

# 33° Congrès de la SCMO 33° CMOS Congress

Programme et résumés Program and Abstracts

# La prévision environnementale

# Environmental Prediction

Société canadienne de météorologie et d'océanographie Canadian Meteorological and Oceanographic Society Université du Québec à Montréal, Montréal, Québec, Canada 31 mai - 4 juin 1999/May 31 - June 4, 1999

> Co-Éditeurs/Co-Editors : Yves Chartier Dr Harold Ritchie Jean-Guy Cantin

> > http://www.cmc.ec.gc.ca/scmo99 http://www.cmc.ec.gc.ca/cmos99

> > > ISBN 0-9698414-6-9







#### Environment Canada

#### Un message de l'honorable Christine S. Stewart, ministre de l'Environnement

À tous les congressistes au 33<sup>e</sup> Congrès annuel de la Société canadienne de météorologie et d'océanographie, je souhaite la bienvenue à Montréal, une ville reconnue au Canada et par le monde entier en matière de prévision environnementale et de recherche.

En tant que source officielle d'information et d'avertissements météorologiques au Canada, Environnement Canada offre quotidiennement à des millions de Canadiens et Canadiennes des prévisions environnementales fiables et précises. Ces prévisions les aident à planifier leurs activités et à se protéger (ainsi que leurs familles et leurs biens) contre les effets des conditions météorologiques et environnementales violentes et dangereuses. D'un océan à l'autre, les Canadiennes et Canadiens peuvent compter sur l'expertise mondiale en prévisions météorologiques et sur le dévouement de météorologues et océanographes réunis ici au Congrès.

Je souhaite que le Congrès suscite des débats intéressants et renforce les liens qui concrétiseront l'engagement du Canada à fournir à sa population des mesures de prédiction environnementale dépassant nos normes d'excellence.

#### A message from the Honourable Christine S. Stewart, Minister of Environment

I am pleased to welcome all delegates to the Canadian Meteorological and Oceanographic Society's 33rd Annual Congress held this year in Montreal, a city renowned within Canada and around the world for its environmental prediction and research.

Everyday, Environment Canada, Canada's official source of environmental information and weather warnings, provides millions of Canadians with dependable and accurate environmental predictions that help them plan their activities and protect themselves, their families and their property from the effects of severe weather and hazardous environmental conditions. From coast to coast, Canadians benefit from Canada's world-renowned expertise in environmental prediction and the dedication of the meteorologists and oceanographers who have assembled at this Congress.

May your deliberations stimulate debate and strengthen links that will further Canada's commitment to offer all Canadians environmental prediction measures that not only meet but exceed our standard of excellence.

Seimac your trusted technology partner with over 25 years of experience and an excellent reputation for the provision of site-specific marine meteorology, offshore environmental monitoring equipment and services, sophisticated software development, satellite telecommunications equipment/services and software/hardware integration to the ocean research community and to the transportation, public utility and defence industries.

We provide cost-effective and value-added instruments and services to meet our clients' specific needs.



271 Brownlow Avenue Dartmouth, Nova Scotia

B3B 1W6

Tel: 902-468-3007 Fax: 902-468-3009 Email: <u>info@seimac.com</u>

www.seimac.com

Delivering custom engineered tracking, meteorological & data solutions

Quelques mots sur la Société ii A Word about the Society ii
Un mot du président de la SCMOiii A word from CMOS Presidentiii
Un mot de notre présidentv A word from our presidentv
Un mot du président du comité scientifiquevii A word from the President of the Scientific Committeevii
Un mot du président du comité organisateur du congrès
Les comités organisateurs du congrès de 1999ix Congress 1999 Organizing Committeesix
Informations et évènements sociauxxi Informations and Social Eventsxi
Réunions des comités et évènements sociaux
Conférenciers des plénièresxix Pleanary Speakersxix
Expositions commercialesxx Commercial Exhibitsxx
Un aperçu de la semainexxvii Week at a glancexxvii
Horaire des présentations
Explication des codes de résumés
Résumés des exposés
Résumés des affiches
Index des auteurs
Adresses des auteurs
34e Congrès annuel

# Table des matières **Table of Contents**



#### Quelques mots à propos de la Société

La Société canadienne de météorologie a été formée en 1967, à partir d'un chapitre de la Royal Meteorological Society. Lorsque les océanographes s'y sont joints en 1977, le nom de la société est devenu Société canadienne de météorologie et d'océanographie.

La Société fut incorporée sous ce nom en 1984. La SCMO est une organisation nationale regroupant des individus, centres et chapitres voués à la promotion au Canada de la météorologie et de l'océanographie, ainsi que des disciplines environnementales connexes, sous tous leurs aspects. La Société offre aussi la certification d'experts conseils en météorologie et l'approbation des présentateurs météo.

Quatorze centres locaux ou sections sont les pivots des activités locales et régionales. Les intérêts scientifiques de la Société incluent : la météorologie opérationnelle, la climatologie, l'hydrologie, la pollution de l'air, la météorologie agricole et forestière, la mésométéorologie, les glaces flottantes, et l'océanographie chimique, physique et halieutique.

La Société offre des bourses de voyages à des étudiants pour assister aux congrès annuels, une bourse de voyage à un enseignant pour l'atelier «Project Atmosphere» de l'AMS/NOAA, et la bourse du troisième cycle «Weather Research House/SCMO/CSNRG».

Les principales publications de la Société sont le CMOS Bulletin SCMO bimestriel et Atmosphere-Ocean (A-O), une revue scientifique trimestrielle qui présente des articles, préalablement soumis à la critique, sur les résultats des recherches originales. La SCMO a aussi une page d'accueil sur son site WEB où on y trouve de l'information générale dur la SCMO et ses activités, ainsi que sur la science et l'enseignement de la météorologie et de l'océanographie au Canada.

On trouvera plus d'information sur la SCMO à http://www.meds-sdmm.dfo-mpo.gc.ca/cmos/.

#### About the Society

The Canadian Meteorological Society was formed in 1967 from a branch of the Royal Meteorological Society. In 1977 when the oceanographic community joined, the name of the Society was changed to the Canadian Meteorological and Oceanographic Society (CMOS).

The Society was subsequently incorporated with this name in 1984. CMOS is a national society of individuals, centres and chapters dedicated to advancing all aspects of atmospheric sciences, oceanography, and related disciplines in Canada. The Society also offers accreditation of meteorological consultants and endorsement of media weathercasters.

Fourteen Society centres and chapters across Canada serve as focal points for local and regional activities. Scientific interests of the Society include: operational meteorology, climatology, hydrology, air pollution, agriculture/forestry meteorology, mesoscale meteorology, floating ice, physical, chemical and fisheries oceanography.

The Society offers travel bursaries for students to attend Annual Congresses, a secondary school teacher travel bursary for the AMS/NOAA Workshop "Project Atmosphere", and the "Weather research House/CMOS/NSERC" graduate student supplementary scholarship.

The main publications of CMOS are the bimonthly "CMOS Bulletin SCMO" and Atmosphere-Ocean (A-O), a quarterly refereed journal for the publication of results of original research. The Society also maintains an electronic Web Site, with information on the Society and its activities, and on meteorological and oceanographic science and education across Canada.

Detailed information on CMOS can be found on this web site at http://www.meds-sdmm.dfo-mpo.gc.ca/cmos/

#### 33° Congrès - Un mot de notre président

Bienvenue à Montréal et au 33° Congrès annuel de la Société canadienne de météorologie et d'océanographie! Bien des gens considèrent Montréal comme le point central de la météorologie au Canada, et ce, depuis les débuts de la SCMO, qui était présente lors de la création dans les années 60 des programmes de deuxième et troisième cycles en météorologie à McGill et plus tard à l'Université du Québec à Montréal. Dans le domaine de la prévision météorologique opérationnelle, Montréal a accueilli le centre météorologique national au sein du «Central Analysis Office» (CAO) de Transports Canada, aujourd'hui appelé le Centre météorologique canadien (CMC) d'Environnement Canada. Dans le secteur privé et les médias plus particulièrement, la chaîne MétéoMédia vient tout juste de fêter son dixième anniversaire de diffusion en continu sur le câble des conditions météorologiques pour tout le Canada, à partir de ses studios de Montréal. Ces trois organismes, McGill, CAO/CMC et MétéoMédia, ont été reconnus en tant que leaders mondiaux dans leurs domaines, non pas seulement une fois, mais pendant plusieurs décennies.

Ce Congrès me rappelle de bons souvenirs puisque c'est à Montréal que j'ai fait mes premières armes comme prévisionniste au bureau météorologique de Dorval et au CAO, mais c'est également là que j'ai terminé mes études supérieures en météorologie. Il n'est pas surprenant que les dirigeants des services gouvernementaux et des universités à l'époque aient été également très impliqués dans les débuts de la SCMO: MM. Hitschfeld, Boville, Orvig et Vowinckel, de McGill; MM. Leaver, Robert, Kwizak et Anderson, du CAO. Et la tradition se perpétue aujourd'hui.

Nous sommes en effet très privilégiés de bénéficier de tout le talent et toute l'expérience du comité organisateur du Congrès, sous la direction du président du centre de Montréal, Pierre Dubreuil. Jean-Guy Cantin a réuni une équipe imposante pour voir aux préparatifs locaux et Hal Ritchie a mis en place un programme scientifique étoffé sur le thème de la Prévision environnementale. En plus d'assister à de nombreuses présentations scientifiques, vous êtes cordialement invités à participer à d'autres événements annuels très importants qui ont lieu pendant les congrès de la SCMO - l'Assemblée générale annuelle, le banquet, le lunch Patterson et le lunch Tully.

Je vous souhaite à nouveau la bienvenue au Congrès. L'atmosphère promet d'être stimulante!

Bill Pugsley, Président

#### Congress 33- A Word from our President

Welcome to Montreal and the 33rd Annual Congress of the Canadian Meteorological and Oceanographic Society! Many people consider Montreal one of the principal foci of Canadian meteorology for at least the lifetime of CMOS itself, having seen the birth of a graduate program in meteorology at McGill in the sixties and later at the University of Quebec at Montreal. In operational weather forecasting, Montreal has been home to the national centre of weather guidance at what was originally the Central Analysis Office of the Meteorological Branch of Transport Canada and is today the Canadian Meteorological Centre of Environment Canada. In the private sector and the media in particular, the Weather Network has just celebrated its tenth anniversary of broadcasting the weather continuously on cable to all of Canada from its studios in Montreal. All three examples, McGill, CAO/CMC and the Weather Network have been recognized as world class leaders in their field, not just in one year but over decades.





This Congress brings back special memories to me personally because Montreal is where I got early experience as a forecaster at the Dorval Weather Office and at CAO and also where I completed a graduate degree in meteorology. It is not surprising that the names at the top of academia and government service then were also the prominent in the early days of CMOS: Hitschfeld, Boville, Orvig and Vowinckel at McGill, Leaver, Robert, Kwizak and Anderson at CAO. And so it continues today.

We are indeed fortunate to have available the skill and experience of the team that organized this Congress, under the leadership of the Chair of the Montreal Centre, Pierre Dubreuil. Jean-Guy Cantin has assembled an impressive team to look after local arrangements and Hal Ritchie has organized a rich scientific program under the theme of Environmental Prediction. In addition to hearing the many scientific papers, you are cordially invited to participate in the other once-a-year events that are an important part of any CMOS Congress, the Annual General Meeting, the Banquet, the Patterson Lunch and the Tully Lunch.

Once again, welcome to the Congress. Enjoy the stimulating atmosphere!

Bill Pugsley, President

Bienvenue à vous tous, chers congressistes,

C'est avec joie, fierté et reconnaissance que je vous souhaite la bienvenue au 33° Congrès de la Société canadienne de météorologie et d'océanographie.

La joie de vous accueillir à Montréal, la deuxième plus grande ville francophone du monde. Je vous encourage à explorer les coins touristiques et les restaurants, et à vous imprégner, pendant quelques jours, de notre joie de vivre et de notre exubérance.

La fierté de la vigueur et de la diversité des organismes oeuvrant en météorologie et en océanographie à Montréal, ainsi que de la qualité de nos chercheurs et professionnels. Plusieurs de nos membres sont reconnus comme leaders de leur spécialité, à l'échelle nationale et internationale.

La reconnaissance envers tous ceux et celles qui se sont dévoués pour organiser ce Congrès. Le Dr. Hal Ritchie et son équipe ont structuré un programme de haute qualité. Le thème "la prévision environnementale" nous centre résolument sur le futur et démontre l'importance grandissante de nos disciplines, à l'aube du 21° siècle. Avec plus de 250 présentations scientifiques, je suis persuadé que chacun saura bénéficier de notre richesse collective.

M. Jean-Guy Cantin et son équipe méritent aussi notre pleine reconnaissance pour avoir organisé tous les aspects logistiques afin que ce Congrès soit agréable pour chacun de vous. Bâtissant sur les succès des Congrès précédents, nous voulons vous permettre de profiter au maximum de votre séjour. Je suis particulièrement heureux que nous ayons pu offrir des logements à un coût très abordable, pour favoriser la participation des étudiants.

Finalement, je vous suis reconnaissant, chers congressistes. Vous êtes l'essence même du Congrès. Bien plus qu'une suite de présentations, le Congrès est l'occasion de contacts, d'échanges, de discussions et d'une remise en question de nos orientations. C'est un temps propice pour développer des amitiés et des collaborations. Merci de votre participation et de votre implication. C'est cela qui fera de ce Congrès un moment mémorable.

Espérant que vous passerez une semaine merveilleuse avec nous,

Pierre Dubreuil Président, Centre de Montréal Société canadienne de météorologie et d'océanographie

Welcome to all of you, dear colleagues,

It is with joy, pride and thankfulness that I welcome you to the 33<sup>rd</sup> Congress of the Canadian Meteorological and Oceanographic Society.

Joy of welcoming you in Montreal, the second largest french-speaking city in the world. I encourage you to explore the touristic areas, the restaurants, and to become part of our exuberant "joie de vivre" for a few days.

Pride in the vigor and diversity of organizations involved in meteorology and oceanography in Montreal, and in the quality of our researchers and professionals. Many of our members are recognized as leaders of their specialty, nationally and internationally.





Thankfulness towards all those that have worked diligently to organize this congress. Dr. Hal Ritchie and his team have structured a high quality program. The theme "environmental prediction" focuses us on the future and demonstrates the growing relevance of our disciplines, as we approach the 21st century. With more than 250 scientific presentations, I am convinced that everyone will benefit from our collective richness.

M. Jean-Guy Cantin and his team also deserve our deepest thanks for organizing all the logistical aspects to make this congress enjoyable to everyone of you. Building on the previous congresses' successes, we want to let you benefit fully from your stay with us. I am particularly happy that we were able to offer very affordable accommodation, to support student participation.

Finally, I am thankful to you, dear participants. You are the essence of the congress. Much more than a sequence of presentations, the congress is an opportunity for contacts, exchanges, discussions and reassessment of our orientations. It is the perfect time to build friendships and collaborations. Thanks for your participation and implication. This is what will make this congress a memorable event.

Hoping you will have a marvelous week with us,

Pierre Dubreuil
President, Montreal Centre
Canadian Meteorological and Oceanographic Society

#### Chers collègues,

Le thème que nous avons retenu, « Prévision environnementale », a suscité une forte réponse de la collectivité scientifique, tant au sein de la SCMO qu'à l'extérieur; nous avons ainsi reçu quelque 260 présentations couvrant une vaste gamme de sujets de météorologie et d'océanographie. Nous avons également le plaisir d'annoncer que des scientifiques de très haut niveau ont accepté notre invitation de prononcer une conférence, ce qui donnera un cadre solide à un programme qui promet d'être intéressant et enrichissant, présentant les résultats de recherches passionnantes dans un domaine scientifique qui évolue très vite.

Je tiens à remercier les membres du Comité du programme scientifique, dont on trouvera la liste dans le présent volume, qui m'ont aidé à examiner les résumés, à trouver les conférenciers invités et à organiser le programme; le Comité organisateur, qui s'est attaqué avec enthousiasme aux nombreux détails grâce auquel le Congrès se déroulera dans une atmosphère agréable et stimulante; et vous tous, les auteurs, qui apportent l'information scientifique, le coeur même du Congrès.

Bienvenue au Congrès!

Harold Ritchie Président Comité du programme scientifique, Congrès 1999 de la SCMO

#### Dear Colleagues,

Our "Environmental Prediction" theme has drawn a very strong response from the scientific community both inside and outside CMOS, with a total of approximately 260 presentations in a wide range of topics in Meteorology and Oceanography. We are also pleased that very high caliber scientists have accepted our invitations to be invited speakers, providing a solid framework for what promises to be an informative and interesting program presenting exciting research in rapidly evolving sciences.

Sincere thanks are expressed to: the members of the Scientific Program Committee, as listed nearby in this volume, for their help in reviewing abstracts, arranging invited speakers, and organizing this program; to the Local Arrangements Committee for their enthusiastic collaboration in organizing the many details that provide a stimulating and enjoyable atmosphere for the Congress; and to all you authors who supply the science at the heart of this Congress.

Welcome to your Congress!

Yours sincerely,

Harold Ritchie Chair, CMOS Congress '99 Scientific Program Committee





En tant que président du comité organisateur, je souhaite à tous et toutes la plus cordiale bienvenue à Montréal. Les membres du comité organisateur et ceux du comité scientifique ont beaucoup travaillé afin que le 33° congrès soit un succès. Je les en remercie. N'hésitez pas à faire appel à leur service.

Je tiens à remercier sincèrement, d'abord, nos commanditaires (par ordre alphabétique):

APMQ (Association professionnelle des météorologistes du Québec) CAMPBELL SCIENTIFIC (CANADA) CORP.

ENVIRONNEMENT CANADA

HYDRO-QUÉBEC

NEC/HNSX

**SEIMAC** 

TELESAT CANADA

et également tous les organismes qui ont contribué de près ou de loin à ce congrès :

AIR CANADA MÉTÉOMÉDIA

UNIVERSITÉ DU QUÉBEC À MONTRÉAL

UNIVERSITÉ McGILL

Au plaisir de vous rencontrer, Jean-Guy Cantin

As the Chairman of the Local Arrangements Committee, I want to welcome you to Montreal. The Local Arrangements Committee and the Scientific Committee members worked hard to make the  $33^{rd}$  Congress a success. I take this opportunity to thank them all. They will be glad to help you.

I want to thank sincerely, first, our sponsors (alphabetical order):

APMQ (Association professionnelle des météorologistes du Québec) CAMBELL SCIENTIFIC (CANADA) CORP.

**ENVIRONMENT CANADA** 

HYDRO-QUÉBEC

NEC/HNSX

SEIMAC

TELESAT CANADA

and also all the organizations which contributed closely to the congress:

AIR CANADA MÉTÉOMÉDIA UNIVERSITÉ DU QUÉBEC À MONTRÉAL McGILL UNIVERSITY

We are looking forward to meeting you. Jean-Guy Cantin

#### Comité local organisateur / Local Arrangements Committee

Président, Centre de Montréal de la SCMO / Chairman, CMOS Montreal Centre: Pierre Dubreuil Environnement Canada Centre météorologique canadien

Président / President: Jean-Guy Cantin Météorologiste retraité

Trésorerie / Treasurer Dr. Monique Tanguay Environnement Canada Recherche en Prévision Numérique

Inscription / Registration André Sévigny Environnement Canada D.E.A. - Région du Québec

Exposition / Exhibit Convenor Robert Mailhot Environnement Canada Centre météorologique canadien

Activités sociales / Social Activities Convenor Louis Lefaivre Environnement Canada Centre météorologique canadien

Publicité auprès des médias / Media Publicity Convenor Denis Bourque MétéoMédia

Révision des textes anglais et français / English and French Documents Revision Convenor Marie-France Guéraud

Site internet / Web site Yves Chartier Environnement Canada Recherche en Prévision Numérique Les comités organisateurs du congrès de 1999 Congress 1999 **Organizing** Committees



Porte-parole / Spokesman

Michel Jean

Environnement Canada

Centre météorologique canadien

Alain Bourque

Environnement Canada

D.E.A. - Région du Québec

Responsable - UQÀM / UQÀM Convenor

Prof. Enrico Torlaschi

Université du Québec à Montréal

#### Comité scientifique / Scientific Committee

Hal Ritchie (Président / Chairman)

Environnement Canada

Recherche en prévision numérique

Richard Greatbatch

Dalhousie University Department of Oceanography

Stéphane Laroche

Environnement Canada

Data Assimilation and Satellite Meteorology Division

Richard Leaitch

Environment Canada

Cloud Physics Research Division

Charles Lin

McGill University

Department of Atmospheric and Oceanic Sciences

René Servranckx

Environnement Canada

Canadian Meteorological Centre

Peter Zwack

Université du Québec à Montréal

Francis Zwiers

**Environment Canada** 

Canadian Centre for Climate Modelling and Analysis

#### BUREAU DE L'INSCRIPTION

Hôtel Gouverneur, Place Dupuis, 1415, rue Saint-Hubert, Montréal (coin Sainte-Catherine Est et Saint-Hubert) :

Dimanche le 30 mai : de 16 : 00 à 21 : 00

Université du Québec à Montréal, Pavillon Judith-Jasmin, 405, rue Sainte-Catherine Est (on peut y accéder par le métro, à la station Berri-UQAM) :

 Lundi le 31 mai :
 de 7 : 30 à 17 : 00

 Mardi le 1<sup>er</sup> juin :
 de 8 : 00 à 17 : 00

 Mercredi le 2 juin :
 de 8 : 00 à 16 : 00

 Jeudi le 3 juin :
 de 8 : 00 à 16 : 00

# Information and Social Events

Information et

événements sociaux

#### <u>BIOSPHÈRE</u>

#### <u>COCKTAIL DE BIENVENUE NEC-HNSX - LA BIOSPHÈRE:</u>

(inclus nourriture, 2 consommations, 2 billets de métro et visite guidée de la Biosphère)

Endroit : La BIOSPHÈRE, 160, chemin Tour-de-L'Isle, Île Sainte-Hélène, Montréal (à 3 minutes de marche du Métro Île Sainte-Hélène)

Date : lundi le 31 mai 1999 Heure : de 18 : 00 à 19 : 30

Transport (Métro) : Nous donnerons avec chaque inscription deux billets de métro (aller - retour)

Aller : Se rendre au Métro Berri-UQAM à quelques pas où se tient les sessions et les kiosques des exposants. Ensuite se diriger vers l'enseigne Métro Longueuil (LIGNE JAUNE). Une fois en route, vous arrêtez à la prochaine station : Métro Île Sainte-Hélène. À la sortie de la station, il faut se diriger vers l'immense SPHÈRE , très visible.

Retour :Faire le trajet inverse vers la station Métro Île Sainte-Hélène. Ensuite se diriger vers l'enseigne Métro Berri-UQAM.

Note : Possibilité de stationnement limité à proximité de la Biosphère en fin d'après-midi.

#### VISITE DE LA BIOSPHÈRE :

Date: lundi le 31 mai 1999 Heure: 18:30

#### ASSEMBLÉE ANNUELLE DE LA SCMO - LA BIOSPHÈRE:

Endroit : La BIOSPHÈRE, 160, chemin Tour-de-L'Isle, Île Sainte-Hélène, Montréal (à 3 minutes de marche du Métro Île Sainte-Hélène)

Date: lundi le 31 mai 1999 Heure: 20:00

Transport (Métro) : Nous donnerons avec chaque inscription deux billets de métro (aller - retour) ;

Aller: Se rendre à la station Berri-UQAM à quelques pas où se tient les sessions et les kiosques des exposants. Ensuite se diriger vers l'enseigne Métro Longueuil (LIGNE JAUNE). Une fois en route, vous arrêtez à la prochaine station: Métro Île Sainte-Hélène. À la sortie de la station, il faut se diriger vers l'immense SPHÈRE, très visible.



Retour : Faire le trajet inverse vers la station Métro Île Sainte-Hélène. Ensuite se

diriger vers l'enseigne Berri-UQAM.

Note : Possibilité de stationnement limité à proximité de la Biosphère en fin d'après-

midi.

REPAS - MÉDAILLE TULLY - RESTAURANT (à venir) :

Endroit : (à venir)

Date : mardi le  $1^{er}$  juin 1999 Heure : De 12:00 à 13:30

RENCONTRE DES ANCIENS DE LA MÉTÉOROLOGIE DE L'UQAM:

Endroit : Foyer de la Salle Alfred Laliberté (Pavillon Judith-Jasmin)

Date : mardi le 1<sup>er</sup> juin 1999 Heure : 18 : 00

BANQUET - HÔTEL GOUVERNEUR, PLACE DUPUIS :

Endroit : Bar payant : Salle Gouverneur (rez-de-chaussée)

Banquet : Salle LA CAPITALE (4e étage),

HÔTEL GOUVERNEUR, PLACE DUPUIS, 1415, rue Saint-Hubert, Montréal (Coin Sainte-Catherine et Saint-Hubert - à environ 5 minutes de marche des sessions et

kiosques des exposants)

Date: mercredi le 2 juin 1999

Heure: Bar payant de 18:00 à 19:00 et Banquet à 19:00

Possibilité d'un repas végétarien pour ceux et celles qui en feront la demande.

REPAS - MÉDAILLE PATTERSON - FACULTY CLUB, UNIVERSITÉ McGILL:

Endroit : FACULTY CLUB, Université McGill, 3450 rue McTavish, Montréal (une rue à l'ouest de McGill College et au nord de Sherbrooke - à environ 10 minutes de

marche du Métro McGill)

Date : jeudi le 3 juin 1999 Heure : de 12 : 00 à 13 : 30

Transport (autobus) : Départ (coin nord de Ste-Catherine et Sanguinet) pour le

Faculty Club à 11 : 30 ; Retour vers l'Hôtel Gouverneur à 13 : 30

Prix de billets : 25 \$ (taxes et services inclus). Possibilité d'un repas végétarien pour

ceux et celles qui en feront la demande. Nombre de places est limité à 80 personnes

VISITES GUIDÉES EN FRANÇAIS OU EN ANGLAIS :

Date : vendredi le 4 juin

Visite guidée, Groupe 1 : du Radar McGill, du Bureau des services météorologiques

environnementaux (BSME) de Montréal et de MétéoMédia

Heure : départ de l'Hôtel Gouverneur Place Dupuis à 9 : 00 et fin de la visite à 15 :

00

Visite guidée, Groupe 2 : de MétéoMédia, du Radar McGill et du Centre

météorologique canadien

Heure : débute à MétéoMédia, 1755 Boul. René-Lévesque à 10 : 30 et se termine à

16:15

#### COURRIEL:

Il y aura un local pour ceux et celles qui seront intéressés à lire leur courriel.

SALLE: R-1170 (PAVILLON R)

1<sup>ER</sup> ÉTAGE AU-DESSUS DES SALLES DES SESSIONS

(Entrée par le métro ou par le 315 rue Ste-Catherine Est)

Note : mot de passe nouveau à chaque jour disponible au bureau de l'inscription

#### AU MUSÉE STEWART AU FORT DE L'ÎLE SAINTE-HÉLÈNE :

Ne manquer pas de visiter l'exposition :

NAPOLÉON BONAPARTE...À L'ÎLE SAINTE-HÉLÈNE

Du 5 mai au 11 octobre 1999 ; Ouvert 7 jours par semaine de 10:00 à 18:00

Jeudi - jusqu'à 21 : 00

Droits d'entrée : 10,00 \$

#### **RESTO**

À L'UQÀM : SURVEILLEZ LE SYMBOLE RESTO SUR LE PLAN

**RESTAURANTS SUR LA RUE ST-DENIS** 

PLACE DUPUIS : CASSE-CROÛTE





#### INFORMATION AND SOCIAL EVENTS

#### **REGISTRATION OFFICE**

Hôtel Gouverneur, Place Dupuis, 1415 Saint-Hubert Street, Montreal (at the corner of Sainte-Catherine East and Saint-Hubert):

Sunday 30 May : from 16 : 00 to 21 : 00

Université du Québec à Montréal, Judith-Jasmin Pavilion, 405 Sainte-Catherine East Street (accessible by the subway, at Berri-UQAM Station) :

Monday 31 May : from 7 : 30 to 17 : 00

Tuesday 1 June : from 8 : 00 to 17 : 00

Wednesday 2 June : from 8 : 00 to 16 : 00 Thursday 3 June : from 8 : 00 to 16 : 00

#### BIOSPHÈRE

#### NEC-HNSX ICE BREAKER - LA BIOSPHÈRE:

(includes food, 2 drinks, 2 subway tickets and the guided tour of the Biosphère)

Location : La BIOSPHÈRE, 160, chemin Tour-de-L'Isle, Île Sainte-Hélène, Montréal (at 3 minutes walking from Île Sainte-Hélène Métro)

,

Date : Monday 31 May 1999 Time : from 18 : 00 to 19 : 30

Transportation (Métro): With each registration, we will provide two subway tickets

(return fare)

Way to go: From the session rooms and exhibitors' site, walk to Berri-UQAM Métro

which is very close. Then look for the sign Longueuil Métro (YELLOW LINE). Once in the wagon, you get off at the next station: Île Sainte-Hélène Métro. When you get out of the station, take the direction towards the big SPHERE; you cannot miss it.

Way back : Just do the reverse way towards the station : Île Sainte-Hélène Métro. Then look for the sign Berri-UQAM Métro.

Note: Possibility of limited parking near the Biosphère.

#### GUIDED TOUR OF THE BIOSPHÈRE:

Date: Monday 31 May 1999 Time: 18:30

#### CMOS ANNUAL GENERAL MEETING - LA BIOSPHÈRE:

Location : La BIOSPHÈRE, 160, chemin Tour-de-L'Isle, Île Sainte-Hélène, Montréal

(at 3 minutes from Île Sainte-Hélène Métro)

Date : Monday 31 May 1999 Time : 20 : 00

Transportation (Métro): With each registration, we will provide two subway tickets

(return fare)

Way to go: From the session rooms and exhibitors' site, walk to Berri-UQAM Métro which is very close. Then look for the sign Longueuil Métro (YELLOW LINE). Once in the wagon, you get off at the next station: Île Sainte-Hélène Métro. When you get out of the station, take the direction towards the big SPHERE; you cannot miss it.

Way back : Just do the reverse way towards the station : Île Sainte-Hélène Métro.

Then look for the sign Berri-UQAM Métro.

Note: Possibility of limited parking near the Biosphère.

#### TULLY MEDAL LUNCH - RESTAURANT (to come) :

Location: (to come)

Date : Tuesday 1 June 1999 Time : from 12 : 00 to 13 : 30

#### MEETING OF THE UQAM GRADUATES:

Location: Foyer of the Alfred Labiberté Room (Judith-Jasmin Pavilion)

Date: Tuesday 1 June 1999 Time: 18:00

#### BANQUET - HÔTEL GOUVERNEUR, PLACE DUPUIS :

Location: Cash Bar: Gouverneur Room (Ground Floor)

Banquet: LA CAPITALE ROOM (4th floor),

HÔTEL GOUVERNEUR, PLACE DUPUIS, 1415 Saint-Hubert Street, Montreal (at the corner of Sainte-Catherine and Saint-Hubert - about 5 minutes walking from the session rooms and exhibitors' site)

Date: Wednesday 2 June 1999

Time: Cash Bar from 18:00 to 19:00 and Banquet at 19:00

Possibility of vegetarian meal for those who require it.

#### PATTERSON MEDAL LUNCH - FACULTY CLUB, McGILL UNIVERSITY:

Location: FACULTY CLUB, McGill University, 3450 McTavish Street, Montreal (one block west of McGill College, north of Sherbrooke - about 10 minutes from McGill Métro)

Date: Thursday 3 June 1999 Time: from 12:00 to 13:30

Transportation (bus) :Departure (north corner of Ste-Catherine and Sanguinet) for the Faculty Club at 11 : 30 ; Return to Hôtel Gouverneur at 13 : 30

Tickets: 25 \$ (taxes et services included). Possibility of vegetarian meal for those who require it.

Number of seats limited to 80 persons

#### GUIDED TOURS IN FRENCH OR IN ENGLISH:

Date: Friday 4 June

Guided tour, Group 1 : of McGill Radar, of the Montreal Environmental and Weather Service Centre, and of the MétéoMédia (WeatherNetwork)

Time : departure from Hotel Gouverneur Place Dupuis at 9 : 00 and the tour ends at 15 : 00

Guided tour, Group 2 : of MétéoMédia (WeatherNetwork), of McGill Radar and of the Canadian Meteorological Centre

Time : starts at the MétéoMédia (WeatherNetwork), 1755 Boul. René-Lévesque at

10 : 30 and ends at 16 : 15





#### **E-MAIL FACILITIES:**

There will be a room for those who want to check their e-mail.

ROOM: R-1170 (PAVILION R)

1<sup>ST</sup> FLOOR ABOVE ROOM SESSIONS

(Entrance by Subway or by the 315 Ste-Catherine East Street) Note: new password every day available at the registration desk

#### AT THE STEWART MUSEUM AT THE FORT ON ÎLE SAINTE-HÉLÈNE:

Don't miss the exhibition:

NAPOLÉON BONAPARTE...AT ÎLE SAINTE-HÉLÈNE

From May 5<sup>th</sup> to October 11<sup>th</sup>, 1999; Open 7 days a week from 10:00 to 18:00

Thursday - until 21:00

Admission fee: \$10.00

AT UQÀM: LOOK FOR THE SYMBOL RESTO ON THE PLAN

**RESTAURANTS ON ST-DENIS STREET** 

PLACE DUPUIS: FAST FOOD

Dimanche	le 30	mai/Sunday	May	30

HEURE /	RÉUNION / MEETING	RESPONSABLE /	SALLE/ROOM
TIME		CONVENOR	
09:00-12:00	Prix et bourses / Prizes and Awards	Mike Leduc	Chicoutimi(1)
09:30-12:30	Publications	Richard Asselin	Montréal(1)
10:00-16:00	Comité national canadien pour SCOR /	Brian Nicholls	Rimouski(1)
	Canadian National Committee for SCOR		
11:00-13:00	La météorologie dans les écoles / High	Gerhard Reuter	J-1130(2)
	School Met Issues		
13:00-16:00	Comité scientifique / Scientific Committee	Charles Lin	Chicoutimi(1)
13:00-16:00	Présidents des Centres de la SCMO /	lan Rutherford	Les Boiseries(2) (J-2805)
	CMOS Centre Chairs		
13:00-15:00	Comité sur l'éducation / Education	Roland Stull	J-1120(2)
	Committee		
16:00-18:00	Conseil SCMO / CMOS Council	Bill Pugsley	Boiseries(2) (J-2805)
19:00-21:00	Secteur privé / Private Sector	Ambury Stuart	Rimouski(1)

# Réunions des comités et évènements sociaux

# **Committee Meetings** and Social Events

#### Lundi le 31 mai/Monday May 31

18:00-19:30	Cocktail de bienvenue NEC - HNSX Ice Breaker	Biosphère(3)
18:30-20:00	Visite de la Biosphère/Tour of the Biosphère	Biosphère(3)
20:00-22:00	Assemblée annuelle de la SCMO/CMOS Annual General Meeting	Biosphère(3)

#### Mardi le 1 juin/Tuesday June 1

12:00-13:30	Repas Tully Lunch	
18:00-21:00	Rencontre des anciens de la météorologie de l'UQAM	Foyer du Studio Alfred-
		Laliberté(2)

#### Mercredi le 2 juin/Wednesday June 2

18:00-19:00	Bar payant / Cash Bar	Gouverneur(1)
19:00-23:00	Banquet de la SCMO / CMOS Banquet	La Capitale(1)

#### Jeudi le 3 juin/Thursday June 3

12:00-13:30	Repas Patterson Lunch	Faculty Club(4)

#### Vendredi le 4 juin/Friday June 4

09:00-16:15	Visites guidées	/Guided Tours	Radar McGill Radar- CMC-
			BSME / EMSO-MétéoMédia

#### Notes:

- (1) Hôtel Gouverneur Place Dupuis : 1415 rue St-Hubert Street (coin/corner St-Hubert et/and Ste-Catherine)
- (2) Université du Québec à Montréal, Pavillon Judith-Jasmin, 405, rue Sainte-Catherine (on peut y accéder par le métro, à la station Berri-UQAM/Accessible by the subway, at Berri-UQAM Station): la salle Les Boiseries est située au 2<sup>ème</sup> étage (J-2805) près des escaliers roulants/Les Boiseries Room is located on the 2<sup>nd</sup> floor (J-2805) near the escalators; et les salles J-1120 et J-1130 sont situées près des ascenseurs/and the rooms J-1120 and J-1130 are located near the elevators.
- (3) Biosphère:

Transport (Métro) : Nous donnerons avec chaque inscription deux billets de métro (aller - retour)

Aller : Se rendre au Métro Berri-UQAM à quelques pas où se tient les sessions et les kiosques des exposants. Ensuite se diriger vers l'enseigne Métro Longueuil (LIGNE JAUNE). Une fois en route, vous arrêtez à la prochaine station : Métro Île Sainte-Hélène. À la sortie de la station, il faut se diriger vers l'immense SPHÈRE , très visible.



Retour :Faire le trajet inverse vers la station Métro Île Sainte-Hélène. Ensuite se diriger vers l'enseigne Métro Berri-UQAM.

Note : Possibilité de stationnement limité à proximité de la Biosphère en fin d'après-midi.

Transportation (Métro): With each registration, we will provide two subway tickets (return fare)

Way to go: From the session rooms and exhibitors' site, walk to Berri-UQAM Métro which is very close. Then look for the sign Longueuil Métro (YELLOW LINE). Once in the wagon, you get off at the next station: Île Sainte-Hélène Métro. When you get out of the station, take the direction towards the big SPHERE; you cannot miss it. Way back: Just do the reverse way towards the station: Île Sainte-Hélène Métro. Then look for the sign Berri-UQAM Métro.

Note: Possibility of limited parking near the Biosphère.

(4) Faculty Club - Université McGill University

Endroit : FACULTY CLUB, Université McGill, 3450 rue McTavish, Montréal (une rue à l'ouest de McGill College et au nord de Sherbrooke - à environ 10 minutes de marche du Métro McGill)

Transport (autobus):

Départ (coin Ste-Catherine et St-Denis) pour le Faculty Club à 11 : 30 ; Retour vers l'Hôtel Gouverneur à 13 : 30

Location : FACULTY CLUB, McGill University , 3450 McTavish Street, Montreal (one block west of McGill College, north of Sherbrooke - about 10 minutes from McGill Métro)

Transportation (bus):

Departure (corner Ste-Catherine and St-Denis) for the Faculty Club at 11 : 30 ; Return to Hôtel Gouverneur at 13 : 30 31 mai / May 31 - 08h50

Présentation d'ouverture / Opening Invited Presentation:

Dr. Gordon McBean

The Future of Environmental Prediction in Canada

1er juin / June 1- 08h30

Dr. Byron Boville

Coupled Numerical Modelling for Comprehensive Environmental Prediction

1er juin / June 1- 09h10

Dr. Charles Schafer

Saguenay River Discharge Proxies: Results from the 1971-1978 Sedimentary

Records (by C.T. Schafer and J.N. Smith)

2 juin / June 2- 08h30

Dr. Peter Davies

FORETELL: Integrated Road and Weather Information Services Across North

America

2 juin / June 2- 09h10

Dr. George Boer

Climate prediction and predictability from seasons to centuries

3 juin / June 3- 08h30

Dr. Florence Rabier

New data assimilation methods and sensitivity results







**GENEQ** offers you a wide range of Meteorological Instruments for all your needs

**ZENO 3200 Data Acquisition System** offering many advantages over the competition.



**ZENO 3200** 32 Bit RESOLUTION

**Meteorological Sensors** 

**System Integration** 

**Installation and Training** 

GENEQ inc. vous offre une gamme complète d'instruments météorologiques.

Acquisiteur de données de marque COASTAL modèle ZENO 3200 offrant une multitude d'avantages sur ceux disponibles sur le marché.

Capteurs météorologiques variés

Intégration de systèmes

Installation et formation.



SENSEUR À ULTRASONS POUR VITESSE DU VENT

ULTRASONIC WIND SENSOR

**GENEQ** inc. 8047 rue Jarry Est Montréal, Qué. H1J 1H6

Tel.: (514) 354-2511

1-800-463-4363

Fax.: (514) 354-6948

Vancouver office 2628 Granville st. Vancouver, B.C

V6H 3H8

Tel.: (604) 731-4944

Fax.: (604) 731-9445

E-mail: meteo@geneq.com E-mail: sbiduk@home.com

Visitez notre catalogue sur l'internet à www.geneq.com, section « Météorologie ».

Visit our catalog on the internet at www.geneq.com, section

« Meteorology ».

#### **Our Company**



SCI-TEC Instruments Inc. located in Saskatoon, SK, is a market leader in the design and manufacture of solar radiation, and atmospheric monitoring instrumentation. The company is composed of SCI-TEC in Canada, and Kipp & Zonen, in the Netherlands. "Kipp" joined SCI-TEC in 1996.

What's New...

#### CSD 1 Sunshine Duration Sensor

- No moving parts
- Wide temperature range
- Easy re-calibration
- Optional heating

The CSD 1 is a sensor for measurement of sunshine duration. Sunshine duration is defined as the time during which the direct solar radiation exceeds the level of 120 W/m2. The CSD 1 can also supply a measurement of the level of direct radiation.

#### LITE Range:

In addition to the high end sensors Kipp & Zonen offers a range of LITE sensors, based on silicon technology. The range comprises:

#### SP-LITE, Silicon Pyranometer

This pyranometer is designed for routine measurement of solar radiation. Applications are:

- Photo Voltaic / solar energy module monitoring
- Agricultural evapotranspiration estimation
- Air pollution dispersion calculations using the Delta-T method

#### NR-LITE, Silicon Net Radiometer

This sensor is designed for routine measurement of net radiation which is the balance between incoming and outgoing radiation under outdoor conditions.

The construction of the NR LITE is unique. The detector is based on a Teflon coated, weather resistant black conical absorber. In contrast to other sensor designs, the NR LITE requires no fragile plastic domes. This results in a virtually maintenance free design.

#### LUX-LITE, Silicon Lux Meter

The lux meter is designed for routine measurement of illuminance.

It is especially suitable for:

- outdoor daylight monitoring
- illumination engineering
- lighting control systems

LUX LITE can be used under all weather conditions. The sensor measures the visible light. The sensor uses a specially designed filter to provide a spectral response equal to that of the average human eye.

#### The Net Radiometer CNR1

The CNR 1 Net Radiometer is an ideal instrument for the analysis of Solar and Far Infrared radiation balance.

- Includes two pyranometers ( 0.3  $3~\mu m$  ) for solar radiation measurement ( incoming / reflected / albedo / balance )
- Includes two pyrgeometers (5 50 µm) for far infrared measurement (balance / soil surface temperature / sky temperature)
- Robust & fully weatherproof
- Heated to avoid dew deposition

Soon to be released in Summer 1999...

#### CM22, The Most Accurate Pyranometer

CM22 is a high precision pyranometer with quartz domes. The spectral range is consequently broadened to 200 -3600 nm (50% points).

- High-end product.
- Negligible zero-offset caused by temperature changes.
- Lowest zero-offset due to FIR radiation.
- Spectral range 200-3600 nm.

#### CG4, The Breakthrough in Pyrgeometer Design

This new pyrgeometer is designed for meteorological measurements of FIR irradiance in the spectral range from 4.5 to 50  $\mu$ m with high reliability and high accuracy. The sensor can be used under all weather conditions. Even in full sunlight the window heating effect is very low compared to other sensors on the market. The CG4 uses a specially designed Silicon window, which is protected on the outside by a diamond-like coating. Inside a solar blind filter blocks all solar radiation.

#### The CV2 Ventilation Unit

The CV 2 is designed for Kipp & Zonen pyranometers

CM 6B, CM 11, CM 21 and pyrgeometer CG 1. Ventilation of the pyranometer improves the reliability and accuracy of the solar radiation measurement. This is achieved by:

- Prevention of precipitation of dew, snow and frost, which would otherwise disturb the measurement.
- Suppression of the infrared offset, which is produced e.g. by cooling down of the glass domes under calm clear sky conditions

The ventilation unit is easy to use. The only part that needs maintenance is the removable filter at the bottom. It has to be checked on regular intervals. The unit can be used under all weather conditions.

#### The CT 24 Solar Sensor 4-20 mA Amplifier

The CT 24 amplifier for solar sensors with remote logging and extended cables.

- two wire technique
- extended temperature range
- negative signals allowed
- voltage output possible
- fixed or adjustable gain
- surge voltage protection
- EMF shielded

#### Contact us:

SCI-TEC Instruments Inc. 1503 Fletcher Road Saskatoon, SK S7M 5S5

PH: 306-934-0101

FX: 306-978-2339

Or come visit our Web site: www.sci-tec.com

#### Service canadien des glaces Chef de file en Service d'information des glaces

Chaque année, le Service canadien des glaces obtient de RADARSAT une grande quantité de données sur l'Arctique, la baie d'Hudson, la côte est canadienne et les Grands Lacs. Son équipe chevronnée de météorologues, de géographes, de climatologues et de spécialistes en informatique se réunit afin de faire l'analyse de ces données et d'offrir un service d'information des glaces hors pair.

Ces experts connaissent très bien l'Arctique de même que toutes les autres régions envahies par les glaces dans tout le Canada. Ensemble, ils aident le Service canadien des glaces à réaliser son mandat : celui de fournir les renseignements sur les glaces les plus récents et précis. Les renseignements et les services offerts par le Service canadien des glaces sont nombreux. Ils comprennent : des cartes et des bulletins spécialisés, des images radar et satellitaires, l'analyse d'images, des analyses météorologiques, des prévisions adaptées, des avertissements et des breffages. Les gens et les industries qui utilisent les renseignements sur les glaces sont, eux aussi, nombreux : ils vont du chercheur, du pêcheur côtier et du touriste aux grandes compagnies de navigation, aux compagnies d'exploitation pétrolières et gazières en mer, ainsi qu'aux croisiéristes.

Rendez-vous au site du Service canadien des glaces ou à sa page web. Celui-ci renferme une abondance de renseignements, parmi lesquels vous trouverez une bibliothèque d'ouvrages à consulter, des archives d'images, des liens vers d'autres sites importants, des catalogues et des listes de prix. Plusieurs produits et services vous sont offerts gratuitement.

Découvrez dès aujourd'hui le Service canadien des glaces.

Service canadien des glaces, Service à la clientèle (800) 767-2885 / (613) 996-1550 Télec. (613) 947-9160 Cis.Client@ec.gc.ca



## Canadian Ice Service World Leader in Ice Information Service

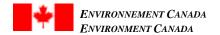
Every year, the Canadian Ice Service obtains and analyses vast amounts of RADARSAT data covering the Arctic, Hudson's Bay, the Eastern seaboard and the Great Lakes. Its team of highly experienced meteorologists, geographers, climatologists, and computer scientists gathers to offer a comprehensive ice information service.

These experts know the Arctic and all other ice-infested waters across Canada very well. Together, they help the Canadian Ice Service accomplish its mission: to provide the most timely and accurate ice information. The information and services available from the Canadian Ice Service are extensive. They include: specialized charts, bulletins, and maps; radar and satellite imagery; image analyses; weather analyses; tailored forecasts; warnings, and briefings. Ice information is essential to a range of people and industries, from researchers, inshore fishermen, and tourists to large shipping companies, offshore oil and gas companies, and cruise ship operators.

Visit the Canadian Ice Service display or Web site. In it, you will find a wealth of information, including a reference library, image archives, links to other notable sites, catalogues, and price lists. Many products and services are available free of charge.

Discover the Canadian Ice Service today.

Canadian Ice Service, Client Service (800) 767-2885 / (613) 996-1550 Fax (613) 947-9160 Cis.Client@ec.gc.ca



# Centre météorologique canadien Canadian Meteorological Centre

## Division du Développement Development Branch

### **SCRIBE**

Système expert pour la production de prévisions météorologiques Expert system for the production of weather forecasts

## **AWeD**

Base de données météorologiques pour l'aéronautique Aviation Weather Database

## MAX / Edigraf

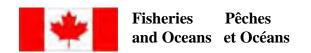
Production et édition de produits météorologiques graphiques Production and edition ot graphical meteorological products

> Venez nous voir au kiosque 14. Come to see us at booth 14.

Franc succès au 33° Congrès de la SCMO Best Wishes to the 33<sup>rd</sup> CMOS Conference









ACCÈS

AUX

DONNÉES

SURLE

MILIEU

MARIN

ACCESS

TO

OCEAN

DATA

SERVICE DES DONNÉES SUR LE MILIEU MARIN MARINE ENVIRONMENTAL DATA SERVICE

Contactez-nous pour obtenir des détails sur des produits et services précis de données océanographiques

Contact us for specific oceanographic data products and services

Téléphone (613) 990-0243 Telephone

Télécopieur(613) 993-4658FaxCourrielservices@meds-sdmm.dfo-mpo.gc.cae-mail

Internet www.meds-sdmm.dfo-mpo.gc.ca



# Section informatique Recherche en prévision numérique



bientôt disponible dans tous les bons centres de recherche Available soon in the best research centres

Venez nous visiter au kiosque 17 Come to see us at booth 17



Lundi 31 mai	Mardi 1 juin	Mercredi 2 juin	Jeudi 3 juin	Vendredi 4 juin
Monday May 31	Tuesday June 1	Wednesday June 2	Thursday June 3	Friday June 4
Session 1-A	Session 2-A	Session 3-A	Session 4-A	Réunions / Meetings
08h30-09h50	08h30-09h50	08h30-09h50	08h30-09h50	08h30-09h50
Environmental	Environmental	Environmental	Data Assimilation I	
Prediction I	Prediction III	Prediction V		
	_	santé / Health Break - 09h5		
Session 1-B 10h10-12h10	Session 2-B 10h10-12h10	Session 3-B 10h10-12h10	Session 4-B 10h10-11h30	Réunions / Meetings 10h10-12h10
1B1:	2B1:	3B1:	4B1:	
Environmental	Environmental	Operational	Data Assimilation II /	
Prediction II	Prediction IV	Meteorology III	Middle Atmosphere I	
1B2:	2B2:	3B2:	4B2:	
Aerosol and Climate	Aerosol and Climate	Climate Modelling I	GEWEX and MAGS II	
(NARCM) I	(NARCM) III	3B3:	4B3:	
1B3:	2B3:	Boundary Layer	University and	
FIRE	Ocean Modelling I	Meteorology	Professional	
1 11(	Cocan Modelling	Wetcorology	Education II	
1B4:	2B4:	3B4:	4B4:	
Coupled Atmosphere-	Climate Variability and	Atmosphere and	Coastal	
Ocean Models	HFP II	Ocean Circulation	Oceanography III	
	Dîner / Lunch		Dîner / Lunch	Dîner / Lunch
	12h10-13h40		11h30-13h40	12h10-13h40
Session 1-C 13h40-15h20	Session 2-C 13h40-15h20	Session 3-C 13h40-15h20	Session 4-C 13h40-15h20	Réunions / Meetings 13h40-15h20
131140-131120	131140-131120	131140-131120	131140-131120	131140-131120
1C1:	2C1:	3C1:	4C1:	
Operational	The Saguenay Flood I	Environmental	Middle Atmosphere II	
Meteorology I		Emergency		
1C2:	2C2:	3C2:	4C2:	
University and	Pollution Transport and	Climate Modelling II	GEWEX and MAGS III	
Professional	Air Quality I			
Education I				
1C3:	2C3:	3C3:	4C3:	
Coastal	Atmosphere	Air-Sea Interactions	Data Assimilation III	
Oceanography I	Modelling I			
1C4:	2C4:	3C4:	4C4:	
Cloud Physics	Climate Variability and	Radar / Remote	Coastal	
, 	HFP III	Sensing I	Oceanography IV	
		Pause santé / Health Breal 15h20-15h40	(	
Session 1-D	Session 2-D	Session 3-D	Session 4-D	Réunions / Meetings
15h40-17h40	15h40-17h40	15h40-17h40	15h40-17h40	15h40-17h00
1D1:	2D1:	3D1:	4D1:	
Operational	The Saguenay Flood II	Pollution Transport and	Middle Atmosphere III	
Meteorology II	,	Air Quality III	,	
1D2:	2D2:	3D2:	4D2:	
Aerosol and Climate	Pollution Transport and	GEWEX and MAGS	Ocean Modelling	
(NARCM) II	Air Quality II			
1D3:	2D3:	3D3:	4D3:	
Coastal	Atmosphere	Atmosphere	Operational	
Oceanography II	Modelling II	Modelling III	Meteorology IV	
4D4.	0D4.	2D4.		
1D4: Climate Variability and	2D4: Transient Climate	3D4: Radar / Remote		
HFP I	Change	Sensing		
Cocktail de bienvenue	Réunion des anciens	Banquet		
Ice Breaker Reception	(UQAM)	18h00		
18h00	18h00		1	

Lundi 31 mai Monday May 31

SESSION 1-A	SESSION 1-A Plénière / Plenary : Environmental Prediction I - Chair: Pierre Dubreuil				
08h30-08h40					
08h40-08h50	Mots de bienvenue (UQAM) / Welcome (UQAM)				
08h50-09h30	Présentation d'ouverture / Opening Invited Presentation: <i>The Future of Environmental Prediction in Canada</i> Gordon McBean				
09h30-09h50	Présentations des exposants / Exhibitors' presen				
09h50-10h10		Pause santé /			
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160	
10h10-12h10	1-B-1: Environmental Prediction II Chair: Jim Abraham	1-B-2 : Aerosol and Climate (NARCM) I Chair: Jean-Pierre Blanchet	1-B-3 : FIRE Chair: Jocelyn Mailhot	1-B-4 : Coupled Atmosphere-Ocean Models - Chair: George Boer	
10h10	1-B-1.1 - RPN/AEPRI Coupled Numerical Modelling Harold Ritchie	1-B-2.1 - Aerosols and Climate: The NARCM Aerosol Modelling Project Leonard A. Barrie	1-B-3.1 - Canadian Participation in FIRE.ACE George Isaac	1-B-4.1 - The Role of Ocean Mixing in Coupled Model Projections of Climate Change Gregory M. Flato	
10h30	1-B-1.2 - On the use of coupled atmospheric and hydrologic models.     Pierre Pellerin	1-B-2.2 - Water Uptake Calculations for NARCM mixed aerosols Glen Lesins	1-B-3.2 - Mesoscale Modeling during FIRE.ACE: Flight Guidance and Model Performance Bernard Bilodeau	1-B-4.2 - Interdecadal Variability in Models with North Atlantic Bottom Topography K. Andrew Peterson	
10h50	1-B-1.3 - Coupled Atmospheric and Hydrologic Models over the St John River Basin Michael Campbell	1-B-2.3 - Sulphate production in sub-grid scale clouds Natalie Hasell	1-B-3.3 - Modeling of the low-level mixed- phase clouds in the Arctic during Spring Eric Girard	1-B-4.3 - A Coupled Atmosphere - Ocean Wave Model for Understanding Air -Sea Fluxes in North Atlantic Storms Bin He	
11h10	1-B-1.4 - Stochastic and deterministic modeling of stream water temperature in a small forested catchment. André St-Hilaire	1-B-2.4 - Modeling size-distributed global sea salt aerosols in the atmosphere: an application using canadian climate models Sunling Gong	1-B-3.4 - Simulations of ice clouds and aerosols during FIRE III using the CCCma single column model Ulrike Lohmann	1-B-4.4 - Verification of a Coupled Atmosphere - Ocean Wave Model with Air - Sea fluxes in the Labrador Sea Experiment Yaocun Zhang	
11h30	Poster (1-6) Introductions	1-B-2.5 - Simulation of size-segregated global sea-salt and sulphate aerosol mixtures using the canadian global climate model [GCM III] Sunling Gong	1-B-3.5 - Measuring Arctic Clouds and Aerosol by using Counterflow Virtual Impactor (CVI) Hong Lin	1-B-4.5 - The role of the thermohaline circulation in the initiation of glaciation Zhaomin Wang	
11h50		1-B-2.6 - The sensitivity of sulphate aerosol concentration and size to changing anthropogenic sulphur emissions Knut von Salzen	1-B-3.6 - Modeling of Arctic Clouds during FIRE.ACE Anna Glazer	1-B-4.6 - The climate-ice sheet interactions in a simple climate model Lawrence A. Mysak	
12h10-13h40		Dîner / I			
13h40-15h20	1-C-1 : Operational Meteorology I Chair: Peter Chen	1-C-2 : University and Professional Education I - Chair: Nathalie Gauthier	1-C-3 : Coastal Oceanography I Chair: François J. Saucier	1-C-4 : Cloud Physics Chair: George Isaac	
13h40	1-C-1.1 - Recent and future improvements in the Canadian Meteorological Center's analysis and forecasting system Richard Hogue	1-C-2.1 - Project EuroMET : Teaching Meteorology Internationally using Internet Christian Pagé	1-C-3.1 (Theme presentation) - Operational Ocean Forecast System with Data Assimilation for the East Coast of Canada Josko Bobanovic	1-C-4.1 - Mesoscale forecast accuracy and cloud microphysics complexity André Tremblay	
14h00	1-C-1.2 - General Description of NWP Modelling at the Canadian Meteorological Centre Louis Lefaivre	1-C-2.2 - Les humeurs du temps Nicole Raymond		1-C-4.2 - A New Microphysics Scheme for Improved Forecasts of Freezing Precipitation and Aircraft Icing André Tremblay	

14h20	1-C-1.3 - CMC's 24km GEM regionalmodel: present status and performance assesment Richard Moffet	1-C-2.3 - Oasis: Life on the edge of the abyss Kim Juniper	1-C-3.2- Tidal currents and mixing quantities off Newfoundland Guoqi Han	1-C-4.3 - Verification of Aircraft Icing Forecasts Using in-situ Aircraft Measurements Hong Guan
14h40	1-C-1.4 - Recent development activities on NWP short term model at the Canadian Meteorological Centre. André Méthot	1-C-2.4 - L'association professionnelle des météorologues du Québec et l'éducation en météorologie Gilles Brien	1-C-3.3 - Drift Pathways on the Western Scotian Shelf Jennifer Shore	1-C-4.4 - The influence of air mass origin on the microphysical structure of arctic boundary layer clouds Ismail Gultepe
15h00	1-C-1.5 - Recent Improvements in the Ensemble Prediction System at the Canadian Meteorological Centre Louis Lefaivre		1-C-3.4 - Baroclinic oscillations generated over the continental shelf by Hurricane Andrew Susan Allen	1-C-4.5 - Comparison of research aircraft observations with numerical simulations using a mixed-phase cloud scheme Paul Vaillancourt
15h20-15h40		Pause santé /	Health Break	
15h40-17h40	1-D-1 : Operational Meteorology II Chair: Richard Hogue	1-D-2 : Aerosol and Climate (NARCM) II Chair: Len Barrie	1-D-3 : Coastal Oceanography II Chair: Dave Greenberg	1-D-4 : Climate Variability and HFP I Chair: Gilbert Brunet
15h40	1-D-1.1 - Forecast verification Richard Verret	1-D-2.1 - Analyses of the Effects of Aerosols on a Regional Climate Simulation Using NARCM Juan Sebastian Fontecilla	1-D-3.1 - Hindcast of Tidal to Inter-Annual 3D Ice-Ocean Conditions in the Estuary François-J. Saucier	1-D-4.1 - The potential vorticity budget of the North-Atlantic oscillation Jacques Derome
16h00	1-D-1.2 - Comparison of model performances for leading NWP Centres Monique Loiselle	1-D-2.2 - Preparation to the first NARCM Simulation of the Direct Effect of Aerosol on High Latitude Climate Khanh-Hung Lam	1-D-3.2 - Fine-scale observations of shear instabilities in the St. Lawrence Estuary Daniel Bourgault	1-D-4.2 - The Arctic and Antarctic Oscillations and their Projected Changes Under Global Warming John Fyfe
16h20	1-D-1.3 - Verification of precipitation: GEM regional vs. other operational models  Monique Loiselle	1-D-2.3 - Simulating the Transportation of Smoke from a Forest Fire in Eastern Canada Lin Hong	1-D-3.3 - A Proposal for a Neutral Regression Richard Marsden	1-D-4.3 - The North Atlantic Oscillation, 1958-1998: A data study Paolo Jr. Petriello
16h40	1-D-1.4 - Are meteorological forecasts improving? Richard Verret	1-D-2.4 - Application of NARCM to Simulation of Tracers at High Resolutions Fabien Zuretti	1-D-3.4 - Surface Pulses in the Lower St. Lawrence Estuary Richard Marsden	1-D-4.4 - Dynamical Characterisation of North Atlantic Climate Variability Lionel Pandolfo
17h00	1-D-1.5 - Intercomparison of climatological observations from manned and automated stations - preliminary results for temperature Ewa Milewska	1-D-2.5 - A model of DMS emission in the western north Atlantic. Mireille Lefèvre	1-D-3.5 - Sea State Forecasting in the St. Lawrence River and Gulf Will Perrie	1-D-4.5 - The Role of Gravity Waves in Slowly Varying in Time Equatorial Motions Gerald Browning
17h20	1-D-1.6 - A comparison of visibility observations by human observers and automated weather observing systems (AWOS) in Canada Ambury Stuart		1-D-1.6 - Dynamics of the Buoyancy-Driven Coastal Jet: The Gaspe Current Jinyu Sheng	1-D-4.6 - Tendance de la Variabilité du Climat au Québec au XX ième Siècle Myriam Montpetit
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160
18h00-19h30		Cocktail de bienvenue / Ice Brea		
19h00-20h00		Visite de la Biosphère /		
20h00	Assemblée générale annuelle SCMO / CMOS Annual General Meeting (Biosphère)			

Lundi 31 mai Monday May 31

Mardi 1er juin Tuesday June 1

SESSION 2-A PI	énière / Plenary : Environmental Prediction III			Tuesday June 1	
Chair: Charles L					
08h30-09h10	2-A-1 - (Invited Presentation): Coupled Numerical Modelling for Comprehensive Environmental Prediction Byron Boville				
09h10-09h50	2-A-2 - (Invited Presentation): Saguenay Rive Charles Schafer	r Discharge Proxies: Results from the 1971-197	8 Sedimentary Records (by C.T. Schafer and J.N	I. Smith)	
09h50-10h10			/ Health Break		
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160	
10h10-12h10	2-B-1 : Environmental Prediction IV Chair: Hal Ritchie	2-B-2 : Aerosol and Climate (NARCM) III Chair: Ulrike Lohmann	2-B-3 :Ocean Modelling I Chair: Lawrence Mysak	2-B-4 : Climate Variability and HFP II Chair: Jacques Derome	
10h10	2-B-1.1 - The Effect of Trough Interactions on Tropical Cyclone Intensity Change Deborah Hanley	2-B-2.1 - A Simulation of Size-Segregated Sulphate Aerosols of Volcanic Origins in the Stratosphere using the CMAM Jonathan Jiang	2-B-3.1 - Impact of internal parameters and surface boundary conditions on oscillatory behaviour of an ocean general circulation model Kitty Brown	2-B-4.1 - CMC Dynamical Seasonal Forecast System: Method and Results André Plante	
10h30	2-B-1.2 - A Study of Tropical to Extratropical Cyclone Transition off the Canadian and US East Coasts, 1963-1996 Christopher T. Fogarty	2-B-2.2 - The NARCM Aerosol Model Applied to E. North America LITE Shuttle Measurement Period Lubos Spacek	2-B-3.2 - A study of the sensitivity of surface circulation to the surface boundary conditions in the Mellor-Yamada turbulence closure Charles Hannah	2-B-4.2 - CMC Dynamical Seasonal Forecast System: Sensitivity Studies Normand Gagnon	
10h50	2-B-1.3 - A New MPI-based Coupler for the CCCma CGCM3 Coupled Model. Scott Tinis	2-B-2.3 - Intercomparison of LITE Tropospheric Aerosol Retrievals with the Northern Aerosol Regional Climate Model Aaron Vandermeer	2-B-3.3 - Boundary Layer Mixing and the Ocean's Thermohaline Circulation Olaf Dravnieks	2-B-4.3 - A Hybrid Multi-Model Approach To Seasonal Predictions Gilbert Brunet	
11h10	2-B-1.4 - A Comparison of GCM Models with Experimental Measurements of Surface Radiative Forcing by Greenhouse Gases Wayne F.J. Evans	2-B-2.4 - NAtChem/Particles: A Particle Database for Atmospheric Research Peter Liu	2-B-3.4 - Modeling the Seasonal Variation of Sea Ice in the Labrador Sea Tom Yao	2-B-4.4 - Response of a simple GCM to tropical and mid-latitude SST anomalies Nick Hall	
11h30	2-B-1.5 - The Benefits of Global Warming to Canada Wayne F.J. Evans	2-B-2.5 - Sunphotometer network for the validation of long term climatic models in Canada Amadou Idrissa Bokoye	2-B-3.5 - Is the neglect of coastal upwelling in QG models Justified ? David N. Straub	2-B-4.5 - Multi-year experiments with the GEM model Bernard Dugas	
11h50	2-B-1.6 - CIPRA: un outil de gestion agro- environnemental René Audet	2-B-2.6 - Ground Comparisons between the the Northern Aerosol Regional Climatological Model (NARCM) and spatio-temporal measurements of passive aerosol optical parameters Norm O'Neill		2-B-4.6 - Variation in predictability associated with large scale circulation patterns Jian Sheng	
12h10-13h40			ınch (Tully)		
13h40-15h20	2-C-1 : The Saguenay Flood I Chair: Charles Schafer	2-C-2 : Pollution Transport and Air Quality I - Chair: Janusz Pudykiewicz	2-C-3 : Atmosphere Modelling I Chair: Robert Benoît	2-C-4 : Climate Variability and HFP III Chair: Gerarld Browning	
13h40	2-C-1.1 - Simulation of Severe Precipitation and Flash Floods (SSPFF) and applications to the Saguenay flood Charles Lin	2-C-2.1 - Semi-operational forecasting of tropospheric ozone with CHRONOS Richard Moffet	2-C-3.1 - The Atmospheric Kinetic Energy Budget Residual Richard E. Danielson	2-C-4.1 - Conditions of predictable ENSO events in neural network models William Hsieh	

17h20-20h00	Rencontre des anciens de l'UQAM				
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160	
17h00		2-D-2.5 - Modélisation des flux de gaz à effet de serre (GES) émis à la surface des réservoirs hydroélectriques Nathalie Barrette	2-D-3.5 - Phase-speed test for numerical models of the atmosphere Ayrton Zadra		
16h40	Poster Session	2-D-2.4 - L'influence du chauffage au bois sur la qualité de l'air dans un quartier de Montréal Mario Benjamin	2-D-3.4 - Non-axisymmetric thermally driven circulations and upper tropospheric monsoon dynamics C. Juno Hsu	2-D-4.4 - Comparisons of global warming due to rising CO2 simulated by climate models lan Watterson	
16h20	3-B-3.5 - The Role of Land Surface Schemes in Short-Range Precipitation Forecasts Lei Wen	2-D-2.3 - Intercomparaison de l'ozone et de ses précurseurs à deux stations en périphérie de Montréal durant la campagne ESOM-96 Marc Beauchemin	2-D-3.3 - Using low-resolution winds to advect high-resolution tracers Peter Bartello	2-D-4.3 - Alpine-level snowcover in Western Newfoundland during the late 20th Century Christian Martin	
16h00	2-D-1.2 - Utilisation des HAP comme indicateurs d'événements sédimentaires récents et de l'activité benthique Émilien Pelletier	2-D-2.2 - Impact of Weekend/Weekday ozone variations on air temperature in the Greater Toronto Area Gary Beaney	2-D-3.2 - Using conservative variables for liquid water content in GEM Gérard Pellerin	2-D-4.2 - Trends in Canadian Extreme Precipitation Events Daithi Stone	
15h40	2-D-1.1 - Importance d'une perturbation environnementale sur l'évolution diagenétique des sédiments du fjord du Saguenay (Québec, Canada) Bruno Deflandre	2-D-2.1 - Modeled estimates of terrestrial isoprene emissions and potential for inducing errors in regional air quality modeling exercises  Dave Fox	2-D-3.1 - Improving the GEM model for medium-range forecasting and analysis. Sylvie Gravel	2-D-4.1 - Changes in annual extremes under transient climate change Francis Zwiers	
15h40-17h40	2-D-1 :The Saguenay Flood II Chair: Alfonso Mucci	2-D-2 : Pollution Transport and Air Quality II - Chair: Richard Leaitch	2-D-3 : Atmosphere Modelling II Chair: Jean Côté	2-D-4 : Transient Climate Change Chair: Gregory M. Flato	
15h20-15h40			/ Health Break		
15h00	Poster (7-12) Introductions	2-C-2.5 - Application d'un modèle de qualité de l'air sur le sud du Québec et comparaison avec les mesures de NARSTO-96 Gilles Morneau	2-C-3.5 - Optimal Interpolation of Climate Data onto Alberta Polygons of Ecodistrict and Soil Landscape of Canada Guilong Li	2-C-4.5 - Trends and variability in the 20th century temperature and precipitation in Canada Xuebin Zhang	
14h40	2-c-1.4 - Evidence for gravity-flow processes as the mechanism for basin-sedimentation in baie des ha! Ha!, Saguenay Fjord, from sidescan sonar data Philip Hill	2-C-2.4 - Modelling Mass Transfer and Aqueous-Phase Chemistry in AES' Regional PM Model (AURAMS) Wanmin Gong	2-C-3.4 - Mesoscale Alpine Programme (MAP) field experiment Robert Benoit	2-C.4.4 - Simulation of Arctic Climate Trends by Increased Greenhouse-Gas Forcing of a Stratospheric Model Gavin Schmidt	
14h20	2-C-1.3 - Trace metal mobility in sediments covered by the 1996 flood deposits in the Saguenay Fjord Alfonso Mucci	2-C-2.3 - Fine particulate matter - Monitoring and Forecasting - Considerations and Challenges David Waugh	2-C-3.3 - Radiation and Localisation of Planetary Waves in a Fluctuating Atmosphere: Theory Lionel Pandolfo	2-C-4.3 - Weather regime dependent seasonal predictability Hai Lin	
14h00	2-C-1.2 - High Resolution Modelling Study of the Saguenay Flood Jason A. Milbrandt	2-C-2.2 - Seasonal Smog Forecasting in New Brunswick: A Case Study Claude Côté	2-C-3.2 - Nonlinear critical layer development of forced wave packets in barotropic shear flows Lucy Campbell	2-C-4.2 - Teleconnections between Pacific sea surface temperatures and Canadian prairie wheat yield William Hsieh	

Mardi 1er Juin Tuesday June 1

Mercredi 2 juin Wednesday June 2

With the turn 2				Wednesday June 2			
SESSION 3-A PI Chair: Francis Z	énière / Plenary : Environmental Prediction V						
08h30-09h10	3-A-1.1 - (Invited Presentation): FORETELL: Integrated Road and Weather Information Services Across North America Peter Davies						
09h10-09h50	3-A-1.2 - (Invited Presentation): Climate prediction and predictability from seasons to centuries George Boer						
09h50-10h10	Pause santé / Health Break						
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160			
10h10-12h10	3-B-1 : Operational Meteorology III Chair: Paul Delannoy	3-B-2 : Climate Modelling I Chair: Norm McFalrlane	3-B-3 : Boundary Layer Meteorology Chair: Peter Taylor	3-B-4 : Atmosphere and Ocean Circulation - Chair: Hal Ritchie			
10h10	3-B-1.1 - A new model for road condition forecast in Canada Louis-Philippe Crevier	3-B-2.1 - Skill as a function of time scale in an ensemble of seasonal hindcasts produced with CCC GCM2 Viatcheslav Kharin	3-B-3.1 - The Blowing Snow Model Intercomparison Project (BSMIP): An Update Stephen J. Dery	3-B-4.1 - Significant Events of Interhemispheric Atmospheric Mass Exchange Marco Carrera			
10h30	3-B-1.2 - The Development of a Winter Weather Index for Benchmarking Winter Road Maintenance Activities in Canada Jianzhong Li	3-B-2.2 - Modelling sulfate aerosols with the Canadian GCM Ulrike Lohmann	3-B-3.2 - Sensible and latent heat fluxes in blowing snow events Jingbing Xiao	3-B-4.2 - Observations and Interpretations of Jet Streaks in Terms of Balanced Dynamics Philip Cunningham			
10h50	3-B-1.3 - Moisture and Mid-Latitude Winter Cyclones Steven Lambert	3-B-2.3 - Canadian RCM: Present status and its applications in climate change research Daniel Caya	3-B-3.3 - A Numerical Study of Boundary- Layer Flow over Complex Terrain Wensong Weng	3-B-4.3 - Relationship Between West Atlantic Pattern In Northern Winter And East Asian Summer Monsoon And Its Numerical Simulation Jinhai He			
11h10	3-B-1.4 - Real-Time Statistical Ground-Level Ozone Predictions William Burrows	3-B-2.4 - A new radiation model for CCC GCM Jiangnan Li	3-B-3.4 - A Lagrangian Solution to Canopy Flux-Gradient Relations Jon Warland	3-B-4.4 - Observation of an unusual baroclinic eddy in the Labrador Sea Ross Hendry			
11h30	3-B-1.5 - The New CMC Updateable Model Output Statistics (UMOS) Forecast System Marcel Vallée	3-B-2.5 - Sockeye salmon return migration and an ecosystem-OGCM model of the North Pacific William Hsieh	3-B-3.5 - Simulation of an intense local storm triggered by lake breeze Xin Qiu	3-B-4.5 - Currents and Transport on the southwestern slope of the Grand Banks Peter C. Smith			
11h50	3-B-1.6 - La tempête de verglas de janvier 1998 Claude Lelièvre	3-B-2.6 - The CCCma third-generation AGCM (GCMIII) Norman McFarlane		3-B-4.6 - Regional Ocean Climate of the North-West Atlantic Igor Yashayaev			
12h10-13h40		Dîner	Lunch				
13h40-15h20	3-C-1 : Environmental Emergency Response - Chair: René Servranckx	3-C-2 : Climate Modelling II Chair: John Fyfe	3-C-3 : Air-Sea Interactions Chair: Peter Smith	3-C-4 : Radar / Remote Sensing I Chair: Isztar Zawadski			
13h40	3-C-1.1 - The Montréal Volcanic Ash Centre: Real-time response to an aviation threat Pierre Bourgouin	3-C-2.1 - Nonlinear principal component analysis by neural networks William Hsieh	3-C-3.1 - The 1997/98 ENSO Event and Impacts on Sea Ice in the Western Arctic and Canadian Arctic Islands Tom Agnew	3-C-4.1 - The Canadian National Radar Project: An Update Paul Joe			
14h00	3-C-1.2 - Participation de CMC à ETEX. Réal D'Amours	3-C-2.2 - Simulation of the interannual variability of the wind driven Arctic sea ice cover during 1958-1998 Gilles Arfeuille	3-C-3.2 - Air-Sea Fluxes from the Labrador Sea Deep Convection Experiment of 1997 Will Perrie	3-C-4.2 - Operational processing of North American radar networks data at the Canadian Meteorological Centre Yves Gingras			

14h20	3-C-1.3 - The Application of Atmospheric	3-C-2.3 - Development of an improved	3-C-3.3 - Regional air-sea interaction in a	3-C-4.3 - The Vertically Pointing Radar: A	
	Modelling in the Comprehensive Test Ban	dynamic-thermodynamic sea ice thickness	1000-year climate simulation	Low-Cost Remote Sensing Instrument for	
	Treaty Verification: A Case study using the Explosion at the Tomsk Radiochemical	distribution model Todd Arbetter	ian waiterson	Education and Precipitation Physics Studies Frederic Fabry	
	Facility (Russian Federation)	1 odd 7 il bolloi		1 Toddio 1 dbiy	
	Michel Jean				
14h40	3-C-1.4 - Gestion et intervention	3-C-2.4 - CRAFT - A Canadian Routing	3-C-3.4 - The Influence of Sea Ice	3-C-4.4 - Simultaneous transmission and	
	environnementales; La météorologie au coeur d'une saine gestion.	Algorithm For Terrestrial Waters Vivek Arora	Distribution in Northeastern North America on Mesoscale Atmospheric Circulations:	reception of linear vertical and linear horizontal polarization for precipitation	
	Claude Rivet	VIVER AIOIA	Monthly Climate and a Polar Low	measurement	
	Glaude Mivet		Peter Zwack	Enrico Torlaschi	
15h00				Poster (13-18) Introductions	
15h20-15h40		Pause santé	/ Health Break		
15h40-17h40	3-D-1 : Pollution Transport and Air Quality III - Chair: Ashu Dastoor	3-D-2 : GEWEX and MAGS I Chair: Ron Stewart	3-D-3 : Atmosphere Modelling III Chair: Peter Bartello	3-D-4 : Radar / Remote Sensing II Chair: Steve Lapczak	
15h40	3-D-1.1 - Sulfur dioxide dispersion and	3-D-2.1 - Scientific challenges and progress	3-D-3.1 - Validation of a limited area model	3-D-4.1 - The use of x-band polarisation	
	subsequent deposition downwind from a	of the gewex hydrometeorology panel	Isztar Zawadzki	radar for hydrology	
	natural stationary point source: Masaya	Ronald Stewart		Marielle Gosset	
	volcano in Nicaragua Pierre Delmelle				
16h00	3-D-1.2 - Dark Conversion of Sulfur (IV) to	3-D-2.2 - An Overview of MAGS and	3-D-3.2 - Champs géophysiques du	3-D-4.2 - The meteorological interpretation	
101100	Sulfur (VI)	CAGES	CMC/CMC's Geophysical Fields	of near-surface radar refractivity	
	Parisa A. Ariya	Geoff Strong	Judy St-James	measurements	
	·	•	•	Charles Creese	
16h20	3-D-1.3 - Plans for tropospheric chemistry in	3-D-2.3 - Canadian Regional Climate Model	3-D-3.3 - A Modelling Study of the Garden	3-D-4.3 - Measurement of Water Vapour	
	the Canadian Middle Atmosphere Model	Surface Climate Evaluation During the	City, Kansas, Storm During VORTEX 95	Mixing Ratios using the Purple Crow	
	David Plummer	MAGS 1994-95 Water Year	David Anselmo	Raman-scatter Lidar	
16h40	3-D-1.4 - Testing of the Toronto emission	Murray MacKay 3-D-2.4 - The Land Surface Water Budget	3-D-3.4 - The Nonhydrostatic GEM Model	Chad Bryant  3-D-4.4 - Performance of the McGill Bistatic	
101140	inventory	for the BOREAS and MAGS Watersheds	Kao-San Yeh	Radar network	
	David Plummer	using Hydrologic Models	Nao-Gail Tell	Ramon de Elia	
		K.R. Snelgrove		Tamon do Liid	
17h00		3-D-2.5 - Validation of the Enhanced BATS	3-D-3.5 - Hybrid neural-dynamical	3-D-4.5 - SYPAI: The Study of SYnergy	
		Within the PILPS Framework	variational data assimilation models	between Passive and Active Instruments	
		Loren White	Youmin Tang	Marc Larocque	
17h20			Poster (19-25) Introductions (for Thursday)		
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160	
18h00-19h00	Bar payant / Cash Bar : HOTEL GOUVERNEUR				
19h00-22h00	Banquet : HOTEL GOUVERNEUR (Place Dupuis)				

Mercredi 2 juin Wednesday June 2

Jeudi 3 juin Thursday June 3

Jeuui 3 juii				Thursday June 3	
SESSION 4-A PI Chair: Michel Bé	énière / Plenary : Data Assimilation I Bland				
08h30-09h10	4-A-1.1 - (Invited Presentation) New data assimilation methods and sensitivity results Florence Rabier				
09h10-09h30	4-A-1.2 - Assimilation of Chemical Tracer Observations Richard Ménard				
09h30-09h50	4-A-1.3 - Estimating the temporal variability of ozone and its sources in the Canadian ozone 3D-VAR data assimilation system. Estimating the temporal variability of ozone and its sources in the Canadian ozone 3D-VAR data assimilation system.  Gilbert Brunet				
09h50-10h10	Pause santé / Health Break				
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160	
10h10-12h10	4-B-1 :-Data Assimilation II / Middle Atmosphere I - Chair: Stéphane Laroche	4-B-2 : GEWEX and MAGS II Chair: Geoff Strong	4-B-3 : University and Professional Education II - Chair: Peter Zwack	4-B-4 : Coastal Oceanography III Chair : Charles Hannah	
10h10	4-B-1.1 - Assimilation of TOVS total ozone data: impact on the forecasts and analyses Simon Pellerin	4-B-2.1 - Residue free atmospheric water budget study of lee cyclones over the Mackenzie River Basin during the BASE period. Vasubandhu Misra	4-B-3.1 University and Professional Education Paul Ruscher	4-B-4.1 - Mesoscale variability in the eastern Alboran sea in December 1997-January 1998 Yves Gratton	
10h30	4-B-1.2 - Observation System Simulation Experiments with satellite based ozone lidar Paul-Antoine Michelangeli	4-B-2.2 - A study of the water vapor transport through the mackenzie river basin Vladimir Smirnov		4-B-4.2 - Characterization of inertial oscillations in the eastern Alboran Sea during Almofront 2 Mathieu Ouellet	
10h50	4-B-1.3 - The Canadian Middle Atmosphere Model: Continuing developments. Stephen Beagley	4-B-2.3 - An Extreme Event of Interhemispheric Atmospheric Mass Exchange Originating in the Mackenzie River Basin Marco Carrera	4-B-3.2 - Projet InterMET: site WEB et cédérom de formation en météorologie pour les jeunes Nathalie Gauthier	4-B-4.3 - The use of tide gauge data in Hudson Bay William A. Gough	
11h10	4-B-1.4 - The Extended Canadian Middle Atmosphere Model Stephen Beagley	4-B-2.4 - Synoptic climatology of Northern Hemisphere available potential energy collapses Werner Wintels	4-B-3.3 - Expérimentation Assistée par Ordinateur (ExAO) Frédéric Fournier	4-B-4.4 - Modelling Tides in the Arctic Archipelago David A. Greenberg	
11h3013h40	Dîner / Lunch (Patterson)				
13h40-15h20	4-C-1 : Middle Atmosphere II Chair: Robert Sica	4-C-2 : GEWEX and MAGS III Chair: Henry Leighton	4-C-3 : Data Assimilation III Chair: Richard Ménard	4-C-4 : Coastal Oceanography IV Chair: Jinyu Sheng	
13h40	4-C-1.1 - Role of the nonlinear Hadley circulation in tropical upwelling. Kirill Semeniuk	4-C-2.1 - Solar Radiation Budgets for MAGS and BALTEX Jian Feng	4-C-3.1 - On the next version of the Canadian 3D-Var analysis scheme on model's coordinate Josée Morneau	4-C-4.1 - Fortnightly modulations of the estuarine circulation in Juan de Fuca Strait Diane Masson	
14h00	4-C-1.2 - Temporal Variability of Middle Atmospheric Temperature Inversions and Their Relation to Large-scale Dynamics Robert Sica	4-C-2.2 - A preliminary assessment of the blowing snow transport and sublimation fluxes for the Mackenzie River Basin Stephen J. Dery	4-C-3.2 - The impact of TOVS radiances in the CMC 3D variational analysis system Jacques Hallé	4-C-4.2 - Eddies in the Northeast Pacific Ocean William Crawford	

14h20	4-C-1.3 - Temperature Climatology of the Middle Atmosphere over Southwestern Ontario Stephen Argall	4-C-2.3 - Cross-lake Variation of Evaporation, Heat Flux and Thermal Responses of Great Slave Lake During the Ice-free Season in 1998 : GEWEX/MAGS William Schertzer	4-C-3.3 - Assimilation of Marine Surface Winds from the ERS-2 Scatterometer Mark Buehner	4-C-4.4 - Turbulent Mixing Studies in the Coastal Mixing and Optics Experiment Neil S. Oakey
14h40	4-C-1.4 - Wave-Induced Transport in an Idealized Stratosphere Diane Pendlebury	4-C-2.4 - Preliminary Analysis and Assessment of the MAGS Enhanced Surface Observations Bob Kochtubajda	4-C-3.4 - Sensitivity analysis with the GEM model Stéphane Laroche	4-C-4.5 - The impact of waves on ocean surface currents and ice floe drift Will Perrie
15h00	4-C-1.5 - Parameterization of thermal effects of saturated gravity waves Alexander Medvedev		4-C-3.5 - Assimilation of Bistatic Radar Network Data and the Near-Surface Index of Refractivity Alain Caya	
15h20-15h40	Pause santé / Health Break			
15h40-17h40	4-D-1 : Middle Atmosphere III Chair: Stephen Beagley	4-D-2 : Ocean Modelling Chair: Drew Peterson	4-D-3 : Operational Meteorology IV Chair: Richard Verret	
15h40	4-D-1.1 - Antarctic ozone depletion study using a photochemically coupled middle atmosphere model Jean de Grandpré	4-D-2.1 - Multiple Equilibria and Instrinsic Low-Frequency Variability in the Wind- Driven Ocean Circulation Francois Primeau	4-D-3.1 - An Interactive Aviation Weather Database (AWeD) Marie-France Turcotte	
16h00	4-D-1.2 - Sensitivity of modeled ozone depletion to Polar Stratospheric Cloud composition  Darryl Chartrand	4-D-2.2 - Comparison between three finite element models and one finite difference model of the ocean Frédéric Dupont	4-D-3.2 - Tornades non super-cellulaires dans le sud-ouest du Québec Pierre Vaillancourt	
16h20	4-D-1.3 - Effect of the Pinatubo Aerosol Loading on Stratospheric Ozone as Modeled by Canadian Middle Atmospheric Model Jonathan Jiang	4-D-2.3 - Sea Level Variability in the Labrador Sea during the WOCE: Hydrography vs TOPEX/POSEIDON Altimetry Igor Yashayaev	4-D-3.3 - The COBEL 1D model as a component of the FAA's Marine Stratus Initiative at the San Francisco airport. Robert Tardif	
16h40	4-D-1.4 - Seasonal Evolution of Ozone- Methane Correlations in the Polar Regions David Sankey	4-D-2.4 - Simple Light Dynamics Model to Investigate Particulate Organic Carbon Variability in Subarctic Pacific Pavel Boubnov	4-D-3.4 - COBEL André April	
17h00	4-D-1.5 - A New Lidar Technique for Measuring Molecular Nitrogen and Oxygen in the Upper Mesosphere and Lower Thermosphere Mike Mwangi		4-D-3.5 - Evaluation of COBEL nowcasts of stratus dissipation at San Francisco Airport Sandra Turner	
17h20	4-D-1.6 - MANTRA - A balloon mission to study the odd-nitrogen budget of the stratosphere Darryl Chartrand			
Salle / Room	R-OM130	R-OM120	R-OM110	R-OM160

Jeudi 3 juin Thursday June 3

### **POSTERS**

LUNDI 31 MAI - MONDAY MAY 31	MARDI 1 JUIN - TUESDAY JUNE 1	MERCREDII 2 JUIN - WEDNESDAY JUNE 2	JEUDI 3 JUIN - THURSDAY JUNE 3
P1 : A Neural Network Atmospheric Model for Hybrid Coupled Modelling Youmin Tang	P7: Intégration des méthodes géophysiques et géotechniques pour le calcul du volume des sédiments de la couche de 1996 dans la Baie des Ha! Ha! Pierre Côté	P13: Integration of UHF profiler information with bistatic radar measurements Pascal Guillemette	P19: Earth coordinate and mesoscale modelling Guy Bergeron
P2: Tornado Simulation : Environmental effects Jose Vergara	P8: Geochemical and micropaleontological tracers of fast sedimentological events and of recent environmental conditions in the Saguenay fjord, Canada Guillaume St-Onge	P14: Climatologie des précipitations liquides dans la région de Montréal en utilisant un réseau de pluviométres et à l'aide de la détection radar Marc Besner	P20: Automated weather forecast products Claude Landry
P3: Ash Forecasting Event over Western Canada 98-7-11: Forensic Study and Operational Response Ken Little	P9: Diagenetic evolution of accidental layers (floods, earthquakes, landslides) in the Saguenay fjord (QC) based on short lived isotopes (228Th, 210Pb, 137Cs) profiles in box-cored sediments Josée Savard	P15: Updates to the McGill RAPID (Radar Data Analysis, Processing and Interactive Display) System Aldo Bellon	P21: Canadian Hurricane Centre Operational Analytic Wind Model Allan Macafee
P4: Coupled Modelling of Local Climate and Peatland Ecosystem: the Contemporary Variability of Carbon Exchange in the System Bill Ouyang	P10: Effets de la bioturbation sur les caractéristiques géotechniques de la couche de 1996 dans la Baie des Ha! Ha! Et dans le Bras Nord du fjord du Saquenay (Québec, Canada) France Maurice	P16: Ground Based Optical Sensing of Western Canada Forest Fire Smoke Near Toronto Norm O'Neill	P22: Fine-Scale condensation process at varying resolution: sensitivity study with the Northern Aerosol Regional Climate Model (NARCM) Wanda Szyrmer
P5: Volcanic Ash Centres: Roles and Challenges René Servranckx	P11: Seasonal and Spatial Variations in Thorium Isotope Composition of Suspended Particulate Matter in the Saguenay Fjord (Canada)  Deke Zhang	P17: Towards a better understanding of El Niño- related temperature patterns in the prairie and foothills regions of Canada Dagmar Budikova	P23: Numerical Investigation of Windstorm VIVIAN with the Canadian RCM Stéphane Goyette
P6: Coupled Atmosphere-Ice-Ocean Forecasts in the Gulf of St. Lawrence François Roy	P12: Distribution of benthic foraminifera in surface sediments of the Saguenay fjord, before and after the flood of 1996 Julie Leduc	P18: Interseasonal Oscillations in the Rains and Floods over the Andes Mountain - Chile Jose Vergara	P24: Adjustment under Gravity in Finite- Difference Models Yuri Geshelin
			P25: Further investigation of modelling the North Water Polynya Todd Arbetter

## Vendredi 4 juin

## Friday June 4

08h30 - 09h50	Réunions / Meetings 5-A-1	Réunions / Meetings 5-A-2	
	100 places	100 places	
09h50-10h10	Pause santé / Health Break		
10h10-12h10	Réunions / Meetings 5-B-1	Réunions / Meetings 5-B-2	
	100 places	100 places	
12h10-13h40	Lunch		
13h40-15h00	Réunions / Meetings 5-C-1	Réunions / Meetings 5-C-2	
	100 places	100 places	
15h00-15h20	Pause santé / Health Break		
15h20-17h00	Réunions / Meetings 5-D-1	Réunions / Meetings 5-D-2	
	100 places	100 places	

Chaque présentation a reçu un code unique, composé de 4 parties, la localisant dans le temps et dans l'espace.

Each paper has been given a unique 4-part code that serves to locate it in time and space.

Un chiffre (1-4) représente le jour de la semaine (lundi à jeudi). Digit (1-4) denoting the day (Monday - Thursday).

Une lettre (A-D) représente la partie du jour (plénière, matin, après-midi). Letter (A-D) denoting the part of the day (plenary, morning, afternoon).

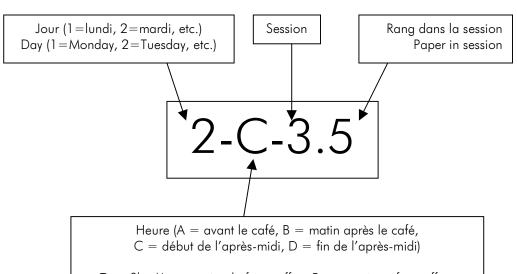
Un chiffre (1-4) qui représente la session parallèle dans laquelle se situe la présentation. Digit (1-4) denoting which of parallel sessions it is in.

Un chiffre (1-n) représentant le rang consécutif de la présentation durant une session. Digit (1-n) denoting the consecutive number of the paper's time slot within a session.

#### Exemple / Example :

2C3.5 peut se décoder comme étant la 5° présentation donnée dans l'après-midi de la journée 2 (mardi).

2C3.5 denotes the paper in the 5<sup>th</sup> time slot of session 3 on the afternoon of Tuesday.



Time Slot (A= morning before coffee, B = morning after coffee,  $C = early \ afternoon, D = midafternoon)$ 

**Explication des** codes des résumés **Coding explanation** 

## **Session 1-A-1** Plénière / Plenary **Prévision Environnementale I Environmental Prediction I** Lundi 31 mai Monday, May 31 08h30-09h50 Salle / Room Marie-Gérin-Lajoie

1-A-1.1 The Future of Environmental Prediction in Canada Gordon A. McBean<sup>1</sup>

Atmospheric Environment Service, Environment Canada, Toronto, Canada

In pursuing enhanced human welfare and economic growth, governments are recognizing that weather, climate, air quality and other environmental factors are of ever increasing importance in governmental and individual decision-making. As we enter the next century, there will be pressure on us to provide further services and advice on atmospheric and related changes on timescales ranging from minutes to decades. These services will go far beyond the daily weather forecasts and provide input to a wide variety of plans and decisions for the protection of human health, disaster mitigation and economic development. In this context a suite of non-traditional meteorological "problems" will be placed on our doorsteps demanding new predictions and services.

The Atmospheric Environment Service will become an organization that warns and informs Canadians and their governments of changes on a seamless time scale stretching from minutes to decades; e.g., warnings of minutes for tornadoes, days for winter storms and air pollution episodes, weeks for floods and droughts and decades for climate variations.

There are truly exciting prospects for prediction systems (the model-human mix) in the next 20-30 years pushing the limits of predictability with forecasts out to nearly two weeks. There will be extensive use of ensemble prediction approaches, which will be used for short and medium range forecasts as well as for seasonal and longer time scales. As the amount of information on the oceans increases continuously, it will be used for oceanic predictions on a more global scale, and to provide accurate time-varying lower boundary conditions for atmospheric predictions. Inclusion of more extensive and accurate observations and models of the hydrological cycle will lead to improved forecasts of precipitation, river flow and soil moisture. Highly accurate predictions of winds, temperatures, etc., leading to several day forecasts of severe weather, will allow much earlier warnings to specific local populations, reducing loss of life and property.

Prediction systems will only reach their full potential if the researchers and forecasters are working closely together. Forecasters will identify priorities and gaps and the researchers will assist the forecasters in understanding the models and improving the science; a two-way continuous learning exercise that is science based.

The public and our clients will play an ever increasing role with greater cohesion between the originators of environmental information, its end-users and policy makers. Products tailored to the decision-making criteria of various sectors will result in forecasts of weather, climate or air quality to user-defined specifications. Furthermore, clients and the public sector will demand certain performance that will be based both on science and decision-making requirements. It is likely that such forecasts will include statements of "forecaster confidence" which will take into consideration the current state of the monitoring-data assimilation-analysis-dissemination continuum.

The future looks exciting and promising.

1-B-1.1 RPN/AEPRI Coupled Numerical Modelling Harold Ritchie<sup>1</sup> Recherche en prévision numérique

Recherche en prévision numérique (RPN) has started a research and development activity for an environmental prediction system based on coupling a variety of numerical prediction models. In this context, we have also established the Atlantic Environmental Prediction Research Initiative (AEPRI) in Halifax, Nova Scotia, to join with other partners in conducting research and development for an environmental prediction capability in the Atlantic region. In the past year significant progress has been made in projects particularly in collaboration with the Atmospheric Environment Branch - Atlantic (AEB) and the Oceanography Department of Dalhousie University (DAL). The main ongoing coupled modelling and AEPRI sub-projects are: coupled atmosphere-wave models, coupled atmosphere-hydrology models, atmosphere-ocean coupling, coupling data assimilation and prediction systems for coastal applications, atmosphere / land-surface coupling, atmosphere / chemical transport model coupling, coupling with estuary models, and developing expert systems for marine applications.

This presentation will give a status report, including results from several of the sub-projects, and outline plans for the future.

#### 1-B-1.2

On The Use of Coupled Atmospheric and Hydrologic Models.

Pierre Pellerin<sup>1</sup>, Robert Benoit<sup>1</sup>, Harold Ritchie<sup>1</sup>, Nick Kouwen<sup>2</sup>, Denis Lefaivre<sup>3</sup>, Norman Donaldson<sup>4</sup> and Paul Joe<sup>4</sup>

<sup>1</sup>Recherche en Prévision Numérique (AES), <sup>2</sup>University of Waterloo, <sup>3</sup>Institut Maurice Lamontagne (MPO,DFO), <sup>4</sup>Atmospheric Environment Service

The purpose of this study is to present the possibilities offered by coupled atmospheric and hydrologic models as a new tool to validate and interpret results produced by atmospheric models. The advantages offered by streamflow observations are different from those offered by conventional precipitation observations. The dependence between basins and sub-basins can be very useful, and the integrating effect of the large basins facilitates the evaluation of state-of-the-art atmospheric models by filtering out some of the spatial and temporal variability that complicate the point-by-point verifications that are more commonly used. Streamflow permits a better estimate of the water amount fallen over a region. The streamflow predicted by the coupled atmospheric-hydrologic model versus the measured stream flow is sufficiently sensitive to clearly assess atmospheric model improvements resulting from increasing horizontal resolution and altering the treatment of precipitation processes in the model.

A case study for several southern Ontario river basins is presented with the Watflood hydrologic model developed at the University of Waterloo. It is passively coupled to a nonhydrostatic mesoscale atmospheric model that is integrated at horizontal resolutions of 35, 10 and 3 km. The Watflood model is also driven by radar derived precipitation amounts from King City Radar observations. Raingauge observations and measured streamflows are also available for this case, permitting multiple validation comparisons. These experiments show the uncertainties of each tool independently, and also their interesting complementary nature when they are used together. The predicted precipitation patterns are also compared directly with raingauge observations and with radar data. It is demonstrated that the hydrological model is sufficiently sensitive and accurate to diagnose model and radar errors. Although a demonstration of the skill of the atmospheric model was not one of the main purposes of this project, we have nevertheless been impressed by the quality of the simulations obtained. This tool brings an additional degree of verification that will be very





important in the improvement of technologies associated with atmospheric models, radar observations and the water resources management.

A new project has started with the Maurice Lamontagne Institute, Department of Fisheries and Oceans. The goals are first to improve the precipitation forecasts from the atmospheric model and second to use the precipitation forecasts operationally in the water level forecast of the St. Lawrence between Montreal and Quebec City. The atmospheric model is coupled with a hydrological model (rivers) and a hydrodynamic model (St. Laurence river). Preliminary results will be presented.

1-B-1.3

Coupled Atmospheric and Hydrologic Models over the St John River Basin Michael Campbell  $^{\rm I}$ 

<sup>1</sup>AEPRI/Environment Canada

A coupled atmosphere-hydrology model was developed at RPN by coupling the MC2 atmospheric model with the WATFLOOD hydrological model in a project sponsored by B.C. Hydro (Pierre Pellerin with Robert Benoit, RPN). In a follow on study, very good results have been obtained for a southern Ontario heavy precipitation case using the GEM model to drive a 15 km resolution data assimilation cycle whose analyses were used to initiate MC2 atmospheric model simulations at high resolutions (nonhydrostatic scales). The WATFLOOD hydrological model was fed by the precipitation forecast by the MC2 model, as well as from precipitation deduced from the King City radar observations. Comparing the resulting streamflows produced by WATFLOOD against the corresponding observed streamflows showed that WATFLOOD was able to produce very realistic streamflows when fed by either the forecast MC2 precipitation or the observed radar precipitation. The comparisions from this coupled atmosphere-hydrology experiment gave much clearer results than are usually obtained from conventional comparisions between forecast precipitation and conventional raingage data, demonstrating the utility of the coupled atmosphere-hydrology system. An article entitled "On the Use of Coupled Atmospheric and Hydrologic Models at Regional Scale" by R. Benoit, P. Pellerin, N. Kouwen, H. Ritchie, N. Donaldson, P. Joe and R. Soulis will soon appear in Monthly Weather Review. Conditions for the southern Ontario study were almost ideal, with relatively simple topography, a region where WATFLOOD has been thoroughly tested, with good radar, raingage, and streamflow measurements. We are now studying another region where the topography might be somewhat more challenging - the St. John River Basin. The project will follow the example of the southern Ontario study, and the required data sets are presently being compiled.

1-B-1 4

Stochastic and deterministic modeling of stream water temperature in a small forested catchment.

André St-Hilaire<sup>1</sup>, Daniel Caissie<sup>2</sup>, Guy Morin<sup>3</sup> and Nassir El-Jabi<sup>4</sup>
<sup>1</sup>INRS-EAU, <sup>2</sup>Pêches et Océans Canada, <sup>3</sup>INRS-Eau, <sup>4</sup>Université de Moncton

Stream water temperature is a very important parameter in aquatic ecosystems. Changes in the variability of the annual temperature cycle often results in changes in the density, abundance or diversity of the aquatic biota. Scientists and managers require tools to assist them in simulating both the natural thermal regime and potential anthropogenic effects.

Catamaran Brook, a third order forested catchment in central New Brunswick, has been the site of intensive water temperature monitoring over the last 8 years. Two modeling approaches were used to simulate mean daily water temperature in Catamaran Brook. The stochastic model used a Fourrier series to establish the long-term annual harmonic. The high frequency residuals were modeled using a second-order Markov process. The deterministic model used was the CEQUEAU model, modified to account for forest canopy and soil

temperature. A number of criteria were used to evaluate the two models and compare their performance. Commonly used criteria such as the root-mean-square-error (RMSE) and Nash coefficient (NTD) showed that both models performed relatively well. The overall RMSE for the deterministic model was 1.77  $^{\circ}\text{C}$  while the stochastic model had a RMSE of 1.13  $^{\circ}\text{C}$ . Nash coefficients for the deterministic and stochastic models were similar (NTD = 0.82 and 0.85 respectively). The Fractional Mean Bias showed a slight tendency for both models to under predict.

1-B-1-5 Posters (1-6) Introductions





1-B-2.1

Aerosols and Climate: The NARCM Aerosol Modelling Project

Leonard A. Barrie<sup>1</sup> and Jean-Pierre Blanchet<sup>2</sup>

Atmospheric Environment Service, <sup>2</sup>Département des Sciences de la Terre, Université du Québec à Montréal

It is widely recognized that aerosols play an important role in climate. The most recent IPCC consensus is that the global mean direct forcing of anthropogenic aerosols is -0.5 W m-2 (confidence limits -0.2 to -0.8 W m-2) while indirect forcing is very uncertain falling in the range 0 to -1.5 W m-2. This forcing is opposite and comparable to that of anthropogenic greenhouse gases. The Northern Aerosol Regional Climate Model (NARCM) is a three year (1997-2000) Canadian university/government project of approximately 20 scientists that is being undertaken under the auspices of the Climate Research Network. It is intended that a Canadian size-distributed aerosol modelling capability is developed by: (i) incorporating sizedistributed aerosols processes in RCM and GCM/MAM (ii) simulating the spatial-temporal distributions of major aerosol types and checking with observations, (iii) linking aerosols actively with clouds and atmospheric radiation, and (iv) assessing the role of aerosols in climate processes. Goals (i) and (ii) above are the main focii of this first phase of NARCM. The NARCM research strategy is to apply a sectional model of 12 discrete size ranges that includes aerosol dynamics and chemistry in climate models tosimulate the movement of aerosols from their sources through the atmosphere, their physical and chemical transformations in clear air and clouds, their interaction with the solar and terrestrial radiation and finally removal by wet and dry deposition processes. The order in which aerosol types are incorporated into the model is: sea salt, sulphate (natural and anthropogenic), black carbon (natural and anthropogenic), volcanic sulphur, soil dust and organics (natural and anthropogenic). To date, the first 3 types have been included. Highlights of NARCM research will be reviewed as an introduction to this session.

1-B-2.2

Water Uptake Calculations for NARCM mixed aerosols Glen Lesins<sup>1</sup>, Petr Chylek<sup>1</sup> and Jeff Wong<sup>2</sup>

<sup>1</sup> Dalhousie University, <sup>2</sup>CCRS - Ottawa

Atmospheric aerosols are generally internal mixtures of various water soluble and insoluble components. The water uptake by these aerosols must be calculated in order to compute the correct size distribution and the optical properties for use in chemical models and radiative forcing calculations. We have developed a fast parameterization scheme that accurately predicts the water uptake of internally mixed sulfate, nitrate and sea salt aerosols as a function of relative humidity right up to the activation point for dry aerosols radii from 0.01 to 10 micrometers. It uses results from laboratory measurements of water swelling by hygroscopic particles and includes the effect of deliquescence and crystallization. The scheme has been incorporated in the CAM package used by NARCM.

1-B-2.3

Sulphate production in sub-grid scale clouds

Natalie Hasell<sup>1</sup>, J. Jiang<sup>2</sup>, Knut von Salzen<sup>1</sup>, Henry G. Leighton<sup>1</sup> and Jean-Pierre Blanchet<sup>2</sup>

Department of Atmospheric and Oceanic Sciences, McGill University, <sup>2</sup>Département des Sciences de la Terre, Université du Québec à Montréal

Understanding the interactions between clouds and aerosols is key to better modelling climate and climate change. As sulphate is the main hygroscopic aerosol constituent of anthropogenic origin, its production as a result of in-cloud oxidation of S(IV) species is of prime interest. Also worth investigation is the degree to which aerosol size spectra are modified by cloud processing.

This numerical study has as its main tool several versions of the Northern Aerosol Regional Climate Model (NARCM) Local Climate Model (LCM). The first version of the LCM contains the CCCma GCMii physical parameterizations (McFarlane, 1992). The GCMii cloud scheme is a diagnostic relative humidity based scheme. The clouds produced by this bulk scheme are treated as homogeneous.

As in-cloud chemistry is dependent amongst other things on temperature, relative humidity and liquid water content, it is likely that modelled sulphate production will vary depending on cloud parameterization. In an attempt to make the treatment of clouds more realistic, a statistical sub-grid scale cloud parameterization, called the UQAM cloud scheme, was developed by Jiang, 1998. In contrast to the GCMii scheme, here vertical motion of sub-grid scale air parcels is distributed throughout the grid square (as turbulence or gravity waves) in a random fashion. Under the premise that condensation and liquid water content are related to updraft speed, the cloud will have a non-homogeneous microstructure. Furthermore, to make the implementation complete, in-cloud chemistry is also applied at sub-grid scale.

The goal of this study is to investigate the dependence of sulphate production on cloud scheme, specifically for stratiform clouds. Since sulphate production is not a linear process, it may well be that although the two cloud schemes produce similar average cloud properties, sulphate production might be significantly different. To investigate this, we compare sulphate production in models with and without sub-grid scale clouds.

#### 1-B-2.4

Modeling Size-Distributed Global Sea Salt Aerosols In The Atmosphere: An Application Using Canadian Climate Models
Sunling Gong¹ and Leonard A. Barrie¹
¹Environment Canada

The spatial and temporal distribution of global sea-salt aerosols were simulated with a size-distributed atmospheric aerosol algorithm developed for the Northern Aerosol Regional Climate Model [NARCM] applied to the Canadian third general circulation model. It incorporates the processes of aerosol generation, diffusive and advective transports and removals as a function of particle size. A comparison was made between observations and model predictions of sea-salt concentrations and size distributions. Size-resolved aerosol properties of global sea-salt such as transport patterns, residence time, fluxes and removals are obtained from the simulations. Since the sea-salt generation term is relatively well quantified, the comparison ensures that a reasonable parameterization of removal and transport schemes is used.

#### 1-B-2.5

Simulation Of Size-Segregated Global Sea-Salt And Sulphate Aerosol Mixtures Using The Canadian Global Climate Model [Gcmiii]

Sunling Gong<sup>1</sup>, Leonard A. Barrie<sup>1</sup>, N. McFarlane<sup>1</sup>, M. Lazare<sup>1</sup>, Ulrike Lohmann<sup>2</sup>, Jean-Pierre Blanchet<sup>3</sup> and Lubos Spacek<sup>3</sup>

<sup>1</sup>Atmospheric Environment Service, <sup>2</sup>Department of Physics Dalhousie University, <sup>3</sup>Department of Earth Sciences UQAM

Sea salt and sulphate are major global aerosol sources that play an important role in tropospheric chemistry and climate. The Canadian Global Climate Model (GCMiii) coupled with CAM - Canadian Aerosol Module was used to simulate the global distribution of size-segregated sea-salt and sulphate aerosols of both anthropogenic and natural origins in the atmosphere. CAM is a sectional model which carries aerosol particles as active constituency. In current configuration, the aerosol mixtures are divided into 12 size sections [r=0.005-10 mm] and assumed to be internally mixed. Processes simulated in CAM include production, nucleation, condensation, aerosol-cloud interaction, removal and transport in the





atmosphere for each type of aerosols. The transport of aerosols in GCMiii includes a semi-Lagrangian advection, vertical diffusion and convection. Interaction between aerosol and cloud is explicitly treated by combining a parameterized aerosol activation and a microphysical cloud scheme.

The results were obtained using the model with a linear physics transform grid of size 96′48 [3.75 degree uniform resolution in longitude], vertical resolution of 22 levels [from surface to 12 hPa pressure level] and 20 minute integration time step. Simulated global aerosol concentrations were compared with observations. Reasonable agreement was found in terms of absolute magnitude and seasonal variations. The relative impact of sea-salt on global sulphate aerosols is discussed.

1-B-2.6

The sensitivity of sulphate aerosol concentration and size to changing anthropogenic sulphur emissions

Knut von Salzen<sup>1</sup>, Henry G. Leighton<sup>2</sup>, Sunling Gong<sup>3</sup>, Lubos Spacek<sup>4</sup>, U. Lohmann<sup>1</sup>
<sup>1</sup>Department of Atmospheric and Oceanic Sciences, McGill University, <sup>2</sup>CCRS - Ottawa, Earth Sciences Department, University of Quebec at Montreal Department of Physics

The present-day radiative forcing by anthropogenic sulphate aerosols represents a pertubation to climate with a magnitude probably of similar order as the forcing due to the greenhouse gas accumulation since preindustrial times, but of opposite sign and different spatial distribution. There is evidence for a nonlinear response of global sulphate aerosol concentrations to sulphur oxide emissions. The majority of sulphate aerosol production by oxidation of sulphurdioxide is believed to occur in clouds with hydrogen peroxide being the most important oxidant. Insufficient concentrations of hydrogen peroxide in regions with high sulphur oxide emissions may have significant limiting effects on the in-cloud production of sulphate aerosol. To assess the response of sulphate aerosol over North America to changing emissions, three-dimensional simulations for different emission scenarios have been performed with the Northern Aerosol Regional Climate Model (NARCM). Results of these simulations are discussed with respect to sulphate aerosol concentration and size

1-B-3.1 Canadian Participation in FIRE.ACE George Isaac<sup>1</sup> Cloud Physics Research Division

Canadian participation in the field phase of the First ISCCP Regional Experiment, Arctic Cloud Experiment (FIRE.ACE) began on April 6 out of Inuvik, N.W.T. and ended on May 1, 1998. FIRE.ACE is a project being led by NASA to improve our understanding of Arctic clouds and how they affect our climate. This project is fully coordinated with the Surface Heat Budget of the Arctic (SHEBA) project being led by the U.S. National Science Foundation who leased the Canadian Coast Guard ice breaker Des Groseilliers to sit locked into the ice pack for one year ending approximately August 98. A National Research Council Convair 580 was flown out of Inuvik to measure cloud and precipitation microphysical properties, radiation fluxes, water and carbon dioxide fluxes, and air quality parameters including gas phase mercury. An onboard LIDAR looking up and down gave excellent data on cloud properties and aerosol layers.

There were 4 flights over the SHEBA ice breaker located at approximately 76N 165W. Remote sensor data (cloud RADAR, radiometer, LIDAR) on the ship will be compared with insitu measurements made by the aircraft. Then satellite measurements will be compared with the ship measurements in an effort to improve our ability to measure cloud properties in the Arctic. Both boundary layer and mid level cloud properties were documented by the aircraft instrumentation during the flights to the ship and on many flights out over the Beaufort Sea north of Inuvik. Ice crystal shapes and sizes were accurately measured using a new generation cloud probe. Fluxes of water vapour and carbon dioxide over leads and polynyas were measured, and clouds forming over polynyas were investigated. Arctic haze layers were encountered and the aerosol chemistry was documented using the onboard instrumentation. The MC-2 model was run in real-time during FIRE.ACE and this model will be used to assist in the development of improved paramterizations for both weather forecasting and climate change models.

The overall FIRE.ACE project will be described and a brief summary of the accomplishments of the Canadian group will be given.

#### 1-B-3.2

Mesoscale Modeling during FIRE.ACE: Flight Guidance and Model Performance Bernard Bilodeau<sup>1</sup>, Jocelyn Mailhot<sup>1</sup>, André Tremblay<sup>2</sup>, Anna Glazer<sup>2</sup> and Stéphane Bélair<sup>1</sup> Recherche en prevision numerique, SEA, <sup>2</sup>Cloud Physics Research Division, SEA

During the Canadian phase of the FIRE.ACE field project (6 April-1 May 1998), a special modeling system has been set up in Inuvik, NWT, to provide specific forecasting guidance for the Convair aircraft flight operations. The MC2 (Mesoscale Compressible Community) model was run at high-resolution (10 km) everyday to give an accurate picture of mesoscale features, especially with regards to the Arctic cloud structure and distributions, near-surface winds and temperatures. The model domain covered the areas of interest, including Barrow (the ARM site) and the SHEBA ice breaker site. Special effort was put in the model physics package to provide a detailed representation of the processes most relevant to the weather in the Arctic, in particular the surface processes both over the ice-covered ocean and the continent, the boundary layer, and the Arctic stratus clouds.

An overview of the various aspects of the modeling system will be presented at the Congress. Some verification statistics will be shown, together with a sensitivity study of the surface fluxes to the ice fraction analysis.





#### 1-B-3.3

Modeling of the low-level mixed-phase clouds in the Arctic during Spring Eric Girard<sup>1</sup>, Judy A. Curry<sup>2</sup> and Amanda H. Lynch<sup>1</sup>

<sup>1</sup>Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, CO, <sup>2</sup>Program in Atmospheric and Oceanic Sciences (PAOS), University of Colorado, Boulder, CO

Recent observation campaigns such as SHEBA, ARM and FIRE have shown that, during spring, Arctic low-level clouds are predominantly mixed with the coexistence of ice crystals and water droplets. These mixed-phase clouds are also observed during the cold season. Global climate models such as ARCSym and ECMWF underpredict the low-level clouds and as a result, they underestimate the downward longwave flux at the surface.

The aim of this work is to investigate the microphysical processes leading to the formation of such clouds. We use the column version of the ARCSyM model. The cloud scheme added to the original model allows to simulate low-level mixed-phase clouds with weak turbulence and entrainment such as thin stratus, fog and clear sky precipitation. Results of the case of May 1998 in the Beaufort Sea will be shown. Model outputs are compared to observations taken during FIRE experiment.

#### 1-B-3.4

Simulations of ice clouds and aerosols during FIRE III using the CCCma single column model Ulrike Lohmann<sup>1</sup>, J. Humble<sup>2</sup>, W. R. Leaitch<sup>2</sup> and H. Lin<sup>3</sup>

<sup>1</sup>Dalhousie University, Halifax, Canada, <sup>2</sup>Dalhousie University, <sup>3</sup>Atmospheric Environment Service

The single column model (SCM) of the Canadian Centre for Climate Modelling and Analysis (CCCma) solves prognostic equations for the number and mass of ice crystals and drop droplets and includes an atmospheric sulfur cycle. Ice crystals either form by either homogeneous freezing of solution droplets below -35C or by heterogeneous nucleation which requires the presence of ice nuclei. We consider contact nucleation and stochastic freezing depending on temperature, liquid water content and the number of cloud droplets. In this talk we will present simulations with the CCCma SCM for periods during the FIRE III campaign, which took place in Inuvik, Northwest Territories during April-May 1998, where ice clouds were observed and measurements of ice crystals and aerosols were conducted. We will investigate how well we are able to simulate ice clouds and aerosols with the current approach of ice nucleation and where model deficiencies are so that we can improve the simulation of ice clouds and aerosol in the CCCma SCM.

#### 1-B-3.5

Programme et résumés

Measuring Arctic Clouds and Aerosol by using Counterflow Virtual Impactor (CVI) Hong Lin<sup>1</sup>, W.R. Leaitch<sup>1</sup>, K.J. Noone<sup>2</sup> and M. Couture<sup>1</sup>

<sup>1</sup>Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ont. M3H 5T4, Canada, <sup>2</sup>Dept. of Meteorology, Stockholm University, 10691 Stockholm, Sweden

A Counterflow Virtual Impactor (CVI) was used to sample ice crystals, droplets and aerosol particles in the FIRE III experiment conducted in the Canadian Arctic region in 1998. The CVI is an instrument inertially separates clouds droplets/crystals larger than a certain aerodynamic size (~ 10 um in diameter) from the surrounding atmosphere and measure their residual particles. It is an instrument suitable for ice crystal measurement, especially the small ice crystals. CVI can also function as an aerosol inlet to sample aerosol particles. In this study, we will present microphysical properties of Arctic aerosol and clouds measured by using the CVI. The comparison of the CVI data to other instruments, such as FSSPs, PMS measurements will also be discussed.

1-B-3.6

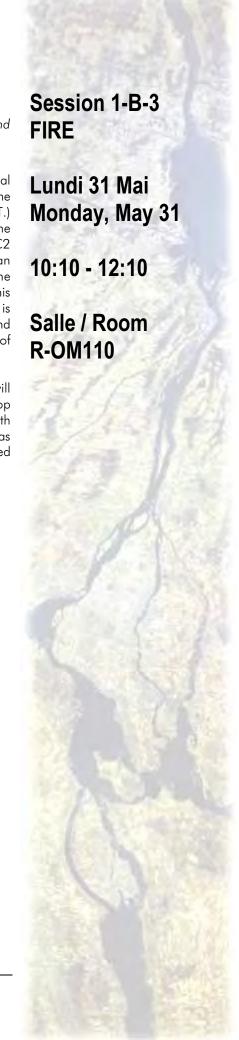
Modeling of Arctic Clouds during FIRE.ACE

Anna Glazer<sup>1</sup>, André Tremblay<sup>1</sup>, Jocelyn Mailhot<sup>1</sup>, Bernard Bilodeau<sup>1</sup>, Stéphane Bélair<sup>1</sup> and George Isaac<sup>1</sup>

<sup>1</sup>Atmospheric Environment Service

Due to the very low density of meteorological observations in the Arctic, the design of optimal research aircraft flight trajectories during FIRE.ACE was particularly difficult. To provide the real-time guidance for the Canadian Convair research aircraft (based in Inuvik N.W.T.) missions, an experimental forecast system was run daily during the Canadian phase of the experiment (April 6th - May 1st 1998). A mesoscale version (10 km) of the Canadian MC2 model was run each day to produce forecasts of various meteorological parameters with an emphasis on the cloud structure and boundary layer fluxes. The clouds were forecast with the mixed-phase cloud scheme developed by Tremblay et al. (Tellus 1996, 48A, 483-500). This scheme considers the total water content (TWC) as a basic prognostic variable. The TWC is diagnostically partitioned into solid and liquid phases at subfreezing temperatures and encompasses the continuum of all solid and liquid phase particles that constitute the mass of condensate in the atmosphere.

The mixed-phase cloud scheme and the MC2 model setup for the FIRE.ACE experiment will be presented. Two cases will be analyzed. The phase, vertical structure, including cloud top and base height, and horizontal extent of simulated cloud fields will be compared with available satellite and cloud radar data. Typical features of Arctic meteorology such as temperature and humidity inversions and multiple layering of cloud fields will be discussed





1-B-4.1
The Role of Ocean Mixing in Coupled Model Projections of Climate Change Gregory M. Flato¹ and George J. Boer¹
¹AES

Global coupled climate models must parameterize the effects of ocean eddies on heat, salt and momentum transport. Historically, most models employed a horizontal/vertical mixing tensor. This is the case in the CCCma first-generation coupled model, CGCM1. A more recent parameterization, due to Gent and McWilliams (GM) rotates the mixing tensor to align with the local isopycnal slope, and in addition, includes a representation of the stirring effects of mesoscale eddies. This scheme is used in the CCCma second-generation coupled model, CGCM2. The model is further modified by the inclusion of Flato-Hibler (FH) ice dynamics. We compare some basic features of the climate change projected using CGCM1 and CGCM2 under a prescribed scenario of increasing greenhouse gas and aerosol forcing. Consistent with some earlier speculations, the result is a reduction in the North/South asymmetry of warming when the GM and FH schemes are implemented. We focus on differences in the evolution of the Southern Ocean temperature and salinity structure and heat transports to illustrate the role of the parameterizations in determining the rate of high southern latitude warming. We contrast these results to a similar experiment conducted by Hirst et al. using the Australian CSIRO coupled model, in which there was little change in the asymmetry of the warming upon inclusion of the GM mixing scheme.

1-B-4.2 Interdecadal Variability in Models with North Atlantic Bottom Topography Andrew K. Peterson<sup>1</sup> and Richard Greatbatch<sup>1</sup> Dalhousie University

It is known that interdecadal variability in flat-bottomed ocean models is associated with the passage of a viscous Kelvin wave that propagates around portions of the model boundaries. The variability developes its interdecadal timescale as a result of this Kelvin wave being severely arrested in areas of weak stratification. When realistic topography is included, the adjustment process associated with these waves is drastically altered. Energy is now allowed to leak into topographic Rossby waves which greatly speeds up the adjustment process. We find a stong self-sustaining oscillation in a flat-bottomed, realistic geometry, North Atlantic model. However, no such self-sustained oscillation occurs in any of our North Atlantic models with a realistic bottom topography. Stochastic forcing is required to produce interdecadal varibility in such models. Attempts will be made to link this stochastic forcing with interdecadal variability found in various atmosphere-ocean coupled models.

1-B-4.3

A Coupled Atmosphere - Ocean Wave Model for Understanding Air -Sea Fluxes in North Atlantic Storms

Bin He<sup>1</sup>, William Perrie<sup>1</sup>, Yaocun Zhang<sup>1</sup> and Bechara Toulany<sup>1</sup> Bedford Institute of Oceanography

Air-sea interaction under high wind conditions, is dominated by processes associated with the upper ocean; for example wave modulation of air-sea fluxes (momentum, sensible heat and moisture) at the ocean-atmosphere interface. The collective impact of these processes is not understood to the same degree as the effect of each individual process. In this study, a limited-area air-sea coupled modelling system developed at BIO is used to carry out numerical sensitivity experiments, as well as real data experiments, for the purpose of evaluating the impact of sea spray and sea-surface waves on air-sea interaction under high wind conditions. Parameterization schemes are used to describe the modulation of air-sea surface fluxes by sea spray and ocean surface waves. Feedbacks between the atmosphere

and the ocean surface wave model make this a realistic framework to assess these parameterization schemes. We use the P-sigma primitive equation atmospheric model and the WAM ocean wave model. Real data verification of model is achieved through comparison with: (1) wind fields, meteorological fields and wave measurements from the Storm of the Century in March 1993, and (2) selected storm periods from the detailed air sea fluxes and other collected data, from the Labrador Sea Deep Convection Experiment.

#### 1-B-4.4

Verification of a Coupled Atmosphere - Ocean Wave Model with Air -Sea fluxes in the Labrador Sea Experiment

Yaocun Zhang<sup>1</sup> and William Perrie<sup>2</sup>

<sup>1</sup>Bedford Institute of Oceanography, Nanjing University, <sup>2</sup>Bedford Institute of Oceanography

The exchanges of the momentum, heat and water vapor at the air-sea interface are very important physical processes for the study of climate dynamics and climate change occurring at different time-scales. This is particularly true with regard to coupled atmosphere - ocean climate models. Correct representations of these fluxes are essential for climate modelling, on all time-scales. In order to assess whether the coupling of ocean surface waves to an atmosphere model can improve the calculation of air - sea flux exchanges, we constructed a coupled regional atmosphere - ocean wave model system for the North Atlantic. We used the WAM ocean wave model and the NCAR RegCM2 atmospheric model. Coupling was achieved through the parameterization derived by Smith and co-workers in the HEXOS North Sea experiment from the late 1980's, which relates sea surface roughness Zo to sea state. This Zo formulation represents a sea-state dependent variation to the more traditional Charnock formulation for Zo. Our coupled model was used to investigate the interaction of atmosphere and ocean waves over the Labrador Sea during February - March 1997. This period corresponds to the Labrador Sea Deep Convection Experiment. We present a detailed verification of our model, using air - sea fluxes and other collected data, from the Labrador Sea Deep Convection Experiment.

#### 1-B-4.5

The Role Of The Thermohaline Circulation In The Initiation Of Glaciation Zhaomin Wang<sup>1</sup> and Lawrence A. Mysak<sup>1</sup>

<sup>1</sup>McGill University

We present a new coupled atmosphere-ocean-sea ice-land surface model for long-term climate change studies which incorporates the seasonal cycle. The three major ocean basins, the Antarctic Circumpolar Current region and the major continents are resolved.

The model components are coupled together using flux adjustments (for heat and fresh water) in order to first simulate the present day climate. The major features of this simulation are consistent with observations and the general results of GCMs. In a global warming (cooling) experiment, the thermohaline circulation (THC) in the North Atlantic Ocean is weakened (intensified) mainly due to the increased (reduced) moisture transport to the northern high latitudes and warming (cooling) in the high latitudes of the North Atlantic.

Lastly, the coupled model is employed to investigate the initiation of glaciation by slowly reducing the solar radiation and increasing the planetary emissivity, only in the northern high latitudes. When land ice is growing, the THC in the North Atlantic Ocean is intensified, resulting in a warm subpolar North Atlantic Ocean, which is in agreement with the observations of Ruddiman and McIntyre. The intensified THC maintains large land-ocean thermal contrast at high latitudes and hence enhances land ice accumulation, which is consistent with the rapid ice sheet growth during the first 10 ka of the last glacial period that was observed by Johnson and Andrews. We conclude that a cold climate is not responsible

Session 1-B-4 Modèles couplés atmosphère - océan Coupled **Atmosphere-Ocean** Models Lundi 31 mai Monday, May 31 10:10 - 12:10 Salle / Room R-OM160



for a weak or collapsed THC in the North Atlantic Ocean; rather we suggest that increased fresh water or massive iceberg discharge from land is responsible for such a state.

1-B-4.6

The Climate-Ice Sheet Interactions In A Simple Climate Model Lawrence A. Mysak<sup>1</sup> and Zhaomin Wang<sup>1</sup> McGill University

A zonally averaged ice sheet model used by Gallee et al. has been coupled to a simple climate model, which incorporates an energy-moisture balance atmospheric model, a zonally averaged ocean model of Wright and Stocker, a zero-layer thermodynamic sea ice model and a simple land surface model. The ice sheets are initiated by reducing the solar insolation and planetary emissivity in the northern high latitudes.

The ice sheets grow rapidly during the first 10 ka due to the strong thermohaline circulation (THC) in the North Atlantic and very small lateral discharge of ice mass. However, during this stage, the climate in the northern high latitudes is only cooled down slightly and ice sheets cannot advance southward easily. On the other hand, if the planetary emissivity is reduced globally, which can mimic the drop of the concentration of carbon dioxide and water vapor after the initiation of glaciation, the ice sheets may extend southward significantly. Also, the weakening of the THC due to the large ice mass discharge leads to the southward advance of sea ice and a significant cooling of the climate.

Since there exist two flow regimes (steady flow and rapid ice mass discharge) of ice sheets, the ice mass discharge to the ocean is suddenly increased once the ice flow reaches a critical value. This causes the drop of ice volume and weakens the THC. The weak THC leads to the advance of sea ice, which cools down the climate further and slows down the growth of ice sheets. When the large ice mass discharge stops, the THC is restored and the sea ice cover retreats. Then the ice sheets grow relatively rapidly and the critical situation is reached again, which causes another large ice mass discharge.

#### 1-C-1.1

Recent and future improvements in the Canadian Meteorological Center's analysis and forecasting system / Améliorations récentes et futures au système d'analyse et de prévision du Centre Météorologique Canadien

Richard Hogue<sup>1</sup>

Operations Branch, Canadian Meteorological Center

The Operations Branch of the Canadian Meteorological Center (CMC) is responsible for running the operational models and analysis systems that have been developed by the R&D Divisions of CMC and RPN (Recherche en Prévision Numérique). Major changes to these operational systems have been implemented in the past year. In September 1998, the resolution of the regional version of the Global Environmental Model (GEM) was increased from 35km to 24km and improvements were brought to the parameterization of the surface processes. The following month, in October 1998, the global version of GEM replaced the global SEF spectral model to produce the Center's medium and long range forecasts. These changes will be reviewed as well as the improvements planned during the next year to the model and analysis systems once all year 2000 compliance issues are resolved. The question of availability as well as transmission of analysis and model outputs to various users will also be discussed. Also, the CMC Operations archive database will be presented as well as how this database is used to support R&D projects such as GEWEX.

#### 1-C-1.2

General Description of NWP Modelling at the Canadian Meteorological Centre Louis Lefaivre<sup>1</sup>, Normand Brunet<sup>1</sup>, Normand Gagnon<sup>2</sup>, Anne-Marie Leduc<sup>1</sup>, Gabriel Lemay<sup>1</sup>, André Méthot<sup>1</sup>, Richard Moffet<sup>1</sup>, Alain Patoine<sup>1</sup>, Gérard Pellerin<sup>1</sup> and André Plante Joseph-Pierre Toviessi<sup>1</sup>

<sup>1</sup>Canadian Meteorological Centre, Environment Canada, <sup>3</sup>Department of Atmospheric and Oceanic Scences, McGill University

The Canadian Meteorological Centre (CMC) is responsible for running models covering a large range of scales, from mesoscale (10-15 km with a lead time of 24 hours) to synoptic scales (250 km with lead time of one season). Some models are run in a deterministic fashion others in probabilistic. The scope also touches environmental prediction with links to Chemical Transport models. The common denominator of the NWP work at CMC is the Global Environmental Multiscale (GEM) model, which is now the main dynamic model for most of the applications that are run operationally. Two recent implementations, in regional and in global mode, effectively involved the GEM model.

The talk will briefly review every aspect of numerical modelling at CMC and will serve as an introduction to a series of presentations on more specific aspects.

#### 1-C-1.3

CMC's 24km GEM Regional Model: Present Status And Performance Assesment Richard Moffet<sup>1</sup>, Stéphane Bélair<sup>2</sup>, Normand Brunet<sup>1</sup>, Louis Lefaivre<sup>1</sup>, André Méthot<sup>1</sup>, Alain Patoine<sup>1</sup> and Gérard Pellerin<sup>1</sup>

<sup>1</sup>Environnement Canada, CMC, CMSN, <sup>2</sup>Environnement Canada, Recherche en Prevision Numerique

In September of 1998, a new version of CMC's regional model became operational. Other than an increase in spatial and temporal resolution, many modifications to its physical parameterization were part of this improved version of the GEM model. A Fritsch-Chappell convection scheme was implemented to better forecast convective activity at a 24 km resolution. Along with this scheme , an improved explicit condensation scheme is also used which better depicts the evaporation of precipitation. Radiation is now called every hour in the model, corresponding to every 5 time steps, rather than every 2 hours. Horizontal

Session 1-C-1 Météorologie opérationnelle I **Operational** Meteorology I Lundi 31 mai Monday, May 31 13:40 - 15h20 Salle / Room R-OM130



resolution increase also allowed for finer scale geophysical fields such as vegetation, surface roughness and topography. All of these changes provide for some improvement in the model's behaviour especially in thge boundary layer and a better handling of meso-scale systems. Rather than statistics, a few examples will be given. First we will show an improved temperature and humidity profiles forecast in the boundary layer, most important in precipitation typing. Second the Fritsch-Chappell scheme allowed for the correction of a few problems noted in the previous version of the regional model such as the overdevelopment of some depressionary systems due to convective feedback mainly over the Gulfstream, and the bias in underforecasting the larger precipitation amount forecast categories.

#### 1-C-1.4

Recent development activities on NWP short term model at the Canadian Meteorological Centre.

André Methot<sup>1</sup>, Richard Moffet<sup>2</sup>, Gérard Pellerin<sup>2</sup>, Stéphane Bélair<sup>3</sup>, André Tremblay<sup>4</sup> and Anna Glazer<sup>4</sup>

<sup>1</sup>Division NWP, CMC, <sup>2</sup>CMC, <sup>3</sup>RPN, Dorval, <sup>4</sup>Cloud Physics Research Division, Dorval

The Canadian Meteorological Centre (CMC) is providing short term (0-48hrs) NWP operational guidance using the GEM regional forecast model currently running at 24 km horizontal resolution and 28 eta vertical levels. The physics package includes the familiar Sundquist scheme to produce explicit condensation resulting in either solid or liquid precipitation. The parameterization of condensation at unresolved convective scale is rendered by the Fritsch&Chappell scheme.

In view of incoming increase in the resolution, work is undergoing on both condensation schemes. The operational explicit Sundquist scheme is compared with the mixed-phase cloud scheme proposed by Tremblay and Glazer (Tellus, 18A pp 483-500). This later scheme provides distinction of freezing precipitation. The operational Fritsch&Chappell scheme is also being revued and challenged by the Kain&Fritsch scheme.

Part of this development is taking place on the experimental GEM model HiMAP framework at 10km horizontal resolution and 35 levels (0-24hrs). The talk summarizes results of comparative forecast performance of GEM model using operational and candidate condensation scheme tandems.

#### 1-C-1.5

Recent Improvements in the Ensemble Prediction System at the Canadian Meteorological Centre

Louis Lefaivre<sup>1</sup>, Peter L. Houtekamer<sup>2</sup>, Anne-Marie Leduc<sup>1</sup>, Philippe Palany<sup>3</sup>, Gérard Pellerin<sup>1</sup> and Richard Verret<sup>1</sup>

<sup>1</sup>Canadian Meteorological Centre, Environment Canada, <sup>2</sup>Meteorological Research Branch, Environment Canada, <sup>3</sup>Météo-France

Ensemble Prediction is part of the operational suite at the Canadian Meteorological Centre since February 1998. Every day, an 8 member ensemble, based on various versions of the T95 spectral model (SEF), is run out to 10 days. It has long been identified that an 8 member ensemble was minimal for probabilistic products. Extension of the ensemble size to 16 members was thus performed, using an additional 8 versions of the Global Environmental Multiscale (GEM) model at 1.875° resolution as driving model. Description of the various versions of the model will be presented, along with the improvement gained using the 16 member ensemble thus obtained. New probabilistic products will also be presented along with the appropriate verifications.

1-C-2.1

Project EuroMET : Teaching Meteorology Internationally using Internet Christian Pagé<sup>1</sup> and Peter Zwack<sup>1</sup>
<sup>1</sup>UQAM

The EuroMET project was undertaken by 22 meteorological educational establishments of which UQAM is the only North American member. The EuroMET project, which won the prestigious European Academic Software Awards in 1998, was inspired by the prototype training module in Project STRATUS.

EuroMET addresses in 4 languages, the continuing education and training needs of professional meteorologists employed by the national meteorological services as well as provides pedagogical support for traditional university courses. It provides open and distance learning in a way which can be customized to fit local needs

Two highly interactive courses are currently available on-line: Numerical Weather Prediction and Satellite Meteorology. The courses are delivered using World Wide Web (WWW) tools and employ a variety of media including text with mathematics, images, video, sound and animation. Main EuroMET WWW servers have a high than can be delivered on a standard workstation. The two main EuroMET WWW servers are located in Meteo-France and at the University of Edinburgh (UK).

The basic structure and philosophy behind the courses will be presented along with examples of specific training modules.

1-C-2.2

Les humeurs du temps Nicole Raymond<sup>1</sup> et Linda Liboiron<sup>1</sup> La Biosphère

Le climat continental du Québec, tout comme celui de la planète fait depuis quelques années l'objet d'une observation attentive et soutenue de la part des scientifiques du monde. La Biosphère, qui est dédiée à l'eau et à la protection du bassin versant Grands Lacs- Saint-Laurent, a identifié cet enjeu comme un élément thématique majeur. Elle a développé des partenariats qui lui permettent de le mettre en valeur et ainsi de sensibiliser la population, particulièrement les clientèles scolaires.

Cette activité éducative s'intitule "Les humeurs du temps". Elle est offerte aux élèves de 3ième à 6ième année, ainsi qu'aux secondaires 1 et 2. Elle a été bâtie en collaboration avec la direction de l'environnement atmosphérique d'Environnement Canada, avec la participation financière du Groupe d'assurance La Mutuelle. Cette activité respecte les principes de travail établis à la Biosphère pour le développement de valeurs et de comportements positifs envers l'environnement. Elle s'arrime aussi aux programmes du Ministère. Il est prévu de la développer en offrant aux classes des activités complémentaires au thème. Description de l'activité:

Après avoir fait appel aux souvenirs des jeunes, nous présentons quelques caractéristiques de l'atmosphère. Les élèves prennent conscience que le climat est variable et que c'est normal.ll a une personnalité. Par la suite, les élèves sont invités à manipuler des instruments météorologiques et environnementaux qui permettent de mesurer: le vent, la pluie, la neige, les heures d'ensoleillement et la visibilité. À travers cette initiation scientifique, ils voient comment la pollution circule dans l'atmosphère et comment l'homme influence le climat. Ils sont invités à donner leurs idées sur des comportements qui peuvent limiter ces dérangements.

Session 1-C-2 Université et formation professionnelle I **University and Professional Education I** Lundi 31 mai Monday, May 31 13:40 - 15h20 Salle / Room R-OM120



Ils poursuivent leur quête en explorant les composantes et les caractéristiques de phénomènes météorologiques tels l'orage ou la tempête de neige. Alors que les plus jeunes terminent l'activité par une intégration artistique en créant un vitrail aux couleurs du temps, les plus âgés explorent le phénomène El Nino qui influence le climat à l'échelle globale. La visite se termine par un retour sur ce qui a été vu dans la visite et sur son appréciation.

1-C-2.3

Oasis: Life on the edge of the abyss

Kim Juniper<sup>1</sup>, Jozée Sarrazin<sup>2</sup>, Johane Haineault<sup>1</sup>, Francine St-Onge<sup>1</sup>, Carole Kearney<sup>1</sup>, Alain Provost<sup>1</sup>, Roland Bréard<sup>1</sup>, Enriette Gagnon<sup>1</sup> and Marcel Pilotte<sup>1</sup>

Université du Québec à Montréal, <sup>2</sup>Woods Hole Oceanographic Institution

This multi-media CD-ROM presents the fascinating world of deep ocean hydrothermal vents on the Endeavour Segment of the Juan de Fuca Ridge, recently named as a pilot Marine Protected Area by Canada's Minister of Fisheries and Oceans. Several themes are developed in parallel including Canadian and American subsea technology, the biology, chemistry and geology of this very unique ecosystem, and the increasing presence of women scientists in oceanography. The interactive CD-ROM features technical fact sheets, narrated video clips, underwater photographs, games and 2-D graphic models, as well as a reference bibliography. There are several levels of complexity for each topic so that the CD-ROM can be appreciated by novices as well as by the informed user. This educational tool will be suitable for schools as well as for general public.

1-C-2.4

L'association professionnelle des météorologues du Québec et l'éducation en météorologie Gilles Brien<sup>1</sup>

APMQ

L'Association professionnelle des météorologistes du Québec, depuis sa constitution en 1990, a mené plusieurs projets d'éducation populaire sur la météorologie. Capsules d'informations radiophoniques, tournée scolaire, colloques, édition de 10 000 cahiers d'activités météo pour les écoles sont quelques uns des produits conçus et produits à ces fins éducatives. A travers ces activités, l'APMQ tente de sensibiliser davantage la population sur les questions touchant l'environnement atmosphérique et le rôle du météorologue dans la société moderne. Les coupures dans les budgets des services météorologiques du fédéral, la fermeture des bureaux météorologiques d'Environnement Canada et le manque de ressources didactiques en météo pour les milieux scolaires font en sorte que les besoins du public et des communautés scolaires sont très grands et criants en matiere d'éducation populaire en météorologie. L'APMQ tente de remplir ce vide avec les moyens dont elle dispose. Malgre le peu de ressources disponibles et le faible bassin de météorologues professionels au Québec, l'APMQ a reussi avec succes à réaliser plusieurs projets intéressants et riches en enseignements.

#### 1-C-3.1

Operational Ocean Forecast System with Data Assimilation for the East Coast of Canada Josko Bobanovic<sup>1</sup> and Keith R. Thompson<sup>1</sup>

Dalhousie University, Department of Oceanography, Halifax, NS, Canada, B3H 4J1

In recent years, there has been increased pressure to supply accurate predictions of the circulation on Canadian Atlantic shelves. Such predictions are required by the maritime transportation and offshore exploration sectors and are needed for marine search and rescue and pollution control. We report on the development of an operational forecast system for the east coast of Canada. The approach taken is based on nesting. First, we use a large-scale non-linear storm surge model that covers the complete east Canadian shelves and adjacent deep ocean from 38N (Gulf of Maine) to 60N with a spatial resolution of 1/12 of the degree. The model is driven by three-hourly forecast surface winds and atmospheric pressure supplied daily by the Canadian Meteorological Center. Forecast fields (sea level and depth averaged currents) are used as a first guess for the open boundary conditions of the nested model.

The nested model covers the Gulf of Saint Lawrence and the Scotian Shelf and parts of the adjacent open ocean (roughly from 40N to 52 N). The ocean model is based on POM (Blumberg and Mellor, 1987), three-dimensional, non-linear, prognostic model that uses sigma-coordinates in vertical. Density fields were obtained from the archives of the Bedford Institute of Oceanography and gridded seasonally. At present the model is run in diagnostic mode, i.e. T and S fields are held fixed in time (season). The open boundary conditions for the model have several components: The 'synoptic part' comes from the storm surge model and it is further refined by assimilating sea level data using representers (Bennett, 1992). The 'tidal part' of the boundary condition is based on a data assimilative study that combines 3D, non-linear dynamics with a 2-D linear adjoint model (Thompson et al.,1998). We use a historic data set to validate the forecast scheme on the Scotian Shelf during winter 1996. Our plan is to allow T and S fields to evolve with time and control them by assimilating seasonal density variability, satellite derived observations, as well as in-situ T and S fields when available.

#### 1-C-3.2

Tidal currents and mixing quantities off Newfoundland Guoqi Han<sup>1</sup>

Bedford Institute of Oceanography

Major semidiurnal (M2, S2, N2) and diurnal (K1, O1) barotropic tides over the Newfounadland Shelf are computed using a three-dimensional nonlinear primitive equation model, with the vertical eddy viscosity calculated from a level 2.5 turbulence closure scheme. Computed elevation cotidal charts are consistent with previous knowledge for this region. Comparisons based on a statistical analysis of the differences between the computed elevations and currents, and in situ observations indicate good agreement. While M2 tidal currents (up to 20 - 30 cm/s) are dominant, there are locally intensified diurnal currents (up to 5 - 10 cm/s) in some outer-shelf locations. The diurnal current intensification is attributed to first-mode continental shelf waves. A detailed evaluation of the model currents againest in situ observations is carried out for the dominant M2 tide, together with an examination of estimated turbulent kinetic energy, mixing length scale, vertical eddy viscosity, and bottom friction velocity. Solutions with fixed vertical statification profiles indicate that the stratification has a significant influence on the vertical profile of tidal mixing parameters and currents in shallow areas.





1-C-3.3

Drift Pathways on the Western Scotian Shelf Jennifer Shore<sup>1</sup>, Charles Hannah<sup>1</sup> and John Loder<sup>1</sup> Bedford Institute of Oceanography, DFO

A quantitative representation of 3-d seasonal and M2 tidal circulation in the Scotia-Maine region has recently been developed from diagnostic and prognostic finite element models forced by observational data. The computed circulation fields have been primarily evaluated through comparisons with Eulerian observations; however, Lagrangian evaluations are more appropriate to biological and other drift issues in such spatially- and temporally- varying flow fields.

In this talk, particle tracking in the 3-d seasonal-mean and tidal current fields is used to develop an overall Lagrangian view of circulation in the Scotian Shelf-Gulf of Maine region, and to explore implications for biota in selected areas of the western Scotian Shelf. Specific areas of focus are seasonal changes in larval retention on Browns Bank, transport of particles into the Gulf of Maine through the mouth of the Northeast Channel (having implications for Calanus finmarchicus), and transport of zooplankton from Emerald and Lahave Basins to the the Browns Bank gadoid nursery. The sensitivity to unmodelled flow components is examined through the inclusion of horizontal random kicks on the particles.

The results indicate significant influences of seasonality, vertical structure, tidal currents and other flow perturbations on drift pathways in the western Scotian Shelf region.

1-C-3.4

Baroclinic oscillations generated over the continental shelf by Hurricane Andrew Susan Allen<sup>1</sup> and Timothy Keen<sup>2</sup>

<sup>1</sup>University of British Columbia, <sup>2</sup>Naval Research Laboratory, Stennis Space Center, Mississippi

Hurricane Andrew entered the Gulf of Mexico at 1000 GMT August 24, 1992, and made landfall 200 km west of the Mississippi River delta at approximately 0900 GMT August 26, after passing over several moored current meter arrays. A very strong inertial oscillation was observed during and after the passage of the hurricane. To isolate and identify the waves generated a simple two-layer shallow water equation model was used. The model shows the generation of near-inertial waves on the interface due to offshore baroclinic inertial oscillations interacting with the continental shelf. The Mississippi canyon is a generator of baroclinic Poincare waves which propagate seaward and of barotropic edge waves which propagate both directions along the coast. Coastal hurricane surge models (barotropic) do predict coastal run-up accurately but to reproduce coastal currents during and after a hurricane stratification must be included

#### 1-C-4.1

Mesoscale forecast accuracy and cloud microphysics complexity André Tremblay<sup>1</sup>, Anna Glazer<sup>1</sup> and André Méthot<sup>2</sup> <sup>1</sup>Atmospheric Environment Service, <sup>2</sup>Centre Meteorologique Canadien

Accurate forecasting of cloud and precipitation types is a key issue in numerical weather prediction. For example, freezing precipitation is a significant threat for virtually all forms of transportation and represents a serious public safety problem. In altitude, supercooled large cloud droplets cause icing on airframes which reduces the ascending force of aircraft and represents severe risks to flight operations. Currently many operational forecast algorithms are unsuccessful in predicting these natural hazards and they need to be improved. Refining atmospheric models may help to obtain better forecasts. Since the operational cloud scheme at the Canadian Meteorological Center (CMC) fails to adequately predict cloud and precipitation types, other schemes are examined.

A series of numerical experiments has been undertaken with both Canadian MC2 and GEM models to evaluate the possibility of incorporating more complex microphysics in weather forecasts. A detailed comparison of four cloud microphysics schemes available at CMC was performed for a number of cases. The schemes used for this study include the operational CMC scheme of Sundqvist (MWR 1989, 117, 1641), the mixed-phase cloud scheme of Tremblay et al. (TELLUS 1996, 48A, 483), the explicit scheme of Zhang (TELLUS 1989, 41A, 132) and the Kong and Yau (ATMOS.-OCEAN 1997, 35, 257) scheme. They parameterize the microphysics of clouds with different degree of complexity. The quality and accuracy of weather forecasts produced with each microphysics scheme will be discussed.

#### 1-C-4.2

A New Microphysics Scheme for Improved Forecasts of Freezing Precipitation and Aircraft lcing

André Tremblay<sup>1</sup> and Anna Glazer<sup>1</sup> Atmospheric Environment Service

In an attempt to include cloud and precipitation types in weather forecasts, to improve predictions of icing and freezing precipitation, a new mixed-phase cloud scheme has been developed (Tremblay et al., 1996:Tellus, 48A, 483). This scheme has the advantage of being computationally fast and easy to implement and has an operational potential. The scheme has been extensively tested by simulating virtually all ice storms during the 1996/97 winter season. The scheme has also been run in a quasi-operational mode for the whole 1997/98 winter season to provide forecasts and guidance for research aircraft flight trajectories during the third Canadian Freezing Drizzle Experiment (Isaac et al., 1998: AMS Conf. Cloud Phys., Everett, Wash.). Finally, the scheme was used as a real-time guidance for the Canadian Convair research aircraft missions over the Arctic Sea during the Canadian phase of the FIRE.ACE experiment (April 6 - May 1st 1998).

A brief description of the scheme will first be presented. Typical results from the 1996/97 winter simulations will then be discussed to show typical forecast products. Quantitative icing and freezing precipitation forecasts are possible with the new scheme and several examples will be given. Furthermore, both qualitative and quantitative comparisons between simulated and commonly observed meteorological parameters will be described. Finally, it will be demonstrated that the inclusion of a nonclassical freezing precipitation mechanism (without a warm layer aloft) in the forecast algorithm significantly improves both the detection and the bias score for freezing precipitation. These results suggest that the scheme is potentially a useful tool for the prediction of supercooled large droplets.





#### 1-C-4.3

Verification of Aircraft Icing Forecasts Using in-situ Aircraft Measurements Hong Guan<sup>1</sup>, Stewart J. Cober<sup>1</sup> and George Isaac<sup>1</sup>

Cloud Physics Research Division, Atmospheric Environment Service

In-situ measurements of temperature, horizontal wind, dew point and liquid water content, made during 51 flights from three research field programs, have been compared to forecasts made with the Global Environmental Multiscale (GEM) model (himap version). The field projects included the Second Canadian Atlantic Storms Program, and the First and Third Canadian Freezing Drizzle Experiments, all of which were designed in part to measure aircraft icing regions in winter storms. The main purpose of the comparisons were to test the accuracies of the GEM forecasted cloud and icing fields. Icing schemes tested included the Tremblay and Appleman schemes, while the cloud schemes tested were the Kuo-symmetric convective cloud scheme and Sundqvist resolved scale scheme. The Hit Rate, False Alarm Rate and True Skill Statistic were determined for each variable. Several sensitivity tests were performed to test the variability of the results to the analysis techniques.

It is shown that the Hit Rate, False Alarm Rate and True Skill Statistic for cloud are 0.53, 0.30, and 0.23 respectively, when the model data are inferred at a horizontal resolution of 1.5 km (averaging scale of the aircraft data). The corresponding values for icing events are 0.34, 0.18 and 0.19 when the Tremblay icing scheme is used. However, the Hit Rate and False Alarm rate for the icing forecast increases to 0.63 and 0.38 respectively when a model resolution of 50 km is used. The comparison between the Tremblay and Appleman icing schemes demonstrates that the Appelman scheme produces a lower Hit Rate (0.25), False Alarm Rate (0.14) and True Skill (0.13). A significant difference between the Appleman and Tremblay schemes occurs at temperatures lower than -10 C, where the Appleman scheme significantly over predicts icing regions. When only cloud forecasts which agree with the aircraft measurements are considered, the icing forecast accuracy increases significantly. This illustrates that a limiting factor in the icing forecasts is the model humidity field. The comparisons and methodology will be discussed.

#### 1-C-4.4

The Influence of Air Mass Origin on The Microphysical Structure of Arctic Boundary Layer Clouds

Ismail Gultepe<sup>1</sup> and George Isaac<sup>2</sup>
<sup>1</sup>AES, <sup>2</sup>AES, Cloud Physics Res. Div.

Observations collected during the First International Satellite Cloud Climatology Project (ISCCP) Regional Experiment -Arctic Cloud Experiment (FIRE.ACE) which took place over the Arctic Ocean during April 1998 were used in this study. Measurements from aircraft microphysical probes, and back-trajectory calculations from the Canadian Meteorological Center (CMC) were analyzed. Eighteen cases, representing air-masses which originated over the Arctic Ocean and Pacific Ocean, were used. Aircraft microphysical data obtained by the hot-wire probes, the Rosemount icing detector, the Particle Measuring Systems (PMS) forward scattering spectrometer probe (FSSP), and 2 dimensional cloud (2D-C) probes were used to characterize liquid and ice regions. The passive cavity aerosol spectrometer probe (PCASP) was used to obtain aerosol number concentration (Na) at a size range of 0.13-2 mm. Preliminary results show that both droplet number concentration (Nd) and ice crystal number concentration (Ni) in air-masses originating from the Arctic Ocean (AO) were larger than those in air-masses originating from the Pacific Ocean (PO). The Na was found larger in AO air-masses as compared to PO air-masses. The in-cloud turbulence was higher in AO airmasses than PO air-masses. The total water content ranged from 0.05 to 0.35 g m-3, with no dependency on air-mass. The results indicated that significant changes in the cloud microphysical parameters could be related to the origin of the air-mass. This work also shows that the Nd-Na, and Ni versus temperature relationships obtained from mid-latitude cloud

systems do not hold in the Arctic region, and they need to be studied in detail for climate change studies.

1-C-4.5

Comparison Of Research Aircraft Observations With Numerical Simulations Using A Mixed-Phase Cloud Scheme

Paul Vaillancourt<sup>1</sup>, André Tremblay<sup>1</sup>, Stewart G. Cober<sup>1</sup> and George A. Isaac<sup>1</sup> AES

The presence of supercooled water (SLW) in clouds is very common as shown by the numerous PIREP's reporting icing of various intensities at any given time. There is also an abundance of more detailed observations of SLW made in a cloud physics research context either from research aircraft or remote sensing. For example, many aircraft measurements of SLW in both maritime and continental conditions were made during the Canadian Freezing Drizzle Experiments (CFDE) I, II and III. The abundance of these observations suggests that liquid water may be present in most cold clouds at some point during their evolution.

The formation and lifetime of SLW in clouds is important to study because of two potential impacts on human activity. The first one is aircraft icing which can cause serious loss of aircraft performance capability (in particular if large supercooled droplets are present) and may result in crashes. The second impact is through its role in the generation of freezing precipitation.

We have recently embarked on a research project to develop a new microphysical scheme capable of forecasting SLW and providing some useful information on the size distribution of hydrometeors. This represents a serious challenge since both "warm rain" and ice processes must be taken into account. As a first step, we use the CFDE I research aircraft data to evaluate the ability of the mixed-phase physically based cloud scheme of Tremblay et al. (1996) to forecast the presence and quantity of supercooled water. The mixed-phase scheme is used in conjunction with the MC2 model. CFDE I was conducted during March 1995 out of St. John, Newfoundland. This campaign comprised 12 research flights into regions of north Atlantic storms where supercooled drizzle was forming.

Results of the comparison of these observations with numerical simulations as well as lessons learned from these comparisons will be presented at the conference.





1-D-1.1 Forecast verification Richard Verret<sup>1</sup>, Guylaine Hardy<sup>1</sup> and Claude Landry<sup>1</sup> Centre météorologique canadien

Forecast verification is a complex meteorological problem. Amongst the issues to consider are the clear definition of the reasons why verification of forecast products is done, the assessment of verifying real weather from available observations, the definition of verification scores and the interpretation of verification results. A complete verification system ought to be able to verify all weather elements that are forecast and observed, over any local time window. It is in that context that a verification system has been designed at the Canadian Meteorological Centre to verify public forecasts.

The verification system is capable of verifying all weather elements normally included in the public forecasts in Canada, mainly: maximum and minimum temperatures, probability of precipitation, precipitation type, precipitation amount, sky cover, and wind speed and direction. The verification can be carried for the Today, Tonight and Tomorrow periods for the early morning forecast issue and for the Tonight, Tomorrow, the following night and the following day for the afternoon issue. The system can generate several types of scores: quadratic scores such as the variance explained and the root mean square error for temperatures and the Brier score or Brier skill score for probability of precipitation forecasts and linear scores such as the bias and mean absolute error for most weather elements. The system can also generate more sophisticated scoring rules such as the Baysian correlation score for temperatures and the Relative Operating Characteristics for probabilistic forecasts. These two scores can take into account the usefulness of the forecasts in a posteriori manner and can assess whether a forecast system is better than another one in all aspects or whether a forecast system includes all the information compared to a different one.

Contingency tables are also applicable to most weather element forecast verification. However, there are inherent problems to contingency tables that are often neglected: depending on the definition of the different categories in the tables, small forecast errors can be considered as wrong forecasts, while big forecast errors can count as perfect forecasts. A different approach to the contingency table verification technique has been developed to take into account near misses, where the observation-forecast couples are assigned to specific categories in the contingency tables according to the size of the discrepancy between the forecast and the verifying observation. The scores that can be calculated from the contingency tables in that framework provide a better picture of the real skill of the forecasts, without modifying the observation and forecast relative frequency distributions.

It is important to point out that considering only one or two verification scores generated on a particular forecast sample may be misleading as it neglects the multi-dimensionality of verification problems and the variability of verification results from a verification sample to the next. All factors, including climatology, must be taken into account when interpreting the verification results, especially when different forecast systems are compared.

The presentation will give an overview of the scores that can be calculated in the verification

#### 1-D-1.2

Comparaisons entre les performances des modèles de prévisions des grand Centres / Comparison of model performances for leading NWP Centres Monique Loiselle<sup>1</sup>

1CMC

Les vérifications des modèles numériques de prévisions sont compilées à tous les mois par chacun des grands centres mondiaux. Ces vérifications sont préparées selon des standards bien établis par la Commission des systèmes de base de l'OMM et sont ensuite échangées électroniquement entre les centres participants.

Un échantillon de ces résultats de vérification sera présenté. On examinera les vérifications contre analyses (chaque centre vérifiant contre sa propre analyse) pour les champs de pression au niveau de la mer, de hauteur, de température et de vent. On examinera aussi les vérifications contre observations (radiosondes) pour les champs de hauteur, de température et de vent.

Ces comparaisons incluront les résultats du Canada (CMC), du Centre Européen, des États-Unis (NCEP), de l'Allemagne, du Japon, de la France, de l'Australie et de la Russie pour les prévisions de 24 à 240 heures.

NWP model verifications are computed and exchanged monthly by many of the world's leading Centres. These verifications are prepared according to strict standards from WMO`s Commission for Basic Systems.

A sample of verification results will be presented here, including verification against analyses (each centre using its own analyses) for MSL pressure, height, temperature and wind fields. We will also look into verification against observations (radiosondes) for height, temperature and wind fields.

This comparison will include results from Canada (CMC), ECMWF, United States (NCEP), Germany (DWD), Australia and Russia for 24 to 240-hour forecasts.

#### 1-D-1.3

Vérifications de précipitations pour le modèle GEM régional en comparaison avec d'autres modèles opérationnels /Verification of precipitation: GEM regional vs. other operational models

Monique Loiselle<sup>1</sup>

1CMC

Les prévisions de précipitations de 24 heures du modèle GEM régional actuel (24 km, 28 niveaux avec schéma de Fritsch-Chappell pour la convection profonde) sont comparées à celles du modèle GEM régional précédent (35 km, 28 niveaux avec schéma de convection de Kuo) pour l'été 98.

Les comparaisons se font à l'aide de tableaux de contingence pour des catégories choisies de quantité de précipitations de 24 heures. Les indices de menace et de biais sont aussi calculés pour les quantités de précipitations au-dessus de certains seuils. On peut constater que le GEM régional actuel a amené une amélioration du biais, de la probabilité de détection et de l'indice de menace dans plusieurs catégories.

Des comparaison similaires sont aussi faites entre les prévisions de précipitations du GEM régional actuel et celles du modèle GEM global, de même qu'avec celles du modèle ETA américain (NCEP) pour les derniers mois. Les comparaisons avec le modèle ETA seront aussi examinées à la lumière des vérifications de précipitations produites et émises par NCEP.

Session 1-D-1 Météorologie opérationnelle II **Operational** Meteorology II Lundi 31 mai Monday, May 31 15h40 - 17h40 Salle / Room R-OM130

# Session 1-D-1 Météorologie opérationnelle II **Operational Meteorology II** Lundi 31 mai Monday, May 31 15h40 - 17h40 Salle / Room R-OM130

Twenty four-hour precipitation forecasts from the current operational regional GEM model (24 km, 28 levels, with Fritsch-Chappell deep convection scheme) are compared to those predicted by the previous regional GEM model (35 km, 28 levels, with Kuo convection scheme) during the summer of 98.

The comparisons are based on contingency tables with selected categories of 24-hour precipitation amounts. Threat scores and biases are also computed for precipitation amount above threshold values. It can be seen that the current regional GEM model has brought improvement in bias, probability of detection and threat scores in several categories.

Similar comparisons were carried out between the precipitation forecasts of the current regional GEM model and those of the global GEM model as will as those from the US (NCEP) ETA model. Comparisons with the ETA model will be discussed in relation to precipitation verification produced and issued by NCEP.

1-D-1.4

Are meteorological forecasts improving?

Richard Verret<sup>1</sup>, Guylaine Hardy<sup>1</sup> and Claude Landry<sup>1</sup>

Centre météorologique canadien

Maximum and minimum temperature and probability of precipitation forecasts extracted from the early morning issue of the public forecast bulletins have been verified since 1984 at an ensemble of twenty-three stations, corresponding to the main cities across Canada. The verified forecasts were valid for Today, Tonight and Tomorrow. Statistical forecasts of maximum and minimum temperature and of probability of precipitation at the same set of stations, based on 00 UTC model run, have also been verified over the past five years. These latter forecasts are based on the Perfect Prog multiple linear regression approach. The same verification system has been used to verify the manually produced forecasts and the objective forecasts. Both verifications have been carried with a seasonal data stratification. It is assumed that the forecasters had access to the objective statistical forecasts as guidance.

The forecast data extraction system used to extract data from the public forecast bulletins and the verification system have evolved considerably over the period of the experiment. The forecast data extraction and the verification tasks were mostly carried manually in the early years, and went through an automation process in the early 1990's. Considerable care was taken in the manual processes to quality control the data and to ensure a maximum of data available for verification. However, quality control of the data has been automated and missing data are not retrieved in the automated data extraction and verification processes. The automated verification system used in the latter years of the experiment is based on the following framework: all available surface observation, synoptic, hourly and supplementary aviation observations are used to create a truth file at a set of stations. The truth file is basically a matrix which includes all observed weather elements with a time resolution of one hour, taking into consideration the special observations produced at non-standard times. The weather elements are cross-checked between themselves to validate the observations and thus create the truth, assumed to be the actual representation of the weather that really occurred. The truth file is generated once a day at each station, for the past twenty-four hours. On the other hand a similar set of matrices are generated for the forecasts. The forecast matrices and the truth matrices can then be compared and the validity and skill of the forecasts assessed.

Different verification scores have been used to assess whether or not there is an improving trend in forecast skill since 1984. Results indicate that the maximum and minimum temperature forecasts have improved globally across Canada over the period of the study.

However, verification prior to 1992 fails to detect any statistically significant trend in the skill of the forecasts, but there is a definite improvement trend in the skill of the forecasts after 1992. The manually produced forecasts have also been compared to the objective forecasts. Although the skill of the objective statistical forecasts and that of the manually produced ones vary significantly from station to station, the results indicate that overall the manually produced forecasts improve upon the objective forecasts.

#### 1-D-1.5

Intercomparison Of Climatological Observations From Manned And Automated Stations - Preliminary Results For Temperature

Ewa Milewska<sup>1</sup>

<sup>1</sup>Atmospheric Environment Service

Atmospheric Environment Service (AES) uses Automated Weather Observing System (AWOS) to automate principal weather stations. One-year long (1995/1996) data set of simultaneous human and AWOS hourly observations is currently used to detect the presence of systematic instrumental and siting biases between the two kinds of observations of certain climatological elements, such as temperature, precipitation amount, wind. Eventually, other systems that are used to automate WMO Climate Reference or CO-OP stations will be included in the study. Some aspects of the analysis of temperature records are highlighted here.

AWOS used YSI Model 44212 thermistors, while observers read the display from the AES Remote Temperature/Dewpoint (RTD) System. The performance and technical specifications of both temperature sensors are nearly identical, although the distribution of auxiliary components, like junction boxes or instrument heads inside the Stevenson screen, differs along with the way the observed values are actually output and recorded. The differences between the AWOS and Human hourly temperature observations were computed at five stations and the overall biases and trends of the complete time series of these differences were assessed. Then, the data was stratified by day and night, wind speed and cloud cover.

Preliminary results indicate that there is a positive instrumental bias of up to +0.2 degree C, as well as up to +0.3 degree C ventilation bias, with AWOS reporting warmer temperature in all these cases. These may not be that significant as manufactures' specifications allow for up to +/-0.3 degree C uncertainty range. The siting biases appear to be more pronounced and could be either positive or negative of up to +/-0.7 degree C.

The daily maximum and minimum temperature biases were also examined. It appears that in some cases the tendency to install new AWOS-es in well-exposed areas close to runways results in negative siting biases of up to -1.3 degree C, which could impact long-term trends of temperature minimums computed for the purpose of global change studies.

#### 1-D-1.6

A Comparison Of Visibility Observations By Human Observers And Automated Weather Observing Systems (Awos) In Canada Ambury Stuart<sup>1</sup>

Weather Research House

In 1994, Transport Canada announced a major initiative to determine how well automated weather observing systems (AWOS) met the operational requirements of the aviation community in Canada. Over the next 3 years a major study involving a 12 month intercomparison of AWOS and human weather observations was carried out by Transport Canada, Environment Canada and representatives of many organizations in the aviation industry. A report on the results of this study was released by Transport Canada in 1997.

Session 1-D-1 Météorologie opérationnelle II **Operational** Meteorology II Lundi 31 mai Monday, May 31 15h40 - 17h40 Salle / Room R-OM130



During the course of this work, hourly and special observations of visibility made by both AWOS and human observers at seven airports in Canada were accumulated, quality controlled and archived. An initial intercomparison of human and automated observations was made, and its results are included in the final report. In this talk, a review of this intercomparison is presented and an alternative approach is proposed. Using the principle that any observation of visibility is "valid" until it is replaced by a later observation, visibilities are defined for every minute of every day that human and AWOS observations are available. Then, an intercomparison of these observations is made for all seven stations in each of the four seasons of the year.

For most locations and seasons, we show significant differences between human and AWOS observations of visibility that cannot be easily explained either by the separation of the locations where the observations are made or by any tardiness of the human observer relative to the AWOS in noticing changes in the weather. Also, these differences show strong seasonal and regional variations that are not easily explained by our current knowledge of the climatology of visibility. We believe that these results will be of great interest and significant importance to the Canadian aviation community, along with the government departments and private organizations that support and regulate the aviation industry in Canada.

#### 1-D-2.1

Analyses of the Effects of Aerosols on a Regional Climate Simulation Using NARCM Juan Sebastian Fontecilla<sup>1</sup> and Jean-Pierre Blanchet <sup>2</sup>

<sup>1</sup>Earth Sciences Department at UQAM , <sup>2</sup>Earth Sciences Department at UQAM and C2GCR

The response of the surface and tropospheric climate to emissions of smoke aerosols on monthly to seasonal time scales is investigated in order to evaluate the sensitivity and the response of the continental climate to a controlled and single intense point source of aerosols. The model accounts for detail size segregated aerosol microphysics and interaction with radiation. The case of the 1991 Kuwait massive oilfire is used as a reference scenario to assess the model. The smoke is injected in the lower troposphere at the estimated observed mean rate and the model is driven at the boundaries by objective analyses for the period of January to August 91. The aerosol is allowed to alter the energy balance of the atmosphere and the surface via the direct solar and infrared radiative processes. Attention is put on primary forcing variables (solar flux, heating rates) and then to gradually less related variables (surface balance, temperature, moisture pressure, precipitation and circulation) to determine their response to the primary radiative forcing. The analysis of anomalies of their time lags shows that some variables respond significantly while others are weakly sensitive. This is a valuable exercise in preparation for longer regional scale simulations where the composition and the sources of aerosols are generally much more variable and complexes.

#### 1-D-2.2

Preparation to the first NARCM Simulation of the Direct Effect of Aerosol on High Latitude Climate

Khanh-Hung Lam<sup>1</sup> and Jean-Pierre Blanchet <sup>2</sup>

<sup>1</sup>Earth Sciences Department at UQAM, <sup>2</sup>Earth Sciences Department at UQAM and C2GCR

The purpose of this research is to investigate the direct radiative effect of aerosols on the energy balance of the Arctic. At first, particular attention is placed on the optical characteristics of aerosols. Optical properties for wet spherical particles have been computed using standard shell Mie scattering algorithm. Then, the optical depth is calculated by doing an integration of the multi- component size segregated aerosol over the 12 bins of NARCM (24 prognostic tracers). Details on the treatment of optical depth will be discussed. Further, to allow for long climate simulations, an alternate aerosol coagulation scheme is introduced and tested versus the detailed explicit method. These steps will lead to the first climate simulation of the direct effects of aerosols on the Northern climate.

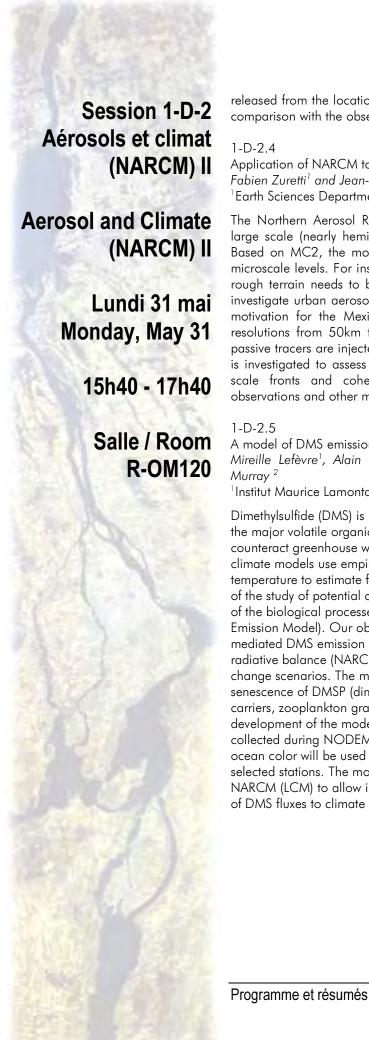
#### 1-D-2.3

Simulating the Transportation of Smoke from a Forest Fire in Eastern Canada Lin Hong<sup>1</sup>, W.R. Leaitch<sup>1</sup>, C.M. Banic<sup>1</sup>, Sunling Gong<sup>1</sup>, Lubos Spacek<sup>2</sup>, P. King<sup>1</sup> and B. Stocks<sup>3</sup>

<sup>1</sup>Atmospheric Environment Service, <sup>2</sup>Earth Sciences department, UQAM, <sup>3</sup>Canadian Forest Service

Smoke originated from forest fires in Quebec, Canada (near 50N and 74W) was transported to the Canadian Maritime Provinces and Maine area on Aug. 22, 1995. Observations of the smoke plume were made at 44N and 66W, about 1000 km downwind of the source, in during the Radiation, Aerosol and Cloud Experiment (RACE 95). The measured aerosol properties include number concentration, size distribution, CCN concentration and major iron chemical composition was measured. The transport of the forest fire plume is studied using a Regional Climate Model coupled with a newly developed Canadian Aerosol Module (CAM). CAM is a size-segregated multi-component aerosol model simulating aerosol processes. It includes nucleation, condensation, coagulation, dry deposition and interaction with clouds as well as wet removal. The simulation has successfully been able to re-produce the observed transport pattern and vertical distribution of the smoke aerosol particles

Session 1-D-2 Aérosols et climat (NARCM) II **Aerosol and Climate** (NARCM) II Lundi 31 mai Monday, May 31 15h40 - 17h40 Salle / Room R-OM120



released from the location of the Quebec fires. We will present details of the simulation and comparison with the observations.

#### 1-D-2.4

Application of NARCM to Simulation of Tracers at High Resolutions Fabien Zuretti<sup>1</sup> and Jean-Pierre Blanchet <sup>2</sup>

<sup>1</sup>Earth Sciences Department at UQAM , <sup>2</sup>Earth Sciences Department at UQAM and C2GCR

The Northern Aerosol Regional Climate Model (NARCM) is developed for application to large scale (nearly hemispheric) aerosol transport and interaction with the climate system. Based on MC2, the model has sufficient flexibility to address questions at mesoscale and microscale levels. For instance, the behavior of particulates at ice edges, over leeds or over rough terrain needs to be considered at times. Alternatively, the model can be applied to investigate urban aerosols for visibility or health issues. These considerations have been the motivation for the Mexico City study. Here, we run NARCM in a cascade of variable resolutions from 50km to 10 km and 2km centered on Mexico City. At this stage, only passive tracers are injected over the city area to represent pollutants. The regional circulation is investigated to assess katabatic winds, flux convergence, convection, valley wind, smallscale fronts and coherent structures in the tracer concentration. Comparison with observations and other model simulations by Bossert and Fast are done to evaluate NARCM.

#### 1-D-2.5

A model of DMS emission in the western north Atlantic.

Mireille Lefèvre<sup>1</sup>, Alain Vézina<sup>1</sup>, Maurice Levasseur<sup>1</sup>, Guy Cantin<sup>1</sup> and Nicholas Charles Murray 2

Institut Maurice Lamontagne, <sup>2</sup>Joint Centre Research, Ispra, Italy.

Dimethylsulfide (DMS) is produced in the oceanic surface layer by biological processes and is the major volatile organic sulfur compound entering the atmosphere. It is suspected to partly counteract greenhouse warming because of its contribution to aerosol formation. Current climate models use empirical relationships between surface DMS concentrations and surface temperature to estimate fluxes of DMS to the atmosphere. This approach is limiting in terms of the study of potential climate feedbacks via biological activity. We are developing a model of the biological processes involved in DMS production (NODEM for Northern Ocean Dms Emission Model). Our objectives are to: (1) provide improved representations of biologicallymediated DMS emission for a climate model that includes the effect of aerosols on the radiative balance (NARCM), and (2) investigate the sensitivity of DMS emissions to climate change scenarios. The model simulates complex interactions including the production and senescence of DMSP (dimethylsufoniopropionate, the precursor of DMS) phytoplankton carriers, zooplankton grazing, microbial processes, photo-oxidation and ventilation. The development of the model relies on experimental and in situ mesurements of DMS and DMSP collected during NODEM cruises in May-June 1997 and 1998. Remote sensing images of ocean color will be used to initialize the model and to compare with fluxes measured at selected stations. The model will then be incorporated in a one-dimensional version of NARCM (LCM) to allow initialisation from atmospheric simulations and to study the sensitivity of DMS fluxes to climate change.

#### 1-D-3.1

Hindcast of Tidal to Inter-Annual 3D Ice-Ocean Conditions in the Estuary and François-J. Saucier.<sup>1</sup>, François Roy<sup>1</sup>, Jia Wang <sup>2</sup> and Marc Besner<sup>3</sup>
<sup>1</sup> Division of Ocean Sciences, Maurice Lamontagne Institute, Dept. Fisheries and Oceans, <sup>2</sup>University of Alaska at Fairbanks, <sup>3</sup>Atmospheric Science Division, Environment canada

We apply a 3D prognostic coastal model to the Estuary and Gulf of St. Lawrence for currents, temperature, salinity, turbulent quantities, and ice thickness and concentration. The ocean model is modified from the North Sea model of Backhaus and the Juan de Fuca and Strait of Georgia model of Stronach and others. The ice model uses the Flato-Hibler dynamics and the Washington and Parkinson thermodynamics. The ocean model incorporates a Mellor and Yamada-type 2nd order turbulence closure model. The model resolution is 5 km in the horizontal with 35 layers in the vertical, extending from the Atlantic Ocean to Quebec city, where it is coupled to a river channel model up to Montreal. The surface meteorological forcing is prescribed by six-hourly air temperature, dew point, relative humidity, pressure, dry/liquid precipitation, and radiation, that are provided at 20 virtual stations over the water. These data are derived by correcting coastal observations with historical ship-based measurements, and the air temperature is further corrected by the presence of the computed ice cover. The hydrological forcing uses observed monthly runoff at Quebec city and daily runoff for all major tributaries, and is adjusted to account for the net basin drainage. The open boundary forcing at Belle-Isle and Cabot Straits includes 15 water level tidal constituents and climatological water mass properties for entering Atlantic Ocean and Labrador Sea waters. Simulations can be performed for periods between 1960 and 1998 but we focus here on the years 1986-1987. We compare the model results with intersecting observations: temperature and salinity profiles, ice concentration charts, AVHRR-derived SST maps, current meter and tide gauge records, ice beacons, summer coastal temperature measurements, as well as the regional climatology. We analyse the transport through subregions and the open straits, the formation and fate of surface and intermediate water masses, and fluxes of heat and salt as functions of the external forcing and internal physics. We examine transient freshwater pulses, the formation, stability and dispersion of the Gaspé current, storm events, and ice formation and export to the Atlantic Ocean.

#### 1-D-3.2

Fine-scale observations of shear instabilities in the St. Lawrence Estuary Daniel Bourgault<sup>1</sup>, Francois J. Saucier <sup>2</sup> and Charles A. Lin<sup>1</sup>

Department of Atmospheric and Oceanic Sciences, McGill University, <sup>2</sup>Institut Maurice-Lamontagne, Peches et Oceans Canada

The breakdown of high-frequency internal waves is an important mechanism by which mixing is enhanced across the pycnocline of partially stratified estuaries. The resulting vertical fluxes of mass and momentum determine the mean residual baroclinic pressure field that drives the estuarine circulation. Knowledge of the timing, location, and the magnitude of the turbulent fluxes associated with these naturally occuring events is still very limited. The short time and spatial scale, the intermittency, and the patchy nature of these instabilities in such an unsteady environment make it difficult to localize and observe. Guided from the results of a 3-D baroclinic numerical model of the St.—Lawrence Estuary, we designed an experiment to measure the fine-scale semi-diurnal variability of the water column where shear instabilities were expected to occur. Simultaneous measurements of the 3-D currents, the density field, and accoustic images revealed that shear instabilities are an active mixing mechanism in the partially stratified section of the estuary. These observations support the numerical results.





1-D-3.3 A Proposal for a Neutral Regression Richard Marsden<sup>1</sup> Royal Military College of Canada

In cases of modest correlation, parameters calculated from a standard least squares linear regression can vary depending on the selection of dependent and independent variates. A neutral regression that addresses this problem is proposed. Theeigenvector corresponding to the smallest eigenvalue of the cross-correlation matrix of the two variates is used as a set of regression coefficients. Error bars are calculated for the eigenvalues and eigenvectors, by means of a perturbartion expansion of the cross-correlation matrix and then verified by Monte-Carlo simulation. A procedure is suggested for extension of the technique to the multivariate case. Conclusions are presented about the strengths and weaknesses of both the least squares and neutral regression.

1-D-3.4

Surface Pulses in the Lower St. Lawrence Estuary Richard Marsden<sup>1</sup> and Yves Gratton<sup>2</sup>

Royal Military College of Canada, <sup>2</sup>INRS, Universite de Quebec a Rimouski

Temperature, salinity, sea level and meteorological data from the `couplage entre les processus physiques et biog\'eochimiques' study of 1990 were examined to determine the forcing of fresh water pulses in the lower St. Lawrence Estuary. Anchor stations, during and after the passage of a pulse event, indicated that profound changes occurred in the hydrography at the head of the Laurentian Channel. A factor analysis of rotated eigenmodes of surface temperTemperature and salinity indicated three co-varying groups -- the first, on the north shore of the river, the second, on the south slope of the Laurentian Channel and the third in the middle of the estuary. A multi-variate regression was used to relate salinity and temperature variations to forcing variates. It was found that sea level elevation and local winds accurately predicted fluctuations on the north shore. Salinity and temperature fluctuations on the south shore were best explained by propagation. In the middle of the estuary, salinity fluctuations were only weakly explained by propagation while temperature fluctuations could not be predicted by any of the forcing variates.

1-D-3.5

Sea State Forecasting in the St. Lawrence River and Gulf Ray Lin and William Perrie<sup>1</sup>

David Taylor Model Basin Laboratory, <sup>2</sup>Bedford Institute of Oceanography

The lower St. Lawrence River and Gulf can experience high wind and wave conditions, particularly when the wind is in the same direction as the river. In this situation intense wave-current interaction events can develop rather rapidly, because of the coupling of waves and currents. These events have resulted in injury and loss of life, in recent years. In this study, we present new wave-current interaction physics, based on action conservation. This is not included in the state-of-the-art operational wave models, for example WAM. We show that for idealized St. Lawrence River topography, currents and wind conditions, this mechanism is important. For a tidal-type current, maximum wave heights exhibit a periodic space-time oscillation, which is enhanced by the presence of bottom topography.

1-D-1.6
Dynamics of the Buoyancy-Driven Coastal Jet: The Gaspe Current Jinyu Sheng¹¹Dalhousie University

A three dimensional primitive equation ocean model is used to study the dynamics of the Gaspe Current and the cyclonic motion over the northwestern Gulf of St. Lawrence (NWGSL). The model is driven by buoyancy forcing associated with St. Lawrence River runoff and barotropic boundary inflows. Two types of model domains are used in this study. The first type is an idealized basin with a flat bottom and a piecewise straight coastline. It resembles roughly the geometry of the NWGSL region. The second type is a realistic basin with a variable bottom and an irregular coastline, representing the model-resolved bathymetry over the NWGSL region. The two model domains are initially filled with horizontally uniform but vertically stratified waters of summer mean temperature and salinity over the NWGSL region. The buoyancy forcing associated with the river runoff is specified as lower salinity waters at the estuary head.

We first apply the model to the idealized basin with the buoyancy forcing at the estuarine head. After a short-period adjustment, a buoyant plume is developed inside the estuary with an eastward current along the north shore. This north shore current veers anticyclonically and flows southward along the offshore front of the plume near the estuary mouth. It turns abruptly eastward at the south shore and forms a surface-intensified coastal current that advects the estuarine water seaward along the right-bounded coastline. We then apply the model to the realistic basin driven by the same buoyancy forcing. The early development of the plume-current system on this realistic basin is qualitatively similar to that on the idealized basin. Nevertheless, the combined effects of the irregular bathymetry and nonlinear dynamics make the intrusion nose to advance considerably slower along the right-bounded coast on the realistic basin than that on the idealized basin. Furthermore, this surface-intensified coastal current tends to follow closely the irregular coastline initially but becomes unstable with multiple backward breaking waves developed. It separates and reattaches the coast sporadically as it propagates downstream. It leaves the coast permanently after passing the eastern tip of the Gaspe Peninsula and forms a southward drift onto the Magdalen Shallows.



# Session 1-D-4 Variabilité du climat et projet de prévision historique I **Climate Variability** and Historical **Forecast Project I** Lundi 31 mai Monday, May 31 15h40 - 17h40 Salle / Room R-OM160

#### 1-D-4.1

The potential vorticity budget of the North-Atlantic oscillation Jacques Derome<sup>1</sup>, Yuhui Wang<sup>1</sup> and Gilbert Brunet<sup>2</sup>

<sup>1</sup>McGill University, <sup>2</sup>Recherche en prévision numérique, AES

NCEP reanalyses have been used to compute the climatological potential vorticity (PV) budget for 39 winters and for those winters with a North Atlantic Oscillation (NAO) anomaly. The analysis is based on the time-averaged PV equation in isentropic coordinates, an equation that expresses a simple balance between the horizontal advection of PV and the sources and sinks of PV due to diabatic heating and friction.

The climatology shows two main sources of PV, each being upstream of the two main centres of positive PV on the east coasts of North America and Asia. The PV advection that balances the PV sources is composed of the advection by the time-mean flow and by the transient eddies. The latter are found to produce a negative feedback in that they work to reduce the amplitude of the PV anomaly.

The results for the winters with an NAO anomaly show, in particular, that the PV anomalies associated with the NAO also have upstream sources. The importance of the latter, however, is not as clear as that of the continental sources that maintain the climatological PV centres.

#### 1-D-4 2

The Arctic and Antarctic Oscillations and their Projected Changes Under Global Warming John Fyfe<sup>1</sup>, George J. Boer<sup>1</sup> and Gregory M. Flato <sup>2</sup>

<sup>1</sup>Canadian Centre for Climate Modelling and Analysis, Atmospheric Environment Service, <sup>2</sup>University of Victoria, Victoria, BC, Canada

The Arctic Oscillation (AO) and the Antarctic Oscillation (AAO) are the leading modes of high-latitude variability in each hemisphere as characterized by the first EOF of mean sealevel pressure. Observations suggest a recent positive trend in the AO and it is speculated that this may be related to global warming. The CCCma coupled general circulation model control simulation exhibits a robust and realistic AO and AAO. Climate change simulations for the period 1900-2100, with forcing due to greenhouse gases and aerosols, exhibit positive trends in both the AO and the AAO. The model simulates essentially unchanged AO/AAO variations superimposed on a forced climate change pattern. The results do not suggest that a simulated trend in the AO/AAO depends on stratospheric involvement nor that forced climate change will be expressed as a change in the occurence of one phase of the AO/AAO over another. This pattern of climate change projects exclusively on the AAO pattern in the southern hemisphere but not in the northern hemisphere where other EOFs are involved. The extent to which this forced climate change pattern and the unforced modes of variation are determined by the same mechanisms and feedbacks remains an open question.

#### 1-D-4.3

The North Atlantic Oscillation, 1958-1998: A data study Paolo Jr. Petriello<sup>1</sup>, Jacques Derome<sup>1</sup> and Charles Lin<sup>1</sup> McGill University, Dept. of Atmospheric and Oceanic Sciences

The North Atlantic Oscillation (NAO) refers to a low-frequency mode of atmospheric variability with two centres of action in the pressure field. One is centred over Iceland and the other, with a pressure anomaly of the opposite sign, is centred over Portugal. The present study examines various atmospheric fields associated with the NAO, with particular emphasis on North America. Such fields as sea-level pressure, surface air temperature, 850 mb. air temperature,

daily precipitation amount, and precipitable water are examined. The NCEP/NCAR reanalysis data set from 1958-1998 is used. It is found that the NAO has a definite impact on seasonal weather conditions in the Labrador, Baffin Island region.

#### 1-D-4.4

Dynamical Characterisation of North Atlantic Climate Variability Lionel Pandolfo<sup>1</sup> and Declan Quinn<sup>2</sup>

<sup>1</sup>University of British Columbia, <sup>2</sup>Department of Mathematics, University of British Columbia, BC

The effect of quasi-stationary anomalies on the surface climate of the North Atlantic is studied. A set of dynamical indices, characterising the climate variability of the North Atlantic, was constructed by filtering wintertime daily observations to remove transient activity. The set includes the strength and position of the surface central pressures of the oceanic "centres of actions" as well as the pressure difference and pressure gradient between centres. The time series (and their associated spatial patterns) describing the various indices show that the large-scale "centres of action" exhibit distinct migrations. Such behaviour is not evident from monthly-mean analyses and it is demonstrated that monthly-mean charts may give a misleading picture of atmospheric behaviour. Significant correlations are found amongst the various dynamical indices and between them and the principal components of wintertime Sea Level Pressure. It is hypothesised that both the central pressure and the location of these centres are of direct relevance to the climate of the North Atlantic region.

# 1-D-4.5

The Role of Gravity Waves in Slowly Varying in Time Equatorial Motions Gerald Browning<sup>1</sup>, H. O Kreiss<sup>1</sup> and W. H. Schubert<sup>1</sup>

Recently a mathematical theory of the relationship between the dominant and gravity wave components of the slowly varying in time solution of midlatitude mesoscale motions dominated by heating and cooling has been developed.

Here it will be shown that this theory applies to slowly varying in time equatorial motions of any length scale. Thus for all equatorial storms the gravity waves that are generated have the same time scale and the same size of pressure perturbations as the dominant component, a horizontal length scale an order of magnitude larger than that of the heating, and very little energy compared to the dominant component. In the large-scale equatorial case the theory explains the origin of global scale 30-60 day Madden-Julian oscillations in the pressure. It is also shown that if a solution of the diabatic system describing equatorial flows (and hence equatorial observational data in the presence of heating) is written in terms of a series of the modes of the linear adiabatic system for those flows, then a major portion of the dominant solution is projected onto gravity wave modes and this result can explain the confusion over the relative importance of equatorial gravity waves.

# 1-D-4.6

Tendance de la Variabilité du Climat au Québec au XX ième Siècle Myriam Montpetit<sup>1</sup>, Peter Zwack <sup>2</sup>, Sandra Turner <sup>2</sup> and Florence Péron<sup>3</sup>

Université du Québec à Montréal, <sup>2</sup>Université du Québec à Montréal, <sup>3</sup>Université Fourier

Depuis plus de 100 ans déjà, des mesures journalières de température et de précipitation sont effectuées à plusieurs endroits stratégiques à travers le Canada. Au Québec, le nombre de stations a varié considérablement au courant de l'histoire, atteignant un optimum de 500 dans les années soixante-dix, pour ensuite décroître jusqu'à environ 200 telles qu'on les connaît aujourd'hui. Malheureusement, en plus d'avoir subi une variation en nombre, certaines stations ont également été déplacées, entraînant ainsi des écarts important au Session 1-D-4 Variabilité du climat et projet de prévision historique I **Climate Variability** and Historical

Lundi 31 mai Monday, May 31

Forecast Project I

15h40 - 17h40

Salle / Room R-OM160

# **Session 1-D-4** Variabilité du climat et projet de prévision historique I **Climate Variability** and Historical **Forecast Project I** Lundi 31 mai Monday, May 31 15h40 - 17h40 Salle / Room R-OM160

niveau des températures et des précipitations enregistrées. Ce n'est que tout récemment que les données mensuelles de 22 stations réparties du nord au sud de la province ont été homogénéisées, afin justement de minimiser le plus possible les différences dans la lecture de ces paramètres.

Une des hypothèses fortement débattue concernant les changements climatiques, consiste à croire qu'une augmentation de la température provoquerait une hausse de la variabilité du climat. Notre étude consiste donc à utiliser ces 22 stations comme point de référence pour vérifier si, avec l'augmentation des températures de 1,5°C enregistrée au Canada depuis 1895, le climat ne serait pas en train de devenir plus variable. Nous présenterons plusieurs analyses, incluant les tendances de l'écart-type des températures et des précipitations. Les résultats seront regroupés en fonction de 5 grandes zones géographiques réparties comme suit: le sud du Québec, les Basses-Terres du St-Laurent, la péninsule gaspésienne, le centre du Québec et le nord du Québec. De cette façon, nous seront plus en mesure de visualiser si les tendances de la variabilité sont semblables d'un région à l'autre.

2-A-1.1 Towards a more complete model of the climate system Byron A. Boville<sup>1</sup>

National Center for Atmospheric Research

Changes in climate, whether anthropogenic or natural, involve a complex interplay of physical, chemical, and biological processes not just of the atmosphere but also of the ocean and the land surface---the ``climate system". As climate system research seeks to explain the behavior of climate over time scales of years to millennia, focus necessarily turns to behavior introduced by physical, chemical, and biogeochemical interactions among climate subsystems. The challenges of modeling the role of anthropogenic emissions of carbon dioxide, of reactive trace gases, and of changing land use in the earth system require a coupled climate system approach.

Several groups around the world are working towards comprehensive climate system models that allow for the interactions among physical, chemical, and biogeochemical processes. However, it will be many years before mature models of this type exist. Even the present physical climate models require coupling an atmospheric general circulation to an ocean general circulation model, a sea ice model, and a land surface model. These component models all communicate with each other through interfacial fluxes of momentum, energy, and water, which generally depend on the state of more than one model, so the structure of a climate system model is exceedingly complex. Moreover, such models are extremely computationally intensive, since they are typically integrated for a century or more.

This talk will focus on the present state of climate system modeling, largely using the NCAR CSM as an example, and including some results for the Climate Model Intercomparison Project. This model now routinely includes sulphate aerosol chemistry and its feedbacks on the radiation. The scientific and computational challenges of including further chemical and biogeochemical processes will be discussed.

Session 2-A
Plénière / Plenary

Prévision
environnementale III

Environmental
Prediction III

Mardi 1er juin
Tuesday, June 1

08h30 - 09h10

Salle / Room Marie-Gérin-Lajoie



2-A-1.2

Saguenay River Discharge Proxies: Data from the 1971-1978 Sedimentary Record in Relation to Older Sediment Observations.

Charles T. Schafer<sup>1</sup> and John N. Smith<sup>2</sup>

<sup>1</sup>Geological Survey of Canada - Atlantic, <sup>2</sup>Department of Fisheries and Oceans, Bedford Institute of Oceanography

The 1971-1976 subset of data from a piston core collected near the head of the North Arm of the Saguenay Fiord (#82008-72) suggests that the grain size distribution of the <420 uM fraction includes material carried to the site by processes other than spring freshet river currents (e.g., sand transport from adjacent shallow subtidal environments and landslide material from upstream sources). When gravitational processes and anomalous sediment sources are accounted for, and given a resolution of the Pb-210 chronology of  $\pm$ - one year or less, 1971-1976 data indicate generally that relatively intense spring freshets can often be characterized by modal diameters greater than 70 uM, by relatively high +200 uM sand populations and magnetic susceptibilities, and by Pb-210 sedimentation rates greater than 4 cm/yr. However, it is also clear from the total set of observations that the link between sediment texture and river discharge intensity is a complex problem, possibly related to distance relative to the mouth of the Saguenay River, temporal changes in the rate of sediment supply to the river channel, and difficulties in resolving the true boundaries of annual deposits. Total grain size results from earlier studies of a core collected upstream from core 72 (core D-1) identified percent sand and sand flux as promising parameters for estimating the variation of spring freshet intensity on a scale of years to decades i.e., generally consistent with some of the core 72 (1971-1976) findings.

Further investigation of the paleodischarge record definition issue has centred on the comparison of laminated versus unlaminated intervals of core 72. Results suggest that relatively high river discharge index values, median diameters and +200 uM particles tend to be characteristic of the unlaminated intervals rather than the laminated intervals. For those laminated deposits that can be shown to be unrelated to landslide sediment "pulses", or to downslope transport of sand from the upper parts of the North Arm basin walls, these results imply that the high spring freshet record at this location in the North Arm may be manifested by the above average deposition of particles in the fine to medium silt size range. This "silt dilution" effect may be reflected by the comparatively high magnetic susceptibility and the surprisingly low average modal diameter value that appears to characterize the 1976 interval of core 72. It seems clear, at this juncture, that attempts to define a paleodischarge record for the Saguenay River should be based on integrated data sets that can resolve both relative hydrodynamic energy as well as sediment source. In addition, it should be anticipated that the indices selected may behave differently from one North Arm basin location to another as a consequence of the inherent heterogeniety of this freshwater/marine interface environment.

# 2-B-1.1

The Effect of Trough Interactions on Tropical Cyclone Intensity Change Deborah Hanley<sup>1</sup>, John Molinari <sup>2</sup> and Dan Keyser <sup>2</sup>

<sup>1</sup>Department of Earth and Atmospheric Sciences, <sup>2</sup>University at Albany, State University of New York

The focus of this study is to investigate the effect of upper-level troughs in the westerlies on the intensity change of tropical cyclones. Conventional wisdom states that increased shear associated with these troughs is detrimental to tropical cyclones. Despite this conventional wisdom, intensification has been documented in cases of an approaching upper-level trough in the westerlies exhibiting moderate vertical wind shear (DeMaria et al. 1993). In some cases, the intensification occurs as the tropical cyclone is tracking up the east coast of the United States into Canadian waters and results in dangerous weather conditions that are often not forecasted. Consequently, the opportunity exists to clarify the role of an upper-level trough that approaches and interacts with a tropical cyclone, in particular whether the interaction will result in intensification or weakening of the tropical cyclone. Consistent with this research opportunity, a long- term goal of this work is to develop recommendations for improving forecasts of tropical cyclone intensity change when there is an interaction with an upper-level trough.

The present study uses 12 hourly 1.125 degree uninitialized ECMWF analyses. All named tropical cyclones in the Atlantic basin during 1985 through 1996 are considered. A trough interaction is defined when the eddy flux convergence of angular momentum (EFC) at 200 hPa over a 300-600 km storm-centred radial band is greater than 10 (m/s)/d and the total pressure change is greater than 10 hPa. Cases are identified and composited for six different situations. In composites 1-4 the tropical cyclone intensifies, while in composites 5 and 6 the tropical cyclone weakens. The categories of composites are: (1) superposition (upper tropospheric PV anomaly within 400 km of storm centre), (2) distant interaction (PV anomaly between 400 and 1000 km from the centre), (3) extratropical transition (intensification after transition), (4) favourable no trough (intensification with EFC less than 5 (m/s)/d for at least 3 consecutive periods), (5) unfavourable interaction (weakening with enhanced EFC), and (6) unfavourable no trough (weakening with EFC less than 5 (m/s)/d for at least 3 consecutive periods). Calculations have been performed on these composites and the results will be presented.

## 2-B-1.2

A Study of Tropical to Extratropical Cyclone Transition off the Canadian and US East Coasts, 1963-1996

Christopher T. Fogarty<sup>1</sup> and Dr. John R. Gyakum<sup>1</sup> McGill University, Montreal, QC, Canada

The goal of this study is to better understand the thermodynamic structure of tropical cyclones undergoing extratropical transition (ET), and to observe the role of synoptic-scale features in the transition and reintensification of tropical cyclones. National Hurricane Center (NHC) best track data and the National Centers for Environmental Prediction (NCEP) reanalyses are used to produce composite geopotential height, thickness, and sea level pressure fields for 45 tropical cyclones affecting the western North Atlantic Ocean between 1963 and 1996. Many of these dissipating tropical cyclones underwent extratropical transition as they moved generally to the northeast off the US and Canadian east coasts. Anomalies in the height and thickness fields are analysed to diagnose large-scale weather patterns associated with ET events. An upper-air data set from the Forecast Systems Laboratory (FSL) is used to produce a sounding climatology for Sable Island, Nova Scotia (WMO YSA). With this data set we have also constructed composite cyclones for selected transition cases using soundings from Sable Island and other coastal stations. The composite sounding cyclones provide us with a wealth of new information on the thermodynamic structure of tropical systems undergoing ET. We

Session 2-B-1 **Prévision** environnementale IV **Environmental Prediction IV** Mardi 1er juin Tuesday, June 1 10:10 - 12:10 Salle / Room R-OM130



also investigate 700 hPa Q-vector divergence fields for five cases during our period of interest. These fields help locate regions where there is forcing for quasigeostrophic ascent using the Q-vector form of the quasigeostrophic (QG) omega equation.

#### 2-B-1.3

A New MPI-based Coupler for the CCCma CGCM3 Coupled Model. Scott Tinis<sup>1</sup>, Bertrand Denis<sup>2</sup>, Gregory M. Flato<sup>2</sup> and George J. Boer<sup>2</sup>
<sup>1</sup> Canadian Centre for Climate Modelling and Analysis, <sup>2</sup>Université du Québec à Montréal, <sup>3</sup>CCCma

A new coupling strategy using the Message-Passing Interface (MPI) parallel computing environment on the NEC SX4 has been developed for use in the latest version of the Canadian Centre for Climate Modelling and Analysis (CCCma) coupled general circulation model (CGCM3). CGCM3 is composed of the newly developed GCM3 atmosphere model and a version of the NCAR NCOM1.3 ocean model.

Earlier versions of the CCCma coupled models (CGCM1 and CGCM2) used a serial coupling scheme in which the atmosphere component is run for one day to provide daily mean forcing to the ocean component, which subsequently runs for one day and returns daily mean sea-surface temperatures to the atmosphere. Data transfer between model components was accomplished through reading and writing files on disk. The MPI coupler allows the atmosphere and ocean components to run simultaneously, with each component multitasked across several computer processors. This takes maximum advantage of the NEC SX4 multi-processor architecture. The savings due to the reduced disk input/output and parallel execution of the coupled model modules is more than 50% (wall-clock). This presentation will provide an overview of the MPI coupling method and address some of the issues that arise from coupling the atmosphere and ocean in parallel.

### 2-B-1.4

A Comparison of GCM Models with Experimental Measurements of Surface Radiative Forcing by Greenhouse Gases
Wayne F.J. Evans<sup>1</sup> and Eldon Puckrin<sup>1</sup>
Environmental Resource Studies, Trent University

Climate models predict that the emission of greenhouse gases into the atmosphere has altered the radiative energy blance at the earth's surface by several percent through increasing the greenhouse radiation from the atmosphere. With measurements at high spectral resolution, this increase can be quantitatively attributed to each of several anthropogenic gases. An energy flux imbalance of about 3 W/m^2 has been created by anthropogenic emissions of greenhouse gases of which we have measured almost 1.0 W/m^2. Calibrated spectra of the greenhouse radiation from the atmosphere have been measured at ground level from Peterborough using an FTIR with a resolution of 0.1 wawvenumbers. This long wave radiation consists of thermal emission from naturally occurring gases such as CO2, H20, and O3 as well as from many trace gases such as CH4, CFC11, CFC12, CFC22, and HNO3. The forcing radiative fluxes from CFC11, CFC12, CCl4, N2O, CH4 and CO2 have been quantitatively measured. The greenhouse radiation fluxes from the various gases have been computed with the radiation code from the NCAR community model for the location and seasons of the measurements. Overall the agreement in most fluxes is reasonable, providing some confidence in the NCAR GCM. Similar comparisons of our experimental measurements with simulations using the column model from the Canadian GCM are in progress. Preliminary results of the comparison will be presented; this cast doubt on the validity of doubled CO2 scenario model runs.

2-B-1.5 The Benefits of Global Warming to Canada Wayne F.J. Evans<sup>1</sup>

<sup>1</sup> Environmental Resource Studies, Trent University

In order to present a balanced debate on the impact of global warming on Canada, the benefits need to be carefully considered. Up to this point the negative impacts of global warming on Canada have been extensively reported by Environment Canada, therefore, the negative impacts will not be covered in this report.

The benefits include an increase in economic wealth, a healthier population and a more liveable climate which is desired by the majority of Canadians. Economic benefits will accrue from lower energy bills in winter and lower transportation costs as well as increased agricultural productivity and increased forest growth. Health benefits will accrue from fewer automobile accidents under improved winter road conditions, fewer deaths and illness from reduced influenza cases and fewer direct deaths from cold exposure in winter. In terms of a more liveable climate, winters will be warmer and the public will be able to enjoy outdoor living more and suffer less in cold winter outdoor working conditions. A few urban legends about global warming such as the Toronto malaria scare will also be debunked. Since the cost of manufacturing and doing business decreases with lower latitude in North America, Canada will gain a relative productivity advantage. A mathematical model will be presented which demonstrates that a warming climate temperature will result in a higher GDP.

2-B-1.6

CIPRA: un outil de gestion agro-environnemental René Audet<sup>1</sup>

<sup>1</sup>Env. Canada - Région du Québec - BSME de Québec

Le milieu agricole est souvent pointé du doigt comme l'un des secteurs économiques qui pollue le plus l'environnement. Il nous suffit à penser à l'utilisation massive de pesticides et de fongicides pour assurer à l'agriculteur une récolte intéressante assurant la rentabilité de son entreprise. Cette rentabilité se fait souvent au détriment de la qualité de l'environnement immédiat. Agriculture Canada, en collaboration avec Environnement Canada - division de la météorologie, a mis au point un outil d'aide à la décision pour l'agronome qui conseille et quide l'agriculteur dans ses pratiques culturales. L'outil se nomme CIPRA. C'est une interface qui intègre diverses données dont météorologiques. Le logiciel travail en modes diagnostic et prognostic (innovation dans le domaine). L'outil permet de cibler et de limiter le nombre de traitements phytosanitaires requis et ainsi assurer une meilleure gestion de l'utilisation des pesticides et fongicides dans l'environnement. La présentation visera à faire connaître l'outil et à faire ressortir la mise en valeur des observations météo ainsi que de l'utilisation des données météorologiques prévues en provenance du modèle GEM. Le paramètre météorologique le plus important est la précipitation ( durée, fréquence et quantité). Également, des résultats préliminaires seront présentés démontrant le potentiel de l'outil. Présentement, l'outil est utilisé au Québec et le sera prochainement dans les Maritimes et en Ontario.

Session 2-B-1 **Prévision** environnementale IV **Environmental Prediction IV** Mardi 1er juin Tuesday, June 1 10:10 - 12:10 Salle / Room R-OM130



#### 2-B-2.1

A Simulation of Size-Segregated Sulphate Aerosols of Volcanic Origins in the Stratosphere using the CMAM

Jonathan Jiang<sup>1</sup>, Sunling Gong<sup>2</sup>, Jean-Pierre Blanchet<sup>1</sup> and Stephen Beagley<sup>3</sup>
<sup>1</sup>University of Quebec at Montreal, <sup>2</sup>AES, Environment Canada, <sup>3</sup>York university

The consideration of sulphate aerosol from volcanic and anthropogenic sources is necessary to account properly for the observed ozone changes over low latitudes during the last decade. The NARCM Canadian Aerosol Module is incorporated into the Canadian Middle Atmosphere Model (CMAM) to simulate the global distribution of size-segregated sulphate aerosols of volcanic origins in the stratosphere with explicit microphysics.

The sulphate aerosol size spectra is divided into 6 size sections [r=0.005-10 mm]. Microphysical processes include production by SO2 oxidation, nucleation, condensation, removal by dry deposition and transport in the atmosphere. The transport of aerosols in CMAM is done by a 3D semi-Lagrangian advection scheme. Vertical diffusion and convection are also accounted for.

Simulated sulphate concentrations and transport were compared with observations. The impact of sulphate aerosols on ozone will be discussed. The inclusion of detailed aerosol microphysics in CMAM pave the way to explicit treatment of PSC cloud and physically based interaction with chemistry and radiation.

### 2-B-2.2

The NARCM Aerosol Model Applied to E. North America LITE Shuttle Measurement Period Lubos Spacek<sup>1</sup>, Sunling Gong <sup>2</sup>, Knut von Salzen<sup>3</sup>, Ulrike Lohmann<sup>4</sup>, Peter Liu<sup>5</sup>, Raymond Hoff <sup>6</sup>, Jean-Pierre Blanchet<sup>1</sup>, Leonard A. Barrie<sup>7</sup> and Henry Leighton<sup>8</sup>

<sup>1</sup>University of Quebec at Montreal, Canada, <sup>2</sup>Atmospheric Environment Service, Toronto, Canada, <sup>3</sup>McGill University, Montreal, Canada, <sup>4</sup>Dalhousie University, Halifax, Canada, <sup>5</sup>Atmospheric Aerosol Research Inc., Mississauga, Canada, <sup>6</sup>Atmospheric Environment Service, Egbert, Canada, <sup>7</sup>Atmospheric Environment Service, <sup>8</sup>McGill University, Montreal, Canada

The Northern Aerosol Regional Climate Model (NARCM) project is being developed to understand how climate is affected by anthropogenic aerosols. It involves approximately 20 university and government scientists and graduate students. The dynamical kernel of NARCM is the same as the dynamical kernel of the CRCM (Canadian Regional Climate Model). The NARCM uses physical parameterization package of the CGCM (Canadian General Circulation Model). Recently, a new cloud microphysics scheme of stratiform clouds that matches better the needs of aerosols modellers has been incorporated into the physics part. Process parameterization schemes being developed in the project include: (1) natural and anthropogenic emissions of aerosols and/or their gases precursors (2) dry deposition and wet removal (3) chemical/physical transformations (4) transport (5) aerosol-cloud interaction and (6) aerosol-radiation interaction.

The presentation will describe the results of one of the benchmark tests of the NARCM model, namely the NARCM/LITE comparison. This involves: (i) the simulation of the atmospheric distribution of anthropogenic sulphate and natural sea salt aerosols in eastern North America during September 1994 during a period of vertical aerosol and cloud profile measurements by LIDAR (LITE study) on board the NASA space shuttle (ii) comparison with ground level observed sulphate, particle mass and sulphur dioxide and sulphate wet deposition and (iii) comparison of vertical profiles of aerosol scattering and cloud top heights predicted by the model with LITE observations from the shuttle. The test area covers North America, North Atlantic, and Western Europe for the period of time from 13 to 20 September 1994 with a

spinup period from 8 to 12 September. The initial and boundary condition are provided by NMC/NCEP Operational Analyses. We will explore first the meteorological performance of the NARCM during the study period followed by NARCM's ability to simulate the atmospheric pathways of sulphur and sea salt compounds in the region of Eastern North America and the western Atlantic where these two aerosol types are likely to be dominant. This will be followed by a comparison of the aerosol vertical profiles from the model and the LITE observations. Finally, the sulphur budget in Eastern North America will be discussed.

The NARCM/LITE comparison constitutes one of several benchmark test of NARCM that will be revisited as our aerosol modelling improves. One area for improvement will be the addition of more realistic simulation of the carbonaceous aerosol component which is rather crudely parameterized in this current version (NARCM1). Another will be the use of an on-line chemistry model to drive gas-to-particle conversion (rather than off-line chemistry).

#### 2-B-2.3

Intercomparison of LITE Tropospheric Aerosol Retrievals with the Northern Aerosol Regional Climate Model

Aaron Vandermeer<sup>1</sup>, Raymond M. Hoff<sup>2</sup>, Lubos Spacek<sup>3</sup>, Sunling Gong<sup>2</sup>, Jean-Pierre Blanchet<sup>3</sup>, Knut von Salzen<sup>4</sup>, Leonard A. Barrie<sup>2</sup>, Norm O'Neill<sup>5</sup>, Alain Royer <sup>6</sup> and Shiv R. Pal<sup>7</sup> <sup>1</sup>Department of Physics, York University, <sup>2</sup>Atmospheric Environment Service, <sup>3</sup>Department of Earth Sciences, University of Quebec at Montreal, <sup>4</sup>Department of Atmospheric and Oceanic Sciences, McGill University, <sup>5</sup>NASA/Goddard Space Flight Centre (L.O.A. from CARTEL, Universite de Sherbrooke), <sup>6</sup>CARTEL, Universite de Sherbrooke, <sup>7</sup>Centre for Research in Earth and Space Science

The Lidar In-Space Technology Experiment (LITE) consisted of a 3-wavelength backscatter lidar flown aboard the space shuttle Discovery from September 9th to 20th, 1994. It was the first demonstration of a lidar instrument operating from space. The measurement of tropospheric aerosols was among one of the primary scientific objectives of the mission. The very high vertical resolution (15m) of this instrument makes it possible to identify the structure of tropospheric aerosols on a global scale not previously seen. Aerosol backscatter coefficients have been derived from LITE backscatter profiles in a region specific to the Northern Regional Aerosol Climate Model (NARCM). This model incorporates size-distributed aerosols in a dynamic circulation model within a domain covering North America, the lower Arctic, North Africa and Europe. Although currently the model contains only sulfate (anthropogenic and biogenic) and sea salt aerosol, it will eventually be expanded to include the contribution of soil dust, black carbon, and organics. The performance of the model is evaluated by comparing the LITE cloud and aerosol results with the NARCM output for the period of the LITE mission. Optical code is used to extract aerosol backscatter coefficients from the NARCM output, which are compared to values calculated from the LITE data. NARCM and LITE cloud top heights and fractional cloud cover are also compared. These comparisons enable an evaluation of the model's ability to predict the presence and location of clouds and aerosol.

Over 35 LITE orbit segments are found to coincide with the NARCM domain. However, since the focus of this comparison is reduced to North America and the Eastern Atlantic only orbits 84, 85, 116, 117, 133, 148 and 149 are selected for this study. Early model versions perform well near the North American source region but have poorer agreement at longer distances. Understanding these differences has led to better parameterization of processes in NARCM. Aerosol from the Sahara seen over the Atlantic in the LITE data is absent from the model prediction since the model does not yet consider soil dust. In many cases, the model produces similar cloud coverage as is seen in the LITE data. This comparison serves to illustrate the utility of space borne lidar measurements and is important in light of future plans for developing satellite mounted lidar instruments.





2-B-2.4

NAtChem/Particles: A Particle Database for Atmospheric Research Peter Liu<sup>1</sup>, Robert Vet<sup>2</sup>, William Sukloff<sup>2</sup> and Chul-Un Ro<sup>2</sup> Atmospheric Aerosol Research Inc., <sup>2</sup>Atmospheric Environment Service

The National Atmospheric Chemistry (NAtChem) Database and Analysis Facility is a federalprovincial facility operated by the Atmospheric Environment Service to archive and analyze regional-scale, long-term, Canadian and U.S. air and precipitation chemistry data for use in atmospheric research projects. Since atmospheric particles play an important role in acid deposition, visibility, human health, climate change and atmospheric chemistry, a large part of the NAtChem Database activity has been dedicated to the archival and analysis of data on the physical and chemical characteristics of particulate matter. This component of the database, known as the NAtChem/Particles Database, currently contains data from 14 largescale monitoring networks in Canada and the U.S.A. including the Canadian Air and Precipitation Monitoring Network, the U.S. Clean Air Status and Trends Network, the U.S. Interagency Monitoring of Protected Visual Environments and Canadian Acid Aerosols Monitoring Program. The NAtChem/Particles Database converts and archives data from the various networks into a single standard format. The database identifies the networks' sampling methods, chemical analysis methods, sampling conditions, sampling periods, units, and solubility characteristics, all of which can vary from network to network. This allows NAtChem staff and other researchers to distinguish important differences between the networks when combining data sets for specific uses. A description of the merged, multinetwork data from the NAtChem/Particles Database is presented. These merged data were used in the Northern Aerosol Regional Climate Model (NARCM) verification exercise for the East North America Lidar In-Space Technology Experiment (LITE) Shuttle measurement period. Gridded data and contour maps of various particle concentrations were produced for comparison with the NARCM model predictions. The NARCM-LITE exercise illustrates the extreme care that must be taken when merging data from different monitoring networks using different sampling methods. An overview of the design, content, quality assurance methods, and uses of the database for the 14 networks are described in the paper.

#### 2-B-2.5

Sunphotometer network for the validation of long term climatic models in Canada Amadou Idrissa Bokoye<sup>1</sup>, Alain Royer<sup>1</sup>, Norm T. O'Neill<sup>2</sup>, Brent Holben<sup>3</sup>, Alexander Smirnov<sup>3</sup>, Oleg Dubovik<sup>3</sup>, Phillippe M. Teillet<sup>4</sup>, Gunar Fedosejevs<sup>4</sup> and Ray Hoff<sup>5</sup>

<sup>1</sup>CARTEL, Université de Sherbrooke, <sup>2</sup>NASA/GSFC, Greenbelt Maryland (NRC Senior Associate on leave from CARTEL, Université de Sherbrooke), <sup>3</sup>NASA/GSFC, Greenbelt Maryland, <sup>4</sup>Canada Centre for Remote Sensing, Ottawa, Ontario, Canada, <sup>5</sup>Atmospheric Environment Service (AES/CARE), Egbert, Ontario, Canada

AEROCAN (AERONET CANada) is a network of sunphotometers which form part of the AEronet Robotoc NEtwork (AERONET), a world wide federated network of sunphotometers managed through NASA's Goddard Space Flight Center (GSFC). The AEROCAN network includes 8 sunphotometers distributed across Canada at sites which were chosen in order to obtain a diverse sampling of continental and maritime aerosols.

A principal objective of this network is to acquire a temporal and spatial data base of aerosol optical properties in order to develop a Canadian aerosol climatology. Extinction and sky radiance measurements from network instruments are converted into aerosol optical depth, water vapour extinction and column averaged phase function, refractive index and single scattering albedo. These optical properties are simultaneously converted into water vapour content, column averaged particle size distribution as well as simpler (more robust) indicators of aerosol particle size. This database, along with satellite remote sensing data will be employed: \* in the validation of global and regional climatological models such as the

Northern Regional Aerosol Climatic Model (NARCM). \* in the comparison with other ground-based measurements.

Aerosol optical depth and water vapour results from several Canadian sites and over several years will be presented. In addition to these temporal climatogical studies we are investigating the potential for producing simplistic aerosol scale height information derivable from the ratio of aerosol optical depth to nephelometer measured scattering coefficients. Some preliminary results which compare sunphotometer/nephelometer scale heights to LIDAR scale heights will be presented.

#### 2-B-2.6

Ground Comparisons between the the Northern Aerosol Regional Climatological Model (NARCM) and spatio-temporal measurements of passive aerosol optical parameters Norm O'Neill<sup>1</sup>, Brent Holben<sup>2</sup>, Martin Aubé<sup>3</sup>, Alain Royer<sup>3</sup>, Jean-Pierre Blanchet<sup>4</sup> and Lubos Spacek<sup>4</sup>

GSFC/NASA (L.O.A. from Université de Sherbrooke), <sup>2</sup>GSFC/NASA, <sup>3</sup>CARTEL, Université de Sherbrooke, <sup>4</sup>U.Q.A.M.

Little effort has been expended in the analysis of aerosol optical properties extracted from spatially-sparse ground station measurements or from temporally-static satellite inversions relative to the predictions of climatological models which incorporate dynamic aerosol transport. The Northern Aerosol Regional Climatological Model (NARCM) actively transports size distributed aerosols over a relatively fine resolution spatial grid (1 degree x 1 degree) and at a high temporal frequency (20 minute time steps). In this communication we present preliminary results which evaluate the aerosol predictive capabilities of NARCM relative to standard aerosol optical measurements. To this end we employ sunphotometer databases from the AERONET and MFRSR networks as well as satellite derived aerosol optical depth databases extracted from AVHRR and POLDER imagery over oceanic and continental regions.

Comparisons made for the LITE period (September, 1994) with the initial and boundary conditions of the model driven by NMC Operational Analyses have underscored the statistical sampling difficulties when comparing four dimensional model data with (effectively) one to two dimensional optical data. Temporal sunphotometer profiles and satellite derived optical depth imagery, while representing reality are very sparse data sets given their limited operational windows as well as the inevitable data gap impact of obscuring clouds. Thin clouds and their removal/acceptance by automatic cloud screening algorithms creates a more subtle and somewhat subjective sampling dilemma. Finally, differences in spatial and temporal resolution between the model and the optical data ensure that the mosaicking of the latter into four dimensional space to arrive at statistically comparable data ensembles is a non trivial exercise in strategical sampling. Examples will be presented which illustrate such difficulties as well as some apparent successes.



# Session 2-B-3 Modélisation de l'océan l Ocean Modelling I Mardi 1er juin Tuesday, June 1 10:10 - 12:10 Salle / Room R-OM110

#### 2-B-3.1

Impact of internal parameters and surface boundary conditions on oscillatory behaviour of an ocean general circulation model

Kitty Brown<sup>1</sup>, William A. Gough<sup>1</sup> and William J. Welch<sup>2</sup>

<sup>1</sup>University of Toronto at Scarborough, <sup>2</sup>University of Waterloo

An ocean general circulation model exhibits a spectrum of oscillatory behaviour as a function of internal modelling parameters such as diffusivities and viscosities. Each case is forced with identical restoring temperatures (Haney condition). This boundary condition is replaced by a simple energy balance model of the atmosphere (Rahmstorf condition). This new boundary condition changes the model's sensitivity to internal parameters in significant ways.

# 2-B-3.2

A study of the sensitivity of surface circulation to the surface boundary conditions in the Mellor-Yamada turbulence closure

Charles Hannah<sup>1</sup>, Jennifer Shore<sup>1</sup> and John Loder<sup>1</sup>

BIO/DFO

The use of velocity fields from circ

The use of velocity fields from circulation models for applications such as larval drift and dispersion often requires resolution of the upper few meters of the water column. An important consideration is the sensitivity of the simulated particle trajectories to the modelling assumptions that affect the vertical structure of the near-surface flow. We investigate the sensitivity of modelled circulation fields to the choice of surface boundary conditions on turbulent kinetic energy and turbulent master length scale in the Mellor-Yamada level 2.5 turbulence closure scheme. Particular attention is paid to near-surface profiles of turbulent kinetic energy, vertical eddy viscosity and velocity. Our results are consistent with recent work which shows that for the Mellor-Yamada closure, the penetration of the turbulent kinetic energy specified at the surface is limited to about 5 times the specified surface roughness scale. The sensitivity of the near-surface (horizontal) particle trajectories to the surface boundary conditions is evaluated in the context of estimating the seasonal mean circulation for the western Scotian Shelf.

#### 2-B-3.3

Boundary Layer Mixing and the Ocean's Thermohaline Circulation Olaf Dravnieks<sup>1</sup> and Andrew Weaver<sup>1</sup>

School of Earth and Ocean Sciences, University of Victoria

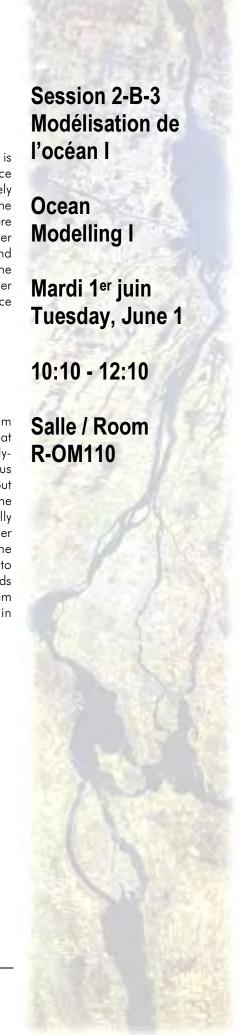
Studies have shown that the meridional heat transport and overturning strength in ocean general circulation models is very sensitive to the value of the vertical tracer mixing coefficient Kv, while observations show that diapycnal mixing is at least an order of magnitude higher at lateral, bottom and seamount boundaries than in the interior of the ocean. The effect of the location and magnitude of the diapycnal mixing coefficient on the equilibrium meridional heat transport and overturning strength is examined in a simple basin model with linearized momentum equations and equation of state, temperature forcing, and using temperature as the sole tracer. The model is run for horizontal and Gent-McWilliams mixing with varying amounts and locations of vertical mixing. Diapycnal tracer mixing is shown to have a larger effect on meridional heat transfer and overturning strength when located on the boundaries than when located in the interior of the basin. For the range of Kv between 0.5cm²/s to 50cm²/s the meridional heat transport is proportional to kv³/5 rather than the kv¹/2 expected from simple scaling analysis. Similarly, the meridional overturning strength is proportional to kv³/5 rather than the kv²/3 expected from the simple scaling analysis.

2-B-3.4 Modeling the Seasonal Variation of Sea Ice in the Labrador Sea Tom Yao<sup>1</sup>, Charles Tang<sup>1</sup> and Ingrid Peterson<sup>1</sup> Bedford Institute of Oceanography

We use a multi-category sea ice model coupled to the Princeton ocean model, which is driven by monthly climatological atmospheric forcing, to study the seasonal variation of ice cover in the Labrador Sea. Initial ocean conditions are derived from a gridded, objectively analysed temperature, salinity data set that provides improved resolution of gradients in the vicinity of the shelf break. The model produces a realistic seasonal variation of sea ice. There is ice growth over the inner shelf and ice melt over the outer shelf and slope. Over the inner shelf, advection and diffusion decrease the ice mass; over the outer shelf, advection and diffusion increase the ice mass, which maintains the location of the ice edge. Near the offshore ice edge, the melt rate exceeds 1 m per month, and the heat to melt ice together with the heat lost to the atmosphere exceeds 500 W m-2. The heat lost at the ocean surface is compensated by advection of heat from an offshore convective region.

2-B-3.5 Is the neglect of coastal upwelling in QG models Justified ? David N. Straub<sup>1</sup> <sup>1</sup>McGill University

Quasigeostrophic models of barotropic wind-driven ocean gyres are driven by an Ekmam pumping term that is proportional to the wind stress curl. The strong up- or downwelling that occurs wherever there is wind stress tangent to lateral boundaries is accounted for--implicitly-by a non-hydrostatic wall layer which lies between the wall and the (QG) inner viscous boundary layer. The wall layer is passive and the QG problem is typically solved without explicit reference to it. (As such, it is not generally required that the vertical velocity at the base of the Ekman layer integrate to zero in QG problems--so that mass is not formally conserved.) Here we suggest that, in the high Reynolds number limit, the wall and inner viscous layers interact. Specifically, it is argued that QG gives way to semi-geostrophy in the inner viscous layer and that the strong vertical velocities associated with an Ekman flux into (or out of) lateral walls should be explicitly accounted for in moderate to high Reynolds number simulations. Analogous problems with the shallow water formulation of this problem are also discussed, as is the relevance of these issues to the problem of inertial runaway in simple gyre models.





2-B-4.1

CMC Dynamical Seasonal Forecast System: Method and Results

André Plante<sup>1</sup>, Normand Gagnon<sup>2</sup>, George J. Boer<sup>3</sup>, Gilbert Brunet<sup>4</sup>, Jacques Derome<sup>2</sup> and Francis W. Zwiers <sup>3</sup>

<sup>1</sup>Centre Météorologique Canadien (CMC), <sup>2</sup>Université McGill, Montréal, Québec, Canada, <sup>3</sup>Canadian Centre for Climate modelling and analysis, Victoria, British Columbia, Canada, <sup>4</sup>Recherche en Prévision Numérique, Environnement Canada, Dorval, Québec, Canada

Dynamical atmospheric models have been used for more than three years at CMC to produce temperature and precipitation seasonal forecasts. The models used are the Canadian Climate Centre for modelling and analysis (CCCma) GCM2 model and the Recherche en Prevision Numerique (RPN) SEF model. An ensemble forecast of 6 members of each model is run using different atmospheric initial conditions. The models are forced by sea surface temperature, sea ice cover and snow field.

To estimate the skill of the models, the forecast system was tested in hindcast mode for the period 1969 to 1994 (the Historical Forecasting Project or HFP). The models show statistically significant skill in forecasting temperature anomaly over many Canadian regions, particularly in winter and summer. However, the performance of the models is much lower for the precipitation anomaly field. There is some indication that when extreme phase of El Nino-Southern Oscillation phenomena occurs the models response is significantly better. A summary of the models performance will be presented for the surface temperature and the precipitation categorical forecasts.

2-B-4.2

CMC Dynamical Seasonal Forecast System: Sensitivity Studies

Normand Gagnon<sup>1</sup> and André Plante<sup>2</sup>

<sup>1</sup>Université McGill,<sup>2</sup>Centre Météorologique Canadien(CMC), Environnement Canada, Dorval, Québec, Canada

The ensemble setup of the CMC dynamical seasonal forecast is composed of 6 members for each model (GCM2 and SEF). The members differ in their starting times that are lagged by 6 hours. This setup was investigated in adding 18 members to the GCM2 ensemble in winter for the 26 years of the Historical Forecasting Project (HFP). The suitable size of the ensemble required to forecast atmospheric fields over Canada will be discussed as well as the correlation between the skill of the ensemble runs and their corresponding spread.

To study the sensitivity of the models to the sea surface temperature anomalies (SSTA), several experiments were done with the November 1998 conditions. The model response induced by different Pacific SSTA (La Nina composite and climatology) were compared to the official forecast. The impacts on the 1998-1999 winter forecast of modifying the SSTA will be presented and discussed.

2-B-4.3

A Hybrid Multi-Model Approach to Seasonal Predictions

Gilbert Brunet<sup>1</sup>, André Plante<sup>2</sup>, Jacques Derome<sup>3</sup>, Normand Gagnon<sup>3</sup>, George J. Boer<sup>4</sup>, Harold Ritchie<sup>1</sup> and Francis W. Zwiers<sup>4</sup>

<sup>1</sup>RPN, Environment Canada, <sup>2</sup>CMC, Environment Canada, <sup>3</sup>DAOS, McGill University, <sup>4</sup>Canadian Centre for Climate Modelling and Analysis, Environment Canada

The Canadian Climate Research Network CLIVAR group has performed a series of historical ensemble seasonal forecasts for the period 1969 to 1994 using the Canadian general circulation model (GCM2) developed by the Canadian Center for Climate Modelling and Analysis (CCCma), and used primarily for climate simulations (Boer et al., 1984; McFarlane et al., 1992) and with a reduced resolution version of the global spectral model (SEF)

developed at Recherche en Prévision Numérique (RPN) primarily for global data assimilation and medium-range weather forecasting (Ritchie, 1991; Ritchie and Beaudoin, 1994).

We will discuss the geographical skill distribution of these two different models. We will argue that the difference in the skill distribution suggests that a hybridization of the different model outputs could improve the overall skill of the predictions. We present the hybridization of these two models for different seasons and for surface air temperature using the best linear unbiased estimator (BLUE) technique that is a general method for blending predictions from different models in order to produce more skillful forecasts. The BLUE technique in EOF space shows significant improvements in the winter season compared to a standard ensemble approach, but gives non significant improvements for the other seasons. We will discuss these results. We will argue that the scheme for the seasons other than winter could be improved with larger prediction ensembles or with an optimal choice of the predicted geographical sector.

#### 2-B-4.4

Response of a simple GCM to tropical and mid-latitude SST anomalies Nick Hall<sup>1</sup>, Jacques Derome<sup>1</sup> and Hai Lin<sup>1</sup> McGill University

A dry global primitive equation model has beed adapted to perform as a simple GCM by adding empirically derived forcing terms which are constant in time. When integrated to a statistical equilibrium, this model gives an excellent simulation of the observed climate in terms of both time-mean quantities and transient eddy activity.

Additional forcing is added to this model to simulate the effect of anomalous heating in the tropical Pacific arising from El-Nino or La-Nina type disturbances. The resulting atmospheric flow over the mid-latitude Pacific and North America resembles the observed atmospheric response to these phenomena. The dynamical mechanisms involved, particularly the role of nonlinearity, the time dependence of the background state and the additional forcing due to transient eddies are investigated by use of a linear perturbation model and a number of ensemble forecast experiments. Nonlinearity alone makes little difference to the results, and some degree of transience is essential for a realistic prediction of the amplitude of the response.

An anomaly in the mid-latitude Pacific sea surface temperature gives a quite different model response. Depending on the position of the anomaly relative to the Pacific jet, the response can either resemble the linear response, with a downstream warm low pressure centre, or lead to a dominant upstream barotropic high. Ensemble forecast experiments will be shown to explore this sensitivity.

The remote response to both these types of forcing will be discussed further in terms of the model's natural modes of ultra-low frequency variability.

## 2-B-4.5

Multi-year experiments with the GEM model Bernard Dugas<sup>1</sup>
<sup>1</sup> RPN / Environnement Canada

RPN / Environnement Canada

Results from a first set of multi-year simulations performed with the GEM (Global Environmental Multi-scale) forecast model are described. The model configuration that is chosen for these experiments is as close as possible to that of the CMC global forecast system. As such, these multi-year simulations provide useful indications of the systematic behavior of the forecast system itself and may suggest modifications to it.





2-B-4.6

Variation in predictability associated with large scale circulation patterns Jian Sheng<sup>1</sup>

Canadian Centre for Climate Modelling and Analysis/AES

Previous studies suggested that atmospheric predictability is influenced by the presence of the Pacific/North American (PNA) pattern. GCM results from 26 winter historic forecasts are investigated for possible relationship between the predictability and large scale circulation patterns.

Several scores are defined to measure the forecast skills. The best and worst forecasts are selected according to these scores. Large scale circulation anoma lies associated with different scores are identified.

#### 2-C-1.1

Simulation of Severe Precipitation and Flash Floods (SSPFF) and applications to the Saguenay flood

Charles Lin<sup>1</sup>, Robert Benoit<sup>2</sup>, Nicholas Kouwen<sup>3</sup>, Alain Pietroniro<sup>4</sup> and Eric Soulis<sup>3</sup>

<sup>1</sup>McGill University, <sup>2</sup>Atmospheric Environment Service, <sup>3</sup>University of Waterloo, <sup>4</sup>National Hydrology Research Institute

The long term objective of the project SSPFF (Simulation of Severe Precipitation and Flash Floods) is to develop a coupled modelling system consisting of a high resolution regional atmospheric model, a distributed hydrological model, and a land surface scheme as the interface. The regional atmospheric model is MC2 (Mesoscale Compressible Community Model), the hydrological model is WATFLOOD and the land surface scheme is CLASS (Canadian Land Surface Scheme). The Saguenay flood of July 1996 is used as a test case. We describe a conceptual framework of model development involving four levels of coupling.

The first level of coupling requires validation of the high resolution regional atmospheric model and the distributed hydrological model separately, and then use the simulated precipitation from the atmospheric model to drive the hydrological model to study flash flood events. This is referred to in our approach as level-0 coupling. Under this modelling scenario, the two models use their own inherent land surface scheme and parameterisations. The hydrologic model forcing are derived directly from the atmospheric forecasts with the dominant input being precipitation. This is of great interest as precipitation is the single most uncertain variable for such hydrological studies.

For the next two coupling levels, the link between the models (MC2 and WATFLOOD) is first established by implementing a common land surface scheme (CLASS) in each model and recalibrating the models separately. This phase of the model development includes level-l coupling (atmospheric and land surface) and level-II coupling (land surface and hydrologic). The final stage of coupling is the complete two-way coupled system using the common land-surface scheme and the parameter identification established during the level-I and level-II coupling. Parameter identification (or calibration) is fundamental to this evolution. The framework described provides a simple method of fully coupling an atmospheric and hydrological model using a common land-surface interface. This modelling strategy is being employed to develop a level-III (two-way coupled) model for the 1996 Saguenay flood. The coupling framework and a summary of the results obtained are described.

# 2-C-1.2

High Resolution Modelling Study of the Saguenay Flood Jason A. Milbrandt<sup>1</sup> and M. K. Yau<sup>1</sup>

McGill University

On 19-21 July, 1996, a rapidly deepening cyclone produced intense precipitation that resulted in severe flooding in the Saguenay region of Quebec, Canada. The Canadian Mesoscale Compressible Community (MC2) model was used to successfully simulate the Saguenay Flood Cyclone. A 48-h simulation with a horizontal resolution of 20 km was performed. The model performed well in terms of standard objective scores and detailed quantitative precipitation distributions. Comparisons with objective analyses were also made to verify the predicted mass, humidity, temperature, and wind fields.

Sensitivity experiments were conducted and diagnostics performed to investigate the interactions and relative importance of the forcing mechanisms that led to the explosive cyclogenesis and heavy precipitation. It was found that condensational heating was integral for the establishment of a phase lock between the surface cyclone and a strong, upper-level short wave trough which steered the cyclone. A weaker trough acted to retard the progression





of the stronger trough, ultimately causing the cyclone to be located in a favorable position to interact with orography. Using potential vorticity (PV) inversion diagnostics, the relative contributions to cyclogenesis were determined to be 50% from upper-level PV anomaly, 35% from the condensation-generated PV anomaly and 15% from the surface potential temperature anomaly (at the time of the most intense cyclone development).

Since the surface winds in the Saguenay area were upslope for most of the integration period, it appeared likely that orographic lifting may have contributed to the high precipitation. Sensitivity experiments were performed to assess the importance of stationary forcing due to orography. In each experiment, some aspect of the orography was artificially removed in the simulation in order to study the effect on the prediction of precipitation. We found that orographic forcing due to upslope flow from the Saguenay valley to the mountain immediately to the south-east of the valley, mainly during the second half of the integration, contributed to approximately 20% of the total 48-h accumulated precipitation in the Saguenay area and up to over 30% in local areas.

#### 2-C-1.3

Trace metal mobility in sediments covered by the 1996 flood deposits in the Saguenay Fjord Alfonso Mucci<sup>1</sup> and Constance Guignard<sup>2</sup>

<sup>1</sup>McGill University, <sup>2</sup>Department of Earth and Planetary Sciences, McGill University

Following the flash floods of July 1996, several million tons of post-glacial sediments were eroded and carried to the Saguenay Fjord. Tens of centimeters of this material were rapidly deposited in the North Arm and the Baie des Ha! Ha! on top of the contaminated sediments of the Fjord. Although the floods left more than \$2 billion in damages on land, it was postulated that this sudden influx of post-glacial sediments may isolate the contaminants associated with the indigenous sediments from the water column and the benthic biota by providing a geochemical barrier to their diagenetic remobilization.

The vertical distribution and concentrations of Fe, Mn, and As were measured in the pore waters and sediments recovered from boxcores taken each year since the flood at up to five locations along the main axis of the Fjord and in the Baie des Ha! Ha!. Time series of these analyses will be presented. Manganese remobilization was unaffected by the accumulation of the flood deposits. Authigenic manganese oxyhydroxides present at the original sediment-water interface were reduced and Mn(II) diffused freely to the newly established interface where it was oxidized and precipitated. In contrast, iron associated with the authigenic oxyhydroxides at the original interface was trapped as sulfides under the sulfate-reducing conditions which were rapidly established. The presence of a sharp extractable-Fe concentration peak and sulfides in the sediment cores clearly marks the position of the former interface. The fate of other trace metals will likely depend on their affinity for these iron sulfides. For example, most of the arsenic, which was also concentrated at the original interface, was trapped by co-precipitation with the iron sulfides, thus limiting its diffusion through the flood deposits.

# 2-C-1.4

Evidence For Gravity-Flow Processes As The Mechanism For Basin-Sedimentation In Baie Des Ha! Ha!, Saguenay Fjord, From Sidescan Sonar Data

Philip Hill<sup>1</sup>, Pierre Côté<sup>2</sup> and Jacques Locat<sup>2</sup>

Institut des sciences de la mer de Rimouski, <sup>2</sup>Université Laval

As part of a multi-researcher project to investigate the potential effectiveness as an environmental capping layer of the sediment layer deposited during the 1996 Saguenay flood, we are studying different methods for detecting and mapping the extent of the deposit. A sidescan sonar survey was carried out in the Baie des Ha! Ha! with the double aim of shaking down a new real-time mosaicing software (Muse-Euterpe) and characterizing bottom

morphology and reflectivity in the region of the 1996 flood deposit. Water depths in the area range from zero to 200m, which presents considerable operational difficulty for a sidescan sonar system. Indeed, the survey was limited by a shallow-towing capacity so that signal strength varied greatly between the shallow margins of the fjord and the basin floor, while bottom-tracking, necessary for accurate mosaic construction, required constant supervision. Because of these factors and the relatively long water column, near-field corrections are likely to be imprecise. Nevertheless, a coherent mosaic of 120 kHz sidescan data was obtained in real-time and improved by subsequent re-processing. The mosaic can be directly compared to EM-1000 multibeam bathymetry and backscatter maps as well as high-resolution seismic reflection profiles and sediment cores. Three broad morphological zones were observed: (1) basin margins, characterised by a canyon-and-ridge morphology; (2) a slope apron that flanks the basin margin and gives rise to a relatively reflective seabed; and (3) the basin floor, characterised by weak reflectivity. A slide complex showing shore-perpendicular chute structures is present on the basin slope between the Rivière à Mars and the Rivière Ha! Ha! The data suggest the importance of gravity-flow both as a general process of basin fill in the Baie des Ha! Ha! and as the specific mechanism for deposition of the 1996 layer.

2-C-1.5 Posters (7-12) Introduction Session 2-C-1 L'inondation du Saguenay

The Saguenay Flood I

Mardi 1er Juin Tuesday, June 1

13h40 - 15h20

Salle / Room R-OM130



2-C-2.1

Semi-Operational Forecasting Of Tropospheric Ozone With CHRONOS Richard Moffet<sup>1</sup>, Paul Pestieau<sup>1</sup>, Janusz Pudykiewicz<sup>2</sup> and Alexander Kallaur<sup>2</sup> <sup>1</sup>CMC, <sup>3</sup>ARQI

During the summer of 1998, daily 24 hr tropospheric ozone forecast maps and bulletins were produced and posted on the CMC internal web. Forecasts were produced overnight starting from 00Z using the GEM model to provide CHRONOS (Canadian Hemispheric and Regional Ozone and NOx System) with the proper meteorological fields. CHRONOS generated full 3-dimensional ozone concentration fields at every 45 minutes over its domain which covers eastern Canada. The products issued from that data were maximum concentrations over 6 hour periods, mean concentrations and the maximum 3 hourly running these periods. Point forecasts available mean same YSJ,YFC,YQB,YOW,YYZ,YQG and Bedford,N.S..The 6 hour maximum concentration maps were available at 10 and 50 meters over the CHRONOS domain. Shortcomings include crude resolution of topography which is important in rugged coastline areas, the neglect of cloud amounts and precipitation wash out, inadequate biogenic and anthropogenic emissions and s deficient dry deposition scheme over water. Nevertheless preliminary results show that the forecasts were well correlated with observations and that the mean forecast values were comparable to observations for inland sites. Foremost CHRONOS proved to be a valid forecast tool including the forecast of exceedance episodes. Active work is currently done to improve the CHRONOS system by correcting its shortcomings.

2-C-2.2

Seasonal Smog Forecasting in New Brunswick: A Case Study

Claude Côté¹ and Michael Howe¹

<sup>1</sup>Environment Canada

Claude Côté, Michael C. Howe, New Brunswick Weather Centre, Atmospheric Environment Branch, 77 Westmorland Street Suite 400, Fredericton, N.B., E3B 6Z3, Canada

Since 1993, the New Brunswick Weather Centre, located in Fredericton, has been producing daily forecasts of smog (ground-level ozone) concentrations for the region of Southwestern New Brunswick. Initially the program consisted of an internal forecast shared with various stakeholders. This lead to the National Pilot Project conducted in 1997 and the first permanent air quality prediction program in Canada in 1998.

The long-range transport of ground-level ozone and its precursors from the heavily industrialized regions of Eastern North America frequently results in elevated concentrations of this offending pollutant. From mid-May through mid-October twice daily Smog forecasts, issued twice daily, are delivered via the Environment Canada Communications Network. This unique program allows individuals, especially those suffering from heart or respiratory illnesses, to take the necessary steps to protect themselves, their families and the environment

This paper will highlight Environment Canada's Smog Prediction Program in New Brunswick focusing on a case study of the July 16-18, 1998 smog event. The formation, evolution and transport of ozone during this event combined with the operational use of numerical and statistical air quality models will be presented.

Future developments for the Air Quality Prediction Program in New Brunswick include the expansion of the daily smog forecasts to the rest of New Brunswick, the development, testing and implementation of ventilation coefficient prediction as well as research in particulate matter forecasting.

#### 2-C-2.3

Fine particulate matter - Monitoring and Forecasting - Considerations and Challenges David  $Waugh^1$ 

AEB - Atmospheric Science Division - Atlantic

Continuous monitoring of fine particulate (PM2.5) has been carried out at several sites in Atlantic Canada for over one year. Data from Kejimkujik National Park in southern Nova Scotia, used primarily for long range transport studies, indicate that episodes with concentrations greater than the proposed national 24-hour average of 20 mg/m3 are not uncommon.

The Air Quality Prediction Program is considering including fine particulate as a forecast pollutant in the future. Many issues need to be considered prior to arriving at the point of forecasting PM2.5. Models are currently being developed to forecast PM2.5 and the continuous monitoring data will be used to verify the model output, as well as to improve scientific understanding of particulates.

Examination of the data indicates some of the challenges related to data handling, quality assurance and loss of data. The case presented here will also highlight the relation of other pollutants to high PM concentrations, and will show episodes evolution through observations and imagery.

### 2-C-2.4

Modelling Mass Transfer and Aqueous-Phase Chemistry in AES' Regional PM Model (AURAMS)

Wanmin Gong<sup>1</sup>, Paul Makar<sup>1</sup>, Sunling Gong<sup>2</sup>, Ashu Dastoor<sup>3</sup> and Mike Moran<sup>1</sup> ARQI, Atmospheric Environment Service, <sup>2</sup>ARQM, AES, Downsview, <sup>3</sup>ARQI, AES, Dorval

Atmospheric aqueous-phase chemistry is known to play important roles in aerosol dynamics. It makes a significant contribution to the S(IV)-to-S(VI) conversion, and is believed to be a significant source of aerosol nitrate during night time. It has also been partially blamed for the formation of the observed urban and regional aerosol "droplet" mode. Mass transfer between condensable gas and atmospheric particles and droplets is also an important process in aerosol dynamics. It is intimately related to, and may limit, aqueous phase chemistry, and therefore needs to be treated as an integral part of the aqueous-phase process that takes place in and on particles and droplets, along with aqueous phase chemistry.

At the initial stage of the AES regional PM model development (a prototype for the AES unified air quality modelling system, AURAMS), the aqueous-phase chemistry module from ADOM was adopted as a starting point. While the ADOM module does include most of the species included in our mixed aerosol considered for the PM model and treats the mass transfer and aqueous phase chemistry in an integrated fashion, the module has some obvious limitations. For example, it was designed for highly diluted solutions as in the case of cloud droplets. It is therefore not directly applicable when treating un-activated aerosols. The module is also in a bulk form which is not compatible to the size-resolved PM model that we are developing. In order to address these problems, modifications to the original ADOM module are introduced. In this paper, we will describe some of these changes, and present the results from the tests on bulk vs. size-resolved and on the incorporation of direct aerosol parameters in the aqueous-chemistry module.





2-C-2.5

Application d'un modèle de qualité de l'air sur le sud du Québec et comparaison avec les mesures de NARSTO-96

Gilles Morneau<sup>1</sup>, Alain Robichaud<sup>1</sup> and Mario Benjamin<sup>1</sup>

<sup>1</sup>Environnement Canada, région du Québec

Plusieurs observations de polluants atmosphériques tels que O3, NOx, CO et COV ont été prises dans le sud du Québec durant l'été 1996 lors de la campagne de mesure NARSTO-Canada-East. Nous disposons de plusieurs observations de surface ainsi que des observations en altitude des champs météorologiques et des concentrations d'ozone en deux endroits de part et d'autre de l'île de Montréal. Cette banque de données nous permettra d'évaluer si un modèle de qualité de l'air contenant la chimie des oxydants est adéquat pour prévoir les niveaux d'ozone au sol, estimer le transport à grande distance de l'ozone et ses précurseurs et estimer les effets sur l'exposition au smog d'éventuels scénarions de contrôle des émissions de polluants. Nous avons utilisé le modèle météorologique de mésoéchelle compressible communautaire (MC2) pour reproduire l'état de l'atmosphère durant la semaine du 8 au 14 juin 1996. Le modèle de qualité de l'air CHRONOS (Canadian hemispheric and regional ozone and NOx system) a été utilisé pour reproduire les processus de transport et de transformation des polluants menant au smog urbain. CHRONOS utilise une méthode semi-lagrangienne pour le transport et la chimie de ADOM (Acid Deposition and Oxidant Model). Nous avons comparé les observations avec les solutions des modèles à deux résolutions spatiales différentes, 35 et 12 km, et sur des domaines d'étendue différente. Nous avons aussi évalué comment les résultats du modèle sont modifiés lorsque les champs d'émissions dites mobiles sont raffinés à plus haute résolution dans la région de Montréal. Les résultats montrent que CHRONOS reproduit les caractéristiques principales des concentrations d'ozone et des NOx précurseurs, mais surestime en général les concentrations d'ozone durant la période du 8 au 14 juin 1996. Les intégrations à haute résolution donnent des résultats plus près des observations et on note que le modèle est peu sensible à une redistribution spatiale à plus haute résolution des émissions mobiles.

### 2-C-3.1

The Atmospheric Kinetic Energy Budget Residual Richard E. Danielson<sup>1</sup>, John R. Gyakum<sup>2</sup> and David N. Straub<sup>2</sup> DAOS, McGill University, <sup>2</sup>McGill University

On the synoptic scale, physical interpretations of terms in most kinetic energy budget formulations are well established, with the possible exception of the budget residual, even when it is formally defined to include the process of frictional dissipation. For instance, diagnosis of the (frictional) residual can result in a local source of kinetic energy. This might be referred to as a physical manifestation of negative viscosity following Starr (1968), and in practice, the use of coarse spatially and temporally discretized analyses also imply the possibility of an unresolved (sub-grid scale) source, but one whose physical nature and identity requires clarification if it is of leading order.

Two sets of kinetic energy budgets are computed for an extratropical marine secondary cyclogenesis event that occurred during the first Canadian Atlantic Storms Project (CASP I), and which has been the subject of intensive study in the context of mesoscale model intercomparisons (the COMPARE project). Computations are based on the six-hourly, pressure-level, lat-lon atmospheric reanalyses from the National Centers for Environmental Prediction (NCEP) global and Canadian regional data assimilation systems (Chouinard et al. 1994). The latter analyses (denoted RPN) have about twice the vertical and five times the horizontal resolution of the NCEP analyses.

A qualitative comparison of residuals reveals an apparent correspondence in the features resolved by both budgets. Only within the boundary layer is it evident that frictional dissipation is a dominant physical process, largely balanced by kinetic energy generation through work done by the pressure gradient force. Positive (energy growing) and negative (energy decaying) residuals are observed as generally increasing in magnitude from the surface to the tropopause. In the lower mid-troposphere during the latter stages of rapid deepening, the RPN budget reveals highly elongated positive and negative residual dipoles. These dipoles also appear to be oriented in the same sense as the attendant cold-frontal cloud features, suggestive of an influence of smaller scale processes associated with frontogenesis and convection. A summary of the tentative results is given in the form of quasi-Lagrangian budgets, following the position of the low-level kinetic energy maxima.

# 2-C-3.2

Nonlinear critical layer development of forced wave packets in barotropic shear flows Lucy Campbell<sup>1</sup> and Sherwin Maslowe<sup>1</sup>

<sup>1</sup>McGill University

We investigate the nonlinear development of a forced wave packet in the presence of a critical layer in a shear flow. Critical layer interactions of the disturbance and the mean flow are examined in the geophysical contexts of Rossby wave packets propagating toward the equator in a zonal flow and of vertically propagating internal gravity wave packets in a stratified shear flow. It has been suggested that critical layer theories may help in the interpretation of certain phenomena observed in the atmosphere and ocean, such as stratospheric sudden warmings in the northern hemisphere and the quasi-biennial oscillation.

Most previous critical layer analyses have dealt with spatially periodic monochromatic waves. Some of the important conclusions made in these studies are the absorption of the perturbations at the critical layer in the initial, linear stages of the development and the subsequent breakdown of the linear theory, leading to nonlinear phenomena such as wave breaking and reflection.



# Session 2-C-3 Modélisation de l'atmosphère l **Atmosphere** Modelling I Mardi 1er Juin Tuesday, June 1 13h40 - 15h20 Salle / Room R-OM110

For a more realistic representation of wave activities in the atmosphere, we employ a forcing in the form of a spatially localized wave packet, rather than a monochromatic wave, and numerically integrate the full nonlinear equations using Fourier transform methods and a high resolution pseudospectral algorithm. We contrast the results with those obtained using a strictly periodic forcing, examining, among other things, the absorption/reflection behaviour of the critical layer, the extent of deformation of the mean flow and the transfer of wave activity to higher harmonics. One of the effects of the spatial localization is to delay the onset of the nonlinear breakdown in the critical layer.

#### 2-C-3.3

Radiation and Localisation of Planetary Waves in a Fluctuating Atmosphere: Theory Lionel Pandolfo<sup>1</sup> and Adam Monahan<sup>2</sup>

<sup>1</sup>University of British Columbia, <sup>2</sup>Department of Earth and Ocean Sciences, University of British Columbia

A simplified barotropic model on the sphere is used to investigate the extent to which random fluctuations in the background zonal wind field inhibit the meridional dispersion of quasi-stationary planetary waves away from a localised source. It is found that perturbations to the background flow of magnitude comparable to those observed in Nature can significantly enhance the meridional trapping of planetary wave energy. It is proposed that these weather-like fluctuations may provide another mechanism to explain the observed focusing of wave energy into midlatitude waveguides.

# 2-C-3.4

Mesoscale Alpine Programme (MAP) field experiment

Robert Benoit<sup>1</sup>, Stéphane Chamberland<sup>1</sup>, Peter Binder<sup>2</sup>, Christoph Schaer<sup>3</sup>, Michel Desgagné<sup>1</sup>, Pierre Pellerin<sup>1</sup> and Steve Thomas<sup>4</sup>

<sup>1</sup>Recherche en Prevision Numerique, Environment Canada, <sup>2</sup>Swiss Meteorological Institute, SMI Zurich, <sup>3</sup>Atmospheric Science, ETH Zurich, <sup>4</sup>National Center for Atmospheric Research, Boulder

With the development of a version of the Canadian non-hydrostatic MC2 model optimized for massively parallel processors, it has become possible to solve very large weather forecast problems in a time sufficiently short to envision a realtime daily calculation over a domain covering the entire Alps. MAP is a large multinational research program that will gather new knowledge about the heavy precipitation over steep topography; its field phase is to take place during Fall of 1999. The tentative grid dimensions are 490 x 400 x 35 at a horizontal resolution of 2 km, with possibly a need to increase the number of vertical layers. This is a very large problem to be solved with realtime constraints. The model results will be accessible to the forecasters at the MAP Operations Centre in Innsbruck, to assist in the scientific briefings to dispatch the flight plans of the research aircrafts. The forecasts are planned to be performed on the NEC-SX/4 (10 PE) at the CSCS (Centro Svizzero di Calcolo Scientifico) in Manno (Canton Ticino), which is affiliated with the ETH. The current state of this joint effort is presented.

### 2-C-3.5

Optimal Interpolation Of Climate Data Onto Alberta Polygons Of Ecodistrict And Soil Landscape Of Canada

Guilong Li<sup>1</sup>, Samuel Shanpu Shen<sup>1</sup> and Peter Dzikowski<sup>2</sup>

<sup>1</sup>Department of Mathematical Sciences, University of Alberta, <sup>2</sup>Alberta Agriculture, Food and Rural Development, Conservation and Development Branch

This talk will describe the optimal algorithms for interpolating the daily station data onto Alberta ecodistrict polygons (EDP) and soil landscape of Canada (SLC) polygons. Four methods commonly used in geostatistics were tested: (i) direct neighborhood assignment, (ii)

inverse distance weighting, (iii) inverse distance-square weighting, and (iv) improved block kriging. The daily data of seven climatic quantities were analyzed: (1) maximum temperature, (2) minimum temperature, (3) precipitation, (4) relative humidity, (5) wind speed, (6) wind direction and (7) solar radiation. The time range was from January 1, 1961 to December 31, 1990. Based upon the criterion of minimum mean square error and by using the cross validation tests, an optimal interpolation method was selected. The use of the data on a CD and the animation of the data will be demonstrated in this talk.

Session 2-C-3 Modélisation de l'atmosphère I

Atmosphere Modelling I

Mardi 1er Juin Tuesday, June 1

13h40 - 15h20

Salle / Room R-OM110



# 2-C-4.1

Conditions of predictable ENSO events in neural network models Benyang Tang<sup>1</sup> and William Hsieh<sup>2</sup>

Oceanography/EOS, Univ. of British Columbia, <sup>2</sup>University of British Columbia,

A neural network (NN) for ENSO forecasting is built with training pairs. A training pair consists of an input of several variables representing the climatic condition of a given month, and a target that is the ENSO index at some leadtime, i.e. a few months later. After training, the model was tested on new cases (new inputs). For a new input, we calculated 2 measures that correlated well with the forecast error: D\_k, the average of distances between the new input and k closest training inputs in the input state space, and S\_k, the standard deviation of the corresponding k targets. These 2 measures make sense if we view NN forecasting as interpolation: For a given point to be interpolated, the closer the neighboring existing points are and the more those neighboring points agree among themselves, the more accurate the interpolation is.

The problem is how to calculate the distance in the input space. In our case, there are 14 input variables; some of them important in producing good forecasts, others not. Each input variable should be weighed accordingly in calculating the distance. We calculated the weights in a leave-one-out experiment described below. For a given input variable, a NN is trained without that input variable. The RMSE (root mean square error) of the NN was calculated using the cross-validation technique. If this RMSE was more than the RMSE of the model with all the input variables, the weight for that input variable was the difference between the two RMSE's, otherwise the weight was set to zero.

Our preliminary calculation showed that the absolute value of the forecast error correlated with D k and S k at around 0.50. Further refinements of the technique is still underway.

We have also improved slightly the forecast skill of our NN ENSO operational forecast model by leaving out those input variables which were found to increase the forecast RMSE in the leave-one-out experiment. The improvement in correlation skill is around 0.05 for leadtimes of 9 and 12 months.

# 2-C-4.2

Teleconnections between Pacific sea surface temperatures and Canadian prairie wheat yield William Hsieh<sup>1</sup>, Benyang Tang<sup>1</sup> and E.R. Garnett<sup>2</sup>

<sup>1</sup>University of British Columbia, <sup>2</sup>Canadian Wheat Board

Relations between Pacific sea surface temperature (SST) and Canadian Prairie wheat yield were investigated by correlation and by composites of SST during the 9 lowest yield years, and the 9 highest yield years. During winter, the SST in the North Pacific displayed a 3-cell pattern of alternating negative-positive-negative correlation with wheat yield, stretching diagonally from the Gulf of Alaska to the Philippine Sea. Major asymmetry between the SST composites for low yield years and those for high yield years implied a nonlinear relation between SST and wheat yield. As the composites for low yield years displayed much stronger SST anomalies than those for the high yield years, low yields seemed more predictable than high yields. The composites also showed La Nina conditions in the equatorial region having a much more significant influence on Canadian wheat yield than El Nino conditions. A new teleconnection index was constructed from normalized SST anomalies. For the March SST data, this index had a correlation of 0.63 with the wheat yield, which is of sufficient long lead time to be useful to the farmers.

### 2-C-4.3

Weather regime dependent seasonal predictability Hai Lin<sup>1</sup> and Jacques Derome<sup>1</sup>

Dept. of Atmospheric and Oceanic Sciences, McGill University

The output from two atmospheric models (RPN's SEF and CCCMA's GCM II) for the Historical Forecast Project (HFP) is used to see if there is evidence in the HFP results that some flow components are systematically forecast more accurately than others. The dataset is composed of 26 year (1969-1994) seasonal forecasts from both models. Six integrations were conducted for each model from different initial conditions with predefined boundary conditions. The result presented in this talk is for forecasts of winter seasonal means, where the winter is defined as December, January and February. 40 year monthly means of NCEP reanalysis are used for definition of weather regimes and verifications.

An EOF decomposition is performed with the NCEP seasonal mean 500mb geopotential height of DJF over the Northern Hemisphere. It is found that the winter seasonal forecasting skill of 500mb extratropical large-scale heights tends to be a function of the EOF index, with those components that project onto the low-index patterns are better forecasted than the components that project onto the high-index patterns. By a linear combination of the first eight EOFs, a single pattern is constructed that has the potential to be the best forecasted pattern. The relations between the forecast skill and the phase of the EOFs are not significant.

The relationships between the models' seasonal forecasts and the eastern tropical Pacific SST are also investigated. It is found that the two models respond differently with the SST changes in the El Nino area.

# 2-C.4.4

Simulation of Arctic Climate Trends by Increased Greenhouse-Gas Forcing of a Stratospheric Model

Lionel Pandolfo<sup>1</sup>, Drew Shindell<sup>2</sup>, Ron Miller<sup>3</sup> and Gavin Schmidt<sup>2</sup>

<sup>1</sup>University of British Columbia, <sup>2</sup>Center for Climate Systems Research, Columbia University, USA, <sup>3</sup>Department of Applied Physics, Columbia University, USA

The Arctic Oscillation (AO) is a prominent feature of climate variability that extends from the surface into the stratosphere. Variability of Arctic sea-level pressure (SLP) is correlated with wintertime variations in Northern Hemisphere (NH) surface air temperature, and warming over Eurasia during recent decades is associated with a decrease in Arctic SLP. We present climate model results demonstrating that the observed trend, including its magnitude, can be induced by increasing greenhouse gases. This suggests that although the warming appears through a naturally-occurring mode of variability, it is likely anthropogenically induced. Furthermore, we find that the AO trend is captured only in climate models that include a detailed stratosphere, although a mode exhibiting the spatial structure of the observed AO dominates the wintertime variability of NH SLP in all the models studied. Forcing by ozone does not appear to be necessary to produce this trend. These results indicate that stratospheric changes may have a significant effect on surface climate, and that dynamical forcing of climate change by greenhouse gases may be quite important, in addition to the direct radiative forcing. Because the AO is associated with a distinctive regional signature of warming, proper simulation of stratospheric dynamics may be important to the detection of climate change.





2-C-4.5

Trends and variability in the 20th century temperature and precipitation in Canada Xuebin Zhang<sup>1</sup>, Bill Hogg<sup>1</sup> and Lucie Vincent<sup>2</sup>

<sup>1</sup>Climate Research Branch, AES, <sup>2</sup>CLimate Research Branch, AES

Trends and variability in temperature and precipitation during the 20th century are analyzed for Canada using recently updated and adjusted station data. Anomalies from the 1961-1990 reference period were first obtained at individual stations, and then were used to generate gridded datasets for subsequent analyses. Trends and variability were computed for 1900-95 for a southern Canada grid (south of 60\deg N), and for 1950-95 for the entire country, separately due to insufficient data in the high arctic prior to the 1940s.

From 1900-95, the annual mean temperature has increased 0.93\deg C in the south. The warming is greater in minimum temperature than in maximum temperature, resulting in a decrease of daily temperature range. The greatest warming occurred in the west, with statistically significant increases mostly during spring and summer. Annual precipitation has increased 11% in southern Canada over the same period. In general, the ratio of snowfall to total precipitation has been increasing, however, negative trends were identified in some southern regions during winter and spring. From 1950-95, the mean temperature over the whole country showed no significant trend. However, there was significant warming in the south and west and cooling in the northeast. This pattern is mostly evident in winter and spring and is similar in both maximum and minimum temperatures. Across Canada, precipitation has increased by 5 to 35\%, with significant negative trends found in southern regions during winter. Overall, the ratio of snowfall over total precipitation has increased in the north and decreased in the south, with significant negative trends mostly during the spring.

Abnormal climate indices are also examined. These indices were defined as areas of Canada with temperature or precipitation anomalies being above the 66th or below the 34th percentiles in their relevant time series. They confirmed the above findings and showed that climate has been gradually becoming wetter and warmer. Specifically, the areas of Canada affected by dry condition when it was cold have decreased and those affected by wet condition when it was warm have increased. However, areas of Canada affected by dry condition when it was warm have not changed, especially during summer and spring.

Preliminary analyses also showed that the major part of interannual variability in precipitation and temperature is ENSO related. Specifically, the spatial patterns and temporal evolutions of precipitation and temperature anomalies associated with El Nino and La Nina events obtained in early studies by composite analyses were identified directly from the precipitation and temperature data. The influence of North Atlantic oscillation is confined only to the eastern Canada.

#### 2-D-1.1

IMPORTANCE D'UNE PERTURBATION ENVIRONNEMENTALE SUR L'ÉVOLUTION DIAGENÉTIQUE DES SÉDIMENTS DU FJORD DU SAGUENAY (QUÉBEC, CANADA) Bruno Deflandre<sup>1</sup> and Jean-Pierre Gagné<sup>1</sup>

Département d'océanographie , Université du Québec à Rimouski

En juillet 1996, la région du Saguenay - Lac St-Jean (Québec, Canada) a connu des pluies diluviennes qui ont entraîné une crue soudaine de nombreuses rivières bordant le fjord du Saquenay. Cette événement catastrophique a entraîné le charriage puis le dépôt d'une importante quantité de sédiments (jusqu'à 40 cm) dans les secteurs de la baie des Ha! Ha! et du bras Nord du fjord du Saguenay. Nos travaux, entrepris dès la mise en place des nouveaux sédiments, nous permettent d'évaluer l'évolution géochimique du nouvel environnement qui se développe. La distribution verticale des traceurs organiques (carbone organique dissous (COD), rapport élémentaire C/N, % C, n-alcanes, acides gras et chlorophylle), des traceurs inorganiques (nitrates, phosphates et ammonium) et de traceurs géochimiques moins spécifiques (porosité, salinité, potentiel redox) montrent d'importants gradients verticaux et horizontaux un mois après l'apport des nouveaux sédiments dans la baie des Ha! Ha!. Depuis maintenant 3 ans, le suivi environnemental nous permet de suivre l'évolution diagenétique des sédiments déposés depuis la perturbation environnementale. Les traceurs mesurés présentent des anomalies de distribution en subsurface pour les stations perturbées correspondant à l'ancienne interface eau-sédiment. Nous présentons et discutons les fluctuations observées dont celles du COD sédimentaire afin d'évaluer la récupération géochimique du système sédimentaire (retour aux conditions antérieures au déluge) perturbé au cours de juillet 1996.

# 2-D-1.2

Utilisation des HAP comme indicateurs d'événements sédimentaires récents et de l'activité benthique

Émilien Pelletier<sup>1</sup>

Institut des Sciences de la Mer de Rimouski

Les hydrocarbures aromatiques polycycliques (HAP) sont produits par la combustion des hydrocarbures fossiles et de la matière organique en général. Le fjord du Saguenay a reçu d'importantes quantités de ces HAP à partir de l'industrialisation et de l'urbanisation de la région Chicoutimi-Arvida après la seconde guerre mondiale jusqu'à la fin des années 70 avec la mise en place de méthodes plus efficaces de contrôle des émissions hydriques et aériennes. Or la crue éclair de juillet 1996 a apporté au fjord et à la baie des Ha!Ha! des millions de tonnes de sédiments pratiquement exempts de HAP provenant d'anciens dépôts fluviatiles ou marins arrachés du lits des rivières en crue. L'analyse de ces composés par HPLC-Fluorescence dans 5 carottes de sédiment prélevées en mai 1998 dans le Bras nord et la baie des Ha!Ha! a permis de mettre en évidence l'utilité de ces composés comme traceurs des bouleversements sédimentaires récents sur venus au Saguenay. Le benzo(a)pyrène, un HAP lourd à cinq cycles particulièrement toxique, se révèle le plus juste de ces traceurs et indique clairement l'interface ancien/nouveau sédiment dans la baie des Ha!Ha!. Sa concentration est de 4 à 10 fois plus faible dans les nouveaux sédiments par rapport aux anciens Il montre aussi très clairement la sédimentation de nouveaux HAP après les événements de juillet 96 et le mélange de ceux-ci sur une épaisseur de l'ordre de 4 cm. Comme le benzo(a)pyrène est très résistant à la biodégradation et très faiblement soluble dans l'eau de mer ( $\Box 5 \mu g/L$  à 22 oC), on peut compter sur un traceur exceptionnel de la bioturbation de la nouvelle couche sédimentaire du Saguenay. La poursuite des analyses sur 4 années permettra de développer avec les biologistes du benthos un modèle numérique simple permettant de relier la bioturbation avec la densité et la diversité des espèces retrouvées aux mêmes endroits.

2-D-1.3 Poster Session





#### 2-D-2.1

Modeled estimates of terrestrial isoprene emissions and potential for inducing errors in regional air quality modeling exercises

Dave Fox<sup>1</sup>, Karen McDonald<sup>1</sup>, Kathy Gaider<sup>1</sup>, Abdel Kharrat<sup>2</sup> and Jim Stewart<sup>3</sup> Environment Canada, <sup>2</sup>Alberta Research Council, <sup>3</sup>Canadian Forest Service

Biogenic emissions of volatile organic compounds, particularly isoprene, have been shown to play an important role in the production of ground-level ozone. Recent environmental impact assessments for the oil sands region of northeastern Alberta indicate that the ability to separate anthropogenic from biogenic emission sources is increasingly important. As development of the oil sands resource increases, proponents need to determine the extent of the issue and propose best mitigation options for control of oxidant issues in the region. The Urban Airshed Model's Biogenic Emission Inventory System (BEIS2) module is used to assess biogenic emissions of isoprene. Here we provide an assessment of natural emissions of isoprene for comparison with other atmospheric sources of volatile organic compounds including oil sands developments, forest fires, and pulp mills. In addition, the potential for inducing error by using existing emission models without incorporating regionally-specific modifications is investigated. Ground-level isoprene concentrations using standard BEIS2 emission factors are compared with those from experimental emission factors measured in Alberta. This information can then be used through the UAM-V to estimate ground-level concentrations of ozone associated with the biogenic component alone. Current regional measurements of isoprene and ozone can be compared with the model for validation.

# 2-D-2.2

Impact of Weekend/Weekday ozone variations on air temperature in the Greater Toronto Area

Gary Beaney<sup>1</sup> and William A. Gough<sup>1</sup> University of Toronto at Scarborough

Due to variations of rush-hour traffic, tropospheric ozone concentrations have been shown to vary between weekdays and weekends. Both ozone and temperature data were examined to determine whether weekday/weekend variations in ozone concentrations resulted in similar temperature variations. When periods of uncharacteristically high ozone concentrations were encountered (exceedance weeks) were isolated, the resulting weekend temperature variations were shown to be statistically significant at the Greater Toronto Area measurement sites.

### 2-D-2.3

Intercomparaison de l'ozone et de ses précurseurs à deux stations en périphérie de Montréal durant la campagne ESOM-96

Marc Beauchemin<sup>1</sup>, Alain Robichaud<sup>1</sup> and Mario Benjamin<sup>1</sup>

<sup>1</sup> Environnement Canada, Direction de l'environnement atmosphérique, Division des services scientifiques

Nous présenterons ici les résultats d'une analyse des données de la campagne de mesure ESOM (Étude sur les Oxydants à Montréal) tenue à l'été 1996.

L'objectif de cette analyse est de caractériser l'ozone et ses précurseurs au-dessus de Montréal par la comparaison des données en deux points stratégiques. Cette analyse s'inscrit dans les travaux en cours à l'échelle du pays afin de caractériser l'ozone dans des régions clefs (dans notre cas, le corridor Windsor-Québec) qui connaissent de façon récurrente des hautes concentrations d'ozone l'été.

Nous décrirons le comportement de l'ozone, des précurseurs traditionnels (oxydes d'azote, composés organiques volatiles « COV ») et de différents polluants indicateurs (particulaires)

en fonctions des paramètres météorologiques de surface aux deux stations (température, radiation, vitesse et direction de vent et autres). Une attention particulière sera portée aux concentrations des polluants en fonction de la direction du vent.

Nous présenterons différents résultats d'intercomparaison des données et de corrélations simples et croisées entre les deux stations utilisant différents critères météorologiques.

Nous présenterons aussi les profils diurnes des polluants comparés entre eux à chaque station ainsi qu'entre les deux stations et mis en parallèle avec les profils météorologiques.

Enfin, des conclusions seront tirées sur les origines possibles de l'ozone à Montréal (production locale versus transport), sur l'interrelation entre l'aval et l'amont de la grande région de Montréal (validité d'une hypothèse « aval/amont » quant aux profils des deux stations en fonction des vents dominants), et sur l'influence possible de sources locales et régionales de ces polluants.

#### 2-D-2.4

L'influence du chauffage au bois sur la qualité de l'air dans un quartier de Montréal Mario Benjamin<sup>1</sup>, Claude Gagnon<sup>2</sup>, Tom Dann<sup>3</sup>, André Germain<sup>3</sup> and Yvette Bonvalot<sup>4</sup>

<sup>1</sup>Environnement Canada, <sup>2</sup>Communauté Urbaine de Montréal, <sup>3</sup>Environnement Canada - Direction de la Protection de l'environnement, <sup>4</sup>Direction de la Santé Publique - Montréal-Centre/Unité de Santé au travail et environnementale

La tempête de verglas de janvier 1998 a incité la population à se procurer des moyens de chauffage alternatifs, notemment des systèmes de chauffage au bois. Or, le chauffage résidentiel au bois, est, selon l'inventaire canadien des émissions des principaux contaminants atmosphériques, la troisième source d'émission de particules respirables de diamètre inférieur à 2,5 micromètres (ci-après appelé PM2,5). Au Québec, le chauffage résidentiel au bois représente 22% de l'émission total de PM2,5 soit plus de 38,2 kilotonnes métriques par année. Selon plusieurs études récentes, ces particules représentent un risque important pour la santé humaine en plus de perturber le bilan radiatif et de nuire à la visibilité.

À l'hiver 1998-1999, Environnement Canada, la Communauté Urbaine de Montréal et la Direction de la Santé Publique de Montréal-Centre ont initié un projet conjoint afin de déterminer l'impact du chauffage au bois sur la qualité de l'air. Une station de mesure a été installée dans le quartier de Rivière-des-Prairies où le chauffage au bois est une source importante de chauffage. En plus des particules respirables (PM2,5 et PM10), les paramètres suivants ont été mesurés au cours de la période hivernale: visibilité horizontale, radiation globale, vents, température, humidité, hydrocarbures aromatique polycyclique (HAP), aldéhydes et métaux. L'influence du chauffage au bois sur les niveaux des HAP et des PM2,5 de même que l'impact de la combustion végétale sur la visibilité et la radiation seront démontrés. Des liens entre la hauteur de mélange, le coefficient de ventilation et les mesures prises au site serviront à établir une base pour un éventuel programme de prévision permettant de minimiser l'influence du chauffage au bois en période où la qualité de l'air est affectée.

#### 2-D-2.5

Modélisation des flux de gaz à effet de serre (GES) émis à la surface des réservoirs hydroélectriques

Nathalie Barrette<sup>1</sup>, René Laprise<sup>1</sup> and Marc Lucotte<sup>1</sup> <sup>1</sup>UQAM

En 1993 débutait un vaste projet d'étude sur la production et l'émission de GES depuis les réservoirs hydroélectriques du moyen Nord québécois. L'un des volets de l'étude consistait à

Session 2-D-2 Transport de la pollution et qualité de l'air II **Pollution Transport** and Air Quality II Mardi 1er Juin Tuesday, June 1 15h40 - 17h40 Salle / Room R-OM120



utiliser un modèle de lac de type diffusif/convectif afin d'étudier la variation annuelle des flux de CO2 et de CH4 mesurés à la surface des réservoirs. Pour valider le modèle de lac, deux campagnes d'échantillonnage ont été réalisées en 1996 au réservoir Laforge 1 (Baie de James) pour trois stations de profondeur différente. Nous allons vous présenter les résultats préliminaires issus de cette validation. Des variables telles que le profil de température et le profil de concentration en gaz dissous (CO2 et CH4) seront étudiées.

### 2-D-3.1

Improving the GEM model for medium-range forecasting and analysis.

Sylvie Gravel<sup>1</sup>, Michel Roch<sup>1</sup>, Bernard Dugas<sup>1</sup> and Anne-Marie Leduc<sup>2</sup>

Division de la recherche en prévision numérique, <sup>2</sup>Centre Météorologique Canadien

In October 1998 the Global Environmental Multiscale (GEM) model replaced the then operational spectral model (SEF) for global medium range forecasting and data assimilation at the Canadian Meteorological Centre. The change completed CMC's transition to a unified forecasting system. A diagnostic study is currently underway to study the systematic errors of the model. The results of this study should provide valuable information on how to improve GEM's medium range forecasts and analysis. A summary of the results obtained so far will be given.

#### 2-D-3.2

USING CONSERVATIVE VARIABLES FOR LIQUID WATER CONTENT IN GEM Gérard Pellerin<sup>1</sup>, Yves Delage<sup>2</sup> and Claude Girard<sup>2</sup>

<sup>1</sup>CMC, <sup>2</sup>RPN

The Canadian Meteorological Centre (CMC) is currently running the GEM global model with the Sundquist scheme and an improved version of the Kuo 1974 scheme. This model is operational since 14 october 1998.

The cloud water content is a prognostic variable in the model, it is advected and interacts with the radiative scheme and with other model processes. It is mostly important in cloud layer representation. The radiative properties of cloud depend on their water content, the phase of water and the distribution of water droplet or ice particle sizes. The treatement of the souce/sink of cloud water due to condensation/evaporation is complicated by the desirability of allowing partial cloudiness. A new scheme, namely a reformulation in terms of cloud-conserved variables, is proposed to better prescribe the different model processes.

The presentation will focus on the impact of this formulation on the model forecasts, in particular in the tropics where the model suffers a moisture bias.

#### 2-D-3.3

Using low-resolution winds to advect high-resolution tracers

Peter Bartello¹

McGill University

In a number of applications numerical modellers have used low-resolution GCM winds as well as winds from low-resolution operational NWP analyses in order to deduce very fine structure in the distribution of several chemical species and of potential vorticity on isentropic surfaces in the stratosphere. At the other end of the atmospheric spectrum of length scales, there has been a long standing tradition of using what little wind data is available for very small-scale dispersion models in the boundary layer. This study aims to measure the error introduced by these mismatchs of wind and tracer resolutions as a function of wind truncation and as a function of the prevalent dynamics at the scale in question. To accomplish this, early work by Batchelor (1959) is enlightening. He considered transport of passive tracers at large Prandtl numbers in isotropic turbulence. Here the tracer is effectively truncated by molecular processes at lengthscales much smaller than the viscous scale. For global-scale barotropic quasigeostrophic flow it was found that, in the limit corresponding to a well-resolved wind field, the wind truncation error is proportional to the square of the truncation scale. In this setting relative errors of below ten percent in the scalar field after 12 days require the wind to be resolved down to only approximately one eighth of the scale describing the most energetic eddies. This encouraging result does not hold for the more general flows observed in the troposphere below O(100) km or in the mesosphere. In these environments low-resolution





winds give tracer distributions that bear little resemblance to those obtained with high-resolution winds, not only in the details concerning locations of individual filaments, but also in the statistics.

2-D-3.4

Non-axisymmetric thermally driven circulations and upper tropospheric monsoon dynamics C. Juno Hsu<sup>1</sup> and R. Alan Plumb<sup>2</sup>

CCCma, <sup>2</sup>Massachusetts Institute of Technology, Cambridge, MA, 02139

The Asian summer Monsoon circulation is driven by differential thermal heating, primarily associated with the localized latent heat release from enhanced precipitation over the Indian sub-continent. Although this heating is of limited zonal extent, it drives a time-averaged, upper level anticylone which is of global extent, extending from the western edge of the bulge of Africa, to the east of the Asian continent. The current theory (originally proposed by Gill (1980)) for explaining this zonally asymmetric component of the tropical circulation is unsatisfactory because it is based on the linear theory of damped equatorial waves while it is known that, at least for the upper level flow near the tropopause, the dynamics are strongly nonlinear. An alternative explanation, which is consistent with the nonlinear nature of the flows, involves the shedding of vortices from the directly forced monsoon anticyclone. The vortices, or eddies, are capable of drifting to the far field to establish a circulation which extends far beyond the local forcing.

We have provided a dynamical explanation for the generation of eddies near the center of a divergent anticyclone, which, through their drift are responsible for the establishment of the global scale of the Asian summer Monsoon. This study consists of two parts, one numerical and one observational. The numerical study systematically investigates localized thermally driven circulations by using a shallow water model. In this part of the study, we seeks to understand how non-axisymmetric elements such as a beta effect, or an external uniform flow, affects the dynamics of a divergent anticyclone for which, in the absence of non-axisymmetric elements, there exists an analytical axisymmetric solution -- the zero absolute vorticity. The control parameter, for example in the beta-plane experiment, is the ratio between the free drift speed of an axisymmetric vortex on a beta plane, \$\beta L^{2}\$, and the strength of the forced localized divergent flow (\$u\_{\chi}\$) where \$L\$ is the size of the axisymmetric circulation. As the control parameter increases, the long-term behavior of the forced vortex evolves from a localized, persistent circulation to a eddy-shedding, global-scale circulation. The eddies, which redistribute PV to the far field, act to weaken the time-mean flow and might be parameterized as a linear damping term in a linear model.

In the second part of the study, the theory is confirmed by discovering eddy shedding from the analysis of observational data. The potential vorticity on the isentropic surfaces are analyzed from 17 isobaric level NCEP-reanalysis data over the region of the Asian summer Monsoon. Two episodes of eddy shedding are found in July of 1990. The shedding events in the potential vorticity field are observed at the levels of isentropic surfaces from 360K to 380K. The induced geopotential perturbation penetrates deeper to 400 mb. The technique of Contour Advection with Surgery, a technique that allows to discriminate between adiabatic and diabatic effects, is used to recapture the shedding events, and confirm that the eddy shedding is indeed due to the essentially inviscid process identified in the idealized shallow water model.

2-D-3.5

Phase-speed test for numerical models of the atmosphere Ayrton Zadra<sup>1</sup>, Gilbert Brunet<sup>2</sup> and Jacques Derome<sup>1</sup>
<sup>1</sup> Dept AOS, McGill University, <sup>2</sup>RPN, MRB, Environment Canada

We propose a comprehensive test to evaluate the dynamical core of global atmospheric numerical models. We expect the results of this test to be a quantitative measure of possible deficiencies in the model dynamics, with a view for further model development. The test is specially designed to assess the near-equilibrium dynamics, assuming that a good performance in quasi-linear regimes is a necessary quality of the fully nonlinear system.

From the model to be tested, we take the output of a close-to-linear run. The dynamic fields are interpolated into isentropic coordinates and decomposed in a zonally symmetric basic state plus perturbations. These perturbations are expanded in terms of a suitable set of oscillating normal modes. We use conserved wave activities, the pseudo-energy and the pseudo-momentum according to the primitive equations, to empirically construct the normal modes of the system - the so called Empirical Normal Modes (ENMs). The model is then evaluated after a comparison between the zonal phase-speed spectrum of the modes with a control spectrum. The observed spectrum is simply obtained from a Fourier analysis of principal components, whereas the control or theoretical spectrum is determined by ratios between the pseudo-energy and the pseudo-momentum of each mode.

As a first application, we intend to test the Canadian Global Environmental Multiscale (GEM) model, with its dynamical core isolated according to the benchmark calculation proposed by Held and Suarez.

Session 2-D-3
Modélisation de
l'atmosphère II

Atmosphere
Modelling II

Mardi 1er Juin
Tuesday, June 1

15h40 - 17h40

Salle / Room R-OM110



2-D-4.1
Changes in annual extremes under transient climate change
Francis W. Zwiers<sup>1</sup> and Slava Kharin<sup>1</sup>

Canadian Centre for Climate Modelling and Analysis, Victoria, BC

This paper briefly describes changes in the annual extremes of surface properties (screen temperature, precipitation and near surface wind speed) under transient climate change as simulated in an ensemble of 3 transient climate change simulations. The simulations were performed with CCCma's first generation global coupled model and incorporate the effects of observed and projected changes in greenhouse gas concentrations and sulphate aerosol distributions. The analysis is performed by comparing extremes simulated by the model in a 21-year window representative of the present (1995-1995) with those simulated at the time of CO2 doubling relative to the present (approximately 2040-2060) and tripling (2080-2100). A limited comparison with Canadian observations and reanalysis data is also described.

2 D 4 2

Trends in Canadian Extreme Precipitation Events

Daithi Stone<sup>1</sup> and Andrew Weaver<sup>1</sup>

<sup>1</sup> School of Earth and Ocean Sciences, University of Victoria

Perhaps the most significant impacts of precipitation variations occur through changes in the frequency and intensity of extreme events. Physical arguments and climate model simulations both suggest that as the world warms, in response to increasing anthropogenic greenhouse gases, the hydrologic cycle should increase in intensity and variability, especially at high latitudes. As such, it is important to determine whether or not the recent, and highly publicized, extreme precipitation events are random, or part of a tendency towards increased frequency of occurrence.

An improved Canadian daily precipitation data set, with corrections made for changing observational biases, is analysed for changes in extreme events. This data set was obtained from the Climate Monitoring and Data Interpretation Division of the Atmospheric Environment Service. Due to the ambiguity of defining an "extreme" event, many criteria are employed. Thus the data set is analysed for trends in the upper quantile events, the variance, the Gamma distrubution parameters, the extreme value distribution parameters, and the return periods. A version of the data with the seasonal cycle subtracted, as well as data for individual seasons, are also examined in order to better understand the nature of the observed changes.

Alpine-level snowcover in Western Newfoundland during the late 20th Century Christian Martin<sup>1</sup>, Colin E. Banfield<sup>1</sup> and John D. Jacobs<sup>1</sup> Memorial University of Newfoundland

Western Newfoundland has gone through several epochs of significantly different mean winter temperatures over the past century. The period 1972-1995 had colder and snowier winters than mid-century ones, while subsequent winters have been warmer. In the Alpine region of western Newfoundland, the amount of winter/spring snowcover and duration of late-lying snowbeds has important implications for the local hydrology and ecology. Furthermore, there is likely to be a close relationship between winter temperatures and winter snowfall at different elevations.

There has been limited research on snow conditions at higher elevations in this region. Data from nearby regional synoptic stations, local climate stations, and autostations on the Big level Plateau of Gros Morne National Park will be used as a basis for estimating the climatic conditions at the alpine level since the 1940s. In particular, the range of snowcover conditions associated with near-normal as opposed to more extreme winters will be illustrated. This will require consideration of the relationships between the winter temperature series and the snowfall and snowcover conditions over the area.

# 2-D-4.4

Comparisons of global warming due to rising CO2 simulated by climate models Ian Watterson<sup>1</sup>

CSIRO Atmospheric Research

Three simple analyses developed at CSIRO are used to compare transient global warming simulated by coupled ocean-atmosphere models from CSIRO, CCCma, and other centres.

Firstly, non-dimensional skill measures are used to quantify local and global mean errors in the simulated present climate over a range of climatological quantities. A convenient graphical display is presented.

A simple energy balance model is used to assess transient global warming rates. From energy input and surface temperature time series, effective climate sensitivity and ocean depth functions are evaluated. Results from the different models are contrasted.

Finally, a simple regional feedback analysis is performed to diagnose causes of differing global sensitivity. The effect of changes in oceanic meridional heat transport on the regional warming rates is considered



# Session 3-A-1 Plénière / Plenary **Prévision Environnementale V Environmental Prediction V** Mercredi 2 juin Wednesday, June 2 08h30 - 09h50 Salle / Room Marie-Gérin-Lajoie

3-A-1.1

FORETELL™: Integrated Road and Weather Information Services Across North America Peter Davies¹ and Omar Choudhry¹

Castle Rock Consultants

Weather has an enormous effect on travel and road conditions. Drifting snow, ice, fog, and gusty winds are some of the weather events that contribute to the deaths of more than 3900 U.S. and Canadian highway users every winter. Adverse conditions cut surface friction, impact highway capacities and reduce accessibility, damaging industry and rural economies alike. Over \$2 billion US is spent on snow and ice control each year in North America. Despite this, estimates indicate that between 25 and 35 percent of inter-urban incidents occur during adverse weather conditions; accidents increase during adverse weather by factors of between two and five; and U.S. injury accidents alone exceed 402,000 annually due to adverse road conditions.

To help address these difficulties, various agencies within the U.S. and Canada are currently working together in the FORETELL(tm) project to develop an integrated strategy for providing detailed, up-to-the-minute weather information dissemination services. However, these efforts will not solely concern winter weather conditions information, and will not target surface transportation alone. In addition to providing information to travelers, industry, and agencies charged with transportation infrastructure maintenance, it is envisioned that links can be forged with the railroad, aeronautical and waterways sectors. Beyond transportation even, is it hoped that by progressive diversification it will be possible to meet the routine and disaster needs of farmers, emergency management agencies, flood control districts, and many others.

The FORETELL(tm) project disseminates information to all types of users using the most common and flexible methods in order to maximize the usefulness and timeliness of road and weather condition information. Surface transportation agencies can use this information for traffic control, within traffic management centers and to assist in road maintenance activities. Commercial vehicle operators will be able to make decisions regarding vehicle routing and schedules based on the most up-to-date road and weather condition information. Other transportation users will be capable of making more informed decisions regarding whether to travel and the conditions they will face.

There is a clear need for improved support to the surface transportation community for road and weather condition information. This information can lead to saving lives on our roads, improved economic vitality, increased efficiency, better mobility and environmental benefits. These are the core goals of FORETELL(tm).

3-A-1.2

Climate prediction and predictability from seasons to centuries George J. Boer<sup>1</sup>

<sup>1</sup>Canadian Centre for Climate Modelling and Analysis, Atmospheric Environment Service, University of Victoria

Climate prediction circumvents the two-week "predictability limit" by trading deterministic forecasts of a quantity for forecasts of some statistic of that quantity. Despite the statistical nature of the result, the approach is based on the physical principles governing the climate system as embodied, for instance, in modern GCMs. Both diagnostic and prognostic approaches are employed to investigate climate prediction and predictability using the CCCma atmospheric and coupled models. Predictability may be embodied in initial conditions, boundary conditions, internal modes, and in the external forcing of the system. Prediction and predictability on timescales from seasons to centuries is discussed. In most cases both "hindcast" and "forecast" information is available.

#### 3-B-1.1

A new model for road condition forecast in Canada

Louis-Philippe Crevier<sup>1</sup>, Yves Delage<sup>1</sup>, Paul Delannoy<sup>2</sup>, Stan Siok<sup>2</sup> and Bruno Premont<sup>2</sup>

<sup>1</sup>Atmospheric Environment Service - Recherche en prevision numerique (RPN), <sup>2</sup>Environment Canada - Ottawa Regional Centre

A road condition forecast model is under development at RPN. The model will be used to forecast road surface temperatures and provide advance icing warning for specific instrumented roadside stations. Sensors at each site collect data for road surface temperature, road temperature (40 cm depth), wind speed, dew point temperature and pavement condition.

Road surface temperature prediction is achieved through computation of the surface energy balance. Forecasted downward radiative fluxes, precipitation and near-surface air temperature, humidity and wind speed are extracted from CMC's regional GEM model. Time series of these variables are obtained for the grid point closest to the forecast station and used to force the ground heat conduction model. In this model, road heat capacities and conductivities are determined for each site from road structure and temperature records. Resolution is typically 1 cm near the surface and slowly degrades with depth. Data from the roadside station is used to initialize the ground temperature profile for the heat conduction model. Road conditions are determined through a combination of forecasted air variables (precipitation, humidity, etc.) and forecasted road temperature.

Preliminary results using data for the winter of 1998 show that the road surface temperature forecast is highly dependent on the quality of the atmospheric forecast. Statistical ( MOS and UMOS ) prediction of air temperature and wind speed or meteorologist intervention may be used to evaluate and eventually correct the forecasted air temperature. Statistical corrections are privileged in our approach as efforts are being made to automate the forecasting process as much as possible.

This talk will focus on model description and atmospheric flux corrections. A review of model performance for winter 1998 and some cases from winter 1999 will be presented.

# 3-B-1.2

The Development of a Winter Weather Index for Benchmarking Winter Road Maintenance Activities in Canada

Jianzhong Li<sup>1</sup>, Brian Mills<sup>2</sup> and Jean Andrey<sup>3</sup>

<sup>1</sup>Wilfrid Laurier University, <sup>2</sup>Environment Canada, <sup>3</sup>University of Waterloo

Canada is one of the snowiest countries in the world, and winter road maintenance activities cost in the order of a billion dollars a year. These activities vary considerably over both space and time, partly due to differences in winter weather, but also because of differences in road and traffic mix, terrain and other factors. The current project explores the association between winter road maintenance activities and winter weather. The objective is to develop a winter weather index that is sensitive to salt use on Provincial highways in Ontario. As a starting point, three winter weather indices that were reported in the literature were applied to Ontario data. Monthly index values were then correlated with monthly salt use, on a maintenance district level. One of these indices was then modified to better reflect the Ontario situation and to improve model fit. Road information was also considered. The resultant r-squared values are typically .8. Potential uses of the winter weather index are then discussed.





3-B-1.3

Moisture and Mid-Latitude Winter Cyclones

Steven Lambert<sup>1</sup>

<sup>1</sup>Canadian Centre for Climate Modelling and Analysis

Several theoretical, observation-based, and modelling studies suggest that moisture is an important factor in the production of intense mid-latitude cyclones.

The importance of moisture is shown by examing the moisture distribution in individual cyclones. In addition, the NCEP Reanalyses are used to compute the vertical motion induced by latent heat release. This vertical motion is normalized by the total vertical motion to indicate the relative importance of the latent heat release.

3-B-1.4

Real-Time Statistical Ground-Level Ozone Predictions

William Burrows<sup>1</sup> and Jacques Montpetit<sup>1</sup>

Atmospheric Environment Service, Meteorological Research Branch, Division de la Recherche en Prevision Numerique

Real-time operational forecasts began in July, 1997 for seven sites in southeastern New Brunswick. The list of sites has since expanded to more than 100, and now covers the Atlantic Provinces, Quebec, Ontario, the prairie provinces, and British Columbia. There are multiple sites in major urban areas. Issue times are 0000 UTC and 1200 UTC daily, with forecasts at each 6-hour interval from 0-60 hours in the future at both issue times. Three predictands are forecast: (1) maximum ozone, (2) maximum 3-hour running average ozone, and (3) average ozone. Forecasts are updated at a website and also transferred to interested weather offices. Statistical models were built with CANFIS, a modern data-mining and modelling technique (Burrows et al., 1997; Walmsley at al., 1999; Faucher at al. 1999). The CANFIS procedure combines the strengths of two modern data-mining methods, Classification and Regression Trees (CART) (Brieman et al., 1984) and the Neuro-Fuzzy Inference System (NFIS) (Chiu, 1994).

Forecasts at CMC for each site and predictand are made with GEM output using statistical models derived from a learning data base of hourly observations of the predictand matched with predictors. Ozone observations were available for 5-10 years or more at all sites. There are 643 potential predictors at each of four times daily (0000 UTC, 0600 UTC, 1200 UTC, 1800 UTC), but the number actually used in each model does not exceed 20. There are several hundred predictors covering meteorology and chemical emissions at 6-hr intervals from 0-hr to 72-hr along back-trajectories at 925 hPa from each site. Meteorology predictors are: temperature, wet bulb potential temperature, relative humidity, geopotential height, wind direction from surface to 500 hPa, precipitation occurrence, mixing layer depth, convective stability index, lapse rate and daily maximum temperature. Emissions predictors are: diffusion-weighted, boundary-layer-weighted and precipitation-weighted emissions of NOX, VOC, SO2 in 1°x1° latitude-longitude squares, and totals for 0-72h, 0-24h, 24-48h, 48-72h. Trajectory locations (latitude, longitude) are used as source predictors. Besides the 0-h predictors listed above, local wind direction in 30§ sectors, sea-breeze potential, and the

3-B-1.5 The New CMC Updateable Model Output Statistics (UMOS) Forecast System Marcel Vallée<sup>1</sup> and Lawrence Wilson<sup>2</sup> <sup>1</sup>RPN

For the past few years, we have been working on a complete overhaul of the operational statistical interpretation system used at the Canadian Meteorological Center (CMC). We have designed and implemented an updateable MOS system which we expect will permit the weather element forecasts to respond to steadily increasing model resolution, and to make effective use of high resolution model output variables that are not observed. Furthermore, the automatic updating feature will ensure that the weather element forecasts are up to date, reflecting the skill of the latest version of the model.

Unlike more standard statistical development where a sufficiently large sample of data is collected before equations are developed, the UMOS procedure involves daily automatic preparation of the most recent data for statistical processing. Equations are then regenerated weekly using forward stepwise screening for predictor selection. To ensure a smooth transition from a significant model change and from one season to another, we include a weighting scheme which is designed to emphasize data from the new model. The blending of data from the new and old model ensures stable statistical relationships until enough data is available from the latest version of the model.

This presentation will provide an overview of the UMOS system along with results from forecast runs of 2m temperature, POP and surface wind. Comparisons with respect to the direct model output and the existing perfect prog forecasts will be shown.

3-B-1.6

La tempête de verglas de janvier 1998 Claude Lelièvre<sup>1</sup> Enviromet International Inc.

Cette présentation illustrera les résultats de l'examen des documents et données météorologiques soumis à la Commission scientifique et technique chargée d'analyser les événements relatifs à la tempête de verglas survenue du 5 au 9 janvier 1998. Plusieurs aspects de cette tempête de verglas sortent de l'ordinaire et seront discutés. L'observation du phénomène souffre de certains problèmes. La prévision de verglas est difficile à réaliser plusieurs jours à l'avance. La climatologie du verglas souffre de certaines lacunes.

Note : un résumé plus détaillé ne pourra être fourni qu'après la parution du rapport de la Commission, ce qui devrait se produire en mars 1999.

Session 3-B-1 Météorologie opérationnelle III **Operational Meteorology III** Mercredi 2 juin Wednesday, June 2 10h10 - 12h10 Salle / Room R-OM130



3-B-2.1

Skill as a function of time scale in an ensemble of seasonal hindcasts produced with CCC GCM2

Viatcheslav Kharin<sup>1</sup> and Francis W. Zwiers<sup>1</sup>

Canadian Centre for Climate Modelling and Analysis

The forecast skill as a function of time averaging and time lag is studied in an ensemble of six 26-year seasonal integrations conducted with the second generation Canadian Climate Centre model. A technique to improve forecasts statistically based on orthonormal transformations of forecast fields is discussed and evaluated.

A simplified one-dimensional linear approximation of the hindcast integrations is used to investigate the behaviour of two common skill scores, correlation skill score and error variance. It is shown that the total skill is a combination of two terms, one of which is related to the information in the initial conditions and the other one is related to the boundary forcing. The total skill in the initial period is dominated by the signal from the initial conditions. The atmospheric response to the boundary forcing becomes more prominent at longer time leads and for longer time averages.

The maximal skill score is investigated in the linear model, and the optimal forecast, for which the maximal skill score is realized, is identified. It is shown that the optimal forecast of n-day averages is obtained by averaging n optimal forecasts for every time lead in the n-day period. The SVD method is moderately successful in improving the skill of monthly to seasonal forecasts of Z500 and T700 in the Northern Hemisphere and in the Pacific/North America region. Skill scores of spatially averaged quantities may be substantially larger than the corresponding skill scores of local forecasts.

3-B-2.2

Modelling sulfate aerosols with the Canadian GCM Ulrike Lohmann<sup>1</sup>, Martin Montero<sup>1</sup> and Norman A. McFarlane<sup>2</sup>

<sup>1</sup>Dept. of Physics, Dalhousie University, <sup>2</sup>Canadian Centre for Climate Modelling and Analysis

A sulfur cycle which solves prognostic equations for DMS, sulfur dioxide and sulfate aerosols has been incorporated into the general circulation model (GCM) of the Canadian Centre for Climate Modelling and Analysis. Additionally prognostic equations for cloud water and cloud ice have been introduced. The mass of sulfate aerosols determines the number of cloud droplets and, hence, the effective cloud droplet radius. Thus, a change in sulfur emissions between pre-industrial and present-day emissions will change cloud optical properties. If the cloud liquid water content remains the same, than more sulfate aerosols will decrease the cloud droplet effective radius, and more sunlight is reflected back to space. The effect of biomass burning aerosols is included by using satellite data for the Amazon region, where a change in aerosol optical depth is empirically related to a change in cloud droplet effective radius. Results from simulations with present-day and pre-industrial emissions will be presented during the talk.

3-B-2.3

Canadian RCM: Present status and its applications in climate change research Daniel Caya<sup>1</sup>, Sebastien Biner<sup>1</sup>, Hélène Côté<sup>1</sup>, Anne Frigon<sup>1</sup>, Michel Giguere<sup>1</sup>, Rene Laprise<sup>1</sup> and Dominique Paquin<sup>1</sup>

Groupe de modelisation regionale du climat - UQAM

The Canadian Regional Climate Model (CRCM), in development at UQAM, is based on a SI-SL dynamic kernel (initially developed by André Robert) and on the physical parameterization package of the Canadian General Circulation Model's second and third versions (GCMII and GCMIII). The CRCM is being developed to produce realistic regional climate change scenarios over the Canadian territory. Such high resolution scenarios are essential to the evaluation of social and economic impacts of the anticipated climate change.

Recent improvements in the model's development will be described. Approaches to adapt the GCM's convective scheme to the CRCM's enhanced resolution will also be addressed.

Collaborations and projects with researchers making use of the CRCM will be presented, providing an insight into regional climate research in Canada and abroad. For example, the CRCM is currently being used:

-by the Northern Aerosol Regional Climate Model (NARCM) research group to understand and evaluate the effects of anthropogenic aerosols on regional climate; -by the Canadian Forest Service to study the effect of climate change on fire potential in boreal forests; -in the Mackenzie GEWEX Study (MAGS), to improve the understanding of the basin's water and energy cycles in order to assess the impact of climate change on the Canadian water resources; -by the Institute of Geography at the University of Fribourg (IGUF) to evaluate the impact of climate change on the intensity and frequency of extremes (wind, temp., precip.) in Switzerland; -at UQAM to study regional hydrological budgets using observations from hydraulic infrastructures; -at UQAM to study the influence of ice cover distribution on mesoscale climate in Northeastern North America; -at UQAM to study the interactions of aerosols and radiation during the Koweit fires; -at UQAM to study aerosol dispersion in the Mexico area, taking account of topography and the effect of slopes on surface absorption of solar radiation.

3-B-2.4 A New Radiation Model For CCC GCM Jiangnan Li<sup>1</sup> 1 member of CMOS

For the further development of CCC GCM, a totally new radiationi model is under construction. This new model will have following features: a. The correlated-k distribution scheme for gaseous transmittance is used. b. The longwave cloud reflectivity will be exactly handled in the new code. Recent studies have shown that cloud's infrared reflectivity can play an important role in the atmosphere. However, the infrared scattering effect for clear sky is very weak and can be neglected. The new proposed radiative transfer scheme can carefully avoid any calculation of longwave reflection for the cloud free layers. The new scheme is therefore very efficient. c. In the new model, the computing time increases linearly with the number of model layers, whereas in the CCC GCM2 the computing time increases quadratically with the number of model layers. This makes it possible to run the new GCM with very high vertical resolution, which is crucial for simulating atmospheric phenomena like QBO. The results for using this new model in CCC GCM is shown.





3-B-2.5

Sockeye salmon return migration and an ecosystem-OGCM model of the North Pacific William Hsieh<sup>1</sup>, Kenneth Denman<sup>2</sup> and Susan Haigh<sup>2</sup>
<sup>1</sup>University of British Columbia, <sup>2</sup>Inst. of Ocean Sciences

Under Canadian GLOBEC, the relation between Pacific sea surface temperature anomalies (SSTA) over the whole Pacific north of 15S and the northern diversion in the migration route of the Fraser River sockeye salmon (Oncorhynchus nerka) has been studied. Composites of SSTA during the 10 highest diversion years and 10 lowest diversion years showed that the high diversion years are associated with stronger SSTA than the low diversion years at long lead time, but at short lead time, the SSTA in the low diversion years are comparable in strength with those in the high diversion years. This suggests that low diversions may be predictable from SST data only at short lead time, whereas high diversions can be predicted at much longer lead times. Major asymmetry between the composites for low diversion years and those for high diversion years implies a nonlinear relation between SSTA and diversion.

A 4-component (nitrogen, phytoplankton, zooplankton and detritus) ecosystem model has been imbedded onto a general circulation model of the North Pacific Ocean. The model has been forced with the climatology of the pre-1976 conditions and the post-1976 conditions to examine the effects of the 1976 climate regime shift.

3-B-2.6

The CCCma third-generation AGCM (GCMIII)

Norman A. McFarlane<sup>1</sup>, Micheal Lazare<sup>2</sup> and Richard Harvey<sup>1</sup>

Canadian Centre for Climate Modelling and Analysis, <sup>2</sup>Atmospheric Environment Service

The third-generation atmospheric general circulation model (GCMIII) of the Canadian Centre for Climate Modelling and Analysis (CCCma) has recently been frozen for use in climate simulations. This model also forms the basis of version 5 of the Canadian Middle Atmosphere Model (MAM5). This new version of the Canadian AGCM has a number of features that make it different from the second-generation model (GCMII). These include higher spatial resolution, optional use of Semi-Lagrangian transport for trace constituents and moisture, and a number of new parameterization features. This new model will be described and selected results of recent climate simulations will be presented to illustrate some basic aspects of sensitivity to parameterizations and spatial resolution.

3-B-3.1

The Blowing Snow Model Intercomparison Project (BSMIP): An Update Stephen J. Dery<sup>1</sup>, Richard Bintanja<sup>2</sup>, Graham Mann<sup>3</sup>, Peter Taylor<sup>4</sup>, Jingbing Xiao<sup>4</sup> and M. K. Yau<sup>1</sup>

<sup>1</sup>McGill University, <sup>2</sup>Utrecht University, <sup>3</sup>Leeds University, <sup>4</sup>York University

In the high latitude regions of the world, including the Canadian Arctic, blowing snow occurs commonly. The redistribution of snow by wind and concurrent sublimation has attracted much interest in the past few years since the water budgets of these remote areas may be considerably influenced by these processes. Estimates of the contribution of blowing snow sublimation to the surface water budget have been of much debate with values ranging from a few millimetres snow water equivalent (swe) annually (King et al., 1996) to 10 or more mm swe annually (Marsh et al., 1994). Since observations of blowing snow are difficult to conduct, a number of numerical models have been developed to estimate the sublimation and transport rates of blowing snow as well as the interactive effects between these processes and the atmospheric boundary layer (ABL). We will present here some of the initial results of the Blowing Snow Model Intercomparison Project (BSMIP). The three models subject of the BSMIP are PIEKTUK-T developed by the group at York University in Canada (Dery et al., 1998), WINDBLAST developed by the group at Leeds University in the United Kingdom (Mann, 1998) and SNOWSTORM developed by the group at Utrecht University in The Netherlands (Bintanja, 1998). Additional results from a bulk version of the PIEKTUK model, modified by Dery and Yau (1999)at McGill University, Canada, will also be reported. These four models, operating in a time-dependent, horizontally homogeneous mode, all show that sublimation is a self-limiting process, with the sublimation rate reaching a peak shortly after initiation of transport. This is due to the inclusion of the interactive thermodynamic feedbacks of the sublimation process in the models. Similarities and differences in model predictions will be discussed and explanations considered.

3-B-3.2

Sensible And Latent Heat Fluxes In Blowing Snow Events Jingbing Xiao<sup>1</sup>, Peter Taylor<sup>1</sup> and Stephen J. Deny<sup>2</sup>

Don't of Earth and Atmospheric Science, York University

Dept of Earth and Atmospheric Science, York University, <sup>2</sup>Department of Atmospheric and Oceanic Sciences, McGill University

During blowing snow episodes, which occur frequently in Arctic and Antarctic environments, snow particle sublimation can be a significant boundary layer sink of sensible heat and a source of latent heat. In this process, the latent heat needed to maintain the sublimation of blowing snow particles can be obtained from three sources: sensible heat diffusing down from above into the blowing snow layer, cooling of the air, plus the blowing snow particles, and solar radiation absorbed by the particles.

Time-dependent and fetch-dependent models of blowing snow (PIEKTUK-T and -F), which incorporate transfers through a particle size spectrum and the negative feedback of relative humidity increases and temperature decreases on the sublimation rate, have been developed to understand the thermodynamic effects of the sublimating blowing snow particles on the atmospheric boundary layer. The models predict that the sensible and latent heat fluxes have opposite signs under typical conditions, as we expected. For example, when the wind speed increases from 10 to 25 m/s under typical conditions, the sensible heat flux minimum changes from -12 to -162 W/m^2, and the latent heat flux maximum increase from 47 to 213 W/m^2. The heat flux perturbations associated with the sublimation of blowing snow decrease with fetch or time since the process is self-limiting due to reduced the sublimation with increased relative humidity. Comparisons with Arctic, Antarctic and American Great Plains.

Session 3-B-3 Météorologie de la couche limite **Boundary Layer** Meteorology Mercredi 2 juin Wednesday, June 2 10h10 - 12h10 Salle / Room R-OM110



3-B-3.3 A Numerical Study of Boundary-Layer Flow over Complex Terrain Wensong Weng<sup>1</sup> and Peter Taylor<sup>1</sup> <sup>1</sup>EATS, York University

The Mixed-Spectral Finite Difference (MSFD) and its Non-Linear extension (NLMSFD) models are used to study neutrally-stratified turbulent boundary-layer flow over the real terrain - Askervein Hill. Different Turbulence closures are used. The model results are compared with the field observations from the Askervein Hill Project of 1982 and 1983 which provided an extensive full-scale data set for studies of wind flow and turbulence over complex terrain. The linear limitation, non-linear effects and impact of different turbulence closures on the model prediction are discussed.

3-B-3.4

A Lagrangian Solution to Canopy Flux-Gradient Relations Jon Warland<sup>1</sup> and George Thurtell<sup>1</sup> <sup>1</sup>University of Guelph

A new model of canopy flux-gradient relations was derived using a Lagrangian analysis. Time-dependent near-field effects were translated to a distance-dependent diffusivity. From this diffusivity, a matrix can be calculated using profiles of the length and velocity scales. The matrix then allows the concentration profile to be determined from any given source distribution. The model produces results in qualitative agreement with known observations. To quantitatively test the model, wind tunnel data collected by Coppin, Raupach and Legg was used. The data set selected used an elevated plane source of heat as a passive scalar inside an artificial canopy composed of metal strips. Excellent agreement was found between measured and modelled temperature profiles.

3-B-3.5

The Role of Land Surface Schemes in Short-Range Precipitation Forecasts Lei Wen<sup>1</sup>, Wei Yu<sup>1</sup>, Charles A. Lin<sup>2</sup>, Michel Béland<sup>1</sup>, Robert Benoit<sup>3</sup> and Yves Delage<sup>3</sup> <sup>1</sup>CERCA (Centre de Recherche en Calcul Appliqué), <sup>2</sup>CERCA and McGill University, <sup>3</sup>RPN, AES, Environment Canada

Many studies have demonstrated the importance of land surface schemes in climate change studies using General Circulation Models (GCMs). However, there have not been many studies which explore the role of land surface schemes in short-range precipitation forecasts. Land surface schemes may not be important for short-range precipitation forecasts, as the atmosphere may not have enough time to react to any significant flux changes occurring at the surface within a short period of time. This study is to examine the sensitivity of simulated precipitation, and study examines the sensible and latent heat fluxes, temperature, specific humidity, and wind fields to different land surface schemes at different spatial resolutions. The meteorological model used is the MC2 (Mesoscale Compressible Community Model), a nonhydrostatic limited-area atmospheric model. The land surface schemes are the force-restore method and the Canadian Land Surface Scheme (CLASS). To test and validate CLASS, a stand-alone run was performed for two potato sites (sites A and B) in the Québec City region for the growing season of 1993. The CLASS simulated soil water content for the depths of 0-0.15, 0-0.45 and 0-0.90 m compared well with field measurements. Having calibrated and verified CLASS, we next perform parallel runs using MC2 with two land surface schemes (MC2/CLASS and MC2/Force- Restore, at spatial resolutions of 10 and 5 km) to simulate the severe precipitation case of July 19-21, 1996 in the Saguenay region of Québec. The precipitation led to severe flooding. The precipitation process is modeled using the Sundqvist parameterization for resolved-scale condensation and Kuo's parameterization for subgridscale convection for 10 km, while for the 5 km run, an explicit microphysics scheme is used. The precipitation results are compared with observations from surface stations. The overall

precipitation patterns obtained with force-restore and CLASS are similar at both 10 and 5 km resolution. MC2/CLASS at 5 km resolution gives the best simulated precipitation when compared with observations from 46 rain-gauges. The negative bias of the simulated peak precipitation is common to use of the two land surface schemes. This is partially due to the effects of spatial averaging of model grid points and the large spatial variability in precipitation fields. However, the sensible and latent heat fluxes, temperature, specific humidity, and wind fields are different. These differences are due to differences in the treatment of vertical transfer processes within the soil and vegetation layers of the model.

3-B-3.5 Simulation of an intense local storm triggered by lake breeze Xin Qiu<sup>1</sup>, David Sills<sup>2</sup> and Peter Taylor<sup>1</sup> York University, <sup>2</sup>King City Radar, Environment Canada

A high-resolution regional simulation of an intense local storm that gave rise to floods near Straford, Southern Ontario on July 14, 1997 was performed using the Canadian non-hydrostatic Mesoscale Compressible Community (MC2) limited-area atmospheric model. A one-way self-nesting procedure allows the MC2 model to make very high resolution simulations (2km) starting from a coarser resolution operational analysis as initial conditions. Model simulations compare well with GOES-8 satellite and King City radar images. The model showed that the merger of lake breeze fronts in central Southern Ontario between Lake Huron and Lake Erie, led to the initiation and evolution of this unusual, quasi-stationary severe storm. MC2 shows a systematic improvement in the simulation of the local storm's formation and maintenance as the resolution is increased from 50km to 2km. The difference between the magnitude of the MC2 precipitation and the observations suggest that the initial conditions from coarser resolution operational analysis also strongly influence on the results of the mesoscale model simulation.





3-B-4.1 Significant Events of Interhemispheric Atmospheric Mass Exchange Marco Carrera<sup>1</sup> and John Gyakum<sup>1</sup>

McGill University, Department of Atmospheric and Oceanic Sciences

The exchange of atmospheric mass between the northern and southern hemisphere occurs with considerable regularity on intraseasonal time scales. Observational evidence from previous studies indicate that anomalous and persistent regional mass distributions (e.g., blocking events) may often be related to interhemispheric atmospheric mass exchange. The physical mechanisms that force this interhemispheric mass exchange remain unclear.

In this study we employ the National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) reanalysis to identify significant events of interhemispheric atmospheric mass exchange. A threshold crossing procedure, following Dole and Gordon in their 1983 Monthly Weather Review article, is used to identify significant events of interhemispheric atmospheric mass exchange for a 30 year period extending from 1968 to 1997. For the northern hemisphere a total of 140 mass fall and 155 mass rise events are identified, spanning a wide spectrum of durations. Owing to the strong seasonality in the atmospheric mass distribution of the northern hemisphere, events were partitioned into cold and warm season for the purposes of compositing.

We examine two categories of events, the 4-5-6 day and 9-10-11 day northern hemisphere cold season atmospheric mass fall events. The composite results for both classes of events reveal two regions in the northern hemisphere, related to orography, where interhemispheric atmospheric mass exchange is active, North and Central America and Southeast Asia. These regions are also recognized for frequent cold surge activity during the cold season. Significant flow of cold, dry air in association with the propagation of the surge from midlatitudes to the tropics is known to occur. We also find mid- to -high latitude precursor signatures to both categories of events. The Aleutian low is shifted eastward, from its climatological position, into the Gulf of Alaska. The enhanced warm advection into the Northwest Territories of Canada, acts to build a ridge at upper levels, and forces a downshear surface anticyclone to propagate to the south and east in conjunction with the northwesterly flow aloft. In addition, for the 4-5-6 day events, two positive/negative normalized sea level pressure anomaly couplets are present, one over the North American continent, the other over the Eurasian continent, a day prior to the onset of the composite event.

3-B-4.2

Observations and Interpretations of Jet Streaks in Terms of Balanced Dynamics Philip Cunningham<sup>1</sup> and Daniel Keyser<sup>1</sup>

University at Albany, State University of New York

Significant observational evidence exists suggesting that some jet streaks in the extratropical upper troposphere may be interpreted in a balanced framework in terms of the superposition of mesoscale monopolar and dipolar vortices (length scale ~500 km) with the enhanced potential vorticity gradients constituting the extratropical tropopause. Recent studies also have indicated that these vortices may correspond to so-called "short-wave troughs," and as such may be important as upper-level precursor disturbances to synoptic-scale surface cyclogenesis. These observations suggest that balanced mesoscale vortices not only may be common features of the upper troposphere, but also, through interactions with the synoptic-and planetary-scale flow, may be integral to the dynamics of extratropical weather systems. The goal of this presentation is to identify and expose issues relevant to the dynamics of balanced mesoscale vortices in relation to jet streaks from an observational perspective. This goal will be accomplished through several case studies that describe the evolving three-dimensional structure of observed vortices and their environment, with particular attention

devoted to the jet streaks and short-wave troughs associated with these features. The case studies will employ model-derived datasets, available from operational numerical weather prediction centres, on scales ranging from regional to global; it is suggested that such a multiscale perspective is necessary given that the interactions between meso-, synoptic-, and planetary-scale flows are likely to be significant for the features of interest. The results of the case studies support the interpretation of jet streaks as the balanced response to the interaction of coherent vortices with a larger-scale background flow. The implications of interpreting jet streak dynamics in terms of coherent vortices are discussed, drawing from the concepts of quasigeostrophic and rotating stratified turbulence.

# 3-B-4.3

Relationship Between West Atlantic Pattern In Northern Winter And East Asian Summer Monsoon And Its Numerical Simulation

Jinhai He<sup>1</sup> and Haiming Xu<sup>1</sup>

Department of Meteorology, Nanjing Institute of Meteorology, China

The NCAR/NCEP reanalyzed data from 1958 to 1994, the monthly mean sea surface 160 stations in China are used in this paper to investigate the relationship between north-western Atlantic teleconnection pattern (WAP) in winter and East Asian summer monsoon (EASM) and possible ways by which WAP affects EASM. The intensity index of northern winter west Atlantic teleconnection pattern (WAI) is defined using a method similar to Wallace?s and WAI shows distinct interannual and interdecadal variations. The correlation analysis of WAI to summer rainfall in China indicates that WAP is negatively significantly related to the subsequent June rainfall in the Changjiang Huaihe valley, i.e. the strong WAP (negative WAI) is corresponding to excessive rain in June in the valley and the weak WAP (positive WAI) to deficient rain. The SVD and lag correlation analysis show that in northern wintertime, WAP is a principal mode among the air-sea coupling modes and the atmosphere plays a leading role in air-sea interaction in the north-western Atlantic, that is to say, the atmosphere affects the sea temperature of north-western Atlantic in air-sea interaction way. As a result of the persistency of sea temperature, the sea surface temperature anomaly (SSTA) of north-western Atlantic induced by the anomalous variation of WAP in winter may sustain to the next spring or even to the next early summer. The distribution of SSTA induced by WAP in precedent winter becomes a principal mode among air-sea coupling modes in spring as well, and its corresponding to atmospheric mode is the Eurasian pattern (EUP). The ocean manifests more leading role in air-sea interactive processes, i.e. by virtue of EUP wavetrains SSTA of the north-western Atlantic in spring affects the anomaly of general circulation over the Eurasian continent, especially the anomaly of Ural blocking high, thus influencing the early summer monsoon rain in China. At last, in terms of CCM3 model the numerical simulation undertaken in this paper confirms the above diagnostic analysis results.

#### 3-B-4.4

Observation of an unusual baroclinic eddy in the Labrador Sea Ross Hendry<sup>1</sup>, John Lazier<sup>1</sup> and Igor Yashayaev<sup>1</sup>
<sup>1</sup>Fisheries and Oceans Canada

The ninth consecutive annual occupation of a Labrador Sea hydrographic section from Hamilton Bank to southern Greenland was carried out between June 26, 1998, and July 3, 1998. Station L3\_19 at 3510 m depth near the base of the continental rise off southern Greenland revealed a remarkable baroclinic feature. The temperature-salinity (T/S) characteristics at this station were essentially identical to those at neighbouring stations, but two distinct well-mixed layers were observed. The first lay at depths between approximately 100 m and 400 m and had density and T/S properties corresponding to water at 100 m at neighbouring stations located 55 km on either side along the section. A second mixed layer between 850 m and 1250 m had the same T/S properties as water found at approximately 400 m at neighbouring stations. Isopycnals just below the base of the deeper mixed layer





were displaced in the vertical by more than 900 m relative to the background stations. At still greater depths, the anomalies in density and the inferred vertical displacements decreased smoothly throughout the water column, but they were still evident at the bottom. The surface geopotential relative to 3500 dbar at the anomalous station was 1.2 J/kg greater than at its nearest neighbours. This is equivalent to a positive sea level anomaly of 0.12 m. The associated inter-station geostrophic currents calculated for the deep reference level had nearsurface maxima of approximately 0.2 m/s and a volume transport of 19 million cubic metres per second. We interpret the feature as an anticyclonic eddy that extended throughout the water column. A tentative estimate of the horizontal extent of the feature is the 110-km distance between the two neighbouring stations. The interpretation of the feature as an eddy also relies on TOPEX/POSEIDON (T/P) sea level measurements along a track that passed over the feature. The T/P measurements during the appropriate time showed a positive sea level anomaly of the order of 0.1 m with a similar along-track horizontal scale. The presence of the mixed layers suggests that air-sea interaction may have played a role in the formation of the feature, but the dynamics of the formation are unclear. To our knowledge, this is the first report of such a feature in the Labrador Sea.

# 3-B-4.5

Currents and Transport on the southwestern slope of the Grand Banks Peter C. Smith<sup>1</sup>, Brian D. Petrie<sup>1</sup> and Gary Bugden<sup>1</sup> Bedford Institute of Oceanography

The westward transport of the Labrador Current is a major factor influencing the water mass properties on the Scotian Shelf and as far south as the Middle Atlantic Bight. On the Scotian Shelf at depths greater than 100 m, periods dominated by Labrador Slope Water have temperatures and salinities as much as 4 degC and 1 below normal. Since the summer of 1996, Bedford Institute of Oceanography has maintained one current meter mooring at the 700 m isobath off St. Pierre Bank on the southern Newfoundland Shelf to monitor the Labrador Current. In the fall of 1997, an additional mooring was placed upslope on the 400 m isobath. The current is strongly sheared at both sites with westward means of 0.24, 0.11 and 0.02 m/s at 50, 150 and 400m. At 680 m, the flow is weak and variable, but shows a persistent cross-isobath upwelling of 0.006 m/s over the entire record. Significant annual cycles in the along-isobath currents at 50 and 150 m have westward maxima in September/October, preceding temperature and salinity maxima in November. Strong interannual variability is also found in the upper layers, as indicated by freshening of 1997 summer/fall 50-m salinities by order 0.5 relative to those in 1996. The average westward volumetric and freshwater transports between the 400 and 700 m isobaths are found to be considerably smaller than those estimated through Avalon Channel and at the Tail of Grand Bank.

#### 3-B-4.6

Regional Ocean Climate of the North-West Atlantic Igor Yashayaev¹and Allyn Clarke¹ ¹Bedford Institute of Oceanography

Not long ago we deeply believed that

- 1) there is a quasi-equilibrium state of the ocean a norm, that can be used to reveal and trace anomalous events in the marine environment, and
- 2) we are able to construct such state averaging all existing observations.

The most recent studies of the climate of the North-West Atlantic show that there is a need to review this concept and account for great low-frequency variations in both property fields and structures (e.g. boundary currents). An examination of the data collected in support of WOCE

between 1988 and 1998 reveals large changes in water mass properties and the strength of the circulation from what had been observed in the 50's through the 70's. These changes projected on variable in time observational grid can produce significant artifacts in climatic fields, derived as a simple blend of available data.

The greatest change in the intermediate and deep waters in the North Atlantic occurred in the time of intense deep convection in the Labrador Sea of the early 90's. Over the whole region, all of the intermediate and deep waters formed through convective processes in the northern North Atlantic have become colder and fresher.

Largely absent in sections crossing the western boundary currents in Newfoundland Basin and Subtropical Gyre during the 60's and 70's, the Labrador Sea Water (LSW) now appears as a strong salinity minimum both in the southward flowing deep western boundary currents and also within the northward flowing North Atlantic Current. By the early 90's, LSW was 0.8 C colder, 0.06 psu fresher, denser and deeper than it was during the 60's state. The deep and bottom waters of the North-West Atlantic also became colder and fresher during the same period. Denmark Strait Overflow Water (DSOW) in the Labrador Sea cooled and freshened by 0.4 C and 0.05 psu. Antarctic Bottom Water entering the subpolar gyre have been getting colder in the past two decades, but the rate of this change was less than that for DSOW, resulting in a change of spatial gradients in the bottom layer.

The upper waters on the offshore side of the Subpolar Front in the central Newfoundland Basin exhibit a 2 C temperature and 0.5 psu salinity raise over the last four decades, similar to what is seen at Bermuda. The changes on the inshore side are larger, but their dominant scale is quasi- decadal.

The changes that we observe throughout the water column imply considerable variations in dynamic heights and potential vorticity, those of a great importance for understanding and modelling the ocean dynamics.

To create the climatic fields we initially used the World Ocean Database (NODC, 1998) and added the missing data from other sources. The other sources were the BIO, WOCE and Soviet "SECTIONS" archives. Each observation in the deep ocean was checked against the T-S curve typical for its time. To remove the low frequency variability from the data a special correction was derived for a given propery (temperature/salinity/density/...) at each level. Beside time, this correction was regressed on a property itself and therefore was specific for different water masses. Application of such corrections minimized the bias of the mentioned above climatic variations and reduced variance within the structures.

Prior to generation of climatic properties over a regular grid, a polar structure function had been created for each grid point. This function was based on the data in their original locations and accounted for typical scale, anisotropy ratio and angle. Utilization of ungridded data in coefficients of the weight function used in the grid generation algorithm significantly improved consistency in presentation of major structures in climatic property fields.





3-C-1.1

Le Centre d'Avis des Cendres Volcaniques de Montréal : Réponse en temps réel à un danger à l'aviation

Pierre Bourgouin<sup>1</sup> and René Servranckx<sup>1</sup>

Centre météorologique canadien, Environnement Canada

Le Centre Météorologique Canadien (CMC) a obtenu la désignation de VAAC (Volcanic Ash Advisory Centre) de l'Organisation de l'Aviation Civile Internationale (OACI) en 1997. Les responsabilités associées à cette fonction incluent la surveillance en temps réel de l'atmosphère pour la détection de cendre volcanique, la prévision du déplacement de cette cendre le cas échéant et l'émission de bulletins décrivant la situation. Ces informations sont utilisées par divers groupes spécialisés, dont les Centres de Veille Météorologique (CVM) qui émettent les avis à l'aviation (SIGMETs). Cette présentation donnera d'abord un aperçu des effets de la cendre sur les avions en vol et du réseau mondial de surveillance de la cendre. Puis, les outils utilisés pour la détection et la prévision de la cendre seront présentés. Nous montrerons un exemple de message d'avis de cendre volcanique et discuterons de l'interaction entre les différents intervenants, dont les CVM au Canada et ailleurs. Finalement, nous décrirons les améliorations anticipées au cours des prochaines années.

The Canadian Meteorological Centre (CMC) was designated a VAAC (Volcanic Ash Advisory Centre) by the International Civil Aviation Organization (ICAO) in 1997. Its responsibilities include real-time monitoring of the atmosphere to detect volcanic ash, forecasting the displacement of the ash cloud and the production and transmission of advisory messages. This information is used by various specialized groups, including the Meteorological Watch Offices (MWO) that issue aviation warnings (SIGMETs). This presentation will first give a brief description of the various impacts of volcanic ash on aircraft, and describe the global ash monitoring network. Some of the tools used to detect and forecast the dispersion of volcanic ash will then be presented. A discussion of the interactions between the various players, including the MWOs in Canada and elsewhere, will follow. Finally, future work in this area will be discussed.

3-C-1.2

Participation de CMC à ETEX.

Réal D'Amours<sup>1</sup>, Michel Jean<sup>1</sup>, René Servranckx<sup>1</sup> and Serge Trudel<sup>1</sup>

Centre météorologique canadien

L'expérience ETEX (European Tracer Experiment) a été conçue pour tester la capacité des participants à répondre en temps réel à une urgence environnementale associée à un rejet important de polluant dans l'atmosphère, de même que pour vérifier la qualité des estimations de transport de polluants, en les comparants aux mesures de concentrations résultant d'un relâchement contrôlé. Deux relâchements ont eu lieu, le 23 octobre 1994, et le 14 novembre 1994. Le CMC a répondu en temps réel aux deux relâchements et a fourni les résultats des simulations de son modèle de dispersion CANERM au centre de coordination à Ispra en Italie, pour être comparé aux observations et évalués. Suite à cette première étape une deuxième phase d'évaluation et de comparaison a été entreprise, dans laquelle les participants ont exécuté leur modèles de dispersion à partir d'un ensemble de données météorologiques commun fourni par le CEPMMT. Une évaluation de ces résultats a également été produite par le centre de coordination.

La réponse en temps réel du CMC du CMC a été excellente en terme de délai. La comparaison des observations et des simulations montre que le CANERM a réussi à bien traiter l'évolution du panache du premier relâchement. Toutefois, en ce qui concerne le deuxième relâchement, aucune des simulations soumises par les participants n'a réussi à reproduire les observations de façon satisfaisante. Même en tenant compte de la situation

météorologique plus complexe on arrive difficilement à comprendre le comportement du panache tel que décrit par les observations.

La présentation montre et discute certains résultats des simulations de CANERM en les comparant aux observations. Quelques hypothèses pouvant expliquer le comportement du modèle sont également formulées. Des comparaisons avec les résultats des autre participants sont présentées.

# 3-C-1.3

The Application of Atmospheric Modelling in the Comprehensive Test Ban Treaty Verification: A Case study using the Explosion at the Tomsk Radiochemical Facility (Russian Federation) *Michel Jean*<sup>1</sup>

Canadian Meteorological Centre, Environment Canada

The verification regime of the Comprehensive Test Ban Treaty requires that the International Monitoring System employs four different monitoring technologies: seismic, hydroacoustic, radionuclide and infrasound. At the <u>Informal Meeting to Discuss the Application of Atmospheric Modelling to CTBT Verification</u> held in Montréal, Canada (October 1996)), it was recognized that when used synergistically these technologies will form a very significant deterrent for a potential violator. However, there are at least *three* related issues that would require meteorological consideration:

- Supposing that an anomalous event is detected by either the seismic, hydroacoustic or infrasound networks, which radionuclide stations are the most likely candidates for detection?
- Supposing suspicious radionuclides are detected at one or more IMS radionuclide stations, how can the source location be determined if it cannot be associated with any event detected by the other IMS sensors?
- By what objective process can a radionuclide event be associated with one of many other (particularly seismic) events that may have occurred several days earlier?

The ability to model the *atmospheric* dispersion of radionuclide particulate and gases, either in forward or backward mode, would be needed to answer the above questions.

The performance of simple trajectory models and more complex 3-D Lagrangian or Eulerian transport and dispersion models has been extensively assessed in the past 20 years using accidental release of radionuclides (Chernobyl, Tomsk), large-scale field experiment, the release of volcanic ash and emergency preparedness exercises. Generally these models, when one takes into consideration their differences and the use of different meteorological drivers, performed well both qualitatively and quantitatively.

The purpose of this short contribution is to use the explosion at the Tomsk radiochemical plant (April 6 1993) as an example to show that currently available complex atmospheric transport models can be used operationally to

- focus effort in securing important additional identification in the case of events detected by other means; and
- provide an objective process to associate radionuclide detection and identification with an event detected by other IMS sensors.

A second example, using a volcanic eruption at the Montserrat volcano (located in the Caribbean), will be shortly discussed. We will conclude by discussing current operational constraints and future work.

Session 3-C-1 Réponse aux urgences environnementales **Environmental Emergency** Response Mercredi 2 juin Wednesday, June 2 13h40 - 15h20 Salle / Room R-OM130

# Session 3-C-1 Réponse aux urgences environnementales **Environmental Emergency** Response Mercredi 2 juin Wednesday, June 2 13h40 - 15h20 Salle / Room R-OM130

3-C-1.4

Gestion et intervention environnementales; La météorologie au coeur d'une saine gestion. Claude Rivet<sup>1</sup> and André Cotnoir<sup>1</sup>

<sup>1</sup>Environnement Canada - DPE

Lors de cette présentation, nous expliquerons le rôle essentiel que joue la météorologie dans la gestion de l'environnement et lors d'interventions environnementales. Dans le cadre de la gestion environnementale, lors de la mise en place de plans d'urgence, par une contribution lors d'études préliminaires de risques et d'études d'impacts. Dans le cadre des interventions environnementales, par une présence du météorologue comme expert scientifique, afin d'assurer un suivi continu des conditions actuelles et à venir. Ceci afin de contribuer à des opérations sécuritaires au site et à une planification efficace des évacuations.

# 3-C-2.1

Nonlinear principal component analysis by neural networks Adam Monahan<sup>1</sup>, William Hsieh<sup>1</sup> and Benyang Tang<sup>1</sup> Oceanography/EOS, Univ. of British Columbia

The old paradigm that principal component analysis (PCA) is the most efficient way to condense the variance of a dataset has been superceded by the nonlinear PCA (NLPCA) method using neural networks (NN). The NN has 3 hidden layers, the middle one being a 'bottleneck' layer. The parameters of the NN model are adjusted to minimize a cost function so that the outputs are made as similar to the inputs as possible. The NLPCA has been applied successfully to the Lorenz (1963) 3-component chaotic system, and to the equatorial Pacific sea surface temperature (SST). The NLPCAs are not standing patterns oscillating in time, but evolve nonlinearly with the amplitude of the mode-- hence the La Nina SST anomalies are located further west in the equatorial Pacific than the El Nino SST anomalies in the 1st NLPCA mode, as were observed in the real data.

# 3-C-2.2

Simulation of the interannual variability of the wind driven Arctic sea ice cover during 1958-1998

Gilles Arfeuille<sup>1</sup>, Lawrence A. Mysak<sup>2</sup> and Louis-Bruno Tremblay<sup>3</sup>
<sup>1</sup>University of Victoria and I.O.S. (British Columbia), <sup>2</sup>McGill University, <sup>3</sup>Lamont-Doherty Earth Laboratory

A thermodynamic-dynamic sea ice model based on a granular material rheology (Tremblay and Mysak) is used to study the interannual variability of the Arctic sea ice cover during the 41-year period 1958-1998. Monthly wind stress forcing derived from the National Centers for Environmental Prediction (NCEP) Reanalysis data for this period is used to determine the year-to-year variations in the sea ice circulation and thickness. we focus on analyzing the interannual variability of the sea ice volume in the Arctic Basin and the subsequent changes in the sea ice export into the Greenland Sea via Fram Strait. The relative contributions of the Fram Strait sea ice thickness and velocity anomalies to the sea ice export anomalies are first investigated, and the former is shown to be particularly important during several large export events. The sea ice export anomalies for these events are next linked to the prior sea ice volume anomalies in the Arctic Basin. The origin and evolution of the sea ice volume anomalies are then related to the sea ice circulation and atmospheric forcing patterns in the Arctic. Large sea ice export anomalies are generally preceded by large volume anomalies formed along the East Siberian Coast due to anomalous winds which occur when the Arctic High is centered closer than usual to this coastal area. When the centre of this high relocates over the Beaufort Sea and the Icelandic Low extends far into the Arctic Basin, the above ice volume anomalies are transported to the Fram Strait region via the Transpolar Drift Stream. Finally, the link between the sea ice export through Fram Strait and the North Atlantic Oscillation (NAO) index is briefly discussed. The overall results from this study show that the Arctic Basin and its ice volume anomalies must be considered in order to fully understand the export through Fram Strait

# 3-C-2.3

Development of an improved dynamic-thermodynamic sea ice thickness distribution model Todd Arbetter<sup>1</sup>, Judy A. Curry<sup>2</sup> and Julie Schramm<sup>2</sup>

<sup>1</sup>McGill University, <sup>2</sup>University of Colorado

One of the major challenges in climate modelling is development and implementation into general circulation models of a sea ice model that accurately predicts sea ice mass balance, ice extent, interfacial fluxes, and the associated feedbacks with the atmosphere and ocean. Initially, general circulation models contained simple parameterizations of sea ice thermodynamic and dynamic processes. The development of sophisticated stand-alone ice





dynamic models facilitated improvement in the treatment of ice dynamics in GCMs. However, while there has been substantial progress in the development of single-column sea themrdynamic sea ice models, little work has been done to unify sophisticated themrmodynamics and dynamics into a single model.

Towards this end, a new sea ice model is described which incorporates the sophisticated thermodynamics of a single-column sea ice model developed at the University of Colorado into an existing basin-scale dynamic-thermodynamic model. Using a viscous-plastic dynamic model and an ice strength parameterization which accounts for a distribution of sea ice thicknesses, the model resolves a domain covering the Arctic Ocean and much of its surrounding seas. Beneath the ice at each grid cell is an interactive ocean mixed layer. A preliminary comparison of baseline characteristics of the model with observations indicates that the new model performs reasonably well in terms of its reproduction of ice surface albedo, ice surface temperature, and ice thickness distribution.

3-C-2.4

A Variable Velocity Flow Routing Scheme for General Circulation Models Vivek Arora  $^1$  and George J. Boer  $^1$ 

Canadian Centre for Climate Modelling and Analysis

A global hydrological routing algorithm is developed for use in the Canadian Centre for Climate Modelling and Analysis' (CCCma) coupled general circulation model. The routing algorithm models the freshwater inflow into the oceans by routing grided runoff from the land cells to the ocean cells.

Unlike, existing schemes that use a constant velocity, the algorithm uses a time-variant velocity to perform surface flow routing, that depends on the amount of runoff generated in the GCM land grid cell. This is expected to yield better river discharge simulations, especially in a climate change experiment, where changes in precipitation cause changes in runoff and therefore streamflow values. The residence time for groundwater reservoir is, however, assumed constant in time and related to the major soil type in the GCM grid cell.

The scheme uses Manning's equation to estimate flow velocities and thecross-section of the river channel is assumed to be rectangular. It uses 1 degree river flow directions, and finds the river flow directions at the requiredGCM resolution using an algorithm that requires minimal manual correction. Thescheme can therefore be used for any GCM resolution easily.

With the use of a suitable roughness coefficient for natural channels inthe Manning's equation, and all other parameters determined from existingliterature, the scheme does not require calibration of any parameters and can be used in GCMs directly. Streamflow simulations at the mouth of major rivers suggest that the scheme performs satisfactorily and preserves the timing of hydrographs.

3-C-3.1

The 1997/98 ENSO Event and Impacts on Sea Ice in the Western Arctic and Canadian Arctic Islands

Tom Agnew<sup>1</sup>, Jim Maslanik<sup>2</sup> and Mark Serreze<sup>2</sup>

AES, <sup>2</sup>Cooperative Institute for Research into Environmental Sciences

The latest global temperatures indicate that 1998 was the warmest year of the last 100 years. Over the 1990's, 1997, 1995 and 1990 have also been record warm years. In addition, 1997/98 was a particularly extreme ENSO event which contirbuted to the warmest temperatures on record for Spring and Summer of 1998 in the northwestern Canadian Arctic and the Canadian Arctic Islands. These two years were also record years for minumum sea ice cover in the western Arctic Ocean (Beaufort and Chukchi Sea) (Maslanik et al, 1999). Two conecutive years of minimum sea ice cover have not occurred before in these regions. This appears to have had long term effects on the distribution of first year and multiyear sea ice in the region (McPhee et al, 1999). This paper will discuss the ENSO related changes in atmospheric circulation which caused these warm temperatures, the impacts these warm temperatures and changes in circulation had on sea ice in the region and possible feedbacks this is having on the sea ice and climate of the region.

3-C-3.2

Air-Sea Fluxes from the Labrador Sea Deep Convection Experiment of 1997 William Perrie<sup>1</sup>, Robert Anderson<sup>1</sup>, Fred Dobson<sup>1</sup>, Yongcun Hu<sup>1</sup> and Bechara Toulany<sup>1</sup> Bedford Institute of Oceanography

An understanding of the climate dynamics and climate change, on all timescales, requires consideration of the ocean surface. Climate models just try to simulate the coupling that occurs between the atmosphere and the ocean through the ocean surface. They must accurately model the air-sea fluxes of momentum, heat and vapour. The Labrador Sea Deep Convection Experiment (LSDCE) was an attempt to directly measure these fluxes and related parameters of the marine boundary layer, the ocean surface and the upper ocean.

We present wind fields measured from the Knorr's IMET system and from the BIO bowmast meteorological system, corrected for flow distortion over the ship, height and stability, during the entire 40-day cruise of the LSDCE. These winds are compared to the raw IMET winds as originally measured from the Knorr, as well as 10-m height wind field analysis values from the CMC GEM model output, interpolated to the position of the ship. Associated scatter-plots correlating ship winds to CMC winds are also presented. Moreover, as LSDCE was conducted in conjunction with NSCAT validation, which provides remotely sensed measurements of the wind field, time-series comparing in situ winds from Knorr with NSCAT winds are also presented.

LSDCE also produced in situ measurements of the wind stress and sea-state parameters, throughout the 40-day cruise of the Knorr. The sea-state parameters include the parameters specifying directional wave spectra, for example wave age, wave height, peak frequency, swell, peakedness, etc. Correlations of these sea-state parameters with WAM model output are presented. Moreover, following the recent attempts to understand wind stress as a function of these sea-state parameters, we also present preliminary parameterizations of wind stress as a function of sea-state parameters, swell etc.

Session 3-C-3 Interactions air-mer **Air-Sea Interactions** Mercredi 2 juin Wednesday, June 2 13h40 - 15h20 Salle / Room R-OM110



3-C-3.3 Regional air-sea interaction in a 1000-year climate simulation

Ian Watterson<sup>1</sup>

CSIRO Atmospheric Research

Variability of monthly means is a significant component of weather, and consists of interrelated anomalies of pressure, wind, temperature, and precipitation. This study considers the regional air-sea interaction that may accompany such variability, through anomalous surface energy fluxes and stresses. At this stage, the analysis has focussed on the comprehensive data set of monthly means from a 1000-year simulation by the CSIRO Mark 2 coupled atmosphere-ocean model.

The spatial patterns of variability of 800 hPa wind velocities in the January and July singlemonth means have been firstly determined through a rotated EOF analysis applied over the North American region. For each of the 12 most important patterns, the associated amplitude time series has then been correlated with a range of variables. Regional maps of the correlations are used to give a coherent picture of the anomalies.

Typically 30% to 70% of the variance of local precipitation and temperature is associated with the 12 time series. Sea surface temperature anomalies (SSTA) are also clearly related. Correlations lagged in time indicate that the wind patterns have limited persistence. However, the SSTA that are evidently forced by the atmospheric patterns have a persistence of several months. The potential for these small anomalies to feed back on the atmosphere is considered, along with the implications for predictability.

3-C-3.4

The Influence of Sea Ice Distribution in Northeastern North America on Mesoscale Atmospheric Circulations: Monthly Climate and a Polar Low Peter Zwack<sup>1</sup>, Philippe Gachon<sup>2</sup> and René Laprise<sup>1</sup>

<sup>1</sup> Université du Québec à Montréal, <sup>2</sup>University of Stockholm

It is well known that northern climates are determined by complex interactions, including positive and negative feedback, between the atmosphere, hydrosphere and cryosphere. Before trying to understand all of these interactions, it would be useful to tackle first how each system acts directly on another. The strategy in this presentation is to attempt to understand the influence of sea ice cover distribution on the mesoscale climate circulation. For this study UQAM's Regional Climate Model (RCM), nested within NMC analyses in 1988, is used to simulate the atmospheric circulation for the month of December over Northeastern North America with two different climatic extremes of ice cover conditions in Hudson's Bay and Hudson Straight. The model's domain which covers a region of 4200 x 4200 km is large enough for the regional model to develop its own mesoscale climate. A comparison between two runs show major differences in the monthly average pressure, wind and temperature.

Much of the difference is due to repeated development of mesoscale lows over Hudson's Bay in the case of minimum ice cover. An enhanced version of DIONYSOS, a synoptic-dynamic diagnostic package, is used to study the development of one of these cyclones, a very shallow polar low which has already been discussed in previous publications. For the first time, the diagnostics reveal quantitatively how, in this very realistic numerical simulation, the advection of cold air over the open water produces a shallow polar low. The results show quantitatively that all of the forcings that contribute directly to the formation of the low (sensible and latent heating and low level vorticity and temperature advection) are all the result of the distribution of sea ice in the presence of strong cold advection. The implication of these results for climate modeling will also be briefly discussed.

# 3-C-4.1

The Canadian National Radar Project: An Update

Paul Joe<sup>1</sup>, Steve Lapczak<sup>1</sup>, Martin Stanley-Jones<sup>1</sup>, John Scott<sup>1</sup>, Paul Van Rijn<sup>1</sup> and Marie Falla<sup>1</sup> Environment Canada

The Atmospheric Environment Service of Canada (AES) is well underway on a five year project to install twenty-nine Doppler radars across the country. The radars will consist of a network C band radars and the McGill S band radar. The justification for the radar network were based on severe weather, hydrology, numerical weather prediction/data assimilation, climate, environmental monitoring and commercial applications which include aviation. Many of these applications are new for the AES and this led to an in-house approach to the hardware, software and training. The main advantages to this approach are a greater number of radars that could be Dopplerized, a greater organizational knowledge of radar systems needed for improved usuage, support and maintenance and flexibility to meet these new mandates.

Ten new radars will be installed as well as retrofits of all existing non-Doppler radars with some relocations to new sites. The radars will use co-axial magnetrons, dual-PRF unfolding to extend the Nyquist velocity, a combination of frequency and time domain processing for moment estimation and ground clutter filtering, random phase processing for range extension, four selectable pulse widths (0.8 to 10 ms) for clear air detection, solid state modulator and digital IF for phase stability enhancement. New radars will have 0.650 beamwidths and retrofit radars will have 1.00 beamwidths. Prototyping of the digital IF has shown great improvements in the phase stability of the radar that approach the quality of coherent systems.

The data from the radar is transferred over a 128Kbaud intranet link using a variety of communications technologies to a Regional weather office for product processing. The in-house built radar processing system is designed to integrate into the existing and future AES computing and communications infrastructure. The software is designed to process data from several radars and the products are user-configurable, can be arbitrarily scheduled and produced in various map projections. The products include images, numeric data formats and volume scans to meet the needs of the various clients. WSR88D data from the NIDS providers, received at the Canadian Meteorological Centre (CMC) in Montreal and transferred to the Regions, will be processed and viewable on an interactive browser based viewer and other systems. A selection of the numeric data products from the Regional processing centres will be sent to CMC to be combined with the WSR88D data to generate North American radar composites. The ability to process several radars will provide the future possibility of network processing of the radar data for quantitative precipitation estimation.

#### 3-C-4.2

Processing of North American radar networks data at the Canadian Meteorological Centre Yves Gingras<sup>1</sup> and Rick Jones<sup>1</sup>

Canadian Meteorological Centre, AES, Environment Canada

North American radar data will be processed on an operational basis at the Canadian Meteorological Centre (CMC). This data includes all of Environment Canada and NEXRAD networks sites. Radar data will be used to meet specific operational needs. One of the important purposes of the data is the evaluation of CMC numerical prediction model output precipitation products, which are currently available at a 24 km spatial resolution. Radial winds are converted using BUFR style parameters in order to be ingested by the assimilation system. In the future it is hoped that the assimilation of radial and velocity-azimuth display winds as initial conditions for the model will improve short term high resolution forecasts. U.S. radar data for sites contiguous to Canada are retransmitted to regional offices for severe weather watch. In this presentation, the CMC radar processing system is also described. It includes North American mosaic production, quality control and methods to handle multiple radar coverage. A radar mosaic image sample is shown superimposed with





model output and surface weather observations to illustrate the possibility to compare various sources of data for model evaluation.

3-C-4.3

The Vertically Pointing Radar: A Low-Cost Remote Sensing Instrument for Education and Precipitation Physics Studies

Frederic Fabry<sup>1</sup>, Abnash Singh<sup>1</sup> and Isztar Zawadzki<sup>1</sup>

Dept. Atmospheric and Oceanic Sciences, McGill University

At the J.S. Marshall Radar Observatory, we have used for the past 10 years a small vertically pointing radar (VPR) for research purposes. This instrument records the reflectivity, and thanks to a recent upgrade, the spectrum of vertical velocities, of weather targets as they move overhead. The instrument's high resolution (a few tens of meters in the vertical, a few seconds in time) allows us to observe with considerable detail a large variety of weather phenomena which include gravity waves, boudary layer velocity structures, ice and water clouds, and all types of precipitation forming from the ice phase and the water phase processes.

A particularly interesting aspect of this instrument is its relatively low cost (\$60K) and very limited maintenance. This allows us to operate the VPR continuously and collect considerable amounts of data. As a result, many research projects have been made possible using data from the VPR. Since the instrument is also relatively small, it has been deployed in field experiments like the 3rd Canadian Freezing Drizzle Experiment in the Ottawa area. Finally, the VPR can be used for education, both as a testbed for an introduction to remote sensing as well as a source of imagery of various microphysical and dynamical phenomena. The interest in this instrument is high enough that we have manufactured several VPR for universities in U.K, U.S.A, and New Zealand.

In this presentation, we will introduce the VPR and give an overview of the research that has been performed using this instrument. We will then show examples of data from various meteorological events and interpret the radar images.

3-C-4.4

Simultaneous transmission and reception of linear vertical and linear horizontal polarization for precipitation measurement

Enrico Torlaschi<sup>1</sup> and Yves Gingras<sup>1</sup>

UQAM - Département des sciences de la Terre

A polarimetric weather radar with alternate transmission of slant linear  $+45^{\circ}$  and  $-45^{\circ}$  polarization and simultaneous reception of both linear vertical and linear horizontal polarization is considered. The equations of the radar observables for a model medium containing non spherical hydrometeors are presented. Assuming the hydrometeors to be axially symmetric with a canting angle distribution symmetric about the mean canting angle, a set of equations for separation of propagation and backscattering effects is developed. The mean apparent canting angle and the degree of common orientation of the hydrometeors, and the differential phase shift are obtained. Using empirical relationships the mean and differential attenuations are estimated by means of the differential phase shift. The intrinsic value of the reflectivity, the differential reflectivity and the copolar correlation coefficient at zero lag time are then determined. Application of this to a model convective rain cell verifies that the use of simultaneous transmission and reception of linear vertical and linear horizontal polarization at S, C, and X band provides estimates of the intrinsic scattering properties of precipitation.

3-C-4.5 Posters (13-18) Introductions 3-D-1.1

Sulfur dioxide dispersion and subsequent deposition downwind from a natural stationary point source: Masaya volcano in Nicaragua

Pierre Delmelle<sup>1</sup>, John Stix<sup>1</sup>, Charles P. Bourque<sup>2</sup> and Peter Baxter<sup>3</sup>

<sup>1</sup>Université de Montréal, <sup>2</sup>Université du Nouveau Brunswick, <sup>3</sup>Cambridge University

Potential effects of air pollutants on ecological systems downwind from pollution sources continue to be of concern. Until now, studies of this problem have focused on anthropogenic sources. However, natural pollution sources may lead to similar effects. Many non-erupting volcanoes release gas plumes into the atmosphere. Volcanic emissions consist mainly of carbon dioxide (CO2), sulfur dioxide (SO2), hydrogen chloride (HCl) and hydrogen fluoride (HF). In some instances, such emissions cause extensive damages to forests and plantations downwind and constitute a hazard for the local populations. The quantity and impacts of volcanic pollutants added through dry and wet deposition to the environment of persistently degassing volcanoes are not well known.

In this paper, we study the downwind dispersion and subsequent deposition of the plume emitted by Masaya volcano, Nicaragua. We focus on SO2. Masaya is a low elevation (530 m) basaltic edifice characterized by periods of intense degassing. The gas plume is typically entrained into a warm and variably moist tropospheric boundary layer and is blown west towards the ocean. In March-April 1998, we monitored (i) SO2 emission rates with a portable correlation spectrometer (COSPEC), (ii) near-ground SO2 concentrations with diffusion tubes distributed throughout the downwind area, (iii) cumulative amounts of SO2 deposited onto the land with PbO2 sulfation plates exposed in the same area and (iv) local atmospheric conditions.

At Masaya, continuing downwind fumigation impacts the forested and cultivated landscape. It is most conspicuously visible on the slopes leading up to the Llano Pacaya ridge, 15 km from the degassing crater. In this area, the cloud forest and other vegetation, including coffee and citrus plants, have been killed and only a few shrubs survive. The volcanic SO2 emission was found to be highly variable over each period of observations. It varied from 7.8 kg s-1 to 65 kg s-1 in March-April 1998. The mean SO2 emission rate was 22 kg s-1. Time-averaged near-ground SO2 concentration isopleths indicate that values above 30 ppbv are common under the plume. The averages probably conceal high concentration exceeding 100 ppbv which are considered unhealthful. A noticeable elevation in SO2 concentration is related to the rise in the terrain along the Llano Pacaya ridge. Field-estimates rates of SO2 deposition closely follow the spatial distribution of SO2 concentrations. Within 15 km from the volcano, the total amount of SO2 deposited onto the land during one day is estimated to be 7 x 103 kg. It corresponds to less than 0.5% of the total SO2 emitted daily by Masaya (2 x 106 kg). The fraction of SO2 deposited downwind from smokestack plumes is generally greater by a factor of 6-10 than this estimate. Preliminary data also reveal that the PbO2 sulfation plates recorded the dry deposition of volcanic HCl and HF.

3-D-1.2 Dark Conversion of Sulfur (IV) to Sulfur (VI) Parisa A. Ariya<sup>1</sup>
<sup>1</sup>McGill University

In search for new mechanisms for generation of atmospheric oxidants during fall and winter, a box- modelling investigation was carried out in which ozonolysis reactions of mostly anthropogenically produced alkenes were considered. Box model MOCCA (Sander and Crutzen, 1996) was created to investigate the couple homogeneous-heterogeneous chemistry of the marine boundary layer and in the course of this study, it was modified to adopt to conditions observed in the continental (urban/suburban and remote) boundary layer. In this paper, we will present our results on the extent of HOx (HO and H2O2) formation due to

Session 3-D-1 Transport de la pollution et qualité de l'air III **Pollution Transport** and Air Quality III Mercredi 2 juin Wednesday, June 2 15h40 - 17h40 Salle / Room R-OM130



these reactions during dark seasons. We will discuss the impact on the oxidation of S(IV) to S(VI) in the gas-phase, also in the oxidation of sulfur (IV) in the liquid phase, as observed in atmospheric aerosols. The implication of importance of these results on the chemistry of the atmosphere will be discussed

3-D-1.3

Plans for tropospheric chemistry in the Canadian Middle Atmosphere Model David Plummer<sup>1</sup> and Jack McConnell<sup>1</sup> York University

The Canadian Middle Atmosphere Model (CMAM) has been developed to study the interaction of chemistry and dynamics in the stratosphere and lower mesosphere. The chemical mechanism used in the CMAM contains a set of reactions valid for stratospheric, mesospheric and background tropospheric conditions, though the effects of chemistry are only calculated for levels above 400 hPa. For levels between the surface and 400 hPa chemical species are treated as inert tracers.

A more comprehensive tropospheric chemistry module is now being added to the CMAM with the inclusion of emission sources, boundary layer mixing, large scale convection and rain out. The general approach required for the description of tropospheric chemistry and the particular scientific issues which may be addressed with the resulting model, including the tropospheric ozone budget, effects of subsonic aircraft and upper tropospheric chemistry, will be discussed.

3-D-1.4

Testing of the Toronto emission inventory David Plummer<sup>1</sup>, Jack McConnell<sup>1</sup>, Jacek Kaminski<sup>1</sup> and Lori Neary<sup>1</sup> York University

Unnaturally high concentrations of ground-level ozone, formed downwind of urban and industrial regions, have been the focus of regulatory efforts for more than 20 years. Emissionbased three-dimensional photochemical models have been routinely used to assess the effects of emission reductions on ozone concentrations, though the emission inventories used in these models may contain large errors. Some studies have suggested emission inventories for hydrocarbons may underestimate the actual emissions by as much as a factor of two.

In an attempt to assess the accuracy of emission inventories for Toronto, calculated concentrations of NO2 and hydrocarbons from a three-dimensional photochemical model have been compared with a set of aircraft-based observations of these species. The aircraft observations include extensive observations made just downwind of Toronto for days when the prevailing gradient flow was from the north to north-west, bringing relatively unpolluted air into southern Ontario.

A total of three days have been modelled and for two of these days good agreement was found between the modelled and observed concentration of NO2, though the model significantly underestimated NO2 for the third day studied. Comparisons of the modelled and observed hydrocarbon concentrations demonstrated a large amount of scatter, though no evidence that hydrocarbon emissions are significantly underestimated was found. Due to the small number of cases studied and uncertainties associated with the modelling, no definitive conclusions about the veracity of the emission inventories were possible.

#### 3-D-2.1

Scientific Challenges And Progress Of The GEWEX Hydrometeorology Panel Ronald Stewart<sup>1</sup>, Pavel Kabat<sup>2</sup>, Rick Lawford<sup>3</sup>, Carlos Nobre<sup>4</sup>, Ehrhard Raschke <sup>5</sup> and Tetsuzo Yasunari<sup>6</sup>

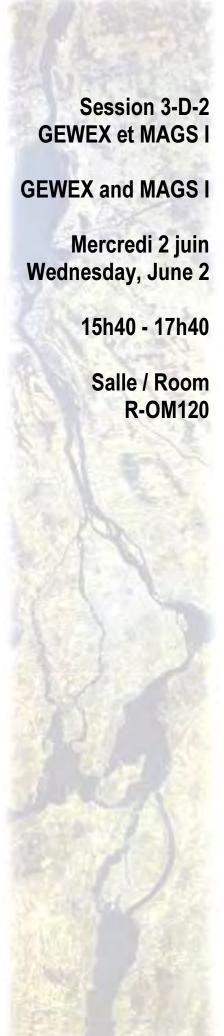
<sup>1</sup>AES, <sup>2</sup>Institute for Land and Water Management Research, The Netherlands, <sup>3</sup>NOAA/OGP Washington D.C., <sup>4</sup>CPTEC-INPE, Brazil, <sup>5</sup>GKSS, Germany, <sup>6</sup>University of Tsukuba, Japan

Water and energy cycles are of fundamental importance to the climatesystem. There are many processes and feedbacks operating within the atmosphere, at the surface, and below the surface that affect these cycles and that are not being adequately addressed within climate and operational weather models. One of the most critical issues associated with water in the climate system is its availability over land areas. This is consequently the focus for the GEWEX Hydrometeorology Panel (GHP) with its goal being by about 2005 to have significantly improved predictive capability in water resources and soil moisture on time scales up to seasonal and annual as an integral part of the climate system. This goal can only be realized once major scientific issues have been adequately addressed. It is of fundamental importance to understand and adequately model the means through which the many atmospheric, surface and hydrological processes operating over land areas interact, and jointly respond to and feed back onto large scale fields. These issues in turn rely upon major progress in addressing a host of specific issues. A few examples of such issues include the determination of soil wetness and its impacts; the characterization and understanding of the impacts of surface inhomogeneities and orography; the routing of runoff through complex surface features; the interacting roles of surface freezing and thawing; the recycling of precipitation under various conditions; and the interacting role of clouds on regional radiation fields.

The strategy being followed within GHP to address water availability is to first tackle water and energy cycles regionally over large continental regions and then to apply the progress from these activities globally. Several of these regional activities are in progress and they collectively cover a wide range of climatic conditions. They are the Continental-Scale International Project (GCIP), the Baltic Sea Experiment (BALTEX), the GEWEX Asian Monsoon Experiment (GAME), the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), and the Mackenzie GEWEX Study (MAGS). Each is quantifying the water vapour flux into and out of their particular region, characterizing the precipitation and evapotranspiration fields, and developing and validating runoff and discharge models. Each is unravelling the many feedbacks operating over, at and below the surface that may have been altered by man. Each is also working with local water resource agencies to provide immediate benefits, such as improved flood forecasting, of their activities. Each effort is consequently examining a host of processes, carrying out many diagnostic and model improvement studies, and engaging user communities.

GHP is collectively applying its progress globally through efforts such as its International Satellite Land Surface Climatology Project's characterization of land surfaces, its transferability studies of validated remote sensing and coupled model capabilities, its encouragement of new continental-scale initiatives and other complementary initiatives over other regions, and its efforts to ensure that water and energy cycles over land areas are properly incorporated into appropriate coupled atmosphere-surface-hydrology prediction tools.





3-D-2.2

An Overview of MAGS and CAGES

Geoff Strong<sup>1</sup>, Philip Marsh<sup>1</sup> and Wayne Rouse<sup>2</sup>

National Hydrology Research Centre, Saskatoon, <sup>3</sup>McMaster University, Hamilton

The Mackenzie GEWEX Study (MAGS) is one of several international studies contributing to the Global Energy and Water Cycle Experiment (GEWEX). The objectives of MAGS and other GEWEX projects are to quantify all aspects of the hydrological cycle of the Mackenzie, to determine the effects which climate change will have on the water budget of the Mackenzie, and to develop numerical modeling capabilities to predict these processes and their potential impacts on the northern climate.

MAGS activities are just past the mid-point, where most CAGES (Canadian GEWEX Enhanced Study) field work will have been completed by August, 1999. This talk will provide an overview of MAGS and CAGES, and discuss some of the preliminary hydrologic and atmospheric findings, highlighting both expected and unexpected results, particularly where the two disciplines overlap as part of the hydrologic cycle of the Mackenzie Basin. Shortfalls in our studies will be open for discussion and recommendation.

3-D-2.3

Canadian Regional Climate Model Surface Climate Evaluation During the MAGS 1994-95 Water Year

Murray MacKay<sup>1</sup>

Atmospheric Environment Service

The Mackenzie GEWEX Study (MAGS) aims to develop an improved understanding and modeling capability of the regional-scale water and energy cycles of the Mackenzie River Basin on the fast climate timescale. One of the goals of this study is an accurate representation of the Mackenzie River discharge into the Arctic Ocean, a process of significance for the entire Arctic climate system. Towards this end a fully coupled atmospheric/land surface/hydrological model will ultimately be employed. The atmospheric component of this modelling system is the Canadian Regional Climate Model (CRCM). In this paper the surface climate produced by the CRCM over Western Canada during the 1994-95 water year is evaluated based on operational and enhanced GEWEX datasets for the region. Limitations of the model as it is currently configured will be discussed, and a general outline of the coupled modelling strategy will be presented.

3-D-2.4

The Land Surface Water Budget for the BOREAS and MAGS Watersheds using Hydrologic Models

K.R. Snelgrove<sup>1</sup>, E.A. Whidden<sup>1</sup>, E.D. Soulis<sup>1</sup>, N. Kouwen<sup>1</sup> and F. Seglenieks<sup>1</sup>

Water Resources Group, Department of Civil Engineering, University of Waterloo, Waterloo

One of the objectives of BOREAS and MAGS is to improve representations of the energy and water budget of a boreal forest in atmospheric models. Work is in progress to develop parameterizations using data collected during the 1994 to 1996 BOREAS field campaigns and then to validate the results on the MAGS data sets. However, one of the difficulties facing all the modelling groups is that neither data set has extensive measurements of the land surface storage term of the water budget. Its magnitude is critical in latent heat and runoff calculations and its time derivative is often as large as the other terms in the budget.

By a combined analysis of meteorological and hydrometric data, distributed hydrologic models can provide estimates of land surface storage. This paper presents such an analysis of the BOREAS and MAGS data sets using WATFLOOD and WATFLOOD/CLASS models. For BOREAS, forcing meteorological data are either gridded AMS data or output from the ECMWF operational

forecast and streamflow data was from runoff measured at six project and two WSC hydrometric stations. There are also 20 Water Survey of Canada network stations along the BOREAS transect, all on tributaries of the Saskatchewan or Nelson Rivers. For MAGS, forcing met data are from NCEP and CMC archives and streamflow from 36 WSC stations.

Typical diurnal cycles and seasonal averages for precipitation, evapotranspiration, runoff and soil moisture are presented for various parts of the study regions. For BOREAS, these are compared with data from the Old Black Spruce Towers in both the Northern and Southern Study Areas (NOBS and SOBS). Major sub-basin summaries are presented for MAGS.

#### 3-D-2.5

Impact Of Atmospheric Forcing On Estimates Of Surface Energy And Water Budgets For The Mackenzie Basin.

Jeana Goldstein<sup>1</sup>, Yves Delage<sup>1</sup>, Ekaterina Radeva<sup>2</sup>, Christiane Beaudoin<sup>1</sup> and Harold Ritchie<sup>1</sup> RPN, AES, Dorval, <sup>2</sup>CMC, AES, Dorval

Estimates of surface energy and water budgets for the Mackenzie basin have been produced using long-range numerical weather prediction model forecasts of one month. In the present study we compare these estimates with those obtained using shorter-range forecasts, in order to minimise the error associated with the forecasts. The problem with short-range forecasts is that, during the first hours, precipitation and cloudiness are underestimated, and this biases the energy and water budgets. To study the impact of this error and to find the optimal configuration, we test various arrangements of forecasts. One example of such an arrangement is to build up monthly budgets by taking the last 6 hours of 12-hour forecasts initiated every 6 hours. In this example, the soil variables (in particular soil moisture contents) would be updated during the last 6 hours of every forecast. Another example is an arrangement in which analysed precipitation fields replace those produced by the forecast model. During the forecasts, the atmospheric turbulent fluxes, the ground fluxes, and the changes in ground and canopy storage are calculated using the land surface scheme CLASS. In order to minimise the error associated with the initial values of the soil variables, experiments have been done with periods longer than one month.

Results are not available at the time of writing the abstract, but we hope to be able to quantify and minimise the error due to atmospheric forcing in estimating water and energy budgets at the surface.

#### 3-D-2.6

Validation of the Enhanced BATS Within the PILPS Framework Loren White<sup>1</sup>

<sup>1</sup> Jackson State University

Results from running a new "enhanced" Biosphere-Atmosphere Transfer Scheme (BATS) (en-BATS) in stand-alone mode will be compared to the standard Version 1E BATS. Cases selected from the PILPS (Project for Intercomparison of Land-surface Parameterization Schemes) experiments will be shown. En-BATS has been developed with the goal of alleviating some possible deficiencies within BATS. In particular it has been used within the seasonal prediction system of the FSU Nested Regional Spectral Model (FSUNRSM) of Cocke (1998) and with the FSU Global Spectral Model.

Although some points of modification in the en-BATS are applicable only to rare, extreme conditions not likely to be represented in the PILPS suite of experiments, we aim to use the PILPS framework nevertheless as a benchmark for general comparison. Results will be presented with and without certain of the more significant en-BATS modifications, to demonstrate both their individual and cumulative effects on the simulations.

Especially of interest are modifications which represent shading of soil by vegetation, and a seasonal variation of vegetation physiology based on local variations of NDVI. We will also evaluate the impact of some variations in computational techniques.





3-D-3.1 Validation of a limited area model Isztar Zawadzki<sup>1</sup>, Ravi Varma<sup>1</sup> and René Laprise<sup>2</sup> <sup>1</sup>McGill University, <sup>2</sup>UQAM

One of the fundamental questions in mesoscale modeling is whether the small scales generated by a high-resolution model are realistic even when the initial and boundary conditions do not contain direct information at these scales. Experience shows that strong orographic forcing helps the energy cascade to generate the correct small-scale features.

In this work numerical experiments are performed to qualitatively evaluate this question. A high-resolution RCM run, in which the initial and boundary conditions are also at high resolution provides the control run. Other high-resolution simulations, but with coarse resolution boundary conditions are compared to the control run. The model outputs are decomposed according to scales for the comparison.

Simulations were made in a domain of strong orographic forcing (Mackenzie Basin). Results show that as long as the boundary (coarse scale) conditions are identical to those present in the control run, the small scale features are correctly generated by the model even if the small scales are absent from the boundary conditions. However, if the coarse scale boundary conditions are provided by a different model (simulating the same situation) the predictability of the small scales degrades dramatically.

3-D-3.2

Champs géophysiques du CMC/CMC's Geophysical Fields Judy St-James<sup>1</sup>

<sup>1</sup>Centre Météorologique Canadien

Depuis le 15 septembre 1998, le centre météorologique canadien fait appel à de nouveaux champs géophysiques pour le Modèle GEM régional à 24 km de résolution. Ces champs proviennent d'un nouveau logiciel, appelé GENESIS, capable de produire la topographie, le masque terre-mer, la végétation, le type de sol et la longueur de rugosité à n'importe quelle résolution et sur n'importe quel type de grille. Ces champs peuvent servir au calcul du frottement dû aux ondes de gravité et à l'estimation des différents paramètres dans les schémas de surface. La résolution et la provenance de ces données ainsi que la méthode employée pour générer ces champs invariants dans le temps seront décrites durant cette présentation. De plus, des résultats d'intégration de modèles incluant la nouvelle longueur de rugosité seront montrés.

Since 15 september 1998, the Canadian Meteorological Center regional 24 km GEM model makes use of new geophysical fields. These fields are now produced by a new package, called GENESIS, that generates topography, land-sea mask, vegetation, types of soil and the roughness length at any resolution and on any type of grid. These fields contribute to the calculation of the gravity wave drag and to the estimation of different parameters found in surface schemes. Information on the data sets will be given followed by a description of the method employed to produce these fields. Also, some model runs with the new roughness length will be showed during this presentation

3-D-3.3

A Modelling Study of the Garden City, Kansas, Storm During VORTEX 95 David Anselmo<sup>1</sup> and Peter Yau<sup>2</sup>

McGill University, <sup>2</sup>Dept. of Atmospheric and Oceanic Sciences McGill University

Despite great advances in our knowledge of mesoscale environments and in computer technology, numerical simulations of mesoscale convective systems remain extremely challenging. In particular, significant problems often arise when attempting to initiate patterns of convection that are, to a reasonable extent, spatially and temporally accurate. The incomplete characterization of the atmosphere's complex behavior by mathematical convective trigger

Page 100

functions, and the inability of many of today's most sophisticated models to resolve individual convective cells are major contributors to these problems. The following study serves to demonstrate how these difficulties may be overcome, while enhancing our overall understanding of mesoscale environments.

Utilizing Environment Canada's Mesoscale Compressible Community (MC2) model, a numerical simulation of the Garden City, Kansas, storm of 16 May 1995 is performed. Late in the afternoon, an isolated supercell, which was intensely observed during the Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX), generated an F1 tornado as it traveled in a northeastward direction across the southwestern corner of Kansas. At 18km horizontal resolution the model results show a successful reproduction of the large-scale synoptic environment, as well as, important smaller scale features (e.g. dryline), which are often associated with outbreaks of severe summertime convection over the Great Plains of the central United States. Most importantly, however, the entire life-cycle of the Garden City convective cell is captured numerically with a high degree of spatial and temporal accuracy. To complete this study, a detailed analysis of the model output is made to provide additional insight into the development of severe weather on the mesoscale.

3-D-3.4

The Nonhydrostatic GEM Model

Kao-San Yeh<sup>1</sup>, Jean Côté<sup>2</sup>, Sylvie Gravel<sup>2</sup>, Alain Patoine<sup>3</sup>, Michel Roch<sup>2</sup>, André Méthot<sup>3</sup> and Andrew Staniforth<sup>4</sup>

<sup>1</sup>CERCA, <sup>2</sup>RPN, <sup>3</sup>CMC, <sup>4</sup>UKMO

GEM is expected to be used in applications ranging in scales from less than a kilometer to hundreds of kilometers. As nonhydrostatic effects are important at high resolution but not at low resolution the model was formulated in terms of hydrostatic pressure, so as to switch easily from the full nonhydrostatic set of equations to the hydrostatic set. Preliminary tests of the nonhydrostatic version are encouraging: at low resolution the nonhydrostatic model reproduces the hydrostatic forecast and the mild wind storm real data case documented in Côté et al. (1998) was rerun successfully at 2.2 km with the nonhydrostatic version. We are pursuing the validation with idealized and real data cases where nonhydrostatic effects are stronger.

#### 3-D-3.5

Hybrid neural-dynamical variational data assimilation models Youmin Tang<sup>1</sup>, William Hsieh<sup>1</sup> and Benyang Tang<sup>1</sup>
<sup>1</sup>Oceanography/EOS, University of British Columbia

The fact that a standard feed-forward neural network (NN) model can be regarded as a variational data assimilation problem opens the possibility of hybrid neural-dynamical variational data assimilation models. Such a hybrid model may be used in situations where some variables, difficult to model dynamically, have sufficient data for modelling them empirically with NN. We tested this idea of using NN to replace some dynamical equations with the Lorenz (1963) 3-component chaotic system, where we replaced one of the three Lorenz equations by an NN equation. Variational data assimilation allowed the estimation of the initial conditions of all 3 Lorenz variables. Forecast skills of the hybrid model appear quite comparable to the original Lorenz model.

3-D-3.6

Posters (19-25) Introductions (for Thursday)





The Use Of X-Band Polarisation Radar For Hydrology Marielle Gosset<sup>1</sup>, Abnash Singh<sup>2</sup> and Isztar Zawadzki<sup>2</sup> <sup>1</sup>IRD, <sup>2</sup>McGill University

Due to severe attenuation at X-band this frequency was all but abandoned in radar meteorology. However, recent deployment of space-borne radars led to a number of promising studies of methods for the correction of attenuation. Given the low-cost and high sensitivity at X-band and the fact that attenuation relates to rain rate with much lower sensitivity to drop size distribution than reflectivity itself, it is worthwhile to revisit the use of this frequency for hydrological purposes. Possible applications could be in urban hydrology, where limited range coverage is not critical, and as a gap-filling complement to existing radar networks, particularly in mountainous regions.

As part of a collaboration between McGill University, and the French laboratories IRD-LTHE and CETP, a prototype X-Band polarized Doppler radar is being assembled at the J. S. Marshall Radar Observatory, for the purpose of testing rain retrieval algorithms.

In this presentation we will discuss the advantages of X-band radars for local hydrology and the coverage expected for a given climatology of precipitation. A selection of algorithms will be reviewed and the experimental set-up we are currently developing will be described.

3-D-4.2

The Meteorological Interpretation Of Near-Surface Radar Refractivity Measurements Charles Creese<sup>1</sup>

McGill University

This new radar-derived variable is related to the speed of electromagnetic waves travelling from a radar to a target. Using changes in phase information from ground targets as proxies for the travel times of radar waves, fields of near-surface refractive index have been generated in real time on McGill University's Doppler S-band radar since 1996. As refractivity increases with both air density and humidity, its meteorological interpretations are not without ambiguity. Nevertheless, it is shown that in summer humidity fluctuations dominate over temperature and pressure changes in the refractivity field, allowing for accurate extraction of moisture fields. Identification of moisture and temperature signatures associated with frontal passages, microbursts and cold pools associated with thunderstorm outflow and other anomalies would be valuable in thunderstorm initiation prediction and boundary-layer evolution studies. This presentation briefly describes the theory behind the measurement of refractivity and the retrieval of surface humidity fields, and demonstrates the interpretation of radar refractivity in examples of meteorological interest. Predictand observation 24h previously (persistence) are included. Julian day (seasonal/biogenic predictor) and day of the week are included. Upper air observations for back trajectory predictors were derived from climate re-analysis data generated by Kalnay et al. (1996). Trajectory locations are found with a 4th order Runge-Kutta solver. Separate models were built with persistence included, and not included, since this is a major predictor and data transmission can be interrupted. In all, twenty-four CANFIS models were built for each site.

Measurement of Water Vapour Mixing Ratios using the Purple Crow Raman-scatter Lidar Chad Bryant<sup>1</sup>, Stephen P. Argall<sup>2</sup>, Robert J. Sica<sup>2</sup> and Ray M. Hoff<sup>3</sup>
<sup>1</sup>University of Western Ontario, <sup>2</sup>Atmospheric Environment Service

The University of Western Ontario's Purple Crow Lidar currently measures temperature and density of the atmosphere using Rayleigh-scattering and sodium resonance-fluoresence. Modifications are online that allow continuous nighttime measurements of water vapour mixing ratios concurrently with the Rayleigh and sodium measurements. The water vapour measurements are important for many scientific studies including climate and weather modelling, gravity-wave source studies, and understanding stratosphere-troposphere exchange. Raman-scattered photons from the 532 nm Nd:YAG laser beam are used to measure molecular nitrogen at 607.3 nm and water vapour at 660.3 nm in order to determine the mixing ratio. Measurements were obtained on April 29, 1998, using simultaneous data collection. These measurements show the boundary layer and a second moist layer near 3 kilometers that varied over the night. We are currently installing a twochannel microwave radiometer, which measures the zenith brightness temperature at 22 GHz to deduce total water vapour and liquid water concentration. These radiometer measurements will allow a continual calibration of the lidar profiles. Coincident measurements from the two systems will be presented. We would like to acknowledge support from the Atmospheric Environment Service (AES), Centre for Research in Earth and Space Technology (CRESTech), and the National Science and Engineering Research Council (NSERC).

# 3-D-4.4

Performance of the McGill Bistatic Radar network
Ramon de Elia<sup>1</sup> and Isztar Zawadzki<sup>1</sup>
Department of Atmospheric and Oceanic Sciences, McGill University

The McGill bistatic network has been functioning during the last three years and provided large amount of data in a variety of meteorological situations. Since the beginning, measured Doppler velocities were utilized as a research tool for three dimensional wind field reconstruction specially in convective systems.

Simultaneously with the efforts in the developing of optimal algorithms for wind field reconstruction, a careful assessment of the data quality is being performed. Several sources of error that affect the measurements were identified and studied both analytically and with real data. Among them, the effect of secondary lobes in the transmitter antenna pattern. They act as an unwanted source of energy that may contaminate the measurements specially at the edges of the storm (usually regions of interest). The inaccuracy may be of such importance that some of the data should be rejected. An algorithm has been developed to detect these regions of high contamination in the data.

Results suggest that future wind field reconstruction or any assimilation in complex numerical models should account for these errors if meaningful results are desired. In addition, suggestion for improvements in the bistatic network are given.

Key words: Bistatic radar, wind retrieval, data assimilation





SYPAI: The Study of SYnergy between Passive and Active Instruments

Marc Larocque<sup>1</sup>, Jean-Pierre Blanchet<sup>2</sup>, Peter Park<sup>3</sup>, Ralph Girard<sup>4</sup>, Shiv R. Pal <sup>5</sup> and Mark

Cane 5

<sup>1</sup>Earth Sciences Department at UQAM, <sup>2</sup>Earth Sciences Department at UQAM and C2GCR, <sup>3</sup>MPB Technology, <sup>4</sup>Canadian Space Agency, <sup>5</sup>CresTech, York University

ESA's Earth Radiation Mission (ERM) has for objective to probe the 3D structure of clouds and aerosol in the atmosphere for improvement of cloud-climate interaction and data assimilation in NWP. The large satellite is to carry passive instruments (radiometers-imagers) and active instruments (radar-lidar) to combine co-located retrievals for determination of all essential properties required to calculate atmospheric heating rates, surface and TOA radiative balances of most cloud types found in the atmosphere. The SYPAI program is a model simulation of all ERM instruments based on numerical representations of the characteristics of most instruments. Its goal is to optimize the system, to plan for mission design and data assimilation. In that context, MC2-RCM-NARCM schemes have been used to generate realistic cloud scenes and atmospheric data sets at resolutions ranging from 100km to 25 meters. The "model pictures" are used as reference for testing instrument synergy and limitations. In turn the exercise provides a solid basis for application of satellite data to the validation of climate models. The study is carried in parallel to the NARCM-LITE assessment to enhance this objective.

4-A-1.1

New data assimilation methods and sensitivity Florence Rabier<sup>1</sup>

<sup>1</sup> Météo-France

The advanced data assimilation method known as four-dimensional data assimilation (4D-Var) will be introduced and compared to the three-dimensional analysis (3D-Var) now widely used in numerical weather centres.

ECMWF switched its operational data assimilation method to four-dimensional data assimilation (4D-Var) in November 1997, and some results of the pre-operational testing of 4D-Var will be presented.

4D-Var uses all the tools from the previous operational system, 3D-Var (same incremental method, same 6-hour assimilation window, same observations and same background term). The new ingredient is the temporal dimension. Over the 6-hour data assimilation window, 4D-Var seeks the atmospheric model trajectory best fitting the observations and the background.

This allows to make a better use of the observations, in a consistent way with the dynamics: the increments caused by observations are influenced by the dynamics, even on a short 6-hour window.

This 4D-Var has been tested in parallel with the previous 3D-Var for several months. A significant improvement of the forecast quality has been noticed in both hemispheres, together with a slight positive impact in the Tropics.

From a synoptic point of view, 4D-Var had a clear advantage over 3D-Var during rapid cyclogeneses occurring during the FASTEX experiment. Other diagnostics were performed. The fast growing components of the analysis errors are shown to be smaller in 4D-Var. Differences in analyses exhibit more baroclinicity in 4D-Var than in 3D-Var, in particular in the Pacific area. A necessary tool to implement this method is the adjoint model (it is basically the transpose of the linearized version of the numerical model used for the forecast).

This adjoint model can also be used to perform sensitivity studies: in particular, one can study the sensitivity of the forecast errors to the initial conditions of the model. Such a type of studies was performed at ECMWF and highlighted the areas where a small change in the analysis could have improved the forecast significantly.

These computations can also be performed to diagnose changes in the forecasting system, by comparing "key analysis errors" (those components of the analysis errors which grow rapidly in the forecast) for various configurations of the system.

4-A-1.2

Assimilation of Chemical Tracer Observations Richard Ménard<sup>1</sup>, Lang-Ping Chang<sup>1</sup> and Stephen E. Cohn<sup>1</sup> <sup>1</sup>NASA Goddard Space Flight Center

We begin by summarizing the main results of the assimilation of stratospheric chemical tracer observations using a Kalman filter system on isentropic surfaces. This computationally intensive scheme has provided much insights to the assimilation problem of chemical tracers. In particular, several simplified covariance evolution schemes have been developed. Using a robust chi-square criterion to validate the error statistics used in the assimilation experiments, an assessment of the different schemes is made. Based on those findings, a three-

Session 4-A-1 Plénière / Plenary Assimilation de données l Data **Assimilation I** Jeudi 3 juin Thursday, June 3 8h30 - 09h50 Salle / Room Marie-Gérin-Lajoie



dimensional tropospheric data assimilation system has been developed using parametrized chemistry of source and sink of CO. Total column CO observations from the MAPS (Measurement of Air Pollution from Satellites) instrument are used. Preliminary results and a presentation of the system will be given.

## 4-A-1.3

Estimating the temporal variability of ozone and its sources in the Canadian ozone 3D-VAR data assimilation system. Estimating the temporal variability of ozone and its sources in the Canadian ozone 3D-VAR data assimilation system.

Gilbert Brunet<sup>1</sup>, Paul-Antoine Michelangeli<sup>2</sup>, Simon Pellerin<sup>2</sup>, John C. McConnell<sup>3</sup> and Jacek W. Kaminski<sup>3</sup>

<sup>1</sup>RPN, Environment Canda, <sup>2</sup>ARMA, Environment Canada, <sup>3</sup>Earth and Atmos. Science, York University

A great challenge is to validate the output of the evolving Canadian ozone 3D-VAR data assimilation system. Some aspects of the system can be validated through a series of Observation System Experiments (OSEs), such as is the case reported here for total ozone. However, Observation System Simulation Experiments (OSSEs) are necessary for testing the assimilation of ozone profiles with an high spatio-temporal density such as from a satellite.

The purpose of this study is to focus our attention on the temporal and spatial variability of assimilated ozone with a Principal Component analysis (PCA) for several different experiments produced by the data assimilation system. As an example, we have used the ozone field combined with the continuity equation, to estimate chemical source terms for the total ozone obtained with the TOVS-OSEs described in Gauthier al. (1998) and Pellerin et al. (1999). We will show how the interpretation of the variability of the ozone and its source permits us to obtain insight into the intrinsic quality of the sink and source regions of our different model configurations. The same approach was used to study the impact of different measurement scenarios developed to mimic measurements that may be obtained using the ODIN satellite. Using a comprehensive chemical package with the SEF model a nature run was obtained which was then used to drive a series of OSSEs with different modes of operation of instruments onboard the ODIN satellite. For example, sometimes the ozone measurements may only be available in daylight (eg., Kaminski et al. (1998)). The PCA of these results shows clearly, qualitatively and quantitatively, the positive and negative qualities of each of the analyzed scenarios. We also present a preliminary PCA of different chemical species within a given chemical family, thus identifying the most important modes, or Empirical Orthogonal Functions (EOF), of variability in a family. Comparing these EOFs between the nature run and the different ODIN-OSSEs helps to assess the efficiency of the different data assimilation system configurations. These results show that the proposed methodology is quite powerful in identifying potential problems and solutions that developers of such a data assimilation system have to face.

#### 4-B-1.1

Assimilation of TOVS total ozone data: impact on the forecasts and analyses Simon Pellerin<sup>1</sup>, Paul-Antoine Michelangeli<sup>1</sup>, Pierre Gauthier<sup>1</sup> and Gilbert Brunet<sup>1</sup> Service de l'environnement Atmosphérique

The Canadian 3D-var analysis system has been used to produce univariate ozone analyses based only on total ozone measurements retrieved from TOVS data. The assimilation experiments were driven by a modified version of the operational global model used at the Canadian Meteorological Centre (CMC) with its top risen to 1 hPa. Its dynamical variables being initialized every 24-h from the UKMO analyses, the model is integrated to transport ozone treated first as a passive tracer. The background-error statistics for ozone were determined from a time-series of lagged forecasts and a comparison to ozonesonde data to provide variances of ozone as a function of latitude and pressure. The correlations are taken to be horizontally homogeneous and isotropic. Preliminary experiments show that the resulting total ozone analyses and forecasts compare well with the data. Currently, a near real-time assimilation of total ozone data is planned for the Spring of 1999 and the results will be presented at the Symposium.

When comparing to ozonesonde data (not used in the analysis), the vertical distribution of the ozone analyses is problematic. Due to the absence of ozone profile data, the vertical distribution is entirely determined by the dynamics of the model, the background-error statistics and the lack of chemistry. Preliminary Observation System imulation Experiments have been performed to investigate the impact of the density of ozone profiles needed to improved significantly the ozone analysis.

#### 4-B-1.2

Observation System Simulation Experiments with satellite based ozone lidar Paul-Antoine Michelangeli<sup>1</sup>, Simon Pellerin<sup>1</sup>, Gilbert Brunet<sup>1</sup>, Pierre Gauthier<sup>1</sup>, John McConnell<sup>2</sup>, Jacek Kaminski<sup>2</sup> and John Hahn<sup>3</sup>

<sup>1</sup>RPN, Environnement Canada, <sup>2</sup>Earth and Atmos. Science, York University, <sup>3</sup>Optech Incorporated

Observation System Simulation Experiments (OSSEs) have been performed in the context of feasibility study of a satellite based ozone lidar project. The Ozone Research with Advanced Cooperative Lidar Experiment (ORACLE) project will provide ozone vertical profiles with an horizontal resolution of 100km and a vertical resolution of 1km. OSSEs that we have performed consist in one-month ozone assimilation cycles with ORACLE "observations". Our assimilation cycles are based on the Canadian Meteorological Center 3D-var assimilation system coupled to the CMC Global Environmental Model. ORACLE profiles are built from a nature run obtained with the SEF model associated to an ozone chemical package with 47 species. Methodology of experiments will be presented along with results illustrating the impact of a global coverage of density of ozone profiles needed to recover the full 3D structure of ozone mixing ratio.

# 4-B-1.3

The Canadian Middle Atmosphere Model: Continuing developments.

Stephen R. Beagley<sup>1</sup>, Jean de Grandpré<sup>1</sup>, John, N. Koshyk<sup>2</sup>, Norman A. McFarlane<sup>3</sup> and Ted G. Shepherd<sup>4</sup>

<sup>1</sup>Department of Earth and Atmospheric Science, York University, <sup>2</sup>Department of Physics, University of Toronto, <sup>3</sup>CCCMA, AES, <sup>4</sup>Department of Physics, University of Toronto,

The Canadian Middle Atmosphere Model (CMAM) has been run for two 10 year simulations utilizing (a) no Non-orographic gravity wave drag scheme and (b) a more comprehensive version using the Medvedev-Klassen gravity wave drag scheme and interactive gas phase chemistry.

Session 4-B-1 Assimilation de données II / **Atmosphère** moyenne I Data Assimilation II / Middle **Atmosphere I** Jeudi 3 juin Thursday, June 3 10h10 - 11h30 Salle / Room R-OM130

# Session 4-B-1 Assimilation de données II / **Atmosphère** moyenne l Data Assimilation II / Middle **Atmosphere I** Jeudi 3 juin Thursday, June 3 10h10 - 11h30 Salle / Room R-OM130

The model simulates the atmosphere from 0 to  $\sim$ 100km's using spectral dynamics at T32 resolution. The chemistry domain spans from 400hPa to the model top at  $\sim$ 0.001hPa.

The latest developmental version of CMAM has a T47 horizontal resolution. The gas phase chemistry set is also combined with a small subset of sulphate aerosol chemistry utilizing a background (SAGE) aerosol distribution. A further adaptation for the CMAM in the near future will add a more complete heterogenoeus chemistry package.

The latest CMAM now uses a Semi-Lagrangian transport scheme (replacing spectral transport) for all tracers, chemistry and the model water vapour. Initial tests of this new version are underway.

The continuing development includes work on: more complex aerosols, heterogeneous chemistry, chemical heating, non-orographic gravity wave drag and middle atmospheric clouds.

4-B-1.4

The Extended Canadian Middle Atmosphere Model

Stephen R. Beagley<sup>1</sup>, Victor I. Fomichev<sup>2</sup>, William E. Ward<sup>3</sup>, John N. Koshyk<sup>4</sup>, Charles McLandress<sup>2</sup>, John C. McConnell <sup>5</sup> and Norman, A. McFarlane<sup>6</sup>

<sup>1</sup>Department of Earth and Atmospheric Science, York University., <sup>2</sup>York University, <sup>3</sup>CRESS/CRESTechs, <sup>4</sup>Physics Dept., Toronto University., <sup>5</sup>York University., <sup>6</sup>CCCma, AES.

The Extended Canadian Middle Atmosphere Model is a modified version of the Canadian Middle Atmosphere Model with an upper boundary at 200 km instead of 95. Its development was motivated by the desire to be able to analyse phenomena in the upper mesosphere and lower thermosphere without the influence of the sponge layer usually present in GCM's which extend to these heights. The model currently includes full infra-red, UV and EUV heating, a parameterized orographic gravity wave scheme and viscous and diffusive processes appropriate to the lower thermosphere. Gravity wave parameterizations and neutral chemistry near the mesopause are under development. In this paper the design of this model will be discussed together with some results from the first runs of this model.

#### 4-B-2.1

Residue free atmospheric water budget study of lee cyclones over the Mackenzie River Basin during the BASE period.

Vasubandhu Misra<sup>1</sup>, M. K. Yau<sup>1</sup> and Nagarajan Badrinath<sup>1</sup>

Dept. of Atmospheric and Oceanic Sciences, McGill University

A high resolution atmospheric water budget is computed diagnostically every time step using the Mesoscale Compressible Community (MC2) model. The objective of the budget study are to discern the precipitation generation mechanism in the most common weather systems in the region and to examine the budget of water vapor, cloud water, rain water and ice. The study reveals that the stable and convective precipitation amounts in the basin are comparable in magnitude. The major contribution to stable precipitation comes from cold rain processes. Convective precipitation is generated in the basin by orographic lifting and favourable formation of a frontal system coinciding with the peak surface evaporation associated with the diurnal cycle. Furthermore, the local tendencies of the hydrometeors are far smaller than their forcings. However in the vapor budget the local tendency of the water vapor is strongly modulated by the moisture flux convergence into the basin.

#### 4-B-2.2

A STUDY OF THE WATER VAPOR TRANSPORT THROUGH THE MACKENZIE RIVER BASIN Vladimir Smirnov<sup>1</sup> and G.W. Kent Moore<sup>1</sup>
<sup>1</sup>Atmospheric physics, University of Toronto

The transport of water vapor through the Mackenzie basin, a typical high-latitude river basin, is studied with the ECMWF reanalyses (ERA) for 15 years (1979-1993). The analysis of water vapor flux fields reveals that the transport is highly variable in time with transient synoptic-scale disturbances being responsible for much of the transport. The track of moisture flows in the vicinity of the region is studied. The relationship between the seasonal shifts of moisture flows and the basin's annual water cycle features is established. It is investigated how the ERA data represent the position and intensity of a zone of high water vapor flux convergence at the western boundary of the basin that is responsible for most of the basin's water budget during the cold season. The values of monthly and annual water budgets obtained from the ERA data are compared to these obtained from interpolated radiosonde data and with the Mackenzie's annual runoff. In addition, as the humidity fields are known to be least accurately described by the objective analyses, values of humidity from the ERA are compared to these from soundings at several radiosonde sites in the Mackenzie basin.

## 4-B-2.3

An Extreme Event of Interhemispheric Atmospheric Mass Exchange Originating in the Mackenzie River Basin

Marco Carrera<sup>1</sup> and John R. Gyakum<sup>1</sup>

McGill University

The exchange of atmospheric mass between the northern and southern hemisphere occurs with considerable regularity on intraseasonal time scales. Observational evidence from prior studies indicate that anomalous and persistent regional mass distributions (e.g., blocking events) may often be related to interhemispheric atmospheric mass exchange. The physical mechanisms that force this interhemispheric mass exchange remain unclear.

In a previous study, the authors employed the National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) reanalysis to identify significant events of interhemispheric atmospheric mass exchange. In this study we examine, in greater detail, the most extreme case in the above sample, a 10 day northern hemisphere cold season atmospheric mass fall event. Between 01 February and 11 February 1996, the hemispheric area averaged dry air surface pressure anomaly for the northern hemisphere





dropped from +0.098 hPa to -1.746 hPa (range=1.844 hPa). To place this event in context, the mean annual cycle of surface pressure due to dry air for the northern hemisphere, owing to seasonal changes in heating and cooling, is approximately 2 hPa.

At the onset of this extreme interhemispheric atmospheric mass exchange event, a large anticyclone, with a central pressure in excess of 1044 hPa is situated over Great Slave Lake in the Mackenzie River Basin. The air mass is extremely cold with surface temperatures in the vicinity of -35 to -40 deg C. In the subsequent 5 day period, this anticyclone expands and propagates southward along the edge of the western cordillera, with the center located in southern Texas by 0000 UTC 5 February. The leading edge of the anticyclonic circulation extends deep into the subtropics (~15 deg N). Simultaneously a deep low expands and intensifies in the north Pacific ocean. A north-south orientated channel of positive normalized sea level pressure anomalies extends from south central Canada to the south Pacific Ocean between the longitudes of 90 and 120 deg W. Analysis of the total meridional mass transport confirms the southward flow of mass in the above channel.

Our results indicate, for an extreme case of interhemispheric atmospheric mass exchange, a mid-to -high latitude forcing. In particular, the interhemispheric exchange event was associated with the southward penetration of a cold anticyclone, originating in the vicinity of the Mackenzie River Basin of northern Canada, deep into the subtropical latitudes.

4-B-2.4 Synoptic climatology of Northern Hemisphere available potential energy collapses Werner Wintels<sup>1</sup> and John R. Gyakum<sup>1</sup>
<sup>1</sup>McGill University

Four recurring regional patterns of extratropical baroclinic development associated with synoptic-scale collapses of Northern Hemisphere available potential energy (APE) are identified using a 1979-95 time series derived from the National Centers for Environmental Prediction (NCEP) reanalysis. Synoptic-scale APE collapses are defined as APE falls exceeding threshold values of both APE tendency and APE depletion rate. The 40 strongest cases are classified based on the evolution of regional synoptic patterns. We propose that these patterns of baroclinic development have a disproportionate effect on the hemispheric circulation, and that their associated regional synoptic structure should therefore be of practical and theoretical interest in studies of climate, the general circulation, and numerical weather prediction. Three of the four patterns directly affect Canada. All are accompanied by deep tropospheric warming. The west Pacific warm surge (Type A) is driven by cyclogenesis over Japan and anticyclogenesis over the west-central North Pacific. The Bering warm surge (Type B) is associated with an intense southerly flow across the Bering Strait brought on by cyclogenesis near the Kamchatka Peninsula and an intense anticyclone over Alaska and the Yukon. The Atlantic Canada warm surge (Type C) is characterized by an onshore flow of warm air ahead of a continental storm track over eastern North America. Eastern Atlantic warm surges (Type D) are supported by cyclogenesis over the northern Atlantic Ocean and include an upstream Newfoundland cold surge and strong anticyclogenesis over Central Canada.

4-B-3.1

(Titre non disponible / Title unavailable)
Paul Ruscher<sup>1</sup>
<sup>1</sup> Florida University

Résumé non disponible / abstract unavailable

4-B-3.3

Projet InterMET: site WEB et cédérom de formation en météorologie pour les jeunes Nathalie Gauthier et Pascale Roucheray <sup>1</sup> Société CyberScol

Le projet InterMET est un environnement de formation permettant aux jeunes d'acquérir des connaissances et des habiletés en sciencesde l'atmosphère et dans l'interprétation des cartes météorologiques. Il est destiné à la formation des élèves et des enseignants du secondaire Il et répondent aux objectifs visés par le programme d'étude du ministère de l'éducation du Québec. Cet environnement de formation peut également être utilisé dans le cadre d'une démarche d'intégration des matières, tel que préconisée par le ministère de l'éducation, puisque la météorologie fait appel à plusieurs sciences (physique, mathématique, chimie, géographie, informatique).

Le projet InterMET est constitué d'un site WEB et d'un cédérom (qui n'est pas une copie du site web) qui sont indépendants et qui utilisent tous deux une approche constructiviste. Le site web et le cédérom mettent l'accent sur l'interactivité par l'entremise d'animations, d'exercices interactifs, d'images satellites du jour, de jeux, de sons (cédérom) et par la communication entre les écoles et les spécialistes. Tous les phénomènes atmosphériques importants sont présentés et leur compréhension repose toujours sur des principes physiques.

Le projet InterMET a été développé par la société CyberScol (dont l'objectif est d'étudier et de promouvoir le potentiel d'Internet en éducation) et financé par : la Société Canadienne de Météorologie et d'Océanographie, le Ministere de la culture et des communications, Météomedia, Vidéotron, C2GCR et CDZ Environnement.

4-B-3.4

Expérimentation Assistée par Ordinateur (ExAO) Frédéric Fournier<sup>1</sup>

<sup>1</sup> Université de Montréal

La technologie informatique permet de changer nos pratiques en enseignement des sciences. L'instrumentation de laboratoire est maintenant devenue plus performante et plus facile d'accès.

Durant cette présentation, nous vous montrerons les principes de l'expérimentation assistée par ordinateur. Ce système permet l'acquisition des données issues d'expériences, la représentation de celles-ci en temps réel, la modélisation mathématique.



Session 4-B-3 Université et formation professionnelle II **University and Professional Education II** Jeudi 3 juin Thursday, June 3 10h10 - 11h300 Salle / Room R-OM110

#### 4-B-4.1

Mesoscale variability in the eastern Alboran sea in December 1997-January 1998 Yves Gratton<sup>1</sup>, Louis M. Prieur<sup>2</sup> and Caroline Lafleur<sup>1</sup> <sup>1</sup>INRS-Océanologie, Rimouski <sup>2</sup>LPCM, Villefranche-sur-mer, France

This paper describes the slow evolution of the mesoscale coherent structures observed in the Eastern Alboran Sea aboard the MV Atalante between November 30, 1997, and January 16, 1998. This scientific cruise was the second segment of the french Almofront (ALMería-Oran front) program. The observed initial configuration is characterized by the Atlantic Jet meandering around an anticyclonic eddy. In this configuration the density front lies exactly on the imaginary line between Almería (Spain) and Oran (Algeria). Three weeks later, the meander structure is more pronounced and the front has moved eastward. A mushroom-shaped structure can be observed in the satellite IR image of December 23. Another three weeks later, the eddy has moved eastward and the coherent structures observed on the thermal images are much more difficult to interpret, but the jet and the density front may still be observed in the density- velocity field. We also show that, contrary to what was observed in April-May 1991 (Almofront I), the structures observed in the satellite thermal images correspond to the deeper, geostrophic structures.

# 4-B-4.2

Characterization of inertial oscillations in the eastern Alboran Sea during Almofront 2 Mathieu Ouellet<sup>1</sup>, Yves Gratton<sup>2</sup> and Louis M. Prieur<sup>3</sup> <sup>1</sup>UQAR, <sup>2</sup>INRS-Océanologie, Rimouski, Qc, Canada, G5L 3A1, <sup>3</sup>LPCM, Villefranche-surmer, France

Ship-mounted ADCP and moored currentmeter data were obtained in the vicinity of the Almeria-Oran front (Eastern Alborán Sea) during the french campaign Almofront 2 (November 1997 - January 1998). The data shows persistent presence of oscillations at near-inertial frequency. Spectral analysis of currentmeter data revealed a near-inertial frequency 7% higher than the local inertial frequency, as well as an important contribution of the inertial band to the energy spectra. In order to determine the signal characteristics of the inertial waves and to remove them from the velocity data, we use complex demodulation on the ADCP series. Preliminary results will be presented.

# 4-B-4.3

The use of tide gauge data in Hudson Bay William A. Gough<sup>1</sup> and Carol Robinson<sup>1</sup> University of Toronto at Scarborough

The Hudson Bay region has only one long term tide gauge time series which is at Churchill, Manitoba. The representativeness of this data for inferences of large scale flow change and sea level variation is examined. This is done by the statistical analysis of Hudson Bay hydrological data, the modelling of thermal expansion and creation of water budgets. The most significant correlation was between local runoff from the Churchill River and the tide gauge data, accounting for 43% of the variability in the tide gauge data. It was also found that seasonal thermal expansion plays a signficant role in the seasonal tide gauge amplitude.

## 4-B-4.4

Modelling Tides in the Arctic Archipelago

David A. Greenberg<sup>1</sup>, Paul S. Chapman<sup>1</sup> and Michael G. Foreman<sup>2</sup>

<sup>1</sup>Coastal Ocean Science, Bedford Institute of Oceanography, <sup>2</sup>Institute of Ocean Sciences

The Arctic Archipelago connects the Arctic Ocean to the North Atlantic through channels of widely varying dimensions that run between the many islands separating the northern Canadian mainland and Greenland. It is difficult to get a good picture of the tides in this area not just because of the complex paths the tidal waves must negotiate, but also because





tides have been seen to vary with the seasonal ice cover and because it is difficult to get reliable longterm observations in the inhospitable Northern environment. We take advantage of the variable resolution capabilities of a linear harmonic finite element model to investigate the complex tides in the area and look at the frictional effects of seasonal ice cover.

#### 4-C-1.1

Role of the nonlinear Hadley circulation in tropical upwelling. Kirill Semeniuk<sup>1</sup> and Ted G. Shepherd<sup>1</sup> University of Toronto

The Brewer-Dobson circulation is driven primarily by extratropical wave drag. This drag acts as a sort of ``vacuum pump" in producing upwelling in the tropical stratosphere. It is believed to account for the seasonal cycle in temperatures above the tropical tropopause and the ``tape recorder" effect in tropospheric water vapour transport into the stratosphere.

But the dynamics of tropical upwelling are not fully understood. The latitudinal profile of the upwelling inferred from observations has the upwelling maximum occurring on the summer side of the equator. This pattern cannot be explained by the extratropical wave drag distribution. Extratropical wave drag also cannot account for annual mean tropical upwelling which is suggested by tropical transport. Without nonlinearity or viscosity the annual mean wave-driven meridional circulation obeys the downward control principle and is confined to extratropical latitudes.

It is argued here that a key ingredient in explaining tropical upwelling is the balanced response to equatorially asymmetric radiative forcing, which Dunkerton (1989) termed the Nonlinear Hadley Circulation (NHC). Through nonlinearity, the NHC gives rise to annual mean upwelling at the equator. We examine the contribution of the NHC to upwelling and its interaction with the wave-driven circulation in a zonally symmetric model. Evidence for the existence of the NHC in a middle atmosphere GCM is also considered.

## 4-C-1.2

Temporal Variability of Middle Atmospheric Temperature Inversions and Their Relation to Large-scale Dynamics

Robert J. Sica<sup>1</sup>, Stephen P. Argall<sup>1</sup>, Albert Russell<sup>1</sup>, Wayne Hocking<sup>1</sup> and Thayananthan Thayaparan<sup>2</sup>

<sup>1</sup>The University of Western Ontario, <sup>2</sup>Defence Research Establishment Ottawa

The large power-aperture product of the Purple Crow Lidar allows the temperature structure of the stratosphere, mesosphere and lower thermosphere to be measured at high temporal-spatial resolution. These measurements have been used to study the intermittency of inversion layers in the middle atmosphere. These layers are apparent in nightly averages (e.g. 8 or more hours of integration) and appear to be fairly static structures. High resolution measurements of these features show they oscillate with periods greater than 4 hours. Since in a nominal nightly integration these features are not present about half the time, the magnitude of the temperature changes due to these events is underestimated by about 50%. Furthermore, the mesospheric heating in these layers appears to often be associated with cooling in the stratosphere. The gravity wave variance at and below the inversion layers suggests that the wave variance may be 20% higher in and below the inversion layers compared to the periods when the inversion layer is not present. The correlation of the gravity wave variation with the tides during this period suggests the inversions are tidally modulated.

## 4-C-1.3

Temperature Climatology of the Middle Atmosphere over Southwestern Ontario Stephen P. Argall¹ and Robert J. Sica¹¹The University of Western Ontario

The lidar group at the University of Western Ontario operates a powerful lidar system (Purple Crow Lidar, PCL) which measures middle atmosphere temperatures using the Rayleigh-scatter technique (30-105 km) and the sodium-resonance-fluorescence technique (85-107 km). It is

Session 4-C-1 **Atmosphère** moyenne II Middle Atmosphere II Jeudi 3 juin Thursday, June 3 13h40 - 15h20 Salle / Room R-OM130



also used for the measurement of water vapour mixing ratio profiles from 1 km up to about 25 km.

A climatology has been derived from the Rayleigh lidar temperature measurements. Temperature profiles have been calculated for about 235 nights since operation started in 1993. These nightly average temperature profiles have been calculated with a vertical resolution of 240 m. This leads to sufficiently large signal-to-noise ratio to allow the individual nightly averages to extend to over 100 km in altitude.

Nightly averaged temperature profiles have been used to determine monthly averages and these have been compared to the CIRA model as well as other climatologies determined from lidar measurements in situ probes and the satellite measurements. The climatology determined from the PCL measurements shows significant differences from the CIRA model. The PCL measurements show that the mesopause is several kilometers lower in the summer months than predicted by the CIRA model. This leads to average temperatures in the region around 95 km being up to 40 K hotter than the model. The altitude of the mesopause determined from the PCL measurements is consistent with other lidar and satellite measurements.

4-C-1.4

Wave-Induced Transport in an Idealized Stratosphere Diane Pendlebury<sup>1</sup>
<sup>1</sup>University of Toronto

The global mass circulation in the stratosphere is caused in part by the downward control principle introduced by Haynes et al. (1991). Extratropical stratospheric wave drag, produced by the breaking and dissipation of planetary waves, acts as a pump, drawing tracers from the equator to the pole and resulting in the observed Brewer-Dobson circulation.

At present, the theoretical understanding of this process has limitations. Although it can be shown, under certain assumptions, that the Lagrangian velocities and the transformed Eulerian mean velocities are the same and are a direct result of the wave drag, it is not clear that this relationship holds in general. Thus, while the existence of the wave-induced circulation is not under debate, its quantitative determination remains problematic. Previous studies have been linear and used Newtonian cooling together with Rayleigh drag. While the relaxational character of the radiative cooling is a reasonably acceptable approximation, Rayleigh drag is not. It is quite clear that in the atmosphere the mechanism for planetary-wave dissipation is a nonlinear process involving wave breaking, the development of small scales and their subsequent dissipation.

This paper will detail some of the problems with the traditional assumptions and present numerical results using a 3D primitive equations model aimed at quantifying the connection between wave driving and Lagrangian transport in the strongly nonlinear regime. The effects of realistic radiative transfer, which act preferentially on the small vertical scales that develop due to the wave breaking process, are also considered.

4-C-1.5

Parameterization of thermal effects of saturated gravity waves Alexander Medvedev<sup>1</sup> and Gary Klaassen<sup>1</sup> <sup>1</sup>York University

Breaking/saturated gravity waves (GWs) do not only provide drag on the mean flow due to their momentum deposition, but also affect the background thermally because of the associated energy flux divergence. We present a rigorous derivation of terms describing thermal effects of GWs on the mean flow. The parameterization is based on the

corresponding energy cycle for wave/mean flow interactions, and on our recent nonlinear theory of GW spectra. The combined effect of saturated GW is to produce both differential heating/cooling by inducing a downward wave heat flux, and an irreversible wave energy loss into heat. The parameterization requires a source GW spectrum as the only tunable parameter. Results of simulations with the Canadian Middle Atmosphere Model, which clarify the role of GW thermal effects in the strato-mesosphere, will be shown.

Session 4-C-1 Atmosphère moyenne II

Middle Atmosphere II

Jeudi 3 juin Thursday, June 3

13h40 - 15h20

Salle / Room R-OM130



4-C-2.1 SOLAR RADIATION BUDGETS FOR MAGS AND BALTEX

Jian Feng¹, Henry Leighton¹, Rainer Hollmann², Johannes Mueller² and Rolf Stuhlmann² ¹Dept. of Atmospheric and Oceanic Sciences, McGill University, ²Institut für Atmosphärenphysik, GKSS

The Mackenzie GEWEX study (MAGS) and the Baltic Sea Experiment (BALTEX) are two of the GEWEX regional experiments. One of the goals of these experiments is to improve understanding of the energy and water cycles of these regions and specifically to improve the capability of modelling these cycles. An important component of the models is the solar radiation absorbed at the surface, since it has a direct impact on the hydrology of these regions through its influence on melting of snow and on evaporation. Although BALTEX has a large number of surface measurement sites, the remoteness of the Mackenzie basin requires that the net solar radiation at the surface be deduced from satellite measurements.

There are two sources of data that are useful for generating radiation budgets for MAGS and BALTEX, the AVHRR on the NOAA polar orbiting satellites and ScaRaB (Kandel et al., 1998). The AVHRR offers the advantages of several passes over the study areas each day and of long-term continuity of coverage. It has the disadvantage that it is a narrowband instrument and is not well calibrated. ScaRaB, on the other hand, has both a well-calibrated broadband channel that covers the whole solar spectrum, and a narrowband channel that approximately corresponds to the AVHRR visible channel. The first ScaRaB instrument (FM1) was mounted on the Russian Meteor-3 satellite on an inclined orbit and so provides useful coverage over the study areas for some periods and poor coverage at others. The FM1 functioned for about one year from March 1994 to February 1995. In July of 1998 the second ScaRaB instrument (FM2) was successfully placed in orbit on the Russian Ressurs-01/4 satellite, in this case in a sun-synchronous polar orbit. The ScaRaB data can be combined with AVHRR data from the NOAA polar orbiting satellites to provide much better temporal coverage of the TOA radiation budgets over the MAGS and BALTEX regions than is obtained from ScaRaB alone. Our approach is to use data from the ScaRaB instruments to calibrate the AVHRR data. Based on ScaRaB A2 data and comprehensive radiative transfer model simulation, a new narrowband to broadband conversion algorithm was developed. Using this algorithm, we then use combined ScaRaB and AVHRR data to generate top-of-the-atmosphere (TOA) solar radiation budgets. From the TOA data we use techniques that we have developed for use with previous earth radiation budget data to produce the surface radiation budgets (Li et al., 1993; Masuda et al., 1995). This approach is being applied to a study of the 1994-95 MAGS water budget year and as the ScaRaB FM-2 data become available it will be applied to the MAGS intensive study period in 1998-99 known as CAGES (Canadian GEWEX Enhanced Study).

4-C-2.2

A prelminary assessment of the blowing snow transport and sublimation fluxes for the Mackenzie River Basin

Stephen J. Dery<sup>1</sup> and M. K. Yau<sup>1</sup>

McGill University

The transport of snow by wind, most prominent in cold, blustery environments, may impact the water and energy budgets by two concurrent processes. Redistribution of snow from easily erodible surfaces to accumulation areas such as ravines and bushes can lead to substantial heterogeneities in the snowcover with meteorological and hydrological implications. Sublimation of suspended blowing snow particles may represent an additional sink of mass in the nival regime.

One location where blowing snow may significantly affect the water and energy budgets is the Mackenzie River Basin (MRB). As part of the field campaign titled the Mackenzie GEWEX Study (MAGS), we will present results depicting estimates of the total blowing snow transport fluxes for the MRB using the 1979-1993 ECMWF Re-Analysis (ERA) data. These will be determined using empirically-based relationships as well as a bulk blowing snow model. Sublimation rates of blowing snow will be further evaluated in a preliminary assessment of the total contribution of blowing snow to the water and energy budgets of the MRB.

## 4-C-2.3

Cross-lake Variation of Evaporation, Heat Flux and Thermal Responses of Great Slave Lake During the Ice-free Season in 1998 : GEWEX/MAGS

William Schertzer<sup>1</sup>, Wayne Rouse<sup>2</sup> and Peter Blanken<sup>3</sup>

<sup>1</sup>National Water Research Institute, CCIW, <sup>2</sup>McMaster University, <sup>3</sup>University of Colorado (Boulder)

The Mackenzie Global Energy and Water Cucle Experiment (GEWEX/MAGS) is a comprehensive study of the hydrologic cycle and energy fluxes of the Mackenzie Basin. As part of the GEWEX/MAGS investigation in 1998, meteorological and thermistor observations were conducted along a cross-lake transect of Great Slave Lake to evaluate temporal and spatial variabilities during the ice-free season. This represents the first detailed investigation of the cross-lake variations in this lake. It provides an understanding of the heat, energy and moisture exchanges at the air-water interface fundamental for understanding of the climate effect on the atmosphere and on the lake itself and for future parameterizations of the exchanges. We provide a summary of some of the key features of the observational and modelling results related to cross-lake meteorology, evaporation, heat exchanges and physical limnological responses (e.g. wave heights and lake thermal structure.

Analysis of the principal meteorological variables (air temperature, relative humidity and wind speed) showed significant differences between nearshore and mid-lake stations especially after the period of ice break-up in June to mid-July indicative of the progression of the spring vernal front. High winds during episodic events, in some cases, generated wind stresses up to 4.5 dynes/cm2 and significant wave heights up to 4 m. Thermal structure varied between nearshore and mid-lake regions. In particular, high winds significantly disrupted developing thermal stratification in early spring by deepening the mid-lake upper mixed layer down from 5 to 20 m depth. Evaporation was highly episodic, varied across the lake and was a function of vapour pressure gradient and horizontal wind speed and not a strong function of net radiation. During spring, much of the energy receipt was used to heat the lake, especially in the mid-lake region. During summer, the total surface heat flux was significantly affected by the episodic nature of the evaporative flux.

## 4-C-2.4

Preliminary Analysis and Assessment of the MAGS Enhanced Surface Observations Paul Louie<sup>1</sup>, Bob Kochtubaida<sup>1</sup> and Pete Kociuba<sup>1</sup>

<sup>1</sup>Environment Canada - Atmospheric Environment Branch, Prairie and Northern Region

A critical issue facing the Mackenzie GEWEX Study (MAGS) concerns the lack of adequate surface observations over the entire basin. An enhancement of the surface-observing network has been set in place to more completely fulfill the requirements of MAGS. Several new meteorological stations, or improvements of existing ones, were installed in data-sparse areas that were representative of the different land cover regimes across the Mackenzie River Basin. Each of the stations reports in real time and is equipped to measure air temperature, humidity, air pressure, wind speed and direction, precipitation, snow depth, and soil temperature. Some sites contain instrumentation for observing soil moisture and/or additional solar radiation information.





The generation of standard high quality, hourly meteorological data sets will assist in process related studies and in the initialization and validation of GEWEX modeling efforts and remote sensing studies.

The measurement protocol has been configured to ensure that the data collected are compatible with the AES climatological auto-station standards. The MAGS surface data transfer protocol and quality control procedures will be described. A preliminary assessment of the surface data collected will be given.

## 4-C-3.1

On the next version of the Canadian 3D-Var analysis scheme on model?s coordinate Josée Morneau<sup>1</sup>, Mark Buehner<sup>2</sup>, Cécilien Charette<sup>2</sup>, Luc Fillion<sup>2</sup>, Pierre Gauthier<sup>2</sup>, Pierre Koclas<sup>1</sup>, Simon Pellerin<sup>2</sup>, Réal Sarrazin<sup>1</sup> and Gilles Verner<sup>1</sup>
<sup>1</sup>CMC, <sup>2</sup>ARMA,SEA

Work is in progress at the Canadian Meteorological Center to develop an incremental 3D-Var analysis scheme directly on the vertical coordinate of the 28 level Gem forecast model. This scheme is planned to replace the current operational 3D-Var analysis that operates on 16 pressure levels. For the target version, spectral (T108) Helmhotz's streamfunction and velocity-potential analysis increments are maintained for the wind, but unbalanced geopotential height is replaced by unbalanced temperature and surface pressure. Furthermore, the logarithm of specific humidity replaces the dew point depression as the humidity analysis variable. Background error covariances are based on the lagged forecast method (the so-called NMC method described in Gauthier et al., 1998 for the Canadian system) which allows for non-separable correlation. Normalization and excision aspects necessary with this method are being carefully examined against conventional methods and also with regard to specific weaknesses of the current operational forecast model over some regions of the forecast domain. Balanced and unbalanced components of the divergent wind analysis increments are produced as compared to the non-divergent analysis increments for the operational version. Tangent-linear observation operators are being used with special treatments of data outside the vertical analysis domain.

A variational quality control is also being developed at the same time. This new version of the 3D-Var analysis will facilitate future extensions, such as (1) the use all significant levels from upper air soundings, (2) the use of TOVS and ATOVS data instead of SATEM data, (3) the assimilation of SSM/I estimates of precipitation rates and total precipitable water, and (4) the assimilation of Scatterometer data.

#### 4-C-3 2

The impact of TOVS radiances in the CMC 3D variational analysis system Jacques Hallé<sup>1</sup> and Clément Chouinard<sup>2</sup>
<sup>1</sup>CMC, <sup>2</sup>ARMA

In June 1997, the CMC implemented its first global 3D-var analysis system for the preparation of daily 10 day forecasts. In the Fall of the same year, this incremental 3D-var was introduced for the preparation of the 35-km regional model analyses. Both the global and regional systems produce increments on a 16 pressure level grid with the top level at 10 hPa. In their first implementation, because geopotential is used as mass variable and not temperature, it was decided to retain SATEM thickness' as the main source of satellite data for analysis.

In preparation for the next analysis system that has been in development for the last 3 years, research in radiative transfer modeling for the purpose of assimilating radiances directly has progressed significantly and a complete system using TOVS radiances has been tested extensively and compared to the system using SATEM data. Monitoring has been integrated in the analysis system serving to control the quality and correct the biases of a dataset used to estimate the observational errors of TOVS radiances. Results clearly indicate that the assimilation using radiances consistently produces better analyses as indicated by improved 5-day forecasts.

In preparation for the assimilation of the Advanced TOVS (ATOVS) radiances, including a higher resolution microwave sounding unit, a complete evaluation has been undertaken and preliminary results will be presented.





4-C-3.3 Assimilation of Marine Surface Winds from the ERS-2 Scatterometer Mark Buehner<sup>1</sup> and Pierre Gauthier<sup>1</sup>

Atmospheric Environment Service

A new version of the Canadian 3D-var is currently under development (Fillion et. al. 1999). The analysis increments are now produced directly on the forecast model's hybrid vertical coordinate (formerly 16 pressure levels) and use temperature and surface pressure to represent the mass field (formerly geopotential height). Also, a divergent component of the wind analysis increment is now included. These changes allow for improved utilization of surface wind observations, including those retrieved from the ERS-2 scatterometer instrument. This presentation will describe recent improvements to the 3D-var that benefit the assimilation of surface winds and will report on preliminary results from the assimilation of scatterometer and conventional marine wind observations.

The effectiveness of assimilating marine surface wind data firstly depends on the observation operator used. Since the analysis is performed on the model's terrain-following vertical coordinate, a simple boundary layer model is used to relate winds at the model's first active level (at about 40m) down to the observation height. Inherent to the scatterometer instrument are possible 180 degree directional errors in the retrieved winds that are taken into account by using an observation cost function based on a bi-modal likelihood function.

The impact of using this data also depends on how the surface wind information is spread both spatially and to the other analysis variables by the 3D-var background covariance model. Within the covariance model, spatial relationships are due to the horizontal and vertical correlations of the unbalanced control variables, estimated from an ensemble of lagged forecast differences (NMC method). The between-variable relationships are determined by balance operators. The turning angle, theta, defines the balance between the stream function and velocity potential that is consistent with Ekman layer theory. The optimal turning angle is estimated, as a function of latitude and vertical level, with a regression analysis on the ensemble of lagged forecast differences. Similarly, the increments of mass and wind are related through a geostrophic and hydrostatic balance between the stream function and the temperature and surface pressure fields. Consequently, the wind increment near the surface has vectors that form the angle theta to the streamlines such that cyclonic circulation coincides with convergence (and anti-cyclonic circulation with divergence) in the extra-tropics of both hemispheres. Cyclonic circulation in the increments also coincides with temperature and surface pressure increments that are hydrostatically consistent with a center of reduced pressure (and anti-cyclonic circulation with increased pressure). Therefore, the results presented show analysis increments due to scatterometer and conventional marine surface wind observations with meteorologically consistent increments to both the divergent wind component and the mass field.

4-C-3.4 Sensitivity analysis with the GEM model Stéphane Laroche<sup>1</sup> and Monique Tanguay<sup>1</sup> Environnement Canada

The current status of sensitivity studies using the adjoint of the GEM model will be presented. The GEM model is a global variable resolution, gridpoint, fully-implicit semi-Lagrangian primitive equations model. It is currently used by the Canadian Meteorological Centre for both short-range and medium-range forecasts. For the purpose of our sensitivity analysis, we have developed an incremental formulation in which the minimization is performed at a lower 3 degrees resolution whereas the the forecasts errors and the background trajectory are calculated at the full 0.9 degree resolution. Preliminary sensitivity analysis on winter cases will be shown.

## 4-C-3.5

Assimilation of Bistatic Radar Network Data and the Near-Surface Index of Refractivity Alain Caya<sup>1</sup>, Stéphane Laroche<sup>2</sup>, Isztar Zawadzki<sup>1</sup> and Frédéric Fabry<sup>1</sup>

<sup>1</sup>McGill University, <sup>2</sup>Data Assimilation and Satellite Meteorology Division, Atmospheric Environment Service, Environment Canada

Velocities from a bistatic radar network, reflectivity, and near-surface index of refractivity are used to retrieve the 3D-wind field, pressure and temperature perturbations, humidity, and cloud contents. The refractivity index gives an improved representation of humidity and temperature structure near the ground. The assimilation of these measurements is performed with a variational method, where a model is used as a weak constraint. The model is based on Euler equations and the anelastic continuity equation, discretized on staggered grids. The model also uses Kessler bulk microphysics, which models the liquid water and cloud water contents.





4-C-4.1

Fortnightly modulations of the estuarine circulation in Juan de Fuca Strait Diane Masson<sup>1</sup> and Patrick Cummins<sup>1</sup>

Institute of Ocean Sciences

Freshwater discharge into the Strait of Georgia sets up a well defined estuarine circulation within Juan de Fuca Strait, the main outflow path to the ocean shelf. At the landward end of the strait, the water flows through a few narrow channels in which strong tidal flows are known to induce significant mixing of the water column. The spring-neap cycle in the tidal mixing modulates the estuarine exchange. To better examine the problem, a threedimensional prognostic numerical model has been developed to study the circulation around Vancouver Island, British Columbia. In a series of simulations, the estuarine circulation is established within Juan de Fuca Strait by the Fraser River fresh water discharge. The mixing over the various sills is then given a fortnightly modulation to simulate the spring-neap tidal regime. The resulting variation in the estuarine circulation is found to be limited to a small area downstream of the sills. Current meter data and salinity data from lighthouse stations are favourably compared with the model results. The effect of local wind on the estuarine exchange is also examined with model simulations which can simulate thoses rare events during which a concurrence of river freshet, neap tide and northwest wind allows a pulse of fresher surface water to escape into the eastern end of Juan de Fuca Strait. Finally, the effect of the fortnighly signal of the buoyancy forcing on the coastal current present on the continental shelf is found to be negligible.

4-C-4.2

Eddies in the Northeast Pacific Ocean William Crawford<sup>1</sup> and Frank Whitney<sup>2</sup>

<sup>1</sup>Canadian Hydrographic Service, <sup>2</sup>Institute of Ocean Sciences

In late August 1998 the Canadian Research Vessel J.P. Tully passed through the core of a 200-km wide, anti-cyclonic eddy along Line-P, at station 15, (49° 12.0′N 133° 40.0′W). Salinity and temperature profiles in this eddy showed it to be to be fresher and warmer than surrounding waters below 100-m depth. Above 100-m, both salinity and temperature were slightly lower. The sea surface in the core of this eddy was 0.3 m higher than outside the eddy. Nutrient levels in thermocline of this eddy were substantially higher than in surrounding waters. The ocean water type of this eddy matches that found off the West Coast of the Queen Charlotte Islands in winter (53°N 133°W). High-resolution images of TOPEX and ERS 2 satellite altimetry data show that this eddy, denoted Haida-1998, was indeed set up along the west coast of the Queen Charlotte Islands in February 1998, and drifted westward toward Bowie Seamount, then southward. In February 1999 it was centred near 47°N 135.5°W, with a surface elevation of about 0.2 m in its core.

Haida-1998 is one of an annual supply of anti-cyclonic eddies in winter from the Canadian and SE Alaskan shores into the Gulf of Alaska. About 3 to 5 eddies are set up in a typical winter, and provide a transport mechanism for fresh water, heat and nutrients from the coast into the deep oceanic waters west of Canadian shores. Based on calculations of dynamic heights of the 100 m surface relative to the 1000 m surface, using archived CTD data, the two of the largest eddies were Haida-1998, and Haida-1983, both generated in strong El Nino winters. This finding adds support to a recent numerical model study that suggests these eddies are larger in El Nino winters when northward, along-shore currents are stronger

The Haida eddies belong to the same class as the Sitka Eddies, found earlier in water property data to be set up off Sitka, Alaska. Although many eddies were created in these regions between the years 1994 and 1999, only Haida-1995 and Haida-1998 drifted southwards across Line-P. Others remained well to the north, and survived for periods of one to three years.

#### 4-C-4.4

Turbulent Mixing Studies in the Coastal Mixing and Optics Experiment Neil S. Oakey<sup>1</sup> and Blair J.W. Greenan<sup>1</sup>

DFO, Bedford Institute of Oceanography

For the first time diapycnal mixing has been studied simultaneously on the same length and time-scales using purposeful tracers and microstructure measurements. These measurements were done in the Coastal Mixing and Optics experiment on the continental shelf in the New York Bight area. Results were obtained in two field programs in the fall 1996 and the summer 1997.

Jim Ledwell of WHOI determined vertical mixing rates using a tracer which was tracked and measured using a towed fluorometer. Concurrently our group from the Bedford Institute of Oceanography measured diapycnal-mixing rates using a vertical profiler, EPSONDE, to obtain temperate gradient microstructure and turbulent shear, which we used by applying various mixing models. In the current paper we will compare these two very different techniques and explore the extension and application of mixing-models to be applied to mixing processes on the continental shelf.

#### 4-C-4.5

The impact of waves on ocean surface currents and ice floe drift William Perrie<sup>1</sup>, Charles Tang<sup>1</sup>, Yongcun Hu<sup>1</sup> and Brendan DeTracey<sup>1</sup> Bedford Institute of Oceanography

Typically, ocean models attempting to estimate the drift of ice floes on the Grand Banks and in the Labrador Sea involve wind fields and surface current models. For example, the current model by Tang and Gui (1996: JGR) and Tang et al (1996: JGR) is composed of currents driven by the sea surface slope, the surface Ekman flows and the geostrophic current. The Ekman current is estimated using the classical Ekman formulae in terms of the wind stress. In this study, we construct a second model for surface currents, using an operational WAM-type ocean wave model to estimate the impact of ocean surface waves on the Ekman currents. These are combined with the current components due to sea surface slope and geostrophy to given an enhanced estimation of surface currents, as well as ice floe trajectories and ice edge evolution.

Comparison of the surface currents, from these two models, is made with drifting buoy data from the recent Labrador Sea Deep Convection Experiment (LSDCE). We show that the wave-current effects are important and we obtain good verification of the wave-current model, particularly under strong wind conditions at positions near the shelf break. Wind fields used in this comparison were provided by CMC and have good overall agreement with in situ measurements obtained during LSDCE.





4-D-1.1

Antarctic Ozone Depletion Study Using A Photochemically Coupled Middle Atmosphere Model

Jean de Grandpré<sup>1</sup>, Darryl J. Chartrand<sup>1</sup>, Stephen R. Beagley<sup>1</sup> and John C. McConnell<sup>1</sup> York University

Middle Atmosphere Models (MAMs) coupled with photochemistry modules are powerful tools to study ozone trends and polar ozone depletion scenarios. These models represent a comprehensive approach allowing the inclusion of complex interactions between chemical, radiative and dynamical processes which is suitable to investigate long term ozone behaviour. However, there are also well known limitations to the capability of these models to reproduce the basic climatology of the middle atmosphere. For example, the understanding of the role played by gravity waves in such models is an important issue given its global impact on the strength and evolution of winter polar vortices. On the photochemical aspects, the basic representation of heterogeneous processes is also required to model an ozone climatology which is representative of the observed state in polar regions throughout the year. Nevertheless, with the development of parameterization schemes and heterogeneous photochemistry modules, such climate studies using MAMs can now be considered. In several cases, basic characteristics of the ozone annual and interannual behaviour can be reproduced with some success. The CMAM (Canadian MAM) has been used to investigate antarctic ozone hole scenarios. Results will show the capability of the model to represent the ozone hole evolution on a seasonal timescale. Studies on the potential impact of various forcing mechanisms involved will be addressed.

4-D-1.2

Sensitivity of modeled ozone depletion to Polar Stratospheric Cloud composition Darryl J. Chartrand<sup>1</sup>, Edna Templeton<sup>2</sup> and John McConnell<sup>2</sup>

Department of Earth and Atmospheric Science - York University, <sup>2</sup>EATS/York University

Heterogeneous reactions in and on stratospheric sulfate aerosols and polar stratospheric clouds are important in the photochemistry and ozone budget of the stratosphere. However, the exact nature of the formation and evaporation of solid water ice and nitric acid hydrates from/to background sulfate aerosols is still a largely unresolved question. These uncertainties will be reflected in the calculations of the heterogeneous reaction rates which affect ozone levels. At York we are using a 3D Chemical Transport Model with comprehensive stratospheric chemistry to test various parameterizations of heterogeneous chemistry in an effort to test the sensitivity of ozone levels to different modeling schemes. The processing schemes include reactions occuring on/in binary sulfate aerosols, super-cooled ternary solutions, NAT, and water ice surfaces. The model can be driven by GCM or forecast winds and temperatures.

4-D-1.3

Effect of the Pinatubo Aerosol Loading on Stratospheric Ozone as Modeled by Canadian Middle Atmospheric Model

Jonathan Jiang<sup>1</sup>, Darryl J. Chartrand<sup>2</sup>, Jean-Pierre Blanchet<sup>1</sup>, Stephen R. Beagley<sup>2</sup>, John McConnell<sup>2</sup> and Jean de Grandpré<sup>2</sup>

University of Quebec at Montreal, <sup>2</sup>York University

Pinatubo eruption provided an excellent opportunities to understand atmospheric processes by comparison of the theoretical atmospheric responses to the observed ones. Even though the eruption of Pinatubo occurred 8 years ago in June of 1991, many researchers suspect that the ozone losses during the past few years were at least partially attributed to this event. If this is indeed the case the effects may still be felt for many years to come.

The Canadian Middle Atmosphere Model (CMAM) and the SAGE II satellite data has being used to study how enhanced aerosols coupled with present-day chlorine and bromine loading directly and indirectly affect stratospheric ozone levels and distribution. The model includes important heterogeneous reactions occurring on sulfate aerosols. Also, the calculated water and ozone densities are fully interactive with the radiation and dynamical components of the model.

Our study reports results of the chemical and radiative response of a large volcanic eruption as recently modeled by CMAM. Preliminary assessment are focused on changes in important species such as NO2, N2O5, HNO3, CLO, CLONO2, HCL and HOx which are responsible for the changes in ozone column. We will also report a statistical assessment on our model results in comparison with a 10-year of CMAM averaged data.

## 4-D-1.4

Seasonal Evolution of Ozone-Methane Correlations in the Polar Regions David Sankey<sup>1</sup> and Ted G. Shepherd<sup>1</sup>
<sup>1</sup>University of Toronto

Correlations with long-lived chemical tracers are a way of eliminating short-term dynamical variability in the atmosphere. Plumb and Ko (1992) showed that a necessary condition to produce a compact correlation between two tracers is that the lifetimes of the tracers involved must be longer than the quasi-horizontal mixing time. A recent application of such correlations is that of Mueller et al (1996), who used the evolution of a measured relationship between ozone and methane in the Arctic polar vortex to quantify the Arctic ozone loss due to chemistry alone.

Their analysis assumes several things. One assumption is that a compact correlation exists when the initial measurement is made. This requires either that a correlation exists when the polar vortex is formed, which seems unlikely due to the short lifetime of ozone under sunlight conditions, or that a correlation forms in the early winter inside an isolated dark vortex. A second assumption is that a compact correlation is maintained even after the rapid destruction of ozone.

There are not sufficiently extensive simultaneous measurements of ozone and methane to determine whether a well-defined correlation exists. Therefore data from a comprehensive middle atmosphere GCM (the Canadian Middle Atmosphere Model) are used to provide a surrogate dataset. The validity of the Mueller et al. approach is first examined by considering the correlations between ozone and methane in the Antarctic polar vortex. The Antarctic provides an ideal environment for compact correlations to occur because the vortex is much more stable than in the Arctic. The results suggest that although there is no correlation between ozone and methane when the vortex is formed, there is sufficient time for one to form through early winter. The situation for the Arctic vortex is much less clear due to the lower stability of the vortex.

## 4-D-1.5

A New Lidar Technique for Measuring Molecular Nitrogen and Oxygen in the Upper Mesosphere and Lower Thermosphere

Mike Mwangi<sup>1</sup>, Robert J. Sica<sup>1</sup>, Stephen P. Argall<sup>1</sup> and Oleg Vassiliev<sup>1</sup>

The University of Western Ontario

The University of Western Ontario's Purple Crow LIDAR system is a monostatic lidar system which can simultaneously measure both Rayleigh and sodium-resonance-fluorescence backscatter. A technique has been developed to derive the number densities [N2(z)] and [O2(z)] in the upper mesosphere and lower thermosphere from the Rayleigh photocount altitude profiles and the sodium-resonance-fluorescence-temperature determinations. Since

Session 4-D-1 **Atmosphère** moyenne III Middle **Atnosphere III** Jeudi 3 juin Thursday, June 3 15h40 - 17h40 Salle / Room R-OM130



empirical and first-principle models of the upper mesosphere and lower thermosphere typically assume a fixed (or nearly fixed) mean molecular mass, knowledge of the absolute number densities of [N2(z)] and [O2(z)] are important for determining abundances and dynamical effects on important species such as odd oxygen. The number densities [N2(z)] and [O2(z)] were calculated in the altitude range 82-92 km for the night of May 21, 1998. The relative uncertainties in the profiles [N2(z)] and [O2(z)] range from 10-30% and 30-100% respectively. These results imply a mean [O2(z)]/[N2(z)] ratio 10% greater than expected from the MSIS model atmospere for that night. The LIDAR's detector system is currently being upgraded, and future profiles should have relative uncertainties one half the values in this pilot study.

4-D-1.6

MANTRA - A Balloon Mission To Study The Odd-Nitrogen Budget Of The Stratosphere Darryl J. Chartrand<sup>1</sup>, K. Strong<sup>2</sup>, M.R. Bassford<sup>2</sup>, J.R. Drummond<sup>2</sup>, P. Fogal<sup>3</sup>, John C. McConnell<sup>1</sup>, C.T. McElroy<sup>4</sup>, F.J. Murcray<sup>3</sup>, B. Quine<sup>2</sup> and B.H. Solheim <sup>5</sup>

Dept. of Earth and Atmospheric Science / York University, <sup>2</sup>Dept. of Physics, University of

Toronto, <sup>3</sup>Dept. of Physics, University of Denver, <sup>4</sup>Atmospheric Process Research Branch, Atmospheric Environment Service, <sup>5</sup>CRESTech, York University

The MANTRA (Middle Atmosphere Nitrogen TRend Assessment) balloon was successfully launched from Vanscoy, Saskatchewan on August 24, 1998, carrying a payload of scientific instruments to measure stratospheric composition. On September 2, after an unexpectedly long and eventful journey, the balloon and payload finally landed in Finland. The goal of the MANTRA mission is to investigate changes in the concentrations of stratospheric ozone and of nitrogen and chlorine compounds that play a role in ozone chemistry. More specifically, we are investigating possible causes for the lack of agreement between theory and observations of mid-latitude stratospheric ozone depletion. The payload included three instruments flown on balloons in the 1970s and early 1980s, along with three newer instruments, thus allowing a comparison between measurements obtained by the same instruments after an interval of 20 years, and a comparison between the old and new measurement techniques. Additional background atmospheric studies were conducted using ozonesondes, radiosondes, aerosol sondes, and ground-based observations by three optical instruments. The resulting data will be used to determine whether there have been long-term changes in the concentrations of those nitrogen compounds that indirectly control ozone destruction. If observed, such changes could help explain the unexpectedly large values of mid-latitude ozone depletion observed during the last two decades. This presentation will describe the MANTRA project, including the scientific objectives, as well as some preliminary modelling studies and data analysis.

## 4-D-2.1

Multiple Equilibria and Instrinsic Low-Frequency Variability in the Wind-Driven Ocean Circulation

Francois Primeau<sup>1</sup>

Scripps Institution of Oceanography

The internal non-linear dynamics of the mid-latitude wind-driven ocean is studied in the context of the classical double-gyre model similar to that of Munk or Stommel. Both stable and unstable time independent solutions are found by varying the models explicit frictional parameters and using Newton's method.

If the wind-stress is kept anti-symmetric, successive pairs of non-symmetric equilibria come into existence via symmetry-breaking pitchfork bifurcations as the model's viscosity is reduced. Successive pairs of mirror image equilibria have an additional half meander in the jet. The distinct energy levels of the steady state solutions can be understood in part by their different inter-gyre fluxes of vorticity. Those solutions with weak inter-gyre fluxes of vorticity have large and energetic recirculation cells which flank the seaward extension of the western boundary current in order that any excess vorticity can be removed through bottom drag. Those solutions with strong inter-gyre fluxes of vorticity on the other hand have much smaller and less energetic recirculation cells.

The multiple equilibria are found to exist in the range of frictional parameters which produces realistic flow fields. Even when the multiple equilibria are found to be unstable they appear to influence the model's time-dependent trajectory in phase space producing intrinsic variability at inter-annual and decadal time-scales. This low-frequency variability is associated with irregular transitions between distinct dynamical regimes. These regimes have flow fields and dynamical balances which, while being different among themselves are quite similar to those of the steady state solutions.

#### 4-D-2 2

Comparison between three finite element models and one finite difference model of the ocean

Frédéric Dupont<sup>1</sup>, Charles A. Lin<sup>1</sup> and David N. Straub<sup>1</sup>

Department of Atmospheric and Oceanic Sciences, McGill university

One possible development in oceanic modeling is to use finite element models (FEM) instead of the usual finite difference models (FDM) for solving the primitive equations for the basin scale oceanic circulation. FEMs have a more realistic representation of the boundaries and offer the possibilty of varying the resolution locally. FEMs are used operationally for regional coastal studies and global tidal problems but the accuracy of existing FEMs is still unknown when solving for the general oceanic circulation. We compare results from 3 different FEMs againt results from a C-grid FDM. They all solve for the shallow water equations in a square basin, beta plane and single gyre forcing. It appears that we cannot retrieve solutions of the FDM using the FEM for circulations on a beta plane. A possible explanation will be drawn investigating the FEM and FDM formulations and boundary conditions

## 4-D-2.3

Sea Level Variability in the Labrador Sea during the WOCE: Hydrography vs  ${\sf TOPEX/POSEIDON}$  Altimetry

Igor Yashayaev<sup>1</sup>, Guoqi Han<sup>1</sup> and John Lazier<sup>1</sup>

<sup>1</sup>Bedford Institute of Oceanography

Hydrographic observations across the Labrador Sea between 1990 and 1998 reveal large variations in the properties of the resident water masses. A series of severe winters in the early 1990s caused intense deep convection creating a homogeneous water mass in the upper





2000 m called Labrador Sea Water (LSW). Between 1988 and 1994 LSW became colder (by 0.6 C) and denser, resulting in a decrease of the steric height in the central Labrador Sea. Compared to 1990 (first occupation of the AR7W WOCE section) the steric height in 1994 was 4 cm lower. Since 1994, when the coldest water was found, convection has become gradually weaker leading to the coexistence of three versions of LSW. Between 1994 and 1998 the entire layer of the LSW warmed up by about 0.4 C. Though salinity increased during the same period, the layer became significantly less dense. This resulted in an increase of the steric height in the central Labrador Sea in the second half of the 1990s. The typical height in the spring of 1998 was about 6 cm higher than that in 1994 and reached the heights observed in the late 1960s, when the convection in the Labrador Sea is known to be weak.

TOPEX/POSEIDON altimeter data from 1992 to 1997 indicated a similar interannual variability of the sea surface height in the central Labrador Sea, with the lowest sea level in the western Labrador Sea in the winter of 1994, as observed in steric heights. The autumn sea level increased about 10 cm from 1993 to 1996. The change of the sea level in this season is the largest among the four seasons. The spring sea level in 1997 was approximately 5 cm higher than that in 1994, also consistent with the hydrographic observations.

We expect that the knowledge of interannual changes of the sea level in the Labrador Sea is important for understanding the relations between the processes in the Sea and the circulation of the North Atlantic.

4-D-2.4

Simple Light Dynamics Model to Investigate Particulate Organic Carbon Variability in Subarctic Pacific

Pavel Boubnov<sup>1</sup> and James Bishop<sup>2</sup>

University of Victoria, <sup>2</sup>E.O. Lawrence Berkeley National Laboratory, Berkeley, California

Marine photosynthesis is the dominant component of the oceans carbon cycle. Particulate organic carbon (POC) cycle in the ocean is the product of biological processes and its temporal and spatial dynamics is a good indicator of how the marine biogeochemical cycle responds to changes in physical environment. We have studied POC variability in Eastern Subarctic Pacific to elucidate the important components governing the production of carbon biomass. We have investigated, how the upper ocean POC values are related to the parameters affecting primary production, including mixed layer depths, availability of light, enhanced nutrient supply through local upwelling and upper layer temperature. The surface POC exhibits significant spatial variability from about 500 nmolC/l to 5000 nmolC/l, strong vertical POC gradient exists everywhere at the halocline. The values of 0-100 m integrated POC standing stock vary from 50 micromolC/m^2 to around 300 micromolC/m^2. The diurnal variability was roughly estimated to be at 10-12 mmolC/m^2.

We have built a simple model of particulate dynamics to investigate the main factors governing the shape of vertical POC profile. Results show that euphotic layer stratification and light availability are dominant factors. The overturn within the mixed layer leads to high light availability for marine biota which enhances photosynthesis and causes the POC values be high and quasi-uniform. Under the base of mixed layer, light availability declines to zero and grazing governs the sharp decrease of POC. The photic layer temperature is one of the most important factors governing the spatial variability of POC through both mixed layer depths shallowing and phytoplankton growth enhancement. Another factor is enhancement of nutrient supply through local upwelling.

4-D-3.1

An Interactive Aviation Weather Database (AWeD)

Marie-France Turcotte<sup>1</sup>, Richard Verret<sup>1</sup>, Vanh Souvanlasy<sup>1</sup> and Michel Baltazar<sup>1</sup>

Centre météorologique canadien

The aviation industry is heavily dependent on accurate and timely information on current and forecast weather conditions for flight planning and safety. The demand to have access to weather information quickly and in an intuitive and easily understandable fashion is ever increasing. Despite the demand and all technological and scientific progresses made in analyzing and forecasting atmospheric conditions, the content and format of aviation weather information have not significantly evolved from the traditional alphanumeric bulletins that are still in use nowadays. However, advancements in computer sciences and in numerical modeling of the atmosphere have brought forward the capability of responding to the demand. Numerical weather prediction models can ingest an ever- increasing amount of data from various sources and produce high-quality gridded forecasts in relatively short periods of time. Computers powerful enough are available at relatively low costs to process impressive amounts of information produced by the numerical models, and coming from other sources, and generate quickly, user tailored information products in graphical formats. Computer applications are available to build user friendly interfaces and make the information available on networks. This opens a whole era of new aviation weather products thus allowing a quick and intuitive understanding of actual and forecast aviation weather conditions

The interactive aviation weather database is the core component of an aviation weather display system to be used as a briefing-aid tool. The database includes gridded aviationimpact variables that can be interactively queried through a user-friendly JAVA based application. The driving model for the database is the operational Canadian Regional model. Variables are computed on the high resolution portion of the model's grid which covers all of Canada, adjacent waters as well as a significant portion of United States at a 24 km horizontal resolution, and every 1000 feet in the vertical from mean sea level up to 40 000 feet interpolated from the 28 sigma levels of the model, and at a 3- hour time resolution from zero to 48 hour projection times. The database is updated twice per day (00 and 12 UTC) in real time. In its current state the aviation weather database includes : temperatures, winds, icing, turbulence, cloud fraction, relative humidity, vertical velocity at all flight levels. It also includes: tropopause pressure and temperature, freezing level, total cloud cover, instantaneous precipitation rate at the surface and station pressure. The current icing algorithm is based on supercooled liquid water content forecast by the driving model. The turbulence algorithm is based on the deformation vertical shear index that involves horizontal and vertical derivatives of the winds. Real-time observation data, METAR, SPECI, FA, SIGMET, AIRMET and PIREP, are also incorporated in the database. Future programs will be developed to include graphical FA, satellite imagery, radar data, and others.

The AWeD database is made accessible on network through a users interface. This application allows the users to enter flight parameters, such as departure and arrival points, alternate airports, check points along the planned route, estimated elapse time of the flight and flight level. Series of meteorological products, all tailored to each particular flight, in plan view and/or vertical cross-section along the route can then be requested. It is the first known fully interactive system that can generate user tailored meteorological aviation products from a numerical model gridded database. A verification system is also under development as part of the database, in order to assess the reliability and performance of the different aviation impact variable algorithms.





4-D-3.2

Tornades non super-cellulaires dans le sud-ouest du Québec Pierre Vaillancourt<sup>1</sup>

<sup>1</sup>Météorologiste Senior, Centre Métérorologique du Québec

Depuis 1993, le radar doppler de l'Observatoire Météorologique J.S.Marshall(MRO) a été dopplérisé. Ce dernier couvre le sud-ouest du Québec et a permis la détection de signatures mésocycloniques caractéristiques de tornades.

En plus des cas classiques de tornades super-cellulaires, plusieurs autres cas ont été détectés sous des orages mineurs ou même des averses modérées. Cette présentation montrera un tel cas, tant du point de vue analyse de la situation synoptique que du point de vue de l'observation.

L'été 1998 a été particulièrement fertile dans ce genre de tornades et nous montrerons également un cas vue par le radar conventionnel de Villeroy (non doppler).

4-D-3.3

The COBEL 1D model as a component of the FAA's Marine Stratus Initiative at the San Francisco airport.

Robert Tardif<sup>1</sup>, Peter Zwack<sup>1</sup> and Sandra Turner<sup>1</sup>

Sciences de l'Atmosphère, Département des Sciences de la Terre, UQAM

The Federal Aviation Administration is funding a research & development team to develop nowcasting tools to predict the time of dissipation of marine stratus clouds in the approach zone of the San Francisco airport (SFO). The presence of these clouds within the San Francisco bay during the airport's morning rush causes important disruptions in the planned air traffic flow within the regional airspace. Thus more accurate forecasts of the time of burnoff (dissipation) of marine stratus would help enhance the air traffic management process.

The use of several techniques to undertake this particularly difficult forecast problem is privileged. The FAA has decided to use this multi-approach methodology based on the STRATUS prototype system developed in Canada. It is believed that a "consensus" forecast of various individual forecasts would provide more comprehensive results over a wider range of cases, than the individual forecasts themselves. The stratus burn-off concensus forecast will include information from an array of readily available and dedicated sensors, analysis tools, along with statistical adaptation techniques and dynamical forecast products.

Here, the contribution of a 1D numerical model producing dynamical forecasts of cloud water content is highlighted. A description of the model itself, and efforts currently underway at UQAM toward its adaptation to the SFO stratus forecasting problem will be presented.

Disclaimer: This research is in response to requirements and funding by the FAA. The views expressed are those of the authors and do not necessarily represent the official policy or position of the US Government.

4-D-3.4 COBEL André April<sup>1</sup> <sup>1</sup>UQAM

De mai a septembre se développe un grand anticyclone au dessus de la région du Pacifique Est. Pendant cette periode des nuages de type stratus maritime sont présents au dessus de l'aéroport de San Francisco et ont pour effet de reduire le taux d'atterrissage permis.

On utilise le modele COBEL auquel on a implanté un module de précipitation pour effectuer une prévision du moment de dissipation des nuages de type stratus maritime. On présente trois cas où les observations sont connues. Le module de précipitation combiné avec un estimé du mouvement vertical permet d'attéenuer considérablement l'ecart entre la prévision et les observations.

From may to september there is a great zone of high pressure on Est Pacific. There is too a marine stratus cloud at the airport of San Francisco. The presence of this cloud reduce the landing admit. We use the model COBEL with a rain module to make a forecast of the burn off of the clouds. The module of rain with one estimate of the vertical mouvement of the atmosphere permit to forecasting the burn-off. We use three case where the observation is know to study the situation.

## 4-D-3.5

Evaluation of COBEL nowcasts of stratus dissipation at San Francisco Airport Sandra Turner<sup>1</sup>, Robert Tardif<sup>1</sup> and Peter Zwack<sup>1</sup>

<sup>1</sup>Université du Québec a Montréal

Results obtained from 2 summers (May to October, 1996 and 1997) of nowcasts of s tratus burnoff in San Francisco airport (SFO) will be presented. The nowcasts ar e produced using the COBEL (Code Brouillard Eau Liquide) column model combined w ith enhanced local observations.

The COBEL model was originally developed in France for simulating the evolution of very stable boundary layers for forecasting the onset of fog. The model was o riginally initiated with a well mixed boundary layer (at the end of the afternoon) and was able to simulate the onset of nocturnal radiation fog and distinguish between fog and near fog. COBEL has now been modified to nowcast the dissipation of marine stratus.

The configuation of COBEL model in this study has very high vertical resolution or the order of 1 meter in the surface layer and 10 meters in and just above the cloud. A series of nowcasts are initiated every hour by assimilating local tem perature and remotely sensed cloud information to update the initial vertical pr ofile. A six hour forecasts requires 5 minutes of CPU on a modest modern sun wor kstation. Results for nowcasts for periods of 1 to 6 hours will be presented.

Disclaimer: This research is in response to requirements and funding by the FAA. The views expressed are those of the authors and do not necessarily represent t he official policy or position of the US Government.





Poster 1

A Neural Network Atmospheric Model for Hybrid Coupled Modelling Youmin Tang<sup>1</sup>, William Hsieh<sup>1</sup>, Benyang Tang<sup>1</sup> and Keith Haines<sup>2</sup>

Oceanography/EOS, University of British Columbia, <sup>2</sup>Department of Meteorology, The University of Edinburgh

The possibility of using a nonlinear empirical atmospheric model for hybrid coupled atmosphere-ocean modelling has been examined with a neural network (NN) model for predicting the contemporaneous wind stress field from the upper ocean state. Upper ocean heat content (HC) from a 6-layer ocean model was a better predictor of the wind stress than the (observed or modelled) sea surface temperature (SST). Our results showed that the NN model generally had slightly better skills in predicting the contemporaneous wind stress than the linear regression (LR) model in the off-equatorial tropical Pacific and in the eastern equatorial Pacific. When the wind stresses from the NN and LR models were used to drive the ocean model, slightly better SST skills were found in the off-equatorial tropical Pacific and in the eastern equatorial Pacific when the NN winds were used instead of the LR winds. Better skills for the model HC were found in the western and central equatorial Pacific when the NN winds were used instead of the LR winds. Why NN failed to show more significant improvement over LR in the equatorial Pacific for the wind stress and SST is probably because the relationship between the surface ocean and the atmosphere in the equatorial Pacific over the seasonal time scale is basically linear.

Poster 2 TORNADO SIMULATION: Environmental effects Jose Vergara<sup>1</sup> and Ferdinand Baer<sup>2</sup> <sup>1</sup>Universidad de Chile, CHILE., <sup>2</sup>University of Maryland, USA.

Several authors have shown, from field observations that environmental conditions can have a significant impact on the determination of the final tornado intensity. These studies show that violent tornadoes (F4/F5) are associated with intense large scale vertical shear. Small tornadoes (FO/F1) are more dependent on a convective parameter, for example convective available otential energy (CAPE) or surface lifted index. In the following study, the development of the tornado-like vortex is studied for different values of two key parameters: the lower level wind shear (surface to 3000 meters) and the surface lifted index. Emphasis is placed on these two large-scale parameters, which are easily calculated in operational work. These features were not included on the past numerical simulations. The following results will show, a clear and unambiguous demonstration of the importance of the environmental parameters to define the tornadoes evolution. The authors are interested to explore the impact of the environmental lower level shear on tornado/parent cloud evolution, because the observational evidence supports the idea that moderate and strong tornadoes are frequently evolved in the presence of environmental wind shear. Therefore, it is obvious that modifications of these environmental parameters would introduce major effects on the dynamics of the tornado/parent clouds. New information on this question would be extremely important for potential forecasts of tornado intensities. Tornado dynamics in a moist unstable convective atmosphere was studied as an initial value problem using a three-dimensional, nonlinear, fully compressible cloud model. The primary goal of the present work was to extend the previous studies on tornado numerical simulations using a model which explicitly resolves both the cloud and the tornado features. The development of the tornado/parent cloud is studied for different values of two key environmental parameters: the lower level wind shear (surface to 3000 meters) and the surface lifted index. Emphasis is placed on these two large-scale parameters, which are easily calculated in operational work. Four idealized atmospheres are generated for the simulations. These four cases included two different lifted index values and two different lower level shear values. All of the four simulations were initialized with a simple Rankine vortex. These experiments demonstrate the importance of the environmental conditions in influencing the dynamics of the evolving vortex/parent cloud and, in particular, the evolution of suction vortices. The most remarkable effect of the lower level wind shear is the modification of suction vortex structure. For lower level shear, a symmetric solution of three suction vortices rotating around a common center is developed, in contrast to the large lower level wind shear experiments, where the solution evolved to a small number of suction vortices. One suction vortex is the most common solution of the shear experiments and rotates around the common center. The writer believes that these effects are important in order to define the final intensity of the simulated tornado. Finally we believe this work demonstrates that simulation of phenomena of the type presented here is computationally feasible with minimum simplification of the original set of equations. However, much higher numerical resolution is required to solve the complete solution of the suction vortex dynamics and the correct determination of the intensities of the simulated tornado. Obviously with the increased of the computing technology, phenomena liketornadoes will be modelled in the future inexpensively in a much more realistic scenario that includes the storm scales. The model presented in this work could be one attractive choice on these cases. A version of our abstract, including animations, is available on the internet:

http://www.dgf.uchile.cl/~jvergara/conf/CMOS99A.html

Poster 3

Ash Forecasting Event over Western Canada 98-7-11: Forensic Study and Operational Response

Ken Little<sup>1</sup> and René Servranckx<sup>2</sup>

<sup>1</sup>Mountain Weather Services Office, Environment Canada, <sup>2</sup>CMC, Environment Canada

At approximately 2200 UTC 10 July 1998, an aircraft over southwestern British Columbia reportedly was forced to divert around a volcanic ash cloud. A pilot on the aircraft, flying at approximately 31 thousand feet was quoted as saying "I have not seen anything like this since Mount St. Helens erupted". Immediately thereafter, an investigation commenced to determine the source of this cloud; concurrently, SIGMET messages were issued and emergency response procedures activated.

The event is chronicled, with an emphasis on the SIGMET messages and the various real-time reports. Backward and forward trajectories are used to demonstrate the probable source of the suspected ash cloud as well as its forecast motion, respectively. It will be shown that this ash travelled for several days over the Pacific Ocean before being reported over British Columbia. Satellite imagery and trajectories are examined to determine if this ash could have been detected prior to its arrival over the busy airways of western North America. Finally, the operational response and impact on the aviation industry will be assessed with specific reference to the challenge of effective warning of an ash event from an unknown or unconfirmed source.

## Poster 4

Coupled Modelling of Local Climate and Peatland Ecosystem: the Contemporary Variability of Carbon Exchange in the System

Bing Ouyang<sup>1</sup>, Jean-Pierre Blanchet<sup>2</sup> and Nigel Roulet<sup>3</sup>

<sup>1</sup>McGill University, <sup>2</sup>Département des Sciences de la Terre, Universite de Quebec a Montreal, <sup>3</sup>Centre for Climate and Global Change Research, McGill University

Canada has three ecosystems that could have a significant effect on carbon cycle within the earth system if their present carbon balance were altered by climate change. These are the boreal forest, the tundra and northern peatlands. Much empirical and modelling work is ongoing to determine the role of the boreal forest and tundra ecosystems, but little work has been undertaken on peatlands, even though they have a greater potential to alter the global





carbon balance. Over the last 6,000 to 10,000 years northern peatlands have accumulated atmospheric carbon in the form of peat soil at rates between 20-30 gC/m2/yr, and the contemporary sink for CO2 in peatlands represents 0.1 Gt C/yr. Approximately 0.05 Gt C/Yr of this occurs in Canadian peatlands. Peatlands are a relatively small sink in the global carbon budget, but their significance lies not in their contemporary sink, but in the latent store of carbon they represent. Approximately 450 Gt C is stored in peatlands, or 30-35% of the world's soil carbon pool. This store has resulted from the persistent sink of carbon in the form of partially decomposed plants and the maintenance of this carbon store is directly related to climate. Sponsored by NSERCC, the objective of the research is to couple a local climate model (LCM) with a peatland carbon simulator (PCARS) in order to assess the sensitivity of the carbon store in northern Canadian peatlands to various past, present and future climate scenarios. The LCM is based on the Canadian Climate Centre's General Circulation Model (CCC-GCM) physics and includes the Canadian Land Surface Scheme (CLASS). The LCM physics is driven by GCM archives or real climate observations using long series of 12-hourly radiosonde data. Its 20 minutes time step and 10-30 layers of resolution simulate all atmospheric processes except for advective transport of the GCM. Within LCM, CLASS provides the surface heat and moisture exchanges that result in a surface water and heat budget of a peatland. These budgets then provide the physical variables to drive the carbon simulator. PCARS is an ecological process model based on three components: net primary production, fast decomposition (upper aerobic zone) and slow decomposition (lower anaerobic zone) respectively. Soil climate (moisture and thermal regimes) and the surface energy and radiation fluxes are input from CLASS. There are 20 fine layers divided in soil profile of PCARS for the calculation of organic carbon decomposition at different rates. The output from PCARS is net sequestration or loss of carbon in peatland ecosystem with a daily time step. The LCM-CLASS-PCARS is being coupled and validated against observations especially the interannual variability of contemporary carbon exchanges and climatic conditions. At the present and as a preliminary result, LCM is forced using 30 years records of radiosonde data from upper atmospheric stations situated near major peatland regions of Canada. This simulation provides a simulated data set from which the contemporary variability of carbon exchange can be assessed beyond the 3.5 years data set that will be produced from measurements of net ecosystem exchange.

Poster 5 Volcanic Ash Advisory Centres: Roles And Challenges René Servranckx<sup>1</sup>, Peter Chen<sup>1</sup> and Ken Little<sup>1</sup> <sup>1</sup>Canadian Meteorological Centre, Environment Canada

Volcanic ash is a major threat to aviation. In response to this threat, the International Civil Aviation Organization (ICAO) has implemented the International Airways Volcano Watch (IAVW) in collaboration with the World Meteorological Organization (WMO). Many agencies and players collaborate in this effort. The objective is to provide real-time support and operational response to the aviation community. As part of this effort, Volcanic Ash Advisory Centres (VAACs) have been designated to:

· Forecast the motion and dispersion of the volcanic ash plume · Locate the volcanic ash clouds through the use of satellite data and other means · Prepare and distribute advisory messages for Air Traffic Controls, Meteorological Watch Offices, etc.

Among the issues and challenges facing the VAACs:

Scientific issues:

 $\cdot$  Eruptions parameters are largely unknown in real time  $\cdot$  Volcanic eruptions are often hard to detect  $\cdot$  Volcanic ash in the atmosphere is not readily identified  $\cdot$  Assimilation of plume

data for forecast models is not yet done  $\cdot$  Concentrations at which volcanic ash becomes a threat to aviation are not known  $\cdot$  Defining criteria to do volcanic ash model forecast comparisons

# Operational issues:

· Avoiding conflicting information between VAACs and MWOs messages · Ensuring consistency of units (latitude, longitude, distances, etc.) in the messages · Finding ways to make the VAAC forecasts charts and messages available as quickly as possible · Need for VAACs to backup one another and to test / compare models in real-time · Coordination between the VAACs / MWOs and 'hand off' procedures are key elements Should default scenario(s) be used to run the volcanic ash forecast models?

## Conclusion

These issues and challenges are all important in determining the ability to alert rapidly and to deliver timely and reliable advice. Finding and implementing solutions to these will require time, effort and international collaboration. Already, we all benefit from long standing close working relationship among various players, agencies and stakeholders around the world with keen interest in the volcanic ash problem. While much work remains to be done, it must be recognized that great advances have been made in this area over the last few years thanks to the work and collaboration of many groups.

#### Poster 6

Coupled Atmosphere-Ice-Ocean Forecasts in the Gulf of St. Lawrence François Roy<sup>1</sup>, Pierre Pellerin<sup>2</sup>, François J. Saucier<sup>1</sup>, Joël Chassé<sup>1</sup> and Harold Ritchie<sup>2</sup>
<sup>1</sup>Ocean Science Division, Maurice-Lamontagne Institute, <sup>2</sup>Recherche en Prévision Numérique, Environment Canada, 2121, North Service Road

In winter, the mean thickness of sea ice in the Gulf of St. Lawrence can reach over 30 cm. In a 48-hour period, winds and currents can produce ice drifts of up to 100 km and create pressure ridges that impede navigation. We present 48-hour forecasts of ice concentration and thickness. Ice conditions are modelled using a 3D coupled ice-ocean model applied to the Estuary and Gulf of St. Lawrence with a 5 km lateral resolution. The 3D ocean model from Stronach et al. (1993) is coupled to the Multi-category Particle-In-Cell sea ice model from Flato (1994). Momentum and heat exchanges are modelled using quadratic drag forms and heat transfer equations from Parkinson and Washington (1979). Boundary forcing includes tides, winds, and river inflows. The results are compared with daily ice charts produced by the Canadian Ice Services, drift measurements from ice beacons, and drift analyses from successive RADARSAT images. Daily forecasts for the winter of 1997 are presented. Thermodynamic effects are first neglected and winds are produced by the atmospheric model GEM applied with a 35 km lateral resolution. Results from 52 forecasts show a mean error of -0.3 cm for ice thickness, -9% for ice concentration, 0.3 cm/s for ice velocity, and 39° for ice drift direction. We focus on March 13, 1997, when strong winds from the NW produced large drifts and the formation of thin ice in the northern Gulf. The addition of ice thermodynamics shows the stabilizing effect of ice growth on deformation and an improvement in coastal ridging modelling. The ice-ocean model's response to an increase in wind resolution is examined by applying the atmospheric model with a 10 km resolution. Finally, results are shown from a preliminary simulation where the atmospheric and ice-ocean models are fully coupled for momentum and heat.





#### Poster 7

Intégration des méthodes géophysiques et géotechniques pour le calcul du volume des sédiments de la couche de 1996 dans la Baie des Ha! Ha!

Pierre Côté<sup>1</sup>, France Maurice<sup>1</sup>, Édouard Kammerer<sup>2</sup>, Philip R. Hill<sup>3</sup>, Jacques Locat<sup>1</sup>, Peter Simpkin<sup>4</sup>, Bernard Long <sup>5</sup> and Serge Leroueil<sup>6</sup>

<sup>1</sup>Département de géologie et de génie géologique de l'Université Laval, <sup>2</sup>Ocean Mapping Group, Université du Nouveau-Brunswick, <sup>3</sup>Université du Québec à Rimouski, <sup>4</sup>IKB Technologies Limited, <sup>5</sup>INRS-Géoressources, <sup>6</sup>Département de génie civil, Université Laval

Les pluies torrentielles de juillet 1996 ont acheminé vers le fjord du Saguenay une quantité impressionnante de sédiments. Les premières estimations ont fait état d'une déposition de plus de six millions de tonnes de matériel qui a recouvert les sédiments contaminés de ce secteur. Plusieurs missions scientifiques ont permis d'amasser de nouvelles données permettant de vérifier cette quantité.

Plus de soixante échantillons ont été prélevés à l'aide d'un carottier à boîte et d'un échantillonneur Lehigh lors de missions scientifiques réalisées en 1997 et en 1998. L'analyse des profils géotechniques et des images prises au scanner a démontré que la couche de 1996 a une épaisseur qui varie de 0,60 mètre à 5 mètres dans la zone deltaïque de la Baie, et de 0 à plus de 60 centimètres dans le reste de la Baie des Ha! Ha!. L'acquisition de données géophysiques a permis de combler le manque d'informations concernant l'épaisseur de la couche en plusieurs zones critiques où des carottages n'ont pas été faits, particulièrement près des embouchures (levés multifaisceaux). Pour compléter l'évaluation, l'acquisition de plus de 200 kilomètres de profils de sismique-réflexion à l'été 1998 ont facilité l'interprétation de l'épaisseur de la couche de 1996 entre les points d'échantillonnage. La compilation de l'ensemble de ces données a permis de déterminer l'épaisseur de la couche de 1996, modélisée à l'aide d'un logiciel de contours de carte et de représentation en trois dimensions. Les valeurs calculées seront comparées aux volumes estimés par les analyses terrestres.

#### Poster 8

Geochemical And Micropaleontological Tracers Of Fast Sedimentological Events And Of Recent Environmental Conditions In The Saguenay Fjord, Canada Guillaume St-Onge<sup>1</sup>, Guy Bilodeau<sup>1</sup>, Anne de Vernal<sup>1</sup>, Rodolphe Devillers<sup>1</sup>, Claude Hillaire-

Marcel<sup>1</sup>, Julie Leduc<sup>1</sup>, Virginie Loucheur<sup>1</sup> and Sylvain Marmen<sup>1</sup> GEOTOP

A 2-m core from the interior bassin of the Saguenay Fjord (48°21.77′N-70°23.72′W; water depth: 270 m; cf. SAG-30) was analysed for its  $C_{org.}$ ,  $C_{inorg.}$  and N contents,  $^{13}C$  and  $^{15}N$  contents of organic matter as well as for its microflora and microfauna (foraminifera, diatoms, dinocysts, pollen, spores etc.). The studied sequence spans approximatively 330 years. One major objective of this study was to determine the characteristics of exceptional sedimentological layers deposited after earthquakes, floods and landslides. The core was subsampled at 10 cm intervals. Geochimical and micropaleontological data depict an epicontinental environment with prominent terrigenous inputs.  $\delta^{13}$ C values are lower than -25.7% and  $\delta^{1.5}$ N values vary between 4.3 and 2.9%. Organic-walled microfossils primarily include foraminifera linings, pollen grains and Pteridophyte spores and vary between 10<sup>2</sup> and 10<sup>3</sup> linings, grains or spores/cm<sup>3</sup>. However, foraminifera tests are rare (0-3 tests/cm<sup>3</sup>). The overall abundance of benthic foraminifera linings suggests a significant benthic production, whereas the rarity of their shells provides evidence for diagenetic CaCO<sub>3</sub> dissolution. Diatom valves are abundant (10<sup>6</sup> valves/cm<sup>3</sup>). Three lithostratigraphic units are defined and likely represent major changes in the sedimentary dynamics. The bottom unit (below 75 cm) reveals high terrigenous inputs characterised by low  $\delta^{13}$ C and  $\delta^{15}$ N values (< -26.5% and < 3.5%, respectively), high C/N ratios (> 20) and the presence of detrital carbonates ( $\sim 3\%$ ). It also

depicts low marine microfossil concentrations. This unit is tentatively assigned to the 1663 earthquake. The second unit (75-55 cm) is characterised by high sand contents and increasing marine productivity indicators matching decreasing terrigenous inputs. This unit either represents a mixed layer between the underlying unit and the overlying unit, or records progressive environmental changes. The upper unit (55-0 cm) consists of hemipelagic sediments with high  $C_{\rm org.}$  contents (up to 2%), high  $\delta^{13}C$  and  $\delta^{15}N$  values ( $\sim$  -26% and  $\sim$  4%, respectively), low C/N ratios (16 to 20) and high marine biogenic inputs. The high diversity of the dinocyst assemblages and the high concentration of diatoms in this unit reveal both autotrophic and heterotrophic planktic productions. Finally, palynological data, from 30 cm to the surface, respond to the progressive anthropic deforestation since the 1663 earthquake.

#### Poster 9

Diagenetic evolution of accidental layers (floods, earthquakes, landslides) in the Saguenay fjord (QC) based on short lived isotopes (228Th, 210Pb, 137Cs) profiles in box-cored sediments

Josée Savard<sup>1</sup>, Bassam Ghaleb<sup>1</sup> and Claude Hillaire-Marcel<sup>1</sup> GEOTOP-UQAM

The present study aims at determining the temporal evolution of layers deposited during exceptional events (landslides, floods, seismic events) and which are frequently reported in Saguenay Fjord sedimentary sequences. One major objective is to assess the efficiency of postdepositional mechanical mixing of such layers, by bioturbation, as a function of the origin and their thickness of the layers, thus to assess their potential role as capping layers for the underlying anthropogenically contaminated sediments. Two box-cored collected in 1997 were used for this study. One was raised from the mouth of the Baie-des-Ha!Ha! (Sag-15: Lat. :48°21,74'N, Long. :70°42,30'O, Longueur : 52cm); a second, from the Bras Nord (Sag-5 : Lat :48°25,40'N, Long. :70°51,57'N, Longueur : 38cm). The short lived isotopes used include 228Th, 210Pb and 137Cs (with half-lifes of 2, 22 and 30 years, respectively). They were analyzed at 1cm-intervals by alpha counting (228Th and 210Pb through 210Po) or gamma counting (137Cs). At Sag-15, lead-210 data suggests a sedimentation rate of about 0,5 cm/year. The layers deposited during exceptional events include, on the top of the sequence, a 5cm-thick unit can be assigned to the 1996 flood. Below, a seismic unit linked to the 1988 seismic event and a layer assigned to the 1971 Saint-Jean-de-Vianney landslide are also still clearly seen. These layers are characterized by negligible 210Pb-excesses, low 137Cs contents, and near equilibrium 228Th/232Th activity ratios. At Sag-5, lead-210 data suggests higher sedimentation rates than Sag-15 (~ 0,8cm/year). The 1996 flood layer is also much thicker (~10cm at the top of the sequence), and the Saint-Jean-de-Vianney layer seems still to be preserved. Here also, these layers are characterized by negligible 210Pbexcesses, low 137Cs contents, and near equilibrium 228Th/232Th activity ratios. Two years after its deposition, the 1996 flood layer shows minimum mixing of its upper and lower limits, but the older layers representing exceptional events all show some smoothing of their upper and lower boundaries. Longer cores to be collected in 1998 will be used to document the evolution of such layers at greater time scales, and a larger set of box-cores will allow to document the effect of their thickness and organic carbon content on mixing processes.

## Poster 10

Effets de la bioturbation sur les caractéristiques géotechniques de la couche de 1996 dans la Baie des Ha! Ha! et dans le Bras Nord du fjord du Saguenay (Québec, Canada)

France Maurice<sup>1</sup>, Jacques Locat<sup>1</sup>, Serge Leroueil<sup>2</sup>, Priscilla Desgagnés<sup>1</sup>, Francis Martin<sup>1</sup>, Rosa Galvez-Cloutier<sup>2</sup> and René Therrien<sup>1</sup>

Département de géologie et de génie géologique, Université Laval, <sup>2</sup>Département de génie civil, Université Laval





Le déluge de 1996 au Saguenay a entraîné la sédimentation rapide de plusieurs tonnes de matériel dans la Baie des Ha! Ha!. Ces sédiments ont été déposés sous forme de turbidite et recouvrent des sédiments fortement bioturbés. Soixante échantillons prélevés au carottier à boîte à l'été 1998 ont été analysés afin de déterminer les caractéristiques géotechniques de la couche de 1996, et afin d'analyser les effets de la recolonisation benthique sur les sédiments.

Dans la Baie des Ha! Ha! et dans le Bras Nord, on retrouve des échantillons bioturbés et peu ou non-bioturbés. Typiquement, les carottes prélevées dans la Baie des Ha! Ha! ont en surface une mince couche (quelques mm) de sédiments post-1996, puis une couche de 5 à 45 centimètres de sédiments de 1996 non ou peu bioturbé et granoclassé (silt-argileux à sableux). Le sédiment pré-1996 est fortement bioturbé et possède une granulométrie fine (argile). En surface, les résistances au cisaillement intact et remanié ont de faibles valeurs (0,1 kPa) et augmentent régulièrement avec la profondeur. L'indice de liquidité varie entre 1 et 4 de la surface vers la base de la couche 1996 et l'indice de plasticité varie entre 17% et 52%. Les limites plastique et liquide varient respectivement de 22% à 46% et de 31% à 97%.

Dans le Bras Nord, la bioturbation s'est développée plus rapidement que dans la Baie des Ha! Ha!: dans les zones fortement bioturbées, la couche de 1996 est plus difficile à identifier. Les profils de teneur en eau, de résistance intact et d'indice de liquidité sont inversés par rapport à un profil géotechnique typique d'une turbidite. Les valeurs de résistances au cisaillement intact varient de 0 à 5 kPa (du bas vers la surface) dans les secteurs bioturbés.

Les profils d'indice de liquidité de terrain sont comparés à des courbes de laboratoire obtenues par des essais SEDCON. Ces essais permettent d'obtenir une courbe de référence applicable à une mise en place rapide des sédiments. Des images prises au microscope électronique à balayage montrant la microstructure du sédiment bioturbé et non-bioturbé sont présentées et permettent d'observer l'effet des organismes benthiques sur le comportement mécanique du sédiment de 1996.

## Poster 11

Seasonal and Spatial Variations in Thorium Isotope Composition of Suspended Particulate Matter in the Saguenay Fjord (Canada)

Deke Zhang<sup>1</sup>, S. Alpay<sup>2</sup>, Claude Hillaire-Marcel<sup>3</sup>, Bassam Ghaleb<sup>3</sup> and Alfonso Mucci<sup>2</sup>
<sup>1</sup>University of Quebec at Montreal, <sup>2</sup>Department of Earth and Planetary Sciences, McGill University, <sup>3</sup>Geotop Center, University of Quebec at Montreal

Thorium isotope activities (232Th, 230Th, 228Th and 234Th) were measured on suspended particulate matter (SPM) sampled in June and October 1997 from the halocline (S=18-22) at four stations along the main axis of a well stratified estuarine system, the Saguenay Fjord. SPM was concentrated from 450-500 litre samples by collecting the retentate of tangential filtration on a 0.45 micron cartridge. The main source of detrital particulate matter to the fjord is upstream in the Saguenay River and its headwaters, although authigenic particles are also produced in the water column. Both datasets (i.e., for June and October) show systematic increases in Th downstream. At least part of this enrichment in Th isotopes is related to the higher abundance of fine particles downstream. Laser particle counting supports this conclusion.

However, when normalized to 232Th activities (e.g., from  $\sim 1.5$  to 2 dpm/g in June), relative enrichments in 228Th and 234Th are observed downstream (with activities from  $\sim 2$  to 4 dpm/g for 228Th and  $\sim 30$  to 70 dpm/g for 234Th in June). The relative enrichments in 228Th and 234Th indicate enhanced scavenging downstream of both isotopes, which are respectively produced by 228Ra and 238U dissolved in the water column. In contrast, 230Th

activities, relative to those of 232Th, decrease slightly downstream, although absolute 230Th activities increase downstream. This may be interpreted as a depletion of 230Th in the fine-grained particles relative to the coarser fraction, possibly inherited from soil processes before erosion and transport to the fjord.

A strong seasonal contrast has also been observed. From June to October, the Th isotope activities increased by a factor of nearly 2 and were slightly higher downstream. Finer SPM and higher scavenging rates or longer transit times of SPM in October could be responsible for this seasonal variation. The continuous increase in 234Th activities suggests that the transit time for SPM is short, possibly of the order of the residence time of freshwater in the fjord (6-8 days or less based on other studies).

### Poster 12

Distribution of benthic foraminifera in surface sediments of the Saguenay fjord, before and after the flood of 1996.

Julie Leduc<sup>1</sup>, Guy Bilodeau<sup>1</sup>, Anne de Vernal<sup>1</sup>, Alfonso Mucci<sup>2</sup> and Patrick Poulin<sup>1</sup> GEOTOP-UQAM, <sup>2</sup>McGill-Earth and Planetary Sciences

Micropaleontological analyses were carried out on surface sediments (0-1 cm depth interval) sampled from box cores recovered in the early nineties (1990 and 1994; before the 1996 flood) and every year following the flood at four stations situated along the main axis of the Saguenay fjord. These analyses served to evaluate the impact of the flood deposits on the abundance and composition of the benthic microfaunal community as well as to estimate the rate of recolonization. Benthic foraminifera are extremely sensitive to variations in physicochemical conditions at the water-sediment interface and, thus, are good indicators of changing environmental conditions (Schafer et al., 1991).

The analyses of the samples revealed a weak diversity of the benthic foraminifera population in the surface sediments of the Saguenay fjord. Agglutinated species, such as Textularia earlandi, Adercotryma glomerata, and Labrospira crassimargo dominate all the assemblages. Only a few tests of calcareous shells of foraminifera were found. A total of 14 species of benthic foraminifera were identified at the 4 stations, and very low concentrations, ranging from 0,5 to 52 tests/cm3, were recorded. Finally, a few tests of planktonic foraminifera and thecamoebians were occasionnally found.

The 4 surface samples collected before the 1996 flood contain a total of 7 species of foraminifera. The majority are agglutinated tests of benthic foraminifera of which T. earlandi is the dominant specie. The total concentrations vary between 2 to 52 tests/cm3. The surface samples collected after the 1996 flood contain similar assemblages with respect to species diversity. However, the abundance of shells in the sediment is much lower (ranging from 0,5 to 15 tests/cm3) as a result of dilution by the rapid sedimentary inputs from the flood. At the upstream site, St-Fulgence station, shell of thecamoebians were observed. They probably originate from wetlands or freshwater environments of the drainage basin and were subsequently transported with the flood material.

According to the preliminary results, it seems that the sudden sedimentary influx of flood material had a major impact on the benthic foraminifera populations inhabiting the upstream part of the fjord, where the flood deposits are thickest. In this impacted area, annual monitoring of the benthic foraminifera populations will provide an insight on the rate of recolonization of the sediments.

Palynological analyses, performed on sediment samples of the seaward station revealed the presence of abundant organic linings of benthic foraminifera (as high as 30,000 organic linings/cm3) (St-Onge et al, submitted). These high concentrations, in contrast to the low





number of calcareous shells, suggest that dissolution of calcium carbonate occurs in the surface sediments of the Saguenay fjord. In order to reconstitute the original populations of benthic foraminifera, a systematic study was initiated to associate the tests of benthic foraminifera to their respective organic linings.

### Poster 13

Integration Of UHF Profiler Information With Bistatic Radar Measurements Pascal Guillemette<sup>1</sup> and Isztar Zawadzki<sup>1</sup>

Department of Atmospheric and Oceanic Sciences, McGill University

The McGill/OU Bistatic Radar Network provides Doppler velocity measurements from three different points of view allowing a three dimensional wind field retrieval. Because the receivers are looking at low elevations, the vertical component of the wind is poorely sampled. The vertical velocity is mainly obtained by integration of the continuity equation with great associated uncertainty. The retrieval can be improved by measurements taken by a vertically pointing Doppler radar.

In this work, we study the impact on the reconstruction of the wind field when a UHF wind profiler information is used as an additional constraint along with bistatic measurements. Experiments were done with a synthetic wind field to study how the information of the profiler can be integrated and how it is propagated. These experiments show significant improvement of the retrieved vertical motion. Consequently, the algorithm for the retrieval of the 3-D wind has been modified to combine the UHF information with the bistatic network.

### Poster 14

Climatologie des précipitations liquides dans la région de Montréal en utilisant un réseau de pluviomètres et à l'aide de la détection radar.

Marc Besner<sup>1</sup>

Env. Canada Div. des sciences atmosphériques et enjeux environnementaux

Une des plus importantes variables à connaître et à prévoir en hydrologie et en météorologie est le champ des précipitations. Une connaissance de la distribution spatiale des précipitations est donc utile pour des domaines reliés à la modélisation hydrologique et météorologique à des fins de prévisions, d'analyses et de vérifications. Les champs de précipitations estimés à l'aide d'un réseau de pluviomètre au sol ne parvient pas toujours à bien représenter la variabilité spatiale et temporelle des précipitations. Afin d'évaluer la climatologie des précipitations liquides dans la grande région de Montréal, des analyses simultanées de deux types d'informations sur les précipitations liquides ont été effectuées: 6 mois de données horaires pluviométrique de surface et les données radar provenant de l'observatoir J. Stewart Marshall de l'université McGill à Sainte-Anne-de-Bellevue.

La transformation des champs de réflectivité radar en taux de précipitations ne fournit malheureusement pas toujours un image réel du patron de précipitations. Différents facteurs sont responsables de la discordance entre le champ de précipitations réel et celui estimé par la technique radar. De plus, les sources d'erreurs peuvent varier de façon spatiale et temporelle. L'information radar consiste en des champs de réflectivité détectés à un niveau constant, transformés par une relation Z-R et accumulés sur des périodes horaires. Différentes procédures sont appliquées aux champs horaires pour caractériser la région couverte par le radar (rayon de 120 km) selon un mode de précipitations ou, de non précipitations. En mode de précipitations, on applique des critères sur la taille et l'intensité des zones de précipitations afin de faire un suivi spatial et temporel pour filtrer les zones pouvant fausser l'estimation radar (exemple les échos de sol ou la propagation anormale du signal radar). Des résultats préliminaires sont présentés avec comme objectif d'utiliser l'information radar pour la modélisation hydrologique ainsi que pour des applications climatologiques.

Poster 15

Updates To The Mcgill Rapid (Radar Data Analysis, Processing And Interactive Display) System.

Aldo Bellon¹ and Alamelu Kilambi¹

McGill Weather Radar Observatory

In our poster presentation, we will be illustrating three recent additions to our RAPID system that is in real-time operation at the Montreal Weather Office.

1) Rainfall accumulation correction using vertical profiles of reflectivity

Vertical profiles of reflectivity for 5 range intervals 20 km wide from 10 to 110 km are displayed every 5 minutes with the CAPPI maps used as input to the rainfall accumulation module. The intensity, height, depth of influence and range variability of a bright band, if present, are clearly revealed as are the characteristics of any other precipitation type like low level growth, virga, convection or snow. The accumulation module also integrates all the 5-minute profiles in order to derive a time-averaged vertical profile of reflectivity. Users can then modify the rainfall estimation to account for the mean vertical reflectivity variation between the height of the CAPPIs (typically between 1.5 and 2.5 km) and the lowest height of the profile at 1 km.

2) Ground echo and AP identification using Doppler and reflectivity data

Until recently, ground echoes were avoided by simply performing an horizontal interpolation across a pre-determined ground echo mask derived during conditions of no precipitation. However, the presence of echoes from anomalous propagation (AP) renders all rainfall estimates practically useless over regions where these AP echoes occur. Thus, in an effort to especially identify these AP regions, we have devised a scheme that generates a ground echo mask every 5 minutes using the following:

a) Vertical Integration of Doppler Velocity over a user-defined layer  $\sim$  (1 to 4 km) b) Vertical Gradient of Reflectivity across the layer c) Horizontal Gradient of Reflectivity in a (3 degree by 3 km) neighborhood centred at each polar pixel contained in that layer.

Any pixel declared as a potential ground echo on the basis of (a) is NOT considered as such if the parameters in b) or c) exceed user-specified thresholds. Examples will highlight how the AP is thereby eliminated from the CAPPI maps used by the accumulation module.

3) Generation of composite radar maps overlayed with GOES images

GOES visible and IR maps are now routinely ingested in our RAPID system every 15 minutes. Low level CAPPIs from 3 neighbouring radars (Quebec City, Ottawa and Britt on the Georgian Bay) are likewise received by the RAPID software every 5 minutes and combined with the McGill CAPPIs. Radar pixels are individually remapped on the same Polar Stereographic projection to permit the overlaying of the resulting composite radar map with the GOES images. Selecting the 'nearest' rather than the 'maximum' intensity for pixels with overlapping radar coverage has the effect of automatically eliminating the AP over those regions. Ground echoes are also removed from composite radar maps where the maximum visible brightness in a neighborhood is below a user-defined threshold or where the coldest temperature is warmer than another user-defined threshold.

Poster 16

Ground Based optical sensing of Western Canadian forest fire smoke near Toronto

Norm O'Neill<sup>1</sup>, Alexander Smirnov<sup>2</sup>, Oleg Dubovik<sup>2</sup>, Tom Eck<sup>2</sup>, Amadou Bokoye<sup>3</sup>, Alain Royer<sup>3</sup>, Zhanging Li<sup>4</sup> and Jim Freemantle <sup>5</sup>

<sup>1</sup>GSFC/NASA (L.O.A. from Universté de Sherbrooke, <sup>2</sup>GSFC/NASA, <sup>3</sup>CARTEL, Université de Sherbrooke, <sup>4</sup>CCRS, <sup>5</sup>Crestech

Forest fires in western and north western Canada produced significant smoke plumes whose optical effects could be detected over thousands of kilometers. These fires were particularily intense during the first two weeks of August, 1998. A sunphotometer located at Egbert Ontario (80 km north of Toronto, Ont.) was used to monitor the diurnal variations of a





smoke plume during a turbid atmospheric event on August 8, 1998. This sunphotometer is part of a Canadian network of sunphotometers (AEROCAN) which in turn is a member of the world wide federated network of NASA sponsered sunphotometers (AERONET).

The diurnal variations of the sunphotometer optical depths were placed in a spatial context by comparisons with smoke enhanced AVHRR, GOES and TOMS images and meteorological maps. Refractive index, single scattering albedo and size distribution results were extracted from the simultaneous application of an inversion procedure to attenuation and sky radiance measurements. Optical depths at 500 nm were found to be  $\sim 1.0$  or greater, single scattering albedos  $\sim 0.8$  or less and Angstrom coefficients were  $\sim 2.0$  (3 wavelength bands between 440 and 670 nm). These results will be compared with background results for Egbert as well as sunphotometer derived parameters for other biomass burning events in Brazil and Alaska.

### Poster 17

Towards a better understanding of El Niño-related temperature patterns in the prairie and foothills regions of Canada

Dagmar Budikova<sup>1</sup>

University of Calgary

The intent of this research is to provide an improved understanding of the spatio-temporal response of surface temperature anomalies in the foothills and prairie region of Canada during El Niño events.

A total of 12 El Niño events that were observed since 1950 were used in the study. A combination of multivariate statistical methods, and geographical information systems technology were used. Factor analysis in S-mode was suitable to extract the principal regions (factors) of temperature response. Ward's clustering method was then applied to the scores of the remaining factors to obtain principal evolutionary patterns of temperature anomalies during El Niño.

The analysis extracted three (4) major regions of distinct temperature anomaly patterns. Central interior of Canada was found to have the most consistent temporal response of temperature anomalies to El Niños. Two (2) principal types of temperature evolution were found for this region. Type I, identified in 58% of El Niño events, is mainly characterized by positive temperature anomalies across the region, that reach maximum spatial extent and intensity (+5°C) around January. Conditions then return to normal around May. In type II, 25% of events, peak negative temperature anomalies are observed in January along the foothills (-4°C). Spatially, the anomalies show the greatest extent around April, and completely dissipate by July. Spatially, type I event shows a gradual local magnification as well as a gradual eastward progression of anomalies. Type II event shows a southern progression of intensifying anomalies early in the winter along the foothills, that then diminish in strength and diffuse towards the northeast, encompassing the entire region by April. Ongoing work in the area is examining the connection of these anomalies to the tropical Pacific Ocean, in turn assessing the predictability of these anomalies.

### Poster 18

Intraseasonal Oscillations in the Rains and Floods over the Andes Mountain-Chile. Jose Vergara<sup>1</sup> and Rainer Schmitz<sup>1</sup>

University of Chile

The subtropical West Coast of South America is particularly suitable to detect intraseasonal variations (Vergara and Fuenzalida, 1993). Climatic conditions, such as subtropical

subsidence, extreme temperatures and precipitation are dependent on such variations which in turn affect the whole troposphere.

Observational evidence of the intraseasonal oscillation of precipitation and river flows in Chile is presented by means of daily data, such as surface pressure, surface temperature over the Andes mountain, precipitation, river flow and compared with regional numerical model output.

According to the presented data low frequency variations are present with a periodicity between 20 to 60 days (figure 1, http://dgf.uchile.cl/~jvergara/conf/CMOS99B.html) along with a large interannual and annual variability. The rain time series present a pronounced annual cycle with a strong maximum during the cold season. However, river flow time series shows a maximum during warm season due to the impact of the intraseasonal variations over the subtropical subsidence and consequently over the temperatures.

The intraseasonal variations discussed in this paper show the existence of a phenomenon which is relevant for the rainfall events (wintertime) and the extreme temperatures episodes (summertime). Both rainfall and temperature explain the floods during the years. The results reported in this paper emphasise the potential benefits of a study of low frequency variation for the implementation of an extended rain and flood forecasting.

http://dgf.uchile.cl/~jvergara/conf/CMOS99B.html

Figure 1: Spectrum for Cachapoal river flow during summer 1990/1991, The peaks corresponds to a period of 31 days.

Acknowledgements:

This work was funded by FONDECYT 1970507, FONDEF 2028 and CODELCO\_ANDINA 98 projects.

Poster 19

Earth coordinate and mesoscale modelling

Guy Bergeron<sup>1</sup>, Robert Benoit<sup>2</sup> and Alain Pietroniro<sup>3</sup>

<sup>1</sup>Department of Atmospheric & Oceanic Sciences, McGill University, <sup>2</sup>Recherche en Prevision Numerique, <sup>3</sup>National Water Research Institute

Coupling high-resolution mesoscale model with distributed and streamflow model imply the coupling of two "realities", one is a virtual spherical earth used in meteorology and the other is a true ellipsoid earth used in hydrology. Each of these earths have their own shape and coordinate system. The link between these two "realities" introduces a possible confusion in the definition of the latitude and a discrepancy of the geographical positioning is the order of 20 km. In the mesocale modelling context, this discrepancy correspond to one or two grid length. The confusion arise from, first, the dependency between the value of the latitude and the spheroid used to define them, and second, the coordinate transformation used historically in meteorology to link the two earth coordinate systems. Two questions emerge form this exercise. Does the historically coordinate transformation used between the ellipsoid earth and the spherical earth is accurate enough for the actual model resolution? Also, does a conformal transformation between ellipsoid and spherical earth is an acceptable alternative?

Poster 20

Automated weather forecast products

Claude Landry<sup>1</sup>, Richard Verret<sup>1</sup>, Denis Vigneux<sup>1</sup>, Jacques Marcoux<sup>1</sup>, Franco Petrucci<sup>1</sup>, Luc Pelletier<sup>1</sup> and Guylaine Hardy<sup>1</sup>





# <sup>1</sup>Centre météorologique canadien

Demand for specialized weather forecast products has significantly increased in the past few years. To fulfill the demand, Regional Weather Centres have to find new working strategies to increase productivity while still maintaining quality, accuracy and usefulness of products and also maintaining consistency between them. Operational meteorologists have to get used to new forecasting tools that can generate automatically several products. The interactive expert system SCRIBE for composition of meteorological forecast products has demonstrated its capability of being an efficient, flexible and reliable tool to achieve improved productivity and better efficiency.

An ensemble of weather element matrices are produced at the Canadian Meteorological Centre at more than 700 points across Canada. These matrices include statistical and direct model output parameters at a 3-h time resolution out to 48-h projection time based on the operational Regional model and out to 144-h based on the Global model. Upon reception of the matrices, the Knowledge Base System of the Regional SCRIBE system processes the data to extract the events or meteorological concepts that are the results of a semantic numerical analysis of the weather element matrices content. The concepts are displayed on a graphical user interface for editing if needed and then the Knowledge Base System is called once more to generate the forecast products. Each product has its own Product Description File which contains all the directives that specify the meteorological content and format of the product. Direct output products are in textual and/or numerical formats, and the system can feed specialized applications to generate graphical products and external software applications.

The efficiency and productivity of the system is achieved when many products are generated using the weather elements of one master product. After editing and quality controlling all needed weather elements included in the master product, series of derived products can be generated as defined in the Product Description Files, from extracted weather elements. The master product can then be considered as the working meteorological table, from which all other products can be derived without extra work. Consistency between all products is then automatically ensured.

Use of SCRIBE product generator in an operational environment has shown that the time required to generate standard forecast products such as public forecasts, was equal, and in some cases even faster than the time normally required when generating the products with usual forecasting tools. However, SCRIBE can generate automatically, and without further intervention, several derived specialized weather forecast products. The meteorological tasks are then devoted to the edition and quality control of a master product or database which contains all the meteorological forecast decisions rather than on formatting the same meteorological forecasts into several different user tailored products.

It is proposed to have a poster presentation with a display of the structure of the SCRIBE system together with examples of SCRIBE generated products. It is also proposed to have live demos of SCRIBE to support the poster presentation.

### Poster 21

Canadian Hurricane Centre Operational Analytical Wind Model Allan Macafee<sup>1</sup> and Brian Peters<sup>2</sup>

<sup>1</sup>Canadian Hurricane Centre, <sup>2</sup>Meteorological Service of New Zealand Ltd, Wellington, New Zealand

A modified version of the Holland (1980) gradient wind model for tropical cyclones is presented. This model includes quadrant dependent asymmetry factors for the inner core region of the hurricane as well as the first order asymmetry introduced by translation. Scalar

winds calculated above the Marine Boundary Layer (MBL) across a node-centered, motion-oriented grid are adjusted to surface values through application of a transfer coefficient representative of the MBL.

Operationally, the model input parameters are prepared as a forecast track is constructed using the Hurricane Forecasting Interface (HURR). The forecaster interactively executes the model and displays isotachs, wind vectors, and isobars at one or more nodes along the track. The primary use of the model is to provide guidance for open ocean wind and wave forecasting in the absence of data observations and real-time, mesoscale model output. In this context, comparisons with 1998 hurricanes Danielle, Mitch, and Georges are presented.

### Poster 22

Fine-scale condensation process at varying resolution : sensitivity study with the Northern Aerosol Regional Climate Model (NARCM)

Wanda Szyrmer<sup>1</sup>, Jean-Pierre Blanchet<sup>1</sup>, Isztar Zawadzki<sup>2</sup> and René Laprise<sup>1</sup>

<sup>1</sup>UQAM, CCRM, <sup>2</sup>McGill University, CCRM

The largest uncertainty in climatic models is attributed to inadequate representation of clouds. There are now increased efforts to improve cloud parameterization schemes, not only with respect to amount of clouds but also through a more physically based description of their microphysical structure. In this study we explore the possibility of adaptating fine-scale explicit treatment of droplet growth by condensation to larger-scale modelling. The adopted parameterization scheme is the one developed by Brenguier and Grabowski and applied originally to small nonprecipitating cumulus. The approach we are taking is to introduce this explicit microphysical scheme into the scaleable regional climate model (RCM). The prescribed concentration of nucleated cloud droplets will be introduced in relation to the prognostic aerosol spectrum generated by NARCM. The model simulated results will be evaluated as function of scales: the initial high spatial resolution of a few of decameters will be progressively extended to climate model scales. The model is made to simulate summertime Arctic stratocumulus in which microphysical structure is closely coupled to the evolution of the droplet spectra growing primarily through condensation. Besides a critical role played by these clouds in the surface radiation balance of this region, the particular interest stems from the possibility that their radiative forcing may be altered in a climatically significant manner by biogenic feedback or anthropogenic influences.

# Poster 23 Numerical investigation of windstorm VIVIAN with the canadian RCM Stéphane Goyette<sup>1</sup>, Martin Beniston<sup>1</sup>, Daniel Caya<sup>2</sup> and Patricia Jungo<sup>1</sup> <sup>1</sup>Institut de Geographie - Universite de Fribourg, <sup>2</sup>UQAM

The windstorm VIVIAN that affected severely Switzerland in February 1990 is investigated numerically with the Canadian regional climate model (CRCM). In order to simulate winds at very high resolution we operated a multiple nesting to increase the horizontal and vertical resolution. The horizontal resolution enhancement is necessary to better capture the orographic details that modulates the atmospheric circulation at a given scale, whereas the vertical resolution enhancement helps to better simulate the surface boundary layer that modulate the windspeed near the ground. We succeed, as a first step, down tracking the windstorm within a three-months simulation. In addition, this study helps the understanding of the importance of cascade nesting and all experiments indicated that the model captured the essential characteristics of the storm namely the location of violent winds and its evolution. The experiments also indicated that the simulated variability of the windfield and of most variables at the finer scales also increases with the increasing nesting frequency. However, higher order statistics of the results are limited by the archival frequency of reanalysis data that serve to update the lateral boundary conditions of the CRCM.





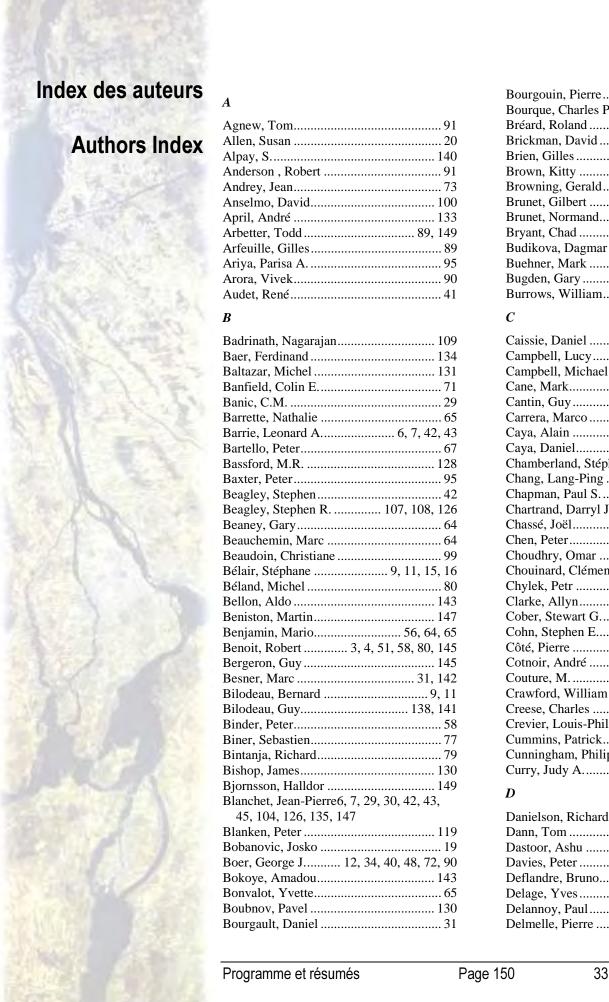
Poster 24
Adjustment Under Gravity In Finite-Difference Models
Yuri Geshelin¹ and Richard Greatbatch¹
Dalhousie University, Dept. of Oceanography

The adjustment of a fluid to the geostrophic state is considered. The behaviour of free gravity waves whose propagation is governed by non-dimensional primitive equations is studied. For numerical solutions, the C-grid is employed as the most common grid type. Both rotational and non-rotational cases are considered. We compare the well-adopted finite difference method (second order) with higher order differential schemes. We demonstrate that neither higher order differential schemes nor the decomposition into Fourier cosine and sine series help to solve the problem of eliminating computational noise. We contend that the output noise due to the time step error cannot be completely removed with the use of the above techniques. We furnish the estimate of that error in all three methods.

# Poster 25 Further investigation of modeling the North Water Polynya Todd Arbetter<sup>1</sup>, Lawrence A. Mysak<sup>1</sup>, Andrew Willmott<sup>2</sup> and Halldor Bjornsson<sup>3</sup> <sup>1</sup>McGill University, <sup>2</sup>Keele University, <sup>3</sup>Geophysical Fluid Dynamics Laboratory

There has been considerable effort during the past decade to use dynamic and thermodynamic analytical and numerical models to improve our understanding of the North Water (NOW) polynya. First, the Pease model, in which ice drift is specified, was used to describe the balance between nearshore ice formation and wind-driven offshore ice transport. More recently, attempts have been made to use a dynamic ice model to compute ice drift due to wind forcing and a prescribed ocean circulation. However, these attempts have involved using idealized forcing and geometry. As a next step toward improving the representation of the polynya, a more realistic geometry is added. Also, improvements to the atmospheric and oceanic forcing, using climatology appropriate for the region and, where available, observations from recent NOW field experiments, are included.





Bourgouin, Pierre	
Bourque, Charles P.	
Bréard, Roland	
Brickman, David	47
Brien, Gilles	18
Brown, Kitty	
Browning, Gerald	
Brunet, Gilbert34, 48, 69, 106,	
Brunet, Normand	
Bryant, Chad	
Budikova, Dagmar	
Buehner, Mark121,	
Bugden, Gary	
Burrows, William	/4
C	
G : : D : 1	
Caissie, Daniel	
Campbell, Lucy	
Campbell, Michael	
Cane, Mark	
Cantin, Guy	30
Carrera, Marco82,	109
Caya, Alain	123
Caya, Daniel77,	147
Chamberland, Stéphane	
Chang, Lang-Ping	
Chapman, Paul S	
Chartrand, Darryl J126,	
Chassé, Joël	
Chen, Peter	
Charing Charact	
Chouinard, Clément	
Chylek, Petr	
Clarke, Allyn	
Cober, Stewart G	
Cohn, Stephen E	
Côté, Pierre52,	
Cotnoir, André	
Couture, M.	
Crawford, William	124
Creese, Charles	102
Crevier, Louis-Philippe	
Cummins, Patrick	
Cunningham, Philip	
Curry, Judy A10	
•	, 0,
D	
Danielson, Richard E.	57
Dann, Tom	
Dastoor, Ashu	
Davies, Peter	
Deflandre, Bruno	
Delage, Yves	
Delannoy, Paul	
Delmelle, Pierre	95

Derome, Jacques
Eck, Tom       143         El-Jabi, Nassir       4         Evans, Wayne F.J       40, 41
F
Fabry, Frederic       94         Falla, Marie       93         Fedosejevs, Gunar       44         Feng, Jian       118         Fillion, Luc       121         Flato, Gregory M.       12, 34, 40         Fogal, P.       128         Fogarty, Christopher T.       39         Fontecilla, Juan Sebastian       29         Foreman, Michael G.       113         Fournier, Frédéric       111         Fox, Dave       64         Freemantle, Jim       143         Frigon, Anne       77         Fyfe, John       34
G
Gachon, Philippe       92         Gagné, Jean-Pierre       63         Gagnon, Claude       65         Gagnon, Enriette       18         Gagnon, Normand       15, 48         Gaider, Kathy       64         Galvez-Cloutier, Rosa       139         Gauthier, Nathalie       111         Gauthier, Pierre       107, 121, 122         Germain, André       65         Geshelin, Yuri       149         Ghaleb, Bassam       139, 140         Giguere, Michel       77         Gingras, Yves       93, 94         Girard, Claude       67         Girard, Eric       10         Girard, Ralph       104         Glazer, Anna       9, 11, 16, 21         Goldstein, Jeana       99

Gong, Sunling7, 8, 29, 42, 43, 55
Gong, Wanmin55
Gosset, Marielle102
Gough, William A46, 64, 113
Gratton, Yves32, 113
Gravel, Sylvie67, 102
Greatbatch, Richard12, 149
Greenan, Blair J.W125
Greenberg, David A113
Guan, Hong22
Guignard, Constance52
Guillemette, Pascal142
Gultepe, Ismail22
Gyakum, Dr. John R39
Gyakum, John R57, 109, 110
•
H
Hahn, John10
Haineault, Johane
Haines, Keith
Hall, Nick49
Hallé, Jacques
Han, Guoqi
Hanley, Deborah39
Hannah, Charles20, 46
Hardy, Guylaine24, 26, 145
Harvey, Richard78
He, Bin
He, Bin
He, Jinhai83
Hendry, Ross
Hill, Philip52
Hill, Philip R
Hillaire-Marcel, Claude138, 139, 140
Hocking, Wayne115
Hoff, Ray4
Hoff, Ray M
Hoff, Raymond42
Hoff, Raymond M43
Hogg, Bill
Hogue, Richard
Holben, Brent
Hollmann, Rainer
Hong, Lin29
Houtekamer, Peter L
Howe, Michael
Hsieh, William60, 78, 89, 101, 134
Hsu, C. Juno
Hu, Yongcun
11a , 1 ongeun
I
Idrissa Bokoye, Amadou44
Isaac, George9, 11, 22
Isaac, George A
15440, George 11





Li, Jiangnan	7
Li, Jianzhong	7
Li, Zhanqing	14
Liboiron, Linda	
Lin , Ray	3
Lin, Charles34	. 5
Lin, Charles A31, 80,	
Lin, H	
Lin, Hai49.	
Lin, Hong	, o
Little, Ken135,	13
Liu, Peter42	13
Locat, Jacques52, 138,	, 4° 12
Locat, Jacques	13
Loder , John20	
Loder, John20	
Lohmann, U	
Lohmann, Ulrike	
Loiselle, Monique	
Long, Bernard	
Loucheur, Virginie	
Louie, Paul	
Lucotte, Marc	6
Lynch, Amanda H	10
M	
Macafee, Allan	1 /
Mailhot, Jocelyn9	
Makar, Paul	
Mann, Graham	
Marcoux, Jacques	
Marmen, Sylvain	
Marsden, Richard	
Marsh, Philip	
Martin, Christian	
Martin, Francis	13
Maslanik, Jim	
Maslowe, Sherwin	5
Masson, Diane	
Maurice , France138,	
Maurice, France138,	
Medvedev, Alexander	
Michelangeli, Paul-Antoine106,	
Milewska, Ewa	
Mills, Brian	
Misra, Vasubandhu	
Moffet, Richard	
Molinari, John	
Monahan, Adam58	
Montero, Martin	
Montpetit, Myriam	
Montpetit, Jacques	
Moore, G.W. Kent	
Moran, Mike	
Morin, Guy	
Morneau, Gilles	5
Mucci, Alfonso52, 140,	14

Mueller, Johannes	Raschke, Ehrhard97
Murcray, F.J	Raymond, Nicole
	Ritchie, Harold
Murray, Nicholas Charles	
Mwangi, Mike	Rivet, Claude
Mysak, Lawlence A 13, 14, 69, 149	Ro, Chul-Un
N	Robichaud, Alain56, 64
Notice Code	Robinson, Carol
Nobre, Carlos	Roch, Michel
Noone, K.J	Roulet, Nigel
0	Rouse, Wayne
0.1 N. 1.0	Roy, François
Oakey, Neil S	Royer, Alain
Ouellet, Mathieu	Ruscher, Paul
Ouyang, Bing 135	Russen, Albert113
P	S
Pagé, Christian	Sankey, David127
Pal, Shiv R	Sarrazin, Jozée
Palany, Philippe	Saucier, François J31
Pandolfo, Lionel	Saucier, François J
Paquin, Dominique	Savard, Josée
Park, Peter	Schaer, Christoph
Patoine, Alain	Schertzer, William
Pellerin, Gérard	Schmitz, Rainer
Pellerin, Pierre	Schramm, Julie
Pellerin, Simon	Schubert, W. H
Pelletier, Luc	Scott, John93
Pendlebury, Diane	Semeniuk, Kirill
Péron, Florence	Serreze, Mark91
Perrie, William	Servranckx, René
Pestieau, Paul	Shen, Samuel Shanpu58
Peters, Brian	Sheng, Jian50
Peterson Andrew, K	Sheng, Jinyu33
	Shore, Jennifer20, 46
Peterson, Ingrid	Sica, Robert J
Petriello, Paolo Jr	Sills, David81
Petrucci, Franco	Simpkin, Peter
Pietroniro, Alain	Singh, Abnash
Pilotte, Marcel	Siok, Stan
Plante, André	Smirnov, Alexander44, 143
	Smirnov, Vladimir
Plumb, R. Alan	Smith, Peter C84
Poulin, Patrick	Solheim, B.H
	Soulis, Eric51
Premont, Bruno	Souvanlasy, Vanh
Prieur, Louis M	Spacek, Lubos
Primeau, Francois	Staniforth, Andrew101
	Stanley-Jones, Martin93
Puckrin, Eldon	Stewart, Jim
r udykiewicz, Janusz	Stewart, Ronald 97
Q	St-Hilaire, André
Qiu, Xin81	Stix, John95
Quine, B	St-James, Judy
Vaine, B	Stocks, B
R	Stone, Daithi
Radeva, Ekaterina	St-Onge, Francine
race va, Erace ma	6-7





St-Onge, Guillaume       138         Straub, David N.       47, 57, 129         Strong, Geoff       98         Strong, K.       128         Stuart, Ambury       27         Stuhlmann, Rolf       118         Sukloff, William       44         Szyrmer, Wanda       147
T
Tang, Benyang       60, 89, 101, 134         Tang, Charles       47, 125         Tang, Youmin       101, 134         Tanguay, Monique       122         Tardif, Robert       132, 133         Taylor, Peter       79, 80, 81         Teillet, Phillippe M       44         Thayaparan, Thayananthan       115         Therrien, René       139         Thomas, Steve       58         Thompson, Keith R       19         Thurtell, George       80         Tinis, Scott       40         Torlaschi, Enrico       94         Toulany, Bechara       12, 91         Tremblay, André       9, 11, 16, 21, 23         Tremblay, Louis-Bruno       89         Trudel, Serge       86         Turcotte, Marie-France       131         Turner, Sandra       35, 132, 133
V
Vaillancourt, Paul       23         Vaillancourt, Pierre       132         Van Rijn, Paul       93         Vandermeer, Aaron       43         Varma, Ravi       100         Vassiliev, Oleg       127         Vergara, Jose       134, 144         Verner, Gilles       121         Verret, Richard       16, 24, 26, 131, 145         Vet, Robert       44         Vigneux, Denis       145         Vincent, Lucie       62

W
Wang, Jia31
Wang, Yuhui34
Wang, Zhaomin13, 14
Warland, Jon80
Watterson, Ian71, 92
Waugh, David55
Weaver, Andrew46, 70
Welch, William J46
Wen, Lei80
Weng, Wensong80
White, Loren99
Whitney, Frank124
Willmott, Andrew149
Wilson, Lawrence75
Wintels, Werner110
Wong, Jeff6
v
X
Xiao, Jingbing79
Xu, Haiming83
Y
-
Yao, Tom47
Yashayaev, Igor83, 84, 129
Yashayaev, Igor83, 84, 129
Yasunari, Tetsuzo97
Yau, M. K51, 79, 109, 118
Yau, Peter100
Yeh, Kao-San101
Yu, Wei80
7
Z
Zadra, Ayrton69
Zawadzki, Isztar94, 100, 102, 103, 123,
142, 147
Zhang, Yaocun12, 13
Zhang, Deke140
Zhang, Xuebin62
Zhang, Yaocun12, 13
Zuretti, Fabien30
Zwack, Peter17, 35, 92, 132, 133
Zwiers, Francis W48, 70, 76
Zwicis, Francis W40, 70, 70



### Agnew, Tom

Atmospheric Environment Service 4905 Dufferin Street, Downsview, Ontario, Canada, M3H 5T4

E-mail: Tom.Agnew@ec.gc.ca

URL: http://www1.tor.ec.gc.ca/crysys/index.html

### Alexander, Smirnov

GSFC/NASA

### Allen, Susan

University of British Columbia Oceanography, 6270 University Boul., Vancouver, BC, Canada, V6T 1Z4

E-mail: allen@ocgy.ubc.ca

URL:

http://www.ocgy.ubc.ca/pages/Susan/Susan.html

### Alpay, Sam

Earth and Planetary Science Department, McGill University, Montreal, Quebec, Canada

### Anderson , Robert

Bedford Institute of Oceanography

### Andrey, Jean

University of Waterloo

### Anselmo, David

McGill University

Dept. of Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke Street West , Montreal, Quebec, Canada, H3A 2K6

E-mail: danselmo@zephyr.meteo.mcgill.ca

URL: http://zephyr.meteo.mcgill.ca

# April, André

UQAM, Montréal, Québec, Canada, E-mail april@sca.ugam.ca

### Arbetter, Todd

McGill University

Department of Atmospheric and Oceanic Sciences 805 Sherbrooke St. West , Montreal, Quebec,

Canada, H3H 1C3

E-mail: arbetter@zephyr.meteo.mcgill.ca

URL: http://www.meteo.mcgill.ca

### Arfeuille, Gilles

University of Victoria and I.O.S. (British Columbia) Institute of Ocean Sciences P.O. Box 6000, Sidney, British Columbia, Canada, V8L 4B2

E-mail: gilles@ocean.seos.uvic.ca

### Argall, Stephen

The University of Western Ontario

### Ariya, Parisa A.

McGill University

Departments of Atmospheric and Oceanic Sciences, McGill University, 801 Sherbrooke St. W., Montreal, QC, CANADA H3A 2K6, Montreal, Quebec

E-mail: ariya@omc.lan.mcgill.ca

URL: http://zephyr.meteo.mcgill.ca/parisa/

### Arora. Vivek

Canadian Centre for Climate Modelling and Analysis University of Victoria PO Box 1700, STN CSC, Victoria, BC, Canada, V8W 2Y2

E-mail: vivek.arora@ec.gc.ca URL: http://www.cccma.bc.ec.gc.ca/

### Aubé, Martin

CARTEL, Université de Sherbrooke

### Audet, René

Env. Canada - Région du Québec - BSME de Québec

1141, Route de l'Église CP 10100 , Sainte-Foy, Québec, Canada, G1V 4H5

E-mail: rene.audet@ec.gc.ca

# Badrinath, Nagarajan

Dept. of Atmospheric and Oceanic Sciences, McGill University

### Baer, Ferdinand

University of Maryland, USA.

### Baltazar, Michel

Centre météorologique canadien

### Banfield, Colin E.

Memorial University of Newfoundland

### Banic, C.M.

Atmospheric Environment Service

# Barrette, Nathalie

UQAM - Département des Sciences de la terre C.P. 8888, succursale Centre-Ville Montréal,(Québec) H3C 3P8, Montréal, (Québec), Canada, H3C 3P8

E-mail: barrette@sca.uqam.ca

### Barrie, Leonard A.

Atmospheric Environment Service 4905 Dufferin St., Toronto, Ontario, Canada, M3H 5T4

# Bartello, Peter

McGill University

805, Sherbrooke ouest , Montreal, Quebec, Canada,

E-mail: bartello@zephyr.meteo.mcgill.ca URL: http://zephyr.meteo.mcgill.ca/pb.html

### . . . .

**Bassford, M.R.**Dept. of Physics, University of Toronto

# Baxter, Peter

Cambridge University

### Beagley, Stephen

Department of Earth and Atmospheric Science, York University, North York, Ontario, M3J 1P3, Canada., North York, Toronto., Ontario, Canada, M3J 1P3

E-mail: beagley@nimbus.yorku.ca

### Beaney, Gary

Environmental Science, Division of Physical Sciences University of Toronto at Scarborough 1265 Military Trail, Scarborough, Ontario, Canada, M1C 1A4 E-mail: gough@scar.utoronto.ca

URL: http://www.scar.utoronto.ca/~gough

### Beauchemin, Marc

Environnement Canada. Direction de l'environnement atmosphérique, Division des services scientifiques 100 blv. Alexis-Nihon 3ieme étage, ville Saint-Laurent, Québec, Canada, H4M 2N8 E-mail: marc.beauchemin@ec.gc.ca

### Beaudoin, Christiane

Recherche en prevision numerique, AES, Dorval

### Belair, Stephane

Environnement Canada, Recherche en Prevision Numerique

### Béland, Michel

**CERCA** 

### Bélanger, Claude

### Université du Québec à Rimouski, Rimouski, , Canada,

E-mail: claude\_belanger@uqar.uquebec.ca

### Bellon, Aldo

McGill Weather Radar Observatory P.O. Box 198 Macdonald Campus, Ste-Anne-de-Bellevue, Quebec, Canada, H9X 3V9 E-mail: aldo@radar.mcgill.ca URL: http://www.radar.mcgill.ca/

# Beniston, Martin

Institut de Geographie - Universite de Fribourg

### Benjamin, Mario

**Environnement Canada** 100 Boul. Alexis-Nihon, suite 300, Ville Saint-Laurent, Québec, Canada, H4M 2N8 E-mail: mario.benjamin@ec.gc.ca

### Benoit, Robert

Recherche en Prevision Numerique, Environment Canada

E-mail: robert.benoit@ec.gc.ca

### Bergeron, Guy

Department of Atmospheric & Oceanic Sciences, McGill University

Recherche en Prevision Numerique Environnement Canada 2121, Trans-Canada N., Suite 524, Dorval, Quebec, Canada, H9P-1J3

E-mail: Guy.Bergeron@ec.gc.ca

### Besner, Marc

Env. Canada Div. des sciences atmosphériques et enjeux environnementaux 100, boul. Alexis-Nihon, 3e étage, Saint-Laurent,

Québec, Canada, H4M 2N8 E-mail: marc.besner@ec.gc.ca

### Betts, Alan

Atmospheric Research 58 Hendee Lane,, Pittsford,, VT, USA, 05763 E-mail: akbetts@aol.com

### Bilodeau, Bernard

Recherche en prevision numerique, SEA 2121, route Transcanadienne, Dorval, Quebec, Canada, H9P 1J3

E-mail: bernard.bilodeau@ec.gc.ca

# Bilodeau, Guy

GEOTOP-UQAM

### Binder, Peter

Swiss Meteorological Institute, SMI Zurich

### Biner, Sebastien

Groupe de modelisation regionale du climat - UQAM

### Bintanja, Richard

Utrecht University

# Bishop, James

E.O. Lawrence Berkeley National Laboratory, Berkeley, California

### Bjornsson, Halldor

Geophysical Fluid Dynamics Laboratory

### Blanchet, J.-P.

Department of Earth Sciences UQAM

### Blanchet, Jean-Pierre

Earth Sciences Department at UQAM and C2GCR

# Blanken, Peter

University of Colorado (Boulder)

### Bobanovic, Josko

Dalhousie University Oceanography Department, Halifax, NS, Canada, B3H 4J1 E-mail: josko@phys.ocean.dal.ca URL: http://www-erp.phys.ocean.dal.ca

### Boer, George

Canadian Centre for Climate Modelling and Analysis, **Environment Canada** 





### Idrissa Bokoye, Amadou

CARTEL, Université de Sherbrooke

### Bonvalot, Yvette

Direction de la Santé Publique - Montréal-Centre/Unité de Santé au travail et environnementale

### Boubnov, Pavel

University of Victoria School of Earth and Ocean Sciences, University of Victoria, Gordon Head Complex, PO Box 3055, Victoria, BC, Canada, V8W 3P6

E-mail: **voron@uvic.ca** URL: http://www.uvic.ca

### Bourgault, Daniel

Department of Atmospheric and Oceanic Sciences, McGill University

Centre de Recherche en Calcul Applique 5160, boul. Decarie, bureau 400 , Montreal, Quebec, Canada, H3X 2H9

E-mail: **bourgaul@cerca.umontreal.ca** URL: http://www.cerca.umontreal.ca

### Bourgouin, Pierre

Centre météorologique canadien, Environnement Canada

2121 TransCanada Nord, Dorval, Québec, Canada, H9P 1J3

E-mail: pierre.bourgouin@ec.gc.ca

### Bourque, Alain

Environnement Canada 100 Alexis-Nihon, 3ième étage , St-Laurent, Québec, Canada, H4M 2N8

E-mail: alain.bourque@ec.gc.ca URL: http://www.qc.ec.gc.ca/atmos/

### Bourque, Charles P.

Université du Nouveau Brunswick

# Bréard, Roland

UQAM

### Brickman, David

Bedford Institute of Oceanography P.O Box 1006 1 Challenger Drive , Dartmouth, N.S., Canada, B2Y 4A2

E-mail: dbrick@diligent.bio.dfo.ca

### Brien, Gilles

**APMQ** 

C.P. 1412 succ Saint-Laurent Saint-Laurent H4L 4X3, Saint-Laurent, QUEBEC, Canada, H4L 4X3

E-mail: metcom@videotron.ca

### Brown, Kitty

Environmental Science Division of Physical Sciences University of Toronto at Scarborough 1265 Military Trail , Scarborough, Ontario, Canada, M1C 1A4 E-mail: kbrown@scar.utoronto.ca

http://www.scar.utoronto.ca/~gough/climate.html

### Browning, Gerald

E-mail: browning@sunshine.fsl.noaa.gov

### Brunet, Gilbert

RPN, Environment Canada 2121 Trans-Canada Highway, Dorval, Quebec, Canada, H9P 1J3

E-mail: Gilbert.Brunet@ec.gc.ca

### **Brunet, Normand**

Canadian Meteorological Centre, Environment Canada

### Brvant, Chad

Dept of Physics and Astronomy, University of Western Ontario , London, Ontario, Canada, N6A 3K7

E-mail: chadb@lucille.physics.uwo.ca

URL: http://pcl.physics.uwo.ca

### Budikova, Dagmar

University of Calgary
Department of Geography 2500 University Dr NW,
Calgary, Alberta, Canada, T2N 1N4
E-mail: dbudikov@acs.ucalgary.ca

### Buehner, Mark

Atmospheric Environment Service 2121 Trans-Canada Hwy, Dorval, PQ, Canada, H9P 1.I3

E-mail: Mark.Buehner@ec.gc.ca

### Bugden, Gary

Bedford Institute of Oceanography

### Burrows, William

Atmospheric Environment Service Meteorological Research Branch 4905 Dufferin St., Downsview, Ontario, Canada, M3H 5T4 E-mail: william.burrows@ec.gc.ca

URL: http://zephyr.cmc.ec.gc.ca/aqpp/index.html

### Caissie, Daniel

Pêches et Océans Canada

# Campbell, Lucy

McGill University

Department of Mathematics, McGill University, 805 Sherbrooke St.W., Montreal, Quebec, Canada, H3A 2K6

E-mail: campbell@math.mcgill.ca

URL: http://www.math.mcgill.ca/~campbell/

### Campbell, Michael

**B2Y 2N6** 

AEPRI/Environment Canada Atmospheric Environment Branch 16th floor, Queen Square 45 Alderney Dr , Dartmouth, NS, Canada,

E-mail: mike.campbell@ec.gc.ca

### Cane. Mark

CresTech, York University

### Cantin, Guy

Institut Maurice Lamontagne

### Carrera, Marco

McGill University

Department of Atmospheric and Oceanic Sciences McGill University, 805 Sherbrooke St. West, Montreal,

Quebec, Canada, H3A 2K6

E-mail: marco@zephyr.meteo.mcgill.ca URL: http://zephyr.meteo.mcgill.ca

### Caya, Alain

McGill University

Department of Atmospheric and Oceanic Sciences 805, Sherbrooke Street West, Montreal, Quebec, Canada, H3A 2K6

E-mail: caya@zephyr.meteo.mcgill.ca

URL: http://www.radar.mcgill.ca

### Caya, Daniel

Groupe de modelisation regionale du climat - UQAM UQAM - Departement des Sciences de la Terre C.P. 8888, Succ. "Centre-Ville", Montreal, (Quebec), Canada, H3C 3P8

E-mail: caya@sca.uqam.ca URL: http://www.sca.uqam.ca/

### Chamberland, Stéphane

Recherche en Prevision Numerique, Environment Canada

E-mail: **stephane.chamberland@ec.gc.ca**URL: http://www.cmc.ec.gc.ca/rpn/map/

# Chang, Lang-Ping

NASA Goddard Space Flight Center

# Chapman, Paul S.

Coastal Ocean Science, Bedford Institute of Oceanography

# Charette, Cecilien

ARMA, SEA

### Chartrand, Darryl

Department of Earth and Atmospheric Science - York University

4700 Keele St., Toronto, Ontario, Canada, M3J 1P3 E-mail: darryl@nimbus.yorku.ca

### Chassé, Joël

Ocean Science Division, Maurice-Lamontagne Institute, Department of Fisheries and Oceans, Mont-Joli, Québec, Canada, G5H 3Z4

### Chen, Peter

Canadian Meteorological Centre, Environment Canada

# Choudhry, Omar

Castle Rock Consultants

### Chouinard, Clément

ARMA

### Chylek, Petr

Dalhousie University, Halifax

### Clarke, Allyn

Bedford Institute of Oceanography

### Cober, Stewart

Cloud Physics Research Division, Atmospheric Environment Service

# Cohn, Stephen E.

NASA Goddard Space Flight Center

### Cote, Claude

**Environment Canada** 

New Brunswick Weather Centre 77 Westmorland Street, Suite 400, Fredericton, New Brunswick,

Canada, E3B 6Z3

E-mail: claude.cote@ec.gc.ca

### Côté, Helene

Groupe de modelisation regionale du climat - UQAM

### Côté, Jean

RPN

# Côté, Pierre

Département de géologie et de génie géologique Local 3754, Pavillon Pouliot Université Laval (418) 656-2131 poste 8604 piercote@ggl.ulaval.ca , Sainte-Foy, Québec, Canada.

E-mail: piercote@ggl.ulaval.ca
URL: http://www.saguenay.ggl.ulaval.ca

### Cotnoir, André

Environnement atmosphérique - Environnement Canada

### Couture, M.

Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ont. M3H 5T4, Canada

### Crawford, William

Canadian Hydrographic Service Institute of Ocean Sciences P.O. Box 6000, Sidney, B.C., Canada, V8L 4B2

E-mail: crawfordb@pac.dfo-mpo.gc.ca

### Creese, Charles

McGill University

Department of Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke St. W., Montreal,

Quebec, Canada, H3A 2K6

E-mail: creese@zephyr.meteo.mcgill.ca

URL: http://zephyr.meteo.mcgill.ca,

http://www.mcgill.ca





### Crevier, Louis-Philippe

Atmospheric Environment Service - Recherche en prevision numerique (RPN)

2121 Route Transcanadienne 5e etage, Dorval,

Quebec, Canada, H9P 1J3

E-mail: Louis-Philippe.Crevier@ec.gc.ca

URL: http://www.cmc.ec.gc.ca

# **Cummins, Patrick**

Institute of Ocean Sciences

### Cunningham, Philip

Department of Earth and Atmospheric Sciences, ES-329 University at Albany State University of New York, Albany, New York, USA, 12222

 $\hbox{E-mail: } \textbf{cunning@atmos.albany.edu}$ 

URL: http://www.atmos.albany.edu/student/cunning/phil\_home.html

### Curry, Judy A.

Program in Atmospheric and Oceanic Sciences (PAOS), University of Colorado, Boulder, CO

### D'Amours, Réal

Centre météorologique canadien

# Danielson, Richard E.

Department of Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke Street West, Montreal, Quebec, CANADA, H3A 2K6 E-mail: rick@zephyr.meteo.mcgill.ca

URL:

http://zephyr.meteo.mcgill.ca/vortex/people/current.html

### Dann, Tom

Environnement Canada - Direction de la Protection de l'environnement

### Dastoor, Ashu

ARQI, AES, Dorval

### Davidson, Fraser

Dept. of Physics and Physical Oceanography Memorial University,, St. John's , NF, CANADA, A1B

E-mail: fraze@physics.mun.ca URL: http://www.physics.mun.ca/~fraze

# Davies, Peter

Castle Rock Consultants

100 Arapahoe Ave Suite #9, Boulder, Colorado, USA,

80302

E-mail: davies@crc-corp.com URL: http://www.crc-corp.com

### Davies, Trevor

School of Environmental Sciences, University of East

Anglia

### de Elia, Ramon

Department of Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke Street West, Montreal, Quebec, Canada, H3A 2K6

E-mail: relia@zephyr.meteo.mcgill.ca

### de Grandpré, Jean

York University

121 Petrie Science Building Department of Earth and Atmospheric Science York University, , Toronto, Ontario, Canada, M3J1P3

E-mail: jean@nimbus.yorku.ca

### de Vernal, Anne

**GEOTOP-UQAM** 

### Deflandre, Bruno

Département d'océanographie Université du Québec à Rimouski 300 allée des ursulines , Rimouski, Québec, Canada, G5L 3A1

E-mail: modefbru@globetrotter.qc.ca

### Delage, Yves

Atmospheric Environment Service - Recherche en prevision numerique (RPN)

# Delannoy, Paul

Environment Canada - Ottawa Regional Centre

### Delmelle, Pierre

Université de Montréal

Département de Géologie, succ. Centre Ville 6128,

Montréal, Québec, Canada, H3C 3J7 E-mail: delmellp@ere.umontreal.ca

# Denman, Kenneth

Inst. of Ocean Sciences

### Derome, Jacques

McGill University

Dept. of Atmospheric and Oceanic Sciences and Centre for Climate and Global Change Research 805 Sherbrooke St. W., Montréal, QC, Canada, H3A 2K6 E-mail: derome@zephyr.meteo.mcgill.ca

URL: http://zephyr.meteo.mcgill.ca

# Dery, Stephen

McGill University

Dept. of Atmospheric and Oceanic Sciences McGill University 805 Shrebrooke St. W. , Montreal ,

Quebec, Canada, H3A 2K6

E-mail: steph@zephyr.meteo.mcgill.ca

URL:

http://limex.meteo.mcgill.ca:8080/steph/steph.html

# Desgagné, Michel

Recherche en Prevision Numerique, Environment Canada

# Desgagnés, Priscilla

Département de géologie et de génie géologique, Université Laval

### Desjardins, Serge

Atlantic Environmental Prediction Research Initiative Environnement Canada, Région de l'Atlantique 45 Alderney Drive, 16 ième étage, Dartmouth, Nouvelle-Écosse, Canada, B2Y 2N6

E-mail: Serge.Desjardins@ec.gc.ca

### DeTracey, Brendan

Bedford Institute of Oceanography

# Devillers, Rodolphe

**GEOTOP** 

# deYoung, Brad

Memorial University

### Dobson, Fred

Bedford Institute of Oceanography

### Donaldson, Norman

Atmospheric Environment Service

### Dravnieks, Olaf

School of Earth and Ocean Sciences, University of

School of Earth and Ocean Sciences, University of Victoria, PO Box 3055, Victoria, BC, Canada, V8W 3P6

E-mail: odrav@ocean.seos.uvic.ca URL: http://wikyonos.seos.uvic.ca/

### Drummond, J.R.

Dept. of Physics, University of Toronto

# Dubovik, Olea

NASA/GSFC, Greenbelt Maryland

# Dugas, Bernard

RPN / Environnement Canada Recherche en Prévision Numérique 2121, Route Transcanadienne, 5e étage, Dorval, Québec, Canada, H9P 1J3

E-mail: Bernard.Dugas@ec.gc.ca URL: http://www.cmc.ec.gc.ca/rpn/

### Dupont, Frédéric

Department of Atmospheric and Oceanic Sciences. McGill university

805 Sherbrooke W, Montréal, Québec, Canada, H3A 2K6

E-mail: dupont@cerca.umontreal.ca

URL: http://www.cerca.umontreal.ca/~dupont

# Dzikowski, Peter

Alberta Agriculture, Food and Rural Development, Conservation and Development Branch

Eck. Tom GSFC/NASA

### El-Jabi, Nassir

Université de Moncton

### Emilien, Pelletier

Institut des Sciences de la Mer de Rimouski 310 allée des Ursulines, Rimouski, Québec, Caanda,

E-mail: emilien\_pelletier@uqar.uquebec.ca

URL: http://uqar.uquebec.ca

# Evans, Wayne F.J.

Trent University

Environmental Resource Studies P.O. Box 4800, Peterborough, Ontario, Canada, K9J 7B8

E-mail: wevans@trentu.ca

### Fabry, Frederic

Dept. Atmospheric and Oceanic Sciences, McGill University

805 Sherbrooke W. Street, Montreal, Québec, Canada, H3A 2K6

E-mail: frederic@radar.mcgill.ca

### Falla, Marie

EC

# Fedosejevs, Gunar

Canada Centre for Remote Sensing, Ottawa, Ontario, Canada

# Feng, Jian

Dept. of Atmospheric and Oceanic Sciences, McGill University, Montreal, H3A 2K6, Canada Dept. of Atmospheric & Oceanic Sciences McGill University 805 Sherbrooke Street West Montreal, H3A 2K6, Canada, Montreal, Quebec, Canada, H3A

E-mail: fengj@zephyr.meteo.mcgill.ca URL: http://zephyr.meteo.mcgill.ca

# Fillion, Luc

ARMA, SEA

# Flato, Gregory M.

**AES** 

Canadian Centre for Climate Modelling and Analysis Atmospheric Environment Service, University of Victoria, Victoria, BC, Canada, V8W 2Y2

E-mail: greg.flato@ec.gc.ca URL: http://www.cccma.bc.ec.gc.ca

Dept. of Physics, University of Denver

### Fogarty, Christopher T.

McGill University, Montreal, QC, Canada 805 Sherbrooke St. West, Montréal, Québec, Canada.

E-mail: fogarty@zephyr.meteo.McGill.CA

# Fomichev, Victor, I,

York University





### Fontecilla, Juan Sebastian

Earth Sciences Department at UQAM P.O. Box 8888, Station "Downtown",, Montreal, QC, Canada, H3C 3P8

E-mail: **fonte@maia.sca.uqam.ca** URL: http://http://www.sca.uqam.ca

### Foreman, Michael G.

Institue of Ocean Sciences

### Fox, Dave

Environment Canada Room 200 Environment Canada 4999-98 Avenue, Edmonton, Alberta, Canada, T6B 2X3 E-mail: **Dave.Fox@ec.gc.ca** 

### François-J., Saucier

Division of Ocean Sciences, Maurice Lamontagne Institute, Dept. Fisheries and Oceans Division of Ocean Sciences Maurice Lamontagne Institute Department of Fisheries and Oceans 850, Route de la Mer, Mont-Joli, Québec, Canada, G5H 374

E-mail: saucierf@dfo-mpo.gc.ca

### Freemantle, Jim

Crestech

### Frigon, Anne

Groupe de modelisation regionale du climat - UQAM

### Fyfe, John

Canadian Centre for Climate Modelling and Analysis, Atmospheric Environment Service Canadian Ctr for Climate Modelling & Analysis PO Box 1700, Victoria, BC, Canada, V8W 2Y2 E-mail: acrnrjf@mri-jma.go.jp

### G., Boer

Canadian Centre for Climate Modelling and Analysis, Atmospheric Environment Service

# Gachon, Philippe

University of Stockholm

# Gagné, Jean-Pierre

Département d'océanographie , Université du Québec à Rimouski

### Gagnon, Claude

Communauté Urbaine de Montréal

### Gagnon, Enriette

UQAM

### Gagnon, N.

Université McGill

Dép. des Sciences atmosphériques & océaniques 805 Sherbrooke O., Montréal, Québec, Canada, H3A 2K6

E-mail: normand.gagnon@ec.gc.ca

### JRL:

http://www.cmc.ec.gc.ca/~cmcdev/saisons/saisons.html

### Gaider, Kathy

**Environment Canada** 

### Galvez-Cloutier, Rosa

Département de génie civil, Université Laval

### Garnett, E.R.

Canadian Wheat Board

### Gauthier, Pierre

ARMA,SEA

### Germain, André

Environnement Canada - Direction de la Protection de l'environnement

### Geshelin, Yuri

Dalhousie University, Dept. of Oceanography , Halifax, N.S., Canada, B3H 4J1 E-mail: **geshelin@phys.ocean.dal.ca** URL: http://www.phys.ocean.dal.ca

### Ghaleb, Bassam

Geotop Center, University of Quebec at Montreal, Montreal, Quebec, Canada

### Giguere, Michel

Groupe de modelisation regionale du climat - UQAM

# Gingras, Yves

Canadian Meteorological Centre, AES, Environment Canada

Implementation and Operational Services Division Canadian Meteorological Centre 2121 Transcanada Highway, Dorval, Quebec, Canada, H9P 1J3

E-mail: **Yves.Gingras@ec.gc.ca**URL: http://www.cmc.doe.ca/indexf.html

### Girard, Claude

RPN

### Girard, Eric

Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, CO ERIC GIRARD, Ph.D. (girard@cires.colorado.edu) Research Associate Cooperative Institute for Research in Environmental Sciences (CIRES) University of Colorado, CB 216 Ekeley Builing: Room S-335 / Aerospace Builing: Room ECAE-130, Boulder, CO, USA, 80309-0 E-mail: girard@cires.colorado.edu

### Girard, Ralph

Canadian Space Agency

### Glazer. Anna

Atmospheric Environment Service, Dorval, Québec,

Canada, H9P 1J3

E-mail: anna.glazer@ec.gc.ca

### Glazer. Anna

Cloud Physics Research Division, Dorval

### Goldstein, Jeanna

Recherche en prevision numerique, AES, Dorval 2121 voie de service nord route trans-canadienne ,

Dorval, Quebec, Canada, H9P 1J3 E-mail: **jeanna.goldstein@ec.gc.ca** URL: http://www.cmc.ec.gc.ca/rpn/

### Gong, Sunling

Atmospheric Environment Service, Downsview, Ontario, Canada, M3H 5T4

### Gong, Sunling

AES, Environment Canada

### Gong, Wanmin

ARQI, Atmospheric Environment Service 4905 Dufferin Street , Downsview, ONT, CANADA, M3H 5T/

E-mail: wanmin.gong@ec.gc.ca

### Gosset. Marielle

IRD

J.S.Marshall Radar Observatory BP 198 McDonald Campus, Ste Anne de Bellevue, QUEBEC, CANADA, H9X 3V9

E-mail: marielle@radar.mcgill.ca

URL: http://www.mpl.orstom.fr/hydrologie/catch/

### Gough, William A.

University of Toronto at Scarborough Environmental Science, Division of Physical Sciences University of Toronto at Scarborough , Scarborough, Ontario, Canada, M1C 1A4

E-mail: gough@scar.utoronto.ca

URL: http://www.scar.utoronto.ca/~gough

### Goyette, Stephane

Universite de Fribourg

Institut de Geographie Universite de Fribourg Perolles , Fribourg, Canton de Fribourg, Suisse, 1700

E-mail: stephane.govette@unifr.ch

URL: http://www.unifr.ch/iguf

### Gratton, Yves

INRS-Océanologie

INRS-Oceanologie 310 Allee des Ursulines,

Rimouski, Qc, Canada, G5L 3A1

E-mail: yves\_gratton@uqar.uquebec.ca

### Gravel, Sylvie

Division de la recherche en prévision numérique

E-mail: sylvie.gravel@ec.gc.ca

Greatbatch, Richard

Dalhousie University, Dept. of Oceanography

### Greenan. Blair J.W.

DFO, Bedford Institute of Oceanography

### Greenberg, David A.

Coastal Ocean Science

Bedford Institute of Oceanography P.O. Box 1006,

Dartmouth, NS, Canada, B2Y 4A2

E-mail: dgreenbe@georgs.bio.dfo.ca

URL: http://dfomr.dfo.ca/science/ocean/welcome.html

### Guan, Hong

Cloud Physics Research Division, Atmospheric Environment Service, Downsview, Ontario, Toronto,

Ontario, Canada, M3H 5T4 E-mail: **Hong.Guan@ec.gc.ca** 

### **Guignard, Constance**

Department of Earth and Planetary Sciences, McGill University

### Guillemette, Pascal

Department of Atmospheric and Oceanic Sciences, McGill University

805 Sherbrooke St. W. Montreal, Quebec H3A 2K6 Canada, Montreal, Quebec, Canada, H3A 2K6 E-mail: pascal@cumulus.meteo.mcgill.ca URL: http://www.radar.mcgill.ca/

gultepe, ismail

ĀES

AES, Cloud Physics Res. Div. 4905 Dufferin St., Downsview, ONT, Canada, m3h 5T4

E-mail: ismail.gultepe@ec.gc.ca

### Gyakum, John

McGill University, Department of Atmospheric and Oceanic Sciences

# Hahn, John

Optech Incorporated

# Haigh, Susan

Inst. of Ocean Sciences

Haineault, Johane

UQAM

# Haines, Keith

Department of Meteorology, The University of Edinburgh

### Hall, Nick

McGill University

Dept. Atmospheric and Oceanic Sciences, McGill University, 805 Sherbrooke St. W., Montreal, QC, Canada. H3A 2K6

E-mail: hall@zephyr.meteo.mcgill.ca

Hallé, Jacques

CMC





2121 Trans-Canada, 4eme étage , Dorval, Québec, CANADA. H9P 1J3

E-mail: Jacques.Halle@ec.gc.ca

### Hamblin, Paul

National Water Research Institute (CCIW) 867 Lakeshore Rd., Burlington, Ontario, Canada, L7R 4A6

E-mail: Paul.Hamblin@cciw.ca

### Han, Guogi

Bedford Institute of Oceanography Coastal Ocean Science Bedford Institute of Oceanography P.O. Box 1006, Dartmouth, NS, Canada, B2Y 4A2

E-mail: ghan@emerald.bio.dfo.ca

### Hanley, Deborah

Department of Earth and Atmospheric Sciences University at Albany ES-234 State University of New York 1400 Washington Ave. , Albany, New York, USA, 12222

E-mail: **dhanley@atmos.albany.edu** URL: http://www.atmos.albany.edu/

### Hannah, Charles

BIO/DFO

Fisheries and Oceans Canada Bedford Institute of Oceanography Box 1006, Dartmouth, N.S., Canada, B2Y 4A2

E-mail: channah@emerald.bio.dfo.ca

### Hardy, Guylaine

Centre météorologique canadien

# Harvey, Richard

Canadian Centre for Climate Modelling and Analysis

### Hasell, Nathalie

Department of Atmospheric and Oceanic Sciences, McGill University 805 Sherbrooke Street West , Montreal, Quebec, Canada, H3A 2K6

E-mail: nhasell@zephyr.meteo.McGill.CA

### He, Bin

Bedford Institute of Oceanography P.O. Box 1006, Dartmouth , Nova Scotia, Canada , B2Y 4A2

E-mail: binhe@emerald.bio.dfo.ca

### He, Jinhai

Department of Meteorology, Nanjing Institute of Meteorology, China

Department of Meteorology, Nanjing Institute of Meteorology, Nanjing, Jiangsu, P.R.CHINA, 210044

# Hendry, Ross

Fisheries and Oceans Canada Bedford Institute of Oceanography P.O. Box 1006, Dartmouth, NS, Canada, B2Y 4A2

# E-mail: hendryr@mar.dfo-mpo.gc.ca

URL: http://dfomr.dfo.ca/science/ocean/welcome.html

### Hill, Philip

Institut des sciences de la mer de Rimouski Université du Québec à Rimouski 301, allée des Ursulines, Rimouski, Québec, Canada, G5L 3A1 E-mail: philip\_hill@uqar.uquebec.ca

### Hillaire-Marcel, Claude

Geotop Center, University of Quebec at Montreal, Montreal, Quebec, Canada

### Hocking, Wayne

University of Western Ontario

# Hoff, Raymond M.

Professor of Physics and Director (JCET)
University of Maryland Baltimore County (UMBC)
Joint Center for Earth Systems Technology (JCET)
Acad IV-A Room 114B
1000 Hilltop Circle, Baltimore, MD 21250

voice: 410-455-1610 fax: 410-455-1291 Secy: voice 410-455-6362

e-mail : hoff@umbc.edu

### Hogg, Bill

Climate Research Branch, AES

### Hogue, Richard

Operations Branch, Canadian Meteorological Center E-mail: richard.hogue@ec.gc.ca

### Holben, Brent

NASA/GSFC, Greenbelt Maryland

### Hollmann, Rainer

Institut für Atmosphärenphysik, GKSS, Max Planck Str., 21502 Geesthacht, Germany

# Hong, Lin

Atmospheric Environment Service 4905 Dufferin Street, , Downsview, Ont., Canada, M3H 5T4

E-mail: lin@armph3.tor.ec.gc.ca

### Houtekamer, Peter L.

Meteorological Research Branch, Environment Canada

### Howe, Michael

**Environment Canada** 

### Hsieh, William

University of British Columbia Oceanography/EOS, Univ. of British Columbia, Vancouver, B.C., Canada, V6T 1Z4

E-mail: william@eos.ubc.ca

URL: http://www.ocgy.ubc.ca/projects/clim.pred

### Hsu. c. Juno

CCCma

Canadian Centre for Climate Modelling and Analysis, University of Victoria P.O. BOX 1700 STN CSC , Victoria, BC, CA, v8w 2y2

E-mail: juno.hsu@ec.gc.ca

### Hu, Yongcun

Bedford Institute of Oceanography

### Humble, J.

Dalhousie University

### Idrissa Bokoye, Amadou

CARTEL (université de Sherbrooke)
Centre d'Applications et de Recherches en
Télédetection (CARTEL), Universite de Sherbrooke,
Sherbrooke, Quebec, Canada, Sherbrooke, Quebec,
Canada, J1K 2R1

E-mail: abokoye@courrier.usherb.ca URL: http://callisto.si.usherb.ca/~cartel

### Isaac, George

Cloud Physics Research Division
Atmospheric Environment Service 4905 Dufferin
Street, Toronto, Ontario, Canada, M3H 5T4
E-mail: george.isaac@ec.gc.ca

### J-P, Blanchet

Département des Sciences de la Terre, Université du Québec à Montréal

### Jacek W., Kaminski

Earth and Atmos. Science, York University

# Jacobs, John D.

Memorial University of Newfoundland

### Jean, Michel

Canadian Meteorological Centre, Environment Canada

E-mail: michel.jean@ec.gc.ca

# Jiang, Jonathan

University of Quebec at Montreal Department of Earth Sciences University of Quebec at Montreal P.O.Box 8888, Stn "Downtown" Montreal, Quebec H3C 3P8, Canada, Montreal, Quebec,

Canada, H3C 3P8

E-mail: jonathan@sca.uqam.ca

URL: http://www.sca.uqam.ca/~jonathan

# Joe, Paul

Environment Canada 4905 Dufferin St, Downsview, Ontario, Canada, M3H

E-mail: paul.joe@ec.gc.ca

### Jones. Phil

Climatic Research Unit, University of East Anglia

### Jones, Rick

Canadian Meteorological Centre, AES, Environment Canada

### Joseph-Pierre Toviessi, André Plante

Canadian Meteorological Centre, Environment Canada

### Jungo, Patricia

Institut de Geographie - Universite de Fribourg

### Juniper, Kim

Université du Québec à Montréal C.P. 8888, Succursale Centre-Ville, Montréal, Québec, Canada, H3C 3P8 E-mail: juniper.kim@uqam.ca URL: http://www.uqam.ca

### K., von Salzen,

Department of Atmospheric and Oceanic Sciences, McGill University

### Kabat, Pavel

Institute for Land and Water Management Research, The Netherlands

### Kallaur, Alexander

Environnement Canada, Meteorological Services Research Branch, ARQI

### Kaminski, Jacek

Earth and Atmos. Science, York University

### Kammerer, Édouard

Ocean Mapping Group, Université du Nouveau-Brunswick

# Kearney, Carole

UQAM

# Keen, Timothy

Naval Research Laboratory, Stennis Space Center, Mississippi

### Keyser, Daniel

University at Albany, State University of New York

### Kharin, Viatcheslav

Canadian Centre for Climate Modelling and Analysis University of Victoria PO Box 1700, STN CSC , Victoria, BC, CANADA, V8W 2Y2

E-mail: **Slava.Kharin@ec.gc.ca**URL: http://www.cccma.bc.ec.gc.ca/

### Kharrat, Abdel

Alberta Research Council

### Kilambi, Alamelu

McGill Weather Radar Observatory

### King, P.

Atmospheric Environment Service





# Klaassen, Gary

York University

### Kochtubajda, Bob

Environment Canada - Atmospheric Environment Branch, Prairie and Northern Region

### Kociuba, Pete

Environment Canada - Atmospheric Environment Branch, Prairie and Northern Region

# Koclas, Pierre

CMC

### Koshyk, John, N.

Department of Physics, University of Toronto

### Kouwen, Nicholas

University of Waterloo

Kreiss, H.\_O

### Lafleur, Caroline

INRS-Océanologie, Rimouski, Qc, Canada, G5L 3A1. Email: caroline\_lafleur@uqar.uquebec.ca

### Lam, Khanh-Hung

Earth Sciences Department at UQAM P.O. Box 8888, Station "Downtown", , Montreal, QC, Canada, H3P 3P8

E-mail: Lam@maia.sca.ugam.ca URL: http://www.sca.uqam.ca

# Lambert, Steven

Canadian Centre for Climate Modelling and Analysis Canadian Centre for Climate Modelling and Analysis Atmospheric Environment Service University of Victoria P.O. Box 1700, Victoria, B.C., Canada, V8W

E-mail: Steven.Lambert@ec.gc.ca

### Landry, Claude

Centre météorologique canadien Division des éléments du temps Direction du Développement Centre météorologique canadien 2121 Trans-Canada Dorval (Québec) Canada h9P 1J3, Dorval, Québec, Canada, H9P 1J3 E-mail: claude.landry@ec.gc.ca

# Lapczak, Steve

EC

### Laprise, Rene

Groupe de modelisation regionale du climat - UQAM

### Laroche, Stephane

Data Assimilation and Satellite Meteorology Division, Atmospheric Environment Service, Environment Canada

E-mail: stephane.laroche@ec.gc.ca

### Larocque, Marc

Earth Sciences Department at UQAM P.O. Box 8888, Station "Downtown", Montreal, QC, Canada, H3P 3P8

E-mail: larocque@maia.sca.ugam.ca

URL: http://www.sca.ugam.ca

### Lawford, Rick

NOAA/OGP Washington D.C.

### Lazare, M.

Atmospheric Environment Service

### Lazare. Micheal

Atmospheric Environment Service

### Lazier, John

Bedford Institute of Oceanography

### Lazier. John

Fisheries and Oceans Canada

### Leaitch. W.R.

Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ont. M3H 5T4, Canada

### Leduc, Anne-Marie

Canadian Meteorological Centre, Environment Canada

### Leduc, Julie

**GEOTOP-UQAM** 

C.P. 8888, Succ. Centre-Ville, Montréal, Québec,

Canada, H3C 3P8

E-mail: M210750@ER.UQAM.CA

http://www.umites.ugam.ca/geotop/wwwgeotop.html

### Lefaivre, Denis

Institut Maurice Lamontagne (MPO,DFO)

### Lefaivre, Louis

**Environment Canada** 

Canadian Meteorological Centre 2121, TransCanada Highway Dorval, Québec H9P 1J3, Dorval, Québec,

Canada, H9P 1J3

E-mail: louis.lefaivre@ec.gc.ca

### LEFEVRE, Mireille

Ministere Peches et Oceans Institut Maurice Lamontagne 850 route de la mer CP 1000, Mont-Joli, QUEBEC, CANADA, G5H 3Z4

E-mail: lefevrem@dfo-mpo.gc.ca

URL: http://www.qc.dfo-mpo.gc.ca/iml Leighton, Henry

Dept. of Atmospheric and Oceanic Sciences, McGill University, Montreal, H3A 2K6, Canada

### Lelièvre. Claude

Enviromet International Inc.

2 Capri, Dollard-des-Ormeaux, Québec, Canada,

H9B 2J2

E-mail: lelievre@aei.ca

### Lemay, Gabriel

Canadian Meteorological Centre, Environment Canada

### Leroueil, Serge

Département de génie civil, Université Laval

### Lesins, Glen

Dalhousie University

Dept. of Physics Dalhousie University, Halifax, NS,

Canada, B3H 3J5

E-mail: lesins@fizz.phys.dal.ca

### LEVASSEUR, Maurice

Institut Maurice Lamontagne

### Li, Guilong

Department of Mathematical Sciences, University of Alberta

Department of Mathematical Sciences, University of Alberta, Edmonton, Alberta, CANADA, T6G 2G1 E-mail: gli@pie.math.ualberta.ca

# Li, Jiangnan

member of CMOS

CCCMA P. O. Box 1700 University of Victoria,

Victoria, BC, Canada, V8W 2Y2 E-mail: **Jiangnan.Li@ec.gc.ca** 

# Li, Jianzhong

Wilfrid Laurier University

75 University Avenue West, Waterloo, ON, Canada,

N2L 3C5

E-mail: lixx1441@mach1.wlu.ca

### Li, Zhanqing

**CCRS** 

### Liboiron, Linda

Biosphère

### Lin, Ray

David Taylor Model Basin Laboratory

### Lin, Charles

McGill University

Department of Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke Street West, Montreal, Quebec, Canada, H3A 2K6

E-mail: lin@zephyr.meteo.mcgill.ca

URL: http://www.meteo.mcgill.ca

### Lin. Hai

Dept. of Atmospheric and Oceanic Sciences, McGill University

Dept. of Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke Street West , Montreal, Quebec. Canada. H3A 2K6

E-mail: hlin@tropo.meteo.mcgill.ca

### Lin, Hong

Atmospheric Environment Service, 4905 Dufferin Street, , Downsview, Ontario, Canada, M3H 5T4,

E-mail: hong.lin@ec.gc.ca

### Little, Ken

Canadian Meteorological Centre, Environment Canada

### Liu, Peter

Atmospheric Aerosol Research Inc.

2566 Innisfil Road, Mississauga, Ontario, Canada, L5M 4J1

E-mail: peter.liu@ec.gc.ca

URL: http://airquality.tor.ec.gc.ca/natchem/particles

### Locat, Jacques

Département de géologie et de génie géologique de l'Université Laval

### Loder, John

Bedford Institute of Oceanography, DFO

### Lohmann, Ulrike

Dept. of Physics

Atmospheric Scince Program Dalhousie University,

Halifax, N.S., Canada, B3H 3J5 E-mail: Ulrike.Lohmann@Dal.Ca

URL

http://www.phys.ocean.dal.ca/people/as/Lohmann\_Ul

### Loiselle, Monique

CMC

2121 Trans-Canada N., Dorval, Qc, Canada, H9P

1J3

E-mail: Monique.loiselle@ec.gc.ca

### Long, Bernard

**INRS-Géoressources** 

# Loucheur, Virginie

**GEOTOP** 

### Louie, Paul

**Environment Canada** 

Climate Processes and Earth Observation Division Climate Research Branch Atmospheric Environment Service 4905 Dufferin Street , Downsview, ON, CANADA, M3H 5T4

E-mail: paul.louie@ec.gc.ca

# Lucotte, Marc

UQAM





### Lynch, Amanda H.

Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, CO

### Macafee, Allan

Canadian Hurricane Centre
19 th Floor Queen Square, 45 Alderney Drive ,
Darmouth, Nova Scotia, Canada, B2Y 2N6
E-mail: al.macafee@ec.gc.ca

URL: http://www.ns.ec.gc.ca

### MacKay, Murray

Atmospheric Environment Service 4905 Dufferin Str, Toronto, Ontario, Canada, M3H 5T4

E-mail: murray.mackay@ec.gc.ca

### Mailhot, Jocelyn

Recherche en prevision numerique, SEA

### Makar, Paul

ARQI, AES, Downsview

# Mann, Graham

Leeds University

### Marcoux, Jacques

Centre météorologique canadien

# Marmen, Sylvain

**GEOTOP** 

# Marsden, Richard

Royal Military College of Canada Physics Department Royal Military College of Canada PO Box 17000, Kingston, Ontario, Canada, K7K 7B4 E-mail: marsden-r@rmc.ca

### Marsh, Philip

National Hydrology Research Centre, Saskatoon

### Martin, Christian

Memorial University of Newfoundland Dept. of Geography Memorial University, St. John's, NF, Canada, A1B 3X9

E-mail: **s87cm@morgan.ucs.mun.ca** URL: http://www.mun.ca/geog

### Martin, Francis

Département de géologie et de génie géologique, Université Laval

### Maslanik, Jim

Cooperative Institute for Research into Environmental Sciences

# Maslowe, Sherwin

McGill University

# Masson, Diane

Institute of Ocean Sciences

P.O. Box 6000 9860 West Saanich Rd , Sidney, BC,

Canada, V8L 4B2 E-mail: massond@dfo-mpo.gc.ca

### Maurice, France

Département de géologie et de génie géologique Pavillon Pouliot Université Laval , Ste-Foy, Québec, Canada, G1K 7P4

E-mail: fmaurice@ggl.ulaval.ca

URL: http://www.saguenay.ggl.ulaval.ca

McConnell, Jack York University

### McConnell, John C.

Earth and Atmos. Science, York University

### McDonald, Karen

**Environment Canada** 

### McElroy, C.T.

Atmospheric Process Research Branch, Atmospheric Environment Service

### McFarlane, Norman

Canadian Centre for Climate Modelling and Analysis University of Victoria P.O. Box 1700 , Victoria, BC , Canada, V8W 2Y2

E-mail: **Norm.McFarlane@ec.gc.ca** URL: http://www.cccma.bc.ec.gc.ca

# McLandress, Charles,

York University

# Medvedev, Alexander

York University

Department of Earth and Atmospheric Science York University 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3

E-mail: asm@yorku.ca
URL: http://www.yorku.ca

# Menard, Richard

NASA Goddard Space Flight Center Data Assimilation Office, Code 910.3 NASA Goddard Space Flight Center, Greenbelt, MD, U.S.A., 20771 E-mail: menard@dao.gsfc.nasa.gov URL: http://dao.gsfc.nasas.gov/DAO\_people/menard/

### OTAL. http://dao.gsic.hasas.gov/DAO\_people/menai

# Methot, Andre

division NWP, CMC

Centre Meteorologique Canadien 2121, voie de service nord, Trans-Canadienne Dorval (Quebec),

Dorval , Quebec, Canada, H9P 1J3 E-mail: **Andre.Methot@ec.gc.ca** URL: http://www.cmc.ec.gc.ca

### Michelangeli, Paul-Antoine

RPN, Environnement Canada 2121, route Transcanadienne, Dorval, Quebec, Canada, H9P 1J3

E-mail: Paul-Antoine.Michelangeli@ec.gc.ca

### Milbrandt, Jason, A

McGill University

Department of Átmospheric and Oceanic Sciences 805 Sherbrooke St. West , Montreal, QC, Canada, H3A 2K6

E-mail: jason@zephyr.meteo.mcgill.ca

### Milewska, Ewa

Atmospheric Environment Service 4905 Dufferin Street , Downsview, Ontario, Canada, M3H 5T4

E-mail: Ewa.Milewska@ec.gc.ca

### Miller, Ron

Department of Applied Physics, Columbia University, USA

### Mills. Brian

**Environment Canada** 

### Misra, Vasubandhu

McGill University, Montréal, Québec 805 Sherbrooke West, Montréal, Québec, Canada, H3A 2K6

E-mail: misra@zephyr.meteo.mcgill.ca

### Moffet, Richard

Environnement Canada, CMC, cmsn Centre meteorologique Canadien 2121 route Transcanadienne Dorval, Quebec H9P 1J3, Dorval,

Quebec, Canada, H9P 1J3 E-mail: richard.moffet@ec.gc.ca

### Molinari, John

University at Albany, State University of New York

### Monahan, Adam

Oceanography/EOS, Univ. of British Columbia

### Montero, Martin

Dept. of Physics, Dalhousie University

### Montpetit, Myriam

Université du Québec à Montréal Département des sciences de la Terre Université du Québec à Montréal C.P. 8888, Succ. Centre-Ville H3C 3P8, Montréal, Québec, Canada, H3C 3P8

E-mail: **m275070@er.uqam.ca** URL: http://www.sca.uqam.ca

### Montpetit, Jacques

Atmospheric Environment Service, Meteorological Research Branch, Division de la Recherche en Prevision Numerique

Moore, G.W. Kent

University of Toronto

### Moran. Mike

ARQI, AES, Downsview

### Morin, Guy

INRS-Eau

### Morneau, Gilles

Environnement Canada, région du Québec 100, boul. Alexis-Nihon, 3ième étage, Saint-Laurent, QC. Canada, H4M 2N8

E-mail: gilles.morneau@ec.gc.ca

URL: http://www.qc.ec.gc.ca

# Morneau, Josee

CMC

2121 voie de service nord, Trans-Canadienne, Dorval, Quebec, Canada, H9P 1J3 E-mail: josee.morneau@ec.gc.ca

### Mucci, Alfonso

McGill University

Department of Earth and Planetary Sciences McGill University 3450 University , Montreal, Quebec, Canada, H3A 2A7

E-mail: al\_m@geosci.lan.mcgill.ca

URL: http://eps.mcgill.ca/

### Mueller, Johannes

Institut für Atmosphärenphysik, GKSS, Max Planck Str., 21502 Geesthacht, Germany

### Murcray, F.J.

Dept. of Physics, University of Denver

# Murray, Nicholas Charles

Joint Centre Research, Ispra, Italy.

# Mwangi, Mike

The University of Western Ontario Dept. of Physics and Astronomy UWO, London, ON, CDN, N6A 3K7

E-mail: mwangi@lucille.physics.uwo.ca

URL: http://pcl.physics.uwo.ca

# Mysak, Lawrence A.

McGill University

Department of Atmospheric and Oceanic Sciences 805 Sherbrooke St. W. McGill University, Montreal, QC, Canada, H3A 2K6

E-mail: mysak@zephyr.meteo.mcgill.ca

### Neary, Lori

York University

# Nobre, Carlos

CPTEC-INPE, Brazil

### Noone, K.J.

Dept. of Meteorology, Stockholm University, 10691 Stockholm, Sweden





# Oakey, Neil S.

)F()

Bedford Institute of Oceanography Ocean Sciences Division PO Box 1006 Dartmouth, Nova Scotia, B2Y4A2, Dartmouth, Nova Scotia, Canada, B2Y4A2 E-mail: oakeyn@mar.dfo-mpo.gc.ca

URL:

http://www.maritimes.dfo.ca/science/ocean/epsonde/welcome.html

### O'Neill, Norm

GSFC/NASA (L.O.A. from Universté de Sherbrooke GSFC/NASA Code 923, Greenbelt, Maryland, U.S.A., 20771

E-mail: norm@spamer.gsfc.nasa.gov

URL:

http://www.callisto.si.usherb.ca/~cartel/noneill/norm.html

### **Ouellet, Mathieu**

UQAR

300 Allée des Ursulines, Rimouski, Qc, Canada, G5L

3A1

E-mail: mathieu\_ouellet@uqar.uquebec.ca

URL: http://www.uqar.uqebec.ca

### Ouyang, Bill

McGill University

Centre for Climate and Global Change Research McGill University 805 Sherbrooke Street Montreal, Quebec H3A 2K6 Canada, Montreal, Quebec,

Canada, H3A 2K6

E-mail: OUYANG@GEOG.MCGILL.CA

URL: http://www.mcgill.ca/ccgcr

### Pagé, Christian

UQAM

Département des Sciences de la Terre Groupe Sciences de l'Atmosphère Université du Québec à Montréal B.P. 8888, Succ. "Centre-ville", Montréal,

Québec, Canada, H3C 3P8 E-mail: **page@sca.uqam.ca** URL: http://euromet.sca.uqam.ca/

# Pal, Shiv R.

Centre for Research in Earth and Space Science

# Palany, Philippe

Météo-France

# Pandolfo, Lionel

University of British Columbia
Oceanography Division Department of Earth and
Ocean Sciences 6270 University Blvd, Vancouver,
BC, Canada, V6T 1Z4

E-mail: lionel@eos.ubc.ca
URL: http://www.eos.ubc.ca

### Paguin, Dominique

Groupe de modelisation regionale du climat - UQAM

### Park, Peter

MPB Technology

### Patoine, Alain

Environnement Canada, CMC, cmsn

### Pellerin, Gérard

Canadian Meteorological Centre, Environment Canada

# Pellerin, Gérard

Canadian Meteorological Centre, Environment Canada

E-mail: gerard.pellerin@ec.gc.ca

### Pellerin, Pierre

Recherche en Prévision Numérique (AES) Environnement Canada 2121, Rte Transcanadienne , Dorval, Quebec, Canada, H9P 1J3 E-mail: pierre.pellerin @ec.gc.ca

### Pellerin, Simon

Sercice de l'environnement Atmosphérique 2121, Trans-Canada N., Dorval, P.Q., Canada, H9P 1J3

E-mail: **Simon.Pellerin@ec.gc.ca** URL: http://www.cmc.ec.gc.ca

# Pendlebury, Diane

University of Toronto
Department of Physics 60 St. George St , Toronto,
Ontario, Canada, M5S 1A7
E-mail: diane@atmosp.physics.utoronto.ca

### Perez-Martell, Esther

Universidad de Las Palmas de Gran Canaria (Spain) Oceanography, Dept. of Earth & Ocean Sciences University of British Columbia 6270 University Blvd., Vancouver, B.C., Canada, V6T 1Z4

E-mail: perez@ocgy.ubc.ca

URL: http://www.ocgy.ubc.ca/projects/clim.pred/

# Péron, Florence

Université Fourier

# Perrie, William

Bedford Institute of Oceanography
P.O. Box 1006 1 Challenger Dr. , Dartmouth , Nova
Scotia , Canada , B2Y 4A2

E-mail: wperrie@emerald.bio.dfo.ca

# Pestieau, Paul

Environnement Canada, CMC

# Peters, Brian

Meteorological Service of New Zealand Ltd, Wellington, New Zealand

### Peterson, Ingrid

Bedford Institute of Oceanography

# Peterson, K. Andrew

Dalhousie University

Department of Oceanography Dalhousie University, Halifax, Nova Scotia, Canada, B3H 4J1

E-mail: drew@phys.ocean.dal.ca

URL: http://www.phys.ocean.dal.ca/~drew/drew.html

### Petrie. Brian D.

Bedford Institute of Oceanography

### Petriello, Paolo Jr.

Mcgill University, Dept. of Atm. Sciences Department of Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke Street West, Montreal, Quebec, Canada, H3A-2K6 E-mail: ppetri@po-box.mcgill.ca URL: http://zephyr.meteo.mcgill.ca/

### Petrucci, Franco

Centre météorologique canadien

### Pieters, Roger

University of British Columbia

### Pietroniro, Alain

National Hydrology Research Institute

### Pilotte, Marcel

**UQAM** 

### Plante. A.

Centre Météorologique Canadien (CMC) 2121, route Transcanadienne, Dorval, Québec, Canada, H9P 1J3

E-mail: andre.plante@ec.gc.ca

URI ·

http://www.cmc.ec.gc.ca/~cmcdev/saisons/saisons.ht

### Plumb, R. Alan

Massachusetts Institute of Technology, Cambridge, MA, 02139

# Plummer, David

York University

Centre for Research in Earth and Space Science, Toronto, ON., Canada, M3J 1P3

E-mail: plummer@nimbus.yorku.ca

### Pond, Steve

University of British Columbia

### Poulin, Patrick

**GEOTOP-UQAM** 

# Premont, Bruno

Environment Canada - Ottawa Regional Centre

# Prieur, Louis

LPCM, 06230 Villefranche-sur-mer, France. Email: prieur@ccrv.obs-vlfr.fr

### Primeau, Francois

Scripps Institution of Oceanography

Climate Modelling and Anaysis P.O. Box 1700, STN CSC, Victoria, BC, Canada, V8W 2Y2

E-mail: fprimeau@alum.mit.edu

# Provost, Alain

UQAM

### Puckrin, Eldon

Environmental Resource Studies, Trent University

# Pudykiewicz, Janusz

Environnement Canada, Meteorological Services Research Branch, ARQI

### Qiu. Xin

306 Petrie Science Bldg. York University 4700 Keele St., Toronto, Ontario, Canada, M3J 1P3

E-mail: Xinqiu@yorku.ca

URL: http://www.yorku.ca/research/blayer/

Dept. of Physics, University of Toronto

### Quinn, Declan

Department of Mathematics, University of British Columbia, BC

### Radeva, Ekaterina

Canadian Meteorological Centre, AES, Dorval

# Ramsden, D.

### Raschke, Ehrhard

GKSS, Germany

# Raymond, Nicole

La Biosphère

160, chemin Tour-de-L'Isle, Île Sainte-Hélène, Montréal, Québec, Canada, H2V 4J9 E-mail: nicole.raymond@ec.gc.ca URL: http://biosphere.ec.gc.ca

# Ritchie, Harold

Recherche en prévision numérique 2121 Trans-Canada Highway, Dorval, Québec, Canada, H9P 1J3

E-mail: Harold.Ritchie@ec.gc.ca

### Rivet, Claude

Environnement Canada - DPE 105, rue McGill, 4° étage, Montréal, QC, Canada, H2Y 2E7

E-mail: claude.rivet@ec.gc.ca

### Ro, Chul-Un

Atmospheric Environment Service

### Robichaud, Alain

Environnement Canada, région du Québec





### Robinson, Carol

University of Toronto at Scarborough

### Roch, Michel

Division de la recherche en prévision numérique 2121, route Transcanadienne, 5ième étage, , Dorval, Québec, Canada, H9P 1J3

E-mail: michel.roch@ec.gc.ca

### Roulet, Nigel

Centre for Climate and Global Change Research, McGill University

### Rouse, Wayne

McMaster University, Hamilton

# **ROY, FRANÇOIS**

Ocean Science Division, Maurice-Lamontagne Institute, Department of Fisheries and Oceans, Mont-Joli, Québec, Canada, G5H 3Z4 850 route de la Mer, , Mont-Joli, Québec, Canada, G5H 3Z4

E-mail: royf@dfo-mpo.gc.ca

### Royer, Alain

CARTEL, Universite de Sherbrooke

### Russell, Albert

University of Western Ontario

### Sankey, David

University of Toronto

Department of Physics University of Toronto 60 St. George Street, Toronto, Ontario, Canada, M5S 1A7 E-mail: sankey@mam.physics.utoronto.ca

UKL.

http://www.atmosp.physics.utoronto.ca/MAM/home.html

### Sarrazin, Jozée

Woods Hole Oceanographic Institution

### Sarrazin, Real

CMC

# Saucier, François J.

Ocean Science Division, Maurice-Lamontagne Institute, Department of Fisheries and Oceans, Mont-Joli, Québec, Canada, G5H 3Z4

### Savard, Josée

GEOTOP-UQAM

C.P. 8888, Succ. Centre-Ville, Montréal, Québec,

Canada, H3C 3P8

E-mail: m314214@er.uqam.ca

IIRI ·

http://www.unites.ugam.ca/geotop/wwwgeotop.html

# Schaer, Christoph

Atmospheric Science, ETH Zurich

### Schertzer, William

National Water Research Institute, CCIW

National Water Research Institute Canada Centre for Inland Waters 867 Lakeshore Road, Burlington, Ontario, Canada, L7R 4A6

E-mail: william.schertzer@cciw.ca

### Schmidt, Gavin

Center for Climate Systems Research, Columbia University, USA

## Schmitz, Rainer

University of Chile

### Schramm, Julie

University of Colorado

Schubert, W. H.

### Scott, John

EC

# Semeniuk, Kirill

University of Toronto

Department of Physics University of Toronto 60 St. George Street, Toronto, Ontario, Canada, M5S 1A7 E-mail: kirill@atmosp.physics.utoronto.ca

URL: http://www.atmosp.physics.utoronto.ca

### Serreze, Mark

Cooperative Institute for Research into Environmental Sciences

### Servranckx, René

Canadian Meteorological Centre, Environment Canada

E-mail: rene.servrancks@ec.gc.ca

### Shen, Samuel Shanpu

Department of Mathematical Sciences, University of Alberta

# Sheng, Jian

Canadian Centre for Climate Modelling and Analysis/AES

Canadian Centre for Climate Modelling and Analysis University of Victoria P.O.Box 1700, Victoria, BC, Canada, V8W 2Y2

E-mail: Jian.Sheng@ec.gc.ca

### Sheng, Jinyu

Dalhousie University

Department of Oceanography Dalhousie University , Halifax, Nova Scotia, Canada, B3H 2J1

E-mail: Jinyu.Sheng@Dal.Ca

URL: http://www.ocean.dal.ca

### Shepherd., Ted, G.

Department of Physics, University of Toronto,

# Shindell, Drew

Center for Climate Systems Research, Columbia University, USA

### Shore, Jennifer

B.I.O./D.F.O.

Coastal Ocean Science, DFO Bedford Institute of Oceanography Box 1006, Dartmouth, Nova Scotia, Canada, B2Y 4A2

E-mail: jshore@georgs.bio.dfo.ca

### Sica, Robert

The University of Western Ontario

Dept. of Physics and Astronomy UWO , London, ON,

CDN, N6A 3K7

E-mail: **sica@physics.uwo.ca** URL: http://pcl.physics.uwo.ca

### Sills, David

King City Radar, Environment Canada

# Simon, Pellerin

RPN, Environment Canada

### Simpkin, Peter

**IKB Technologies Limited** 

### SINGH, Abnash

McGill University

### Singh, Abnash

Dept. Atmospheric and Oceanic Sciences, McGill University

### Siok, Stan

Environment Canada - Ottawa Regional Centre

### Slonosky, Vicky

Climatic Research Unit, University of East Anglia Climatic Research Unit University of East Anglia , Norwich, , United Kingdom, NR4 7TJ E-mail: v.slonosky@uea.ac.uk

URL: http://www.cru.uea.ac.uk/

### Smirnov, Alexander

NASA/GSFC, Greenbelt Maryland

# Smirnov, Vladimir

atmospheric physics

University of Toronto, Department of Physics, 60 St. George St., Room 619, Toronto, ON, Canada, MES 147

M5S 1A/

E-mail: vladimir@atmosp.phycsics.utoronto.ca

### Smith, Peter C.

Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth, Nova Scotia, CANADA,

E-mail: SmithPC@mar.dfo-mpo.gc.ca

URL: http://www.mar.dfo-mpo.gc.ca/science/ocean

Solheim, B.H.

CRESTech, York University

### Soulis. Eric

University of Waterloo

### Souvanlasy, Vanh

Centre météorologique canadien

### Spacek, Lubos

UQAM

Earth Sciences Department, University of Quebec at Montreal (UQAM), P.O. Box 8888, Stn "Downtown", Montreal, QC, Canada, H3C 3P8, Montreal, Quebec, Canada, H3C 3P8

E-mail: **spacek@sca.uqam.ca** URL: http://www.sca.uqam.ca

### St-Hilaire, André

INRS-EAU

926 ch. Melanson , Dieppe, , Nouveau-Brunswick,

Canada, E1A 7N9

E-mail: hilpag@nbnet.nb.ca

# St-James, Judy

Centre Météorologique Canadien

E-mail: judy.st-james@ec.gc.ca

# St-Onge, Francine

UQAM

# St-Onge, Guillaume

**GEOTOP** 

GEOTOP Université du Québec à Montréal Case Postale 8888, Succursale Centre-Ville , Montréal,

Québec, Canada, H3C 3P8 E-mail: m363574@er.uqam.ca

URL: http://unites.uqam.ca/geotop/wwwgeotop.html

### STACEY, Michael W.

Royal Military College of Canada

# Staniforth, Andrew

UKMO

# Stanley-Jones, Martin

EC

# Stewart, Jim

Canadian Forest Service

### Stewart, Ronald

AES

4905 Dufferin Street , Downsview, Ontario, Canada, M3H 5T4

E-mail: Ron.Stewart@ec.gc.ca

### Stix, John

Université de Montréal

### Stocks, B.

Canadian Forest Service





### Stone. Daithi

School of Earth and Ocean Sciences, University of Victoria

School of Earth and Ocean Sciences University of Victoria P.O. Box 3055, Victoria, British Columbia, Canada. V8W 3P6

E-mail: stone@ocean.seos.uvic.ca

URL:

http://wikyonos.seos.uvic.ca/people/stone/stone.html

### Straub, David N.

McGill

Atmospheric and Oceanic Sciences 805 Sherbrooke O. McGill, Montreal, QC, Canada, H3A 2K6 E-mail: david@gumbo.meteo.mcgill.ca

### Strong, Geoff

National Hydrology Research Centre 11 Innovation Boulevard , Saskatoon, Sask., cANADA, S7N 3H5 E-mail: Geoff.Strong@ec.gc.ca

URL: http://www.tor.ec.gc.ca/GEWEX/

### Strong, K.

Dept. of Physics, University of Toronto

### Stuart, Ambury

Weather Research House 77 Glendora Avenue , Willowdale, Ontario, Canada, M2N 2V9

E-mail: wxresrch@netcom.ca

### Students of the UQAR Mission Stage 1998,

Université du Québec à Rimouski

### Stuhlmann, Rolf

Institut für Atmosphärenphysik, GKSS, Max Planck Str., 21502 Geesthacht, Germany

# Sukloff, William

Atmospheric Environment Service

# Szyrmer, Wanda

UQAM, CCRM

Universite du Quebec a Montreal B.P.8888, Succ."Centre-ville", Montreal, Quebec, Canada, H3C

E-mail: wanda@sca.uqam.ca URL: http://www.sca.uqam.ca

### Tang, Benyang

Oceanography, Dept of Earth & Ocean Sciences, Univ. of British Columbia,

# Tang, Charles

Bedford Institute of Oceanography

# Tang, Youmin

University of British Columbia Oceanography/EOS, University of British Columbia, Vancouver, B.C. Canada, V6T 1Z4

### E-mail: tym@ocgy.ubc.ca

URL: http://www.ocgy.ubc.ca/prejects/climate.pred/

### Tanguay, Monique

**Environnement Canada** 

### Tardif, Robert

Sciences de l'Atmosphère, Département des Sciences de la Terre, Université du Québec à Montréal

CP 8888, Succursale "Centre-Ville", Montréal,

Québec, Canada, H3C 3P8 E-mail: tardif@sca.uqam.ca URL: http://www.sca.uqam.ca/~tardif

### Taylor, Peter

EATS, York University

### Taylor, Peter

Dept of Earth and Atmospheric Science, York University

### Teillet, Phillippe M.

Canada Centre for Remote Sensing, Ottawa, Ontario, Canada

### Templeton, Edna

EATS/York University

### Thayaparan, Thayananthan

Defence Research Establishment Ottawa

### Therrien, René

Département de géologie et de génie géologique, Université Laval

### Thomas, Steve

National Center for Atmospheric Research, Boulder

### Thompson, Keith R.

Dalhaousie University, Department of Oceanography, Halifax, NS, Canada, B3H 4J1

# Thurtell, George

University of Guelph

# Tinis, Scott

Canadian Centre for Climate Modelling and Analysis Canadian Centre for Climate Modelling and Analysis University of Victoria , Victoria, BC, Canada, V8W 2Y2

E-mail: Scott.Tinis@ec.gc.ca

### Torlaschi, Enrico

UQAM - Département des sciences de la Terre Case postale 8888, succursale Centre-Ville , Montréal, Québec, , H3C 3P8

E-mail: torlaschi.enrico@uqam.ca

URI ·

http://www.unites.ugam.ca/~sct/sct\_torlaschi.html

### Toulany, Bechara

Bedford Institute of Oceanography

### Tremblay, André

Atmospheric Environment Service 2121 Trans Canada Highway, Dorval, Québec, Canada. H9P 1J3

E-mail: andre.tremblay@ec.gc.ca

### Tremblay, Louis-Bruno

Lamont-Doherty Earth Laboratory

### Trudel, Serge

Centre météorologique canadien

### **Turcotte, Marie-France**

Centre météorologique canadien Division des éléments du temps Direction du développement Centre météorologique canadien 2121 Trans-Canada Dorval (Québec) Canada H9P 1J3, Dorval, Québec, Canada, H9P 1J3 E-mail: marie-france.turcotte@ec.gc.ca

# **TURNER, SANDRA**

Universite du Quebec a Montreal Departement des Sciences de la Terre Universite du Quebec a Montreal B.P. 8888, Succ. "Centre-ville", Montreal, Quebec, Canada, H3C 3P8 E-mail: sandrat@sca.uqam.ca URL: http://sca.uqam.ca

### Vaillancourt, Paul

**AES** 

2121 route transcanadienne, Dorval, Québec, Canada, H9P 1J3

E-mail: paul.vaillancourt"ec.gc.ca

### Vaillancourt, Pierre

Environnement Canada 100 Alexis-Nihon, Suite 300, Saint-Laurent, Québec, Canada, H4M 2N8 E-mail: pierre.vaillancourt@ec.gc.ca

Vallee, Marcel

2121 route TransCanadienne suite 500, Dorval,

Quebec, Canada, H9P 1J3 E-mail: marcel.vallee@ec.gc.ca

URL: http://zephyr.cmc.ec.gc.ca/stats-mos/index.html

### Van Rijn, Paul

EC

### Vandermeer, Aaron

Department of Physics, York University 4700 Keele St., North York, Ontario, Canada, M3J 1P3

E-mail: aaron@lidar.crestech.ca

# Varma, Ravi

McGill

### Vassiliev, Oleg

The University of Western Ontario

### Vergara, Jose

University of Chile

Av. Blanco Encalada 2085, Santiago, Santiago, Chile,

E-mail: jvergara@dgf.uchile.cl

URL:

http://www.dgf.uchile.cl/~jvergara/conf/CMOS99B.html

### Verner, Gilles

CMC

### Verret, Richard

Centre météorologique canadien
Division des éléments du temps Direction du
développement Centre météorologique canadien
2121 Trans-Canada Dorval (Québec) Canada H9P
1J3, Dorval, Québec, Canada, H9P 1J3
E-mail: richard.verret@ec.gc.ca

### Vet. Rober

Atmospheric Environment Service

### **VEZINA**, Alain

Institut Maurice Lamontagne

# Vigneux, Denis

Centre météorologique canadien

### Vincent, Lucie

CLimate Research Branch, AES

# Viterbo, Pedro

ECMWF

# von Salzen, Knut

Department of Atmospheric and Oceanic Sciences,McGill University 805 Sherbrooke St. W. , Montreal, PQ, Canada , H3A 2K6

### Wang, Jia

University of Alaska at Fairbanks

### Wang, Yuhui

McGill University

# Wang, Zhaomin

McGill University

Department of Atmospheric and Oceanic Sciences 805 Sherbrooke St. W. McGill University, Montreal, QC. Canada. H3A 2K6

E-mail: zhaomin@whale.meteo.mcgill.ca

### Wang, Zhaomin

McGill University

### Ward, William, E,

CRESS/CRESTechs





### Warland, Jon

University of Guelph

Department of Land Resource Science University of Guelph , Guelph, Ontario, Canada, N1G 2W1 E-mail: iwarland@lrs.uoquelph.ca

### Watterson, lan

CSIRO Atmospheric Research

Private Bag 1, Aspendale, Victoria, Australia, 3195

E-mail: lan.Watterson@dar.csiro.au URL: http://www.dar.csiro.au

### Waugh, David

AEB - Atmospheric Science Division - Atlantic 45 Alderney Drive 16th Floor, Dartmouth, Nova Scotia B2Y 2N6 , Dartmouth, NS, Canada, B2Y 2N6 E-mail: david.waugh@ec.gc.ca

### Weaver, Andrew

School of Earth and Ocean Sciences, University of Victoria

# Welch, William J.

University of Waterloo

### Wen, Lei

CERCA (Centre de Recherche en Calcul Appliqué 5160, boul. Décarie, bureau 400, Montréal, Québec, Canada. H3X 2H9

E-mail: leiwen@cerca.umontreal.ca URL: http://www.cerca.umontreal.ca

### Weng, Wensong

EATS, York University

4700 Keele Street , Toronto, Ontario, Canada, M3J

E-mail: wweng@yorku.ca

URL: http://www.yorku.ca/research/blayer

### White, Loren

Jackson State University
Jackson State University Dept. of Physics,
Atmospheric Science, and General Science Just
Science Hall 1400 J.R. Lynch St., Jackson, MS,
U.S.A., 39217-0460

E-mail: lwhite@stallion.jsums.edu

# Whitney, Frank

Institute of Ocean Sciences

### Willmott, Andrew

Keele University

### Wilson, Lawrence

RPN

### Wintels, Werner

McGill University

4127 Northcliffe #2 Montreal, Qc H4A 3L2, Montreal,

Quebec, Canada, H4A 3L2

E-mail: wintels@zephyr.meteo.mcgill.ca URL: http://zephyr.meteo.mcgill.ca

# Wong, Jeff

CCRS - Ottawa

### Xiao, Jingbing

Dept of Earth and Atmospheric Science, York University, 4700 Keele St., , Toronto, Ontario, Canada, M3J 1P3

E-mail: **jingbing@yorku.ca**URL: http://www.yorku.ca

# Xu, Haiming

Nanjing Institute of Meteorology

### Yao, Tom

Bedford Institute of Oceanography
Fisheries and Oceans Canada Ocean Sciences
Division Bedford Institute of Oceanography P.O. Box
1006, Dartmouth, NS, Canada, B2Y 4A2
E-mail: tyao@hp200ice.bio.dfo.ca

### Yashayaev, Igor

Bedford Institute of Oceanography Ocean Circulation Section, Ocean Sciences Division, Bedford Institute of Oceanography P.O.BOX 1006, Dartmouth, N.S. B2Y 4A2, Canada, Dartmouth, NS, Canada, B2Y 4A2

E-mail: Yashayaevl@mar.dfo-mpo.gc.ca

URL: http://www.mar.dfo-

mpo.gc.ca/science/ocean/woce/welcome.html

### Yasunari, Tetsuzo

University of Tsukuba, Japan

### Yau, M. K.

Dept. of Atmospheric and Oceanic Sciences, McGill University

### Yeh, Kao-San

CERCA

2121 Trans-Canada Hwy, 5th Floor , Dorval, Quebec, CANADA, H9P 1J3

E-mail: kaosan.yeh@ec.gc.ca

# Yu, Wei

CERCA

# Zadra, Ayrton

Dept. Atmospheric and Oceanic Sciences McGill University 805 Sherbrooke St. W, Montreal , Quebec, Canada, H3A 2K6

E-mail: azadra@strato.meteo.mcgill.ca URL: http://zephyr.meteo.mcgill.ca/

# Zawadzki, Isztar

McGill University

805 Sherbrooke St. W Dept. of Atmospheric Sciences, Montreal, Quebec, Canada, H3A 2K6

E-mail: isztar@radar.mcgill.ca

# Zhang, Yaocun

Bedford Institute of Oceanography

### Zhang, Deke

Geotop Center, University of Quebec at Montreal Geotop Center, University of Quebec at Montreal, Montreal, Quebec, Canada, H3C 3P8

E-mail: d252334@er.uqam.ca

# Zhang, Xuebin

Climate Research Branch, AES CCRM/CRB 4905 Dufferin Street , Downsview, Ontario, , M3H 5T4

E-mail: Xuebin.Zhang@ec.gc.ca

# Zhang, Yaocun

Bedford Institute of Oceanography, Nanjing University P.O. Box 1006, Dartmouth, Nova Scotia, Canada, B2Y 4A2

E-mail: zhangy@mar.dfo-mpo.gc.ca

### Zuretti, Fabien

Earth Sciences Department at UQAM P.O. Box 8888, Station "Downtown",, Montreal, QC, Canada, H3C 3P8 E-mail: Blanchet.Jean-Pierre@uqam.ca

URL: http://http://www.sca.uqam.ca

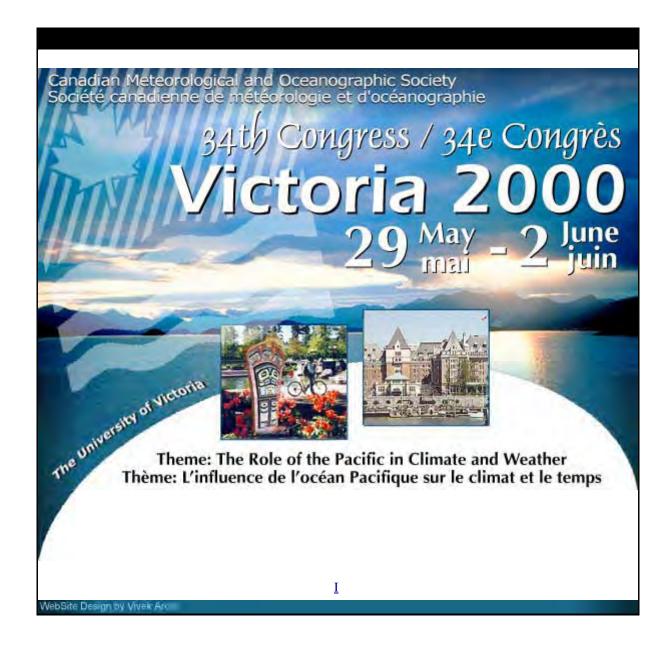
### Zwack, Peter

Université du Québec à Montréal Earth Sciences Department Université du Québec à Montréal P.O. Box 8888, Station A , Montreal, Quebec, Canada, H3C 3P8
E-mail: zwack.peter@uqam.ca
URL: http://www.sca.uqam.ca/~peter/peter\_res.html

### Zwiers, Francis W.

Canadian Centre for Climate modelling and analysis, Victoria, British Columbia, Canada





# 34<sup>th</sup> Annual CMOS Congress Victoria, British Columbia May 29 to June 2, 2000

Theme: The Role of the Pacific in Climate and Weather

# **Scientific Program Committee**

# **Local Arrangements Committee**

George Boer	Howard Freeland	Chair(s)	John Fyfe
250-363-8226	250-363-6590	Telephone	250-363-8236
250-363-8247	250-363-6746	Fax	250-363-8247

Please contact the Local Arrangements Committee for general information and the Scientific Pro-gram Committee regarding special sessions and workshops. Exhibitors, please contact Diane Masson of the Local Arrangements Committee at 250-363-6521.

Plan to attend the first CMOS Congress of the new millennium in Victoria. Victoria - the "City of Gardens" is the vacation capital of Canada and the premiere tourist spot of the Pacific Northwest.

34e Congrès annuel de la SCMO Victoria, Colombie-Britannique 29 mai au 2 juin, 2000

Thème: L'influence de l'océan Pacifique sur le climat et le temps

# Comité du programme scientifique

# Comité local organisateur

George Boer	Howard Freeland	Président(s)	John Fyfe
250-363-8226	250-363-6590	Téléphone	250-363-8236
250-363-8247	250-363-6746	Télécopieur	250-363-8247

Veuillez contacter le Comité local organisateur pout toute information d'ordre général, et le Comité du programme scientifique pour les sessions et les ateliers spéciaux. Nous demandons aux exposants de contacter Diane Masson du Comité local organisateur au 250-363-6521.

Venez donc participer au premier congrès de la SCMO du millénaire, à Victoria. Victoria, la "Ville aux mille jardins", est considérée comme la capitale canadienne des vacances et l'endroit touristique de premier choix dans la région du Pacifique Nord-Ouest.



# **HNSXSUPERCOMPUTERS**

est heureux d'offrir son parrainage au is pleased to provide sponsorship for

OB

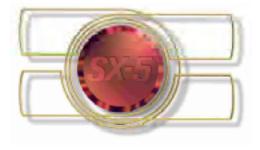
Congrès de la Société canadienne de météorologie et d'océanographie

Canadian Meteorological and Oceanography Congress

OB

31 mai - 4 juin 1999 May 31 – June 4, 1999

Montréal, Quebec



SX-5 SERIES High Performance Computers Weather Prediction, Climate Modeling and Environmental Research