ROYAL METEOROLOGICAL SOCIETY

CANADIAN BRANCH

PROGRAM

THE NATIONAL METEOROLOGICAL CONGRESS

Montreal

June 6 and 7, 1961

CONSPECTUS

Tuesday, June 6 — Registration, Salle d'honneur, University of Montreal, 8.30 - 5 pm.

SESSIONS AT THE UNIVERSITY OF MONTREAL

9 - 12 noon — "Ozone and the Stratosphere", R.H. Douglas, Chairman

2 - 5 pm. — "Dynamics and Synoptic Meteorology", W.L. Godson, Chairman

5 pm. — Vin d'honneur, offered by University of Montreal

Wednesday, June 7 — Registration, Physics Bldg., McGill University, 8.30 - 4 pm.

SESSIONS IN PHYSICS BUILDING, McGILL UNIVERSITY

9 - 12 noon — Jointly with Session III, Royal Society of Canada:

"Precipitation Physics", J.S. Marshall, F.R.S.C., Chairman

2 - 4 pm. — "The Troposphere", P.D. McTaggart-Cowan, Chairman

5 pm. — Special public session: "Observations from Satellites"

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Congress Registration Fee $1.00

NATIONAL METEOROLOGICAL CONGRESS

6 and 7 June, 1961

The technical sessions of the Congress include four papers (marked P on the Program) which have recently appeared, or will shortly appear, in our Quarterly Journal. It is intended that these papers be discussed fully; a brief summary of the discussion will appear in a subsequent issue of the Journal. Quite apart from this, we hope to produce a brief permanent record of the Proceedings; part of the responsibility for this, too, will devolve on the session chairmen and the rapporteurs.

Alternate chairmen: David Atlas, H.M. Hutchon, J.M. Leaver, D.P. McIntyre

Rapporteurs: J.L. Galloway (chief rapporteur), Rev. C. East, S.J., P.M. Hamilton, Captain H.A. Million, Captain H.A. Steiner

Congress Committee

Walter Hitschfeld, McGill University, Montreal, Chairman
J.L. Galloway, Meteorological Service, Montreal
Michael Kwizak, Meteorological Service, Montreal
D.P. McIntyre, Meteorological Service, Toronto
J.S. Marshall, McGill University, Montreal
G.J.W. Oddie, Internat. Civil Aviation Organization, Montreal
Svenn Orvig, McGill University, Montreal
Raymond Perrier, Meteorological Service, Montreal

Tuesday, June 6 — 9 - 12 noon — Room G'404, University of Montreal

"OZONE AND THE STRATOSPHERE"

Chairman: R. H. Douglas, President, Canadian Branch, R. M. S.

Minutes*	
40 P	WALTER HITSCHFELD AND J. T. HOUGHTON: Radiative transfer in the lower stratosphere due to the 9.6-micron band of ozone.
40 P	C. L. MATEER AND W. L. GODSON: The vertical distribution of atmospheric ozone over Canadian stations from Umkehr observations.
15	RECESS
40 P	B. W. BOVILLE AND F. K. HARE: Total ozone and cold lows in the middle stratosphere.
20	B. W. BOVILLE: Energy components of the stratospheric polar vortex.
20	H. A. STEINER: The structure of the Ferrel westerlies in the lower stratosphere.

2 - 5 pm. — Room G'404, University of Montreal

"DYNAMIC AND SYNOPTIC METEOROLOGY"

Chairman: W. L. Godson

30	C. O. HINES: Some hydromagnetic effects in the motion of the upper atmosphere.
20	A. H. GORDON: Seasonally induced meridional flux of momentum in the atmosphere.
25	W. L. GODSON AND A. J. ROBERT: A baroclinic model incorporating statistical concepts.
20	RECESS
20	A. G. EDDY: A statistical model of the construction of the atmosphere in the vicinity of one of its major temperature discontinuities.
25	D. DAVIES: The anatomy of a front.
15	M. KWIZAK AND J. M. LEAVER: Numerical weather prediction in Canada.

* Includes discussion, for which speakers must leave ample time.

Wednesday, June 7 9 - 12 noon Physics Bldg., McGill University

"PRECIPITATION PHYSICS"

Joint Session with the Royal Society of Canada - Section III

Minutes* Chairman: J.S. Marshall, F.R.S.C.

25 R.H. DOUGLAS, WALTER HITSCHFELD, E.J. STANSBURY: The development of hail from rain.

20 R.W. LONGLEY AND C.E. THOMPSON: A synoptic study of the occurrence of hail in central Alberta, 1959.

40 P D. ATLAS, W.G. HARPER, F.H. LUDLAM AND W.C. MACKLIN: Radar scatter by larger hail.

20 RECESS

25 J.D. HOLLAND AND C.L. CROZIER: Precipitation physics project in northwestern Quebec.

20 P.M. HAMILTON AND K.L.S. GUNN: Areal integration of precipitation observed by radar.

20 J. MAYBANK: The evaporation of large drops under free fall conditions.

2 - 4 pm. Physics Bldg., McGill University

"THE TROPOSPHERE"

Chairman: ~~P.D. McTaggart-Cowan~~

20 A.B. LOWE AND G.A. McKAY: Tornado composite charts for the Canadian prairies.

30 D.R. HAY AND W.M. REID: Fine structure of the air in the layer of frictional influence.

20 O. JOHNSON: A study of vertical wind shear in the lower troposphere and its effect on the propagation of sound waves.

10 RECESS

20 P.W. SUMMERS: Air pollution in Montreal related to local meteorological factors.

20 R.E. MUNN AND C.R. ROSS: Analysis of smoke observations at Ottawa.

5 pm. McGill University

Special Public Session: "OBSERVATIONS BY SATELLITE"

Chairman: F.K. Hare

D.S. JOHNSON, United States Weather Bureau, Washington: Some results of the U.S. meteorological satellite program: Tiros I and II.

RADIATIVE TRANSFER IN THE LOWER STRATOSPHERE DUE TO THE 9.6-MICRON BAND OF OZONE

Walter Hitschfeld, McGill University, Montreal, and J. T. Houghton, Clarendon Laboratory, Oxford.

Precise numerical calculations of the flux divergence due to narrow regions of the ozone 9.6-micron band were made, using the relative strengths and positions of the spectral lines calculated by Kaplan, Migeotte and Neven (1956). Absolute line strengths were estimated on the basis of Walshaw's (1957) laboratory measurements. Spectral models or the Curtis-Godson approximation were not used, but Lorentz shapes and uniform widths were assumed for all lines. Calculations up to a height of 33 km were made for two ozone ascents of Brewer and Milford (1960). The atmospheric heating rates for the parts of the band so obtained were then combined to estimate the heating rate by the whole band, with results in qualitative agreement with, though nearly two times greater than, those of Plass (1956), who had used older spectroscopic data and an entirely different method of computation. The effect of the radiative temperature of the base of the ozone layer (whether of ground or cloud top) appears to be great. The radiative heating by ozone in the 10 to 20 km region is about 0.4° per day for a base temperature of 10°C, but may disappear altogether, if cloud is present just below the tropopause. The procedure adopted can be applied to any absorption band, and is flexible enough to permit the use of any desired pressure and temperature dependence of the shape, width and strength of the spectral lines; results from it might serve as a standard against which conclusions reached by approximate methods can be checked.

THE VERTICAL DISTRIBUTION OF ATMOSPHERIC OZONE OVER CANADIAN STATIONS FROM UMKEHR OBSERVATIONS

C. L. Mateer and W. L. Godson, Meteorological Service of Canada, Toronto.

The vertical distribution of ozone is estimated from umkehr observations at the Canadian ozone stations at Edmonton, Moosonee and Resolute. Average seasonal vertical distributions are presented and compared with European and Indian results. The Canadian results indicate the existence of two levels of maximum ozone density, one at about 27 km and a lower one at about 15 km. During the spring, summer and autumn seasons the higher-level maximum is slightly more predominant than the lower. However, during the winter months, the lower-level maximum becomes much more pronounced. As a result, there is an extremely good correlation between ozone amount between 12 and 24 km and total ozone, three-quarters of the seasonal changes in total ozone being attributable to changes in this layer.

TOTAL OZONE AND COLD LOWS IN THE MIDDLE STRATOSPHERE

B. W. Boville and F. K. Hare, McGill University, Montreal.

Total ozone amounts are shown to vary with the motion systems of the stratospheric polar vortex. Two cold outbreaks, one over Europe in 1959 and the other over North America in 1960 produced similar pronounced minima in the total ozone records. The studies support the thesis that major anomalies in the horizontal and seasonal distributions of total ozone are related to dynamical activity in the polar-night vortex and the stratospheric warm belt.

ENERGY COMPONENTS OF THE STRATOSPHERIC POLAR VORTEX

B. W. Boville, McGill University, Montreal.

The circumpolar circulation of the 1958-59 winter has been studied by geostrophic, Fourier techniques. Computations of energy components and conversions show the dominance of large waves in the polar stratosphere. About forty percent of the total kinetic energy at 25 millibars is found in the eccentric and bipolar wave numbers. Correspondence between stratosphere and troposphere was found at those wave numbers.

THE STRUCTURE OF THE FERREL WESTERLIES IN THE LOWER STRATOSPHERE

Harold A. Steiner, Captain U. S. A. F., McGill University, Montreal.

The stratospheric wind structure for the 1958-1959 winter season has been studied by means of vertical cross sections along the 80 W meridian, supported by Project Jet Stream data. Particular emphasis is given to the transition layer between the lower and upper stratospheric wind regimes. The reversal in wind direction or velocity minimum on the wind profile in the lower stratosphere is considered the upper boundary or crest of the Ferrel westerlies. Logarithmic wind profiles from cross section data suggest that the mid-latitude jet streams are symmetrical wind systems, and the crests occupy essentially the same spatial layer throughout the season. The amount of baroclinity above and below the jet stream cores is compared as a means of establishing the wind structure, and it is shown that the baroclinic couple varies together in sign but not in absolute magnitude. When the average monthly crest positions are compared with the average temperature profiles and resultant wind profiles, the crest layer is observed to occur in a quasi-barotropic region for winter-type wind profiles. In summer-type wind profiles the crest layer occurs where the baroclinity approaches a constant value. The quasi-conservative nature of the positions in space and time suggest that the level(s) where the Ferrel westerlies stop and the upper stratospheric wind regime beings occurs within the same general atmospheric layer in both winter and summer.

SOME HYDROMAGNETIC EFFECTS IN THE MOTION OF THE UPPER ATMOSPHERE

C. O. Hines, DRB Theoretical Studies Group, Defence Research Board, Ottawa.

At heights above 100 km or so, the combined action of atmospheric ionization and the geomagnetic field introduces dynamical forces of a type not encountered at lower levels. These forces, which are hydromagnetic in nature, can act both to perturb the usual types of motion and to control quite new circulatory systems. The basic nature of the hydromagnetic forces is described in this paper, and developed to indicate the two limiting types of behaviour. Specific examples are then given in which the hydromagnetic effects are believed to play an important if not crucial role. These include the damping of atmospheric oscillations on the one hand, and the generation of a vast convective system at high-to-medium latitudes.

SEASONALLY INDUCED MERIDIONAL FLUX OF MOMENTUM IN THE ATMOSPHERE

A. H. Gordon, Meteorological Office, London.

The changing meridional heating differential which accompanies the seasonal northward and southward march of the sun creates changes in the mean zonal index of geostrophic wind. These changes in the mean zonal wind induce a mean meridional circulation which is superimposed upon the frictionally driven actual meridional circulation. The seasonally induced meridional circulation gives rise to fields of convergence and divergence which are consistent with the known pattern of changes in the mean pressure and with the known mass transfers which take place throughout the year between the hemispheres.

A BAROCLINIC MODEL INCORPORATING STATISTICAL CONCEPTS

W. L. Godson and A. J. Robert, Meteorological Service of Canada, Toronto and Montreal.

A two-level statistical-dynamical model of the atmosphere is constructed using the vorticity equation in conjunction with the first law of thermodynamics by means of a statistically derived three-dimensional representation of the pressure-height field. The success of the integration depends primarily on the adequacy of the representation. For this purpose the various methods of curve-fitting are investigated. The advantages of the statistical method over its analytical equivalent are examined. The derivation and physical interpretation of the inherent empirical constants are explored in a two-level model. The differential equations are transformed into a form suitable for numerical prediction. Schematic diagrams representing the stability characteristics of the model are constructed.

THE ANATOMY OF A FRONT

David Davies, Meteorological Service of Canada, Montreal.

Classical meteorology is faced with the paradox of the persistence and continuous development of fronts and tropopause in spite of natural diffusion processes. These phenomena are explained on the basis of their turbulent fine structure by assigning a mathematical description to a turbulent flow, defining it to be a flow wherein the vorticity is piecewise continuous. This involves applying a refined Reynolds meaning process in the derivation of the eight independent equations governing a discontinuity through which mass-transfer occurs.

For fronts the physical interpretation is that initially a weak directional turbulent zone develops between cold and warm air masses. Once the turbulent zone is in existence the air in the zone is heated by three processes, the turbulence itself, gravitational subsidence and a Coriolis resonance effect. The net result of this heating process within the turbulent zone is that cold air moves through the zone into the warm air supplying the necessary counterbalance to the diffusion forces. The Coriolis phenomenon plays a fundamental role in the development and sharpening of a front.

A STATISTICAL MODEL OF THE CONSTRUCTION OF THE ATMOSPHERE IN THE VICINITY OF ONE OF ITS MAJOR TEMPERATURE DISCONTINUITIES

A. G. Eddy, Meteorological Service of Canada, Montreal.

Observed height and wind data at the 500, 300, 150 and 100 m.b pressure levels comprise the basic data which are transformed into a grid point objective analyses. Maps corresponding to the tropopause and the level of maximum wind are derived from the above four levels. Correlations between twenty-four-hour changes in heights and thicknesses which define this layer are transformed into regression equations. The regression equations permit reconstruction of the layer given the history and the present 500 mb data. This new "derived" layer is examined statistically and synoptically with respect to its adequacy: firstly as a three-dimensional first-guess field for the current objective analyses, and secondly as a method for deriving these pressure levels from a barotropic prog for use either as a synoptic tool or as an aid to aviation.

NUMERICAL WEATHER PREDICTION IN CANADA

M. Kwizak and J.M. Leaver, Meteorological Service of Canada, Montreal.

Canadian efforts in Numerical Weather Prediction (NWP) until 1959 were confined to studies of theoretical models of the atmosphere and to a few simple trial integrations on electronic computers. In 1959 a concentrated effort was initiated at the Central Analysis Office using the IBM 650 computer at McGill University. This introductory program involved experimental and developmental work in Objective Analysis of tropospheric height and wind fields, barotropic prediction (geostrophic and non-geostrophic) of the 500 mb height fields and statistical derivation of height and wind fields at other levels. Currently the program has been extended to include baroclinic models and automatic data processing. Results of the program have led to plans for the implemention of NWP on a routine operational basis using a large high speed computer during 1962.

THE DEVELOPMENT OF HAIL FROM RAIN

R.H. Douglas, Walter Hitschfeld, E.J. Stansbury, McGill University, Montreal.

Recent observations suggest that hailstones grow without disintegration even if containing large fractions of liquid water. This allows us to compute the fast growth of large hail in the dense rain caught in an updraft. To understand the hailstorm requires that this growth information be combined with the known freezing probabilities of cloud and rain drops. This probability increases with height, and the resulting stones increasingly compete for the available water. The simultaneous consideration of many factors - notably of temperature, cloud and rain density, stone consistency, and updraft - allow the specification of the relatively narrow ranges in the variables for which sustained hail development is possible.

A SYNOPTIC STUDY OF THE OCCURRENCE OF HAIL IN CENTRAL ALBERTA, 1959

R.W. Longley, University of Alberta and C.E. Thompson, Meteorological Service of Canada, Edmonton.

Seven meteorological variables were identified which showed some correlation with Alberta hail: (1) an outbreak of colder air; (2) a north-westerly flow at low levels; (3) cyclonic vorticity at 500 mb; (4) cyclonic vorticity at 500 mb over British Columbia during the preceding night; (5) a steep vertical temperature gradient to 300 mb; (6) a steep horizontal temperature gradient at 850 mb between Edmonton and Great Falls, Montana; and (7) unstable air over Great Falls.

None of these, by itself, could be used to identify a day with hail, but if three or more of these variables were present with sufficient intensity, the probability of considerable hail somewhere in Alberta was over fifty percent. If less than three were present, hail was improbable.

RADAR SCATTER BY LARGE HAIL

D. Atlas, Geophysics Research Directorate, AFCRC., Boston, Mass., W. G. Harper, Meteorological Office, London, F. H. Ludlam, Imperial College, London, W. C. Macklin, University of Western Australia.

Results of experiments to measure the back-scatter from individual hail stones are reported. A dry ice sphere scatters much better than an equal particle of water or metal when its diameter exceeds the wave length. As melting starts the scatter decreases towards and occasionally falls below the all-water value. The results are confirmed by the theoretical computations of Herman and Battan. The behaviour of the ice as a scatterer is also explained semi-quantitatively using geometric optics by which it is found that the particle acts as a dielectric lens. The implications of the results with regard to radar observation of hail storms are noted.

PRECIPITATION PHYSICS PROJECT IN NORTHWESTERN QUEBEC: ITS DESIGN AND OPERATION

J. D. Holland and C. L. Crozier, Meteorological Service of Canada, Toronto.

A precipitation physics project aimed at discovering basic relationships in the chain of cause and effect in precipitation mechanisms has been operated in Northwestern Quebec since 1959. In addition to conventional observational techniques, this project employs randomized cloud seeding of synoptic-scale weather systems as one method of studying these mechanisms. The seeding is done by aircraft, and the randomization is applied in a cross-over pattern designed to hasten the attainment of significant statistical results. This paper discusses the experimental design and the operational techniques being employed in the project. With at least three more years for the project to run, significant statistical results are not yet available.

AREAL INTEGRATION OF PRECIPITATION OBSERVED BY RADAR

P. M. Hamilton and K. L. S. Gunn, McGill University, Montreal.

We have set up a scale of precipitation intensity consisting of seven thresholds, proceeding by factors of four in rainfall rate from 0.1 mm hr^{-1}. The radar has an area of 60,000 mi^2 under surveillance. At each of six heights, we derive the fraction of that area covered by precipitation of greater than threshold value for each of the seven thresholds. The results are most usefully viewed as profiles of areal coverage as a function of height. These data, in turn, are readily converted to the average flux of precipitation yielded by each threshold, averaging over the total area. Of the weather radar information relevant to the continent-wide picture, this family of profiles is probably the most helpful. While the information is presently derived rather laboriously from CAPPI maps in stepped grey scale, it should be possible to derive and process it automatically and with negligible time delay.

THE EVAPORATION OF LARGE DROPS UNDER FREE FALL CONDITIONS

J. Maybank, Defence Research Board, Suffield Experimental Station, Ralston, Alta.

A small vertical wind tunnel has been designed in which drops of liquids, ranging in size from 100μ to several millimeters diameter, may be freely suspended. Under these conditions it is possible to investigate the effective fall speeds of the floating drops, and the air-flow patterns around them, using for this purpose a fine thermistor probe. The drop evaporation has also been studied by time lapse photography over lifetimes of 10 - 30 minutes under different conditions of ambient vapour pressure and impurity content within the drop. Evaporation rates are increased over those obtained under still air conditions, not only by the ventilation rates, but also by the increase in surface/volume ratio due to flattening of the drop in the air stream. In addition, rapid fluctuations of the shape also increase the evaporation; these fluctuations, which are apparent in droplets as small as 200μ in diameter, can be altered in magnitude and frequency by changing the viscosity and surface tension of the liquid. Finally, internal drop temperatures have been obtained using the thermistor probe so that a comparison between actual values of this important parameter, and the wet bulb temperature may be made.

TORNADO COMPOSITE CHARTS FOR THE CANADIAN PRAIRIES

A. B. Lowe and G. A. McKay, Meteorological Service of Canada, Winnipeg.

Composite charts are prepared for the surface, 850, 700, 500 and 200 mb levels for tornado occurrences in Saskatchewan and Manitoba. The charts are discussed in relation to the larger scale synoptic features which are revealed, and the differences in pattern due to geographic location.

FINE STRUCTURE OF THE AIR IN THE LAYER OF FRICTIONAL INFLUENCE

D. R. Hay and W. M. Reid, University of Western Ontario, London, Ont.

A vertically directed microwave radar has been operated over a period of one year at the University of Western Ontario, to record the incidence of weak radio reflections from irregularities in the lower troposphere. Only clear weather reflections (angels) are considered in this paper. The relationship between the incidence of angels and surface wind speed, temperature, and insolation is in general agreement with results reported elsewhere, but new information has been obtained on angel characteristics. The duration of angel echoes has a frequency distribution that is different for each of the four types of air mass above the radar. Further, the angels have persistence from one to thirty minutes when surface air temperature is between 30°F and 55°F; at other temperatures between 20°F and 85°F, the persistence is of the order of one second. Power reflection coefficients of the angels vary from 10^{-13} to 10^{-16}. These results are examined first for an estimate of the refractivity gradients present in the air, and secondly for possible air structures that lead to angels.

A STUDY OF VERTICAL WIND SHEAR IN THE LOWER TROPOSPHERE AND ITS EFFECT ON THE PROPAGATION OF SOUND WAVES

O. Johnson, Meteorological Service of Canada and Defence Research Board, Suffield Experimental Station, Ralston, Alta.

Simultaneous measurements of winds aloft, by means of double theodolite balloon ascents and vertical temperature profiles from Radiosonde ascents, have been made up to heights of about ten thousand feet. These ascents were made for periods of four to five hours in the mornings on several days, mainly during the fall and winter. The data have been analyzed in order to determine the variation of vertical wind shear during the morning hours and the effect of the vertical temperature gradient on the wind shear. The anomalous propagation of sound waves has also been studied during these periods. In general, there is considerable wind shear in the surface inversion. As the inversion breaks up this shear gradually decreases. Considerable time variations in the wind shear are simetimes observed above the inversion layer and these variations can have marked effect on the propagation of sound

AIR POLLUTION IN MONTREAL RELATED TO LOCAL METEOROLOGICAL FACTORS

Peter W. Summers, Weather Engineering Corporation of Canada Ltd. and McGill University, Montreal.

Measurements of smoke concentration in downtown Montreal have been taken by Weather Engineering Corporation since January 1960, and are supplemented by readings from the McGill Campus and atop Mount Royal since January 1961. The seasonal and diurnal variations are analysed and related to changes in atmospheric stability with particular reference to the effects of winter snow cover. Some typical synoptic situations producing high smoke pollution levels are also discussed and variations between sampling locations are considered in terms of local topographic effects.

ANALYSIS OF SMOKE OBSERVATIONS AT OTTAWA

R. E. Munn, Meteorological Service of Canada, Toronto, and C. R. Ross, Department of National Health and Welfare, Ottawa.

Simultaneous A. I. S. I. smoke observations made at two locations in central Ottawa have been analyzed in a number of different ways, along with wind speed and wind direction observations taken at Ottawa Airport. The purpose of the study was to determine the best methods of evaluating air pollution data when the only weather data available are those recorded at a local airport.