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C.M.O.S. 26th Annual Congress

Université Laval, Québec, Canada
8 au 12 juin 1992 / June 8-12th 1992

MÉTÉOROLOGIE ET OCÉANOGRAPHIE À LA MÉSOÉCHELLE

MESOSCALE METEOROLOGY AND OCEANOGRAPHY

26e congrès annuel
Société canadienne de météorologie et d'océanographie

26th Annual Congress
Canadian Meteorological and Oceanographic Society

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26e CONGRÈS ANNUEL

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UNIVERSITÉ LAVAL, QUÉBEC

CANADIAN METEOROLOGICAL AND OCEANOGRAPHIC SOCIETY
26th ANNUAL CONGRESS

MESOSCALE METEOROLOGY AND OCEANOGRAPHY
LAVAL UNIVERSITY, QUEBEC

La Société de météorologie de Québec vous souhaite la bienvenue au 26e Congrès annuel de la SCMO. Votre hôte officiel pour cet événement est l'Université Laval. Le Comité organisateur espère que votre séjour sera des plus agréables.

The Québec Meteorological Society welcomes you to the CMOS 26th Annual Congress. Your official host for this meeting is Laval University. The Local Organizing Committee hopes that your stay will be most enjoyable.

QUELQUES INFORMATIONS UTILES AUX PARTICIPANTS

Toutes les activités du Congrès se dérouleront au Pavillon Vachon sauf la réception de bienvenue (pavillon Pollack), la soirée musique (Théâtre de la Cité Universitaire), le buffet (pavillon de Koninck) et le banquet (pavillon Pollack).

Il est important de conserver votre preuve d'inscription pour participer aux activités sociales. Afin d'éviter les contraventions, veuillez stationner votre véhicule uniquement dans les stationnements publics de l'Université ou procurez-vous une vignette de stationnement pour votre séjour. Vous pourrez profiter des installations sportives de l'Université (PEPS) en vous procurant un laissez-passer à cet effet.

Encouragez nos commanditaires et mentionnez que vous participez au Congrès de la SCMO.

Afin d'assurer un bon déroulement du Congrès, nous vous demandons de respecter les horaires prévus. N'hésitez pas à fréquenter les kiosques des exposants commerciaux et n'oubliez pas la séance d'affichage le jeudi matin. De plus, tous les membres de la SCMO sont invités à participer à l'Assemblée Générale Annuelle qui se tiendra mardi le 9 juin, à compter de 20 heures, au local 3860 du Pavillon Vachon.

SOME USEFUL INFORMATION TO PARTICIPANTS

All the activities will be held at Pavillon Vachon except the Welcome Party (pavillon Pollack), the concert (Théâtre de la Cité Universitaire) and the following buffet (pavillon de Koninck) and the Banquet (pavillon Pollack).

Keep your proof of registration necessary for social activities. In order to avoid parking tickets, park your vehicule in public parkings only or buy a pass for the other parkings. You can benefit from the sports installation if you buy the necessary pass.

Please keep on schedule in all your activities at the Congress. Do not hesitate to visit the exhibits and do not forget the poster session to be held on Thursday morning. Please also encourage our sponsors.

All CMOS members are invited to the Annual General Assembly to be held Tuesday June 9 starting at 20:00h in room 3860 of Pavillon Vachon.

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Ishtar Zawadski	Université du Québec à Montréal
Peter Zwack	Université du Québec à Montréal

CONFÉRENCIERS INVITÉS
INVITED SPEAKERS

Dr Richard Anthes, University Corporation for Atmospheric Research,
Modélisation à mésoéchelle / Mesoscale modeling

Dr Jean-Pierre Blanchet, Université du Québec à Montréal,
Scénarios climatiques / Climatic scenarios

Dr David M. Checkley Jr., Scripps Institute of Oceanography,
Océanographie des pêches à mésoéchelle / Mesoscale fishery oceanography

Dr Louis A. Codispoti, Monterey Bay Aquarium Research Institute,
Intéractions atmosphère-cycles géochimiques marins à mésoéchelle / Atmospheric-marine geochemical cycles interactions

Dr Stewart J. Cohen, Service de l'Environnement Atmosphérique du Canada, Canadian Climate Centre
Le climat et ses répercussions / Climate and its impacts

Dr Fillipo Giorgi, National Center for Atmospheric Research,
Modélisation climatique à mésoéchelle / Mesoscale climatic modeling

Dr Jocelyn Mailhot, Service de l'Environnement Atmosphérique du Canada, Recherche en prévision numérique
Modélisation à mésoéchelle au Canada / Mesoscale modeling in Canada

Dr Trevor Platt, Bedford Institute of Oceanography,
Télédétection et production biologique à mésoéchelle / Remote sensing and biological production

Dr Jacques Testud, Centre d'Études en télécommunications,
Réseaux d'observation à mésoéchelle / Mesoscale observation networks

Dr Peter Yau, McGill University,
Physique des phénomènes à mésoéchelle / Physics of mesoscale phenomena

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REMERCIEMENTS / ACKNOWLEDGEMENTS

Le comité organisateur du congrès tient à remercier les personnes et organismes suivants pour leur support et/ou leur aide financière.

The Congress organization commitee is very greatful to the following persons and organizations for their support and/or sponsorships or grants.

Association de Climatologie du Québec (ACLIQ)
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Association Professionnelle des Météorologistes du Québec (APMQ)
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Ainsi que les restaurants suivants / and the following restaurants
Le Bistrot sous le Fort, 48 rue sous le Fort, Québec
Brasserie La Table du Roi, Centre Innovation, 2360 Chemin Sainte-Foy, Ste-Foy
La Closerie, 966 Saint-Cyrille ouest, Québec
Le Saint-Amour, 48 rue Sainte-Ursule, Québec

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- promouvoir la science de la météorologie et la profession de météorologiste;
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Au plaisir de vous accueillir en juin prochain, nous vous souhaitons un excellent séjour à Québec.

Votre Equipe de Congrès d'Air Canada

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ABOVE AND BEYOND

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RÉUNIONS DES COMITÉS DE LA SCMO
CMOS COMMITTEE MEETINGS

TOUTES CES RÉUNIONS SE TIENNENT AU PAVILLON VACHON
ALL THESE MEETINGS TO HELD IN PAVILLON VACHON

LUNDI 8 JUIN / MONDAY JUNE 8

Heure / Time: 09h00-12h00

	local/room
Scientifique-Scientific	1216
WOCE	1613
Publications	2820
Bulletin Climatologique-Climatological Bulletin	2826
Présentateurs médias-Broadcaster Endorsement	3620
SHOGON	3820
CNC-SCOR	3624
GIS-SIG: Mesoéchelle-Mesoscale	3840
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GIS-SIG: Agr. et foresterie-Agr. and forestry	2860

Heure / Time: 13h30-16h30

	local/room
WOCE	1613
Publications	2820
Professionnalisme-Professionalism	1216
Education	2826
Présidents des Centres-Centers Chairman	3620
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Heure / Time: 16h30-18h30

GLOBEC	3860

AUTRES RÉUNIONS IMPORTANTES
OTHER IMPORTANT MEETINGS

LUNDI 8 JUIN / MONDAY JUNE 8

Heure / Time: 16h00-18h00 et de / and from 20h00

	local/room
SCMO Conseil d'administration	Pollack
CMOS Executive Meeting	Salle 2

MARDI 9 JUIN / TUESDAY JUNE 9

Heure / Time: 18h00-20h00

APMQ Assemblée Générale Spéciale	Vachon
APMQ Special General Assembly	2840

Heure / Time: de/from 19h00

BASE	Vachon 2820

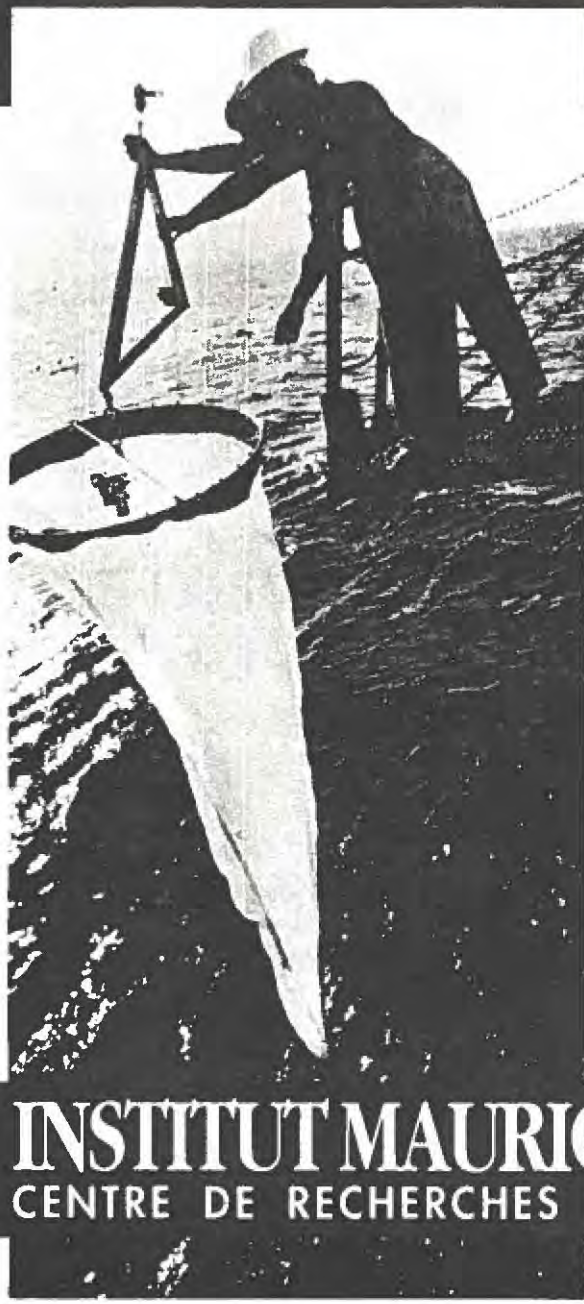
Heure / Time: de/from 20h00

SCMO Assemblée Générale Annuelle	Vachon
CMOS Annual General Assembly	3860

MERCREDI 10 JUIN / WEDNESDAY JUNE 10

Heure / Time: 15h00-17h00

ACLIQ Assemblée Générale Annuelle	Vachon
ACLIQ Annual General Assembly	2860



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Les eaux de l'estuaire, du golfe du Saint-Laurent et celles bordant le Québec nordique regorgent de ressources. Depuis Mont-Joli, notre équipe de plus de 250 personnes poursuit des recherches de pointe sur l'état de cet environnement marin et sa mise en valeur. Nous sommes fiers d'être un partenaire important dans la recherche sur le milieu marin au Québec.

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Pêches et Océans | Fisheries and Oceans

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Lundi, 8 juin 1992

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Mardi, 9 juin 1992

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Mercredi, 10 juin 1992

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19H00-	Buffet	

(*) INDIQUE LES SESSIONS AVEC CONFÉRENCIER(S) INVITÉ(S)
LES NUMÉROS DE SALLE INDIQUÉS SONT AU PAVILLON VACHON SAUF MENTION CONTRAIRE

RÉSUMÉ DES SESSIONS (SUITE)

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(*) INDIQUE LES SESSIONS AVEC CONFÉRENCIER(S) INVITÉ(S)
LES NUMÉROS DE SALLE INDIQUÉS SONT AU PAVILLON VACHON SAUF MENTION CONTRAIRE

SUMMARY OF SESSIONS

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17H45-18H45	Concert	Theatre
19H00-	Buffet	de Koninck

(*) INDICATES SESSIONS WITH INVITED SPEAKER(S)
ROOM NUMBERS REFER TO PAVILLON VACHON EXCEPT OTHERWISE INDICATED

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10H50-12H30	SESSION 12D: Inland and semi-enclosed seas	3830
13H30-15H10	SESSION 13A: Mesoscale meteorology III	2830
13H30-15H10	SESSION 13B: Regional climate models	2840
15H30-17H30	SESSION 14A: Satellite-meteorology	2830
15H30-17H30	SESSION 14B: Global climate models	2840

(*) INDICATES SESSIONS WITH INVITED SPEAKER(S)
ROOM NUMBERS REFER TO PAVILLON VACHON EXCEPT OTHERWISE INDICATED

PROGRAMME / PROGRAM

MARDI / TUESDAY, 09H15-12H10 — **SALLE / ROOM: 2850**
SESSION PLÉNIERE THÉMATIQUE: MÉTÉOROLOGIE ET OCÉANOGRAPHIE À LA MÉSOÉCHELLE
PRÉSIDENT / CHAIRMAN: L. A. HOBSON, PRÉSIDENT SCMO/CMOS
PLENARY THEME SESSION: MESOSCALE METEOROLOGY AND OCEANOGRAPHY

09:15 **MOTS DE BIENVENUE / WELCOMING REMARKS**

09:50 **AN OVERVIEW OF MESOSCALE MODELLING IN CANADA: TODAY AND TOMORROW**
Jocelyn Mailhot (conférencier invité / invited speaker)
Recherche en prévision numérique, Atmospheric Environment Service, Dorval, Québec, Canada

10H30-10H50 PAUSE-CAFÉ / COFFEE BREAK

10:50 **INVESTIGATING THE RELATIONSHIP BETWEEN MESOSCALE METEOROLOGY AND CHEMICAL OCEANOGRAPHY: PROBLEMS, PROMISE AND A SUGGESTED PLAN OF ATTACK**
Louis A. Codispoti (conférencier invité / invited speaker)
Monterey Bay Aquarium Research Institute, Pacific Grove, California 93950, U.S.A.

11:30 **OBSERVATIONAL SYSTEMS FOR MOIST CONVECTION AND MESOSCALE DYNAMICS IN THE ATMOSPHERE**
Jacques Testud (conférencier invité / invited speaker)
Centre de Recherche en Physique de l'Environnement, CNET, Issy les Moulineaux, France

12H10-13H30 DÉJEUNER / LUNCH

MARDI / TUESDAY, 13H30-15H10 — **SALLE / ROOM: 2860**
SESSION 2A: MODÈLES NUMÉRIQUES DE PRÉVISION DU TEMPS ET ASSIMILATION DES DONNÉES I
PRÉSIDENT / CHAIRMAN: JEAN CÔTÉ, DIVISION DE RECHERCHE EN PRÉVISION NUMÉRIQUE, SEA
SESSION 2A: NUMERICAL WEATHER PREDICTION MODELS AND DATA ASSIMILATION I

13:30 **HISTORY AND PRESENT STATUS OF THE FRENCH PERIDOT NWP SYSTEM**
R. Juvanon du Vachat
Direction de la Météorologie - SMIRIC, Paris, FRANCE
H.L. Pham
Direction de la Météorologie - DMN, Boulogne, FRANCE
J.F. Geleyn
Direction de la Météorologie - CNRM, Toulouse, FRANCE

13:50 **THE REGIONAL FORECAST SYSTEM AT CMC: DESCRIPTION AND PRELIMINARY RESULTS**
Michel Jean, Richard Hogue
Canadian Meteorological Centre, Dorval, Québec, Canada

14:10 **PHYSICAL PARAMETERIZATION FOR THE FUTURE CANADIAN FORECAST MODELS**
B. Bilodeau, J. Mailhot
Recherche en prévision numérique, Service de l'environnement atmosphérique, Dorval, Québec, Canada
G. Pellerin
Canadian Meteorological Centre (CMC), Service de l'environnement atmosphérique, Dorval, Québec, Canada

14:30 **TOWARDS A HIGHER RESOLUTION VERSION OF THE CANADIAN GLOBAL SPECTRAL MODEL**
Harold Ritchie, C. Beaudoin
Recherche en prévision numérique Service de l'environnement atmosphérique, Dorval, Québec, Canada

14:50 **MEDIUM RANGE STRATOSPHERIC FORECASTS WITH A GLOBAL SPECTRAL MODEL**
M. Tanguay, H. Ritchie
Recherche en prévision numérique Service de l'environnement atmosphérique, Dorval, Québec, Canada

MARDI / TUESDAY, 13H10-15H10 **SALLE / ROOM: 2840**
SESSION 2B: COUCHE LIMITE
PRÉSIDENT / CHAIRMAN: MONIQUE LECLERC, DÉPARTEMENT DE PHYSIQUE, UNIVERSITÉ DU QUÉBEC À MONTRÉAL
SESSION 2B: BOUNDARY LAYER

13:10 **NEW PBL RESISTANCE LAWS: A PROPOSAL**
John L. Walmsley
Atmospheric Environment Service, Environment Canada, Downsview, Ontario, M3H 5T4

13:30 **LARGE EDDY SIMULATIONS OF THE ATMOSPHERIC BOUNDARY LAYER**
X. Cai, D.G. Steyn
Institute of Applied Mathematics and Atmospheric Science Program, Department of Geography, University of British Columbia, Vancouver, B.C., Canada

13:50 **BOUNDARY LAYER PROCESSES NEAR AND OVER LAKE ONTARIO**
Keith W. Ayotte, Peter A. Taylor
Department of Earth and Atmospheric Science, York University, North York, Ontario, Canada

14:10 **AN EXAMINATION OF THE OF ROLE TURBULENCE CLOSURE IN MODELED FLOW OVER COMPLEX TERRAIN**
Keith W. Ayotte, Dapeng Xu, Peter A. Taylor
Department of Earth and Atmospheric Science, York University, North York, Ontario, Canada

14:30 **THE INNER BOUNDARY LAYER OVER A PRAIRIE LAKE**
Bernard C. Kenney
National Hydrology Research Institute, Environment Canada, Saskatoon, Sask., Canada

14:50 THE REGIONAL EVAPORATION STUDY, PART III: MODEL PREDICTIONS OF BOUNDARY LAYER EVOLUTION

C.M. Sackiw
Atmospheric Environment Service, Environment Canada, Saskatoon, Sask., Canada

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MARDI / TUESDAY, 13H30-15H10 **SALLE / ROOM: 3830**

SESSION 2C: OCÉANOGRAPHIE À GRANDE ÉCHELLE: ECOM I

PRÉSIDENT / CHAIRMAN: PAUL LEBLOND, DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF BRITISH COLUMBIA

SESSION 2C: LARGE SCALE OCEANOGRAPHY: WOCE I

13:30 LA CIRCULATION DANS L'OCÉAN NORD-ATLANTIQUE OUEST

T.H. Reynaud, A.J. Weaver
Département des Sciences Atmosphériques et Océanographiques, Université McGill, Montréal, Québec, Canada
R.J. Greatbatch
Department of Physics, Memorial University, St. John's, Newfoundland, Canada

13:50 INTERPENTADAL CHANGES IN THE NORTH ATLANTIC CIRCULATION

Richard J. Greatbatch, Augustus F. Fanning, Allan D. Goulding, Jie Xu
Department of Physics, Memorial University of Newfoundland, St. John's, Newfoundland, Canada
Sidney Levitus
National Oceanographic Data Center/NOAA, Washington, D.C., U.S.A.

14:10 MICROSTRUCTURE MEASUREMENTS DURING THE NORTH ATLANTIC TRACER RELEASE EXPERIMENT (WOCE CORE-3)

Barry Ruddick, Jim Burke
Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada
Neil Oakey
Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

14:30 SUMMER SEA SURFACE TEMPERATURE VARIABILITY OFF VANCOUVER ISLAND

Wendong Fang, William W. Hsieh
Dept. of Oceanography, University of British Columbia, Vancouver, B.C., Canada

14:50 OPTIMAL CONTROL OF OPEN-OCEAN BOUNDARY BY ASSIMILATING ALTIMETRY DATA INTO A REGIONAL CIRCULATION MODEL

Jieping Zou, William W. Hsieh
Dept. of Oceanography, University of British Columbia, Vancouver, B.C., Canada

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15H10-15H30 PAUSE-CAFÉ / COFFEE BREAK

MARDI / TUESDAY, 15H30-17H10 SALLE / ROOM: 2860

SESSION 3A: MODÈLES NUMÉRIQUES DE PRÉVISION DU TEMPS ET ASSIMILATION DES DONNÉES II

PRÉSIDENT / CHAIRMAN: ANDRÉ ROBERT, DÉPARTEMENT DE PHYSIQUE, UNIVERSITÉ DU QUÉBEC À MONTRÉAL

SESSION 3A: NUMERICAL WEATHER PREDICTION MODELS AND DATA ASSIMILATION II

15:30 SPECTRAL CHARACTERISTICS OF KALMAN FILTER SYSTEMS FOR ATMOSPHERIC DATA ASSIMILATION

Roger Daley

Atmospheric Environment Service, Downsview, Ontario, Canada

Richard Ménard

Département des sciences atmosphériques, et océaniques, Université McGill, Montréal, Québec, Canada

15:50 RECOVERY OF UNOBSERVED VARIABLES FROM SINGLE-DOPPLER RADAR OBSERVATIONS

Stéphane Laroche et Isztar Zawadzki

Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

16:10 EXPERIMENTS WITH NON-NORMAL MODE INITIALIZATION OF A SHALLOW-WATER LIMITED-AREA MODEL

R. Juvanon du Vachat

Direction de la météorologie, SMIRIC, Paris, FRANCE

16:30 SEMI-LAGRANGIAN TECHNIQUES AND OROGRAPHY

Chantal Rivest, Andrew Staniforth

Service de l'environnement atmosphérique, Dorval, Québec, Canada

16:50 PRELIMINARY DYNAMIC EXTENDED RANGE FORECASTS WITH THE CANADIAN GLOBAL SPECTRAL MODEL

Harold Ritchie, B. Dugas

Recherche en prévision numérique, Service de l'environnement atmosphérique, Dorval, Québec, Canada

A.M. Leduc

Centre Météorologique Canadien, Service de l'environnement atmosphérique, Dorval, Québec, Canada

J. Derome, J. Sheng

Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, Quebec, Canada

MARDI / TUESDAY, 15H30-17H30 SALLE / ROOM: 2840

SESSION 3B: TEMPÊTES, SYNOPTIQUE, ÉTUDES DE CAS ET ÉLÉMENTS ASSOCIÉS

PRÉSIDENT / CHAIRMAN: J. R. GYAKUM, DEPARTMENT OF ATMOSPHERIC AND OCEANIC SCIENCES, MC GILL UNIVERSITY

SESSION 3B: STORMS, SYNOPTICS, CASE STUDIES AND ASSOCIATED ELEMENTS

15:30 BAROCLINIC INSTABILITY IN A TWO-LAYER MODEL WITH PARAMETERIZED SLANTWISE CONVECTION

G. Balasubramanian, M.K. Yau

Dept. of Atmospheric and Oceanic Sciences, McGill University, Montreal, Québec, Canada

15:50 **Dynamics of a Mature Front in a Uniform Potential Vorticity Semigeostrophic Model**

John N. Koshyk
Numerical Modelling Division, Canadian Climate Centre, Downsview, Ontario, Canada
Han-Ru Cho
Department of Physics, University of Toronto, Toronto, Ontario, Canada

16:10 **A Diagnostic Study of the Early Phases of 16 North Pacific Cyclones**

R.W.P. Kelly, J.R. Gyakum
Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, Québec, Canada

16:30 **Sensitivity Study of the EFR Model on the 28 September 1990 Pacific Bomb Case**

Richard Hogue, Louis Lefaivre
Analyses and Satellite Division, Canadian Meteorological Centre, Dorval, Québec, Canada
Normand Brunet
Numerical Weather Prediction Division, Canadian Meteorological Centre, Dorval, Québec, Canada

16:50 **Estimation du mouvement vertical à l'aide des données de surface seulement: vérification objective**

Robert Tardif
Centre Météorologique Canadien, Service de l'environnement atmosphérique, Dorval, Québec, Canada
Peter Zwack
Département de Physique, Université du Québec à Montréal, Montréal, Québec, Canada

17:10 **Severe Wind Damage Due to a Rear Inflow Jet: A Case Study of the 28 March 1991 Mesoscale Convective System**

Steve Knott, Paul Joe
Atmospheric Environment Service, Toronto, Ontario, Canada
Catherine Denis Van de Velde
Météo-France, Toulouse, France

Mardi / Tuesday, 15H30-16H30 **Salle / Room: 3830**

SESSION 3C: Océanographie à grande échelle: ECOM II

Président / Chairman: Richard Greatbatch, Department of Physics, Memorial University, St. John's

SESSION 3C: Large scale oceanography: WOCE II

15:30 **Deep Water Mass Properties in a 2.5-D Model of the Global Ocean**

Dan Wright
Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada
Thomas Stocker
Lamont-Doherty Geological Observatory, New-York, N.Y., Canada

15:50 **On Equatorial Kelvin Waves in Numerical Ocean Models**

Max K.F. Ng, William W. Hsieh
Dept. of Oceanography, University of British Columbia, Vancouver, B.C., Canada

16:10 **INTENSE CURRENTS IN THE DEEP NORTH-EAST PACIFIC OCEAN**
Howard Freeland
Institute of Ocean Sciences, Sidney, B. C., Canada

MERCREDI / WEDNESDAY, 08H30-09H10 **SALLE / ROOM: 2880**
SESSION THÉMATIQUE PLÉNIERE EN MÉTÉOROLOGIE: LA PHYSIQUE DES PHÉNOMÈNES À MÉSOÉCHELLE
PRÉSIDENT / CHAIRMAN: GEORGE ISAAC, CLOUD PHYSICS RESEARCH DIVISION, SEA
PLENARY SESSION IN METEOROLOGY: THE PHYSICS OF MESOSCALE PHENOMENA

08:30 **THE PHYSICS OF MESOSCALE PHENOMENA**
M.K. Yau (conférencier invité / invited speaker)
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

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MERCREDI / WEDNESDAY, 09H10-10H30 **SALLE / ROOM: 2840**
SESSION 4A: PHYSIQUE DES NUAGES: MICROPHYSIQUE
PRÉSIDENT / CHAIRMAN: GEORGE ISAAC, CLOUD PHYSICS RESEARCH DIVISION, AES
SESSION 4A: CLOUD PHYSICS: MICROPHYSICS

09:10 **THE EFFECT OF VARIOUS DISDROMETER CALIBRATIONS UPON THE MEASUREMENT OF RAINDROP-SIZE DISTRIBUTIONS IN MALAYSIA**
Greg M. McFarquhar, Roland List
Department of Physics, University of Toronto, Toronto, Ontario, Canada

09:30 **A NEW APPROACH TO CALCULATE COLLISION RATES FOR DROPLETS IN TURBULENT CLOUDS**
Anna S. Koziol and Henri G. Leighton
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

09:50 **CHARACTERISTICS OF A DRY LAYER BENEATH A CIRRUS CLOUD**
Ismail Gultepe
NASA, GSFC Code 913, Greenbelt, Maryland, U.S.A.

10:10 **NUMERICAL MODELING OF ENTRAINMENT AND CLOUD DROPSIZE DISTRIBUTION**
P. Vaillancourt and M.K. Yau
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

MERCREDI / WEDNESDAY, 09H10-10H30 SALLE / ROOM: 2830
SESSION 4B: MÉTÉOROLOGIE D'EXPLOITATION I
PRÉSIDENT / CHAIRMAN: PETER ZWACK, DÉPARTEMENT DE PHYSIQUE, UNIVERSITÉ DU QUÉBEC À MONTRÉAL
SESSION 4B: OPERATIONAL METEOROLOGY I

09:10 **WSR-88D: MESOSCALE CHARACTER OF INTENSE WINTER STORMS**
Leslie R. Lemon
Paramax Systems Corporation, Great Neck, New York, U.S.A.
Larry J. Ruthi
National Weather Service, Weather Service Forecast Office, Norman, Oklahoma, U.S.A.
David A. Imy
WSR-88D Operational Support Facility, Operations Training Branch, Norman, Oklahoma, U.S.A.

09:30 **PRÉVISIONS DE LIGNES DE BOURRASQUES DE NEIGE À LA MÉSO-ÉCHELLE**
Denis Bachand, Jean Morissette
Centre Météorologique du Québec, Ville Saint-Laurent, Québec, Canada

09:50 **EVALUATION DU MODÈLE DE VENT À LA MÉSO-ÉCHELLE BOLON 1 DANS LA VALLÉE DU SAINT-LAURENT**
Gilles Morneau, Michelle Hardy
Service de l'Environnement Atmosphérique, Environnement Canada, Ville Saint-Laurent, Québec, Canada

10:10 **L'ÉVALUATION DU POTENTIEL TORNADIQUE ET SON SUIVI AU C.M.Q. POUR LE CAS DU 27 AOÛT 1991 (MASKINONGÉ)**
Henri-Paul Biron, Mario Benjamin, Richard Moffet, Guy Viau
Centre Météorologique du Québec, Ville Saint-Laurent, Québec, Canada

MERCREDI / WEDNESDAY, 08H30-10H30 SALLE / ROOM: 3830
SESSION 4C: PLATEAUX CONTINENTAUX: MÉTÉOROLOGIE ET OCÉANOGRAPHIE I
PRÉSIDENT / CHAIRMAN: PETER C. SMITH, DEPARTMENT OF FISHERIES AND OCEANS, BEDFORD INSTITUTE OF OCEANOGRAPHY
SESSION 4C: CONTINENTAL SHELVES: METEOROLOGY AND OCEANOGRAPHY I

08:30 **LONG-TERM TEMPERATURE AND SALINITY VARIABILITY ON THE SCOTIAN SHELF AND IN THE GULF OF MAINE**
B. Petrie, K. Drinkwater and R. Pettipas
Department of Fisheries and Oceans, Physical and Chemical Sciences Branch, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

08:50 **CURRENT AND HYDROGRAPHIC VARIABILITY ON THE SOUTHEAST SHOAL OF THE GRAND BANK**
J.W. Loder, C.K. Ross
Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

09:10 **ON THE BAROCLINIC DYNAMICS, HAMILTONIAN FORMULATION AND GENERAL STABILITY CHARACTERISTICS OF DENSITY-DRIVEN SURFACE CURRENTS AND FRONTS OVER A SLOPING CONTINENTAL SHELF**
Gordon E. Swaters
Department of Mathematics, University of Alberta, Edmonton, Alberta, Canada

09:30 **LOCAL AND REMOTE FORCING OF THREE-DIMENSIONAL CIRCULATION ON THE SCOTIAN SHELF**
Jinyu Sheng and Keith R. Thompson
Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

09:50 **LAGRANGIAN CIRCULATION ON GEORGES BANK FROM A FINITE ELEMENT MODEL**
H. Ridderinkhof
Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada
D.R. Lynch, C.E. Naimie
Dartmouth College, Hanover, Hew Hampshire, U.S.A.

10:10 **ASSIMILATION OF ACOUSTIC DOPPLER CURRENT PROFILER (ADCP) DATA INTO A TIDAL MODEL USING THE ADJOINT METHOD**
Dowd, M.G. and K.R. Thompson
Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

10H30-10H50 PAUSE-CAFÉ / COFFEE BREAK

MERCREDI / WEDNESDAY, 10H50-12H10 **SALLE / ROOM: 2840**
SESSION 5A: PHYSIQUE DES NUAGES: RADIATION
PRÉSIDENT / CHAIRMAN: HENRY LEIGHTON, DEPARTMENT OF ATMOSPHERIC AND OCEANIC SCIENCES, MC GILL UNIVERSITY
SESSION 5A: CLOUD PHYSICS: RADIATION

10:50 **SOLAR RADITION ABSORBED AT THE SURFACE FROM 5 YEARS OF ERBE MEASUREMENTS**
Henry G. Leighton
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada
Z. Li
Aerospace Meteorology Division, Atmospheric Environement Service, Dorval, Québec, Canada

11:10 **A STUDY OF THE EFFECTS OF LONGWAVE RADIATION IN CLOUD DEVELOPMENT**
Hong Guan, M. K. Yau, R. Davies
Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, Québec, Canada

11:30 **RADIATIVE FORCING OF OPTICALLY THIN WATER CLOUDS, HAZE AND DUST LAYERS**
Mario M. Ouellet and Glen B. Lesins
Atmospheric Science Program, Dalhousie University, Halifax, Nova Scotia, Canada

11:50 **EFFECTS OF CLOUD SHAPE ON CLOUD ALBEDO**
Tamas Varnai, R. Davies
Department of Meteorology, McGill University, Montreal, Québec, Canada

MERCREDI / WEDNESDAY, 10H50-12H10 SALLE / ROOM: 2830
SESSION 5B: MÉTÉOROLOGIE D'EXPLOITATION II
PRÉSIDENT / CHAIRMAN: MICHEL JEAN, CENTRE MÉTÉOROLOGIQUE CANADIEN, SEA
SESSION 5B: OPERATIONAL METEOROLOGY II

10:50 A REAL TIME WEATHER FORECAST DATA BASE FOR POWER SYSTEM APPLICATIONS
I. Karl Pavasars, Klaus H. Schaedlich
Ontario Hydro, Mississauga, Ontario, Canada

11:10 SCRIBE: AN INTERACTIVE SYSTEM FOR COMPOSISITION OF METEOROLOGICAL FORECASTS
J. Boulais, G. Babin, D. Vigneux, M. Mondou, R. Parent, R. Verret
Development Branch, Canadian Meteorological Centre, Dorval, Québec, Canada

11:30 VALUE ADDED TO STATISTICAL WEATHER ELEMENT FORECAST THROUGH ERROR-FEEDBACK POSTPROCESSING SYSTEME
Richard Verret and Nathan Yacowar
Development Branch, Canadian Meteorological Centre, Dorval, Québec, Canada

11:50 AN OPERATIONAL EVALUATION OF REMOTE ENVIRONMENTAL AUTOMATIC DATA ACQUISITION CONCEPT (READAC) AUTOMATIC STATIONS TO DETECT MESOSCALE WEATHER EVENTS THAT ARE IMPORTANT TO AVIATION INTERESRS.
Doug Dixon
Canadian Forces Forecast Center, CFB Edmonton, Edmonton, Alberta, Canada

MERCREDI / WEDNESDAY, 10H50-12H10 SALLE / ROOM: 3830
SESSION 5C: PLATEAUX CONTINENTAUX: MÉTÉOROLOGIE ET OCÉANOGRAPHIE II
PRÉSIDENT / CHAIRMAN: JOHN LODER, DEPARTMENT OF FISHERIES AND OCEANS, BEDFORD INSTITUTE OF OCEANOGRAPHY
SESSION 5C: CONTINENTAL SHELVES: METEOROLOGY AND OCEANOGRAPHY II

10:50 INERTIAL PEAK SUPPRESSION ABOVE STEEPLY SLOPING TOPOGRAPHY
Denis Gilbert
Institut Maurice Lamontagne, Mont-Joli, Québec, Canada

11:10 CANADIAN ATLANTIC STORMS PROGRAM II: THE OCEANOGRAPHIC COMPONENT
Peter C. Smith, Charles Tang, Simon Prinsenberg
Physical and Chemical Sciences, Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, Nova Scotia, Canada
J. Ian MacPherson
Flight Research Laboratory, National Research Council, Ottawa, Ontario, Canada
Richard McKenna
Institute for Marine Dynamics, National Research Council, St. John's, Newfoundland, Canada
Mona El-Tahan
C-CORE, Memorial University of Newfoundland, St. John's, Newfoundland
Paris Vachon, Mike Manore
Canadian Centre for Remote Sensing, Ottawa, Ontario, Canada
Savi Narayanan, Pierre Pépin and Jim Helbig
Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, St. John's, Newfoundland, Canada

11:30 **CANADIAN ATLANTIC STORMS PROGRAM II: THE METEOROLOGICAL FIELD EXPERIMENT**
Ronald E. Stewart[1] and the CASP II Meteorology Group
1 Atmospheric Environment Service, Environment Canada, Downsview, Ontario, Canada

11:50 **MESOSCALE METEOROLOGICAL AND OCEANOGRAPHIC PHENOMENA IN THE NORTH ATLANTIC - THE VIEW FROM SPACE**
G.W.K. Moore, J.R. Drummond, M. Mackay and J. York
Department of Physics, University of Toronto, Toronto, Ontario, Canada

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MERCREDI / WEDNESDAY, 10H50-12H10 **SALLE / ROOM: 3820**
SESSION 5D: CIRCULATION OCÉANIQUE THERMOHALINE
PRÉSIDENT / CHAIRMAN: GORDON MCBEAN, DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF BRITISH COLUMBIA
SESSION 5D: THERMOHALINE OCEAN CIRCULATION

10:50 **LOW-FREQUENCY OCEANIC VARIABILITY UNDER SEASONAL FORCING**
P.G. Myers, A.J. Weaver
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

11:10 **EVAPORATION MINUS PRECIPITATION FORCING OF THE NORTH ATLANTIC**
Aura S.M.O. and Weaver A.J.
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

11:30 **A TWO-DIMENSIONAL COUPLED ATMOSPHERE-OCEAN-SEA ICE MODEL FOR LONG-TERM CLIMATIC SIMULATIONS**
L.D. Danny Harvey
Department of Geography, University of Toronto, Toronto, Ontario, Canada

11:50 **ON THE SALINITY BUDGET OF THE NORTH PACIFIC OCEAN**
Gordon A. McBean
Atmospheric Science Programme, Departments of Geography and Oceanography, University of British Columbia, Vancouver, British Columbia, Canada

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12H10-13H30 DÉJEUNER / LUNCH

MERCREDI / WEDNESDAY, 13H30-15H10 **SALLE / ROOM: 2840**
SESSION 6A: RADAR-MÉTÉOROLOGIE ET INSTRUMENTATION I
PRÉSIDENT / CHAIRMAN: ENRICO TORLASCHI, DÉPARTEMENT DE PHYSIQUE, UNIVERSITÉ DU QUÉBEC À MONTRÉAL
SESSION 6A: RADAR-METEOROLOGY AND INSTRUMENTATION I

13:30 **DOPPLER INTERPRETATION OF A CONTINENTAL WINTER STORM**
Norman R. Donaldson
Atmospheric Environment Service, Weather Radar Station, King City, Ontario, Canada

13:50 **DOPPLER RADAR OBSERVATIONS OF REAR INFLOW JETS IN SOUTHERN ONTARIO**
Paul Joe
Atmospheric Environment Service of Canada, Downsview, Ontario, Canada

14:10 **DOPPLER "FINGER" SIGNATURE: A CASE STUDY OF THE JUNE 29 1991 SUPERCELL**
Stephen Knott, Jean-Pierre Aubagnac, Mike Leduc
Atmospheric Environment Service, Toronto, Ontario, Canada

14:30 **NON LINEAR VAD ANALYSIS OF SINGLE DOPPLER DATA**
J. Sun, P. Joe
Atmospheric Environment Service, Weather Radar Station, King City, Ontario, Canada
I. Zawadzki
Département de Physique, Université du Québec à Montréal, Montréal, Québec, Canada

14:50 **LE PROFILEUR DE COUCHE LIMITE COMME INSTRUMENT D'OBSERVATION DE MICROPHYSIQUE**
Marie-France Turcotte et Isztar Zawadzki
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada
R.R. Rogers
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

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MERCREDI / WEDNESDAY, 13H30-15H10 **SALLE / ROOM: 2830**
SESSION 6B: MÉTÉOROLOGIE DYNAMIQUE À GRANDE ÉCHELLE I
PRÉSIDENT / CHAIRMAN: JACQUES DEROME, DEPARTMENT OF ATMOSPHERIC AND OCEANIC SCIENCES, MC GILL UNIVERSITY
SESSION 6B: LARGE-SCALE DYNAMIC METEOROLOGY I

13:30 **A MODELING STUDY OF THE ATMOSPHERIC IMPACT OF SEA SURFACE TEMPERATURE ANOMALIES IN THE MID AND HIGH LATITUDE OF THE NORTH ATLANTIC**
S. Peng, H. Ritchie and L.A. Mysak
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Canada

13:50 **ON THE INTERACTION BETWEEN THE SYNOPTIC SCALE EDDIES AND THE LOWER FREQUENCY FLOW IN THE ATMOSPHERE**
J. Sheng and J. Derome
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

14:10 **ON THE INTERACTIONS BETWEEN SYNOPTIC SCALE EDDIES AND THE PNA TELECONNECTION PATTERN**
M. Klasa, J. Derome and J. Sheng
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

14:30 **A NONLINEAR MODEL OF STATIONARY PLANETARY WAVES IN THE WINTER STRATOSPHERE**
T.C. Box and J. Derome
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

14:50 **An Assessment of the WKBJ Approximation Used in Gravity-Wave Drag Parameterization Schemes**
René Laprise
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

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Mercredi / Wednesday, 13H30-15H10 **Salle / Room: 3830**
SESSION 6C: Glace-océan en zones nordiques: modélisation et observations
Président / Chairman: Lawrence Mysak, Department of Atmospheric and Oceanic Sciences, Mc Gill University
SESSION 6C: High latitude ice-ocean: modelling and observations

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13:30 **Interannual Variability of Artic Sea-Ice Using a Coupled Sea Ice - Ocean Model**
David M. Holland and L.A. Mysak
Department of Meteorology, McGill University, Montréal, Québec, Canada
J.M. Oberhuber
Meteoroligisches Institut, Universitat Hamburg, Hamburg, Germany

13:50 **Simple Two-Layer Circulation in the Arctic-Greenland Sea Basin**
S. Piacsek, R. Allard
Naval Research Laboratory, Stennis Space Center Detachment, MS 39529, U.S.A.

14:10 **A Numerical Simulation of Sea Ice Circulation in Hudson Bay**
Jia Wang, L.A. Mysak, R.G. Ingram
Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, Québec, Canada

14:30 **Measurements of the Motion, Thickness and Topography of Sea Ice Using Moored Subsea Sonar**
Humfrey Melling
Institute of Ocean Sciences, Sidney, B.C., Canada

14:50 **Seismic-Acoustic Sensing of Properties and Fracturing of Sea Ice**
Yunbo Xie and David M Farmer
Institute of Ocean Sciences, Sydney, B.C., Canada

Mercredi / Wednesday, 13H30-14H50 **Salle / Room: 3820**
SESSION 6D: Ondes, mélange et convection I
Président / Chairman: Yvon Ouellet, Département de Génie civil, Université Laval
SESSION 6D: Waves, mixing and convection I

13:30 **Comportement asymptotique du passage d'une onde solitaire sur le talus continental**
Abdelhak Kabbaj et Smael Naasse
École normale supérieure Takaddoum, Rabat, Maroc

13:50 **On the Nonlinear Coupling Between Swell and Wind Waves**
Diane Masson
Institute of Ocean Sciences, Sidney, British Columbia, Canada

14:10 **THE EFFECT OF ALONGSHORE TOPOGRAPHIC VARIATION AND BOTTOM FRICTION ON SHELF WAWE INTERACTIONS**

François W. Primeau
Department of Mathematics, Applied Mathematics Institute, University of Alberta, Edmonton, Alberta, Canada

14:30 **MODELLING OF TWO-LAYER STRATIFIED FLOW UNDER A TWO-DIMENSIONAL OBSTACLE**

Patrick F. Cummins, Dave R. Topham
Institute of Ocean Sciences, Sidney, B.C., Canada

15H10-15H30 PAUSE-CAFÉ / COFFEE BREAK

MERCREDI / WEDNESDAY, 15H30-17H10 **SALLE / ROOM: 2840**
SESSION 7A: RADAR-MÉTÉOROLOGIE ET INSTRUMENTATION II
PRÉSIDENT / CHAIRMAN: PETER YAU, DEPARTMENT OF ATMOSPHERIC AND OCEANIC SCIENCES, MC GILL UNIVERSITY
SESSION 7A: RADAR-METEOROLOGY AND INSTRUMENTATION II

15:30 **ESTIMATES OF PRECIPITATION IN SUMMER STORMS IN CENTRAL ALBERTA**

D.A. Holland, A.R. Holt, R. McGuinness
Mathematics Department, University of Essex, Colchester, U.K.
Enrico Torlaschi
Communications Research Laboratory, McMaster University, Faculty of Engineering, Hamilton, Ontario, Canada
B. Kochtubajda
Resource Technologies Department, ARC, Edmonton, Alberta, Canada

15:50 **FINE RAINGAUGE NETWORK COMPARISON WITH RADAR RAINFALL**

F.J. Eley
Hydrometeorological Processes Division, Atmospheric Environment Service, Saskatoon, Sask., Canada

16:10 **WIND PROFILE ETIMATION BY CONVENTIONAL RADARS**

Frédéric Fabry
Radar Weather Observatory, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada

16:30 **IPIX RADAR - OCEAN AND METEOROLOGICAL APPLICATION**

Vytas Kezys, Enrico Torlaschi, Brian Currie, Simon Haykin
Communications Research Laboratory, McMaster University, Faculty of Engineering, Hamilton, Ontario, Canada

16:50 **IMPROVEMENTS IN TEMPERATURE PROFILE RETRIEVALS FROM MICROWAVE RADIOMETRIC MEASUREMENTS**

P.R. Shepherd, W.F.J. Evans
Centre for Research in Earth and Atmospheric Science, North York, Ontario, Canada

MERCREDI / WEDNESDAY, 15H30-17H30 SALLE / ROOM: 2830
SESSION 7B: MÉTÉOROLOGIE DYNAMIQUE À GRANDE ÉCHELLE II
PRÉSIDENT / CHAIRMAN: KENT MOORE, DEPARTMENT OF PHYSICS, UNIVERSITY OF TORONTO
SESSION 7B: LARGE-SCALE DYNAMIC METEOROLOGY II

15:30 A NON-HYDROSTATIC MODEL IN HYDROSTATIC-PRESSURE COORDINATE
René Laprise
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

15:50 BAROCLINIC FORCING OF THE MEAN ATMOSPHERE
Murray MacKay and G.W. Kent Moore
Department of Physics, University of Toronto, Toronto, Ontario, Canada

16:10 UPPER-TROPOSPHERIC SYNOPTIC-SCALE WAVES
Chantal Rivest, Brian Farrell
Service de l'environnement atmosphérique, Dorval, Québec, Canada

16:30 TWO VARIATIONS ON A THEME BY RAYLEIGH
Theodore G. Shepherd
Department of Physics, University of Toronto, Toronto, Ontario, Canada

16:50 NONLINEAR SYMMETRIC STABILITY
Theodore G. Shepherd
Department of Physics, University of Toronto, Toronto, Ontario, Canada

17:10 GEOSTROPHIC SCATTER PLOTS AND THE APPLICATION OF QUASI-GEOSTROPHIC FREE MODE THEORY TO A NORTHEAST PACIFIC BLOCKING EVENT
Nils R. Ek and Gordon E. Swaters
Departments of Meteorology and Mathematics, University of Alberta, Edmonton, Canada

MERCREDI / WEDNESDAY, 15H30-17H30 SALLE / ROOM: 3820
SESSION 7C: MOUVEMENTS TOURBILLONNAIRES
PRÉSIDENT / CHAIRMAN: MOTO IKEDA, DEPARTMENT OF FISHERIES AND OCEANS, BEDFORD INSTITUTE OF OCEANOGRAPHY
SESSION 7C: EDDIES AND RINGS

15:30 WARM-CORE RINGS AND CROSS-SHELF EXCHANGE
M.L. Cahill
Oceanography Department, Dalhousie University, Halifax, Nova Scotia, Canada
K. Drinkwater
Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

15:50 DYNAMIC TOPOGRAPHY AND SURFACE FRONTS NEAR BARBADOS, W.I.
M.J. Bowman, S.J. Fauria, K.L. Stansfield
Marine Sciences Research Center, University of New York, Stony Brook, NY, U.S.A.

16:10 UPWELLING OVER A CANYON
Susan E. Allen
Department of Oceanography, University of British Columbia, Vancouver, British Columbia, Canada

16:30 **SPREAD OF OIL FROM THE TENYO MARU, JULY 1991**

William R. Crawford
Canadian Hydrographic Service, Department of Fisheries and Oceans, Institute of Ocean Sciences, Sidney, B.C., Canada
S. Venkatesh
Environment Canada, Atmospheric Environment Service, Downsview, Ontario, Canada

16:50 **NUMERICAL SIMULATION OF MESOSCALE FEATURES IN THE NORTH ATLANTIC CURRENT OBSERVED BY GEOSAT ALTIMETER DATA**

M. Ikeda
Physical and Chemical Sciences, Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

17:10 **NEAR-EQUATORIAL EDDIES OFF SOUTH AMERICA**

J. G. Bruce
Naval Oceanographic Office, Stennis Space Center, Naval Research Laboratory, MS 39522, U.S.A.

MERCREDI / WEDNESDAY, 15H30-17H10 **SALLE / ROOM: 3820**
SESSION 7D: OCÉANOGRAPHIE CÔTIÈRE ET ESTUARIENNE I
PRÉSIDENT / CHAIRMAN: YVES GRATTON, INSTITUT MAURICE LAMONTAGNE
SESSION 7D: COASTAL AND ESTUARINE OCEANOGRAPHY I

15:30 **LONG-TERM RUNOFF EFFECTS ON SURFACE CIRCULATION IN NORTHERN BRITISH COLUMBIA WATERS**

Renée Jacques
Department of Oceanography, The University of British Columbia, Vancouver, B.C., Canada

15:50 **MODÉLISATION NUMÉRIQUE TRI-DIMENSIONNELLE DE LA CIRCULATION DE L'ESTUAIRE DU SAINT-LAURENT: RÉSULTATS PRÉLIMINAIRES**

J. Chassé, Mohammed I. El-Sabh
Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada
T. S. Murty
Institute of Ocean Sciences, Fishery and Ocean Canada, Sidney, B. C., Canada
J. Stronach
Pacific Ocean Sciences Ltd., Burnaby, B. C., Canada

16:10 **2D FINITE ELEMENT TIDAL MODEL OF ST.LAWRENCE ESTUARY**

Gagnon, M., J.L. Robert and Y. Ouellet
Departement of Civil Engineering, Pavillon Pouliot, Laval University, Sainte-Foy, Québec, Canada

16:30 **DISPERSION OF RHODAMINE FROM AN UNDERWATER DIFFUSER IN THE RIMOUSKI COASTAL ZONE**

V. G. Koutitonsky, S. Côté
Institut National de la Recherche Scientifique (INRS), Océanologie, Rimouski, Québec, Canada

16:50 NUMERICAL MODELLING OF THE CIRCULATION AND LARVAE DRIFT IN THE ANSE-À-L'ORIGNAL BAY

S. Côté
Department of Oceanography, Université du Québec à Rimouski, Rimouski, Québec, Canada
V.G. Koutitonsky
Institut National de la Recherche Scientifique (INRS), Océanologie, Rimouski, Québec, Canada
Y. Gratton
Institut Maurice-Lamontagne, Fisheries and Oceans Canada, Mont-Joli, Québec, Canada

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JEUDI / THURSDAY, 08H30-09H10 **SALLE / ROOM: 2850**
SESSION PLÉNIERE THÉMATIQUE: LE CLIMAT ET SES RÉPERCUSSIONS
PRÉSIDENT / CHAIRMAN: PIERRE DUBREUIL, CENTRE MÉTÉOROLOGIQUE CANADIEN, SEA
PLENARY THEME SESSION: THE CLIMATE AND ITS IMPACTS

08:30 THE CLIMATE AND ITS IMPACTS

S.J. Cohen (conférencier invité / invited speaker)
Canadian Climate Centre, Atmospheric Environment Service, Environment Canada, Downsview, Ontario, Canada

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JEUDI / THURSDAY, 09H10-10H50 **HALL DES EXPOSANTS 2IÈME NIVEAU / EXHIBIT HALL 2ND FLOOR**
SÉANCE D'AFFICHAGE
PRÉSIDENT / CHAIRMAN: PIERRE DUBREUIL, CENTRE MÉTÉOROLOGIQUE CANADIEN, SEA
POSTER SESSION

09:10 KINEMATICS OF MIXING IN COASTAL WATERS

David Booth and Jean-François Dumais
Département d'océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada

09:10 THE CANADIAN WEATHER RADAR DATA PROCESSING SYSTEM

R.G. Humphries
MacDonald Dettwiler, Richmond, B.C., Canada
Henri-Paul Biron
Centre météorologique du Québec, Service de l'Environnement atmosphérique, Ville Saint-Laurent, Québec, Canada

09:10 OBSERVING ICE PROCESSES IN THE NEWFOUNDLAND MARGINAL ICE ZONE DURING CASP II, MARCH 1992

Richard F. McKenna
Institute for Marine Dynamics, National Research Council Canada, St. John's, Newfoundland, Canada
M. El-Tahan
C-CORE, Memorial University of Newfoundland, St. John's, Newfoundland, Canada
C.L. Tang
Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada
A. Cavanie, F. Gohin
IFREMER, Plouzané, France

09:10 **DATA INTEGRATION AT THE 5 KM GRID SCALE (INTÉGRATION DE DONNÉES À L'ÉCHELLE DE 5 KM)**
Normand Bussières
Division de l'intégration des données, Centre climatologique canadien, Downsview, Ontario, Canada

09:10 **LA TORNADE DE MASKINONGÉ**
Henri-Paul Biron, Mario Benjamin, Richard Moffet, Guy Viau, Pierre Pelletier, Guy O. Bonsawin
Centre météorologique du Québec, Service de l'Environnement atmosphérique, Ville Saint-Laurent, Québec, Canada
Maurice Dubé
Service de l'environnement atmosphérique, Bureau Météorologique de Trois-Rivières, Québec, Canada

09:10 **ANALYSE DE COMPOSÉS UV-PROTECTEURS PRÉSENTS DANS DES CULTURES DE PHYTOPLANCTON ET DANS DES EAUX MARINES**
L. Lorrain, S. Roy
Centre Océanographique de Rimouski, INRS-Océanologie, Rimouski Québec, Canada

09:10 **MESOSCALE OBSERVATIONS OF SURFACE FRONTS IN SOUTHERN ONTARIO STORMS**
Rosemary Tabory
CRESS, York University, North York, Ontario, Canada

09:10 **ÉTUDES DES MASSES D'EAU DANS L'ESTUAIRE DU SAINT-LAURENT**
Mohammed I. El-Sabh et Joël Chassé
Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada

09:10 **EFFET DE LA NATURE DU SUBSTRAT ET DE LA PROFONDEUR SUR LA VARIABILITÉ SPATIALE DU TAUX DE FIXATION DES POST-LARVES DE PÉTONCLE (PLACOPECTEN MAGELLANICUS)**
Michel Harvey, E. Bourget
Département de biologie, Université Laval, Sainte-Foy, Québec, Canada

09:10 **CONCENTRATIONS D'OZONE SUR LE QUÉBEC MÉRIDIONAL DURANT LA PÉRIODE 1989-1991**
Alain Robichaud
Ministère de l'Environnement, Direction des Réseaux atmosphériques, Sainte-Foy, Québec, Canada

09:10 **ATMOSPHERIC SOUNDING ANALYSIS ON A MICROCOMPUTER**
Tony Keck
Environnement-Canada, Winnipeg, Manitoba, Canada

09:10 **DESCRIPTION OF THE GEOPHYSICAL FIELDS AT CMC AND THEIR USE IN THE REGIONAL AND GLOBAL MODELS**
Richard Hogue, Jacques Hallé, Bruce Brasnett
Analyses and Satellite Division, Canadian Meteorological Centre, Dorval, Québec, Canada
Réal Sarrazin, Normand Brunet
Numerical Weather Prediction Division, Dorval, Québec, Canada

09:10 **CYCLONE TRAJECTORIES IN CCC GCM SIMULATIONS WITH DOUBLED CO_2**
Vladimir Pierre-Lys, Peter Zwack, René Laprise
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

09:10 THE INFOMET PACKAGE OF SOFTWARE MODULES FOR COLLECTION, ARCHIVING AND DISPLAY OF DATA FROM THE ANIKOM SATELLITE LINK

Keith W. Ayotte, Peter A. Taylor, David Sills
Department of Earth and Atmospheric Science, York University, Noth York, Ontario, Canada

09:10 VARIABILITY TRENDS IN BRITISH COLUMBIA PRECIPITATION

Stanton E. Tuller
Department of Geography, University of Victoria, Victoria, British Columbia, Canada

10H30-10H50 PAUSE-CAFÉ / COFFEE BREAK

JEUDI / THURSDAY, 10H50-12H30 **SALLE / ROOM: 3830**
SESSION 8A: TÉLÉDÉTECTION SATELLITAIRE I
PRÉSIDENT / CHAIRMAN: KEITH THOMPSON, SCIENCES GÉODÉSIQUES ET TÉLÉDÉTECTION, UNIVERSITÉ LAVAL
SESSION 8A: SATELLITE REMOTE SENSING I

10:50 A STUDY ON THE ANNUAL VARIABILITY OF TROPICAL MARINE SC AND IST RELATIONSHIP WITH ATMOSPHERIC AND OCEANIC SEASONAL CHANGES

L. Oreopoulos and R. Davies
Department of Meteorology, McGill University, Montréal, Québec, Canada

11:10 CLOUD AND OCEAN ANALYSIS OF INSAT-II DATA

Nancy Bepple, Len Laba
MacDonald Dettwiler, Richmond, British Columbia, Canada

11:30 INTERPRETING NOAA-9 SEA-SURFACE TEMPERATURE RETRIEVALS WITH IN SITU AND METEOROLOGICAL DATA

A.R. Condal
Département des sciences géodésiques et de télédétection, Pavillon Casault, Université Laval, Sainte-Foy, Québec, Canada
D. Lefaivre
Institut Maurice-Lamontagne, Ministère des Pêches et Océans, Mont-Joli, Québec, Canada
I. Martel
Département des sciences géodésiques et de télédétection, Pavillon Casault, Université Laval, Sainte-Foy, Québec, Canada

11:50 MODÉLISATION ET SUIVI DE LA CLIMATOLOGIE DES EAUX DU GOLFE SAINT-LAURENT À PARTIR DES IMAGES NOAA-7 ET NOAA-9

Alain A. Viau, Alfonso Condal, France Boucher
Département des sciences géodésiques et de télédétection, Pavillon Casault, Université Laval, Sainte-Foy, Québec, Canada

JEUDI / THURSDAY, 10H50-12H10 SALLE / ROOM: 2840
SESSION 8B: CHIMIE ATMOSPHÉRIQUE: MESURES
PRÉSIDENT / CHAIRMAN: LEN BARRIE, MEASUREMENTS AND ANALYSIS RESEARCH DIVISION, SEA
SESSION 8B: ATMOSPHERIC CHEMISTRY: MEASUREMENTS

10:50 DEVELOPMENT OF A GAS CHROMATOGRAPH FOR TRACE LEVEL MEASUREMENT OF PEROXYACETYL NITRATE IN AMBIENT AIR
Pierrette Blanchard, Paul B. Shepson
Department of Chemistry and Centre for Atmospheric Chemistry, York University, North York, Ontario, Canada

11:10 EMISSIONS OF NITROUS OXIDE FROM THE HUDSON BAY LOWLANDS
C.L. Schiller, D.R. Hastie
Faculty of Pure and Applied Science, York University, North York, Ontario, Canada

11:30 ULTRAVIOLET RADIATION MONITORING AND FORECASTING
W.F.J. Evans
Environmental Resource Studies, Trent University, Peterborough, Ontario, Canada

11:50 CARBON MONOXIDE AND METHANE MEASUREMENTS FROM SPACE
J. R. Drummond
Department of Physics, University of Toronto, Toronto, Ontario, Canada

JEUDI / THURSDAY, 10H50-12H10 SALLE / ROOM: 2860
SESSION 8C: OCÉANOGRAPHIE CÔTIÈRE ET ESTUARIENNE II
PRÉSIDENT / CHAIRMAN: GRANT INGRAM, DEPARTMENT OF ATMOSPHERIC AND OCEANIC SCIENCES, MC GILL UNIVERSITY
SESSION 8C: COASTAL AND ESTUARINE OCEANOGRAPHY II

10:50 NUMERICAL MODELLING OF TIDES IN BAIE-DES-CHALEURS
Mohammed I. El-Sabh et Joël Chassé
Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada

11:10 LARGE-SCALE HYDRODYNAMIC STUDIES OF BAIE-DES-CHALEURS IN SUPPORT OF SCALLOP RESEARCH
Mohammed I. El-Sabh
Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada
Grant Ingram
Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, Quebec, Canada

11:30 TEMPERATURE AND SALINITY CHARACTERISTICS OF BAIE DES CHALEURS
C. Le Quéré and R.G. Ingram
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada
M.El Sabh
Oceanography, University of Québec at Rimouski, Rimouski, Québec, Canada

11:50 CIRCULATION OF THE JACQUES-CARTIER STRAIT INFERRED USING DATA ASSIMILATION
Marie-Claude Bourque
Dalhousie University, Halifax, Nova Scotia, Canada

JEUDI / THURSDAY, 10H50-12H10 **SALLE / ROOM: 2830**
SESSION 8D: ONDES, MÉLANGE ET CONVECTION II
PRÉSIDENT / CHAIRMAN: VLADIMIR G. KOUTITONSKY, INRS-OCÉANOLOGIE
SESSION 8D: WAVES, MIXING AND CONVECTION II

10:50 EFFECTS OF TIDAL MIXING OVER A SILL ON ESTUARY/OCEAN EXCHANGE
A. Valle-Levinson and Robert E. Wilson
Marine Sciences Research Center, Suny at Stony Brook, Stony Brook, NY, U.S.A.

11:10 BUOYANCY FLUX ESTIMATES FROM OVERTURNING SCALE QUANTITIES
Peter Galbraith
Oceanography Department, Dalhousie University, Halifax, Nova Scotia, Canada

11:30 SALINITY CONTROL OVER DEEP CONVECTION
Dan Kelley
Oceanography Department, Dalhousie University, Halifax, Nova Scotia, Canada

11:50 TIME-DEPENDENT CONVECTIVE INSTABILITY
David Brickman
Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

12H10-13H30 DÉJEUNER / LUNCH

JEUDI / THURSDAY, 13H30-15H10 **SALLE / ROOM: 3830**
SESSION 9A: TÉLÉDÉTECTION SATELLITAIRE II
PRÉSIDENT / CHAIRMAN: ALAIN VIAU, SCIENCES GÉODÉSIQUES ET TÉLÉDÉTECTION, UNIVERSITÉ LAVAL
SESSION 9A: SATELLITE REMOTE SENSING II

13:30 SATELLITE-VIEWED GLOBAL CLOUD DISTRIBUTIONS AND STATISTICS
Zhen S. Yu, J. R. Drummond
Department of Physics, University of Toronto, Toronto, Ontario, Canada

13:50 INTÉGRATION SPATIALE DES OBSERVATIONS CLIMATOLOGIQUES À PARTIR D'OBSERVATIONS AÉROPORTÉES DES FLUX
P.H. Schuepp, P.H. Caramori, Y. Guo
Département des ressources renouvelables, Université McGill, Macdonald Campus, Sainte-Anne-de-Bellevue, Québec, Canada
R.L. Desjardins
Centre pour la recherche en ressources terrestres et biologiques, Agriculture Canada, Ottawa, Canada
J.I MacPherson
Institut pour la recherche aérospatiale, Centre National de la Recherche, Ottawa, Ontario, Canada

14:10 **ESTIMATING AREAL EVAPOTRANSPIRATION FROM REMOTELY-SENSED AND SURFACE DATA**
B. Singh, P. Péléja
Département de Géographie, Université de Montréal, Montréal, Québec, Canada

14:30 **L'IMAGERIE DES SATELLITES-MÉTÉO NOAA POUR LA SURVEILLANCE DU COUVERT VÉGÉTAL**
Jean Beaubien
Centre de foresterie des Laurentides, Forêts Canada, Sainte-Foy, Québec, Canada

14:50 **AN AVHRR 1-KM NORTH AMERICAN CONTINENT DATA SET FOR GLOBAL CHANGE MONITORING**
Claude-Roger Morasse
Intera Kenting, Ottawa, Ontario, Canada
Josef Cihlar
Canada Centre for Remote Sensing, Ottawa, Ontario, Canada

JEUDI / THURSDAY, 13H30-15H10 **SALLE / ROOM: 2840**
SESSION 9B: CHIMIE ATMOSPHÉRIQUE: MODÈLES, TRANSPORT ET CHIMIE DES NUAGES
PRÉSIDENT / CHAIRMAN: JACK C. MCCONNELL, DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCE, YORK UNIVERSITY
SESSION 9B: ATMOSPHERIC CHEMISTRY: MODELS, TRANSPORT AND CLOUD CHEMISTRY

13:30 **EVALUATION OF THE ADOM WET SCAVENGING MODULE**
A. Glazer and H.G. Leighton
Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

13:50 **COMPARISON BETWEEN CLOUD CHEMISTRY OBSERVATIONS AND SIMULATIONS**
L. Lauzon and H.G. Leighton
Department of Atmospheric and Oceanographic Sciences, McGill University, Montréal, Québec, Canada

14:10 **THE EFFECTS OF CYCLOGENESIS ON REGIONAL TRANSPORT**
Mark Hedley and H.R. Cho
University of Totonto, Department of Physics, Toronto, Ontario, Canada

14:30 **A 3-D SPECTRAL MIDDLE ATMOSPHERE MODEL**
S.R. Beagley, J. de Grandpre, J.W. Kaminski, N. McFarlane
Department of Earth and Atmospheric Sciences, York University, North York, Ontario, Canada
J.C. McConnell
Canadian Climate Centre, Atmospheric Environment Service, North York, Ontario, Canada

14:50 **MODELLING OF ATMOSPHERIC BOUNDARY-LAYER OXIDANTS: A 1-D (VERTICAL) STUDY**
Wanmin Gong
ARQI, Atmospheric Environment Service, Downsview, Ontario, Canada

JEUDI / THURSDAY, 13H30-14H10 SALLE / ROOM: 2880

SESSION PLÉNIERE THÉMATIQUE EN OCÉANOGRAPHIE: LA TÉLÉDÉTECTION ET LA PRODUCTION BIOLOGIQUE MARINE

PRÉSIDENT / CHAIRMAN: MOHAMMED EL-SABH, DÉPARTEMENT D'OCÉANOGRAPHIE, UNIVERSITÉ DU QUÉBEC À RIMOUSKI

PLENARY THEME SESSION IN OCEANOGRAPHY: REMOTE SENSING AND MARINE BIOLOGICAL PRODUCTION

13:30 **FISHERIES OCEANOGRAPHY IN RELATION MESOSCALE METEOROLOGY**
David M. Checkley Jr. (conférencier invité / invited speaker)
Marine Life Research Group, Scripps Institution of Oceanography, La Jolla, U.S.A.

JEUDI / THURSDAY, 14H10-15H10 SALLE / ROOM: 2860

SESSION 9C: OCÉANOGRAPHIE DES PÊCHES: OPEN I

PRÉSIDENT / CHAIRMAN: MOHAMMED EL-SABH, DÉPARTEMENT D'OCÉANOGRAPHIE, UNIVERSITÉ DU QUÉBEC À RIMOUSKI

SESSION 9C: FISHERY OCEANOGRAPHY: OPEN I

14:10 **VERTICAL MIGRATION AS A MEAN TO INCREASE FORAGING IN MACKEREL LARVAE (*SCOMBER SCOMBRUS*) SAMPLED IN SOUTHWESTERN GULF OF ST.LAWRENCE**
A. Ferron, B. Côté and M. I. El-Sabh
Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada

14:30 **CYCLONE CLIMATOLOGY OF SOUTHEASTERN CANADA AND ITS RELATION TO SCALLOP FISHERY**
Maria Cintia Piccolo and Mohammed I. El-Sabh
Centre Océanographique de Rimouski, Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada

14:50 **FORECASTING OCEANIC "WEATHER" ON THE SCOTIAN SHELF**
David Griffin, Tony Bowen, Michael Dowd, Jinyu Sheng, Keith Thompson
Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

15H10-15H30 PAUSE-CAFÉ / COFFEE BREAK

JEUDI / THURSDAY, 15H30-17H30 SALLE / ROOM: 3830

SESSION 10A: CLIMATOLOGIE

PRÉSIDENT / CHAIRMAN: PETER SCHUEPP, DEPARTMENT OF RENEWABLE RESOURCES, MC GILL UNIVERSITY

SESSION 10A: CLIMATOLOGY

15:30 **RECONSTRUCTING HOLOCENE CLIMATES FROM ARCTIC POLLEN DATA**
K. Gajewski
Centre d'études nordiques, Université Laval, Sainte-Foy, Québec, Canada

15:50 **ÉTUDE DES CHANGEMENTS CLIMATIQUES À PARTIR DES CAROTTES DE GLACE: L'EXEMPLE DE LA CALOTTE GLACIAIRE AGASSIZ, ÎLE D'ELLESMERE**
Jocelyne C. Bourgeois
Commission géologique du Canada, Ottawa, Ontario, Canada

16:10 **ESTIMATING THE IMPACT OF GLOBAL WARMING ON PERMAFROST LAYERS IN THE NORTHERN HEMISPHERE**
Ambury Stuart
Weather Research House, Downsview, Ontario, Canada
Alan S. Judge
Terrain Sciences Division, Geological Survey of Canada, Ottawa, Ontario, Canada

16:30 **SAMPLING ERRORS IN ESTIMATING THE GLOBAL TEMPERATURE WITH POINT GAUGES: ASYMPTOTICS AND MONTE CARLO SIMULATIONS**
Samuel Shan-Pu Shen
Department of Mathematics, Faculty of Science, University of Alberta, Edmonton, Alberta, Canada

16:50 **ESTIMATION OF THE TEMPERATURE-PRECIPITATION INDEX USING HOURLY DATA FROM SABLE ISLAND, NOVA SCOTIA IN JANUARY**
George A. Isaac
Cloud Physics Research Division, Atmospheric Environment Service, Downsview, Ontario, Canada
R. Ambury Stuart
Weather Research House, Downsview, Ontario, Canada

17:10 **SPATIAL COHERENCE OF VARIATIONS IN ANNUAL PRECIPITATION TOTALS IN SOUTHEAST LABRADOR**
John P. Newell
Kitchener, Ontario, Canada

JEUDI / THURSDAY, 15H30-16H50 **SALLE / ROOM: 2840**
SESSION 10B: CHIMIE ATMOSPHÉRIQUE: OZONE
PRÉSIDENT / CHAIRMAN: RAYNALD BRULOTTE, DIRECTION DES EXPERTISES SCIENTIFIQUES, ENVIRONNEMENT-QUÉBEC
SESSION 10B: ATMOSPHERIC CHEMISTRY: OZONE

15:30 **THE CURRENT STATUS OF OZONE DEPLETION AND UVB RADIATION**
W.F.J. Evans
Environmental Resource Studies, Trent University, Peterborough, Ontario, Canada

15:50 **HETEROGENEOUS O_3 LOSS IN THE STRATOSPHERIC POLAR O_3 LOSS BUDGET?**
J.C. McConnell
Department of Earth and Atmospheric Sciences, York University, North York, Ontario, Canada
G. S. Henderson
Department of Geology, University of Toronto, Toronto, Ontario, Canada

16:10 **STRATOSPHERIC POLAR OZONE DEPLETION AND IT'S IMPACT ON SURFACE UV-B RADIATION**
R.K.R. Vupputuri
Atmospheric Environment Research, Richmond Hill, Ontario, Canada

16:30 **COMPUTING DRY DEPOSITION VELOCITIES OF O_3 AND CO_2 FROM MEASUREMENTS OF THEIR VARIANCES**
Jacob Pedro
Atmospheric Environment Service, Downsview, Ontario, Canada

JEUDI / THURSDAY, 15H30-16H30 SALLE / ROOM: 2860
SESSION 10C: OCÉANOGRAPHIE DES PÊCHES: OPEN II
PRÉSIDENT / CHAIRMAN: DAVID CHECKLEY, SCRIPPS INSTITUTE OF OCEANOGRAPHY
SESSION 10C: FISHERY OCEANOGRAPHY: OPEN II

15:30 A NEW MODEL FOR PREDICTING THE NORTHERN DIVERSION RATE AND RETURN TIMING OF FRASER RIVER SOCKEYE SALMON
K.A Thomson, P.H. LeBlond, M.C. Healey
Department of Oceanography, The University of British Columbia, Vancouver, B.C., Canada
W.J. Ingraham
NOAA/Alaska Fisheries Science Center, Seattle, WA, U.S.A.
C. Groot
Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C., Canada
C.G. Healey
Department of Computer Science, University of British Columbia, Vancouver, B.C., Canada

15:50 FLOW FIELDS AND DRIFTER TRACKS ON WESTERN BANK, SCOTIAN SHELF
David Griffin
Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

16:10 VARIABILITY OF LIPID AND MORPHOMETRIC CONDITION INDICES OF INDIVIDUAL COD LARVAE (GADUS MORHUS) FORCED BY FEEDING REGIME IN THE LABORATORY
S. McClatchie, G.I. Maillet
Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada
T.J. Miller, T. Herra, W.C. Leggett
Biology Department, McGill University, Montréal, Québec, Canada
C.T. Taggart
Department of Fisheries and Oceans, NW Atlantic Fisheries Centre, St. John's, Newfoundland, Canada
K.T. Frank
Department of Fisheries and Oceans, Marine Fish Division, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

JEUDI / THURSDAY, 15H30-16H50 SALLE / ROOM: 2830
SESSION 10D: OCÉANOGRAPHIE SATELLITAIRE: ERS-1 I
PRÉSIDENT / CHAIRMAN: FRED DOBSON, BEDFORD INSTITUTE OF OCEANOGRAPHY
SESSION 10D: SATELLITE OCEANOGRAPHY: ERS-1 I

15:30 THE ERS-1 CALIBRATION-VALIDATION EXPERIMENT: AN OVERVIEW
Fred Dobson
Bedford Institute of Oceanography, Dartmouth, N.S., Canada
M. Khandekar
Atmospheric Environment Service, Downsview, Ontario, Canada
P. Vachon
Canada Centre for Remote Sensing, Ottawa, Ontario, Canada

15:50 **SPACEBORNE AND AIRBORNE SAR IMAGERY OF OCEAN WAVES FROM ERS-1 VALIDATION**
Paris W. Vachon
Canada Centre for Remote Sensing, Energy, Mines and Resources Canada, 588 Booth Street, Ottawa, Ontario, Canada
A.S. Bhogal
Intera Kenting, Nepean, Ontario, Canada

16:10 **AIRBORNE RADAR MEASUREMENTS OF OCEAN SURFACE CHARACTERISTICS DURING THE ERS-1 SAR CALIBRATION/VALIDATION EXPERIMENT**
Douglas C. Vandemark, Edward J. Walsh, John L. Ward
NASA Goddard Space Flight Center, Laboratory for Hydrospheric Processes, Wallops Flight Facility, Wallops Island, VA, U.S.A.
Calvin T. Swift, Ellen J. Martin
Microwave Remote Sensing Laboratory, University of Massachusetts, Amherst, MA, U.S.A.
Bertrand Chapron
Department of Spatial Oceanography, IFREMER Centre de Brest, Plouzane, FRANCE

16:30 **THE PERFORMANCE OF THE CANADIAN SPECTRAL OCEAN WAVE MODEL (CSOWM) DURING THE SAR "CALIBRATION/VALIDATION" EXPERIMENT**
R. Lalbeharry, M.L. Khandekar
Atmospheric Environment Service, Environment Canada, Downsview, Ontario, Canada

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VENDREDI / FRIDAY, 08H30-09H10 **SALLE / ROOM: 2880**
SESSION PLÉNIERE THÉMATIQUE EN MÉTÉOROLOGIE: LA MÉTÉOROLOGIE À LA MÉSOÉCHELLE
PRÉSIDENT / CHAIRMAN: RONALD E. STEWART, CLOUD PHYSICS RESEARCH DIVISION, AES
PLENARY THEME SESSION IN METEOROLOGY: MESOSCALE METEOROLOGY

08:30 **MESOSCALE METEOROLOGY — BEYOND WEATHER PREDICTION AND WARNINGS**
Richard A. Anthes (conférencier invité / invited speaker)
University Corporation for Atmospheric Research, Boulder, CO, U.S.A.

VENDREDI / FRIDAY, 09H10-10H30 **SALLE / ROOM: 2880**
SESSION 11A: MÉSO-MÉTÉOROLOGIE I
PRÉSIDENT / CHAIRMAN: RONALD E. STEWART, CLOUD PHYSICS RESEARCH DIVISION, AES
SESSION 11A: MESOSCALE METEOROLOGY I

09:10 **PREDICTABILITY OF PRECIPITATION PATTERNS ON THE MESOSCALE**
Isztar Zawadzki
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

09:30 **TROPOPAUSE FOLDS AND THE DEVELOPMENT OF MESOSCALE STRUCTURE IN THE POTENTIAL VORTICITY FIELD**
G.W.K. Moore
Department of Physics, University of Toronto, Toronto, Ontario, Canada

09:50 **THE INFLUENCE OF ROTATION ON MESO-SCALE VORTICES**
Peter Bartello, Olivier Métais and Marcel Lesieur
Institut de Mécanique de Grenoble, Grenoble, France

10:10 **A Numerical Study of Precipitation Type Transition Regions**
Kit Kong Szeto, Ronald E. Stewart
Atmospheric Environment Service, Downsview, Ontario, Canada

Vendredi / Friday, 08H30-09H10 **Salle / Room: 3830**
SESSION PLÉNIERE THÉMATIQUE EN OCÉANOGRAPHIE: La télédétection et la production biologique marine
Président / Chairman: Alain Vézina, Département d'Océanographie, Université du Québec à Rimouski
PLENARY THEME SESSION IN OCEANOGRAPHY: Remote sensing and marine biological production

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08:30 **Remote Sensing and Mesoscale Biological Productivity**
Trevor Platt (conférencier invité / invited speaker)
Department of Fisheries and Oceans, Biological Oceanography Division, Bedford Institute of Oceanography, Dartmouth, N.S., Canada

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Vendredi / Friday, 09H10-11H30 **Salle / Room: 3820**
SESSION 11C: Océanographie biologique
Président / Chairman: Alain Vézina, Département d'Océanographie, Université du Québec à Rimouski
SESSION 11C: Biological oceanography

09:10 **Large Scale Ecological Patterns: Discontinuous Distribution of Marine Benthic Epifauna**
Pedro-Luis Ardisson
Institut Maurice-Lamontagne, Pêches et Océans Canada, 850, route de la Mer, C.P. 1000, Mont-Joli, Québec, Canada
E. Bourget
Département de biologie, Université Laval, Sainte-Foy, Québec, Canada

09:30 **Influence de l'hétérogénéité du substrat sur le taux de fixation des larves d'invertébrés benthiques**
Michel Harvey, E. Bourget
Département de biologie, Université Laval, Sainte-Foy, Québec, Canada
G. Ingram
Dept. of Atmospheric and Oceanic Sciences, McGill University, Montreal, Québec, Canada

09:50 **Variations du potentiel de croissance de *Mya arenaria* dans l'étage intertidal de l'estuaire maritime du Saint-Laurent**
J. Pellerin-Massicotte, L. Bourassa, B. Vincent, A. Dagnault
Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada

10:10 **Temporal Variations in the Taxonomy and Ecology of Nanoplankton in a Temperate Canadian Fjord**
P.J. Smith, Louis A. Hobson
Department of Biology, University of Victoria, Victoria, B.C., Canada

10H30-10H50 PAUSE-CAFÉ / COFFEE BREAK

10:50 **EVIDENCE FOR STRONG COUPLING BETWEEN CALANUS PRODUCTIVITY AND LARVAL REDFISH (SEBASTES SPP.) DISTRIBUTION IN THE NORTHERN GULF OF ST.LAWRENCE**

Runge, J.A. and Y. de Lafontaine
Institut Maurice Lamontagne, Fisheries and Oceans, Mont-Joli, Québec, Canada

11:10 **EFFECTS OF SALINITY AND SURFACE TENSION ON MICROBUBBLE-MEDIATED SEA-TO-AIR TRANSFER OF SURFACTANTS**

Ruo-Shan Tseng
Department of Marine Resources, National Sun Yat-Sen University, Kaohsiung, Taiwan, R.O.C.
John W. Brown and Richard A. Skop
Division of Applied Marine Physics, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, U.S.A.

VENDREDI / FRIDAY, 09H10-10H30 **SALLE / ROOM: 3830**
SESSION 11D: OCÉANOGRAPHIE SATELLITAIRE: ERS-1 II
PRÉSIDENT / CHAIRMAN: PARIS VACHON, CANADA CENTRE FOR REMOTE SENSING
SESSION 11D: SATELLITE OCEANOGRAPHY: ERS-1 II

09:10 **A PRELIMINARY EVALUATION OF THE ERS-1 SAR SPECTRA USING THE 1G (FIRST GENERATION) AND THE 3G (THIRD GENERATION) VERSION OF A SPECTRAL OCEAN WAVE MODEL**

M.L. Khandekar, R. Lalbeharry
Atmospheric Environment Service, Environment Canada, Downsview, Ontario, Canada

09:30 **RADAR-DETERMINED DIRECTIONAL SEA-SURFACE SPECTRA DURING THE ERS-Q CAL/VAL EXPERIMENT**

Joseph R. Buckley, M. Allingham
Department of Physics, Royal Roads Military College, FMO Victoria, B.C., Canada

09:50 **WIND STRESS AND SEA STATE IN THE ERS-1 CALVAL EXPERIMENT**

Stuart D. Smith, Fred W. Dobson, Robert J. Anderson
Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, N.S., Canada

10:10 **A SYSTEM FOR MEASURING WIND STRESS AT SEA**

Robert J. Anderson, Stuart D. Smith, Fred W. Dobson
Dept. of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

10H30-10H50 PAUSE-CAFÉ / COFFEE BREAK

VENDREDI / FRIDAY, 10H50-12H10 SALLE / ROOM: 2830
SESSION 12A: MÉSO-MÉTÉOROLOGIE II
PRÉSIDENT / CHAIRMAN: DOUW G. STEYN, ATMOSPHERIC SCIENCE PROGRAMME, UNIVERSITY OF BRITISH COLUMBIA
SESSION 12A: MESOSCALE METEOROLOGY II

10:50 MODELLING OF GAP WINDS IN HOWE SOUND, BRITISH COLUMBIA
Peter L. Jackson
Department of Geography, The University of Western Ontario, London, Ontario, Canada
Douw G. Steyn
Atmospheric Science Programme, The University of British Columbia, Vancouver, British Columbia, Canada

11:10 MESOSCALE BLOCKING AHEAD OF COLD FRONTS AND MOUNTAIN RIDGES
Peter Taylor, Keith Ayotte
Department of Earth and Atmospheric Science, York University, North York, Ontario, Canada

11:30 BUDGETS DE MASSE ET DE QUANTITÉ DE MOUVEMENT À L'AIDE DE RADIO-SONDAGES À HAUTE RÉSOLUTION SUR LES PYRÉNÉES (PYREX)
Robert Benoît
Recherche en prévision numérique, Environnement Canada, Dorval, Québec, Canada

11:50 THE REGIONAL EVAPORATION STUDY, PART II: PRELIMINARY MOISTURE BUDGET/EVAPORATION RESULTS
G.S. Strong
Hydrometeorological Processes Division, Atmospheric Environment Service, Environment Canada, Saskatoon, Saskatchewan, Canada

VENDREDI / FRIDAY, 10H50-12H30 SALLE / ROOM: 2840
SESSION 12B: MODÈLES CLIMATIQUES MONDIAUX I
PRÉSIDENT / CHAIRMAN: STEVEN J. LAMBERT, CANADIAN CLIMATE CENTRE
SESSION 12B: GLOBAL CLIMATE MODELS I

10:50 LES SCÉNARIOS CLIMATIQUES
Jean-Pierre Blanchet (conférencier invité / invited speaker)
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

11:30 CLIMATE CENTRE GCM: SENSITIVITY TO THE REPRESENTATION OF MOIST CONVECTION
N.A. McFarlane and G.J. Zhang
Canadian Climate Centre, Downsview, Ontario, Canada

11:50 CLOUD RADIATIVE FORCING AT THE TOP AND BOTTOM OF THE ATMOSPHERE: A COMPARISON OF THE AES-CCC GCM WITH ERBE SATELLITE MEASUREMENTS
Howard Barker, Zhanqiug Li
Canadian Climate Centre, Downsview, Ontario, Canada

12:10 A MASS-CONSERVING SEMI-LAGRANGIAN NUMERICAL TRANSPORT SCHEME
André Plante, René Laprise
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

VENDREDI / FRIDAY, 10H50-12H30 SALLE / ROOM: 3830
SESSION 12D: MERS INTÉRIEURES ET SEMI-FERMÉES
PRÉSIDENT / CHAIRMAN: T. S. MURTY, INSTITUTE OF OCEAN SCIENCES, FISHERIES AND OCEANS CANADA
SESSION 12D: INLAND AND SEMI-ENCLOSED SEAS

10:50 **THREE-DIMENSIONAL DIAGNOSTIC MODELLING OF THE DENSITY-DRIVEN CIRCULATION IN THE GULF OF ST. LAWRENCE**
C. Toro
Department of Oceanography, Université du Québec à Rimouski, Rimouski, Québec, Canada
V.G. Koutitonsky
Institut National de la Recherche Scientifique (INRS), Océanologie, Rimouski, Québec, Canada
R.E. Wilson
Marine Sciences Research Center (SUNY), Stony Brook, N.Y. U.S.A.

11:10 **VARIABILITÉ INTERANNUELLE ET INTRASAISONNIÈRE DE LA COUVERTURE DE GLACE DANS LE GOLFE DU SAINT-LAURENT, 1963-1990**
Francis Déry, R. Grant Ingram
Département des sciences atmosphériques et océaniques, Université McGill, Montréal, Québec, Canada
G.L. Bugden
Institut d'Océanographie de Bedford, Dartmouth, Nouvelle-Écosse, Canada

11:30 **A THREE-DIMENSIONAL HYDRODYNAMICAL MODEL OF CIRCULATION IN THE GULF OF SUEZ, EGYPT**
M. A. Rady, Mohammed I. El-Sabh
Département d'Océanographie, Université du Québec à Rimouski, Rimouski, Québec, Canada
T. S. Murty
Institute of Ocean Sciences, Fishery and Ocean Canada, Sidney, B. C., Canada

11:50 **A FINITE ELEMENT MODEL STUDY OF CIRCULATION IN THE GULF OF MAINE REGION**
D.A. Greenberg, J.W. Loder, Y. Shen
Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, N.S., Canada
D.R. Lynch
Dartmouth College, Hanover, N.H., U.S.A.
F.E. Werner
Skidaway Institute of Oceanography, Savannah, GA, U.S.A.

12:10 **MEDITERRANEAN HEAT CONTENT AND FLUXES: 1950 - PRESENT**
Bryan Marks
Dalhousie University, Halifax, Nova Scotia, Canada

12H10-13H30 DÉJEUNER / LUNCH

VENDREDI / FRIDAY, 13H30-15H10 SALLE / ROOM: 2830
SESSION 13A: MÉSO-MÉTÉOROLOGIE III
PRÉSIDENT / CHAIRMAN: ANDRÉ TREMBLAY, CLOUD PHYSICS RESEARCH DIVISION, AES
SESSION 13A: MESOSCALE METEOROLOGY III

13:30 MESOSCALE VORTICITY STRUCTURE OF AN INTENSE SQUALL LINE
Da-Lin Zhang
Department of Meteorology, McGill University, Montréal, Québec, Canada

13:50 MECHANISMS FOR THE MESOSCALE ORGANIZATION OF TROPICAL CLOUD BANDS IN GATE PHASE III
V. Balaji, G. P. Klaassen
Department of Earth and Atmospheric Science, York University, North York, Ontario, Canada
J. L. Redelsperger
Centre National de Recherches Météorologiques, Toulouse, France

14:10 A THEORY OF SQUALL LINE EVOLUTION
Kit Kong Szeto
Atmospheric Environment Service, Downsview, Ontario, Canada
Han-Ru Cho
Department of Physics, University of Toronto, Toronto, Ontario, Canada

14:30 NUMERICAL SIMULATION OF A HELICAL VORTEX
L. Deng and D.K. Lilly
School of Meteorology, University of Oklahoma, Norman, Oklahoma, OK, U.S.A.

14:50 THE THUNDERSTORMS OF 8 JULY 1989 IN THE NORTHERN GREAT PLAINS
Alexander H. Paul
Department of Geography, University of Regina, Regina, Sask., Canada
Dan E. Blair
Department of Geography, University of Winnipeg, Winnipeg, Manitoba, R3B 2E9

VENDREDI / FRIDAY, 13H30-15H10 SALLE / ROOM: 2840
SESSION 13B: MODÈLES CLIMATIQUES RÉGIONAUX
PRÉSIDENT / CHAIRMAN: RENÉ LAPRISE, DÉPARTEMENT DE PHYSIQUE, UNIVERSITÉ DU QUÉBEC À MONTRÉAL
SESSION 13B: REGIONAL CLIMATE MODELS

13:30 REGIONAL CLIMATE MODELING
Filippo Giorgi (conférencier invité / invited speaker)
National Center for Atmospheric Research, Boulder, CO, USA

14:10 SIMULATION OF REGIONAL CLIMATE OVER EUROPE USING THE LIMITED AREA MODEL OF THE GERMAN WEATHER SERVICE
Alexander Cress, Detlev Majewski, Ralf Podzun, Volker Renner
German Weather Service, Deutscher Wetterdienst, Offenbach, Germany

14:30 ON THE INTERPRETATION OF REGIONAL CLIMATE CHANGE SCENARIOS GENERATED BY GCMS
Diana L. Verseghy
Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ontario, Canada

14:50 **MESOSCALE MODELLING OF THE ATMOSPHERE WITH A VARIABLE-RESOLUTION GLOBAL MODEL**

Sylvie Gravel, Jean Côté, Michel Roch, Andrew Staniforth
Recherche en prévision numérique, Environnement Canada, Dorval, Québec, Canada

15H10-15H30 PAUSE-CAFÉ / COFFEE BREAK

VENDREDI / FRIDAY, 15H30-17H30 **SALLE / ROOM: 2830**
SESSION 14A: MÉTÉOROLOGIE SATELLITAIRE
PRÉSIDENT / CHAIRMAN: R. DAVIES, DEPARTMENT OF ATMOSPHERIC AND OCEANIC SCIENCES, MC GILL UNIVERSITY
SESSION 14A: SATELLITE-METEOROLOGY

15:30 **THE INFLUENCE OF HUMIDITY PROFILES DERIVED FROM GOES IMAGERY IN THE CANADIAN GLOBAL FORECAST MODEL**

Louis Garand, Jacques Hallé
Atmospheric Environment Service, Dorval, Québec, Canada

15:50 **WATER VAPOR PLUME CHARACTERISTICS ASSOCIATED WITH THE EXTREME HEAVY RAINFALL**

Wassila Thiao
Satellite Application Laboratory, WWB-601, Washington, DC, U.S.A.
Roderick A. Scofield
NOAA/NESDIS/Satellite Applications Laboratory, Washington, DC, U.S.A.

16:10 **A NEW APPROACH AT CLOUD DETECTION USING THE MULTI-ANGLE IMAGING SPECTRORADIOMETER (MISR)**

Larry Di Girolamo, R. Davies
Department of Meteorology, McGill University, Montreal, Québec, Canada

16:30 **WINDII — THE WIND IMAGING INTERFEROMETER ON THE UPPER ATMOSPHERE RESEARCH SATELLITE**

G.G. Shepherd, W.A. Gault, B.H. Solheim, C. Hersom, Y. Rochon, C. McLandress, C. Tai, D.-Y. Wang, W.E. Ward, R.H. Weins
Institute for Space and Terrestrial Science, York University, North York, Ontario, Canada
G. Thuillier
Service d'Aéronomie du CNRS, Verrières-le-Buisson, FRANCE

16:50 **WIND AND TEMPERATURE PROFILING**

Edward F. Hudson
Paramax Systems Corporation, Great Neck, New York , USA

17:10 **ANALYSE DE L'EFFET DES VARIATIONS HORIZONTALES DES PARAMÈTRES MÉTÉOROLOGIQUES SUR LA CORRECTION TROPOSPHÉRIQUE DES DISTANCES TERRE-SATELLITE**

Jean-Guy Leclerc, Abdellah El Abdi Elalaoui
Département des sciences géodésiques et de télédétection, Pavillon Casault, Université Laval, Sainte-Foy, Québec, Canada

VENDREDI / FRIDAY, 15H30-17H30 SALLE / ROOM: 2840

SESSION 14B: MODÈLES CLIMATIQUES MONDIAUX II

PRÉSIDENT / CHAIRMAN: JEAN-PIERRE BLANCHET, DÉPARTEMENT DE PHYSIQUE, UNIVERSITÉ DU QUÉBEC À MONTRÉAL

SESSION 14B: GLOBAL CLIMATE MODELS II

15:30 DIAGNOSTIQUE DE LA VAPEUR D'EAU ET DE LA NÉBULOSITÉ DANS LA STRATOSPHÈRE DU MODÈLE DE CIRCULATION GÉNÉRALE CANADIEN

Michel Bouchard et Jean-Pierre Blanchet
Département de physique, Université du Québec à Montréal, Montréal, Québec, Canada

15:50 EXAMINATION OF THE REGIONAL VALIDITY OF THE CCC GCM CLIMATE SIMULATIONS FOR THE EASTERN ARCTIC

H. Wang, J.D. Jacobs
Department of Geography, Memorial University of Newfoundland, St. John's, Newfoundland, Canada

16:10 INTRASEASONAL VARIABILITY AND THE GREENHOUSE EFFECT

Steven J. Lambert
Canadian Climate Centre, Downsview, Ontario, Canada

16:30 POTENTIAL IMPACTS OF CO_2-INDUCED CLIMATE CHANGE USING THE GISS, GFDL AND CCC SCENARIO ON CORN FIELDS IN ESSEX COUNTY REGION

C. Mitic
Department of Renewable Resources, McGill University, Macdonald Campus, Sainte-Anne-de-Bellevue, Québec, Canada
Alain A. Viau
Département des sciences géodésiques et de télédétection, Pavillon Casault, Université Laval, Sainte-Foy, Québec, Canada

16:50 A NEW METHOD OF TESTING TEMPERATURE AND PRECIPITATION PREDICTIONS FROM CLIMATE GCM'S USING THE TEMPERATURE-PRECIPITATION INDEX (TPI)

Ambury Stuart
Weather Research House, Downsview, Ontario, Canada
George A. Isaac
Cloud Physics Research Division, Atmospheric Environment Service, Downsview, Ontario, Canada

17:10 ON THE ACCURACY OF TEMPERATURE AND PRECIPITATION ESTIMATES OF THE CCC GCM IN THE MACKENZIE VALLEY AREA OF NORTHERN CANADA

Ambury Stuart
Weather Research House, Downsview, Ontario, Canada

RÉSUMÉS / ABSTRACTS

UPWELLING OVER A CANYON

Susan E. Allen
Department of Oceanography, University of British Columbia, Vancouver, British Columbia, V6T 1Z4.

The presence of a canyon cutting the continental shelf has been observed to enhance wind driven upwelling. In particular, in the vicinity of Juan de Fuca canyon at the mouth of the Strait of Juan de Fuca an eddy containing deep water (depth approx. 450 m) has been documented. We develop a linear theory for a barotropic flow over an infinitely thin canyon to illustrate the basic mechanism. The upwelling wind stress generates a growing along-shore current which avoids the finite length canyon. The shape of this current guides the onshore flow, enhancing it through the canyon. Maintenance of a high pressure area over the ridge also increases the flux required through the canyon. Strong velocities at the mouth of the canyon allow upwelling from greater depths than at other regions of the shelf break. Numerical simulations show that the linear theory has applicability to finite but narrow canyons and weakly nonlinear flow. Effects of baroclinicity will be discussed.

A SYSTEM FOR MEASURING WIND STRESS AT SEA

Robert J. Anderson, Stuart D. Smith and Fred W. Dobson
Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia B2Y 4A2

The ERS-1 Cal-Val experiment and other ongoing research require measurements of wind stress on the sea surface at particular times and locations. The inertial dissipation method has been developed over the past few years to determine wind stress from measurements of wind speed and temperature fluctuation spectra, which can be made from a mast placed at the bow of a ship for minimal flow distortion. (More direct eddy flux measurements require a slender, stabilized tower so that measured vertical wind gusts can be free of platform motion and flow distortion errors.)

The system consists mainly of commercially available components and so can be duplicated for use on other ships. A mast at the bow of CSS Hudson carries a Gill fast-response propeller anemometer and miniature thermistors at 14 m elevation. A PC-based analysis package logs time series data at pre-determined intervals, computes wind and temperature spectra, makes quality checks, applies corrections for the frequency response of the sensors and fits an $f^{-5/3}$ power law to the portion of the spectra lying in the inertial subrange. Based on similarity theory the wind stress and heat flux are computed. At present the ship must remain on station during measuring periods; interfacing to the ship's navigation system so that winds can be adjusted for ship velocity and heading will make it possible to take data with the ship underway. The software is designed to operate with only occasional checks by technicians or watchkeepers. It rejects invalid data such as cases with wind astern or insufficient wind speed, and has the capability to resume data logging and analysis following a power interruption. During the Cal-Val cruise the system functioned well on its first deployment. Ongoing development will make it capable of running with only occasional checking by technicians.

RADAR-DETERMINED DIRECTIONAL SEA-SURFACE SPECTRA DURING THE ERS-1CAL/VAL EXPERIMENT

M. Allingham and J.R. Buckley
Department of Physics, Royal Roads Military College, FMO Victoria, British Columbia V0S 1B0

A digitizing X-band marine radar system was deployed as part of the ERS-1 wave spectrum validation cruise on board CSS Hudson over the Grand Banks in November, 1991. In excess of 3000 sea surface backscatter images were collected. From this data set approximately 100 fully-resolved directional spectra have been produced.

Comparisons between these radar-derived spectra and those calculated from directional wave buoy data and other directional wave measurements show many similarities. The directionally ambiguous results of the temporal aliasing associated with a relatively slow sampling rate were largely overcome by a re-mapping based on the general dispersion relation for surface gravity waves. Investigation into the azimuthal dependence of the backscattered signal has shown that the most unbiased estimation of the directional spectrum is produced through the combination of individual spectra derived from a number of look directions.

MESOSCALE METEOROLOGY --- BEYOND WEATHER PREDICTION AND WARNINGS

Richard A. Anthes
UCAR, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307

It is indisputable that a better understanding of mesoscale atmospheric processes and the development of mesoscale observational and modeling systems are keys to improved short-term weather forecasts and warnings of severe weather. However, the importance of the mesoscale extends into far broader aspects of science and society than weather prediction and warnings.

In recent years it has become clear that human activities are causing significant changes in the composition of the atmosphere. These changes alter the radiation balance of the earth, and are expected to cause changes in the weather and climate within the lifetime of today's children that will impact societies in major ways. These impacts extend far beyond the expected mean global warming of several degrees Celsius, and many of these impacts are expected to be associated with a more active and intense hydrologic cycle. In a *hyper-hydrologic cycle*, the frequency and intensity of heavy rainfall systems, including thunderstorms, hurricanes and floods would likely increase world-wide. Paradoxically, while rainfall increases are expected in some regions, models suggest a greater frequency of droughts in others, demonstrating the need for better understanding and predictions of regional climates and hydrologic cycles.

In response to concerns about global climate change, major new interdisciplinary programs such as the International Geosphere-Biosphere Program (IGBP), the U.S. Global Change Research Program (USGCRP) and the Global Energy and Water Experiment (GEWEX) have been developed over the past few years. Although the focus of these programs have been on global issues, they contain significant components related to mesoscale weather. This is appropriate, since global climate and mesoscale weather phenomena are closely related, and progress in understanding one demands similar progress in understanding the other.

The study of climate, broadly defined, includes the study of the entire spectrum in time and space of weather --- the integration over time of individual weather events determines the climate of a region or a locality. Mesoscale weather events, determined by the interactions of the large-scale flow with smaller-scale variations in topography and surface characteristics such as land-water contrasts are significant, even dominant contributors to climate in many regions or the world. Understanding the climate of the Great Lakes, for example, would be impossible without considering mesoscale atmospheric effects and phenomena.

Similarly, it would be impossible to understand the large-scale, global climate, without taking into account mesoscale atmospheric processes. Many of the exchanges of heat, moisture, momentum and chemical trace species that determine the global physical and chemical climates occur on the mesoscale --- in the surface and boundary layers of the atmosphere, in mesoscale frontal zones, and in cloud systems that range from individual cumulus clouds to mesoscale complexes of thunderstorms.

The greatest uncertainties and limitations of global climate models arise from the treatment in the models of mesoscale physical and chemical processes, notably cloud-radiation interactions. Mesoscale weather phenomena such as hurricanes, severe thunderstorms and ice storms are not randomly occurring phenonema, but are strongly dependent upon the large-scale circulation and associated thermodynamic and moisture fields. Observational programs directed toward answering questions relevant to both the global scale and the mesoscale are needed to advance understanding in both areas. Atmospheric scientists who are specialists in mesoscale meteorology and climate stand to gain much from improved communication and collaboration with each other, and national and

international programs such as the TOGA-COARE experiment will increasingly serve the research needs of both communities.

LARGE SCALE ECOLOGICAL PATTERNS: DISCONTINUOUS DISTRIBUTION OF MARINE BENTHIC EPIFAUNA

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Spatial distribution patterns of benthic littoral fauna were studied over a 12-yr period in a large subarctic ecosystem, the Estuary and northwestern Gulf of St. Lawrence. Binary presence-absence data obtained from suspended collectors (navigation buoys) moored yearly, from May through November, were used to examine ecological affinities and spatial heterogeneity in species distribution. Analyses of species co-occurrence followed by arithmetic average clustering, conducted at large (whole system, Gulf, Estuary) and intermediate (North Shore plus Lower North Shore) spatial scales, revealed a recurrent species association (composed of 12 species among which Obelia longissima, Mytilus edulis, Balanus crenatus, Hiatella arctica, and Semibalanus balanoides) characterizing the entire Estuary-Gulf area. Frequency analyses carried out along three potential pathways of larval dispersal, made it possible to identify major spatial discontinuities in species distribution as well as the community members contributing most to them. The outstanding changes in composition and distribution of benthic species throughout the study area were highly coincident with well defined physiographical (e.g. presence of straits, islands, contour of shoreline) and hydrographical (e.g. zones of freshwater inputs, upwellings, frontal zones) features of the system, particularly along the estuarine gradient.

EVAPORATION minus PRECIPITATION FORCING OF THE NORTH ATLANTIC.

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Several numerical experiments involving long-time integrations are carried out using the Bryan-Cox Ocean General Circulation Model to investigate the variability of the Thermohaline Circulation under non-zonal steady surface forcing and realistic geometry. To this end the surface forcing fields are derived from the observed climatological data sets of Levitus (1982), Hellerman and Rosenstein (1983) and, Schmitt et al., (1989). Further, the Arctic fresh water fluxes, an important part of the hydrological cycle within the North Atlantic Deep Water formation region, are taken into account. It is found that even under present day climatology forcing the system may oscillate at decadal to interdecadal period. The oscillations appear to be advective phenomena linked to the propagation of temperature and salinity anomalies from one region of the model domain to another.

AN EXAMINATION OF THE ROLE OF TURBULENCE CLOSURE IN MODELED FLOW OVER COMPLEX TERRAIN

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Shear generated boundary layer turbulence is subject to modification as it passes over complex terrain. These modifications are due to a number of processes including rapid distortion and variations in production rates associated with streamline curvature. These processes are examined in the context of a comparison between modeling results using a number of turbulence closures. The closures range in complexity and physical completeness from very simple first order closures which assume local equilibrium of turbulence fields, to the more complex and physically complete q2l turbulence closure. The q2l closure solves equations for turbulent kinetic energy, mixing length and a symmetric matrix of second order turbulence moments. As a basis, the study uses the mixed

spectral-finite difference (MSFD) model of Beljaars et. al. (1987) in which the model equations for mean and turbulence variables are Fourier transformed in horizontal space and solved as a boundary value problem in the vertical dimension.

Model results are presented for /z0=103 to 107 (where is the length of the hill) and are discussed within the physical framework of inner and outer layer flow as defined by Jackson and Hunt (1975). The results are also compared to linear rapid distortion theory and wind tunnel studies.

BOUNDARY LAYER PROCESSES NEAR AND OVER LAKE ONTARIO

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Thermally and topographically forced circulations over Lake Ontario are studied using a two dimensional, hydrostatic mesoscale model. The model employs second order turbulence closure and has been shown to reproduce a number of observed boundary layer structures. Model runs are made over a section across Lake Ontario passing north-south through the Pickering nuclear generating station and extending into New York state. Model results are verified against MesoNet wind observations in the area surrounding Pickering. Model results showing the evolution of turbulence fields throughout a diurnal cycle are presented. These results show that diurnally forced inertial oscillations are generated as offshore parcel trajectories pass from a highly turbulent boundary layer to nearly laminar flow over the lake. These oscillations are found to propagate across the lake and are of a magnitude sufficient to significantly alter air parcel trajectories. This has importance in the context of studies involving trajectories of atmospheric releases from nearby industrial sources.

THE INFOMET PACKAGE OF SOFTWARE MODULES FOR COLLECTION, ARCHIVING AND DISPLAY OF DATA FROM THE ANIKOM SATELLITE LINK

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Following the advent of the Anikom satellite link providing real-time alpha-numeric data and raster format meterological charts, universities across Canada have begun to make use of this data in research and teaching. A number of commercial software and hardware solutions for the archiving and display of this data are available. This display describes a system of PC-based software modules that have been developed within the Canadian university community with some private sector help. They provide a low cost, effective alternative for archiving and display of the data. The software has been developed for free distribution to academic institutions across Canada. Information is presented regarding the capabilities, availability and future extensions of the software.

PRÉVISIONS DE LIGNES DE BOURRASQUES DE NEIGE À LA MÉSO-ÉCHELLE.

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Une étude comparative de cas de bourrasques de neige se développant en ligne au passage d'un front froid intense a été faite au CMQ. Il en ressort l'établissement des conditions synoptiques favorables à la formation de ces bourrasques et le développement d'une stratégie de prévision permettant d'émettre des alertes météorologiques pour ce phénomène de la méso-échelle. Le radar est mis à profit pour la détection du phénomène et la prévision à courte échéance.

Un cas particulier, soit celui du 18 janvier 1991 sur le sud-ouest du Québec, sera présenté pour illustrer les conditions synoptiques impliquées et montrer la formation et l'évolution de la ligne de grain hivernal qui en est

résultée. L'approche prévisionnelle préconisée au CMQ sera brièvement abordée.

MECHANISMS FOR THE MESOSCALE ORGANIZATION OF TROPICAL CLOUD BANDS IN GATE PHASE III

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Mesoscale cloud clusters are a frequently observed feature of the tropical atmosphere, and are responsible in large part for the observed large-scale vertical mass flux. Given that the forcing for such convection comes from widely separated scales (boundary layer motions on the scale of 1 km, and large-scale ascent on the scale of over 1000 km) the organization of low-level ascent into the 10-50 km scale associated with deep convection and cloud clusters remains an important problem. We present numerical simulations which identify the mechanism responsible for the transition in the low-level mass distribution and show that it operates even in the presence of a capping inversion at 2km, and in the absence of large scale forcing. The case study is one of several reported by LeMone and Meitin (1984) during GATE Phase III of shallow cloud bands with a horizontal periodicity in the range 15-50 km: as the convective depth in these cases was on the order of 1km or less, the predictions of the linear theory for an isolated boundary layer do not appear to hold. Based upon a numerical study of one of these cases in a non-linear non-hydrostatic model of a deep layer including the stable free troposphere, we show that mesoscale organization of shallow cloud bands can be attributed to a mechanism where the scale selection is modified by the presence of deep gravity wave modes above the cloud layer. A turning wind profile, especially one where the boundary layer mean shear is perpendicular to the shear in the lower troposphere, is shown to be particularly conducive to the operation of such a modulation, and furthermore, leads to line organization. This kind of profile is typical of the disturbed conditions of GATE Phase III, where the African Easterly Jet undergoes rotation due to a passing easterly wave trough.

BAROCLINIC INSTABILITY IN A TWO LAYER MODEL WITH PARAMETERIZED SLANTWISE CONVECTION

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A two layer primitive equation model is used to study the effect of parameterized slantwise convection on baroclinic waves. The model produces, in terms of pressure drop, an explosive cyclone. Assuming that the latent heat release by clouds is balanced by adiabatic cooling, the effect of convection is transferred from thermodynamic to continuity and momentum equations. The large scale is assumed stable to convection and where there is local instability, convection distributes the mass flux on angular momentum surfaces. Two types of clouds are considered. The deep clouds heat the atmosphere and the shallow clouds are important for the boundary layer budget of entropy. The model could realistically produce the increase in large scale vertical velocity and large scale subsidence is noted to the east of cyclone centre in the mature stage. The maximum vertical velocity is to the north of the storm-centre. The scheme heats the model atmosphere and hence brings it to a state of neutrality to slantwise convection. The shallow clouds transport low entropy tropospheric air into the boundary layer and hence are important for bringing the atmosphere to slantwise neutral state.

Diagnostic studies of the differential thermal advection and the vorticity advection pattern indicate a strong correlation between convection and large scale pressure drop. The increased differential thermal advection is related to increased frontogenetic forcing along the warm front. The model seems to have a weak dependence on the fractional cloud cover. The location of the SST anomaly relative to the storm-centre is found to be crucial to the development of the storm.

CLOUD RADIATIVE FORCING AT THE TOP AND BOTTOM OF THE ATMOSPHERE: A COMPARISON OF THE AES-CCC GCM WITH ERBE SATELLITE MEASUREMENTS

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The radiative characteristics of Earth's clouds are amongst the most difficult atmospheric variables to both model and measure. With several years of Earth Radiation Budget Experiment (ERBE) satellite data, however, it is possible to isolate the monthly averaged contribution of all clouds to net broadband radiative fluxes at the top of atmosphere (TOA). The main point of this study is to assess the treatment of clouds, moisture transport, and radiative transfer in the AES-CCC global climate model (GCM). This is achieved by comparing GCM results with ERBE inferred cloud radiative forcings at both the top and bottom (surface) of the atmosphere.

Cloud radiative forcing (CRF) is defined as the difference between net radiative fluxes in cloudless and cloudy (realized) conditions. In theory, CRF can be defined at any level within the atmosphere, but global observation is obtained by satellites and so CRF analysis has been restricted to the TOA. With the advent of methods for estimating surface absorptance in all sky conditions from satellite data, however, CRF can be easily and naturally extended to the surface. CRF at the surface and TOA are readily and systematically computed in the CCC GCM. The CCC GCM has been run with 10 years (1979-1988) of observed monthly sea-surface temperatures (PCMDI/AMIP experiment). This coincides with ERBE and ISCCP cloud datasets which span 1985-1988. Thus, using this GCM simulation to compare with observed data should provide much insight into the GCM's portrayal of clouds and radiation for much of the lower boundary condition is prescribed correctly.

THE INFLUENCE OF ROTATION ON MESOSCALE VORTICES

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Numerical simulations investigating the stability of isolated 2D coherent vortices in rotating homogeneous 3D flow are described. In a study of shear flows, Lesieur et al. (1991) found that 2D cyclones (anticyclones) with vorticity, ω_{2D} oriented parallel to the rotation axis and with central values of the order of twice the rotation rate, Ω are stabilized (destabilized) by the rotation. This result implies an asymmetric limitation to the two-dimensionalizing influence of rotation at mesoscale timescales of the order of a day.Their explanation, in terms of sheared absolute vorticity filaments, can be applied to quasi 2D homogeneous flow, where the transfer is effected by the quasi-passive straining of small-scale vorticity by the large-scale flow. A study of triply-periodic pseudo-spectral simulations of rotating turbulence 64^3 was undertaken in order to illustrate both the three-dimensionalization of initially-2D vortices as well as the emergence of 2D structures in initially-isotropic 3D turbulence. Isolated coherent 2D vortices, obtained from a 2D decay simulation, were superposed with a low-amplitude 3D perturbation, and used to initialize the first set of simulations. With $\Omega = 0$, a three-dimensionalization of all vortices was observed.

This occurred first in the small scales in conjunction with the formation of longitudinal vorticity structures with vorticity perpendicular to that of the initial quasi 2D flow. When $g2\Omega \approx [\omega_{2D}]_{rms}$, a rapid destabilization of anticyclones was observed to occur, whereas the initial 2D cyclonic vortices persisted throughout the simulation. At larger Ω , both cyclones and anticyclones remained 2D, consistent with the Taylor-Proudman theorem. A second set of simulations starting from isotropic 3D fields was initialized by allowing a random velocity field to

evolve ($\Omega = 0$) until maximum energy dissipation. When the simulation was continued with $2\Omega \approx [\omega.\Omega]_{rms} / |\Omega|$, the 3D flow was observed to organize into 2D cyclonic vortices. At larger Ω , 2D anticyclones also emerged from the initially-isotropic flow.

When considered in isolation, the effect of rotation on mesoscale vortices is clear. For quasi 2D vortices with characteristic circulation times of the order of a day, there is a complete disruption of anticyclonic eddies and an increased stability of cyclonic ones.

Lesieur, M., Yanase, S. and Métais, O., 1991, Stabilizing and destabilizing effects of a solid-body rotation on quasi-two-dimensional shear layers, Phys. Fluids}, A3, 403-407.

A 3-D SPECTRAL MIDDLE ATMOSPHERE MODEL

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An important environmental issue is the evolution of the ozone layer in the stratosphere and in particular, its response to increasing chlorine and bromine levels. In the past 1- and 2-D models have been applied to study these effects and most recently 3-D models have begun to be applied to this problem. A group from several universities, York, UT, McGill, UQAM will be forming a consortium to build a middle atmosphere model and use it as a community tool for studying the middle atmosphere chemistry and dynamics. The model will be based on a prototype currently being developed between AES and York using the CDT (Chemistry and Dynamics of the Troposphere) version of the AES CCC GCM6 model with chemistry which has been run with the top at 1 mb. The chemical module will be based on the York stratospheric spectral CTM (chemical transport model) which has recently been used with both model and objectively analysed wind fields to investigate the austral and boreal polar ozone holes. The talk will describe the current GCM and CTM and the status of the prototype and present results if available.

L'IMAGERIE DES SATELLITES-MÉTÉO NOAA POUR LA SURVEILLANCE DU COUVERT VÉGÉTAL

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L'imagerie AVHRR transmise par les satellites-météo de la série NOAA gagne en popularité avec la multiplication des études environnementales face aux changements climatiques prévisibles. Cette imagerie, d'une résolution spatiale de 1.1 km et captées quotidiennement, constitue actuellement le seul moyen d'observation globale, répétitive et continue de la biosphère.

Pour caractériser le milieu végétale on utilise généralement un indice de végétation normalisé ("NDVI") calculé à partir des deux bandes spectrales réflectives disponibles : rouge (R) et proche infrarouge (PIR). Il a été démontré que cet indice est corrélé à des paramètres de végétation tels le recouvrement, l'indice foliaire ou la biomasse.

Pour obtenir plus de définition en forêt, des méthodologies d'accentuation et de classification développées au Centre de foresterie des Laurentides (CFL) pour l'imagerie Landsat MSS et TM ont été adaptées aux données AVHRR: combinaisons linéaires de bandes spectrales, segmentations, interprétation et classification d'accentuations, etc. Les études ont surtout porté sur les bandes R et PIR; l'apport de la bande MIR-Thermique a aussi été examiné. Malgré la faible résolution de ces données (1.1 km), il est possible de distinguer globalement trois densités de résineux, les mélangés à dominance résineuse et feuillue, les feuillus, de larges pertubations (feux,

coupes), les landes boisées, la toundra et d'autres thèmes en fonction du milieu environnant.

Après une brève description des méthodologies utilisées, le potentiel de l'imagerie NOAA pour des études environnementales sera discuté. Tout en offrant une vue synoptique incomparable, elle renferme une information très valable sur le couvert végétal.

BUDGETS DE MASSE ET DE QUANTITÉ DE MOUVEMENT À L'AIDE DE RADIO-SONDAGES À HAUTE RÉSOLUTION SUR LES PYRÉNÉES (PYREX)

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Durant la phase 'terrain' de la campagne PYREX (Bougeault et al., Bull. Amer. Meteor. Soc., 71, 1990), des sites additionnels de radio-sondage furent érigés autour du massif montagneux des Pyrénés. Répartis sur deux polygones concentriques de 300 et 600 km de diamète, 11 postes ont fourni des observations en altitude à intervalle de six heures durant toutes les périodes d'observation intense (POI). Les mesures sur l'anneau interne sont à haute résolution verticale.

Cette étude vise à obtenir certaines des composantes des bilans de la masse et de la quantité de mouvement horizontale, tels que déterminés seulement à partir d'observations, i.e. sans le concours d'aucun modèle de simulation atmosphérique ni d'un schème d'assimilation de données. Les bilans sont calculés sur une couche de 15 km. En relation avec des études bi- ou tri-dimensionnelles, on choisit comme base du volume de bilan soit la ligne du transect principal PYREX (vallée d'Aure - Aïnsa), soit un rectangle recouvrant tout le massif montagneux.

Les données du flux atmosphérique sont projetées sur une grille fine de 10 km au moyen d'une technique d'interpolation spline vectorielle avec contrôle sur la divergence et le tourbillon.

Des résultats sur les POI de première priorité sont présentés et reliés avec les mesures de traînée déterminées uniquement à partir du réseau des observations en surface.

CLOUD AND OCEAN ANALYSIS OF INSAT-II DATA

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With the launch of the INSAT-II satellite in (April, May, ...) 1992, the India Meteorological Department (IMD) required an upgrading of their meteorological satellite data processing system. MacDonald Dettwiler, of Richmond B.C., and its Indian partner CMC Limited, provided a new system to process all data from INSAT-I, INSAT-II geostationary and TIROS-N polar orbiting satellites. The system provides extensive analyzed product generation including cloud and ocean analysis, and TOVS processing, as well as support for the International Satellite Cloud Climatology Program (ISCCP). The cloud and ocean analysis methods used in the system, which include approaches of the japanese, U.S., European and Indian meteorological departments, will be discussed. The system's TOVS processing, including the ITPP statistical and physical retrieval algorithms from the University of Wisconsin, and the 3I package from the Laboratoire de Météorologie Dynamique du Centre National de la Recherche Scientifique in Paris, will be outlined. The INSAT-II Meteorological Data Processing System will ensure that the India Meteorological Department can continue to support its national and international mandate to provide high-quality and timely meteorological information.

PHYSICAL PARAMETERIZATION FOR THE FUTURE CANADIAN FORECAST MODELS

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The Canadian Meteorological Centre and Recherche en Prévision Numérique currently support two operational models. The Regional Finite Element Model (RFE) is used for short-range forecasting (0-2 days) over Canada and adjacent areas, whereas the Global Spectral Model provides guidance for the longer range (up to 5 days). Improved versions of both models are being developed for future implementation on the NEC supercomputer.

The two models run operationally with basically the same physical parameterization package. They both use a relatively simple infrared and terrestrial radiation scheme, a moist convective adjustment scheme, and a large-scale condensation and diagnostic cloud parameterization. In addition, a gravity wave drag parameterization and an enhanced vertical diffusion of moisture have been implemented in the spectral model. Other modules are available as options: a Kuo-type convection scheme, an explicit liquid water scheme due to Sundqvist, and a sophisticated radiation package with fully interactive clouds.

Our objective is to select an optimal combination of the above-mentioned options, which will become the new operational physical parameterization package for both Canadian models. In order to achieve that goal, we have tested the available options on the NEC supercomputer with a high-resolution version of the RFE model. The most promising results will be presented.

L'ÉVALUATION DU POTENTIEL TORNADIQUE ET SON SUIVI AU C.M.Q. POUR LE CAS DU 27 AOÛT 1991 (MASKINONGÉ).

Henri-Paul Biron, Mario Benjamin (C.M.Q.), Richard Moffet, Guy Viau Section de la formation professionnelle, S.E.A., Centre Météorologique du Québec (CMQ), 100 Boul. Alexis-Nihon, Ville Saint-Laurent, Québec

L'évaluation du potentiel tornadique a subi récemmnent de profondes modifications au C.M.Q. (Centre Météorologique du Québec). La venue du logiciel SHARP n'est pas étrangère à ces changements. SHARP (Skew T/Hodograph Analysis and Research Program) est un logiciel, fonctionnant sur PC, qui permet de visualiser et de modifier les sondages atmosphériques. De plus, ce logiciel permet le calcul rapide de différents indices, dont ceux d'hélicité relative et d'énergie/hélicité, qui ont contribué grandement à réviser notre approche quant à l'évaluation du potentiel tornadique. La tornade qui s'est produite à Maskinongé le 27 août 1991 nous servira de véhicule pour la démonstration de cette nouvelle approche prévisionnelle de ce type de temps violent.

LA TORNADE DE MASKINONGÉ.

Henri-Paul Biron et Mario Benjamin du C.M.Q., Richard Moffet et Guy Viau section de la formation professionnelle du S.E.A., Pierre Pelletier et Guy O'bomsawin des services météorologiques du S.E.A, région du Québec et Maurice Dubé du Bureau Météorologique de Trois-Rivières.

Dans la journée du 27 août 1991 plusieurs événements violents se sont produits au Québec. La nature s'est particulièrement déchaînée dans la région de Maskinongé, où une tornade s'est produite. Cette tornade, à elle seule, aura causé jusqu'à 17 millions de dollars de dommages dans la seule municipalité de Maskinongé. Heureusement aucune perte de vie humaine n'a été déplorée lors de son passage. Selon différentes enquêtes, dont celle de Maurice Dubé (BM4 de Trois-Rivières), il s'agissait d'une tornade d'intensité F3 sur l'échelle de Fujita, ce qui est un phénomène assez rare au Québec.

Dans cette affiche nous présentons des boucles d'animation radar de l'événement, de même que des boucles d'animation satellitaire. De plus, un vidéo montrant des dommages causés par la tornade sera également présenté.

DEVELOPMENT OF A GAS CHROMATOGRAPH FOR TRACE LEVEL MEASUREMENT OF PEROXYACETYL NITRATE IN AMBIENT AIR.

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Peroxyacetyl Nitrate (PAN, CH3C(O)OONO2) is an atmospheric oxidant that plays an important role in the transport and chemistry of NOy and thus impacts significantly on tropospheric ozone. PAN is often found at very low concentrations, e.g. < 5 ppt. There is thus a need for reliable measurements of PAN with good time resolution at trace, i.e. low ppt, levels.

Here we report results of a modification of a gas chromatograph based on post-column chemical amplification. The amplification of the PAN to NO2 conversion is achieved through a CO/NOx chain reaction. For NO and CO concentrations of 3ppm and 6% respectively the instrument can yield a constant chain length of the order of ~70 which results in an improvement of the instrument detection limit. This instrument should enable ambient PAN measurement with excellent detection limits (<1 ppt), good time resolution (5 min.) and can be calibrated in the field with NO2 standards.

LES SCÉNARIOS CLIMATIQUES

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L'intérêt croissant pour les questions environnementales met en évidence la nécessité d'établir des scénarios des changements climatiques tant à l'échelle régionale qu'à l'échelle mondiale. Le climat influence plusieurs aspects de notre environnement. Suite à un réchauffement du climat, certaines régions du globe, déjà soumises à des conditions climatiques rigoureuses, se retrouveront dans une situation précaire alors que d'autres régions seront avantagées. Le réchauffement mondial moyen prévu de 2 à 4°C pour le milieu du siècle prochain représente un taux de changement inégalé dans l'histoire de la biosphère. La simulation numérique est la méthode la plus appropriée pour évaluer les conséquences physiques de l'activité humaine sur le climat. Pour atteindre ce but, la communauté scientifique internationale a mis en oeuvre des projets de modèles climatiques élaborés, nécessitant l'emploi de puissants ordinateurs et des méthodes de plus en plus sophistiquées.

La complexité du système atmosphère-océan-terre rend cette tâche très ambitieuse. Pour y arriver, il nous faudra comprendre les liens existant entre les différents processus physiques de ce système. Depuis une quinzaine d'années, le centre climatologique canadien travaille à développer des Modèles de Circulation Générale (MCG) pour étudier le climat de l'atmosphère et de la surface terrestre. Bientôt, ces modèles seront étendus pour simuler la dynamique de l'océan, la stratosphère et, éventuellement, la biosphère de façon interactive avec le climat. La recherche adresse des questions scientifiques sur notre environnement et apporte des informations importantes pour les décideurs. Ce projet ambitieux impliquera un groupe de plus en plus important de chercheur à travers le Canada.

Cette présentation fait un survol d'outils disponibles ou actuellement en développement et permettant la simulation de scénarios pouvant affecter le climat. Ces outils et le résultat de leurs simulations seront de plus en plus accessibles aux chercheurs canadiens de disciplines variées. La nécessité d'une expertise multidisciplinaire s'impose de par la nature même du problème.

KINEMATICS OF MIXING IN COASTAL WATERS

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In an attempt to visualize dispersion in shallow tidal waters, we consider regions where particle trajectories are sensitive to position. Flow separation is an example of such a region. From a kinematic point of view, these regions play a role in the general dispersion when they are coupled to a mechanism of temporary trapping. From the trapping, the particles return to the original flow but are separated from their original neighbours. Shear dispersion displays aspects of coupling between sensitivity and trapping, but the coupled combination is expected to be important elsewhere when the horizontal scale of topography is shorter than the tidal excursion. Dispersion by this means occurs with a minimum of turbulence. The poster will present a simple case illustrating the necessary elements of such dispersion.

DIAGNOSTIQUE DE LA VAPEUR D'EAU ET DE LA NÉBULOSITÉ DANS LA STRATOSPHÈRE DU MODÈLE DE CIRCULATION GÉNÉRALE CANADIEN

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La formation du "trou d'ozone" dans les régions polaires est intimement reliée à la présence de nuages (PSC) se développant dans la stratosphère polaire durant l'hiver et le début du printemps. Avec l'intensification de l'effet de serre provoquée par l'augmentation de CO_2, la troposphère se réchauffe. Par contre la stratosphère se refroidit, ce qui tend à augmenter la fréquence et la couverture des PSC, avec des conséquences probables sur la concentration de l'ozone.

L'objectif de ce projet est, dans un premier temps, d'évaluer le bilan de la vapeur d'eau dans la stratosphère tel que simulé par le MCG canadien; c'est-à-dire l'injection de vapeur d'eau, son transport vers les pôles et sa précipitation aux latitudes élevées de l'hémisphère d'hiver. La circulation de la vapeur d'eau dans la stratosphère est assez mal connue, d'où l'importance d'évaluer les résultats du MCG et de tenter d'établir des comparaisons avec les donnés observées disponibles. Par la suite, l'étude sera étendue au climat de double CO_2 de façon à déterminer si les changements de température et d'humidité favoriseront l'expansion des PSC et éventuellement la destruction de l'ozone dans les régions polaires.

SCRIBE: AN INTERACTIVE SYSTEM FOR COMPOSITION OF METEOROLOGICAL FORECASTS

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The Canadian Meteorological Centre (CMC) has developed RAPELS, a prototype plain language public forecast generation system for days 1 to 3, to produce automated forecasts at 264 Canadian stations. The initial reaction from the Regional Weather Centres evaluating it was positive, although the system needed refinements. The CMC designed the SCRIBE system based on previous expertise, to address these problems and provide to the Regions an operational system tailored to their needs to help the composition of public forecasts. The prototype version of SCRIBE has been developed with the close collaboration of the Québec Weather Centre and the Maritimes Weather Centre.

The philosophy behind SCRIBE is as follows: a set of objective weather element guidance matrices at stations or sample points, prepared centrally at CMC, transmitted and decoded at the Regional Weather Centres are edited through a user-friendly interface. Plain language bilingual public forecasts are then generated from the modified guidances.

The weather element forecasts found in the matrices are prepared at 3-hour intervals giving SCRIBE a 3-hour time resolution. Weather element matrices for forecast areas (sub-regions) are generated locally from those available at the sample points within each area. These matrices are then combined in space and time by the Space Combination System to create matrices for forecasts regions. They then are combined to produce matrices for groups of regions (super-regions). The three levels of matrices (sub-regions, regions and super-regions) are all in the same format.

The weather element matrices are pre-processed by the Concept Generator before being displayed on the interface. The Concept Generator works through a domain space of rules to generate the concepts which are the results of a semantic numerical synthesis of the weather element matrices content. The main task of this module is thus to extract from the raw data the ideas or constructs that are hidden behind the digital weather element forecasts, or the numbers in the matrices. The concepts follow standards of codification based on the normalized Backus-Naur notation form. The concepts provide a simpler way to display the content of the weather element matrices rather than displaying the raw numbers.

The concepts are displayed on the graphical interface to be modified if needed. The concepts are represented by a series of bar graphs and/or icones. They can be modified through simple actions on the mouse or through simple quickly accessed menus. The interface has to be as user-friendly as possible so that the operational forecasters can perform this editing task efficiently. The interface is bilingual and file driven so that it can be adapted to the local needs. The inputs and outputs (concepts) of the interface are all in the same format.

The modified concepts are then quality checked, before being fed to the text generator. If inconsistencies are found, the system reverts back to the interface for corrections.

The prototype version of the interface has been designed and developed by the Québec Weather Centre. The consistency check module has been developed by the Maritimes Weather Centre. Both Weather Centres looked at the grammar used in the text generator.

A complete description of SCRIBE will be presented and a demonstration of the system will also be given.

ETUDE DES CHANGEMENTS CLIMATIQUES A PARTIR DES CAROTTES DE GLACE: L'EXEMPLE DE LA CALOTTE GLACIAIRE AGASSIZ, ILE D'ELLESMERE

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Des carottages glaciologiques effectués aux calottes glaciaires Devon (île de Devon) et Agassiz (île d'Ellesmere) ont livré un long registre de données environnementales couvrant approximativement les dernières 100 000 années. La glace formée durant l'Holocène représente cependant plus de 90% de l'épaisseur totale de ces calottes glaciaires.

A Agassiz, les valeurs isotopiques moins négatives et des concentrations polliniques relativement élevées obtenus à la base de deux des carottes suggèrent que la glace la plus ancienne s'est formée au dernier interglaciaire. Ceci implique que la glace de la glaciation précédente a disparu du site durant ce même interglaciaire (stage océanique 5e?) et que la formation de la calotte actuelle s'est faite alors que le climat était encore relativement chaud. Le passage de la période interglaciaire à glaciaire est marqué par une baisse des valeurs isotopiques et des concentrations polliniques mais l'âge de cette transition est indéterminé et il est présentement difficile de faire les corrélations entre les carottes.

La transition de la période glaciaire à l'Holocène est bien définie dans la stratigraphie isotopique des carottes de glace. Les valeurs sont le plus élevé au début de l'Holocène et elles diminuent progressivement vers le présent. Ces valeurs représentent une diminution de température d'approximativement 2,5°depuis 9 500 BP jusqu'au présent. Les pourcentages des couches de fonte (calculés par tranche de 50 ans) dans les carottes ont aussi été

corrélés avec les températures d'été depuis les derniers 10 000 ans. Au début de l'Holocène le pourcentage de fonte s'élevait peut-être jusqu'à 100% alors qu'il est présentement de 3%. Le plus faible pourcentage est enregistré à environ 150 années BP et le dernier cent ans semble être le plus chaud depuis mille ans. L'analyse pollinique de cette glace holocène est en cours et devrait révéler la réponse de la végétation à ces variations climatiques.

CIRCULATION OF THE JACQUES-CARTIER STRAIT INFERRED USING DATA ASSIMILATION.

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Jacques-Cartier Strait is one of the least studied areas of the Gulf of St-Lawrence. Satellite imagery of the region reveals a band of cold water along the coast and instabilities in the western part of the strait. A suggested explanation for the presence of the cold coastal water is upwelling induced by north-easterly winds. Measurements of temperature and currents were collected as part of the COHJAC (Circulation, Oceanography and Hydrography of the Jacques-Cartier Strait) project conducted in 1986-1988 by Fisheries and Oceans.

In order to determine the circulation of the Strait, we have used the method of data assimilation. By minimizing deviations between data and the predictions of a dynamical model, this technique finds optimal values for "control variables" (e.g., upwelling rate). We will discuss results of this analysis and outline future work.

DYNAMIC TOPOGRAPHY AND SURFACE FRONTS NEAR BARBADOS, W.I.

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Dynamic topographies of the seas near Barbados, W.I. (13° 10' N, 59° 30' W) were calculated from dense arrays of CTD data (0-500 dbar) gathered during two cruises around the island in April-May 1990 and 1991. Although there were significant differences in places, geostrophic surface currents were in general agreement with integrated ADCP (RDI 150 khz) current measurements made in the same area. The geostrophic streamlines showed much meandering and eddying near the island, in contrast to historical depictions of the flow. A sudden shift to a strong southeastward flow south of Barbados during the 1990 survey suggests the approach of a large anticyclonic eddy, possibility originating in the retroflexion zone of the Brazil Current (~ 3-7 °N).

A major surface salinity front with a cross-frontal contrast of 2.0 psu, and a thickness ~15 m swept past the island during the 1991 cruise from the northeast to the southwest, overflowing the ambient waters of upper mixed layer depth 100-120 m. It is thought that the low salinity plume had its origin in the Amazon River outflow, some 2 000 km to the southeast. Comparisons are presented between near-surface ADCP current measurements across the front and geostrophic shear calculated from the density field.

A NONLINEAR MODEL OF STATIONARY PLANETARY WAVES IN THE WINTER STRATOSPHERE

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A nonlinear steady-state primitive equations model is used to study the structure of stationary planetary waves in the Northern Hemisphere stratosphere. The zonal mean circulation is specified using observed January mean data, as is the wave structure at the lower boundary of 100 hPa. Numerical solutions are then found for the structures of zonal wavenumbers 1 to 3 throughout the Northern Hemisphere stratosphere. The inclusion of wave-wave

interactions, principally between zonal wavenumbers 1 and 2, is found to result in a significantly better simulation of the observed stratospheric wave structure than that given by an otherwise identical linear model.

Experiments have been performed using data from four years, 1982-84 and 1986. The importance of the wave-wave interactions is found to vary considerably from year to year.

Forcing of the stationary planetary waves by transient eddy momentum and heat fluxes in the stratosphere will also be discussed.

TIME-DEPENDENT CONVECTIVE INSTABILITY

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The linear stability of a rotating fluid heated from below (or cooled from above) is investigated numerically. The time-dependent mean field is the analytic solution to the diffusion equation with constant heat flux boundary condition. The velocity and density fields (expressed as modal expansions in x,y,z) are linearized about this time-dependent mean field. The stability of the system is investigated by introducing a perturbation in the vertical velocity field and monitoring its evolution. When growth occurs, the integration is stopped and the Rayleigh and Taylor numbers of the convectively unstable boundary layer are calculated. For a given heat flux and rotation rate this procedure is repeated until the horizontal wave number of the fastest growing mode is determined.

It is proposed that this analysis can be used to understand some of the scales that are found in oceanic and atmospheric convection. A laboratory experiment is described that corroborates some of the numerical results.

NEAR-EQUATORIAL EDDIES OFF SOUTH AMERICA

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The near-equatorial eddies off the northeast (NE) coast of south America are associated with the convergence-divergence and mixing of several water types. Considerable variability, particularly seasonal, occurs here. In the surface layer, the North Brasilian Current (NBC) flows northwest along the coast from the southern hemisphere; it is observed to turn in part offshore, combine with the southern branch of the North Equatorial Current (NEC), and then loop south and eastward into the North Equatorial Counter Current (NECC).

The near-synoptic airborne expendable bathythermograph (AXBT) surveys by the Naval Oceanographic Office (NAVOCEANO) in this region can be used to estimate the eddy-like circulation patterns (anticyclonic) during the seasonal extremes (March and September), both in the upper mixed layer (retroflection) and the layer in the lower thermocline, where a degree of recirculation occurs in the northern (3 °N - 10 °N) and southern (2 °N - 5 °N) eddies off the coast. Other earlier surveys in this region, although not necessarily designed to study the eddy field, allow estimates of volume transport associated with the eddies to be calculated. For example, during February through March the northern eddy transport (0-400 dbar, rel. 800 dbar) is 10 to 14 X $10^6 m^3 sec^{-1}$, whereas during late summer and autumn it is 25 to 30 X 10^6 m^3 sec^{-1}, with a considerable portion of the flow supplying the NECC.

At various levels, both salinity and dissolved oxygen assist in tracing circulation patterns of this region. The relatively fresh and plankton-rich Amazon outflow advected offshore in the surface water of the northern eddy is clearly shown in a map of surface salinity or Coastal Zone Color Scanner (CZCS) imagery. The subtropical underwater salinity maximum depicts the NEC convergence with the northern eddy. Both O_2 minimum and maximum sources are useful in tracing the southern eddy where it turns offshore (below the mixed layer) near 5 °N.

DATA INTEGRATION AT THE 5 KM GRID SCALE (INTÉGRATION DE DONNÉES À L'ÉCHELLE DE 5 KM)

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Considerable skills are required in combining various types of meteorological satellite radiance measurements with site specific data on a cartesian grid. Canadian Climate Centre's GLIGRID system approach to generate 5 km by 5 km arrays is discussed. Results of experiments with algorithms to produce maps of rainfall, air temperature, near ground temperature, heat flux, crop stress index, albedo, net radiation, evapotranspiration are presented. A method to monitor lake freeze-up and break-up is also discussed.

Il faut tenir compte de bien des facteurs pour la combinaison, sur une grille cartésienne, des mesures des radiances satellitaires avec les données des sites d'observation météorologiques. On discute ici l'approche 5 km par 5 km du système GLIGRID du Centre Climatique Canadien. On présente les résultats d'expériences avec des algorithmes pour produire des cartes des chutes de pluies, des températures de l'air et celles près de la surface, du flux de chaleur spécifique, d'un index du stress des récoltes, de l'albédo, du rayonnement net et de l'évapotranspiration. On discute aussi d'une méthode pour surveiller l'embâcle et la débâcle des glaces.

WARM-CORE RINGS AND CROSS-SHELF EXCHANGE

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Satellite images suggest that a large volume of cold water was drawn from the Scotian shelf in Spring 1991, apparently by Gulf Stream warm-core rings. An interdisciplinary field program on the Scotian Shelf in late April permitted opportunistic sampling of this feature. The hydrographic observations show that the feature was at least 30 m deep and consisted of cold, fresh water that probably originated from the eastern part of the Scotian Shelf. The surface area of the entrained shelf water was in the order of 10% of the surface area of the Scotian Shelf, so it would appear that warm-core rings have a profound effect on both the biology and hydrography of the Scotian Shelf. We are currently using Haidvogel's semi-spectral primitive equation model (SPEM) to investigate the dynamics of the cross- shelf exchange due to an anti-cyclonic ring impinging on an idealised shelf and slope. Initial model runs for a shelf without a shelf/slope front result in very little exchange. The Scotian Shelf, however, has a persistent shelf/slope front and we shall present the results of model runs which include this front.

LARGE EDDY SIMULATIONS OF THE ATMOSPHERIC BOUNDARY LAYER

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Since the Monin-Obukhov similarity theory was proposed in the 1950s, numerous experimental works, appearing in the 1970s and 1980s, have been performed to verify this theory. Among them Businger et al. form of ϕ_m and ϕ_h is the most popular, but nevertheless evoked some controversies. Due to difficulties and high costs of the measurements, and variable conditions in the atmosphere, such field experiments are not conducted easily. Large eddy simulation (LES), however, leads to an alternative for verifying the Monin-Obukhov similarity theory. This work, much of which was done on an IBM workstation, explores the extent to which the atmospheric boundary layer can be modelled using a three-dimensional LES and the possible derivation (on non-empirical grounds) of a Monin-Obukhov similarity formula. An ideal geometry, flat but rough surface, horizontal lower boundary is treated, and horizontal homogeneity of all dependent mean variables is assumed except the mean pressure, which is a driving force of the whole turbulent boundary layer due to the geostrophic flow aloft. Another driving

mechanism is the sensible heat flux through the surface in the entire domain. Smagorinsky's sub-grid scale (SGS) model is adopted. The computed flow fields give explicit descriptions of those turbulent eddies resolved by the numerical mesh, and therefore give the statistical properties of the atmospheric boundary layer. Averages of velocity fields over the whole horizontal plane and time domain yield a velocity profile in the atmospheric surface layer, from which the value of

$$S=\frac{\kappa z}{u_*}\frac{\partial u}{\partial z}=\phi_m(\frac{z}{L})$$

can be derived, where κ is the von Karman constant, z the height from the surface, u_* the friction velocity and L the Monin-Obukhov length. By taking averages of second moments of resolved velocity fields we obtain profiles of resolved velocity variances, resolved shear stresses and resolved sensible heat flux in the atmospheric boundary layer. If the neutral case is simulated, an Ekman spiral and correspondent shear stress profile are clearly shown in the whole boundary layer, and a logarithmic velocity profile is found in the surface layer. For the slight unstable cases, our simulations show a linear profile of the sensible heat flux in the boundary layer and yield some values of ϕ_m for $\zeta = z / L$ from -1.5 to -0.2. These values of ϕ_m are generally smaller than those obtained from observations but they have the same trends. Because of computational limitation, relatively small grid numbers were used, in this case, 16 x 16 x 52 and 24 x 24 x 52. It is expected that with a finer mesh values of ϕ_m closer to the measurement values would be derived from LES.

MODÉLISATION NUMÉRIQUE TRI-DIMENSIONNELLE DE LA CIRCULATION DE L'ESTUAIRE DU SAINT-LAURENT: RÉSULTATS PRÉLIMINAIRES

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Un modèle tri-dimensionnel, semi-implicite et aux différences finies, est utilisé pour la modélisation de la marée et des courants dans l'estuaire du Saint-Laurent. La grille du modèle s'étend du milieu de l'Ile d'Orléans jusqu'à 40 km en aval de Pointe-des-Monts, avec une maille de 2 km par 2 km. L'élévation de la surface est obtenue par itérations successives dans lesquelles la contribution des éléments hors-grille, relativement au point de solution, est augmentée. La formulation semi-implicite permet un pas de temps de l'ordre de dix minutes. Le frottement sur le fond est de type Chezy. La viscosité turbulente verticale dépend du cisaillement des vitesses et du nombre de Richardson dans les cas baroclinques. Les marées modélisées sont en excellent accord avec les observations. Un champ de particules est suivi dans son déplacement.

FISHERIES OCEANOGRAPHY IN RELATION TO MESOSCALE METEOROLOGY

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Fish recruitment, distribution, and evolution are each affected by mesoscale motions of the atmosphere, especially extratropical cyclones. Here, I discuss such effects by first considering the case of a pelagic-spawning fish and its relation to mid-latitude cyclones and a western boundary current. I then consider the cumulative effects of cyclones and their interannual variation due to long-term weather patterns.

The Atlantic menhaden, *Brevoortia tyrannus*, was studied during the Genesis of Atlantic Lows Experiment, GALE. A cycle of NE (pre-cyclone), SW (cyclone), and NW (cold air outbreak) winds occurs on average every 2-14 days in winter off the mid-Atlantic coast of the US. This cycle causes upwelling at the NW wall of the Gulf Stream and shoreward movement of surface water, due to the combined effects of wind stress and heat flux. Menhaden appear to spawn in this shoreward, eutrophic surface flow, thereby maximizing larva growth, survival, and transport towards estuarine nurseries. While cyclone passage has a short-term deleterious effect on menhaden larva growth and condition, the long-term effects of this weather cycle can be beneficial, and it is the balance of these effects which appears critical to recruitment and evolution. Our results with Atlantic menhaden are consistent with an emerging paradigm which states that fish benefit from mesoscale disturbances of a certain frequency and type. Additional examples are cited, including the northern anchovy (*Engraulis mordax*) in an upwelling region and cod (*Gadus morhua*) in the NW Atlantic.

Interannual variation of the frequency, intensity, and trajectory of extratropical cyclones may have important, cumulative effects on fish and the associated food web. For example, if during strong El Nino years east coast cyclogenesis and heat flux are reduced, recruitment of fish such as the Atlantic menhaden may be lessened. Similar interannual effects are plausible for other fish.

Significant improvement to our understanding of the relation of fisheries oceanography to mesoscale meteorology has certain requisites. First, the design of observations, experiments, and models must fully include air and sea components. Second, biological, chemical, and physical measurements must be commensurate in time and space scales.

INVESTIGATING THE RELATIONSHIPS BETWEEN MESOSCALE METEOROLOGY AND CHEMICAL OCEANOGRAPHY: PROBLEMS, PROMISE AND A SUGGESTED PLAN OF ATTACK

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It is easy to make the case from existing data, that mesoscale processes have an important effect on marine geochemical cycles. For example, the nitrous oxide flux from the ocean to the atmosphere may be strongly influenced by mesoscale processes, and coastal upwelling ecosystems are strongly influenced by the mesoscale nutrient field.

In some cases, sufficient data exist to derive correlations between mesoscale chemical distributions and meteorological forcing, but existing data make it difficult to go much further. This is because the observational base does not adequately describe chemical fields over mesoscale time and space scales. Examples of some of the typical problems are provided by studies of Monterey Bay.

Our ability to collect chemical data is improving and devices under development such as self-tending mapping systems, pumping systems and in situ analysis systems will help to alleviate the sampling problem in the near future. Progress is lagging, however, in at least two areas 1) developing quasi-real-time data assimilating systems and 2) breaking down institutional barriers to the truly interdisciplinary suite of activities that are needed to make progress.

The biological and chemical effects of poleward waves in the atmospheric marine boundary layer found above eastern boundary upwelling regions represents a research area that is at the point where it might be profitably attacked in a truly interdisciplinary way. The reversals of upwelling winds associated with these waves should have significant biological and chemical effects. In addition, adding biological and chemical observations to the physical observations may help to resolve the orientation and strength of the cross isobath circulation, a problem that physical oceanographers have found to be particularly vexing.

THE CLIMATE AND ITS IMPACTS

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The Intergovernmental Panel on Climate Change (IPCC) recently concluded that increasing concentrations of carbon dioxide and other trace gases would result in an increase in global average temperature. Moderate warming scenarios would exceed all known temperatures in the historic record, during which modern systems of resource development and management have been designed and implemented. Arid and semi-arid regions, natural terrestrial ecosystems and coastal zones are particularly vulnerable. What would the impacts of these scenarios be for specific regions? How do we use information from impacts models and analyses of historical events in assessing possible future impacts of climatic variability and change?

Regional impact assessments could provide valuable linkage between regional concerns and global warming science, enable the establishment of assessment frameworks which could integrate information from many sources, and facilitate the development of new partnerships between disciplines, jurisdictions and nations. However, the research challenge is considerable. A survey of case studies by the IPCC concluded that our knowledge base is limited and further research is needed on a wide range of issues. As part of the Government of Canada's Green Plan, the Global Warming Science Program includes studies of regional impacts of global warming scenarios in the Mackenzie Basin, Prairies and the Great Lakes - St. Lawrence Basin.

INTERPRETING NOAA-9 SEA-SURFACE TEMPERATURE RETRIEVALS WITH IN SITU AND METEOROLOGICAL DATA

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Sequences of daily NOAA-9 AVHRR sea-surface temperatures retrievals (SST) are interpreted jointly with in situ and meteorological data. The analysis is part of the COHJAC project (Circulation, Oceanography and Hydrography of the Jacques-Cartier Strait). The studied area is centered at the Jacques-Cartier Strait, north of Anticosti Island in the Gulf of St-Lawrence (Latitude: ≈ 50°, Longitude: ≈ -64°). The objective of the project is to study the dynamics of the circulation and mixing processes in relation to fresh water run-off, local wind stress and large scale meteorological forcing. A large scale CTD (conductivity - temperature - depth) ship sampling program (1986-87-88) has provided accurate (for point samples) time series temperature measurements as a function of depth in the water column. Infrared AVHRR data have provided SST maps for the same region. This work focus in one of the remote sensing aspect of the COHJAC program: pair ship/satellite observations, with contemporaneous defined as location within 2 km and time within 6 hrs., the Lowtran atmospheric transmittance/radiance model together with radiosonde and wind data have been used to evaluate present AVHRR atmospheric correction algorithms and their dependence on atmospheric conditions. Our work shows that the total amount and vertical distribution of water vapor, sea surface wind and atmospheric aerosols are parameters to be considered for an accurate determination of SST in a coastal environment such as the Jacques-Cartier strait. For example, for a constant atmospheric water vapor content (1 to 2 g cm-2), an increase in wind speed from 2 to 7 m sec-1 gives a temperature difference of about 3 deg. C. Furthermore, SST retrievals for this region show that the atmospheric correction algorithm is very sensitive to the water-air temperature difference. The work by the COHJAC group represents the first step in the analysis and integration of the AVHRR data with the oceanographic and meteorological information present available for the Gulf region. These results are also useful in the development of suitable atmospheric correction algorithms in coastal zones for the ATSR in ERS-1.

NUMERICAL MODELLING OF THE CIRCULATION AND LARVAE DRIFT IN THE ANSE-À-L'ORIGNAL BAY.

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A two dimensional numerical model, which allows for the periodic flooding of tidal flats, was developed for Anse-à-l'Orignal, a small bay along the St. Lawrence Estuary. The model was calibrated with water level and current observations. Results of model simulations, illustrating the main features of the circulation and the different transport mechanisms, are presented. The tidal residual circulation is shown to be the main transport mechanism. Particle drift simulations show results in good accord with observed larvae distributions in the bay.

SPREAD OF OIL FROM THE TENYO MARU, JULY 1991

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We provide background oceanography, and observations and hindcast simulations of spreading oil leaked from the wreck of the *Tenyo Maru*, a fishing vessel that sank off the western entrance to Juan de Fuca Strait in July 1991. The vessel sank in the region of the Tully Eddy on the continental shelf. Although this eddy is normally present in summer, its location shifts and its "trapping time" varies considerably. The drift of the *Tenyo Maru* oil is represented reasonably well by assuming the eddy to be 5 km east of its position as observed during drifter studies in 1986. Observations in 1985 showed that the preferred exit route of surface water from the eddy is toward the southeast, the direction followed by the *Tenyo Maru* oil in 1991, however, other drift paths are possible, and under different weather conditions the oil have drifted toward the Vancouver Island coast.

SIMULATION OF REGIONAL CLIMATE OVER EUROPE USING THE LIMITED AREA MODEL OF THE GERMAN WEATHER SERVICE

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Global climate models are widely used to simulate the large scale features of past and present day climate as well as possible future climate changes. However, due to their low resolutions they are not able to reproduce adequately regional scale forcing like highly structured topography, large water bodies, complex coastlines, which strongly influence the regional climate over complex areas like Europe.

Therefore, the Europa-Modell, a regional weather forecast model developed at the German Weather Service (MAJEWSKI, 1991), is employed to simulate the regional distribution of climate variables like temperature or precipitation in more detail. The model has 20 vertical layers and a horizontal resolution of $\Delta\phi = \Delta\lambda = 0.5°$ in a transformed latitude-longitude grid. Two different areas are being used in our simulations, covering most of Europe and either a small or a large part of the North Atlantic.

The aim of the project is the regionalization of global climate scenarios. In a first step the model is used to simulate present day climate driven by either, global ECMWF T106 analyses or fields from the Hamburg global model ECHAM (Roeckner et al., 1989). The dependence of simulated regional climate upon model domain, resolution of the driving fields and model physics will be investigated.

So far, some January and July experiments have been conducted. When driven by sequences of global analyses, the model reproduces the monthly mean atmospheric fields and their mean time variability rather closely, i.e. it does not drift away from the observed atmosphere. As far as near surface weather elements are concerned, their distribution compares well with corresponding climatic fields.

Considering the results from experiments with the ECHAM as the driving model, we find that despite the coarse resolution of the global model (T21 or T42), the regional model is able to take advantage of its own detailed representation of topography and land-sea distribution and produces realistic mean fields of near surface climate elements.

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MODELLING OF TWO--LAYER STRATIFIED FLOW UNDER A TWO--DIMENSIONAL OBSTACLE

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Laboratory measurements are presented of the interface displacement generated by the flow of a two--layer fluid under a two--dimensional obstacle representing an idealized ice keel. Results are obtained for a family of Witch of Agnesi obstacles of fixed height and increasing slenderness ratio over a Froude number range from sub--critical to super--critical. A detailed comparison is made of the experimental data with simulations from two numerical models. The first model is the SOLA--VOF code of Jameel et. al. (1992), based on the Marker and Cell finite difference technique for the Euler equations. The second model is a new one formulated in terms of vorticity and stream function. Good agreement is obtained between the laboratory measurements and the modelled interface displacements and obstacle forces. The superior performance of the new model encourages application to the continuously stratified fluid case which is more difficult to implement in the laboratory.

SPECTRAL CHARACTERISTICS OF KALMAN FILTER SYSTEMS FOR ATMOSPHERIC DATA ASSIMILATION

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In recent years, there has been increasing interest in the application of Kalman filter systems to atmospheric data assimilation. One important aspect of any data assimilation system is its filtering properties. This is examined by spectral decomposition of a simple one-dimensional Kalman filter system. It was found that with certain assumptions, the complete space and time behaviour of the forecast and analysis error covariances could be explicitly determined from the model and observation error covariances and the initial forecast error covariance. The resulting solutions could then be examined by elementary dynamic systems analysis. The multivariate, inviscid, dissipative, unstable mode and non-stochastic cases were analyzed. The stationary solutions and convergence properties were found and certain unstable, periodic and quasi-periodic solutions were discussed.

NUMERICAL SIMULATION OF A HELICAL VORTEX

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A tornado-like vortex generated from a helical inflow without azimuthal mean angular momentum is simulated with a three dimensional numerical model in an invert T-shaped cylindrical domain. A uniform cyclonic vortex core is obtained, although the inflow is nonaxisymmetric. This study emphasizes the generation of surface vertical vorticity from the shear flow. The tilting mechanism is checked by imposing a helical inflow with a vertically varying angular momentum into a two dimensional model. It is found that the tilting does not control the surface vortex formation since the produced vortex is of the wrong sign. Budget analysis of the mean angular momentum from a three dimensional numerical model shows that after a transition period positive mean angular momentum is produced in the lower part of the acceleration region while negative angular momentum is produced in the upper part. A cyclonic vortex is formed by transporting the lower positive angular momentum inward and upward in the mean streamwise direction.

Simulation results agree well with the experiments and analysis (Rothfusz, 1986, Rothfusz and Lilly, 1989). The comparison study with two model parameters, vertical shear angle and the Reynolds number, is carried and discussed. And how the vorticity gets to the ground with a freeslip boundary condition is also explained.

VARIABILITÉ INTERANNUELLE ET INTRASAISONNIÈRE DE LA COUVERTURE DE GLACE DANS LE GOLFE DU SAINT-LAURENT, 1963-1990

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Les meilleurs estimés hebdomadaires de la couverture de glace provenant des cartes d'observations de glaces ont été reportés sur une grille de 83 points recouvrant le Golfe du Saint-Laurent pour l'ensemble de la période 1963-1990. Nous avons examiné leur variabilités intrasaisonnière et interannuelle dans l'ensemble du golfe et sur le détail de six sous-divisions distinctes. Les relations avec le débit des rivières, les profiles de température et de salinité et le forçage atmosphérique au-delà de l'échelle synoptique sont analysés pour établir les causes de la variabilité. La principale découverte est la tendance à l'accroissement de la couverture glacielle en dépit du réchauffement des eaux de la couche profonde du golfe durant la période étudiée. Ceci est attribué à la variabilité d'échelle décennialle reliée au forçage fluvial et aux événements océaniques de l'Atlantique Nord subarctique. Le cycle principale se situe autour de 13 à 15 ans pour l'ensemble de la région et domine particulièrement dans les parties profondes du golfe. D'autres oscillations autour de 5.5 à 6 ans, de 3.6 à 4 ans et de 2.5 ans sont importantes dans l'embouchure fluviale et dans la partie sud-ouest du golfe.

A NEW APPROACH AT CLOUD DETECTION USING THE MULTI-ANGLE IMAGING SPECTRORADIOMETER (MISR)

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The Multi-angle Imaging SpectroRadiometer (MISR), scheduled on the first platform of the Earth Observing System, has a unique capability of combining a variety of cloud detection techniques, including visible/near-infrared thresholding and discrimination, stereo, and angular signatures, which are combined to detect and classify all cloud types. Focus has been placed on improving thin cirrus cloud detection because of the ongoing difficulties in detecting these clouds using conventional satellite cloud algorithms as well as their important role in the Earth's

climate system as stressed in recent literature.

Radiative transfer simulations, using LOWTRAN 7 coupled with an ocean surface model, have been made showing that current schemes for the global detection of thin cirrus can be greatly improved upon by utilizing the *band-differenced angular signature* of the target area. This new scheme takes the difference between two solar spectral bands as a function of view angle. The resulting angular signature, based on the different Rayleigh scattering contributions from the clear sky component, is used to discriminate between low-level and high-level clouds, as well as surface reflectance anomalies. Cirrus clouds of visible optical thickness greater than 0.5 can be detected without any assumptions or *a priori* knowledge of atmospheric conditions. Such knowledge with further modelling can reduce the minimum detectable cloud optical thickness by about an order of magnitude.

AN OPERATIONAL EVALUATION OF REMOTE ENVIRONMENTAL AUTOMATIC DATA ACQUISITION CONCEPT (READAC) AUTOMATIC STATIONS TO DETECT MESOSCALE WEATHER EVENTS THAT ARE IMPORTANT TO AVIATION INTERESTS.

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Two READAC stations were placed in an operational setting, at existing weather observing sites in central Ontario, in the summer of 1990. The stations were equipped with their full suite of observing sensors, except for the icing occurrence sensor, in October 1990. The observations from the READAC stations were evaluated for a combined total of 15 months.

The observations provided by the READAC systems were compared with the manually prepared reports from the same sites for completeness, as well as quantitatively for values reported by the various sensor systems.

The ability of users to infer weather phenomena, such as fog, not reported by the READAC systems, the losses and gains resulting from automation of weather observing, and the importance of REMARKS in the manually produced observations describing the weather situation were also evaluated. Finally the impact of using the weather information from these AUTO systems to evaluate and forecast the weather during the test period are discussed.

THE ERS-1 CALIBRATION-VALIDATION EXPERIMENT: AN OVERVIEW

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The ERS-1 Calibration-Validation Experiment was carried out on the Grand Banks of Newfoundland (Virgin Rocks area) from November 10-27, 1991. It was organized primarily to provide in situ, aircraft and numerical forecast model validation of the Synthetic Aperture Radar (SAR) on the "ERS-1" satellite launched by the European Space Agency in July 1991. Other goals included the open-ocean determination of the relation between the wind stress and the sea state, validation of the algorithms used to invert SAR images and assimilate them in numerical wave models, testing of the wave-imaging capabilities of shipboard marine radars, intercalibration of the meteorological sensors on buoys and ships, and the relation of SAR image features to near-surface currents in the ocean.

To achieve these goals a sharply focussed cooperative experiment was organized and carried out. The ERS-1 "Commisioning phase" orbit produced a "crossover node" on the Grand Banks of SAR swaths from descending and ascending passes within 11 hours of each other every 3 days. An array of two ships: CSS "Hudson" and the Soviet RV "Georgi Ushakov", four meteorological buoys and three wave buoys, all deployed at grid points of the AES "CSOWM" operational wave forecast model, were overflown at ERS-1 overpass times by two aircraft: the CCRS CV-580 with C-band SAR and the NASA P-3 with Radar Ocean Wave Spectrometer or Surface Contour Radar and

Radar Altimeter. The crossover node lay within the swath of a high-frequency radar at Cape Race, which provided winds and waves at overpass times on a 1-km grid. On Hudson were a bow-mounted wind stress measurement system, two x-band marine radars, and an acoustic Doppler current profiler (ADCP). On the Ushakov, at the site from November 19-21, were a radiosonde system and standard meteorological sensors.

During the experiment an extensive data set was collected over a moderate range of winds and sea states. The CV-580 underflew ERS-1 seven times, and the P-3 four times. The wind stress package gathered data in conjunction with both the meteorological buoys and with the meteorological sensors of the two ships. Two meteorological buoys deployed by AES gave complete time series of winds, pressures, air and sea temperatures and waves. The two meteorological buoys and three wave buoys (two directional, one wave height only) deployed by Hudson gave partial time series. The ADCP on Hudson was used during non-daylight hours to make transects of the ocean current profiles in the crossover area.

This session will begin to address the questions implied in the stated goals of the experiment. It will provide a forum for the thoughts of the participants at a time when the initial screening has been carried out on the data sets but before final conclusions have been reached.

DOPPLER INTERPRETATION OF A CONTINENTAL WINTER STORM

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On January 14, 1992, a 974 mb low produced a succession of rain, freezing rain, snow, thunder and blizzard conditions in Southern Ontario. The low centre and fronts passed within the coverage of the King Doppler radar, and provided a unique opportunity to study the mesoscale flow patterns in a strong continental winter storm. Doppler data show the complicated flow in the area immediately north of the low pressure centre.

ASSIMILATION OF ACOUSTIC DOPPLER CURRENT PROFILER (ADCP) DATA INTO A TIDAL MODEL USING THE ADJOINT METHOD.

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The adjoint method for data assimilation is used to combine ADCP data with a tidal model of the Western Bank region of the Scotian Shelf. Our purpose is twofold: i) to show that data from a moving observational platform (a ship-borne ADCP) can be readily assimilated into a numerical tidal model and, ii) to demonstrate how the adjoint method can be used to estimate the amplitude and phase of the various tidal constituents at the open boundaries from the data. In this manner the relevant tidal information is extracted from the ADCP data and optimal estimates for the velocity and sea-level over the entire model domain are obtained.

CARBON MONOXIDE AND METHANE MEASUREMENTS FROM SPACE

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It now appears to be possible to measure tropospheric constituents from space. However the exact nature of the measurements and their limitations is still the subject of active research. This subject is extremely important from the perspective of the Earth Observing System satellites which are intended to carry instruments to sound the troposphere.

The Measurements Of Pollution In The Troposphere (MOPITT) instrument team have been examining the potential

for carbon monoxide and methane measurements from space using correlation spectroscopy techniques. This paper will discuss the potential for such measurements to an accuracy of 10% for carbon monoxide and 1% for methane. The problems of interpretation and calibration will also be addressed.

GEOSTROPHIC SCATTER PLOTS AND THE APPLICATION OF QUASI-GEOSTROPHIC FREE MODE THEORY TO A NORTHEAST PACIFIC BLOCKING EVENT

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A time series of scatter diagrams of geostrophic stream-function, Ψ, versus quasi-geostrophic potential vorticity, q, is derived on isobaric surfaces in the mid-troposphere during an episode of Northeast Pacific blocking in January and February 1989. The use of the diagrams as a diagnostic tool together with conventional isobaric charts has been previously employed by Butchart et al. (1989) for a Northeast Atlantic block. This is the first known application of this technique to a Northeast Pacific block.

Visual inspection of the diagrams suggests that blocking can be modelled by localized free mode solutions of the governing equations, characterized by potential vorticity and stream-function of the form $q = q(\Psi)$. We are able to quantitatively detect free mode tendencies of this block using an equation due to Read et al. (1986) that relates the area of scatter plots to the departure of a stationary system from any free-mode of the quasi-geostrophic equations. The $q(\Psi)$ plot area is equivalent to the net geostrophic flux of vorticity across the boundary of the blocking region. We have computed both these quantities, and our results are in very good agreement with the theory.

We suggest that the block approaches two different free modes during its lifetime. The first and longest stage is the familiar Omega-block, which persists during the first two weeks of February 1989. During the second stage, between February 18 and 22, the 500 mb stream-function displays a dipolar form, and the scatter plots are quite similar to $q(\Psi)$ plots for a geostationary, equivalent barotropic modon in a westerly flow. We examine the applicability of the modon free mode in modelling the block by using the slopes of least-squares-fit $q(\Psi)$ lines to formally compute a modon radius. This is found to correspond closely to the actual block dimensions, for the period in which the block has a dipolar structure. An application of Arnold's theorem suggests that a sufficient condition for Liapunov stability is more likely to be satisfied by the Omega-block, than by the dipole form of the block. This may help to explain why the Omega-block lasts longer than the dipole block.

The initial formation of the block coincides with the emergence of an intense synoptic-scale cyclonic disturbance over North America. This feature is clearly associated with a steepening of the scatter plots. The latter effect was also observed by Malanotte-Rizzoli and Hancock (1987) before the onset of blocking over the North Atlantic, and is consistent with the finding of Hansen and Chen (1982) that blocking appears to be preceded by intense synoptic-scale activity, in which non-linear forcing of the planetary-scale flow, by synoptic-scale systems, leads to rapid block formation. We suggest that the time series of $q(\Psi)$ plot area, together with the scatter plots, may be useful in identifying such synoptic-scale disturbances in advance.

Within the quasi-geostrophic framework, we model the block as a superposition of a stationary blocking eddy, and a zonal flow having no meridional shear. A separation of variables leads to the equivalent barotropic modon solution, and a vertical structure equation. The latter is solved asymptotically, through the use of a power law for the tropospheric static stability, yielding a set of vertical normal modes. We use the first four modes to examine the evolution of the baroclinicity of the block. We find that the blocking eddy component of the stream-function is dominated by the gravest mode. The dipole form of the block appears to have the same degree of barotropicity as the Omega-block. A small but abrupt increase in baroclinicity immediately prior to the formation of the dipole could be evidence of the so-called eddy-straining mechanism (Shutts 1986), whereby synoptic-scale eddies can maintain a dipole block.

FINE RAINGAUGE NETWORK COMPARISON WITH RADAR RAINFALL

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Processing the central Saskatchewan radar at Elbow for precipitation climatology raised questions of its real capability to describe convective rainfall patterns, in terms of both quantitative precision and spatial representation. A network 73 conventional raingauges complemented by an overlapping network of 23 recording rain gauges was operated near Saskatoon during the convective rainfall season of 1991. The ground network, radar system and data processing will be described. Analysis results to date will be presented. Results will relate the capabilities of this radar system to the requirements of precipitation climate analysis.

LARGE-SCALE HYDRODYNAMIC STUDIES OF BAIE-DES-CHALEURS IN SUPPORT OF SCALLOP RESEARCH

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Baie-des-Chaleurs (BDC) is notable for its outstanding physical dimensions and freshwater volume input. Its length (120 km) and depth (40-120 m) make it an interesting case among other embayments, but particularly important is that its width L (30 to 50 km) is several times the internal Rossby radius. Mesoscale phenomena such as coastal jets, baroclinic eddies created by adjustment to transient forcing, fronts, wind-induced upwelling and unstable shear waves become possible in such large-scale embayments. Furthermore, biological oceanographic studies suggest that such phenomena will influence biological production, the early life stages and retention of larvae, and possibly fish migration. Having this in mind, large-scale current and water-mass measurements were carried out, in conjunction with related biological projects, in 1990 and 1991 to examine the nature and time scales of the different energy inputs.

The response of the BDC to tidal forcing has been estimated from harmonic analysis. Tidal elevations are dominated by the M_2 constituent in the semidiurnal band and by the K_1 constituent in the diurnal band. The semidiurnal tides exhibit neap-spring fortnightly modulations about mean sea level, stronger at the Quebec side. Spectral analysis of the same data show that the kinetic energy is predominated by the semidiurnal tidal currents. The analysis also reveal strong oscillation in the inertial frequency band (around 16-17 h), occurring in the wake of wind stress transients. This inertial oscillation is more important at the central basin compared to the area near both shores. Furthermore, the low-frequency velocity component fluctuations about mean value reveal two distinct synoptic scales of variability: (a) fluctuations with periods ranging from 2-11d, and (b) slowly varying trends with time scales of the order of the record length (>20 days). The shorter time scale corresponds to similar variability in the synoptic wind forcing due to the rapid propagation of extra-tropical cyclones and the passage of pressure systems over the Gulf of St.Lawrence, including the BDC. Freshwater pulses and non-local forcing by very low frequency density perturbations from the Gulf of St.Lawrence (e.g. Gaspé Current) may contribute to the longer time-scale fluctuations.

ÉTUDE DES MASSES D'EAU DANS L'ESTUAIRE DU SAINT-LAURENT

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Un traitement des données de température et de salinité a été fait de façon à caractériser les masses d'eau de l'estuaire du Saint-Laurent ainsi que leur évolution dans le temps et l'espace. Toutes les données disponibles pour la période entre 1973 et 1975 ont été interpolées verticalement et horizontalement de façon à combler tout

l'estuaire. Des profils verticaux, transversaux, longitudinaux et une série de diagrammes quantitatifs (montrant le volume d'eau associé à chaque intervalle de température-salinité) sont utilisés pour arriver à mieux comprendre la structure thermohaline. La distribution des paramètres physiques est obtenue et leurs changements avec les saisons ont été étudiés. La majorité des masses d'eau ont une salinité comprise entre 32 et 35 ppm et une température comprise entre -2 et 4 °C. Les plus grandes variations saisonnières sont obtenues entre l'hiver et l'été dans les 50 premiers mètres.

NUMERICAL MODELLING OF TIDES IN BAIE-DES-CHALEURS

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We have developed a two-dimensional vertically integrated barotropic model for the Baie-des-Chaleurs (BDC). The model used is based on the finite difference staggered grid scheme, with a resolution of 1 km X 1 km. Although baroclinic effects are not considered, this model is the first tidal model for the BDC that makes use of real data for the five important tidal constituents, namely M_2, S_2, N_2, K_1 and O_1. The results have an average accuracy of 2.9% for water level displacements associated with the principal semidiurnal tidal component (M_2) and for their phases. Co-amplitude and co-phase lines show that tides enter the bay as a Kelvin wave, with amplitudes being higher along the Quebec shore. Tidal currents are maximum along the north shore (50-70 cm/s) during the flood and ebb stages of tides and decrease during slack periods. This model will be used to investigate the role of the tidally-generated residual circulation and the presence of frontal zones in the distribution of scallop eggs and larvae in the bay.

THE CURRENT STATUS OF OZONE DEPLETION AND UVB RADIATION

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The current status of the ozone depletion problem and ultraviolet radiation levels is presented since the depletion of the ozone layer due to chlorofluorocarbons continues to increase. Ozone levels at midlatitudes in the northern hemisphere have declined by 6 % over the last 12 years and it is expected that depletion levels will continue to increase to over 12 % by the year 2000. The NASA report of a large cloud of active chlorine over high latitudes in the northern hemisphere in late January, 1992 led to high concern that there would be a dramatic thinning of the ozone layer and a large increase in UVB levels this spring over Canadian latitudes. The actual ozone depletion and UVB increase which occurred will be evaluated using data available in May, but these are expected to be modest although measurable. The future depletion of the ozone layer and increase in UVB radiation levels over the next 20 years is considered to be a cause for concern.

ULTRAVIOLET RADIATION MONITORING AND FORECASTING OVER SOUTHERN ONTARIO

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The current status of the ultraviolet radiation levels is important since the depletion of the ozone layer due to chlorofluorocarbons continues to increase. Ozone levels at midlatitudes in the northern hemisphere have declined by 6 % over the last 12 years and it is that UVB levels will continue to increase over the next 20 years. The relationship between the ozone column and ultraviolet radiation (UVB) levels is important to most of the biology of the planet. Measurements of the UVB levels and the climatology of UVB over southern Ontario are shown.

One measure of the effect of UVB radiation on humans is the SUNDEX sunburn time. At the latitudes of southern Ontario, the SUNDEX varies from less than 20 minutes in July to over a day in December. The generation of the

SUNDEX and UVB intensities from satellite ozone fields is also discussed and demonstrated by example. In a pilot project in the summer of 1990, the SUNDEX was measured in the morning and broadcast on the media in the afternoon. It is planned to develop the forecast and disseminate the SUNDEX to the media across Canada in the future. The problems associated with forecasting UVB levels are discussed.

WIND PROFILE ESTIMATION BY CONVENTIONAL RADARS

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When precipitation forms from the same moving source region for a long enough period, a precipitation trail is formed. These trails move at the velocity of their source region but the slope of the trail at any height is a function of two parameters: the difference between the wind at that level and the velocity of the source region, and the average fall speed of the hydrometeors. The wind profile can then be retrieved by measuring the slope of the trails, their advection velocity and by estimating the average fall speed of the hydrometeors.

High resolution radar data from 24 elevation angles were collected by the McGill Radar in order to test the technique. The advection velocity of trails was measured by the movement of weather echoes between the 5 minute volume scans. Small PPI sub-regions with trails were correlated with the PPI above to measure the slope of the trails. Fall speed were assigned based on the reflectivity of the trails and corrected for the height of the observation.

Wind speeds were computed for a snowstorm and a rain shower. Retrieved wind profiles matched available radiosonde measurements well. The main source of error of the technique was due to the difficulty of estimating fall speeds.

SUMMER SEA SURFACE TEMPERATURE VARIABILITY OFF VANCOUVER ISLAND

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Satellite-sensed Advanced Very High Resolution Radiometer (AVHRR) Sea Surface Temperature (SST) data collected over eight summers (1984-1991) were used to study summer upwelling off the west coast of Vancouver Island. Empirical Orthogonal Function (EOF) analysis of the 131 images was performed. The first EOF mode showed a strong cold water band located at the northwestern part of Vancouver Island and a cool tongue extending from Juan de Fuca Strait. The second mode revealed cool water over the shelf region and a cold eddy near the Juan de Fuca Canyon. The third mode showed a cool water band off Brooks Peninsula extending southwestward, while the fourth mode revealed a cold water plume off Cape Scott. From these images, we also estimated the total upwelling for each summer, with 1986 and 1991 showing the greatest amount of upwelling.

VERTICAL MIGRATION AS A MEAN TO INCREASE FORAGING IN MACKEREL LARVAE (*SCOMBER SCOMBRUS*) SAMPLED IN SOUTHWESTERN GULF OF ST.LAWRENCE

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Recruitment variability in fish populations has often been attributed to variability in the mortality rates affecting the eggs and larvae. Larval condition is a mean by which the vulnerability to starvation could be estimated. In order to test the hypothesis that condition of larval fish was influenced by food availability in the field, mackerel larvae (*Scomber scombrus*) and their food were collected hourly for 129 consecutive hours, at a fixed station in

southwestern Gulf of St.Lawrence, between July 11 and July 16, 1986. The amount of DNA, RNA and proteins were measured in larvae of the 7.0 mm size class, and the RNA-DNA ratio used as a condition index. The density of copepod nauplii measured in the upper mixed layer, dropped by half in the middle of the sampling period, suggesting the horizontal advection of two distinct water masses. The biological identification of these water masses was not supported by any changes in their T-S characteristics, but corresponded to a shift from offshore to onshore winds, resulting in a major change in the main orientation of the residual currents. Despite the fact that the food availability was reduced by half in the water mass advected after July 13, the RNA-DNA ratio indicated a constant proportion of starving larvae. Daily vertical migrations by the larvae started to appear after the drop in food availability, suggesting a behavioral response of the larvae to increase foraging in a poorer environment.

INTENSE CURRENTS IN THE DEEP NORTH-EAST PACIFIC OCEAN

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Observations of deep currents in the N.E. Pacific Ocean are reported which indicate that although the eddy kinetic energy level is, as expected, generally low, the deep N.E. Pacific is subject to occasional intensely energetic events. These events are energetic enough to dominate the distribution of kinetic energy in the water column. We can no longer make the assumption that deep flows are weak when estimating near surface flows, and, depending on how common these events are, we may need to modify our estimates of the heat transport that can be accomplished by deep eddies.

2D FINITE ELEMENT TIDAL MODEL OF ST.LAWRENCE ESTUARY

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Un modèle hydrodynamique bi-dimensionnel basé sur la technique des éléments finis a été développé pour l'estuaire du Saint-Laurent. Ce modèle s'appuie sur un double maillage triangulaire irrégulier: le maillage à haute résolution comprend 12000 éléments alors que le maillage à résolution plus faible en contient 436. La possibilité d'échanges bidirectionnels entre les résultats provenant des deux maillages et l'introduction de conditions aux limites périodiques correspondant aux marées et aux courants observées sont parmi les innovations du modèle. Les résultats obtenus à partir de différents types d'éléments (T3,T3B,T6) et différents shémas numériques seront discutés et analysés en fonction de leur précision et de leur consommation en mémoire et en CPU.

A 2D finite element model based on a double irregular triangular grid is used to describe water level and tidal streams in the St.Lawrence estuary. The possibility of bidirectional exchange between results coming from the two grids systems and inclusion of unsteady condition algorithm for water level and tidal streams are the most important behavior of the model. Results obtain with different elements type (T3,T3B,T6) and different numeric schemes are analysed and discussed in terms of precision and CPU time and memory.

RECONSTRUCTING HOLOCENE CLIMATES FROM ARCTIC POLLEN DATA.

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Information about past climates in the Canadian arctic comes from a variety of sources, but the sites are widely spaced, most have discontinuous records and frequently are poorly dated. Continuous records of past conditions can be interpreted by the analysis of the physical and chemical characteristics of ice cores but these are available from only a limited geographic range, where ice caps or glaciers are found. An alternate data source for past climates is the fossil pollen deposited in lake sediments, which can potentially be obtained from sites across the

entire arctic region.

Arctic pollen analysis is difficult due to the low pollen concentration in the sediments, the broad geographic range of many of the plant taxa, and the problems of dating the highly inorganic sediments. Although past positions of treeline have been estimated, less in known of conditions in the tundra of northern Canada. Some progress has been made, particularly from sites in Greenland and the eastern Canadian Arctic. In this communication, the state of arctic paleoclimate reconstructions using pollen assemblages will be reviewed, including discussions of the data, methods, problems and potentials.

BUOYANCY FLUX ESTIMATES FROM OVERTURNING SCALE QUANTITIES

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Mixing occurs at microscales (mm) although it has signatures at larger scales. For example, the rate of creation of finescale (e.g., overturning) variability is balanced by the rate of dissipation at microscales. Thus finescale properties provide a signature of microscale mixing. For a steady-state to exist, both the buoyancy flux and dissipation must be equal to the potential energy divided by a suitable decay time.

The potential energy of the fluctuations can be measured in energetic cases. We show that the decay time is inversely proportional to overturn-scale shear for isotropic growing turbulence, and that it is proportional to the buoyancy period for turbulence in inertial-buoyancy balance, whether it is isotropic or not. This leads to estimates of buoyancy flux from overturning scale quantities. The predictions of our simple model compare favourably with laboratory turbulence data as well as Dillon's (1982) lake and oceanic data.

THE INFLUENCE OF HUMIDITY PROFILES DERIVED FROM GOES IMAGERY IN THE CANADIAN GLOBAL FORECAST MODEL

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A new method based on cloud classification has been developed for the estimation of humidity profiles from geostationary satellites. The method uses the visible, infrared window and infrared water vapor channels. The first step consists of classifying areas 100 x 100 km into nine (VIS-IR) or seven (IR only) classes. Cloud type dependent relationships are then used to produce the final result at six standard levels (300 mb to 1000 mb).

Full disk retrievals (60 S to 60 N, 40 W to 170 W) from GOES-7 were obtained for a two-week period in June 1991. Forecasts with and without the new humidity data show a positive impact of the satellite data on forecasts up to three days. Geopotential errors are slightly lowered at all levels and convective areas such as the intertropical convergence zone better analysed and predicted. The interaction of the new data with the condensation scheme of the model is the key process that differentiates the forecasts.

INERTIAL PEAK SUPPRESSION ABOVE STEEPLY SLOPING TOPOGRAPHY.

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Some of the consequences of the phase locking of incident and reflected internal waves at a sloping boundary are explored in this paper. We show that when the bottom slope is much steeper than the wave ray slope for the entire near-inertial band, destructive interference of the incident and reflected waves in the immediate vicinity of the bottom leads to a suppression of the near-inertial peak. It also leads to quasi-rectilinear motions oriented in the

alongslope direction, and thus to a ratio of anticlockwise to clockwise kinetic energy close to one, in the near-inertial band. We present some observations from the continental slope off Nova Scotia and from the near-equatorial Atlantic that appear to be consistent with the theory.

REGIONAL CLIMATE MODELING

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The primary available tools for projecting future climate change or simulating present and past climates are general circulation models (GCMs). These models can incorporate all the relevant global forcings, e.g. greenhouse gases, and can describe the large scale features of global atmospheric circulations. However, current GCMs have a resolution (~300-500 km) which is too coarse to provide adequate detail for regional studies, especially in areas of complex topography, coastlines and surface vegetation cover. A modeling framework has been recently developed at the National Center for Atmospheric Research (NCAR) in which a fine mesh (~20-80 km) regional model (the Penn State/NCAR MM4) is embedded in a GCM (the NCAR CCM1). In the embedding procedure the initial and lateral boundary conditions necessary to drive the mesoscale model are provided by the GCM output. The strategy of this approach is that the GCM can describe the response of the general circulation to large scale forcings and the nested regional model can account for the effect of local, sub GCM-grid scale forcings. This regional climate modeling methodology is being tested over various regions of the world. One of them is the continental United States. Recently, continuous multi-year simulations for present day and 2XCO2 climate conditions over the U.S. with the climate version of MM4 nested in a version of the NCAR CCM have been completed. Results will be presented from these simulations, which show how the coupled regional model/GCM system produces regional patterns of climatic quantities such as temperature and precipitation which show much more realistic detail than those produced by the GCM alone. These experiments also show that it is feasible to perform good quality, long-term simulations with regional models nested in GCMs for climate applications. An important advantage of the nested modeling technique is that, since its components are physically rather than empirically based, it can be applied to a wide variety of climate conditions different from present and it can be coupled in interactive ways to regional hydrologic and ecosystem models.

EVALUATION OF THE ADOM WET SCAVENGING MODULE

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The Acid Deposition and Oxidant Model (ADOM) is an Eulerian long-range transport and deposition model. One of the most highly parameterized and least well established parts of the model is the module that computes the scavenging by convective clouds. As a means of gaining insight into the scavenging module, results from simulations with the module are compared with the results of simulations for equivalent conditions with a three-dimensional dynamic convective cloud chemistry model.

Comparisons of results for a variety of initial conditions show that wet-deposition of sulphate, nitrate and ammonium ions tends to be underpredicted by the scavenging module and that rain acidity is overpredicted. However, the differences are for the most part not large. The results of the scavenging module do seem to be sensitive to the model cloud top height. Concentrations of hydrogen peroxide deposited at the surface are significantly smaller in the ADOM module than in the 3-D model. For the particular conditions that have been considered, oxidation is limited by the hydrogen peroxide concentration in the air for the 3-D model but by the sulphur dioxide concentration for the ADOM module.

MODELLING OF ATMOSPHERIC BOUNDARY-LAYER OXIDANTS: A 1-D (VERTICAL) STUDY

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The behaviour of atmospheric oxidants is very complex and a proper modelling of such problem a usually requires three-dimensional comprehensive models. On the other hand, under certain circumstances the problem can reduce to approximately one-dimension, and a 1-D model, which is certainly a lot easier to handle, can provide some understanding of the physical and chemical mechanisms pertinent to the problem.

Diurnal simulations of atmospheric boundary-layer oxidants are conducted using a 1-D (vertical) oxidant model, which includes vertical diffusion/mixing and sources/sinks due to chemical reactions, emissions and dry deposition. ADOM gas-phase chemistry is employed involving 45 species and 114 reactions, and the vertical mixing is modelled using acquired vertical diffusivity profiles. This is taken as a first step towards a comprehensive 1-D model of the atmospheric boundary-layer dynamics and chemistry. Sensitivity studies are carried out to examine the effect of individual component on the behaviour of the boundary-layer oxidants. Attempts are also made to simulate some of the EMEFS' hyper-intensive cases at Egbert, Ontario. Some useful insights are drawn from the 1-D study with respect to the modelling of the atmospheric oxidants in the boundary layer.

MESOSCALE MODELLING OF THE ATMOSPHERE WITH A VARIABLE-RESOLUTION GLOBAL MODEL.

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A new operational model is being developed that will meet the requirements of short-range regional forecasting, medium-range global forecasting, and data assimilation. Its versatility is due to the global variable-mesh strategy used for the spatial discretization. The method has the advantage of allowing variable resolution which permits a focusing of resolution over an area of interest. This offers an efficient and simple alternative to the nesting problem for regional forecasting: the planetary waves are adequately resolved outside the high-resolution subdomain (which resolves small-scale disturbances), and there is no abrupt change of resolution across an internal boundary since the resolution is varied smoothly in the outer part of the domain. The approach also proves to be extremely competitive for mesoscale limited-area modelling because of the slow growth of the computational cost as a function of resolution. We integrate a shallow-water version of the global model to produce forecasts for a limited-domain where the horizontal resolution is typical of meso-g models. We find the approach very robust, with no sign of noise or internal reflection at the interface between the high-resolution subdomain and the surrounding coarser grid.

INTERPENTADAL CHANGES IN THE NORTH ATLANTIC CIRCULATION

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Diagnostic calculations using objectively analysed density data and COADS wind data for the pentads 1955-59 and 1970-74 suggest that the Gulf Stream was up to 30 Sv weaker in the later pentad with roughly two-thirds of this change being due to a dramatic weakening of the subtropical gyre. The difference between the average wind stress field in the pentad 1970-74 and that in 1955-59 makes little contribution to this change, almost all of which can be attributed to changes in bottom pressure torque. Diagnoses of the velocity field through sections across the Gulf Stream are used to analyze the vertical structure of the transport changes. Preliminary results are also presented from a two-density level model driven by monthly means of wind stress for the period 1951-1979.

A FINITE ELEMENT MODEL STUDY OF CIRCULATION IN THE GULF OF MAINE REGION

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Previous modelling studies of circulation in the Gulf of Maine and Georges Bank regions have pointed out the needs for adequate resolution of topographic features, inclusion of adjacent areas in the model domain, and inclusion of baroclinic circulation. To address these deficiencies, finite element models are being used to study the three-dimensional circulation in the region. The flows associated with tidal, wind, density gradient and boundary inflow forcing are being examined. The flow fields are being used to investigate the role of the circulation in the distributions of fish eggs and larvae in the Georges Bank region.

The progression of models and techniques will be described. Results will be presented for the responses to wind stress and upstream inflow, including comparisons with previous models and sensitivity studies of bottom and internal friction. Future plans will be discussed.

FLOW FIELDS AND DRIFTER TRACKS ON WESTERN BANK, SCOTIAN SHELF.

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An array of current meters and pressure gauges was deployed on Western Bank on the outer Scotian Shelf from February to December 1991 as part of the cod larval tracking component of OPEN. Loran-C drifters were also deployed during a 2-week period. Sub-tidal flow fields are richly structured in both space and time, as evidenced by the low correlation of velocity across the 40km array. Nevertheless, the flow is primarily geostrophic once the locally wind-driven response is accounted for and hence may be interpolated by fitting a surface to the pressure and velocity data. Resulting hindcasts of particle trajectories compare well with those of drifter cluster centroids but cannot reproduce the high observed shear dispersion. Hindcast residence times within the 40km array appear to be of only O(10d). So why were cod larvae found centered over the crest of the Bank from November 1991 through to February 1992? Results of an April-May 1992 cruise designed to see whether a zone of retention exists over the crest of the bank (just outside our 1991 array) are presented.

FORECASTING OCEANIC 'WEATHER' ON THE SCOTIAN SHELF

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One of the goals of the fisheries biologists in the Ocean Production Enhancement Network is to determine what is special about the small number of cod larvae that survive their early life stage and recruit to the fishery. This will involve tracking a cohort of larvae in the field for about 20 days and monitoring the changing condition and genotypic-phenotypic profile of the survivors. In order to do this, the biologists' sampling locations must evolve with the changing position and shape of the larval patch. This, in turn, requires both nowcasts and short-term forecasts of the three dimensional flow field over the outer continental shelf. In close analogy to the procedures used by weather forecasters, we will rely heavily on real-time data acquisition and numerical models. Velocity estimates from a telemetering moored current meter, Loran-C drifter trajectories and the ship's Acoustic Doppler Current Profiler will be fed to a suite of increasingly sophisticated empirical and dynamical models. The most sophisticated of these will be a 3-dimensional numerical model with the data being assimilated by the adjoint method. We will discuss progress to date and illustrate our approach with data collected during a Spring cruise to Western Bank in 1991.

A STUDY OF THE EFFECTS OF LONGWAVE RADIATION ON CLOUD DEVELOPMENT

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Most clouds experience strong longwave radiative cooling from their tops and sides. To study the radiation effects on convective cloud development, a two-dimensional longwave broadband radiation model is developed. The model uses high spatial and spectral resolutions to provide broadband flux divergence and cloud cooling rates within atmospheric window region. Wiscombe's Mie code is used to provide the optical characteristics of cloud droplets. The model can be applied to either homogeneous or inhomogeneous clouds.

The results show that 1) high radiative cooling rate are located near cloud tops and cloud sides, with maximum cooling rate at the upper cloud corners, 2) the horizontal net flux divergence has important contributions to total cooling rate near the cloud sides, which are neglected by the two-stream parameterization scheme.

The effect of longwave radiative cooling is being incorporated into a dynamic cloud model and some preliminary results would be presented.

CHARACTERISTICS OF A DRY LAYER BENEATH A CIRRUS CLOUD

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Data for this study were collected by the instruments mounted on the NCAR King Air and NASA ER-2 Aircrafts, and rawindsonde during First ISCCP (International Satellite Cloud Climatology Project) Regional Experiment (FIRE) which took place over the Minnesota region on 19 October, 1986. Cirrus cloud top and base from rawindsonde measurements were found at about 7 and 11 km, respectively. Relative humidity with respect to water (RH_w) ranged between 52 % at the top and 25 % at the base of dry layer which formed below the cirrus. The same dry layer was also indicated on the imagery obtained by the NASA ER-2 aircraft lidar. Using the data from the optical probe measurements and a one-dimensional time-dependent model, evaporative cooling rate and downward vertical vertical velocity (w_d) were calculated in the various environmental conditions. Results showed that w_d can be as high as 6 m s^{-1} using RH_w of about 25 % and an environmental lapse rate of approximately -0.8 K/100 m. The evaporative cooling rate just below the cirrus base was found to be about 10 K h^{-1} in the same environmental conditions. Overall, the results were found to be comparable with observations and earlier studies.

A TWO-DIMENSIONAL COUPLED ATMOSPHERE-OCEAN-SEA ICE MODEL FOR LONG-TERM CLIMATIC SIMULATIONS

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A two-dimensional (latitude-depth) deep ocean model is presented which is coupled to a sea ice model and an Energy Balance Climate Model (EBCM), the latter having land-sea and surface-air resolution. The processes which occur in the ocean model are: thermohaline overturning driven by the horizontal density gradient; shallow wind-driven overturning cells; convective overturning; and vertical and horizontal diffusion of heat and salt. Mixed layer salinity is affected by evaporation, precipitation, runoff from continents, and sea ice freezing and melting, as well as by advective, convective, and diffusive exchanges with the deep ocean.

The ocean model is first tested in an uncoupled mode, in which hemispherically symmetric mixed layer temperature and salinity, or salinity flux, are specified as upper boundary conditions. An experiment performed with previous models is repeated in which a mixed layer salinity perturbation is introduced in the polar half of one hemisphere after switching from a fixed salinity to a fixed salinity flux boundary condition. For small values of the vertical

diffusion coefficient K_v, the model undergoes self-sustained oscillations with a period of about 1500 years. With larger values of K_v, the model locks into either a symmetric mode or an asymmetric mode with a single overturning cell spanning both hemispheres (depending on the details of the convection parameterization), or a quiescent state with downwelling near the equator, upwelling at high latitudes, and a warm deep ocean (with sufficiently large K_v). When the ocean model is forced with observed mixed layer temperature and salinity, no oscillations occur. The model successfully simulates the very weak meridional overturning and strong Antarctic Circumpolar Current at the latitudes of the Drake Passage.

The coupled EBCM-deep ocean model displays internal oscillations with a period of 3000 years if the ocean fraction is uniform with latitude of K_v and the horizontal diffusion coefficient in the mixed layer are not too large. Globally averaged atmospheric temperature changes of 2 K are driven by oscillations in the heat flux into or out of the deep ocean, with the sudden onset of a heat flux out of the deep ocean associated with the rapid onset of thermohaline overturning after a quiescent period, and the sudden onset of a heat flux into the deep ocean associated with the collapse of thermohaline overturning. When the coupled model is run with prescribed parameters (such as land-sea fraction and precipitation) varying with latitude based on observations, the model produces a reasonable deep ocean temperature field but a completely unrealistic salinity field. Resetting the mixed layer salinity to observations on each time step – equivalent to the "flux correction" method used in atmosphere/ocean GCM'S – is sufficient to give a realistic salinity field throughout the ocean depth, but dramatically alters the flow field and associated heat transport.

EFFET DE LA NATURE DU SUBSTRAT ET DE LA PROFONDEUR SUR LA VARIABILITÉ SPATIALE DU TAUX DE FIXATION DES POST-LARVES DE PÉTONCLE GÉANT (*Placopecten magellanicus*)

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Il est bien connu que les post-larves de pétoncle géant passent la première année de leur vie fixées à un substrat dur à l'aide de filaments byssaux. Cependant, nous conaissons très peu de choses sur la nature des substrats sélectionnés ainsi que sur les facteurs qui favorisent le choix d'un substrat par rapport à un autre. Des échantillonnages qualitatifs effectués dans la baie des Chaleurs, à l'automne 1991, ont montré que le nombre de post-larves fixées sur les hydrothèques d'hydraires morts de l'espèce *Tubularia larynx* était 20 fois plus élevé que sur les autres substrats échantillonnés. De plus, il y a une relation positive significative entre la profondeur et le nombre de post-larves colonisant des hydraires prélevés à différentes profondeurs sur des cordes. Des expériences en laboratoire réalisées à l'aide de post-larves nouvellement fixées ont aussi montré que (1) les post-larves se refixaient très rapidement sur leur substrat d'origine lorsqu'elles étaient délogées de ce dernier, (2) lors d'expériences à choix unique et à choix multiple, les post-larves se refixaient en plus grand nombre sur *Tubularia* plutôt que sur une algue rouge filamenteuse (*Ptilota serrata*; un substrat où on a aussi retrouvé des post-larves) ou sur du monofilament (un substrat habituellement utilisé dans les collecteurs de larves de pétoncle). Nous discuterons des implications potentielles de ces résultats sur l'aquaculture du pétoncle géant.

INFLUENCE DE L'HÉTÉROGÉNÉITÉ DU SUBSTRAT SUR LE TAUX DE FIXATION DES LARVES D'INVERTÉBRÉS BENTHIQUES

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Nous avons examiné le rôle de l'hétérogénéité du substrat et de l'hydrodynamisme dans la couche limite benthique sur le taux de fixation des larves d'invertébrés benthiques à partir d'expériences multifactorielles réalisées sur le terrain. Ces expériences ont été effectuées à l'aide de structures tri-dimensionnelles, s'apparentant par leur forme à des hydraires ou à des algues benthiques. Les principaux facteurs considérés ont été le degré d'hétérogénéité

(nombre de ramifications), le diamètre des ramifications et la surface disponible pour la fixation. Nos résultats montrent que, pour l'ensemble des structures, il y a une corrélation positive significative entre le nombre d'individus fixés par cm^2 de chacune des espèces (*Mytilus edulis, Cerastoderma pinnulatum, Hiatella arctica*). Ce résultat semble indiquer que la fixation est un phénomène passif à l'échelle de la couche limite benthique. De plus, on observe un effet hautement significatif de l'hétérogénéité du substrat et du diamètre des ramifications sur le nombre de larves fixées par cm^2. Les structures offrant le plus petit diamètre des ramifications et la plus faible hétérogénéité, celles qui perturbent le moins l'écoulement dans la couche limite benthique, ont récolté plus d'individus par cm^2 que les structures offrant un diamètre des ramifications plus élevé et une forte hétérogénéité.

THE EFFECTS OF CYCLOGENESIS ON REGIONAL TRANSPORT

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The CDT (Chemistry and Dynamics of the Troposphere) regional scale transport model is used to simulate the OSCAR 4 cyclone of 22-24 April, 1981. The model includes the RADM 1 gas phase reaction set, and the spatial distribution of various species during a cyclogenetic event is discussed. Certain species (eg. NO) are strongly influenced by the temperature structure of the fronts, while others (eg. OH) are affected by the water vapour distribution in the cyclone. The ozone concentration is substantially reduced in the vicinity of the cyclone, and the results of a tracer analysis are used to explore the causes of this.

DESCRIPTION OF THE GEOPHYSICAL FIELDS AT CMC AND THEIR USE IN THE REGIONAL AND GLOBAL MODELS

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As the resolution of models and analysis systems increase they become more and more sensitive to the specification of certain fields related to physical characteristics of the surface. We refer to these fields as geophysical fields. In this context, we will describe the geophysical fields currently used at CMC as well as those soon to be implemented and we will see how they are used by the models. This will be an opportunity to clarify to the operational community the contents of these fields and their subtle impact on model output.

Geophysical fields are divided into two main branches. First, we find the geographical fields such as topography and land-water mask fields. We will examine these fields and see why they are somewhat smoothed before actually being used by the models. Secondly, we have the surface variables (land and sea temperature, albedo, snow depth, ice, soil moisture, etc...) which include the climatological fields and the analyzed fields. We will examine these with special emphasis on the analyzed fields of ice, albedo and snow depth as they were recently introduced operationally at CMC. Results of their positive impact on the analysis and model forecasts will be presented. Special emphasis will also be devoted to the effect apt these fields on the higher resolution EFR model.

SENSITIVITY STUDY OF THE EFR MODEL ON THE 28 SEPTEMBER 1990 PACIFIC BOMB CASE

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The first two major systems of fall 1990 to hit the west coast were significantly underforecast by the Canadian models. We will present results of a sensitivity study of the EFR model on the case of the September 28, 1990 storm. This case shows once again the crucial importance of the analysis over the oceans, where data are generally

sparse. We examine the model's sensitivity to the position of EFR grid by moving the high resolution central window over the Pacific. Also, to study the effect of the model's resolution, tests were performed by running the model at 50 km. We will show that the model was sensitive to grid resolution to some degree despite obvious deficiencies to the initial analysis. Furthermore, we evaluate the model's sensitivity to initial analysis and to the insertion of bogus data to that analysis. It turns out that the model's poor performance can be mostly attributed to a faulty initial analysis, as is often the case with Pacific systems.

The NGM model was more successfull in this case than the EFR or the Spectral V9. In order to examine the effect of the initial analysis, we have obtained NMC's analysis for that case and we will present results of EFR model runs using the American analysis. Interestingly, the EFR model run with NMC's analysis produced very similar results to what the NGM model indicated. We will also closely examine the differences between the NMC and CMC analysis for that case.

ESTIMATES OF PRECIPITATION IN SUMMER STORMS IN CENTRAL ALBERTA

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A field experiment was conducted in central Alberta during the period 18 July to 7 August 1991. The field experiment involved observing storms within about a 70 km radius from Red Deer with the Alberta Research Council S-band polarisation diversity radar and C-band radar, and measuring rainfall at the ground through a small network of fixed, volunteer observers, a mobile storm-chase operation and automatic recording stations belonging to AES and Alberta Environment. Information on the occurrence of hail was also recorded. Significant events occurred on seven days.

This presentation will discuss the estimation of heavy rain rates and the identification of hail by using the full polarisation information from the S-band radar.

INTERANNUAL VARIABILITY OF ARCTIC SEA-ICE USING A COUPLED SEA ICE - OCEAN MODEL

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A coupled ice-ocean numerical model is used to study interannual variations in the Arctic ice-pack. The sea-ice component of the model includes both dynamics and thermodynamics based on Hibler and Oberhuber respectively. The ocean component is a diabatic isopycnal ocean circulation model with prognostic temperature and salinity fields and realistic topography (Oberhuber). The models are coupled through an ocean mixed layer. The coupled model is forced using monthly atmospheric fields spanning several decades. The simulation of sea-ice thickness, concentration, and circulation is compared with observations. In particular, the model is used to hindcast the great ice and salinity anomaly of the 1960s.

WIND AND TEMPERATURE PROFILING

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The Wind Profiler is an unattended, highly sensitive Doppler radar that detects and processes returns from the clear air directly above the radar to derive vertical profiles of wind speed and direction in increments of 250 m to an

altitude of approximately 16 km. NOAA has now established a network of 30 of these systems in the central part of the U.S. Data from the network is being used to assess the effectiveness of this new technology for making upper air observations. Preliminary results will be presented.

In 1991, Paramax Systems Corporation (formerly known as Unisys Defense Systems, Inc.) completed a company-sponsored project to add a temperature profiling capability to the Wind Profiler System based on utilizing the Radio Acoustic Sounding System (RASS) technique. NOAA is planning to add this capability to several of the profilers in the network.

With the RASS technique, the temperature profile is measured by vertically transmitting an acoustic wavefront over the radar and tracking its upward velocity. Since the speed of sound in air varies directly with temperature, a temperature profile can be obtained. Results of temperature measurements in increments of 250 m to altitudes of approximately 5 km will be presented.

Highlights of a trip in 1991 to the AES Upper Air Station at Mould Bay to survey potential sites for a Wind Profiler will also be presented.

THE CANADIAN WEATHER RADAR DATA PROCESSING SYSTEM

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As part of its modernization program, the Canadian Atmospheric Environment Service has contracted MacDonald Dettwiler to provide a Radar Data Processing system (RDP) for its weather radar network. The system will provide for the acquisition and display of volume scan radar data as well as the production of various radar-derived products known to be useful for severe storm detection and forecasting. RDP is based upon original radar data processing algorithms developed by McGill University, which have been verified by AES in operational use at the Quebec Weather Centre. MacDonald Dettwiler has incorporated these algorithms in a production system with modular hardware capable of functional expansion as demands on the system increase.

This paper describes the hardware and software architecture of RDP and shows examples of the type of products available from the system as well as the form of the human machine interface. Future expansion possibilities are discussed in light of new algorithms being tested at the Quebec Centre and in light of the AES Doppler radar program.

NUMERICAL SIMULATION OF MESOSCALE FEATURES IN THE NORTH ATLANTIC CURRENT OBSERVED BY GEOSAT ALTIMETER DATA.

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The Geosat altimeter data have been analyzed for 3 years to show mesoscale meanders and eddies in the North Atlantic Current over the Newfoundland ridge and basin. The decorrelation scales of the sea surface height variabilities are ~40 days in time and ~120 km in both along-track and cross-track directions. Although significant waves propagate westward at speeds of 3 ~ 15cm/s near the NAC axis, some individual mesoscale features are chaotic: they are sometimes persistent for several repeat cycles (~100 days) and then suddenly propagated westward or disappeared within one cycle. To examine the cross-track resolution of the altimeter data, an additional data set is created by smoothing the raw data between the tracks.

An eddy-resolving, quasi-geostrophic model is employed to simulate the mesoscale variabilities. The model is

forced (updated) only by the altimeter data at times of the observations. To evaluate model performance, correlation between the new data and the model solution just before data injection is compared with correlation between the new data and the 1 cycle (17-day) old data; i.e., predictability is compared with persistence. When the raw data are used to force the model, the data-solution correlation coefficients are comparable with the lagged data-data correlation coefficients: predictability is not superior to persistence. Only when the smoothed data are used, does the predictability become superior to the persistence. Prediction is degraded by unpredictable evolution of the mesoscale features that are not well captured by the altimeter with the low cross-track resolution, and rapidly grow due to instability. The degradation could occur also when the mesoscale features, whose lower layer component is underestimated due to inefficient downward transfer of the surface data, receive effects of steep bottom topography.

ESTIMATION OF THE TEMPERATURE-PRECIPITATION INDEX USING HOURLY DATA FROM SABLE ISLAND, NOVA SCOTIA IN JANUARY.

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At last years' Congress in Winnipeg, Isaac and Stuart (1991) introduced the Temperature-Precipitation Index (TPI), and with this concept, examined the relationship between mean daily temperature and total daily precipitation for 56 Canadian stations. Daily TPI values gave no evidence of increased precipitation near 0°C as suggested by Szeto et al. (1988) and Stewart and King (1990). However, since temperatures can vary considerably over the course of a 24 hour period, it was argued that the daily TPI is not an appropriate test of this theory.

In this paper we describe the development of a temperature-precipitation index derived from hourly data. Our study had the following objectives: (1) To estimate hourly precipitation data from daily accumulation amounts and hourly reports of precipitation occurrence and intensity; (2) Assuming that hour to hour data on temperature and precipitation will give a more realistic impression of the temperature-precipitation relationship, to determine how much degradation is sustained when daily means and totals are used; (3) To compare hourly temperature-precipitation indices with analogous dew point-precipitation indices; and (4) Using the hourly archive, to test the specific hypothesis of increased precipitation near the freezing point of water. These objectives are addressed in this study through an analysis of the hourly climate archive for Sable Island data for the month of January. Since the mean monthly temperature at this site in January is near 0°C, any increased precipitation amounts should be clearly identifiable in an analysis of these data.

An analysis of hourly data for Sable Island in January demonstrated with increased clarity than previously possible that there is no increase in either the occurrence or accumulation of precipitation near 0°C as has been predicted elsewhere. On the contrary, the frequency of precipitation occurrence is at is lowest value of approximately 30 per cent in the temperature range (-2°C - +2°C). Maximum values of precipitation occurrence near 100 per cent are observed at temperatures less than -10°C, while values in excess of 80 per cent are observed for temperatures greater than +8°C. Mean hourly accumulations of precipitation increase from near zero at -10°C to approximately 0.2 mm/h at 0°C to approximately 2 mm/h at +10°C. The estimates of TPI from hourly and daily data were 24 per cent and 23.5 per cent respectively.

MODELLING OF GAP WINDS IN HOWE SOUND, BRITISH COLUMBIA.

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Gap winds in western North American coastal fjords are the shallow, often very strong seaward flow of air which occurs when arctic anticyclones move southward against the interior side of the coast mountain barrier. This synoptic scale configuration creates strong low level horizontal pressure gradients oriented down the fjords which

result in gap wind flow through them. A 3-dimensional, primitive equation, mesoscale numerical model (CSU RAMS) has been applied to a case of moderate gap wind flow in Howe Sound. Results from numerical modelling, supported by observations, suggest that the gap wind flow is analogous to the hydraulic flow of water in a channel with phenomena such as supercritical flow and hydraulic jumps apparent.

This leads to the creation of much simpler models based on shallow water hydraulic theory to represent the phenomenon. Observations and results from various models will be presented.

LONG-TERM RUNOFF EFFECTS ON SURFACE CIRCULATION IN NORTHERN BRITISH COLUMBIA WATERS.

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Daily river discharges with daily observations of surface sea-water temperature and salinity from six lighthouse stations on the northern British Columbia coast from 1930 to 1990 have been analysed. Long-term variations, trends and interdependencies of temperature, salinity and runoff data for the different stations as well as their possible causes and consequences will be discussed.

REMOTE SENSING OF SEA SURFACE FEATURES ALONG THE NORTHERN BRITISH COLUMBIA COAST

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This poster presents an overview of surface oceanographic features identified by AVHRR imagery in Hecate Strait and adjacent waters surrounding the Queen Charlotte Islands, Canada, an area still poor in in-situ observations. The observed features and their temporal variability are interpreted in terms of meteorological and hydrological forcing. The effects of tidal mixing are discussed through the application of a finite element numerical model.

THE REGIONAL FORECAST SYSTEM AT CMC: DESCRIPTION AND PRELIMINARY RESULTS

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With the advent of one of the most powerful computers in the world, the NEC SX3\44, the Canadian Meteorological Centre and Recherche en Prévision Numérique will implement an integrated and coherent regional (mesoscale) analysis and forecast system during the fall of 1992.

The regional analysis will provide the Regional Finite Element model with an analysis at a horizontal and vertical resolution identical to that of the model's working grid. This higher resolution analysis scheme will allow a more efficient assimilation of higher spatial and temporal resolution data from new observing systems (wind profilers, ACARS, etc.).

The horizontal resolution of the RFE model will be increased to somewhere in the range of 25-50 kilometers, while the number of levels in the vertical will be increased to approximately 30. Also, improvements to the RFE's dynamics and physics packages will be implemented. These improvements will place the RFE among the highest resolution operational models in the world.

DOPPLER RADAR OBSERVATIONS OF REAR INFLOW JETS IN SOUTHERN ONTARIO

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Many mesoscale convective systems (MCS) have been observed at the King radar station. These MCS are difficult to forecast or observe because the scale size is below the resolution of the synoptic network. Typically, they have squall lines 10-20 km wide at the front edge of the precipitation structure. If the system is sufficiently long lived and steady, a rear stratiform rain region 40-200 km in width may develop that may reveal the presence of a rear inflow jet. Observations of this jet have important implications regarding the forecast of precipitation and severe weather. The origins of this jet have often been attributed either to the convective downdrafts in the squall line or the mesoscale effects in the stratiform region. Evidence will be presented that supports the latter explanation and illustrate the significance of the rear inflow jet for forecasting.

EXPERIMENTS WITH NON-NORMAL MODE INITIALIZATION OF A SHALLOW-WATER LIMITED-AREA MODEL

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A non-normal mode initialization scheme, i.e. an initialization scheme which does not require an explicit computation of the normal modes of the linearized equations is considered. Such a scheme is applied to a shallow-water limited-area model cast on a stereographic projection, for which the computation of the normal modes is too expensive, due to non-separability. In that case of limited area model the relaxation scheme is used in a boundary zone to prescribe the large scale evolution. At first a model whose the domain has a very limited extent (1750 km x 1750 km) is considered and the initialization scheme successfully filters the gravity waves from the simulations. Particular attention is given to: the choice of an initialized or uninitialized field for the relaxation target; the coherence of the initialization scheme with the semi-implicit scheme of the model and the effect of the orography in such a shallow-water model. Then we consider a model with an enlarged domain (10 000 km x 10 000 km), with the preceding regular grid domain at the center and a stretching grid up to the boundaries. In that case we test the impact of using a linearization including most of the ß-terms, against one without ß-terms for the initialization of such a model. The impact of the comprehensive scheme appears less than the impact of using an initialized field for the relaxation, even with such a large domain. As a conclusion and in the two model cases we present the behaviour of the diagnostic quantities used to test the convergence of the initialization scheme, but during the simulations, that confirm the main results of the study.

HISTORY AND PRESENT STATUS OF THE FRENCH PERIDOT NWP SYSTEM

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We briefly present the history of the research project PERIDOT (Prévision à Échéance Rapprochée Intégrant des Données Observées et Télédétectées) that leads to a fine mesh (35 Km) operational NWP system at the beginning of 1985 at the French Meteorological Service. This research project was in the continuity of the high resolution dynamical adaptation studies but trying to improve the prediction by using all the fine scale information available. We mainly discuss the experiments done in a research mode concerning the radiances assimilation, the nonlinear mode initialization and the use of different physical packages. Then we describe the necessary trades off to put all these elements in a coherent operational model and the main changes done in the operational suite through the years. Also are presented the verifications of the fine mesh model with the surface weather observations, that explain how

the low-level meteorological parameters are predicted. Then the different results at higher resolutions (10 km, 3 km) are presented, indicating a way to improve the predictability of the whole system (especially the flow over mountainous regions). At last a tentative evaluation is given indicating the success of the PERIDOT system for the forecasters but also the fields where more research must be done.

COMPORTEMENT ASYMPTOTIQUE DU PASSAGE D'UNE ONDE SOLITAIRE SUR LE TALUS CONTINENTAL

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L'objet d'une telle étude consiste à décrire le comportement d'une onde longue et plus particulièrement d'une onde solitaire incidente lors de son passage sur un seuil dans un fluide homogène. Après avoir déterminé les coefficients de réflexion et de transmission au droit de rupture de pente d'après la théorie de l'eau peu profonde, nous étudions de façon analytique l'équation non-linéaire de Korteweg et De-Vries (K.D.V.) qui régit la propagation de telles ondes. Cette étude nous a permis d'avoir une meilleure compréhension du phénomène. K.D.V. équation est résolue par la méthode de l'inverse-scattering. Cette méthode est particulièrement bien adaptée à l'étude du comportement asymptotique de l'équation de Korteweg-De-Vries.

In this paper we describe the behaviour of a long-wave and specially an incident solitary wave passing over a sill in a homogenious fluid. We determine the coefficients of reflexion and transmission right at the sill using the shallow water theory. We study analytically the nonlinear Korteweg and De-Vries equation which is governed the propagation of long waves. This allow us to understand the mechanisms of the phenomenon. K.D.V. equation is solved using the inverse-scattering method which is specially adapted to study the asymptotic behaviour of the Korteweg-De-Vries equation.

ATMOSPHERIC SOUNDING ANALYSIS ON A MICROCOMPUTER

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Traditionally, all analysis of atmospheric soundings has been performed on paper thermodynamic diagrams. For some calculations, such as buoyant energy or helicity, this can be rather tedious and inaccurate. Aerological sounding have been displayed on computers in recent years, and the software has allowed some manipulation of the data. With the advent of high speed micro computers with excellent video screen resolution, it has become possible to develop software to calculate, display, and modify parameters currently in use, and as a tool for the investigation of new parameters or concepts. The Atmospheric Sounding Analysis Program is software designed to allow the display of individual tephigrams and hodographs, allow historical or spatial overlays, and calculate a wide variety of stability indices, convective, or hodograph parameters. The actual sounding may be modified in a variety of methods and the various calculations may be redisplayed. In addition there is the option to display a number of parameters from up to 30 radiosonde stations on a background map of a significant portion of North America.

SALINITY CONTROL OVER DEEP CONVECTION

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The thermohaline circulation of the world ocean is driven by deep convection at high latitudes. The convection is forced by destabilizing surface buoyancy fluxes which result when cold, dry winds blow over relatively warm water. The process is thought to be inhibited by low surface salinities since relatively fresh water freezes before it cooling enough to become as dense as the deep water. This led Malmberg (1969, Jokull, 19, 30-43), in a study of the hydrography near Iceland, to suggest a simple criterion: deep convection will not occur in regions with surface water fresher than 34.7 PSU.

Malmberg's analysis neglected the increase of salinity which results from the evaporation. The present work extends Malmberg's work by allowing for evaporative flux as well as heat flux.

For typical conditions, the evaporative flux will increase the salinity by about 0.03 PSU for each degree of temperature decrease. This leads to a new criterion: deep convection will be inhibited in regions with surface salinity less than 34.9-(T+T0)/30, where T0 is 1.8C. This new criterion agrees roughly with Malmberg's criterion, in the sense that each is consistent with the observation that deep convection takes place in the North Atlantic and not in the North Pacific. However, in many regions where deep convection occurs, the difference between the criteria is very significant: for example, in the decade-long Bravo time series of TS measurements in the Labrador Sea, about a third of the observations fall between the two criteria.

A DIAGNOSTIC STUDY OF THE EARLY PHASES OF 16 NORTH PACIFIC CYCLONES

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The difficulty in prediction and the devastating effects of explosive cyclogenesis are well known. Considerable effort has been made in the past to understand the mechanisms at work during the period of most rapid deepening. It is however being increasingly understood that analysis of the period before the rapid development is of equal importance in the accurate prediction of explosive cyclones.

This study uses quasi-geostrophic diagnostics to compare 8 rapidly developing cyclones with 8 more weakly developing cyclones. These cyclones all underwent their period of most rapid deepening within a 5 degree latitude by 5 degree longitude region over the Kuroshio.

A previous study of these cyclones showed considerable differences in the composite, synoptic and diagnostic fields of the two groups, at the time of commencement of most rapid deepening. This study extends the time period back 36 hours before this time and forward 24 hours. An ensemble of anticyclone tracks for the early times shows a distinct preference for a downstream high for the stronger cases. This is supported by a similar result found at 500mb. Statistically significant wind asymmetries of the surface cyclones reflect this result too. The physical significance of a downstream high is the transport of warm moist air into the region of cyclogenesis.

THE INNER BOUNDARY LAYER OVER A PRAIRIE LAKE

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Evaporation from open water is an important component of the water budget in semi-arid regions of the prairies. A study on the effects of wind speed, spray from breaking waves, atmospheric stability and the advection of sensible heat on evaporation began in 1991. Experiments were conducted in the summer of 1991 in Quill Lake, Saskatchewan. The lake is shallow and roughly circular with a diameter of 20 km. Little or no vegetation exists on the 1 km wide mud flats that ring the lake. The surrounding terrain is very flat (largely wheat fields with few trees). Vertical profiles of air temperature, humidity and wind velocity were measured at 10 minute intervals immediately downwind of the lake. Simultaneous profiles were made at the upwind edge of the lake to establish incident stability conditions. A hydrometeorlogical tower recorded air temperature, humidity and net radiation over the lake as well as vertical profiles of temperature in the water column and in the lake sediments. Using results on the distribution of water vapour, temperature and velocity in the inner boundary layer, estimates of evaporation integrated across the lake will be presented.

IPIX RADAR - OCEAN AND METEROLOGICAL APPLICATION

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The Communications Research Laboratory (CRL) of McMaster University has developed an X-Band research radar for use in ocean surveillance and radar meteorology applications. Features of this radar include Doppler, polarization and frequency agility. In addition, the system is extremely flexible and is transportable. An overview of the system and its capabilities is outlined.

Results of experiments performed off the Newfoundland coast are also presented. These include measurements in both Doppler and polarization domains of sea clutter and floating targets as well as rain in the presence of sea clutter. In addition, preliminary polarization measurements of the bright band in stratiform rain will be used to illustrate the potential use of the radar in meteorology.

A PRELIMINARY EVALUATION OF THE ERS-1 SAR SPECTRA USING THE 1G (FIRST GENERATION) AND THE 3G (THIRD GENERATION) VERSION OF A SPECTRAL OCEAN WAVE MODEL

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The ERS-1 Synthetic Aperture Radar (SAR) wave spectra validation experiment was carried out over the Grand Banks region off Newfoundland from November 10-26, 1991. During this period, there were 12 ascending and descending ERS-1 passes over a cross-over node located about 185 km southeast of St. John's, Newfoundland. The cross-over node was the principal validation site where in situ measurements were taken with three wave buoys (two directional Wavec buoys and one non-directional waverider buoy) and up to four meteorological buoys. The buoys were deployed at locations which coincided with a selected set of grid points of the Canadian Spectral Ocean Wave Model (CSOWM). Besides in situ measurements, a C-band SAR was flown aboard a Convair-580 aircraft on seven occasions which coincided with ERS-1 satellite passes over the validation site.

A preliminary evaluation of the SAR-derived spectra aboard the satellite ERS-1 as well as aboard the Convair aircraft is presented in this paper. The two sets of spectra are compared against the two dimensional wave spectra generated by the 1G and 3G versions of CSOWM. The CSOWM was driven by the boundary layer winds obtainable from the regional weather prediction model of the Canadian Meteorological Centre (CMC) in Montreal. The two sets of SAR-derived spectra are matched against model generated spectra to delineate differences and similarities. These differences and similarities are interpreted in the context of in situ measurements.

ON THE INTERACTIONS BETWEEN SYNOPTIC SCALE EDDIES AND THE PNA TELECONNECTION PATTERN

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The kinetic energy exchanges between the synoptic scale eddies and the mean-monthly Pacific/North American (PNA) anomaly patterns are investigated. This study involves 23 winters of upper tropospheric data for the Northern Hemisphere. Composites of synoptic scale momentum and vorticity fluxes are calculated separately for the positive and negative phases of the PNA pattern. Maps of the Northern Hemisphere are produced to illustrate the locations of energy exchanges between the synoptic scale eddies and the mean-monthly flow during periods when the PNA pattern is strong and positive or strong and negative. The geographical distribution of eddy vorticity forcing and its interaction with the teleconnection pattern are shown. In particular, the steering effect of the PNA pattern on the synoptic scale eddies is illustrated. Calculations are under way to determine whether the height tendencies generated by the synoptic scale eddies are such as to reinforce or to weaken the PNA anomalies.

DOPPLER "FINGER" SIGNATURE: A CASE STUDY OF THE JUNE 29, 1991 SUPERCELL

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During the evening of June 29, 1991 a short lived supercell produced significant damage 40 km north of King City radar in southern Ontario. Satellite imagery shows this cell split near Georgian Bay with the "right mover" passing through radar coverage. One hour prior to supercell formation an anomalous "finger" of outbound velocities was observed at the location of the convective cell. This pattern has been observed in a number of previous cases under similar synoptic settings (Mike Leduc, 1991; Paul Joe, 1988). The lead time given by this signature has important implications to severe weather forecasting. Evidence presented will show that this doppler signature is characteristic of a mesolow which, combined with high helicity values, enhances the development of these warm frontal convective cells.

SEVERE WIND DAMAGE DUE TO A REAR INFLOW JET: A CASE STUDY OF THE 28 MARCH 1991 MESOSCALE CONVECTIVE SYSTEM

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On the early mornings hours of 28 March 1991, a mesoscale convective system with damaging winds passed through southern Ontario. Early in its life history, in Michigan, tornadoes were reported with this system while the damage in Ontario was attributed to straight line winds. A clue to the character change in the system may be due to a change in the environmental conditions described by helicity. Doppler radar and satellite observations showed that the system was decaying while in Ontario. The damage was attributed to a rear inflow jet observed on Doppler radar. This jet appeared to have its origins in the stratiform rain region trailing the leading squall line. The sudden evolution of the jet and the damage pattern suggests a periodicity to the its formation.

DYNAMICS OF A MATURE FRONT IN A UNIFORM POTENTIAL VORTICITY SEMIGEOSTROPHIC MODEL

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Early models of atmospheric frontogenesis have demonstrated the existence of solutions to an inviscid, two-dimensional subset of the equations for large scale atmospheric motion, that develop discontinuities after a finite integration period. These equations, known collectively as the semigeostrophic system, can be reduced to a Laplace equation with the aid of a coordinate transformation and thus can be treated analytically.

In the study presented here, the solution of the semigeostrophic system forced by a horizontal deformation field, is extended beyond the initial formation of a discontinuity. The dynamical aspects of the time-dependent flow are compared to observational studies and results from more sophisticated frontogenesis models. Features of interest include the development of a low-level vertical velocity jet originating at the point of intersection of the discontinuity surface with the lower boundary. Other aspects of the model dynamics are also examined by considering the fields of potential temperature, alongfront wind, and Richardson number.

DISPERSION OF RHODAMINE FROM AN UNDERWATER DIFFUSER IN THE RIMOUSKI COASTAL ZONE.

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An underwater diffuser releases in the Rimouski coastal zone, at a location 500 m offshore where depths are about 2 meters, some 25 000 liters of treated sewage water per minute . An experimental program was set up to measure the dilution of this sewage water as it reaches a marine natural resources park located along the shoreline, some 3 km to the east of the diffuser.

Results from current meters , lagrangian drifters, tide gages and a meteorological station, deployed in the region in order to understand the variability of the circulation, are presented. It is shown that waters from the site of the diffuser are advected to the marine park, under predominant wind conditions.

A continuous release of Rhodamine wt from the diffuser, during one tidal cycle, was then monitored at sea with a fluorometer in order to quantify its dilution as it progressed away from the diffuser. It is shown that, for an original Rhodamine injection concentration of 2500 ppb, the surface waters at the diffuser site have a concentration of about 500 ppb, implying a 1:5 dilution. Three kilometers away from the diffuser, concentrations dropped to about 50 ppb, implying an overall dilution rate of about 1:50. Provided the sewage waters contain toxic soluble materials, this rate is well under the rate of 1:200 which is often suggested for negligeable environmental impacts from sewage underwater diffusers.

A NEW APPROACH TO CALCULATE COLLISION RATES FOR DROPLETS IN TURBULENT CLOUDS.

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The role of turbulence in the formation of precipitation by the warm-rain process is still unclear. We have developed a method to systematically examine the effect of turbulence on the collision rates. In order to apply the stochastic coalescence equation, the probability of collisions between droplets is calculated by following droplet trajectories in turbulent flow. Scale analysis of the problem indicates that only the smallest scales of turbulence affect the collision process. The trajectory calculations constitute an initial value problem for two droplets interacting hydrodynamically under the influence of gravity which, additionally, are embedded in the external turbulent field.

The turbulent field is assumed to be stationary, homogeneous and isotropic, and modeled as a series of random Fourier modes. The spectrum assumed is the Pao spectrum for the dissipation subrange. The hydrodynamic interactions between droplets are obtained by direct calculation of the hydrodynamic forces parallel and perpendicular to the line of center of the droplets. Both, no-slip and slip-flow boundary conditions are used.

THE PERFORMANCE OF THE CANADIAN SPECTRAL OCEAN WAVE MODEL (CSOWM) DURING THE SAR "CALIBRATION/VALIDATION" EXPERIMENT

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During the "calibration/validation" experiment for the ERS-1 Synthetic Aperture Radar (SAR) over the Grand Banks area off Newfoundland, a first-generation (1G) version of the CSOWM was run in real time, being driven by the boundary layer winds obtainable from the regional weather prediction model of the Canadian Meteorological Centre (CMC) in Montreal. The model generated wave products were transmitted in real time to the research vessel CSS Hudson which was involved in collecting in situ measurements at several locations within the ERS-1 cross-over

node, the principal validation site for the experiment.

In this paper, preliminary results of the evaluation of the CSOWM against buoy measured wind and wave data are presented. For this evaluation, wave model products were generated by running two versions, 1G (first generation) and 3G (third generation) of the CSOWM in a hindcast node using three-hourly winds which were archived during the field experiment. The evaluation will focus on the differences between the model products generated by the 1G and 3G versions of the CSOWM.

INTRASEASONAL VARIABILITY AND THE GREENHOUSE EFFECT

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Doubled CO_2 simulations by the Canadian Climate Centre (CCC) general circulation model (GCM) show a decrease in the intraseasonal (25 day - 120 day) variability compared to the model's "base" or "1 x CO_2" climate. The intraseasonal variability of the 500 mb geopotential, for example, displays a decrease of over 10 percent when averaged over the Northern Hemisphere and a decrease of nearly 15 percent over the Southern Hemisphere.

The intraseasonal variability of the 500 mb geopotential of the GCM's base climate is compared to observations. The model's base climate is quantitatively similar to the observed field but exhibits only about one-half the observed values.

The 500 mb geopotential is a relatively straightforward quantity to observe and a fairly long record of observations exists for the Northern Hemisphere. This record is examined for the decreasing trend inferred from the GCM simulations.

AN ASSESSMENT OF THE WKBJ APPROXIMATION USED IN GRAVITY-WAVE DRAG PARAMETERIZATION SCHEMES

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The vertical structure of topographically induced, infinitesimal amplitude internal waves in atmospheres with varying wind and stability profiles is studied with a numerical model. Despite its simplifications, this model nevertheless retains transient effects and internal reflections that may result from time and vertical variations of the index of refraction. It is shown that these two factors may lead to wave structures differing substantially from those obtained through the WKBJ approximation that neglects them. This is an important finding considering that the WKBJ approximation is always invoked in gravity-wave drag parameterization schemes implemented in virtually all large-scale models today to account for the composite effect of subgrid-scale topographic disturbances.

A NON-HYDROSTATIC MODEL IN HYDROSTATIC-PRESSURE COORDINATE

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With the anticipated advances in supercomputing, numerical weather prediction models will soon be integrated at resolution such that non-hydrostatic effects could no longer be neglected. Tanguay, Robert and Laprise (Monthly Weather Review, 1990) have developed an efficient model for the integration of the Euler equations using semi-implicit and semi-Lagrangian numerical techniques. Topography has since been incorporated in this model by Denis and Robert using a height coordinate transformation similar to that used by Clark in an anelastic model. An alternative coordinate termed "hydrostatic-pressure" coordinate appears to be quite convenient for implementing the semi-implicit marching scheme in a model based on the Euler equations. The field equations formulated in a

terrain-following version of this novel coordinate take a form which conveniently parallels that of "sigma" coordinate hydrostatic models.

RECOVERY OF UNOBSERVED VARIABLES FROM SINGLE-DOPPLER RADAR OBSERVATIONS

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In the next few years, many conventional radars will be replaced by Doppler radars. Thus, there is a need to develop techniques able to extract as much information as possible from Single-Doppler measurements. Recently, the adjoint technique (a 4D data assimilation method), has been proposed to retrieve the full three-dimensional wind and temperature fields around the radar site.

The application of the adjoint technique for Doppler data processing will be presented using a simple two-dimensional advective model. Observational and model errors as well as the problem of including boundary conditions as control values will be discussed.

COMPARISON BETWEEN CLOUD CHEMISTRY OBSERVATIONS AND SIMULATIONS

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Cloud chemistry models are needed to understand the relative importance of different species and processes that influence the chemistry of cloud and precipitation. To evaluate the level of confidence of a model, it is necessary to compare the results of simulations with field measurements. Observed temperature, humidity, wind and air chemistry profiles are therefore used to initialize a three dimensional convective cloud chemistry model, and afterwards the simulated aqueous phase concentrations are compared with cloud and rain water sample analyses. The model includes detailed dynamical and microphysical processes and aqueous phase chemistry. Sulphur dioxide, nitric acid, hydrogen peroxide, ozone, ammonia and sulphate chemistry are present in the model. The observations used come from a field study undertaken in the Muskoka area during July-August 1988.

TEMPERATURE AND SALINITY CHARACTERISTICS OF BAIE DES CHALEURS.

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Time series data of temperature and salinity from three current meters moored in 1988 at different locations along the north shore of Baie des Chaleurs, Gulf of St-Lawrence, were analysed to characterize the TS field including frequent upwelling events. Cross correlation analysis show moderate to high correlation between the three stations. The time lags observed suggest that the two eastern stations, Gascon and Bonaventure, experience the same event, propagated through a front, while the remaining station farther west, Carleton, would be a region of local upwelling. The dominant frequency of the upwelling events is 10 days which fits with meteorological forcing. The relation with wind as the driving mechanism is also discussed.

ANALYSE DE L'EFFET DES VARIATIONS HORIZONTALES DES PARAMÈTRES MÉTÉOROLOGIQUES SUR LA CORRECTION TROPOSPHÉRIQUE DES DISTANCES TERRE-SATELLITE

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L'effet des paramètres météorologiques (pression, température, humidité) sur la réfractivité est bien connu. De façon générale, les corrections troposphériques appliquées aux distances terre-satellite ne tiennent compte que des variations verticales des paramètres météorologiques. Cette hypothèse est généralement bien acceptée pour des distances terrestres qui sont en général inférieures ê 30 km. La même hypothèse est cependant discutable lorsqu'il s'agit de distances observées sur des satellites terrestres. Pour une distance zénithale de 90o, la partie troposphérique d'une distance terre-satellite est d'environ 400 km lorsque la tropopause est ê 16 km de la surface terrestre. La trajectoire suivie par l'onde électromagnétique subit l'effet des variations horizontales des paramètres météorologiques utilisés dans le calcul de la correction troposphérique.

L'objectif de cet article est d'analyser l'effet des variations horizontales des paramètres météorologiques sur le calcul de la correction troposphérique ainsi que de vérifier l'exactitude des formules standards utilisées pour ce calcul. La correction troposphérique est déterminée, d'une part, par intégration numérique avec une quadrature Gaussienne. L'indice de réfraction le long de la trajectoire de propagation est évalué par le Krigeage universel transitif en utilisant des observations météorologiques de surface et dans l'espace. Les résultats de cette intégration numérique sont comparés aux résultats obtenus par la formule de Saastamoinen pour différentes distances zénithales. Différentes configurations météorologiques sont utilisées afin d'évaluer l'effet des variations horizontales des paramètres météorologiques sur la correction troposphérique ainsi que pour vérifier l'exactitude des formules standards utilisées pour le calcul de cette correction.

Les résultats préliminaires indiquent que les conditions atmosphériques doivent être connues dans un rayon de 400 km autour de la station d'observation si on désire une correction troposphérique précise. Dans des conditions météorologiques semblables, on constate également que l'imprécision des formules standards augmente avec une augmentation de la distance zénithale et que cette imprécision peut atteindre 1 mètre dans des conditions extrêmes.

SOLAR RADIATION ABSORBED AT THE SURFACE FROM 5 YEARS OF ERBE MEASUREMENTS

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As a result of recent satellite-based observation programs, knowledge of the radiation budget at the top of the atmosphere (TOA) has improved substantially. In comparison, there has been relatively little improvement in knowledge of the surface radiation budget, even though radiation budgets at the surface are at least as important as TOA budgets.

Based on extensive radiative transfer modelling a simple parameterization has been developed that relates the net solar flux at the surface to the scattered flux at the TOA. The validity of the parameterized relationship has been verified by comparing the net surface flux deduced from applying the parameterization to ERBE measurements with the results of tower measurements. The parameterization was then applied to 5 years of ERBE radiances and ECMWF humidity data to obtain global climatologies of the net solar radiation at the surface on a 2.5°x2.5° latitude - longitude grid. In addition to the net solar radiation, shortwave cloud forcing at the surface and in the atmosphere are calculated from the solar radiation budgets obtained separately for clear and cloudy conditions. Spatial and temporal variabilities of these quantities are analyzed, and global and zonal means of the solar radiation budgets are compared with values based on surface observations.

WSR-88D:MESOSCALE CHARACTER OF INTENSE WINTER STORMS

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The Weather Surveillance Radar-1988 Doppler (WSR-88D) previously known as NEXRAD has been used operationally in the United States for over a year at this writing. Although, data have been collected only in Connecticut, Oklahoma, Florida, Virginia, and surrounding areas, a variety of weather events have been sampled and considerable mesoscale storm characteristics have been revealed. These events include severe convective storms, as well as larger scale winter storms. Characteristics revealed include mesocyclones, associated complex gust front structure, supercellular reflectivity structure; a tropical-like, small, eye-associated winter storm circulation center; and less dramatic, mesoscale structures of other snow storms. Radar characteristics, especially the very high system sensitivity enable observation of structures not previously observed. These features permit improved diagnostics, understanding, nowcasts, and forecasts. While details of some of the convective storms have appeared elsewhere, in this paper we will examine the structure of three winter storms, one on the U. S. mid Atlantic coast, and two in the southern Great Plains. Synoptic, subsynoptic, and mesoscale structural aspects of these storms as revealed by conventional upper air, surface, and radar-revealed detail will be shown and inter-related.

CURRENT AND HYDROGRAPHIC VARIABILITY ON THE SOUTHEAST SHOAL OF THE GRAND BANK

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The structure and variability of currents and hydrography over the Southeast Shoal in spring-fall are described using moored measurements taken in 1986-89, hydrographic surveys, and hydrographic data obtained from the Marine Environmental Data Service.

Current variance is dominated by the tidal-inertial band, with the vertical average of the principal M2 tidal current in reasonable agreement with the Petrie et al. (Atmos-Ocean, 1987) numerical model. Residual currents on the Shoal are generally westward at a few cm/s, in agreement with numerical model predictions (Greenberg and Petrie, J. Geophys. Res., 1988; Hukuda et al., J. Geophys. Res., 1989) for steady flow of the Labrador Current into the region. The low-frequency current standard deviations are a few cm/s, with associated excursion standard deviations of order 5 km.

The hydrographic observations show the seasonal development of strong two-layer stratification with the following additional features: (1) the persistent occurrence of relatively-warm bottom water over the Shoal (Loder, Can. J. Fish. Aquat. Sci., 1991), but with varying structure and position; (2) interannual variations in salinity of nearly 1 unit, apparently associated with Labrador Current variability; (3) a strong influence from Tropical Storm Charlie in August 1986, including a local surface temperature drop of nearly 10 degrees C; (4) occasional intrusions of Slope Water onto the Bank's southwestern slope; and (5) suggestions of isolated eddies occasionally moving across the Shoal.

ANALYSE DE COMPOSÉS UV-PROTECTEURS PRÉSENTS DANS DES CULTURES DE PHYTOPLANCTON ET DANS DES EAUX MARINES.

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Suite aux suppositions récentes concernant une déplétion de la couche d'ozone dans l'hémisphère nord, nous avons analysé les effets d'une augmentation des radiations ultra-violettes sur le phytoplancton marin. Deux espèces ont été étudiées: Alexandrium excavatum, un dinoflagellé démontrant une forte absorbance dans la zone spectrale de

l'UV, et Thalassiosira nordenskioldii, une diatomée absorbant peu dans l'UV. Ces 2 espèces sont communes dans l'estuaire et le golfe du Saint-Laurent. Les acides aminés de type mycosporine (AAM) ont été proposés comme un des principaux agents UV-protecteurs (Dunlap et al. 1988). Ces composés ont été séparés et identifiés par chromatographie liquide haute performance - spectroscopie à barrette de diodes chez les 2 espèces étudiées et dans des échantillons d'eaux de surface récoltés au printemps 1992 dans le Saint-Laurent. Le présent travail montre également les effets sur la concentration et la composition d'AAM d'un supplément d'UV-A fourni en accompagnement à une lumière blanche (néons) pendant plusieurs semaines de croissance des cultures d'algues.

ANALYSIS OF UV-PROTECTIVE COMPOUNDS IN ALGAL CULTURES AND MARINE WATERS.

Recent speculations about ozone depletion over the Northern hemisphere have prompted us to look at effects of increases in UV radiation on marine phytoplankton. Two algal species, common in the estuary and the gulf of St. Lawrence, were selected: Alexandrium excavatum, a dinoflagellate that possesses strong absorbance in the UV range, and Thalassiosira nordenskioldii, a diatom with little absorbance in that range. Mycosporine-like amino acids (MAAs) are compounds that have been proposed as UV-protective (Dunlap et al. 1988). We separated and quantified by HPLC-PDAS the various MAAs present in the two algal species tested as well as in samples of surface waters collected during the spring of 1992 in the St. Lawrence. The present work also shows the effects of daily exposure to UV-A-supplemented white light on the MAAs composition and concentration in the 2 algal species.

BAROCLINIC FORCING OF THE MEAN ATMOSPHERE

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The linearized quasigeostrophic potential vorticity equation is solved in a b-channel under conditions of uniform vertical shear but non-uniform static stability. This model includes both a tropopause and b and is thus considered more representative of the real atmosphere than the models of both Charney and Eady, while retaining a high degree of simplicity. The mean atmospheric response to the fastest growing normal mode is deduced by solving the Eulerian - mean equations. This analysis yields second order tendencies in the zonal mean temperature and zonal wind. In the centre of the channel these tendencies are consistent with Gutowsk's (1985,1989) notion of baroclinic adjustment. In particular, the vertical shear is reduced and the static stability increased in such a way as to eliminate the potential vorticity gradient near the surface and thus stabilize the flow as per the Charney - Stern theorem. In the northern part of the channel, however, a region of enhanced baroclinicity forms, with reduced static stability and enhanced vertical shear. This suggests the possibility of secondary development at smaller scales, and may provide a dynamical mechanism relevant to certain types of polar low formation which are baroclinic in nature and tend to form north of the polar front. Indeed, Gutowski et al (1989) , and others, have found such development in non - linear primitive equation models of baroclinic instability.It is seen that linear quasigeostrophic theory captures much of the essence of the baroclinic adjustment hypothesis, which can be viewed as the end result of basic dynamical processes such as the heat flux convergence of the primary baroclinic wave.

AN OVERVIEW OF MESOSCALE MODELLING IN CANADA: TODAY AND TOMORROW

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Over the past decade, regional-scale numerical models have gradually emerged as important research tools for increasing our understanding of mesoscale weather systems and for improving quantitative precipitation forecasts. In Canada, considerable work has taken place in both mesoscale model development and applications. Various groups are active within the Canadian university community. Within AES, most of the operational forecasting and research work at the regional- and meso-scale has been done in connection with versions of the regional finite element (RFE) model. Our modelling capabilities also include a meso- / cloudscale version of a nonhydrostatic,

anelastic model which can be nested into the mesoscale RFE model.

An overview of recent mesoscale modelling development and research is given. The presentation is illustrated with results from recent modelling work. Examples of applications are taken from a wide variety of phenomena including explosive marine cyclogenesis over the Atlantic and the Pacific, springtime continental cyclonic development, polar lows over Canadian waters, polar air mass transformation over the Gulf of Mexico, and the environment of summertime severe weather. An outlook at work being done for future versions of mesoscale models concludes the presentation.

MEDITERRANEAN HEAT CONTENT AND FLUXES: 1950-PRESENT

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The semi-enclosed nature of the Mediterranean sea makes it a useful test basin for studying water properties that might reveal trends or interannual variability.

There exists much historical data for the Mediterranean. We have focused on developing an objective analysis scheme based on the Barnes algorithm to map out temperature time series from the data compiled in the NODC database. The time series of the heat flux has been calculated and compared with the work of Garrett et al. (1991). These data are also being compared with the results of models being developed to represent the circulation in the Mediterranean. Results of the analysis and an outline of work to be done will be presented.

ON THE NONLINEAR COUPLING BETWEEN SWELL AND WIND WAVES

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The effect of nonlinear coupling due to resonant interactions on a bimodal spectrum is examined in the case of deep water waves. Following Hasselmann (1963), a swell decay time scale is first estimated for a monochromatic swell coupled with a typical wind wave spectrum. This time scale indicates that the nonlinear coupling generally causes the swell to decay at a rate which decreases rapidly as the swell frequency moves away from the peak frequency of the short waves. However, it is also shown that the coupling makes the swell grow at the expense of the local sea in the frequency range just below the peak frequency of the short waves. Estimation of the nonlinear transfer for a swell of finite bandwidth confirms these results, and also indicates a maximum coupling when the swell direction is about 40 deg. to the mean direction of the short waves.

ON THE SALINITY BUDGET OF THE NORTH PACIFIC OCEAN

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Salinity is one of the critical factors determining ocean circulation and characteristics. The budget of salinity or freshwater for the North Pacific Ocean basin is considered. Based on hydrographic and related measurements across a section at 35 N, it is possible to compute the oceanic freshwater flux. This should be balanced by precipitation-evaporation-river runoff north of the section and by flow through the Bering Strait. Uncertainty in precipitation estimates is a major difficulty. The other data can be used to provide limits on possible magnitudes of total precipitation. The salinity budget will be compared with recently published information on meridional heat flux.

VARIABILITY OF LIPID AND MORPHOMETRIC CONDITION INDICES OF INDIVIDUAL COD LARVAE (*GADUS MORHUS*) FORCED BY FEEDING REGIME IN THE LABORATORY

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Recent interest in lipid class measures of condition demand an assessment of this technique in relation to gravimetric and multivariate morphometric measures. We examined variability in triacylglycerol (TG) / sterol and morphometric condition indices of post-yolk sac cod larvae first starved and then fed copepod nauplii at realistic field concentration (100 particles l^{-1}). Before feeding, we starved larvae for 11 days after the modal hatch date (4 to 8 days after yolk sac resorption) to reduce condition. The duration of starvation brought larvae close to the point after which the effects of starvation are irreversible. Coefficients of variation in lipid condition (triacylglycerol/sterol) were 30-150 % (N = 18-85 individuals), compared with 10-25 % for dry weight. Eighty-six to 90 % of larvae contained no detectable TG, even after feeding had resumed for 6 days. Our assessment that TG was either not present or below the TLC-FID measurement threshold in small individually analyzed cod larvae shows important limitations of the lipid condition index. Principal components analysis revealed a hierarchy of factors describing variability among individual larvae: body area and gut dimensions accounted for more of the variance than dry weight, which in turn explained more of the variance than TG. Lipid classes alone provide less resolving power to assess changes in condition over a few days than do combined multivariate morphometric, gravimetric and biochemical indices when working with these very small, individual larvae.

HETEROGENEOUS O_3 LOSS IN THE STRATOSPHERIC POLAR O_3 LOSS BUDGET ?

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The current chemical mechanism believed to be responsible for the depletion of ozone in the polar regions is perturbed gas phase chemistry involving reactions of ClO and Cl_2O_2. The source of the perturbed chemistry is the reactions of Cl_x and NO_y species on polar stratospheric clouds (PSCs), type I and type II. However, recent studies have indicated that the current chemical mechanism believed to explain the Antarctic ozone hole is unable to completely account for the total column O_3 loss observed in the spring. The O_3 minimum observed in the spring is lower than that calculated even when all the odd chlorine is converted to active forms and allowance is made for bromine chemistry. Further, the rate of O_3 depletion is likely to be more rapid than previously thought in light of the recent re-analysis of low zenith angle TOMS data which indicate that retrieved TOMS ozone levels are too low at high solar zenith angles. In order to reproduce the observed column O_3 depletion the PSC processing region must be much larger than presently thought (17-20 km) or additional depletion mechanisms must be operating over this height range. One such mechanism that we consider is the heterogeneous O_3 loss on the surface of atmospheric aerosols. We have proposed such a mechanism to explain O_3 loss at the ground in the Arctic spring. A similar mechanism may operate in the polar stratosphere and involve direct destruction of O_3 upon the surface of the H_2SO_4 aerosols which may be supercooled at the ambient low temperatures. In addition, concomitant production of Cl_2 occurs in the presence of HCl which enhances the conversion of inert Cl to active Cl. However, for the mechanism to operate in the polar stratosphere would require some sort of temperature dependence, such as the solubility of HCl in H_2SO_4, so that the reaction occurs over a limited height regime. We will present results of a numerical study investigating the possibility of such a mechanism and its impact on the O_3 loss budget. Of course, these results must also be compatible with constraints involving H_2SO_4 ozone interactions at other latitudes and we will address these constraints.

SIMULATION OF THE ASIAN SUMMER MONSOON WITH THE CANADIAN CLIMATE CENTRE GCM: SENSITIVITY TO THE REPRESENTATION OF MOIST CONVECTION

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The monsoon circulation is the most prominent feature of the summer climate of India and Southeast Asia. The location and structure of the Asian summer monsoon, as simulated by the CCC GCM, while broadly realistic, has systematic deviations from observed climatology. These biases are sensitive to the treatment of moist convection in the model. This paper provides a brief outline of recent improvements in the parameterization of moist convection in the CCC GCM and illustrates some of the effects of these on simulations of the monsoon.

THE EFFECT OF VARIOUS DISDROMETER CALIBRATIONS UPON THE MEASUREMENT OF RAINDROP-SIZE DISTRIBUTIONS IN MALAYSIA.

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Raindrop spectra with multiple peaks in number density have been frequently observed using Joss-Waldvogel disdrometers. The relative heights of these peaks are similar to those of peaks produced when a Marshall-Palmer distribution is input to the disdrometer signal processing unit and caused by the discrepancies between the actual channel boundaries and the manufacturer specified channel boundaries into which raindrops are sorted. Thus,the peaks observed in the field are almost certainly instrument-related and are shown to be due to the manner in which a best fit curve is chosen to represent the calibration data. When analyzing data collected during Phases I and II of the Joint Warm Rain Experiment of the Malaysian Meteorological Service and the University of Toronto it is seen that multiple peaks in the time-integrated raindrop spectra appear when best fits of the calibration data are used, but only single peaks when a linear interpolation between calibration points is used. However, rainfall and radar reflectivity calculated from the best fits differ by at most 4 % from that obtained using the linear interpolation between calibration points.

The implications of this work on the utility of disdrometers for measuring raindrop spectra are discussed. A comparison of measured raindrop spectra with the results of numerical models, which independently show raindrop spectra with three peaks, will be made.

OBSERVING ICE PROCESSES IN THE NEWFOUNDLAND MARGINAL ICE ZONE DURING CASP II, MARCH 1992

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Experiments were conducted in the Newfoundland marginal ice zone (MIZ) during March 1992 to address the processes which influence the drift and decay of pack ice, to calibrate remotely sensed observations and to improve ice drift forecasts. The work was carried out as part of the Canadian Atlantic Storms Program (CASP II) from the research ship CSS Hudson. The present results focus on the region between latitudes 50° and 51°N, and longitudes 52° and 48° W. Ice drift in the Newfoundland MIZ is influenced by many factors - winds, ice properties and ocean properties. A suite of instruments was deployed on an ice floe about 100 km west of the ice edge to collect ice velocity, wind, air temperature and water temperature/salinity data. In addition, three satellite tracked beacons were deployed in a triangular array to monitor ice drift. An intense storm passed through the area during the study period. The vertical current shear increased by a factor of two and the thickness of the mixed layer increased from 100 m to 130 m. The data are used to explain the ice response to wind forcing in different ice and oceanic conditions.

The interaction between floes is a contributor to ice deterioration and a major influence on wave attenuation in the pack ice. It is also a factor in MIZ mechanics and ice drift. Motion packages were used to record the wave induced motion of individual floes with diameters of 10-50 m and ranging between 0.3-3.5 m thick. Three translational accelerations, two tilts and compass orientation were sampled digitally at 62.5 Hz, and extensive use was made of video to estimate ice contact area during collisions and impact velocity. A pressure sensitive panel provided some direct measurements of contact area and allowed collision forces to be estimated by ignoring the influence of added mass. Maximum pressures averaged over contact areas of 0.2 m^2 were of the order of 1 MPa, while most pressures were an order of magnitude below this value. Waves propagated into the ice pack are a necessary contributor to collisions. Ice motion spectra 100-150 km within the ice pack show that waves are from the eastern ice edge and are dominated by swell with a period greater than 12 s. Floes collide and separate under wave induced motion; there is little evidence of elastic rebound and floes separate slowly following collision due to their position in the direction of wave propagation. When secondary collisions occur, it is through the transfer of angular momentum.

Ice observations using the European Space Agency Satellite, ERS-1, are possible over a wide range of spatial scales using the different microwave sensors (SAR, scatterometer, altimeter, ATSR/M). During the cruise, several ship transects were made through the ice at 51°N. Systematic ice observations made from the bridge compared well with high resolution video recordings made at different heights during helicopter flights. The important spatial variability in ice type and coverage illustrated by these observations will have to be considered when evaluating ERS-1's remote sensing capabilities in estimating sea ice cover.

The above mentioned processes and observations are important inputs to the Integrated Sea Ice and Iceberg Forecast System (IIFS) which is an ice data management and forecast system. This PC-based system consists of iceberg, sea ice and iceberg ensemble models, a database management system and mapping software. Starting with observed ice conditions, forecasts for periods of up to 48 hours are based on observed and forecast spatially varying environmental conditions. During CASP II, the IIFS was used to provide sea ice edge forecasts in real time which assisted in planning cruise activities. In addition, research objectives focused on (1) evaluating the forecasts against actual conditions, (2) studying the effects of currents, winds (gridded and site-specific), waves, air and water temperatures on the position of the ice edge, (3) comparing satellite-sensed daily ice edge information with ship and helicopter transects and (4) processing all incoming real-time weather data for the IIFS.

MEASUREMENTS OF THE MOTION, THICKNESS AND TOPOGRAPHY OF SEA ICE USING MOORED SUBSEA SONAR

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A self-contained Ice-Profiling Sonar (IPS) has been developed which is capable of measuring, at very high resolution, the thickness of sea ice and its small-scale topography. The IPS can observe the ice cover throughout the year, monitoring seasonal changes in ice cover over track lines several thousand kilometres in length. A self-contained doppler sonar is operated in conjunction with the IPS to provide a horizontal spatial coordinate for the thickness measurements. Analyses of ice-profile data are providing ice-thickness statistics, and information on the occurrence of sea ice of extreme draft over the shallow continental shelf of the Beaufort Sea. A continued series of deployments over several years is allowing fluctuations in the ice thickness climate of the area to be observed. Interpretation of the sonar data in conjunction with imagery obtained by visible, thermal and active microwave sensors on satellites is providing "ground truth" data for spaceborne systems. Differences between the sonar signatures of first-year and multi-year sea ice will be discussed.

POTENTIAL IMPACTS OF CO_2-INDUCED CLIMATE CHANGE USING THE GISS, GFDL AND CCC SCENARIO ON CORN YIELDS IN ESSEX COUNTY REGION

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This study examines the effect of a CO_2-induced climate change on corn yield using a multivariate regression model in conjunction with three General Circulation Models; GISS, GFDL and CCC scenarios. A historical study over the baseline period from 1960 to 1990 inclusive, shows a very strong correlation between corn yields and climate variables of precipitation, temperature and evapotranspiration. These relationships are then used to estimate possible changes in corn yield as a result of changes in climate.

The GISS and GFDL scenarios (without the inclusion of evapotranspiration) estimate an increase in yields of 4.6 % and 2.1 %, respectively. However, when evapotranspiration was included, the GFDL showed a decrease of 12.4 % while the GISS maintained an increase of 6.3 %. The CCC scenario also estimated a decrease in corn yields by 14.4 %. The generalised effect of the combined scenarios is a decrease in precipitation for June, July, and September, and an increase in temperatures and evapotranspiration throughout the growing season. The net effect of these changes translates into water stress for corn, especially in the critical stages of its development. The results of the study clearly indicate that irrigation systems are going to become even more important for the future cultivation of corn in the Essex county region. Development of systems with the flexibility to accommodate changes in climate appears imperative.

TROPOPAUSE FOLDS AND THE DEVELOPMENT OF MESOSCALE STRUCTURE IN THE POTENTIAL VORTICITY FIELD

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The geostrophic momentum approximation will be employed to investigate the mechanism of tropopause folding that occurs within upper-level fronts formed by the action of a stretching deformation field in a non-uniform potential vorticity fluid. The tropopause, in such a fluid, is represented by a shallow layer in which there is a large change in the potential vorticity. A fold is defined as a region in which the tropopause height is a multiple-valued function of the cross-front co-ordinate. Observational studies have demonstrated that tropopause folds form during frontogenesis as a result of the penetration of stratospheric air down into the troposphere. These studies have also shown that associated with the development of a fold is the generation of fine, mesoscale, structure in the potential vorticity field.

Earlier studies of this phenomena within the context of semi-geostrophic theory have been hampered by the fact that the surface fronts"collapse" before the upper-level fronts have had a chance to develop. In order to get around this difficulty, previous studies have relied upon either unrealistic cross-front temperature gradients or nascent folds (or both) to generate any appreciable development at upper-levels.

In this paper, a different approach is used. It will be shown that the introduction of a cross-front gradient in the potential vorticity field allows one to specify an isentropic lower boundary condition. This allows one to study the frontogenetic processes active in the vicinity of the tropopause in isolation from those active near the surface. As frontogenesis proceeds in such a fluid, deep folds are indeed observed to develop. The structure and evolution of the folds will be shown to be remarkably similar to that of observed cases. In particular: it will be shown that the potential vorticity field has the same mesoscale structure as is observed.

MESOSCALE METEOROLOGICAL AND OCEANOGRAPHIC PHENOMENA IN THE NORTH ATLANTIC: THE VIEW FROM SPACE

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In support of the second phase of the Canadian Atlantic Storms Program (CASPII), the atmospheric physics group at the University of Toronto operated a ground station in Newfoundland capable of receiving the digital High Resolution Picture Transmissions (HRPT) from the Advanced Very High Resolution Radiometer (AVHRR) aboard the NOAA polar orbiting meteorological satellites. The ground station consisted of a 1.8 meter steerable parabolic dish, related acquisition hardware and a PC based image processing software. The one kilometer resolution of the High Resolution Picture Transmissions along with the ability of the system to track any satellite while it was above the horizon allowed for the reception of data as to mesoscale meteorological and oceanographic phenomena over the entire North Atlantic. In addition,In total, over 18 GigaBytes of data was received and archived by the ground station during the CASP II field experiment.

In this paper, we will present a broad overview of the various phenomena that we observed. Among the meteorological phenomena that will be discussed will be examples of: convection forced by localized heating in the open leads in the sea ice, modification of the arctic air mass by its passage over relatively warm surface waters of the North Atlantic, turbulent jet streaks forced by katabatic air flow down the fiords of Greenland, extra-tropical cyclones and their embedded mesoscale structure, and polar lows in the Labrador Sea and in Hudson Bay. Among the oceanographic phenomena that will discussed will be examples of Gulf Stream ring formation and dynamical instabilities along the northern frontal boundary of the Gulf Stream.

AN AVHRR 1-KM NORTH AMERICAN CONTINENT DATA SET FOR GLOBAL CHANGE MONITORING

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Global change research studies require large intercontinental data sets. The availability of reliable and timely information is necessary for monitoring vital signs of our environment. The basic data requirement for a global coverage is medium-resolution dataset, presently obtainable from the Advanced Very High Resolution Radiometer (AVHRR) data at a nominal resolution of 1 km. Such data can be used to derive baseline information on vegetation distribution and land cover change.

The EROS Data Center (EDC) of the U.S. Geological Survey and the Canada Centre for Remote Sensing (CCRS) have initiated programs to produce periodic AVHRR 1-km data sets for national coverage over the past several years. The compositing process at both centres is based on preferred selection of pixels from daily AVHRR scenes over a specified period of time to minimize cloud cover and emphasize maximum vegetation greenness over regional and continental land areas. This process is refered to as maximum NDVI compositing.

Through a joint effort between CCRS and EDC, a coordinated processing approach was defined and a prototype NDVI composite AVHRR data set of the North American continent was produced at 1-km resolution. The project has demonstrated international collaboration in the development of consistent satellite-acquired data sets for global change studies.

The final result of the joint project is a 10-day composite image of North America (with the exception of the northern portion of the Canadian Arctic, northeastern Greenland, islands east of Puerto Rico, and the extreme western portion of the Aleutian Islands). Two outputs have been produced from this composite data so far: an NDVI classified map, and a pseudo-natural colour image-map. The data set will be also available in a variety of other products, including a digital version in the Global Change Encyclopedia which is in preparation under the coordination of the Canadian Space Agency and CCRS.

ÉVALUATION DU MODÈLE DE VENT A LA MÉSOÉCHELLE BOLON 1 DANS LA VALLÉE DU ST-LAURENT

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Le réseau de stations à la mésoéchelle déployé par Environnement Canada le long du St-Laurent lors de l'événement Québec 1534-1984 a été utilisé pour évaluer le modèle de vent BOLON 1 entre Donnacona et l'Ile-aux-Coudres. Ce modèle à la mésoéchelle est bi-dimensionnel, ne requiert qu'un minimum de données initiales et fonctionne sur micro-ordinateur. Ces qualités le rendent apte à être utilisé en météorologie opérationnelle pour la prévision des vents de surface à l'échelle méso. Une étude de sensibilité du modèle a d'abord été menée relativement à deux paramètres initiaux requis: la longueur de rugosité et le vent au-dessus de la couche limite. Les résultats démontrent que le vent au-dessus de la couche limite est un paramètre très important. Il faut apporter un soin particulier dans son estimation. Le modèle a par la suite été exécuté sur environ soixante cas de l'été 1984 afin de déterminer son habileté à prévoir les vents modérés à forts sur le fleuve et le long des côtes. Les statistiques de base ainsi que les indices de post-concordance et de pronostic ont été calculés en comparant les vents prévus avec plus de 400 observations disponibles.

LOW-FREQUENCY OCEANIC VARIABILITY UNDER SEASONAL FORCING

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A series of numerical experiments are conducted using the Bryan-Cox Ocean General Circulation Model to investigate the potential existence of low-frequency variability of the thermohaline circulation under seasonal forcing. Experiments are performed with different combinations of a seasonal cycle being present or not on the restoring temperature, the surface freshwater flux fields (mixed boundary conditions) and the surface wind forcing. Despite the presence of the forcing on the dominant seasonal timescale, it is found that the system may oscillate at the decadal period or longer. The decadal variability is excited by changes in the net surface density flux which are due to the advection of temperature and salinity anomalies in the model domain. The magnitude of the seasonal cycle also plays an important role in determining the timescale of variability. Violent overturning events may occur on the century timescale under seasonal forcing. The magnitudes of the flushes are reduced compared to those found in similar experiments without the presence of a seasonal cycle.

SPATIAL COHERENCE OF VARIATIONS IN ANNUAL PRECIPITATION TOTALS IN SOUTHEAST LABRADOR

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The density of precipitation monitoring sites in northern Canada is extremely low and the few sites that do exist are generally situated in coastal locations. The degree to which these sites can be taken as representative of conditions in surrounding regions and especially of conditions further inland is not well documented. This study makes use of precipitation data from four principal climate stations and runoff from four gauged river basins to examine the spatial coherence of variations in annual precipitation/runoff across southeast Labrador. The runoff data was considered as a proxy measure of annual precipitation. Both types of data were converted to standardized departures from the mean to facilitate comparisons between the precipitation and runoff data sets.

The premise of the study is that a high degree of correlation between the sites would indicate a spatially coherent pattern of variations in annual precipitation across the region. Analysis of the data base revealed that the correlation between sites is not simply a function of separation. Cluster analysis demonstrated that inland sites, irrespective of their type, are more strongly correlated with each other than with coastal stations. Annual precipitation/runoff at the interior sites was significantly correlated over distances of more than 200 km, while the site with the most

exposed coastal location was poorly correlated with all other sites in the region. Taken to their fullest extent these findings suggest that the precipitation regime over much of Canada north of 50 °N is poorly represented by the existing climate network, which is predominantly composed of coastal stations.

ON EQUATORIAL KELVIN WAVES IN NUMERICAL OCEAN MODELS

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Numerical global ocean models tend to poorly resolve many smaller scale phenomena. Equatorial Kelvin waves which are responsible for the onset of El Nino have a longitudinal e-folding scale of only 250 km, and their resolvability in conventional coarse-resolution global models is therefore questionable. We report on the behaviour of equatorial Kelvin waves in finite-difference models with the Arakawa B or C grids by first considering the inviscid case and then the Rayleigh damping case. Analytic solutions for these finite-differenced equatorial Kelvin waves are found in terms of modified Bessel functions. Potential applications of this theory include estimating the accuracy of zonal heat transport by the Kelvin wave during an El Nino in numerical models, and generalizing the finite-difference effects to the equatorial current system.

A STUDY ON THE ANNUAL VARIABILITY OF TROPICAL MARINE Sc AND ITS RELATIONSHIP WITH ATMOSPHERIC AND OCEANIC SEASONAL CHANGES

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The strong negative radiative forcing of the marine stratocumulus (mSc) clouds and the sensitivity of the top of the atmosphere (TOA) radiation budget to changes in their amount is qualitatively well recognized. As cloud climatologies and ERBE – measured albedoes (a) show, there is a strong seasonal cycle of mSc cloud amount in the Sc regions off the west coasts of Africa and South America and this cycle is almost out of phase with that of the sea surface temperature (SST).

We estimate the field of cross-correlations (CC) for different time lags between monthly ERBE albedo and CAC SSTs and the field of $\partial a/\partial SST$ at the above regions (using temporal variability). The spatial variability of albedo and SST is also large enough to allow us examine if the same type of anticorrelation exists in a spatial sense, i.e. if more clouds are formed over the colder grid elements. Similar analysis can also be applied for the air temperature (AIRT) and dew point temperature (DPT) at 2m which follow the SST in its seasonal cycle. We also explore the existence of correlations between the differences AIRT-SST & AIRT-DPT and albedo. We summarize our results as follows:

The field of CC and $\partial a/\partial SST$ has its maximum (absolute) values in the limited area covered by mSc and reveals a strong seasonality. The spatially averaged maximum of CC is at a lag of -1 month for the South America mSc (clouds leading SSTs) and at 0 lag (contemporaneous correlation) for the Africa mSc. There is no anticorrelation in a spatial sense for individual months. This fact suggests a decoupling between SST and albedo, driven by seasonal changes in other factors, for example, ocean current induced upwelling for the former, and Haldey cell movement for the latter. The role of AIRT-SST and AIRT-DPT which have no conspicuous seasonality is not clear at least in a climatological sense.

RADIATIVE FORCING OF OPTICALLY THIN WATER CLOUDS, HAZE AND DUST LAYERS

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Thin clouds, which are defined here as layers for which single scattering is valid, contain very small amounts of condensed water but are still able to modify the radiation stream significantly. Typical formation mechanisms include detrainment or downwind shearing from precipitating systems and radiative cooling from the top of a moist layer, the release of volcanic material into the stratosphere and the presence of haze in an inversion-capped boundary layer.

LOWTRAN 7 is used to compute the spectral radiative fluxes with a resolution of 10 cm -1 for a given cloudless atmospheric sounding. A thin, horizontally uniform cloud, with a given depth, liquid water content and droplet size distribution is added and the perturbation of the radiative fluxes are computed using Mie theory. Using a two-stream approach the model computes all the incoming and outgoing fluxes for the solar and terrestrial components from which the heating rate for the cloud layer is computed and compared to the cloudless case.

Results show that the introduction of an optically thin layer usually leads to a positive radiative feedback that cools the layer even further, thus promoting the condensation process. The exception comes when the layer is capped by a strong temperature inversion, such as is common near the ground in winter or arctic cases, where heating is expected. Maximum cooling can reach several degrees per day under the single scattering assumption.

COMPUTING DRY DEPOSITION VELOCITIES OF O3 AND CO2 FROM MEASUREMENTS OF THEIR VARIANCES

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An alternative method to the eddy correlation technique for estimating surface fluxes of trace gases is investigated. Estimates of surface fluxes and dry deposition velocities are estimated from two separate variance-flux equations and are compared with observations. The first equation relates the flux of O3 or CO2 to either that of the temperature and its variance or water vapour and its variance. The results show that the estimated fluxes compare better with the observations when the water vapour flux and its variance are used in the equation instead of the temperature flux and its variance. The second flux-variance equation makes use of an empirical universal function of stability ($\phi(Z/L)$) that represents the non-dimensional normalized variance of the trace gas. The form of this function for O3 is shown to vary from site to site and can be optimized by adjusting its two constants. It is demonstrated that by adjusting the constants with local data, the estimates of the dry deposition velocity of O3 can be made to agree better with the observations. The measurements for the present study were made over a deciduous forest in Ontario in the summer of 1988 and in the winter of 1990 and over the heterogeneous surface of lake Kinoje in the northern Ontario wetland region during the summer of 1990.

THE THUNDERSTORMS OF 8 JULY 1989 IN THE NORTHERN GREAT PLAINS

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This paper analyzes in detail an outbreak of severe thunderstorms in southeastern Saskatchewan, southern Manitoba and North Dakota. Unexpectedly severe wind damage, extensive crop-hail losses and very rapid translatory motion characterized these storms. Data and information are derived from official meteorological sources such as weather stations, cooperative observers and regular publications including the Monthly Record and Storm Data; and from unofficial sources such as local newspapers, crop-hail insurance records and private individuals. Multi-million-dollar damages were incurred even in this largely rural region, and the nature of the devastation at some localities was suggestive of tornado occurrences. Despite the advent of weather radar, an effective weather-watcher network throughout the study area, and an adequate job of forecasting on both sides of the Canada-U.S. border, many local

residents were unaware of the significant threat which they faced. The paper concludes with some observations on the problems at the general public's end of the weather warning issuance-dissemination-receipt-protection sequence.

A REAL TIME WEATHER FORECAST DATA BASE FOR POWER SYSTEM APPLICATIONS

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A forecast of weather conditions is critical for the safe and economical operation of a power system. Site and time specific forecasts of temperature, humidity, wind direction, wind speed and illumination are integral to calculations of transmission line loading, transformer limits and generation demand planning.

At any instance, the ambient weather conditions and a forecast of weather conditions for the next several hours are required for any stretch of high voltage transmission line or for any high voltage transformer. A forecast of the probability of adverse weather conditions such as lightning, icing and damaging winds must also be available. In addition, a forecast of hourly weather conditions for the next ten days is required on a daily basis for several sites.

The requirement for coverage of a broad spectrum of weather parameters on an hourly basis, for a great number of sites, spanning almost the entire area of the province of Ontario, has prompted the development of a real time weather forecast data base.

The real time weather forecast data base is a relational data base, managed with the EMPRESS data base management system. Data is stored in tables, also called relations, in row and column format. A station table holds the values of weather forecast parameters for most of the weather observing stations in Ontario for which model output, model output statistics (MOS) or perfect prog (PP) guidance products are available. A grid square table holds the values of weather forecast parameters for 102 grid squares, covering the entire area of the province of Ontario and forming a small subset of the CMC Spectral model grid.

Forecast data from the CMC Spectral and NMC MRF models, as well as MOS and PP guidance products are decoded upon arrival. The processed forecast data is then stored in the station table and the grid square table. Objective analyses of the various fields through interpolation techniques ensures that the forecast data is spatially and temporally consistent for each station and for each grid square.

The forecast data in the station table and the grid square table is adjusted for issue-time influences and mesoscale influences. The issue-time adjustment ensures reliable nowcasting by adjusting the values of weather parameters to trend from the observed values of the past hour. The mesoscale adjustment consolidates human forecasting expertise and climatological characteristics into coded empirical routines and future artificial intelligence applications.

Coded empirical routines are used to calculate values of weather parameters from characteristic weather parameter values of model output, MOS and PP guidance products based on numerical or theoretical equations. Such routines include the calculation of illumination from opacity forecasts and stability indices from temperature and dewpoint forecasts.

Artificial intelligence applications under development will be used to calculate values of weather parameters that are mesoscale influenced. Such applications will include the prediction of values of temperature, wind direction and skycover for lake/land breeze scenarios.

The real time weather forecast data base allows for real time verification of all of the forecast data. A quality index for the values of weather parameters from model output, MOS and PP guidance products and coded empirical routines is calculated on an ongoing basis. The quality index is utilized to select the best source of forecast data from any one of the available sources. The quality index also identifies weather parameters which may require additional human forecasting expertise or recalibration of their derivational empirical codes. The final value of any weather parameter requested from the real time weather forecast data base by an application or a forecaster is the best available for that time and location, as based on a quality indexed selection criteria.

VARIATIONS IN THE SCOPE FOR GROWTH OF MYA ARENARIA IN AN ESTUARINE ENVIRONMENT.

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We studied the variations in the scope for growth and the O:N ratio of the clam Mya arenaria according to the spatial position in the intertidal zone of the St. Lawrence maritime estuary. Filtration rate was higher in clams inhabiting the upper level, probably due to a compensatory process occurring with reduced immersion periods. Assimilation efficiency, NH_4 excretion, O_2 consumption and biochemical composition varied on a seasonal basis, while the scope for growth and O:N ratio were similar for both groups. Observed differences in growth of clams according to spatial position, could then not be explained by variations in physiological responses. We conclude that clams inhabiting the upper level have a higher phenotypic plasticity leading to faster acclimation to environmental changes.

VARIATIONS DU POTENTIEL DE CROISSANCE DE MYA ARENARIA DANS L'ÉTAGE INTERTIDAL DE L'ESTUAIRE MARITIME DU SAINT-LAURENT.

Nous avons étudié les variations du potentiel de croissance et du rapport O:N chez Mya arenaria, sur une base saisonnière, et en fonction de la position dans l'étage intertidal de l'estuaire maritime du Saint-Laurent. Les myes du haut de plage avaient un taux de filtration supérieur, qui s'expliquerait par un phénomène compensatoire résultant de périodes d'immersion plus courtes. L'efficacité d'assimilation, l'excrétion de NH_4, la consommation d'O_2 et la composition biochimique variaient sur une base saisonnière tandis que le potentiel de croissance et le rapport O:N demeuraient similaires pour tous les groupes. Les différences spatiales dans la croissance des myes ne peuvent donc s'expliquer par des variations des réponses physiologiques. Nous concluons que les myes du haut de plage ont une plus grande plasticité phénotypique qui s'exprime par une acclimatation plus rapide aux changements environnementaux naturels.

A MODELLING STUDY OF THE ATMOSPHERIC IMPACT OF SEA SURFACE TEMPERATURE ANOMALIES IN THE MID- AND HIGH-LATITUDES OF THE NORTH ATLANTIC

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A previous study (Peng and Mysak) of SST (sea surface temperature) in the northern North Atlantic, SLP (sea level pressure) over the high latitude Northern Hemisphere and precipitation and runoff in Siberia using 50 years of data (1930 - 1979) suggested that there are significant correlations among these variables. Positive (negative) winter SST anomalies in the northern North Atlantic are related to less (more) precipitation, and hence less (more) runoff in Siberia.

In order to further assess the impact of Atlantic SST fluctuations on the high latitude atmospheric circulations, experiments are conducted using the global spectral model at RPN (Recherche en Prévision numérique). Analyses from these experiments will be presented. In particular, the roles of SST anomalies in the Icelandic-Norwegian-Barents Seas in the movement and development of cyclones over these regions and in the variations of precipitation over Siberia will be discussed.

LONG-TERM TEMPERATURE AND SALINITY VARIABILITY ON THE SCOTIAN SHELF AND IN THE GULF OF MAINE

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Examination of historical data (1946-1988) from Emerald Basin on the Scotian Shelf has revealed a large component of the temperature variability at all depths occurs at very long periods (10-20 y). The pattern of this variability is similar at all depths but was found to be of greatest amplitude in the subsurface waters below the cold intermediate layer (>100 m), pointing to the slope water from regions offshore of the continental shelf. Comparison with data from the Gulf of St. Lawrence to the Gulf of Maine shows similar temperature trends, indicating that the observed variability is part of a broad scale, coherent ocean climate fluctuation. Interannual variability of salinity from the Bay of Fundy and the slope water region is also discussed. A simple model involving advection and lateral mixing in the slope water is developed. It can account for some of the very low frequency variability.

SIMPLE TWO-LAYER CIRCULATION IN THE ARCTIC-GREENLAND SEA BASIN

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The ocean circulation has been studied in the Arctic Basin and in its marginal seas by simple 1- and 2-layer hydrodynamic models. These included a reduced gravity, a rigid lid barotropic and a free-surface 2-layer model with bottom topography. The motivating factor was the attainment of high horizontal resolution and a delineation, in simpler terms, of the basic response to the atmospheric forcing and of the topographic effects. For the free surface case an ADI-type method was developed that allows bypassing the CFL condition associated with the surface gravity waves without resorting to a Helmholtz solver. An interesting momentum balance was found in the barotropic case near the pole, where both beta and the divergence of transport and velocity vanish over flat terrain. Some of the observed currents (e.g. East Greenland) show up only marginally, possibly due to the fact that they are primarily density-driven. Resolution was also fond to be an important ingredient, with a minimum of 30km required to represent some of the currents (e.g. West Spitsbergen Current).

CYCLONE CLIMATOLOGY OF SOUTHEASTERN CANADA AND ITS RELATION TO SCALLOP FISHERY

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The scallops fishery in eastern Canada are characterized by large year-to-year fluctuations in harvest. While some of this variability can be attributed to changes in fishing pressure, there is general agreement that a strong component of natural variability is present. Recruitment mechanisms involving meteorological forcing are known. Therefore, annual, seasonal and monthly cyclone, cyclogenesis and cyclolysis frequencies were tabulated for 2.5° latitude by 5° longitude grid cells for the years 1972-1990. It was found that cyclones over the study area have an average period of 10-11 days with different mean patterns in summer and winter. More cyclones are found in winter with a decrease in their numbers with latitude in all months. An EOF analysis was performed for the 24 grid cells. The first eigenvector showed the cyclone frequency variability of the St.Lawrence Gulf and surroundings areas. The second eigenvector contrasted cyclone frequency in Atlantic ocean waters with continental zones northward the St.Lawrence river. Regression analysis was used to investigate the effect of annual and seasonal cyclone frequency on scallop fishery. The results indicate that fluctuations could be related to changes in cyclone frequencies.

CYCLONE TRAJECTORIES IN CCC GCM SIMULATIONS WITH DOUBLED CO_2

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The climatology of cyclone trajectories in simulations performed with the Canadian General Circulation Model is studied. Comparisons are made between integrations performed under normal and doubled CO_2 concentrations, and between the simulated climate and the NMC analyses of observed data.

A MASS-CONSERVING SEMI-LAGRANGIAN NUMERICAL TRANSPORT SCHEME

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The semi-Lagrangian (SL) advection scheme introduced in meteorological models by Robert (Atmos. Ocean 1981) has gained increasing popularity in the numerical weather prediction community for the computational savings it affords over Eulerian schemes. An interesting side advantage of the SL is that it reduces substantially the numerical dispersion errors of Eulerian schemes; for this reason, a number of otherwise Eulerian models employ SL techniques for mass transport, including water vapour and trace substances. For general circulation models, the conservation properties of a numerical scheme can be just as important as its formal accuracy. In its usual form, the SL scheme does not conserve mass. A variant of the SL has been developed to ensure mass conservation: the Semi-Lagrangian Integrated-by-Cell (SLIC) scheme. Results are presented on the application of SLIC scheme in one and two dimensions.

REMOTE SENSING AND MESOSCALE BIOLOGICAL PRODUCTIVITY

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Satellite observations of ocean colour at selected wavelengths have made it possible to map near-surface distribution of phytoplankton pigment at the global scale. The advantage of remote sensing in providing synoptic coverage of large-scale surface features is incontestable. But the estimation of primary production from these data requires additional information inaccessible to present-day satellite remote sensing, such as the parameters for conversion of *biomass to growth rates*, and the parameters describing the vertical structure of biomass. The value of remote sensing is enhanced considerably if the satellite data can be combined with *in situ* data to provide the missing information. Since satellite and *in situ* data are collected at very different time and space scales, conceptual schemes are necessary to render the two data sets compatible. The idea of bio-geochemical provinces has proved to be very useful in this context.

THE EFFECT OF ALONGSHORE TOPOGRAPHIC VARIATION AND BOTTOM FRICTION ON SHELF WAVE INTERACTIONS

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The theory of resonant interactions between shelf waves developed by Hsieh and Mysak (JPO 1980) is extended to include the effect of bottom friction and alongshore topographic variation. The model equations are derived via a multiple-scale asymptotic expansion in which it is assumed that the alongshore topography varies over a length-scale over which the nonlinear interactions make an order-one contribution to the dynamics. For the case with no bottom friction, it is shown that the total energy of the three interacting waves is conserved and that the Manley-Rowe relations are preserved. Moreover, for the case with no bottom friction and the additional condition that the alongshore topography is restricted to a piecewise constant configuration, the steady state equations can be solved

exactly. An illustrative solution for this case is given. It is shown that, in the presence of alongshore topographic forcing, the nonlinear energy exchange will induce a permanent wavenumber mismatch, so that the wave resonance conditions are no longer completely satisfied. For the case with bottom friction, the damping coefficients of each interacting wave depends on the initial conditions and the cross shelf profile, but not on the alongshore topographic variation. Because the three damping coefficients are not equal the model equations can not be solved exactly. Numerical solutions for some initial conditions are obtained for the purely temporal problem. It is found that the damping due to bottom friction does not induce any wavenumber mismatch.

A THREE-DIMENSIONAL HYDRODYNAMICAL MODEL OF CIRCULATION IN THE GULF OF SUEZ, EGYPT

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A three-dimensional hydrodynamical numerical model was used to study the water movement of the shallow gulf of Suez at the northern extremity of the Red Sea. The computational grid used to schematize the Gulf has a horizontal resolution of 3 x 3 km, with levels at 5, 15, 30 and 60 m. The M_2-simulations clearly revealed the Kelvin wave nature with partial reflection for the Gulf-like configuration. The model results show that the residual circulation of the Gulf has three main components, namely, in order of importance, the tidal residual, the wind-driven and the density induced residuals. The simulated circulation pattern, produced by an idealized density field that represents summer conditions, generated the classical circulation pattern in negative estuarine systems, i.e. a northward inflow at the surface and an outflow at depth. A decrease in the velocity associated with an increased eddy activity is noticeable throughout the upper three layers. However, the bottom layers show a current reversal associated with an increased velocity 0 (1.5-3 cm/s) and more stable south east flow. The computed wind-induced circulation associated with a northwesterly and a northerly wind stress fields produced the classical type of estuarine circulation i.e. an outward flow from the Gulf near the surface, and an inflow at depth. It is winds blowing steadily from NE direction that could generate a surface inflow and a bottom outflow establishing and/or enhancing the typical negative estuarine circulation pattern of the Gulf. Comparison with similar systems are presented.

LA CIRCULATION DANS L'OCÉAN NORD-ATLANTIQUE OUEST

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Les données archivées, de la température et de la salinité dans l'océan Nord-Atlantique ouest, de MEDS (Marine Environment Data Service) et NODC (National Oceanographic Data Center) obtenues entre 1910 et 1989 ont été mises sur grille en utilisant une variante de la technique d'analyse objective de Levitus (1982). Les champs de température et de salinité moyens pour chacune des saisons avec une résolution horizontale de 1/3°x1/3° et 33 niveaux verticaux standards ont été ainsi obtenus et sont comparés à des résultats publiés. Des techniques d'inversions ont été appliquées sur les champs de densité afin de déterminer les courants. Les résultats obtenus en utilisant la technique de Bernoulli (Killworth, 1986) et ceux obtenus en utilisant l'équation du vent thermique en supposant une vitesse nulle à une profondeur de 1200m sont présentés, comparés et discutés.

LAGRANGIAN CIRCULATION ON GEORGES BANK FROM A FINITE ELEMENT MODEL

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The trajectories of passive particles in vertically-averaged velocity fields are analyzed to characterize the Lagrangian flow field on and around Georges Bank. The velocity fields are obtained from a three-dimensional linearized harmonic model on a finite element grid, under tidal and wind stress forcing. Tidally-driven residual currents are computed via an iterative technique.

Results for a velocity field composed of semidiurnal tidal and tidally-driven residual currents on a relatively coarse grid serve as a reference case. This reference case is characterized by the presence of a 'separation line' on the southern side of the Bank delineating particles which circulate around the Bank and those which exit towards the Middle Atlantic Bight. The addition of current components driven by steady along-shelf (northeastward) and cross-shelf (southeastward) wind stress displaces this separation line towards the top of the Bank, indicating that wind-induced currents substantially reduce the trapping of particles on the Bank.

In a model with increased resolution of the bathymetry on the top of Georges Bank, through the use of smaller elements, small-scale topographic eddies are present in the residual current fields. These residual eddies appear to induce distinct regions of trapped particles on top of the bank, Lagrangian eddies with a typical length scale of O(10 km). The presence of these features indicates the importance of models resolving the small-scale bathymetry for a realistic modelling of Lagrangian flows in this area.

TOWARDS A HIGHER RESOLUTION VERSION OF THE CANADIAN GLOBAL SPECTRAL MODEL

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The global spectral model used as the data assimilation model and medium range forecast model at the Canadian Meteorological Centre has a triangular 79-wave (T79) truncation in the horizontal, 21 levels with variable spacing in the vertical, and uses a semi-implicit semi-Lagrangian time integration scheme with a 30-minute time step. Due to operational constraints, this configuration is the highest resolution that could be implemented on the CRAY X-MP computer. However, with the recent installation of the NEC SX3 computer we will have the capability to implement a higher resolution version.

Based on the experience at other leading forecast centres, when increasing the resolution it is important to maintain a balance between the horizontal and vertical resolutions. With the stability of the semi-Lagrangian scheme, it is also important to adjust the time step to keep a balance between the time truncation and space truncation errors. We have performed preliminary experiments in which we have examined results for the northern hemisphere averaged over four FGGE cases: 2 January, 21 January, 12 February and 18 May, 1979. To see if the time truncation errors are acceptable in the current configuration, we calculated the evolution of the northern hemispheric root-mean-square (rms) differences between runs using a 10 minute time step and a 30 minute time step. In medium range forecasts to 5 days the results show a sensitivity of approximately 3 metres per day at mid-atmospheric levels, which is considered as the upper limit for acceptable sensitivity for any single change in a numerical weather prediction model. Horizontal resolution tests have also been performed by comparing integrations at resolutions of T59, T79 and T99. The results show that there is improvement in the accuracy of the medium range forecasts as we increase the resolution in this range, and further improvements are anticipated at even higher resolutions.

In view of these encouraging preliminary results, a more extensive series of experiments will be performed in order to further study the sensitivity to the spatial resolution and the time step in preparing a higher resolution version of the Canadian global spectral model. Latest results will be presented at the congress.

PRELIMINARY DYNAMIC EXTENDED RANGE FORECASTS WITH THE CANADIAN GLOBAL SPECTRAL MODEL

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With the implementation of the global analysis and forecast system at the Canadian Meteorological Centre in March 1991 and the recent installation of a new supercomputer (SX3-44), we now have the tools to study the feasibility of producing dynamic extended range forecasts (DERF) for Canada. Currently we produce forecasts out to five days, which is much shorter that the predictability limit estimated by other dynamic studies. In addition to very high potential economic benefits from operationally producing skillfull DERF products, extending the range should also improve the quality of our short and medium range forecasts, since a good performance at long range requires an excellent performance at shorter ranges.

We have embarked on a research project in which our first priority is to identify and eliminate, where possible, the systematic errors in the forecasts. This is being done by running an ensemble of extended range forecasts and using sophisticated diagnostics to analyze the climatology and energy transfers of the model. Some preliminary 45-day integrations have been performed and have produced encouraging results. There is no evidence of serious climate drift, and the diagnostics for the integrations generally compare favourably with those for the corresponding analyses. Nevertheless, we have identified some weaknesses in the simulations and are investigating model improvements that should correct the associated systematic errors. Results of these investigations will be presented at the congress.

UPPER-TROPOSPHERIC SYNOPTIC-SCALE WAVES

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Upper-tropospheric waves of synoptic scale are important dynamical entities at midlatitudes. They often induce surface cyclogenesis (Peterssen and Smebye, 1971), and their life duration is typically longer than time scales for disruption by the ambient shear (Sanders, 1988). The objectives of the present work are to explain the maintenance and genesis of upper-tropospheric synoptic-scale waves in the midlatitude flow.

We develop an analytical model of waves on generalized Eady basic states that have uniform tropospheric and stratospheric potential vorticity, but allow for the decay of density with height. The Eady basic state represents the limiting case of infinite stratospheric stability and constant density. We find that the Eady normal mode characteristics hold in the presence of realistic tropopause and stratosphere. In particular, the basic states studied support at the synoptic scale upper-level normal modes, which provide simple models for the dynamics of upper-tropospheric synoptic-scale waves, as waves supported by the large latitudinal gradients of potential vorticity at the tropopause.

In the presence of infinitesimal positive tropospheric gradients of potential vorticity, the upper-level normal mode solutions no longer exist, as was demonstrated in Green (1960). Disappearance of the normal mode solution when a parameter changes slightly represents a dilemma that we seek to understand. We examine what happens to the upper-level normal modes in the presence of tropospheric gradients of potential vorticity in a series of initial-value experiments. Our results show that the normal modes become slowly decaying quasi-modes. Mathematically the quasi-modes consist of a superposition of singular modes sharply peaked in the phase speed domain, and their decay proceeds as the modes interfere with one another. We repeat these experiments in basic states with a smooth tropopause in the presence of tropospheric and stratospheric gradients, and similar results are obtained. Basic states with positive tropospheric and stratospheric gradients of potential vorticity are found to support upper-level synoptic-scale waves for time scales consistent with observations.

Following Farrell (1989), we then identify a class of near optimal initial conditions for the excitation of upper-tropospheric waves. The initial conditions consist of upper-tropospheric disturbances that lean against the

shear. They strongly excite upper-level waves not only in the absence of tropospheric potential vorticity gradients, but also in their presence. This result demonstrates that quasi-modes are as likely to emerge from favorably configured initial conditions as real normal modes, although their excitation is followed by a slow decay.

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SEMI-LAGRANGIAN TECHNIQUES AND OROGRAPHY

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Semi-Lagrangian techniques were developed in order to increase the time steps used in the integration of the operational forecast models (Robert, 1981). Larger time steps made possible the inclusion of more elaborate physical parameterizations. Semi-Lagrangian techniques are very useful and are currently used in most meteorological centers.

However it has been known for some time that there is a problem incorporating orographic forcing in semi-Lagrangian models (Staniforth and Côté, 1991; Coiffier et al., 1987). The problem arises when the Courant number criterion typical of Eulerian models is violated, and the main advantage of semi-Lagrangian techniques is to allow the relaxation of this criterion. A solution involving spatial averaging has been proposed recently (Tanguay et al., 1991). Nevertheless the analysis presented in the paper itself suggests that the severity of the problem has only been reduced, not eliminated.

We present in this work an analysis of a simple one-dimensional model that isolates the essence of the problem. Possible avenues for solution will also be discussed.

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CONCENTRATIONS D'OZONE SUR LE QUÉBEC MÉRIDIONAL DURANT LA PÉRIODE 1989 - 1991

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Le réseau d'échantillonnage REMPAFAQ (réseau de mesures des polluants atmosphériques en milieux forestier et agricole au Québec) collecte des données depuis 1989. Cet article présente les premiers résultats des concentrations d'ozone pour un réseau en milieu extra-urbain au Québec et montre que les niveaux moyens annuels d'ozone sont souvent nettement plus élevés qu'en milieu urbain. De plus, les dépassements de la norme horaire surviennent plusieurs fois par année à plusieurs localités à l'extérieur des grands centres urbains. D'autre part, on constate que le coefficient de corrélation entre les concentrations moyennes horaires d'ozone et celles des NO_x est faible à modérée en milieu urbain et n'est pas physiquement significatif en milieu extra-urbain. La température maximale est la variable météorologique ayant le plus fort coefficient de corrélation avec l'ozone durant le semestre d'été étant mieux corrélée que la température moyenne et le nombre d'heures d'ensoleillement. Un indice de stress

sur les écosystèmes dû à l'ozone est proposé et montre que la zone critique d'exposition à l'ozone couvre une grande partie du Québec méridional. Finalement, les résultats de l'étude suggèrent que les fluctuations interannuelles d'ozone sont déterminés largement par les fluctuations météorologiques et que les valeurs élevées des concentrations d'ozone se produisent à l'échelle régionale et sont souvent attribuables au transport à longue distance. En effet, les journées où on enregistre des dépassements de la norme horaire sont très souvent associées à des situations météorologiques favorables à la pénétration de masses d'air venant des grands centres industriels des États-Unis et du sud-ouest de l'Ontario.

MICROZOOPLANKTON GRAZING ACTIVITY DURING THE 1990 SPRING BLOOM IN CONCEPTION BAY, NEWFOUNDLAND.

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Conception Bay on the eastern shore of Newfoundland shows Spring blooms which extend in time from early March to May. As part of a study aiming to understand the initiation, development & fate of the Spring bloom in this environment (Cold Ocean Productivity Experiment), we investigated the microzooplankton grazing activity using Landry's dilution technique. We coupled this technique with HPLC determination of photosynthetic pigments, allowing discrimination of the types of algal food eaten. Results will be presented in terms of the impact on phytoplankton. We also show that a number of pheopigments are produced as a result of microzooplankton grazing, contrary to common belief that protozoa do not produce this type of pigments.

MICROSTRUCTURE MEASUREMENTS DURING THE NORTH ATLANTIC TRACER RELEASE EXPERIMENT (WOCE CORE-3)

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Do turbulence measurements really tell us about vertical mixing? In May 1992, a group of oceanographers from the U.S., the U.K., and Canada will paint an isopycnal patch of water with sulphur hexafluoride, an anthropogenic tracer detectable at exceptionally low concentrations. This patch will be followed for a year with acoustically tracked drifters so that the diapycnal (vertical) spread of the dye can be monitored. This will provide direct estimates of the rate of diapycnal mixing of heat and salt in the main thermocline of the Eastern North Atlantic.

The talk will be a "hot-off-the ship" report of how the dye injection proceeded, followed by an outline of the methods for monitoring the dye patch. I will describe plans for measuring the small-scale shear and turbulent microstructure during the following year, and how we hope to use these to forecast the rate of dye spread.

If our forecasts and models correctly predict the dye spread, then the existing methods and models can be applied with greater confidence to the global ocean to parameterize diapycnal mixing rates, and to tell us which physical mechanisms dominate. If our forecasts are wrong, then the comparison will tell us a great deal about what is wrong with our methods and models for interpreting microstructure observations.

EVIDENCE FOR STRONG COUPLING BETWEEN *CALANUS* PRODUCTIVITY AND LARVAL REDFISH (*SEBASTES SSP.*) DISTRIBUTION IN THE NORTHERN GULF OF ST.LAWRENCE

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In early summer, *Calanus finmarchicus* dominates the productivity of net zooplankton in the north central Gulf of St. Lawrence. *Calanus* females reside day and night in the surface 30 m, which is separated from the cold (0°C), underlying water by a pronounced thermocline. Despite very low phytoplankton biomass, females produce eggs at high rates (20-60 eggs female^{-1} d^{-1} in 1989 and 1991), supporting egg concentrations of 12 liter^{-1} or more near

the surface. *Sebastes* larvae are also resident near the surface, where they feed on *Calanus* eggs almost exclusively, despite the availability of alternate microzooplankton prey. Our observations are consistent with the hypothesis that the temporal/spatial distribution of *Sebastes* larvae is coupled to the distribution of *Calanus* females and the cycle of their egg production.

THE REGIONAL EVAPORATION STUDY - PART III: MODEL PREDICTIONS OF BOUNDARY LAYER EVOLUTION

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The Regional Evaporation Study (RES) field project took place during the summer of 1991. The data archive includes serial radiosonde releases at 2-4 hour intervals for several 36-hour periods of interest.

These soundings provide an ideal data set from which to evaluate numerical models which predict the evolution of the boundary layer. One such model adopted for RES is Blackadar's model, which incorporates budgets of heat, moisture and momentum to predict diurnal changes in the boundary layer. This paper presents some preliminary model comparisons with RES sounding data and discusses its usefulness for operational forecast use.

EMISSIONS OF NITROUS OXIDE FROM THE HUDSON BAY LOWLANDS

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Emissions of nitrous oxide were measured from five sites in the Hudson Bay Lowland during the period of June to October, 1990, as part of the Northern Wetlands Project. Over 1500 emission measurements were made over this period from a number of chambers set up over a variety of vegetative types within a number of ecosystems. The sites were chosen to obtain a good representation of the ecosystems that characterize the Hudson Bay Lowland. The emissions of nitrous oxide were measured from over both land and water, and these results were then used to characterize the emissions of nitrous oxide from a given ecosystem, that could be detected by remote sensing. These calculated emission values, and the remote sensing data, allowed the calculation of the emissions of nitrous oxide, along a transect from the James Bay coast, to Kinosheo Lake, as well as integrated over the entire Hudson Bay Lowland.

The results obtained, indicate a number of interesting patterns. The majority of the emissions of nitrous oxide are being emitted from the open fen areas, while the treed areas, both fen and bog, result in negative emission rates. Although it was seen, that the emissions of nitrous oxide from separate ecosystems are significantly different, as would be expected, one might not expect to see that often the largest differences in the emission rates of nitrous oxide are seen from within ecosystems that are very similar.

INTÉGRATION SPATIALE DES OBSERVATIONS CLIMATOLOGIQUES À PARTIR D'OBSERVATIONS AÉROPORTÉES DES FLUX

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La télédétection par satellite jouera un rôle grandissant dans l'étude du climat et des budgets d'énergie, de l'eau, du carbone et des gaz traces à l'échelle du globe. La validation de modèles sur les processus d'échange entre la terre et l'atmosphère ne pourrait s'effectuer que sur base d'observations nombreuses près de la surface terrestre, à cause de la variabilité énorme des caractéristiques physiques et biologiques de cette surface. Ceci serait

pratiquement irréalisable. Par contre, les techniques d'observation aéroportée des flux d'énergie ou de masse, développées durant les derniers 15 ans, peuvent effectuer un lien entre les observations locales et les caractéristiques régionales, à l'échelle allant jusqu'à des centaines de km. Notre participation aux expériences internationales récentes (e.g. FIFE 1987, 1989; NOWES 1990; SJVAQS 1991) a permis la mise au point de techniques aéroportées dans plusieurs domaines comme: effet de filtrage et l'analyse des tendances sur l'estimation des flux par la méthode des corrélations; advection locale entre les régions sources/puits à la surface et le trajet d'échantillonnage des flux par l'avion; comparaison entre les flux mesurés par avion à ceux mesurés à la surface; analyze structurale du transfert turbulent et organisation spatiale de ce transfert à l'intérieur de la couche limite atmosphérique. L'effet de ces facteurs sur l'interprétation des observations aéroportées en termes de caractéristiques de surfaces, ainsi que nos projets futurs, seront discutés.

SAMPLING ERRORS IN ESTIMATING THE GLOBAL TEMPERATURE WITH POINT GAUGES: ASYMPTOTICS AND MONTE CARLO SIMULATIONS

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This paper considers the mean squared error (MSE) incurred in estimating an idealized earth's global average temperature with a finite number of point gauges located in a specified or stochastic way over the globe. For a class of model earths with rotationally invariant statistics, the MSE formula can be cast into the form of a summation over spherical harmonic indices. The summand factors into a part which depends on the design of the gauge network and a second part which is the degree variance spectrum of the surface temperature field. After presenting this formalism, we provide an example spectrum for the surface temperature field derived from a simple two parameter stochastic climate model defined on the sphere. An example calculation is given for the case of N gauges randomly arranged on the sphere. In addition, the sampling error is computed for some simple regular arrays of gauges as illustrative examples.

ON THE INTERACTION BETWEEN THE SYNOPTIC SCALE EDDIES AND THE LOWER FREQUENCY FLOW IN THE ATMOSPHERE

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Atmospheric data at 300 hPa from 1981 to 1986 are used to investigate the interaction between the synoptic scale eddies (period 2 to 10 days) and the lower frequency flow (period 10 to 90 days). The atmospheric mean-monthly and mean-seasonal anomalies are a reflection of the anomalies in the low frequency flow, so that understanding the circulation anomalies on time scales of a month to a season will necessitate a better understanding of the dynamics of the low frequency flow. The primary goal of the present study is to determine the extent to which the evolution of the low frequency flow is related to that of the synoptic disturbances.

The vorticity flux divergence due to the synoptic scale transients acts as a vorticity source for the low frequency flow. Calculations of this divergence using upper level ECMWF analyses reveals that it is very well correlated with the low frequency vorticity evolution, particularly over the eastern oceans. It is found that the time lag between the "forcing" of positive (negative) vorticity by the synoptic scale eddies and the appearance of positive (negative) vorticity in the low frequency flow is very small (about one day). It is thus seen that the fast transients act as a source of enstrophy for the low frequency flow in the middle latitudes.

LOCAL AND REMOTE FORCING OF THREE-DIMENSIONAL CIRCULATION ON THE SCOTIAN SHELF

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A new, computationally efficient three-dimensional spectral model is used to calculate the circulation on the Scotian

Shelf forced by local wind and coastal trapped waves propagating into the region across the "upstream" boundary. Sensitivity analyses show that the flow forced by local wind has greater vertical structure and less horizontal structure than the remotely forced component. A comparison of measured currents on Western Bank for the period February 1 to April 25, 1991 with model results suggests that remote forcing is important and, further, that coastal sea level may prove extremely useful in assimilative models of circulation in this region.

WINDII - THE WIND IMAGING INTERFEROMETER ON THE UPPER ATMOSPHERE RESEARCH SATELLITE

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WINDII, the WIND Imaging Interferometer, was launched on the Upper Atmosphere Research Satellite on September 12, 1991. This joint project, sponsored by the Canadian Space Agency and the French Centre National d'Etudes Spatiales, in collaboration with NASA, has the responsibility of measuring the global wind pattern at the top of the altitude range covered by UARS. WINDII measures wind, temperature and emission rate over the altitude range 80 to 300 km altitude by using the visible region airglow emission from these altitudes as a target, and employing optical Doppler interferometry to measure the small wavelength shifts of the narrow atomic and molecular airglow emission lines induced by the bulk velocity of the atmosphere carrying the emitting species. The instrument used is an all-glass field-widened achromatically and thermally compensated phase-stepping Michelson interferometer, along with a bare CCD detector that images the airglow limb through the interferometer. A sequence of phase-stepped images is processed to derive the wind velocity for two orthogonal view directions, yielding the vector horizontal wind. These are used to produce daily wind maps at a series of altitude levels. The process of data analysis including the inversion of apparent quantities to vertical profiles is described and preliminary results are shown.

IMPROVEMENTS IN TEMPERATURE PROFILE RETRIEVALS FROM MICROWAVE RADIOMETRIC MEASUREMENTS

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An investigation of potential improvements in the inversion of ground-based microwave radiometic measurements for atmospheric temperature has been conducted. The temperature profiles retrieved from microwave radiometric systems generally have low vertical resolution and suffer from larger errors than radiosonde temperature profiles. It is shown that the incorporation of meteorological forecast geopotential height information produces a major improvement in the retrieved temperatures from the ground up to 200 mb, with error levels reduced to those for radiosondes. There is little information in the weighting functions about the atmosphere above 200 mb. This combined algorithm would be particularly useful in a field measurement situation.

TWO VARIATIONS ON A THEME BY RAYLEIGH

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In 1880 Lord Rayleigh solved the problem of the linear instability of a free shear layer (equivalently a strip of constant vorticity embedded in irrotational fluid). Two variations on this classical analysis are presented here. In the first, the shear layer is subjected to a uniform strain field. This is a simple model for a vorticity filament in the presence of large-scale coherent vortices, a generic scenario in geophysical turbulence. The basic state for the stability problem is now time-dependent, and normal-mode solutions no longer exist. Disturbances may grow temporarily, but must (within the context of linear theory) ultimately decay. The complete linearized initial-value

problem is solved, and the way in which strain stabilizes the Rayleigh instability is quantified. Nonlinear effects are explored by numerical means. The results help explain why vorticity filaments in geophysical turbulence are only rarely observed to roll up into coherent vortices. There are also implications concerning the likelihood of frontal instabilities in the atmosphere. In the second variation, a narrow layer of stratification is inserted in the middle of the shear layer. There is nothing novel about this model of stratified shear flows, which was solved by Holmboe (1962). The novelty lies rather in the method of analysis, which uses wave-activity conservation principles to elucidate the underlying instability mechanisms in terms of the interaction of oppositely-signed neutral modes. This sheds new insight on the nature of the Holmboe mode.

NONLINEAR SYMMETRIC STABILITY

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The problem of symmetric stability is examined within the context of Arnold's so-called "energy-Casimir" stability method. The sufficient conditions for linearized stability derived by Fjortoft (1950) are shown to imply finite-amplitude, normed stability. This finite-amplitude stability theorem is then used to obtain rigorous upper bounds on the saturation amplitude of disturbances to symmetrically unstable flows. The case of moist adiabatic systems is also considered.

ESTIMATING AREAL EVAPORATION FROM REMOTELY-SENSED AND SURFACE DATA

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Remote sensing methods offer a viable means of deriving regional-scale estimates of surface evapotranspiration (ET). This paper presents a method whereby a variant of the Priestley-Taylor formulation when combined with remotely sensed data provides reasonable estimates of regionalized ET. Satellite-derived (Landsat V) values of surface albedo (αs) and temperature (Ts) are used to derive the components of the Priestley-Taylor formulation. However sine-generated extrapolations from a single measurement to derive daily ET is affected by varying sky conditions, especially cloud cover, relative to the time of satellite measurement. A correction factor, when introduced to correct for cloud effects, increases the similarity between our method for daily ET and the reference method. Also spatial variations of daily ET between pixels were found to be within 5 percent.

La télédétection nous pourvoit d'un outil fiable pour l'estimation de l'évapotranspiration (ET) à échelle régionale. Nous présentons une méthode où les données satellitaires (Landsat V) de l'albedo (αs) et de la température (TS) de la surface sont intégrées dans une version de l'équation de Priestley-Taylor afin de calculer l'ET régionalisée. Cependant, dans le calcul de l'ET journalière, il fallait extrapoler selon une relation sinusoïdale à partir d'une mesure ponctuelle instantanée. Celle-ci est influencée par les conditions du ciel, surtout la nébulosité, relatives au moment du passage satellitaire. Quand nous avons introduit un facteur pour corriger pour les effets des nuages, la relation entre l'ET calculée selon notre approche et l'ET de référence, est sensiblement améliorée. D'ailleurs les variations de l'ET journalière entre pixels pour notre site de recherche étaient de l'ordre de 0 à 5 pourcent.

CANADIAN ATLANTIC STORMS PROGRAM II: THE OCEANOGRAPHIC COMPONENT

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The CASP II oceanographic field experiment, consisting of three main components:

1) current, surface wind and SAR measurements, hydrographic surveys and surface drifter studies near the Labrador Current on the northern Grand Banks of Newfoundland;
2) sea ice process studies in the marginal ice zone on the Northeast Newfoundland Shelf; and
3) airborne measurements of heat and momentum fluxes in the planetary boundary layer over the marginal ice zone;

was conducted between November, 1991 and May, 1992. In addition, separate but related investigations, including:

4) sea ice flux measurements on the Newfoundland and Labrador Shelves; and
5) large-scale current measurements and hydrographic surveys on the Newfoundland Shelf in relation to studies of environmental influences on northern cod;

were carried out concurrently in the same region. Preliminary results from these five coordinated programs are presented.

TEMPORAL VARIATIONS IN THE TAXONOMY AND ECOLOGY OF NANOPLANKTON IN A TEMPERATE CANADIAN FJORD.

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A temporal study of the taxonomy and ecology of nanoplankton, organisms with longest dimensions varying between 2 and 20 μm, in a temperate Canadian fjord, Saanich Inlet, was carried out with the aid of electron microscopy. Eighty-three species were recorded during the period from April, 1990 to April, 1991, of which we observed fifty for the first time in waters of the west coast of North America, supporting the conclusion that most of these organisms have cosmopolitan distributions.

The nanoplankton were responsible for a large fraction of the planktonic chlorophyll throughout the year except during the spring diatom bloom. During summer, prasinophyte and prymnesiophyte flagellates were abundant, while during winter, most cells were chrysophyte flagellates, of which many were freshwater, heterotrophic species. Also, a greater number of choanoflagellate species were observed in winter than in summer. These observations suggest the possible importance of terrestrial runoff and heterotrophic production to the marine food web in coastal waters during winter months. e importance of terrestrial runoff and heterotrophic production to the marine food web in coastal waters during winter months.

WIND STRESS AND SEA STATE IN THE ERS-1 CAL-VAL EXPERIMENT

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Measurements of wind stress and wind speed were logged using a bow anemometer and analysis package at satellite overpass times and at other times of interest during the Cal-Val Cruise of CSS Hudson. The primary purpose was to test estimates of wind stress and wind speed from satellite data.

Directional wave data from Wavek directional wave buoys and from ship- air- and satellite-borne radar will allow us to calculate appropriate wave parameters and refine relationships between wind stress and the "age" of wind waves. In earlier wind stress studies at offshore sites, without directional wave information, it had not been possible to separate locally-generated wind sea from swell that propagates in from outside the immediate area and has little influence on the wind stress.

Readings of the ship's anemometer will be compared with bow anemometer and Minimet buoy anemometer winds to assess the influence of flow distortion by the ship on routine wind readings.

CANADIAN ATLANTIC STORMS PROGRAM II: THE METEOROLOGICAL FIELD EXPERIMENT

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The CASP II field experiment was conducted from January 15 to March 15, 1992 over Newfoundland and the surrounding ocean. During the experiment, more than 15 storms were studied with a wide variety of surface-based and airborne platforms. Weather features examined during the experiment included explosively deepening storms, warm and cold fronts, troughs, tropospheric folds, blizzards, precipitation type transition regions, and freezing precipitation. Special aircraft missions were also carried out in support of aircraft icing studies and satellite validation. In this presentation, an overview is presented of the observational facilities, participants, weather phenomena, and preliminary results.

THE REGIONAL EVAPORATION STUDY - PART II: PRELIMINARY MOISTURE BUDGET/EVAPORATION RESULTS

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During the summer of 1991, sequential balloon soundings were released from three sites within a mesoscale research network of automatic weather stations in support of the Regional Evaporation Study (RES). The main goals of RES are to estimate areal evaporation using atmospheric moisture budgets, and to assess the role of local evaporation in the production of convective clouds and precipitation using existing numerical models of boundary layer and cloud processes.

The rationale for adopting the moisture budget approach developed out of the need for improved operational estimates of areal evaporation (where there are no measurement standards), and the inaccuracy of subjective approaches to estimating diurnal changes in the boundary layer moisture due to evaporation and advection. Estimating diurnal changes in the moisture field is important to making accurate daily predictions of convective potential.

The moisture budget estimates of areal evaporation will be compared with results from other semi-empirical methods, as well as results from the modeling tests. Models used in this study include boundary layer process models which compute evapotranspiration, and cloud models which predict liquid water content and convective intensity. This paper will review the background for RES, 1991 field research operations, mesoscale data management obstacles, and some preliminary analysis results.

A NEW METHOD OF TESTING TEMPERATURE AND PRECIPITATION PREDICTIONS FROM CLIMATE GCM'S USING THE TEMPERATURE-PRECIPITATION INDEX (TPI)

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The Temperature-Precipitation Index (TPI) was calculated for 260 grid points of the Canadian Climate Centre (CCC) General Circulation Model (GCM). Grid points were selected to include all of Canada and some of its off-shore areas. Mean daily temperatures and total daily precipitation amounts were used in this calculation which was applied to both the 1xCO2 and 2xCO2 scenarios.

Maps of TPI values for the CCC GCM will be presented and compared with values obtained through time series of observed temperature and precipitation values. Preliminary analysis suggests that model estimates and observations compare favourably in January, but disagree markedly in July. The implications of these results on the accuracy of precipitation parameterization procedures used in the CCC GCM will be explored. Also, an intercomparison of results from the two scenarios will provide an indication of what if any impact global warming might have on TPI values in Canada.

ON THE ACCURACY OF TEMPERATURE AND PRECIPITATION ESTIMATES OF THE CCC GCM IN THE MACKENZIE VALLEY AREA OF NORTHERN CANADA

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At last year's Congress in Winnipeg, a comparison of actual temperature and precipitation normals and corresponding 1xCO2 scenario estimates from three U.S. GCM's was made for the Mackenzie Valley area. It was demonstrated that the climate of the Mackenzie Valley is greatly affected by the presence of the topographical features in the area. Since none of the GCM's reviewed could resolve these features, it came as no surprise that the capabilities of these models in replicating the Mackenzie Valley climate was very poor.

A subsequent study of the higher resolution model of the Canadian Climate Centre has now been carried out. We will present comparisons between this model and the U.S. models for temperature and precipitation in January, April, July and October. In addition, we will present each model's estimate of the modified climate of the Mackenzie Valley according to the 2xCO2 scenario. The implications of these results for the Mackenzie Basin impact studies will then be reviewed.

ESTIMATING THE IMPACT OF GLOBAL WARMING ON PERMAFROST LAYERS IN THE NORTHERN HEMISPHERE

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A simple model of permafrost stability has been developed which depends only on mean monthly temperature and winter precipitation amounts. This model will be briefly described and applied to climate data sets from approximately 100 observing stations north of 60°N latitude. A comparison of modelled and observed northern limits of continuous and discontinuous permafrost will be presented.

The permafrost stability model has also been tested using grid point values of monthly temperature and precipitation from three U.S. GCM's. Results will be presented on the accuracy of these models in locating current locations of permafrost boundaries in the northern hemisphere, and on the movement of these boundaries under scenarios of global warming.

NON LINEAR VAD ANALYSIS OF SINGLE DOPPLER DATA

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The VAD analysis (Browning and Wexler, 1968) of single Doppler data is widely used to retrieve vertical profiles of horizontal velocities and divergence above the radar in case of relative uniform and smooth wind field. The assumption about the linear variation of wind field remains as a severe limitation to apply this analysis to situations where the non linearity is important. To circumvent this limitation, the harmonics of order higher than two in the Fourier expansion of radial velocity versus azimuth angle should be kept, which contain the information on irregular variations of winds. This non linear VAD analysis has been applied to a clear air observation case (Caya and Zawadzki, 1992). It is known that non linear winds are more common in case of convection and precipitation. However, the contribution of vertical velocity to radial velocity observed by radar make the analysis more complicated. The horizontal non linear variation of vertical winds together with that of horizontal winds should be taken into account. The non linear VAD analysis is proved to be superior to the classical VAD analysis when both applied to simulated sinuous waves with or without the contribution of vertical winds. A real case of stratiform precipitation will also be analyzed.

ON THE BAROCLINIC DYNAMICS, HAMILTONIAN FORMULATION AND GENERAL STABILITY CHARACTERISTICS OF DENSITY-DRIVEN SURFACE CURRENTS AND FRONTS OVER A SLOPING CONTINENTAL SHELF

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A new theory is presented to describe the baroclinic of density-driven currents and fronts over a sloping continental shelf. The frontal dynamics is geostrophic to leading-order but not quasi-geostrophic since the dynamic frontal height is not small in comparison to the scale frontal thickness. The evolution of the underlying slope water is modelled quasi-geostrophically and includes the influence of a background vorticity gradient due to the sloping bottom. The two layers are coupled together via baroclinic vortex-tube stretching associated with the perturbed density-driven current. The current dynamics includes the advection of mean flow vorticity. The model equations are obtained in a formal asymptotic expansion of the relevant two-layer shallow water equations and boundary conditions. It is shown that the governing equations for the model can be put into noncanonical Hamiltonian form.

A comprehensive analysis of the general linear and nonlinear stability characteristics of the governing equations is given. The normal mode problem associated with steady along-shore currents is studied and sufficient stability and necessary instability conditions are presented. It is shown that a zero in the frontal vorticity gradient is not needed for instability. Jump conditions for the perturbation frontal thickness are systematically derived associated with the continuity of pressure and normal mass flux for steady frontal configurations that possess discontinuities in the velocity or vorticity, and rigorous regularity conditions are obtained for the perturbation thickness on outcroppings. The 'formal' stability of arbitrary steady currents is studied. It is shown how to obtain general steady current solutions as a variational solution to a suitably constrained Hamiltonian. General criteria are obtained for establishing the linear stability of these steady density-driven currents in the sense of Liapunov. In the limit of steady parallel along-shore flow, the formal stability results reduce to the sufficient conditions found for the normal modes. Finally, the nonlinear stability of steady density-driven currents and fronts is studied. Based on the formal stability analysis, appropriate convexity hypothesis are found that rigorously establish nonlinear stability of steady currents in the sense of Liapunov, and establish nonlinear saturation bounds on the perturbation flow with respect to a potential enstrophy/energy norm.

A NUMERICAL STUDY OF PRECIPITATION TYPE TRANSITION REGIONS

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Precipitation type transition at the surface often occurs in winter storms. To improve prediction of these transitions requires better understanding of the physical processes occurring in the transition region. A two-dimensional, anelastic, cloud-resolving numerical model is used to simulate the transition region. Large domain and fine grid resolutions are utilized so that both the large scale and mesoscale precipitation features in winter storms can be handled adequately by the model. Microphysical processes considered in the model include evaporation/condensation, deposition/sublimation, melting/freezing. coalescence, accretion, riming and growth. Background large scale updrafts are specified to produce the stratiform synoptic scale precipitation. It is found that cooling-by-melting produced significant thermal and momentum perturbations in the environment which in turn modulated the precipitation field. Model results will be presented with reference to some observed cases. Sensitivity of the results to some model physics and various environmental conditions will also be discussed.

A THEORY OF SQUALL LINE EVOLUTION

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Observations show that squall lines often evolve from a vigorous upright convective line into a mesoscale convective system (MCS) possessing an extensive trailing stratiform precipitation region. This transformation of storm structure often takes place in an abrupt manner. A two-dimensional, anelastic, cloud-resolving numerical model was used to study the physical processes responsible for this transformation of storm structure during the evolution of squall systems. Both the life-cycle and storm structure of observed squall systems have been simulated successfully. Careful analysis of model results leads us to propose a feedback mechanism involving the convective heating aloft, storm-generated horizontal momentum and cooling-by-melting to explain the evolution of the model squall line into a quasi-steady MCS state. Both observations and model results will be presented to illustrate this theory.

MESOSCALE OBSERVATIONS OF SURFACE FRONTS IN SOUTHERN ONTARIO STORMS

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The intent of this study is to determine the mesoscale nature of surface frontal passages in Southern Ontario using a network of nine PAQMOS (Portable Air Quality and Meteorological Observing System) towers situated around Pickering. These stations recorded ten minute averages of temperature, pressure, humidity, wind speed and wind direction for 1988 and 1989. This data is compared to surface synoptic charts to identify frontal passages. Time series plots of the data are used to determine the temporal extent of the frontal zone. The synoptic charts are analyzed for orientation from true north and frontal speed so that the width of the front and estimates of frontogenesis can be made. Specific fronts are then analyzed intensively to provide illustrative cases with special attention paid to warm fronts.

MEDIUM RANGE STRATOSPHERIC FORECASTS WITH A GLOBAL SPECTRAL MODEL

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Due to heightened interest in the radiative impact of stratospheric ozone it will become increasingly important to produce good forecasts of the stratospheric circulations that control the redistribution of ozone in the medium range time frame. Another related question is how an improvement of the stratospheric forecasts will benefit the tropospheric circulations.

In this context we have started evaluating the quality of medium range stratospheric forecasts produced by the Canadian global spectral model. It has been found that the forecasts are sensitive to the position of the top of the model. Integrations were performed with a control model having its top two levels at $\sigma_1 = .010$ and $\sigma_2 = .045$. The impact of the position of the top was tested by removing the level at $\sigma_1 = .010$ and the results showed that removing this level produces a significant deterioration in the accuracy of the forecasts, especially in the stratosphere. The impact of even higher tops will be investigated. Other tests have shown a sensitivity to the formulation of the upper boundary condition and the strength of the horizontal diffusion in the stratosphere. The vertical resolution (and implicitly the vertical discretization) is also being examined, as well as the physical influence of the solar and infrared radiation.

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ESTIMATION DU MOUVEMENT VERTICAL À L'AIDE DES DONNÉES DE SURFACE SEULEMENT: VÉRIFICATION OBJECTIVE

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Le mouvement vertical (oméga) à l'échelle synoptique et à la méso-échelle est l'un des paramètres importants à considérer dans le processus de prévision à court terme. L'étude d'une suite temporelle de diagnostics présentant la structure horizontale du mouvement vertical, peut permettre au prévisionniste d'inférer sur la probabilité d'occurrence de différents éléments du temps sensible. En effet, en plus d'être directement responsable de la couverture nuageuse et de la précipitation associée aux systèmes synoptiques, le mouvement vertical joue un rôle de premier plan dans la modification de la stabilité dans la basse atmosphère. Conséquemment, le diagnostic de la vitesse verticale peut représenter une importante source d'informations en ce qui concerne le déclenchement de conditions sévères du temps. Les méthodes habituelles pour le calcul de oméga demandent un ensemble de données représentant la structure tri-dimensionnelle et temporelle de l'atmosphère. Ces données ayant une résolution spatiale et temporelle insuffisante pour représenter l'évolution à court terme des systèmes d'intérêts, il devient nécessaire d'utiliser le réseau de données de surface pour atteindre le but recherché. Une méthode permettant d'estimer oméga strictement à l'aide de ces données, a été proposée par Zwack et Kabil (1988). Le but spécifique de cette étude est l'évaluation de cette méthode sur plusieurs cas réels, dans l'optique d'identifier son potentiel opérationnel. La vérification s'effectue sur une base de 40 cas (diagnostics). L'évaluation se présente sous la forme d'une comparaison entre le mouvement vertical et la couverture de nuages bas et moyens. De plus, une comparaison est faite avec les prévisions 0-12 heures de la vitesse verticale produites par le modèle aux Éléments Finis Régional du Centre Météorologique Canadien.

Cette dernière comparaison représente une mesure de l'utilité de la méthode proposée, qui demande une banque de données et des ressources informatiques beaucoup plus restreintes que celles nécessaires à l'exploitation d'un

modèle numérique. Donc la méthode d'estimation du mouvement vertical à l'aide des données de surface, peut représenter une alternative intéressante aux produits numériques, en plus d'être utilisée comme plate-forme à l'évaluation et à la critique des prévisions numériques du mouvement vertical.

MESOSCALE BLOCKING AHEAD OF COLD FRONTS AND MOUNTAIN RIDGES

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Detailed examination of cold frontal passages over Sable Island during the 1986 CASP field study shows that in many cases the change in wind direction started 15-60 min ahead of the temperature decrease. We believe that this is a mesoscale blocking effect, not linked to wind shifts associated with preceding warm fronts, upper level cold fronts or warm conveyor belts. The phenomenon is apparently 'known' to operational mesoscale forecasters but we have been unable to find an explanation or much discussion in the literature. In most of our cases the frontal zone velocity was greater than the near-surface (10m) front-normal component of wind speed in the cold air behind the front. This could lead to the creation of an elevated 'nose' to the front but it is hard to envisage the temperature decrease being delayed by more than a few minutes as a result since the air column beneath the nose would be hydrostatically unstable, convective overturning would occur and surface temperatures would start to decrease. Our hypothesis is that the delays are dependent on stable stratification, characterised by the Brunt-Vaisala frequency, N, in the warm air ahead of the fronts and that the process is similar to upstream blocking in stably stratified flow over topography.

For upstream blocking or deflection in stably stratified, hydrostatic airflow over a mountain barrier or escarpment of height h, the dividing streamline height analysis provide by Sheppard (1956), Snyder et al (1985) and Smith (1989, 1990) can be extended to include downward momentum transfers in the turbulent boundary-layer and leads to an estimate of the approximate upwind extent of the 'blocked' flow at the surface as $L_B \quad (U^2/4u_*^2)(h\text{-}U/N)$, where u_* is a characteristic friction velocity in the flow ahead of the blocked region. This is of the right order of magnitude to explain our frontal observations. Numerical model results for stably stratified hydrostatic boundary-layer flow over 2D ridges will be used to illustrate the process.

OBSERVATIONAL SYSTEMS FOR MOIST CONVECTION AND MESOSCALE DYNAMICS IN THE ATMOSPHERE

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The role of mesoscale dynamical processes in moist convection is now well recognized, at midlatitude and in the tropics as well. At midlatitude, the "conditional symmetric instability" (CSI), a typical mesoscale instability, is often used to explain some frontal rainbands. In the tropics, the spiral rainbands of the hurricanes developing on the Gulf of Mexico, or the great squall lines which sweep regularly West Africa at the rainy season, are among the most typical examples of the manifestation of a mesoscale process.

To understand this kind of phenomenon, a wide range of scales should be covered, from the synoptic to the microphysical. This justifies the conception and the deployment of big field experiments coordinating a wide variety of instruments: radiosonding units, wind profiler radars, meteorological Doppler radars, in situ ground mesonetwork, in situ aircraft measurements, etc. To interpret the data of such experiment, the "natural" approach would be to assimilate them in a mesoscale numerical model. However there are limitations in this approach bounded to the difficulty for any model to assimilate high density data. The other approach followed by the experimenters has been to introduce some physics in the data processing in order to retrieve from them meaningful information, as the flow field or the pressure and temperature field, directly comparable with the output of a mesoscale model. The aim of the present paper is to illustrate by specific examples this last approach and to show how it has helped experimenters i) in providing new insights in the physical processes, ii) in testing the validity of theoretical ideas, and iii) in elaborating comparison between experience and model.

WATER VAPOR PLUME CHARACTERISTICS ASSOCIATED WITH THE EXTREME HEAVY RAINFALL

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GOES 6.7 um Water Vapor (WV) imagery have been used to study the relationships between the WV plumes and the extreme Heavy rainfall (5 inches or more) over the United States. The work covers a 3-year summer period (June through September 1989-1991).

More than 80 cases have been selected and nearly 94% were associated with a well defined WV plume. These WV plumes originating either from the ITCZ or from the polar regions often interact and are associated with a coupling of low-level and upper-level forcing mechanisms i.e. Equivalent Potential Temperature and Jet Stream respectively. Therefore a classification of the WV plume characteristics evolved into 5 categories. An examination of the 300 MB analyses shows that for 86% of the cases, the rainfall area is located in the trough to ridge position while 14% is located in the ridge to trough position.

The present study shows that the WV plume appears to be one connecting link between the global (climate) scale and the meso-storm scale resulting in the flash flooding.

A NEW MODEL FOR PREDICTING THE NORTHERN DIVERSION RATE AND RETURN TIMING OF FRASER RIVER SOCKEYE SALMON

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We hypothesized that the variability of Northeast Pacific Ocean currents affects the latitude of landfall, migration speed, and time of arrival of sockeye salmon (*Oncorhynchus nerka*) returning to the Fraser River. The OSCURS (Ocean Surface Current Simulations) model was used to simulate the return migration paths of sockeye by seeding the model with non-passive drifters. Initial simulations focused on 1982 and 1983, two years with significantly different Northern Diversion Rates of 22 % and 80 %, respectively. Consistent with our hypothesis, the relatively strong circulation of 1983, compared to 1982, accounted for northward deflections of over 550 km, migration speed differences of over 20 cm/s, and differences in arrival dates of over two weeks (Thomson et al., 1992a and 1992b). We suggested that the effects of Northeast Pacific currents must be included in sockeye migration models, and proposed a new conceptual model for the prediction of the Northern Diversion Rate and return timing which includes Blackbourn's (1987) temperature-displacement model, enhanced to include the effects of currents during the ocean phase of migration, and the use of two predictive formulas for the coastal phase of migration: the formula of Xie and Hsieh (1989) for sockeye approaching Vancouver Island directly from the ocean, and a yet-to-be-developed formula for sockeye approaching Vancouver Island from the north in the Coastal Downwelling Domain.

We have since simulated the migrations of compass-orientated sockeye from 1946 to 1990. This paper will present our conceptual model and discuss our progress towards verifying the model components.

THREE-DIMENSIONAL DIAGNOSTIC MODELLING OF THE DENSITY-DRIVEN CIRCULATION IN THE GULF OF ST. LAWRENCE

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A three-dimensional eddy-resolving model was developed for the Gulf of St. Lawrence, with levels at 30, 50, 100 m. Diagnostic simulations were performed , using monthly-averaged three-dimensional density fields, in order to describe the density-driven circulation at monthly time scales. Results show that the circulation is generally cyclonic, and mostly confined to the upper layers. This confirms earlier findings. The bottom circulation shows an upstream flow from the north-eastern Gulf and Cabot Strait which is directed to the north-western Gulf and to the St. Lawrence Estuary, respectively through the Jacques-Cartier and Honguedo straits.

the major features of the circulation are a cyclonic eddy situated in the north-western region, a strong almost year-round seaward flow in surface and intermediate layers that follows the Laurentian Trough, the Gaspé Current, and a coastal current along the western Newfoundland shore. Other important features that appear periodically in the numerical simulations are different eddies. The results also show a coastal current which originates near the southern side of Cabot Strait and flows southward into the Magdalen Shallows, along the west coast of Cape Breton Island.

One conclusion of this study is that the different regions of the Gulf of St. Lawrence show an important interdependence at climatic time scales. This suggests that the Gulf must be considered as a coherent dynamic entity which affects most of its regions.

EFFECTS OF SALINITY AND SURFACE TENSION ON MICROBUBBLE-MEDIATED SEA-TO-AIR TRANSFER OF SURFACTANTS

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A series of experiments in artificial seawater were conducted to study the effects of salinity and surface tension on the bubble-mediated sea-to-air transfer of surfactants. The surface tension induced by bubbling and the bubble transport of C14-labeled oleic acid from seawater to the air-water interface and, thence, to a height of 10 cm above the water surface by bubble bursting were measured. We have found that as the salinity increased from 0 ppt to 35 ppt (in conditions free from contamination), slightly more oleic acid was transported from seawater to the water surface and, in turn, to the air. It was also found that the effects of contamination by surface-active substances in the seawater was to increase the surface pressure (i.e., reduce the surface tension), which, in consequence, altered the droplet ejection process, resulting in increased transport of oleic acid to the air.

VARIABILITY TRENDS IN BRITISH COLUMBIA PRECIPITATION

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Tuller (1990) and Moore (1991) reported apparent increases since 1950 in the variability of precipitation at two stations in southwestern British Columbia and in Fraser River flow, respectively. The present paper investigates in more detail the year-to-year variation of annual total precipitation at 13 B.C. stations. Lag-1 autocorrelation and the probability of two years wetter or drier than the long-term median occurring consecutively indicated that stations located in the Fraser, Thompson and Okanagan River basins and on southern Vancouver Island had somewhat greater variability in the latter part of their records. Stations located in the southeast, northeast and north coast areas

of the province showed no change or a decrease in variability. Station density is not sufficient to confirm the coherence of these regional patterns, however, and shorter cycles in variability dominate the records of all stations. Considering all stations together; the late 1920s, mid-1940s and mid-to-late 1950s were periods of relatively low variability. The late 1930s through early 1940s and the mid-1980s had relatively high variability.

Moore, R.D. 1991 "Hydrology and water supply in the Fraser River basin" in A. Dorcey and J. Griggs eds. Water in Sustainable Development: Exploring Our Common Future in the Fraser River Basin, Westwater Research Centre, pp. 21 - 40.
Tuller, S.E. 1990 "Precipitation trends at Victoria, British Columbia", Climatological Bulletin, 24:158 - 167.

LE PROFILEUR DE COUCHE LIMITE COMME INSTRUMENT D'OBSERVATION DE MICROPHYSIQUE

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Le profileur (radar Doppler pointé quasi-verticalement) de $\lambda \approx 30$ cm a été développé pour pallier la déficience des profileurs troposphériques-stratosphériques à courtes distances. Un profileur de couche limite sera installé prochainement à Montréal. Les caractéristiques de ce radar et les possibilités d'observation des distributions de tailles d'hydrométéores seront présentées avec des exemples de mesures prises durant l'expérience HARP à Hawaii.

SPACEBORNE AND AIRBORNE SAR IMAGERY OF OCEAN WAVES FROM ERS-1 VALIDATION

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The European Space Agency's ERS-1 satellite was launched in July 1991. The ERS-1 Synthetic Aperture Radar (SAR) Wave Spectra Validation Project is one ERS-1 geophysical validation activity. The field program ran from 10 to 26 November, 1991. During that time there were 12 ascending or descending ERS-1 SAR passes over a cross-over node located on The Grand Banks of Newfoundland, about 100 nm south-east of St. John's. The cross-over node formed the principal validation site and the focus of the in situ measurements conducted from the Bedford Institute of Oceanography (BIO) research vessel 'CSS Hudson'. The in situ data include wave and wind measurements from 'Hudson' and moored buoys.

In addition to the ship-based program, the validation site was overflown by the Canada Centre for Remote Sensing (CCRS) CV-580 C-band SAR on seven occasions. Each flight was coincident with an ERS-1 SAR pass.

In this paper, we present some initial spectral analysis results from nearly coincidental spaceborne and airborne SAR imagery of ocean waves obtained during the validation field program. We consider the effect of the platform height-to-velocity ratio (h/V) on velocity bunching (the principle wave imaging mechanism for SAR) for the spaceborne (h/V = 120 s) and airborne (h/V = 15 s) cases. We provide preliminary comparisons of the SAR spectra with the other field program data and consider the wave field homogeneity as measured by the two SARs.

NUMERICAL MODELING OF ENTRAINMENT AND CLOUD DROPSIZE DISTRIBUTION

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A dynamic cloud model with a detailed treatment of the condensation process is used to simulate the development of cloud dropsize spectra in a non-precipitating cumulus cloud. It was found that vortex circulations and penetrative downdrafts entrained environmental air into the could both from the cloudtop level and from the sides. Mixing leads

to multimodal cloud dropsize distributions when the mixture undergoes some lifting resulting in new drops being nucleated. In diluted regions, the mean radius of the distribution decreases while the standard deviation increases. However, the simulation gives no evidence that mixing would lead to the production of large drops.

EFFECTS OF TIDAL MIXING OVER A SILL ON ESTUARY/OCEAN EXCHANGE

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Long Island Sound is subject to strong cooscillating barotropic tides. Basin morphology is characterized by both a channel constriction and a sill at the seaward end. Current and CTD observations provide evidence for a modulation of density circulation over the sill. The outflow is confined to a relatively thin surface layer; inflow occurs in a tidally mixed bottom layer occupying much of the water column. Strong bottom fronts are found towards the seaward side of the sill and occasional surface fronts appear landward of the sill. Numerical experiments are presented to elucidate the interaction of density driven circulation with the spatially variable tidal mixing. The numerical experiments involved the adjustment of a uniform longitudinal density gradient over a simple sill topography. Effects of tidal mixing were incorporated through use of a mixed layer model forced by the spatially variable barotropic tidal current and the evolving ambient stratification.

Results illustrate the sensitivity of the baroclinic adjustment to the tidal velocity amplitude and to the height of the sill. At lower tidal velocity amplitudes the effects of vertical mixing are evident only near the bottom. The surface flow accelerates and is confined to the upper layers of the water column. At higher tidal velocity amplitudes, vertical mixing is more vigorous and affects the entire water column over the sill. This contributes to the formation of a strong surface front and a weaker bottom front near the sill. Secondary motion at these fronts tends to recirculate much of the gravitational flow landward and seaward of the sill.

AIRBORNE RADAR MEASUREMENTS OF OCEAN SURFACE CHARACTERISTICS DURING THE ERS-1 SAR CALIBRATION/VALIDATION EXPERIMENT

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Measurements of ocean directional wave spectra, significant wave height and mean surface roughness over the Grand Banks of Newfoundland were recently made using the combined capabilities of the radar ocean wave spectrometer (ROWS), scanning radar altimeter (SRA) and advanced applications flight experiment (AAFE) Ku-band altimeter. The instruments were flown aboard the NASA WFF P3A aircraft during a series of ERS-1 underflights from 14-20 November 1991.

The NASA/Goddard Space Flight Center's ROWS is a 14-GHz pulse-compressed radar which uses a near-nadir pointing scanned antenna to derive directional spectra from the radar return [Jackson, 1985]. For this experiment, the ROWS was modified to cycle at a 50 Hz rate between the scanning spectrometer antenna and a wide beamwidth nadir altimeter mode. This change allows the sensor to simultaneously measure directional wave spectrum, wave height and surface roughness. Goddard's SRA sensor [Parsons and Walsh, 1989] is a 36-GHz short pulse radar altimeter which uses a cross track scanning technique combined with a large aperture antenna to produce directional wave spectra by directly measuring surface wave topography. The SRA is an improved replacement of the Surface Contour Radar [Walsh et al, 1985, 1989]. The University of Massachusetts has recently refurbished the AAFE altimeter. The AAFE is a 14-GHz pulse-compressed radar altimeter with very fine (41 cm) range resolution. Because of conflicting operating altitude requirements, the SRA and ROWS are not operated together. The SRA flew the first underflight; ROWS the remaining three. The AAFE altimeter collected data on all flights.

A brief summary of each instrument's measurement capabilities will be given followed by intercomparison of ROWS and SRA directional wave field estimates with in situ and SAR derived wave products. Additionally, we will present altimeter derived estimates of sea surface wave height and wind speed along the 600-800 km flight lines which should provide additional information on ocean submesoscale (< 10 km) variations near the time of the satellite overpass.

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EFFECTS OF CLOUD SHAPE ON CLOUD ALBEDO

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The intensity of solar radiation reflected by clouds depends strongly on the cloud geometry. Thus cloud shape is an important factor affecting the energy budget of the whole climate system.

Significant research has already been done to describe the effect of cloud geometry on the radiation field. Investigators often assume that the clouds' horizontal cross section is either a square or a disk. The albedo of cuboidal and cylindrical clouds have been compared by Welch and Wielicki and by Breon; however, they drew contradicting conclusions. In the present work, we compared these two cloud shapes to evaluate their conclusions. We used Monte Carlo simulation for the comparison and have obtained results for both cloud albedos and bidirectional reflection functions. Also the differences have been examined in cases of random cloud orientation.

Our results seem to indicate that the albedo of cloud fields depends mainly on two factors. One is the cross sectional area of the clouds as seen from the direction of the Sun. This determines the number of photons entering the clouds. The other main factor is the optical thickness of the clouds in the direction of smallest value, which is the main determinant of the average time the photons spend within the cloud. This assumption was found to be fairly good if the cloud spacing was large enough, so that the cloud-cloud interactions were not significant.

VALUE ADDED TO STATISTICAL WEATHER ELEMENT FORECASTS THROUGH ERROR-FEEDBACK POSTPROCESSING SYSTEMS

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Weather element forecasts may be available from different sources and may be based on the output of different driving models. The sources may include direct model output and statistical-dynamical forecasts based on Model Output Statistics(MOS) or Perfect Prog (PP) techniques. The MOS technique has the advantage over the PP approach by implicitly taking account of systematic errors in the driving model and using predictors which are not available in the PP system. The MOS technique also recognizes the predictability of the model parameters and allows for the selection of different predictors according to reliability with projection time. As the skill of the model predictions deteriorates, the MOS forecasts will tend toward the mean of the development sample. On the other hand the PP technique uses a much larger development data base, is independent of the driving model and by its nature tends to produce sharper forecasts than the MOS system. The experience at the Canadian Meteorological Centre (CMC) has shown that the PP forecasts have higher skill scores for the early projection times and the MOS forecasts in later projection times. The PP forecasts are sharper, the MOS forecasts have higher reliability.

However, as model changes are becoming more numerous, the dependency on MOS techniques is severely curtailed. MOS forecast systems become unrepresentative as the model changes. Recomputation of statistical relationships are required. The short lenght of data that is available often may be unrepresentative of the true climate because of the particular weather regime that existed during that period.

The approach at CMC has been to apply error feedback postprocessing techniques to the basic PP forecasts to allow the forecast system to take on many of the desired MOS attributes. The objectives are to reduce the forecast errors, increase the reliability, improve the forecast distribution and the sharpness of the forecasts. Calibration, bias correction, error feedback and anomaly reduction techniques have been imposed to reduce biases in the forecasts as well as the departures from normal with projection time. In another application, the frequency distribution of forecast ranges is made to resemble that of the observed data. These techniques are model dependent and must be updated continuously. However, the manipulations are simple to perform, are not nearly as cumbersome as regression schemes and can be automated to some extent. The adaptations are dependent on forecast type, projection time, forecast range, time of year and location. This provides an efficient and inexpensive replacement for a full scale MOS system.

The merging of PP forecasts with important model dynamical variables indicates considerable promise for future development. Probability of Precipitation forecasts were blended with direct model forecasts of precipitation amount to produce improved forecasts. This later parameter contains the most important predictors that would have been used in a pure MOS system, mainly vertical motion, precipitable water and relative humidity.

The identification of synoptic patterns associated with anomalous weather occurrences will be useful in increasing the sharpness in forecasts and the detection of extreme events. The use of rule based system such as the tree diagram approach will then be applied to enhance and supplement the original forecasts.

Different error-feedback techniques applied on CMC operational statistical weather element forecast systems will be discussed and their value added clearly demonstrated.

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(1): N. Yacowar retired from the Canadian Atmospheric Environment Service in March 1991.

ON THE INTERPRETATION OF REGIONAL CLIMATE CHANGE SCENARIOS GENERATED BY GCMS

Dr. D.L. Verseghy
Canadian Climate Centre

Doubled-CO2 simulations have been carried out by a number of GCM groups worldwide, including the numerical modelling division of the Canadian Climate Centre. With the publication of the results of these experiments, data on projected regional changes in surface screen temperature, precipitation rates, soil moisture, etc., have been made available to general public.

Some researchers have been prompted to use the information thus provided to undertake detailed analyses of regional climate change, with its impacts on agriculture, forestry, water resources, etc. However, such attempts are fraught with pitfalls for the unwary. Because the resolutions used to date have been quite coarse, and because the land surface schemes coupled to GCMs have hitherto been rather crude, there are large uncertainties associated with the regional climates simulated even under present-day conditions. In this presentation, an analysis will be given of the problems caused by coarse resolution, and the systematic errors associated with land surface schemes which are based on the force-restore method for soil temperatures and the "bucket" model for soil moisture. The improvements gained by using a more physically-based land surface scheme will be discussed.

MODÉLISATION ET SUIVI DE LA CLIMATOLOGIE DES EAUX DU GOLFE SAINT-LAURENT À PARTIR DES IMAGES NOAA-7 ET NOAA-9.

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La compréhension du rôle du golfe sur les changements climatiques régionaux nécessite celle des schémas de circulation océanique saisonnier ainsi qu'une bonne connaissance de la climatologie des eaux du golfe sur une base inter-annuelle, inter-mensuelle et inter-saisonnière.

Cela supporte la thèse qu'il faut avant tout définir la climatologie des eaux du golfe et d'en évaluer la sensibilité aux variations climatiques. La dynamique du golfe Saint-Laurent au niveau de son régime thermique a fait l'objet de nombreuses études (Lauzier et Marcotte, 1965; Neu, 1970; Weiler et Keely, 1980; Vigeant, 1987). L'ensemble des études démontrent clairement le besoin d'un meilleur support en terme d'outils et bases de données pour le suivi et la modélisation de la climatologie du golfe.

Dans cette avenue, Condal et al., (1984, 1991) ont développé une approche permettant la restitution des températures de surface pour la région du golfe Saint-Laurent à partir des données satellitaires (AVHRR-NOAA). L'intégration des données multi-sources (climatologiques, océanographiques et satellitaires) à l'intérieur d'un SIRS devient alors la solution pour l'établissement et le suivi de la climatologie du golfe. Ainsi à partir d'une série d'images NOAA-9 couvrant la période 1984 - 1988, nous avons effectué une première classification des champs thermiques des eaux de surface pour une région du golfe Saint-Laurent (centre des images: Lat 49o N Long. 63oO). Les résultats démontrent que le suivi de la variation spatiale des températures de surfaces, à partir de l'imagerie satellitaire, associée aux schémas de circulation océanique rend possible le suivi et l'étude des transformations globales du régime thermique des eaux du Golfe. Cette étude vise l'élaboration d'un système intégré d'analyse du régime thermique du Golfe par l'utilisation d'un modèle de simulation numérique.

STRATOSPHERIC POLAR OZONE DEPLETION AND ITS IMPACT ON SURFACE UV-B RADIATION

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Since the discovery of large spring ozone decline in the Antarctic by Farmer et al. (1985), a number of theories have been advanced to explain the phenomenon of anomalous seasonal ozone decline in the polar regions. Some of the theories are chemically oriented while others are purely dynamical in nature. This paper presentation reports on a study which examines these proposed theoretical mechanisms in a 2-D time dependent Eulerian circulation model which takes into account the major interactions between chemistry and dynamical transports in the stratosphere. The model simulations are carried by modifying the normal large-scale eddy mixing coefficients and the standard gas phase chemistry to represent the anomalous dynamical and heterogeneous chemical conditions during winter and spring in the polar regions. The results will show that both dynamics and heterogeneous chemistry play important roles and that it is necessary to invoke a mixed dynamical-chemical mechanism to explain the anomalous seasonal ozone column declines in the polar regions. Also discussed will be the impact of calculated stratospheric polar (both Arctic and Antarctic) ozone depletions on UV-B radiation reaching the earth's surface.

NEW PBL RESISTANCE LAWS: A PROPOSAL

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A best-fit polynomial through observations of geostrophic drag coefficients suggests that the traditional form of the Planetary Boundary Layer (PBL) Resistance Laws, also known as Drag Laws or Similarity Laws, is inadequate. A new form is derived from a generalization of the theory. Following are some conclusions of this work:

a) According to theory, both Y = (k/Cg)cos a and Z = (k/Cg)sin a are linear in ln(Ro*), where Cg = u*/G is the geostrophic drag coefficient, u* is the friction velocity, G is the geostrophic wind speed, a is the surface cross-isobar angle, k is von Karman's constant, Ro* = u*/(f z0), f is the Coriolis parameter and z0 is the roughness length, regardless of whether the traditional or proposed new values of the constants are used.

b) Provided G, a, u*, f and z0 are available, the most appropriate way to present data is by plotting Y vs. X and Z vs. X.

c) The new formulation for Resistance Laws for the neutral PBL allows for four rather than the traditional two constants, giving two extra degrees of freedom when fitting to observed data.

d) When comparing the neutral PBL Resistance Law with a set of data assembled for the purpose, plots of Y vs. X and Z vs. X show that the new form achieves slightly better results than the traditional form for Y and significantly better for Z.

EXAMINATION OF THE REGIONAL VALIDITY OF THE CCC GCM CLIMATE SIMULATIONS FOR THE EASTERN ARCTIC

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Equilibrium simulations by current general circulation models to estimate the sensitivities of climate to a doubling of CO2 concentration are in general agreement in the sense of global annual average. However, with respect to regional and seasonal projections, there are substantial differences among the simulations of various models (Grotch, 1991).

As a first step, attempts have been made to examine the ability of the Canadian Climate Center general circulation model (CCC GCM Version II) to simulate the present climate on a regional scale; specifically, a region centered on Baffin Island in the Canadian Arctic (60-80°N, 60-90°W). Comparison between 1xCO2 simulations and observations of temperature and precipitation in the region reveals large errors in the model simulations. This suggests that, although the model is able to simulate the present climate in the global perspective, regional departures can be large. Inadequacies of the observational record (baseline) in the Canadian Arctic, on the other hand, obviously result in the uncertainties of the model validation in the sense of the baseline. A method of improving the resolution of the baseline climate by integrating data from short period stations, including automatic stations, will be presented.

Comparisons between 1xCO2 and 2xCO2 climate simulated by the CCC GCM present a possible scenario of climatic change induced by increased CO2 in the eastern Arctic. However, this is only one possible equilibrium climate of the future rather than a prediction. The low quality of the model simulation of present regional climate clearly indicates the uncertainty of sensitivity studies using general circulation models. Therefore, impact studies on the model simulation should be carried out with the awareness of 'regional uncertainty'. The method presented here can contribute to the reduction of that uncertainty.

A NUMERICAL SIMULATION OF SEA ICE CIRCULATION IN HUDSON BAY

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The thermodynamic and dynamic numerical model of the plastic-viscous sea ice (the Hibler 2-level model, 1979), was used to simulate the sea ice flow, thickness, and compactness in Hudson Bay under atmospheric thermodynamic and dynamic forcing. The seasonal cycle of sea ice has been simulated using monthly forcing. Sea ice flow mainly depends on the wind stress and direction. Sea ice in James Bay appears inactive due to the boundary constraint. In agreement with observations, sea ice in summer piles up in the southern shore in Hudson Bay, even though the surface air temperature there is higher than the central and the northern Hudson Bay. This is mainly due to the northwestern wind. Similarly, the breakup in spring to the northwest of the Bay is also due to the northwest wind

forcing. The simulated sea-ice thickness distribution is also comparable to the observations. A sensitivity study shows the capability of this model in application to a mesoscale ocean basin.

DEEP WATER MASS PROPERTIES IN A 2.5-D MODEL OF THE GLOBAL OCEAN

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A model of the global ocean is described in which each of the Pacific, Atlantic, Indian and Southern Oceans are separately represented by zonally averaged equations for the conservation of momentum, mass, heat and salt. We present a fully nonlinear equation of state, which allows very efficient calculation of in situ density.

We study the model's sensitivity to parameter changes and high latitude water mass modifications. The resulting ability to tune models is considered and the dangers of obtaining the 'right answers for the wrong reasons' are discussed. Deep water mass properties are studied with the help of a palette of stable, passive tracers plus a tracer modelling radiocarbon, which reveals the time scales associated with the thermohaline circulation. Under annual mean forcing, using observed zonal means of surface temperature and salinity, we find an excess of North Atlantic Deep Water below 2000 m. By more realistically representing high-latitude surface forcing it is possible to bring the deep water mass properties substantially closer to observed values.

Reactions to changes in external forcing suggested by paleoclimatic data are considered, and results are related to geochemical evidence for the state of the ocean under these conditions. Implications for the role of the oceans in determining climate change are discussed.

THE PHYSICS OF MESOSCALE PHENOMENA

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Organized severe convection over Alberta and the rapidly developing east coast storms are two prominent mesoscale phenomena affecting Canada. These systems may be viewed as the product of interactions between mesoscale and larger scale circulations. In the former case, it is the proper phasing of the upper-level flow and the low-level mountain-plain circulation which leads to the outbreak of severe convection. In the latter case, the release of potential instability in slantwise convection can sometimes interact with frontogenetic and cyclogentic processes leading to rapid spin-up. These processes will be clarified from a synthesis of field observations and modeling results.

SEISMIC-ACOUSTIC SENSING OF PROPERTIES AND FRACTURING OF SEA ICE

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The fracturing of sea ice results from stresses due to cooling, ridging or any straining processes that induce internal stress. The sound of ice fracturing reveals the failure process a cracking ice cover is undergoing, thus providing a useful signal for acoustic remote sensing of failure events. On the other hand, artificial sound sources can be used at an experimental site to probe the mechanical properties of the local ice in a scale of 1 km.

In this paper, we describe an ice mechanics experiment which took place in March 1992 in Allen Bay near Resolute of NWT. For the first time, a combined geophone-hydrophone array was deployed for ice fracturing and

tomography studies. Both naturally occurring fracturing sound and artificially generated sound were digitally recorder. Our data sets show that fracturing sound recorded on hydrophone channels contains more information on failure processes than geophone data alone can provide; geophone data reveal the mechanical properties of the ice in terms of elastic wave speeds. While further analyses are still underway, our preliminary analysis has yielded a shear wave speed of 1777 $m.s^{-1}$ and a compressional wave speed of 3654 $m. s^{-1}$ for the first year ice over a scale of 200 metres. We will also show an upper-lifting failure event and the seismic and acoustic waves generated by this event.

SATELLITE-VIEWED GLOBAL CLOUD DISTRIBUTIONS AND STATISTICS

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In an attempt to create synthetic CO datasets used for data analysis and processing of the MOPITT (Measurements Of Pollution In The Troposphere) project, various ways of recreating real-time global cloud distributions have been investigated. It has been found that the ISCCP (International Satellite Cloud Climatology Project) cloud data enable us to present a realistic satellite-viewed global cloud distribution and to study cloud statistics, its diurnal, seasonal and regional variations.

Various approaches to present real-time cloud distributions and their time variations will be described. Results of combining the MOPITT satellite tracks with cloud data will be reported. We will also present some aspects of cloud statistics made using the ISCCP C1 type cloud data.

PREDICTABILITY OF PRECIPITATION PATTERNS ON THE MESOSCALE

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To a certain extent conditions at a larger scale predetermine the behavior of phenomena at the smaller scale. A notion is developing that synoptic scale forcing renders the mesoscale behavior very predictable. This notion, that we could call conditional predictability, comes from experience with numerical modeling.

On the other hand, researchers trying to develop methods of short-term forecasting of precipitation had little success beyond the use of persistence and linear advection of patterns.

Taking the Lagrangean decorrelation time as a measure of predictability at the meso-ß-scale a evidence will be given on the relationship between predictability and the degree of larger scale forcing.

MESOSCALE VORTICITY STRUCTURE OF AN INTENSE SQUALL LINE

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There have been some ambiguities in recent observational studies on whether midlevel mesovortices develop in the descending or ascending flow of mesoscale convective systems (MCSs), and have a warm- cold-core structure. In this study, the mesoscale vorticity structure of an intense squall line, that occurred on 10-11 June 1985 during PRE-STORM, is examined using a 20-h high-resolution real-data simulation.

It is found that the squall system is characterized by a warm-core vortex along the leading convective line and a cold-core mesovortex in the stratiform region with an intermediate deep anticyclonic vorticity zone. Of particular interest is that the cold-core vortex is intensified in the descending rear-to-front inflow as a result of continued sublimative, melting and evaporative cooling in the stratiform region. It has a horizontal scale of 120-150 km in the across-line dimension and more than 300 km in the longitudinal dimension, with its maximum intensity located

above the melting level. More importantly, this vortex tends to decouple from the upper-level front-to-rear ascending flow and the divergent outflow in the lowest layers.

It is also found that the warm-core vortex dissipates and eventually merges into the cold-core vortex circulation as the system propagates into a convectively less favorable environment. At the end of the lifecycle, the vortex circulation becomes the only remaining element of the squall system that can be observed in a deep layer and at a larger scale in the low- to mid-troposphere. The results suggest that mesovortices are ubiquitous in MCSs and the associated mesoscale rotational flow represents the basic dynamic effects of MCSs on their larger-scale environments.

OPTIMAL CONTROL OF OPEN-OCEAN BOUNDARY BY ASSIMILATING ALTIMETRY DATA INTO A REGIONAL CIRCULATION MODEL

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Open boundary conditions, in particular radiating boundary conditions, have been applied to regional circulation models with mixed success. The adjoint assimilation method enables optimal open-boundary control by assimilating data inside the model domain. The present availability of altimetry data prompted us to investigate the feasibility of using altimetry data to optimally control an open-boundary ocean model. To begin this exploration, data from a 2-gyre closed-domain barotropic quasi-geostrophic model are assimilated into a smaller regional open-boundary QG model of the northern gyre. Preliminary numerical experiments with our new scheme for optimal boundary control appear promising. The long-term goal will be to develop an open-boundary adjoint assimilation model of the North Pacific sub-Arctic domain.

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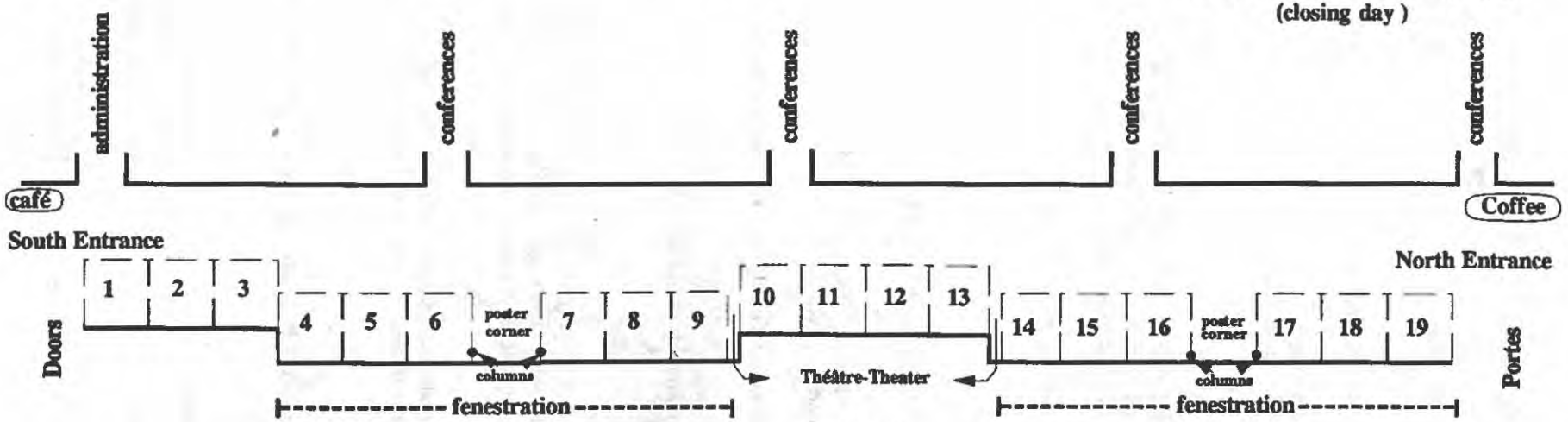
(set up day)
92-06-09
'Till 09:00 A.M.-17:00 P.M.
92-06-11
Friday-Vendredi
92-06-12 09:00 A.M.-17:30 P.M.
(closing day)



1 - GENEQ
2 - "SEA"MONTREAL
3 - PLAN D'ACTION ST-LAURENT
4 - CAMPBELL SCIENTIFIC
5 - SEIMAC
6 - GUILDLINE
7 - BENDIX AVELEX
8 - BENDIX AVELEX
9 - 10'X 11'

10 - 8'X13'
11 - 8'X13'
12 - METEOCEAN
13 - 8'X13'
14 - PCi TORONTO
15 - "IML" RIMOUSKI
16 - AANDERAA
17 - SOCOMAR
18 - SIMRAD
19 - HOSKIN

TWENTY-SEVENTH ANNUAL CMOS CONGRESS

The 27th Annual Congress of the Canadian Meteorological and Oceanographic Society will be held at the University of New Brunswick, Fredericton, N. B., Canada from June 8-11, 1993.

The Congress will feature Theme Sessions on:

- Forest and Agricultural Meteorology;
- Biological-Physical Interactions in the Ocean;
- Climate Modelling; and
- Remote Sensing.

Special sessions are also being planned on CASP II, circulation over abrupt topography, modernized weather services, ozone depletion, and tracers in the ocean. In addition, there will be sessions based on contributed papers in other areas of meteorology and oceanography.

Oral and poster papers, and exhibits will be invited in a later announcement with an **Abstract Deadline of 29 January 1993.**

VINGT-SEPTIÈME CONGRÈS ANNUEL DE LA SCMO

Le 27ième Congrès annuel de la Société Canadienne de Météorologie et d'Océanographie se tiendra à l'Université du Nouveau-Brunswick, Frédéricton, N.B., Canada, du 8 au 11 juin 1993.

Le Congrès présentera des sessions thématiques portant sur les sujets suivants:

- Météorologie forestière et agricole;
- Interactions biologiques-physiques dans l'océan;
- Modélisation climatique; et
- Télédétection.

Sont également prévues des sessions spéciales portant sur: PCETA II, la circulation au-dessus de topographies très accidentées, les services météorologiques modernes, l'amincissement de la couche d'ozone et les traceurs dans l'océan. De plus, des sessions sur divers autres domaines de la météorologie et de l'océanographie seront organisées.

Un appel de communications orales, de sessions d'affichage ou de présentation d'exhibits sera lancé ultérieurement. **La date limite pour la soumission des résumés sera fixée au 29 janvier 1993.**

For further information, contact: / Pour plus d'information, contacter:

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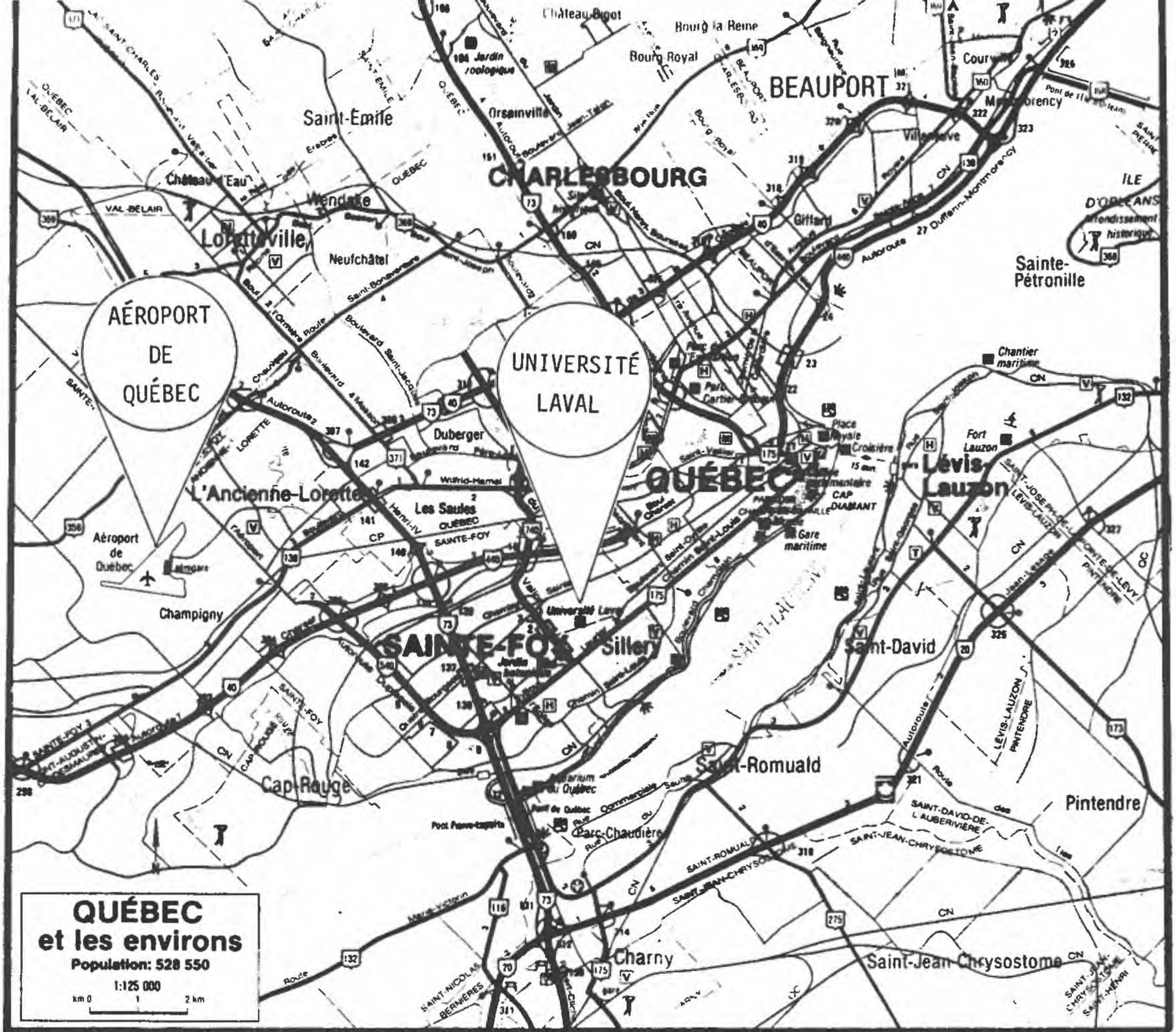
University of New Brunswick
Fredericton, N.B. E3B 6C2
Tel.: 506/453-4501; FAX: 506/453-3538
INTERNET: daug@UNB.ca

Dr. John Loder
Chairman, Scientific Program Committee
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, N.S. B2Y 4A2
Tel.: 902/426-4960; FAX: 902/426-7827
INTERNET: jloder@sable.bio.dfo.ca



QUÉBEC
et les environs
Population: 528 550
1:125 000
km 0 1 2 km
AÉROPORT DE QUÉBEC
UNIVERSITÉ LAVAL
Château-Bigot
Bourg la Reine
Bourg Royal
BEAUPORT
Courville
Montmorency
Villeneuve
Saint-Émile
Orsainville
CHARLESBOURG
Château-d'Eau
Wendake
Loretteville
Neufchâtel
Giffard
ÎLE D'ORLÉANS
Arrondissement historique
Sainte-Pétronille
Chantier maritime
Fort Lauzon
Lévis-Lauzon
Duberger
L'Ancienne-Lorette
Les Saules
Aéroport de Québec
Champigny
QUÉBEC
Place Royale
CAP DIAMANT
Gare maritime
Université Laval
SAINTE-FOY
Sillery
Saint-David
Cap-Rouge
Saint-Romuald
Pintendre
Parc-Chaudière
Charny
Saint-Jean-Chrysostome
SAINT-DAVID-DE-L'AUBERIVIÈRE
SAINT-JEAN-CHRYSOSTOME
SAINT-ROMUALD
Jardin zoologique
Aquarium du Québec
Pont de Québec
Pont Pierre-Laporte
CN
CP

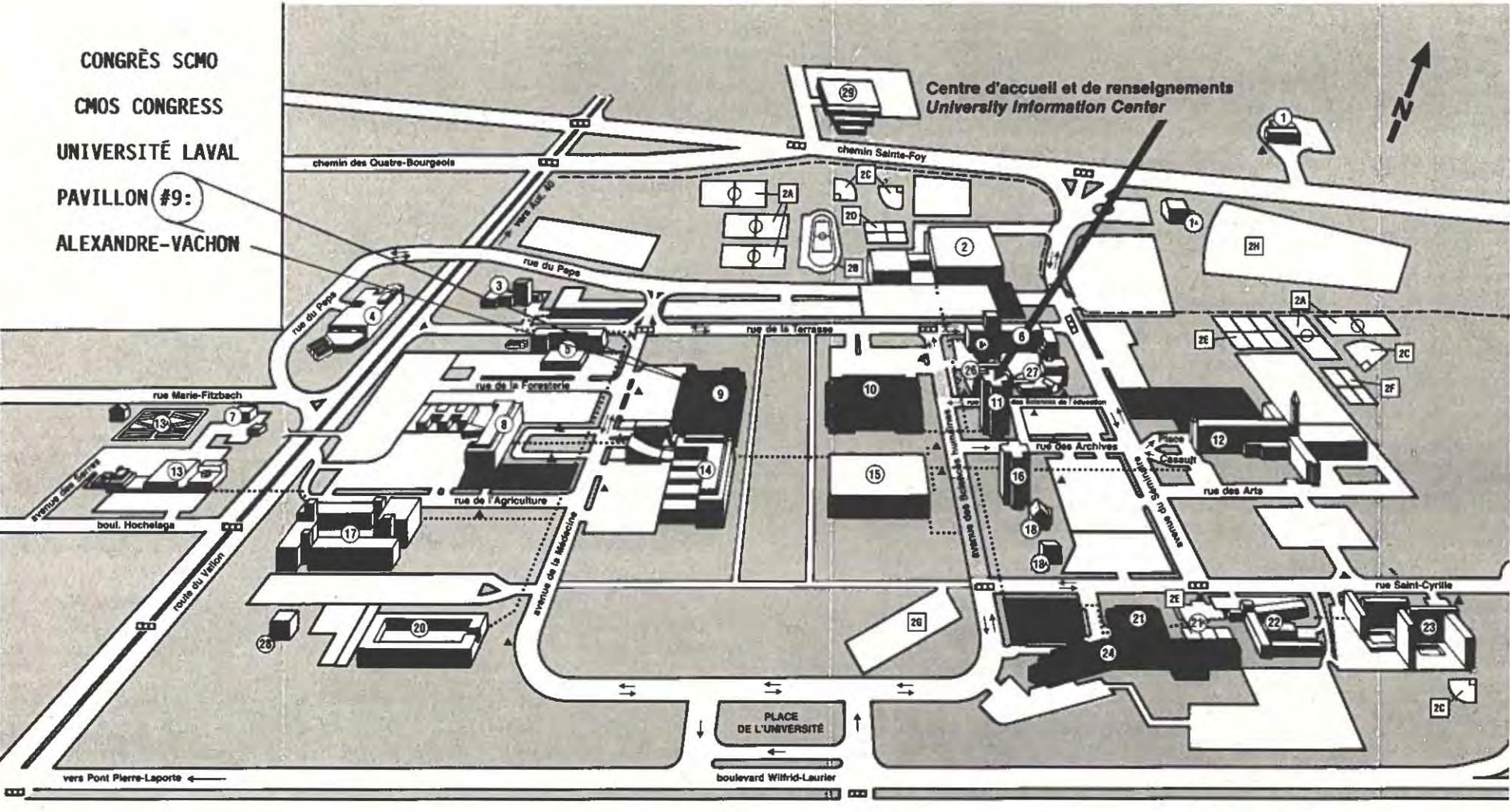
CONGRÈS SCMO

CMOS CONGRESS

UNIVERSITÉ LAVAL

PAVILLON #9:

ALEXANDRE-VACHON



(11) Centre d'accueil et de renseignements
University Information Centre

Stationnement pour visiteurs $
Visitors' Parking $

Stationnement gratuit
de 11 h à 14 h 30 et de 17 h à 3 h
Free Parking from 11 h to 14:30 and from 17:00 to 3:00

Doubles voies *Two-way Streets*

Voies à sens unique
One-way Streets

Feux de circulation
Traffic Lights

Tunnels pour piétons
Pedestrian Tunnels

Parcomètres
Parking Meters

Pavillons dans lesquels se déroulent généralement les congrès et colloques
Buildings where conventions and meetings usually take place