Atmosphere

5th ANNUAL CONGRESS
May 12 to 14, 1971
Macdonald College, P.Q.

2nd Canadian Conference
on Micrometeorology
May 10 to 12

Canadian Meteorological Society
Société Météorologique du Canada

ATMOSPHERE

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PROGRAM

FIFTH ANNUAL CONGRESS
Second Canadian Conference on Micrometeorology

The Fifth Annual Congress and Annual Meeting of the Canadian Meteorological Society will be held at Macdonald College, P.Q., May 12-14, 1971. On May 12, the Congress will hold joint sessions with the Second Canadian Conference on Micrometeorology which is to be held at the same location, May 10-12, 1971. The theme of the Congress is "Meteorology and the City" and the joint sessions on May 12 will be devoted to invited and contributed papers on this topic. On subsequent days, contributed scientific papers on other aspects of meteorological research will be presented. Program Chairman for the Congress is Dr. C.L. Mateer.

Co-sponsors of the Second Canadian Conference on Micrometeorology are the Canadian Meteorological Society and the National Research Council, through its Associate Committee on Geodesy and Geophysics, Sub-committe on Meteorology and Atmospheric Sciences. Chairman of the Conference Planning Committee is Dr. R.E. Munn.

The Montreal Centre of the CMS is host for both meetings. Chairmar of the Physical Arrangements Committee is Professor R.H. Douglas, Macdonald College.

SUMMARY OF SESSIONS

Second Canadian Conference on Micrometeorology (SCCM)

Mon.	9:00 a.m.		Opening Remarks and Welcome
	9:10 a.m.	M1:	Agriculture and Forestry
	1:30 p.m.	M2:	Climatonomy
	3:00 p.m.	M3:	Air Pollution
	3:00 p.m.	M4:	Heat and Water Budgets of Small Lakes
Tues.	8:30 a.m.	TU1:	Instruments - 1
	8:30 a.m.	TU2:	The Ekman Layer
	1:30 p.m.	TU3:	GARP and Small-Scale Meteorology
	3:00 p.m.	TU4:	Turbulence and Fluxes
	3:00 p.m.	TU5:	Instruments - 2

FIFTH ANNUAL CONGRESS

Wed.			Joint Sessions with SCCM (May 12)
	9:00 a.m.		Opening Welcome, CMS President
	9:05 a.m.	W1:	Urban Meteorology
	1:30 p.m.	W2:	Human Responses
	3:30 p.m.	W3:	Urban Air Pollution
	8:00 p.m.		Annual General Meeting of the CMS
Thur.	8:30 a.m.	TH1:	Numerical Weather Prediction I
	1:30 p.m.	TH2:	Numerical Weather Prediction II
	1:30 p.m.	TH3:	Radiation
	TBA p.m.		Banquet and Award of Patterson Medal
Fri.	8:30 a.m.	F1:	Hail and Fog
	1:30 p.m.	F2:	Hail and Cloud Physics
	1:30 p.m.	F3:	General Meteorology

SECOND CANADIAN CONFERENCE ON MICROMETEOROLOGY

MONDAY MORNING MAY 10, 1971 — 9:00 a.m. - noon

OPENING: Prof. A. Brewer, on behalf of the National Research Council — 5 min.
Dr. R.E. Munn, on behalf of the Planning Committee — 5 min.

Session M1: Agriculture and Forestry

Chairman: Prof. R.H. Douglas

Invited Discussant: Prof. C. Tanner, University of Wisconsin

CONVECTIVE HEAT TRANSFER MEASUREMENTS OF PLANTS IN A WIND TUNNEL — 15 min.
A. Kumar and N. Barthakur, Macdonald College

MODEL EXPERIMENTS ON FORCED CONVECTION, HEAT AND MASS TRANSFER OF LEAVES; THE EFFECT OF FLUTTER AND LEAF SHAPE — 15 min.
P. Schuepp, Macdonald College

HORIZONTAL FLUX DIVERGENCE OF HEAT, WATER VAPOUR AND CO_2 IN A CORN FIELD; CASE STUDIES — 15 min.
L.H. Allen, Jr. U.S. Department of Agriculture, Ithaca, New York

Coffee (10:15 - 10:45)

AVERAGE BOWEN-RATIO METHODS OF CALCULATING EVAPOTRANSPIRATION APPLIED TO A DOUGLAS FIR FOREST — 15 min.
T.A. Black and K.G. McNaughton, University of British Columbia

COMPARISON OF PINE FOREST EVAPOTRANSPIRATION ESTIMATED BY ENERGY BUDGET, AERODYNAMIC AND PRIESTLEY METHODS — 15 min.
E.I. Mukammal, Canadian Meteorological Service, Toronto

AN EXTENDED BOWEN-RATIO PROFILE METHOD FOR THE CALCULATION OF ENERGY FLUX DENSITIES ABOVE VEGETATION — 15 min.
T.R. Sinclair, L.H. Allen, Jr. and E.R. Lemon, Cornell University

MONDAY AFTERNOON MAY 10, 1971 — 1:30 - 5:00 p.m.

Session M2: Invited Lecture

Chairman: Prof. A. Brewer

CLIMATONOMY — 45 min.
H.H. Lettau, University of Wisconsin

Coffee (2:30 - 3:00)

Session M3: Air Pollution 3:00 - 5:00 p.m.

Chairman: Prof. A. Brewer

ANALYSIS OF DOWNWIND DEPOSITION OF DRIFTING SPRAY-CLOUD BY NEUTRON ACTIVATION AND GAMMA RAY SPECTROMETRY — 15 min.
K. Yoshida, J. Maybank, H. Mizuma and S. Iwamoto, Saskatchewan Research Council, Saskatoon

CROSS-WIND SHEAR EFFECTS ON ATMOSPHERIC DIFFUSION — 15 min.
G.T. Csanady, University of Waterloo

A TURBULENT DISPERSION COMPUTATION — 15 min.
G.B. Frame and R.D. Rowe, University of Calgary

BUOYANT MOIST BENT-OVER VAPOUR PLUMES AT A PILOT STACK FACILITY — 15 min.
P. Slawson, University of Waterloo

TURBULENCE STATISTICS AT 16, 48 AND 92 METRES AT DEFENCE RESEARCH ESTABLISHMENT, SUFFIELD — 15 min.
O. Johnson and B.R. Larson, Suffield Experimental Station

Session M4: Heat and Water Budgets of Small Lakes 3:00 - 5:00 p.m.

Chairman: Dr. P.J. Barry

AN INTRODUCTION TO THE PERCH LAKE STUDY — 10 min.
P.J. Barry, A.E.C.L., Chalk River

A COMPARISON OF EVAPORATION ESTIMATE METHODS AT PERCH LAKE — 15 min.
H.L. Ferguson, Canadian Meteorological Service, Toronto

THE DETERMINATION OF THE HEAT CONTENT OF PERCH LAKE — 15 min.
R.J. Polavarapu, Canadian Meteorological Service, Toronto

THEORETICAL ASPECTS OF THE EVAPORATION OF TRITIATED WATER FROM PERCH LAKE — 15 min.
W.N. Selander, A.E.C.L., Chalk River, Ontario

THE HEAT AND WATER BUDGETS OF A BEAVER POND — 15 min.
E. Vowinckel and S. Orvig, McGill University

TUESDAY MORNING MAY 11, 1971 — 8:30 a.m. - noon

Session TU1: Instruments - 1

Chairman: R. Vockeroth

THE DEVELOPMENT OF ACCURATE WIND-MEASURING INSTRUMENTS FOR THE RESEARCH METEOROLOGIST — 25 min.
G.C. Gill, University of Michigan

A PROPELLER-TYPE WIND SENSOR — 15 min.
D. Champ, Canadian Meteorological Service, Toronto

A "DAMPED" WIND DIRECTION DIGITIZER — 15 min.
J.S. Dickson, Canadian Meteorological Service, Toronto

Coffee (9:45 - 10:15)

A GAS EXCHANGE METER BASED ON THE EDDY CORRELATION TECHNIQUE — 15 min.
R.L. Desjardins, CDA, Plant Research Inst., Ottawa and M. Johnson, Cornell University

MECHANICAL BALANCE - ELECTRICAL READOUT WEIGHING LYSIMETER — 15 min.
E.I. Mukammal, G.H. McKay and V.R. Turner, Canadian Meteorological Service, Toronto

THERMISTOR-BASED AVERAGING THERMOMETERS WITH DIGITAL OUTPUTS — 15 min.
A. Bootsma and T.J. Gillespie, University of Guelph

INSTRUMENTS FOR TURBULENCE MEASUREMENTS NEAR A WATER SURFACE — 15 min.
F.W. Dobson, Bedford Institute, Dartmouth, N.S.

Session TU2: The Ekman Layer — 8:30 a.m. - noon

Chairman: Prof. A. Davenport

THEORY OF THE WIND PROFILE UP TO 100-M HEIGHT — 15 min.
A.K. Blackadar and H.A. Panofsky, The Pennsylvania State University

THE GEOSTROPHIC DRAG COEFFICIENT OVER HETEROGENEOUS TERRAIN — 15 min.
F. Fiedler, Munich and H.A. Panofsky, The Pennsylvania State University

GEOSTROPHIC DRAG, HEAT AND MASS TRANSFER COEFFICIENTS FOR THE DIABATIC EKMAN LAYER — 15 min.
G.T. Csanady, University of Waterloo

Coffee (9:40 - 10:10)

LABORATORY SIMULATION OF NATURAL CONVECTION INTO A LAYER OF NEUTRAL STABILITY — 15 min.
D.R. Hay, University of Western Ontario

AIRCRAFT MEASUREMENT OF TURBULENT FLUXES — 15 min.
M. Miyake, University of British Columbia

THE MICROSTRUCTURE OF DRY COLD FRONTS — 15 min.
H.C. Martin, Canadian Meteorological Service, Toronto

ON THE VERTICAL STRUCTURE OF EDDIES — 15 min.
O. Johnson, K. Kembry and J.A. McCallum, Suffield Experimental Station

TUESDAY AFTERNOON MAY 11, 1971 — 1:30 - 5:00 p.m.

Session TU3: Invited Lecture

Chairman: Dr. W.L. Godson

GARP AND SMALL-SCALE METEOROLOGY — 45 min.
R.W. Stewart, University of British Columbia

Coffee (2:30 - 3:00)

Session TU4: Turbulence and Fluxes

Chairman: Dr. W.L. Godson

Invited Discussant: Dr. W. Swinbank, NCAR, Colorado

TURBULENT TRANSFER MECHANISMS: A TIME-DOMAIN ANALYSIS — 15 min.
G.A. McBean, Canadian Meteorological Service, Toronto

WIND STRESS OVER ICE AND OVER WATER IN THE BEAUFORT SEA — 15 min.
S.D. Smith, Bedford Institute, Dartmouth, N.S.

MICROSTRUCTURE TURBULENCE AND KOLMOGOROFF CONSTANTS — 15 min.
R.W. Burling, University of British Columbia

CHARACTERISTICS OF TEMPERATURE FLUCTUATIONS AT 1 AND 2 METERS — 15 min.
E. Ryzner and D.J. Portman, University of Michigan

THE USSR INTER-COMPARISON EXPERIMENT — 15 min.
J. McDonald and M. Miyake, University of British Columbia

Session TU5: Instruments - 2 — 3:00 - 5:00 p.m.

Chairman: R. Vockeroth

MEASUREMENTS OF EVAPOTRANSPIRATION FROM A DOUGLAS FIR FOREST — 15 min.
T.A. Black and K.G. McNaughton, University of British Columbia

A NEW SUNSHINE DETECTOR — 15 min.
J. Cook, Canadian Meteorological Service, Toronto

A SOUNDING SYSTEM FOR URBAN PROFILES — 15 min.
J. Markes, H.E. Turner and M.S. Hirt, Canadian Meteorological Service, Toronto

SECOND GENERATION SENSORS FOR REMOTE AUTOMATIC WEATHER STATIONS — 15 min.
J. Whiting, Saskatchewan Research Council

A REVIEW OF CANADIAN METEOROLOGICAL SERVICE INVESTIGATIONS INTO MEASUREMENT OF PRECIPITATION — 15 min.
D.J. McKay, Canadian Meteorological Service, Toronto

FIFTH ANNUAL CONGRESS

May 12 - 14

Joint Wednesday Sessions with the
Second Canadian Conference on Micrometeorology
on
METEOROLOGY AND THE CITY

WEDNESDAY MORNING MAY 12, 1971 — 9:00 a.m. - noon

Opening Welcome: D.N. McMullen, President, Canadian Meteorological Society — 5 min.

Session W1: Urban Meteorology

Chairman: M.K. Thomas

THE URBAN AREA AS TARGET FOR METEOROLOGICAL RESEARCH (Invited Paper) — 30 min.
H.E. Landsberg, University of Maryland

NOCTURNAL TEMPERATURES IN EDMONTON — 15 min.
K.D. Hage, University of Alberta

CHALEUR URBAINE A MONTREAL — 15 min.
C. East, Université de Montréal

Coffee (10:20 - 10:50)

COMPARISON OF URBAN/RURAL ATMOSPHERIC COUNTER RADIATION — 30 min.
T.R. Oke, University of British Columbia
R.F. Fuggle, McGill University

SIMULATION OF THE NEUTRALLY STRATIFIED URBAN WIND IN CONVENTIONAL WIND TUNNELS — 15 min.
N.M. Standen and R.J. Templin, National Research Council, Ottawa

WIND STRUCTURE IN CITIES — 15 min.
A.G. Davenport, M. Hogan, N. Isyumov and T. Jandali, University of Western Ontario

WEDNESDAY AFTERNOON MAY 12, 1971 1:30 - 4.45 p.m.

Session W2: Human Responses

Chairman: J.L. Knox

WINTER CLOTHING REQUIREMENTS FOR CANADA 15 min.
A. Auliciems and F.K. Hare, University of Toronto

INDICES OF WIND CHILL OF CLOTHED PERSONS 15 min.
R.G. Steadman, University of Manitoba

VARIATION OF THE SKIN TEMPERATURE UNDER THE INFLUENCE OF FLUCTUATING WIND IN A COLD ENVIRONMENT 15 min.
F.H. Fanaki, Canadian Meteorological Service, Toronto

PERCEPTION OF LOCAL CLIMATE IN THE URBAN AREA OF ABERDEEN, SCOTLAND 15 min.
G.R. McBoyle, University of Waterloo

Coffee (3:00 - 3:30)

Session W3: Urban Air Pollution

Chairman: J.L. Knox

A SIMULATION MODEL FOR AIR POLLUTION OVER TORONTO 15 min.
N.E. Bowne, T.R.C. Hartford, Conn., D.G. Cooper, H.H. Angus and Assoc. Ltd., Toronto, L. Shenfeld and A.E. Boyer, Ontario Dept. of Energy and Resources Management, Toronto

TIME-LAPSE PHOTOGRAPHY FOR THE STUDY OF AIR POLLUTION KINETICS OVER AN URBAN AREA 15 min.
J. Havlena and M.F. Mohtadi, University of Calgary

BLOWIN' IN THE WIND 15 min.
P.J. Barry, A.E.C.L., Chalk River, Ontario

THURSDAY MORNING MAY 13, 1971 — 8:30 a.m. - noon

Session TH1: Numerical Weather Prediction I

Chairman: Dr. André Robert

THE CURRENT STATUS OF WEATHER FORECASTING BY NUMERICAL METHODS (Invited Paper) — 20 min.
A. Robert, Canadian Meteorological Service, Montreal

A PROGRESS REPORT ON PRECIPITATION FORECASTING — 30 min.
D. Davies, Canadian Meteorological Service, Montreal

TRUNCATION ERROR IN A SPECTRAL MODEL — 25 min.
P.E. Merilees, McGill University

Coffee (10:00 - 10:30)

EXPERIMENTS WITH A PRIMITIVE EQUATIONS MODEL — 25 min.
M.B. Danard, University of Waterloo

HORIZONTAL TRUNCATION ERRORS — 30 min.
C. Chouinard, McGill University

QUANTITATIVE EVALUATION OF INITIALIZATION PROCEDURES — 20 min.
R. Asselin, Canadian Meteorological Service, Montreal

THURSDAY AFTERNOON MAY 13, 1971 — 1:30 - 5:00 p.m.

Session TH2: Numerical Weather Prediction II

Chairman: Dr. André Robert

ASSIMILATION OF GEOPOTENTIAL BY A PRIMITIVE EQUATIONS MODEL — 20 min.
I.D. Rutherford and R. Asselin, Canadian Meteorological Service, Montreal

TIME-DEPENDENT BOUNDARIES IN A BAROCLINIC PREDICTION MODEL — 25 min.
W.S. Creswick and M.P. Olson, Canadian Meteorological Service, Montreal

U.S. AIR FORCE GLOBAL WEATHER CENTRAL BOUNDARY-LAYER MODEL — 30 min.
A.L. Friend, U.S. Air Force, Offutt AFB, Nebraska

Coffee (3:00 - 3:30)

SOME OPERATIONAL DIAGNOSTIC FIELDS FOR THE BOUNDARY LAYER — 25 min.
M.W. Balshaw, Canadian Meteorological Service, Winnipeg

NON-LINEAR INTERACTIONS BETWEEN WAVE FIELDS AND NON-WAVE FIELDS — 25 min.
M. Shabbar, Canadian Meteorological Service, Toronto

SOME RESULTS OF THE PREDICTIVE DECOMPOSITION OF ATMOSPHERIC TURBULENCE — 25 min.
B.R. Kerman, The Pennsylvania State University

THURSDAY AFTERNOON MAY 13, 1971 — 1:30 - 5:00 p.m.

Session TH3: Radiation

Chairman: Father C. East

LIDAR PROBING OF THE ATMOSPHERE — 20 min.
A.I. Carswell, A.K. McQuillan and R. McNeil, York University

LABORATORY MEASUREMENTS OF LIGHT SCATTERING BY AEROSOLS — 20 min.
R.G. Quiney and A.I. Carswell, York University

ON THE INTER-RELATIONSHIP BETWEEN NET RADIATION, SOIL MOISTURE AND EVAPORATION — 20 min.
B. Padmanabhamurty, Canadian Meteorological Service, Toronto

EVALUATING AND MAPPING SURFACE VARIATIONS IN GLOBAL RADIATION — 20 min.
B.J. Garnier, McGill University

Coffee (3:10 - 3:40)

A METHOD AND EXAMPLE OF ESTIMATING EFFECTIVE NET RADIATION FOR A MOUNTAINOUS WATERSHED — 20 min.
D. Storr, Canadian Meteorological Service, Calgary

TOPOGRAPHIC VARIATION OF FOREST CANOPY TEMPERATURE AS MEASURED BY AN AIRBORNE RADIATION THERMOMETER — 20 min.
R.B.B. Dickison and D.O. Greenbank, University of New Brunswick

ON THE VARIATION OF ANGLES OF INCIDENCE AND PHASE VELOCITIES OF ANOMALOUS SOUND WAVES — 20 min.
E.R. Reinelt, University of Alberta, Edmonton

FRIDAY MORNING MAY 14, 1971 — 8:30 a.m. - noon

Session F1: Hail and Fog

Chairman: Professor Walter Hitschfeld

ALBERTA HAIL STUDIES IN THE FIELD AND AT MCGILL UNIVERSITY (Invited Paper) — 30 min.
W. Hitschfeld, McGill University

HAILSTORM FORECASTING FOR PROJECT HAILSTOP — 20 min.
A.J. Chisholm, Canadian Meteorological Service, Toronto

PROJECT HAILSTOP 1970 — 25 min.
Peter W. Summers, Research Council of Alberta

Coffee (10:00 - 10:30)

THE LARGE MONTREAL HAILSTORM OF 1 AUGUST 1969 — 20 min.
Marianne English and Charles Warner, McGill University

THE EDMONTON HAILSTORM OF 4 AUGUST 1969 — 20 min.
Len N. Rogers and Peter W. Summers, Research Council of Alberta

SUMMARY OF THE 1970 FOG DISPERSAL PROGRAM AT VANCOUVER INTERNATIONAL AIRPORT — 20 min.
W.C. Thompson, Canadian Meteorological Service, Vancouver

URBAN GROWTH EFFECTS ON LOW-TEMPERATURE FOG IN EDMONTON — 20 min.
K.D. Hage, University of Alberta, Edmonton

FRIDAY AFTERNOON MAY 14, 1971 — 1:30 - 5:00 p.m.

Session F2: Hail and Cloud Physics

Chairman: Professor Roland List

MESOSCALE RAIN AND HAILFALL PATTERNS IN SEVERE CONVECTIVE STORMS — 20 min.
Peter W. Summers, Research Council of Alberta

RADAR MAXIMUM REFLECTIVITY PROFILES OF CELLS IN A PERSISTENT MULTI-CELLULAR ALBERTA HAILSTORM — 20 min.
James H. Renick, Research Council of Alberta

AIR BUBBLES IN HAILSTONES — 20 min.
Roland List, William A. Murray and Carole L. Dyck, University of Toronto

THE DETECTION OF SILVER IODIDE PARTICLES IN HAIL — 20 min.
Len N. Rogers, Research Council of Alberta

Coffee (3:10 - 3:40)

FREEZING OF WATER DROPS AT TERMINAL VELOCITY — 20 min.
W.A. Murray and R. List, University of Toronto

ELECTRIFICATION ASSOCIATED WITH SPLASHING OF SUPER-COOLED DROPLETS ON ICE — 20 min.
H.G. Hengeveld, P.Y.T. Louie and J.V. Iribarne, University of Toronto

INFLUENCE OF INITIAL CHARGES AND EXTERNAL FIELDS ON SPLASHING ELECTRIFICATION — 20 min.
J.B. Maxwell and J.V. Iribarne, University of Toronto

FRIDAY AFTERNOON MAY 14, 1971 — 1:30 - 5:00 p.m.

Session F3: General Meteorology

Chairman: R. Fichaud

AN APPROACH TO THE MAPPING OF GRADIENT-LEVEL WINDS OVER CANADA — 20 min.
A.G. Davenport and C. Baynes, University of Western Ontario

ON THE SATURATION VAPOUR PRESSURE OF WATER — 20 min.
J.M. Richards, University of Waterloo

THE ECONOMIC EVALUATION OF METEOROLOGICAL INFORMATION FOR SNOW CLEARING IN MONTREAL — 20 min.
A. Dasgupta, M. Inagaki, Sir George Williams University,
R. Robinson, Canadian Meteorological Service, Montreal

AN OPERATIONAL METHOD OF TOTAL INSTABILITY ANALYSIS AND FORECASTING — 20 min.
W.S. Harley, Canadian Meteorological Service, Toronto

Coffee (3:10 - 3:40)

THE PASSAGE OF A LAKE-BREEZE-FRONT - A COMPARISON BETWEEN THE CITY AND THE SUBURBS — 20 min.
M.S. Hirt and R.W. Shaw, Canadian Meteorological Service, Toronto

HORIZONTAL TEMPERATURE FIELD - GREATER VANCOUVER, B.C. — 20 min.
J.H. Emslie, Canadian Meteorological Service, Vancouver

AN INTERESTING ARCTIC STORM — 20 min.
H.P. Wilson, Canadian Meteorological Service, Edmonton

ABSTRACTS

SESSION M1: Agriculture and Forestry

CONVECTIVE HEAT TRANSFER MEASUREMENTS OF PLANTS IN A WIND TUNNEL

A. Kumar and N. Barthakur

Heat transfer was studied between intact leaves of various sizes and shapes in vivo under free and forced air condictions. Use of a wind tunnel and a microwave transmitter to heat the leaves facilitated measurements of convective, along with radiative and evaporative, heat losses from plant leaves. Knowledge of input energy, analysis of cooling curves, and established formulae, respectively, formed the bais of the steady-state, unsteady-state, and analytical methods for the determination of heat transfer coefficients.

Typical values of steady-state free convection coefficients for Peperomia Obtusifolia varied from 1.5×10^{-4} to 1.9×10^{-4} cal cm^{-2} sec^{-1} C^{-1} as the temperature difference was increased from 5.9 to 9.6C, while the forced convection coefficient was found to be 4.2×10^{-4} cal cm^{-2} sec^{-1} C^{-1} at 122 cm sec^{-1} wind velocity. For egg-plant, this value was about 9×10^{-4} cal cm^{-2} sec^{-1} C^{-1} at 488 cm sec^{-1} wind velocity. Convection coefficients, as determined under steady-state conditions, are compared with those for the unsteady-state and analytical values for a single leaf and leaves of three different plants. In general, experimental values were found to be higher than the analytical ones.

MODEL EXPERIMENTS ON FORCED CONVECTION, HEAT AND MASS TRANSFER OF LEAVES: THE EFFECT OF FLUTTER AND LEAF SHAPE

P. Schuepp

The convective mass transfer - and by analogy, heat transfer - of various nickel-plated leaves and of cedar foliage was examined with an electrochemical method for Reynolds numbers $3 \times 10^3 < Re < 4 \times 10^4$. The leaves were mounted both rigidly and also flexibly on stems. Similar measurements were made on flat plates of various two-dimensional shapes, also mounted rigidly and flexibly in the flow, and the results are compared in order to test the validity of the commonly-used analytical expressions which represent the leaf by a flat plate and which assume the effect of flutter to be negligible.

The results, extrapolated for the transfer in air, show good agreement between calculated and measured results only for the rigidly-mounted flat plates. The flutter of plates on flexible stems causes increases in transfer of the order of 20 to 30%. Actual leaf shapes mounted flexibly in the flow show typical increases between 25 and 50%; in some cases, higher. This strongly indicates that heat transfer coefficients calculated for flat plates do not adequately represent the actual convective heat and mass transfer of leaves. The (very high) transfer coefficients measured for cedar foliage are also discussed.

HORIZONTAL FLUX DIVERGENCE OF HEAT, WATER VAPOR, AND CO_2 IN A CORN FIELD: CASE STUDIES

L. H. Allen, Jr.

Four anemometer masts were placed 15 m apart along a straight line in a field of corn. Temperature, water vapor concentration, and CO_2 concentration were measured at two of these sites, 30 m apart, at 10 levels up to a height of 6 m. Horizontal flux divergences of heat, water vapor, and CO_2 were calculated from data averaged over 30 minutes.

The energy (or mass-diffusion) equation for a fluid volume was simplified to include only two-dimensional flux terms (horizontal and vertical). Experimental data showed that the turbulent flux terms were negligible compared with the mean flux terms. Horizontal flux divergences of heat, water vapor, and CO_2 were found to be caused mainly by variations in measured wind speed from one mast to the other. Except in the case of a line source CO_2 release, horizontal flux divergences due to horizontal changes in temperature, water vapor concentration, or CO_2 concentration were negligible. Theoretical predictions based on our estimates of the errors in determining wind speed, temperature, water vapor concentration, and CO_2 concentration gave the same conclusion.

Total mass flux divergence (horizontal variations in wind speed) can be caused by slight variations in the ground level between the masts and to variations in canopy density. Accuracy and placement of anemometers (heated-thermocouple type) in the crop can influence the flux divergence calculations. Both theory and experimental data show that accurate horizontal wind speed measurements are essential in computing the horizontal flux divergence of heat, water vapor, or CO_2. This wind speed accuracy requirement, plus the need for many sensors, makes it difficult to evaluate flux divergences in such studies as the heating of orchards for frost protection or releasing CO_2 from a line source.

AVERAGE BOWEN-RATIO METHODS OF CALCULATING EVAPOTRANSPIRATION APPLIED TO A DOUGLAS FIR FOREST

T.A. Black and K.G. McNaughton

Forest hydrologists speculate about the influence of the surface organic soil layer of the forest on the amount and timing of water yield, especially where this layer may be several inches thick, as in the cool, humid forests of the west coast of British Columbia. To determine the water balance components of the forest floor, a reliable estimate of evaporation is required.

The energy balance/Bowen ratio technique was chosen because the net radiation flux and soil heat flux can be measured relatively accurately, thereby putting some limits on the magnitude of the evaporative flux. As an independent check, the evaporative flux was measured with a simple lysimeter having a resolution of 0.003 mm of water.

The study site was located within an 11-year old Douglas fir plantation having no understory vegetation. A linear net radiometer and 4 heat flux plates connected in series measured net radiation flux and soil heat flux, respectively. The Bowen ratio apparatus measured wet and dry bulb temperature differences over 90 cm with shielded and aspirated thermocouples.

The preliminary results showed that 3 to 5% of the net radiation flux above the canopy reached the forest floor. The dry bulb gradient 50 cm above the forest floor ranged from 0.02C cm^{-1} at night to 1.2C cm^{-1} during the day. The daily vapour pressure gradient was between -0.05 and -2.2 mb m^{-1}. The Richardson number was estimated to be larger than 0.5, indicating extremely stable conditions. On the other hand, smoke studies showed that there was some turbulence. The possibility of advection is not discarded but calculations indicate that it was small compared to vertical energy fluxes.

The energy budget/Bowen ratio estimates of evaporation for 24 hours were approximately 70% higher than lysimeter measurements, while the latter were 20% higher than the evaporation calculated from net radiation flux minus soil heat flux. This indicates that, under prevalent conditions, the similarity assumption used in the Bowen ratio method was not valid.

It is concluded that the energy budget/Bowen ratio approach has

serious limitations for use under the canopy. The eddy correlation measurement of the sensible heat flux component of the energy budget is suggested as an alternative to the Bowen ratio method.

COMPARISON OF PINE FOREST EVAPOTRANSPIRATION ESTIMATED BY ENERGY BUDGET, AERODYNAMIC AND PRIESTLEY METHODS

E.I. Mukammal

Evapotranspiration of a uniform heterogeneous pine forest was estimated using the energy budget, aerodynamic and Priestley methods. The latter two techniques, although quite different in approach, gave similar results, the Priestley method yielding values about 7% higher than the aerodynamic method. The energy budget estimate derived from net radiation and temperature and humidity gradients above the canopy (Eb 1) gave values greater than the aerodynamic and Priestley methods by about 22% and 15%, respectively. When separate energy budgets were obtained for the canopy and below the canopy their sum was about 17% greater than Eb 1. This difference is attributed to horizontal advection below the canopy.

The Bowen ratio was found to vary with intensity of net radiation, being about 0.9 when the net energy was about 50 cal/cm^{2}hr, and decreasing to an average of about 0.3 when it was about 15 cal/cm^{2}hr. There was also evidence that the Bowen ratio varied with wind speed when net energy was relatively low, being lower with relatively strong and higher with relatively weak wind speeds. Zero displacements ranged from 16.7 m to 15.2 m, and the roughness parameter from 1.5 m to 1.9 m. The former varied with upwind homogeneity of topographical features and of the forest, but not with wind speed. On the average, conditions at night were found to favour the continuation of evapotranspiration. The accuracy of measurement, method of measurement, and handling of data are also discussed.

AN EXTENDED BOWEN-RATIO PROFILE METHOD FOR THE CALCULATION OF ENERGY FLUX DENSITIES ABOVE VEGETATION

T.R. Sinclair, L.H. Allen, Jr., and E.R. Lemon

An extended Bowen-ratio profile method for calculating total carbon dioxide, latent heat, and sensible heat flux densities above vegetation is proposed. Temperature, water vapor, and CO_2 concentrations were measured at several heights in the aerodynamic boundary layer above a corn crop. The ratio of sensible heat flux density to carbon dioxide flux density (α) as well as the Bowen ratio (β), were used in our computations. The height variable was eliminated by plotting temperature vs. CO_2 concentration and temperature vs. water vapor concentration. The two ratios, α and β, were determined graphically from the slopes of the two plots. Each of the energy flux densities were computed as a function of the two ratios and net radiation minus soil heat flux density.

An error analysis was performed on this extended Bowen-ratio profile method to evaluate the accuracy of the flux density estimates. Less than 10% error was found for latent heat flux density and less than 15% for carbon dioxide flux density under normal midday conditions for the instrumentation used. However, the carbon dioxide flux density error increased substantially (up to 40%) when the sensible heat flux was small. Nevertheless, the extended Bowen-ratio profile method was found to be inherently more accurate than the standard energy balance method for calculating total crop flux densities.

SESSION M2: Climatonomy

CLIMATONOMY

H.H. Lettau

Abstract not available.

SESSION M3: Air Pollution

ANALYSIS OF DOWNWIND DEPOSITION OF DRIFTING SPRAY-CLOUD BY NEUTRON ACTIVATION AND GAMMA-RAY SPECTROMETRY

K. Yoshida, J. Maybank, H. Mizuma, and S. Iwamoto

Field trials of spray deposition were conducted under various turbulent conditions by using flat-fan nozzles and manganese sulphate solution as a tracer. The nozzle can produce droplets smaller than 200-micron diameter in at least 8% of the total volume of spray; subsequently these droplets become a drift potential for herbicide spray operations in the Prairies.

Spray deposited on targets of low ash-content filter paper was then irradiated at a thermal neutron flux of $3.5 \times 10^{13} N/cm^2/sec$ at (Pn -1); and the activity of tracer element in each sample was obtained by means of a pulse analyser and was converted into the deposition density by a comparison method.

A 10-m meteorological tower near the source, provided information for the wind and temperature profiles. Horizontal (X-Y) and vertical (Z) components of the eddy velocity were obtained by using a set of Gill-type propeller-anemometers at 1-m height.

The downwind deposition density, which was obtained, ranged from 470 to 0.1 microgram/cm^2/min, and can be empirically expressed as an exponential function of the downwind distance. The downwind deposition density increased proportionally with the horizontal component of the mean eddy velocity $\sqrt{\overline{u'^2} + \overline{v'^2}}$. The deposition density reduction factor, which is a ratio of deposition density at 10 m to that at 2.5 m, decreased proportionally with the vertical component of the mean eddy velocity $\sqrt{\overline{w'^2}}$ and with the Richardson number Ri.

The value of $\sqrt{\overline{w'^2}}$, which is related to the eddy diffusivity, appears to give an orientation to the droplet trajectory in the initial stage of the transport process and controls the distribution pattern of deposition. On the other hand the value of $\sqrt{\overline{u'^2} + \overline{v'^2}}$, with respect to the mean windspread, controls the quantity of deposition downwind. The physical properties of the spray liquid were found to influence the value of the eddy diffusivity.

The results provide information required for a realistic assessment of the threshhold level of the deposition from drifting herbicidal spray in the Prairies.

CROSS-WIND SHEAR EFFECTS ON ATMOSPHERIC DIFFUSION

G.T. Csanady

Some experimental data on atmospheric diffusion over a "medium" distance range (order 30 km) have been analyzed in an attempt to discover any effects on lateral spread attributable to the skewed wind profile of the planetary boundary layer. The observations analyzed were obtained over "natural" terrain (containing woodlots and villages) in Arkansas. Wind shear effects on diffusion were considered "significant" when the cloud decisively outgrew the size predicted by the Hay-Pasquill technique from fixed-point cross-wind velocity fluctuations. Such "significant" effects were found only on a few occasions, associated with quite extreme rates of cross-wind shear, accompanied by strong stability.

A TURBULENT DISPERSION COMPUTATION

G.B. Frame and R.D. Rowe

Turbulent dispersion from single and multiple sources, such as urban areas and industrial stacks, is currently under investigation at the Department of Chemical Engineering, University of Calgary. The phenomena of turbulence have been represented by many different mathematical methods with varying degrees of sophistication. The turbulent field methods, as summarised by W.C. Reynolds at the recent Amer. Instit. Chem. Eng. workshop, offer some expectation for modelling the atmospheric boundary layer containing the above-mentioned sources of heat and pollution. In this paper one such method, developed by Harlow of the Los Alamos Group and others, known as "Mean Turbulent Energy Closure" (MTE) is used.

The case of the turbulent jet in an infinite fluid has been studied so far. Numerical results are presented for various quantities including the mean velocity distribution. These results indicate that the MTE method adequately represents the momentum plume and can therefore be used to predict dispersion from jets.

(The buoyant plume is now being investigated and some preliminary results for this case may also be available in time for the Conference).

BUOYANT MOIST BENT-OVER VAPOUR PLUMES AT A PILOT STACK FACILITY

P.R. Slawson

Dry buoyant plume-rise theory has been extended to moist plumes for the prediction of the condensation and reevaporation points. Also, a simplified formula for predicting condensed plume lengths is developed. Observations on condensation and condensed plume lengths from a pilot stack facility compare favourably with those predicted.

TURBULENCE STATISTICS AT 16, 48 AND 92 METRES AT DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

O. Johnson and B.R. Larson

For a number of years, measurements of the three components of turbulence have been made at three levels on the DRES tower in a variety of stability conditions. Most of these were made during summer and fall, but a few measurements were made during one winter. Mean values of the standard deviations of the azimuth and elevation angles are given for various wind and stability conditions and also as a function of height. The results are discussed in relation to practical systems which have been suggested for estimating downwind diffusion.

SESSION M4: Heat and Water Budgets of Small Lakes

AN INTRODUCTION TO THE PERCH LAKE STUDY

P.J. Barry

Abstract not available.

A COMPARISON OF EVAPORATION ESTIMATE METHODS AT PERCH LAKE

H.L. Ferguson

Among the methods being used to estimate evaporation from Perch Lake are the Penman Method, various mass-transfer equations and Class A Pan measurements. A correlation analysis has been carried out using three years of data, on a time-scale ranging from a day to a month. The Penman Method was found to have a relatively high correlation with lake evaporation estimated from pan measurements on the downwind side of the lake, the daily correlation coefficient being 0.87. This high value is attributed in part to the fact that net radiation, used in the Penman Equation, is measured over the water surface rather than a standard grass surface. Analysis and intercomparison of wind and pan evaporation data between upwind and downwind sides of the lake reveal large differences. For example daily lake evaporation estimated from pan measurements on the downwind side averages 14% higher than that obtained on the upwind side, about 3000 ft away.

THE DETERMINATION OF THE HEAT CONTENT OF PERCH LAKE

R.J. Polavarapu

Lake temperatures from June to September 1969 were measured hourly at 12 levels right from the air-water interface down to a depth of 8 ft including 2 ft within the soil of the lake bed. From these measurements the hourly changes in heat content of the lake were determined in order to estimate the evaporative flux from the measurements of net radiation and Bowen ratio. An attempt was made to estimate the time derivative of heat content from measurements of the net radiative flux, surface wind speed and air-water temperature gradient.

The diurnal and seasonal changes in the heat content of the lake are discussed. The net radiative flux is mostly expended to increase the heat content of the lake rapidly in the spring and to evaporate the water in the fall.

The water temperature profile is parabolic during clear nights when the net radiation at the surface is negative; the temperature is higher in the middle layers and drops in value toward both the air-water interface and the soil-water interface. During clear days the temperature is higher at the surface and decreases with depth until very close to the lake bottom thus forming a stable stratification. The water temperature very close to the soil-water interface is slightly higher than that for the water above, indicating that a portion of the visible radiation is still reaching the lake bottom to heat the soil surface. During cloudy days the temperature profile is either parabolic or nearly isothermal.

THEORETICAL ASPECTS OF THE EVAPORATION OF TRITIATED WATER FROM PERCH LAKE

W.N. Selander

The concentration v of vapour over a lake satisfies approximately a mass transfer equation of the form

$$u(z)\,\partial v/\partial x = \partial/\partial x\,(K(z)\,\partial v/\partial z)$$

where u (z) and K (z) are, respectively, the wind speed and eddy diffusivity associated with turbulent conditions. The coordinates z and x are measured in the vertical and downwind directions, respectively. Lateral or cross-wind variations as well as diffusion in the x-direction, are

ignored. Under appropriate assumptions, K (z) can be expressed in terms of u (z), which can in turn be measured. Under many conditions, the wind profile is proportional to z^m, where the exponent m varies from one set of conditions to another.

Perch Lake contains a small concentration of tritiated water (HTO, where T is a radioactive isotope of hydrogen), which evaporates with the lake water. Because it is radioactive its concentration in the air above the lake can be measured accurately. Wind speed and tritium concentration have been measured on the down-wind side of the lake during a variety of wind and weather conditions, as a function of elevation. These observations permit a check on theory.

The agreement between theory and observation depends critically on the model used to describe the wind profile. The simplest assumptions predict concentrations which are consistently too high at low elevations and too low at higher elevations. The agreement between theory and experiment can be improved considerably by varying the wind profile exponent m and by varying the length of fetch which for a small lake is critically dependent on wind direction.

The implications of this analysis for further experimental studies are discussed.

THE HEAT AND WATER BUDGETS OF A BEAVER POND

E. Vowinckel and Svenn Orvig

Small water bodies create their own characteristic local meteorological environments. Generally, the heat and water budgets will vary with surface area and water depth. If a small pond gradually becomes covered by vegetation, its meteorological conditions will change. On occasion, a vegetated area may be turned into pond, complete with the established vegetation in water and extending above the surface. Such are beaver ponds and other flooded areas.

The paper discusses the main features of the development of beaver ponds and their heat and water budgets at different stages. The energy budget procedures used were previously developed by the authors, but were modified to account for the different phases of the pond development. The effects of the various physical changes are evaluated by comparing the individual heat and water budget terms for the stages from an open lake surface, through different degrees of progression in the development of a vegetated pond, to a forest cover.

SESSION TU1: Instruments - 1

THE DEVELOPMENT OF ACCURATE WIND-MEASURING INSTRUMENTS FOR THE RESEARCH METEOROLOGIST

Gerald C. Gill

During the past twenty years the writer has employed and developed a number of mechanical and electrical wind speed and direction sensors for the accurate measurement of the wind near the ground. He has used anemometers of the hot-wire, 3-cup and propeller types; wind vanes of the flat plate, splayed, and aerodynamic shapes; anemometer transducers of the D.C. tachometer, light-chopper and gear-reducer-potentiometer types; and, wind vane transducers of the D.C. selsyn, A.C. selsyn and potentiometer types. He has developed light weight fragile "fair-weather" bivanes; "all-weather" anemometer bivanes; vertical flow anemometers and a triaxial U V W anemometer. The merits and limitations of most of these sensors or systems will be briefly discussed or demonstrated.

For highest fidelity measurement of the three components of wind speed at a tower location the writer suggests the use of two adjacent sensors - a "propeller vane" to measure the horizontal component of the wind speed and the corresponding azimuth angle of the wind; and an adjacent vertical-shaft propeller anemometer to measure the vertical component of the wind speed. Identical light weight expanded polystyrene propellers of true helicoidal shape, each driving miniature precision direct current tachometers, are normally used for the two-speed sensors. A light-weight expanded polystyrene wind vane of the flat plate style, appropriately damped, and driving a precision low torque potentiometer is used for azimuth wind direction measurements. Recording can be on three channels of a magnetic tape or other suitable recorder. Fidelity of recording is good for wind speeds in the range 1 - 25 m sec^{-1} and for gusts of 10 meters or longer in wavelength. The starting speed of the propeller anemometers is usually 0.2 to 0.3 m sec^{-1}.

A PROPELLER-TYPE WIND SENSOR

D. Champ

A relatively simple flat-bladed propeller was designed for wind profile measurements in the International Field Year on the Great Lakes. At speeds more than double the starting speed, it displays a cosine response within 5% of wind speed, linearity within 0.5%, a sensitivity of 0.95 m per revolution and an incremental distance constant of 2.1 m. Its starting speed is about 0.3 m/sec. The sensor principle could be adapted to special anemometers for micrometeorological use by producing a lighter, less rugged, model.

Since its cosine error is quasi-symmetrical about 45°, simple computer calculations will resolve the wind vector with speed inaccuracies less than 2.5% and angular inaccuracies less than 3° at speeds greater than 2.5 m sec^{-1}.

In the transducer, form A reed switch closures are fed to C/MOS integrated circuitry for propeller direction determination and wind component accumulation. The C/MOS logic allows operation at low power (microwatts) over a wide temperature range (-40 to 85C).

A "DAMPED" WIND DIRECTION DIGITIZER

J.S. Dickson

A Wind Direction Digitizer that has a voltage controlled slewing rate is described, the voltage being selected to meet the user's requirements. Digital and voltage outputs of the instantaneous difference between the lagged position and the vane position are also available, permitting measurements of the wind direction variation about a slowly varying mean value to be recorded.

A GAS EXCHANGE METER BASED ON THE EDDY CORRELATION TECHNIQUE

R.L. Desjardins and M. Johnson

A newly developed sampling system for measuring fluxes of gases will be described. The operation of this system is based on the eddy correlation technique. Air is sucked into special bags at a rate proportional to the vertical wind speed. This gives integrated values of the flux of any gas. Water vapor and carbon dioxide fluxes above a corn crop at Ithaca, New York, during the summer of 1970 will be discussed. The results will be compared with the Bowen ratio approach for a few special cases. An extensive discussion of errors will be presented.

Applications of this system to air pollution studies on a national scale will also be discussed.

MECHANICAL BALANCE - ELECTRICAL READOUT WEIGHING LYSIMETER

E.I. Mukammal, G.H. McKay and V.R. Turner

As part of the research programme of the Canadian Meteorological Service a large, sensitive, weighing lysimeter has been constructed north of Toronto on the research site of the Canadian Meteorological Service. Features of the instrument include: measurement of runoff; free water drainage; drainage for water held by tension; addition of water from below during dry conditions; equalization of soil temperature profile inside with that outside the lysimeter; humidity control to eliminate condensation; low area of discontinuity at the rim to reduce the edge effect; and semi-monolith filling. This paper describes the construction and installation of the lysimeter, problems encountered and some infrequently considered sources of error.

THERMISTOR-BASED AVERAGING THERMOMETERS WITH DIGITAL OUTPUTS

A. Bootsma and T.J. Gillespie

Thermistor-based instruments have been built which produce, for any desired averaging period, a single number representing the average temperature during that period. A small volume of data is thus obtained even for observations over lengthy periods of time.

An inexpensive, battery-operated averaging thermometer was first developed for use in orchards as a guide for scheduling spray programs to control apple scab. For this and many other temperature measurements in the air there is no need for shielding and aspirating because very tiny thermistors can be used. The same simple circuit has also been used to monitor soil temperatures. A more complex thermistor bridge device was later built for an air temperature application requiring greater accuracy. Both circuits produce pulses at a rate proportional to temperature with the more complex device having a linear calibration. Electromechanical or electronic counters were used to log the data in digital form.

INSTRUMENTS FOR TURBULENCE MEASUREMENTS NEAR THE WATER SURFACE

F.W. Dobson

Results from field tests of a hydraulic wave-following device designed and constructed at Chesapeake Bay Institute have been analysed using spectral techniques. The analyses show the device to be suitable for maintaining turbulence sensors at small fixed distances above the surface of wind-driven waves. The uses of such a device for air-sea interaction studies are discussed.

SESSION TU2: The Ekman Layer

THEORY OF THE WIND PROFILE UP TO 100-m HEIGHT

A.K. Blackadar and H.A. Panofsky

Under the assumption that the turning of the wind with height can be neglected up to about 100 m height, a log-linear wind profile is derived for neutral conditions. The vertical variation of stress and mixing length are obtained from earlier Ekman layer theories.

The results show that corrections to the logarithmic profile must be taken into account when stress and roughness length are determined from winds observed above 15 m. Generalizations to unstable air are discussed, along with practical methods to determine roughness lengths and surface stress from tower profiles over homogeneous terrain.

THE GEOSTROPHIC DRAG COEFFICIENT OVER HETEROGENEOUS TERRAIN

F. Fiedler and H.A. Panofsky

The geostrophic drag coefficient and contour wind-angle are functions of surface Rossby number and a stability parameter. Over heterogeneous terrain, the Rossby number is expressed in terms of an "effective" roughness length which gives the correct surface stress under the same large-scale conditions if the ground were homogeneous. Typical effective roughness lengths are evaluated from vertical-velocity variances observed in the Lo-Lo-Cat project.

In order to allow for stability, an empirical diagram is developed for geostrophic drag coefficient in terms of both surface Rossby number and insolation.

GEOSTROPHIC DRAG, HEAT AND MASS TRANSFER COEFFICIENTS FOR THE DIABATIC EKMAN LAYER

G.T. Csanady

The "asymptotic matching" principle has been applied to the equilibrium Ekman Layer with vertical heat flux. This principle requires that the properties of the "surface" or "inner" layer overlap asymptotically (at large z) with those of the "outer" layer, or rather with the asymptotic behavior of the latter as $z \rightarrow 0$. In this manner, it is possible to derive relationships for the geostrophic drag-, heat and mass transfer coefficients (i.e., relate surface fluxes to large-scale properties of the motion) without considering the detailed dynamics of the outer Ekman layer, by relying on the fairly accurately known surface layer distributions of non-dimensional velocity, temperature and humidity gradients. Such bulk transfer coefficients are presented as a function of non-dimensional parameters involving large-scale measures of the flow only.

LABORATORY SIMULATION OF NATURAL CONVECTION INTO A LAYER OF NEUTRAL STABILITY

D.R. Hay

A laboratory simulation of convection within the lowest kilometer of the troposphere has been developed at the University of Western Ontario and was described earlier by Fanaki. The present work is an extension of the earlier work towards larger surface heat fluxes flowing upwards into a region of neutral stability, in the absence of general horizontal flow. As the surface flux increases to about 8 mW cm^{-2} the observed convective plumes increase in number and in vertical penetration while each maintains constant diameter. These plumes may migrate over the lower boundary while maintaining their identity. At larger surface fluxes, the individual plumes lose their identities as the plume field degenerates. These observations are related to Telford's recently published theory of the convective plume field in the lower atmosphere.

AIRCRAFT MEASUREMENTS OF TURBULENT FLUXES

M. Miyake

By combining the information of fast response sensors of atmospheric turbulence and the motion of an aircraft, it is possible to determine the fluxes of momentum, heat and moisture from the ocean surface by use of an aircraft. A Beechcraft Queen-Air has been used off the west coast of Vancouver Island and over the tropical ocean off Barbados. The results of the flux measurements as compared to measurements from FLIP and the inferred structure of the planetary boundary layer will be discussed.

THE MICROSTRUCTURE OF DRY COLD FRONTS

H.C. Martin

On seven occasions when dry cold fronts passed over a coastal site, the fine structures of temperature and horizontal wind speed were measured at a height of 14 m. On one occasion the fine structure of refractive index (essentially humidity) was also measured.

The frontal zone is very narrow and turbulent with the bulk of the change occurring within a minute. The wind freshens in the few moments before the temperature starts to drop and reaches a maximum some seconds after the temperature starts to change.

The temperature and refractive index are highly correlated over a wide range of scales. It is suggested that the steep gradients in refractive index are typical of gradients at greater heights which gave rise to the band or line echoes observed on five occasions by means of 10-cm radar.

From the microstructure records the existence of two mesoscale features was inferred: the friction head which is characteristic of flow in stratified fluids and the circulation associated with complex fronts.

ON THE VERTICAL STRUCTURE OF EDDIES

O. Johnson, K. Kembry and J.A. McCallum

To determine the slopes of eddies producing atmospheric turbulence, the relationships between the three components of turbulence for three vertically separated points on a 92-metre tower were studied by cross-spectral analysis. The analysis can be completed by utilizing the mean wind speed and the lag of maximum power, or by taking the ratio of the quadrature-spectrum and the co-spectrum - both methods are used in the present paper and the results compared. The analysis is given for nine trials performed in a variety of stability conditions. It is found that the slopes of longitudinal eddies are less than half the slopes of the lateral eddies for all stabilities. In near neutral conditions the slope is found to be a function of mean wind shear. The coherence as a function of the normalized frequency is also investigated.

SESSION TU3:

GARP AND SMALL-SCALE METEOROLOGY

R.W. Stewart

Abstract not available.

SESSION TU4: Turbulence and Fluxes

TURBULENT TRANSFER MECHANISMS: A TIME-DOMAIN ANALYSIS

G.A. McBean

Direct measurements of the turbulent fluxes of momentum, heat, and moisture were made in the atmospheric surface layer. These data were previously examined in the frequency domain by the author in order to investigate and to compare the turbulent transfer mechanisms of the three fluxes. In this paper the results of the analyses in the time domain will be presented. Single and joint probability density distributions of the turbulent variables were computed for a range of atmospheric stability conditions. The interpretation of these results, as they apply to the turbulent transfer mechanisms, will be compared with the earlier results based on spectral analysis.

WIND STRESS OVER ICE AND OVER WATER IN THE BEAUFORT SEA

S.D. Smith

A sonic anemometer-thermometer has been used in a preliminary study of Reynolds stress, sensible heat flux, and velocity and temperature spectra over ice (3 runs) and over water (2 runs) in the Beaufort Sea. The wind drag coefficient C_{10} is 0.0025 over ice (stable conditions) and 0.0014 over water (unstable).

MICROSTRUCTURE TURBULENCE AND KOLMOGOROFF CONSTANTS

R.W. Burling

Abstract not available.

CHARACTERISTICS OF TEMPERATURE FLUCTUATIONS AT 1 AND 2 METERS

E. Ryznar and D.J. Portman

Temperature fluctuations were measured at 1 and 2 meters over a level grass field coincidently with temperature and wind profiles up to 4 meters. Measurements were made at one height for some observation periods and simultaneously at both heights for others. Intensity and spectral characteristics of the fluctuations are discussed in relation to the Richardson number for lapse and inversion conditions.

For lapse conditions, average values of the power $p = \ln(\sigma_{T_2}/\sigma_{T_1}) / \ln(Z_2/Z_1)$ in the relation $\sigma_T = AZ^p$, where σ_T is the standard deviation of temperature, A a constant, and Z the height, are shown by the results to: (1) increase gradually from about -0.15 for Ri = -0.002 to -0.05 for Ri = -0.05; (2) increase abruptly to about +0.24 between Ri = -0.05 and -0.1; and (3) gradually level off at about +0.3 for Ri = -0.2.

Aspects of the results are not in agreement with either similarity theory or the results of others. They are discussed in relation to the heights of the measurements and the formation and structure of microthermals in unstable thermal stratification.

THE USSR INTER-COMPARISON EXPERIMENT

J. McDonald and M. Miyake

During the period 15 June to 20 July 1970 an international intercomparison of turbulence equipment was held at Tsimlyansk, U.S.S.R. Groups from Australia, the United States, Canada and the U.S.S.R. participated. Synchronized measurements of fluctuations of horizontal and vertical winds, temperature, and humidity were carried out using different instruments placed near each other. Some results of this experiment will be presented and discussed.

SESSION TU5: Instruments - 2

MEASUREMENT OF EVAPOTRANSPIRATION FROM A DOUGLAS FIR FOREST

T.A. Black and K.G. McNaughton

Reliable estimates of evapotranspiration from west coast forests are required for the testing of hydrologic models and for management decisions in forested watersheds. The objectives of this study were: (1) to measure evapotranspiration from an 11-year old, 9-meter high Douglas

fir forest during the summer months when drought limits forest growth; and (2) to determine the feasibility of measuring evapotranspiration using the energy balance/Bowen ratio method continuously over an extended period of weeks.

The Sargeant-Tanner psychrometric Bowen ratio apparatus design was modified for use on a micrometeorological tower by making a sturdier frame and sensing heads, epoxy mounting the diode-thermometer elements in the sensing heads rigidly, and eliminating the influence of lead resistance in the bridge circuit. The apparatus continuously measured the differences in the wet and dry bulb temperatures over 1 meter to less than 0.01C. The Bowen ratio apparatus and a net radiometer were mounted on a 10-meter tower. Canopy heat storage was calculated from the canopy air and tree temperatures, and canopy air vapour pressures. Soil heat flux density was measured by soil heat flux plates and integrating thermometers.

The contribution of the soil heat flux and canopy heat storage rate to the total evapotranspiration over several days could be neglected. The temperature and vapour pressure gradients did not exceed -0.4C/m and -0.4 mb/m respectively. The Bowen ratio rarely exceeded 2.0 during the daytime hours. The sensible heat flux reached a maximum just prior to noon while the latent heat flux and canopy vapour pressure deficit maxima occured in mid-afternoon on clear days.

The energy balance system operated successfully over a period of six weeks continuously regardless of rain. Evapotranspiration was measured to within 20%. This data will be used in a water balance model at this site.

A NEW SUNSHINE DETECTOR

John Cook

The design and performance of a sensor whose output is directly related to the duration of bright sunshine is described. The system was designed to meet W.M.O. recommendations for a sunshine detector, compatible with automatic weather stations.

The new instrument's output is compared to the standard Campbell Stokes' record, and corresponds well with the output from the Eppley sun-tracking pyrheliometer.

The sensor appears to have potential application as a relatively inexpensive quantitative radiation sensor.

A SOUNDING SYSTEM FOR URBAN PROFILES

J. Markes, H.E. Turner and M.S. Hirt

A portable sounding system for obtaining wind and temperature profiles in an urban environment is described. The sonde is an expendable, solid-state, 403 MHz device which can be carried aloft by a standard pilot balloon. The ground receiving system is compact, light-weight and operates from a 12 volt d.c. source. Temperature is read directly from a chart recorder.

SECOND GENERATION SENSORS FOR REMOTE AUTOMATIC WEATHER STATIONS

J. Whiting

This paper surveys the sensors commercially available for use with remote recording weather stations. Tables are presented for typical models, and give the accuracies and time responses of the sensors: (a) by themselves and, (b) in actual field operation associated with specific

analogue and analogue-to-digital recorders. The importance of the choice of the sensors is shown to have dramatic effects on the quality of the data and on the representativeness of the data with respect to the actual micro-climatic history. The conclusion reached stresses the need for further research especially into the question of frequency response: is the response of the sensor to the actual oscillations of the parameter measured, either under-damped, damped, filtered, or over-damped?

A REVIEW OF CANADIAN METEOROLOGICAL SERVICE INVESTIGATIONS INTO THE MEASUREMENT OF PRECIPITATION

D.J. McKay

Investigations over the past several years have concentrated mainly on improving the accuracy and reliability of precipitation measurements made by conventional gauges. These include development of a new larger capacity ordinary or standard rain gauge and a replacement metering unit for the tipping-bucket rain gauge.

The Service has also investigated some relatively new methods of measuring winter precipitation, such as those using the heated liquid surface volumetric gauge and the snow pillow.

Some details of these new instruments are given, as well as a discussion of their limitations under operating conditions.

SESSION W1: Urban Meteorology

THE URBAN AREA AS TARGET FOR METEOROLOGICAL RESEARCH

H.E. Landsberg

Meteorological research in the recent past has placed most emphasis on large-scale atmospheric motions, storms and damaging weather patterns, synoptic scale forecasting, and applications to aviation and agriculture. With continuing concentration of population in urban areas (in western countries now 70%) greater attention than heretofore has to be focussed on the meso- and micrometeorological problems of densely settled areas, which also coincide with high concentrations of industry and road traffic. These have, for example, created pollution hazards intimately related to meteorological conditions. A considerably higher premium has also been placed on pin-pointed forecasts of snow conditions.

	Parameters under notable influence of								
			Synoptic situation			local conditions			
Surface characteristics	T	$\frac{\Delta T}{\Delta z}$	U	N	Zo/cm^3	V	q	precip.
Total urban area	2	1	2	2	2	1	2	1
Portion vegetated	1		1		1	1	2	1
Albedo	2	2						
Roughness		2	3	1				2
Combustion & other heat products	2	3	1	1	3	2	2	3

1 weak 2 moderate 3 strong interaction
T temperature, $\Delta T/\Delta z$ low-level temperature gradient, U wind speed, N cloudiness, Zo/cm^3 nuclei number, V visibility, q specific humidity, precip. amount and character of precipitation.

Adequate density of surface observations and low-level vertical soundings have become essential needs. Model formulation has lagged because of the great complexity of interaction. Much of the current research is still phenomenological. The problem can be illustrated in the form of a very simplified and schematized matrix.

Neither the columns nor the rows are independent of each other, so that various boxes are more or less highly correlated.

Some of the implications will be discussed with illustrations drawn from recent pertinent literature and experiments conducted in an area undergoing rapid urbanization.

NOCTURNAL TEMPERATURES IN EDMONTON

K.D. Hage

A network of seven thermographs has been operated continuously within the city of Edmonton since February, 1968 by Geoscience Research Associates Ltd. under contract to the Department of Health of the Government of Alberta. Data from these stations, together with hourly observations from two rural airports, and one urban airport, in the Edmonton area are inadequate for mapping the temperature field, but provide an unusual opportunity for the study of some climatological characteristics of urban temperatures over relatively flat terrain undisturbed by lake and sea influences. All thermographs are calibrated at regular intervals and supplementary calibrations are carried out using airport observations during periods of continuous precipitation. Annual variations in heat island intensity, based on analyses of two years of data, are ill-defined because of large variations in month-to-month frequencies of favourable nights. Stratified monthly samples consisting only of nights with intense heat islands appear to show weak intensity maxima in mid winter and early summer. A well-defined diurnal cycle in heat island intensity is found with a maximum before midnight in the cold season and just after midnight in the warm season. The results are discussed in relation to the development of realistic heat island models.

CHALEUR URBAINE A MONTREAL

Conrad East

Grâce à des sondages de température effectués en hélicoptère à 12 sites de l'île de Montréal, on a pu calculer la chaleur générée par la ville en 38 jours assez bien distribués à travers l'année.

Une relation linéaire inverse entre la chaleur urbaine et la température ambiante a pu être établie. Toutefois, la chaleur artificielle estimée à partir de la consommation des combustibles de l'industrie et du chauffage représente à peine 25 pourcent de la chaleur urbaine totale, telle que mesurée directement dans l'atmosphère. On discute l'hypothèse selon laquelle le reste de la chaleur urbaine devrait être attribuée au rayonnement solaire absorbé, puis réemis par les surfaces et structures de la ville.

COMPARISON OF URBAN/RURAL ATMOSPHERIC COUNTER RADIATION

T.R. Oke and R.F. Fuggle

The effect of an urban atmosphere upon the incoming longwave radiation is investigated by direct measurement. Counter radiation and air temperatures were continuously monitored during automobile traverses across the Island of Montreal at night. Results show that urban counter radiation values are consistently higher than those for rural locations, but that the magnitude of the differences is small. Comparison between

the measured radiation and that computed from empirical equations shows good agreement in rural areas, but important differences in the city. There is a correspondence between the air temperature and incoming longwave radiation profiles across the city. However, it is felt that, contrary to previous opinion, the increased counter radiation is an effect rather than a cause of the urban heat island. It is concluded that increased incoming longwave radiation in urban areas is not a major contributor to urban/rural heat balance differences.

SIMULATION OF THE NEUTRALLY STRATIFIED URBAN WIND IN CONVENTIONAL WIND TUNNELS

N.M. Standen and R.J. Templin

The Low Speed Aerodynamics Section of the National Aeronautical Establishment is currently engaged in a programme to produce scale models of urban winds in conventionally sized wind tunnels. At present, contoured, two-dimensional "spires", mounted on the tunnel floor at the entrance to the working section, are being used in the attempt to generate a shear layer approximately the height of the spires and with a mean velocity profile and turbulence characteristics similar to a neutrally stable wind over a city.

A recent test in the NAE thirty-foot tunnel at Uplands compared the characteristics of a shear layer generated by four-foot spires with those of a shear layer generated by a boundary layer growing over 3-inch cube roughness along the entire working section floor. The effects of these two shear layers on a 1/400 scale model of downtown Montreal were also compared. Quantities measured included the mean velocity profile, longitudinal turbulence intensity, Reynolds stress and longitudinal turbulence power spectral density.

WIND STRUCTURE IN CITIES

A.G. Davenport, M. Hogan, N. Isyumov and T. Jandali

The paper describes a number of wind climate studies for large cities carried out while establishing the wind loading on tall buildings. Meteorological records of both surface and upper level winds are used extensively.

In addition the use of topographic models in conjunction with the boundary-layer wind tunnel is described for the purpose of describing general airflow characteristics.

The situation in Toronto will be discussed in detail. Field data on the mean flow and turbulence will also be described and compared with wind tunnel observations.

SESSION W2: Human Responses

WINTER CLOTHING REQUIREMENTS FOR CANADA

A. Auliciems and F.K. Hare

Amounts of clothing insulation needed to maintain thermal equilibrium have been calculated from hourly observations of air temperature, wind velocity and cloud cover over a period of ten years at eighty stations. This enables the prediction of actual clothing requirements (in clo units) for a variety of activities, and provides a human classification of the country for the months of September to April.

INDICES OF WIND CHILL OF CLOTHED PERSONS

R.G. Steadman

The concept of wind chill as a measure of the combined effects of low temperature and wind is reviewed. An analysis is presented of the effect of these variables on a person dressed for cold climates and takes account of all important modes of heat loss, including breathing, and heat transfer through clothing. This analysis leads to two chief indices of wind chill: the wind-chill equivalent temperature, which is tabulated and compared with existing tables, and the clothing thickness required to maintain a person in thermal equilibrium. The distributions of clothing thickness and of the wind chill of exposed skin at 30°C are described.

VARIATION OF THE SKIN TEMPERATURE UNDER THE INFLUENCE OF FLUCTUATING WIND IN A COLD ENVIRONMENT

F.H. Fanaki

The loss of heat from a man exposed to a fluctuating wind of short and long periods is analyzed. In the analysis it is assumed that heat is lost from the body to the environment by convection, conduction, radiation and through breathing. The loss of heat by evaporation has been ignored. With this assumption the governing equation for the transfer of heat is described and is solved by the application of a Laplace transformation. The solution is expressed in terms of the amplitude and periodicity of the wind fluctuations. Numerical results are given. The results obtained serve as a guide to the degree of refinement required in determining the chill factor.

PERCEPTION OF LOCAL CLIMATE IN THE URBAN AREA OF ABERDEEN, SCOTLAND

G.R. McBoyle

The most frequented living area today is the urban scene but what is known of people's perception of climate in the urban environment is very little. In order to obtain some information on the problem a postal questionnaire was sent to 600 adults within the urban area of Aberdeen, Scotland during the summer of 1970.

The respondents' answers indicate that Aberdonians in general dislike damp conditions, excessively high and low temperatures, and consider that their city is colder and windier than the surrounding countryside. The public's opinions on the warmest and coldest areas of the city by day are very accurate when compared with scientific observations. The situation by night, however, is different with Aberdonians appearing to be unaware of such phenomena as frost hollows and night-time, urban heat islands. It is surprising that most respondents accurately named the most windy and least windy parts of the city yet 7 out of every 10 respondents considered that there was little difference in precipitation within the city even with a 600-foot amplitude of relief. Since fog is one of the main dislikes of Aberdonians its predominant areas are well known, namely, near the sea and along the valleys. At the other end of the spectrum the different slope aspects have resulted in varying amounts of sunshine in different parts of the city. This too has been translated accurately into people's minds.

Aberdonians always tend to open a conversation with a comment on the weather and it would appear from the study that they are well qualified to do so with the exception of night-time, intra-urban temperature differences.

The survey's results should be encouraging to most researchers

because they indicate that the average citizen is knowledgeable, interested and probably able to assimilate more knowledge about neteorology and climatology than we give him credit for. A follow-up study would be to ascertain if the respondents put their weather knowledge to use in every-day decisions and in weather-sensitive activities.

SESSION W3: Urban Air Pollution

A SIMULATION MODEL FOR AIR POLLUTION OVER TORONTO
N.E. Bowne, D.G. Cooper, L. Shenfeld and A.E. Boyer

The devlopment of a mathematical model to simulate the atmospheric environment over Toronto has provided a means of evaluating the relative importance of pollutant emissions, meteorological factors, and the geographic distribution of pollution sources in determining air quality.

Changes in air quality produced by atmospheric changes must be evaluated side by side with air quality changes resulting from the increased or decreased pollutant emissions.

An extensive emission inventory is described, including a review of major pollution sources.

Toronto Model predictions, based on hour-by-hour measurements of meteorological variables from a network of observation points and pollutant emissions from thousands of sources, are compared with air quality measurements from eight sampling locations. The relative importance of meteorological changes and pollutant emission changes is illustrated.

TIME-LAPSE PHOTOGRAPHY FOR THE STUDY OF AIR POLLUTION KINETICS OVER AN URBAN AREA
J. Havlena and M.F. Mohtadi

A photogrammetric technique using time-lapse cine-photography has been developed for the study of the formation and movement of pollution clouds over an urban area. Qualitative evaluation of results for the City of Calgary obtained during the summer of 1970 shows that this technique provides information on:

1) the formation of pollution clouds,
2) the movement of pollution clouds due to meteorological factors,
3) the extent of the contribution of traffic and industrial sources to pollution, and
4) certain optical properties of the pollution cloud.

The technique appears also suitable for monitoring of polluted air. Densitometric evaluation of results planned for the future will provide a basis for verification of the mathematical model of air pollution above a given area.

BLOWIN' IN THE WIND
P.J. Barry

More than one way of managing our industrial and residential airborne wastes is open to us. Our options include:

(i) Meteorological control, whereby the strength of selected sources is reduced during periods of poor atmospheric dispersion,
(ii) Siting, meaning the horizontal or vertical displacement of sources relative to sensitive receptors,
(iii) Source strength reduction, achieved by removing to a greater or lesser degree, potential pollutants from effluents.

Which of these alternatives or combination of them we choose will depend on their effectiveness per unit cost. Effectiveness of a control measure is the amount by which the harmful effects of pollution are reduced when the control is applied. To assess the harm done we must know how particular adverse effects are related quantitatively to the time course of exposure of sensitive receptors (e.g., people, buildings, agricultural crops, etc.).

To elucidate these relationships, meteorologists will have to cooperate closely with epidemiologists, toxicologists, plant pathologists and other specialists. In addition, meteorologists will have to predict temporal and spatial distributions of pollution levels for a variety of alternative source conditions and alternative source-receptor configurations so that the amount of harm per unit of release corresponding to each case can be estimated.

Unfortunately, we do not yet know enough about atmospheric dispersion. More research is needed but of a kind different from and having a different emphasis from that which has been popular hitherto. The meteorologist will have to answer questions other than his own and his answers will have to be expressed so that they will contribute to the solution of practical problems.

SESSION TH1: Numerical Weather Prediction I

THE CURRENT STATUS OF WEATHER FORECASTING BY NUMERICAL METHODS

André Robert

Records of verification scores for the past 25 years show a drop of the order of 35% in the errors associated with weather forecasts. Experiments dealing with the predictability of the atmosphere indicate that the errors in current short-range forecasts could be reduced by at least a factor of four. The various sources of errors in numerical models are examined with the percentage contribution given in each case. Short-term projections are made of the expected increase in the accuracy of numerical predictions.

A PROGRESS REPORT ON PRECIPITATION FORECASTING

David Davies

Numerical forecasts of precipitation amount for transmission over the facsimile circuits have been produced operationally on the Central Analysis Office computer since February 1968. The basic scheme was designed to work in conjunction with a baroclinic model. It features three-layer moisture resolution in the vertical, the gradual onset of large-scale precipitation at some threshold value of dew point depression, and the prediction of small-scale precipitation by means of empirical formulae.

For the last three years further development work has been carried out on experimental versions of the same baroclinic-precipitation package. This has resulted in several successful innovations which have already been incorporated into the operational run. For instance, the eddy diffusion of potential vorticity has replaced smoothing in the baroclinic model, and associated changes have been made in the vertical motion computations. Crude radiation and ocean heating terms have been added to the predictive equations for temperature and dew point depression. Some temperature dependence has been introduced into the maximum total precipitation permitted at a grid point, and also in the threshold criteria for frontal precipitation. And some non-linearity has been introduced into the formula for large-scale precipitation.

Other aspects of the experimental integrations did not have immediate operational application, but appear to have interesting implications. For instance, the release of latent heat appears to affect the large-scale circulation in a manner which is highly dependent on the scale of the precipitating cells. The effective eddy diffusion constants appear to be highly dependent on the baroclinicity. And a highly sensitive model appears to be a disadvantage in no-data areas.

The baroclinic-precipitation package is now being converted to operate over a fine grid mesh with a spacing half the standard size.

TRUNCATION ERROR IN A SPECTRAL MODEL

P.E. Merilees

A spectral barotropic model of the northern hemisphere is integrated from the same initial condition using various resolutions for a five-day period. The various integrations are compared as a function of time in order to determine the dependance of truncation error on wave number.

The initial data are truncated at longitudinal wave number 6, using 6 degrees of freedom for latitude variations. Subsequent integrations use the same number of degrees of freedom in latitude and truncate successively at longitudinal wave numbers 9, 12, 15, and 18.

Preliminary results indicate that the truncation error falls off with increasing resolution but at a rate which is considerably less than exponential.

EXPERIMENTS WITH A PRIMITIVE EQUATIONS MODEL

Maurice B. Danard

An 8-level primitive equations model has been developed including orography, large-scale release of latent heat, long-wave radiation, friction, and fluxes of heat and water vapor from water surfaces. The clouds and moisture patterns used in the radiation calculations are predicted (i.e., vary with time). Drag coefficients vary spatially. Thirty-six hour predictions are performed for an intense mid-latitude winter cyclone over North America.

The influences of long-wave radiation, surface friction, and the Great Lakes have been studied. Truncation error has also been investigated by halving the grid size from 380 to 190 km. The improvement in the lower troposphere is quite striking. After 36 hours the Great Lakes cause a lowering of the 1000-mb heights by about 70 m (i.e., surface pressure is dropped about 7 mb). Effects on wind speeds and precipitation are also noted.

HORIZONTAL TRUNCATION ERRORS

C. Chouinard

Spatial auto-correlation functions designed for objective analysis schemes provide a meaningful method of evaluating truncation errors associated with the calculations of finite-difference derivatives involved in the integration of an atmospheric model.

A simple hemispheric barotropic model was integrated using grid sizes of 400, 280, 200 and 140 km. A comparison of these results provides another method of evaluating truncation errors and their behaviour with time.

A third method consists of evaluating spectrally, the so called "exact values" of the vorticity, advection and tendency fields. Comparing these to grid calculations, also produces reasonable estimates of truncation errors. All three methods show that the usual 381-km grid, still used operationally, does not provide us with sufficient horizontal resolution.

QUANTITATIVE EVALUATION OF INITIALIZATION PROCEDURES

Richard Asselin

With the help of the Dynamic Prediction Research Unit 5-level P.E. model (simplified pressure-coordinate version) the consequences of starting an integration with non-divergent winds, or winds satisfying the linear or non-linear balance equation, have been evaluated in terms of differences from a forecast started from "ideal" initial conditions. Statistics on the height, divergence and vorticity errors for up to several days will be presented and interpreted.

SESSION TH2: Numerical Weather Prediction II

ASSIMILATION OF GEOPOTENTIAL BY A PRIMITIVE EQUATIONS MODEL

I.D. Rutherford and R. Asselin

The so-called assimilation problem involves the periodic updating of the fields produced by a forecast model with data from the real atmospheric fields. Observations of any of the variables are unevenly distributed in space or time and must be combined with the predicted values (containing past observations) in such a way as to best define the "true" state of the atmosphere. In the past the fields of geopotential and wind have generally been adjusted according to some constraints (i.e., the balance equation) at each assimilation cycle.

The experiments to be described have been conducted using a (barotropic) P. E. model with the aim of investigating the adjustment of the wind field to periodic assimilation of only the geopotential during the integration. The particulars of the adjustment process have been found to depend upon the assimilation frequency, the dissipation properties of the model, the spectral distribution of the variables, the type of motion (rotational or divergent) and other details.

TIME-DEPENDENT BOUNDARIES IN A BAROCLINIC PREDICTION MODEL

W.S. Creswick and M.P. Olson

A four-level baroclinic model is integrated over a limited area with lateral boundaries prescribed by forecast values from the same model integrated from earlier data over a hemispheric grid. Radiation and ocean heating terms are simulated through an error feed-back technique.

U.S. AIR FORCE GLOBAL WEATHER CENTRAL BOUNDARY-LAYER MODEL

A.L. Friend

An eight-level physical numerical model has been developed for the lower tropospheric region (surface-1600 m). This model is an integral part of the complete AFGWC meso-scale (sub-synoptic) numerical analysis and prediction system. It provides greater horizontal and vertical resolution in both the numerical analyses and forecasts by predicting the more detailed smaller scale atmospheric perturbations.

Important features include: a completely automated objective numerical analysis of input data; the three-dimensional transport of heat and moisture; terrain and frictionally induced vertical motion; latent heat exchange in water substance phase changes; and eddy flux of heat and moisture.

Input data are conventional synoptic surface and upper air reports.

Other AFGWC prediction models provide horizontal wind components at the upper boundary and an estimate of cloudiness above the boundary-layer region. A case study is used to demonstrate the potential of this model, despite some approximations which broadly simplify the real planetary boundary-layer processes, to realistically simulate and accurately predict the actual behaviour of the atmosphere in the boundary-layer region for up to 24 hours.

SOME OPERATIONAL DIAGNOSTIC FIELDS FOR THE BOUNDARY LAYER

M.W. Balshaw

Problems in diagnosis and short-range prediction of subsynoptic scale weather patterns, such as low cloud and precipitation isohyets, are discussed and related to vertical motion fields induced in the boundary layer. Three principal kinematic fields are identified: low level divergence, orographic lift and turbulent mixing. An operational method for evaluating these fields from the synoptic surface observations has been developed and programmed on the Prairie Weather Central CDC 6500. A test run was made on 29 days of 1200Z data observed in June 1970 (3113 cases), and a statistical study was made of the usefulness of these fields in the operational diagnosis and short-range prediction of cloud and precipitation. The fields for a few days are presented in detail and these will demonstrate dramatically the ability of the fields to assist in the diagnosis of weather patterns.

Other operationally useful fields of low-level temperature advection, available moisture, potential temperature, geostrophic wind and wind trend are also included in the operational package of charts available to the meteorologists approximately 45 minutes after time of observation. Finally an approach to evaluating explicitly the vertical motion induced through the boundary layer, using available surface data, is discussed and preliminary results are presented.

NON-LINEAR INTERACTIONS BETWEEN WAVE FIELDS AND NON-WAVE FIELDS

M. Shabbar

This contribution focuses on the importance of resonance mechanisms in the atmosphere. The problem studied concerns the longtime behaviour of the planetary motions of the atmosphere. It is demonstated that by adopting an approach based on different time-scales - a short time-scale characterising the period of pertubations and a long time-scale characterising slow secular changes, i.e., period of modulations - the resonant non-linear interaction theory provides a new and suggestive mechanism for the forcing of stratospheric zonal flow by the vertically propagating planetary wave packets.

The analysis is restricted to a conservative physical system, and a wave package approach is adopted.

SOME RESULTS OF THE PREDICTIVE DECOMPOSITION OF ATMOSPHERIC TURBULENCE

Bryan R. Kerman

Several theoretical attempts have been made recently to expand turbulence in terms of associated stochastic processes. Most have utilized the properties of wide-band "white" noise with a Gaussian probability distribution. The paper outlines how this concept, as well as associated features of systems theory, can be directed towards an empirical expansion of atmospheric turbulence in terms of response functions. The procedure is a consequence of Wold's decomposition theorem and Wiener's functional

representation of stochastic processes. In principle, the decomposition is a synthesis of the realizations of a self-excited, non-linear process, such as turbulent fluid flow, without the artifice of explicit external excitation. Some preliminary results concerning the low-order response functions for atmospheric turbulence as measured by an aircraft in the upper planetary boundary layer over a flat plain will be given. Some dynamical interpretations and measures of the approximations of the representation are attempted.

SESSION TH3: Radiation

LIDAR PROBING OF THE ATMOSPHERE

A.I. Carswell, A.K. McQuillan and R. McNeil

A LIDAR (Laser Radar) system has been constructed at York University to investigate the use of optical scattering for atmospheric diagnostics. The system is capable of providing up to 150 MW peak power at the ruby fundamental (6943 Å) and up to 10 MW at the doubled frequency in the ultraviolet (3472 Å). The transmitter has a Pockel's cell Q-switch to generate 20 ns pulses at a repetition rate of 10/min. An 8-inch Newtonian telescope serves as the receiver. The entire unit is mounted on a mobile and steerable platform to permit field operation. Details of the LIDAR will be presented along with a discussion of its application to obtain information on atmospheric constituents from measurements of the Rayleigh, Mie and Raman backscattered return. Sample scattering measurements for a variety of atmospheric conditons will be presented.

LABORATORY MEASUREMENTS OF LIGHT SCATTERING BY AEROSOLS

R.G. Quiney and A.I. Carswell

As part of a continuing programme of investigation of the optical properties of the atmosphere, we are presently investigating the scattering properties of aerosols. Using the Stokes vector formulation we have measured the four principal components of the scattering matrix under controlled laboratory conditions, both for atmospheric air as a function of relative humidity and for laboratory generated water droplet clouds. A 50 mW He-Ne laser is used as the light source and a sensitive automated polar nephelometer, which has been developed for these measurements, records the scattering matrix as a function of scattering angle. Data reduction is accomplished rapidly using the IBM 360/50, the final results being drawn with an automatic plotter. Measurements under controlled conditions for a series of parameters will be presented.

ON THE INTERRELATIONSHIP BETWEEN NET RADIATION, SOIL MOISTURE AND EVAPORATION

B. Padmanabhamurty

Diurnal and seasonal variations of evaporation and net radiation along with the space and time variations of soil moisture over bare soil at Waltair will be presented and discussed. Variations of evaporation in relation to soil moisture and net radiation have been examined under diverse meteorological conditions obtained at Waltair. The results suggest that the fraction of net incoming energy utilised for evaporation is linearly proportional to soil moisture at one foot depth.

EVALUATING AND MAPPING SURFACE VARIATIONS IN GLOBAL RADIATION

B.J. Garnier

Although micrometeorology has taken considerable heed of the variation of radiation with slope and aspect, little attention has been given to the problem of portraying the actual spatial distributions which occur in a given region under different weather conditions. A method to evaluate such variations has been developed and perfected over the past three years (Garnier and Ohmura).

The basic data required consist of observations of global and diffuse radiation at a site representative of the area to be mapped. Calculation of surface variations from these data is effected by reference to earth/sun relationships and the surface geometry, which can be analysed from a standard topographic map. Tests of the system in tropical latitudes (at Barbados, 13°N) and in middle latitudes (at Mont St.Hilaire, Quebec, 45°N) show it to be accurate to within ±5%. Results from Barbados emphasize three features: (a) the range of topographic variation from one month to another is much greater than the observations taken on a horizontal surface might lead one to suspect; (b) many slopes receive their maximum radiation during low-sun periods of the day, east slopes in particular being rapidly warmed during the first hour or two after sunrise in the clear air before clouds develop; (c) surface variations are negligible during the four hours centred on noon. At Mont St. Hilaire, daily totals of the topographic variations have been found to be greatest in the six-week period centred on the equinox; at other times the surface variations in daily totals are minimised, despite different short-period intensities, because of (a) small radiation values in winter, and (b) long summer days whereby the lower intensities on northern slopes as compared with southern slopes are compensated for by the duration of daylight. In general, days of low atmospheric transmissivity ($P \leq 0.45$) in both test areas display an insignificant amount of surface variation owing to the high component of diffuse sky radiation in the global totals. Results in general encourage the hope that a rational climatology of radiation on slopes in relation to characteristic weather conditions can be developed.

A METHOD AND EXAMPLE OF ESTIMATING EFFECTIVE NET RADIATION FOR A MOUNTAINOUS WATERSHED

D. Storr

There are several methods of calculating the short-wave radiation received by the terrain in mountainous areas, but none for calculating net radiation.

After a discussion with some examples of the variability of net radiation in a mountainous watershed, including the effects of topography and cloudiness, annual curves of measured net and short-wave radiation under clear skies at one point in the basin are shown.

From these and Ferguson's curve for clear sky effective insolation for the basin, and from a consideration of the ratio between net and incoming short-wave radiation and its relationship to albedo, the annual curve of effective clear-sky net radiation for the basin is obtained. The variable ratio between basin effective clear-sky net radiation and measured point clear-sky net radiation is the numerical factor applied to measured data in order to obtain the basin average of effective net radiation for all weather conditions.

Some conclusions are drawn about the representativeness of the measuring site, while areas of need for further refinement are outlined.

TOPOGRAPHIC VARIATION OF FOREST CANOPY TEMPERATURE AS MEASURED BY AN AIRBORNE RADIATION THERMOMETER

R.B.B. Dickison and D.O. Greenbank

A Barnes PRT-5 radiation thermometer was flown over a section of northwestern New Brunswick during the period 16-21 June 1970 in an attempt to determine the topographic variability of canopy-level temperature. The purpose of the project was to develop a local climate map to overlay a forest cover map in order to identify areas most favourable for spruce budworm development. Recognition and mapping of such areas or epicentres would prove valuable in surveying and monitoring incipient outbreaks and reduce the extent and cost of applying insecticides.

Six flights were carried out during the six-day period under cloud conditions varying from clear to overcast, and including one night-time flight under ideal conditions of radiative cooling.

The greatest variations of temperature occurred at noon on a day of high values of solar radiation, but the influence of topographic slope and aspect produced temperature differences of only 1 - 2C between north-facing and south-facing slopes in areas of solid forest cover. Much greater temperature differences resulted from variations in forest cover. In some cut-over areas surface temperatures of 55C (131F) or higher were measured, 25C higher than average canopy-level temperatures in areas of solid forest cover. Elevation was unimportant during the mid-day flight but was the dominating factor during the pre-dawn flight.

ON THE VARIATION OF ANGLES OF INCIDENCE AND PHASE VELOCITIES OF ANOMALOUS SOUND WAVES

E.R. Reinelt

Precise timing of the arrival of individual pulses of sound at arrays of detectors permits the calculation of angles of incidence and phase velocities of sound waves propagated anomalously over large distances. Measurements made some 200-400 km from large test explosions, set off at Suffield in the past ten years, show 10 to 15 per cent variations in the phase velocity of sound waves returned to the ground from the mesosphere. Some of the smaller fluctuations can be accounted for by low-level variations of wind and temperature, but the larger variations are due to the sonic fine-structure, e.g., subducts, in the lower mesosphere.

Angles of descent deduced from the observed phase velocities range from 10 to 30 degrees at most recording sites, indicating that the pulses of sound energy have travelled along different ray paths.

SESSION F1: Hail and Fog

ALBERTA HAIL STUDIES IN THE FIELD AND AT McGILL UNIVERSITY

Walter Hitschfeld

In the late fifties, a cooperative program for studying the hail storms of Alberta was instituted by the Research Council of Alberta (which took the first initiatives and undertook to look after the logistics in the field), the Canadian Meteorological Service (which was to provide a variety of services, including forecasting, climatology and sondes), and the National Research Council (responsible for the radar and related installations). The Story Weather Group at McGill was asked to provide scientific advice, and initially to staff the project in the field.

Many changes have taken place in the organization, especially in the division of the responsibilities of sponsors and participants. But the essential mission of the project has remained the elucidation of the

structure and dynamics of the hail storm, the mechanism of formation of hail stones within the storm, and the specification of a method of suppressing hail, or of at least reducing the damage. In line with these goals, such techniques as detecting the hail by radar, measuring the freezing characteristics of the precipitation, modelling the storms numerically, forecasting the incidence of hail, and many others were undertaken. An extensive field program was built up, which at the same time prompted the development of such techniques, allowed their verification and led to their refinement. An important success is the high precision with which many observing techniques can be focussed on a single storm.

Though many questions about the physics of the storm remain unresolved, a field experiment in seeding for suppression has been initiated in 1970, and is being continued in 1971.

HAILSTORM FORECASTING FOR PROJECT HAILSTOP

A.J. Chisholm

Project "Hailstop" is a hail suppression experiment operated by the Alberta Hail Studies (ALHAS) Project under the joint sponsorship of the Research Council of Alberta, the Canadian Meteorological Service, the National Research Council and McGill University. Accurate hailstorm forecasts are highly desirable for the successful operation of this project. The various hailstorm forecast requirements may be outlined as follows:

(i) Occurrence
(ii) Location and timing
(iii) Depth and intensity
(iv) Maximum hailstone size
(v) Storm type
(vi) Direction of motion
(vii) Updraft velocity and temperatures for cloud-seeding.

The basic problems of forecasting hailstorms in central Alberta are outlined and the forecast methodology used during the 1970 summer operation is reviewed including the operation of a computer convection model. A summary of the forecast results is given which yields an overall Hail-No Hail forecast accuracy of 86% and a skill score of 0.71. Based on operational experience from the 1970 season, problem areas are defined and suggestions for their solution outlined.

PROJECT HAILSTOP 1970

Peter W. Summers

Since 1956 the Alberta Hail Studies Project has been collecting data on hailstorms in Alberta. Substantial progress has been made in developing realistic models of hailstorm kinematics and the growth of the hailstones themselves within the storm. Whilst still far from complete, the understanding of hailstorms has now reached the point where worthwhile experiments can begin. The eventual aim of these experiments is to develop cloud seeding techniques capable of interfering with the natural growth of hailstones in such a way that the amount and size of the hail reaching the ground causes less crop and property damage. The economic potential of such a seeding system is self-evident, since damage to crops alone is estimated to average $20 to $30 million annually in Alberta.

A seeding concept applicable to Alberta hailstorms was developed. The National Aeronautical Establishment in Ottawa supplied a T-33 jet aircraft and the engineering required to convert it into an experimental seeding platform. Specifications for droppable pyrotechnic cloud seeding flares were drawn up to include the unique feature of 10-cm radar chaff

which was released at the end of the burn and could then be used as a marker of targetting accuracy. The flares were manufactured by Olin Corporation.

The seeding system was tested in Alberta during July 1970, and five cloud seeding experiments were carried out. The operational logistics of this seeding technique turned out to be quite straightforward. By means of radio communication between the project radar control room and the seeding aircraft, it was always possible to unambiguously identify and seed the selected target storm.

Detailed case studies have been made of the seeded storms of 11 July and 9 July 1970. The analysis includes the behaviour of the radar reflectivity in three dimensions, hail fallout patterns, visual appearance of the cloud recorded photographically from the ground and the aircraft, freezing nuclei spectra and silver content of precipitation. These results will be presented along with some preliminary conclusions.

THE LARGE MONTREAL HAILSTORM OF 1 AUGUST 1969

Marianne English and Charles Warner

Exceptional hail fell on Montreal on 1 August 1969. Largest dimensions up to 7.5 cm and masses up to 70 gm were measured.

Radar and other data provided a simple picture of the storm circulation. Feeding on its left front flank, the storm moved to the left of all wind directions above cloud base, reached 12 km altitude, and produced a hail swath about 40 km long and 6 km wide. 115 hailstones were collected, and for each a mean diameter and minor axis were measured. The axial ratios calculated from these measurements ranged from 0.24 to 0.95, the mean being 0.6. Calculations based on a simple model consistent with the observations showed that spherical hailstones can grow to a mass of 35 gm in 18 min in a single up-and-down trajectory. With reasonable assumptions as to the effect of shape, aspherical hailstones can grow to 75 gm in the same time under the same conditions. The results of the calculations thus agree with the observations, and strengthen our confidence in the assumptions made both in the construction of the model and in the growth calculations.

THE EDMONTON HAILSTORM OF 4 AUGUST 1969

L.N. Rogers and P.W. Summers

On 4 August 1969 a severe hailstorm passed over Edmonton, Alberta causing several million dollars worth of property damage. The synoptic situation was a classical one for the development of severe persistent-type storms in Alberta. As a result of a radio and TV appeal about 300 residents of the city and the nearby countryside saved hail samples. When these samples were collected detailed information on the storm was solicited. Analysis of these data shows that, although a continuous hail swath was produced by the storm, many pockets of intense hail occurred. Over Edmonton two cells centred about 7 miles apart started to produce hail simultaneously. There were significant differences in the shape of the hail in these two cells. The total amount of hail that fell on Edmonton is estimated to have been about 1.1 million tons.

The radar analysis shows evidence of a large echo-weak vault with strong rotation; also a tornado was reported at least three locations along the storm's path.

SUMMARY OF THE 1970 FOG DISPERSAL PROGRAM AT VANCOUVER INTERNATIONAL AIRPORT

Wm. C. Thompson

During the three months October to December, 1970, six fog seeding operations were conducted at Vancouver International Airport under a program financed by seven airlines. The objective of the program was to improve runway visibility by the aerial seeding of warm fogs with hygroscopic particles.

An analysis of transmissometer traces, visual observations, the official weather observations and aircrew comments from a few of the operations indicate differences of opinion regarding the effectiveness of the program. Some reasons for these disparities are discussed.

URBAN GROWTH EFFECTS ON LOW-TEMPERATURE FOG IN EDMONTON

K.D. Hage

Visibility observations at rural and urban airports in the Edmonton area during the severe winter of 1968-69 are compared with similar observations described in 1955 by G.W. Robertson for the winter of 1949-50. The new observations tend to confirm Robertson's finding that low-temperature fog in Edmonton is due mainly to saturation of the air by water vapour produced in burning natural gas. Visibilities in such fog are strongly temperature-dependent. The urban population more than doubled between 1950 and 1969, and new large sources of water vapour were added to the city. The effects of both changes are apparent in the visibility data. Estimates of future low-temperature fog frequencies together with the assumptions needed for such estimates are included for the city of Edmonton.

SESSION F2: Hail and Cloud Physics

MESOSCALE RAIN AND HAILFALL PATTERNS IN SEVERE CONVECTIVE STORMS

P. W. Summers

With the current telephone survey system, the Alberta Hail Studies Project is able to obtain hundreds of hail reports from farmers within two days of a storm. Most farmers have a simple type of rain gauge and during the last three years an effort has been made to solicit storm-point rainfall data also. For specific storms the reporting density is between 20 and 50 reports per 100 square miles.

Using these data for about 15 well documented severe convective storms in the summers of 1968-1970 detailed hailfall and rainfall patterns are plotted. While the hail and rain swaths are continuous, there is a great variation of intensity. The heaviest hail and rain falls in pockets which are typically 10 miles long and 2 to 5 miles wide. In many cases the heaviest rainfall is displaced a few miles downwind from the heaviest hailfall indicative of a size sorting mechanism due to the different fall velocities of hail and rain and/or the presence of vertical wind shear.

The implications of these findings on the use of climatological statistics in an area such as the Canadian Prairies where most of the summer precipitation comes from convective storms is discussed.

RADAR MAXIMUM REFLECTIVITY PROFILES OF CELLS IN A PERSISTENT MULTI-CELLULAR ALBERTA HAILSTORM

J. H. Renick

Individual cells in a persistent multi-cellular hailstorm in central Alberta have been tracked by means of the Alberta Hail Studies 10-cm radar. Vertical profiles of the maximum radar reflectivity within these individual cells for each successive three-minute scan sequence of the radar have been prepared for several cells in the storm complex. These "time-height max Ze" profiles show the beginning and vertical development of the radar echoes within the cells and, as such, are radar histories of the growth of precipitation and its eventual fallout to the ground.

The structure and dynamics of a persistent multi-cellular storm will be illustrated and the significance of the profiles as related to precipitation growth models and hail growth trajectories will be discussed.

AIR BUBBLES IN HAILSTONES

Roland List. W.A. Murray and Carole L. Dyck

One of the first things obvious to any investigator of natural hailstones is their shell structure, i.e., the alternating layers of opaque and more or less clear ice. The opacity is caused by the presence of air bubbles, however, their concentration and size distributions have never been measured, except for the bulk densities of shells (List, Cantin and Ferland, 1970).

A recent attempt to measure cumulative distributions of bubbles and total shell densities of hailstones from an Alberta sample was, surprisingly, very successful. It was possible to show that size versus cumulative occurrence (plotted with lognormal probability) can always be approximated by straight lines, their slope essentially constant and not affected by concentration or opacity. The mean diameter of bubbles of opaque layers turned out to be rather smaller than that of clear shells. Correlations with density or crystallographic features definitely show the different bubble history. Opaque shells seem to consist of "primary" or original bubbles whereas in clear ice those initial bubbles might have had time enough to diffuse and coalesce with others in order to form larger entities.

In summary, it is obvious that air bubble size distributions and concentrations may represent the needed final clue to unravel the life history of hailstones which is imprinted in their structure.

THE DETECTION OF SILVER IODIDE PARTICLES IN HAIL

L.N. Rogers

A technique for the detection of silver iodide particles in situ is described. A thin section of a hailstone is evaporated on a Millipore filter in such a manner that the particles present in the section maintain their original positions relative to one another. The filter is then treated with a supersaturated solution of silver iodide. Any silver iodide particles originally present in the section act as seed crystals for the solution and grow sufficiently large to be easily observed. A study of the positions of the silver iodide particles in conjunction with the structure of the stone can provide information as to whether the particles were effective as nucleating agents or whether they were collected by accretion without having a nucleating effect.

Data from a number of hailstones will be presented.

FREEZING OF WATER DROPS AT TERMINAL VELOCITY

W.A. Murray and R. List

An investigation was made of the ice structures and heat exchanges of water drops frozen while they were suspended at terminal velocity in a vertical wind tunnel. The diameter range for the drops was 3 to 8 mm. Air temperatures varied from -1 to -18.5C. Asymmetry of the freezing is evident from thin sections made from partially frozen drops. Despite the asymmetry, the observed freezing times agree reasonably well with the estimates from a symmetric freezing model. A microcalorimeter was used to determine the amount of ice in frozen drops at different stages of freezing. The mass of ice increased linearly with time. Air bubble and crystal sizes, and crystal orientations were determined from replicas and microphotographs of vertical main sections of the frozen drops. Air bubble sizes were corrected for spatial effects, that is, the effects of sampling from a plane rather than a volume. The volume of air in the frozen drops is up to 70% lower than the amount estimated to have been dissolved in the water originally. Both the air bubble and crystal sizes decrease with the increase in rate of freezing at lower air temperatures. Purity of the water affects the crystal size; crystals are smaller in drops of impure water. Histograms of c' axis orientation show a preferred orientation with the axis perpendicular to the radial direction. This relationship weakens as the temperature decreases.

ELECTRIFICATION ASSOCIATED WITH SPLASHING OF SUPERCOOLED DROPLETS ON ICE

H.G. Hengeveld, P.Y.T. Louie and J.V. Iribarne

The charge separation occurring during the splash of supercooled droplets on rotating ice spheres was investigated. Droplets of 360 and 500 microns were used with varying impact velocities (1 to 9 m/sec) and temperatures (ice at -2 to -15C); pure water and solutions were tested. The splashes impart a positive charge (in the order of 10^{-5} e.s.u.) to the ice, except for the larger droplets and lower temperatures, when the sign is reversed. Flash photography shows the development of a crown and droplet ejection during the splash. The results are compared with previous measurements with larger drops at 0C, and the possible charge separation mechanisms are discussed.

INFLUENCE OF INITIAL CHARGES AND EXTERNAL FIELDS ON SPLASHING ELECTRIFICATION

J.B. Maxwell and J.V. Iribarne

The separation during the splash of large drops on rotating spheres was studied. The impact velocity, the initial charge of the spheres and of the drops, and the intensity of an applied vertical field could be varied. The charges were measured by induction. Saturation curves were obtained for room temperature and for a cold room using ice-coated spheres and drops at 0C. The saturation charges are independent of the impact velocity but vary with the nature of the surface, the liquid composition and the field strength. The results are interpreted in terms of a superposition of electrical double layer shearing and induction effects.

AN APPROACH TO THE MAPPING OF GRADIENT-LEVEL WINDS OVER CANADA

A.G. Davenport and C. Baynes

This work was initiated to try to establish the pattern of gradient-level winds over Canada. This information is relevant to many problems including the wind loading of structures, air pollution and other environmental problems. The advantage of gradient-level winds is their independence of local terrain influences.

The data from which the preliminary maps were prepared were recorded by twice-daily radiosonde ascents at a network of ten Canadian upper air stations. Almost continuous records are available for the decade 1960-1969, and these were used in conjunction with the U.S. Weather Bureau's "Winds Aloft Summaries" for selected points in the northern United States. Existing maps of "Upper Winds over Canada" have also proved useful in establishing the overall pattern.

Data analysis and subsequent mapping initially centred on certain statistical properties of winds at the 300- and 500- metre levels, corresponding to the approximate gradient heights over very flat terrain and built-up city centres, respectively. These statistical properties include the mean, vector mean and vector standard deviation.

The obvious relevance of extreme wind conditions in building design prompted investigation of maximum gradient winds using Weibull and "probability of exceedance" models. Some preliminary maps have been prepared for extreme wind occurrences and the parameters of the associated extreme-value distributions.

ON THE SATURATION VAPOUR PRESSURE OF WATER

J.M. Richards

In theoretical and numerical work on convective processes, as in other fields, one often desires a simple, yet accurate, expression for the relation between the saturation vapour pressure of water and the temperature.

The paper introduces a neat approximation to represent this pressure between -50 and 140C. Over this range the accuracy of the approximation is about 0.1 percent, and over the range between 0 and 100C the accuracy is about 0.02 percent.

THE ECONOMIC EVALUATION OF METEOROLOGICAL INFORMATION FOR SNOW-CLEARING IN MONTREAL

A. Dasgupta, M. Inagaki and R. Robinson

This paper outlines an attempt to measure the economic benefits resulting from the use of meteorological information in the snow removal activity in Montreal.

Among cities of comparable size, Montreal suffers from one of the highest levels of Winter snow fall in the world, much of which occurs during snow storms with a paralysing effect on ground transportation.

To aid in the efficiency of snow clearing and snow removal operations, the Dorval Weather Office has for the past several years provided a special forecast service to the City Roads Department.

The service includes written messages, transmitted four times daily, indicating detailed forecasts of important meteorological variables. These are supplemented when required, by direct telephone consultation.

The benefits accruing from the use of the forecast service consist

primarily of faster snow clearing, leading to improved road conditions, and hence to reductions in the accident rate and in travel-time.

The paper consists of three parts describing:

(1) the development of a mathematical model relating the use of the meteorological service to the resulting benefits,

(2) the application of the model to estimate the quantity of benefits of various types, on the basis of detailed time-series data relating to storm occurrences, taken in conjunction with data on observed accident rates, absenteeism and late arrivals, and

(3) the conversion of benefits into monetary terms by the use of appropriate techniques of cost-benefit analysis.

AN OPERATIONAL METHOD OF TOTAL INSTABILITY ANALYSIS AND FORECASTING

W.S. Harley

A method of determining and combining into a single instability index, the Potential and Latent Instabilities for the 700-850 mb and for the 500-700 mb layers, based on equivalent potential temperatures, is outlined. The relation between the instability index patterns for each layer and thunderstorm occurrence is demonstrated. A method of determining the region of greatest increase in instability is also demonstrated.

THE PASSAGE OF A LAKE-BREEZE FRONT: A COMPARISON BETWEEN THE CITY AND THE SUBURBS

M.S. Hirt and R.W. Shaw

The penetration and retreat of a lake-breeze front in the urban, lake-shore environment of Toronto was observed by means of two instrumented towers, one in the downtown business section and the other in the suburbs. The effects of the additional city heating upon the front were most evident. In the city, there was a greater contrast between the inland air and the lake air, with the result that the advancing front was steeper and more sharply defined in the city than in the suburbs. Overland heating during the day modified the air so that in the suburbs, the front was steeper when it was retreating than when it was advancing. Over the city, the lake air was even more extensively modified by the additional man-made heat sources, with the result that the lake-breeze front was hardly detectable by the time it retreated.

HORIZONTAL TEMPERATURE FIELD - GREATER VANCOUVER, B.C.

J.H. Emslie

Conventionally, a single official temperature reference is provided at most Canadian cities, and in many cases this temperature is taken at an airport located in the outskirts. Is this temperature representative of the city as a whole, and if not, what range of values might be expected across a city? Further, what local influences produce this temperature range?

In view of the current Public Forecast experiment, providing ranges of maximum and minimum forecast temperatures instead of spot values, some appreciation of the factors affecting the temperature field across a city is essential if the forecaster is to issue realistic figures.

At Vancouver, British Columbia, the official temperature is taken at Vancouver International Airport, located approximately six miles south-southwest of the city centre. Additionally, maximum and minimum temperatures have been recorded at twenty-four Climatological Stations in the Greater Vancouver area, during various periods, since 1957.

This study analyses published climatological mean daily maximum and minimum temperatures at these stations, expressed as seasonal departures from the temperature reference point, Vancouver International Airport, and illustrates the effects of elevation, urban heat island, sea breeze and nocturnal drainage, and points out locations where additional climatological stations should be established to complete the urban temperature-range picture.

AN INTERESTING ARCTIC STORM

H.P. Wilson

On 15 September 1970 a storm with two major centres developed over the Beaufort Sea and moved to Cambridge Bay in three days. The first low was a baroclinic wave. The second deepened because of diabatic heating but partly also as a result of its amalgamation with two smaller centres. It caused some loss of life and produced serious erosion to the peninsula on which Tuk Tuk is located.

CANADIAN METEOROLOGICAL SOCIETY

5th Annual General Meeting, May 12, 1971
Macdonald College

AGENDA

The President in the Chair

1. Minutes of 4th Annual General Meeting, June 17, 1970

2. Reports of the Executive Committee
   - (a) Annual Report of C.M.S.
   - (b) Treasurer's Report
   - (c) Nominating Committee Report
   - (d) Editor's Report
   - (e) Prize Committee Report

3. Reports from Local Centres

4. Budget for period 1 January 1972 to 31 December 1972

5. Membership Fees

6. Sustaining Membership in SCITEC

7. 1972 and 1973 Congresses

8. Other Business

9. Installation of Officers

CANADIAN METEOROLOGICAL SOCIETY

DRAFT MINUTES

CANADIAN METEOROLOGICAL SOCIETY

Minutes of the Fourth Annual General Meeting of the Canadian Meteorological Society held at the University of Manitoba, Winnipeg, Manitoba, Wednesday, June 17, 1970 at 8:00 p.m.

1. Minutes of the 3rd Annual General Meeting of the Canadian Meteorological Society held May 27, 1969, at the University of Toronto, Toronto, Ontario.

Mr. Crowley moved that the minutes of the 3rd Annual General Meeting be approved. Seconded by Dr. Merilees. Carried.

2. Reports of the Executive Committee

(a) Annual Report of the Society

After Mr. J.D. Holland presented the Annual Report and answered questions clarifying minor points:

It was moved by Mr. S.J. Buckler, seconded by Mr. J. Lauder that the Society contribute the sum of fifty dollars, in addition to our prize, to the 1971 Science Fair. After discussion indicating a need for better guidance to our judges in the future, the motion was carried.

(b) Treasurer's Report

Mr. D.N. McMullen moved that the Report as published be approved. Seconded by Dr. J. Maybank. Carried.

(c) Nominating Committee Report

Professor A. Brewer, Chairman of the Nominating Committee, moved that the following be considered for office during 1970-71:

Executive

President	Mr. D.N. McMullen
Vice President	Mr. C.M. Penner
Treasurer	Mr. M.S. Webb
Corresponding Secretary	Mr. G.A. McPherson
Recording Secretary	Mr. G.L. Pincock
Editor	Mr. E.J. Truhlar

Councillors at Large

Mr. J.L. Knox
Dr. K.D. Hage
Dr. C. East

Auditor

Mr. R.D. Easto

The President advised that no additional nominations had been received from members at large and declared the above nominees elected.

(d) Editor's Report

Mr. M.K. Thomas presented the Report. The arrangement for reprints was explained to Dr. Maybank. In discussion it was agreed that the present arrangements for special Congress Issues of Atmosphere would continue.

(e) Prize Committee Report

Mr. G.A. McKay, Chairman of the Awards Committee, reported that the following awards were recommended and had been approved by Council.

(i) President's Prize

Professor G.T. Csanady, University of Waterloo, for his paper "Diffusion in an Ekman Layer", J.Atm. Sc., 26, 414-426, 1969, and which was presented at the 2nd Annual Congress of the Canadian Meteorological Society.

(ii) Prize in Applied Meteorology

M.K. Thomas, Meteorological Branch, Toronto, in view of his extensive contributions which include work relating to people and construction, the preparation of national and international atlases, and continued enthusiastic promotion of all aspects of applied meteorology, which culminated in 1969 when the Society, of which he is president, held the first Canadian Congress on Applied Meteorology.

(iii) Graduate Student Prize

T. Warn, graduate student in Meteorology, McGill University, for his M.Sc. Thesis "Initialization Problems of a Primitive Equations Model of the Atmosphere" which is considered to warrant special merit. The thesis was rated excellent and very good by the two examiners.

(iv) Dr. A. Thomson Undergraduate Student Prize

T. Agnew, undergraduate student in mathematics and physics, University of Toronto, for his report "Terrain induced vertical velocities obtained using a direct method of stream - function computation" which was published as a Meteorological Branch Technical Memorandum, TEC-721, September 15, 1969, and who has collaborated on a "Note on the Computation of terrain and frictionally induced vertical velocities" which has been submitted to the Journal of Applied Meteorology.

The Graduate Student Prize was presented to Mr. Warn by the President, Mr. M.K. Thomas. The Applied Meteorology Prize was presented to Mr. Thomas by the Vice-President, Mr. D.N. McMullen. The other two Prizes will be mailed to the recipients who were not present at the Annual Meeting.

3. Reports from Local Centres

Reports from the following Local Centres were presented:

British Columbia Centre	Mr. K.F. Harry
Alberta Centre	Dr. K.D. Hage
Regina Centre	Mr. S.J. Buckler
Winnipeg Centre	Mr. P. Kowal
Toronto Centre	Mr. G.L. Pincock
Ottawa Centre	Mr. L. MacHattie
Montreal Centre	Dr. P. Merilees
Quebec Centre	Dr. G. Villeneuve
Halifax Centre	Mr. J.D. Holland

4. Budget for Period 1st January, 1971 to 31st December, 1971

The Budget was reviewed by Mr. D.N. McMullen. The President requested that motions concerning the budget be deferred until later in the meeting.

5. Amendments to the By-Laws

Prof. A. Brewer moved amendments to the By-Laws as follows:

BY-LAW 2 - Membership

(i) Delete present By-Law 2 (c) and substitute therefor:

"c) Corporate membership is open to consulting meteorologists."

(ii) Add new By-Law 2 (d) :

"d) Sustaining membership is open to institutions, companies, firms and organizations."

BY-LAW 14 - Society's Awards

(i) Amend By-Law 14 (d) by adding the following:

"..... The Corresponding Secretary will pass this information, together with a list of papers and authors from national Canadian Meteorological Society or Canadian Meteorological Society sponsored meetings during the year, to the Awards Committee for their consideration".

(ii) Add New Clause 14 (e) :

"(e) Nominations for the Society's Awards from members and Centres will be called for by the Corresponding Secretary in an appropriate issue of ATMOSPHERE each year, with March 1 as the deadline for receipt of nominations. Nominations received by this date will be forwarded to the Awards Committee for their consideration".

Seconded by Mr. G.A. McKay. The motion was carried after minor discussion to clarify the purpose of the proposed amendments.

6. Future of the Society

(a) The President reminded the meeting that the complete CMS Development Committee Report had been distributed to Centres. The two proposals of the Executive for action have also been distributed and are printed in the Congress Issue of Atmosphere.

(b) Mr. McMullen explained the recommendations of the Executive with respect to Standing Committees and asked for comments from the meeting.

Discussion followed with respect to the proposed terms of reference of Standing Committees with the indication that they were possibly too restrictive. It was agreed that the terms of reference must be definite, that the committees must be active and that each committee must know the funds it would have available.

It was moved by Mr. McMullen that the Executive Committee be encouraged to appoint Standing Committees on :

1. Scientific and Professional Matters,
2. Public Information.

and others, from time to time, as may be expedient for the effective operation of the Society. Seconded by Prof. Gregory. Carried.

It was requested by Mr. Harry that the membership of the Standing Committees be as broad geographically, as possible. All members should not be from Toronto.

(c) The President then reported on the proposals for "Atmosphere" as included in the Congress Issue and presented samples of the proposed format.

Considerable discussion followed with Mr. J.D. McTaggart-Cowan pointing out that while the proposal to improve "Atmosphere" with respect to appearance and format was important, there must also be an attempt to improve the contents. It was generally agreed that the original proposals for "Atmosphere" which were established when the Society was formed, should be followed.

It was then moved by Prof. Brewer, that the fee for members for 1971 be increased to $14.00 and that the additional funds realized be used to improve "Atmosphere". Seconded by Prof. Boville. Carried.

7. SCITEC

The President reported briefly on the formation and activities to date of SCITEC and advised the meeting of the request that a founding grant be provided during 1970 of perhaps one hundred dollars ($100.00).

Dr. P.D. McTaggart-Cowan provided clarification of the purposes of SCITEC and indicated that it would need the support of the Learned Societies.

It was then moved by Dr. P.D. McTaggart-Cowan that the C.M.S. affiliate with SCITEC and make a founding grant of $100.00 during 1970. Seconded by Dr. P. Summers. Carried.

8. 1971 and 1972 Congresses

(a) Mr. Holland advised the meeting that the 1971 Congress would be held at MacDonald College, the week of May 10th in conjunction with the Second Canadian Conference on Micrometeorology. The latter will meet on May 10, 11 and 12; the C.M.S. Congress on May 12, 13 and 14. The Montreal Centre will host these meetings. Dr. R.H. Douglas will be Arrangements Chairman. A Program Chairman for the C.M.S. Congress will be appointed in the fall.

(b) Mr. Holland also advised that an invitation had been received from the University of Alberta to hold the 1972 Congress there, in conjunction with the 1972 meetings of the Learned Societies. Dr. Hage indicated the willingness of the Alberta Centre to host the Congress if Edmonton was selected as the location for it.

It was moved by Dr. McTaggart-Cowan, seconded by Dr. Summers that the invitation from the University of Alberta be accepted. Carried.

9. Other Business

(a) Dr. Brewer moved that the fees for 1971 for all Student Members be $2.00, for Corporate Members be $40.00. Seconded by Mr. McHattie. Carried.

(b) Mr. K.F. Harry requested that consideration be given in future planning to an associate grade of membership at a somewhat lower fee than regular members.

(c) Mr. S.V.A. Gordon moved a vote of thanks to outgoing members of the Executive, Prof. A. Brewer, Mr. J.D. Holland and Mr. L. Shenfeld. Seconded by Mr. McMullen. Carried.

10. Installation of Officers

Mr. Thomas welcomed the incoming Council and turned the meeting over to the incoming President, Mr. McMullen.

11. Adjournment

The meeting was adjourned at 11:10 p.m.

REVISED

CANADIAN METEOROLOGICAL SOCIETY

PROPOSED BUDGET FOR 1971.

RECEIPTS			
Canadian Meteorological Service Grant		500.00	
Fees - general memberships	400 at $14.00	5,600.00	
- corporate memberships	1 at $40.00	40.00	
- student memberships	100 at $ 2.00	200.00	
Subscriptions	200 at $ 9.00	1,800.00	
Total Receipts			$ 8,140.00
EXPENDITURES			
Atmosphere - billing	$1,500.00		
- distribution	700.00		
- printing	5,200.00		
		7,400.00	
Annual Congress - typing	$ 40.00		
- mailing	60.00		
- printing	600.00		
		700.00	
Awards and Prizes		150.00	
Auditor Honorarium		30.00	
Grants to Centres		300.00	
Operating Costs of Executive			
- bank charges	$ 40.00		
- postage	300.00		
- stationery	100.00		
- printing	100.00		
- clerical	100.00		
		640.00	
Total Expenditures			9,220.00
BUDGETED DEFICIT			1,080.00

ANNUAL REPORT

CANADIAN METEOROLOGICAL SOCIETY

MEMBERSHIP

Between 40 and 50 new members have been accepted into the Society in the past year and our membership list stands at well over 600 at present. However, at the time of writing of this report it is not possible to say just how the membership will be affected by the increase in fees or the promotional campaign which will accompany the change in format of our journal, ATMOSPHERE. We will probably have to wait until late in May or June before an assessment can be made. The University of Toronto Press, which has some experience in such matters, feels that fees are being received at a normal rate and that there is no indication of a problem at present.

In addition to the promotional campaign which is to be conducted by the University of Toronto Press, the Membership Committee will also be mounting a drive through the Local Centres to boost membership.

FOURTH ANNUAL CONGRESS

The Fourth Annual Congress of the Society was held at the University of Manitoba, June 17-19, 1970. Over the three-day period 7 scientific sessions were held and a total of 43 papers presented. The first two sessions dealt with "Education in Meteorology" followed by single sessions on "Winds", "Precipitation", "Climatology and Physical Meteorology", "Electrification and Cloud Microphysics", and "Forecasting and Synoptic Meteorology". The program was considered an excellent one by those who attended and much credit is due to Dr. J. Maybank and his program committee.

In addition to the scientific sessions there were many other features of the conference arranged for the convenience and entertainment of those who were in attendance. The executive of the Society would like to thank Mr. Eric Dexter and his local arrangements committee for the many hours of work that went into the program.

FOURTH ANNUAL GENERAL MEETING

The Fourth Annual Meeting of the Society was held on the evening of June 17th at the University of Manitoba. Following the reports from the executive the report of the Nominating Committee was presented. The following were declared elected as officers of the Society for 1970-71.

EXECUTIVE

President	Mr. D.N. McMullen
Past President	Mr. M.K. Thomas
Vice-President	Mr. C.M. Penner
Treasurer	Mr. M.S. Webb
Corresponding Secretary	Mr. G.A. McPherson
Recording Secretary	Mr. G.L. Pincock
Editor	Mr. E.J. Truhlar

COUNCILLORS AT LARGE

Mr. J.L. Knox
Dr. K.D. Hage
Dr. C. East

AUDITOR

Mr. R.D. Easto

The Prize Committee report recommended the following for the 1969 awards:

President's Prize:	Professor G.T. Csanady
Prize in Applied Meteorology:	Mr. M.K. Thomas
Graduate Student Prize:	Mr. T. Warn
Dr. A. Thomson Undergraduate Student Prize:	Mr. T. Agnew

The following motions among others received approval at the meeting:

- that the Executive Committee be encouraged to appoint Standing Committees on (1) Scientific and Professional Matters, and (2) Public Information
- that fees for members for 1971 be increased to $14.00 and that these additional funds be used to improve ATMOSPHERE
- that the Society affiliate with SCITEC and make a founding grant of $100 during 1970.

The meeting was adjourned following installation of the new executive.

ANNUAL DINNER

The Annual Dinner of the Society was quite a novel affair, having been on board a paddle wheel boat while cruising down the Red River. Dr. P.D. McTaggart-Cowan was the special speaker on this occasion and his address, dealing with the Arrow oil spill incident, was extremely interesting and informative.

Another highlight of the evening was the presentation of the Patterson Distinguished Service Medal to Dr. G.O. Villeneuve by J.R.H. Noble, Administrator of the Canadian Meteorological Service.

OTHER ACTIVITIES

During the past year the Executive Committee has carried out the wishes expressed by the members of the Society at the Fourth Annual Meeting by arranging for the University of Toronto Press to publish ATMOSPHERE and handle our mailing and fee collecting chores. Details of these arrangements will be presented in the report from the Editor of ATMOSPHERE.

Standing Committees on Scientific and Professional Matters and on Public Information were established by the Executive this past year and, although their activities were somewhat limited, it appears certain that they will serve a very useful purpose and it is expected that their involvement in Society matters will grow rapidly over the next year or two. The Society has provided a founding grant of $100 to SCITEC and a representative from our Society attended and reported on the First Core Conference held in Halifax in August 1970. It is expected that our Society will become involved in reacting to the Lamontagne Report along with other professional societies and scientific organizations as a result of our association with SCITEC. The question of paying a sustaining membership fee to SCITEC will have to be considered at this year's annual meeting.

The Society has continued its support of the Youth Science Foundation by contributing $50 to the Canada-Wide Science Fair and by sponsoring an award for a meteorological exhibit of merit on the occasion of the 10th Fair to be held at the University of Alberta in May, 1971.

The Society assisted in arranging for a national speaking tour sponsored by the Canadian Meteorological Service. Professor F.K. Hare toured western Canada in February speaking to Society meetings on "Climate and Ecology in the Canadian North". The tour, which has been very well received, will continue in eastern Canada during April.

REPORT OF NOMINATING COMMITTEE

The following have been nominated for the Canadian Meteorological Society Council for 1971-72, and all have agreed to serve, if elected:

President:	Mr. C.M. Penner
Vice-President:	Mr. G.A. McKay
Treasurer:	Mr. M.S. Webb
Corresponding Secretary:	Mr. G.A. McPherson
Recording Secretary:	Mr. A.H. Campbell
Editor:	Mr. E.J. Truhlar
Councillors-at-Large:	Mr. J.L. Knox
	Dr. C. East
	Mr. S.V.A. Gordon
Auditor:	Mr. R.D. Easto

T.L. Wiacek, Chairman.

PRIZE COMMITTEE REPORT

The Awards Committee, after due deliberation, wishes to recommend the following candidates for awards of the Society for the year 1970:

Dr. R.E. Munn, Canadian Meteorological Service, Toronto -
The President's Prize for his important work and contributions to micrometeorological and environmental problems and particularly his book "Biometeorological Methods".

N. Yacowar, Canadian Meteorological Service, Montreal -
The Prize in Applied Meteorology, for his work on developing the objective temperature forecast procedures now in operational use in the Canadian Meteorological Service.

N.A. McFarlane, McGill University -
The Graduate Student Prize, for the valuable work on atmospheric stability incorporated in his M.Sc. thesis "An Eigensystem Study of the Stability of Atmospheric Zonal Flows".

J.A. Fitzgerald, University of New Brunswick -
The Dr. Andrew Thomson Undergraduate Student Prize, for his work on evaluating forecast accuracy incorporated in his papers "Errors in Temperature Forecasts for the Atlantic Provinces" and "Evaluation of CAO Baroclinic QPF for the Atlantic Provinces".

J. Clodman, Chairman.

CANADIAN METEOROLOGICAL SOCIETY
STATEMENT OF RECEIPTS AND EXPENDITURES
FOR THE YEAR ENDED DECEMBER 31, 1970

RECEIPTS		
1969 Fees	$ 112.65	
1970 "	3,833.13	
1971 "	60.00	$4,005.78
OTHER INCOME		
Bank Interest	51.34	
Dividends - Bell Telephone	30.00	
Refund from 1970 Congress	447.35	
Grant - Meteorological Branch	1,000.00	1,528.69
TOTAL RECEIPTS:		$5,534.47
EXPENDITURES		
SCITEC - grant	100.00	
SCITEC - attendance costs	109.90	
Centres - expenses	165.00	
Prizes	100.22	
Audit expense	30.00	
Stationery and Printing	456.77	
Congress Expenses	538.01	
Bank Charges	31.37	
Postage	94.95	
ATMOSPHERE - printing and mailing	3,200.00	
TOTAL EXPENDITURES:		$4,826.22
Bank Balance - January 1, 1970		$1,859.44
Plus receipts 1970		5,534.47
Less expenditures 1970		4,826.22
		$2,567.69
Balance - Bank of Montreal - December 31, 1970		867.44
Canadian Imperial Bank of Commerce - December 31, 1970		1,700.25
		$2,567.69

CANADIAN METEOROLOGICAL SOCIETY
BALANCE SHEET AS AT DECEMBER 31, 1970

ASSETS

Bank	- Balance, December 1970	$2,567.69	
Bonds	- 1969 Canada Savings Bonds (1 Nov 1978 - average 8%) (a)	950.00	
Bell Telephone	- market value December 31/70 $44.00 x 12 shares	528.00	$4,045.69

LIABILITIES

Surplus - December 31, 1969	$3,337.44	
Surplus for year 1970	708.25	$4,045.69

Note (a) - interest rate on bonds

first year	7 %
second and third years	8 %
fourth to the ninth years inclusive	8 1/4 %

AUDITOR'S REPORT

I have examined the records of the Canadian Meteorological Society and am satisfied that the Treasurer's Report presents a proper statement of the financial position as at December 31, 1970.

R.D. Easto,
Auditor.

CANADIAN METEOROLOGICAL SOCIETY
STATEMENT OF ACCOUNTS FOR "ATMOSPHERE"
YEAR ENDED 31ST DECEMBER, 1970

INCOME		EXPENDITURE	
Subscriptions & Back issues	$ 141.66	Atmosphere Printing	$3258.30
Reprints	60.50	Distribution costs	502.00
CMS Subsidy	3200.00	Typing services	143.25
Advertising Revenue	60.00	Reprint charges	147.00
Bank adjusting credit	0.08	Misc. postage	52.92
Refund of Sales Tax	665.04	Misc. printing & office supplies	25.32
	$4127.28	Subscription transfer to CMS	8.15
Current Account 1 January, 1970	139.09	Bank Service charge	4.00
	$4266.37		$4140.94
		Current Account 31 December 1970	125.43
			$4266.37

Anthony W. Smith
24 February, 1971

ESTIMATED FINANCIAL POSITION OF C.M.S.
AT THE END OF 1972

ASSETS (1 January 1971)	cash	$2570		
	reserves	1526		
			$4096	
LIABILITIES	budgeted deficit (1971)	1080		
	design of Atmosphere	290		
	promotion of Atmosphere	1000		
	Atmosphere (1970 issue)	1000		
			$3370	
ASSETS (1 January 1972)				$726
BUDGETED DEFICIT FOR 1972				$608
SURPLUS END OF 1972				$118

Five issues of ATMOSPHERE were printed and distributed: number 4 of Volume 7, numbers 1, 2 and 3 of Volume 8 and the 4th Annual Congress issue. The regular issues contained 152 pages with 9 articles and papers, 5 notes, 1 book review, 7 announcements and 18 reports about meetings, and a number of other items; one half-page ad was also published. The special Congress issue contained 48 pages of material including Society reports along with the Congress program and abstracts.

Early in 1970 the CMS Development Committee recommended that ATMOSPHERE should be developed and improved to support the professional interest of the Society. The President and Editor met with University of Toronto Press officials in February to obtain estimates regarding services that the Press could provide for our Society as follows: design a new format for ATMOSPHERE; initiate a promotional campaign to obtain more institutional and library subscriptions; print and distribute the issues; bill and collect annual membership dues and subscription fees; and maintain the mailing lists. Proposals to improve ATMOSPHERE were presented at the Annual General Meeting at Winnipeg on June 17, and accepted by the Society members. In September an agreement was signed with the Press. During November the Editor met with staff of the U of T Press to arrange for the implementation of the services.

Indexes to the contents of ATMOSPHERE were published for the first time during 1970 and include all material published since 1963: a cumulative index for Vols. 1-6 (1963-1968) and an annual index for Vol. 7 (1969) appeared in Volume 8 issues Nos. 1 and 3, respectively.

ATMOSPHERE is now listed nationally in the Canadian Serials Directory and internationally in Ulrich's International Periodical Directory. Articles are regularly indexed in Meteorological and Geoastrophysical Abstracts.

Refunds for Federal and Provincial sales taxes paid for printing ATMOSPHERE during the period from September 1968 to September 1969, were received in the amount of $665.04 from the printing company, AMG Lithographers, Ltd.

Thanks are extended to all those members who supported ATMOSPHERE by contributing papers or by giving encouragement and advice when these were most needed.

E.J. Truhlar.

ANNUAL REPORTS FROM CENTRES

B.C. CENTRE

The following are the names of the executive of the B.C. Centre of the C.M.S.

Chairman:	Dr. T.A. Black, Department of Soil Science, University of British Columbia
Vice-Chairman:	Mr. D. Faulkner, Pacific Weather Central, Vancouver International Airport
Secretary-Treasurer:	Prof. B. Sagar, Department of Geography, Simon Fraser University
Program Convener:	Dr. M. Miyake, Institute of Oceanography, University of British Columbia

The B.C. Centre experienced a successful year judging by the attendance at the meetings. The Centre has had five meetings so far during the year which included a banquet honouring the Centennial of the Canadian Meteorological Service.

Meetings have been held at the University of British Columbia, Simon Fraser University and the Vancouver International Airport. It has been customary to have coffee and donuts afterwards except in the case of public lectures. Graduate student participation has been evident. Graduate students come from the Faculties of Agriculture and Forestry, the Department of Geography and the Institute of Oceanography.

The first meeting of the 1970-71 season was held on October 20, 1970 at which Mr. S. Nikleva, Scientific Support Services, Canadian Weather Service, made a very interesting report on "Progress in Fire Weather Forecasting".

Dr. R.E. Munn, Supervisor of the Met. Service's Micro-meteorology Research Unit, gave a clear, comprehensive talk on "Air Pollution as a Global Problem" on December 8, 1970. On the following day many of the C.M.S. members joined in a Regional Pollution Workshop held in the Institute of Oceanography, with Dr. R.W. Stewart as Chairman. The workshop brought together members from the university, federal and provincial governments to discuss the problem of air pollution in the B.C. region.

Dr. F.K. Hare, Department of Geography, University of Toronto, distinguished speaker sponsored by the Canadian Meteorological Service, gave a lucid address on "Climatology and Ecology in the Canadian North" to some 350 members and guests at a public meeting at U.B.C., February 15, 1971.

Dr. T.A. Black, professor of biometeorology, in the Department of Soil Science, University of British Columbia, discussed meteorological methods of estimating evapotranspiration from forests on March 30, 1971. His comments were of particular interest to regional forest hydrologists.

The spring banquet was held on April 15 with Dr. H. Fraser as afterdinner speaker. This is the first year that a spring banquet has been organized. It is hoped to continue this activity in the future.

ALBERTA CENTRE

Executive of the Centre

Chairman	-	C.E. Thompson
Secretary	-	S.M. Checkwitch
Treasurer	-	J. Dublin
Calgary Member	-	R.K. Holbrook

Meetings of the Season

Sept. 9, 1970	Dr. A. Chisholm, Atmospheric Research Section, Canadian Meteorological Service	"Radar Studies of Alberta Hail Storms"
Nov. 5, 1970	Dr. Ignaz Verginer, Laboratory for Atmospheric Research, University of Illinois	"Lee Waves and Chinook Winds in the Colorado Rocky Mountains"
Feb. 16, 1971	Dr. F.K. Hare, University of Toronto	"Climate and Ecology in the Canadian North"
Mid-April, 1971 (tentative)	Dr. K. Hage, Dept. of Geography, University of Alberta	"Activities of the Institute of Earth and Planetary Physics"

Meetings were held in the Henry Marshall Tory Building on the Campus of the University of Alberta at the invitation of the Geography Department.

All meetings were extremely well attended. In particular Dr. Hare's timely subject drew well over 100 members and visitors.

The meeting tentatively set for mid-April is to elect a new executive and commence planning for the 6th Annual Congress of the Canadian Meteorological Society to be held in Edmonton in 1972.

REGINA CENTRE

Officers of the Regina Centre for 1970 - 71

Chairman	-	S.J. Buckler
Secretary	-	L.S. Meeres

Two scientific meetings have been held in 1970 - 71.

February 1, 1971 - S.J. Buckler, Officer-inCharge, Prairie Hydrometeorological Office

Topic - A Report on the 51st Annual Meeting of the AMS, San Francisco

February 18, 1971 - Dr. F.K. Hare, University of Toronto

Topic - Climate and Ecology in the Canadian North

The meeting of February 18th with Professor Hare was held in

the Classroom Building of the University of Saskatchewan, Regina Campus, arranged through the cooperation of the Geography Department.

In the afternoon of February 18th, a group of 30 Hydrologists, Engineers, Geographers and Meteorologists assembled in the board room of the Motherwell Building in Regina to hear and discuss a presentation by Professor Hare on "Climatology and the Water Resources of Canada".

WINNIPEG CENTRE

After hosting the Fourth Annual Congress in June the members of the Winnipeg Centre relaxed and enjoyed the famous Manitoba sunshine. However with the advent of the fall season a Junior High School project was organized. This was advertised through the local school districts and news media. The purpose of the competition was to increase public interest in meteorology and the Junior High level was chosen since meteorology is on their curriculum. The entries in this contest were displayed and judged during an exhibit at the Winnipeg International Airport during Easter week.

The 1970-71 objective was a program of monthly meetings that would highlight applied meteorology. The following series of meetings were held:

November — "Some Meteorological Aspects of Forest Protection" with Mr. Allan Jeffrey of Forest Protection Service, Manitoba Government. The talk included meteorological services to fire-fighting, reforestration, aviation fire patrols and pest control. In addition the opportunities for integrating observational programs were discussed.

December — "The Operational Use of Computer Produced Diagnostic Charts" with Mr. Michael Balshaw of the Prairie Weather Central. Mike outlined the work he has done in the calculation of vorticity and convergent fields, orographic lift and moisture patterns in the Planetary Boundary Layer and the combination of these factors in the development of a precipitation index.

January — "Weather Requirements of Agricultural Interests" with Mr. Glen Arnott, Assistant Director, Extension Service of the Manitoba Department of Agriculture. There was a lively discussion of the needs of grain farmers, specialty crops, the establishment of specially tailored weather services and methods of communication.

February — "Climate and Ecology of the Canadian North" with Professor Hare as visiting speaker courtesy of the Canadian Meteorological Service. There was a special dinner meeting with attendance the largest in the history of the Winnipeg Centre.

March — Guest speaker for World Meteorological Day was Mr. William Ward of the Environmental Health Laboratory of the Manitoba Department of Health. His talk outlined the studies being carried forward in air pollution, industrial hygiene, and water and waste disposal, and the interdependence of this work and meteorological conditions.

April — A special graphic walk-through exhibit and audio-visual presentation on the inner concourse of the mezzanine floor

at Winnipeg International Airport was held during the period April 10th to 18th. It marked the Canadian Meteorological Centennial, World Meteorological Day and the Junior High School Competition. Tape-slide presentations alternated with films in the audio-visual section while special graphics included early Winnipeg weather records, computer products, satellite and radar pictures and special weather phenomena.

The local executive for 1970-71 were Eric Dexter, Chairman; Dale Henry, Vice-Chairman; Paul Kowal, Past Chairman; and Paul Lemieux, Secretary-Treasurer.

TORONTO CENTRE

Officers of the Toronto Centre for 1970-71

Chairman	-	C.I. Taggart
Programme Secretary	-	D.W. Phillips
Treasurer	-	D. Sparrow
Secretary	-	G. Schaefer

Meetings

October 6, 1970: Dr. R.E. Munn, of the Canadian Meteorological Service, described some of the research carried out in the field of air-pollution during his six-month sabbatical in Sweden. Scientific content gave way later in the evening to a fine collection of slides centred on living conditions, sports activities and cultural aspects of life in Sweden.

December 1, 1970: Dr. L.A. Clarenburg, air-pollution consultant in the Netherlands, presented one approach to regional and town planning in relation to air-pollution. The Rotterdam region is one of concentrated chemical industry, and hence of stench. Dr. Clarenburg described a mathematical model of random spills of odorous compounds verified by response over the public complaint telephone system. An automated sulphur-dioxide sensing network and an alert system have been set in the area.

February 9, 1971: Mr. D.C. Archibald, of the Canadian Meteorological Service, took his audience via color slides and descriptive narrative across the barren lands of Antarctica. Members shared his enthusiasm as the under-ice city of Byrd Station was entered, and again as the final few hundred yards to the South Pole were crossed. Historic sites of the early days of Antarctic exploration were photographed as well as the latest in scientific activities.

March 2, 1971: Dr. Chester Langway, of the U.S. Army Cold Regions Research and Engineering Laboratory, presented a film depicting the snow and ice research activities of CRREL in both Greenland and

Antarctica. Slides and discussion then zeroed in upon particular aspects of their work. A highlight of the evening was the presentation of temperature trends dating tens of thousands of years into the past, as revealed by oxygen isotope ratios from deep ice-cores recovered from both Greenland and Antarctica.

April 7, 1971: Dr. F.K. Hare, of the University of Toronto, continued his national tour with the presentation of his lecture "Climate and Ecology in the Canadian North" as a free public lecture at the Ontario Science Centre.

The annual banquet of the Toronto Centre will feature an address by Dr. P.D. McTaggart-Cowan on the subject 'Operation Oil' which will deal with the task of restoring Chedebucto Bay after the sinking of the tanker Arrow. Time and place have yet to be established for this wind-up event.

MONTREAL CENTRE

ACTIVITIES - 1970-71 SEASON

EXECUTIVE:

Chairman:	Dr. I. Rutherford
Secretary:	Mr. C. Turnbull
Treasurer:	Mrs. A.W. Pratt
Member-of-the-executive:	Dr. K.L.S. Gunn

MEETINGS:

Sept. 16/70 Prof. James E. McDonald, University of Arizona, spoke on the environmental effects of supersonic transports. One fear discussed was that NO emissions, converted to nitrates in the ozone layer, may significantly increase the particulate matter concentration in the troposphere.

Oct. 20/70 Dr. T.J. Simons, Canada Centre for Inland Waters, gave an interpretation of atmospheric instability theory in terms of practical meteorology, suggesting that in baroclinic instability studies traditional normal mode theory must be augmented by initial value considerations. His experiments indicate a large dependence on the level at which the perturbation is introduced, with the most favourable level roughly in mid troposphere.

Dec. 10/70 Dr. Syukuro Manabe, ESSA, described his 1/3 sea-2/3 land model, which includes all ocean-atmosphere transactions, but assumes that all rivers run E - W. The model achieves reasonable circulation when run to a state of equilibrium, the main difficulties being the enormous time required for the sea to reach equilibrium and the highly critical value of the solar constant. Dr. Manabe

hopes to be able to clarify somewhat the effects of the CO_2 content of the atmosphere.

Jan. 26/71 — Mrs. Beatrice Barge, McGill, gave a well-illustrated talk about the expedition she has led the past few summers studying glacier-climate interactions on Meighen Island. She hopes to show that the glacier influences only the climate in its immediate vicinity, but that this interaction keeps the glacier alive.

Mar. 4/71 — Dr. G.A. McBean, Micrometeorology Research Unit, was to discuss some recent developments bearing on the problem of the interaction of the atmosphere with the underlying surface, both land and sea. Unfortunately, his talk had to be cancelled due to record snow-falls in Montreal.

Arrangements have been finalized to hold Prof. Hare's lecture "Climate and Ecology in the Canadian North" on Thursday April 29 under joint sponsorship with the McGill Meteorology Department. A special invitation is being extended to geographers and members of the Arctic Institute.

CENTRE DE QUEBEC

Membres du conseil d'administration:

Président:	Raymond Perrier
Vice-président:	Jean-Guy Fréchette
Conseillers:	Raymond-M. Gagnon
	Dr. André Hufty
	Rénald-C. Naud
	Dr. Lawrence-J. O'Grady
	Joseph Verrette
Secrétaire-trésorier:	Michel Ferland

Réunions d'information

6 octobre 1970 — Dr. M.M. Grandtner, professeur d'écologie forestière, Université Laval
Sujet: "Les relations climat-végétation au Québec médidional".

27 octobre 1970 — Dr. D.J. Lamberts, pédologue, Université de Louvain
Sujet: "Les changements de climat réflétés dans le développement des sols".

1er décembre 1970 — Dr. E.J. Langham, physicien, Centre Québécois des Sciences de l'Eau (Cequeau)
Sujet: "Les recherches hydrométéorologiques dans les Prairies".

26 février 1971 — M. Alcide Ouellet, chef du Bureau Météorologique de Dorval
Sujet: "Faites vos prévisions".

20 avril 1971 — Professeur F.K. Hare, Université de Toronto
Sujet: "Climate and Ecology in the Canadian North".

CANADIAN METEOROLOGICAL SOCIETY

Tentative Budget for 1972

RECEIPTS				
Fees - general	500 @ 14.00		$7,000.00	
- student	100 @ 2.00		200.00	
- corporate	1 @ 40.00		40.00	
Subscriptions	300 @ 9.00		2,700.00	
Total Receipts				$9,940.00
EXPENDITURES				
Atmosphere				
- billing & mailing	(20% of 9940)	$1988.00		
- distribution	(900 x 1)	900.00		
- printing		5800.00		
			$8,688.00	
Annual Congress - typing	40.00			
- mailing	60.00			
- printing	700.00			
			$800.00	
Awards & Prizes			150.00	
Auditor			30.00	
Grants to Centres			300.00	
Operating Costs of Executive				
- bank charges		30.00		
- postage		100.00		
- printing & stationery		450.00		
Total Expenditures			$580.00	
				$10,548.00
BUDGETED DEFICIT				$ 608.00

STANSTEAD SEMINAR 1971

The Ninth Stanstead Seminar will be held this coming summer at the Macdonald Campus of McGill University, July 12th to 16th, 1971. The theme for this year is "Dynamical and Numerical Modelling of Atmospheric Motions." Among the invited speakers will be: Dr. D.K. Lilly, NCAR; Dr. T.N. Krishnamurti, Florida State University; Dr. J. Brown, National Meteorological Center, NOAA; and Dr. A.J. Robert, Canadian Meteorological Service. For further information contact Dr. P.E. Merilees, Dept. of Meteorology, Burnside Hall, McGill University, Montreal, Canada. Tel: 514-392-4462.

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.

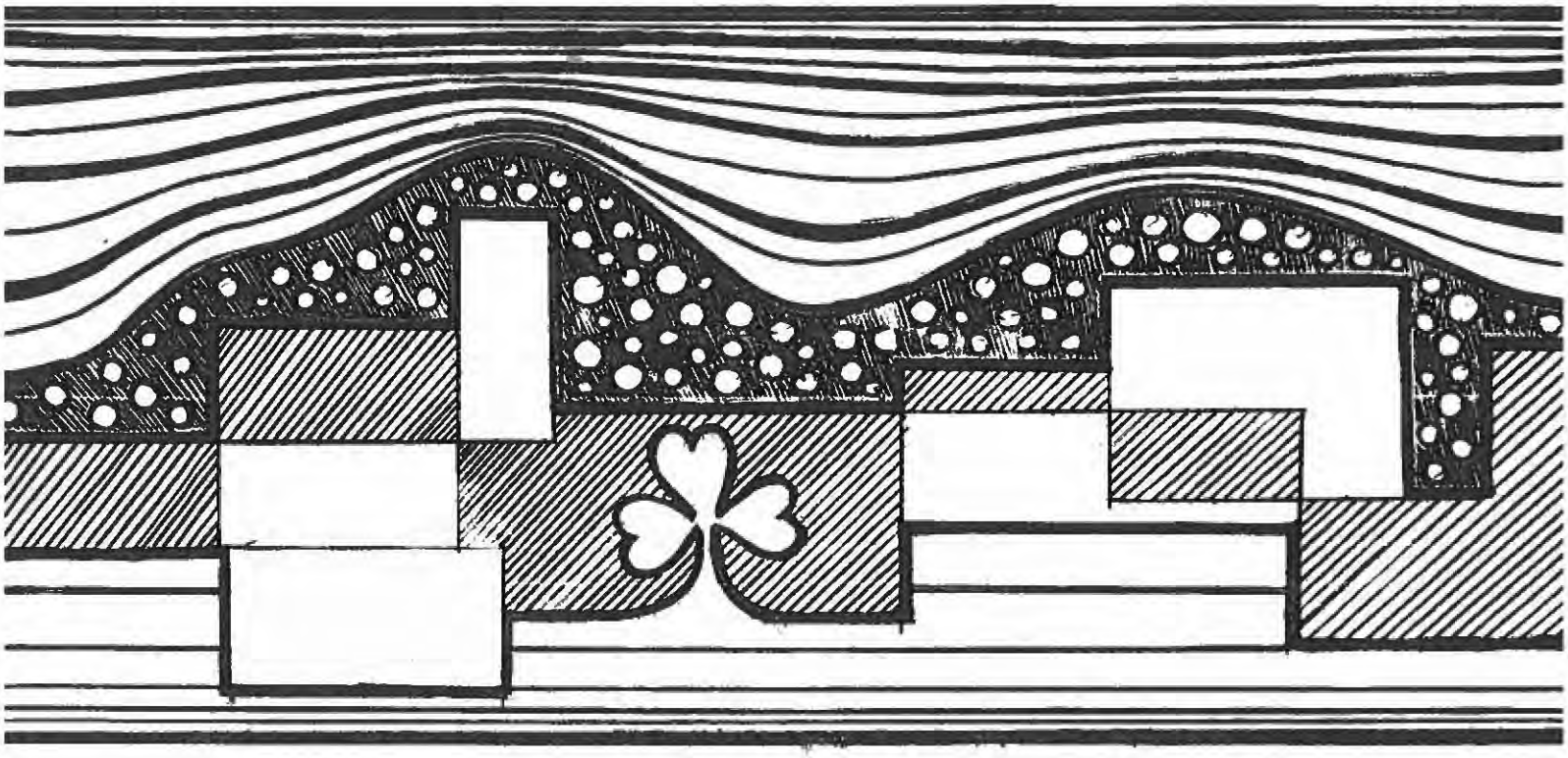
For further information regarding membership, please write to the Corresponding Secretary, Canadian Meteorological Society, P.O. Box 851, Adelaide Street Post Office, Toronto 210, Ontario.

There are three types of ordinary membership - Member, Student Member and Corporate Member. For 1971, the dues are $14.00, $2.00 and $40.00, 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.

Compton 1971

2ND CANADIAN CONFERENCE ON MICROMETEOROLOGY

5TH ANNUAL CONGRESS C.M.S.



MACDONALD COLLEGE MAY 10-14, 1971

SECOND CANADIAN CONFERENCE ON MICROMETEOROLOGY

FIFTH ANNUAL CONGRESS, CANADIAN METEOROLOGICAL SOCIETY

PROGRAM

Monday May 10

0830:	Registration.	
0900-1130:	Opening, Second Canadian Conference on Micrometeorology.	
	Session 1: Agriculture and Forestry.	Room C250
1330-1425:	Session 2, Lecture: Climatonomy - H. H. Lettau.	Room C250
1425-1445:	Coffee.	
1445-1630:	Session 3a: Air Pollution.	Room C250
	Session 3b: Heat and Water Budget of Small Lakes.	Room C218

Tuesday May 11

0900-1200:	Session 4a: Instruments (1).	Room C250
	Session 4b: The Ekman Layer.	Room C218
1400-1455:	Session 5, Lecture: GARP and Small Scale Meteorology - R. W. Stewart.	Room C250
1455-1515:	Coffee.	
1515-1700:	Session 6a: Turbulence and Fluxes.	Room C250
	Session 6b: Instruments (2).	Room C218

Wednesday May 12

0830-1130:	Opening, Congress of Canadian Meteorological Society.	
	Session 7: Urban Meteorology.	Room C250
1230:	Buses leave Macdonald Campus for McGill. Sessions 8 and 9 will be held in the Main Lecture Theatre, Otto Maass Chemistry Building, McGill.	
1330-1450:	Session 8: Human Responses.	
1450-1600:	Session 9: Urban Air Pollution.	
1600-1730:	Official opening of Burnside Building and reception by occupying Departments.	
1730-2000:	Dinner "en ville".	

Wednesday May 12 (cont'd.)

1745: One bus leaves for Macdonald Campus.

2000-2230: Annual Business Meeting, Canadian Meteorological Society, Burnside Building, McGill.

2230: Buses leave McGill for Macdonald Campus.

Thursday May 13

0830-1130:	Session TH 1:	Numerical Weather Prediction I.	Room C250
1330-1630:	Session TH 2:	Numerical Weather Prediction II.	Room C250
	Session TH 3:	Radiation.	Room C218

1700-1930: Pre-banquet "warm-up"; cash bar, new Dining Room, Stewart Hall.

1930: Banquet, Canadian Meteorological Society.
Presentation of Patterson Metal.
Salute to Centennial of Canadian Meteorological Service.
Guest Speaker: Prof. Roger Bider, Macdonald College -
"The Ecology Project on the New Montreal International Airport".

Friday May 14

0830-1130:	Session FR 1:	Hail and Fog.	Room C250
1330-1630:	Session FR 2:	Hail and Cloud Physics.	Room C250
	Session FR 3:	General.	Room C218

MACDONALD COLLEGE

Macdonald College of McGill University was founded by Sir William Macdonald (of tobacco fame) for the furtherance of education and research, with particular reference to the needs of the population in rural districts, including teacher training; classes began in the Fall of 1907. For many years, the College consisted of three major divisions - Agriculture, Household Science, and Education. In 1970 the Faculty of Education moved to the McGill Campus in downtown Montreal, leaving on this Campus the Faculty of Agriculture, in which is included the School of Food Science.

This Fall will bring a new look to the academic activities of the College. The "traditional" professional programs in the agricultural sciences are being re-vamped, and a number of new B.Sc. programs introduced, extending the Faculty's concern with the environment and with world resources, within the four major divisions of Agricultural Sciences, Biological Sciences, Food and Consumer Science, and Renewable Resources Development. A number of the planned courses will acquaint the students with the problems of atmospheric interaction with earth, water, and the living materials that populate the biosphere. As a consequence, many members of the Faculty, and graduate students, have expressed interest in this week's conference proceedings, and will be attending some or all of the sessions. We hope you will welcome them into the conference halls with the same warmth as that with which they welcome you to this Campus.

THE CAMPUS AND SURROUNDINGS

Ste. Anne de Bellevue and the Macdonald Campus lie on the southwestern tip of Montreal Island, where the Ottawa River flows into the St. Lawrence beneath the bridge at Ste. Anne. Under the bridge is a lock, through which pleasure boats bypass the rapids. Above the rapids is the Lake of Two Mountains, where the Ottawa River broadens as its waters are directed around Montreal Island. It is a short and pleasant walk to the lock, from where can be obtained a fine view of the rapids and of the Lake of Two Mountains.

The old fur brigades, paddling to the west from Lachine via the Ottawa River, used to stop at Ste. Anne and to congregate in the church there to pray for a safe voyage, and again upon their return to offer thanksgiving. The old church stood near the site of the present one, near the lock.

Simon Fraser owned a house in Ste. Anne, which is maintained as an historic site. Light lunches are served in the Simon Fraser House, on Ste. Anne Street, near the bridge.

The Morgan Arboretum is a nature and wild-life preserve, situated north of the Trans-Canada Highway, the entrance being near the Radar Observatory. Here are 60 acres of sugar bush, 22 acres of undisturbed natural environment, collections of Canadian trees, forest tree nurseries, etc. You can drive only as far as the parking lot at the entrance, but there are many beautiful walks and trails through the area. But please do not disturb the environment - the wildlife, flowers and trees are to be enjoyed, not disturbed. And no smoking, please. Maps are available at the registration centre.

ENERGY INTAKE AND THE ALCOLOGIC CYCLE

Meals will be available in the gracious Old Dining Room, Stewart Hall; see the notice board for hours of service. There are several restaurants in the town of Ste. Anne de Bellevue, along the main street; these include the historical old Simon Fraser House, near the bridge at the end of Ste. Anne Street, about ten minutes' walk from the Campus. Those with cars will find restaurants at Ile Perrot (just across the bridge), at Dorion (about 5 miles southwest on Route 2/20), at Baie d'Urfé Plaza (about 2 miles east, corner of Route 2/20 and Morgan Road), as well as further along Route 2/20 towards Montreal at Beaconsfield, Pointe Claire, Dorval, etc.

A variety of dispensing machines (coffee, soft drinks, snacks, etc.) are to be found in the basement of the Main Building. Light lunches (soup, sandwich, hamburger) are also obtainable at the Snack Bar, Centennial Centre (the stone/brick/glass cube a few hundred yards to the rear of Stewart Hall). Hours there are 11:00 a.m. to 2:00 p.m. only.

The alcological cycle can be studied - under field conditions - at the BAR-DISCO, operated by the students for the benefit of the Conferences, and located in the basement of the Centennial Centre. See the hours on the notice board. Other oases can be found in Ste. Anne, and at the various restaurant locations mentioned above. Those who aspire to total saturation (field capacity) are referred to the local QLB retail outlets, one in Ste. Anne and one at Baie d'Urfé Plaza.

STORMY WEATHER GROUP RADAR OBSERVATORY

The radar observatory of McGill's Stormy Weather Group is located near the Macdonald Campus, at the entrance to the Morgan Arboretum on the north side of the Trans-Canada Highway. Conference delegates are welcome to visit the installation. If transportation is needed, phone the Observatory at 453-7370.

BURNSIDE HALL, McGILL UNIVERSITY

Burnside Hall, the newest building on the downtown campus, will be officially opened by the Principal at 4:00 p.m., Wednesday May 12. The opening ceremony is but one of the many events celebrating McGill's one hundred and fiftieth anniversary this year. The Departments that occupy the building - Computing Centre, Computing Sciences, Geography, Mathematics, and Meteorology - have arranged special seminars and lectures in honour of the occasion. The Wednesday afternoon joint sessions of the Conference on Micrometeorology and of the Canadian Meteorological Society will be held on the McGill campus, and will conclude in time for the opening ceremonies. Participants are invited to attend the ceremonies and the reception in Burnside Hall.

Buses will leave Macdonald College for McGill at 1230 Wednesday, and will return at 2230 after the Annual Meeting of the CMS. For anyone wishing an earlier return to Macdonald, one bus will leave McGill at 1745.

DINNER "EN VILLE"

Following the Wednesday afternoon session on the downtown McGill campus and before the CMS business meeting at 2030, you will have an ideal opportunity to sample the gourmet delights of Montreal. It is but a short walk or drive from McGill to many fine restaurants and dining-rooms. In particular, don't overlook

Old Montreal, where parts of the original town have undergone restoration and where many quaint eating places are to be found in old stone buildings on cobbled side streets. Members of the Montreal Centre will be happy to serve as advisors and guides and to share your company at table.

MISCELLANY

A POST OFFICE is located on the Campus, in the basement of the Main Building; and another one is located on Ste. Anne Street, Ste. Anne.

There are branch offices, Bank of Montreal and Banque Canadienne Nationale, in Ste. Anne; the Bank of Montreal has also a branch at the Baie d'Urfé shopping plaza (Route 2/20 at Morgan Road).

Ste. Anne de Bellevue is served by the Autobus Metropolitain Provincial, whose buses leave Ste. Anne every half-hour (at 3 and at 33 minutes past the hour) for downtown Montreal; they can be boarded in Ste. Anne at the Bellevue Snack Bar, or on the Lakeshore Road at the campus gate. From the city, they leave the downtown area on a similar schedule, with a stop at the campus gate. The town is also served by the C.P. Railway, the station being about a ten-minute walk from the campus. Bus and CPR timetables are posted in the registration area. Taxi services are available; phone numbers are listed below.

Bellevue Radio Taxi	453-2000
Ste. Annes Taxi	453-1100
Lakeshore Radio Taxi	695-5555
Pincourt Radio Taxi	453-8037
Air Canada (Canada and U.S.A.)	931-4411
Air Canada (international)	937-8555

Autobus Metropolitain	453-5623
CNR (Montreal)	877-6550
CN Telegraph	861-4211
CPR (Ste. Anne)	453-5644
(Montreal)	866-5581
CP Telegraph	861-4211