
P.C. Okot
Joseph Thomas Zawatsky

Graduate Student Member

Anthony John Arnfield
William Russell Burrows
Vupputuri Rama Krishna Rao

Membership of the Society on May 13, 1970, stands at 605, including 86 student members.

1970 CONGRESS

Council has again decided that a special Congress supplement to ATMOSPHERE should be printed. Due to the lead-time required for printing, the Supplement was not mailed to all members prior to the Congress, but was available at registration for those who attended. This special issue will be mailed to members in July, postal services permitting.

QUEBEC CENTRE - ANNUAL REPORT, 1969-70

"La Sociéte de Météorologie de Québec", known since 1968 as the Québec Centre of the Canadian Meteorological Society, has completed its sixth year of activities. The Council of the Québec Centre held four meetings on the following dates:

10 July, 1969
15 September, 1969
19 January , 1970
5 March , 1970.

At these meetings, the Council mainly dealt with the program of activities for the 1969-1970 season. The activities consisted in conferences, whose speakers and subjects are listed below in chronological order:

7 October , 1969:	Dr. André Hufty, geographer, Laval University. Subject: "The Thermal Climates of Southern Québec".
4 November, 1969:	Dr. Jean-Louis Tremblay, biologist, Laval University. Subject: "Oceanography and Meteorology".
2 December, 1969:	A panel of meteorologists and engineers from the Québec Department of Natural Resources and Laval University. Subject: "Weather Modification".
3 February, 1970:	Mr. Ralph Silver, Hydrology Engineer (ALCAN). Subject: "Hydrometeorology in Electric Power Generation, Yesterday, Today and Tomorrow".
16 March , 1970:	Dr. T.R. Oke, climatologist, McGill University. Subject: "Urban Climate and Air Pollution".

These conferences have all been held at the Faculty of Agriculture of Laval University. Members of the Council for the 1969-1970 season were:

President :	Rénald Naud	
Vice-president:	Raymond Perrier	
Councillors :	Jean-Guy Fréchette Lawrence-J. O'Grady Jospeh Verrette	G.-Oscar Villeneuve Cynthia Wilson

Secretary-treasurer: Michel Ferland

The eighth Annual General Meeting was held on April 7. The minutes of the seventh Annual General Meeting were approved and the reports of the president, the secretary-treasurer and the Nominating Committee were received. The new Council members elected at this meeting are:

President	:	Raymond Perrier	
Vice-president	:	Jean-Guy Fréchette	
Councillors	:	Raymond Gagnon André Hufty Rénald Naud	Lawrence-J. O'Grady Joseph Verrette

Secretary-treasurer: Michel Ferland

The General Meeting included the projection of a film on meteorology and a cheese and wine party.

Thirty-six (36) members were registered in our Centre for the 1969-1970 season.

CMS AWARD

AT THE NINTH CANADA-WIDE SCIENCE FAIR

Mickey Mah, a Grade 9 student from Peace River, Alta., was awarded the CMS prize for his exhibit in a field related to meteorology at the 9th Canada-Wide Science Fair, held in Hamilton, Ont., May 12-16, 1970. Mr. Mah constructed a Newtonian reflecting telescope with a $4\frac{1}{2}''$ diameter spherical concave mirror having a focal length of 45 inches; a $\frac{1}{2}''$ focal length Ramsden eyepiece gives 90X magnification and enables stars as faint as magnitude 11.9 to be viewed at a working resolution of 1.9 seconds.

Mr. J.M. Wingfield, Chief Officer of the Hamilton Weather Office, presented the prize on behalf of the CMS to Mr. Mah, who indicated a keen interest in meteorology, which hopefully will be whetted by the two books awarded: "Introduction to Meteorology" by Petterssen, and "Weather" in the "Life" Science Series.

SECOND CANADIAN CONFERENCE ON MICROMETEOROLOGY

The Second Canadian Conference on Micrometeorology is planned for May 10-12, 1971,at Macdonald College, P.Q. Co-sponsors of the conference meetings are the Canadian Meteorological Society and the National Research Council, through its Associate Committee on Geodesy and Geophysics, Sub-committee on Meteorology and Atmospheric Sciences.

Special sessions are planned on the following topics:

Methods of measurement
Air/water interactions
Micrometeorology over snow and ice
Agrometeorology
Forest meteorology
Topoclimatology
Mesometeorology
Urban climate
Air pollution meteorology

There will be invited speakers, including several from the U.S.A. and overseas. In addition the program will contain a limited number of contributed papers.

Joint sessions will be held on May 12 with the CMS 5th Annual Congress(May 12-14). The Montreal Centre will be host for the conference meetings.

Chairman of the Physical Arrangements Committee is Professor R.H. Douglas, Department of Agricultural Physics, Macdonald College, P.Q. Chairman of the Planning Committee is Dr. R.E. Munn, Meteorological Service of Canada, 315 Bloor Street, West, Toronto 181, Ontario.

ATMOSPHERE
INDEX TO VOLUME 7, 1969

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3rd Annual Congress Issue (32 pages, unpaginated)

Corrigendum: 120

Section A: Index of contributions by author
Section B: CMS subject index
Section C: General subject index

Section A: Index to Contributions by Authors

C(p): C refers to 3rd Annual Congress issue of ATMOSPHERE,
p, to page number in this issue.

Section C: General Subject Index

CORRIGENDUM

In the paper "Pollution Wind-Rose Analysis" by R.E. Munn (ATMOSPHERE 7, 97-105), the units for SO_2 concentrations quoted in Figures 4, 5, 8, 9, 12 and 13 should be parts per 10 million rather than parts per hundred million (pphm).

INSTRUCTIONS TO AUTHORS

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

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

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

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

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

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

7. Metric Units are preferred.

8. Footnotes to the text should be avoided.

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The 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 -

Cost:	(First 500 pages)	-	$20.00
	(Next 500 pages)	-	$15.00
	(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.