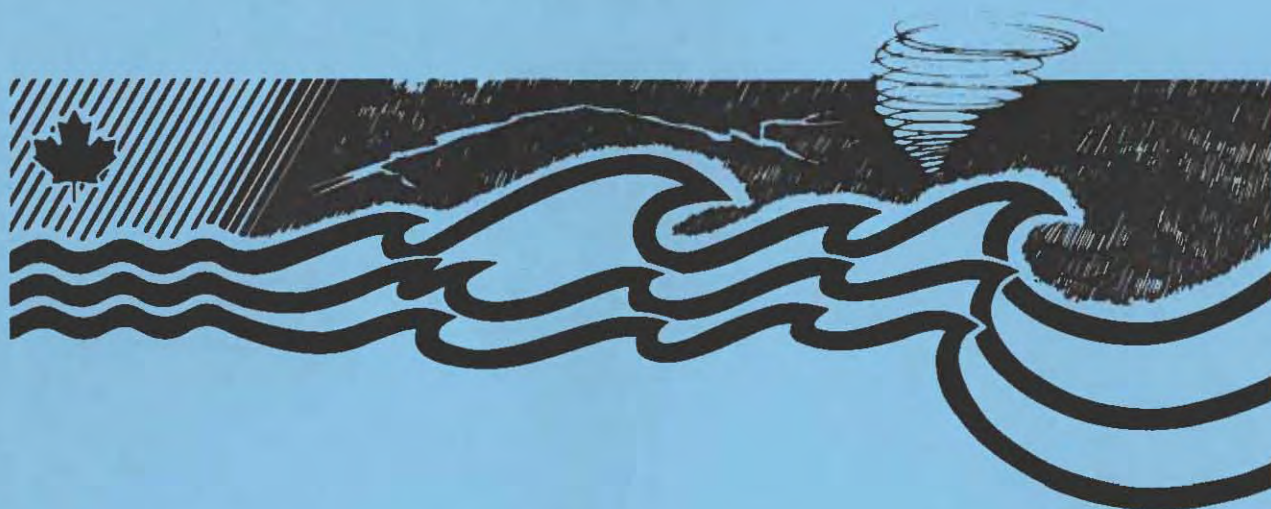

PROGRAMME ET RÉSUMÉS PROGRAM AND ABSTRACTS

SCMO, XXIII^e CONGRÈS ANNUEL

LES CATASTROPHES ATMOSPHÉRIQUES ET OCÉANIQUES: MODÉLISATION ET OBSERVATION



CMOS XXIII ANNUAL CONGRESS

ATMOSPHERIC AND OCEANIC HAZARDS: MODELING AND OBSERVATION

Université du Québec à Rimouski,
Rimouski, Québec, Canada

6-9 juin/June 1989

PROGRAMME ET RÉSUMÉS / PROGRAM AND ABSTRACTS

23^e Congrès annuel de la SCMO / 23rd Annual CMOS Congress

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Vingt-troisième congrès annuel

Société canadienne de météorologie et d'océanographie

Le Centre de Rimouski vous souhaite la bienvenue au XXIII^e Congrès annuel de la Société Canadienne de Météorologie et d'Océanographie (SCMO) qui se tiendra à Rimouski, Québec, du 6 au 9 juin 1989. Le Congrès a pour thème: "Les catastrophes atmosphériques et océaniques: modélisation et observation". Cette année, nous désirons souligner la participation de plusieurs de nos collègues (environ le tiers des communications) en biologie marine ainsi qu'en chimie atmosphérique et océanique.

Twenty-third Annual Congress

Canadian Meteorological and Oceanographic Society

The Rimouski Centre welcomes you to the XXIIIrd Annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS) that will be held in Rimouski, Québec, from June 6 to 9, 1989. The theme is: "Atmospheric and Oceanic Hazards: Modeling and Observation". This year we want to emphasize the contribution of our colleagues (about a third of the presentations) in marine biology and in atmospheric and oceanic chemistry.

Remerciements / Acknowledgements

La Société canadienne de météorologie et d'océanographie tient à remercier les organismes suivants pour leur assistance financière:

The Canadian Meteorological and Oceanographic Society is very grateful to the following organizations for sponsorships or grants:

La Conseil National de Recherche en Sciences et en Génie du Canada
L'Université du Québec à Rimouski (UQAR)
L'Institut National de la Recherche Scientifique (INRS)
L'Institut Maurice Lamontagne (Pêches et Océans Canada)
Le département d'Océanographie de l'UQAR
Le Groupe Interuniversitaire de Recherches Océanographiques du Québec
La compagnie Québec-Téléphone
La ville de Rimouski
Aanderaa Instruments
Campbell Scientific
MacDonald Dettwiler

Conférenciers invités / Invited speakers

Sessions plénières / Plenary Sessions

Dr. David Greenberg, Bedford Institute of Oceanography
Dr. Michael E. Schlesinger, Oregon State University
Dr. Peter J. Wangersky, Dalhousie University
Dr. Hugh Willoughby, NOAA, Miami, Florida

Sessions spéciales / Special Sessions

Dr. Steve Calvert, The University of British Columbia
Dr. Mohammed I. El-Sabh, Université du Québec à Rimouski
Dr. Paul H. LeBlond, The University of British Columbia
Dr. Marlon Lewis, Dalhousie University
Dr. J.C. McConnell, York University

Exposants commerciaux au moment de la parution Commercial Exhibitors at the time of publication

Aanderaa Instruments
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Weather Research House

de: Pour ce congrès, l'organisation et le programme scientifique dépendaient

For the Congress, the local arrangements and the scientific program were organized by:

Comité d'Organisation Locale

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Trésorier Treasurer	Dr. M. Khalil ²
Equipements Facilities	Dr. J.P. Chanut ² Dr. Y. Gratton ²
Inscription Registration	Dr. A. Mauviel ² Dr. J.-F. Dumais ²
Activités sociales Social	Dr. G. Drapeau ¹
Exposition Exhibits	Mr. P. Larouche ³
Liaison IML	Dr. D. Lefaiyre ³ Dr. D. Booth ³
Conseillers Councillors	Mme L. Themens ⁹ M. R. Lavoie ⁹ Dr. M.I. El-Sabh ²
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Biologie marine Marine Biology	Dr. L. Legendre ⁷ Dr. J.A. Gagné ³
Géologie Geology	Dr. G. Drapeau ¹
Océanographie physique Physical Oceanography	Dr. Y. Gratton ² Dr. D. Lefaivre ³
Chimie atmosphérique Atmospheric Chemistry	Dr. J. McConnell ⁸

1. INRS-Océanologie
310 Allée des Ursulines, Rimouski, Qc, Canada, G5L 3A1
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300 Allée des Ursulines, Rimouski, Qc, Canada, G5L 3A1
3. Institut Maurice Lamontagne
850 Route de la mer, C.P. 1000, Mont-Joli, Qc, Canada, G5H 3Z4
4. Department of Meteorology, McGill University
850 Sherbrooke west, Montreal, Qc, Canada, H3A 2K6
5. Département de Physique, UQAM
C.P. 8888, Station B, Montréal, Qc, Canada, H3C 3P8
6. Department of Geological Sciences, McGill University
3450 University, Montreal, Qc, Canada, H3A 2A7
7. Département de Biologie, Université Laval
Cité Universitaire, Québec, Qc, Canada, G1K 7P4
8. Department of Earth and Atmospheric Science, York University
North York, Ontario, Canada, M3J 1P3
9. Service de développement du tourisme et des congrès
Ville de Rimouski

Résumé des réunions

Toutes les réunions seront tenues à l'Université du Québec à Rimouski, le lundi 5 juin 1989.

<u>Comité</u>	<u>Heure</u>	<u>Local</u>
Accréditation	0900-1200	E-303
CHOGUN	0900-1200	E-304
Education en météorologie	0900-1200	E-305
Situation des membres	0900-1200	E-311
Professionnalisme	0900-1200	E-312
Scientifique	0900-1200	E-313
Publications	0900-1200	E-314
CNC / CSRO	0900-1700	E-315
Rédaction du Bulletin climatologique	1330-1700	E-303
Rédaction de Chinook	1330-1700	E-304
Rédaction d'Atmosphere-Ocean	1330-1700	E-305
Sous-comité sur l'échelle moyenne	1330-1700	E-311
GIS: Météorologie agricole et forestière	1330-1700	E-312
GIS: Météorologie de la pollution de l'air	1330-1700	E-313
GIS: Glaces flottantes	1330-1700	E-314
GIS: Hydrologie	1330-1700	D-305
GIS: Météorologie d'exploitation	1330-1700	D-310
Présidents des centres de la SCMO	1330-1700	D-315
Conseil national I	1600-1700	F-210
Conseil national II	2000-2400	F-210

Réception d'accueil	1700-1900	Atrium
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Mardi le 6 juin

Assemblée générale annuelle	2000-2400	F-210
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Résumé des sessions

Les AFFICHES, de même que les EXPOSITIONS COMMERCIALES, pourront être examinées dans le gymnase du mardi 13h00 jusqu'au banquet, le jeudi soir. Tous les auteurs devront être présents le jeudi après-midi.

Heure	Session	Titre	Local
<u>Mardi, le 6 juin</u>			
0830-0930		Bienvenue	F-210
0930-1030	01	Plénière I : Dynamique des cyclones tropicaux	F-210
1030-1100		Café	Gymnase
1100-1200	02	Plénière II : Les biotoxines	F-210
1200-1330		Déjeuner	
1330-1510	03A	Catastrophes météorologiques	F-210
	03B	Tourbillons et circulations océaniques	F-215
	03C	Géochimie marine	C-410
1510-1540		Café	Gymnase
1540-1700	04A	Dynamique atmosphérique	F-210
	04B	Modélisation à l'échelle océanique	F-215
	04C	Ecologie de l'alimentation du zooplancton	C-410
1700-1900		VINS ET FROMAGES	Atrium
2000-2400		Assemblée générale annuelle	F-210
<u>Mercredi, le 7 juin</u>			
0830-0950	05A	Pollution atmosphérique	F-210
	05B	Turbulence et mélange	F-215
	05C	Bioénergétique et dynamique des communautés benthiques I	C-410
0950-1020		Café	Gymnase
1020-1200	06A	Analyse de données aux échelles meso et synoptique	F-210
	06B	Ondes océaniques	F-215
	06C	Bioénergétique et dynamique des communautés benthiques II	C-410
1200-1315		Déjeuner	
1315-1345		<u>Voyage à l'IML</u> (en autobus: départ de l'Atrium)	
1400-1505	07	Plénière III : L'effet du CO ₂	Auditorium
1505-1545		CAFE et visite guidée de l'IML	
1545-1645	08	Plénière IV : Les niveaux d'eau	Auditorium
1700-1745		Retour à Rimouski	
1800-1900		Cocktail à l'Hotel de Ville	
2030-2130		Conférence pour le public	F-210

Heure	Session	Titre	Local
<u>Jeudi, le 8 juin</u>			
0830-0950	09A	Méthodes numériques et modélisation de la grande échelle I	F-210
	09B	Océanographie côtière	F-215
	09C	Pollution chimique	C-410
0950-1020		Café	Gymnase
1020-1220	10A	Méthodes numériques et modélisation de la grande échelle II	F-210
	10B	L'estuaire et le golfe du St-Laurent	F-215
	10C	Programmes internationaux	C-410
1220-1330		Déjeuner (déjeuner des anciens de UBC)	
1330-1510	11A	Climatologie de la grande échelle	F-210
	11B	Océanographie du plateau continental	F-215
	11C	Diagénèse et paléocéanographie	C-410
1510-1540		Café	Gymnase
1540-1720	12A	Climatologie régionale	F-210
	12B	Lagunes et "baies"	F-215
	12C	Transport vertical et diagénèse de la matière organique	C-410
1700-1900		BAR PAYANT	Atrium
1900-2200		BANQUET ANNUEL	Atrium

Vendredi, le 9 juin

0830-0950	13A	Prévisions opérationnelles	F-210
	13B	Catastrophes océaniques	F-215
	13C	Chimie atmosphérique I	C-410
0950-1020		Café	Atrium
1020-1200	14A	Physique des nuages	F-210
	14B	Modélisation en présence de glace	F-215
	14C	Chimie atmosphérique II	C-410

Summary of Meetings

All meetings will be held at the Université du Québec à Rimouski, on Monday June 5, 1989.

<u>Committee</u>	<u>Time</u>	<u>Room</u>
Accreditation	0900-1200	E-303
CHOGUN	0900-1200	E-304
Education for Meteorology	0900-1200	E-305
Membership	0900-1200	E-311
Professionalism	0900-1200	E-312
Scientific	0900-1200	E-313
Publications	0900-1200	E-314
CNC / SCOR	0900-1700	E-315
Climatological Bulletin Editorial Board	1330-1700	E-303
Chinook Editorial Board	1330-1700	E-304
Atmosphere-Ocean Editorial Board	1330-1700	E-305
Mesoscale Subcommittee	1330-1700	E-311
Agricultural and Forest Meteorology SIG	1330-1700	E-312
Air Pollution Meteorology SIG	1330-1700	E-313
Floating Ice SIG	1330-1700	E-314
Hydrology SIG	1330-1700	D-305
Operational Meteorology SIG	1330-1700	D-310
CMOS Centre Chairpersons	1330-1700	D-315
CMOS National Council I	1600-1700	F-210
CMOS National Council II	2000-2400	F-210
Ice-Breaker	1700-1900	Atrium

Tuesday, June 6

Annual General Meeting	2000-2400	F-210
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Summary of Sessions

The POSTERS can be viewed, in the Gymnasium together with the COMMERCIAL EXHIBITS, from Tuesday 13h00 until the Banquet on Thursday evening. All authors must be present on Thursday afternoon.

<u>Time</u>	<u>Session</u>	<u>Title</u>	<u>Room</u>
<u>Tuesday, June 6</u>			
0830-0930		Opening	F-210
0930-1030	01	Plenary I : The Dynamics of Tropical Cyclones	F-210
1030-1100		Coffee	Gymnasium
1100-1200	02	Plenary II: Biotoxins and Other Natural Hazards	F-210
1200-1330		Lunch	
1330-1510	03A	Meteorological Hazards	F-210
	03B	Oceanic Eddies and Gyres	F-215
	03C	Marine Geochemistry	C-410
1510-1540		Coffee	Gymnasium
1540-1700	04A	Atmospheric Dynamics	F-210
	04B	Ocean Scale Modeling	F-215
	04C	Zooplankton Feeding Ecology	C-410
1700-1900		WINE AND CHEESE	Atrium
2000-2400		Annual General Meeting	F-210
<u>Wednesday, June 7</u>			
0830-0950	05A	Atmospheric Pollution	F-210
	05B	Turbulence and Mixing	F-215
	05C	Bioenergetics and Dynamics of Benthic Communities I	C-410
0950-1020		Coffee	Gymnasium
1020-1200	06A	Meso- and Synoptic-Scale Data Analysis	F-210
	06B	Oceanic Waves	F-215
	06C	Bioenergetics and Dynamics of Benthic Communities II	C-410
1200-1315		Lunch	
1315-1345		<u>Trip to MLI</u> (by bus from the Atrium)	
1400-1505	07	Plenary III : The CO ₂ Effect	Auditorium
1505-1545		Coffee and MLI guided tour	
1545-1645	08	Plenary IV : Sea-Level Changes	Auditorium
1700-1745		Return to Rimouski	
1800-1900		Cocktails at City Hall	
2030-2130		General Public Conference	F-210

<u>Time</u>	<u>Session</u>	<u>Title</u>	<u>Room</u>
<u>Thursday June 8</u>			
0830-0950	09A	Numerical Methods and Large-Scale Modeling I	F-210
	09B	Coastal Oceanography	F-215
	09C	Chemical Pollution	C-410
0950-1020		Coffee	Gymnasium
1020-1220	10A	Numerical Methods and Large-Scale Modeling II	F-210
	10B	St. Lawrence Estuary and Gulf	F-215
	10C	International Programs	C-410
1220-1330		Lunch (UBC graduates and associates special lunch)	
1330-1510	11A	Large-Scale Climatology	F-210
	11B	Continental Shelf Oceanography	F-215
	11C	Diagenesis and Paleoceanography	C-410
1510-1540		Coffee	Gymnasium
1540-1720	12A	Regional Climatology	F-210
	12B	Lagoons and "Bays"	F-215
	12C	Vertical Transport and Diagenesis of Organic Matter	C-410
1700-1900		CASH BAR	Atrium
1900-2200		ANNUAL BANQUET	Atrium

Friday, June 9

0830-0950	13A	Operational Forecasting	F-210
	13B	Oceanic Hazards	F-215
	13C	Atmospheric Chemistry I	C-410
0950-1020		Coffee	Atrium
1020-1200	14A	Cloud Physics	F-210
	14B	Sea-Ice Circulation Models	F-215
	14C	Atmospheric Chemistry II	C-410

Programme / Program

Mardi le 6 juin / Tuesday June 6

0830-0930 Séance d'ouverture / Opening remarks

Président / Chairperson : Vladimir Koutitonsky
Local / Room : F-210

0930-1030 Session 01 : Plénière I / Plenary Session I

Président / Chairperson : Jim Young
Local / Room : F-210

THE DYNAMICS OF TROPICAL CYCLONES
H.E. Willoughby
Hurricane Research Division
AOML / NOAA
Miami, FL

1030-1100 Café / Coffee

1100-1200 Session 02 : Plénière II / Plenary Session II

Président / Chairperson : Jim Young
Local / Room : F-210

BIOTOXINS AND OTHER NATURAL HAZARDS
Peter J. Wangersky
Department of Oceanography
Dalhousie University
Halifax, N.S.

1200-1330 Déjeuner / Lunch

1330-1510 Session 03A
Catastrophes météorologiques
Meteorological Hazards

Président / Chairperson : Mohammed El-Sabh
Local / Room : F-210

- 1330-1350 ✓ PRAIRIE DUSTSTORMS- A NEGLECTED HAZARD
E.E. Wheaton, Saskatchewan Research Council, Saskatoon,
Saskatchewan
- 1350-1410 ✓ THE RECORD STORM OF SEPTEMBER 25, 1986
R.F. Hopkinson, Scientific Services Division, AES,
Regina, Saskatchewan
- 1410-1430 ✓ HAILSTORM STUDIES IN SASKATCHEWAN FROM CROP-INSURANCE DATA
A.H. Paul, Dept. of Geography, Univ. of Regina, Regina,
Saskatchewan
- 1430-1450 A FRAMEWORK FOR THE STUDY OF PRAIRIE DROUGHTS
R.G. Lawford, Hydrometeorological Research Division, AES,
Saskatoon, Saskatchewan
- 1450-1510 INTERNATIONAL DROUGHT INFORMATION CENTER: PURPOSE AND OBJECTIVES
D.A. Wilhite, Center for Agricultural Meteorology and
Climatology, Univ. of Nebraska, Lincoln, Nebraska
-

- 1330-1510 Session 03B
Tourbillons et circulations océaniques
Oceanic Eddies and Gyres

Président / Chairperson : Brian Sanderson
Local / Room : F-215
- 1330-1350 TRACKING THE ALASKAN GYRE: RESULTS OF THE NORTHEAST PACIFIC CURRENT STUDY (NEPCS)
P.H. LeBlond, Dept. of Oceanography, UBC, Vancouver, B.C.
R. Thomson, Institute of Ocean Sciences, Sidney, B.C.
D. Williams, Royal Roads Military College, Victoria, B.C.
W. Emery, Univ. of Colorado
- 1350-1410 PROPAGATION OF FRICTIONALLY-DECAYING BAROTROPIC MODONS OVER FINITE-AMPLITUDE TOPOGRAPHY
L. Yan, Dept. of Geography,
G.E. Swaters, Dept. of Mathematics, Univ.
of Alberta, Edmonton, Alberta
- 1410-1430 DYNAMICS OF ISOLATED BAROCLINIC EDDIES ON A SLOPING BOTTOM
G.E. Swaters, Dept. of Mathematics, Univ. of Alberta,
Edmonton, Alberta
- 1430-1450 ALTIMETRIC SATELLITE MEASUREMENTS OF SEA-LEVEL VARIABILITY NEAR THE SOUTHEAST NEWFOUNDLAND RIDGE
R.M. Hendry and M. Ikeda, Bedford Institute of Oceanog-
raphy, Dartmouth, Nova Scotia
-

- 1450-1510 INTÉGRATION ET DIFFUSION DE DONNÉES SUR LE MILIEU
MARITIME
M.-C. Mouchot, Centre Canadien de Télédétection, Ottawa,
Ontario
-
- 1330-1510 Session 03C
Géochimie marine
Marine Geochemistry

Président / Chairperson : Steve Calvert
Local / Room : C-410
- 1330-1350 A RE-EXAMINATION OF DISSOLVED ORGANIC PHOSPHORUS LEVELS
IN OCEANIC WATERS
J.J. Ridal and R.M. Moore, Dept. of Oceanography,
Dalhousie Univ., Halifax, Nova Scotia
- 1350-1410 LATE QUATERNARY HISTORY OF THE OXYGEN MINIMUM IN THE
NORTHWEST ARABIAN SEA
T.F. Pedersen, Dept. of Oceanography, Univ. of British
Columbia, Vancouver, B.C.
G.B. Shimmiel, Grant Inst. of Geology, Univ. of
Edinburgh, Edinburgh, Scotland,
S.A. Macko and A. Muzuka, Dept. of Earth Sciences,
Memorial Univ., St John's, Nfld
- 1410-1430 THE COMPARATIVE MARINE GEOCHEMISTRIES OF ALUMINIUM,
GALLIUM AND TITANIUM
K.J. Orians and E.A. Boyle, Dept. of Earth, Atmospheric
and Planetary Sciences, MIT, Cambridge, MA, and
K.W. Bruland, Institute of Marine Sciences, Univ. of
California, Santa Cruz, CA
- 1430-1450 DISSOLVED ALUMINIUM IN REGIONS OF NAWD FORMATION: RESULTS
FROM THE RECENT GREENLAND SEA PROJECT CRUISE
S. Bradley Moran and R.M. Moore, Dept. of Oceanography,
Dalhousie Univ., Halifax, N.S.
- 1450-1510 HEAT TRANSFER FROM ATLANTIC WATERS TO SEA ICE IN THE
ARCTIC OCEAN: EVIDENCE FROM DISSOLVED ARGON
R.M. Moore, Dept. of Oceanography, Dalhousie Univ.,
Halifax, N.S.,
W. Spitzer, Chemistry Dept., Woods Hole Oceanographic
Institution, Woods Hole, MA
-
- 1510-1540 Café / Coffee
-

- 1540-1700 Session 04A
 Dynamique atmosphérique
 Atmospheric Dynamics
- Président / Chairperson : Jacques Derome
 Local / Room : F-210
- 1540-1600 BAROCLINIC INSTABILITY AND THE SUMMER SOUTHERN HEMISPHERE
 WAVENUMBER 5 CIRCULATION
 C.A. Lin and A.C.M. Chan, Dept. of Meteorology, McGill
 Univ., Montréal, Qc
- 1600-1620 RECENT DEVELOPMENTS IN THE STUDY OF marginally UNSTABLE
 BAROCLINIC WAVES IN A QUASI-GEOSTROPHIC BETA-PLANE MODEL
 P. Gauthier, Recherches en prévision numérique, SEA,
 Dorval, Qc
- 1620-1640 PROBLÈME À LA CONDITION INITIALE POUR DES ONDES DE
 ROSSBY SUR UN JET PARABOLIQUE
 G. Brunet et T. Warn, Dept. of Meteorology, McGill Univ.,
 Montréal, Qc
- 1640-1700 DYNAMICS OF FRONTAL DISCONTINUITIES IN THE SEMI-GEOSTRO-
 PHIC THEORY
 H.-R. Cho and J. Koshyk, Dept. of Physics, Univ. of
 Toronto, Toronto, Ont.

- 1540-1700 Session 04B
 Modélisation à l'échelle océanique
 Ocean Scale Modeling
- Président / Chairperson : Richard Marsden
 Local / Room : F-215
- 1540-1600 ON CALCULATING VORTICITY BALANCES IN PRIMITIVE EQUATION
 MODELS
 M.G.G. Foreman, Institute of Ocean Sciences, Sidney, B.C.
 A.F. Bennett, Oregon State Univ., Corvallis, OR
- 1600-1620 HORIZONTAL RESOLUTION AND MERIDIONAL HEAT AND FRESHWATER
 TRANSPORTS IN A NUMERICAL UPPER OCEAN MODEL
 J.Y. Cherniawsky, Dept. of Meteorology, McGill Univ.,
 Montréal, Qc
- 1620-1640 NUMERICALLY MODELLING THE INTERANNUAL VARIABILITY OF THE
 NORTHEAST PACIFIC OCEAN AND ITS INFLUENCE ON SOCKEYE
 SALMON
 W.W. Hsieh and W.G. Lee, Dept. of Oceanography, Univ. of
 British Columbia, Vancouver, B.C.,
 L.A. Mysak, Dept. of Meteorology, McGill Univ., Montréal,
 Qc

1640-1700	TOPOGRAPHIC DE-PHasing AND AMPLITUDE MODULATION AND ROSSBY WAVE TRIAD PACKETS W. Cree, Dept. of Geography, G.E. Swaters, Dept. of Mathematics, Univ. of Alberta, Edmonton, Alberta
1540-1700	<u>Session 04C</u> Écologie de l'alimentation du zooplancton Zooplankton Feeding Ecology Président / Chairperson : Patrick Mayzaud Local / Room : C-410
1540-1600	DYNAMIC OF THE NUTRITIONAL METABOLISM IN RESPONSE TO THE VARIATION OF QUANTITY AND QUALITY OF FOOD IN <u>CALANUS</u> <u>FINMARCHICUS</u> O. Roche-Mayzaud, Institut Maurice Lamontagne, Mont-Joli, Qc
1600-1620	"SLOPPY FEEDING" OF COPEPODS: POTENTIAL CONTRIBUTION TO THE FLUX OF PARTICULATE MATTER IN THE OCEANS S. Roy, R.P. Harris and S.A. Poulet, INRS-Océanologie, Rimouski, Qc
1620-1640	ZOOPLANKTON GRAZING EFFECTS ON CHLOROPIGMENT DIAGENESIS AND FLUX DURING A SPRING PHYTOPLANKTON BLOOM A. Redden, D. Deibel and R. Thompson, Marine Sciences Research Lab., Ocean Sciences Centre, Memorial Univ., St John's, Nfld
1640-1700	PARTICLE-SIZE SELECTION BY THE PELAGIC TUNICATE <u>OIKO-</u> <u>PLEURA VANHOEFFENI</u> : LABORATORY AND FIELD EVIDENCE FOR A SHUNT OF THE MICROBIAL LOOP D. Deibel and A. Redden, Marine Sciences Research Lab., Ocean Sciences Centre, Memorial Univ., St John's, Nfld
1700-1900	VINS ET FROMAGES / WINE AND CHEESE
2000-2400	Assemblée générale annuelle Annual General Meeting

Mercredi le 7 juin / Wednesday June 7

- 0830-0950 Session 05A
Pollution atmosphérique
Atmospheric Pollution
- Président / Chairperson : Michel Ferland
Local / Room : F-210
- 0830-0850 MODEL RESULTS OF FLUXES AND CONCENTRATIONS OVER A HILL
J. Padro, AES, Downsview, Ont.
- 0850-0910 LA MESURE ET LE SUIVI DES DÉPÔTS DE SUBSTANCES ACIDIFIANTES AU QUÉBEC
G. Boulet, Direction de la météorologie, Ministère de l'environnement, Ste-Foy, Qc
- 0910-0930 OXIDATION IN A RAINBAND: SOURCES AND REACTIONS OF H₂O₂
A.M. Macdonald and H.G. Leighton, Dept. of Meteorology, McGill Univ., Montréal, Qc
- 0930-0950 CANADIAN DISASTERS - A HISTORICAL SURVEY
R.L. Jones, AES, Hull, Qc
-

- 0830-1010 Session 05B
Turbulence et mélange
Turbulence and Mixing
- Président / Chairperson : David Booth
Local / Room : F-215
- 0830-0850 TURBULENT MIXING IN THE NORTHEAST PACIFIC OCEAN IN NOVEMBER, OBSERVED DURING THE OCEAN STORMS PROGRAM
W.R. Crawford, Inst. of Ocean Sciences, Sidney, B.C.,
R.G. Lueck, Chesapeake Bay Inst., Johns Hopkins Univ., Baltimore, MD
- 0850-0910 LITTLE STIRRERS IN THE OCEAN
B. Sanderson, Dept. of Physics, Memorial Univ., St John's, Nfld,
A. Okubo and J. Yen, Marine Sciences Research Center, SUNY, Stony Brook, NY
- 0910-0930 ON THE INFERENCE OF DIAPYCNAL FLUXES OF HEAT, SALT AND NUTRIENTS FROM OBSERVATIONS OF TURBULENT MICROSTRUCTURE
B.R. Ruddick, Dept. of Oceanography, Dalhousie Univ., Halifax, N.S.
J. Hamilton, Bedford Institute of Oceanography, Dartmouth, N.S.
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- 0930-0950 DIFFUSION BY GRAVITY WAVES
B.K. Pal and B.G. Sanderson, Dept. of Physics, Memorial Univ., St. John's, Nfld
- 0950-1010 BOUNDARY MIXING IN THE OCEAN VIA INTERNAL WAVE BREAKING
D. Gilbert, Dept. of Oceanography, Dalhousie Univ., Halifax, N.S.
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- 0830-0950 Session 05C
Bioénergétique et dynamique des communautés benthiques I
Bioenergetics and Dynamics of Benthic Communities I

Président / Chairperson : Edwin Bourget
Local / Room : C-410
- 0830-0850 CHEMICAL AND BIOLOGICAL CHARACTERIZATION OF A MUSSEL CULTURE AREA, MAGDALEN IS., QUEBEC
S. Roy, P. Souchu, and P. Mayzaud, INRS-Océanologie, Rimouski, Qc
- 0850-0910 INTERACTION TROPHIQUE DES MOULES CULTIVÉES - MILIEU PARTICULAIRE EN MILIEU LAGUNAIRE AUX ÎLES-DE-LA-MADELEINE
P. Mayzaud, P. Souchu, S. Roy et O. Roche-Mayzaud, INRS-Océanologie, Rimouski, Qc
- 0910-0930 VARIATIONS DES RÉSERVES ÉNERGÉTIQUES DE MYA ARENARIA DANS UN CYCLE DE VIVE-EAU, AU BIC, DANS L'ESTUAIRE DU ST-LAURENT
J. Pellerin-Massicotte, B. Vincent, Y. Gratton et M.-C. Lévesque, Dép. d'Océanographie, UQAR, Rimouski, Qc
- 0930-0950 SUSPENSION-FEEDER DOMINATED DEEP-SEA HYDROTHERMAL VENT COMMUNITIES: INDICATION OF NON-SYMBIOTIC ORGANIC MATTER SOURCES
S.K. Juniper, Dép. d'Océanographie, UQAR, Rimouski, Qc
-
- 0950-1020 Café / Coffee
-
- 1020-1200 Session 06A
Analyse de données aux échelles meso et synoptique
Meso- and Synoptic-Scale Data Analysis

Président / Chairperson : Michel Jean
Local / Room : F-210
- 1020-1040 HORIZONTAL WIND FIELD FROM SINGLE DOPPLER RADAR
I. Zawadzki and S. Laroche, Dép. de Physique, UQAM, Montréal, Qc
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- 1040-1100 AIRBORNE RADAR OBSERVATIONS IN ERICA
O. Hertzman, Dept. of Oceanography, Dalhousie Univ.,
Halifax, N.S.
- 1100-1120 LIMEX-85: THE PROCESSING OF DATA SETS FROM AN ALBERTA
MESOSCALE UPPER-AIR EXPERIMENT
G.S. Strong, National Hydrology Research Centre, AES,
Saskatoon, Saskatchewan
- 1120-1140 CALCUL DU MOUVEMENT VERTICAL AVEC DES DONNÉES EN SURFACE:
NOUVEAU DÉVELOPPEMENT
J. Montpetit et P. Zwack, Dép. de Physique, UQAM,
Montréal, Qc
- 1140-1200 PRECURSOR METEOROLOGICAL CONDITIONS ASSOCIATED WITH
EXPLOSIVE CYCLOGENESIS OVER THE KUROSHIO CURRENT
J.R. Gyakum and T. Bullock, Dept. of Meteorology, McGill
Univ., Montréal, Qc
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- 1020-1200 Session 06B
Ondes océaniques
Oceanic Waves

Président / Chairperson : Paul LeBlond
Local / Room : F-215
- 1020-1040 WIND ESTIMATES FROM WAVE SLOPES
R.F. Marsden, Royal Roads Military College, Victoria, B.C.
B.-A. Juszko, Juszko Scientific Services, Victoria, B.C.
- 1040-1100 THE WOTAN WINDS FROM CASP
F.W. Dobson, Bedford Institute of Oceanography, Dartmouth,
N.S.
- 1100-1120 THE JOINT DISTRIBUTION OF WAVE HEIGHTS AND PERIODS FOR
SHOALING WAVES
J.C. Doering and M.A. Donelan, Canadian Centre for Inland
Waters, Burlington, Ont.
- 1120-1140 INTERACTION OF INTERNAL WAVES WITH THE SEABED ON
CONTINENTAL SHELVES
B. Boczar-Karakiewicz, INRS-Océanologie, Rimouski, Qc,
J.L Bona, Dept. of Mathematics, Pennsylvania State Univ.,
B. Pelchat, Institut Maurice Lamontagne, Mont-Joli, Qc
- 1140-1200 MASS FLUX OF HEXACHLOROBENZENE ACROSS THE AIR-WATER
INTERFACE IN THE PRESENCE OF WIND WAVES
N. Merzi, M.A. Donelan, M. Servos, and W.M. Strachan,
Canadian Centre for Inland Waters, Burlington, Ont.
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1020-1140	<u>Session 06C</u> Bioénergétique et dynamique des communautés benthiques II Bioenergetics and Dynamics of Benthic Communities II Président / Chairperson : Bruno Vincent Local / Room : C-410
1020-1040	DISTRIBUTIONS ET VARIATIONS INTRA-POPULATIONS DE DEUX POLYCHÈTES INTERTIDIAUX DE L'ESTUAIRE MARITIME DU ST-LAURENT G. Miron et G. Desrosiers, Dép. d'Océanographie, UQAR, Rimouski, Qc
1040-1100	RECRUTEMENT LARVAIRE DU POLYCHÈTE <u>NEREIS VIRENS</u> (SARS) DANS TROIS TYPES DE SÉDIMENTS DIFFÉRENTS DANS LE HAUT DE PLAGE DE L'ANSE À L'ORIGNAL, PARC DU BIC, QUÉBEC M. Olivier, G. Desrosiers et Bruno Vincent, Dép. d'Océanographie, UQAR, Rimouski, Qc
1100-1120	VARIABILITÉ SPATIO-TEMPORELLE DE QUELQUES PARAMÈTRES DÉMOGRAPHIQUES DE LA REPRODUCTION ET DE LA CROISSANCE CHEZ UNE POPULATION INTERTIDALE DU BIVALVE <u>MACOMA</u> <u>BALTHICA</u> (L.): ACTION DES FACTEURS ENVIRONNEMENTAUX M. Harvey et B. Vincent, Dép. d'Océanographie, UQAR, Rimouski, Qc
1120-1140	LA STRUCTURE DE LA COMMUNAUTÉ ÉPIBENTHIQUE DE L'ESTUAIRE ET DU GOLFE DU ST-LAURENT, ET SA RELATION AVEC LES APPORTS D'EAU DOUCE P.-L. Ardisson et E. Bourget, Dép. de Biologie, Univ. Laval, Québec, Qc
1200-1315	Déjeuner / Lunch
1315-1345	VOYAGE À L'IML / TRIP TO MLI
1400-1505	<u>Session 07: Plénière III / Plenary Session III</u> Président / Chairperson : Yves Gratton Local / Room : Auditorium (IML) THE CO ₂ EFFECT Michael E. Schlesinger Department of Atmospheric Sciences Oregon State University Corvallis, OR
1505-1545	Café et visite guidée de l'Institut Coffee and guided tour of the Institute

1545-1645 Session 08 : Plénière IV / Plenary Session IV

Président / Chairperson : Yves Gratton
Local / Room : Auditorium (IML)

SEA-LEVEL IMPACTING MAN IMPACTING SEA-LEVEL
David A. Greenberg
Department of Fisheries and Oceans
Bedford Institute of Oceanography
Dartmouth, N.S.

1700-1745 Retour à Rimouski / Return to Rimouski

1800-1900 Cocktail à l'Hotel de Ville
Cocktails at City Hall

2030-2130 Conférence pour le public
General Public Conference

Président / Chairperson : Vladimir Koutitonsky
Local / Room : F-210

À être annoncé / To be announced
Jacques Lavigne
Météorologiste
Radio-Canada (CBC), Sept-Iles, Qc

Jeudi le 8 juin / Thursday June 8

0830-0950 Session 09A
Méthodes numériques et modélisation de la grande échelle I
Numerical Methods and Large-Scale Modeling I

Président / Chairperson : Michel Béland
Local / Room : F-210

0830-0850 TESTS OF SIMPLE DEEP CONVECTION PARAMETRIZATION SCHEMES
C. Girard, Recherche en prévision numérique, SEA, Dorval,
Qc

- 0850-0910 THE EFFECT OF OROGRAPHIC WAVE DRAG ON LARGE-SCALE EDDY HEAT AND MOMENTUM TRANSPORTS IN THE LOWER ATMOSPHERE
N.A. McFarlane, Canadian Climate Centre, AES, Downsview, Ont.
- 0910-0930 A NEW CANADIAN LAND SURFACE SCHEME FOR GCMS
D. Versegny, Canadian Climate Centre, AES, Downsview, Ont.
- 0930-0950 SUR L'INITIALISATION VARIATIONNELLE PAR MODES NORMAUX IMPLICITES
L. Fillion, Recherche en prévision numérique, SEA, Dorval, Qc
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- 0830-0950 Session 09B
Océanographie côtière
Coastal Oceanography

Président / Chairperson : Peter Smith
Local / Room : F-215
- 0830-0850 UPWELLING AND FRONTOGENESIS NEAR A COASTAL PROMONTORY
R.E. Wilson, Marine Sciences Research Centre, SUNY, Stony Brook, NY
- 0850-0910 A TIDAL + RESIDUAL MODEL FOR THE SOUTHWEST COAST OF VANCOUVER ISLAND
M.G.G. Foreman, Institute of Ocean Sciences, Sidney, B.C.
R.A. Walters, US Geological Survey, Tacoma, WA,
A.M. Baptista, Oregon Graduate Centre, Beaverton, OR
- 0910-0930 PREDICTION OF OCEAN SURFACE PROPERTIES IN JUAN DE FUCA STRAIT
P. LeBlond, D. Griffin and B. Fellenius, Dept. of Oceanography, Univ. of British Columbia, Vancouver, B.C.,
R.E. Thomson, Institute of Ocean Sciences, Sidney, B.C.
- 0930-0950 A SIMPLE EVOLUTIONARY MODEL FOR WATER AND SALT IN THE BLACK SEA
B.P. Boudreau, Dept. of Oceanography, Dalhousie Univ., Halifax, N.S.,
P.H. LeBlond, Dept. of Oceanography, Univ. of British Columbia, Vancouver, B.C.
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- 0830-0950 Session 09C
Pollution chimique
Chemical Pollution

Président / Chairperson : Alfonso Mucci
Local / Room : C-410
- 0830-0850 PULP MILL POLLUTION IN A BRITISH COLUMBIA FJORD
D. Stucchi, Dept. of Fisheries and Oceans, Ottawa, Ont.
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- 0850-0910 CHEMICAL CONTAMINATION IN SEDIMENTS FROM HALIFAX HARBOUR
D.E. Buckley, Atlantic Geoscience Centre, Bedford
Institute of Oceanography, Dartmouth, N.S.
- 0910-0930 NATURAL AND POLLUTANT HYDROCARBONS IN THE SEDIMENTS OF
THE ST. LAWRENCE ESTUARY
J.N. Gearing and R. Lambert, Institut Maurice Lamontagne,
Mont-Joli, Qc
- 0930-0950 LANDFILL SITES ALONG THE ST. LAWRENCE, A POSSIBLE SOLUTION
FOR CONTAINMENT OF SPILLED OIL OR DREDGED SEDIMENTS
M. Khalil, Dép. d'Océanographie, UQAR, Rimouski, Qc

0950-1020 Café / Coffee

- 1020-1200 Session 10A
Méthodes numériques et modélisation de la grande échelle II
Numerical Methods and Large-Scale Modeling II

Président / Chairperson : Michel Béland
Local / Room : F-210
- 1020-1040 ÉTUDE DE SENSIBILITÉ À LA RÉOLUTION SPATIALE ET
TEMPORELLE
G. Bergeron, A. Robert et J. Côté, Dép. de Physique,
UQAM, Montréal, Qc
- 1040-1100 PROPRIÉTÉS DES SCHÉMAS NUMÉRIQUES DE TRANSPORT DE
SUBSTANCES
L. Ostiguy et R. Laprise, Dép. de Physique, UQAM,
Montréal, Qc
- 1100-1120 A PIECEWISE-CONSTANT FINITE-ELEMENT VERTICAL DISCRETIZA-
TION METHOD FOR A GCM IN HYBRID COORDINATES
C. Girard, Recherche en prévision numérique, SEA, Dorval,
Qc
R. Laprise, Dép. de Physique, UQAM, Montréal, Qc
- 1120-1140 SENSIBILITÉ DES SIMULATIONS DU MCG CANADIEN À LA FORMULA-
TION DE SA DISCRÉTISATION VERTICALE
R. Laprise, Dép. de Physique, UQAM, Montréal, Qc
C. Girard, Recherche en prévision numérique, SEA, Dorval,
Qc
- 1140-1200 UN SCHÉMA STABLE POUR LA DIFFUSION VERTICALE NON-LINÉAIRE
DANS LE MODÈLE SPECTRAL CANADIEN
C. Girard et Y. Delage, Recherche en prévision numérique,
SEA, Dorval, Qc
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- 1020-1220 Session 10B
L'estuaire et le golfe du St-Laurent
St Lawrence Estuary and Gulf
- Président / Chairperson : Grant Ingram
Local / Room : F-215
- 1020-1040 WIND-INDUCED SYNOPTIC EDDY MOTION IN THE LOWER ST LAW-
RENC ESTUARY
G. Mertz, NW Atlantic Fisheries Laboratory, St John's,
Nfld,
V. Koutitonsky, INRS-Océanologie, Rimouski, Qc,
Y. Gratton and M. El-Sabh, Dép. d'Océanographie, UQAR,
Rimouski, Qc
- 1040-1100 THREE-DIMENSIONAL NUMERICAL SIMULATIONS OF WIND AND
TIDALLY-INDUCED CIRCULATIONS IN THE ST LAWRENCE ESTUARY
V.G. Koutitonsky, INRS-Océanologie, Rimouski, Qc,
R.E. Wilson, Marine Sci. Res. Center, SUNY, Stony Brook,
NY,
C. Toro, Dép. d'Océanographie, UQAR, Rimouski, Qc
- 1100-1120 TIDE ANALYSIS AND MODELING IN JACQUES CARTIER PASSAGE
D. Lefaivre, Institut Maurice Lamontagne, Mont-Joli, Qc,
V.G. Koutitonsky, INRS-Océanologie, Rimouski, Qc,
D. Hains, P. Ouellet, Institut Maurice Lamontagne, Mont-
Joli, Qc
A.R. Conda, Dép. des Sciences Géodésiques et de Télédé-
tection, Univ. Laval, Québec, Qc
- 1120-1140 ÉTUDE PRÉLIMINAIRE DE LA STRUCTURE TRIDIMENSIONNELLE DE
LA CIRCULATION BAROCLINIQUE CAUSÉE PAR L'INTRUSION DE
L'EAU DES RIVIÈRES À L'AIDE D'UN MODÈLE MULTI-NIVEAUX
C. Toro, Dép. d'Océanographie, UQAR, Rimouski, Qc,
V.G. Koutitonsky, INRS-Océanologie, Rimouski, Qc,
R.E. Wilson, Marine Sci. Res. Center, SUNY, Stony Brook,
NY
- 1140-1200 RÉSURGENCES CÔTIÈRES OBSERVÉES AU SECTEUR NORD-OUEST DU
GOLFE DU ST-LAURENT À L'AIDE D'IMAGES SATELLITES NOAA
J. Lacroix, M. El-Sabh et D. Proulx, Dép. d'Océanographie,
UQAR, Rimouski, Qc,
A. Conda, Laboratoire télédétection, Univ. Laval, Québec
J.-M. Dubois, CARTEL, Univ. Sherbrooke, Sherbrooke, Qc
- 1200-1220 SUBTIDAL SALINITY AND VELOCITY VARIATIONS IN THE ST
LAWRENCE ESTUARY
K.-T. Tee, Bedford Institute of Oceanography, Dartmouth,
N.S.
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1020-1220	<u>Session 10C</u> Programmes internationaux International Programs Président / Chairperson : Alain Vézina Local / Room : C-410
1020-1050	THE WORLD OCEAN CIRCULATION EXPERIMENT: CANADIAN UNIVERSITY PARTICIPATION (invité / invited) P.H. LeBlond, Dept. of Oceanography, Univ. of British Columbia, Vancouver, B.C.
1050-1120	JGOFS (invité / invited) M. Lewis, Dept. of Oceanography, Dalhousie Univ., Halifax, N.S.
1120-1150	NATURAL CATASTROPHES: WHAT CAN BE DONE TO PREVENT AND MITIGATE THEM (invité / invited) M.I. El-Sabh, Dép. d'Océanographie, UQAR, Rimouski, Qc
1150-1220	NEPTUNE: PROSPECTS FOR VOYAGER ENCOUNTER (invité/invited) J.C. McConnell, Dept. of Earth and Atmospheric Science, York Univ., North York, Ont.
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1220-1330	Déjeuner / Lunch (special UBC associates lunch)
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1330-1510	<u>Session 11A</u> Climatologie de la grande échelle Large-Scale Climatology Président / Chairperson : René Laprise Local / Room : F-210
1330-1350	ENERGETICS OF THE 30-60 DAY OSCILLATION S.J. Lambert, Canadian Climate Centre, AES, Downsview, Ont.
1350-1410	HOUGH MODE DECOMPOSITION OF THE TROPICAL MADDEN-JULIAN WAVE K.J. Keen, Dept. of Meteorology, McGill Univ., Montréal, Qc
1410-1430	ENERGY EXCHANGES AMONG VARIOUS FREQUENCIES IN ATMOSPHERIC AND GCM DATA J. Sheng and J. Derome, Dept. of Meteorology, McGill Univ., Montréal, Qc
1430-1450	REGIONAL ANALYSIS OF THE NORTHERN HEMISPHERE 50-KPA HEIGHTS FROM 1946 TO 1987 A. Shabbar, K. Higuchi and J.L. Knox, Climate Diagnostic Research Group, AES, Downsview, Ont.

1450-1510 VISCIOUS EFFECTS IN ATMOSPHERIC AND OCEANIC CIRCULATIONS
A.K. Ray, Fundamental Research Institute, Gloucester, Ont.

1330-1510 Session 11B
Océanographie du plateau continental
Continental Shelf Oceanography

Président / Chairperson : Howard Freeland
Local / Room : F-215

1330-1350 CIRCULATION AND DISPERSION ON BROWNS BANK
P.C. Smith, Bedford Institute of Oceanography, Dartmouth,
N.S.

1350-1410 LOW-FREQUENCY CIRCULATION ON THE LABRADOR SHELF
S. Narayanan, NW Atlantic Fisheries Laboratory,
St John's, Nfld

1410-1430 THE EFFECT OF BAROCLINIC SHEAR CURRENTS ON COASTAL-TRAPPED
WAVES
D.M. Holland, NW Atlantic Fisheries Laboratory, St. John's,
Nfld,
I.T. Webster, Dept. of Environmental Mechanics, CSIRO,
Canberra, Australia

1430-1450 AN ANALYTIC MODEL FOR THE LEEUWIN CURRENT OFF WESTERN
AUSTRALIA
A.J. Weaver, Joint Institute for the Study of the
Atmosphere and Ocean, Univ. of Washington, Seattle, WA

1450-1510 NUMERICAL SIMULATIONS OF THE LEEUWIN CURRENT OFF WESTERN
AUSTRALIA
A.J. Weaver, Joint Institute for the Study of the
Atmosphere and Ocean, Univ. of Washington, Seattle, WA

1330-1520 Session 11C
Diagénèse et paléocéanographie
Diagenesis and Paleoceanography

Président / Chairperson : Bjorn Sundby
Local / Room : C-410

1330-1400 GEOCHEMICAL EVIDENCE FOR OCEANOGRAPHIC CHANGES IN THE
EASTERN MEDITERRANEAN DURING THE LATE PLEISTOCENE (invité
/ invited)
S.E. Calvert, Dept. of Oceanography, Univ. of British
Columbia, Vancouver, B.C.

- 1400-1420 THE INFLUENCE OF SALINITY ON THE PRECIPITATION KINETICS OF CALCITE AND ARAGONITE IN SEA-WATER
A. Mucci and S. Zhong, Dept. of Geological Sci., McGill Univ., Montréal, Qc
- 1420-1440 A THEORETICAL STUDY OF DIAGENETIC CONCENTRATION FIELDS NEAR MANGANESE NODULES AT THE SEDIMENT-WATER INTERFACE
B.P. Boudreau, Dept. of Oceanography, Dalhousie Univ., Halifax, N.S.,
R.J. Taylor, Dept. of Oceanography, Texas A&M Univ., College Station, TX
- 1140-1500 A 9,000-YEAR RECORD OF GEOCHEMICAL CHANGE IN HALIFAX INLET
D.E. Buckley, Atlantic Geoscience Centre, Bedford Institute of Oceanography, Halifax, N.S.
- 1500-1520 RESPONSE OF TH/U IN DEEP LABRADOR SEA SEDIMENTS (ODP-SITE 646) TO CHANGES IN SEDIMENTATION RATES AND PALEOPRODUCTIVITIES
C. Hillaire-Marcel, A. Aksu¹, C. Causse², A. de Vernal, B. Ghaleb, GEOTOP, UQAM, Montréal, Qc
¹ Dept. of Earth Sciences, Memorial Univ., St. John's, Nfld
² Laboratoire de Géologie du Quaternaire, C.N.R.S., Marseille, France

1510-1540 Café / Coffee

1540-1700 Session 12A
Climatologie régionale
Regional Climatology

Président / Chairperson : Ghislain Jacques
Local / Room : F-210

1540-1600 RECENT CLIMATE VARIATIONS IN THE MACKENZIE VALLEY AND THEIR ANTICIPATED IMPACT ON PERMAFROST STABILITY
A. Stuart, Weather Research House, Downsview, Ont.

1600-1620 SOME CUMULATIVE PROCESSES WITHIN THE HYDROLOGICAL CYCLE IN WESTERN CANADA
R.G. Lawford, Hydrometeorological Research Division, AES, Saskatoon, Saskatchewan

1620-1640 QUANTITATIVE APPROACH TO ASSESS THE OPTIMUM NUMBER OF STATIONS IN A CLIMATE NETWORK
G. Vigeant, Scientific Services Division, AES, Ville St-Laurent, Qc

1640-1700 TOTAL OZONE IMAGERY FROM METEOROLOGICAL UPPER-AIR MAPS
W.F.J. Evans and L.R. Poulin, AES, Downsview, Ont.

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- 1540-1720 Session 12B
Lagunes et "baies"
Lagoons and "Bays"
- Président / Chairperson : Denis Lefaivre
Local / Room : F-215
- 1540-1600 VARIABILITÉ SAISONNIÈRE DU PATRON ÉNERGÉTIQUE ASSOCIÉ AUX
COURANTS CÔTIERS DU SUD-EST DE LA BAIE D'HUDSON
S. Lepage et R.G. Ingram, Dept. of Meteorology, McGill
Univ., Montréal, Qc
- 1600-1620 EFFECTS OF RIVER RUNOFF, SEA-ICE MELT AND WIND FORCING ON
VERTICAL MIXING DURING SPRING BREAKUP IN HUDSON BAY
R.G. Ingram et S. Lepage, Dept. of Meteorology, McGill
Univ., Nontréal, Qc
- 1620-1640 FLUSHING OF A SHALLOW BAY
D.A. Booth, Institut Maurice Lamontagne, Mont-Joli, Qc
- 1640-1700 ON THE HYDRODYNAMICS OF GRANDE-ENTRÉE LAGOON, MAGDALEN
ISLANDS
V.G. Koutitonsky and M. Couture, INRS-Océanologie,
Rimouski, Qc,
N. Navaro, Dép. d'Océanographie, UQAR, Rimouski, Qc,
E. Gomez-Reyez, Marine Sci. Res. Center, SUNY, Stony
Brook, NY
- 1700-1720 RÉOUVERTURE DE LA LAGUNE DU HAVRE-AUX-BASQUES, ÎLES-DE-
LA-MADELEINE
G. Drapeau, INRS-Océanologie, Rimouski, Qc
R.P. Rasoanilana, Dép., d'Océanographie, UQAR, Rimouski,
Qc
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- 1540-1720 Session 12C
Transport vertical et diagénèse de la matière organique
Vertical Transport and Diagenesis of Organic Matter
- Président / Chairperson : Tom Pedersen
Local / Room : C-410
- 1540-1600 VERTICAL CARBON AND NITROGEN FLUXES IN THE ARCTIC OCEAN
OFF AXEL HEIBERG ISLAND
B.T. Hargrave, Bedford Institute of Oceanography,
Dartmouth, N.S.
- 1600-1620 DEEP WATER FORMATION AND TRANSPORT OF CO₂ IN THE
NORWEGIAN-GREENLAND SEA REGION IN WINTER
E.P. Jones and R.A. Clarke, Bedford Institute of Oceano-
graphy, Dartmouth, N.S.
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1620-1640	CARBON, NITROGEN AND AMINO ACID COMPOSITION OF SETTLING PARTICLES AND SEDIMENTS OF THE LAURENTIAN TROUGH J.C. Colombo and N. Silverberg, Dép. d'Océanographie, UQAR, Rimouski, Qc, J.N. Gearing, Institut Maurice Lamontagne, Mont-Joli, Qc
1640-1700	PHOSPHOROUS FLUXES IN THE WATER COLUMN AND SEDIMENT OF THE GULF OF ST LAWRENCE, CANADA: ATTENUATION OF PHOSPHATE FLUXES FROM SEDIMENTS BY SORPTION EQUILIBRIA C. Gobeil and B. Sundby, Institut Maurice Lamontagne, Mont-Joli, Qc N. Silverberg, Dép. d'Océanographie, UQAR, Rimouski, Qc
1700-1720	BILAN SAISONNIER DE LA MATIÈRE ORGANIQUE TOTALE SÉDIMENTÉE DANS LA ZONE INTERTIDALE DU BIC (ESTUAIRE DU ST-LAURENT) A. Mauviel, G. Miron et G. Desrosiers, Dép. d'Océanographie, UQAR, Rimouski, Qc
1700-1900	BAR PAYANT / CASH BAR
1900-2200	BANQUET ANNUEL / ANNUAL BANQUET

Vendredi 1e 9 juin / Friday June 9

0830-0950	<u>Session 13A</u> Prévisions opérationnelles Operational Forecasting Président / Chairperson : Peter Zwack Local / Room : F-210
0830-0850	PRÉVISION DES ACCUMULATIONS DE NEIGE: UNE MÉTHODE OPÉRATIONNELLE BASÉE SUR UN ENSEMBLE DE PARAMÈTRES PHYSIQUES D. Bachand, J. Morissette et V. Turcotte, Centre météorologique du Québec, SEA, Ville St-Laurent, Qc
0850-0910	LE TRAITEMENT À POSTERIORI DES PRÉVISIONS STATISTIQUES D'ÉLÉMENTS DU TEMPS R. Verret et N. Yacowar, Centre météorologique canadien, SEA, Dorval, Qc

0910-0930 L'UTILISATION D'UN SYSTÈME INTERACTIF DE TRAITEMENT DE
DONNÉES RADAR POUR LA DÉTECTION ET LA PRÉVISION DES
ORAGES VIOLENTS DANS UN CENTRE MÉTÉOROLOGIQUE
H.P. Biron, Centre météorologique du Québec, SEA, Ville
St-Laurent, Qc

0930-0950 VERIFICATION OF CANADIAN MONTHLY TEMPERATURE FORECASTS
A. Shabbar, Canadian Climate Centre, AES, Downsview, Ont.

0830-0950 Session 13B
Catastrophes océaniques
Oceanic Hazards

Président / Chairperson : Tad Murty
Local / Room : F-215

0830-0850 METEOROLOGICAL FACTORS AFFECTING WATER LEVELS OF LAC
SAINT-JEAN, QUEBEC
M. Jean, Scientific Services Division, AES, Ville St-
Laurent, Qc,
G. Renaud, SAGIE,
C. Gignac, ALCAN

0850-0910 EVALUATION OF THE STORM SURGE MODEL FOR THE NOVA SCOTIA
SHELF WITH DATA FROM THE CANADIAN ATLANTIC STORMS PROGRAM
M. Danard and J. Galbraith, Atmospheric Dynamics Corpora-
tion, Victoria, B.C.,
S. Venkatesh, AES, Downsview, Ont.

0910-0930 TSUNAMI GENERATION BY A MEGATHRUST EARTHQUAKE
M. Ng and P.H. LeBlond, Dept. of Oceanography, Univ. of
British Columbia, Vancouver, B.C.,
T.S. Murty, Institute of Ocean Sciences, Sidney, B.C.

0930-0950 NON-LINEAR NUMERICAL MODELLING OF TSUNAMI GENERATION AND
PROPAGATION IN THE ST. LAWRENCE ESTUARY
J. Chassé and M.I. El-Sabh, Dép. d'Océanographie, UQAR,
Rimouski, Qc
T.S. Murty, Institute of Ocean Sciences, Sidney, B.C.

0830-0950 Session 13C
Chimie atmosphérique I
Atmospheric Chemistry I

Président / Chairperson : Jack McConnell
Local / Room : C-410

0830-0850 PHOTOCHEMISTRY AND CONDENSATION: THEIR ROLES IN THE
FORMATION OF HAZE IN THE ATMOSPHERE OF URANUS
C. Blanchette, Dept. of Earth and Atmospheric Science,
York Univ., North York, Ont.

- 0850-0910 SIMULATION ASSESSMENT OF LOCAL PHOTOCHEMISTRY AS A SOURCE OF OXIDANTS IN EDMONTON AND CALGARY
K.P. Gladstone, H. Niki, P.B. Shepson, H.I. Schiff, Dept. of Earth and Atmospheric Science, York University, North York, Ont.,
J. Bottenheim, AES, Toronto, Ont.
- 0910-0930 SEASONAL VARIATION OF HYDROCARBON CHEMISTRY IN THE SATURNIAN ATMOSPHERE: A COMPARISON BETWEEN MEASUREMENTS AND MODELS
Y. Rochon, CRESS, York Univ., North York, Ont.
- 0930-0950 A STUDY OF THE WINTER ARCTIC OZONE LAYER
W.F.J. Evans, AES, Downsview, Ont.
-
- 0950-1020 Café / Coffee
-
- 1020-1200 Session 14A
Physique des nuages
Cloud Physics

Président / Chairperson : Ed Lozowski
Local / Room : F-210
- 1020-1040 A NUMERICAL INVESTIGATION OF SQUALL LINES
K.K. Szeto and H.-R. Cho, Dept. of Physics, Univ. of Toronto, Toronto, Ont.
- 1040-1100 POLARISATION CIRCULAIRE: CORRECTION DES EFFETS DE PROPAGATION
B. Pettigrew et E. Torlaschi, Dép. de Physique, UQAM, Montréal, Qc
- 1100-1120 SURFACE TEMPERATURE DIFFERENCES ON GYRATING HAILSTONES
R. List and B. Greenan, Dept. of Physics, Univ. of Toronto, Toronto, Ont.
- 1120-1140 DROP-SIZE DISTRIBUTIONS IN PULSATING TROPICAL RAIN
R. List and G. McFarquhar, Dept. of Physics, Univ. of Toronto, Toronto, Ont.
- 1140-1200 RIGICE: DEVELOPMENT OF A CLIMATOLOGICAL FREEZING SPRAY MODEL FOR OFFSHORE STRUCTURES
R.D. Brown, Hydrometeorology and Marine Division, AES, Downsview, Ont.
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- 1020-1200 Session 14B
 Modélisation en présence de glace
 Sea-Ice Circulation Models
- Président / Chairperson : Jean-François Dumais
 Local / Room : F-215
- 1020-1040 A SIMPLE ICE-OCEAN MODEL FOR THE GREENLAND SEA
 R.G. Wood and L.A. Mysak, Dept. of Meteorology, McGill
 Univ., Montréal, Qc
- 1040-1100 APPLICATION OF A SIMPLE ICE-OCEAN MODEL TO THE LABRADOR
 SEA
 S. Peng, R.G. Wood and L.A. Mysak, Dept. of Meteorology,
 McGill Univ., Montréal, Qc
- 1100-1120 ON THE RELATIONSHIP BETWEEN ARCTIC SEA-ICE ANOMALIES AND
 FLUCTUATIONS IN NORTHERN CANADIAN AIR TEMPERATURE AND
 RIVER DISCHARGE
 D.K. Manak and L.A. Mysak, Dept. of Meteorology, McGill
 Univ., Montréal, Qc
- 1120-1140 EFFECTS OF SALINITY IN A TWO-AND-A-HALF-LAYER UPPER-OCEAN
 GENERAL CIRCULATION MODEL
 C.W. Yuen and J.Y. Cherniawsky, Dept. of Meteorology,
 McGill Univ., Montréal, Qc
- 1140-1200 SEA-ICE MOTION OFF LABRADOR AND NEWFOUNDLAND DURING THE
 WINTER OF 1988/89
 S. Prinsenberg and I. Peterson, Bedford Institute of
 Oceanography, Dartmouth, N.S.
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- 1020-1200 Session 14C
 Chimie atmosphérique II
 Atmospheric Chemistry II
- Président / Chairperson : Wayne Evans
 Local / Room : C-410
- 1020-1040 PRELIMINARY RESULTS FROM A 3-D CHEMICAL TRANSPORT
 MODEL
 J.W. Kaminski, CRESS, York Univ., North York, Ont.
- 1040-1100 CLOUD DYNAMICS AS AN EFFICIENT TRANSPORT MECHANISM FOR
 CHEMICAL SPECIES IN THE UPPER TROPOSPHERE
 I. Hare, St Johns, Nfld
- 1100-1120 ARCTIC SUNRISE O₃ DEPLETION: A POSSIBLE SCENARIO WITH
 BROMINE CHEMISTRY
 G.S. Henderson, J. Bottenheim, and L. Barrie, AES,
 Toronto, Ont.,
 J.C. McConnell, York Univ., North York, Ont.
-

- 1120-1140 A 1-D BOUNDARY CHEMISTRY MODEL: A TOOL FOR EMEFS
MEASUREMENT PROGRAM ANALYSIS
J.C. McConnell, York Univ., North York, Ont.,
G.S. Henderson, J. Bottenheim and L. Barrie, AES, Toronto,
Ont.
- 1140-1200 CHEMICAL AND MICROPHYSICAL PROPERTIES OF WINTER FOGS IN
SOUTHERN ONTARIO
O.T. Melo and Y.T. Tam, Ontario Hydro, Toronto, Ont.
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AFFICHAGES / POSTERS

- P01 NOUVEAUX RÉSERVOIRS EXPÉRIMENTAUX POUR DES ÉTUDES ENVIRON-
NEMENTALES EN CONDITIONS HIVERNALES
E. Pelletier, C. Brochu, R. Siron, S. Roy et P. Mayzaud, INRS-
Océanologie, Rimouski, Qc
- P02 RIVER PLUME LIFT-OFF UNDER A COMPLETE ICE COVER IN HUDSON BAY
L.M. Veilleux, Dept. of Meteorology, McGill Univ., Montréal, Qc
- P03 IRRIGATION ADVISORY DEVELOPMENT
F.J. Eley, Hydrometeorological Research Division, AES,
Saskatoon, Saskatchewan
- P04 NON-STEADY-STATE DIAGENESIS IN A COASTAL MARINE SEDIMENT
A. Mucci, Dept. of Geological Sci., McGill Univ., Montréal, Qc
H.M. Edenborn, U.S. Bureau of Mines, Pittsburgh Research
Center, Pittsburgh, PA
- P05 CALCITE SOLUBILITY BEHAVIOUR IN SEA-WATER IN THE PRESENCE OF
MN(II): PRELIMINARY RESULTS
A. Mucci, Dept. of Geological Sci., McGill Univ., Montréal, Qc
- P06 THE MARINE KILLERS DINOFLAGELLATES: A GLOBAL PERSPECTIVE
M.I. El-Sabh, Dép. d'Océanographie, UQAR, Rimouski, Qc
S.N. Messieh, Bedford Institute of Oceanography, Dartmouth,
N.S.
- P07 BAROTROPIC MOTIONS IN THE GULF OF SUEZ, EGYPT
M.A. Rady and M.I. El-Sabh, Dép. d'Océanographie, UQAR,
Rimouski, Qc,
J.O. Backhaus, Inst. fur Meereskunde, Hamburg Univ., Hamburg,
West Germany,
T.S. Murty, Institute of Ocean Sciences, Sidney, B.C.
- P08 STORM SURGES IN THE ARABIAN GULF
M.I. El-Sabh, Dép. d'Océanographie, UQAR, Rimouski, Qc,
T.S. Murty, Institute of Ocean Sciences, Sidney, B.C.
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- P09 MODÉLISATION NON-LINÉAIRE DES MARÉES DANS L'ESTUAIRE DU SAINT-LAURENT
J. Chassé et M.I. El-Sabh, Dép. d'Océanographie, UQAR, Rimouski, Qc,
T.S. Murty, Institute of Ocean Sciences, Sidney, B.C.
- P10 MOVEMENT AND DISPERSION OF OIL SLICKS IN THE ARABIAN GULF
M.I. El-Sabh, Dép.d'Océanographie, UQAR, Rimouski, Qc,
T.S. Murty, Institute of Ocean Sciences, Sidney, B.C.
- P11 MOPITT: AN LMR /PMR INSTRUMENT DESIGN FOR TROPOSPHERIC CO MEASUREMENT ON THE POLAR ORBITING PLATFORM OF EOS
J.R. Drummond, Univ. of Toronto, Toronto, Ont.,
J.C. McConnell, York Univ., North York, Ont.,
G.P. Brasseur and J.C. Gille, NCAR, Boulder, Co
- P12 ADSORPTION ET COMPÉTITIVITÉ DES PHÉNOMÈNES SUR DES ARGILES EN SUSPENSION: MÉTAUX ET COMPOSÉS PHÉNOLIQUES
C. Gagnon, M. Arnac et J.-R. Brindle, Dép. d'Océanographie, UQAR, Rimouski, Qc

Résumés / Abstracts

0930-1030 (F-210)

Mardi / Tuesday

SESSION 01 : PLÉNIÈRE I
PLENARY I

THE DYNAMICS OF TROPICAL CYCLONES

H.E. Willoughby

Tropical cyclones are intense warm-core cyclonic vortices driven by condensation of vapour extracted from the tropical sea. They occupy the depth of the troposphere and have lower tropospheric cyclonic circulations extending 1000 km (the outer spatial scale) from their centres. The strongest swirling winds, typically 50 m s^{-1} , lie a few tens of kilometres (the inner spatial scale) from the centre. The time-scale for a tropical cyclone to evolve significantly is an inertia period (35 h at 20° latitude); whereas the orbital period in which air moving with the swirling wind circles the centre may be 1-2 h (the slow and fast time-scales). The tropical cyclone core is the region near the centre where the local Rossby number exceeds unity and a significant separation exists between the slow and fast time-scales. The radius of the core is approximately the geometric mean of the outer and inner spatial scales.

Within the core, the cyclonic primary circulation is in balance with the pressure. Asymmetric motions and the axisymmetric secondary circulation are much weaker than the primary circulation. The asymmetries - internal gravity waves or Rossby waves - modulate precipitation and cloud into trailing spirals. The secondary circulation is driven by both latent heat release and surface friction. It contains low-level inflow that extracts latent heat from the sea and imports angular momentum from large radius; convective ascent, largely in the eyewall; forced descent inside the eye; and upper tropospheric outflow. The eyewall commonly moves inward in response to differential adiabatic heating across it. Often two concentric eyewalls form in intense tropical cyclones, leading to cyclic intensity changes while the outer replaces the inner.

The region surrounding the core is not so well understood. Inasmuch as the synoptic environment controls motion and intensity through asymmetric flow there, these non-balanced motions may be the key to better forecasts.

1100-1200 (F-210)

Mardi / Tuesday

SESSION 02 : PLÉNIÈRE II
PLENARY II

BIOTOXINS AND OTHER NATURAL HAZARDS

Peter J. Wangersky

Marine biotoxins have a long history in folklore and in the written historical record. In recent years their occurrences have become more frequent, have lasted longer, and have appeared in areas with no previous

history of such phenomena. In some cases, the appearances in new areas may be the result of the introduction of a new species into regions formerly free of toxic species, as in the appearance of *Pyrodinium bahamense* var *compressa* in the western Pacific; in other cases, the spread of a locally well known species into adjacent regions may be involved, as in the movement of *Ptychodiscus brevis* out of the Gulf of Mexico and into the coastal waters off North Carolina.

Perhaps more important in the long run is the increased duration of such incidents. The bloom of *Nitzschia pungens*, which led to the "toxic mussels" incident of late 1987, would not have had such catastrophic results had it followed the usual diatom bloom sequence and collapsed after reaching its peak values; instead, it maintained itself in senescent bloom status through November and December, producing large quantities of the toxic domoic acid. Similarly, *P. brevis* blooms, although well known in the Gulf of Mexico, have not normally lasted long enough to enter the Florida Current and the Gulf Stream, as has been suggested for the North Carolina bloom. Large-scale changes in the local supplies of nutrients are suggested by these temporal extensions of the blooms.

Overblooms of non-toxic organisms can also result in catastrophes for the local fisheries and for aquaculture, possibly through clogging of the gills of fish and shellfish during the bloom peaks, and certainly through exhaustion of oxygen during bloom decomposition. These incidents can result from excessive addition of organic or inorganic nitrogen and phosphorus to inshore waters through man's activities; in a sense, they are self-inflicted wounds, and can be prevented by taking sensible precautions in siting of aquacultural activities and in waste disposal. These incidents point out that we cannot continue to consider the inshore waters as a handy waste container; the removal of pollution by dilution is no longer an effective waste disposal method.

1330-1510 (F-210)

Mardi / Tuesday

SESSION 03A : CATASTROPHES MÉTÉOROLOGIQUES
METEOROLOGICAL HAZARDS

PRAIRIE DUSTSTORMS - A NEGLECTED HAZARD E.E. Wheaton

Although duststorms are quite frequent in the Canadian Prairies, few scientific studies of prairie duststorm characteristics exist. The droughts of the 1980s have resulted in above normal numbers of duststorms, even in winter. Duststorms can no longer be considered phenomena of the past. The effects of duststorms are numerous, costly and severe. They cause severe and extensive wind erosion of soil. Wind erosion is a major soil degradation process in the Prairies.

The climatology of Prairie duststorms is in its infancy. This work is a preliminary step to depict the temporal and spatial variations of duststorms in the Prairies. Duststorms occur at least once a year in the northern Prairies to as often as five times a year, on average, in the southern Prairies. The core of highest duststorm risk appears to be in south-central Saskatchewan. More than ten times the number of duststorms

occur in the spring, specifically April, than in most other months. The knowledge of these temporal and spatial patterns should facilitate the control or avoidance of the impacts of duststorms. Much further work is needed to advance the duststorm climatology of the Prairies and the modelling of duststorms.

THE RECORD STORM OF SEPTEMBER 25, 1986

R.F. Hopkinson

Hydrometeorologists and hydrologists in Canada are well aware of the devastating flooding over southern Ontario caused by hurricane Hazel. Until September 25, 1986, it was believed that storms of tropical origin such as Hazel were unlikely to affect the Canadian Prairies; however, moisture input from former hurricane Madeline was identified as a key element in this September 25 storm, which brought 100 to 175 mm of rain to areas of southeast Alberta, southwest Saskatchewan and adjacent Montana, producing record runoffs on some streams.

The hazard of flooding from rapid snowmelt and intense summer convective storms is well recognized on the Prairies. However, the possible influence of tropical storms was not identified previously as another potential hazard. Although there is nothing that can be done to reduce the rainfall, engineers and water resource managers should be able to reduce the hazards of flooding or catastrophic dam failure by proper design and operation of structures and by flood risk mapping and subsequent zoning.

HAILSTORM STUDIES IN SASKATCHEWAN FROM CROP-INSURANCE DATA

A.H. Paul

The hail hazard in Saskatchewan has been partially defined in previous studies. The approach of the climatological study of hailfall through use of a network of volunteer observers has provided some general information. Crop-insurance data have their shortcomings but do permit the study of damaging hail throughout the agricultural portions of the province. This paper presents some initial results from a climatological and cartographic study of crop-hail insurance claims for the years 1980-87. The characteristics of hail and rain from several storms of special significance are described with the aid of other sources including AES official data.

A FRAMEWORK FOR THE STUDY OF PRAIRIE DROUGHTS

R.G. Lawford

The drought of 1988 had many severe impacts on agriculture, water resources and waterfowl management. The synoptic conditions and the climatological patterns that accompanied the drought are documented. In addition, a number of environmental factors that may have influenced the drought and aggravated its impacts are described. Processes contributing to the 1988 drought are considered in terms of their scale, timing and possible effects.

Based on events in 1988, Prairie droughts are discussed in more general terms. Several specific hypotheses concerning drought-related processes are advanced and an overall plan for addressing the scientific aspects of Prairie droughts is proposed.

PROPAGATION OF FRICTIONALLY-DECAYING BAROTROPIC MODONS OVER FINITE-AMPLITUDE TOPOGRAPHY

Lok Yan and Gordon E. Swaters

An analytical asymptotic theory is developed that describes the propagation of the finite-amplitude solitary Rossby wave called a modon under the combined effects of weak frictional dissipation and finite-amplitude but slowly varying topography. The asymptotic theory developed here explicitly assumes the modon undergoes an adiabatic deformation governed by globally averaged energy and enstrophy balances. The theory presented therefore unifies and extends the accurate frictional dissipation theory developed by Swaters and Flierl and the topographic theory developed by Swaters. The results of the unified theory predict that the topographic forcing has an influence on the rate of the frictional dissipation.

DYNAMICS OF ISOLATED BAROCLINIC EDDIES ON A SLOPING BOTTOM

Gordon E. Swaters

A theory is presented that describes the propagation and structure of coherent cold-core eddies on a sloping bottom and their interaction with the surrounding ocean. In the weakly interacting eddy limit, the Nof (Deep-Sea Res. 30: 171-182, 1983) results are recovered. We show that the propagating eddies do not excite a field of (topographic) Rossby waves in contrast to the warm-core eddy study by Flierl (J. Phys. Oceanogr. 14: 47-58, 1984). The observed cross-slope drift observed by Mory et al. (J. Fluid Mech. 183: 45-62, 1987) may be explained as the result of a bottom frictional boundary layer.

ALTIMETRIC SATELLITE MEASUREMENTS OF SEA-LEVEL VARIABILITY NEAR THE SOUTHEAST NEWFOUNDLAND RIDGE

R.M. Hendry and M. Ikeda

Data from the first 15 months of the Exact Repeat Mission of the US Navy GEOSAT altimetric satellite have been analysed to investigate the energy levels and space- and time-scales of low-frequency sea-level variability associated with current meandering and eddy formation and propagation in the vicinity of the Southeast Newfoundland Ridge. Maxima in sea-level variability in the study region, between 60 and 35°W, are associated with the regional currents and with major topographic features. The Gulf Stream shows an overall maximum in root-mean-square sea-level variability of about 35 cm near 55°W and a secondary maximum at the Tail of the Grand Banks centred near 49°W and extending eastward into the southern Newfoundland Basin. The North Atlantic Current shows maximum sea-level variability in the vicinity of the Newfoundland Seamount Chain near 44°N and a secondary maximum offshore of Flemish Cap near 47°N. Events in the altimeter data can be correlated with features in sea surface temperature maps, but the mixed space and time sampling of the altimetric data set makes comprehensive spatial mapping difficult.

INTERNATIONAL DROUGHT INFORMATION CENTER: PURPOSE AND OBJECTIVES

Donald A. Wilhite

In the fall of 1988 the University of Nebraska-Lincoln established an International Drought Information Center (IDIC) to foster and promote a better understanding of drought through improved communication of information about prediction, monitoring, impact assessment, adjustment and adaptation, and planning and response. The IDIC is an outgrowth of recommendations emanating from the International Symposium and Workshop on Drought held at the University of Nebraska in September 1986.

The objectives of the IDIC are (1) to collect, analyse, package, and disseminate information on current episodes of drought and its impacts; response, mitigation, and planning activities of government and international organizations; and research results and the application of new technologies to drought planning and management; (2) to conduct regional seminars to train persons from developed and developing countries in the science of drought planning and management; and (3) to stimulate and coordinate drought-related activities, including information flow about current conditions and impacts, between the Regional Climate Centers in the United States.

The IDIC has established an international network of scientists and policy officials with interest in drought planning and management. Publication of a newsletter, Drought Network News, began in January 1989. The newsletter is published three times a year in cooperation with the World Climate Program of the World Meteorological Organization.

This paper will discuss current international interest in drought and review progress to date in dealing with problems associated with improved management of drought from an institutional or governmental perspective.

1330-1510 (F-215)

Mardi / Tuesday

SESSION 03B : TOURBILLONS ET CIRCULATIONS Océaniques
OCEANIC EDDIES AND GYRES

TRACKING THE ALASKAN GYRE: RESULTS OF THE NORTHEAST PACIFIC CURRENT STUDY (NEPCS)

P.H. LeBlond, R. Thomson, D. Williams and W. Emery

Deep-drogued (100 m) satellite-tracked drifting buoys were released in two deployments in the Gulf of Alaska to explore the continuity of the Alaskan Gyre below the level of direct wind influence. The motion mapped over 1.5 years by the drifters suggests only a poorly defined subsurface cyclonic gyre. Strong eddy motion has been identified west of the Queen Charlotte Islands. The response of the buoys to wind forcing shows mainly in the inertial band. Lagrangian dispersion estimates on a quartet of buoys launched together show initial separation from the centroid increasing with time squared and thereafter approaching a constant value. The results will be reviewed and interpreted in the light of ongoing studies of the northeast Pacific circulation.

PROPAGATION OF FRICTIONALLY-DECAYING BAROTROPIC MODONS OVER FINITE-AMPLITUDE TOPOGRAPHY

Lok Yan and Gordon E. Swaters

An analytical asymptotic theory is developed that describes the propagation of the finite-amplitude solitary Rossby wave called a modon under the combined effects of weak frictional dissipation and finite-amplitude but slowly varying topography. The asymptotic theory developed here explicitly assumes the modon undergoes an adiabatic deformation governed by globally averaged energy and enstrophy balances. The theory presented therefore unifies and extends the accurate frictional dissipation theory developed by Swaters and Flierl and the topographic theory developed by Swaters. The results of the unified theory predict that the topographic forcing has an influence on the rate of the frictional dissipation.

DYNAMICS OF ISOLATED BAROCLINIC EDDIES ON A SLOPING BOTTOM

Gordon E. Swaters

A theory is presented that describes the propagation and structure of coherent cold-core eddies on a sloping bottom and their interaction with the surrounding ocean. In the weakly interacting eddy limit, the Nof (Deep-Sea Res. 30: 171-182, 1983) results are recovered. We show that the propagating eddies do not excite a field of (topographic) Rossby waves in contrast to the warm-core eddy study by Flierl (J. Phys. Oceanogr. 14: 47-58, 1984). The observed cross-slope drift observed by Mory et al. (J. Fluid Mech. 183: 45-62, 1987) may be explained as the result of a bottom frictional boundary layer.

ALTIMETRIC SATELLITE MEASUREMENTS OF SEA-LEVEL VARIABILITY NEAR THE SOUTHEAST NEWFOUNDLAND RIDGE

R.M. Hendry and M. Ikeda

Data from the first 15 months of the Exact Repeat Mission of the US Navy GEOSAT altimetric satellite have been analysed to investigate the energy levels and space- and time-scales of low-frequency sea-level variability associated with current meandering and eddy formation and propagation in the vicinity of the Southeast Newfoundland Ridge. Maxima in sea-level variability in the study region, between 60 and 35°W, are associated with the regional currents and with major topographic features. The Gulf Stream shows an overall maximum in root-mean-square sea-level variability of about 35 cm near 55°W and a secondary maximum at the Tail of the Grand Banks centred near 49°W and extending eastward into the southern Newfoundland Basin. The North Atlantic Current shows maximum sea-level variability in the vicinity of the Newfoundland Seamount Chain near 44°N and a secondary maximum offshore of Flemish Cap near 47°N. Events in the altimeter data can be correlated with features in sea surface temperature maps, but the mixed space and time sampling of the altimetric data set makes comprehensive spatial mapping difficult.

INTÉGRATION ET DIFFUSION DE DONNÉES SUR LE MILIEU MARITIME
Marie-Catherine Mouchot

L'utilisation rationnelle des données liées au milieu maritime, qu'elles proviennent de capteurs de télédétection ou de sources conventionnelles, nécessite la mise en place de systèmes informatiques spécifiques. En effet, pour être utilisables, les différentes informations doivent être combinées les unes aux autres à l'intérieur d'une structure normalisée et diffusées aux utilisateurs dans des délais de validité déterminés.

Afin de répondre à ces besoins, le Centre canadien de télédétection, en collaboration avec le ministère des Pêches et Océans, a mis sur pied un prototype de données intégrées regroupant des données de télédétection et des données de SDMM. Ce prototype, basé sur un système d'information géographique dont la référence est la carte numérique du Service Hydrographique du Canada, permet à un utilisateur, muni d'un PC et d'un modem d'accéder en tout temps aux données disponibles sur sa zone d'intérêt. Les informations réunies dans un format compatible, peuvent être combinées les unes aux autres au gré de l'utilisateur.

Le prototype, qui regroupe actuellement des données SEASAT, GEOSAT et AVHRR, sera développé pour permettre l'utilisation de la nouvelle génération de satellites à vocation océanographique (Sea-WIFS, ERS-1, JERS-1, RADARSAT, HIRIS/MODIS, ...).

Dans une phase subséquente, on utilisera ces données pour créer des modèles prévisionnels d'aide à la pêche et à la navigation ainsi que des modèles de prédiction des changements environnementaux.

1330-1510 (C-410)

Mardi / Tuesday

SESSION 03C : GÉOCHIMIE MARINE
MARINE GEOCHEMISTRY

A RE-EXAMINATION OF DISSOLVED ORGANIC PHOSPHORUS LEVELS IN OCEANIC WATERS

J.J. Ridal and R.M. Moore

Recent investigations by Sugimura and Suzuki of dissolved organic matter in oceanic waters have indicated higher concentrations of organically bound carbon and nitrogen than those previously estimated. An attempt has been made to examine the possibility of similarly greater concentrations of dissolved organic phosphorus (DOP) than those measured with conventional methods. The mechanical methods employed in this study were designed to provide more extreme oxidizing conditions than normally used in the analysis of DOP, and include a combination of ultraviolet and persulphate oxidation. Preliminary results indicate the presence of up to 0.1 μM more DOP (ca 50% of the total dissolved phosphorus) in Sargasso Sea surface waters than that measured with the conventional techniques. However, observed increases of DOP are insignificant when compared with total phosphorus concentrations for sea-water samples taken at depths greater than 50 m. Relative oxidation efficiencies of the methods, and the partitioning of DOP between high and low molecular weight fractions will also be discussed.

LATE QUATERNARY HISTORY OF THE OXYGEN MINIMUM IN THE NORTHWEST ARABIAN SEA
T.F. Pedersen, G.B. Schimmiel, S.A. Macko and A. Muzuka

High resolution records of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ in planktonic and benthic foraminifera collected from Site 724 (ODP Leg 117) on the Oman Margin are presented for the last few hundred thousand years, along with $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements in sedimentary organic matter, and organic carbon, nitrogen and major and minor element measurements made on bulk sediments. The $\delta^{13}\text{C}$ values recorded by the benthic foram *U. peregrina* are about 1 per mil lighter during glacial stages, indicating either a severe intensification of the oxygen minimum during such periods or a greatly enhanced addition to shallow pore waters (where *Uvigerina* spp. are thought to live) of light carbon derived from an increased rate of oxidation or an increased rate of accumulation of organic matter. These alternatives will be weighed in the light of major and minor element compositional data, and the isotope measurements made on the organic fraction.

THE COMPARATIVE MARINE GEOCHEMISTRIES OF ALUMINIUM, GALLIUM AND TITANIUM
Kristin J. Orians, Edward A. Boyle and Kenneth W. Bruland

Aluminium, gallium and titanium are readily hydrolysed in sea-water, forming the dissolved species $\text{Al}(\text{OH})_4^-$, $\text{Al}(\text{OH})_3^0$, $\text{Ga}(\text{OH})_4^-$ and $\text{TiO}(\text{OH})_2^0$. Dissolved Al concentrations in the open Pacific Ocean are $\leq 0.06\text{--}6.0 \text{ nmol kg}^{-1}$, 1-3 orders of magnitude lower than reported values from other ocean basins. Dissolved Ga concentrations are 2-30 pM in the Pacific and 20-60 pM in the northwest Atlantic. Dissolved Ti concentrations are 5-120 pM in the open Pacific.

Distributions of dissolved Al and Ga in the oceans reflect geographic variations in atmospheric sources and scavenging intensities. Both elements also have deep water sources. Dissolved Ti concentrations increase with depth, similar to silicate - unlike scavenging-type elements.

Estimates of dissolved Al residence times in surface waters are 35 days to 4 years, decreasing with productivity and inferred scavenging intensity. Deep water residence times are 30 to 200 years, decreasing near the margins. The 40-fold depletion of dissolved Al in the older deep waters of the North Pacific relative to those in the North Atlantic is the largest inter-ocean fractionation yet observed for a scavenged element. Dissolved Ga is less reactive in the oceans than dissolved Al, and shows less of an inter-ocean fractionation. Oceanic residence times of dissolved Ga are 5-10 times longer than those of Al.

A Ga/Al enrichment of 1-2 orders of magnitude is observed in the oceans, relative to the earth's crust, consistent with the longer residence time of dissolved Ga in the oceans. The lack of a Ti/Al enrichment in the ocean, relative to the earth's crust, suggests that the residence time of Ti in the oceans may be similar to that of dissolved Al. This is surprising owing to their markedly different vertical distributions. Whether Ti behaves in a nutrient-type manner throughout the oceans or exhibits the scavenging-type behaviour predicted for this element is presently under investigation.

DISSOLVED ALUMINIUM IN REGIONS OF NADW FORMATION: RESULTS FROM THE RECENT GREENLAND SEA PROJECT CRUISE

S. Bradley Moran and Robert M. Moore

In contrast to the relatively low (6-11 nmol L⁻¹) and invariant levels of dissolved aluminium in deep waters (> 1 km) of the eastern North Atlantic, by dissolved aluminium concentrations that increase linearly below 1 km to levels of 25-30 nmol L⁻¹ near the bottom (2,3). The latter distribution has been argued to be the result of an advective input of aluminium enriched NADW, the ultimate source being entrainment of North Sea water into NADW formation areas (3). The North Sea is known to be seasonally enriched in dissolved aluminium, mainly from river runoff.

We present the first measurements of dissolved aluminium from regions of NADW formation, obtained during the recent Greenland Sea Project cruise (Jan.-Mar. 1989). Vertical and horizontal distributions of dissolved aluminium will be discussed, with particular reference to the importance of the northern seas as a source of dissolved aluminium to deep waters of the western North Atlantic.

- (1) Hydes, D.J. (1983) *Geochim. Cosmochim. Acta*, 47, 967-973.
- (2) Hydes, D.J. (1979) *Science*, 205, 1260-1262.
- (3) Measures, C.I., Edmond, J.M. and Jickells, T.D. (1986) *Geochim. Cosmochim. ACTA*, 50, 1423-1429.

HEAT TRANSFER FROM ATLANTIC WATERS TO SEA ICE IN THE ARCTIC OCEAN: EVIDENCE FROM DISSOLVED ARGON

R.M. Moore and W. Spitzer

In a recent paper, Moore and Wallace (1988, *J. Geophys. Res.* 93: 565-571) showed that the temperature-salinity properties of waters in the Atlantic layer of the Arctic Ocean can apparently be accounted for by a simple model involving the transfer of heat from the water into melting sea ice. In an attempt to find evidence for this process using chemical tracers, measurements were made of dissolved argon concentrations in a vertical profile located at 80°58'N, 112°29'W. A change was observed from supersaturation of dissolved argon in the upper waters, to undersaturation below a depth of 275 m. This is consistent with predictions from the ice-melting model. Using the known dependence of the solubility of argon on temperature and salinity, it has been calculated that ca 0.6°C of cooling can be attributed to the transfer of heat to sea ice.

BAROCLINIC INSTABILITY AND THE SUMMER SOUTHERN HEMISPHERE WAVENUMBER 5 CIRCULATION

Charles A. Lin and Agnes C.M. Chan

We examine the linear instability of the observed two-dimensional (latitude/height) January 1979 zonal wind of the mid-latitude Southern Hemisphere. The model used is a 10-level, linear, quasi-geostrophic 45°S β -plane channel model, with 30 Fourier harmonics in the meridional direction and a single harmonic in the zonal direction. The fastest growing mode has a zonal wavelength corresponding to wavenumber 12 at 45°S . The mode corresponding to zonal wavenumber 5 at 45°S is also baroclinically unstable. Its latitude-height structure bears qualitative resemblance to the observed wavenumber 5 circulation, which frequently dominates the summer Southern Hemisphere mid-latitude circulation. The latitude of the maximum eddy amplitude at 50°S is simulated, but the maximum is located near the surface instead of aloft. Effects of surface dissipation and a normalization of the zonal wind by the cosine of latitude are also considered.

RECENT DEVELOPMENTS IN THE STUDY OF marginally UNSTABLE BAROCLINIC WAVES IN A QUASI-GEOSTROPHIC β -PLANE MODEL

Pierre Gauthier

At the point of minimum critical shear (MCS) of a quasi-geostrophic two-layer model on the β -plane, Warn and Gauthier (1989) have recently shown that the weakly non-linear dynamics of a marginally unstable baroclinic wave is such that even though the amplitude of the unstable wave equilibrates to a constant value owing to potential vorticity mixing, the absolute potential vorticity field remains transient. A particular geometry of the channel is required to be at MCS and it is only in that case that an analytical solution seems to be possible. In this paper, a numerical investigation of the behaviour of the vorticity field and of the unstable wave is presented when the problem is not exactly set at MCS. The results show that potential vorticity mixing now occurs only in part of the domain and that the region of mixing decreases as we move off MCS while the amplitude of the unstable wave is now oscillating around a non-zero mean. The small scales that develop in the absolute potential vorticity field imply that the numerical solutions can only be adequate for a finite period of time. The analytical solution is therefore very useful to evaluate the accuracy and efficiency of different numerical schemes. A comparison is made between a spectral model and a Lagrangian one with equivalent resolution.

PROBLÈME À LA CONDITION INITIALE POUR DES ONDES DE ROSSBY SUR UN JET PARABOLIQUE

G. Brunet et T. Warn

Nous avons étudié dans ce travail le problème à la condition initiale pour l'équation du tourbillon barotrope dans le plan bêta linéarisée autour d'un état de base zonal. Le vent zonal employé dans cette étude est le jet $U(y) = U_0 + U'y + U''y^2/2$ dans le plan infini. Il est montré que l'équation non dimensionnelle de ce problème ne dépend que d'un paramètre $a = -2(\beta - U'')/U''$. L'équation de Rayleigh-Kuo associé a pour tout "a" un spectre continu de modes singuliers et pour $a < -0,25$ il existe une infinité de modes discrets de Rossby. Dans l'espace de Fourier le problème a une formulation hamiltonienne qui permet une discussion qualitative simple de l'énergétique reliée à l'interaction du jet avec la perturbation.

En utilisant la théorie des groupes de Lie nous avons obtenu pour $a \geq 0,75$ et dans le contexte de l'approximation de l'onde longue des séparations des variables qui nous permettent de résoudre complètement le problème à la condition initiale. En plus nous avons obtenu des solutions invariantes localisées en y. Ces solutions invariantes sont pour certaines valeurs de "a" analytiquement simples et permettent une comparaison avec les résultats qu'on retrouve dans la littérature à propos d'un vent zonal linéaire. En particulier pour certaines conditions initiales nous obtenons des phénomènes d'amplifications temporaires comme pour le vent zonal linéaire et qui dépendent de "a". L'évaluation des taux de croissances de l'énergie pour ces périodes d'amplifications se comparent bien à celles observées pour des flots zonaux ayant des instabilités barotropes.

DYNAMICS OF FRONTAL DISCONTINUITIES IN THE SEMI-GEOSTROPHIC THEORY

Han-Ru Cho and John Koshyk

A deformation forced, semi-geostrophic frontogenesis model is extended in time to include frontal evolution after the initial formation of a discontinuity at the surface. Dynamical fields associated with the frontogenesis (e.g. along front, cross front and vertical winds, Richardson number) are calculated and compare favourably with the qualitative features of atmospheric cold fronts. In particular, a strong vertical velocity jet exists at the position of the surface front in agreement with observational studies. Results from primitive equation models that include thermal and momentum diffusion are compared with the results presented here in order to assert the validity of the semi-geostrophic approximation and to examine the effect of neglecting friction and mixing processes on our model.

ON CALCULATING VORTICITY BALANCES IN PRIMITIVE EQUATION MODELS

M.G.G. Foreman and A.F. Bennett

It is shown that the discrete conservation of vorticity equation associated with a primitive equation model on an Arakawa 'B' grid (e.g., the Cox GFDL model) contains a term that approximates $\beta \Delta y^2 \partial^2 u / \partial x \partial y$. Although this term has no counterpart in the continuous equations, it should be included in all vorticity balance calculations. Regions within ocean models where this term might be significant are discussed and the relative magnitude of the term with respect to βv is calculated for a simple barotropic model of the North Pacific Ocean. It is shown that a similar spurious term can also arise with a 'C' grid model.

HORIZONTAL RESOLUTION AND MERIDIONAL HEAT AND FRESHWATER TRANSPORTS IN A NUMERICAL UPPER OCEAN MODEL

J.Y. Cherniawsky

Most ocean general circulation models (CGCMs) contain free parameters that, to a varying degree, influence their mass, heat and freshwater transports. One of the most important parameters is the spatial resolution of a model. The dependence of the meridional transports on horizontal resolution is explored here by comparing the results from numerical experiments with two non-eddy-resolving upper CGCMs, one with a grid size of $4^\circ \times 5^\circ$ and the other $1^\circ \times 1.25^\circ$. The two models were set in a subtropical-subpolar basin and forced from above with an idealized wind stress function. Heat and salinity fluxes were applied both at the top and the bottom surfaces and were derived in each case from the zonally averaged climatological (Levitus, 1982) temperature and salinity fields. As expected, the higher-resolution ($1^\circ \times 1.25^\circ$) experiment had a much stronger horizontal mass transport. The effect of the latter on the meridional heat and freshwater transports will be discussed.

NUMERICALLY MODELLING THE INTERANNUAL VARIABILITY OF THE NORTHEAST PACIFIC OCEAN AND ITS INFLUENCE ON SOCKEYE SALMON

William W. Hsieh, Warren G. Lee and Lawrence A. Mysak

The GFDL Bryan-Cox primitive-equation model was used to hindcast the variability of the northeast Pacific Ocean from 1955 to 1979 with forcing from the monthly averaged observations of wind stress and the surface heat flux (estimated from the difference between the observed air temperature and model surface temperature). Empirical orthogonal function (EOF) analysis was used to analyse both the atmospheric forcing fields and the oceanic response fields. Although the near-surface temperature EOFs agreed closely with the air temperature EOFs, the current EOFs did not resemble the wind stress EOFs.

We then applied our results to the Fraser River sockeye salmon (*Oncorhynchus nerka*). Stepwise multiple regression between the time-varying amplitudes of the EOFs and the fish variables (the rate of northward diversion, the return timing, the weight and the number of sockeye) was used to determine which EOF was significantly correlated to a fish variable. Comparing the regressions using the atmospheric forcing variables with those using the oceanic response variables, we concluded that there was indeed a better correlation with the fish variables when using the model ocean variables.

TOPOGRAPHIC DE-PHASING AND AMPLITUDE MODULATION AND ROSSBY WAVE TRIAD PACKETS

Warren Cree and Gordon E. Swaters

We describe a theory for the topographic de-phasing and amplitude modulation of resonantly interacting Rossby wave triads. The model equations are derived via a formal asymptotic expansion in which the topographic gradients have the same assumed small order of magnitude as the non-linear Jacobian terms in the quasi-geostrophic potential vorticity equation. For piecewise continuous linear topographic configurations the perturbed interaction equations can be solved exactly.

1540-1700 (C-410)

Mardi / Tuesday

SESSION 04C : ÉCOLOGIE DE L'ALIMENTATION DU ZOOPLANKTON
ZOOPLANKTON FEEDING ECOLOGY

DYNAMIC OF THE NUTRITIONAL METABOLISM IN RESPONSE TO THE VARIATION OF QUANTITY AND QUALITY OF FOOD IN CALANUS FINMARCHICUS

Odile Roche-Mayzaud

The nutritional response of organisms to the trophic variations depends on the spatial and temporal scales. During seasonal variations digestive enzymes can be related to the increase of particulate matter, since the marine particle-grazing zooplankton are thought to live in a "nutritionally dilute environment". The nutritional strategy for a shorter period of time is different especially in a coastal environment (Gaspé current, Gulf of St Lawrence) where wind-driven mixing is a factor of local perturbation. The results show independance between quantity (chlorophyll *a* as biomass index) and quality of food as defined by chemical parameters (total proteins, total and soluble carbohydrates, lipids). The particulate protein fraction was predominant in the natural diet as seen in the nutritive value (protein : carbohydrate : lipid). Zooplankton, as heterotroph consumer, must obtain their nitrogenous precursors for protein synthesis from their diet. For the temporal scale (about a week) the nutritional response of the organisms seems more related to the quality than quantity of food.

The nutritional strategy of the biological system is different for a short temporal scale showing the ability of the organisms to respond to a change in quality of the trophic environment without a linear relationship with the food supply.

"SLOPPY FEEDING" OF COPEPODS: POTENTIAL CONTRIBUTION TO THE FLUX OF PARTICULATE MATTER IN THE OCEANS

S. Roy, R.P. Harris and S.A. Poulet

Inefficient or "sloppy" feeding behaviour by copepods results in algal cell fragmentation and ingestion of only a fraction of the debris produced. In the work, 2 copepod species, Calanus helgolandicus and Temora longicornis were fed the large diatom Coscinodiscus wailesii to investigate this process in the laboratory. Chlorophyll-type pigments tracked particulate debris production. The influence of food cell breakage upon dissolved free amino acids was also assessed. Serial filtrations following food and grazer removal after short grazing sessions showed that, for C. helgolandicus and T. longicornis, respectively, 26 and 35% of the pigments contained in the cells removed during feeding were recovered as larger than 0.7 μm particulate debris. The animals, however, contained only 5 to 20% of the chlorophyll ingested, estimated on the basis of cell disappearance. DFAA showed little change, suggesting rapid uptake after cell breakup.

ZOOPLANKTON GRAZING EFFECTS ON CHLOROPIGMENT DIAGENESIS AND FLUX DURING A SPRING PHYTOPLANKTON BLOOM

A. Redden, D. Deibel and R. Thompson

Herbivorous marine zooplankters are important biological mediators in the transformation and vertical flux of organic matter, particularly during periods of high primary production. Though zooplankton grazing can have a considerable impact on the fate of phytoplankton stocks, the nature of the transformation processes and products of algal ingestion are poorly understood.

In order to investigate the fate of ingested phytoplankton and the importance of zooplankton grazing during spring bloom production in cold coastal waters, we used chloropigments as biomarkers to trace algal biomass and pigment diagenesis in grazer gut tracts and fecal material. Phytoplankton production, gut and fecal pigment composition in dominant zooplankton grazers and sediment trap collections were monitored over a 10-week period covering the development and crash of the 1988 spring phytoplankton bloom in coastal Newfoundland waters. The effect of prolonged storm conditions and strong vertical mixing on phytoplankton composition and subsequent utilization by copepod and larvacean grazers was also examined.

Conventional fluorometric and HPLC analyses of chloropigments in size-fractionated seston and the gut tracts of grazers indicated ingestion of small particles, primarily algae < 70 μm by copepod grazers (Calanus finmarchicus, Pseudocalanus minutus and Temora longicornis) and particles < 15 μm by the larvacean, Oikopleura vanhoeffeni. In contrast to larvacean grazers, all copepod species exhibited a diel feeding periodicity and maximum algal ingestion at the peak of the phytoplankton bloom. The various pigment degradation products of larvacean grazing also differed from those formed in copepod gut tracts. The importance of understanding the feeding mechanics and size selection abilities of grazers and the effects of particle manipulation on pigment transformation processes and products will be discussed in relation to the pigment signatures of various grazer types.

**PARTICLE-SIZE SELECTION BY THE PELAGIC TUNICATE OIKOPLEURA VANHOEFFENI:
LABORATORY AND FIELD EVIDENCE FOR A SHUNT OF THE MICROBIAL LOOP**

D. Deibel and A. Redden

The numerous predator-prey interactions between bacteria, flagellates and ciliates represent a sink of matter and energy and thus are known as the "microbial loop". Although it has been suggested that pelagic tunicates retain bacteria efficiently and constitute a shunt of the loop, the hypothesis has not been investigated. Our recent ultrastructural studies of O. vanhoeffeni showed that the pore size of the pharyngeal filter was surprisingly large, causing us to wonder if oikopleurid tunicates really do retain bacteria with high efficiency.

To explore this question we determined the retention efficiency of O. vanhoeffeni by offering animals fluorescent beads of 0.6-, 1-, 3- and 7- μ m diameters. Contrary to expectation, the retention efficiency of 0.6- μ m beads was never 100%, ranging from 30-80% for juveniles and falling sharply to < 5% for adults. Retention of 1- μ m beads was only marginally higher. However, retention of 3- μ m beads clustered around 100% with no decrease for adults. Individual retention efficiency spectra indicated that the size of 50% retention ranged from 0.3-2.0 μ m depending on body size, and the size of 100% retention ranged from 2.2-3.5 μ m. This showed that free-living bacteria should be ingested much less efficiently than nanoflagellates and that the pores of the pharyngeal filter became larger as the animals grew.

These retention efficiencies were applied to laboratory-determined filtration rates and depth-specific densities of O. vanhoeffeni from coastal Newfoundland waters to estimate the grazing pressure of natural populations of non-bacteria. Results indicated that O. vanhoeffeni had little impact on the standing stock of bacteria (< 10% removed per day) but often accounted for more than 100% of daily bacterial production during the spring when subzero temperatures suppressed bacterial metabolism. HPLC studies of gut contents and fecal pellets of O. vanhoeffeni showed high concentrations of chl *b* typical of small phytoflagellates, supporting our laboratory observations of maximal ingestion of 2-4 μ m particles. We conclude that O. vanhoeffeni is not an important grazer of free-living bacteria but competes with protozoan ciliates for nanoflagellate prey. Thus, appendicularians are likely an effective shunt of the microbial loop linking nanoflagellates with much larger Metazoa including larval fish.

0830-0950 (F-210)

Mercredi / Wednesday

SESSION 05A : POLLUTION ATMOSPHERIQUE
ATMOSPHERIC POLLUTION

MODEL RESULTS OF FLUXES AND CONCENTRATIONS OVER A HILL

Jacob Padro

The present manuscript presents an extension to the one by Padro (1987). In Padro (1987, Boundary-Layer Meteorol. 38: 17-28), an analytic solution was obtained for concentration perturbations that arise as a result of incident flow over a hill with a gentle slope. The flow was assumed neutrally stratified and the dimensions of the hill were of the order of hundreds of

metres. The upstream flow was assumed to be in equilibrium with the surface, thus yielding vertical logarithmic profiles for the concentration and velocity perturbations. The advantage of having an analytic solution constrained the model to the use of mixing length theory for the closure of the vertical concentration fluxes. Thus, the choice of surface boundary conditions was also restricted. These restrictions are removed in the model described in the present manuscript, which resorts to numerical and spectral solutions of the governing equations. The closure formulation of the vertical fluxes is more general than the previous local theory.

The input to the concentration model are solutions from the Beljaars et al. (1987) flow model. These are the turbulent energy E , dissipation ϵ and the vertical motion perturbation. Spatial distributions of pollutant concentration and flux perturbations will be shown. For a hill with a cosine-square shape, the cross-section of the concentration perturbation is 180° out of phase with the corresponding cross-section for the velocity perturbation, obtained from Beljaars et al.'s model (1987, Boundary-Layer Meteorol. 38: 273-303).

LA MESURE ET LE SUIVI DES DÉPÔTS DE SUBSTANCES ACIDIFIANTES AU QUÉBEC

Gilles Boulet

Le transport transfrontalier des polluants atmosphériques est une réalité auquel fait face le Québec. Il en résulte que les dépôts atmosphériques de substances acidifiantes y sont ici parmi les plus importants en Amérique du Nord. De plus, les effets néfastes de ces polluants sur les écosystèmes forestier et aquatique sont maintenant bien établis.

Le ministère de l'Environnement du Québec mesure et suit l'évolution spatio-temporelle des dépôts de substances acidifiantes à l'aide de deux réseaux de mesure : le REPQ et le REMPAFAQ. Le réseau d'échantillonnage des précipitations du Québec (REPQ) compte actuellement 42 stations de mesure réparties sur l'ensemble du Québec. Chacune de ces stations est équipée d'instruments météorologiques et d'un collecteur qui recueille la fraction humide des dépôts atmosphériques.

Le réseau de mesure des polluants atmosphériques en milieux forestier et agricole du Québec (REMPAFAQ) est actuellement en phase d'implantation. Cette phase se poursuivra au cours des deux prochaines années. Il en résultera un nouveau réseau de 23 stations servant à mesurer et à suivre la qualité des eaux de précipitations et de l'air au Québec. Chacune de ces stations disposera d'instruments permettant la mesure des éléments météorologiques, des dépôts secs et humides et des concentrations de polluants gazeux et particulaires.

Lors de cet exposé, nous discuterons de ces deux réseaux de mesure. Une description sommaire du plan d'assurance de la qualité existant au sein de ces réseaux suivra. Enfin, des données récentes de déposition humide seront présentées.

OXIDATION IN A RAINBAND: SOURCES AND REACTIONS OF H_2O_2

A.M. Macdonald and H.G. Leighton

The function of clouds in the formation and deposition of acidic species has been the subject of many investigations in recent years. In particular, the aqueous-phase oxidation of SO_2 to sulphuric acid by the primary oxidants

H₂O₂ and O₃ has been of great interest. The relative importance of the two oxidants depends to a great deal on the amount of H₂O₂ available for reaction in clouds.

The role of H₂O₂ in the oxidation of SO₂ in a rainband was investigated by means of a two-dimensional numerical model. A base simulation was carried out in which the aqueous H₂O₂ concentration was derived entirely by dissolution of H₂O₂(g) from the cloud interstitial air. Results show an initial dominance of H₂O₂ as oxidant. However, while the H₂O₂ was being depleted, its contribution to the overall oxidation decreased significantly. An additional source of H₂O₂ to the rainband could be its in-cloud production through the scavenging of the HO₂ radical and subsequent aqueous-phase reaction. The relative importance of this process as a source of H₂O₂(aq) was then examined.

CANADIAN DISASTERS - A HISTORICAL SURVEY

Robert L. Jones

The major Canadian disasters from the 1500s to date are identified by cause and type. This is an update of the original paper, first given at the 1988 CMOS Congress in Hamilton, which described the meteorological factors contributing to the disasters.

General disaster criteria are defined. Twenty or more deaths occurring at one time is the primary criterion. Other principal criteria are events included that have occurred in Canada and offshore within our 200-mile economic zone, and events excluded, such as wars, disease epidemics and battles between natives and European settlers during colonization. These criteria limit the events that are discussed to a manageable number.

The results of an expanded literature search are presented and a brief description of the disasters by type, rather than by weather-related causes, is given. A historical perspective is discussed with a view to illustrating disasters that were common in our early history, and those that have occurred in modern times. Conclusions are drawn as to which types of natural and man-made disasters are likely to occur in Canada in the future.

The "Journal of Natural Hazards" defines hazards in the following areas: Atmospheric, climatological, floods; oceanographic, waves, storm surges; tsunamis; snow, avalanches; landslides, erosion; earthquakes; volcanoes; and man-made/technological. If the above criteria are applied, the survey finds that Canada has experienced all these types of hazards except volcanoes and severe earthquakes.

0830-1010 (F-215)

Mercredi / Wednesday

SESSION 05B : **TURBULENCE ET MÉLANGE**
TURBULENCE AND MIXING

TURBULENT MIXING IN THE NORTHEAST PACIFIC OCEAN IN NOVEMBER, OBSERVED DURING THE OCEAN STORMS PROGRAM

William R. Crawford and Rolf G. Lueck

The Ocean Storms program was undertaken in the autumn of 1987 to determine

the response of the upper ocean to intense storms, and to investigate the role of inertial-period currents in deepening the upper mixed layer. A turbulence profiler was operated from the CSS Parizeau in early November, near 139°W, 48°N, the centre of an array of current meters. The peak wind speed during this period was 17 m s⁻¹; major storms passed to the north of the ship. Shear probes and a thermistor on this instrument produced measurements of the rate of dissipation of turbulent energy and estimates of the rate of downward mixing of heat in the upper thermocline. These data were supplemented with profiles of expendable shear probes. A ship-board Doppler current meter measured currents to 130-m depth.

These estimates of heat flux reveal isolated events of strong mixing, lasting less than an hour in time and a kilometre in space, which transfer heat downward from the upper mixed layer. These events are frequently, but not always, in a region of strong large-scale shear at the base of the mixed layer. The cause of this shear has not been determined.

LITTLE STIRRERS IN THE OCEAN

Brian Sanderson, Akira Okubo and Jeannette Yen

We analyse the flow field around a feeding copepod. From the deformation field we calculate a dissipation rate of 1.17×10^{-9} watts per zooplankton. In some circumstances the energy dissipation and vertical mixing due to zooplankton swarms might be comparable with physical processes.

ON THE INFERENCE OF DIAPYCNAL FLUXES OF HEAT, SALT AND NUTRIENTS FROM OBSERVATIONS OF TURBULENT MICROSTRUCTURE

Barry R. Ruddick and Jim Hamilton

Microstructure observations are usually interpreted in terms of diapycnal diffusivity by assuming that a fraction of the observed viscous dissipation of turbulent kinetic energy goes to raise the centre of mass of the local density gradient, i.e. that the only mixing mechanism in operation is mechanically driven turbulence, with a mixing efficiency near the maximum that has been observed. In regions of the ocean undergoing strong evaporation, the potential energy of the salt left behind can provide an additional source of energy for mixing by salt fingers. A simple model shows that salt fingers are very "efficient" in the sense that, compared to turbulence, several times as much salt can be transported for the same observed energy dissipation. In addition, the diffusivity for nutrients is the same as that for salt, so that regions of strong salt finger mixing can effect significant transport of nutrients into the photic zone. It is argued that several regions of the ocean can be significant regions of carbon fixation, and that the carbon flux from the photic zone in these regions is directly linked to the local excess of evaporation over precipitation. We outline a plan for interpreting microstructure measurements in terms of turbulent and salt finger fluxes of salt, heat and nutrients, and describe plans to test our methodology in the WOCE Tracer Release/Experiment.

DIFFUSION BY GRAVITY WAVES
B.K. Pal and B.G. Sanderson

A perturbation analysis of the 3-D Lagrangian equations of motion is used to examine the diffusion induced by a random field of gravity waves in a viscous and non-viscous irrotational ocean. At second order, the inviscid solutions yield a random field of shearing motion in the horizontal plane. These solutions exhibit horizontal diffusion as a particular case of zero-frequency interaction identical to that in Herterich and Hasselmann (1982) but no vertical diffusion. For the viscous case, we solve the Lagrangian equations of motion for a spectrum of decaying surface waves. At second order, the zero-frequency solutions yield a random field of shearing motion with mixing properties.

BOUNDARY MIXING IN THE OCEAN VIA INTERNAL WAVE BREAKING
Denis Gilbert

When internal waves reflect off sloping bottoms, large amplifications in energy density and vertical shear are expected to occur. Shear instability over vertical scales as large as a few tens of metres is predicted, leading to intense internal wave breaking. Preliminary estimates of the resulting dissipated energy flux are provided, and are found to be important for deep ocean mixing rates and the energy balance of the oceanic internal wave field. Most of the mixing should take place above locally convex rather than locally concave topography.

0830-0950 (C-410)

Mercredi / Wednesday

SESSION 05C : BIOÉNERGÉTIQUE ET DYNAMIQUE DES COMMUNAUTÉS BENTHIQUES I
BIOENERGETICS AND DYNAMICS OF BENTHIC COMMUNITIES I

CHEMICAL AND BIOLOGICAL CHARACTERIZATION OF A MUSSEL CULTURE AREA, MAGDALEN IS., QUEBEC
S. Roy, P. Souchu and P. Mayzaud

Commercial mussel culture has been going on for a few years in the Grande Entrée lagoon, Madgalen Is. (Quebec). A study of the support capacity and of the impact of this industry on the environment of the lagoon has been undertaken (CORPAQ-funded). Within this context, a number of chemical and biological parameters were studied at the mussel culture site and at a reference site. Inorganic nutrients, particulate and dissolved organic matter, particle counts, pigments, primary production and plankton taxonomy will be discussed. Of particular interest is the undetectable level of nitrate and ammonium over the whole summer season (May to September) and the dominant presence of small flagellates and microzooplankton in the lagoon waters.

INTERACTION TROPHIQUE DES MOULES CULTIVÉES - MILIEU PARTICULAIRE EN MILIEU LAGUNAIRE AUX ÎLES-DE-LA-MADELEINE

P. Mayzaud, P. Souchu, S. Roy et O. Roche-Mayzaud

La définition de la capacité de support des lagunes des îles-de-la-Madeleine pour une mytiliculture intensive repose sur une triple connaissance du milieu. Connaissance physique (taux de renouvellement, circulation, etc.), connaissance des interactions trophiques et performance des moules cultivées au plan de leur rendement de croissance. Dans le cadre d'une étude réalisée aux îles pendant une période estivale, la lagune de Grande-Entrée a été caractérisée en termes de régime hydrologique, de variations des sels nutritifs, de production primaire, de dynamique particulière et de budget énergétique des moules en culture. La production primaire est de type régénérée (carence d'azote) et s'exprime surtout dans les fractions de petite tailles. Homogène au plan vertical, la dynamique particulière montre une certaine hétérogénéité horizontale pouvant être associée soit à l'existence d'intrusion d'eaux du Golfe, soit à l'activité des moules. Le budget énergétique de ces dernières [Croissance = Ingestion x Assimilation - (Excrétion + Respiration)] et les teneurs en réserves glycogéniques montrent des valeurs relativement faibles suggérant un milieu limitant. La très faible diversité de la communauté zooplanctonique et sa faible biomasse suggère une compétition trophique en faveur du compartiment moule du système.

VARIATIONS DES RÉSERVES ÉNERGÉTIQUES DE MYA ARENARIA DANS UN CYCLE DE VIVE-EAU, AU BIC, DANS L'ESTUAIRE DU SAINT-LAURENT

Jocelyne Pellerin-Massicotte, Bruno Vincent, Yves Gratton et Marie-Claude Lévesque

Les organismes soumis à des conditions environnementales particulières peuvent développer une série de réponses adaptatives (biochimiques, physiologiques et comportementales) qui les rendent aptes à survivre et à se reproduire. Chez les bivalves en général, et plus précisément, les organismes intertidaux, il existerait un patron rythmique de la nutrition dû à la présence des marées. Ainsi, selon McHenery (1983) le rythme des marées réglerait les rythmes digestifs par des modifications de pH, de la longueur et du contenu en protéines du stylet cristallin ainsi que par des variations d'activité de l'amylase dans la glande digestive. Par contre, le même auteur (1984) rapporte que l'activité de l'amylase dans le stylet suivrait un rythme jour-nuit tandis que Langton (1974) soutient qu'elle suivrait le rythme des marées. Suite à une prise de nourriture, les conditions étant favorables, il devrait donc y avoir une augmentation des niveaux des sucres libres dans la glande digestive, niveaux qui suivraient l'augmentation de l'activité de l'a-amylase. L'objectif de notre recherche est donc d'étudier les patrons nutritionnels et leurs modifications selon les variations des facteurs physiques tels le balancement des marées, les courants, la température et la quantité de chlorophylle disponible. Nos travaux se sont déroulés sur une période de 15 jours dans le parc du Bic, avec des échantillonnages de 10 myes, préalablement transplantées au niveau moyen de l'eau, à tous les balancements de marées. Des enregistrements de données physiques et biologiques telles la courantologie, la force et la direction des vents, la température, la salinité et les niveaux de chlorophylle ont été faits durant cette période. Les pesées et les mesures de longueur ainsi que la dissection des tissus et la congélation de ceux-ci ont été faites sur

le terrain. Les résultats que nous avons à date, démontrent que les concentrations de sucres libres dans le manteau et l'hépatopancréas suivent le même profil rythmique diurne, principalement en période de morte-eau. Ce profil se modifie à l'approche de la période de vive-eau et nous postulons qu'il serait influencé par les variations de température occasionné par les fortes marées. L'activité de l'amylase semble pour sa part, suivre un patron plus régulier selon le rythme des marées. Ces résultats préliminaires démontrent l'importance des facteurs physiques sur le profil nutritionnel de Mya arenaria. Une étude plus approfondie du bilan énergétique nous permettra dans l'avenir de préciser et de caractériser la cinétique d'assimilation des matières nutritives dans la glande digestive.

**SUSPENSION-FEEDER DOMINATED DEEP-SEA HYDROTHERMAL VENT COMMUNITIES:
INDICATION OF NON-SYMBIOTIC ORGANIC MATTER SOURCES**

S. Kim Juniper

Chemosynthesis by invertebrate-bacterial symbioses is now generally accepted as an important, if not dominant, form of organic matter production at deep-sea hydrothermal vents, while potential contributions of non-symbiotic sources to vent food webs remain poorly known. Benthic communities associated with hydrothermal activity in the westernmost Gulf of Aden and at 17°S, East Pacific Rise (EPR) are unusual in that they are dominated by suspension feeding rather than by invertebrate-bacterial symbioses. The apparent absence of sulphide in Gulf of Aden vent fluids and recent volcanic activity at 17°S EPR likely explain the absence or insignificance of invertebrate-bacterial symbioses. Particulate organic matter (POM) produced in vent fluids by free-living chemolithotrophic bacteria is a likely food source for these suspension feeders, although in one case POM import via inflowing bottom currents cannot be ruled out. These two examples draw attention to the possible importance of alternative sources of POM at more classical hydrothermal sites where suspension feeding food webs may be relatively independent of invertebrate-bacterial symbiosis. Other recent discoveries also indicate that significant biological exploitation of hydrothermal activity need not necessarily be based on symbioses.

1020-1200 (F-210)

Mercredi / Wednesday

SESSION 06A : ANALYSE DES DONNÉES AUX ÉCHELLES MÉSO ET SYNOPTIQUE
MESO- AND SYNOPTIC-SCALE DATA ANALYSIS

HORIZONTAL WIND FIELD FROM SINGLE DOPPLER RADAR

I. Zawadzki and S. Laroche

Recently a number of ideas have been tested for the retrieval of the second component of the horizontal wind field from single Doppler measurements. These methods will be discussed and a tentative discussion on the relative merits will be given.

AIRBORNE RADAR OBSERVATIONS IN ERICA

Owen Hertzman

The Experiment on Rapidly Intensifying Cyclones over the Atlantic (ERICA) has produced a unique airborne radar data set. This presentation provides an overview of some of the important aspects of that data set, the planning that was done to obtain it, and some of the plans for it.

ERICA's field phase was from December 1, 1988 to February 28, 1989. The radar aircraft, the NOAA WP-3Ds from OAO, were both equipped with horizontally scanning incoherent lower fuselage radars and vertically scanning Doppler tail radars. The new programmable colour display systems were available on both aircraft. These systems provided excellent real-time reconnaissance capability to the on-board radar scientists and significantly improved the quality of the other data sets that were gathered on the aircraft.

The Doppler data for Intensive Operation Period 4 (January 3-5, 1989) include at least one pattern where the radars from the two planes performed a simultaneous dual-Doppler pattern near the centre of a rapidly intensifying cyclone as well as several pseudo-dual-Doppler patterns. Though no dual-Doppler data have been processed, both the horizontal and vertical reflectivities and single-Doppler data from the individual legs show some rather classic pictures of cyclone development and structure on the mesoscale.

The data from several of the IOPs reveal a rather chaotic picture of the precipitation near the centres of these developing storms, with strange mixtures of stratiform and convective echoes apparent in unusual places. Weak echo regions were noted near the centres of some of the storms, though these regions were quite turbulent. In the strongest storms, the precipitation intensity was strong enough to force sweeping changes in the sampling strategies that had been planned for the aircraft before the field phase of the project. A combination of the sampling strategies developed on GALE, CASP and hurricane flights was found to work well in most cases.

LIMEX-85: THE PROCESSING OF DATA SETS FROM AN ALBERTA MESOSCALE UPPER-AIR EXPERIMENT

G.S. Strong

Until recently, efforts to improve our understanding of mesoscale processes have been restricted by the lack of special mesoscale data sets to provide basic upper-air thermodynamic and wind data for research. One of the first true mesoscale upper-air experiments in Canada was the little-known Limestone Mountain Experiment (LIMEX-85), conducted by the Alberta Research Council Hail Project (AHP) over the foothills and mountains of southwestern Alberta during July 1985. LIMEX experiments were focussed on mesoscale convective processes, orographic effects, and interactions with synoptic processes, with particular emphasis on forecasting applications.

Archived data from LIMEX-85 include 2-h soundings from 9 upper-air sites in a 50-km grid, continuous SODAR profiles, research aircraft soundings at 20-km intervals, radar data, surface data from 8 automated systems, full hourly surface observations from all sounding sites, and an extensive cloud photography component. All synoptic surface and upper-air data for north-western North America were also processed and are included in the LIMEX archive. In addition, the archive contains upper-air data from several precursor experiments, such as LIMEX-80 and the Capping Inversion Study (CIS-82).

In spite of the demise of AHP during 1986-87, most of the LIMEX-85 data were processed and archived as designed. Plans are under way to complete the processing and to continue scientific analysis. This paper will briefly describe the scientific goals and technical logistics of the LIMEX experiments of 1980-85, and provide information on the availability of data. Some interesting results from recent LIMEX analyses will also be presented.

CALCUL DU MOUVEMENT VERTICAL AVEC DES DONNÉES EN SURFACE : NOUVEAU DÉVELOPPEMENT

J. Montpetit et P. Zwack

Le calcul du mouvement vertical à la mésoéchelle est d'une importance primordiale pour la prévision météorologique à court terme. Il influence les précipitations et modifie la stabilité dans la basse troposphère. Zwack et Kabil (1988, Mon. Weather Rev.) propose une méthode qui permet le calcul d'oméga jusqu'à 600 mb grâce aux données de surface (pression et tendance de pression). Le mouvement vertical au sommet de la couche limite est calculé par soulèvement orographique et pompage d'Ekman. Oméga en atmosphère libre est évalué en intégrant la divergence du sommet de la couche limite jusqu'à 600 mb. La divergence quasigéostrophique (QG) au sol est calculée et linéairement interpolé à tous les niveaux jusqu'à 600 mb où elle est supposée nulle. Chénard (mémoire, UQAM, 1987) montre une façon d'améliorer la méthode en exploitant les champs en surface de température et de tendance de température. Elle consiste essentiellement à calculer (au lieu d'interpoler) la divergence QG au sommet de la couche limite en supposant que cette dernière est suffisamment brassée. Cette hypothèse permet d'inclure les effets de la température et de ses variations temporelles (réchauffement et/ou refroidissement) dans la couche limite. Par la suite on interpole la divergence à tous les niveaux en atmosphère libre pour le calcul d'oméga. Les résultats seront comparés avec ceux de la méthode précédente et la méthode cinématique et des mesures radar en complèteront l'analyse.

PRECURSOR METEOROLOGICAL CONDITIONS ASSOCIATED WITH EXPLOSIVE CYCLOGENESIS OVER THE KUROSHIO CURRENT

John R. Gyakum and Timothy Bullock

One of the most difficult forecasting problems involves determining whether explosive surface cyclogenesis will in fact occur. This problem is attacked through the examination of large-scale dynamical forcing mechanisms associated with all cold-season cyclogenesis activity over the Kuroshio current for 8 years. We find a coherent pattern of planetary-scale waves prior to and during the explosive cyclogenesis. We also find important synoptic-scale conditioning processes occurring both upstream and downstream of the incipient explosive cyclogenesis event.

This research effort involves the use of two distinct data sets. The first is a Pacific basin surface cyclone climatology for the 8 years of 6-month cold season periods beginning 1 October 1975. The domain covered is 20-70°N from 120°E eastward to 120°W. We have recently compiled this cyclone climatology from the National Meteorological Center (NMC) 6-hourly final hemispheric surface analyses. The second data set is the National Meteorological Center's gridded analysis at the standard levels. We derive this information from the compact disk, currently made available to the research community from the University of Washington.

An examination of approximately 44 cases of both incipient explosive (defined as a central pressure fall of at least 24 mb/24 h) and non-explosive cyclogenesis events in a 5° latitude-longitude square over the Kuroshio current reveals the presence of an upstream 500-mb trough for both incipient explosive and non-explosive cases. Perhaps more important is the presence of a deep occluded cyclone over the Aleutians downstream of the incipient cyclone. The 850-500 mb static stability is substantially weaker over the downstream track of the explosive cyclone than it is over the future path of the weaker surface cyclone. Additionally, the downstream 850-mb geostrophic frontogenesis and quasi-geostrophic Q-vector forcing for ascent is substantially stronger for the future explosive cyclone than it is for the weaker surface cyclone. The implication of these results is that the enhanced surface vorticity generation associated with the explosive cyclogenesis is strongly associated with enhanced lower tropospheric frontogenesis and the required enhanced vertical circulations. Furthermore, the weaker middle tropospheric static stability will allow these vertical circulations to become deeper and stronger.

1020-1200 (F-215)

Mercredi / Wednesday

SESSION 06B : ONDES Océaniques
OCEANIC WAVES

WIND ESTIMATES FROM WAVE SLOPES

R.F. Marsden and B.-A. Juszko

Wave slopes, from a pitch and roll buoy, and wind velocity components, from a platform-mounted anemometer, were sampled simultaneously during a 1984 study on the Grand Banks of Newfoundland. The principal direction of wave slope was highly correlated with the 10-m wind direction. Residual errors in direction were large only for wind speeds less than 5.0 m s^{-1} . When these estimates were removed from the record, there was an 8.0° RMS error in the estimated wind direction. The up-wind slope variance correlated at 0.90 with the 10-m wind speed. A quadratic regression of wind speed to up-wind slope variance resulted in an RMS error of 1.9 m s^{-1} . A rotary spectral analysis showed an extremely high coherence between the slope-estimated wind components and the directly measured surface wind components for periods greater than 18.0 h. It is suggested that the technique could be applied to surface-following pitch and roll buoys to estimate surface wind speeds.

THE WOTAN WINDS FROM CASP

F.W. Dobson

Robust techniques have been applied to produce an objective automatic technique for extracting scalar winds from a WOTAN (Wind Observation Through Ambient Noise) instrument. After allowing for all sources of possible error, it appears possible to estimate the scalar wind to within $\pm 5\%$, given the depth, representative ocean temperature and sound velocity profiles, and some information on bottom type.

Time series for the CASP (Canadian Atlantic Storms Program) marine

winds are compared with series from shoreline anemometers, in conditions where they should agree. There is a clear indication that shoreline anemometers are in general inadequate for the precise estimation of marine winds.

THE JOINT DISTRIBUTION OF WAVE HEIGHTS AND PERIODS FOR SHOALING WAVES

J.C. Doering and M.A. Donelan

The wave induced forces exerted on a coastal structure and its response to the incident wave field clearly depend on the range of wave heights and periods, i.e., the joint distribution of wave heights and periods. Yet the study of the joint distribution of wave heights and periods has been almost entirely confined to deep water waves. Cavanie et al. (1976) and Longuet-Higgins (1983) have proposed theories for the joint probability density function (jpdf) of wave heights and periods for a narrow-banded Gaussian sea. These jpdfs are expressed in closed analytical form. Lindgren (1972) has developed a statistical theory that has been used to model the amplitude and period of Gaussian waves (Lindgren and Holmstrom, 1978). A recent comparison of these three theories by Srokosz and Challenor (1987) indicates that Lindgren's approach is widely applicable, whereas those of Cavanie et al. and Longuet-Higgins are not well suited to broad-banded data. However, Lindgren's method is complex and computationally intensive.

Thornton and Schaeffer (1978) examined the jpdf of wave heights and periods for breaking waves in the nearshore zone. They found that heights and periods were well correlated; in particular, they observed that larger waves were associated with longer periods. No theory for the jpdf of heights and periods for shoaling and breaking waves has been proposed. Moreover, there is a distinct paucity of observations regarding this phenomenon.

Using data collected during the WAVES '87 experiment, which was conducted in the western end of Lake Ontario, we examine the joint distribution of wave heights and periods for shoaling and breaking waves over a range of wave conditions. We discuss the major differences between the joint distributions for shallow and deep water waves, with a view towards establishing the requirements of a model of the joint distribution for shoaling waves.

INTERACTION OF INTERNAL WAVES WITH THE SEABED ON CONTINENTAL SHELVES

B. Boczar-Karakiewicz, J.L. Bona and B. Pelchat

Internal gravity waves are frequently observed in stratified waters on the continental shelf as highly coherent groups having well defined wavelengths and propagating shoreward with crests oriented generally along isobaths. The average wavelength of these waves is of the order of 400 m (with a range of 200-1600 m), which is longer than the fluid depth above the shelf. These waves are associated with the disintegration of internal tides when they encounter the continental shelf propagating from the deep ocean. Observations indicate that currents induced by these waves have a strong impact on the seabed composed of loose sediment.

The purpose of the work presented is to analyse the potential of internal waves in transporting sediment and in forming large-scale sand ridges that are observed in many regions of continental shelves.

MASS FLUX OF HEXACHLOROBENZENE ACROSS THE AIR-WATER INTERFACE IN THE PRESENCE OF WIND WAVES

N. Merzi, M.A. Donelan, M. Servos and W.M. Strachan

The rate of exchange of pollutants across the air-water interface is an important consideration in tracking their fate in the natural environment. In these preliminary experiments in the new Gas Transfer facility at the Canada Centre for Inland Waters, we examine the air-water transfer properties of hexachlorobenzene - an organochlorine fungicide.

The flux of hexachlorobenzene across the air-water interface is determined mainly by the resistance to transfer in the thin viscous sublayer in the water. It is believed that various turbulence-creating mechanisms, such as wind stress applied at the surface and wave breaking at different scales, play an important role in the transfer. The experiments were carried out in a 31-m long, 0.75-m wide, 0.85-m high air-tight flume; the water depth was 0.25 m. Hexachlorobenzene concentration in air, wind speed, wave height and wave slope were measured at three different fetches. Free-stream wind speed was varied between 2 and 18 m s⁻¹. The mass transfer velocity of hexachlorobenzene was calculated on the basis of hourly concentration measurements. It was observed to increase dramatically when gravity waves start to break. The mass transfer velocity is parametrized in terms of wind and wave properties.

1020-1140 (C-410)

Mercredi / Wednesday

SESSION 06C : BIOÉNERGÉTIQUE ET DYNAMIQUE DES COMMUNAUTÉS BENTHIQUES II
BIOENERGETICS AND DYNAMICS OF BENTHIC COMMUNITIES II

DISTRIBUTIONS ET VARIATIONS INTRA-POPULATIONS DE DEUX POLYCHÈTES INTERTIDIAUX DE L'ESTUAIRE MARITIME DU ST-LAURENT

G. Miron et G. Desrosiers

Un échantillonnage intensif de la distribution spatiale de Nereis virens (Sars) et de Nephtys caeca (Fabricius) a été réalisé au printemps et à l'automne 1986 à l'intérieur de la zone intertidale de l'anse à l'Orignal, Parc National du Bic (Québec). Les analyses de variance et de covariance indiquent, principalement pour N. virens, qu'il existe une corrélation entre la distribution spatiale de certains paramètres démographiques (densité, poids et maturité sexuelle) et plusieurs facteurs environnementaux (niveau altimétrique, caractéristiques sédimentaires et profondeur de la couche colonisable). Les densités de N. virens augmentent de la côte vers le large, tandis que celles de N. caeca décroissent dans la même direction. Le poids de chacune de ces espèces augmente des niveaux supérieurs aux niveaux inférieurs du profil de plage. D'autres relations existent avec les caractéristiques sédimentaires. Chez N. virens, les individus sexuellement matures ne sont retrouvés que dans la base de plage. Aucune variations significatives ne furent notées entre les deux périodes. La distribution spatiale de N. virens reflète son habilité à vivre dans des environnements devenant physiquement instables du large vers la côte. Cette distribution appuie un modèle où le recrutement larvaire est réalisé dans les niveaux supérieurs suivi d'une migration vers les niveaux inférieurs du profil de plage.

RECRUTEMENT LARVAIRE DU POLYCHÈTE NEREIS VIRENS (SARS) DANS TROIS TYPES DE SÉDIMENTS DIFFÉRENTS DANS LE HAUT DE PLAGE DE L'ANSE À L'ORIGNAL, PARC DU BIC, QUÉBEC

Marc Olivier, Gaston Desrosiers et Bruno Vincent

La collecte hebdomadaire d'échantillons dans la partie supérieure du haut de plage de l'Anse à l'Orignal, nous a permis de suivre les variations des densités, la croissance et la mortalité des jeunes recrues de l'annélide polychète Nereis virens dans trois types de sédiments différents. Cette partie de la zone intertidale est formée d'une zone homogène composée de sables fins et d'une zone hétérogène formée par des sables vaseux graveleux, avec une proportion variable de ces deux dernières fractions.

Il semble que la partie supérieure de cette zone soit plus propice au développement des jeunes recrues de l'espèce Nereis virens. La ponte, qui a débuté le 14 mai 1986, s'est étalée sur 10 jours. L'étalement de la ponte chez cette espèce peut expliquer l'arrivée par pulsations des larves dans les trois environnements sédimentaires que nous avons étudié. Au niveau des densités, les variations observées dans les quatre premiers stades larvaires s'estompent par la suite et nous avons alors l'apparition régulière de nouveaux segments. Nous avons pu suivre l'accroissement du nombre de segments en milieu naturel, du stade nectochète (3 segments) jusqu'au stade d'apparition du 40ième segment vers la fin du mois d'octobre. Nous croyons que la dissémination se fait au hasard sur la partie supérieure de la zone intertidale, les jeunes recrues de Nereis virens ne semblant pas privilégier un type de sédiment plutôt qu'un autre. Le fait que ces trois faciès sédimentaires soient relativement riches en matière organique peut assurer une nourriture abondante et nécessaire à la croissance des jeunes recrues. Les courbes de croissance indiquent que la croissance est segmentaire, les taux de croissance calculés selon l'équation proposée par Dales (1950) pour les trois types de sédiments que nous avons étudiés sont sensiblement les mêmes pour les sables fins ($G = 0,036$) et les sables vaseux graveleux ($G = 0,032$ et $0,031$). Les courbes de mortalité de type concave (Type IV) montrent que la mortalité affecte les stades jeunes et que l'espérance de vie augmente avec l'âge; ce type de courbe est très répandu dans la nature en particulier chez les espèces à forte fécondité comme le polychète Nereis virens.

VARIABILITÉ SPATIO-TEMPORELLE DE QUELQUES PARAMÈTRES DÉMOGRAPHIQUES DE LA REPRODUCTION ET DE LA CROISSANCE CHEZ UNE POPULATION INTERTIDALE DU BIVALVE MACOMA BALTHICA (L.) : ACTION DES FACTEURS ENVIRONNEMENTAUX

M. Harvey et B. Vincent

En 1985 et 1986, nous avons suivi la variabilité spatiale et temporelle de quelques paramètres démographiques de la reproduction et de la croissance chez deux groupes d'individus d'une même population qui colonise des niveaux intertidaux différents. Pendant toute la durée de cette étude, nous avons enregistré la température de surface des sédiments à chacun des niveaux. Il y a des variations spatiales et temporelles significatives des principaux paramètres démographiques de la croissance et de la reproduction dans la population étudiée. On observe une forte variabilité spatiale de la fécondité et de la croissance en chair et en coquille entre les individus qui colonisent le haut (3 m au-dessus des basses mers de vives eaux) et le bas (1,5 m au-dessus des basses mers de vives eaux) de la zone intertidale

et le sens de ces variations change au cours de la saison. Au printemps, les températures plus élevées au niveau supérieur favorise un début de croissance plus hâtif et un taux de croissance plus rapide chez les individus du niveau supérieur. Par contre à l'été, les facteurs environnementaux liés au pourcentage d'immersion dont la température, semblent défavorables aux individus du niveau supérieur et favorables à ceux du niveau inférieur. Contrairement aux individus du niveau inférieur, ceux du niveau supérieur subissent un fort ralentissement de la croissance de la coquille en juillet, un arrêt de la croissance en chair à la mi-juillet suivi d'une perte de poids pendant l'automne et une forte diminution de la fécondité chez les individus plus âgés. Les variations temporelles des poids de produits sexuels qui sont beaucoup plus importantes que celles des poids de chair et de coquille, indiquent qu'aux deux niveaux intertidaux, les individus utilisent une stratégie reproductive opportuniste en allouant les surplus annuels d'énergie dans la reproduction plutôt que dans la croissance. Là aussi les variations de température coïncident avec celles des paramètres démographiques étudiés bien que la variabilité temporelle observée découle probablement de l'interaction d'un ensemble de facteurs d'ordre biotiques et abiotiques. Des expériences de transferts réciproques entre les deux niveaux montrent que les différences de croissance de la coquille et de la chair sont, au moins en partie, fixés génétiquement.

LA STRUCTURE DE LA COMMUNAUTÉ ÉPIBENTHIQUE DE L'ESTUAIRE ET DU GOLFE DU SAINT-LAURENT ET SA RELATION AVEC LES APPORTS D'EAU DOUCE

P.-L. Ardisson et E. Bourget

L'étude des variations naturelles ou anthropiques des régimes d'écoulement des eaux douces dans l'estuaire et le golfe du Saint-Laurent revêt un grand intérêt pour la compréhension des mécanismes qui contrôlent la productivité biologique dans ce milieu. Dans cette perspective, l'étude de la communauté épibenthique, en raison de son caractère sédentaire, de la durée du cycle de vie et du mode de nutrition des espèces dominantes, constitue un moyen privilégié pour mettre en évidence l'influence de ce facteur. La structure de la communauté épibenthique de l'estuaire et du golfe a été étudiée durant 10 ans, de 1975 à 1984. Un échantillonnage quantitatif a été effectué sur 161 collecteurs (bouées de navigation) mouillés pendant 7 mois, de mai à novembre de chaque année. La biomasse maximale des espèces sessiles constituant l'assemblage dominant commun à toutes les régions étudiées, a été utilisée pour caractériser la variabilité spatio-temporelle de la communauté. Des résultats préliminaires des analyses multidimensionnelles de groupement et d'ordination avec et sans contrainte de continuité ont permis de dégager, sur le plan spatial, six zones biogéographiques majeures dont les limites varient sensiblement d'une année à l'autre. Par ailleurs, la variation de la biomasse des espèces dominantes est autocorrélée spatialement et le type de structure spatiale observée varie selon l'espèce et l'échelle d'observation considérée. Sur le plan temporel, le test multidimensionnel de Mantel a mis en évidence l'existence d'un cycle de variations de huit ans dans la structure de la communauté, dont l'amplitude augmente lorsque l'échelle spatiale considérée diminue. La structure de l'assemblage épibenthique est mise en relation avec les apports d'eau douce dans les différentes parties du système Estuaire-Golfe.

1400-1505 (Auditorium, IML)
SESSION 07 : PLÉNIÈRE III
PLENARY III

Mercredi / Wednesday

THE CO₂ EFFECT
Michael E. Schlesinger

Abstract not available.

1545-1645 (Auditorium, IML)
SESSION 08 : PLÉNIÈRE IV
PLENARY IV

Mercredi / Wednesday

SRA-LEVEL IMPACTING MAN IMPACTING SEA-LEVEL
David A. Greenberg

How far up the shore must you be and how long can you stand there and be sure your feet will not get wet? To answer this, it is necessary to look at many processes that cover a diverse range of time and space scales that affect different areas at widely varying magnitudes. The coefficients in the very complex probability distribution are changing in time, partially owing to man's activity. In this presentation we look at the magnitude and time and space scales of different processes that can change sea-level and how some of these might change, given a "helping hand" from civilization.

0830-0950 (F-210)
SESSION 09A : MÉTHODES NUMÉRIQUES ET MODÉLISATION DE LA GRANDE ÉCHELLE I
NUMERICAL METHODS AND LARGE-SCALE MODELING I

Jeudi / Thursday

TESTS OF SIMPLE DEEP CONVECTION PARAMETRIZATION SCHEMES
Claude Girard

One-dimensional tests are made of simple mass-flux type parametrizations for deep moist convection using GATE (phase III) data and the semi-prognostic approach. Using a Kuo-type scheme as a basis for comparison, various closure assumptions are tested and compared. It is found that precipitation forecasts are relatively successful for many of the schemes using this approach and this data set. But the schemes may differ appreciably in the inferred vertical distribution of heating and drying. One of the main difficulties in trying to validate convection schemes seems to be that deep moist convection does not only interact with the large-scale mean environment, since the boundary layer can play an important role.

THE EFFECT OF OROGRAPHIC WAVE DRAG ON LARGE-SCALE EDDY HEAT AND MOMENTUM TRANSPORTS IN THE LOWER ATMOSPHERE

N.A. McFarlane

Parametrizations of orographic gravity wave drag are now widely used in global atmospheric models and atmospheric general circulation models (AGCM). These parametrizations have contributed to the reduction of systematic errors in numerical forecasts and global climate simulations (McFarlane, 1987; McFarlane et al., 1987).

The effect of wave-drag parametrizations on the modelling of planetary wave structure and the resulting indirect effects on resolved eddy heat and momentum transports have not been systematically investigated hitherto. This paper will focus on the effects of orographic wave drag on these quantities on seasonal time-scales. Climate simulations of several annual cycles duration have been carried out with the Canadian Climate Centre AGCM, both with and without an orographic wave-drag parametrization. Selected results from these simulations will be presented to document the effects of orographic wave drag on simulations of heat and momentum transport by resolved eddies. Sensitivity to details of the wave-drag formulation will be discussed.

A NEW CANADIAN LAND SURFACE SCHEME FOR GCMs

D. Versegny

This paper describes Phase I of the development of "CLASS" - "Canadian Land Surface Scheme" - for use with GCMs, and the testing of the model within the framework of the CCC GCM. The land surface model currently used in the CCC GCM incorporates the force-restore method for the calculation of ground temperatures, a bucket model for ground hydrology, and an implicitly modelled snowpack. CLASS features two soil thermal layers, determination of the surface temperature by solution of the energy balance equation, a three-layer model of soil moisture with physically based algorithms for infiltration and groundwater movement, and an explicitly modelled snowpack. (A canopy model is to be added in Phase II of the project.) The predictions of ground climate and surface-atmosphere fluxes produced by the old land surface scheme and CLASS are compared and contrasted, both in stand-alone mode and coupled with the GCM.

SUR L'INITIALISATION VARIATIONNELLE PAR MODES NORMAUX IMPLICITES

Luc Fillion

La méthode d'initialisation par modes normaux adjointe à la procédure d'analyse objective dans un cadre opérationnel d'assimilation de données occasionne parfois des corrections dépassant l'erreur attendue sur les variables à ajuster. Depuis la dernière décennie, on a tenté vainement de bâtir un schéma variationnel d'initialisation par modes normaux qui puisse satisfaire les trois critères suivants :

1. Maintenir une balance dynamique dans les données initiales.
2. Tenir compte de la variabilité tri-dimensionnelle sur la précision des champs issus d'une analyse objective.
3. Simplicité et efficacité de l'algorithme.

On présentera la mise en oeuvre d'une version variationnelle basée sur une formulation récente d'initialisation par modes normaux dite "implicite". Cette dernière étant équivalente à l'initialisation par modes normaux classiques offre cependant l'avantage d'opérer complètement dans l'espace physique. Des résultats d'expériences seront présentés pour le cas d'un modèle barotrope quasi-hémisphérique (avec éléments-finis) et global (spectral). Un aperçu de l'utilisation de la méthode pour un modèle à plusieurs niveaux sera présenté brièvement.

0830-0950 (F-215)

Jeudi / Thursday

SESSION 09B : Océanographie Côtière
COASTAL OCEANOGRAPHY

UPWELLING AND FRONTOGENESIS NEAR A COASTAL PROMONTORY

Robert E. Wilson

Observations and numerical simulations are presented that indicate that wind-induced upwelling near a coastal promontory can lead to the formation of a front oriented offshore. Associated with this front is an along-front geostrophic flow. The process depends on orographic steering of surface winds. Possible relevance to regional processes in the Gulf of St Lawrence is discussed.

A TIDAL + RESIDUAL MODEL FOR THE SOUTHWEST COAST OF VANCOUVER ISLAND

M.G.G. Foreman, R.A. Walters and A.M. Baptista

The tides and residuals calculated with a finite-element model of the southwest coast of Vancouver Island are compared with observations and the discrepancies are discussed. Using the currents predicted by the model, drogues are inserted in key areas and tracked using Lagrangian techniques.

PREDICTION OF OCEAN SURFACE PROPERTIES IN JUAN DE FUCA STRAIT

P.H. LeBlond, D. Griffin, B. Fellenius and R.E. Thomson

A method of predicting surface salinity and non-tidal current fluctuations in Juan de Fuca Strait is described. The method uses information on tides, winds and freshwater runoff from the Fraser River. Its success will be assessed by comparing predictions with observations for the test period of May-September 1988.

A SIMPLE EVOLUTIONARY MODEL FOR WATER AND SALT IN THE BLACK SEA

Bernard P. Boudreau and Paul H. LeBlond

This paper presents a time-dependant variable-size box model for the total fluid and salinity balances of the Black Sea. In addition to the advective flows due to riverine and Mediterranean inputs of water, the model accounts for entrainment flows that are parametrized using the theory of Ellison and

Turner (1959), and employs a modified version of the Gargett (1984) formulation for eddy diffusivity in describing cross-pycnocline mixing flows. The variable volume of the boxes permits explicit simulation of the replacement of the pre-existing late-Pleistocene lake water by the inflow of denser Mediterranean water.

Our results indicate that the time needed to displace the old deep water with new saltier water is 2000 years or less. Because of the effects of mixing, the salinity of both the surface and deep waters requires a greater time interval to obtain present-day values, i.e. ~4000 years if the inflow of Mediterranean water is constant in time at its present value and ~6000 years if this input changes with time in approximation to the rate of sea-level rise. The occurrence of the marine coccolithophorid E. huxleyi in the Holocene sapropel layer requires a minimum surface salinity of 11‰, which takes some 1600 to 3100 years to develop. This range is a result of the uncertainty in the history of the Mediterranean water input.

The model is also employed to investigate the freshening of the Black Sea after cut-off of Mediterranean input. The salinity of both surface and deep waters is found to fall below 11‰ in less than 3000 years. The salinity thus halves in ~2500 years and the freshening process is complete in ~9000 years.

0830-0950 (C-410)

Jeudi / Thursday

SESSION 09C : POLLUTION CHIMIQUE
CHEMICAL POLLUTION

PULP MILL POLLUTION IN A BRITISH COLUMBIA FJORD

Dario Stucchi

Oceanographic and water quality data from Neroutsos Inlet, B.C., collected by the Institute of Ocean Sciences (Can. Dep. of Fisheries and Oceans) and staff of Port Alice Pulp Mill, are used to describe the mill's impact on the dissolved oxygen levels in the fjord, and also to examine the dominant terms in the oxygen budget. The most severe depressions of dissolved oxygen caused by the high BOD effluent occur from the mill site to the head of the fjord. In this region oxygen levels are on average below 4 ppm at the two innermost stations. At the outermost station oxygen levels are depressed by 0.2 ppm below average background levels. The general circulation consists of an outflowing surface layer (0 to 5 m) with inflow below. This circulation pattern is driven by the local winds, which are predominately down inlet, but the sense of the circulation is also consistent with classical estuarine flow. An examination of the sources and sinks for oxygen in this fjord has revealed that the advective flux of oxygen is the dominant source term, but none of the sources and sinks could be accurately quantified. A simple box model of the fjord incorporating the principal source and sinks of oxygen was used to explore the effects of flushing times and BOD reaction constants on the oxygen deficit in the fjord.

CHEMICAL CONTAMINATION IN SEDIMENTS FROM HALIFAX HARBOUR

Dale E. Buckley

At the present time more than 50 outfalls discharge a total of $66 \times 10^6 \text{ m}^3$ of untreated sewage directly into Halifax Inlet each year. The environmental quality of this marine coastal system has been assessed from chemical analyses of 259 surficial sediment samples for metals and carbon content. Average and extreme high concentrations of some total metals and organic carbon are as follows: Cu 131 ppm, 1900 ppm; Hg 1.00 ppm, 10.5 ppm; Pb 166 ppm, 1400 ppm; Zn 146 ppm, 724 ppm; organic carbon 2.2%, 12.5%. The chemical dispersion impacts of some of the major outfall areas can be clearly identified in geochemical maps of the sea-floor sediments. Several of the transition and heavy metals have strong associations with the percentage of organic carbon in the sediments. At the present time there is minimal penetration of oxygen into the bottom sediments, especially in those areas receiving high loads of organic input or where estuarine flushing is restricted. These bottom sediments are therefore highly reduced, and thus pose a potential environmental hazard by long-term release of toxic metals into the overlying water column, especially if these sediments subsequently become exposed to oxidizing conditions.

NATURAL AND POLLUTANT HYDROCARBONS IN THE SEDIMENTS OF THE ST LAWRENCE ESTUARY

J.N. Gearing and R. Lambert

Hydrocarbons, being hydrophobic and stable, are preserved in sediments where they provide a record over time of past environments. The absolute amounts and the relative abundances of different individual hydrocarbons are indicators of phytoplanktonic production, bacterial activity, terrigenous organic matter, petroleum, sewage, and combustion by different sources (forest fires, factories, wood stoves, diesel engines, etc.).

Six box cores were taken in the St Lawrence Estuary, including the Upper Estuary, Saguenay Fjord, and Lower Estuary. The cores were sampled with depth, and particular emphasis was placed on the unconsolidated flocculant surface layer. Total hydrocarbons were extracted, purified, and analysed by high-resolution gas chromatography and GC-MS.

The three regions are compared over time in regard to levels of low and high molecular weight n-alkanes, phytadienes, isoprenoid hydrocarbons (including the C20, C25 and C30 alkenes), and substituted and unsubstituted aromatic hydrocarbons.

LANDFILL SITES ALONG THE ST LAWRENCE, A POSSIBLE SOLUTION FOR CONTAINMENT OF SPILLED OIL OR DREDGED SEDIMENTS

Michel Khalil

Landfill sites along the St Lawrence are used mainly for municipal wastes disposal. These sites are chosen in accordance with many factors, the most important being the permeability tests, the containment of the buried materials in the site and the danger of contaminating underground waters.

In December 1985, the barge "Pointe-Levy" went aground at Matane (Quebec). This barge was charged with 34 thousands barrels of bunker oil #6. In this accident about 200 t of bunker oil were released on the shore.

It agglutinated with sand, ice and snow. This mixture was recovered using heavy equipment such as pay loaders, cranes and trucks. The Matane landfill site was chosen as a temporary place to contain the oil spill. It was assumed that the following period of thaw would enhance a natural separation of water from the oil. The monitoring we carried out on the landfill for nearly two years and the corrections we made will be discussed. We arrived at the conclusion that the Matane landfill could be considered a permanent solution for containment of an oil spill.

According to the geological and hydrogeological conditions pertaining to this site, this experience could be extended to the use of landfill sites for dredged materials rather than to the use of open waters to disperse them.

1020-1200 (F-210)

Jeudi / Thursday

SESSION 10A : MÉTHODES NUMÉRIQUES ET MODÉLISATION DE LA GRANDE ÉCHELLE II
NUMERICAL METHODS AND LARGE-SCALE MODELING II

ÉTUDE DE SENSIBILITÉ À LA RÉOLUTION SPATIALE ET TEMPORELLE

G. Bergeron, A. Robert et J. Côté

Les schémas semi-lagrangiens semi-implicites ont permis d'éliminer la contrainte de stabilité liant le pas de temps à la longueur de maille dicté par le critère CFL. Si la stabilité n'est plus vraiment une contrainte pour l'efficacité du schéma, la précision elle, définit une nouvelle limite pour le pas de temps en fonction de la résolution spatiale. Le pas de temps optimisant l'efficacité du schéma doit être tel que l'erreur de troncature temporelle soit comparable à son homologue spatiale. Nous nous proposons d'évaluer quel doit être le pas de temps qui respecte ce critère de précision lorsque nous utilisons une résolution spatiale suffisamment précise.

Une étude de sensibilité à la résolution spatiale pour le schéma eulérien semi-implicite nous a permis d'observer une décroissance de l'écart quadratique moyen (EQM) qui se comporte comme une loi de puissance en fonction de la troncature spectrale utilisée. Avec une troncature T63 pour les données initiales et T126 pour le schéma d'intégration, un EQM pour les hauteurs du géopotential à 500 mb d'environ 10 % de l'erreur totale sur la prévision de 120 h est observé.

Du côté de la sensibilité à la résolution temporelle, le schéma semi-lagrangien interpolatif possède un EQM qui croît de façon linéaire en fonction du pas de temps utilisé, du moins sur l'intervalle de pas de temps considéré. L'utilisation d'un pas de temps de 1 heure avec une résolution spatiale suffisamment précise génère après 120 h d'intégration une erreur de troncature temporelle comparable à son homologue spatiale. Pour ce qui est du schéma semi-lagrangien non-interpolatif, nous avons remarqué qu'il semble plus bruyant que le schéma interpolatif. Un pas de temps d'environ 35 min est nécessaire pour que ce schéma ait des erreurs de troncature spatiale et temporelle comparables après 120 h d'intégration.

PROPRIÉTÉS DE SCHÉMAS NUMÉRIQUES DE TRANSPORT DE SUBSTANCES
Luc Ostiguy et René Laprise

Les caractéristiques de plusieurs schémas numériques de transport de substances sont analysées quant à leur performance en termes d'erreur de phase, de la conservation de la masse et de la variance. La plupart des schémas numériques produisent des extrémums fictifs qui peuvent avoir un impact négatif sur la modélisation du transport de substances telles que la vapeur d'eau dans l'atmosphère. Dans cette étude on évalue les mérites respectifs de différentes méthodes qui ont été récemment proposées pour contourner ces problèmes.

A PIECEWISE-CONSTANT FINITE-ELEMENT VERTICAL DISCRETIZATION METHOD FOR A GCM IN HYBRID COORDINATES
Claude Girard and René Laprise

A description of an application of the finite-element technique to the vertical discretization of a spectral General Circulation Model using a hybrid vertical coordinate is presented. A novel aspect of this application of the finite-element technique is that only the prognostic variables are projected on the basis functions - here chosen to be piecewise constant - whereas the diagnostic relations continue to be satisfied exactly by the discretized variables. The scheme is general enough to allow for an arbitrary placement of the thermodynamic layers with respect to the momentum layers, and hence effectively allows staggering or not of the variables in the model. A hybrid vertical coordinate is used that gradually changes from being terrain-following at low levels to becoming constant pressure surfaces at the top of the computational domain. In addition, this discretization allows the implementation of the upper boundary condition at a fixed, non-zero pressure while retaining the conservation properties of the vertical discretization. When this scheme is specialized to no staggering and with the top at $p = 0$, it effectively becomes equivalent to the finite-difference discretization currently used in the operational model at the ECMWF.

SENSIBILITÉ DES SIMULATIONS DU MCG CANADIEN À LA FORMULATION DE SA DISCRÉTISATION VERTICALE
René Laprise et Claude Girard

Les erreurs systématiques du Modèle de circulation générale (MCG) canadien sont analysées en terme de leur sensibilité à la formulation de la discrétisation verticale dans ce modèle. Les diverses variantes de cette nouvelle formulation qui utilise la méthode aux éléments finis constants par morceaux (Girard et Laprise, à ce Congrès) est comparée à celle couramment employée dans ce modèle. Des tests avec la nouvelle formulation étudient l'impact d'utiliser une coordonnée verticale hybride plutôt que la coordonnée sigma traditionnelle, ainsi que l'imposition de la condition de toit à une hauteur finie. L'effet d'intercaler ou non les variables thermodynamiques par rapport aux vents est aussi analysé. Finalement des tests effectués à diverses résolutions verticales révèlent clairement la nécessité d'employer une résolution verticale suffisante dans la basse stratosphère du modèle pour des simulations fiables.

UN SCHÉMA STABLE POUR LA DIFFUSION VERTICALE NON-LINÉAIRE DANS LE MODÈLE SPECTRAL CANADIEN

Claude Girard et Yves Delage

Dans les modèles numériques, les transports verticaux turbulents de chaleur, d'humidité et de quantité de mouvement sont souvent simulés à l'aide des schémas de diffusion verticale avec coefficients d'échange variables. Des schémas numériques dits implicites sont alors généralement employés pour résoudre le problème et on les suppose absolument stables. Cependant, lorsque les coefficients dépendent localement des variables elles-mêmes, à travers le gradient de vent et/ou la stabilité statique par exemple, le problème de diffusion devient non-linéaire et les schémas numériques mentionnés plus haut sont désormais conditionnellement stables seulement. Dans certaines conditions qui dépendent spécifiquement de la définition des coefficients d'échange, ils deviennent instables pour un pas de temps long. Ici, nous décrivons un nouveau schéma numérique qui demeure absolument stable dans le cas non-linéaire. Le schéma s'applique à la formulation utilisée dans le modèle spectral canadien de prévision mais la méthode pour obtenir un tel schéma est assez générale. Nous montrons aussi des résultats d'intégrations comparant l'ancien et le nouveau schéma.

1020-1220 (F-215)

Jeudi / Thursday

SESSION 10B : L'ESTUAIRE ET LE GOLFE DU ST-LAURENT
ST LAWRENCE ESTUARY AND GULF

WIND-INDUCED SYNOPTIC EDDY MOTION IN THE LOWER ST LAWRENCE ESTUARY

G. Mertz, V.G. Koutitonsky, Y. Gratton and M.I. El-Sabh

The lower St Lawrence Estuary is a wide estuary, in the sense of being several internal Rossby radii in breadth. Thus, the Coriolis effects are significant, and complex circulation patterns are to be expected. We analyse the response of this body to a strong up-channel pulse of wind, using data from an array of current meters. Interesting features of the flow are found, such as coastal jets accelerating into the wind while the wind speed relaxes (apparently due to the establishment of an along-channel pressure gradient), and a pair of synoptic-scale eddies developing in the current pattern.

THREE-DIMENSIONAL NUMERICAL SIMULATIONS OF WIND AND TIDALLY-INDUCED CIRCULATIONS IN THE ST LAWRENCE ESTUARY

V.G. Koutitonsky, R.E. Wilson and C. Toro

A fully non-linear three-dimensional numerical level model is developed for application to circulation studies in stratified estuaries and semi-enclosed seas. The model has a free surface, and can be forced by wind stress, heat flux, and atmospheric pressure at its upper boundary, and by freshwater runoff and tides at its open boundaries. Preliminary results are presented for wind- and tidally-induced circulations in the St Lawrence Estuary, for the case of a homogeneous vertical density distribution. Ongoing efforts to include vertical stratification are discussed.

TIDE ANALYSIS AND MODELLING IN JACQUES CARTIER PASSAGE

D. Lefaivre, V.G. Koutitonsky, D. Hains, P. Ouellet and A.R. Condal

The study of the tide of the Gulf and Estuary of the St Lawrence system has been tackled both from the analysis of observations and from the modelling point of view. However, the region of Jacques Cartier Passage in the northern part of the Gulf was never presented satisfactorily owing to a lack of field measurements of sufficient coverage and length. The presence of a sill at the narrowest part along with the geometry of the coastline perturbs the tides and induces a rapid change of phase and amplitude along the Passage. As part of the COHJAC program (Circulation, Oceanography, and Hydrography of Jacques Cartier Passage) a number of moorings were spread out in and around the Passage, sampling data over 12 months in 1986 and 1987. These moorings were instrumented with bottom pressure gauges, current meters and thermistor chains. Also some shore-based tide-gauges were deployed in summertime. Results of the analysis of the data of the bottom pressure gauges and of the tide-gauges will be presented showing the variation of the major components of the tide through the Passage. The M2 component of the tide will be extracted from the data for the tide-gauges at both ends of the Passage. These data will drive a 2-D numerical finite-element circulation model of the Passage. Results of the model will give the progression of the M2 component in amplitude and phase. Also of interest, the model will map the areas of potential tidal mixing. Sea surface temperatures from infrared AVHRR satellite imagery will be shown in order to compare the predicted and observed mixed areas.

ÉTUDE PRÉLIMINAIRE DE LA STRUCTURE TRIDIMENSIONNELLE DE LA CIRCULATION BAROCLINIQUE CAUSÉE PAR L'INTRUSION DE L'EAU DES RIVIÈRES À L'AIDE D'UN MODÈLE MULTI-NIVEAUX

C. Toro, V.G. Koutitonsky et R.E. Wilson

Une étude préliminaire de la structure tridimensionnelle de la circulation baroclinique causée par l'intrusion de l'eau des rivières dans le golfe du Saint-Laurent à l'aide d'un modèle à plusieurs niveaux ("Multi-level") couplé avec les équations thermodynamiques est présenté.

Le propos est d'étudier la distribution saisonnière, quasi-permanente de propriétés telles que la densité (température et/ou salinité), du champ de vitesses et de vorticité, qui nous permettrons de décrire et prédire les situations caractérisées par l'intrusion de l'eau douce des rivières dans un milieu stratifié tel que le golfe du Saint-Laurent, et ainsi estimer son importance parmi l'ensemble des facteurs.

RÉSURGENCES CÔTIÈRES OBSERVÉES AU SECTEUR NORD-OUEST DU GOLFE DU SAINT-LAURENT À L'AIDE D'IMAGES SATELLITES NOAA

Jacinthe Lacroix, Mohammed El-Sabh, Denis Proulx, Alfonso Condal et Jean-Marie M. Dubois

L'analyse des images satellites prises en 1984 et 1985 nous permettra d'observer le long de la côte nord du golfe Saint-Laurent, entre Pointe-des-Monts et Natashquan, ainsi que le long de la rive sud de l'île d'Anticosti des zones de résurgences côtières induites par des vents à dominance de l'ouest. Associées à ces zones de résurgence d'eau froide, on

trouve des zones frontales en surface. À l'embouchure de l'estuaire maritime, le front de Pointe-des-Monts est caractérisé par un gradient thermique important, de près de 5°C sur quelques kilomètres. Cette zone d'eau froide peut également se former occasionnellement plus à l'ouest ou à l'est du secteur immédiat de Pointe-des-Monts. Le long de la côte nord du Golfe, les zones de résurgence sont observées entre Pointe-des-Anglais et Sept-Îles ainsi que dans le détroit de Jacques-Cartier. L'ensemble de ces zones d'eau froide s'étire latéralement sur près de 20-25 km de la surface. La variation de la température de surface dans les zones de résurgence, autant le long de la rive nord du Golfe, à l'embouchure de l'estuaire maritime que le long de la rive sud-ouest de l'île d'Anticosti, nous permet d'observer généralement une périodicité de l'ordre de 10-12 jours. Ce cycle, observé pour la première fois, est très rapproché de celui du passage d'un système atmosphérique dans cette région. L'action du vent est donc le principal facteur qui conditionne la manifestation de ces résurgences côtières. Nos résultats montrent également que la présence et les variations du front à Pointe-des-Monts et celle des remontées d'eau le long de la côte nord sont reliées et qu'elles évoluent en fonction d'un même système météorologique. Au nord de l'île d'Anticosti, on observe des eaux de surface dont les températures sont relativement homogènes. Lors des périodes de résurgence le long de la côte nord du Golfe, on assiste à un refoulement des eaux vers l'île, et une zone frontale prend place entre les deux nappes d'eau.

La zone de résurgence d'eau froide observée le long de la rive sud de l'île d'Anticosti est de petite dimension, comparativement aux autres zones, et n'apparaît jamais plus de 25 heures consécutives. De plus, cette remontée d'eau apparaît moins fréquemment, bien que ses apparitions coïncident toujours à des périodes où l'on note des maximum le long de la côte nord durant lesquelles des vents d'ouest sont dominants.

SUBTIDAL SALINITY AND VELOCITY VARIATIONS IN THE ST LAWRENCE ESTUARY

K.-T. Tee

Between April and September 1982, 14 current meters were moored at 6 stations along the St Lawrence Estuary: two stations each in the lower, middle and upper estuaries. The experimental data reveal a complex structure in the subtidal salinity and velocity variations, caused by a combination of tidal, atmospheric and density forcing.

The meteorological forcing shows oscillations with periods of 10-15 and 40-50 d, and a long-term trend with a time-scale of approximately 130 d. The salinity data indicate that the 10-15 d forcing induced an interfacial oscillation that propagated anticlockwise in the lower estuary as a free internal Kelvin wave. However, the velocity data provide a different picture of wave propagation. The 40-50 d forcing induces an oscillation that occurs initially near the transition region between upper and lower estuaries, and then propagates toward upstream and downstream regions. The oscillation also propagates toward the surface in the lower estuary. The long-period salinity variation in the upper estuary observed in 1982 is induced mainly by wind forcing. Tidally rectified salinity and velocity oscillations at monthly and fortnightly periods were observed at two stations. The freshwater runoff from the St Lawrence River produces a seasonal pulse in the estuary. It also produces large eddies with a fine scale of approximately 73 d in the lower estuary.

**SESSION 10C : PROGRAMMES INTERNATIONAUX
INTERNATIONAL PROGRAMS**

THE WORLD OCEAN CIRCULATION EXPERIMENT: CANADIAN UNIVERSITY PARTICIPATION
Paul H. LeBlond

The process towards Canadian participation in the World Ocean Circulation Experiment (WOCE), particularly by university scientists, will be reviewed. The overview will cover the process of program formulation, proposal preparation and funding plans. Proposed research will be outlined within the context of the international WOCE program.

JGOFS
M. Lewis

Abstract not available.

NATURAL CATASTROPHES: WHAT CAN BE DONE TO PREVENT AND MITIGATE THEM
Mohammed I. El-Sabh

Natural catastrophes pose threats to almost every nation, and each year disasters occur: Tornadoes in Canada, storm surges and floods in Bangladesh, typhoons in the Philippines, volcanic eruptions in the United States, earthquakes in Soviet Armenia, wildfires in China, tsunami in Japan, and destructive landslides in Ecuador. These are a few of the more recent events and it is believed that during forty years alone, from 1938 to 1977, more than 1000 catastrophic events have been recorded in which ten or more people were killed. It is a well known fact that, as the world's population increases, the likelihood of natural catastrophes will continue to increase as people move closer to volcanoes, build near or across geologic faults, and so on. It seems that no earthquake ever discouraged people from rebuilding their city, nor recurring floods ever convinced man to move out of dangerous flood plains along the world's river deltas. It is also a fact that human response to disasters varies from culture to culture, from society to society, as well as from individual to individual. Such reactions depend, at least in part, on sociological, psychological, economic, religious and even political differences. In this paper, we discuss the interacting role to be played by the different actors in preventing and mitigating any catastrophic crisis. We also discuss the steps taken at present towards the formation of a Canadian Disaster Research Center (CDRC) at Rimouski.

NEPTUNE: PROSPECTS FOR VOYAGER ENCOUNTER
J.C. McConnell

Abstract not available.

ENERGETICS OF THE 30-60 DAY OSCILLATION

Steven J. Lambert

The observed features of the 30-60 day wave in the tropical wind field first reported by Madden and Julian are reviewed and its kinetic energy budget based on five years of ECMWF/WMO operational analyses is presented.

Some results of the examination of simulations from the Canadian Climate Centre General Circulation Model for the presence of this oscillation are also discussed.

HOUGH MODE DECOMPOSITION OF THE TROPICAL MADDEN-JULIAN WAVE

K.J. Keen

Hough modes are the eigensolutions of the barotropic primitive equations on a rotating sphere. Special cases of these modes for the atmosphere are the eastward-propagating Kelvin gravity waves and the westward-propagating Rossby-Haurwitz waves. Past studies have indicated that Kelvin gravity waves trapped in the equatorial region and planetary Rossby-Haurwitz waves appear to drive the 40-50 Day Oscillation in the tropics - the so-called tropical Madden-Julian wave. Researchers in the past have relied on applying univariate and bivariate spectral methods to time series of wind velocity and geopotential height at selected tropical upper-air stations in order to detect the Madden-Julian wave. In contrast, this study focusses instead on the direct estimation of potential and kinetic energies associated with the Hough modes responsible for this phenomenon from a 9-year record of twice-daily observations of globally gridded geopotential heights and winds produced by the European Centre for Medium Range Weather Forecasting.

ENERGY EXCHANGES AMONG VARIOUS FREQUENCIES IN ATMOSPHERIC AND GCM DATA

J. Sheng and J. Derome

The large-scale energetics of atmospheric motions are studied spectrally in the frequency domain. The data sets used are from the ECMWF operational analyses and from the CCC general circulation model. The distribution of kinetic energy (KE) for the fast transients (with periods shorter than 10 d) assumes the shape of elongated bands suggestive of storm tracks. The slow transients (with periods longer than 10 d) exhibit the maxima of KE off the west coasts of the major continents. During the winter-time both barotropic energy conversions and non-linear interactions are responsible for the energy balance of the slow transients. The geographical patterns of the energy conversion terms are discussed to identify regional characteristics of the energy balance for different frequency bands. One of the important results in this study highlights the difference between the energetics in the summer and in the winter seasons.

CIRCULATION AND DISPERSION ON BROWNS BANK

Peter C. Smith

Year-long current measurements reveal a permanent clockwise gyre over the western cap of Browns Bank. Maximum mean currents (0.25 m s^{-1}) over the steep northern flank are uniform in the upper water column, except when pulses of low salinity water arrive from the Scotian Shelf producing stratification and vertical shear. Significant offbank Eulerian mean currents found near the bottom on the 100-m isobath are consistent with the models for topographic interactions of the semidiurnal tides. A multiple regression analysis in the spectral domain reveals most low-frequency energy is concentrated in the 14- to 28-d bands where wind- and tidally-forced currents make roughly equal contributions (30-40%) to the total variance. In the synoptic bands (2 to 10 d), wind forcing alone contributes 60-80% of the variance. The temporal and spatial variability of the gyre is supported by satellite-tracked drogue studies on the Bank in three seasons. April and November 1983 observations show that the gyre circulation may be broken down by wind-forced currents. In July/September 1983, drogues consistently exited the western cap of the Bank from the northern flank and after a "residence time" of 14 d, comparable with the near-surface recirculation time. Isotropic dispersion coefficients ($30 \leq K_H \leq 160 \text{ m}^2 \text{ s}^{-1}$) are found to follow Okubo's (1971) empirical formulae.

LOW-FREQUENCY CIRCULATION ON THE LABRADOR SHELF

Savithri Narayanan

Current measurements from 11 locations on the Labrador Shelf are analysed using the empirical orthogonal function (EOF) method in the frequency domain to examine the weather band variability on the Shelf. To explain these measurements dynamically, the estimated EOF modes are compared with output from a barotropic shelf model. The applicability of barotropic shelf modelling to the Labrador Shelf is discussed.

THE EFFECT OF BAROCLINIC SHEAR CURRENTS ON COASTAL-TRAPPED WAVES

David M. Holland and Ian T. Webster

A numerical method is presented for solving the coastal-trapped wave problem in the presence of a baroclinic shear current flowing parallel to the coast. The method is the explicitly shifted inverse power algorithm for the generalized eigenvalue problem. The mean density and velocity fields are specified in the model using density transects from the Australian Coastal Experiment (ACE). The velocity fields are calculated from the density fields under the assumption of geostrophic balance. The sensitivity of the modal structure and phase speed of the first three CTW modes to three

scenarios of mean alongshore current is presented. The three scenarios are a nearshore coastal jet, an offshore coastal jet, and the average alongshore conditions during the ACE experiment.

AN ANALYTIC MODEL FOR THE LEEUWIN CURRENT OFF WESTERN AUSTRALIA

Andrew J. Weaver

A linear, steady-state, analytical model for the Leeuwin Current is developed by coupling a continental shelf region to a two-layer deep ocean. The model is forced by both the observed annual mean alongshore density gradient in the Indian Ocean and the seasonal winds. It is shown that even during the period between September and February, when the winds are strongest, the forcing due to the alongshore density gradient in the Indian Ocean is sufficient to overcome opposing wind effects, with the net result that a strong southward flow exists near the shelf break. While the current flows southwards it accelerates into the opposing winds. It is shown that average seasonal southerly wind speeds of the order of 17 m s^{-1} are required to arrest the southward transport. These speeds, while attainable during the strongest storms, are unrealistic for an average over a seasonal time-scale. The model results are also shown to compare favourably with observations made during the Leeuwin Current Interdisciplinary Experiment (LUCIE). A discussion of the difference between the Leeuwin Current and other global eastern boundary currents is also presented.

NUMERICAL SIMULATIONS OF THE LEEUWIN CURRENT OFF WESTERN AUSTRALIA

Andrew J. Weaver

Four numerical experiments are conducted using the Bryan-Cox Ocean General Circulation Model in order to investigate mechanisms for the generation of the Leeuwin Current off the west coast of Australia. In the first experiment an alongshore density gradient is imposed in the Indian Ocean, whereas in the second and third experiments the additional effects of warm, fresh Northwest shelf waters are considered. The final experiment examines the importance of the continental shelf. The alongshore density gradient in the Indian Ocean produces an onshore geostrophic flow that turns southward and intensifies while it flows along the coast of Western Australia and into the Great Australian Bight. Maximum alongshore surface velocities occur just off the shelf break; below this poleward current is a weak equatorward flow. The magnitudes of the velocity vectors and associated advection of temperature and salinity, and the width, structure and geographical location of the current all agree well with field observations. The effect of the warm, fresh Northwest shelf waters is the enhancement of the alongshore barotropic current on the shelf. This response is mainly local and diminishes with alongshore distance. The continental shelf is found to be important in arresting the westward drift of the boundary current. These results are deduced from movies of the model solutions. Model results therefore suggest that the Leeuwin Current is a baroclinic current driven by an alongshore density gradient in the Indian Ocean that is maintained by convective surface cooling.

GEOCHEMICAL EVIDENCE FOR OCEANOGRAPHIC CHANGES IN THE EASTERN MEDITERRANEAN DURING THE LATE PLEISTOCENE

S.E. Calvert

The presence of sapropels (organic-rich horizons in normal marl-ooze sequences) in the eastern Mediterranean provides clear evidence for marked changes in oceanographic conditions during the late Pleistocene. Such facies are generally considered to have formed as a consequence of wholesale basin-wide anoxia brought about by high freshwater input to the basin during glacial retreat. An alternative explanation involves increased primary production, leading to a higher settling flux of organic matter, during periods of altered circulation in response to post-glacial freshwater flooding.

A detailed geochemical and stable isotope study of a 12-m piston core from the Nile cone shows that the bulk compositions of the sapropels are distinctly different from those of the associated marls, implying that the conditions of sedimentation were quite different during the sapropel events. Moreover, the sapropels are markedly enriched in Ba, signifying increased primary production and, hence, increased fluxes of carbon to the bottom sediments during these periods.

Organic $\delta^{13}\text{C}$ values in the sapropels range from -21 to -22‰ , whereas values in the intervening marls range from -16 to -18‰ . Such differences show that the organic matter in the sediments has different sources and, consequently, that the sapropels cannot be explained solely by the preferential preservation of deposited carbon. The data are consistent with the formation of the sapropels by increased production during periods of reversed (i.e. estuarine) circulation in response to a different hydrological balance during post-glacial times.

THE INFLUENCE OF SALINITY ON THE PRECIPITATION KINETICS OF CALCITE AND ARAGONITE IN SEA-WATER

A. Mucci and S. Zhong

The rate and composition of calcite and aragonite overgrowths precipitated from sea-water solutions of various salinities (i.e. 5, 15, 25, 35 and 44) were determined at 25°C and $10^{-2.5}$ atm CO_2 partial pressure using a constant disequilibrium seeded technique. The rate data were fitted to an empirical rate law of the form: $\log R = n \log (\Omega_{\text{c(or a)}} - 1) + \log k$, where n is the empirical reaction order and k is the reaction rate. Calcite and aragonite precipitation rates in sea-water solutions are independent of salinity over the range investigated. Results of this study also confirm previous findings that, above a slight supersaturation (i.e. $\Omega_{\text{a}} \geq 1.7$), aragonite precipitates more rapidly than calcite at 25°C , even though calcite is more stable than aragonite under these conditions.

The incorporation of Sr^{2+} in aragonite and Mg^{2+} in calcite over-

growths are independent of the precipitation rate. The partition coefficient of Sr^{2+} in aragonite is approximately equal to 1 and is unaffected by salinity. The Mg^{2+} partition coefficient in calcite increases with decreasing salinity of the parent sea-water solution, possibly as a result of variations in the sulphate content of the solutions and solids.

These results will be discussed in the context of a number of geological environments (e.g. beachrock formation, the occurrence and distribution of "whittings" on the Grand Bahamas Banks and, the temporal oscillations in the mineralogy of carbonate precipitates during the Phanerozoic).

A THEORETICAL STUDY OF DIAGENETIC CONCENTRATION FIELDS NEAR MANGANESE NODULES AT THE SEDIMENT-WATER INTERFACE

Bernard P. Boudreau and Robert J. Taylor

The effects of manganese nodules on concentration fields in adjacent pore-waters and sediments are investigated theoretically with a three-dimensional (axi-symmetric) diffusion-reaction model. The nodules are idealized as impermeable and poorly permeable disks and hemispheres.

The first part of this paper examines the organic matter and coupled porewater oxygen fields in order to evaluate the local redox conditions under an isolated nodule. Oxygen is allowed to disappear on a free surface that is calculated as an output of the model.

In sediments that become suboxic, like those at MANOP Site C, the model predicts that porewaters neighbouring a nodule are markedly more depleted in oxygen than in its absence. Although these reduced conditions may remobilize metals that would be available for nodule growth, these same conditions would appear to favour nodule dissolution. Typically, the presence of a nodule raises the local position of the zero-oxygen surface, but it is deeper than expected for large nodules on sediments containing only highly reactive organic matter.

The redox changes calculated for a nodule on a hypothetical, but representative, oxidized abyssal red clay appear inadequate to raise the redox boundaries enough to facilitate metal transport from reduced regions deeper in the sediment.

In the later part of the paper the model is used to evaluate the influence of a nodule field on the outward flux of dissolved silica from a siliceous ooze. Although the flux attenuation is generally modest, some dense packings observed in the Pacific should produce substantial reductions (> 35 %), which should promote opal preservation.

A 9,000-YEAR RECORD OF GEOCHEMICAL CHANGE IN HALIFAX INLET

Dale E. Buckley

A 7.2-m long piston core of sediments from the centre of Bedford Basin, Halifax Inlet, penetrated marginal marine sediments approximately 9,000 years old. Superimposed on these oldest sediments is a sequence of fine-grained reduced muds deposited under restricted basin marine conditions. The surficial sediments in this location are now highly contaminated under the influence of at least 100 years of sewage and other waster disposal from the Halifax-Dartmouth urban area.

Although the basic mineral geochemical matrix has remained virtually

unchanged over the entire period of deposition recorded in this core, there are several environmental and diagenetic changes that are evident. About 2.5 ka ago the amount of preserved organic carbon began to increase from 2.5% up to more than twice that amount in the present-day deposits. The redox potential coincident with the 2.5-ka stratigraphic layer indicates suboxic, or mildly reducing conditions, but younger sediments above this horizon are progressively more strongly reducing, reaching pE values as low as -1.17 (-lg M) at the top of the core. The intensity of the chemical reduction is further evident by the lack of sulphate in the pore water throughout the core, by a high rate of diffusion of ammonia from concentrations as high as 5.2 mM at 2.6-m depth in the core, and by the presence of methane in the sediments surrounding the core site. Total metal concentrations of Cu and Zn increase by more than factors of 8 and 4, respectively, in the anthropogenically dominated surficial sediments. These geochemical characteristics indicate the influence of both natural physical changes on the earth's environment, and the strong influence that man can have in changing the present-day quality of the environment.

RESPONSE OF TH/U IN DEEP LABRADOR SEA SEDIMENTS (ODP-SITE 646) TO CHANGES IN SEDIMENTATION RATES AND PALEOPRODUCTIVITIES

C. Hillaire-Marcel, A. Aksu, C. Causse, A. de Vernal and B. Ghaleb

Since the early work of Piggot and Urry (1939), several authors have developed the Th/U method for the study of deep sea sediments. For example, ^{230}Th has been used both for the calculation of Mn-nodule growth rates, to assess sedimentation rates, and more recently as a paleoclimatic indicator. Uranium concentration seems to respond more directly to organic carbon inputs and therefore to their climatic forcing. Since several factors account for the concentrations and activity ratios of U and Th in deep-sea sediments, interpretations are far from unequivocal. The Labrador Sea is a particularly suitable high latitude basin for investigation of U and Th behaviour. During the Late Quaternary, the cyclic development and decay of huge ice sheets on adjacent land masses resulted in large amplitude changes in sedimentation rates and organic paleoproductivities. The resulting magnification of U and Th response in deep-sea sediments is well illustrated by high-resolution studies of piston cored sediments from the Greenland continental rise at ODP Site 646 (Leg 105) spanning over isotopic stages 8 to 1. Our results show a clear positive shift of $^{230}\text{U}/^{232}\text{Th}$ and $^{230}\text{Th}/^{232}\text{Th}$ activity ratios during episodes of increased paleoproductivity (Interglacials). ^{230}Th -excesses (over ^{234}U) higher than expected from the ^{230}Th -rain from the overlying water column indicate strong horizontal fluxes of ^{230}Th . Changes in these fluxes and/or sedimentation rate may both account for "unsupported" ^{230}Th fluctuations downcore. The direct paleoproductivity/ ^{230}Th -excess relationship reported by other authors at lower and higher latitudes would thus seem invalid here.

**SESSION 12A : CLIMATOLOGIE RÉGIONALE
REGIONAL CLIMATOLOGY**

**RECENT CLIMATE VARIATIONS IN THE MACKENZIE VALLEY AND THEIR ANTICIPATED
IMPACT ON PERMAFROST STABILITY****Ambury Stuart**

Over the past 20 years, AES observing stations in the Mackenzie Valley have observed significantly warmer temperatures during winter and annually compared with long-term climate averages. The impact of recent air temperature and snow cover fluctuations on permafrost is simulated using a frost index model previously developed by Stuart (1986).

The presentation will document both surface and upper-air temperature and snow cover variations in the Mackenzie Valley area since 1971. The frost index model will then be briefly described and the results of its application to these recent observations will be presented.

SOME CUMULATIVE PROCESSES WITHIN THE HYDROLOGICAL CYCLE IN WESTERN CANADA**R.G. Lawford**

The mass balance curve has frequently been used in hydrology to study the variability of stream flow and to provide insights into cumulative hydrological processes. This simple technique is applied to precipitation data to investigate the evolution of long-term precipitation means for stations on the Canadian prairies, to examine relationships between precipitation and the volume of runoff for specific watersheds and to document the accumulation of variations in the freshwater fluxes into the Arctic and Pacific oceans.

The results indicate that short-term trends appear in precipitation data for the Prairies. These trends have distinctive regional and seasonal variations at some stations. The results indicate that short-term trends in precipitation are not necessarily reflected in the trends in runoff. This suggests that the relationship between rainfall and runoff in larger watersheds in western Canada is complex and may involve other climatological factors such as temperature. Trends in accumulated runoff into the Arctic and Pacific oceans are also presented. The possible effects of trends and variations in runoff and precipitation on coastal ocean currents are briefly discussed.

**QUANTITATIVE APPROACH TO ASSESS THE OPTIMUM NUMBER OF STATIONS IN A CLIMATE
NETWORK****Gérald Vigeant**

This study deals with the determination of the optimum number of stations and their spatial distribution in a climate network required to measure adequately a daily climatological parameter in the province of Quebec. The methodology used can be divided into five steps: (a) from elevation data at

every 10 km, identify regions of similar topographical variability; (b) for each topographically homogeneous region, evaluate a continentality index that takes into account the influence of nearby major water bodies on temperature/precipitation regimes; (c) choose a simple statistical parameter to measure accuracy (resemblance between stations) for temperature and precipitation; (d) determine a statistical relation between accuracy, topographical variability, continentality and distance between stations; (e) calculate the minimum number and the spatial distribution of stations to attain a particular precision for a given parameter. This technique gives good results and seems to be applicable elsewhere in Canada and therefore covers a broad range of topographical variability and continentality. The implications of this method on the management of climate networks will also be discussed.

TOTAL OZONE IMAGERY FROM METEOROLOGICAL UPPER-AIR MAPS

W.F.J. Evans and L.R. Poulin

An algorithm has been developed that calculates total ozone fields from meteorological upper-air maps. This paper proposes an algorithm that calculates total ozone amounts using the correlation between stratospheric temperatures and total ozone. As well, the method also accounts for the well known correlation between tropopause height and total ozone. An empirical equation using stratospheric temperatures and tropopause height information has been derived that can produce total ozone fields on a daily basis. This algorithm allows for the plotting of total ozone fields for the polar regions when sunlight is not available for the TOMS instrument measurements. The product compares favourably with the measured ozone fields from the TOMS satellite instrument. The derivation of the equations and the algorithm development are described. A synthetic total ozone field computed for March 15, 1986 is compared with the measured TOMS image of March 16, 1986. A comparison with actual observed ground-based ozone from Brewer stations shows less than a 10% variance; the errors are largest near sharp gradients or rapidly changing meteorological situations. The morphology of the 1989 polar vortex is demonstrated with this imagery.

1540-1720 (F-215)

Jeudi / Thursday

SESSION 12B : LAGUNES ET "BAIES"
LAGOONS AND "BAYS"

VARIABILITÉ SAISONNIÈRE DU PATRON ÉNERGÉTIQUE ASSOCIÉ AUX COURANTS CÔTIERS DU SUD-EST DE LA BAIE D'HUDSON

Serge Lepage et R. Grant Ingram

Des séries temporelles de courants recueillies au sud-est de la baie d'Hudson sont utilisées pour étudier les changements saisonniers associés à la présence et au départ du couvert de glace hivernal. Le partage des observations selon les bandes de fréquences semi-diurne, inertielle et de basses fréquences ($< 0,01 \text{ h}^{-1}$) démontre que la marée est la principale source énergétique, particulièrement sous couvert de glace. En eau libre,

les basses fréquences associées aux systèmes météorologiques contribuent de façon significative à l'écoulement et au mélange des eaux. Des mouvements inertiels ont également été observés à une station située à 12 km de la côte. Le partage des différents contributeurs a été effectué à l'aide d'un filtre digital Butterworth.

EFFECTS OF RIVER RUNOFF, SEA-ICE MELT AND WIND FORCING ON VERTICAL MIXING DURING SPRING BREAKUP IN HUDSON BAY

R. Grant Ingram and Serge Lepage

Freshwater budget calculations based on river discharge and sea-ice melt show a comparable buoyancy input from both sources during late spring in southeast Hudson Bay. Using CTD profiles and moored current-meter data taken during breakup, the change in the rate of vertical mixing in the surface waters over the period including the transition from landfast ice to open water is presented. Comparison of kinetic energy dissipation to potential energy change at this location with that found elsewhere shows similar values. Estimates of the minimum energy input required to destabilize the highly stratified regime found immediately after ice melt are given.

FLUSHING OF A SHALLOW BAY

David A. Booth

Caraquet Bay, New Brunswick, an important centre of oyster culture, is a shallow (2 m) bay with a narrow entrance. The average tidal range is 1.6 m, and thus efficient flushing might be expected. Oyster larvae, however, which float in the water for two or three weeks before settling, succeed in amply seeding collectors installed within the bay.

Tidal currents tend to follow the south shore, but drifting buoys demonstrated that the net tidal displacement is erratic owing to exchanges between different regimes. To estimate the dispersion of passive oyster larvae, the physical mechanisms that influence flushing are examined, with particular reference to wind and horizontal shear.

ON THE HYDRODYNAMICS OF GRANDE-ENTRÉE LAGOON, MAGDALEN ISLANDS

V.G. Koutitonsky, N. Navaro, M. Couture and E. Gomez-Reyez

A multidisciplinary research program was undertaken in 1988 to evaluate the biological production potential of Grande-Entrée Lagoon, in relation to mussel aquaculture. The objective of the hydrodynamic component of this program is to describe the circulation and water mass variability, and to estimate the flushing time of the lagoon, and that through field measurements and numerical modelling.

Time series analysis of the 1988 current and tide measurements indicate that tides and winds are the major forcing functions, and that the St Lawrence Estuary spring runoff is advected into the lagoon by late summer.

Numerical simulations of the circulation in the lagoon, obtained from a fully non-linear two-dimensional finite-element model are presented, and ongoing research is outlined.

RÉOUVERTURE DE LA LAGUNE DU HAVRE-AUX-BASQUES, ÎLES-DE-LA-MADELEINE

Georges Drapeau et R.P. Rasoanilana

La passe de la lagune du Havre-aux-Basques aux îles-de-la-Madeleine a été complètement bloquée par la construction d'une route à la fin des années 50. Ce faisant on a diminué de 30 % la superficie de l'ensemble des lagunes des îles-de-la-Madeleine. On réalise maintenant que les lagunes jouent un rôle très important dans l'écologie marine de cette région particulièrement au stade juvénile des organismes marins. Différentes alternatives sont explorées pour évaluer les conditions qui devraient prévaloir pour que la ou les passes permettant de rétablir la communication avec le Golfe soient sédimentologiquement stables. On considère d'abord le cas d'une seule ouverture dont on peut déterminer les caractéristiques optimales pour éviter l'ensablement en se basant entre autres sur le modèle d'Escoffier. Une solution particulièrement intéressante serait de creuser une ouverture de chaque côté de la lagune puisque l'onde de marée diffère considérablement du côté ouest et du côté est des îles-de-la-Madeleine à cause d'un point amphidromique de la marée semi-diurne situé à une vingtaine de kilomètres au sud-ouest des îles-de-la-Madeleine. Les simulations d'ouvertures de chaque côté de la lagune sont élaborées à partir d'un modèle simple basé sur l'équation de Manning qui permet néanmoins de simuler différentes combinaisons d'ouvertures.

1540-1720 (C-410)

Jeudi / Thursday

SESSION 12C : TRANSPORT VERTICAL ET DIAGÉNÈSE DE LA MATIÈRE ORGANIQUE
VERTICAL TRANSPORT AND DIAGENESIS OF ORGANIC MATTER

VERTICAL CARBON AND NITROGEN FLUXES IN THE ARCTIC OCEAN OFF AXEL HEIBERG ISLAND

B.T. Hargrave

An increase in concentrations of suspended particulate organic carbon and nitrogen (equivalent to $1.5 \text{ mg C m}^{-2} \text{ d}^{-1}$ and $0.3 \text{ mg N m}^{-2} \text{ d}^{-1}$) was measured under ice cover in the upper 60 m of the Arctic Ocean off Axel Heiberg Island (81°N , 97°W) between June and August 1986. Sedimentation of particulate matter at 100 m between September 1986 and June 1987 averaged $0.3 \text{ mg C m}^{-2} \text{ d}^{-1}$ ($0.05 \text{ mg N m}^{-2} \text{ d}^{-1}$). The combined fluxes require an annual nitrogen supply of $2.2 \times 10^{-9} \text{ mmol N m}^{-3} \text{ s}^{-1}$ to the upper 100 m. This could be provided across the chemocline (50-100 m, $\text{dN/dz} = 0.2 \text{ mmol N m}^{-3}$) by a vertical eddy diffusivity (K_z) of $0.08 \text{ cm}^2 \text{ s}^{-1}$. Wallace et al. (1987, Deep-Sea Res. 34: 1957) calculated $K_z = 0.02 \text{ cm}^2 \text{ s}^{-1}$ as a bulk value for the cold halocline in the central Arctic Ocean. The higher value is consistent with the location of the present observations over the continental shelf with water depths of 200-500 m. The increase in suspended concentration and sedimentation of organic carbon (total - $0.25 \text{ mg C m}^{-2} \text{ d}^{-1}$) is equivalent to 25% of annual primary production measured under the ice in the central Arctic Ocean. Estimates of production derived from oxygen distribution in the interior of the Arctic Ocean and from measurements in open water areas of the Canadian Arctic Archipelago are 50 times higher.

DEEP WATER FORMATION AND TRANSPORT OF CO₂ IN THE NORWEGIAN-GREENLAND SEA REGION IN WINTER

E.P. Jones and R.A. Clarke

Oceanographic processes in the Norwegian-Greenland Sea are significant in determining global climate by producing the deep waters of the North Atlantic Ocean, and thus regulating the transport of heat and salt in the North Atlantic Ocean. Deep water formation occurs during the winter season when near-surface water is made more dense by cooling and by increasing the salinity while brine is rejected from newly-formed sea ice. While the near-surface water sinks, it is replaced in part with water from warmer regions to the south. The newly formed deep water also transports carbon dioxide along with other gases from the atmosphere to the deep oceans of the world, sequestering them from the atmosphere for hundreds of years and therefore ameliorating the climatic effects of the buildup of fossil-fuel carbon dioxide and other radiatively active gases in the atmosphere.

Although mechanisms have been proposed describing this deep water formation, direct observations to verify the processes involved have been virtually non-existent. We report preliminary results of a month-long study in the Norwegian-Greenland Sea region in the winter of 1989 that was designed to observe deep water formation and the rate of transport of carbon dioxide to deep water. Measurements include a comprehensive survey using standard hydrographic measurements (salinity, temperature, oxygen, nutrients) together with transient tracers including freons, carbon tetrachloride and total carbonate. The expedition was part of the multinational Greenland Sea Project and the results will form a basis for a more detailed description and modelling of this crucial region in climate studies when subsequent data from summer cruises by other participants become available.

CARBON, NITROGEN AND AMINO ACID COMPOSITION OF SETTLING PARTICLES AND SEDIMENTS OF THE LAURENTIAN TROUGH

J.C. Colombo, N. Silverberg and J.N. Gearing

The composition and distribution of organic matter (OM) were examined for sinking macroparticles intercepted at 150-m depth, and in detailed vertical profiles of the underlying sediments. Sampling was carried out in May and July at a landward (Sta. 24) and a seaward (Sta. 22) site in the Lower St Lawrence Estuary. Geographic differences in the total flux and input of C, N and total hydrolyzable amino acids (THAA) affect the preservation of OM in the underlying sediments, as indicated by the C/N ratios, and the different rates of increase in BGLU/GLU ratios. In July, the sediments showed decreased TOC contents and increased levels of dissolved free amino acids (DFAA) near the top of the cores. Biological activity appears to be stimulated by the addition of fresh OM in summer.

Porewater DOC, DFAA, dissolved combined amino acids (DCAA), and solid phase TOC and THAA profiles show consistent patterns in all the cores, indicating the presence of three different zones:

- A surface zone extending to 30-40 mm, where solid phase OM is most intensely mineralized but dissolved OM phases are at a minimum, perhaps owing to high bacterial and macrofaunal consumption rates. Also, high biodiffusion rates may promote exchange across the sediment-water interface.

- An intermediate zone extending down to about 200 mm, where the rates of solid OM mineralization are more moderate, but the production of dissolved OM outstrips its removal by biological uptake, biodiffusion, and adsorption onto mineral particles.
- A deep zone extending to at least 350 mm, where the available OM is less readily metabolizable and the levels of DFAA and DCAA are lower. Removal by microbial activity and adsorption onto particles probably outstrips their rate of production.

PHOSPHOROUS FLUXES IN THE WATER COLUMN AND SEDIMENT OF THE GULF OF ST LAWRENCE, CANADA: ATTENUATION OF PHOSPHATE FLUXES FROM SEDIMENTS BY SORPTION EQUILIBRIA

Charles Gobeil, Norman Silverberg and Bjorn Sundby

Vertical fluxes of phosphorous in the water column and the sediment were measured at a 325-m deep site in the Gulf of St Lawrence. Of the annual flux of particulate phosphorous to the sediment ($80 \text{ mmol m}^{-2} \text{ a}^{-1}$), one third is regenerated and returned to the bottom water whereas two thirds is trapped in the accumulating sediment. The flux to the sediment is highest in spring and declines during summer and fall.

Porewater profiles of phosphate in more than twenty box cores taken at different times and locations in the Laurentian Trough show that the phosphate concentration is virtually constant ($6 \pm 3 \text{ } \mu\text{mol}$) in the porewater near the sediment-water interface. This constancy in time and space suggests that the phosphate concentration is regulated by sorption equilibria, so that phosphate is adsorbed during periods of intense mineralization of organic matter and desorbed at other times. In consequence, the concentration difference across the sediment-water interface is kept constant. Since the phosphate flux from the sediment is driven by the concentration difference across the interface, the flux is independent of the mineralization rate of organic matter. Thus the flux is attenuated by the sorption equilibria, and is likely to be out of phase with the particulate phosphorous flux to the sediment.

BILAN SAISONNIER DE LA MATIÈRE ORGANIQUE TOTALE SÉDIMENTÉE DANS LA ZONE INTERTIDALE DU BIC (ESTUAIRE DU SAINT-LAURENT)

Anne Mauviel, Gilles Miron et Gaston Desrosiers

Les sédiments superficiels de la zone intertidale du Bic contiennent le même taux de matière organique au printemps (départ des glaces) et à l'automne (arrivée des glaces). Toutefois, une augmentation est notée après le "bloom" phytoplanctonique printanier, reconnu dans la colonne d'eau. Cette augmentation est temporaire et est anéantie au cours de l'été, quelque soit le niveau altimétrique du littoral. Les niveaux les plus élevés sont toujours les plus riches et présentent une couche fine de vases. Les niveaux plus bas sont pauvres et sont caractérisés par une épaisse couche de sables. La répartition de ces sédiments est reliée à l'hydrodynamisme, influencé par la météorologie, et détermine la distribution des populations de certains polychètes (*Nereis virens*, (Sars)).

PRÉVISION DES ACCUMULATIONS DE NEIGE : UNE MÉTHODE OPÉRATIONNELLE BASÉE SUR UN ENSEMBLE DE PARAMÈTRES PHYSIQUES

D. Bachand, J. Morissette et V. Turcotte

La prévision des accumulations de neige lors d'une tempête d'hiver continue d'être un défi de taille pour le météorologiste opérationnel. L'amélioration constante des modèles de simulation atmosphérique s'est également répercutée sur les prévisions des hauteurs de précipitations en général, mais la performance des modèles peut varier grandement d'une situation à l'autre.

La technique a été développée suite à une étude détaillée de 15 tempêtes de neige ayant touché la province de Québec. Les accumulations observées à plusieurs stations ont été corrélées à des champs couramment disponibles directement reliés aux processus de formation des précipitations.

Les résultats montrent que les accumulations de neige sont corrélées aux valeurs de l'advection du tourbillon par le vent thermique, de l'eau précipitable et du tourbillon à 100 kPa, ainsi que des tendances temporelles de ces champs. La méthode d'application de la technique sera illustrée au moyen d'un cas réel.

LE TRAITEMENT A POSTERIORI DES PRÉVISIONS STATISTIQUES D'ÉLÉMENTS DU TEMPS

R. Verret et N. Yacowar

Le Centre météorologique canadien a développé deux systèmes statistiques pour prévoir l'opacité totale des nuages à toutes les trois heures, et les probabilités de précipitations sur des périodes de six et de douze heures. L'un des deux systèmes est basé sur l'approche "prévision parfaite" (PP) et l'autre sur l'approche "Model Output Statistics" (MOS). La fiabilité des prévisions et l'élimination des erreurs systématiques du modèle numérique moteur demeurent parmi les principaux avantages de la technique MOS, tandis que la précision des prévisions est une caractéristique de l'approche PP.

Une technique d'ajustement des prévisions statistiques d'éléments du temps produites par les équations de régression linéaire PP, a été développée, basée sur des règles simples et sur la rétro-action des erreurs. Les prévisions statistiques PP sont ajustées en fonction de leur performance pendant les derniers 90 jours. Cette technique met l'accent sur le glissement des prévisions vers les valeurs extrêmes et tient compte du glissement de la climatologie du modèle moteur. Elle force les prévisions ponctuelles de l'opacité totale des nuages à avoir une distribution de fréquence conforme à l'observation. Les résultats des vérifications indiquent que les prévisions ajustées ont une précision nettement accrue, et une habileté par rapport à la climatologie supérieure à celle des prévisions originales.

Les prévisions de probabilités de précipitations basées sur l'approche MOS et sur la technique PP ont aussi été combinées, avec emphase sur l'augmentation de la précision du produit final. Le but de la technique de combi-

naison des prévisions est de tenter de réunir les principaux avantages des approches MOS et PP. Les prévisions combinées ont une habileté par rapport à la climatologie supérieure à celle du meilleur des deux systèmes originaux de prévisions, avec une précision accrue et une fiabilité améliorée.

L'UTILISATION D'UN SYSTÈME INTERACTIF DE TRAITEMENT DE DONNÉES RADAR POUR LA DÉTECTION ET LA PRÉVISION DES ORAGES VIOLENTS DANS UN CENTRE MÉTÉOROLOGIQUE

H.P. Biron

Les orages violents observés chaque année dans la province de Québec ont une structure qui leur est spécifique : fortes réflectivités radar jusque dans les hauts niveaux de l'atmosphère, échos en surplomb et organisation caractéristique des patrons de précipitations sont rarement observés dans le cas d'orages n'atteignant pas les critères de temps violent.

Le prototype d'un système d'analyse et de traitement des données radar a été installé au Centre météorologique du Québec en octobre 1987. Ce système permet la réception et le traitement des données volumétriques du radar de McGill à intervalles de 5 min, permettant aux météorologistes d'exploitation une étude détaillée et en temps réel de la structure des orages et, par conséquent, une détermination de leur violence. Cette étude est rendue possible grâce à un système informatique permettant de dériver, à partir des données volumétriques, des coupes horizontales et verticales multiples d'un orage ainsi qu'une multitude d'autres produits et ce, à intervalles de 5 min. Le système comporte également plusieurs autres fonctions, incluant l'animation à haute vitesse, un schème d'extrapolation des échos radar, et tout un interface usager permettant de générer différents produits sur une base interactive ou automatique.

Plusieurs exemples démontrant l'utilisation opérationnelle de ce système seront présentés. Entre autres, la diversité des produits disponibles et le cycle d'obtention et de traitement des données à intervalles de 5 min ont fait ressortir des comportements inattendus et encore inexploités de certains complexes orageux.

VERIFICATION OF CANADIAN MONTHLY TEMPERATURE FORECASTS

Amir Shabbar

The Canadian Climate Centre prepared monthly temperature anomaly forecasts for Canada from January 1986 to April 1988 on an experimental basis. In May 1988, these forecasts became the official AES monthly temperature forecasts. We have compiled a number of verification statistics on these forecasts since 1986. These statistics include per cent correct sign, Heidke skill score and scatterplots of surface temperatures, and pattern correlations of 50-kPa height anomalies. At present, surface temperatures are verified for the signs of the anomalies only. The purpose of this study is twofold: first, to present verification results that have been seasonally stratified, and second to investigate if we have skill in forecasting the magnitude of the surface temperatures. More generally, this study attempts to investigate the skill of 3-class surface temperature forecasts.

Surface temperatures from 35 Canadian locations are verified by the signs of the anomalies and in a 3-class category (30:40:30 to BELOW:NORMAL: ABOVE). Heidke scores using chance as a standard are calculated. In order

to investigate bias in the forecast, histograms of the mean error are plotted. Finally, a pattern correlation is calculated between the forecast and observed 50-kPa height anomalies. In all cases, persistence is used as a control for comparison.

Our major findings are as follows:

- a) We have skill over persistence in winter and spring in both 2- and 3-category forecasts. In summer and fall persistence has outperformed the forecasts. Our forecasts have skill over chance in all four seasons.
- b) We tend to underforecast winter temperatures, but error bias is not endemic to a particular month.
- c) Skilful forecasts at 50 kPa are reflected in the surface temperatures, and a strong reliance of forecast on persistence does not necessarily show in pattern correlations at 50 kPa.

0830-0950 (F-215)

Vendredi / Friday

SESSION 13B : CATASTROPHES OCÉANIQUES
OCEANIC HAZARDS

METEOROLOGICAL FACTORS AFFECTING WATER LEVELS OF LAC SAINT-JEAN, QUEBEC
Michel Jean, Gérard Renaud and Claude Gignac

Simultaneous readings of water levels at three recording stations along the shore of Lac Saint-Jean (Roberval, Saint-Henri de Taillon and Saint-Gédéon) have been taken by Alcan (Aluminium Canada) since 1981. This data base is used to find storm surge and seiche episodes.

A review of the various forcing mechanisms of the storm surge (and the subsequent seiche) will be given. A scale analysis enables us to consider the meteorological factors, primarily the wind stress, as main forcing factors. The behaviour of the wind with respect to the water levels during the episodes will be presented.

Finally, the role of certain parameters that have been neglected (particularly the bathymetry and the representativity of the measurement sites) will be examined.

EVALUATION OF THE STORM SURGE MODEL FOR THE NOVA SCOTIA SHELF WITH DATA FROM THE CANADIAN ATLANTIC STORMS PROGRAM

M. Danard, J. Galbraith and S. Venkatesh

The AES storm surge model for the Nova Scotia shelf (expanded area version) has been further tested during the last half of CASP (14 February to 10 March 1986) and the period 24-26 October 1983. A number of improvements have been made so that with subjective sea-level pressures as input data it is now possible to use a realistic Charnock Constant.

Linear surge predictions have been made for the last half of CASP using subjective sea-level pressures, CMC prog data and adjusted CMC prog data (friction velocities multiplied by 2 or stresses multiplied by 4). As expected, the subjective data produced the best results. The predicted surge appears to lead the observed surge by 8 h on average.

The importance of tides and non-linear interactions was examined in predictions for 21-24 February 1986 and 24-26 October 1983. Residual surge predictions (non-linear tide plus surge minus non-linear tide) were slightly better than linear surge predictions, but require four times as much computing time, not counting tidal spin-up.

Predictions are generally better for the southern half of Nova Scotia than farther north. This may be due to the proximity of the northern boundary of the model to Cape Breton Island, or due to the import of waves from outside the model domain.

TSUNAMI GENERATION BY A MEGATHRUST EARTHQUAKE

M. Ng, P.H. LeBlond and T.S. Murty

Evidence from turbidity currents and analogy with other young subducting margins (e.g. Chile) has led seismologists to foresee the possibility of a very large, "megathrust" earthquake off the coast of British Columbia. The spectre of large, destructive tsunamis has been raised. Tsunami amplitudes and run-up are, however, strongly dependent on bathymetry and shoreline configuration. We are performing calculations of tsunami amplitudes on the coast of British Columbia, based on available models for bottom deformation, and using a resolution sufficient to address the complexity of the coastline. We will report on the model formulation and the results obtained to date.

NON-LINEAR NUMERICAL MODELLING OF TSUNAMI GENERATION AND PROPAGATION IN THE ST LAWRENCE ESTUARY

J. Chassé, M.I. El-Sabh and T.S. Murty

The St Lawrence Estuary is considered one of the high-hazard seismic zones in eastern Canada. This could be associated not only with naturally occurring earthquakes, as in the Charlevoix region, but also with induced earthquakes triggered by man's activity, such as the filling of certain reservoirs near Manicouagan Peninsula. The present study is a continuation of our efforts to provide realistic data on probable tsunami amplitudes at some selected locations along the estuary. We developed a two-dimensional, numerical non-linear model to simulate possible tsunamis resulting from 4 large hypothetical earthquakes at different areas in the estuary, namely, near île-aux-Coudres, between La Pocatière and La Malbaie, at the head of the Laurentian Channel and at mid-estuary off Rivières-aux-Outardes. The duration of an earthquake was taken as 5 s and bottom uplifts as ranging from 2 to 5 m. The results obtained from all numerical simulations show that tsunami waves with amplitudes between 1 and 3.5 m propagated more rapidly along the relatively deeper north shore and in the downstream direction. Tsunami hazards at any locality in the St Lawrence Estuary depend on the location of the epicentral area, the magnitude of the earthquake, the phase of the tide during which an earthquake occurs in addition to the morphology of that locality.

PHOTOCHEMISTRY AND CONDENSATION: THEIR ROLES IN THE FORMATION OF HAZE IN THE ATMOSPHERE OF URANUS

C. Blanchette

Voyager 2 observations showed the presence of extensive haze layers in the stratosphere of Uranus that may form by the condensation gases in the cold (50-100 K) stratosphere or be initiated by cosmic ray ionization. Products of the cracking of methane by photodissociation, such as ethane, acetylene, and possibly diacetylene, are likely to be the main condensates. These gases may form in the upper atmosphere and then flow down to lower temperature regions where they condense. Eventually, the newly formed particles are removed from the atmosphere by sedimentation. In this presentation, we calculate the range of size distributions expected using a 1-D model of the haze particle cycle and of the photochemistry of the atmosphere and compare them with the estimates from the observations.

SIMULATION ASSESSMENT OF LOCAL PHOTOCHEMISTRY AS A SOURCE OF OXIDANTS IN EDMONTON AND CALGARY

K.P. Gladstone, H. Niki, J. Bottenheim, P.B. Shepson and H.I. Schiff

Abstract not available.

SEASONAL VARIATION OF HYDROCARBON CHEMISTRY IN THE SATURNIAN ATMOSPHERE: A COMPARISON BETWEEN MEASUREMENTS AND MODELS

Yves Rochon

A one-dimensional photochemical model with eddy diffusion is used to simulate the latitudinal and seasonal variation of hydrocarbon chemistry in Saturn's stratosphere. The sensitivity of the calculations to changes in temperature structure and eddy diffusion will be examined. The results will be compared with measurements obtained by the IUE (International Ultraviolet Explorer) satellite and the IR and UVS instruments on board the Voyager spacecraft in order to assess possible changes in dynamics in the Saturnian stratosphere and the possible influence of auroral precipitation on stratospheric chemistry. In addition the potential influence of the absorption of solar radiation by the Saturnian ring system will be investigated.

A STUDY OF THE WINTER ARCTIC OZONE LAYER

W.F.J. Evans

CANOZE, a project to study the Arctic ozone layer in winter, has been successfully conducted from Alert at 82.6°N since 1986. A series of small scientific balloon payloads were flown to study Arctic ozone depletion chemistry. Ozonesondes were flown in January, February and March and total

ozone was monitored with a Brewer instrument using the moon as a light source. The ice particles associated with high-altitude polar stratospheric ice clouds were measured with backscatter sondes flown by J. Rosen from the University of Wyoming. In 1989, water vapour sondes were flown by NOAA. Miniprobe flights with the AES miniature infrared emission spectrometer were flown successfully. Excellent results were obtained in 1988 and 1989. The stratospheric temperatures were cold and the stable vortex remained over Alert during the entire month of January 1989. Conditions were suitable for the formation of polar stratospheric clouds with temperatures frequently below 195 K at altitudes from 15 to 23 km. Polar stratospheric clouds were found to be present and a nitric acid vapour profile was measured in the clouds. The low mixing ratios of nitric acid measured in this region confirm that the polar stratospheric ice clouds are composed of nitric acid ice as predicted by theory for their formation at temperatures around 195 K. Depleted layers of ozone were observed on some ozonesonde flights as in previous years. A comparison of the ozone measurements with TOMS data will be conducted.

1020-1200 (F-210)

Vendredi / Friday

SESSION 14A : PHYSIQUE DES NUAGES
CLOUD PHYSICS

A NUMERICAL INVESTIGATION OF SQUALL LINES

Kit Kong Szeto and Han-Ru Cho

The structure and evolution of squall lines are investigated numerically with a two-dimensional cloud model that includes ice-phase microphysics. The numerical simulations are performed on a large domain (750 km wide) with reasonably fine horizontal resolution such that both mesoscale and cloud-scale responses of the atmosphere can be accurately represented. The kinematic and precipitation structures of the numerically simulated squall lines are very similar to the ones observed in nature. The model momentum, heat and moisture budgets are used to diagnose the model outputs. The sensitivity of the model outputs to various ice-phase microphysics is also studied.

POLARISATION CIRCULAIRE : CORRECTION DES EFFETS DE PROPAGATION

Bernard Pettigrew et Enrico Torlaschi

Les particules contenues dans la précipitation sont généralement non-sphériques et cette anisotropie est responsable de la dépolarisation du signal radar. Lorsque le radar émet une onde polarisée circulairement cette dernière est dépolarisée lors 1) de la propagation radar-cible, 2) de la diffusion à la cible, et 3) de la propagation du signal rétrodiffusé vers le radar. Le signal reçu, polarisé elliptiquement, peut s'interpréter comme la superposition de deux composantes circulaires orthogonales. La dépolarisation de l'onde causée par le milieu anisotrope de propagation doit être attentivement considérée si l'on veut éviter une interprétation fortuite des mesures radar.

Les composantes circulaires de l'onde reçue sont décrites en terme des paramètres radar usuels : le facteur de réflectivité équivalente, \tilde{Z}_e , le rapport de dépolarisation circulaire, \tilde{C}_{DR} , et la covariance complexe entre les deux composantes $\tilde{\rho} \exp(j\tilde{\chi})$. Ces paramètres observables sont reliés aux caractéristiques de polarisation de la cible au moyen du terme de propagation $p \exp(j\chi)$. Il en résulte un système non-fermé de quatre équations. Cependant pour la pluie, il a été montré qu'à 3 GHz, le déphasage différentiel de diffusion égale à π , et $\chi \approx \pi/2$. Avec ces hypothèses, et considérant une fonction delta de Dirac $\delta(\alpha)$ comme distribution d'orientation des hydrométéores, on obtient \hat{Z}_e , \hat{C}_{DR} , $\hat{\rho}$ et $\hat{\chi}$ (ou \wedge indique la valeur estimée). Dans le but de valider cette méthode de correction, un modèle simulant numériquement les mesures de radar est considéré, et les caractéristiques de polarisation de la cible sont comparées aux valeurs estimées. En conclusion, la méthode de correction qu'on propose permet une meilleure interprétation des paramètres de radar à polarisation circulaire.

SURFACE TEMPERATURE DIFFERENCES ON GYRATING HAILSTONES

Roland List and Blair Greenan

Simulations of the growth of gyrating hailstones were performed in a closed circuit wind tunnel. The initial hailstone models were smooth, oblate ice spheroids with a major axis diameter of 2 cm and an aspect ratio of 0.67. At laboratory pressure, air temperatures of -5, -10, -15 and -20°C were selected and liquid water contents were varied between 1.1 and 17.1 g m⁻³.

Simultaneous measurements of the surface temperatures in the equatorial and polar regions were made during the growth of the hailstones using two infrared radiometric microscopes. Results indicate that a temperature difference of as much as 5.9°C existed between these regions, depending on the conditions of growth. The maximum temperature differences occurred in the liquid water content range of 1.5 to 6.4 g m⁻³, and growth in this region was generally characterized by a dry regime at the poles and a wet regime at the equator. These non-homogeneous surface conditions demonstrate the need to extend the existing heat and mass transfer theories.

DROP-SIZE DISTRIBUTIONS IN PULSATING TROPICAL RAIN

Roland List and Greg McFarquhar

Using the results of laboratory experiments on raindrop collisions, numerical models studying the temporal evolution of raindrop spectra beneath warm rain clouds verify the existence of the three-peak equilibrium distribution previously proposed for boxes by Valdez and Young (1985) and for shafts by List, Donaldson and Stewart (1987). Further investigations of raindrop spectra behaviour are then made by using a one-dimensional Eulerian shaft model, where the vertical advection of drops is based on an advection scheme with limited numerical diffusion. A pulsating input of drops at the shaft top produces drops arriving at the ground in packets, with the larger drops first, followed by the smaller ones. This replicates patterns of rainfall observed in Malaysia for the case of non-steady rain. The rain spectra averaged over time resemble the three-peak equilibrium distribution for steady rain. The significance of these results to remote sensing, hydrology and radar meteorology is briefly discussed.

RIGICE: DEVELOPMENT OF A CLIMATOLOGICAL FREEZING SPRAY MODEL FOR OFFSHORE STRUCTURES

Ross D. Brown

Freezing spray is a frequently encountered hazard in the Gulf of St Lawrence and water off the east coast of Canada. For the design and operation of offshore structures, it is useful to be able to quantify this hazard for extreme events. In 1986, the Hydrometeorology and Marine Division initiated the development of a spray icing model suitable for cylindrical offshore structures such as drilling platforms and bridge piers. The model, RIGICE, follows the structural segmentation approach of Horjen and Vefsnmo (1984) and breaks down complex structures into a series of horizontal and vertical cylinders. The model incorporates the boundary-layer model of Makkonen (1985a) for calculating heat transfer from the front half of a cylinder, and includes salinity effects and spongy ice following Makkonen (1985b).

In 1987, a joint project was initiated between Canada and Norway to evaluate the performance of RIGICE and the state-of-the-art time-dependent icing model, ICEMOD, developed by the Norwegian Hydrotechnical Laboratory. Preliminary results revealed that model response was similar where sea surface temperatures were above 0°C. However, RIGICE was found to greatly overpredict ice loads as sea surface temperatures approached the freezing temperature of sea-water. It was concluded that this was the result of RIGICE not including the time-dependent feedback mechanism of increasing brine film salinity following splashing with spray. This effect is considered critical for the successful modelling of spray icing in cold water environments, and efforts are currently under way to incorporate this into RIGICE. A preliminary climatological version of RIGICE has been implemented using 14 years of the NEDN 6-hourly hindcast of atmospheric and oceanographic parameters. Initial results have shown the need to incorporate ice cover effects into the system to obtain realistic ice-load return period values.

1020-1200 (F-215)

Vendredi / Friday

SESSION 14B : MODÉLISATION EN PRÉSENCE DE GLACE
SEA-ICE CIRCULATION MODELS

A SIMPLE ICE-OCEAN MODEL FOR THE GREENLAND SEA

Rosemary G. Wood and Lawrence A. Mysak

A steady, coupled model of the upper-ocean circulation and ice cover in a meridional channel will be described and applied to the Greenland Sea. The ocean flow is driven by wind stress, and a non-zero boundary condition on the meridional velocity is applied at the western side to produce a southward-flowing coastal current, which is representative of the East Greenland Current (EGC). To match the EGC to the interior Sverdrup solution, a Munk-type western boundary-layer current is introduced. The upper-ocean temperature is governed by an advection-diffusion equation, which is forced at the boundaries and by heat exchange with the atmosphere. The ice model is purely thermodynamic and the ice-edge position is determined iteratively since the stream function and temperature fields depend on the ice cover and, in turn, the ice cover is determined by both the ocean and air temperature. The range

of behaviour of the temperature field and ice-edge position is studied as a function of the parameters that characterize the ice-ocean drag, the ice transmission factor of the wind stress, the eddy heat diffusion coefficient and the air-ice heat exchange coefficient. The results compare favourably with observed ice data. In particular, the model simulates an often observed winter ice-edge bulge that extends from Greenland towards Spitsbergen.

APPLICATION OF A SIMPLE ICE-OCEAN MODEL TO THE LABRADOR SEA

Shiling Peng, Rosemary G. Wood and Lawrence A. Mysak

A simple steady, coupled ice-ocean model (developed by Willmott and Mysak, 1987) is applied in the Labrador Sea. The model consists of a thermodynamic reduced-gravity ocean forced by the surface wind stress, and a thermal equilibrium ice model. We determine the ice-edge position, ice thickness, ocean circulation and temperature field in a meridional channel domain. The optimum heat exchange parameters for the model in the Labrador Sea are found. The results show that the predicted ice-edge position compares favourably with the 50% ice-concentration isoline obtained from an analysis of 32 years of Arctic sea-ice data. The sensitivity of the model ocean fields and ice distribution for different atmospheric thermodynamic and dynamic forcings will be examined and shown for both climatology and individual years.

ON THE RELATIONSHIP BETWEEN ARCTIC SEA-ICE ANOMALIES AND FLUCTUATIONS IN NORTHERN CANADIAN AIR TEMPERATURE AND RIVER DISCHARGE

Davinder K. Manak and Lawrence A. Mysak

A lagged cross-correlation analysis of climatic data from the period 1953-1984 was carried out for three subregions of northern Canada (Beaufort Sea, Hudson Bay, Baffin Bay/Labrador Sea) to determine the relationships between sea-ice anomalies and surface air temperature and river discharge anomalies. The sea-ice data set consists of monthly Arctic sea-ice concentration data for the 32-year period 1953-1984. Significant negative correlations at the 95% level were found between sea-ice and temperature anomalies. There was a positive lag between ice and air temperature anomalies, with the maximum centred at a lag of 0 to 7 months depending on the region. Significant correlation at the 95% level was found between sea-ice and river discharge anomalies in only one of the two regions studied.

EFFECTS OF SALINITY IN A TWO-AND-A-HALF-LAYER UPPER-OCEAN GENERAL CIRCULATION MODEL

C.W. Yuen and J.Y. Cherniawsky

Results from a time integration of a $4^\circ \times 5^\circ$ global upper-ocean general circulation model will be presented. The model represents the upper ocean by two vertically homogeneous layers of variable thickness. The upper layer is the oceanic mixed layer, whereas the second layer represents a vertical average of the pycnocline. A thermodynamic sea-ice model is also included. The model is forced at the surface with seasonally-varying (a) observed wind stress, (b) heat fluxes, as defined by an atmospheric equilibrium temperature, and (c) surface salt fluxes representing the effects of evaporation and precipitation. The upper mixed layer interacts with the

second layer through entrainment and detrainment processes. The second layer is forced from below with heat and salinity fluxes that are derived using climatological temperatures and salinities at a local model depth. We compare the results from this experiment having prognostic salinity with those having fixed climatological salinity fields. The effects of predicting salinity on the model vertical mixing and stability, sea-ice distribution, and heat storage and transports will be discussed.

SEA-ICE MOTION OFF LABRADOR AND NEWFOUNDLAND DURING THE WINTER OF 1988/89
S. Prinsenberg and I. Peterson

The properties and motion of the pack-ice off the Labrador and Newfoundland shelves during the winter of 1988/89 were abnormal because of mild, early winter conditions and above normal westerly wind conditions. Ice beacons, tracking the thick pack-ice, could only be deployed at the end of the ice-growing season (early March) when the pack-ice finally extended into southern areas of the Labrador Shelf. Continual offshore ice motion caused open water or thin locally grown ice to occur between the offshore pack-ice and the land-fast ice. This paper will present the ice drift data from the ice beacons and the controlling atmospheric parameters encountered during the winter of 1988/89.

1020-1200 (C-410)

Vendredi / Friday

SESSION 14C : CHIMIE ATMOSPHERIQUE II
ATMOSPHERIC CHEMISTRY II

PRELIMINARY RESULTS FROM A 3-D CHEMICAL TRANSPORT MODEL
J.W. Kaminski

Preliminary results from a global chemical transport model will be presented from a model integration for a winter Antarctic scenario. The discussion will include the model domain, model components, the set of simplified chemical reactions used (odd oxygen, water), scenario selections and future modelling strategies.

CLOUD DYNAMICS AS AN EFFICIENT TRANSPORT MECHANISM FOR CHEMICAL SPECIES IN THE UPPER TROPOSPHERE
I. Hare

Abstract not available.

ARCTIC SUNRISE O₃ DEPLETION: A POSSIBLE SCENARIO WITH BROMINE CHEMISTRY
G.S. Henderson, J.C. McConnell, J. Bottenheim and L. Barrie

Several studies have observed a rapid decrease in Arctic O₃ mixing ratios within the stable planetary boundary layer. This appears to be correlated with the polar sunrise in the Arctic. An anticorrelation between O₃ and particulate bromine has also been noted. Previous model studies have not

been able to reproduce the observed behaviour. We speculate that heterogeneous chemistry during the long polar night results in the conversion of HBr and other unreactive forms of Br_x to active Br_x that rapidly forms Br and BrO with the onset of sunlight. In order to prevent the rapid conversion of active Br_x to HBr it is essential that species, such as HCHO and HO_2 , that react rapidly with Br, are present at concentrations much below normal. This requires that RO_2 rapidly reacts on the surfaces of aerosols and ice crystals, k_a . Efficiencies of HO_2 laboratory sticking coefficients and observed surface areas of the aerosols and ice crystals indicate that the effective heterogeneous rates that we require are reasonable. Starting with 30 pptv BrO and $k_a = 1 \times 10^{-2} \text{ s}^{-1}$ we find that O_3 decreases from 40 to 1 ppbv within 10 days. If we adjust the rate for the disproportionation reaction of BrO within current uncertainties and $k_a = 1 \times 10^{-2} \text{ s}^{-1}$ the O_3 drops to 6.1 ppbv after 1 day and 150 pptv after 2 days. Incorporation of ClO and continuing heterogeneous chemistry in separate scenarios enhance the depletion rate.

A 1-D BOUNDARY CHEMISTRY MODEL: A TOOL FOR EMEFS MEASUREMENT PROGRAM ANALYSIS

J.C. McConnell, G.S. Henderson, J. Bottenheim and L. Barrie

The Eulerian Model Evaluation Field Study (EMEFS) is designed to provide detailed measurements of acidic and oxidizing species, and their precursors for one of the grid squares of the ADOM Eulerian long-range transport model. Forest systems are often observed to emit copious quantities of volatile organic compounds and NO_x . Some of these compounds are sufficiently reactive that unusually high concentrations of O_3 result. During some of the EMEFS measurement intensives, meteorological conditions were sufficiently stable that a 1-D boundary model can be used to analyse the contribution of local chemistry to the oxidation state of the atmosphere. We have developed a 1-D boundary model of the troposphere that includes the chemistry of light non-methane hydrocarbons and a simplified oxidation scheme for isoprene. We present preliminary model results that have been applied to one of the hyper-intensive periods of measurements for early August 1988. We also compare the model results with the currently reduced measurement set in order to assess the impact of the advection of oxidants to the measurement site.

CHEMICAL AND MICROPHYSICAL PROPERTIES OF WINTER FOGS IN SOUTHERN ONTARIO

Ottario T. Melo and Yam T. Tam

Winter storms, particularly those involving freezing rain and extended periods of fog, are a threat to high voltage transmission systems and other facilities. The impacts of these storms depend on a number of poorly understood meteorological, microphysical and chemical factors. A study of the properties of winter storms in Southern Ontario has been under way during the past two winters. Measurements included ambient temperature, relative humidity, winds, precipitation intensity and type, and the occurrence of fog. Freezing precipitation and fog water samples were also collected and analysed for pH, conductivity and major ion concentrations.

This paper presents results dealing with the chemistry and microphysics of winter fogs. The chemistry of winter precipitation is also given for comparison.

NOUVEAUX RÉSERVOIRS EXPÉRIMENTAUX POUR DES ÉTUDES ENVIRONNEMENTALES EN CONDITIONS HIVERNALES

E. Pelletier, C. Brochu, R. Siron, S. Roy et P. Mayzaud

Des études antérieures sur le vieillissement du pétrole brut sous la glace dans un petit réservoir protégé ($1,6 \text{ m}^3$) nous ont conduit au développement d'un nouveau concept de mésocosmes expérimentaux spécialement adaptés aux recherches écotoxicologiques en conditions hivernales. Un groupe de 5 réservoirs expérimentaux a été construit à proximité de la station aquicole de l'INRS.

Chaque réservoir, d'une capacité de $3,5 \text{ m}^3$ (770 gal imp.), est constitué d'une paroi double en acier où circule un liquide réfrigérant permettant un contrôle précis de la température de l'eau du réservoir aussi bien en été qu'en hiver. La paroi interne des réservoirs est en acier inoxydable très résistant à la corrosion qui peut être recouverte d'une pellicule plastique selon les besoins des utilisateurs. Le fond conique de chaque réservoir est muni d'une trappe à sédiment permettant d'échantillonner les particules tombant de la colonne d'eau. Des échantillons de sédiments et d'animaux benthiques peuvent être déposés dans des bacs sur un support grillagé placé à la base de la colonne d'eau de 2,5 m. Deux échantillonneurs de 15 cm de diamètre ont été percés à 1 et 2 m de hauteur d'eau respectivement pour permettre d'introduire diverses sondes de mesure, un diffuseur d'air et des collecteurs d'échantillons d'eau. On peut aussi y aménager des hublots pour des observations directes des organismes étudiés. Le sommet de chaque réservoir est exposé à la lumière naturelle et le plafond du laboratoire d'échantillonnage et d'observation sert de pont de travail extérieur. L'air ambiant peut être soufflé au-dessus de la surface de l'eau permettant de générer des vaguelettes dans des conditions proches du milieu naturel. Tous les réservoirs peuvent être opérés en mode statique, en flôt continu indépendant ou même en cascade inter-réservoirs.

Les mésocosmes INRS ont été conçus par des chercheurs intéressés par des travaux écotoxicologiques en eaux glacées et même sous un couvert de glace. Pour cette raison, le sommet des réservoirs est exposé aux conditions climatiques extérieures. En hiver, la circulation d'air très froid à la surface de l'eau provoque la formation rapide d'une couche de glace pouvant atteindre 50 cm tout en maintenant la section inférieure protégée des mésocosmes à une température juste au-dessus du point de congélation de l'eau de mer. Le couvert de glace peut être maintenu plusieurs semaines et les travaux peuvent se poursuivre en utilisant les deux échantillonneurs latéraux sans perturber la surface de la glace.

RIVER PLUME LIFT-OFF UNDER A COMPLETE ICE COVER IN HUDSON BAY

L.M. Veilleux

Measurements of the temperature and salinity fields were made at the mouth of Great Whale River, southeastern Hudson Bay, during a period of complete sea-ice cover, just before spring breakup when discharge levels are reaching the highest values of the year. The aim of this experiment was to characterize the lift-off region of the freshwater plume as a function of tidal phase, bathymetry and discharge rate. There have been some laboratory

and analytical studies dealing with the lift-off point of surface buoyant jets and plume (e.g. Hearn et al., 1985) but none of them were based on field observations under ice-covered conditions. From vertical and longitudinal salinity profiles, the lift-off region of the plume was delineated. A description of the intrusion and turbulence features that were observed at the halocline level will be given. The differences and similarities between observations and the existing models for predicting the plume lift-off point will also be discussed.

IRRIGATION ADVISORY DEVELOPMENT

F.J. Eley

Problems with drainage and salinity make optimal watering essential on most Saskatchewan irrigation developments. The Irrigation Branch of Saskatchewan Water Corporation advises farmers on irrigation management. The Irrigation Branch is interested in having the capability to provide real-time advice for individual fields from the District Office, which will require a centrally operated water demand model with inputs of gridded precipitation data. The Hydrometeorological Research Division of the Canadian Climate Centre is working to develop such a system using radar-derived precipitation data and an optimized water-use model. Saskatchewan's main irrigation district at Outlook is ideally located near a weather radar station. The model will operate on a micro-computer.

NON-STEADY STATE DIAGENESIS IN A COASTAL MARINE SEDIMENT

A. Mucci and H.M. Edenborn

The vertical distribution of many chemical species in sediments can be described by steady-state diagenetic modelling. Steady-state conditions imply that the rates of diffusion, sedimentation and chemical/biological reactions are constant with time. Although violations of the steady-state assumptions occur in all environments, natural variations are often too small to influence the predictive ability of the models. However, when sedimentation rates are rapid, a non-uniform distribution of reactive organic matter can lead to large deviations from model predictions.

In 1971, a catastrophic landslide occurred on the north side of the Saguenay river at the town of St-Jean Vianney. An estimated $5.5 \times 10^6 \text{ m}^3$ of post-glacial marine clays were displaced and transported into the Saguenay Fjord. This resulted in the deposition of a layer of organic-poor marine clay on top of the relatively organic-rich indigenous mud and subsequent burial.

We measured a number of chemical parameters and the distribution of microbial activity in the sediments collected from two box cores taken on the landward slope of the largest basin of the Saguenay Fjord. These measurements were used to interpret the post-depositional behaviour of several redox-sensitive elements across the organic-poor landslide deposit.

The distributions of dissolved and extractable iron in the sediments clearly show the effects of the non-steady state sedimentation. The low sulphate reduction rates and associated low $\text{[H}_2\text{S]}$ concentrations in the organic-poor landslide deposit allowed the buildup of relatively high dissolved Fe(II) concentrations. The particulate iron maximum, which is normally found at or near the sediment-water interface and which is derived

from sedimentation and oxidation of Fe(II) diffusing to the thin redox boundary, was trapped by the landslide deposit and rapidly converted to acid-volatile-sulphides (AVS) following the rapid onset of sulphidic conditions.

Unlike iron, dissolved and extractible manganese profiles do not give any strong indications of the non-steady state conditions under which it was remobilized. Indirect evidence for the influence of the landslide deposit on manganese post-depositional migration is the presence of a solid-phase Ni peak at the top of the landslide deposit.

CALCITE SOLUBILITY BEHAVIOUR IN SEA-WATER IN THE PRESENCE OF MN(II): PRELIMINARY RESULTS

Alfonso Mucci

In view of recent field and laboratory studies it has become clear that the characterization of CaCO_3 equilibria in sea-water by the behaviour of pure calcite is often inappropriate. The incorporation of divalent cations that are present in sea-water or sediment pore waters and that substitute for calcium in the calcite crystal lattice can significantly alter its chemical properties. Of potential importance to the diagenesis of carbonate-rich deep-sea sediments is the influence of Mn^{2+} incorporation in calcite. The formation of manganoan calcite overgrowths or kutnahorite has been proposed to explain the apparent supersaturation of pore waters collected at depth ($> 10\text{-}15$ cm sub-bottom) in deep-sea carbonate-rich sediments.

Reagent-grade calcite was equilibrated with artificial sea-water at 25°C in a closed system in the presence of 1, 3, 5, 10 and 25 ppm of dissolved Mn^{2+} . During the equilibration of supersaturated solutions the $[\text{Mn}^{2+}]$, $[\text{Ca}^{2+}]$ and carbonate alkalinity decreased progressively with time until calcite saturation was reached (< 1 month). In undersaturated solutions, $[\text{Mn}^{2+}]$ remained constant whereas $[\text{Ca}^{2+}]$ and carbonate alkalinity increased. The CaCO_3 ion-concentration product (ICP) measured from undersaturation levelled off at values well below calcite saturation. The apparent steady-state CaCO_3 ICP decreased with increasing Mn^{2+} concentration in solution. However, after 248 days of equilibration, a pink overgrowth was observed on the calcite seed that had been in contact with the calcite undersaturated sea-water solution containing 25 ppm Mn^{2+} . The appearance of this overgrowth was associated with a sharp decrease in dissolved Mn^{2+} concentration in the solution. The overgrowth was identified as rhodochrosite by X-ray diffraction spectrometry.

THE MARINE KILLERS DINOFLAGELLATES: A GLOBAL PERSPECTIVE

Mohammed I. El-Sabh and Shoukri N. Messieh

Recent records show that toxic dinoflagellate blooms and associated outbreaks of paralytic shellfish poisoning (PSP), diarrhetic poisoning (DSP) and neurotoxic poisoning (NSP) are world-wide problems that constitute public health hazards. At the present time, there is no general consensus on the chain of events that would lead to red tide development and PSP outbreaks. Available information indicates that the areas of dinoflagellate blooms and PSP/DSP outbreaks have common oceanographic features that are best described as transitional zones between stratified and mixed waters. We show that on a world-wide scale, almost all reported areas of PSP/DSP occurrences coincide with areas of high tidal energy and strong frontal zones.

Cycles of dinoflagellate blooms and PSP outbreaks were attempted in the past, but with little success. Here we examine available records in both the Bay of Fundy and St Lawrence Estuary and show a mean cycle of 4.5-5.5 years in both areas. This may coincide with similar cycles of 5.8 years in the Bay of Fundy and 4.8 years in the St Lawrence Estuary obtained from Fourier spectra of long-term sea-level data. The observation of these cycles is intriguing. However, more analysis would be required for an objective evaluation of the causality of these cycles, if they indeed occur.

BAROTROPIC MOTIONS IN THE GULF OF SUEZ, EGYPT

M.A. Rady, J.O. Backhaus, M.I. El-Sabh and T.S. Murty

A two-dimensional numerical model is developed to study the barotropic motion in the shallow (average depth 40 m), elongated (300-km long, 40-km wide) Gulf of Suez, Egypt. The non-linear hydrodynamical vertically integrated equations are solved by means of a semi-implicit numerical technique, using a grid of 3 km x 3 km. The results obtained show the southern part of the Gulf is dominated by strong tidal currents, whereas the northern sector is dominated by non-tidal motions. For the tidal motions, the results obtained are in good agreement with observations and reveal the Kelvin wave nature with partial reflection. The non-tidal motions, induced by wind stress and horizontal density gradient, show the presence of three gulf-wide eddies, two clockwise in the northern part and one counter-clockwise in the southern part. Contrary to what was speculated earlier, the against-wind current that is confined to the central relatively deep channel is produced mainly by the long-channel pressure gradient resulting from the persistent NW axial winds and enhanced by the permanent S-N slope of mean sea-level and density gradient.

STORM SURGES IN THE ARABIAN GULF

M.I. El-Sabh and T.S. Murty

The storm surge phenomenon in the Arabian Gulf including the Strait of Hormuz is discussed with particular emphases on the development of mathematical models for prediction purposes. The Gulf is mainly influenced by extra-tropical weather systems, whereas the region south of the Strait of Hormuz is affected by tropical cyclones. The west-to-east directed extratropical cyclone tracks and the generally east-to-west directed tropical cyclone tracks converge near the Strait of Hormuz. A mesoscale weather system that deserves special attention in prescribing the meteorological forcing functions is the so-called "winter-Shamal". A two-dimensional numerical model is developed to study the storm surges in the Arabian Gulf. The results show that the Gulf is subject to major negative and positive storm surges. Strong winds associated with the Shamal system, coupled with atmospheric pressure gradients, topography and tidal effects, can give rise to water-level deviations of several metres. Storm surges observed during the period 17-19 January 1973 show negative values in the 0.5 to 1.0 m range and were widespread in the Gulf.

MODÉLISATION NON-LINÉAIRE DES MARÉES DANS L'ESTUAIRE DU SAINT-LAURENT

J. Chassé, M.I. El-Sabh et T.S. Murty

Un modèle numérique bi-dimensionnel, aux équations du mouvement non-linéaires, est développé afin de modéliser les marées dans l'estuaire du Saint-Laurent. L'amplitude et la phase des quatre composantes principales (M_2 , S_2 , N_2 et K_1) sont appliquées aux extrémités aval de la région modélisée et sur un transect transversal aux environs de Saint-Jean-Port-Joli. Les résultats obtenus présentent une amélioration par rapport à ceux de travaux antérieurs et sont compatibles avec les observations faites dans l'estuaire. Ces résultats montrent une accumulation d'eau dans une grande partie de l'estuaire, le long de la côte nord par rapport à la côte sud. L'amplitude des quatre composantes subit une augmentation de l'aval vers l'amont et leur longueur d'onde présente une diminution dans ce même sens. L'importance des composantes, l'une par rapport aux autres, est exactement la même que celle qui est obtenue par l'analyse harmonique.

MOVEMENT AND DISPERSION OF OIL SLICKS IN THE ARABIAN GULF

M.I. El-Sabh and T.S. Murty

The extensive oil drilling and transportation activities in the Arabian Gulf increased the possibility of oil spills and the consequent threat of oil pollution to the regional ecology. The available literature concerning the main aspects of the physical oceanographic characteristics affecting the movement and spreading of oil spills in the Gulf are reviewed. It is concluded that evaporation, wind-driven currents and sandfall are important as weathering processes whereas tidal currents are causes of the lateral spreading of slicks. Oil-spill modelling has shown some usefulness in estimating the trajectories of a few major spills as illustrated by reference to three models developed for the Gulf. The performance of these models, their capabilities and limitations are reviewed. Recommendations are made to gather more data on the behaviour of oil spills in this particular environment.

MOPITT: AN LMR/PRM INSTRUMENT DESIGN FOR TROPOSPHERIC CO MEASUREMENT ON THE POLAR ORBITING PLATFORM OF EOS

J.C. McConnell, J.R. Drummond, J.C. Gille and G.P. Brasseur

Carbon monoxide (CO) is an important species in determining the oxidation state of the troposphere owing to its role controlling OH abundances and as an indicator of biological activity. Thus careful measurements of the CO concentration on a global basis have been recognized as being important to our understanding of tropospheric chemistry. We are developing a satellite-based instrument to obtain profile and column densities of troposphere CO with a horizontal resolution of about 25 km. The instrument is based on an advanced form of gas correlation technique called a Length-Modulated Radiometer (LMR), a development from the Pressure Modulator Radiometer (PMR) instrument. It operates by sensing the upwelling infrared radiation from the atmosphere in several wavelength regions. The operating principles of the LMR, some laboratory results and the performance of a satellite-based instrument will be discussed.

ADSORPTION ET COMPÉTITIVITÉ DES PHÉNOMÈNES SUR DES ARGILES EN SUSPENSION : MÉTAUX ET COMPOSÉS PHÉNOLIQUES

Christian Gagnon, Michel Arnac et Jean-Rock Brindle

Le phénomène d'adsorption/désorption des polluants est un processus fondamental de séquestration par lequel le milieu marin peut maintenir un certain équilibre vis-à-vis le milieu extérieur. Quelques études ont déjà démontré certains aspects compétitifs du phénomène mais malheureusement avec des concentrations trop éloignées de celles du milieu naturel.

Les argiles (illite, kaolinite et chlorite) sont les adsorbants étudiés. Les isothermes d'adsorption ont été établis pour les métaux Cd, Zn et Ni ainsi que pour deux composés organiques (eugénol et acide vanillique). D'après les études de cinétique, il ressort qu'une adsorption in vitro quasi-stationnaire est obtenue rapidement (3-5 h) pour les cations. La chlorite, suivie de l'illite et de kaolinite, s'avère être l'argile qui présente la capacité d'adsorption la plus élevée. Les phénomènes de compétitivité d'adsorption sont évalués en combinant d'une part, les effets des cations métalliques entre eux et d'autre part en faisant intervenir les interactions des polluants phénoliques hautement électronégatifs.

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Institute of Ocean Sciences
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Téléphone : (604) 356-6311**

Prière de contacter le Comité d'organisation pour les renseignements d'ordre général et le Comité scientifique pour les sessions spéciales, ateliers de travail, etc.

**Exposants, prière de contacter :
Ms Gail Gabel
Aanderaa Instruments
560 Alpha Street
Victoria, Colombie-Britannique, V8Z 1B2**

La liste des conférenciers invités n'a pas encore été finalisée. Quelques conférenciers internationaux très prestigieux seront aussi choisis parmi les participants à la conférence commémorant la retraite du Dr R.W. Stewart, qui aura lieu à Victoria, juste avant la conférence de la SCMO.

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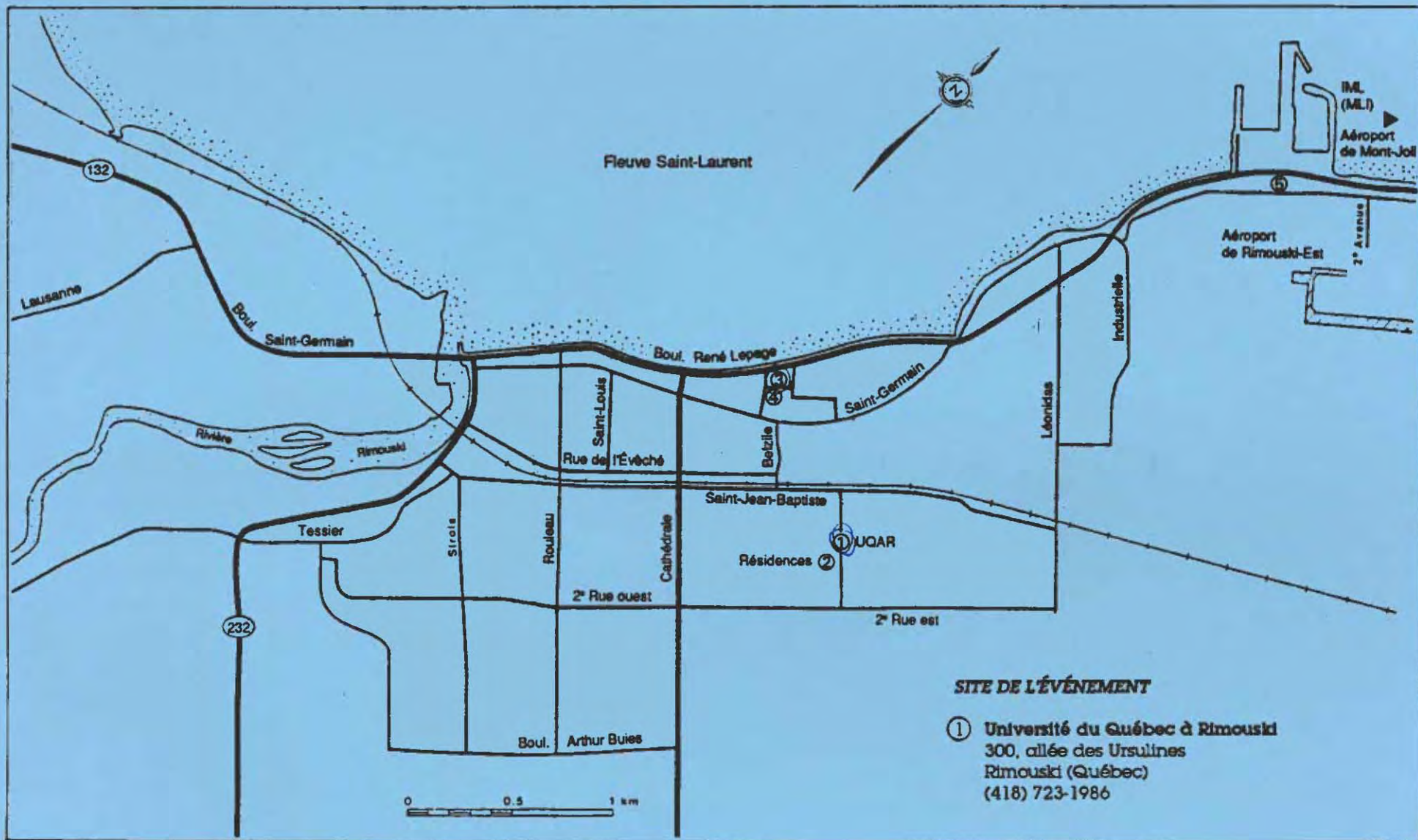
Please contact the organizing committee regarding general inquiries and the scientific committee for special sessions, workshops, etc.

**Exhibitors please contact:
Ms Gail Gabel
Aanderaa Instruments
560 Alpha St.
Victoria, British Columbia, V8Z 1B2**

The list of invited speakers has not yet been finalized. Some highly prestigious international speakers will also be drawn from the attendees at the conference commemorating the retirement of Dr R.W. Stewart, which will be held in Victoria, just prior to the CMOS Conference.

NOTES

BIENVENUE À RIMOUSKI



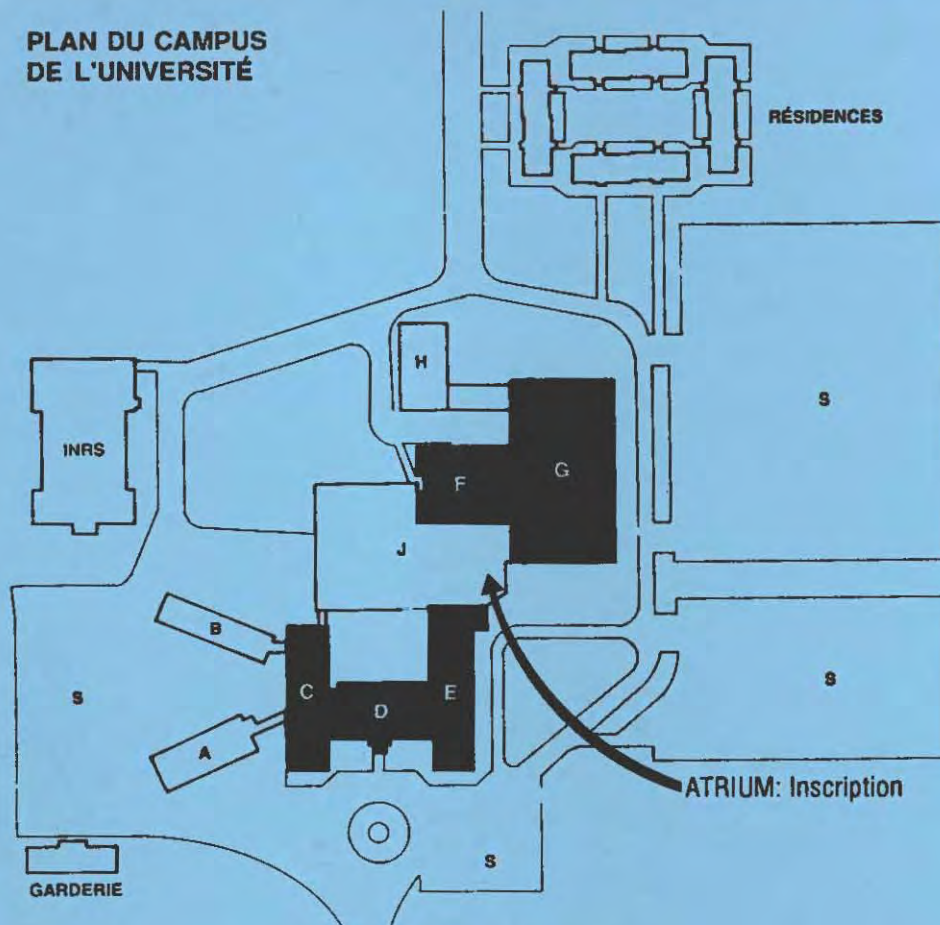
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