Atmosphere-Ocean

Canadian Meteorological and Oceanographic Society

La Société Canadienne de Météorologie et d'Océanographie

17th Annual Congress

3 – 5 May 1983
Banff, Alberta

17^{e} Congrès Annuel

3 – 5 mai 1983
Banff (Alberta)

17th Annual Congress Issue

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The new symbol for Canadian Meteorological and Oceanographic Society which is shown on the cover was designed at University of Toronto Press by Beth Earl.

The Image

The symbol depicted is comprised of three elements of the natural world: air, water and ice. The initial impression is of ice, then ice in water, and then atmosphere surrounding both.

The 'arrowhead' iceberg points upward to suggest growth, positive research, and mobility, and the clean, clear, uncomplicated lines suggest the open, new directions of the Society. The floating shape suggests another aspect of the membership, that of balance and stability.

The emphasis on ice is appropriate for this Canadian society. Canada's research position in atmospheric and oceanographic studies indicate this as a potential area of specialization. This very Canadian aspect is appropriate in its uniqueness.

The square shape works well conceptually and graphically; it represents the unity of natural elements; it creates a clean, strong shape that is appropriate to many applications.

The name of the Society, in English and French, is used at the base of the symbol in a formal, modern style.

Le nouvel emblème de la Société Canadienne de Météorologie et d'Océanographie, qui figure sur la couverture, a été dessiné aux Presses de l'Université de Toronto par Beth Earl.

Le Dessin

Cet emblème se compose de trois éléments du monde naturel: l'air, l'eau et la glace. Ce qui retient d'abord l'attention c'est la glace, puis la glace dans l'eau et enfin l'atmosphère qui les entoure.

L'iceberg "en fer de lance" est dirigé vers le haut, donnant ainsi une idée de croissance, de recherche et de mobilité; les lignes parallèles simples, nettes et droites représente la nouvelle direction très souple prise par la Société. L'iceberg qui flotte se réfère à une autre caractéristique de l'association: équilibre et stabilité.

Que l'accent soit mis sur la glace convient particulièrement à cette société canadienne. En raison de la place occupée par le Canada dans le champ des études atmosphériques et océanographiques, il se peut que cela devienne un domaine de spécialisation. C'est là un des aspects uniques du Canada.

D'un point de vue conceptuel et graphique la forme carrée convient tout à fait: elle représente l'unité des éléments naturels et donne une impression de force et de netteté dont le symbolisme est plurivalent.

Dans un style à la fois moderne et conventionnel, le nom de la Société figure, en anglais et en français, au bas de l'emblème.

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Seventeenth Annual Congress
Canadian Meteorological and Oceanographic Society

The Seventeenth Annual Congress and Annual General Meeting of the Canadian Meteorological and Oceanographic Society will be held at the Banff Springs Hotel, Banff, Alberta, May 3-5, 1983. The primary theme of the meeting is *Day-1 Forecasting*; the secondary theme is the *Remote Sensing of Sea Ice*. The Congress affords Society members the opportunity of attending sessions that cover all aspects of meteorology and oceanography.

The Scientific Programme and the local arrangements were organized by:

SCIENTIFIC PROGRAMME COMMITTEE

G.L. Austin, Chairman
H. Allard
H.-R. Cho
J.M. Powell
R.O. Ramseier

LOCAL ARRANGEMENTS COMMITTEE

J.M. Powell, Chairman
F. Robitaille, Facilities
E. Hudson, Exhibits
N. Parker, Social
F. Finstad and L. Stovel, Secretary/Publicity
T. Medlicott, Treasurer/Registration
C. Sakiw, Alberta Centre Liaison

Dix-septième congrès annuel
Société Canadienne de Météorologie et d'Océanographie

Les dix-septièmes congrès annuel et réunion générale annuelle de la Société canadienne de météorologie et d'océanographie auront lieu à l'Hôtel Banff Springs à Banff (Alberta), et dureront du 3 au 5 mai, 1983. Le congrès a pour thème principal les *Prévisions pour 1 jour*; le thème secondaire est la *Télédétection de la glace de mer*. Ce congrès offre aux membres de la Société l'opportunité d'assister à des sessions qui englobent tous les aspects de la météorologie et de l'océanographie.

Le programme scientifique et les arrangements locaux ont été préparés par:

LE COMITÉ DU PROGRAMME SCIENTIFIQUE

G.L. Austin, Président
H. Allard
H.-R. Cho
J.M. Powell
R.O. Ramseier

LE COMITÉ DES ARRANGEMENTS LOCAUX

J.M. Powell, Président
F. Robitaille, responsable de la location des lieux
E. Hudson, responsable des expositions
N. Parker, responsable des activités sociales
F. Finstad et L. Stovel, Secrétaire/Publicité
T. Medlicott, Trésorier/inscriptions
C. Sakiw, liaison avec le Centre de l'Alberta

Summary of Sessions

Monday, May 2			**Room**
0900 - 1200		CMOS Editorial Committee	Frontenac
0900 - 1200		CMOS Education Committee	Duchess
0900 - 1200		CNC/SCOR	Mackenzie
1230 - 2100		Registration/Information Desk	
1300 - 1645		CMOS Scientific Committee	Frontenac
1300 - 1645		CNC/SCOR	Mackenzie
1400 - 1645		CMOS Centre Chairperson Committee	Duchess
1400 - 1700		CMOS Professionalism Committee	Empress
1700 - 1800		CMOS Council Meeting (Session I)	Frontenac
1900 - 2100		CMOS Council Meeting (Session II)	Frontenac
2030 - 2230		Wine and Cheese Ice Breaker	Riverview Lounge
2100 - 2130		Registration	Oval
Tuesday, May 3			
0830 - 1030	1	Welcome and Plenary	Ballroom
		Day-1 Forecasting	
1050 - 1230	2A	Forecast Verification	Ballroom
	2B	Climatology I	Champlain
	2C	Oceanography I	Oak
1230 - 1330		Patterson Award Luncheon	
1330 - 1520	3	Remote Sensing of Sea Ice	Ballroom
1540 - 1730	4A	Aviation Meteorology	Ballroom
	4B	Climatology II	Champlain
	4C	Sea Ice	Oak
Wednesday, May 4			
		Field Trip - Avalanche Hazard System	
0830 - 1000	5A	Operational Meteorology I	Ballroom
	5B	Dynamic Meteorology	Champlain
	5C	Oceanography II	Oak
1020 - 1200	6A	Operational Meteorology II	Ballroom
	6B	Numerical Modelling	Champlain
	6C	Oceanography III	Oak
1300 - 1430	7A	Operational Meteorology III	Ballroom
	7B	Cloud Physics	Champlain
	7C	Oceanography IV	Oak
1430 - 1600	8	Exhibits and Posters	Ballroom
1600 - 1745	9A	Meteorological Remote Sensing	Champlain
	9B	Boundary Layer	Oak
	9C	Agricultural and Forest Meteorology	Norquay
1745 - 1830		Special Interest Group Meetings	
1830 - 1930		Cocktail Hour	Alhambra
1930 -		Banquet	Alhambra
Thursday, May 5			
0830 - 1000	10A	Mesoscale Meteorology Workshop Report	Alhambra
	10B	Meteorological Techniques	Champlain
	10C	Environmental Meteorology	Oak
1020 - 1200	11	Day-1 Forecasting Panel Discussion	Alhambra

Résumé des sessions

Lundi le 2 mai			**Salle**
0900 - 1200		Comité de rédaction de la SCMO	Frontenac
0900 - 1200		Comité de l'éducation de la SCMO	Duchess
0900 - 1200		CNC/SCOR	Mackenzie
1230 - 2100		Inscription / Renseignement	
1300 - 1645		Comité scientifique de la SCMO	Frontenac
1300 - 1645		CNC/SCOR	Mackenzie
1400 - 1645		Comité des présidents des centres de la SCMO	Duchess
1400 - 1700		Comité de la SCMO sur le professionalisme	Empress
1700 - 1800		Conseil de la SCMO (Session I)	Frontenac
1900 - 2100		Conseil de la SCMO (Session II)	Frontenac
2030 - 2230		Vins et fromage pour briser la glace	Riverview Lounge
2100 - 2130		Inscription	Oval
Mardi le 3 mai			
0830 - 1030	1	Souhait de bienvenue et séance plénière Prévisions pour 1 jour	Ballroom
1050 - 1230	2A	Vérification de la prévision	Ballroom
	2B	Climatologie I	Champlain
	2C	Océanographie I	Oak
1230 - 1330		Repas à l'occasion de la remise de la médaille Patterson	
1330 - 1520	3	Télédétection de la glace de mer	Ballroom
1540 - 1730	4A	Météorologie aéronautique	Ballroom
	4B	Climatologie II	Champlain
	4C	La glace de mer	Oak
Mercredi le 4 mai			
		Visite d'une installation d'avertissement en cas d'avalanches	
0830 - 1000	5A	Météorologie opérationnelle I	Ballroom
	5B	Météorologie dynamique	Champlain
	5C	Océanographie II	Oak
1020 - 1200	6A	Météorologie opérationelle II	Ballroom
	6B	Modélisation numérique	Champlain
	6C	Océanographie III	Oak
1300 - 1430	7A	Météorologie opérationnelle III	Ballroom
	7B	Physique des nuages	Champlain
	7C	Océanographie IV	Oak
1430 - 1600	8	Séance d'affichage et affiches	Ballroom
1600 - 1745	9A	Télédétection en météorologie	Champlain
	9B	La couche limite	Oak
	9C	Agrométéorologie et météorologie forestière	Norquay
1745 - 1830		Réunion des groupes d'étude de sujets particuliers	
1830 - 1930		Cocktails	Alhambra
1930 -		Banquet	Alhambra
Jeudi le 5 mai			
0830 - 1000	10A	Rapport de l'atelier sur la météorologie à l'échelle moyenne	Alhambra
	10B	Techniques en météorologie	Champlain
	10C	Météorologie environnementale	Oak
1020 - 1200	11	Réunion-débat sur les prévisions pour 1 jour	Alhambra

Programme

Tuesday morning, 3 May 1983

Session 1: Day-1 Forecasting *Chairman: D. Beran*	Tuesday 0830 – 1030, Ballroom
The AES's Day-1 priority	*D.K. Smith, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
The requirements for improved short-range forecasting	*Don Beran, NOAA, Boulder, Colorado 80303*
Nowcasting of convective storm outflows	*James Wilson and John McCarthy, National Center for Atmospheric Research, Boulder, Colorado 80307*
The use of satellite imagery in forecasting convective weather	*John M. Bullas, Atmospheric Environment Service, Western Region, Edmonton, Alta T6H 5H6*
Case studies of mesoscale prediction using combined GOES satellite data and radar imagery	*A. Bellon, G.L. Austin and A. Kilambi, McGill Weather Radar Observatory, Ste-Anne-de-Bellevue (Québec) H9X 1C0*
Test results from Rainsat	*Patrick King and J. David Steenbergen, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Maximum snowfall trajectories for East Coast storms: 0- to 12-hour forecasts from satellite imagery	*John Pearce, Atlantic Weather Centre, Bedford, N.S. B4A 1E5*
Coffee (1030 – 1050)	
Session 2A: Forecast Verification *Chairman: I. Rutherford*	Tuesday 1050 – 1230, Ballroom
An assessment of the performance of operational probability of precipitation amount forecasts	*L.J. Wilson and H.R. Stanski, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
MOS and Perfect Prog wind forecasts in Canada – development and comparison with subjective wind forecasts	*W.R. Burrows and A. Maarouf, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
A study of hemispheric forecast error correlation structure	*H.J. Thiébaux, Dalhousie University, Halifax, Nova Scotia B3H 4H8* *H.L. Mitchell and D.W. Shantz, Recherche en prévision numérique, Service de l'environnement atmosphérique, Dorval (Québec) H9P 1J3*
Comparison of CMC 36-h prognostic 500-mb height before and after ship PAPA's removal	*Daniel Poirier, Pacific Weather Centre, Atmospheric Environment Service, Vancouver, B.C. V6P 6H9*
A measure of forecast reliability	*M.D. Hewson, NORDCO Ltd, St John's, Nfld A1B 3T2*

National verification system – a summary of the first year's data	*Doug Fraser, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Temperature forecast verification at the Ontario Weather Centre	*J. Vanos, Ontario Weather Centre, Atmospheric Environment Service, Malton, Ont.*
Session 2B: Climatology I *Chairman: E. LeDrew*	Tuesday 1050 – 1230, Champlain Room
Cloud statistics for Ontario and Québec	*P. Joe, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Offshore advection climatology for the East Coast of North America	*T.B. Low and R.J. Kolomeychuk, Environmental Applications Group Ltd, Toronto, Ont. M5R 2H4* *D.M. Whelpdale, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Climatology of the Scotian Shelf	*K.F. Harry, Seaconsult Marine Research Ltd, Vancouver, B.C. V6P 6G5*
On calculation of vertical fluxes of heat and momentum through the sea surface using historical data from ships	*Fred W. Dobson and Stuart D. Smith, Bio 50, Dartmouth, N.S.*
A method for developing offshore wind rose climatologies for data-sparse areas on the east coast	*T. Agnew, Canadian Climate Centre, Downsview, Ont. M3H 5T4* *T.B. Low and R.J. Kolomeychuk, Environmental Applications Group Ltd, Toronto, Ont. M5R 2H4*
Session 2C: Oceanography I *Chairman: G. Ingram*	Tuesday 1050 – 1230, Oak Room
The alongshore structure of low-frequency current fluctuations on the British Columbia continental shelf	*T. Yao and L.A. Mysak, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5* *H.J. Freeland, Institute of Ocean Sciences, Sidney, B.C. V8L 4B2*
Is the Sitka eddy topographically induced?	*G.E. Swaters and L.A. Mysak, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5*
Dispersion of patches with non-zero initial dimensions	*B. Sanderson, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5* *A. Okubo, Marine Sciences Research Center, State University of New York, Stony Brook, New York 11794*
Solitary internal waves in Davis Strait	*Patrick Cummins and Paul LeBlond, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5*
Mesoscale eddy statistics from North Pacific synoptic XBT surveys	*W.J. Emery and K. Thomson, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5*

Real-time dynamic heights from digital XBT data	*W.J. Emery and W.G. Lee, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5*

Lunch (1230 – 1330)

Tuesday afternoon, 3 May 1983

Session 3: Remote Sensing of Sea Ice *Chairman: R. Ramseier*	Tuesday 1330 – 1520, Ballroom
An operational demonstration study by using NIMBUS-7 passive microwave data	*R.O. Ramseier and H. McRuer, Atmospheric Environment Service, Ice Centre, Environment Canada, Ottawa, Ont. K1A 0H3*
Near real-time sea-ice maps from satellite data	*F.W. Thirkettle and P. Filseth, Ph.D. Associates Inc., Rexdale, Ont. M9W 2T6*
Retrieval of sea-ice properties from the Nimbus-7 SMMR	*I. Rubinstein, Ph.D. Associates Inc., Rexdale, Ont. M9W 2T6*
Microwave emission from high arctic sea ice during freeze-up	*B.E. Troy, Jr. and J.P. Hollinger, Space Sensing Application Branch, Naval Research Laboratory, Washington, D.C. 20375* *R.O. Ramseier and K.W. Asmus, Atmospheric Environment Service, Environment Canada, Ottawa, Ont. K1A 0H3* *M.F. Hartman, Computer Sciences Corporation, Silver Spring, Maryland 20910* *C.A. Luther, Office of Naval Research, Arlington, Virginia 22217*
Arctic marine ice cover relief investigation using aerial microwave, laser and photographic data	*S. Martindale and V.L. Shaw, F.G. Bercha and Associates Ltd, Calgary, Alta T2N 0E6* *R.O. Ramseier, Atmospheric Environment Service, Ice Centre, Environment Canada, Ottawa, Ont. K1A 0H3*
Étude de la distribution et de la taille des floes dans les eaux de Terre-Neuve	*Y. Carrier, Département de géographie, Université d'Ottawa, Ottawa, Ont.* *W.S. Appleby, Météorologue du milieu marin, Administration du pétrole et du gaz des terres du Canada, Ottawa, Ont. K1A 0E4*
A time-series study of gulf of St Lawrence sea ice using Nimbus-7 SMMR data	*Anne E. Owens, Ph.D. Associates Inc., Rexdale, Ont. M9W 2T6*

Coffee (1520 – 1540)

Session 4A: Aviation Meteorology *Chairman: J. Wilson*	Tuesday 1540 – 1730, Ballroom
Low-level wind shear: detection and warning for the aviation system	*John McCarthy and James Wilson, National Center for Atmospheric Research, Boulder, Colorado 80307*
Verification of aviation terminal forecasts for Halifax International Airport	*H.R. Stanski and A.P. Leganchuk, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*

Thunderstorm nowcasting utilizing Doppler radar	*James Wilson, National Center for Atmospheric Research, Boulder, Colorado 80307*
Local variations in visibility restrictions as observed on Melville Island	*D.M. Leahey, A.L. Jamieson and M.C. Hansen, Western Research & Development Ltd, Bow Valley Resource Services Limited, Calgary, Alta T2E 6L5*
Forecasting airframe icing: some problems and recommendations	*Heather Auld, Canadian Forces Base Trenton, Astra, Ont. K0K 1B0*
Doppler radar measurements in the pre-storm environment	*I. Zawadzki, Université du Québec à Montréal, Montréal (Québec) H3C 3P8* *R. Rabin, NSSL, Norman, Oklahoma*

Session 4B: Climatology II *Chairman: G. Boer*	Tuesday 1540 – 1730, Champlain Room
Possible climatic effects of volcanic stratospheric aerosols investigated in a 1-D radiative-photochemical-convective model	*R.K.R. Vupputuri and J.-P. Blanchet, Canadian Climate Centre, Atmospheric Environment service, Downsview, Ont. M3H 5T4*
The simulation of five annual cycles with the CCC General Circulation Model	*G.J. Boer, N.A. McFarlane and R. Laprise, Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
A comparison of various snow gauges on the Canadian Prairies for the winter 1981 – 1982	*K.H. Jones, Scientific Services, Atmospheric Environment Service, Regina, Sask. S4P 3W5*
Dynamic climatology associated with the fall interval of ice expansion in the Beaufort Sea	*Ellsworth F. LeDrew, University of Waterloo, Waterloo, Ont. N2L 3G1*
Snow climatology of the southern Canadian Rockies	*F.D. Barlow, F.E. Robitaille, J.D. Mason and C.M. Sackiw, Alberta Research Council, Edmonton, Alta T6H 5R7*
An equatorial sea-surface temperature anomaly experiment with the CCC General Circulation Model	*G.J. Boer, Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
A global carbon cycle model	*K. Higuchi, Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*

Session 4C: Sea Ice *Chairman: R. Inkster*	Tuesday 1540 – 1730, Oak Room
Forecasting sea-ice conditions in Alaskan coastal waters	*Bruce D. Webster, Ocean Services Unit, National Weather Service, Anchorage, Alaska 99513*
On simulating large-scale iceberg drift	*Donald O. Hodgins, Seaconsult Marine Research Ltd, Vancouver, B.C. V6P 6G5*
Estuarine flow driven by ice growth (Bridport Inlet, N.W.T.)	*P. Greisman, Dobrocky SEATECH Limited, Sidney, B.C. V8L 4M7* *R.A. Lake, Institute of Ocean Sciences, Sidney, B.C. V8L 4B2*

A comparative study of two sea-ice thermodynamic models	*R. Gabison, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Under-ice plume characteristics in Hudson and James Bays	*R. Grant Ingram, Institute of Oceanography, McGill University, Montréal (Québec) H3A 2B2* *S. Peck, Fisheries and Oceans Canada, Québec (Québec)*
A two-layer numerical model of freshwater plumes under an ice cover	*N.G. Freeman, Ocean Science and Surveys, P.O. Box 5050, Burlington, Ont. L7R 4A6*

Wednesday morning, 4 May 1983

Session 5A: Operational Meteorology I *Chairman: D. Smith*	Wednesday 0830 – 1000, Ballroom
Forecast delivery	*A.H. Campbell, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
The use of Telidon technology for the dissemination of weather information	*D. Dueck, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
On the role of the meteorological technician in short-range forecasting	*Roy Lee, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
ABC verifications	*B.W. Crowe, Prairie Weather Centre, Atmospheric Environment Service, Winnipeg, Man. R3C 3V4*
Proposed system for the tabulation of forecast elements and verification of public forecasts	*B.Q. de Lorenzis, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Wind chill – a new perspective	*R.V. Colpitts, Atmospheric Environment Service, Bedford, N.S. B4A 1E5*
Enhancement of a numerical weather element prediction system by statistical error feedback	*E.J. Kirkwood and K.R. Johnstone, Atmospheric Environment Service, Dorval (Québec)*
Session 5B: Dynamic Meteorology *Chairman: J. Derome*	Wednesday 0830 – 1000, Champlain Room
A study of the energetics of the Southern Hemisphere summertime wavenumber five	*S. Lambert, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
A diagnostic study of the momentum balance in the Northern Hemisphere winter stratosphere	*Kevin Hamilton, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5*
Blocking-like solutions of the potential vorticity equation	*Herschel Mitchell, Recherche en prévision numérique, Service de l'environnement atmosphérique, Dorval (Québec) H9P 1J3* *Jacques Derome, Department of Meteorology, McGill University, Montréal (Québec) H3A 2K6*
On finite-amplitude topographic disturbances	*Jacques Derome, Department of Meteorology, McGill University, Montréal (Québec) H3A 2K6*

Analytical surface pressure and drag for linear, hydrostatic flow over three-dimensional elliptical mountains	*Doug S. Phillips, The University of Alberta, Edmonton, Alta T6G 2H4*
First-order dynamics of tropical disturbances	*Han-Ru Cho and Mary Ann Jenkins, Department of Physics, University of Toronto, Toronto, Ont. M5S 1A7*

Session 5C: Oceanography II — Wednesday 0830 – 1000, Oak Room
Chairman: P. LeBlond

The disappearance of the Alaskan Gyre 1981 – 82: the anomalous tracks of drogued buoys	*W.J. Emery, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5*
Modelling and observations of the fluctuations of the Fraser River Plume	*Louise Royer, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1W5*
Circulation and dispersion on Browns Bank	*Peter C. Smith, Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2*
The anticyclonic, baroclinic eddy off Sitka, Alaska	*S. Tabata, Institute of Ocean Sciences, Sidney, B.C. V8L 4B2*
Hydrochimie de l'estuaire moyen du Saint-Laurent et du fjord du Saguenay	*Jean Lebel, Département d'océanographie, Université du Québec à Rimouski, Rimouski (Québec) G5L 3A1*

Coffee (1000 – 1020)

Session 6A: Operational Meteorology II — Wednesday 1020 – 1200, Ballroom
Chairman: H. Allard

Cyclogenesis in the lee of the Alaska Range	*Jeffrey P. Walker, National Weather Service Forecast Office, Anchorage, Alaska 99513*
The use of enhanced visible imagery in analysis and short-range forecasting	*Philip R.J. Chadwick, Maritimes Weather Office, Bedford, N.S. B4A 1E5*
Heavy rainfall in east central Saskatchewan on 16 – 17 July 1982: a case study of a mesoscale analysis and short-range forecast problem	*Gerald D. Machnee, Box 2, Group 336, RR3, Selkirk, Man. R1A 2A8*
The Spatial/Temporal RESolution Study (STRESS) of upper-air data	*C.M. Sackiw and G.S. Strong, Alberta Research Council, Edmonton, Alta T6H 5R7*
The identification of severe weather from satellite imagery	*A. Kilambi, A. Bellon and G.L. Austin, McGill Weather Radar Observatory, Ste-Anne-de-Bellevue (Québec) H9X 1C0*
Applications of the Synoptic Index to regional forecasts of convective complexes	*G.S. Strong and W.D. Wilson, Alberta Research Council, Red Deer, Alta*

Session 6B: Numerical Modelling *Chairman: H.-R. Cho*	Wednesday 1020 – 1200, Champlain Room
Introduction of a finite-element boundary-layer model into a NWP model	*Robert Benoit and Jean Côté, Recherche en prévision numérique, Service de l'environnement atmosphérique, Dorval (Québec) H9P 1J3*
Normal mode initialization of the RPN finite-element model	*Gilles Verner and Robert Benoit, Recherche en prévision numérique, Service de l'environnement atmosphérique, Dorval (Québec) H9P 1J3*
The CMC MOS system of weather element prediction	*N. Brunet, G. Richard, H. Yang and N. Yacowar, Service de l'environnement atmosphérique, Dorval (Québec) H9P 1J3*
Application of the semi-Lagrangian scheme to the moisture equation in a regional forecast model	*Hal Ritchie, Recherche en prévision numérique, Service de l'environnement atmosphérique, Dorval (Québec) H9P 1J3*
A third-order closure model for the atmospheric boundary layer	*S. Csanady, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
A finite-element cloud dynamics model	*Garry Toth and Ambury Stuart, INTERA Environmental Consultants Ltd, Calgary, Alta T2H 1X9*
A numerical model of surface outflows from convective storms	*Robert P. Addis, University of Hawaii at Manoa, Honolulu, Hawaii 96822*
Session 6C: Oceanography III *Chairman: W. Emery*	Wednesday 1020 – 1200, Oak Room
Nanticoke II Shoreline Dispersion Experiment, June 1982	*R.M. Hoff, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
A new approach to extreme wave estimation in the Beaufort Sea	*Donald O. Hodgins and Ronald H. Goodman, Seaconsult Marine Research Ltd, Vancouver, B.C. V6P 6G5*
Three-dimensional modelling of tidal residual flow	*D. Lefaivre, Centre Champlain des sciences de la mer, Québec (Québec) G1K 7Y7* *K.-T. Tee and P.C. Smith, Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2*
Bottom currents in the Central Basin of Lake Erie	*F.M. Boyce and M.N. Charlton, National Water Research Institute, Burlington, Ont. L7R 4A6*
On the frictionally-induced depth-dependence of tidally-rectified flow	*Daniel G. Wright and John W. Loder, Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2*
Channel waves over parabolic topography	*Yves Gratton, Département d'océanographie, Université du Québec à Rimouski, Rimouski (Québec) G5L 3A1*

Lunch (1200 – 1300)

Wednesday afternoon, 4 May 1983

Session 7A: Operational Meteorology III *Chairman: E. Reinelt*	Wednesday 1300 – 1430, Ballroom
Mesoscale forecasting in the marine environment	*M.D. Hewson, NORDCO Ltd, St John's, Nfld A1B 3T2*
Mesocyclones over Canada's continental shelf	*W.G. Richards, Atmospheric Environment Service, Bedford, N.S. B4A 1E5*
Storm forecasting in the Beaufort Sea	*E. Taylor and R. Black, Atmospheric Environment Service, Edmonton, Alta*
A comparison between computed and measured oceanic winds near the British Columbia coast	*Richard E. Thomson, Institute of Ocean Sciences, Sidney, B.C. V8L 4B2*
The influence of heavy precipitation on the intensity of surface circulation around developing East Coast storms	*John Pearce, Atlantic Weather Centre, Atmospheric Environment Service, Bedford, N.S. B4A 1E5*
On the use of the 850-mb chart in nowcasting	*E.R. Reinelt, Department of Geography, University of Alberta, Edmonton, Alta T6G 2H4*

Session 7B: Cloud Physics *Chairman: G. Isaac*	Wednesday 1300 – 1430, Champlain Room
Large-scale energetics and small-scale convection over Alberta	*G.S. Strong, Alberta Research Council, Red Deer, Alta*
Rocky Mountain House tornado, 30 June 1982: a case study	*Gerard Neault, Alberta Weather Centre, Atmospheric Environment Service, Edmonton, Alta T6H 5H6* *Arjen Verkaik, Skyart Productions, Islington, Ont.*
Cloud seeding by ground generators in Alberta: field studies of generator targetting	*F.E. Robitaille, F.D. Barlow and J.D. Mason, Alberta Research Council, Edmonton, Alta T6H 5R7*
On the optical properties of Arctic haze	*Jean-Pierre Blanchet, Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ont. M3H 5T4* *Roland List, World Meteorological Organization, Case Postale n° 5, 1121 Geneva 20, Switzerland*
Modification potential of orographic cloud systems in the southern Canadian Rockies: preliminary aircraft observations	*F.E. Robitaille, F.D. Barlow and J.D. Mason, Alberta Research Council, Edmonton, Alta T6H 5R7*
Results of a cumulus seeding experiment	*B. Kochtubajda, Alberta Research Council, Edmonton, Alta T6H 5R7*
Ice crystal evolution in a hailstorm feeder cloud following AgI seeding	*Terrence W. Krauss, Alberta Research Council, Edmonton, Alta T6H 5R7*

Session 7C: Oceanography IV *Chairman: P. Smith*	Wednesday 1300 – 1430, Oak Room
Current-meter measurements in Hudson Strait, 1982	*Ken Drinkwater, Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2*
Results of year-long current meter array from Hudson Bay	*S.J. Prinsenberg, Bayfield Laboratory for Marine Science and Surveys, Burlington, Ont. L7R 4A6*
Deep ocean turbulence measurements	*J.N. Moum, University of British Columbia, Vancouver, B.C. V6T 1W5* *T. Osborn, Department of Oceanography, Naval Post Graduate School, Monterey, California*
Winter-time temperature structure in ice-covered lakes: examples from the headwater lakes of the Yukon River Basin	*Eddy C. Carmack, (NWRI) Environment Canada, West Vancouver, B.C. V7V 1N6*
The statistical properties of sea clutter in the Beaufort Sea and its significance in the detection of sea ice	*M. Riley and G.L. Austin, McGill Weather Radar Observatory, Ste-Anne-de-Bellevue (Québec) H9X 1C0*
Session 8: Exhibits and Posters *Chairman: E. Hudson*	Wednesday 1430 – 1600, Ballroom
The autocorrelation of lagged wind speeds on the B.C. Coast	*Stanton E. Tuller, Department of Geography, University of Victoria, Victoria, B.C. V8W 2Y2*
Urban terrain climatology – Brandon, Manitoba	*R.A. McGinn, Brandon University, Brandon, Man.* *P.M. Lafleur, Trent University, Peterborough, Ont.*
The *Ocean Ranger* storm	*W.G. Richards, Atmospheric Environment Service, Bedford, N.S. B4A 1E5*
Canadian climate information – the Atmospheric Environment Service	*G.E. Bristow, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
MAST (marine statistics) and LAST (land statistics) systems for analysis of weather and sea-state observations	*A. Saulesleja, T.W. Mathews and L.D. Mortsch, Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Session 9A: Meteorological Remote Sensing *Chairman: I. Zawadzki*	Wednesday 1600 – 1745, Champlain Room
Pacific Weather Centre Geostationary Meteorological Satellite Data Reception and Analysis System	*John Spagnol and Mert Horita, Pacific Region, Atmospheric Environment Service, Vancouver, B.C. V6P 6H9*
On the separability of various classes from satellite data	*A.A. Tsonis, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
AES TOVS processor	*T.C. Yip, B. Green and D. Steenbergen, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
An overview of Bristol Aerospace's Data Collection Platform development	*B.C. Wiebe, Bristol Aerospace Ltd, Winnipeg, Man. R3C 2S4*

Drifting buoys	*J.R. Buckley and W.C. Thompson, Petro-Canada, Offshore and International Division, Calgary, Alta T2P 3E3* *D. Fissel, Arctic Sciences Ltd, Calgary, Alta*
Waverider Information Processing System – Shipboard Automatic Weather Station (WRIPS-SAWS)	*W.C. Thompson and J.R. Buckley, Petro-Canada, Offshore and International Division, Calgary, Alta T2P 3E3* *L. Adamo, L. Adamo Inc., Solano Beach, California*
TIROS sounding data compared with STREX dropsonde data	*John Spagnol and Ian Okabe, Pacific Region, Atmospheric Environment Service, Vancouver, B.C. V6P 6H9*

Session 9B: Boundary Layer Wednesday 1600 – 1745, Oak Room
Chairman: G. McBean

Practicability of prediction of the surface arrival of chinook winds using acoustic sounders	*T. Mathews and R.B. Hicks, Department of Physics, University of Calgary, Calgary, Alta T2N 1N4*
Boundary-layer structure over the ocean	*G.A. McBean, Institute of Ocean Sciences, Sidney, B.C. V8L 4B2*
Comparisons between Rainsat precipitation measurements and thermodynamic parameters	*N. Bussières, Boundary Layer Research Division, Atmospheric Environment Service, Downsview, Ont. M3H 5T4* *I. Zawadzki, Université du Québec à Montréal, Montréal (Québec) H3C 3P8* *G.L. Austin, McGill Radar Weather Observatory, Ste-Anne-de-Bellevue (Québec) H9X 1C0*
MS3DJH/3 – further steps in the development of a simple model of boundary-layer flow over low hills	*P.A. Taylor, Boundary Layer Research Division, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Application of a boundary-layer model to flow over a barchan sand dune	*John L. Walmsley, Atmospheric Environment Service, Downsview, Ont. M3H 5T4* *Alan D. Howard, Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia 22903*
Assessment of a suburban water balance	*C.S.B. Grimmond, University of British Columbia, Vancouver, B.C. V6T 1W5*
Deep 0°C isothermal layers and their importance to precipitation bands	*Ronald E. Stewart, University of Toronto, Toronto, Ont. M5S 1A7*

Session 9C: Agricultural and Forest Meteorology Wednesday 1600 – 1745, Angus Room
Chairman: P. Schuepp

Day-1 forecasting in forest fire danger rating	*P.M. Paul, Canadian Forestry Service, Environment Canada, Ottawa, Ont. K1A 1G5*
An ecophysiological approach to optimizing energy storage in farmed forests	*Roger B. Street, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Fire weather forecasting: a synoptic overview	*Roger B. Street, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*

Meteorological conditions for the transport and outbreak of blue mould spores of tobacco in Southern Ontario region	*S. Bhartendu, Ontario Region, Atmospheric Environment Service, Toronto, Ont. M4T 1M2*
Variations in the reflection coefficient of a strawberry canopy	*William J. Blackburn, Crop Production Division, Agriculture Canada, Ottawa, Ont. K1A 0C5* *John T.A. Proctor, Department of Horticultural Science, University of Guelph, Guelph, Ont. N1G 2W1*
On quantitative description of heat and mass transfer in "unconventional" agrometeorological boundary-layer flow	*Peter H. Schuepp, Macdonald Campus of McGill University, Ste-Anne-de-Bellevue (Québec) H9X 1C0*
The use of mesoscale meteorological information for agriculture in Manitoba and Saskatchewan	*L.R. Legal, Prairie Weather Centre, Atmospheric Environment Service, Winnipeg, Man. R3C 3V4*
Potential uses of the β-gauge in agrometeorological research	*N.N. Barthakur, Department of Agricultural Chemistry and Physics, Macdonald Campus of McGill University, Ste-Anne-de-Bellevue (Québec) H9X 1C0*
Cocktail Hour	Wednesday 1830 – 1930, Alhambra Room
Banquet	1930 –

Thursday morning, 5 May 1983

Session 10A: Mesoscale Meteorology Research Planning Workshop – Report *Chairman: P.E. Merilees*	Thursday 0830 – 1000, Alhambra Room
Session 10B: Meteorological Techniques *Chairman: B. Barge*	Thursday 0830 – 1000, Champlain Room
Analysis of hourly temperature data	*A.J. Keck, Prairie Weather Centre, Atmospheric Environment Service, Winnipeg, Man. R3C 3V4*
Wideband magnetic direction finder networks for locating cloud-to-ground lightning	*M.W. Maier, R.C. Binford, L.G. Byerley, E.P. Krider, A.E. Pifer and M.A. Uman, Lightning Location and Protection Inc., Tucson, Arizona 85719*
1982 flight testing and ground-referencing on an airborne CO_2 flux-measuring technique	*R.L. Désjardins, Agriculture Canada, and J.I. MacPherson, National Aeronautical Establishment, Ottawa, Ont.* *P. Alvo and P.H. Schuepp, Macdonald Campus of McGill University, Ste-Anne-de-Bellevue (Québec) H9X 1C0*
Evaporation modelling using satellite-derived surface temperatures	*Neil Trivett, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Use of radioactive tritiated water to study evaporation from a small natural lake	*P.J. Barry and E. Robertson, Atomic Energy of Canada Ltd, Chalk River, Ont. K0J 1J0*

Session 10C: Environmental Meteorology *Chairman: R. Shaw*	Thursday 0830 – 1000, Oak Room
Precipitation chemistry in Pacific coastal regions	*G.A. McBean, Atmospheric Environment Service, Institute of Ocean Sciences, Sidney, B.C. V8L 4B2*
A preliminary evaluation of the sulphate concentration forecasts for the PEPE project	*M.P. Olson and K.K. Oikawa, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Evidence of large-scale pollution episodes	*Y.-S. Chung, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
Nuclear generating station emergency plans and the Meteorological Advisor	*Roger Caiazza, Niagara Mohawk Power Corporation, Syracuse, New York 13202*
Diffusion of heavy gases – micrometeorological study	*F. Fanaki and A. Sirois, Atmospheric Environment Service, Downsview, Ont. M3H 5T4*
A climatological model for predicting mesoscale patterns of acid deposition	*R.W. Shaw, Environmental Protection Service, Dartmouth, N.S. B2Y 2N6*
Prediction of sulphur compound ground-level concentrations and frequencies of exceedance produced by three different source scenarios	*T.M. Morrow, W.A. Murray and R.L. Findlay, Promet Environmental Group Ltd, Calgary, Alta T2E 6T6*
Coffee (1000 – 1020)	

Session 11: Day-1 Forecasting Panel Discussion Thursday 1020 – 1200, Alhambra Room
Chairman: G. Austin

Abstracts

Session 1: Day-1 Forecasting Tuesday 0830 - 1030

The AES's Day-1 priority

D.K. Smith

In 1981 the Atmospheric Environment Service adopted as its top priority the improvement of the information services it provides for the first 24 hours of the forecast period. In addition to the accuracy and verification of the Day-1 forecast, the priority draws attention to the importance of the credibility, timeliness and utility of the information available to users.

The reasons for adopting this priority and the factors influencing the actions to be taken are presented. It is suggested that improvement in Day-1 services during the next few years will stem from improvements in the design and packaging of information, better dissemination, and better focussing of human effort through recognition of the different contributions made by forecasters and by numerical models in the prediction process.

A new communications system, sophisticated methods of handling remotely-sensed data, and advances in NWP are identified as key elements affecting the evolution of the Canadian Forecast System in the last half of the decade.

The requirements for improved short-range forecasting

Don Beran

The quality of very short-range forecasting depends on our knowledge and understanding of atmospheric processes, our ability to observe the atmospheric state at any given time with high resolution and supporting automation that allows rapid manipulation and integration of observed quantities and fields. The status and interdependence of these three elements of Day-1 forecasting are discussed.

Nowcasting of convective storm outflows

James Wilson and John McCarthy

The horizontal scale of outflows from convective storms varies from 1 km to 100 km. The strength of surface winds in extreme cases may exceed 50 m s^{-1}. The general public needs warning for the more extreme cases and the aviation industry for almost all cases effecting the terminal area. Outflows with horizontal velocity differentials in excess of 20 m s^{-1} in less than 4 km (microburst) can be particularly dangerous to aircraft taking off or landing. Larger scale events are less dangerous but still require pilot awareness and rearranging of traffic flow patterns.

Utilizing special sounding, mesonetwork and radar data, the concept of issuing a Microburst Watch is explored. Once an outflow is present, Doppler radar can be used for detection. The larger scale outflows have lifetimes of 30 min to at least 3 h and extrapolation techniques can be used to provide advanced warning. The lifetimes of microbursts are $<$ 10 min. Thus automatic detection warning and dissemination is required.

Examples will be shown of various scale wind shear events as depicted by Doppler radar and surface networks. Also shown will be Doppler based man-machine derived displays that can be provided to meteorologists, controllers and pilots.

The use of satellite imagery in forecasting convective weather

John M. Bullas

Satellite imagery has traditionally been used to *monitor* the occurrence of convective weather. A number of techniques to employ satellite imagery in short-term *forecasting* of convective events were introduced in the spring of 1982 to the severe weather programme at the Alberta Weather Centre. This paper summarizes some of these techniques, and an illustrative case study is presented.

Case studies of mesoscale prediction using combined GOES satellite data and radar imagery

A. Bellon, G.L. Austin and A. Kilambi

Several cases of summer frontal systems are analysed from the point of view of establishing the utility of both rain identification algorithms and extrapolation schemes. The significance of the results for Day-1 Forecasting is discussed briefly.

Test results from Rainsat

Patrick King and J. David Steenbergen

The Rainsat technique developed at McGill University is now running at the Meteorological Services Research Branch of AES, Downsview. The Rainsat system identifies areas of rain over Eastern Canada using half-hourly data from GOES East and from radars near Toronto and Montreal. Data from one radar are used to determine a relationship between IR and VIS intensity counts and radar rain areas. The other radar is used as an independent check on the accuracy of the analyses. Short-range forecasts can be generated by cross-correlating two successive images.

We have tested the system with data from the summers of 1981 and 1982. Analyses have been verified for both dependent and independent data sets. Results indicate that the analyses will be useful in areas where radar data are unavailable. The quality of the analysis depends strongly on the synoptic situation.

Currently the system is set up to do 3-h forecasts. Results deteriorate somewhat at this time range but are still better than persistence. We hope to establish a data link to the AES Satellite Data Laboratory GOES ground station by spring 1983 and to begin a real-time test in cooperation with a weather office.

Maximum snowfall trajectories for East Coast storms: 0- to 12-hour forecasts from satellite imagery

John Pearce

The heaviest snowfall rates with East Coast winter storms are observed on the southern edge of the rear half of the so-called "Comma-Head" of cloud imagery. This relationship is useful where rates inferred from surface visibilities are inconclusive because of the presence of fog or blowing snow, and is invaluable over the ocean where radar and ship observations offer very limited coverage.

Sample cases where areas of heavy snowfall are extrapolated from GOES hourly imagery for 6 to 12 h are discussed. The maximum threat areas thus derived are used for provision of detailed short-range guidance and warnings. These are especially useful where storms track onshore from the date-sparse Atlantic.

An assessment of the performance of operational probability of precipitation amount forecasts

L.J. Wilson and H.R. Stanski

Objective probability of precipitation amount (POPA) forecasts have been issued twice daily from the Canadian Meteorological Centre since 22 December 1980. The forecasts are for 5 consecutive 12-h periods from 0 to 60 h, for 74 stations across Canada. Unconditional probabilities are given for light (0.2 to $\leqslant$ 2 mm) moderate ($>$ 2.0 to $\leqslant$ 10.0 mm) and heavy ($>$ 10.0 mm) precipitation accumulations. The three probabilities for each station are also added together to give probability of precipitation (POP) values for use as guidance in preparation of public forecasts of POP.

The forecast equations are based on the "perfect prog" formulation where observed or analysed data are related statistically to concurrent predictand observations. In the forecast mode, the predictor values are obtained from the operational spectral model forecasts. Development was carried out using multiple discriminant analysis (MDA) and regression estimation of event probabilities (REEP). Although complete sets of forecasts are generated and saved for both techniques the operational system uses MDA equations for 0 to 36 h (3 periods) and REEP equations for 36 – 60 h (2 periods).

The performance of both MDA and REEP equations will be assessed in terms of standard verification measures appropriate to probability forecasts and categorical forecasts derived from probability forecasts. These measures include reliability tables, Brier, ranked probability and skill scores, and contingency tables. Results show that for most stations, forecasts are useful for all 5 periods, but there are considerable differences in performance across the country. Characteristic errors will be identified and will be related to the known characteristic errors in the spectral model. Differences between the performance of the MDA and REEP equations will also be described and assessed. Finally, the results will be evaluated in terms of the expected performance of perfect prog methods for probability forecasts.

MOS and Perfect Prog wind forecasts in Canada – development and comparison with subjective wind forecasts

W.R. Burrows and A. Maarouf

Statistical relationships for several Canadian stations were derived between surface wind observations (predictand) and a set of potential predictors including forecasts output from the CMC operational model (MOS procedure). Relationships were also derived between surface wind observations and a set of observed variables as potential predictors (Perfect Prog procedure). Relevant predictors were selected with a forward stepwise screening procedure. Separate equations were derived for 12-, 24-, and 36-h forecasts of u and v wind components and wind speeds. The results show that reliable MOS surface wind forecast equations can be derived with as little as 2 years of data when no seasonal separation is made. For an independent data set (about one year) comparison of MOS and PP forecast errors shows PP is dominant. Comparison of 6- and 18-h MOS and PP forecasts for the same period shows both MOS and PP forecasts have comparable or less error, overall, than FTs, particularly after 12 h.

A study of hemispheric forecast error correlation structure

H.J. Thiébaux, H.L. Mitchell and D.W. Shantz

The research reported here had two objectives: 1) a detailed study of hemispheric forecast-error statistics for the Canadian forecast model, in order to provide an immediate re-parameterization of the isobaric correlation model used in the data assimilation step of the forecast cycle, to bring the objective analysis into agreement with the current numerical model; and 2) the development of an algorithm for automatic updating of the forecast-error correlation model, so that parameters used operationally are adjusted to changes in statistical structure with time-of-year, with changes in the amount, distribution, and types of observation assimilated, and with changes to the numerical model itself.

The choice of an appropriate function-type for the correlation model has received careful attention, and our work has included both isotropic and anisotropic representations for the statistical structure of forecast-minus-observation differences. We have used accumulated forecast-errors from the CMC 00 and 12Z updates. With pressure-level- and region-specific parameterizations of correlation models, we compare geographic and level dependencies and discuss the implications for updating forecast initialization procedures with periodic adjustment of the objective analysis scheme.

Comparison of CMC 36-h prognostic 500-mb height before and after ship PAPA's removal

Daniel Poirier

Ocean Weathership PAPA located at 50°N, 145°W was decommissioned on 22 June 1981. One of the Pacific Weather Centre's (PWC) main concerns was the effect of the ship's removal on the numerical analyses and prognostics prepared by the Canadian Meteorological Centre (CMC). This study presents and compares the performance of the CMC 36-h 500-mb prognostic heights at Port Hardy before and after the ship's removal.

For both situations, before and after the removal, data available over a one-year period were used. the CMC 36-h prognostic height values were abstracted from CMC charts and tabulated against the 500-mb height values recorded by radiosonde. The error in the prognostics for each valid period, both 00 and 12Z were tabulated.

For the first part of the study, distributions of the errors were plotted versus season. Comparison of the distributions showed an overall poorer performance without the ship than with the ship.

A new approach was used in the second part. The synoptic situations were classified in terms of the 500-mb height tendencies over a 24-h period that consisted of two different 12-h periods, before and after the valid time of the prognostic. The distributions of the error-versus-height tendencies were used to evaluate more precisely the variabilities in the model performances versus different synoptic situations. This method clearly indicated the situations where the model performed at its best or at its worst.

A measure of forecast reliability

M.D. Hewson

Users of environmental forecasts frequently require an indication of how reliable the forecasts are in order to use them most effectively for operational decision-making purposes. The concept of forecast reliability is discussed using parameter-value forecasts and event numbers, and a reliability index for both event and non-event forecasts is developed. The index, which is a measure for forecast/event post-agreement, is shown to be independent of the mixture of event and non-event forecasts in the tested sample. Some of the types of forecast situations in which the index can be

used are examined, and the procedure is shown to be applicable to measuring the reliance to be placed in forecasts of significant events. The concept of forecast utility is introduced and the index modified by the use of a utility matrix, resulting in a measure of overall forecast usefulness. Some results of applications of the index to specific forecasting projects are presented along with a discussion of how these results can be applied by the forecast user in making operational decisions based on the forecast parameter values.

National verification system - a summary of the first year's data

Doug Fraser

Verification of temperature and precipitation forecasts for 22 Canadian locations for the full calendar year 1982 have been compiled and the results analysed. The forecasts verified were from the early morning issue and include the remainder of today and tomorrow. The extended range outlooks for days three to five were not included. The 22 locations include all capital cities and forecast centre locations. The temperature forecasts were measured in terms of absolute mean error and bias, and precipitation was measured as a categorical forecast in terms of percentage correct, bias and Heidke Skill Score, and for the last half of the year the probability of precipitation forecasts were measured using the Brier technique. The controls used to measure skill were persistence for temperature, climatology for temperature and probability of precipitation, and chance for the Heidke Skill Score. Month-by-month trends will be examined, as will the diminishing accuracy of the forecast versus time into the forecast period. Comparisons will be made of accuracies for the home location versus a remote location, and of the local forecasts versus the available guidance.

The aviation terminal forecast verification software was installed in most AES forecast offices in the Spring of 1982. Some problems still exist with the system but six to nine months of data are available and will be examined.

Temperature forecast verification at the Ontario Weather Centre

J. Vanos

The Ontario Weather Centre issues forecasts of daily maximum and minimum temperatures in the 1 - 5 day range for numerous cities in the Province. Data for 11 locations were collected for the four seasons over 1981 - 82 and compared with observed temperatures. Results show that the forecasts were consistently better than climatology or persistence for all ranges, with one exception. A comparison of results for 3 - 5 day forecasts from this study with earlier work using 1974 - 78 data showed some improvement in prediction at this range.

Session 2B: Climatology I — Tuesday 1050 - 1230

Cloud statistics for Ontario and Québec

P. Joe

Cloud statistics are needed in order to describe precipitation processes relating to acid rain. Hourly observations for 99 weather stations in Ontario and Québec spanning a period of 30 years were seasonally averaged for cloud type, amount, opacity and base height. The data were also examined for storm duration as a function of cloud type and for correlations between precipitation rate and cloud type. This study is needed before clouds and their dynamics and precipitation may be parameterized into LRTAP models.

Offshore advection climatology for the East Coast of North America

T.B. Low, R.J. Kolomeychuk and D.M. Whelpdale

An offshore air mass advection climatology for the East Coast of North America was prepared in relation to air pollution concentration measurements as an estimate for long-range trans-oceanic transport. The coastline from Ungava Bay to the southern tip of Florida was divided into eight segments according to regions of surface and upper-air climatic airstream influence and cyclonic/anticyclonic activity. The troposphere was divided into four layers, and the mean wind speeds, directions, and standard deviations were derived from climatological surface and upper-air radiosonde wind measurements for each coastal segment. Seasonal probability frequency distributions of wind speed and direction were calculated assuming a bivariate circular normal distribution. The air mass advected offshore was estimated by integrating the wind distributions over each layer according to the orientation of the mean wind vectors to the coastal segments. Overall contributions to the offshore air mass flux from Canadian and U.S. sources were found to be nearly equal on an annual basis.

Climatology of the Scotian Shelf

K.F. Harry

The climate of the Scotian Shelf, the ocean area immediately to the southeast of Nova Scotia, an important resource development area, is examined in relation to existing climatological data. Included in the presentation are statistics obtained from suitably located climatological stations on mainland Nova Scotia, from Sable Island, N.S. and from shipboard weather observations published in the *Summary of Synoptic Meteorological Observations* by the U.S. Naval Weather Service. Finally, to complement the review of statistical data, attention is directed to such severe weather phenomena as strong winds, extreme temperatures, dense fog, structural icing, that are part of the weather regime of the Scotian Shelf.

On calculation of vertical fluxes of heat and momentum through the sea surface using historical data from ships

Fred W. Dobson and Stuart D. Smith

The recent establishment by WMO and ICSU of a World Climate Research Programme for the purpose of enhancing man's ability to predict the global climate has resulted in a careful reassessment of all the factors influencing climate. The fluxes, heat, momentum and fresh water through the sea surface, which are universally acknowledged to be of crucial significance, are not yet well-enough understood to be of direct use in climate prediction.

The accepted method for calculating the sea surface fluxes is to use "bulk" measurements (i.e. mean values of wind speed, cloud amount, temperature of air and sea, air humidity) in semi-empirical formulae that relate the bulk values to the fluxes. At sea, almost the only source of data is the historical file of WMO meteorological observations, which now extends over about 40 years and includes (in the Northern Hemisphere) high-quality data from the various Ocean Weather Stations.

Various evaluations of the accuracy with which the air-sea fluxes can be estimated will be found in the literature. The present one investigates two aspects of the problem: it compares averaged fluxes computed from weathership data with those computed using data from nearby (± 2° in latitude) WMO selected ships, and calibrates the formulae whenever possible with measured data taken at sea.

The results to date indicate that: 1) for climate prediction purposes, and setting aside biases due to storm avoidance, the data from WMO selected ships are as accurate as the weathership data; 2) the bulk formulae presently used to compute sensible and latent heat fluxes and momentum flux, may introduce errors in the fluxes of up to ± 25% in the monthly mean values; and 3) when calibrated against the OWS P measured data, the formulae used to compute solar short-wave

radiation (Lumb, 1964; Budyko, 1974) are either inadequate (as is the case with the Lumb formula; it only covers 50% of the cloud conditions encountered) or inaccurate (the Budyko formula underestimates the long-term mean short-wave radiation by about 25%). Such inaccuracies indicate an overall uncertainty in existing sea surface heat flux budgets that far exceeds the ± 10 W m^{-2} accuracy estimated by the WCRP studies to be necessary for useful climate prediction.

Twenty-year time series of the air-sea flux budgets, using our best estimates of the bulk formulae, are presented for some of the North Atlantic weatherships and for OWS P.

A method for developing offshore wind rose climatologies for data-sparse areas on the East Coast

T. Agnew, T.B. Low and R.J. Kolomeychuk

Wind observations are relatively sparse in marine areas away from the shipping routes. However, with increased offshore oil and gas exploration activities it is both desirable and necessary to develop wind climates for these data-sparse areas. Ten years of wind data from Grindstone and Sable Islands have been fitted to a bivariate elliptical normal distribution. Both the chi-square test and Kolmogorov-Smirnoff test indicate that the distributions are very close to elliptical normal. Construction of wind roses applying this distribution on a smaller data set of ship observations reliably reproduce the correct ship wind rose. The method can also estimate the minimum amount of ship data required to reconstruct the wind rose for a given confidence level.

The most important criterion for application of the technique is the maintenance of physical homogeneity within the statistical population. The techniques of Wolfe (1971) and Crutcher and Joiner (1977) are applied to test for homogeneity and to separate mixed sets into like clusters using a comparison of maximum likelihood estimates.

Session 2C: Oceanography I — Tuesday 1050 - 1230

The alongshore structure of low-frequency current fluctuations on the British Columbia continental shelf

T. Yao, H.J. Freeland and L.A. Mysak

An array of five current-meter moorings was deployed along the edge of the continental shelf off British Columbia for a year beginning in September 1981. The alongshore extent of the array was approximately 600 km. Analysis of the subtidal fluctuations is presented.

There is coherence in the alongshore currents at 0.09 cpd over the extent of the array. The alongshore currents within this frequency band are coherent with local, alongshore winds and show a phase shift across Queen Charlotte Sound.

Currents off Vancouver Island are dominated by fluctuations at about 0.03 cpd. These fluctuations are not coherent with wind nor are they observed at the mooring north of Queen Charlotte Sound.

Mean currents over the winter months off the southern tip of the Queen Charlotte Islands, where the shelf narrows to less than 5 km, are in opposition to the mean winds. Elsewhere, the seasonally averaged currents reflect the seasonal cycle in the winds.

Is the Sitka eddy topographically induced?

G.E. Swaters and L.A. Mysak

Near Sitka, Alaska, an anticyclonic eddy of about 200-km radius is a semi-permanent feature. The immediate vicinity contains a variety of unusual topographic features, in particular seamounts and an "anomalous" protrusion of the continental slope. We derive analytical solutions of the quasi-geostrophic potential vorticity equations with exponential Brunt-Väisälä frequency and topographic forcing. The solutions predict anticyclonic motion; however, the vertical structure of the solutions, while in qualitative agreement with the observations, do present some interesting differences.

Dispersion of patches with non-zero initial dimensions

B. Sanderson and A. Okubo

An analogous development to that of Taylor (1921) is used to find an expression for the variance of a cluster of drifters that are initially distributed over some area not equal to zero. In flow fields that are homogeneous in both space and time the growth of variance of the cluster is a function of the Lagrangian autocorrelation coefficient and turbulent kinetic energy. However, the results of ocean and lake drogue cluster experiments show that such flows are not homogeneous and under such circumstances the growth of variance depends strongly on the correlation of the initial position with the subsequent displacement from the initial position. The problem is therefore reformulated using deterministic (non-homogeneous) and turbulent (homogeneous) components of motion. This allows an expression for the variance to be calculated for any general field of flow without any inappropriate assumptions.

Fundamental differences are required to formulate the cases for discrete particles and continuously distributed material. Only the discrete formulation is tested experimentally in the present work, however, an experiment to test the continuous formulation in an oceanic environment is suggested.

Solitary internal waves in Davis Strait

Patrick Cummins and Paul LeBlond

A Rip Current Warning System (RCWS) deployed by Aquitaine Petroleum (now Canterra Ltd) in the proximity of a drillship over the continental shelf off southern Baffin Island revealed the presence of large amplitude internal waves. The RCWS consisted of three current-meter moorings and a thermistor chain. In addition, several CTD stations were occupied within a short time of the deployment. This paper reviews the properties of the internal waves, observed to be travelling away from the coast and to coincide closely with the local low water phase of the tide, at the drillship. We also discuss the application of a non-linear wave model (LEE. C and R. BEARDSLEY 1974, *J. Geophys. Res.* 79:453), incorporating the effects of continuous stratification and shear, to the data. The model underpredicts the length of the disturbances for a given amplitude. A KdV type of equation including second-order non-linear effects provides a better fit. Richardson number calculations based on wave-induced shear show that instabilities are likely to occur.

Mesoscale eddy statistics from North Pacific synoptic XBT surveys

W.J. Emery and K. Thomson

Repeated multi-ship and aircraft-deployed XBT surveys are used to describe the upper ocean (0 - 500 m) thermal structure on a quasi-synoptic basis. Five multi-ship surveys, collected in the region of the Subtropical Front just northeast of Hawaii, document changes in the mesoscale structure occurring between successive months and years. Located southeast of Hawaii the four air-XBT surveys sample the same area approximately every two weeks. Autocorrelation and wavenumber statistics, in both meridional and zonal directions, are used to document the temporal evolution of the mesoscale eddy field in all surveys. Cross-correlations establish the degree of independence of samples in the same area, widely separated in time. Recommendations for future sampling strategies are given.

Real-time dynamic heights from digital XBT data

W.J. Emery and W.G. Lee

A simple interface has been developed to collect digital XBT data on a modern microprocessor. The interface can be used with most existing 8-bit processors. In the present configuration the XBT temperature trace is displayed on the CRT screen when taken and is stored on magnetic floppy disks. Software has been developed to utilize these temperature data in conjunction with mean temperature-salinity and salinity-depth curves (Emery and Dewar, 1982) to compute upper-layer inferred dynamic height from the XBT trace directly, providing almost real-time dynamic heights. These dynamic heights are printed (along with the observed temperature and inferred salinity profiles) and plotted by the same microprocessor. Comparisons between dynamic heights derived from XBT data and those computed from nearly simultaneous CTD casts reveal the accuracy of the method. In addition, the tracks of four drogued buoys, in the North Atlantic just south of the Azores, agree well with the 0/700 db dynamic height field inferred from a series of XBT casts.

Session 3: Remote Sensing of Sea Ice — Tuesday 1330 – 1520

An operational demonstration study by using Nimbus-7 passive microwave data

R.O. Ramseier and H. McRuer

During the month of November 1982, the motor vessel MV *Arctic* tried to reach Little Cornwallis Island, NWT to obtain a load of lead zinc ore. The MV *Arctic* intended to do this trip without the assistance of an ice-breaker. The MV *Arctic* had an ice forecaster, an ice observer on board plus the capability of directly receiving side-looking airborne radar (SLAR) data from the AES *Electra*. At the Ice Centre in Ottawa full support was available in the form of visible satellite data to provide a strategic view of the ice conditions along the route.

At the same time the Nimbus-7 scanning multi-channel microwave radiometer (SMMR) data became available in a near real-time mode for use in operational demonstrations. The SMMR data provide all-weather, day and night information on ice conditions. The interest is to evaluate the SMMR data by comparing the data with the ice information that was available both at the MV *Arctic* and at AES Ice Central. The result of this analysis will provide a direct indication of the usefulness of SMMR data for a) ship routing, b) strategic ice information and c) tactical support.

Near real-time sea-ice maps from satellite data

F.W. Thirkettle and P. Filseth

The scanning multifrequency microwave radiometer (SMMR) on board the NIMBUS-7 satellite is utilized for the remote sensing of sea ice. The development of algorithms to convert the supplied temperature brightness to ice concentration and ice type has been conducted with historical data provided on computer tapes and, where possible, coincident ground-truth information. However, data that are more than even a few days old are of little use to ship captains or ice forecasters who are working in an immediate mode.

A near real-time data collection, analysis, display and distribution system currently functioning in an operational mode will be discussed. NIMBUS-7 SMMR temperature brightnesses are extracted directly from a computer at the U.S. Navy Fleet Numerical Oceanography Center in Monterey, California via the NODDS (formerly SDDS) data distribution system. A microcomputer in Toronto is responsible for the data communication aspects of hauling the temperature brightness values from Monterey, passing them to a mainframe computer (also in Toronto) for analysis, receiving back from the mainframe the contoured ice concentration maps for each ice

type and the transmission of these final data products to a similar microcomputer for the user's on-site printing (e.g. Ice Central in Ottawa). Optionally the map product may be sent directly to a ship via facsimile. These ice maps can be in the hands of the end-user within 36 h of the satellite's full-day sensing of a particular region of interest.

Retrieval of sea-ice properties from the Nimbus-7 SMMR

I. Rubinstein

Passive microwave radiometry for global sea-ice mapping has been used ever since the Nimbus-5 spacecraft carrying a radiometer (the ESMR) was launched in 1972. Sea-ice parameters derived from the brightness temperatures produced by the Nimbus sensors include ice concentrations, age and extent. The use in the U.S. Navy derived SSM/I algorithm, of 37 GHz and both horizontal and vertical polarizations, allows one to differentiate first-year and multi-year ice. However, the presence of newly formed sea ice may be interpreted in the above algorithm as a multi-year ice component because thin ice and multi-year ice have similar microwave signatures at 37 GHz. This problem can be resolved by using an algorithm (modified version of a model by Cal Swift) that uses two frequencies and both polarizations. The new model has capabilities of discriminating three different ice types.

The usefulness of the new algorithm depends on specific emissivities of various ice types; therefore, an attempt is made to employ an input table of emissivities that reflects seasonal and geographical variations. Old and new algorithm results will be discussed in the light of defining a single "best" model.

Microwave emission from high arctic sea-ice during freeze-up

B.E. Troy, Jr, J.P. Hollinger, R.O. Ramseier, K.W. Asmus, M.F. Hartman and C.A. Luther

In October 1981 a cooperative Canada/U.S. sea-ice experiment was performed in the eastern Beaufort Sea near Prince Patrick Island. Airborne microwave measurements of sea ice were obtained while personnel on the ice were making concurrent measurements of ice salinity, temperature, depth and snow cover. A Naval Research Laboratory P-3 aircraft took passive 90- and 140-GHz ice imagery and profile radiometer measurements at 19, 22, 31 and 37 GHz, and an Atmospheric Environment Service *Electra* aircraft obtained SLAR imagery of the same ice areas. Brightness temperatures and emissivities of several ice types were determined, including second-year ice, multi-year ice, landfast ice and young ice.

Arctic marine ice cover relief investigation using aerial microwave, laser and photographic data

S. Martindale, R.O. Ramseier and V.L. Shaw

Many agencies use marine ice relief data for planning operations within Arctic waters. From the surficial morphology, inferences can be made concerning the type, thickness, strength and condition of ice hazards. Marine ice relief data are commonly recorded by a variety of airborne remote-sensing methods, including panchromatic aerial photography, side-looking airborne radar (both SLAR and SAR), and laser profilometer.

Using data generated from coincident or near-coincident laser, profilometer, SLAR and aerial photography, a statistical analysis of ice relief sample features was conducted from one hundred sections selected from a broad data bank of sea ice in the Bering, Chukchi, south Beaufort Seas and the Canadian Arctic islands. The sections were chosen for the variety of ice types recorded and the quality of data. For the study, first-year, second-year, multi-year, fast and grounded ice were represented. Spring and fall data were released for this study from the north Bering and Chukchi Seas courtesy of the Alaska Oil and Gas Operators Association and from the Atmospheric Environment Service Radarsat project.

Étude de la distribution et de la taille des floes dans les eaux de Terre-Neuve

Y. Carrier et W.S. Appleby

À cause des dangers de collision que représentent les floes au large de Terre-Neuve, une étude de leur taille et de leur distribution pourrait s'avérer nécessaire à la conception des structures d'exploration pétrolière en mer. L'Administration du pétrole et du gaz des terres du Canada a donc entrepris d'extraire ces données des films SLAR déposés aux archives du Service de l'environnement atmosphérique.

Tous les films produits depuis 1978 furent analysés et les floes furent groupés en 5 catégories selon leur axe le plus long ($<$ 0,5, 0,5 - 2,0, 2,0 - 5,0, 5,0 - 10,0 et $>$ 10 km). Les résultats sont présentés à intervalles bimensuels entre les mois de février et mai. La région examinée se trouve à l'est de Terre-Neuve entre les paralèlles 46 et 53°N.

Nous concluons par une discussion des problèmes méthodologiques particuliers à cette étude afin d'évaluer la faisabilité de cette approche.

A time-series study of Gulf of St Lawrence sea ice using Nimbus-7 SMMR data

Anne E. Owens

The Nimbus-7 satellite has been in operation since it was launched by NASA in October of 1978. Research work concerning sea ice has been focussed on information from one of the sensors on board, the Scanning Multichannel Microwave Radiometer (SMMR). This paper will describe some of the results from a time-series study of SMMR data for the Gulf of St Lawrence region covering the period February 3 to March 17, 1979. For each satellite day, a linear modelling first-year ice algorithm was used to convert the SMMR data (brightness temperatures) into sea-ice concentrations. An automatic computerized mapping technique was used to depict this information on a geographic background. Ice concentration contours were also computer-generated to summarize the values derived from the satellite orbit data. Comparisons of these maps with Atmospheric Environment Service ice charts were performed focussing on the location of ice edges and specific concentration regions, as well as the actual ice concentrations. The results of this effort were very encouraging with respect to the validation of the SMMR data and will be discussed in this paper. Also to be outlined are the effects of cloud conditions, sea state, and the presence of very thin ice on the satellite microwave emission values.

Session 4A: Aviation Meteorology — Tuesday 1540 - 1730

Low-level wind shear: detection and warning for the aviation system

John McCarthy and James Wilson

Analysis of data from the Joint Airport Weather Studies (JAWS) Project indicates the vital requirement for more accurate and timely detection and warning of low-level wind shear phenomena in the airport terminal environment. Small-scale (less than 4 km), short-lived (2 - 8 min) microbursts have strong downdrafts near the surface, along with radial horizontal outflows of velocity differential in the 20 to 40 m s^{-1} range. These events are quite capable of causing an accident if an aircraft encounters this type of shear on immediate approach or departure. Preliminary analyses of microburst events will demonstrate the viability or lack thereof of several systems designed to provide warnings of low-level wind shear. Particular emphasis is placed on an airport-located pulsed microwave Doppler radar as an optimum system to provide automatic warnings to the aviation user without the real-time interface of a radar meteorologist. Discussion will include an evaluation of the capability of the Doppler system, and some recommendations regarding the development of an operational system for airports, including direct links to air traffic control personnel and to the pilot.

Verification of aviation terminal forecasts for Halifax International Airport

H.R. Stanski and A.P. Leganchuk

A National Aviation Terminal Forecast Verification Programme has been implemented at Weather Centres across Canada. The system is completely automated, operating on the Regional minicomputers.

The forecast is categorized into six operationally-significant ceiling and visibility classes. The qualifier terms actually used in terminal forecasts are transformed into expressions of probability for each of six classes. The accuracy of the forecast is determined by calculating the ranked probability score and associated contingency-table scores. Forecast skill is assessed by comparison with climatological and persistence forecasts.

The forecasts and observations are obtained in real-time from the communication system. Special observations are included, thus permitting minute-by-minute verification during the forecast's valid period.

Scores produced during a 21-month period for Halifax International Airport are analysed and explained in terms of the climatology of Halifax. Some of the problems of the computerized system will also be highlighted.

Thunderstorm nowcasting utilizing Doppler radar

James Wilson

Examination of Doppler radar data from summer research field programmes shows that thunderstorms are frequently triggered by localized regions of enhanced low-level convergence in the clear air. These regions are windshift boundaries most frequently produced by thunderstorm outflows. They may even be left over from the previous day's storms. Other wind-shift boundaries are orographically induced or of synoptic-scale origin. Doppler radar is capable of detecting these boundaries, whereas, normally their existence would be unknown to the forecaster using conventional data.

Examples will be presented of thunderstorm development: along individual clear-air boundaries, upon the collision of two boundaries, passage of a gust front beneath cumulus congestus clouds, and collision of gust fronts with mountains. The nowcaster with a knowledge of the location and movement of these boundaries, and of the vertical stability and winds aloft, is in a position to make detailed forecasts of thunderstorm development and movement.

Local variations in visibility restrictions as observed on Melville Island

D.M. Leahey, A.L. Jamieson and M.C. Hansen

A knowledge of local variations in visibility restrictions is often important to the siting of many facilities such as roads, cooling towers, telescopes and airports. This paper presents results of a study of fog occurrence conducted on Melville Island for Petro-Canada.

Visibility observations were made during 1980 and 1981 at two potential airstrip sites. The lower site is located about 70 m above sea level; the upper on a plateau at ~ 180 m amsl. A third camera was focussed on a 90-m high hill to obtain data for evaluating cloud ceiling heights. The study involved four individual observational periods:

Late Summer 1980	(July 31 – August 18)
Early Autumn 1980	(September 5 – September 14)
Late Spring 1981	(May 16 – June 24)
Summer 1981	(July 10 – July 26)

Data collected during all four observational periods indicated that heavy fog (ground visibility of less than 800 m) occurred more frequently and for longer durations at the upper site than at the lower site.

Heavy fog occurred 27.2% of the time at the upper site, compared to only 9.1% of the time at the lower site. It tended to persist for approximately 1.1 and 0.9 h at the upper and lower sites, respectively. At the upper site, 11% of the heavy fog occurrences lasted for more than six h, versus 4% at the lower site.

Cloud ceilings were assessed using data from the hill-site camera. They were greater than 90 m for about 70% of the time when there was moderate to heavy fog at the upper site.

Forecasting airframe icing: some problems and recommendations
Heather Auld

The operational meteorologist encounters a number of difficulties when forecasting airframe icing potential. One significant problem is that the forecaster must work with definitions of icing intensity that are aircraft-specific. The categories of icing intensity – trace, light, moderate, severe – were formulated in terms of the anti-/de-icing capabilities of transport aircraft from 1968.

It is suggested that a forecasting system be devised that accounts for the interaction of the meteorological and aerodynamic factors on the airframe. This study attempts to relate icing intensities to icing accretion rates on a standard object. A quasi-steady thermodynamic model is used to grow ice on a translating non-rotating cylinder. The model is based on earlier work by Lozowski, Stallabrass, and Hearty.

Doppler radar measurements in the pre-storm environment
I. Zawadzki and R. Rabin

The possibility of short-term forecasting of the convection onset time from single Doppler measurements is explored. Doppler measurements of average divergence over an area of increasing radius contain information on scales of convection at the same time as they provide the vertical profile of large-scale divergence. A case study of the time evolution of the divergence measurements by Doppler radar in clear air shows their potential in short-term forecasting.

Session 4B: Climatology II Tuesday 1540 – 1730

Possible climatic effects of volcanic stratospheric aerosols investigated in a 1-D radiative-photochemical-convective model
R.K.R. Vupputuri and J.-P. Blanchet

It is suggested that the injection of dust and sulphur oxides into the stratosphere by the El Chichón volcanic eruption would alter the existing radiative energy balance of the earth's atmosphere which in turn would lead to changes in both the vertical temperature structure of the atmosphere and the surface climate. A one-dimensional radiative-photochemical-convective model is used to compute the thermal response of the atmosphere and the earth's surface to the increase in volcanic stratospheric aerosols under the conditions of different aerosol optical thicknesses and compositions.

The results show that for an assumed stratospheric aerosol optical depth of 0.1 and aerosol composition of 75% H_2SO_4 and 25% H_2O the surface temperature decreases by about 0.3 K while causing a significant warming in the lower stratosphere (about 5 K). Changing the composition from sulphuric acid droplets to silicate dust has the effect of decreasing the cooling at the surface and increasing the warming in the lower stratosphere.

The simulation of five annual cycles with the CCC General Circulation Model
G.J. Boer, N.A. McFarlane and R. Laprise

A "frozen" version of the CCC general circulation model has been integrated for five simulated annual cycles. The resulting climate is compared with observations and with other GCMs.

The five-year simulation of the CCC GCM permits an estimate of the year-to-year "natural" variability of the model to be calculated. Since the model has perfectly regular forcing this variability is due only to the inherent non-linearity of the model.

The model's interannual variability is compared to that of the atmosphere and it appears that the model's natural variability is a substantial fraction of that of the atmosphere.

A comparison of various snow gauges on the Canadian Prairies for the winter 1981 – 82
K.H. Jones

Measurements of snowfall water equivalent were recorded by five gauges located in Regina, Saskatchewan for the winter of 1981 – 82. Three types of shields were used on the gauges for the field tests. The MSC Nipher-shielded snow gauge and the Fischer and Porter recording gauge with a scaled-up Nipher shield showed superior catch efficiency in comparison to the Wyoming-shielded Belfort weighing gauge and the Alter-shielded Standpipe and Sacramento storage gauges.

Dynamic climatology associated with the fall interval of ice expansion in the Beaufort Sea
Ellsworth F. LeDrew

In studies of air-ice interaction in the Polar Basin, a significant question that has been raised is whether the atmosphere leads the ice processes or whether the ice leads the atmospheric processes. Studies have emphasized statistical analysis of lag times in the evolution and decay of events in both media. Insight may also be provided through an understanding of the dynamics of the atmospheric systems responsible for growth and decay in the seasonal sea-ice zone. In particular, the relative roles of the advection of vorticity and thickness in comparison to that of local heat sources on synoptic development may indicate dominance of either the atmosphere or the ice dynamics.

A diagnostic model (the omega equation) is applied to National Meteorological Centre grid aerological data in the Beaufort Sea region for September and October of 1975 and 1976. The model is partitioned to yield the relative contribution by vorticity and thickness advection, local heat sources, friction and orography to the total vertical circulation. These partitioned fields are analysed for specific mean synoptic patterns to determine the significant formative mechanisms associated with expected advance or decay of seasonal sea ice. Individual synoptic events are examined in conjunction with Electronically Scanning Microwave Radiometer (ESMR) imagery as case study verifications.

Snow climatology of the southern Canadian Rockies
F.D. Barlow, F.E. Robitaille, J.D. Mason and C.M. Sackiw

A preliminary analysis of the snow climatology of the Rockies south of Banff, ALTA is presented. This background study is part of a planned research effort to determine the modification potential of orographic cloud systems during the snow season. Its purpose is to assess the current snow-

fall climate data for assistance in experimental site selection, network design and possible seeding evaluation activities.

Precipitation data information from a variety of data sources were analysed including AES climate stations, snow courses, snow pillows, and snow and precipitation storage gauges. Included were historical records from Alberta, British Columbia and Montana. The temporal, spatial and altitudinal variability of the regional snowfall is discussed. Possible experimental sites and network designs are noted.

An equatorial sea-surface temperature anomaly experiment with the CCC General Circulation Model

G.J. Boer

The CCC general circulation model has been used to simulate the atmospheric response to anomalously warm equatorial sea-surface temperatures in the Pacific. Such "El Niño" episodes are proposed as producing major circulation changes and as having an impact on extratropical winters.

The model response is generally as expected but the level of significance of the response is low. This implies that this mechanism would provide only modest skill if used in a predictive mode.

A global carbon cycle model

K. Higuchi

A new model (Model II) of the global carbon cycle is developed to assess the capability of the present atmospheric CO_2 monitoring network for providing an indication of the north-south distribution of CO_2 in the atmosphere. Analysis of the existing data from the monitoring stations indicates that the north-south distribution of CO_2 has a bimodal profile with a mid-latitude peak in the Northern Hemisphere almost twice as large as the equatorial peak. The north-south gradient is observed to be around 3.0 ppmv. Simulation of these observations and the Mauna Loa data by the model indicates a possible carbon sink in the mid-latitude region of the Northern Hemisphere of about 2.0×10^{15} g of carbon per year. Identification of this sink (or sinks) requires more intensive monitoring poleward of 30° N of the carbon reservoirs and the fluxes that occur between them.

Model II is a "pseudo three-dimensional" model. The three-dimensionality of the model is derived, albeit crude, from the fact that each of the world's major oceans (Atlantic, Pacific and Indian) is represented by a two-dimensional advective model. The atmosphere is represented by a two-dimensional (north-south and vertical) advective diffusive model. The biosphere is treated as a variable boundary condition that is adjusted to tune the model to reproduce the Mauna Loa observation.

Session 4C: Sea Ice — Tuesday 1540 - 1730

Forecasting sea-ice conditions in Alaskan coastal waters

Bruce D. Webster

Commercial marine operations including fisheries, cargo ferrying, and oil and gas exploration in Alaskan waters are frequently jeopardized by the presence of sea ice. It is a year-round problem since sea ice affects the fishing industry in the Bering Sea and shipping in Cook Inlet during winter and ship traffic and oil and gas related activities in the Chukchi and Beaufort Seas during summer.

As part of the marine forecasting programme conducted by the U.S. National Weather Service, a sea-ice advisory service has evolved to support marine operations in the proximity of ice-infested waters. This paper describes the techniques employed in making short-range (5 days or less) sea-ice forecasts that include: (1) application of ice drift and sea-ice growth/decay principles

to meteorological forecasts, (2) composite analogues and (3) computer-generated predictions of ice motion using a simple wind driven/thermodynamic ice model.

On simulating large-scale iceberg drift

Donald O. Hodgins

A predictive drift model for icebergs was developed for Petro-Canada as an essential component for assessing the feasibility of floating drilling operations in western Baffin Bay. Unlike more conventional models that infer the motion of icebergs over large distances from a knowledge of the mean (non-tidal) current structure through a deterministic law (e.g. Mountain, 1980), this model is based directly on observed patterns of iceberg motion. In 1978, radar tracking stations were established on the northern and southern shores of Lancaster Sound to map the motion of icebergs following the coastal currents. Radar ranges varied from 60 to 90 km and data were acquired from July 7 to October 4. A simultaneous survey of water mass properties yielded three maps of dynamic topography for the area of interest. The iceberg position data were interpolated to give smoothed 20-min time histories and differentiated to provide estimates of berg velocity. These berg velocities were then vector averaged in 7.5′ lat. by 30′ long. elements over time periods corresponding roughly to the seasonal partitioning provided by the dynamic topographies. In areas of good mutual coverage the iceberg motion vectors were correlated with the surface geostrophic currents calculated from the dynamic topographies, assuming a level of no motion at 300 dbars. The ratio of surface current speed to iceberg speed determined by these data was 0.6 ± 0.3 (one standard deviation) and no systematic angular difference between the iceberg and surface current vectors was found. These results were then used to construct iceberg motion vector maps: Where the radar data were reliable the mean berg motion vectors were used directly. Outside the radar ranges, the geostrophic currents were scaled to provide the berg motion vectors. This process yielded three berg motion vector maps dividing the 1978 open-water season about equally into thirds for drift simulation studies.

The water mass survey was repeated in 1979 and once again yielded three dynamic topographies. Using the berg-to-surface current correlations from 1978, three additional berg motion vector maps were derived and used to examine the interannual variability in the patterns of iceberg motion. Each of the six resulting maps was then tuned to eliminate the unrealistic drift behaviour produced by convergent eddies and poor resolution of the strong coastal currents by the model grid. This constituted a form of vector map smoothing.

The simulation of iceberg drift was then carried out by a simple transport algorithm based on the mean motion vector maps; i.e. $\dot{\mathbf{x}} = \bar{\mathbf{V}} + \mathbf{V}'$, where $\bar{\mathbf{V}}$ is the berg motion vector as derived above and $\mathbf{V}'$ is a deviation motion vector introduced to provide dispersion of bergs within the model grid. This equation was integrated by a first-order forward finite-difference method with a time step of 3 h. The model grid was 15 km × 14.2 km, and the components of $\bar{\mathbf{V}}$ were found by linear interpolation at each time step. The simulated drift patterns were verified to the greatest extent possible using satellite-tracked berg data from 1979 (data not used in deriving the vector maps). The predicted drift captured the essential features of the observed patterns in mid-summer 1979. It was concluded that this method of drift simulation would provide time-varying spatial iceberg distributions with sufficient accuracy to examine the encounter frequency at specific sites in western Baffin Bay knowing the arrival rate of icebergs at the northern boundary.

Estuarine flow driven by ice growth (Bridport Inlet, N.W.T.)

P. Greisman and R.A. Lake

Measurements made in Bridport Inlet in the Spring of 1980 show a two-layer flow at the entrance. The flow is characteristic of a negative estuary in which processes of densification predominate. In this case brine drainage from growing sea ice drives the flow of denser waters out of the Inlet below a return flow of lower density in the surface layer. The flow is accelerated from the interior of the Inlet through the entrance by the pressure gradient established by the density dif-

ferences. The accelerative balance of forces yields current shears in general agreement with the mean current measurements, and the computed salt transport through the entrance is in excellent agreement with the mean rate of brine rejection.

The convective process during the flow appears to be intermittent, in that density profiles are generally just statically stable below the ice.

A comparative study of two sea-ice thermodynamic models

R. Gabison

Results from the application of two sea-ice thermodynamic models are compared in terms of observed versus calculated ice accretion, ablation and freeze-up.

The impact of various formulations of the turbulent fluxes on the cooling rate in the oceanic mixed layer is examined.

Under-ice plume characteristics in Hudson and James Bays

R. Grant Ingram and S. Peck

Characteristics of the Great Whale River plume during three different winters are analysed. Observed variability is related to ambient circulation, changes in freshwater discharge and the rate of vertical mixing. Comparison of the Great Whale and La Grande Rivière plumes shows a marked influence of differing tidal current amplitudes on areal extent and other characteristics. A general discussion on the influence of an ice cover in modifying river plumes in coastal areas is also presented.

A two-layer numerical model of freshwater plumes under an ice cover

N.G. Freeman

The equations for conservation of mass, salt and momentum on a rotating reference frame are integrated vertically over two layers of fluid of uniform but different densities. A river discharge is specified at the shoreward boundary of the upper layer and a cross-flow along the open boundary normal to the shoreline. These time-dependent equations are written in an implicit transient finite-difference formulation, which enables run-time modification of the maximum allowable time step. The pressure-velocity coupling is achieved through the development of local mass conservation velocity correction equations and Poisson equations for updated pressure. An Alternating Direction Implicit Scheme is used to solve each of the equations on a 12×25 horizontal grid.

The numerical model is first tested on a two-layer open channel flow problem to evaluate different E values for numerical stability, and to check on mass conservation and pressure fields in a simplified flow problem. Next, the model is used to simulate the fluid motion and salt concentration fields resulting from the discharge of fresh water into the upper layer. The overall solution convergence is demonstrated and different E values are tested to optimize the rate of convergence while maintaining numerical stability. To test model sensitivity a number of parameters are changed and the effect on the solution evaluated. Some of these parameters include friction factors, cross-flow velocities in the upper layer, and vertical diffusion and entrainment coefficients. Finally, the model is run for calibration with the 1980 La Grande Rivière salinity field. A further run is made without change of parameters for the lower discharge 1976 La Grande Rivière plume for validation. The horizontal salinity distributions and flow fields from the model runs compare favourably with the actual field measurements made off La Grande Rivière in 1976 and 1980.

Forecast delivery

A.H. Campbell

The Atmospheric Environment Service relies on other agencies to a large extent to deliver weather warnings, forecasts and other weather information to its users in the general public and in the broad economic sectors such as marine, aviation, agriculture and commercial fishing.

The historical evolution of the delivery of forecasts and other weather information is briefly traced. The advantages and disadvantages to the user and to the AES of the present delivery arrangements and some possible future scenarios are discussed.

The use of Telidon technology for the dissemination of weather information

D. Dueck

Telidon is the name given to a videotex communications protocol developed by the Canadian Department of Communications. Various field trials are under way to test the feasibility of providing public access to data bases of Telidon-encoded information. The Atmospheric Environment Service has provided climatological and educational information for some of these field trials; as well, real-time weather information such as observations and forecasts have been manually entered at the Ontario Weather Centre and Centre Météorologique du Québec for the Bell Canada VISTA field trial. Software to automate this task has been developed at the Meteorological Services Research Branch, and is now undergoing field testing.

This paper will give a brief introduction to Telidon technology and the public field trials. Some examples of the weather "pages" in the VISTA data base will be presented, and the present capability for automated "page" creation will be discussed.

On the role of the meteorological technician in short-range forecasting

Roy Lee

The Atmospheric Environment Service has accepted the strategic principle that the Meteorological Technician Group will have responsibilities for short-range forecasting in 1990. This paper is an attempt to examine the meaning of this decision in the light of the nature of short-range prediction problems. The resulting proposal is a contribution to an early resolution of that role.

ABC verifications

B.W. Crowe

A simple public forecast verification scheme that originated in November 1977 is described. Forecasts are separated into 3 categories each, for weather and temperature, and simple statistics are generated. Verification scores since July 1978 are displayed.

Proposed system for the tabulation of forecast elements and verification of public forecasts

B.Q. de Lorenzis

The designs of a Forecast Element Data Base and Public Forecast verification system for use on an HP1000 minicomputer are presented. These systems are under concurrent development at the Meteorological Services Research Branch of the Atmospheric Environment Service.

The Forecast Element Data Base is designed to contain weather elements retrieved from communications circuits as well as data entered interactively by a user/forecaster. This data base is

intended for immediate use by the Public Forecast verification system under development. It also is intended to have future applications, e.g. as an automated Public Forecast preparation system.

The verification system proposed will give basic scores for weather elements as they appear in the Public Forecast, for a five-day period in 12- and 24-h windows. As these scores are updated in real-time a utility for the display of these scores will be available as a forecast tool.

Wind chill – a new perspective

R.V. Colpitts

Various scales to describe wind chill are outlined. Media representatives have indicated a deficiency in the handling of this parameter. A review of the various medical and meteorological considerations is presented. A simplified table of units designed to be accountable to both operational forecasters and weather broadcasters is proposed.

Enhancement of a numerical weather element prediction system by statistical error feedback

E.J. Kirkwood and K.R. Johnstone

Forecast weather element data are abstracted routinely from the currently operational Spectral model (Version 8) at the CMC. The output is on a station-by-station basis for locations mainly in Canada and the United States, and is presented in a format similar to that of the hourly aviation weather report. This system has become known as the WEDGE system (Weather Element Digital Guidance Evaluation) and has been operational since 1980.

A statistical enhancement scheme of the WEDGE system has been added on a test basis. The scheme uses detailed verification data from the original forecasts to make statistical corrections, as a function of weather element type, station and forecast period. These corrections are generated and applied as part of a real-time feedback system in an attempt to improve subsequent forecasts.

Pseudo-operational production of these enhanced forecasts has been in place during the past six months. Comparative verification scores support the success of the system in a number of areas.

Session 5B: Dynamic Meteorology — Wednesday 0830 – 1000

A study of the energetics of the Southern Hemisphere summertime wavenumber five

S. Lambert

A striking transient zonal wavenumber five was observed in the Southern Hemisphere troposphere during the summer of the FGGE year. The wave is so strong and persistent that day after day contours of the mid-tropospheric analyses of the height field assume pentagonal shapes. Subsequently, investigators have shown that this wave is present in previous years' observations and as a result is an important feature of the Southern Hemisphere circulation.

The observed features of the wave will be presented and the components of its kinetic energy budget will be discussed.

A diagnostic study of the momentum balance in the Northern Hemisphere winter stratosphere

Kevin Hamilton

A large number of theoretical studies of the possible contribution of small-scale gravity waves to the zonal mean momentum balance in the stratosphere and mesosphere have recently appeared. Direct verification of any of these theories would appear to be virtually impossible, given our

inability to monitor the small-scale wind and temperature fields in the upper atmosphere on anything like a global basis. The present investigation aimed at determining the gravity wave contribution to the momentum balance in the stratosphere as a residual needed to reconcile the zonal mean heat and momentum balances derived from global scale satellite observations. The results appear to be broadly consistent with the current theoretical ideas about gravity wave interaction with the large-scale circulation. There are, however, some important discrepancies between theory and observations in the region poleward of about 60° latitude. Here the theories predict easterly gravity wave induced mean flow accelerations, while the present diagnostic study reveals the presence of both easterly and westerly accelerations in different winters.

Blocking-like solutions of the potential vorticity equation
Herschel Mitchell and Jacques Derome

Three-dimensional flows for which $q = -\lambda^2(p)\psi$, where q is the potential vorticity, ψ is the streamfunction and λ^2 is some arbitrary function of pressure, are examined. We find that flows that satisfy this condition and are quite similar to atmospheric blocking patterns can be generated by the superposition of a zonal current independent of the meridional coordinate, plus zonal and eddy components that have the same three-dimensional wavenumber. These flows, for which the Jacobian of ψ and q is zero, are of interest because (a) in the absence of forcing they constitute steady-state solutions of the potential vorticity equation; and (b) the possibility exists that they can be forced resonantly to a finite amplitude by means of a potential vorticity source. The arbitrariness in the choice of λ^2 is removed by specifying the vertical profile of the diabatic heating. We have shown that when the latter is a linear function of pressure the resultant forced flow is nearly equivalent barotropic, with a tendency for the blocking patterns to become somewhat more prominent with increasing pressure, in rather good agreement with observations of blocking highs.

By integrating a three-level beta-plane model in time, it is shown that it is indeed possible, in the absence of dissipation, to thermally force the above types of flows at resonance and to generate flow patterns that are quite similar to atmospheric blocking patterns. It is also shown that even when a rather broad spectrum of modes is thermally forced, the above resonant modes tend to dominate the flow, in spite of the possible interaction among modes. This would imply that provided the mean zonal flow has the proper strength to produce a resonance condition, the thermal forcing field need not have a very special structure to produce a finite amplitude disturbance through resonance.

On finite-amplitude topographic disturbances
Jacques Derome

It is shown that, in the absence of dissipation, the topographically forced disturbances that Charney and Eliassen (1949) obtained as solutions to the linearized barotropic vorticity equation are actually *finite amplitude* solutions. Similarly, in a baroclinic quasi-geostrophic model with no dissipation, topographically forced disturbances obtained as solutions to the linearized potential vorticity equation also satisfy the non-linear version of the latter, and are therefore finite amplitude solutions, for arbitrary shapes of the topography provided the index of refraction is a function of the vertical coordinate only.

Analytical surface pressure and drag for linear, hydrostatic flow over three-dimensional elliptical mountains
Doug S. Phillips

A linear, hydrostatic model of the flow of stably stratified air over a three-dimensional mountain with an elliptical horizontal cross-section is considered. Analytical expressions for the surface pressure perturbation are used to study the differences between two- and three-dimensional flows.

The maximum pressure perturbation due to a barrier with a circular cross-section is about 30% less than that due to an infinitely long ridge perpendicular to the mean flow. For a barrier three to four times as wide across the wind as along the mean flow, the assumption of two-dimensional flow, in vertical planes, leads to an extreme pressure perturbation differing from the three-dimensional solution by only about 10%. For an elliptical barrier with an axis parallel to the mean flow, the maximum difference between the pressure fields for two- and three-dimensional flows occurs along that axis. Other aspects of the flow that are studied include horizontal divergence and the velocity component perpendicular to the mean flow. Also, the force exerted by the mountain on the incoming airstream is calculated as a function of the barrier eccentricity and orientation. If an axis of the elliptical terrain is not parallel to the upstream flow, there is a transverse force on the air that can be an appreciable fraction of the drag force acting in the direction opposite to the mean wind. The effect on the drag of smoothing the terrain is also briefly considered.

First-order dynamics of tropical disturbances

Han-Ru Cho and Mary Ann Jenkins

A set of first-order equations applicable to weather systems in tropical latitudes is derived. These equations indicate that the evolution of the vorticity field in the tropical atmosphere is influenced mainly by the horizontal advection of vorticity, and a vorticity source produced by cumulus clouds.

The effects of cumulus clouds on the temperature or geopotential fields depend on the ability of clouds to influence the vertical velocity field in the cloud environment. A diagnostic equation is derived for this vertical velocity field. It is controlled by both the large-scale and the cloud-scale processes. This diagnostic equation, together with the first-order vorticity equation and the thermodynamic equation forms a complete set of first-order equations for tropical disturbances.

The GATE data were analysed to illustrate the first-order processes and to provide a consistency check between the first-order equations and the observed behaviour of the tropical atmosphere.

Session 5C: Oceanography II — Wednesday 0830 – 1000

The disappearance of the Alaskan Gyre 1981 – 82: the anomalous tracks of drogued buoys

W.J. Emery

Four buoys, deployed in August 1982 (from 50 to 55° N along 160° W) to study the oceanic circulation in the Gulf of Alaska, did not reveal the presence of the Alaskan (or Subarctic) Gyre but rather drifted due eastward with two buoys eventually turning south in the fall of 1982. These year-long tracks are consistent with the tracks of other buoys deployed farther south and a month later along the same meridian. All of these trajectories are in strong contrast to the tracks of earlier buoys (1976 – 77, 1978 – 80), which indicate the presence of a cyclonic Alaskan Gyre with a significant contribution from part of the North Pacific Current that turns northward at its eastern terminus. This departure, in the recent buoys tracks, marks a major shift in the mean circulation of the eastern North Pacific. The relationships between this shift as depicted by the buoy tracks, and changes in upper-layer (0/200 db) monthly dynamic topography are explored along with changes in the monthly and daily atmospheric pressure fields.

Modelling and observations of the fluctuations of the Fraser River Plume

Louise Royer

Temporal and spatial variations of the Fraser River Plume (British Columbia, Canada) have been monitored by continuous salinity sampling of the engine cooling water on two B.C. ferries. The observed salinities are formulated as time series and used to compute cross-correlations with the probable driving forces of wind, tide and river discharge. The observations are also compared with salinities given by a numerical model of the plume previously developed by Dr J.A. Stronach.

Periods of high river discharge lead to decreases in the observed salinities. Weak correlation of the salinity with the along-strait wind component is consistent with the advection by the wind. The numerical model with, as input, the daily variations of the discharge and the hourly wind data has been able to reproduce the main features of the variations of the observed salinities.

Circulation and dispersion on Browns Bank

Peter C. Smith

Recent moored measurements suggest that a clockwise gyre around Browns Bank is a permanent feature of the circulation off southwest Nova Scotia. The main driving force for this flow appears to be associated with topographic rectification of the semidiurnal tide. However, Lagrangian measurements using satellite-tracked drogues indicate that the surface gyre is subject to periodic breakdown due to the influences of wind and offshore currents. "Residence times", defined as the length of time the drifters remain within 25 km of the 100-m isobath, range from 1 week to 2 months. The effects of wind on "residence time" are discussed and preliminary results from a field experiment designed to measure dispersion on the bank are presented.

The anticyclonic, baroclinic eddy off Sitka, Alaska

S. Tabata

A physical description of a recurring anticyclonic, baroclinic eddy off Sitka, Alaska is given. The eddy, whose diameter ranges from 200 – 300 km and whose depth extends to as much as 2000 m is characterized by the following features: the surface water is less saline and only somewhat warmer than at its periphery; at depths within and below the halocline it is warmer, less saline and contains more dissolved oxygen than at the periphery; and a warm core is situated within the halocline. At the centre the isopycnals are depressed by as much as 185 m. The average surface speed of the eddy is approximately 15 cm s^{-1}, with the maximum reaching almost 40 cm s^{-1} (relative to 1000-db surface), and the average baroclinic transport in the upper 1000-db layer is 5×10^6 m^3 s^{-1}, with the maximum approaching 8×10^6 m^3 s^{-1}. The average surface speed of the eddy, according to drifting buoy trajectories, is 70 cm s^{-1} with a maximum daily speed of 110 cm s^{-1}. Atmospheric forcing and topographic interaction are the probable generating mechanisms for the eddy.

Hydrochimie de l'estuaire moyen du Saint-Laurent et du fjord du Saguenay

Jean Lebel

La dilution d'une eau marine par une eau fluviale entraîne un certain nombre de modifications des espèces chimiques en présence selon les conditions existantes. Pour mesurer ces modifications nous avons effectué une campagne de prélèvement dans l'estuaire moyen du Saint-Laurent et le fjord du Saguenay pour lesquels la source d'eau douce est très différente. Les affluents du Saguenay drainent les hautes terres du Bouclier Canadien pauvre en dépot calcaire amenant dans le fjord des eaux douces acides et peu concentrées en espèces ioniques; par contre, le bassin du Saint-Laurent comprend des régions riches en carbonates fournissant à l'estuaire des eaux douces

à pH d'environ 8 dont la charge ionique est plus importante. Les résultats obtenus fournissent une excellente description des propriétés physicochimiques des deux systèmes: salinité, température, oxygène dissous, alcalinité, pH *in situ* en plus de fournir des indications sur l'influence de l'apport d'eau douce sur la saturation en calcite en milieu estuarien.

Session 6A: Operational Meteorology II — Wednesday 1020 - 1200

Cyclogenesis in the lee of the Alaska Range

Jeffrey P. Walker

A synoptic pattern that produces one third of the significant snowfall at Anchorage, Alaska, has been attributed to a form of lee cyclogenesis. Numerical models with smoothed terrain do not simulate this phenomenon and subsequently underestimate the precipitation amount. The dynamics of cyclogenesis in the lee of the Alaska Range have much in common with those in the lee of the Rocky Mountains and the Alps. Composites of observed cases showing the persistence of this synoptic pattern will be presented as well as a summary of diagnostic techniques used to supplement numerical guidance in forecasting this event. Also included will be some results of numerical simulations incorporating more realistic terrain and a discussion of the mechanisms involved and their similarity to those that occur in other areas.

The use of enhanced visible imagery in analysis and short-range forecasting

Philip R.J. Chadwick

Specialized visible imagery has been designed to achieve optimal contrast and to enhance high albedo surfaces.

The analysis and identification of various meteorological and geographical features is made easier by the increased contrast achieved. In addition, high albedo surfaces can be related to cloud or fog thickness, which has implications on the probability of precipitation. Higher resolution visible imagery also reveals details that are not apparent on lower resolution infrared imagery.

Enhanced visible imagery may be used to identify cloud thicknesses capable of producing precipitation. There is also the possibility that enhanced visible imagery can differentiate between areas of differing precipitation rate although this has not been verified.

Enhanced visible imagery can also discern relative fog and stratus thicknesses allowing relative estimates of fog dispersal times.

Heavy rainfall in east central Saskatchewan on 16 - 17 July 1982: a case study of a mesoscale analysis and short-range forecast problem

Gerald D. Machnee

A slow moving weather system over the eastern Prairies developed rapidly on the evening of July 16 and resulted in numerous tornadoes over southern Manitoba and 100 - 150 mm of rain that extended in a narrow band from Indian Head through Canora, Saskatchewan to Swan River, Manitoba. Regularly reporting stations measured less than half of the amounts recorded at climate stations. The problem of reporting high precipitation amounts and forecasting them is examined and several methods to supplement our system are suggested.

The Spatial/Temporal RESolution Study (STRESS) of upper-air data

C.M. Sackiw and G.S. Strong

Synoptic-scale rawinsonde networks are capable of resolving features larger than 1000-km wavelength, and more than 24-h life cycle. For this purpose, errors of uncertainty are usually ignored for upper-air analyses and prognoses. The ability to diagnose and forecast mesoscale features such as thunderstorms, however, is often limited by the lack of upper-air data at that scale. Even

given these data, the analysis of pertinent features may be masked by data sampling uncertainties.

Convection weather is of major concern for Day-1 forecasting on the Prairies. Severe convective storms, particularly hailstorms, have been the main focus of Alberta Hail Project research for many years. A small-scale upper-air network appears to be necessary for investigating the interactions between synoptic-scale processes and mesoscale thunderstorm systems. It was desirable to establish upper-air data accuracy and resolution capability before such a network could be established. To this end, the Spatial and Temporal RESolution Study (STRESS) was commenced, comparing data sets from Alberta and elsewhere. This paper reports on preliminary STRESS findings.

The identification of severe weather from satellite imagery

A. Kilambi, A. Bellon and G.L. Austin

The ability of the GOES imagery to detect and track clouds producing severe weather is discussed. The importance of accurate normalization of the visible imagery for sun angle is emphasized. Results indicate that electrically-active storms may be identified by a pair of visible and IR thresholds (e.g. $C_{vis} \geq 50$ and Temp. $< -20°C$). The skill of such a technique is believed to be sufficiently high to justify further studies and perhaps an operational test.

Applications of the Synoptic Index to regional forecasts of convective complexes

G.S. Strong and W.D. Wilson

The Synoptic Index of Convection (Sc10) was developed for forecasting the maximum convective intensity for a day over the 130-km radius Alberta Hail Project operations area (AHP) in central Alberta. It has been a reliable hail predictor for cloud-seeding operations for five years (1978 - 82), but data extrapolation and computations for even a single value of Sc10 are time-consuming and too cumbersome for automated use. A simpler version, the Sc4, is easily computed from two synoptic and two instability predictor variables. Unlike the Sc10, there is no subjective input. The Sc4 showed almost the same predictive skill as the Sc10 for 1980 - 82 AHP operations, while the linear correlation between the two indices was 0.93.

An automated regional version of the Sc4 was tested during 1982 field operations. It yields a convective forecast for southern Alberta and adjacent regions of Saskatchewan and British Columbia, and also provides hourly updates. This paper evaluates the 1982 performance of this regional forecast index for a wide range of convective weather types, from no convection to severe hail-producing thunderstorm complexes. Included with these tests is a hindcast of the most expensive hailstorm in Canadian history, which occurred on 28 July 1981. These tests show potential economic benefits from using the Synoptic Index for severe thunderstorm advisories, as well as for field research activities and cloud-seeding operations.

Session 6B: Numerical Modelling — Wednesday 1020 - 1200

Introduction of a finite-element boundary-layer model into a NWP model

Robert Benoit and Jean Côté

The atmospheric boundary layer (ABL) model of Mailhot and Benoit (1982) is introduced into a three-dimensional primitive equation numerical weather prediction model. The coupling of the ABL to the dynamical model is through the operators of vertical diffusion of momentum, temperature and moisture. These operators depend here essentially on the turbulent energy.

To insure the numerical stability of the algorithm the diffusion step is performed after the usual semi-implicit advection step. This procedure is stable inasmuch as the model is stable in the absence of diffusion.

The evolution of the turbulent energy is handled using a split Crank-Nicholson method, which is absolutely stable.

This scheme is being implemented in the finite-element regional model (Staniforth and Daley, 1979) and could easily be adapted to the spectral model with finite-element vertical discretization (Staniforth and Daley, 1977).

Normal mode initialization of the RPN finite-element model

Gilles Verner and Robert Benoit

At the present time, it is not clear how one could apply the non-linear normal mode initialization technique (e.g. Daley, 1979) or the bounded derivative method (e.g. Browning and Kreiss, 1982) in order to properly initialize a limited area model such as the RPN finite-element regional model (Staniforth and Daley, 1979). The main difficulty is the non-separability of the normal mode equations in polar stereographic projection coordinates (map scale and Coriolis factor).

Results are presented of initialization experiments using a finite-element version of the Canadian Spectral Model (Daley et al., 1976) initialized by the non-linear normal mode technique where the initialized fields (sigma coordinate, Gaussian grid) are interpolated to the domain of the regional model (sigma coordinate, polar stereographic grid).

Both models have the same vertical discretization, a common physics package and an explicit lid at their top level. In order to minimize interpolation errors, the spectral model is run at high resolution (rhomboidal truncation of order 40).

Initialized fields as well as time evolution graphs of both models are compared to evaluate the usefulness of using an existing spectral hemispheric normal mode scheme for indirectly initializing a regional model and thus avoiding the tedious task of determining its normal modes.

The CMC MOS system of weather element prediction

N. Brunet, G. Richard, H. Yang and N. Yacowar

Using a data base of two years output from the Spectral Model and the output of an analogue model, regression equations were developed for a network of Canadian stations to forecast the probability of precipitation for six consecutive 12-h periods.

The forecasts were verified for the 1982 – 83 winter season, and the results show improvement over existing forecasts models. The system is being extended to produce forecasts of other weather elements such as total cloud cover and maximum and minimum temperatures.

Application of the semi-Lagrangian scheme to the moisture equation in a regional forecast model

Hal Ritchie

It has been demonstrated recently (Robert, 1981; Bates and McDonald, 1982) that the semi-Langrangian technique may offer significant computational advantages over the purely Eulerian approach for numerical weather prediction. Although the main appeal of the semi-Langrangian technique is that it permits treating advection terms with time steps that exceed the CFL limit, this scheme also has other desirable properties. In particular, it does not exhibit the scale-dependent phase errors that are characteristic of Eulerian schemes and can lead to serious erroneous dispersion, especially for features whose length scales are near the resolution limits of the model.

We attempt to exploit this latter property by introducing a semi-Lagrangian formulation in the moisture equation of the RPN regional baroclinic finite-element primitive equations model (Staniforth and Daley, 1979). The impact of this change is assessed by comparing the resulting specific humidity and precipitation fields with those obtained from the version of the model in which all variables are treated using the Eulerian formulation.

A third-order closure model for the atmospheric boundary layer

S. Csanady

Since, generally, the effects of higher order correlations are smaller on the mean (first-order) quantities with increasing order of such correlations and the overall effect of fourth-order correlations is to regulate the growth rate of third-order ones, it seemed a good idea to use third-order rate equations in a boundary-layer model. As a first approximation we used a model having 26 partial differential equations without humidity and humidity covariances. In a previous similar model J.C. Andre (1978) used the quasi-normal theory to express fourth-to-second moment relations. We modified this approach by using the Wiener-Hermite expansion of turbulence quantities to express the flatness factor and the corresponding limiting relations for the third-order correlations to derive the model equations (Schwartz inequalities).

This is a 1-D model with explicit Adams-Bashforth time integration, which was successfully tested on the Wangara Data (Clarke et al., 1971). The CPU time requirement with the present 40 vertical levels set-up is 25 min for each hour of forecast time. Boundary conditions for first- and second-order quantities are constructed by using the Monin-Obukhov similarity theory, while third-order quantities are uniformly set to zero everywhere.

The 24-h forecast results will be presented for quasi-normal and Wiener-Hermite closure using radiation effects in the thermodynamic equation and in the temperature variance equation. Some adjustment had to be made at the second-order correlation level to assure realizability.

A finite-element cloud dynamics model

Garry Toth and Ambury Stuart

A one-dimensional, time-dependent, shallow convection cloud dynamics model has been developed using the finite-element method in the numerical integration of the equations. The model equations used are those of Ogura and Phillips (1962) in the form presented by Holton (1973). The model simulates buoyancy, latent heat release and liquid water production, perturbation pressure, entrainment, turbulence and drag due to the presence of liquid water. It does not simulate any microphysical processes such as ice growth or precipitation fallout.

The finite-element method offers the advantages of increased accuracy (compared to the finite-difference method) and ease of using grids with variable grid spacing. As far as the authors are aware, this is the first time that finite-element technology has been applied to a cloud dynamics model. One of the authors (Stuart) has experimented with finite-element solutions of the condensation and coalescence equations.

The model has been designed to run efficiently on small minicomputers. Runs with various grids and time steps have been undertaken. The model clouds are similar to those of Holton (1973). Solutions using variable grids have been compared to those using uniform grids. Some high frequency noise appears in the variable grid solutions. A potential method for reducing this noise is suggested.

A numerical model of surface outflows from convective storms

Robert P. Addis

A one-dimensional hydrostatic and incompressible numerical model based upon the "shallow water" wave equations is used to simulate surface outflows from convective storms. Axial symmetry is employed to simulate outflows in a non-shearing environment, while slab symmetry is employed to simulate unidirectional outflows.

The model is initialized with observed data from GATE and found to be capable of simulating the slope, depth, overall shape and propagation speed of the outflow of tropical squall lines.

The model is used to construct a series of nomograms relating the depth of the gust front head

to the origin and strength of the downdraft for various density differences and downdraft radii. It is inferred from these model results that wide downdrafts, originating deep within cumulonimbi and growing in a strongly sheared environment, which encourages unidirectional outflow, produce the deepest gust fronts. Such outflows require the weakest downdraft velocities to be maintained, and do not decay rapidly when the downdraft ceases.

Conversely, it is also inferred that narrow downdrafts originating near the base of a cloud and growing in an environment encouraging radial outflow produce the shallowest gust fronts, require the strongest downdraft velocities to be maintained and decay most rapidly when the downdraft ceases.

Session 6C: Oceanography III — Wednesday 1020 - 1200

Nanticoke II Shoreline Dispersion Experiment, June 1982

R.M. Hoff

In June 1982, the Atmospheric Environment Service coordinated a major atmospheric dispersion field experiment near the Nanticoke, Ontario industrial complex. The experiment was designed to obtain detailed meteorological information on the formation of the Thermal Internal Boundary Layer (TIBL) near the Lake Erie shoreline and to assess the effect that the TIBL has on the complex industrial source configuration at Nanticoke. The project involved 50 scientists and technical personnel from AES, Ontario Ministry of Environment, Ontario Centre for Remote Sensing, Ontario Hydro, Nanticoke Environmental Management Program, the Commission of the European Communities, the Dutch Public Health Institute, the Japan Environment Agency, and the University of South Florida.

The project built upon knowledge gained from the previous experiments at Nanticoke and provided new data on the forcing parameters for TIBL growth: surface temperature, water temperature, surface heat flux and turbulent characteristics of the lake-breeze flow. Use of thermal infrared imagery from both satellite and aircraft provided unique spatial and temporal information on surface temperature. Ground truthing for the remote-sensing information was provided by a tower network. The growth of the internal boundary layer was measured by four minisonde/airsonde stations, three acoustic sounders (one Doppler), and two tethered balloons. One tethered balloon carried a sonic anemometer aloft to determine vertical velocities and turbulent spectra below and above the TIBL.

During the study, four days had lake-breeze conditions that led to shoreline fumigation. The use of three correlation spectrometer units and two LIDARs provided coverage of these events. From these results, it is possible to assess the effect shoreline meteorology has on the two new industrial sources in the Nanticoke area.

Existing shoreline dispersion models were applied in real-time to predict the location of fumigation maxima. The results from this attempt will be discussed and areas of future modelling research will be reviewed.

A new approach to extreme wave estimation in the Beaufort Sea

Donald O. Hodgins and Ronald H. Goodman

Hindcasting extreme wave heights in the Beaufort Sea must account properly for the probability of occurrence of storms of a specified severity and for the probability of ice conditions that give sufficient open water to allow severe waves to be generated. In the usual approach the return period of the design wave state is determined in advance and the problem consists of finding those combinations of storm and ice conditions that produce this sea state. In a new analysis of 12 years of meteorological data, two storm populations that would produce extreme wave conditions are distinguished by their trajectories. The return period of storms in each class is less than one year, and all major synoptic-scale storms known to have produced severe wave or surge conditions

since 1970 fall into one of these two classes. The probability of storms occurring in bi-weekly periods over the open-water season has been determined for each class. A complementary analysis of nineteen years of digital sea-ice data compiled by the Atmospheric Environment Service was then used to estimate the probability of occurrence of open-water fetch in the same bi-weekly periods. With these probability distributions it is possible to calculate the severity of a storm in either class required to give wave conditions with a selected return period for a particular definition of open water (or fetch). This allows some flexibility in seeking design wave conditions that are important to the project under consideration. The procedure is applied for duration-limited wave conditions having a 100-year return period. When the ice conditions are characterized by a northwest fetch exceeding 500 km the significant wave height at a point near the Kopanoar well site is about 9 m. It is shown that this value is approximately 30% lower than the 100-year significant wave height calculated by a method that neglects the probability of open-water occurrence.

Three-dimensional modelling of tidal residual flow
D. Lefaivre, K.-T. Tee and P.C. Smith

The area off southwestern Nova Scotia is among the most productive ones on the East Coast of North America. An array of moorings was maintained over a three-year period to monitor the mean and seasonal circulation. Current-meter observations suggest a tidal rectification effect is present. To investigate this effect, a three-dimensional model of the tidal current was set up. The following sequence of computation was carried out: (1) A horizontal two-dimensional M2 tidal model. (2) The vertical profile of the tidal current. (3) A horizontal two-dimensional residual flow model. (4) The vertical profile of the residual flow. Comparisons with field data have been made.

Bottom currents in the Central Basin of Lake Erie
F.M. Boyce and M.N. Charlton

Recent work has shown that biochemical processes occurring in the hypolimnion of Lake Erie's Central Basin are strongly governed by physical processes such as sediment resuspension and entrainment. Currents, temperatures, dissolved oxygen, and sediment trap measurements were made in the Central Basin during 1979 and 1980. the spatial and temporal variabilities of bottom currents are examined as well as their capacity for resuspension and downward entrainment. A diagnostic model is proposed for the distribution of horizontal currents with depth.

On the frictionally-induced depth-dependence of tidally-rectified flow
Daniel G. Wright and John W. Loder

A simple model for the topographic rectification of tidal currents in a viscous, homogeneous, rotating fluid is used to examine the dependence of the resulting mean flow on various non-dimensional parameters. Key simplifications are the approximations of a rigid lid, uniformity along isobaths, zero depth-averaged mean flow across isobaths and weak non-linearity. The model is depth-dependent with vertical friction parameterized through a depth-independent eddy viscosity and a bottom stress law at the top of the constant stress layer.

The mean flow depends on six non-dimensional ratios: f/σ, E and F - the ratios of tidal period to inertial period, vertical mixing time and frictional spindown time; and the ratios of topographic length scale to horizontal tidal excursion and the horizontal length scales over which the vertical eddy viscosity and bottom friction coefficient vary. When $EF^{-1} >> 1$, vertical structure in the flow is negligible and the model reduces to its depth-independent analogue. However, for common values of E and F, there is significant vertical structure in both the along-isobath and cross-isobath components, and the depth-averaged along-isobath mean flow can be substantially greater than in the depth-independent model.

With $f/\sigma \sim 1$ and $F \lesssim 1$ (typical of many mid-latitude continental shelf regions), anticyclonic

mean circulation around shallow regions is favoured with a much weaker cross-isobath component. There is generally a significant Stokes velocity associated with the rectification such that the cross-isobath component of mean Lagrangian velocity is often in the direction opposite to that of the mean Eulerian velocity.

Channel waves over parabolic topography

Yves Gratton

A two-layer model is used to study analytically the properties of topographic waves propagating along a channel with an O(1) parabolic topography cross-section. The results are applied to the St Lawrence Estuary.

Session 7A: Operational Meteorology III Wednesday 1300 - 1430

Mesoscale forecasting in the marine environment

M.D. Hewson

Operational meteorologists employed in the private sector by companies engaged in the provision of forecast services to particular users, are mainly involved in preparing parameter predictions of mesoscale and sub-mesoscale phenomena. The various scales of environmental phenomena are examined and defined, and the requirements of clients of private sector firms are delineated and shown to be predominantly in the mesoscale. The methodologies used in mesoscale forecasting over oceans and immediately adjacent land masses are compared and contrasted with methodologies used in synoptic and macroscale forecasting, and those areas of forecasting technology that are transferrable between scales are described. The types of research required in support of the marine mesoscale forecasting problem are outlined and priorities in this area are given. The difficulties associated with data acquisition for both the mesoscale forecaster and the mesoscale researcher are examined and some possible solutions are suggested. Finally, the particular problems of forecasting in the near term (Day-1 forecasting) that are encountered by the mesoscale marine meteorologist are reviewed and technology relevant to that particular task is described.

Mesocyclones over Canada's continental shelf

W.G. Richards

Recent observations of intense disturbances over the Scotian Shelf confirm the existence of a phenomenon sometimes referred to as an "Arctic Low" in Canadian waters. Winds over 70 kt were recorded as a cyclone of horizontal length scale less than 50 km passed near Sable Island in January of 1982. Weather phenomena of this scale are poorly understood yet could have a serious impact on weather-sensitive coastal or offshore activities.

Storm forecasting in the Beaufort Sea

E. Taylor and R. Black

Rapidly developing, intense storms have a substantial impact on the safe and efficient operation of the offshore drilling programme in the southern Beaufort Sea. The weather, sea and ice forecast programme of the Beaufort Weather and Ice Office located in Tuktoyaktuk, NWT is described. Two particularly severe storms that occurred during the summer of 1982 are compared. The development scenarios are described with reference to the controlling topographic features and available observational data. The importance of numerical guidance and experienced personnel in a short-range prediction programme is discussed.

A comparison between computed and measured oceanic winds near the British Columbia coast

Richard E. Thomson

Winds measured over the continental shelf off Vancouver Island during the summers of 1979 and 1980 are compared with winds computed by the National Marine Fisheries Service (Monterey, California) using synoptic surface atmospheric pressures. Although there is considerable qualitative similarity between the two sets of data, the computed six-hourly winds fail to resolve accurately the short-period fluctuations associated with transient wind systems and tend to underestimate the percentages of time of the low and high wind speeds. In the frequency domain, the computed winds are representative of the oceanic winds for periods exceeding about 2 days but only marginally representative for periods of 1-1/2 to 2 days. At periods less than about 1-1/2 days, computed winds are not reliable indicators of oceanic wind variability. Moreover, the computed winds possess a large amplitude sea-breeze (diurnal) component that is present in the inner-shelf wind data but not in the outer-shelf wind data. This sea-breeze component in the computed winds originates through use of land-based atmospheric pressure values and is not idicative of the offshore wind field. Spectra of the observed winds suggest a $k^{-5/3}$ law behaviour (where k is the horizontal wavenumber) consistent with the existence of a mesoscale, two-dimensional reverse-cascading energy inertial range. Spectra for computed winds, on the other hand, are more consistent with a k^{-3} law appropriate to geostrophic turbulence and the existence of a macroscale, two-dimensional cascading enstrophy inertial range.

The influence of heavy precipitation on the intensity of surface circulation around developing East Coast storms

John Pearce

The intensity of surface circulation (winds) around developing East Coast storms is observed to be strengthened considerably when accompanied by heavy precipitation. The linkage mechanism is suspected to be latent heat, which lowers surface pressure in the core of the storm.

Some specific cases are investigated where precipitation of 50 to 75 mm produced winds of 80 to 100 kt. Techniques for identifying these extreme cases 12 to 24 h in advance are described.

On the use of the 850-mb chart in nowcasting

E.R. Reinelt

Of all the "mandatory" upper-air charts regularly available in forecast offices, the 850-mb chart is usually paid the least attention, and only rarely is it part of a formal forecast procedure. This is odd, for with nowcasting all but synonymous with mesoscale forecasting, it is the chart best suited for the depiction and prediction of mesoscale phenomena. Three case studies are presented which show that, when updated with extrapolated surface reports and augmented by terrain contours, radar data, streamlines and trajectories, the 850-mb map is well suited for use in nowcasting and short-range prediction.

Large-scale energetics and small-scale convection over Alberta

G.S. Strong

For many years, forecasters have used the term *trigger mechanism*, implying the existence of interacting mechanisms between synoptic-scale processes and thunderstorms. Many involved in severe storm research are only recently giving tacit approval to the *scale interaction* concept. This may be a natural consequence of research being focussed primarily on the visible processes and results, namely clouds and precipitation. These scale-to-scale interactions are, in fact, poorly understood. We have little concept as to how the mysterious trigger is pulled, and perhaps little notion about how the projectile (?) is directed to its target. Furthermore, the forecaster can at best only approximate where the target (in this case, the thunderstorm) will be. Now may be the time for a concentrated effort in this area. Results should lead to significant gains in the Day-1 forecasting of severe storms. The solutions are also paramount to the development of a total conceptual model of thunderstorms, and to understanding the overall problems of weather modification.

This paper approaches the subject in terms of atmospheric energetics, first reviewing some recent findings. A hypothesis is presented to partially explain the role that large-scale energetics may play in the initiation and life cycle of sub-synoptic scale clusters of convective clouds, and of resulting thunderstorms. It is theorized that the energy cascade and exchange initially takes place at low levels, with the formation and removal of *capping inversions* (about 1 km above ground) playing a key role in the more severe storm cases. Sounding data obtained in Alberta during 1982 are presented to test this hypothesis, and compared with similar data from a severe Oklahoma storm case that resulted in tornadoes.

Rocky Mountain House tornado, 30 June 1982: a case study

Gerard Neault and Arjen Verkaik

In the afternoon of 30 June 1982, a severe tornado ripped through the countryside southwest of Rocky Mountain House, injuring one person and damaging seven farms. Damage has been estimated at $500,000.

A detailed account of the event, supported by photographic evidence and eyewitness reports, is given. The meteorological conditions that led to the tornado are examined according to classical severe thunderstorm forecast guidelines and relative to conclusions reached in a previous study of tornadic events at the Alberta Weather Centre. Finally, the presently known characteristics of Alberta tornadoes are outlined.

Cloud seeding by ground generators in Alberta: field studies of generator targetting

F.E. Robitaille, F.D. Barlow and J.D. Mason

The Alberta Research Council (ARC) is conducting a multi-year program to assess the efficacy of ground-based silver iodide generators for weather modification in the summer months. As part of this programme, networks of generators of the coke and arc types were operated by I.P. Krick Associates of Canada, Ltd in the summers of 1981 and 1982 under contract to ARC. In 1981, 66 sites and 86 generators were operated. Slight changes were made to the network for 1982 to include one additional site and two additional generators.

During 1981 and 1982 the principal objective of the programme was to measure the concentrations of seeding material delivered by generator networks to target volumes. To do this the INTERA/ARC research aircraft was used to measure ice nuclei concentrations in the target volume using an NCAR ice nuclei counter. Results from several aircraft missions are presented.

On the optical properties of arctic haze

Jean-Pierre Blanchet and Roland List

The optical parameters of the arctic haze, e.g. the scattering and absorption coefficients and the asymmetry factor, have been established by a theoretical haze model. The Aden and Kerker's solution for spherical nuclei coated with a spherical shell is employed to account for the observed coating by sulphuric acid on the arctic aerosol. Six original aerosol materials are considered; four are natural and two have an anthropogenic origin (H_2SO_4 and soot). The relative humidity is varied between 0 and 99% and the effects of anthropogenic substances are examined. Carbonaceous material increases the absorption coefficient by about one order of magnitude in the visible range, while H_2SO_4 significantly increases the growth of particles and affects all optical parameters. The haze model is found to be consistent with available measurements of aerosol characteristics and optical parameters. As an application, the haze model is used to convert a vertical profile of the extinction coefficient to one of particle concentration. Applications to radiative budgets and the climate of the Arctic are forthcoming.

Modification potential of orographic cloud systems in the southern Canadian Rockies: preliminary aircraft observations

F.E. Robitaille, F.D. Barlow and J.D. Mason

A preliminary experiment was performed from 16 to 26 March 1982 as a prelude to a proposed multi-year programme to assess the modification potential of orographic clouds in the southern Canadian Rockies during the snow season. The INTERA/ARC research aircraft flew five missions during the experimental period. Case study analysis for a mission on 23 March is presented.

Additional research aircraft missions are planned for March and April 1983. Preliminary results from these missions will be presented.

Results of a cumulus seeding experiment

B. Kochtubajda

Controlled seeding experiments on towering cumulus clouds, using silver iodide flares for dry ice pellets, have been conducted in Alberta for a number of years. The results of a cumulus seeding experiment performed on 15 June 1982 are presented. A test cloud meeting the required criteria, was seeded with silver iodide flares. A radar detectable echo, oriented parallel to the seeding track and displaced downwind, was observed about 10 min after seeding. Microphysical measurements were made employing the INTERA/ARC research aircraft facility. The ice crystal concentration within the seeding plume increased by two orders of magnitude 6 min after seeding. This enhancement is consistent with previously defined weather modification hypotheses.

Ice crystal evolution in a hailstorm feeder cloud following AgI seeding

Terrence W. Krauss

Three cloud turrets (feeder clouds) within the convective new growth zone of a severe Alberta hailstorm on 30 June 1982 were seeded with AgI flares as part of a controlled seeding experiment. One of the seeded feeder clouds was penetrated six times by the INTERA/ARC instrumented cloud physics aircraft within a 20-min period before the feeder cloud merged with the main storm complex. The natural ice concentration during an initial aircraft penetration near the -10°C level was less than $1\ L^{-1}$. Six minutes following seeding the ice concentration was greater than $100\ L^{-1}$. The seeded feeder cloud developed millimetre-size graupel and produced a distinct radar echo within 20 min after seeding. This case study demonstrates our ability to artificially increase the ice particle concentrations within one hail embryo source region. Cloud physics aircraft data and radar data will be presented.

Current-meter measurements in Hudson Strait, 1982

Ken Drinkwater

Initial results from a current-meter array moored northeast of Cape Hopes Advance in Hudson Strait during 1982 will be discussed. The M_2 tidal currents ranged in amplitude from 0.3 to 0.4 m s^{-1}. Mean currents were directed out of the Strait (southeastward) along the southern coast, into the Strait on the northern side and southward across the Strait in the middle. Estimated transports for each of these flows was 1×10^6 m^3 s^{-1}. The data are compared to earlier current measurements based on iceberg drift and satellite-tracked drogues, and geostrophic estimates. The low frequency variability of the currents will also be discussed.

Results of year-long current meter array from Hudson Bay

S.J. Prinsenberg

A current-meter array located 100 miles northeast of Churchill collected data at 3 depths from 3 September 1981 to 4 September 1982. These are the first year-long oceanographic time-series data from an offshore location in Hudson Bay that is covered by a seasonal ice cover for half of the year.

The currents are dominated by the tidal component. It rotates counter-clockwise at all depths, and decreases in amplitude with depth. During the summer, low-pressure systems passing close to the array cause inertial currents and variations in the mean current. The inertial currents persist for several days and at times cause the total current to reverse its rotation direction when the inertial current is stronger than the tidal current. Although the inertial period (13.8 h) is close to that of the main tidal period (12.4 h), it is clearly distinguishable in the power spectra of the residue current. During the period of permanent ice cover, the tidal current is slightly reduced in magnitude and the inertial currents are nearly absent. However, oscillations in the mean currents caused by passing low-pressure systems are still present with an ice cover.

Deep ocean turbulence measurements

J.N. Moum and T.R. Osborn

Measurements of velocity microstructure in the ocean to date have been made in the upper kilometre of the water column and largely concentrated in the top 300 m where mean current shear, wind mixing and gravitational instability are the primary mechanisms for generating turbulence.

A large number of measurements below 500 m, and some to 2200 m have recently been made in the Pacific equatorial region (137 – 153°W) and along 152°E from 22 to 43°N in the region of the Kuroshio extension. These show considerable turbulent activity in randomly occurring patches that range in vertical thickness from 2 to 30 m. The Kuroshio extension data are marked by less thick but more frequently occurring turbulent patches. From the measurements, the turbulent kinetic energy dissipation is calculated. It has been predicted that the small-scale turbulence parameters such as the dissipation follow a lognormal distribution and the fit of this distribution is tested using the Kolmogoroff-Smirnoff goodness-of-fit test.

Winter-time temperature structure in ice-covered lakes: examples from the headwater lakes of the Yukon River Basin

Eddy C. Carmack

A description is given of midwinter (inverse) temperature structure in the large, headwater lakes of the Yukon River Basin; specifically: lakes Atlin, Tagish, Marsh, LeBerge and Teslin. Since the temperature profile left behind by a retreating mixed-layer, before freeze-up, depends on the ratio

of wind mixing to buoyancy flux, then profiles obtained through the ice should provide a record of these conditions, provided that the effects of non-linearity and pressure dependence on the density of water near and below 4°C are taken into account. However, the temperature structure may be modified by other mechanisms occurring after freeze-up, e.g. river through-flow (Lake LaBerge), heat release from sediments (Marsh Lake), and the effect of suspended sediments on water density (Atlin Lake). An additional feature of the three deepest profiles, from Lakes Tagish, Atlin and Teslin, is that a temperature maximum is observed at depths of 100 to 140 m. Traditionally, this feature has been explained as a consequence of the dependence on pressure of the temperature of maximum density; however, existing models do not fully describe the present data.

The statistical properties of sea clutter in the Beaufort Sea and its significance in the detection of sea ice

M. Riley and G.L. Austin

The fluctuation statistics for radar echo returns from sea surfaces in the Beaufort Sea are described. The implications of these data for the design and operation of sea-ice detecting marine radar systems is discussed.

Session 8: Exhibits and Posters — Wednesday 1430 - 1600

The autocorrelation of lagged wind speeds on the B.C. Coast

Stanton E. Tuller

The autocorrelation coefficient between wind speeds recorded at different lag times is a simple parameter that provides an initial indication of how the wind speed record might be influenced by sampling frequency or how representative the value recorded at one time might be of those at other times.

Between 16 and 23 years of hourly wind data from seven British Columbia coastal stations were analysed as a preliminary step in a project investigating the effects of sampling frequency on the resulting wind speed record. The autocorrelation between hourly observations with lag times between 1 and 120 h (5 days) was computed.

The correlation coefficient declined rapidly in the first 18 h. The r^2 values indicate that for a lag time of 1 h (sampling every 2 h) between 18 and 40 per cent of the information in the sample might be lost. This increased to between 54 and 83 per cent with a lag of 5 h (sampling every 6 h).

A diurnal cycle in the autocorrelation coefficient is seen for lags greater than 24 h. The peaks occur at multiples of 24 h, the troughs 12 h later. The correlation coefficients for time lags separated by 24 h are similar after the first 36 h.

The stations ranked in order of decreasing autocorrelation are 1) Cape St James, 2) Spring Island, 3) Comox Airport, 4) Victoria Gonzales Heights, 5) Vancouver International Airport, 6) Tofino Airport, and 7) Victoria International Airport. This ranking seems to be controlled, in part, by the type of surface surrounding the stations. Stations with uniform surface and/or strongly prevailing directions have the highest correlations. Those with a variety of surface types and more variable directions seem to have more irregular winds with less persistence.

Urban terrain climatology - Brandon, Manitoba

R.A. McGinn and P.M. Lafleur

The various summertime terrain climates that occur in Brandon, Manitoba are examined in terms of their energy balance components and spatial distribution. A tri-level urban canopy model composed of a simplified terrain surface classification is also used to investigate the impact of residential irrigation, urban forest development, and intermittent free water surfaces on these terrain climates.

The *Ocean Ranger* storm

W.G. Richards

The Grand Banks area of Newfoundland is recognized as one of the stormiest areas of the North Atlantic. An analysis of conditions experienced there on 14 - 15 February 1982 shows that while the storm during which the *Ocean Ranger* sank was a severe one, the return period of such an occurrence is of order 1 - 2 years. This poster will display meteorological analyses, selected surface observations from drilling rigs and climatological information for the Grand Banks.

Canadian climate information - the Atmospheric Environment Service

G.E. Bristow

Climate data and derived information are useful, and in some cases crucial for those engaged in climate-related activities. This poster will indicate what climate information, services and products are available from the AES and how they may be obtained. Examples of periodicals, the various non-routine publications, and data on microfiche will be on display. Emphasis will be given to recent publications and to publicizing the content and extent of the newly created 1951 - 80 climate statistics that required three years to develop; these are available on microfiche, publication or magnetic tape, and include normals, percentiles and extremes. This session should be of interest to designers, developers, application specialists, planners and in fact anyone who requires climate data whether for design, planning or operational purposes. If space is available some topical climatic maps may also be displayed.

MAST (marine statistics) and LAST (land statistics) systems for analysis of weather and sea-state observations

A. Saulesleja, T.W. Mathews and L.D. Mortsch

A marine statistics (MAST) software system has been developed for the purpose of providing climatological analyses for offshore design, planning and operations. Waves, winds, air and sea temperatures, visibility, wind chill, cloud and sea spray icing are parameters whose magnitude and frequency of occurrence are important inputs for the design and planning of offshore structures and operations.

The land statistics (LAST) software system modifies the format of data from coastal land stations for input to MAST. Climatological analyses similar to those from MAST are produced. This information is useful for application where marine observations are scarce.

The MAST and LAST systems and their outputs are described. MAST software accesses historical marine observations of weather and sea state in an area bounded by 40° W, 100° W, 40° N and 90° N. The LAST system utilizes data from the Atmospheric Environment Service National Climatological Archive. The analyses are defined by time period and areal boundary points; considerable flexibility exists for output tables and graphics.

Session 9A: Meteorological Remote Sensing — Wednesday 1600 - 1745

Pacific Weather Centre Geostationary Meteorological Satellite Data Reception and Analysis System

John Spagnol and Mert Horita

A geostationary satellite data reception and analysis system has been built as part of the alternative data programme to mitigate the effects of the loss of data from ship PAPA (decommissioned June 1981). This new facility is located at the Pacific Weather Centre. The entire system is expected to be operational by the spring of 1983.

The Pacific Weather Centre Geostationary Meteorological Satellite Data Reception and Analysis System is basically composed of two parts. The first part, the Weather Information Processing System II (WIPS II), captures the satellite signal and stores it. WIPS II also automatically or under operator control extracts a subportion of the raw stored image, grids it, enhances it, and then transmits the image over three photofacsimile circuits.

The second part, the Meteorological Data Analysis System (METDAS) uses the raw stored image provided by WIPS II via shared disks. The METDAS is then capable of extracting various subportions into several files to build up a continuum in time of like images. The METDAS then can present on a colour video monitor the images in still or animated form. Another source of data for METDAS is the grid-point field values from numerical models. Initially only CMC model grid-point data will be available. Grid-point values for heights, isotachs, streamlines, vorticity, thickness, temperature, vertical velocity, relative humidity, etc. will be automatically or manually contoured by METDAS. Storage is provided for up to 706 analysis and prognosis fields. Raw data may be written onto magnetic tape for archiving or other non-real-time use.

The capabilities of the Pacific Weather Centre Geostationary Meteorological Satellite Data Reception and Analysis System will provide the meteorologist with the most up-to-date technology for the analysis of satellite images. Furthermore, the significance of this system lies in its being located at a forecast office, therefore providing the on-line forecasters with immediate interactive response. Added benefits will accrue from the operational research and development that will be done to further the forecasting aspect of meteorology.

On the separability of various classes from satellite data

A.A. Tsonis

The spatial characteristics of the GOES VIS and IR satellite imagery are examined. The main interest is their relation to various classes (clear air, cloudy, precipitation, etc.) as well as the degree of "separability" between the different classes. It is believed that an understanding of these spatial properties will be useful in improving algorithms for extracting precipitation (rain or snow) data from satellite data.

AES TOVS processor

T.C. Yip, B. Green and D. Steenbergen

TOVS (TIROS-N Operational Vertical Sounder) is flown on the current TIROS-N and NOAA series of polar orbiting satellites. It is used to sense radiance in reflected light, thermal infrared and microwave. From these data, the current AES assimilation module can retrieve temperature profiles from the surface to 115 mb and moisture profiles from the surface to 300 mb. Thence, the total-totals and Showalter instability indices can be calculated. The vertical resolution of the retrieved profiles is about 100 mb. The horizontal resolution is about 30 km at the subsatellite point for the infrared sounder and 110 km for the microwave sounders.

When comparing the satellite retrieved temperature profile data with the radiosonde data, the r.m.s. error is usually about 1.5 – 2.5°C but is about 3 – 4°C from the surface to 700 mb and near the tropopause. The moisture retrievals can recover about 50% of the variance of the radiosonde moisture measurements.

One potential area for utilizing the horizontally dense TOVS retrieved data is to delineate mesoscale features. The AES TOVS processor is an interactive system. An operator can take a morning NOAA-7 orbit, select a potential convective area and perform a detailed analysis on the data. This can assist in isolating areas where afternoon convection may occur.

An overview of Bristol Aerospace's Data Collection Platform development

B.C. Wiebe

The paper will present a review of the last nine years of Data Collection Platform development. This covers a family of five generations with a variety of offshoots for specialized applications. A general review of the first three generations will be presented along with a more in-depth presentation of the current basic intelligent DCP as well as the sophisticated READAC system and their capabilities. In addition, a general commentary will be provided on the direction of future DCPs from both the technological and cost viewpoints.

Complementing the hardware aspect of Bristol's offerings will be a brief resume of Bristol's service centre including a synopsis of its various customer-oriented services.

Drifting buoys

J.R. Buckley, W.C. Thompson and D. Fissel

Petro-Canada deployed eight drifting buoys in the Labrador Sea during 1982 to assist with weather and sea-state prediction programmes, and to aid in identifying surface current patterns. Two were anchored, two others were air deployed and the remainder were drogued. One buoy deployed near the former OWS Bravo location remained nearly stationary and provided useful information for weather forecasting during September and October, the critical months for conducting drilling operations on the Labrador coast. The other buoys drifted southeastward along the Labrador Shelf. Data from this programme will be presented.

Waverider Information Processing System - Shipboard Automatic Weather Stations (WRIPS-SAWS)

W.C. Thompson, J.R. Buckley and L. Adamo

In 1982, Petro-Canada contracted L. Adamo Inc. to supply a Waverider Information Processing System for use on board a semi-submersible drilling vessel to monitor and analyse data from a nearby Datawell Waverider buoy. The system was integrated with a previously designed shipboard automatic weather station to include a GOES transmitter and antenna, meteorological and other ocean sensors, and a unit to interface with the ship's navigation system. The complete system monitors wind speed and direction, atmospheric pressure, air temperature, relative humidity, ship speed, heading, and position, ocean currents and sea-surface temperature. Performance of the integrated system during its test phase is discussed.

TIROS sounding data compared with STREX dropsonde data

John Spagnol and Ian Okabe

The removal of the Weathership at Ocean Station PAPA (50°N, 145°W) has prompted increased interest in satellite remote sensing to help provide an alternative data source. The TIROS and the GOES both carry instruments that are capable of indirectly sounding the atmosphere. These instruments are called the TOVS and VAS, respectively. Unfortunately, there appears to be much uncertainty as to the accuracy of the satellite sounding technique. One of the problems has been the lack of comprehensive data sets to compare the "satellite" derived parameters and establish their accuracy.

During the months of November and December 1980, a unique experiment was conducted in the Gulf of Alaska. This experiment (called STREX) investigated the air-sea interaction in mid-latitude storms over the North Pacific. During the experiment a U.S. Air Force Reserve WS-130 (920 Weather Recon. Group) flew a prescribed track to provide dropsonde data spaced at intervals of approximately 300 km. The dropsonde data included pressure, height, temperature, dew

point, and wind speed and direction. These data were ideal for use as an independent data source to verify the TOVS data.

Comparison of TOVS and STREX data showed impressive correlations except near the sea surface. Since the STREX data were purposely taken during times of intense cyclonic activity, the above represents a "worst case" comparison. This suggests that the TOVS data could be representative for all levels of the atmosphere during "normal weather" conditions.

If the above facts are accepted, the TOVS data should be given greater weight in the operational objective analysis over data-sparse areas such as the Pacific.

Session 9B: Boundary Layer — Wednesday 1600 - 1745

Practicability of prediction of the surface arrival of chinook winds using acoustic sounders

T. Mathews and R.B. Hicks

Acoustic remote-sensing techniques provide a method for tracking the descent of elevated warm air masses associated with westerly chinook flow over the Rocky Mountains. The turbulent interface between warm and cold air produces a clear signature in acoustic sounder records when it descends to within a kilometre of the surface. The practicability of predicting the arrival of the warm chinook winds at ground level is examined using data derived from several consecutive winters of operation of monostatic and bistatic Doppler sounders.

Boundary-layer structure over the ocean

G.A. McBean

During the Storm Transfer and Response Experiment (STREX), special observations were made from ships and aircraft. This paper will report on boundary-layer structure after a cold front passage with emphasis on measurements by the NOAA P-3 aircraft. The vertical and horizontal variations of the turbulent fluxes and mean parameters will be investigated. The use of "L" pattern flight data allow for computation of local geostrophic and thermal winds. Comparisons will be made between the observational data and some models of baroclinic boundary layers. These studies are aimed at understanding and eventually modelling the evolution of boundary layers and their interaction with storms over the sea.

Comparisons between Rainsat precipitation measurements and thermodynamic parameters

N. Bussières, I. Zawadzki and G.L. Austin

Synoptic analysis of θ_w and potential convective energy have been produced for two precipitation days. These thermodynamic parameters have been compared, on a Cartesian grid, to precipitation probabilities obtained from the GOES satellite by the Rainsat method. The computation of the correlation between θ_w and the probabilities of precipitation gives $r = 0.51$ for the case of 26 June 1980 at 20Z. Stronger correlations are obtained by considering only the precipitation cells located out of the continuous zones of precipitation. The results contribute to a better understanding of this satellite detection technique, which is part of a short-term forecasting method.

MS3DJH/3 - further steps in the development of a simple model of boundary-layer flow over low hills

P.A. Taylor

MS3DJH/3 is the latest version of a model of neutrally stratified boundary-layer flow over low hills and other complex terrain features. The 3-D model is based on the work of Mason and Sykes (1979) and Jackson and Hunt (1975), adapted for real terrain application as described by

Walmsley et al. (1982). For MS3DJH/3 the length and velocity scales used have been calibrated against the output of finite-difference models for flow over simple, analytically specified 2-D terrain and are allowed to become wavelength-dependent parameters. Blended inner and outer layer velocity perturbation fields replace the separate solutions previously presented as the model becomes more "user oriented".

Applications to several real hills will be presented and compared with field data.

Application of a boundary-layer model to flow over a barchan sand dune
John L. Walmsley and Alan D. Howard

The prediction of sand movement over a dune requires an accurate wind-flow model in combination with a physically realistic model for the transport of sand by the wind. As part of a larger project to predict the movement of sand over a barchan dune, the present paper describes a wind flow simulation that results from an application of the MS3DJH model (Walmsley et al., 1982) to the dune studied by Howard et al. (1978). A comparison is made between the calculations and observations of surface wind direction and speed at 80 cm above terrain on the upwind side of the dune. The mean error and r.m.s. deviation from the mean error are tabulated and maps of the error are plotted. The results of the wind-flow model are sufficiently encouraging that it is now planned to use them to drive a sand transport model.

Assessment of a suburban water balance
C.S.B. Grimmond

The paper presents the details and preliminary results of a measurement programme that was carried out for a year in a suburban area of Vancouver, B.C. to determine its water balance. The water balance provides a framework to assess both the amount and the importance of sources and sinks in the suburban environment.

The temporal variation of the partitioning of the components of the water balance will be presented with special emphasis upon the role of evapotranspiration. Previous researchers in Vancouver have found the vapour flux to be rather large based on summertime energy balance measurements; the water budget provides an independent means of assessing their results.

Deep 0° C isothermal layers and their importance to precipitation bands
Ronald E. Stewart

Isothermal layers having a temperature of 0°C and depths up to 1 km were measured within two precipitation bands occurring within autumn storms over southern Ontario. Substantial wind shear, up to 0.2 s^{-1}, existed across the layers and, relative to the updraft region on the trailing edge of each band, air was moving towards the updraft region below the top of each layer and was moving away from the updraft region above the layer.

It is proposed that evaporative and melting effects jointly produced these deep layers and consequently affected temperature and stability profiles across the bands. Essentially saturated conditions existed below the top of the 0°C layer near the updraft region, and relatively dry conditions with dew-point depressions $\lesssim$ 10°C occurred below the 0°C level at the opposite edge of the band. Accompanying these changes is a progression from neutral or slightly unstable convective instability near the updraft to convectively stable conditions on the opposite edge.

Because of such observed interactions between the thermodynamic structure of bands and their dynamics, it appears that the microphysical effects of melting and evaporation are affecting the nature of the bands themselves.

Day-1 forecasting in forest fire danger rating

P.M. Paul

An effective forest fire weather forecasting system requires the rapid dissemination of pertinent information necessary for fire control. The system must deal with the acquisition of current weather as well as with the prediction of future weather. In Canada the routine daily fire weather forecasting procedure is handled in a number of different ways. The system described is a much improved version of a system originally introduced into the Maritime Provinces by the author in 1970. It is, however, applicable to all of Canada east of the Rocky Mountains.

The paper deals exclusively with the daily forecasting procedure rather than the special forecasting routine that is activated when fires start. The description is achieved by illustrating an area in northeastern New Brunswick that experienced first dry and then wet weather during which the fire danger dropped from EXTREME to LOW.

An ecophysiological approach to optimizing energy storage in farmed forests

Roger B. Street

Within the framework of international cooperation and coordination provided by the Forest Energy / International Energy Agency Implementing Agreement a project designed to examine the efficiency of energy storage in farmed forests has been proposed. The primary objective of the project is to elucidate the environment-forest energy processes critical to maximizing the rate of usable / harvestable energy storage of fast-growing hardwoods. The scope of this project includes an integrated examination of the meteorological, biological, hydrological and pedological components of the ecophysiological approach and their impact on the rate of energy storage of forest energy species. Attention is focussed upon genetic engineering and cultural management and the impacts of these various management practices (e.g. species and genotype selection, weed control, fertilization, irrigation, stand architecture) and their manipulation on energy productivity.

The project has support in principle at the strategy level with three participating countries identified: Canada, Sweden and the United States. Within each of the participating countries sites will be established that have an experimental design that can provide comparable results. The proposed basic design involves establishment at each site, of a different forest energy species as the dominant cover type and a secondary or calibration species that will provide a means by which intra- and inter-site comparisons can be made. The forest energy species currently under consideration include *Populus, Salix* and *Alnus*.

Fire weather forecasting: a synoptic overview

Roger B. Street

Severe fire weather can be directly related to prolonged periods of dry weather. Climatological analyses of the temporal and spatial characteristics of extratropical cyclones and anticyclones and the general circulation reveal some plausible explanations for this relationship. A study of the synoptic-scale weather associated with severe forest fires shows that a significant proportion of these fires are associated with weather systems that dynamically and thermodynamically promote rapid growth of the fire and block low-level moisture advection. Historical case studies of severe forest fires in central and western Canada serve to demonstrate the relationships between fire behaviour and synoptic-scale weather features.

The primary cause of the prolonged periods of dry weather and thus severe fire weather is persistent upper-air long-wave ridging of the atmosphere circulation pattern, which effectively blocks low-level moisture advection. In addition, this upper-air pattern favours the establishment of a subsidence inversion that can affect surface weather and therefore fire behaviour. In addition, surface weather systems associated with this type of upper-air circulation pattern usually lack significant atmospheric moisture and therefore promote severe fire behaviour.

Knowledge of the relationships between synoptic-scale weather features and fire behaviour, augmented with an understanding of the impact of topographic features on the local weather, will enable a fire weather forecaster to predict severe fire weather. Recognition of the initiation and termination of a severe fire weather event and communication of this information to fire managers provides them with an opportunity to develop fire management strategies regarding prescribed burning, wildfires, preparedness and prevention.

Meteorological conditions for the transport and outbreak of blue mould spores of tobacco in Southern Ontario region

S. Bhartendu

An epidemic of blue mould spore disease occurred during 1979 in practically the whole tobacco growing areas of Brant, Norfolk-Haldimand, Oxford, Elgin and Middlesex Counties in Southwestern Ontario. The disease was also observed for the first time in history during 1980 in Northumberland County in Southern Ontario. Backward air trajectories at the surface and 850-mb level were computed by manually analysing the weather maps and using two different computer models to determine whether the spores were transported to Ontario, Canada by air currents from the affected states in the U.S.A. during 1979 and 1980. Isohyet maps were plotted and the temperature variations were studied. It was found that during 1979, conidia from Virginia could have reached Southwestern Ontario 12 – 13 days before the reported date of the disease, and during 1980, conidia from Pennsylvania, Maryland and Virginia could have reached Southern Ontario 10 – 11 days before the reported date. Rainfall amounts of up to 20 – 30 mm were recorded during the two-day periods in 1979 and 1980 and the daily mean temperatures varied in the optimum range of 15 – 26°C. The study indicates that meteorological conditions played a part in the transport and outbreak of blue mould spores in Ontario during 1979 and 1980.

Variations in the reflection coefficient of a strawberry canopy

William J. Blackburn and John T.A. Proctor

Measurements of solar irradiance over a strawberry canopy revealed that the reflection coefficient (albedo) of strawberry plantings and bare soil varied diurnally and had a mean daily value of about 0.22 for 7 days in an approximately 1-month period during the major plant growth and fruit bearing period. Exposing moist soil, or soil wetting, reduced the reflection coefficient by about 20%; this reduction was greatest in the 700 – 1350 nm region. The spectral distribution of reflected radiation from strawberry leaves had broad peaks in the 700 – 1300 nm range and was greater than that from soil in the same range.

On quantitative description of heat and mass transfer in "unconventional" agrometeorological boundary-layer flow

Peter H. Schuepp

"Unconventional" boundary-layer flow in the given context stands for two- and three-dimensional time-varying flow, such as is characteristic for the lowest layers of the atmosphere, where vegetation and other obstacles introduce deviations from the assumption of one-dimensionality that underlies most predictive models of heat and mass transfer.

This paper deals with the following aspects:

a) Transfer to porous, fibrous surface structures for which the few existing analytical models, together with some alternatives, will be tested by comparing predictions with observations made on ion transfer in a liquid under Reynolds and Schmidt similarity to atmospheric transfer of submicron-size aerosol. The results show that most models are capable of producing some agreement between predictions and observations owing to the inclusion of poorly-known, hard-to-measure parameters that can be adjusted for optimum agreement. The most preferable models are those with the least degree of such arbitrary adjustment and relative merits of the models will be discussed.
b) An attempt will be made to pin-point reasons why observations on evaporation in two- and three-dimensional flow generally exceed predictions much more than heat transfer observations do.

The use of mesoscale meteorological information for agriculture in Manitoba and Saskatchewan

L.R. Legal

This study examines a mesoscale meteorological information flow system aimed at helping the agricultural community. The three components of this system include collecting mesoscale data, handling the data within the forecast system and disseminating information to the farm user-groups.

An attempt is made to assess the usefulness of on-site mesoscale networks versus remote-sensing methods, and to determine the optimum mix of the two. Once the data are collected, they must be processed efficiently within the forecast system, and the meteorological products generated from the data must be effectively communicated to the farm users. Benefits and costs of this information flow system are evaluated and a discussion on who should bear these costs is included.

Potential uses of the β-gauge in agrometeorological research

N.N. Barthakur

The percentage transmission rate of β-particles through intact leaves of various species of potted plants was studied as a function of moisture stress in the laboratory. Any significance increase in the β-transmission rate with time could be taken as a quantitative index of plant moisture stress of the species. Marble queen, a xerophyte, maintained the constant β-transmission rate for 15 days without water supply. Tobacco, a mesophyte, showed two non-stress days under similar conditions. The β-gauge could provide valuable information on drought endurance characteristics of species under both laboratory and field conditions.

The concept of the existence of the critical transmission rate (CTR) is being proposed. Below the CTR no significant effect on plant injury and nutrient uptake may be observed. CTR could serve as an objective criterion for scheduling optimum timing of irrigation of field crops.

The β-gauge was used as a dew meter in the field. The amount, and the times of initiation and termination of dew could be determined accurately with the β-gauge. The results will be discussed.

Session 10A: Mesoscale Meteorology Research Planning Workshop – Report

Thursday 0830 – 1000

A Mesoscale Meteorology Research Planning Workshop sponsored by the Scientific Committee of the CMOS was held 24 – 26 January 1983. The Workshop consisted of two days of presentations reviewing the state of Canadian knowledge and expertise in the mesoscale area followed by working group sessions in which reports and recommendations were forthcoming directed toward a Canadian Mesoscale Research Programme.

This session is intended to summarize these activities and to inform the members of the Society about the Workshop results, and to encourage discussion on the proposed research programme.

Session 10B: Meteorological Techniques

Thursday 0830 – 1000

Analysis of hourly temperature data

A.J. Keck

W.S. Harley abstracted integrated hourly temperature data for major population centres across Canada and devised a graphical procedure to compute hourly temperatures.

The author automated the procedure using Fourier analysis and linear interpolation. The paper describes the procedures and evaluates the results.

Wideband magnetic direction finder networks for locating cloud-to-ground lightning

M.W. Maier, R.C. Binford, L.G. Byerley, E.P. Krider, A.E. Pifer and M.A. Uman

During the past five years there has been a dramatic increase in the total area covered by networks of wideband magnetic Direction Finders (DFs). At the time of this writing, about 170 magnetic DF stations are operating in the United States, Canada, Mexico, Norway, Sweden, South Africa, the Peoples Republic of China, Japan and Australia. We conservatively estimate that these systems are locating lightning over a surface area of approximately 21×10^6 km^2. Currently 53 Direction Finders are operating in Canada and provide extensive coverage of most of the Western Provinces and partial coverage of the Eastern Provinces. To the best of our knowledge, these are the largest and most accurate lightning locating systems that are operating in the world today. These networks are making substantial contributions to our understanding of lightning phenomenology and are used in a variety of operational applications ranging from early detection of lightning-caused fires to warning of impending lightning hazards for launches of spacecraft. Here, we review the principles of operation of these Direction Finders and describe the development of large networks that utilize advanced (polled) data communication techniques and color graphics displays of lightning location data. As we will show, the real-time color graphics displays of recent lightning locations provide valuable information upon which short-term thunderstorm forecasts and warnings can be based. These displays are unique to the short-term warning and forecast problem because they graphically illustrate storm development trends in a manner easily discernable by the operational user.

1982 flight testing and ground-referencing on an airborne CO_2 flux-measuring technique

R.L. Désjardins, J.I. MacPherson, P. Alvo and P.H. Schuepp

The first CO_2 flux results obtained by eddy-correlation technique from aircraft-mounted measuring systems over crops, forests and other ecosystems (in 1980 and 1981) showed the basic feasibility of the technique, but also the need for improvement in ground referencing, flight testing and equipment. The contributions made in these areas in 1982 will be discussed.

(i) *ground referencing*: Eddy-correlation measurements of heat and CO_2 fluxes over a corn crop during most of the growing season showed daily and seasonal variations of CO_2 uptake, its high correlation with intercepted solar radiation and allowed definition of a potential (maximum) photosynthetic CO_2 flux against which the actual flux, affected by environmental impact, might be compared.

(ii) *flight testing*: Since full evaluation of previous data had shown great variability in aircraft-measured fluxes over the same terrain and since the space- and time-variability of the near-ground boundary-layer structure is not yet well understood, the sampling problem associated with short flights over limited fields was assessed by repeated flights at the same height over the same terrain. Average fluxes obtained are realistic and compare well with ground-based data although individual runs may be strongly affected by "singular events" in the boundary layer.

(iii) *instrument design*: There was little improvement in *instrument design*: but aerodynamic modification of the external part of the CO_2 analyzer has greatly reduced previously-noticed noise problems.

Evaporation modelling using satellite-derived surface temperatures

Neil Trivett

When the water supply to vegetated surfaces becomes limiting, the actual evaporation rate falls below the potential rate and there is a corresponding increase in surface temperature. Several methods of utilizing this phenomenon for large-scale evaporation are examined and some of the preliminary results of the Nanticoke Surface Temperature Project are discussed.

Use of radioactive tritiated water to study evaporation from a small natural lake

P.J. Barry and E. Robertson

Perch Lake, which has an area of 45 ha, has for many years received radioactive tritiated water from the waste disposal operations of the nearby nuclear research laboratories. Concentrations of tritiated water in the lake have been high enough to support vapour concentrations in the air above the lake that can be measured using relatively simple techniques and that are very large compared to those arising from natural sources or the fallout from nuclear weapon testing in the atmosphere. Thus tritiated water detected in the air above the lake has unequivocably originated from the lake and its concentration distribution in the vertical and along the fetch is entirely the result of processes contributing to evaporation from the surface.

In the experiments described in this paper tritiated water vapour concentrations and wind speeds were measured in the vertical at up to six locations from shore to shore along a fetch of about 800 m.

The results are presented in detail for the insights they provide into the qualitative nature of the mixing processes operating in the developing internal boundary layer. They are also compared with solutions proposed for the two-dimensional eddy diffusion equation. Closest agreement was obtained with a solution originally given by Sutton and later modified by Selander to include a laminar sublayer immediately above the surface.

As far as we are aware, these sets of measurements are unique in the degree of sensitivity with which theoretical and empirical aspects of evaporation can be tested in a natural lake setting.

Precipitation chemistry in Pacific coastal regions

G.A. McBean

For the past two years precipitation samples have been collected from ships at sea and from selected land locations near the coast. In addition, snow samples from cores and the surface of the pack have been chemically analysed. This paper will review the findings to date. Generally, it is seen that the samples are less acidic than eastern North America but do sometimes show a depressed pH. The geographic and temporal variability will be investigated. For some instances it is possible to relate the events to synoptic events. This study is aimed at understanding the precipitation chemistry of the marine environment away from major pollution source areas.

A preliminary evaluation of the sulphate concentration forecasts for the PEPE project

M.P. Olson and K.K. Oikawa

A study to investigate the formation, movement and development of Persistent Elevated Pollution Episodes (PEPE) was undertaken during July and August 1980 by the Canadian Atmospheric Environment Service (AES) in close cooperation with the U.S. Environmental Protection Agency. The Canadian Long Range Transport of Air Pollutants (LRTAP) trajectory and concentration models were modified to produce two-day real-time trajectory forecasts and sulphur dioxide and sulphate concentration forecasts to assist in field-study planning and to serve as an experimental air quality forecast procedure.

The model used wind and precipitation forecasts from the Canadian Meteorological Centre (CMC) operational spectral forecast model to produce 48-h forecast trajectories and concentrations on a 127-km grid. The forecast trajectories appeared to be consistent with the flow patterns on the verifying synoptic maps. The concentration forecasts predicted regional plume-like patterns that emanate from the high emissions regions and are elongated along the flow directions.

The original LRTAP forecast model that was evaluated using measured daily sulphate concentration data at 8 southern Ontario sites showed only marginal statistical skill. However, the forecast statistics showed noticeable improvement when recent parameter modifications, an improved inventory and various initial conditions were applied. Several pollution episodes that were forecast to occur were actually measured although some were forecast to terminate about one day too soon because of inadequate resolution of frontal passages and precipitation events.

The temporal correlation coefficients ranged from about 0.2 near Ottawa to about 0.8 at Peacock Point on Lake Erie. The spatial correlation coefficient using all the data averaged for each site was about 0.7 with a mean sulphate concentration underprediction of about $2\mu g\ m^{-3}$. The evaluation will be extended to the United States when data become available.

Evidence of large-scale pollution episodes

Y.-S. Chung

Recently, a considerable amount of criticism and publicity has been directed at the consequences of acid rain and air pollution. Acidic precipitation can be formed by the large-scale transport of air pollutants and it causes some damage to natural and human environments. Evidence of large-scale pollution episodes is required for verification of data analysis and numerical modelling.

The present study assesses regional air-quality problems and discusses the detection of long-range transport of air pollutants (LRTAP) from natural and man-made sources. Our observations include visual examples of the pollution transport (up to ~ 5,000 km) from volcanoes, forests fires, dust storms, and from urban centres in the United States. Detection of smoke plumes by satellite imagery using three basic colours (red, green and blue) is emphasized.

Nuclear generating station emergency plans and the Meteorological Advisor

Roger Caiazza

In the wake of the Three Mile Island incident the U.S. Nuclear Regulatory Commission promulgated new emergency planning requirements for U.S. nuclear generating facilities. Niagara Mohawk Power Corporation owns and operates a 610-MW nuclear station 7 miles northeast of Oswego, New York on the southern shore of Lake Ontario. The Emergency Planning Procedures developed by Niagara Mohawk for this station include a Meteorological Advisor position. This paper outlines the duties and responsibilities of that position and the meteorological programme associated with the emergency action plan for the generating station.

The Meteorological Advisor is part of a team whose job is to project offsite doses and recommend protective actions. The duties of the Meteorological Advisor include verifying on-site meteorological data, assisting with downwind survey teams, providing weather forecasts, and verifying dose projections.

Nine Mile Point Generating Station has recently upgraded its meteorological monitoring programme, its dose assessment modelling capabilities and the emergency action plan that uses the data and model. In the course of the revisions the duties and responsibilities of the Meteorological Advisor position were more clearly defined. Niagara Mohawk Power Corporation has also contracted with a private meteorological consulting firm to provide real-time meteorological data and weather forecasts during an emergency.

Diffusion of heavy gases – micrometeorological study

F. Fanaki and A. Sirois

Diffusion of heavy gases is a function not only of the nature of the source and type of gas but also of the atmospheric wind, turbulence and thermal stability.

Three methods are usually employed to examine these effects on the dispersion of a heavy gas: (a) direct probing by means of a field test, (b) model testing using a wind tunnel, and (c) a numerical solution of the governing equations.

The former and the latter methods were chosen for this work. Field studies have been conducted at the Meteorological Field Station at Woodbridge, Canada. The tests include a heavy gas source, which is a mixture of carbon dioxide and air. Three micrometeorological towers were used at the test site. The flow of the heavy gas plume was studied by measuring its concentration and determining its modification by the ground, wind speed and thermal stability. The temporal and spatial dispersion parameters were obtained.

The experiments have provided information on the formation, expansion and dilution of the heavy gas cloud. The cloud's behaviour differs with atmospheric conditions. The cloud at its earliest stage is highly turbulent especially at its rim where mixing with the ambient air is strong. At a later stage, the top layer of the cloud is irregular, where mixing is governed by atmospheric conditions.

There have been considerable efforts to model the diffusion of heavy gases numerically. Two of these models were used in this study. Examples of the model predictions are presented and compared with the field study. These in turn helped in the design of a model that will be applicable to the Canadian climate.

A climatological model for predicting mesoscale patterns of acid deposition

R.W. Shaw

During the past decade, there has been much attention devoted to the long-range atmospheric transport of acidic pollutants and their subsequent deposition at distances from several hundred to 2000 kilometres from the source. However, there is also evidence that, under certain meteorological conditions, transformation and deposition of atmospheric acid can occur closer than 100 km from the source. A climatological model has been designed that uses values of wind frequency, wind speed, mixing height, chemical transformation and deposition rates in each of 16 compass sectors. It then predicts mesoscale patterns of annual concentration and deposition of sulphur dioxide, primary sulphate and secondary sulphate on a 40 × 40 grid. The grid spacing can be varied and the model can distinguish between high and low sources. The effects of varying the meteorological and chemical parameters are examined, and the model is applied to the observed patterns of concentration and deposition around Halifax/Dartmouth.

Prediction of sulphur compound ground-level concentrations and frequencies of exceedance produced by three different source scenarios

T.M. Morrow, W.A. Murray and R.L. Findlay

Long-term ground-level concentrations of sulphur dioxide and hydrogen sulphide were predicted for a proposed gas conservation plant near St Albert, ALTA. Three different emission scenarios were studied, corresponding to three distinct operating phases. Various computer models were employed to assess the following:

1. Maximum ground-level concentration of sulphur dioxide from a single flare stack.
2. For a single flare stack, average ground-level concentration and frequencies that sulphur dioxide concentrations exceeded specified values (frequencies of exceedance).
3. Average ground-level concentration of sulphur dioxide from three flare stacks.
4. For a single extinguished flare stack, average ground-level concentration and frequencies of exceedance for hydrogen sulphide.

The dispersion climatology was approximated by using Atmospheric Environment Service STAR data for Edmonton Namao Airport. The results of the study suggested that normal plant operation would produce pollutant concentrations comparable to background levels.

Session 11: Day-1 Forecasting Panel Discussion Thursday 1020 – 1200

17th Annual Congress Issue

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

The Canadian Meteorological and Oceanographic Society assumed its present constitution in 1977. The organization was first established in 1940 as the Canadian Branch of the Royal Meteorological Society, later becoming the Canadian Meteorological Society in 1967. The Society exists for the advancement of Meteorology and Oceanography (including Limnology) and membership is open to persons and organizations sharing these interests. There are twelve Local Centres and two Chapters of the Society that hold meetings of interest to the membership. *ATMOSPHERE-OCEAN* is the scientific journal published quarterly by the Society and is distributed free to all members except Associate Members. Each spring the Society convenes a National Congress.

There are four types of membership – Member, Student Member, Corporate Member and Associate Member. For 1983 the dues are $40.00, $12.00, $75.00 (min.), and $20.00, respectively. The annual Institutional subscription rate for *ATMOSPHERE-OCEAN* is $50.00. Cheques should be made payable to the Canadian Meteorological and Oceanographic Society.

Correspondence regarding Society affairs, membership, Institutional subscriptions and back issues of the journal should be directed to the Corresponding Secretary, Canadian Meteorological and Oceanographic Society, Suite 805, 151 Slater Street, Ottawa, ONT. K1P 5H3. Telephone: (613)-237-3392.

La Société canadienne de météorologie et d'océanographie a adopté la présente constitution en 1977. La Division canadienne de la Société royale de météorologie a été fondée en 1940 et remplacée par la Société météorologique du Canada en 1967. Cette société existe pour le progrès de la météorologie et de l'océanographie (y compris la limnologie) et accueille comme membre toute personne ou organisation intéressée à ces sciences. Les douze centres locaux et les deux sections de la Société réunissent les membres pour des discussions et conférences. *ATMOSPHERE-OCEAN*, la revue scientifique de la Société publiée trimestriellement, est distribuée gratuitement à tous les membres sauf aux Membres associés. La Société organise chaque printemps un Congrès national.

Il y a quatre types de membres: Membre, Membre étudiant, Membre moral et Membre associé. Les cotisations pour 1983 sont de $40.00, $12.00, $75.00 (min.) et $20.00 Les institutions peuvent souscrire à *ATMOSPHERE-OCEAN* au coût de $50.00 par année. Les chèques doivent être faits à l'ordre de la Société canadienne de météorologie et d'océanographie.

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Editorial Policy. *ATMOSPHERE-OCEAN* is a medium for the publication of the results of original research, survey articles, essays, book reviews, notes, and comments on published papers in all fields of the atmospheric, oceanographic, and hydrological sciences. It is published quarterly by the Society with the aid of grants from the Canadian Government and the Natural Sciences and Engineering Research Council. Articles may be in either English or French. Contributors need not be members of the Society nor need they be Canadian; foreign contributions are welcomed. All contributions will be subject to a critical review before acceptance. Because of space limitations articles should not normally exceed 16 printed pages.

Manuscripts should be submitted to: *ATMOSPHERE-OCEAN*, Dept. of Meteorology, McGill University, 805 Sherbrooke St. West, Montreal, P.Q. H3A 2K6. Four copies should be submitted, typewritten with double spacing and wide margins. Headings and sub-headings should be clearly designated. A concise, relevant and substantial abstract is required preferably in both English and French.

Tables should be prepared on separate sheets, each with concise headings.

Figures should be provided in the form of four copies of an original which should be retained by the author for later revision if required. A list of legends should be typed separately. Labelling should be made in generous size so that characters after reduction are easy to read. Line drawings should be drafted with India ink at least twice the final size on white paper or tracing cloth. Photographs (halftones) should be glossy prints at least twice the final size.

Units. The International System (SI) of metric units is preferred. Units should be abbreviated only if accompanied by numerals, e.g. "10 m" but "several metres".

Footnotes to the text should be avoided.

Literature citations should be indicated in the text by author and date. The list of references should be arranged alphabetically by author, and chronologically for each author, if necessary.

Page charges are not levied against the author, but excessive alterations made by the author at the proof stage will be charged. Voluntary contributions are appreciated and will entitle the author to 50 free offprints.

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Les tableaux doivent être préparés et présentés séparément accompagnés d'un titre concis et d'un numéro.

Les figures doivent être présentées en quatre copies dont les originaux devraient être conservés par l'auteur au cas où il serait nécessaire de les réviser. Une liste des légendes pour les figures doit être dactylographiée séparément. Les titres doivent être grands de façon à ce qu'ils soient facilement lisibles après réduction du format. Le traçage des lignes doit s'effectuer au moyen d'encre de chine le double au moins, du format définitif sur papier blanc ou sur papier à calquer et identifié adéquatement. Les photographies (demi-teintes) devraient être présentées sur épreuves glacées au double du format définitif.

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